Doc ID 49104062	**Custodian** Senior Principal Engineer - Water Treatment
Version Date 20 March 2020	**Accountabilities Framework** Level 1 - Acquire Infrastructure Assets Level 2 - Design Assets
Next Review Date 30 June 2022	

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Acronyms and Abbreviations

3D	The task of modelling using BIM enabled tools to produce a 3D representation of the asset.
4D	The task of producing animations or graphically representing the BIM with an electronic version of the project schedule to illustrate the sequence of installation. To be performed by the contractor.
5D	The task of linking the BIM to an electronic version of the cost plan. To be performed by the cost estimator.
6D	The task of linking to or embedding the BIM with asset information. This information can be exported by the contractor to input into the Asset Information Model.
AIM	Asset Information Model - as per ISO 19650-2. Final coordinated and verified asset information deliverables including graphical and non-graphical data used for management reporting and data exchange with other systems
AM	Asset Management - A systematic process of deploying, operating, maintaining, upgrading, and disposing of assets cost-effectively
BEP	BIM Execution Plan - Refer DEXP (i.e. BEP is a synonym of DEXP)
BIM (verb)	The generation, sharing and leveraging of structured digital information that represents an asset over the asset lifecycle
BIM (noun)	Building Information Model - means all models (including, without limitation, native models and any Federated Models) which the Contractor is (or its subcontractors are) required to produce and deliver in accordance with the Digital Engineering Execution Plan (DEXP).
CapEx	Capital Expenditure - Funds used to acquire or upgrade a physical asset
CDE	Common Data Environment - A single source of information for any given project, used to collect, manage and disseminate all relevant approved project documents for multi-disciplinary teams in a managed process
CAD	Computer Aided Design/Drafting - The process of creating a technical drawing with the use of computer software
CAFM	Computer Aided Facilities Management - The support of facility management by information technology
CMMS	Computerised Maintenance Management System
Data Normalisation	The process of organising the fields and tables of a relational database to minimise redundancy
DE	Digital Engineering - The process of capturing engineering information digitally throughout the CapEx and OpEx stages of a project. DE encompassed P&ID, BIM, CAD, GIS, Cost and project controls. Water Corporation's preferred terminology / alternative terminology to "BIM". DE is a collaborative way of working, using digital processes, to

	enable more productive methods of planning, design, constructing, operating and maintaining of assets.
DEXP	DE Execution Plan - A detailed document describing use of Digital Engineering on a project. It outlines who is responsible for what in the DE process, when in the process they are responsible for it, and how they will execute the employer requirements. (Sometimes called BEP i.e. BIM Execution Plan)
EDMS	Electronic Document Management System. Water Corporation currently uses Nexus as its internal EDMS.
EOI	Expression of Interest
FM	Facility Management – a specialised field in operations devoted to the coordination of space, infrastructure, people and organisation, often associated with the administration of infrastructure
Federated Model	A combined building information model containing multiple discipline models
FM Middleware	A tool that integrates DE information with existing systems such as CAFM, SCADA, BMS and GIS
FMS	Facilities Mapping System (GIS Asset Register)
GIS	Geographic Information System - A computer system designed to capture, store, manipulate, analyse, manage, and present all types of geographical data
HAZOP	Hazard reviews in design and construction to mitigate risks to people or equipment during Operation.
HAZID	A HAZID study is a tool for Hazard Identification used early in a project.
IFC	Issued for Construction documentation
Information Manager	Water Corporation resource assigned to ensure the supplier complies with the Digital Engineering Manual (PIR) and DEXP enabling the creation of the PIM and AIM.
Key Decisions	A decision that the business values as a priority and must be answered through the project delivery and ongoing operations of the asset
Laser Scanning	The process of capturing digital information about the shape of an object with equipment that uses a laser to measure the distance between itself and the object
LOD	Level of Development - The progressive development of the objects data and geometric accuracy within the BIM
LOI	Level of Information – the specific data associated within the individual objects within the BIM or P&ID
MEP	Mechanical, Electrical and Plumbing.
Operate and Maintain / Operations and Maintenance	The care and minor maintenance of assets or facilities using procedures that do not require detailed technical knowledge of the asset's function and design.
OpEx	Operational Expenditure - An ongoing cost / expense
P&ID	Piping and Instrumentation Diagram – is a detailed diagram which

	shows the piping and vessels in the process flow, together with the instrumentation and control devices.
PIM	Project Information Model – an Information model developed during the design and construction phase of a project, consisting of documentation, non-graphical information and graphical information, defining the delivered project typically using P&ID, BIM, CAD & GIS
PIR	Principal's Information Requirements - The Digital Engineering Manual (PIR) identifies the Asset Owner's (Water Corporation) Information Requirements across all project types and all stages.
PLQ	Plain Language Questions - A set of questions that the Water Corporation intends to answer at each stage of a construction project that form the Key Decision points
Project DE Manager	Supplier provided resource to manage the DE and asset information processes on the project
Smart P&ID	Piping and Instrumentation Diagram authoring tools that are connected to a database and also have bidirectional links with 3D modelling tools and spreadsheet registers (e.g. equipment, instrument, valve registers, etc.)
SPOT	Single Point of Truth
Supplier/s	Any external party engaged by Water Corporation to provide goods and services such as the head contractor, sub-contractors, designers and vendors

1 INTRODUCTION

1.1 DOCUMENT SCOPE

The intent of this document is to provide a Brief, supporting the implementation of Building Information Modelling (BIM) and Digital Engineering (DE) on the project. The use of BIM/DE will support the creation of the Project Information Model (PIM) and Asset Information Model (AIM) as defined in ISO 19650-2 (see Figure 1). For clarity, the PIM is defined as all of the information created during the course of delivering a project which is needed to design, construct and operate the asset. This information will be communicated through graphical geometric models (BIM), documents (e.g. drawings, schedules, specifications, etc.) and tabular data. This project information (PIM) is then validated by the Water Corporation and added to the Water Corporation Asset Information Model which covers all assets under Water Corporation management. Depending on the scale and complexity of the project, Water Corporation's PIR (i.e. this document, the Digital Engineering Manual) may differ.

