



HUNTER WATER CORPORATION

**WATER AND SEWER
DESIGN MANUAL**

**SECTION 5
WATER PUMPING STATIONS**

AMENDMENT HISTORY

Date	Clause	Amendment
May 2006	All	New document
September 2007	5.11.6	New clause – Pump operation to facilitate shutdowns
July 2008	5.2 Appendix C	Added references to Appendix 1A for electricity cost.

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GLOSSARY OF TERMS

Term	Definition
air release valve	A manually operated or automatic valve to release or admit air
building	A brick structure with gable roof and concrete floor
butterfly valve	Quarter turn valve with disc and central shaft through valve body
close coupled	Pump whereby impeller is supported on a stub shaft connected to motor shaft or an extension of the motor shaft
commissioning	The running of the plant and equipment to ensure flow through the pumping system and carrying out any testing and adjustments required
Consultant	Designer
Corporation	The Hunter Water Corporation (HWC)
design life	Generally taken as a building 100 years, pit type station 80 years, switchboards 30 years, pumpsets 30 years for VSD driven, 40 years for fixed speed driven and telemetry 15 years
developer	A person or business that develops land and property
developer's representative	An agent representing the interests of the developer
direct driven	Where the pump shaft has its own bearings and is connected to the drive motor via a coupling
direct on line (DOL)	Starter which connects power direct to pumpset for instant starting, causing momentary high current draw on startup
duty cut-in level	The reservoir level or pressure setting at which the duty pump is requested to start
duty point	The rate of flow and the corresponding total head for which a pump is designed or selected
flowmeter	Electromagnetic flowmeter to measure instantaneous flowrate which is provided as a 4-20mA electrical signal
footpath	The paved section in a footway
footway	A public way largely reserved for the movement of pedestrians. More specifically the area between the property boundary and road carriageway.
generator	Diesel driven device to provide 415V AC power when mains supply fails
HWC	The Hunter Water Corporation
inground pit	A reinforced concrete structure set into the ground complete with covers and drainage
interlock	Interconnection between two devices to prevent their simultaneous operation
non return (reflux) valve	A valve which allows one-way flow only
Owner	Developer or Hunter Water
pneumatic	Operated by compressed air
pre-commissioning	Preparation of plant or equipment so that it is in a safe and proper condition ready for commissioning and operation
pressure main	A pipe through which water is pumped from the pumping station under pressure into the distribution system
pressure switches	Control devices operating at single point levels to effect control of pump operation
pressure transmitter	A sensor that continuously measures water pressure variations in

Term	Definition
	the pipeline and converts the pressure to an electrical signal for use in a monitoring, control or alarm circuit
programmable logic controllers (PLC)	A microprocessor device for controlling processes
protection	Devices which will stop pump/motor operation in the event of a condition which may lead to damage
pumping installation	A pumping station together with any associated pressure main(s)
pumping station	Building, structures and equipment used to transfer water through a pressure main
radio path survey	A survey taken to determine the radio signal strength, and hence suitability of radio communications, between two telemetry stations
RTU	Remote terminal unit
SCADA	Supervisory control and data acquisition system which allows monitoring and control of remote sites via telemetry
soft starter	Electronic starter to start pumpset using reduced starting current to start item slowly
spacer coupling	Removable flanged make-up piece between pump and motor coupling to allow back section of pump to be removed from casing and pipework without disturbing motor
standby cut-in level	The pressure level at which the standby pump is asked to start
station control	The operation of pump start/stop sequences, alarms and control devices
stop valve	A wedge type gate or sluice valve with non-rising spindle and full bore opening
strainer	Device to collect larger particles than the pump can safely pass without damage
surge	The rapid, very short-term pressure variations in a pipeline above or below the normal resulting from changes in flow caused by events such as an emergency shut-down resulting from a power failure. Surge generates pressures generally rising in excess of the allowable working pressure. Surge events are characterised by high-pressure rise rates with no time spent at the peak pressure. The maximum duration of a surge event is about 5 minutes.
swabbing	Insertion of a swab or 'pig' into pipeline to be propelled along by pump pressure to clean inside of pipe
telemetry	The transmission of data from one site to another via wiring or radio signals
telemetry unit	A unit that collects and stores operational data from the remote pumping station and transmits data to the attended receiving station
variable speed drive (VSD)	A device able to vary the rotational speed of a motor
ventilation	Natural or forced movement of air to introduce outside air and expel inside air to remove heat from building or pit
waterhammer	A vibration or shock occurring in a closed pipe system, usually accompanied by a thumping noise, caused by pressure surges due to sudden changes in velocity of fluid flow, for example, by pump start or stoppage

5.1. INTRODUCTION

5.1.1 GENERAL

The purpose of this document is to provide a guideline for the design of small to medium sized water pumping stations for the Hunter Water Corporation (Hunter Water). These stations will range from small inground pit type stations to larger cavity brick buildings with up to three pumps and a duty capacity of up to 150L/s with pump motors up to approximately 110kW.

Section 2 of Hunter Water's Water and Sewer Design Manual relates to the determination of design demands and watermain design. These pumping station design guidelines cover the issues in relation to the actual water pumping station design. Hunter Water has Standard Technical Specifications which detail the construction requirements, including material properties, of inground pit type water booster stations with outdoor switchboards. Key Standard Technical Specifications relating to the construction of water pumping stations include STS 405 (Construction of Water Booster Pumping Stations) and EIS 91 (General Requirements for Electrical Installations).

The objective of this document is to provide a standardised guide (containing Hunter Water's general requirements relating to the design of water pumping stations) and reduce the variability in designs and improve overall the efficiency.

This document sets out to provide guidance by way of general principles, criteria and good practice. The guidelines shall be looked upon as being applicable in the majority of situations. These guidelines are to be read in conjunction with Hunter Water Standard Technical Specifications and Drawings.

The pump types covered under this document are typically inline centrifugal pumps and end suction centrifugal pumps. Other pump types not addressed in this document may be required to meet special circumstances or to overcome other specific issues.

The key issues addressed in these guidelines are:

1. Pumping station types
2. Site selection, layout, landscaping and vehicular access
3. Environmental considerations
4. Land Matters, Freehold titles and easements
5. Building design - type, floor, roofing, lifting beam and doors
6. Materials of construction
7. Hydraulic considerations
8. Pump selection
9. Pipework arrangement and valving
10. Electrical design and control system including telemetry and SCADA.
11. Operation and Control Philosophy
12. Security
13. Documentation and drawings
14. Commissioning
15. Maintenance

This document provides typical layout drawings from small to medium size pumping stations which cover a wide range of flows and pump motor sizes. The drawings show typical pit and building layouts, along with pump, pipework and switchboard arrangements, switchboard lengths, access doorways and nominal clearances required. They also show typical vehicular access which is needed to provide for maintenance vehicle access, parking and turning area.

The document also covers matters such as design capacity and projected demand, along with possible staging where areas are developing and the projected demand will require future upgrading of the station by way of additional pumps, larger impellers, higher operating speed etc.

Pumping stations may be required to:

- pump into a trunk main
- pump into the reticulation system
- supply reservoirs, or
- be dedicated to servicing a particular high level zone, etc.

The stations can either be required for full time operation or only to operate during periods of high demand or low system pressure where areas would otherwise suffer low pressure if the pumping station had not been provided.

This document is a guide only and sound engineering judgement must be applied at all times. It remains the designer's responsibility for all aspects of the design and the designer must justify any variation from these guidelines.

5.1.2 DESIGN OBJECTIVES

The objectives of the design are to ensure that the water pumping station is functional, reliable, fit for purpose, cost effective, is readily constructible, able to be maintained and complies with the requirements of Hunter Water.

In principle, the pumping system shall:

1. Satisfy the water demand criteria including fire flows as per Hunter Water's Water and Sewer Design Manual.
2. Have minimal adverse environmental and community impact.
3. Comply with environmental requirements.
4. Comply with OH&S requirements.
5. Minimise energy consumption by efficient operation.
6. Have reliable and long service life with minimal maintenance and least whole of life cost.
7. Provide adequate weather protection and stormwater management.
8. Provide vehicular and personnel access for maintenance.

The initial process for design is to identify and establish the need and basic requirements for the water pumping station.

Installations shall be planned and designed with particular reference to the following practice:

Table 5.1.2-1: Planning and Design Factors for Water Pumping Stations

Factors	Requirements
Functionality	Efficiently deliver water from a defined extraction system to an appropriate receiving system
	Operation to comply with the requirements outlined in the HWC Water and Sewer Design Manual
	Pump a range of flows from minimum to maximum demand, including fire flows
	Meet regulatory Department of Environment and Conservation (DEC) odour, noise and vibration requirements
	Have minimum visual impact on neighbourhood
	Incorporate remote monitoring, control and telemetered alarms
	Provide safe working conditions for operation and maintenance personnel
	Satisfy local Council zoning requirements
Maintainability	Be designed for minimal operator attendance and low maintenance
	Be easily maintained using standard maintenance practices
	Incorporate features to allow for flexibility of operation
	Utilise standard components that are readily available and interchangeable
Reliability	Operate reliably, effectively and automatically (i.e. normally unattended)
	Have redundancy so that failure of any one item shall not cause total failure
	Incorporate adequate security measures

5.2. ECONOMICS

Where technical constraints allow a choice in the type of pumping station arrangement or type of pumping machinery, the final choice will normally be determined as the most cost-effective method. Cost effectiveness should be determined by a net present value analysis.

Factors to be considered are:

- Cost of pumping station structure and its life.
- Energy cost over the life of the pumping station.
- Maintenance cost and confined spaces requirements.
- Life and replacement cost of pumping machinery, including ancillary items such as switchgear, lifting gear and ventilation equipment.
- Risk costs
- Land acquisition cost
- Net present values of alternatives.

The net present value analysis shall allow for the different efficiencies for each suitable pump, the variation in pump duty required for different pipe materials and class of pipe and the economic life of different pipe materials.

In terms of power cost electricity is to be costed at the rates in Appendix 1A of the Design Manual Section 1.

Appendix C provides details of an NPV template for calculations and discount rates.

5.3. PUMPING STATION TYPES

Hunter Water operates a wide range of pumping stations of different configurations and capacities. A number of these are major pumping stations, some of which draw raw water and pump to water treatment plants. Most pumping stations are located within the distribution system, on major trunkmains, in high level areas or to service distribution reservoirs.

Traditionally, pumping stations have either drawn directly from a service reservoir or pipeline and pump into a pipeline with the pumping system being either:

- hydropneumatic (air/water vessel) type
- variable speed drive pump operation
- fixed speed pump operation

All stations shall contain at least two pumps, being a duty pump and a standby (backup) pump. Duty pump(s) shall be sized to deliver up to the maximum design demand. The standby pump is programmed to operate in the event that the duty pump fails or is unavailable. Major stations may have more than two pumps but will always incorporate a standby pump. The standby pump must have at least the same capacity as the largest duty pump.

5.3.1 CRITERIA FOR PIT OR BUILDING TYPE STATION - GENERAL

This design guideline document is intended for:

- pit type (inground) stations, and
- building type (above ground) stations.