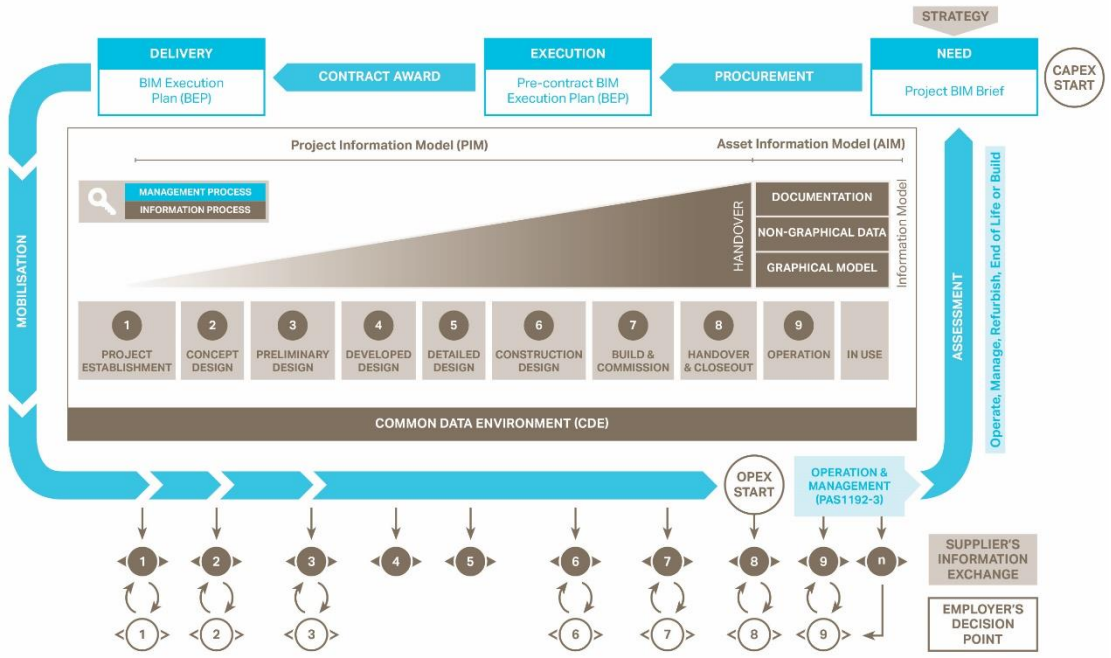

Figure 1 - ISO 19650 PIM and AIM creation/management

Terminology relating to BIM is in accordance with the terms used in the NATSPEC BIM Guide v.1.0 Sept 2011, Project BIM Brief v2.0, BIM Management Plan v2.0, and ISO 19650. This document shall be read in conjunction with other Water Corporation requirements documentation and the specific Principal's Design Brief or Contract Specification/Contract Scope.

The Water Corporation categorises projects as either Major Projects (Category A, B or C) or Minor Projects (Category D and Service Connections). Refer to the Guideline for Project Categorisation (Nexus#58611560) and the Engineering Design Manual (Nexus#58547221) for further information.

The project category dictates the level of resources required to deliver the project and the scale of the information to be provided in the business case. The Digital Engineering

strategy may differ based on the size, complexity, capability of suppliers and level of certainty involved with the project.

Nothing in this document is intended to relieve the supply chain of responsibility to comply with Water Corporation standards including those relating to the creation of P&IDs, functional location numbering and the handover procedure.

1.2 PRINCIPAL'S INFORMATION REQUIREMENTS (PIR)

The Digital Engineering Manual (i.e. this PIR document) is an important element of project DE implementation. It is used to set out clearly to the bidder/contractor (supplier) what information is required and how the information will be structured and delivered in a staged approach. These requirements will in turn be written into the project's contractual documentation and implemented through the project by way of a DE Execution Plan (DEXP), managed by the supplier's Project DE Manager.

1.3 CONTEXT

The advent of relay control and then PLC control provided the means for automation of many operating activities, providing cost savings through improved efficiencies, and providing greater reliability and improved safety. Digital Engineering (DE) presents similar opportunities for increased levels of automation of business activities in areas such as design, construction, maintenance and asset management. Consequently, the value of DE is more than the potential savings from design efficiencies and the capital savings from construction and procurement efficiencies, but is also an investment in providing ready access to asset information required during maintenance, asset management, and future upgrades. This overall value to the Water Corporation should be considered by the design manager when specifying the extent of DE required in design briefs and contract specifications.

Other benefits of DE include:

- The digital model of the asset allows information to be attached to individual components of the model, making the model a repository for information relevant to the asset. For example, attached to an item of equipment could be the procurement data sheet and the maintenance manual from the equipment supplier. This also provides opportunity for *ad hoc* storage such as attaching photo images to the item depicted in the image.
- 3D model data of features such as pipelines provide opportunity for greater automation of importing this data into applications such as MyWorld.
- 3D models enable related efficiencies such as collecting as-constructed information using drones (i.e. with laser survey – LIDAR with GPS – capability).
- Any modification to the asset can be documented by modifying the model with the as-constructed information, which avoids inconsistencies if the change were inadvertently not updated on every affected 2D drawing.
- Opportunity for maintainers to use augmented reality on a GPS-enabled tablet PC on which software can overlay model details on the image from the tablet PC's camera.

1.4 STAGED IMPLEMENTATION

Water Corporation is staging its implementation over a number of years. Early adoption of outcomes is encouraged (and may be mandated on specific projects) and the **minimum** staged outcomes for Water Corporation on the implementation of DE during design and construction are:

Stage 1 (2019 – 2021 on key projects)

1. Capturing and making accessible any Safety in Design, HAZOPs and HAZIDs information as per Water Corporation standards & National and State legislation. The goal is to improve Health and Safety through the use of P&IDs and the 3D model as the centre piece of the safety reviews.
2. Improved stakeholder engagement through the use of 3D models, static renders and (if beneficial such as on complex plants) interactive walk-through (Virtual Reality) of the proposed facility. These 3D Models will be used to undertake Safety in Design reviews (including Hazard identification) throughout design, construction and operations to manage operational hazards.
3. Improved coordination and design certainty through using the 3D model to detect and resolve coordination issues during design (clash avoidance).
4. Reduced duplication of effort during design and construction through the implementation and enforcement of a model element author schedule and responsibly matrix.
5. Project data must be housed, managed and securely accessible to relevant stakeholders through a Common Data Environment, throughout project delivery phases.
6. A connected P&ID and BIM environment must be progressively developed and maintained whereby 2D drawings must be derived from this same environment to consider optimal asset resilience & reliability and Whole of Life Costs.
7. Use of the Equipment Schedules (Nexus#58648907), where information has been derived from the P&IDs (controlling document) at milestone deliverables to enable decision making (asset resilience & reliability).

Stage 2 (2021 - TBD)

8. Leverage Safety in Design information created during design (3D and data) into construction phases by the supplier to improve safe work method statements and construction.
9. Construction scheduling by the supplier using BIM and Work Breakdown Structures connected to the construction program (4D) to enable optimised construction planning of resources and materials.
10. Improving Whole of Life costs by linking the BIM to the vendor costs and overall cost plan (5D). Improve the monitoring and management of project and operational costs to avoid unplanned cost overruns.
11. Reliable and complete as-built information (P&IDs, Drawings and Asset Data) through capturing and incorporating construction variations into the Works as an executed Project Information Model (PIM).
12. Improved coordination through using the 3D model to detect and resolve coordination issues during fabrication and construction stages (clash avoidance).
13. Optimised handover through collecting asset data progressively from BIM and P&IDs throughout project delivery, directly into the Equipment Schedules (Nexus#58648907) generated directly from the authoring tools.
14. Improved Quality Assurance on information deliverables.