The majority of pumping stations will comprise of a cavity brick building, with the size dependant upon the size and number of pumps and pipework. In recent years an unobtrusive inground pit type station has seen application for boosting pressure or for the servicing of new developments. These stations have been located in dedicated parcels of land or in or adjacent to footpath areas where minimal community impact has been caused. Providing adequate drainage is available in the event of pump shaft seal failure or flange joint leakage, etc. these pit type stations have proven to be a lower cost alternative to building type stations.

However, there are more OH&S issues associated with pit type stations. In particular these relate to access, confined space and restricted work area. As such, there is a limit to the size of pumps allowed for use in a pit type station.

Given some of the issues associated with pit type stations, including pump size, noise, heat and OH&S, such stations can incorporate pumps with motors as follows:

- No pump shall have a motor size greater than 11kW, and
- No more than three pumps (being 2 duty/ 1 standby) shall be installed, and
- Pumps can be operated as fixed or variable speed.

Typical layout arrangements of pit and building type stations are enclosed in Appendices A and B respectively.

5.4. SITE INFRASTRUCTURE

5.4.1 LOCATION

The location of a pumping station is strongly influenced by hydraulic considerations so that the pumps and pipeline operate satisfactorily under the design demand conditions. Adequate suction pressure (10m minimum) under all conditions must be available at the station.

The location shall be selected so that there are not unnecessarily high heads (i.e. no greater than 50m) in the suction pipeline and also so that water pressure to consumers on the suction and delivery side of the pumping station meets Hunter Water's criteria.

Given normal latitude, the choice of site is usually determined by land availability and aesthetic conditions, but the location should allow for a suitable layout for the incoming and outgoing watermains. There should also be sufficient clearance from surface and subsurface obstructions to allow for construction. Sites located under power lines should be avoided.

To ensure that the proposed pumping station location and layout are acceptable, the proposed site shall be approved in advance by Hunter Water. Pits and buildings are to be located above flood level, with the floors being a minimum of 300mm above the 1:100 year flood level. Any pad mounted substation or emergency generator on the site must also be located at least 300mm above 1:100 year flood level.

The average size of a pumping station site for a small to medium pumping station may be up to 30m x 30m, with an increase in site size requirements for larger installations. If the pumping station is to be located within a road reserve, laneway etc., its position should be determined in conjunction with the local Council.

If the pumping station is located within private land, crown land, etc, it should be so located that the site and any easements will have the least detrimental effect on the property with regard to existing, proposed or potential development including possible subdivision etc. That is, the site should not be isolated in the middle of a block so that complicated and long access and watermain easements are required.

Consultation with the various stakeholders is required prior to and during the design process. This should be commenced early in the project as consultation can become prolonged. Consideration must be given to key issues associated with the project and relevant stakeholders associated with these issues.

Copies of relevant approvals from authorities and private landowners shall be included in the designer's report as required in Section 1 of Hunter Water's Water and Sewer Design Manual.

5.4.2 LAND SELECTION

The order of preference for land choice for a pumping station site shall be:

1. Land provided within the development by the person or business that is developing the land or their agent. (Hunter Water is to be given title or easement rights)
2. Hunter Water owned land (if Hunter Water is the developer)
3. Council land (Community land/Operational land)
4. Vacant Crown land.
5. Established private property
6. Vacant private property

7. Established Crown land
8. Road reserve

The consultant on behalf of the Developer is to negotiate with the owner(s) and obtain easement rights or freehold title (vested in Hunter Water) for any pumping station sites, access and services. The station shall be contained within an easement if wholly within a public reserve or a designated lot if not within a public reserve. The easement or lot is to include batters, embankments and retaining walls. Access and services should be contained within an easement.

Consideration should also be given to the potential likelihood of future development.

5.4.3 LOCATION FACTORS TO BE TAKEN INTO ACCOUNT

The following factors shall be considered during the site selection process:

Table 5.4.3-1: Location Factors

Factors	Requirements
Site selection	Located on a lot, ownership of which is dedicated to Hunter Water or an easement dedicated to Hunter Water
	Provide all weather access to the pumping station for routine and emergency operation and maintenance activities
	Sufficient space for possible pad mounted power substation, generator, flowmeter and strainer
	Power facilities should be available or able to be economically provided to the site
	Adequate radio communication access (radio path survey required)
	Site should have available safe access and consideration should also be given to construction and maintenance requirements. A deceleration lane may be applicable in some cases
	The station should not be located on a localised high point in order to avoid air entrapment at the station in the event of a watermain failure on the suction side of the station
Amenity and environment	Provision of sufficient buffer from houses, built-up areas and future development
	The station should be unobtrusive, comply with DEC noise control requirements and preferably be screened by trees and shrubs
	Develop a landscape plan at the design stage in consultation with local residents and Council
Design	Proximity to pipeline
	Accessibility
	Site slope and soil conditions
	Accessibility depth of incoming and outgoing pipelines
Easements	Easements for the site and services may be necessary
Flooding	Ensure that adequate stormwater management drainage from the pumping station and site including access roads is designed so that flooding of the facility is avoided
	The site and access road shall not be liable to flooding during a 1 in 100 year ARI
Supporting Systems	In conjunction with determining the requirements for the site infrastructure, the designer shall consider the requirements for supporting systems to enable efficient and safe operation of the pumping station, as

Factors	Requirements
	<p>follows:</p> <ul style="list-style-type: none"> – water supply (building type stations only) – power and general lighting – security – fire fighting facilities – telemetry (radio path survey required)

5.4.4 SITE SURVEY

The whole of the pumping station site is to be surveyed by a registered surveyor to identify the boundaries, surface contours and existing services. This information is to be used by the designer in siting the pumping station, considering the levels for the pumping station building and route of the suction and delivery sections of pipeline, flowmeter, strainer, bypass, water service, power supply and drainage as well as the access roadway and turning area.