Stage 3 (TBD - onwards)

15. Improved operation and maintenance through Water Corporation taking ownership of asset data (Asset Register), 2D documentation and as-built 3D model, collectively defined as the PIM, at the same time as taking ownership of the built asset.
16. Information will be checked at asset handover gateways for compliance at defined project milestone stages and at Asset Handover. This information will be imported into Water Corporation Asset Information Systems so must be of high accuracy and compliance.

1.5 POTENTIAL BIM USES FOR THE SUPPLIER

The use of BIM processes can also benefit the design and construction teams. The supplier may or may not prefer to use BIM or other technologies for the purposes nominated below, however the uses nominated in Section 2.1 cannot be excluded.

1. Reduced duplication of effort during design and construction – better project planning and project implementation by defining tasks, responsibilities and information delivery plans through implementing the DE Execution Plan;
2. Optimised construction schedule - reduce errors and rework by leveraging the model for construction planning.
3. Enhanced coordination of asset information through the use of interconnected data (P&IDs, BIM and 2D documentation)
4. Laser scanning to complement traditional surveying techniques. The use of point clouds can assist in locating existing assets
5. Automated routines for clash detection, discrepancy identification and contract handover information auditing.

1.6 PROCESS OF DEXP DEVELOPMENT

The responsibility for the production, development and implementation of the DEXP lies with the supplier. The supplier shall ensure that the contents of the DEXP document, and also those documents referenced within it, are collaboratively developed with their supply chain in order to enable all parties to meet these requirements.

The supplier shall include a comprehensive, pre-contract DEXP with their bid response to demonstrate their proposed approach, capability, capacity and competence to meet the requirements of the Digital Engineering Manual (PIR). In addition to information requested as part of the tender process, the pre-contract DEXP shall include the following content:

1. Assigned roles, responsibilities and relevant company authorities
2. Standards, tasks, methods and procedures including collaboration practices
3. Capability, capacity and competence of the nominated Project DE Manager;
4. Enhanced coordination of asset information through the use of interconnected data (P&IDs, BIM and 2D documentation)
5. Proposed staged approach for delivery of the Information exchanges and PIM
6. Software, versions and information exchange formats

A compliant pre-contract DEXP will demonstrate how the requirements outlined in the PIR will be met. The PIR will therefore be used as the basis to review the contents of the supplier's pre-contract DEXP.

The successful supplier, post award, must continue to develop the DEXP in consultation with Water Corporation or their advisor (strictly within 45 days). The DEXP forms the primary instrument to manage DE on the project and is contractually binding.

Note: in the supplier response, consideration shall be given to capability, capacity and competence through the completion of Appendix A – Supplier Capability Assessment form. Members of the supply chain shall be detailed in the DEXP as they are appointed to the project.

Reference is made through the Design Brief or Contract Specification to the Project Information Model (PIM). For clarity, the PIM is defined as *all of the information needed to design, construct and operate an asset*. This information will be communicated through graphical models (BIM), Piping and Instrumentation Diagrams (P&IDs), documents (e.g. drawings, schedules, system specifications, etc.) and tabular data – collectively called the Project Information Model.

The supplier will be required to submit data (as a minimum) to support the information requirements and key decisions set out in Section 3.1.

1.7 KEY INFORMATION AND CAPABILITY PRINCIPLES

Water Corporation requires that the principles of information management (ISO 19650) are implemented for the design and construction of the project. The key Information principles are set out as follows:

1. There will be a Common Data Environment (CDE) for the project, managed by the supplier. This shall be structured and secure with managed access, data and information clearly categorised and labelled. ISO 19650 should be used to guide the implementation of the CDE and the supplier approach documented in the DEXP.
2. Object based design models (referred to as BIM) shall be created to satisfy the requirements of this document (and other Water Corporation requirements) to drive efficiency and predictability throughout the project. BIM shall be interoperable and available for review by the Principal using a complimentary (i.e. free) model viewer.
3. A pre-contract DEXP shall be created by the supplier with a collaborative approach to its development. This will communicate the team's / discipline's proposals and approach, in direct response to this Digital Engineering Manual (PIR). The pre-contract DEXP shall also identify what (if any) of the requirements in this document, or other Water Corporation standards cannot be met.
4. Once the delivery team is appointed, the pre-contract DEXP will be reconciled and further developed to form an overarching DEXP for the project covering design, HAZOP, and ultimately construction and handover. This process is to be led by the Project DE Manager with input from all key stakeholders.

2 PROJECT INFORMATION AND MANAGEMENT REQUIREMENTS

2.1 PROJECT BRIEF

Refer to the main contract documentation for project information and proposed project schedule. The supplier shall detail any proposed additional DE uses (for Design and Construction), beyond those required by Water Corporation in the pre-contract DEXP to support and optimise the project objectives identified in the table below.

Priority	Project Objectives		How	DE Use(s)
Design Phase				
High	Information Managed		Supplier appointed DE Manager to oversee and manage the PIM	Reliable decision making
High	Improved stakeholder engagement		Using the 3D model as a highly effective visual communication aid, through the use of virtual 'walk throughs' of facilities and static renders	Design authoring and design reviews
High	Reduced duplication of effort during design		Through creating, sharing and reusing digital information throughout the design process	Design authoring
High	Improved Health and Safety		Safety in Design reviews using the 3D model and P&IDs as a visual aid and tracking tool for issues/concerns	Safety reviews, HAZOP and HAZID reviews
High	Optimised construction schedule		A reduction in errors and reduced rework through an improvement in design coordination	Design authoring, 3D design reviews, Design Clash Detection
Medium	Common Data Environment		Supplier to manage Information and enable Water Corporation access to the Published area	SPOT (Single Point of Truth) for project information
Medium	Related and connected Information		P&IDs connected to BIM	Design Authoring and design reviews
Construction Phase				
High	Optimised construction schedule		A reduction in errors and reduced rework through an improvement in construction coordination	Design Authoring, 3D Design Reviews, Trade Model Clash Detection
High	Improved cost certainty		BIM linked to a cost plan	Cost estimating
High	Optimised handover, Improved O&M,	Model Geometry	A digital as-built model at handover that includes site verified information about	Record Modelling

Priority	Project Objectives		How	DE Use(s)
	Reliable and complete as built information		assets such as mechanical, electrical, hydraulic and SCADA equipment.	
		Data	Tabular data deliverable at handover containing asset information that can be imported into the CAFM / CMMS system.	Asset Management

2.2 DIGITAL ENGINEERING USE COMPETENCY REQUIREMENTS

This table identifies the potential value, experience and competencies required of responsible parties for the execution of DE on this project.