The site survey shall also indicate the proximity of adjoining properties, particularly those which may be impacted upon adversely by the construction and operation of the pumping station.

5.4.5 GEOTECHNICAL

A geotechnical investigation is required to determine ground conditions which will impose requirements on the designer. The designer shall address:

- The proposed pumping station pit or building foundations and the thrust restraint blocks for the pipeline
- The access road and hardstand area
- Settlement issues

The appropriate treatment of the earthworks foundation below the building slab or inground pumping station is to be outlined in the technical specification.

Pit/Building

Distress to a structure at the foundation can occur through two different processes:

- Shear failure of the underlying soils
- Differential settlement of the foundation driven by consolidation settlement of substrata

Shear failure can occur when soft silty clays are encountered directly below the foundation. These require detailed site specific insitu subsurface investigation to evaluate appropriate design parameters. When such soils are encountered there are varieties of solutions that a Geotechnical Engineer may recommend depending on the site conditions.

Consolidation settlement is dependent on the following critical parameters:

- Preloading condition experienced by the soil and the proposed loading conditions
- The thickness of the particular substratum and its depth from the foundation level
- The consolidation parameters specific to the type of soil

The influence of loading for a strip foundation extends a minimum of twice its shortest width below the base of the foundation. The entire substratum encountered within this region will be subject to the extra loading if applicable. However, if a competent sandstone, mudstone

or conglomerate medium is encountered within this zone of influence then extra loading may not extend beyond this zone.

Where settlement is considered to be an issue an experience Geotechnical Engineer's advice should be sought. Typically such investigation can be a two stage approach to win undisturbed samples for laboratory consolidation tests.

Access Road & Hardstand Area

Access roads and hard stand areas are normally designed based on the results of the California Bearing Ratio Tests (CBR). This is typically obtained indirectly by Scalar Penetrometer Test. An assessment of the CBR values is to be made at the proposed road foundation level (subgrade) to determine the thickness of the pavement required.

5.4.6 ACCESS

All weather access is to be provided from the closest public road to the pumping station. Where access from a public road is not available then a suitable access easement shall be created in favour of Hunter Water. The design of the access road shall reflect the size and operating requirements of Hunter Water maintenance vehicles.

The road shall be an all weather sealed road and have a suitable turning area for a 5 tonne maintenance truck or as required for a larger vehicle if nominated by Hunter Water. The minimum road width shall be as stated below with local widening as required at bends. Allowance for the parking of two 5t trucks shall be provided adjacent to the pumping station.

Minimum access Road Requirements

- Minimum pavement width 3 metres
- Desirable maximum grade 12.5%
- Absolute maximum grade 20%
- Preferred crossfall 3%
- Maximum crossfall 5%

The access road shall be designed in one of the following materials:

1. Compacted gravel pavement with AC seal
2. Concrete pavement
3. Compacted gravel pavement with two coat bitumen seal

The surfacing of the pumping station site and access road is site specific.

Hunter Water (and the relevant local Council where the pumping station and /or access road is within a Council reserve or public road) shall be consulted to determine whether the type of surfacing proposed is adequate.

Road and footway crossings shall be designed to satisfy local Council requirements.

5.4.7 DEVELOPMENT APPROVAL

The Environmental Planning and Assessment Model Provisions describe works for the supply of water, including development at or below the surface of the ground, which do not require development consent from Council.

However, Council requirements vary and some Councils may require a Development Application for pit type stations even though the station is below ground. This is because the

switchboard is constructed above ground level. The relevant Council must be contacted in regard to their particular requirements.

All building type pump stations require development approval.

5.4.8 EASEMENTS

As part of the planning phase, property requirements need to be taken into consideration. Easements are to be obtained for the access road, watermain, water service, stormwater drainage and power supply. Site layout shall be arranged to minimise the number of easements. If possible, underground power supply shall not cross other services.

Approval of all relevant Statutory Authorities and bodies shall be obtained in relation to the proposed locations of access road, watermain, power supply, water service and stormwater drainage.

Minimum clear easement width for the access road shall be 4 metres. Where it is intended to lay stormwater pipes as well as the watermain, water service and power supply within the access road easement, the easement width must be increased to accommodate the services.

If the proposed works are to construct a water pumping station on private land, then the Developer should seek to obtain from the affected landowner a Construction lease over the land required for the pumping station and for the storage of materials. The aim of taking out such a Lease is to compensate the landowner for any inconvenience that may be caused during the construction stage.

Negotiations are to take place with the affected landowner for the granting of the Construction Lease for an agreed rental.

The construction contractor will be required to prepare a plan of survey at or near completion of construction, suitable for lodgement at the Land and Property Information NSW. The purpose of this plan is to delineate the land that is required for the pumping station site and associated services and access. If any part of the watermain is contained within private or public land, then the construction contractor will be required to supply Hunter Water a plan of survey showing the proposed 4 metre wide easements within the affected properties.

Following the registration of the plan of survey at the Land and Property information NSW, negotiations are to be held with the affected landowners for the transfer of land or the granting of the easements.

5.4.9 DRAINAGE

The designer is to detail site drainage so that it provides adequate protection to the access road, pumping station and surrounds in accordance with local Council requirements.

The site is to be prepared so that good access and drainage is provided.

5.4.10 LIGHTING, ALARMS AND SENSORS

Sensors are to be fitted to doors of building type stations, connected to the PLC and are to raise an alarm on the SCADA. Larger stations are to have key pad security alarm panels and sensors in accordance with Hunter Water's specification STS 105. Outdoor switchboards are to be fitted with door sensors.

Buildings are to be fitted with an outside light mounted above the personnel doorway and switched via a switch inside the door.