DE Use	Project Value	Responsible Party	Value to Responsible Party	Competencies Required
Design Authoring	High	All design disciplines Sub-trades	High Med	• Ability to create and develop a Building Information Model • Design, engineering and construction experience
P&ID linked to BIM	High	Process Engineering	High	• Integration and linkage of P&ID documentation with the 3D Model
3D Design Reviews	High	All design disciplines	High	• Ability to manipulate, navigate and review a 3D model • Strong understanding of how building/facility systems integrate
Design Clash Detection and resolution	High	All design disciplines	High	• Ability to manipulate, navigate and review a 3D model • Ability to run clash detection software • Knowledge of engineering and building systems • Ability to resolve conflicts
Construction Clash Detection (Trade models)	High	Contractor Sub-trades	High High	• Ability to manipulate, navigate and review a 3D model • Ability to run clash detection software • Knowledge of engineering and building systems • Ability to resolve conflicts

DE Use	Project Value	Responsible Party	Value to Responsible Party	Competencies Required
Asset Management	High	All design disciplines Contractor	Low Low	• Ability to input data into P&IDs and a 3D model • Understanding of Microsoft Excel and structured data • Understanding of facilities management software • Strong understanding of how plant and process systems integrate
Record Modelling	Med	Contractor	Low	• Ability to manipulate, navigate and review a 3D model • Ability to capture as constructed conditions during construction and commissioning • Ability to use BIM Authoring Software for model updates • Ability to effectively communicate between the design, construction and Facilities Management teams.

3 COMMERCIAL

Water Corporation's approach to BIM differs depending on the type and scale of the project. This enables Water Corporation to make certain Key Decisions based on the project scale, budget and complexity. Refer to the main contract documentation for project information and proposed project schedule. The Supplier will be required to submit data (as a minimum) to support the information requirements in Section 0 and key activities set out below.

3.1 KEY DECISIONS

Key decisions (also known as Organisational Information Requirements) are questions whose answers define the asset information required to meet asset management objectives. The supplier will be required to generate data (graphical models, P&IDs, drawings, schedules, specifications, etc.) to support the DE uses specified in Section 2.1 and aligned to the capabilities in Section 2.2 and the specific purposes / activities as defined in the Design Brief or Contract specification. Certain information is required so Water Corporation can make Key Decisions at each design and construction stage. This is in accordance with the Water Corporation project lifecycle phasing.

The following tables define the Key Decisions at each project stage to support the Water Corporation project gateway process.

	Key Decision	P&IDs & Functional Control Specification	3D BIM	2D .PDF Drawing Files	2D .DWG Drawing Files	Tabular Data (.xls)
Design stages	How do we minimise risks in our Designs (Concept & Early Engineering Design stages eg. HAZOP)?	X	C	C	C	
	How do we minimise risks in our Designs (Engineering & Detailed Design stages)?	X	X	C	C	X
	How do we minimise Whole of Life (WoL) costs while delivering stakeholder requirements?	X	X		X	X
	How do we maximise design certainty to reduce rework and risk in meeting stakeholder needs?	X	X			X
	How do we optimally consider asset resilience & reliability in the design phase?	X	X		X	
Construction	How do we reduce & better manage program volatility year on year to improve capital efficiency?	X		X	X	X
	How do we optimise the construction schedule to maximise use of resources and timescales?	X	X		X	X
	How do we maximise safety	X	X		X	X

	Key Decision	P&IDs & Functional Control Specification	3D BIM	2D .PDF Drawing Files	2D .DWG Drawing Files	Tabular Data (.xls)
	during construction (leveraging information)?					
	How do we better monitor and manage project cost drivers to minimise cost overruns?	X	X			X
Handover	Has the Supply Chain delivered an asset that meets the Asset Management specified requirements?	X	X			X
	Do I have all the required information to manage and operate my asset post-handover?	X	X	X	X	X

Note: X indicates formally submitted to Water Corporation, whereas C indicates that it has been created for use in workshops and for information (e.g. PDF files) but not yet submitted for Water Corporation acceptance.

Full details of the key decision framework are available in the Asset Information Strategy (Nexus#58585881).

Note that provision of digital models does not currently make redundant the Water Corporation requirement for 2D drawings to be submitted. Water Corporation currently require 2D PDF drawing files for reasons including stakeholder review. The 2D DWG drawing files are required for reasons including DMS archival of design drawings for document management (providing a repository where drawings can be accessed, database searches performed, and for version control) and where there is a requirement that drawings are signed prior to Water Corporation review. This requirement may change in the future if Water Corporation adopts software that allows every user to interface with the asset model thereby making 2D drawings redundant (with associated cost savings and efficiencies).

3.2 CAPITAL EXPENDITURE PROJECTS

The following requirements apply to all category A, B & C capital projects and brownfield category D / regional minor works projects where there is an existing DE model of the asset.

1. The supplier is responsible for enabling, creating and delivering information that increases in detail (geometric and attributed data) from design through construction to an as-built status in accordance with the Design Brief or Contract Specification as appropriate.
2. Asset Data must be progressively delivered to Water Corporation as the project documentation develops for use with Asset Management systems. This is termed an "information exchange" and consists of the Design Deliverables listed in the Design Brief or Contract Specification.
3. Water Corporation will audit the supplier's information deliverables to ensure compliance with the Digital Engineering Manual (PIR), Design Deliverables, Design Standards and other related documents such as DE Execution Plan (DEXP) for major projects (Category A, B, C). Minor projects (Category D and Service

Connections) require a short form DEXP documenting the staged information deliverables.

4. A supplier capability assessment (Refer to Appendix A – Supplier Capability Assessment form) will be completed by the supplier as part of the RFP response. The design panel will be assessed separately.
5. Nothing in this document is intended to relieve the supplier or its subcontractors of their responsibility to comply with Water Corporation and local standards (and embedded standards) such as:
    a. WCX CAD Standard DS80
    b. Process Engineering design standard DS81.
    c. Engineering Design Manual (Nexus#58547221)
    d. Equipment Schedule Template (Nexus#58648907)
    e. Level of Definition tables
6. As a minimum the supplier shall provide a pre-contract draft DE Execution Plan as part of the RFP response. The draft DEXP must directly respond to this Digital Engineering Manual (PIR), referencing the relevant sections for ease of assessment by Water Corporation.
7. The supplier shall nominate a Project DE Manager to oversee, coordinate and report on the DE process, ensuring that all suppliers conform to the content of the Project DE Execution Plan post award.

3.3 REGIONAL MINOR WORKS

If there is an existing DE model of the asset refer section 3.2; otherwise, the following requirements apply to Regional minor works.

Ensuring Water Corporation has accurate and complete as-built information and Operation and Maintenance Manuals is critical to ongoing operations of assets. The minimum requirements for minor works are:

1. Providing a complete set of Operations and Maintenance Manuals for the asset prior to handover to the asset operations team; and
2. Providing a complete and accurate set of as-built documentation (including P&IDs) prior to works being granted Practical Completion.