5.4.11 FENCING

The designer shall consider the risk of vandalism when determining the level of site fencing. If required, the designer shall detail security fencing around the perimeter of the site providing it does not preclude access to the pumping station equipment.

Where pumping stations are located in remote areas, the site is to be fully fenced and be complete with a lockable 4m wide access gate. Other site security may be required for some locations and Hunter Water is to be consulted as to their requirements for each site.

Inground pit type pumping stations having only minor above ground features do not normally require fencing. Protection in the form of traffic barriers for above ground features such as switchboards should be considered in conjunction with Hunter Water.

The following guidelines should be considered:

- Sites adjacent to developed residential property may require fencing of the Colorbond type. Other sites may require welded mesh type, cattle-proof or security fences.
- As fencing itself can have an adverse visual effect, when security fencing is required the pumping station should be sited where the property is large enough to allow the fenced area to be adequately screened from general view; or in property either previously owned or purchased specifically for the installation of the pumping station where screening may not be necessary.

5.4.12 LANDSCAPING

The designer is to ensure that the aesthetics of the area are maintained and put forward a landscape plan that addresses this as part of the design drawings and specification. The landscape plan shall be designed to blend into the local area and be determined on lowest cost for ongoing maintenance.

Choices of flora shall be suitable to the area. Trees and shrubs shall be Australian natives. If the station is within a public reserve or crown land then the local Council shall be consulted to identify appropriate types of planting and any other specified requirements.

No planting over services or under powerlines is allowed and special attention shall be paid to the type of trees and shrubs planted in the vicinity of water pipes. Consideration shall also be given to the location of plants in the vicinity of the access route to ensure that they do not block or interfere with access as they develop.

Hunter Water has guidelines for tree species suitable for planting near watermains. These guidelines can be found in Hunter Water Corporation's website:

<http://www.hunterwater.com.au/docs/reports/TreeRoots.pdf>

5.5. DETERMINATION OF DESIGN CAPACITY

The method for calculating the design demands, and hence station capacity, is set out in Section 2 of the Hunter Water - Water and Sewer Design Manual.

The initial design capacity of the pumping station should be adequate for a minimum of 25 years of projected flows taking into account possible future development and/or demand as determined by Hunter Water or based on the developer's servicing strategy.

Provision must be made in the design to allow for a 20% increase in the projected flows and, accordingly, the installation of larger pumps and switchgear. Subsequent staging should

involve upgrading of pumping machinery and switchgear only, with the pipework and civil structure being adequate for the design life stated in 6.1.

5.6. STATION DESIGN

5.6.1 DESIGN CRITERIA AND DESIGN LIFE

These guidelines cover the pumping station and pipework within close proximity of the station. Whilst they do not include the suction main or reticulation/distribution system, both suction and distribution pipework must be sized to ensure that sufficient flow and pressure are able to be provided in order to satisfy the Hunter Water design criteria. A minimum suction pressure of 10m must be provided to the pumps under all demand conditions. The pumping station must complement the overall network performance.

The design capacity of the civil structure should allow for future development (as detailed in Section on Determination of Design Capacity), while for pumping machinery the design life can vary with any future staging requirements. The following table provides details on asset life requirements:

Table 5.6.1-1: Asset Life

Asset Lifespan (Years)						
Watermain	Pumping Station					
	Civil		Mechanical		Electrical	Telemetry
	Building	Pit	Fixed Speed	Variable Speed		
100	100	80	40	30	30	15

5.6.2 LIFE COSTS

Where requirements allow a choice in the type of pumping station arrangement, or type of pumping machinery, the final choice will normally be determined by the most cost-effective method. Cost effectiveness should be determined by a net present value analysis.

Factors to be considered are:

1. Cost of pumping station structure.
2. Discounted energy cost over the life of the pumping station.
3. Maintenance costs.
4. Life and replacement cost of pumping machinery, including ancillary items such as switchgear, telemetry, lifting gear, ventilation equipment and emergency generator (where applicable).
5. Net present values (NPV's) of alternatives.

The net present value analysis shall include the different efficiencies for each suitable pump, the variation in pump duty required for different pipe materials, class of pipe and the economic life of different pipe materials. Appendix C provides an example of an NPV calculation.

5.6.3 MATERIALS

The designer shall adopt materials selection, application, design and protection measures to minimise material degradation and the need for ongoing maintenance needed to prolong the

life of the station, fittings and equipment used. Approved products and manufacturers are listed on Hunter Water's website under www.hunterwater.com.au.

Where stainless fittings are generally available they should be used. If not used, and since protective coatings require ongoing maintenance, the designer shall justify the use of alternative materials and protective coatings to achieve corrosion resistance.

Pit type stations shall be of reinforced concrete. The pit is to incorporate lockable aluminium treadplate covers and hot dip galvanised mild steel (GMS) cover support beams.

Pumping station buildings shall primarily consist of reinforced concrete floor and cavity brick wall construction with metal framed roof, roof sarking and corrugated "colorbond" or equivalent sheet metal roofing, guttering and natural ventilation with built-in wall/door vents.

5.6.4 PREFERRED EQUIPMENT LIST

Hunter Water has approved products and manufacturers for equipment used in water supply and associated electrical works. These are listed on Hunter Water's website under www.hunterwater.com.au. This lists approved equipment able to be used for installation in Hunter Water's water pumping stations.

In most cases, specific equipment is not nominated in specification documents except where reasons exist that a particular brand or model must be used. As such, the designer would need to justify this with Hunter Water.

Reference to the listing of approved products and manufacturers is to be incorporated in the Technical Specifications.

5.6.5 LAYOUT AND STRUCTURAL CONSIDERATIONS

Pit type stations which use in-line pumps enable the pipework to be run straight through the station at one level, simplifying the pipework, valve and pump arrangement. However, with pit type stations being in the ground, excavation may be costly. In addition, the floor of the pit may flood from rainwater, pump shaft seal failure or a leaking joint and therefore good drainage is necessary. Access to inground installations must comply with OH&S Regulations.

General building layout will be double outward opening doors at the front with monorail lifting beam extending out from the door opening, a single personnel door at the rear, the switchboard located along one wall and the pumps standing out from and perpendicular to the other wall.

For both building and pit type stations adequate access must be provided around all pumps, with a minimum clearances being provided between pump plinths or pumps and between the plinth/pump and wall at the side and end of the plinth.

Sufficient clearance around open doors of electrical switchboards according to AS/NZS3000 must be provided.

Minimum clearances are to be as follows (refer drawings for details):

- | | |
|--|-------|
| • Flanges to wall | 200mm |
| • Between inline pumps in pit | 400mm |
| • Between pump plinths in pit | 360mm |
| • Between pump plinths and wall in pit | 500mm |
| • Between pump plinths in building | 600mm |
| • Between pump plinth and wall in building | 800mm |

Adequate clearance shall be provided around all pipework and between flanges and walls or floor. Pipework is to be flanged for easy removal and assembly. At least one easily removable section of pipework is required on each pump to enable efficient pump removal and replacement.

Sufficient thrust restraint must be provided for the pipework in the event that the pipework is isolated and a pump is removed. This may require a dismantling joint (DJ) to be provided and the designer must determine whether this is to be a thrust type DJ or non-thrust type. Non-thrust adapter flanges (eg Uniflanges or Adapta-Flanges) are not acceptable. Pump flanges are not to be used to provide pipework support or restraint.

In some cases it is possible that the station capacity will need upgrading in the future. A viable upgrade option for building type stations will be to extend the building lengthways in order to incorporate an additional pump. Adequate land free of services at the back end of the building is to be provided to accommodate this possibility.

5.6.6 FLOOR SLAB

The slab design must be appropriate to the building size, layout, construction and bearing support provided by the foundation material.

Floor is to be graded to a central box trench drain along axis of building complete with cast iron or GMS grating. This drain is to connect with the building stormwater drainage system.

5.6.7 WALLS AND DOORS

Buildings will normally be double brick cavity construction with engaged piers to support lifting beams. Pumping station buildings do not usually have windows.

Buildings are to have a double access doorway and a single personnel access door, all being outward opening and able to be stayed in the open position. The double doors are to incorporate layback hinges to allow the doors to open 180 degrees.

Doors are to be faced on both sides and along all edges with grade 316 stainless steel and the doors are to be painted. The double doors are to be fitted with ventilation louvres. Louvres are to be fitted with painted stainless steel or painted GMS security grilles to prevent removal or damage to the louvres and possible intruder entry to the building. Double doors are to be recessed at the top to suit the protruding lifting beam.

The height of the building is governed by:

- Door height to allow installation of electrical switchboard
- Position of monorail lifting beam

The height of the lifting beam above floor level is to allow for the pump/motor or complete pumpset furthest from the door to be lifted clear and over the top of the pump(s) closer to the doorway and allow the items to be lowered onto the tray of a maintenance truck. This must take into account the following heights:

- Beam girder trolley
- Chain block
- Minimum length of chain from chain block to hook
- Sling from hook to load
- Size of load
- Tray height of truck

5.6.8 ROOF FRAME AND ROOF

Roof framing will be of galvanised metal truss construction fitted with battens, sarking and 'Colorbond' or equivalent sheet metal roofing.

Where required for the purpose of supporting additional acoustic or thermal insulation, a ceiling is to be installed in the building.

Where excessive heat will be an issue, forced draught ventilation is to be installed.

5.6.9 LIFTING BEAMS

Lifting facilities are required to allow removal of pumps, motors or the whole pumpset complete with base frame. For pit type stations a lifting beam is not required as a mobile crane or hoist from a maintenance vehicle can be used to remove the small pump units, etc.

For building type stations a central monorail lifting beam parallel to the building axis is to be provided over the motors. A similar parallel beam is to be located over the pump units.

This will result in an arrangement where the pumpset, which is typically located at right angles to the building axis, will have a lifting beam provided over each motor and each pump unit.

The central beam is to extend outside the doorway by at least 2000mm to allow the pump, motor or pumpset to be lowered onto the tray of a vehicle. Girder trolleys and manual chain blocks are to be provided for each lifting beam (ie two girder trolleys and chain blocks). The lifting beams and chain blocks are to be clearly labelled with the SWL.

5.6.10 PIT TYPE STATIONS

The most common pumps used in pit type stations are single stage in-line units mounted with the motor shaft vertically. However, end suction centrifugal pumps can also be utilised.

A pit type station comprises a rectangular concrete pit, GMS cover support beams and aluminium treadplate covers. Pits greater than 1.2m deep are to incorporate a ladder and handposts to allow personnel access to the station floor. The pit walls are to be a minimum of 200mm thick.

The top of the pit is to be located above finished ground level sufficient to ensure no entry of surface water. The area surrounding the station lip is to be battered (1 in 6) and built up with soil and turfed up to the lip to remove any tripping hazard where pedestrian traffic is likely. Battering of the ground level is to prevent water runoff etc. entering the station.

Generally, pit type stations are to be located in areas of land away from significant pedestrian access such as footways (for example, located in a dedicated reserve). Where a station is constructed in a footway area it must not constitute a trip hazard and the section of ground around the station is to be near flush with the station.

Where, due to site constraints, it is not possible to have a level area around the pit, the pit must be located away from normal pedestrian access.