4 MANAGEMENT

This section deals with setting the standards to be used for the delivery of the project, along with how the co-ordination and review processes will be managed.

4.1 APPLICABLE BIM STANDARDS AND GUIDELINES

Except where otherwise noted, the external documents and standards that shall be followed are:

Standards and Guidelines
NATSPEC BIM Guide v1.0 Project BIM Brief v2.0 BIM Management Plan Templates v2.0
BIM Forum Level of Development Specification, 2016.
ISO 19650-1:2018 - Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) – Information management using building information modelling – Part 1: Concepts and principles
ISO 19650-2:2018 – Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) – Information management using building information modelling – Part 2: Delivery phase of assets.

4.2 ROLES AND RESPONSIBILITIES

1. The pre-contract DEXP shall define the supplier's proposed DE roles and responsibilities and detail how these roles will be delivered and coordinated.
2. The Project DE Manager will oversee and report on the DE process ensuring that suppliers conform to the content of the Project DE Execution Plan.

Any replacement of the Project DE Manager must be approved by the Water Corporation.

4.3 PLANNING THE WORK AND DATA SEGREGATION

The pre-contract DEXP shall define the bidder's proposed strategy for the following:

1. Development and management of the CDE
2. Model management (file break up, model author responsibilities)
3. Zones and area references for location identification
4. Naming conventions

4.4 COORDINATION AND CLASH DETECTION

Design and Construction clash detection reviews shall be carried out intermittently as required to satisfy design development and to minimise project risk and waste. As a minimum, this shall take place bi-monthly and at mid-point before each project milestone from the end of HAZOP onwards.

Particular focus shall be on hard clashes, construction tolerances and safe working / maintenance zones.

The pre-contract DEXP shall identify details of the clash detection process including:

1. Software to be used for model federation and clash detection/management
2. The clash detection/management/resolution process
3. Responsibilities
4. Outputs
5. Tolerance strategy
6. Clash resolution process
7. Meetings, frequency and location

4.5 COLLABORATION PROCESS

The pre-contract DEXP shall detail the proposed collaboration process. Consideration shall be given (as a minimum) to the following:

1. Form of sharing – how is model data going to be shared?
2. Extent of modelling – what LOD is required?
3. Frequency of collaboration and information exchange requirements
4. The format and attendance at model review / coordination workshops and any other associated collaborative working practices

4.6 DE MEETINGS

The supplier shall allow sufficient time for DE meetings which shall be held to complement traditional design meetings. As a minimum, Water Corporation anticipates the following meeting requirements:

Meeting Type	Frequency / Stage
DE Execution Planning	2 weeks after contract award, a review cycle until each party is in agreement with its contents. Submit the final no later than 45 days post award. As additional stakeholders become involved with the project, revisions may be necessary. This will need approval from Water Corporation prior to implementation.
HAZOP Workshop	As required by project timeline
3D Coordination / Clash Resolution	As a minimum, this shall take place bi-monthly and at mid-point before each project milestone from the end of preliminary design onwards.
3D Design Review Meetings	It is expected that the graphical models will be used in client and design team meetings

4.7 SYSTEM PERFORMANCE

To ensure that all information is accessible to all project stakeholders including Water Corporation:

1. Individual and federated model files shall be accessible by all parties, if model files become slow or unmanageable[1] they shall be segregated. Methods for data segregation shall be detailed in the pre-contract DEXP.
2. Access and use of free model viewers must not be limited or restricted as a result of model file formats.
3. It is critical that if Water Corporation is required to access the supplier CDE to view information, especially BIM, the performance of this system must be acceptable and useable. If it is deemed unworkable, Water Corporation will require the supplier to make good.

These requirements shall be addressed in the pre-contract DEXP.

4.8 QUALITY CONTROL

The pre-contract DEXP shall detail model and data quality control. Consideration shall be given to:

1. Quality assurance/control procedures.
2. Software used to support quality control procedures.
3. Retaining data integrity/accuracy in model format and its 2D output.
4. The suppliers shall provide evidence to the Project DE Manager to show that the activities identified in this Brief and in the project DE Execution Plan are taking place.

4.9 AUDITING AND VALIDATION

Water Corporation Information Manager (or representative) will, at defined stages through the generation of the PIM, audit the information created by the supplier.

An audit report will be created highlighting any errors or omissions based on the requirements of this document and the subsequent supplier generated post award DEXP.

The supplier will nominate the time required to remedy these issues to Water Corporation (maximum is 5 business days).

Water Corporation will not allow the project to progress through project gates until all information has been validated as complete to the standards nominated in Section 4.

4.10 DIGITAL ENGINEERING COMPETENCE ASSESSMENT

The Supplier capability assessment form shall be completed by all appropriate organisations within the supply chain so that they can demonstrate their competence and understanding of DE. Refer to Appendix A – Supplier Capability Assessment form for further information

[1] An example is where an equipment supplier provides a 3D model (e.g. for a pump) that contains a large amount of internal detail that is not relevant to the plant 3D model. If this impacts the overall 3D model performance, then consideration should be given to omitting the internal detail.

5 TECHNICAL

This section establishes technical information requirements, including the software, information exchange contents and Level of Development (LOD). The items in this section shall be addressed in the DEXP.

5.1 SOFTWARE PLATFORMS

The purpose of this section is to communicate software platforms and versions where these are known and where they might influence the preparation of a bid.

The Water Corporation preferred software platform is the Autodesk AEC (Architecture, Engineering and Construction) collection which includes AutoCAD, AutoCAD Plant 3D, AutoCAD Electrical, AutoCAD Mechanical, AutoCAD Civil3D, Revit & Navisworks, amongst other software.

With prior approval of the Senior Principal Engineer Water Treatment, Bentley's package may be used which includes OpenPlant, MicroStation and Projectwise amongst others.

5.2 2D DRAWINGS

2D drawings shall comply with DS80. Water Corporation prefers the use of AutoCAD. MicroStation may be used only with prior approval of the Water Corporation DMS Manager.

5.3 CAFM SYSTEM

The CAFM system currently in use by the Water Corporation is SAP. Data must be provided in a structured format for upload into these systems. Currently this is based on data import from equipment lists, valve lists, instrument lists and motor lists in Microsoft Excel format (a Water Corporation template containing the required table formats is provided).

5.4 COMMON DATA ENVIRONMENT

The Common Data Environment (CDE) is defined as a single source of information for any given project (Figure 2 - Common Data Environment). It will function as a digital hub within which internal and external stakeholders can collect, manage and disseminate all relevant approved project data in a managed environment.