The floor of the pit must be located 300mm above 1 in 100 year flood level. This is to ensure no damage to pumping equipment and that adequate drainage is always provided.

The pit is to incorporate a sloping floor which is to drain to a DN100 (minimum) UPVC drain pipe. This drain pipe is to extend to a location lower than the station floor which can provide

drainage from the station and the pipe is to be covered at the end with vermin-proofing. The discharge point is to incorporate a headwall.

Where adequate fall cannot be achieved, the drainpipe is to be directed to a sullage pit designed to accept the anticipated flow.

Because there will be electric motors in the pit, flooding is to be avoided. A float switch is to be installed and connected to the telemetry system to raise an alarm and inhibit the pumps if the pit starts to fill with water. A SCADA alarm is to be raised when the water level reaches 150mm depth from floor and pumps are to be inhibited from operating when the level reaches 300mm.

Pit type stations can have different configurations, with some being more compact than others and different size pits can be selected from a standard range of sizes. Appendix A shows typical layouts for pit type station arrangements for 2 and 3 pumps which can be used by the designer to achieve an appropriate arrangement to satisfy the duty requirements.

In the case of the pit type station the pressure transducers are located on the wall of the station and electrical cables run via underground conduit to the switchboard. Underground conduit also allows the running of the motor cables and protection pressure switch, transmitter, flowmeter and flow switch cables.

5.6.11 PUMPING STATION STAGING FOR FUTURE DEMAND

On occasions a station may need to be designed to meet an initial duty but with provision to supply a higher duty at a future time.

Such an arrangement could result in provision for three pumps but with only two pumps initially installed. Similarly, the switchboard would have two starters but a spare cabinet for a third future starter to be installed. The decision as to whether the third pump or switchgear would be installed initially would be made based on when the proposed upgrading was required.

Pipework would be installed to suit the third pump but the third pump not necessarily installed. Provision for the upgrade would need to be allowed at the time of the initial design to ensure compatibility. That is, the third (future) pump and switchgear must be identical to that installed initially in terms of performance and physical size.

Alternatively, the initial pumps could be replaced later with larger pumps and motors. The starters could be sized for the future load but initially fitted with smaller circuit breakers and overloads. However, the main switch and power supply would be installed for the future capacity.

Sometimes future upgrading can be achieved by the initial installation of a smaller diameter impeller in the pumps. The impellers can be replaced with larger diameter impellers at a future time. However, the designer must ensure that the motor size is large enough to operate the future sized impellers without overloading.

5.6.12 VENTILATION

Pit Type Stations

For pit type stations, ventilation is to be provided for motor sizes 5kW and above. This ventilation is to comprise an induct and educt vent to allow the cross flow of air through the pit to remove heat. This will be by natural convection for motors less than 8kW.

For 8kW motor size and above, forced draught (mechanical) ventilation is to be provided by the use of an electrically driven fan. This is to draw fresh air in and exhaust the hot air. The fan is to operate on a thermostatically controlled switch to operate when the inside temperature reaches 30°C.

Buildings

For most pumping station buildings, natural ventilation through low level louvres incorporated into the doors or building walls, combined with high level louvres or wind driven extractors, will generally be adequate.

Such systems, whether natural or mechanical ventilation, will rely on introducing fresh air at low level vents around the building and exhausting such air from one end or side of the building to ensure that it is drawn across motors and switchboards and out of the building.

Pumps with large motors (for example, over 40kW) or VSD units can generate considerable heat and forced draught ventilation of the pumps, motors and VSD units is likely to be required. This is to prevent unreasonable temperatures being experienced for the equipment in the cabinets and personnel inside the building while the station is in operation. A thermostatically controlled fan switch is to ensure the ventilation system operates when the inside temperature reaches 30°C.

Once the thermostat operates the fan, sufficient outside air must be passed through the station to reduce heat build-up to ensure the space is not more than 2°C above outside ambient. This is to be determined from:

- Electrical load with all duty pumps in operation at full motor speed
- A portion of the electrical load being generated as heat

Where noise is of concern, ventilation using open ventilation louvres which would allow the passage of noise should not be used. In such cases acoustically treated louvres, ducts etc. are to be used in the station ventilation system to prevent the noise from within the station escaping to the outside of the building. In such cases, forced draught ventilation may be required to achieve the required air flow.

5.6.13 NOISE

Noise generated by electric motors, pumps and variable speed drives is to be limited to acceptable levels both within the station and outside where it may affect adjoining properties. This can be assisted by installing low speed pumps, premium efficiency (low noise) motors, building insulation and filters etc. on the VSD's.

The use of acoustic covers over pumpsets to reduce noise to acceptable levels is not permitted as this can make visual inspections and maintenance access difficult.

Internal noise levels must be controlled for operator comfort in accordance with OH&S requirements. Noise levels within the pumping station building or pit are not to exceed 85dB(A) measured at 1m from the source. Noise levels outside the building or pit type station, measured at the nearest boundary, are not to exceed the level criteria of the Department of Environment and Conservation (DEC), Environment Protection and Regulation Division, noise control guide for the particular location as set out in the Noise Guide for Local Government. This can be obtained from www.epa.nsw.gov.au/noise.

For pit type stations, the covers of the pit may need to be insulated with noise absorption and deadening material.

Provide documentary evidence that the installation will comply with the designated noise levels at the time of submitting the final design.