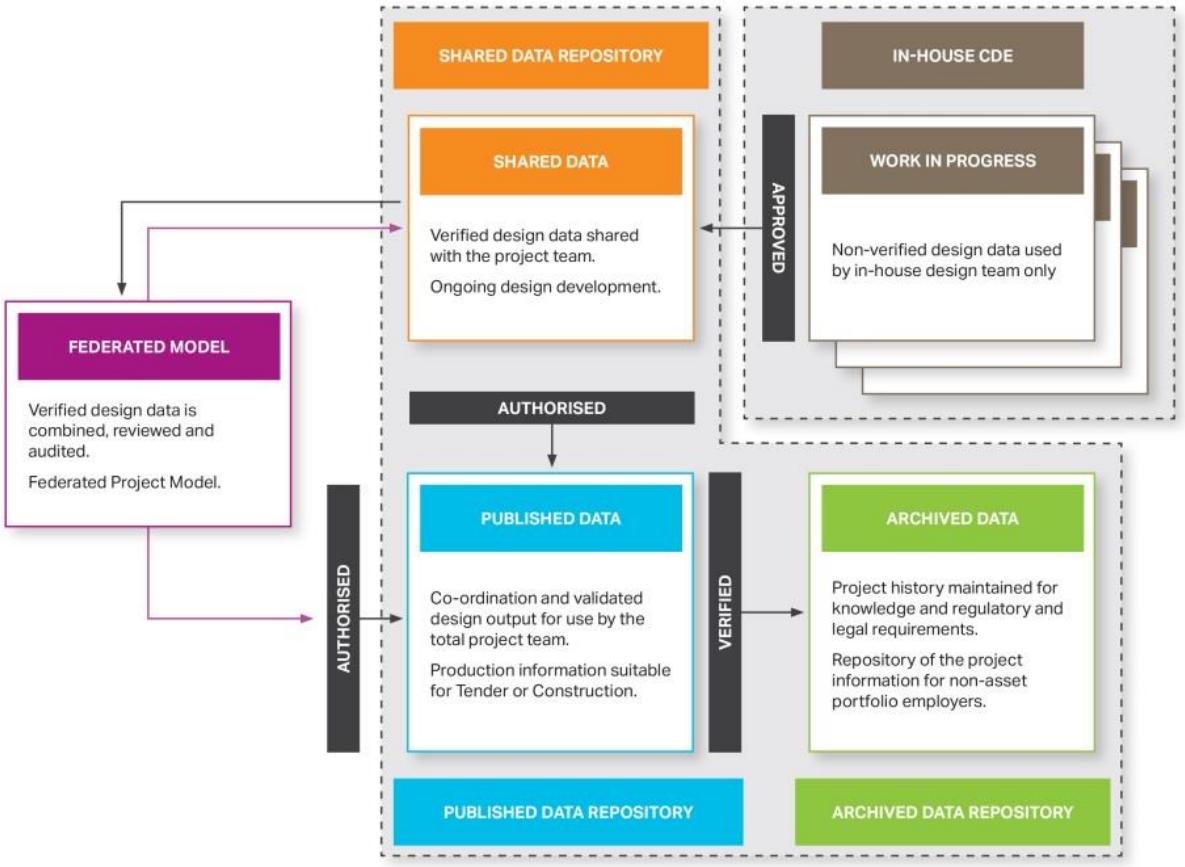

Figure 2 - Common Data Environment

It is the responsibility of the supplier to manage a CDE to house all Work in Progress (WIP) and Shared Information. All Work in Progress models are to be transmitted and saved to the shared folder, replacing the previously issued model; therefore, model naming can remain consistent.

Once information is quality checked by the supplier in the Shared area, it will be made accessible to Water Corporation through the Published area for review and checking.

Water Corporation currently uses Nexus, SAP and FMS (i.e. Small World) as its internal EDMS. These are not setup as an archive site and each party is responsible for the downloading and saving of transmitted models, drawings and information to their own company backup.

For indicative purposes the Shared area (in Figure 3) is shown as a single shaded region. This may, in practice, be synchronised locations for each stakeholder.

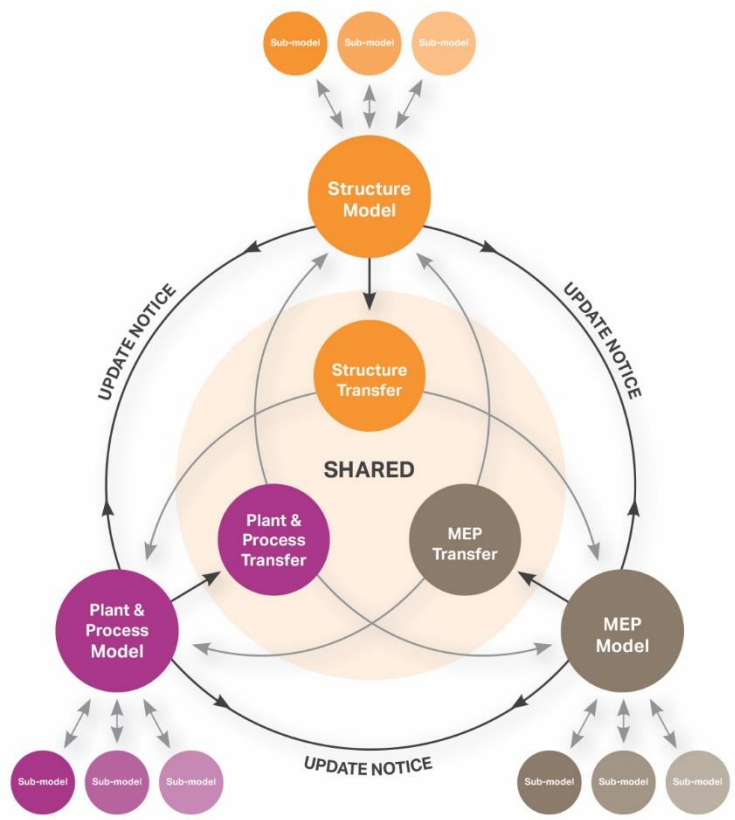

Figure 3 - Shared repository & exchange (AEC UK BIM Protocol)

5.5 DESIGN, ANALYSIS AND SIMULATION

The pre-contract DEXP shall identify specific software (plus version) proposed to be used for design, analysis and simulation with connected P&IDs where applicable:

1. Individual BIM files for creating the design for (as a minimum) building fabric, building structure, building services equipment, plant and process equipment.
2. Individual BIM in a format that supports model federation and design coordination
3. Any 2D documentation tool(s) and how this/these tool(s) will integrate with BIM

Model files shall be exchangeable, interoperable and readable.

5.6 DATA AND EXCHANGE FORMAT

For each of the information exchange points, information will be required in the following formats:

1. Native design authoring tool format for individual design models

2. If the 3D model is not native to AutoCAD 3D (e.g. native to AutoCAD Plant 3D) then also provide a copy in AutoCAD 3D format[2].
3. Navisworks NWC format for individual design models
4. Navisworks NWF format for federated models
5. A tabular asset dataset (in MS Excel format .xls) - the dataset will be derived from the BIM and the P&IDs to be imported into SAP. Refer to Appendix B – Equipment List for the Equipment Schedule Template (Nexus#58648907) requirements. This includes instrument, valve, mechanical and electrical equipment lists.
6. PDF 2D files (the 2-dimensional drawings) shall be derived from a dimensionally accurate Building Information Model and not be created using separate 2-dimensional 'drafting views'.

The pre-contract DE Execution Plan shall indicate additional proposed file formats for other deliverables, e.g. federated models, visualisations, cost estimating, project scheduling, etc. Any Drawings that will be developed outside of the BIM (in CAD) are to be clearly identified in the Project DE Execution Plan and be in accordance with DS80.

5.7 LEVEL OF DEVELOPMENT (LOD)

The supplier's pre-contract DEXP shall consider the format of required information and the extent to which BIM will be developed.

BIM shall be developed in consideration of the best and most appropriate means of communicating data and information and managing project risk in accordance with the specified DE uses in Section 2.1 and capabilities in Section 2.2. Consideration shall also be given to file sizes and volume breakup ensuring that BIM can be accessed by Water Corporation and data extracted and analysed. The suppliers pre-contract DEXP shall specify the LOD for each element that will be generated at each project milestone and information exchange to meet the specified DE uses. The LOD determines the extent and nature of geometry and data to be included within BIM objects.

The different Levels of Development are defined below based on the BIM Forum Level of Development Specification, 2016.

[2] The purpose of the copy in AutoCAD 3D format is to allow multiple users to access the model).

Level of Development	Model Element
LOD 100	The Model Element may be graphically represented in the Model with a **symbol** or other **generic representation**, but does not satisfy the requirements for LOD 200. Information related to the Model Element (i.e. cost per square metre, tonnage of HVAC, etc.) can be derived from other Model Elements. *Note: LOD 100 elements are not geometric representations. Examples are information attached to other model elements or symbols showing the existence of a component.*
LOD 200	The Model Element is graphically represented within the Model as a **generic** system, object, or assembly with approximate quantities, size, shape, location, and orientation. Non-graphic information may also be attached to the Model Element. *Note: At this LOD elements are generic placeholders. They may be recognizable as the components they represent, or they may be volumes for space reservation. Any information derived from LOD 200 elements must be considered **approximate**.*
LOD 300	The Model Element is graphically represented within the Model as a **specific** system, object or assembly in terms of quantity, size, shape, location, and orientation. Non-graphic information may also be attached to the Model Element. *Note: The quantity, size, shape, location, and orientation of the element as designed can be measured directly from the model without referring to non-modelled information such as notes or dimension call-outs.*
LOD 350	The Model Element is graphically represented within the Model as a **specific** system, object, or assembly in terms of quantity, size, shape, location, orientation, and interfaces with other building systems. Non-graphic information may also be attached to the Model Element. *Note. Parts necessary for coordination of the element with nearby or attached elements are modelled. These parts will include such items as supports and connections. The quantity, size, shape, location, and orientation of the element as designed can be measured directly from the model without referring to non-modelled information such as notes or dimension call-outs.*
LOD 400	The Model Element is graphically represented within the Model as a **specific** system, object or assembly in terms of size, shape, location, quantity, and orientation with detailing, fabrication, assembly, and installation information. Non-graphic information may also be attached to the Model Element. *Note. An LOD 400 element is modelled at sufficient detail and accuracy for fabrication of the represented component. The quantity, size, shape, location, and orientation of the element as designed can be measured directly from the model without referring to non-modelled information such as notes or dimension call-outs.*

Level of Development	Model Element
LOD 500	The Model Element is a site **verified** representation in terms of size, shape, location, quantity, and orientation. Non-graphic information may also be attached to the Model Elements. *Note: The intent is that LOD 500 capture as-constructed information in similar fashion as the verification traditionally undertaken for 2D drawings. The BIMForum LOD Specification does not address LOD 500.*

5.8 LEVEL OF INFORMATION (LOI) – ASSET DATA REQUIRMENTS

Information shall be generated and exchanged to support specific purposes / activities at each design stage in accordance with Water Corporation project lifecycle phasing and asset handover gateways. The supplier must manage this in close collaboration with Water Corporation.

It is a key requirement of Water Corporation that Level of Information about an asset is progressively developed in the design and construction phases of the project so it can be incorporated into the Water Corporation Asset Management System, SAP.

This is often referred to as an "information exchange" as information is exchanged with other systems that may or may not use BIM, at nominated asset lifecycle stages.

Asset data will be provided to Water Corporation by way of attributes embedded within the BIM objects. The relevant data required by Water Corporation at each stage is described in Water Corporation Equipment Schedule Template (Nexus#58648907). Refer to Appendix B – Equipment List.

5.9 TRAINING

Training of the supplier personnel in the use of BIM, GIS, CAD and other such systems to meet the requirements of this Digital Engineering Manual (PIR) will be the responsibility of the supplier. The supplier should allow for up to 2 days of training for Water Corporation staff in the proposed BIM tools and processes to enable close collaboration around the federated model.

6 VIRTUAL REALITY

In addition to review of operability and maintainability using the 3D model, it may be worthwhile to also use Virtual Reality (VR). Judgement is required to decide whether the effort to set up and use VR provides enough benefit to be worthwhile. VR is typically only justified if:

- The layout is very complex;
- There is significant human interaction expected with the finished asset and therefore operators and other stakeholders will benefit from "seeing" the asset before it is built;
- New or novel processes or equipment are to be used; and/or
- The 3D model provided is not overly complex. (Note: at this stage of maturity of the technology, a very complex model may be too computationally intensive for the VR unit to process).

6.1 DESIGN BENEFITS

Using this technology, design issues can be identified more readily than by reviewing a two dimensional drawing or a 3D model on a screen. Other benefits include:

- Designers can better convey their vision of how the end product will look to operators and stakeholders. The visualisation of the 3D models and VR engages the audience and sparks discussion, which improves the quality of review.
- Designer/Consultant can produce a better final design due to a thorough review and input from the end users. Quality design also leads to lessened risk of construction variations and project delays. The finished product is safer, more operable and maintainable.
- 3D and VR are critical for review of some elements of design that are particularly hard to review using paper drawings. For example:
    - Assessing access to plant areas and process units;
    - Adding sample points in more accessible locations and raising elevation of pipework/flowmeters for improved ergonomics;
    - Moving pipework to eliminate trip hazards;
    - Identifying pipework changes to aid disassembly (i.e. adding flanges/unions in certain locations);
    - Identifying trees to be cleared & visualising changes to earthworks, including access track changes; and
    - Minor improvements to finished earthworks surfaces and rainwater drainage.

6.2 REQUIREMENTS FOR VR

When VR review is to be used, 3D deliverables need to conform to specific requirements. Note the following:

- The 3D model should be submitted in DWG or other AutoCAD compatible format. This model should be built from AutoCAD 3D solids or any digital terrain modelling submitted as 3D Faces (Triangles/Tins)
- To ensure the VR environment runs smoothly without performance issues, the 3D environment should be built from an AutoCAD model that is not overly detailed. These solids should be representative of the object while at the same time the designer should minimise the amount of faces on that object so that it is not overly

complex. For example a pipe flange would show the flange only, without bolt holes, nuts or bolts.

- Vendor supplied 3D models often have a large amount of detail associated with them. In the past these vendor models have created significant lagging issues in VR due to their complexity. Where possible and practical, the designer should simplify these models to improve VR performance.
- A layering system should be employed to ensure that AutoCAD objects representing the same Mechanical process or civil/structural components are grouped into the same layer. The layering requirements of DS80 serve as a starting basis. Further examples of layers are:
    - Raw Water Pipeline
    - Inlet Works Handrail
    - Inlet Works Floor Grating

6.3 USE OF VR IN AN OPERABILITY AND MAINTAINABILITY WORKSHOP

The following are recommended steps for review of design using VR. Note that this assumes that the VR unit is being used with a screen mirroring what is seen by the person who is wearing the VR goggles and operating the unit.

- Brief introduction to the VR tool
- Brief introduction to scope of project
- Design presentation
    - Summary of design
    - Highlight key changes and updates
    - Highlight key issues remaining for design or construction
- Operability and design review using VR tool
    - Designer to don goggles and walk through model
    - Designer to highlight key design changes and updates (previously agreed with the Project Manager)
    - Audience can ask the Designer to move to an area to investigate an issue. One person can act as facilitator to field questions while the designer demonstrates in the model. In fielding questions, the facilitator may be able to eliminate them immediately to maximise productivity (e.g. particularly where detail is not sufficient to show up in the model or the image is some way inaccurate to the actual design)
    - Have a scribe available to record comments and feedback for subsequent design updates or corrections as needed. A possible alternative is to record design comments and actions live in the model
    - Have a second computer available with the Navisworks model of the asset so that any design review items and comments could be quickly added to the Navisworks file (using viewpoints and tags) whilst the VR review is underway
- Final comments

Consideration should be given to allowing stakeholders to wear the VR headset and walk through the model. This should be planned prior to the meeting and scheduled in the agenda to ensure sufficient time available. It should be noted that this can be a time consuming exercise with little additional value. Stakeholder use of the VR tool may be warranted where a stakeholder

- is familiar and knowledgeable in the asset type;
- is a key influencer in the design; and
- can explore the design and present their ideas or inputs.

6.4 BOOKING THE VIRTUAL REALITY UNIT

The VR unit can be booked (e.g. by the Water Corporation design manager) via the Water Corporation's Microsoft™ Outlook™ calendar. The calendar account name is *Virtual Reality Unit* and can be booked into a meeting as you would a person. The unit is stored in the Engineering Business Unit, but is a mobile unit. If it is required for a project involving a large team of stakeholders, it is also appropriate to book a meeting room as a resource. Unless the design manager has experience in setting up the unit, it is also appropriate for the booker of the unit to invite one of the drafting staff who has set up the VR walkthrough so the unit can be properly set up for best use.

Note: The VR Software does not work with native Autocad (or Navisworks) model files. The models need to be converted beforehand to work with the Unity VR Engine software that is installed on the VR Unit PC. The Engineering Business Unit Drafting Team can assist with conversion. Provide notice and allow sufficient time for this conversion to be done and checked before the VR review date.

7 APPENDICES

7.1 APPENDIX A – SUPPLIER CAPABILITY ASSESSMENT FORM

Please answer the below questions with a brief response i.e. typically a few sentences will suffice.

No	Question	Answer/Understanding	Supporting Evidence
1.	Where has BIM/DE been implemented within your organisation and projects already and to what extent?		
2.	Does your organisation have multi-disciplinary BIM/DE Experience, if so, illustrate experience.		
3.	Does your organisation have mandatory BIM/DE Standards in place?		
4.	Have you experience of implementing client BIM/DE standards and if so, where?		
5.	Do you have any specific concerns about IP rights and ownership of the BIM/DE models? If so, then please outline these concerns.		
6.	What is your current status and future plan for BIM/DE rollout?		
7.	What are your plans for BIM/DE implementation in respect to staff and their related training?		

7.2 APPENDIX B – EQUIPMENT LIST

Water Corporation will provide a spreadsheet template for asset information interchange between BIM and the Corporations CAFM systems. The template contains worksheet tables for Electrical, Instrument, Mechanical and Valve Schedules with the following structures.

ELECTRICAL SCHEDULE																
ENGINEERING DESIGN									DETAILED DESIGN		PROCUREMENT					
REVISION	PI&D DRAWING	TAG No.	FUNCTIONAL LOCATION	EQUIPMENT TYPE	EQUIPMENT DESCRIPTION	STATUS	POWER (kW)	VOLTAGE (V)	MAKE	MODEL	SERIAL No.	SUPPLIER	INSTALLED BY	DATASHEET	COMMENTS	

INSTRUMENT SCHEDULE																		
ENGINEERING DESIGN														DETAILED DESIGN		PROCUREMENT				
REVISION	PI&D DRAWING	TAG No.	FUNCTIONAL LOCATION	EQUIPMENT TYPE	EQUIPMENT DESCRIPTION	STATUS	POWER (kW)	VOLTAGE (V)	SIZE	DESIGN PRESSURE (KPA)	INPUT	OUTPUT	RANGE	SCALE	MAKE	MODEL	SERIAL No.	SUPPLIER	INSTALLED BY	DATASHEET	COMMENTS

MECHANICAL SCHEDULE																			
ENGINEERING DESIGN													DETAILED DESIGN		PROCUREMENT				
REVISION	PI&D DRAWING	TAG No.	FUNCTIONAL LOCATION	EQUIPMENT TYPE	EQUIPMENT DESCRIPTION	STATUS	SERVICE	POWER (kW)	VOLTAGE (V)	SIZE	MATERIAL	PN RATING	WC SPECIFICATION	MAKE	MODEL	SERIAL No.	SUPPLIER	INSTALLED BY	DATASHEET	COMMENTS

VALVE SCHEDULE																						
ENGINEERING DESIGN																				DETAILED DESIGN		PROCUREMENT				
REVISION	PI&D DRAWING	TAG No.	FUNCTIONAL LOCATION	EQUIPMENT TYPE	EQUIPMENT DESCRIPTION	STATUS	SERVICE	ACTUATION	VOLTAGE (V)	SIZE	MATERIAL	PN RATING	WC SPECIFICATION	STANDARD	PURPOSE	ORIENTATION	END CONNECTION	POSITIONER	FAIL POSITION	LIMIT SWITCHES	MAKE	MODEL	SERIAL No.	SUPPLIER	INSTALLED BY	DATASHEET	COMMENTS