5.7. PUMPING STATION PIPEWORK

5.7.1 PIT AND BUILDING LAYOUTS FOR PUMPS AND PIPEWORK

Enclosed as Appendices A & B are typical layouts which are to be used as the basis for pumping station designs. These are:

Appendix A – Pit Type Stations

- | | | |
|--|---|-------------------|
| • Station with 2 inline pumps (duplex) | - | Drg No. D1742C-01 |
| • Station with 3 inline pumps (triplex) | - | Drg No. D1742C-02 |
| • Station with 2 end suction pumps (duplex) | - | Drg No. D1742C-03 |
| • Station with 3 end suction pumps (triplex) | - | Drg No. D1742C-04 |
| • Typical Site Layout | - | Drg No. D1742C-05 |

Appendix B – Building Type Stations

- | | | |
|-----------------------------------|---|-------------------|
| • Station with 2 pumps (duplex) | - | Drg No. D1742C-06 |
| • Station with 3 pumps (triplex) | - | Drg No. D1742C-07 |
| • Elevations and Typical Sections | - | Drg No. D1742C-08 |
| • Typical Site Layout | - | Drg No. D1742C-09 |

Note:

1. Concrete pump plinths - the pump supplier must be consulted in each case to ensure no less than 100mm is provided between the baseframe holding down bolts and edge of plinth.

5.7.2 PIPE MATERIALS

Pipe materials inside all water pumping stations will be flanged ductile iron cement lined (DICL) Class K12 or flanged continuously welded grade 316 stainless steel manufactured to the appropriate pressure rating. For delivery pipework this is to be for the total maximum pressure (i.e. operating plus waterhammer surge).

The inlet and outlet flanges of some pumps may not be compatible in size with standard ductile iron fittings such as tapers, bends, etc. and it is often necessary to supply connections fabricated from grade 316 stainless steel.

All DICL pipework is to be flanged and bolted using HD galvanised or grade 316 stainless steel bolts, washers and nuts. Stainless steel flanges are to be bolted using stainless steel bolts, washers and nuts.

Adequate clearance shall be provided around all pipework and generally a minimum of 200mm clearance is to be provided between flanges and walls or floor. At least one section of pipework connected to each side of the pump (suction and delivery) is to be removable to allow for pump removal and replacement.

Suction Pipework

The suction manifold should be sized according to the maximum flow demand, including fire flow (refer Section on Hydraulic Design) with a velocity limit (refer Table 8.1). The branches from this manifold to the individual pumps are to be similarly sized according to the range of flows for the pumps.

Flow is to be directed into the suction of the pumps in a uniform manner without turbulence. Valves, tapers and changes of direction or pipe section are to be no closer than three pipe diameters upstream of the pump suction intake.

Inlet tapers (reducers) are to be eccentric, with the obvert horizontal in order to prevent an air pocket developing. The sides of all tapers are to be straight and the taper is to be gradual with an included angle not greater than 15 degrees (ie butt weld tapers are not to be used on the suction).

The inlet pipe which connects directly to the pump is to be horizontal, straight and of the same internal diameter as the pump inlet and of three pipe diameters in length.

Puddle flanges are to be incorporated to take thrust on suction pipework when passing through a wall.

Delivery Pipework

The delivery pipework is to be sized in order to allow for the maximum flow plus fire flow through the pipeline within a velocity limit (refer Table 8.1).

Tapers used on the pump delivery may be concentric or eccentric but are to be straight sided.

Delivery pipe work is to be restrained so that there is no loading back onto the pump flange. Puddle flanges are to be incorporated to take thrust on delivery pipework when passing through a wall.

Dismantling Joints

A dismantling joint (DJ) is to be provided adjacent to at least one pump flange to allow removal and re-installation of the pump without significantly disturbing the pipework. As a minimum the DJ is to connect the straight section of inlet pipe to the inlet flange of the pump.

Fittings and Thrust Restraint

The designer is responsible for the provision of adequate thrust restraint. The details of the proposed restraint together with the design test pressure are to be clearly shown on the plan.

To determine the maximum and minimum pressures to which the pipework and restraints are to be exposed, reference should be made to the section on Waterhammer.

Pipework, fittings and anchorages (including straps, puddle flanges and thrust blocks) must be able to sustain maximum pressures, including surge. Thrust restraint for pipework can also be achieved by the use of thrust type dismantling joints. The use of adapter type flanges (eg UniFlanges, Adapta-Flanges or TYTON–LOK joints) is not permitted.

Within the pumping station particular care is to be taken to ensure that there is no loading onto the pump flanges caused by poor installation or pressure generated forces as this can cause distortion of the pump body and lead to premature failure of components such as mechanical shaft seals. The pump is not to be used to support the pipework.

Field testing is often carried out with the pipework outside the station at least partially uncovered. Anchorages required to resist uplift should therefore be designed without the soil load being taken into account or attention must be specially drawn to the fact that extra temporary anchorage is required.

Flexible jointed pipes and fittings are to be adequately restrained.

Where an existing pumping station is being upgraded, pipe pressure class, thrust restraint and possible fatigue of existing reticulation pipes due to cyclic loading must be checked.

Pressure Gauges

Pressure gauges are required to measure the pipeline suction and delivery pressures and the differential pressure (DP) across the inlet strainer. Tapping points complete with ball type isolation valves are to be located on the common suction pipe and common delivery pipe and pressure tubing from these connected to the pressure gauges which are to be mounted on a gauge board inside the station. Globe valves are not to be used.

For pit type stations the gauges will be direct mounted on top of the gauge cocks located in the pipework. The DP gauge is to be mounted on the pit wall adjacent to the pressure transmitters.

Suction and delivery pressure gauges are to read in kPa, have a 100mm dial face and the range of each gauge is to be such that the maximum pressure reading is around 50% to 60% of the range. The DP gauge is to be a single gauge with a 150mm face and a range of 0-50kPa.

Flange Drillings

All flanges are to be drilled in accordance with AS 4087 off centre. Flange thicknesses are to be rated for the test pressure of the system.

Testing of Pipework

All pipework is to be tested to the design test pressure. Design test pressure is to be nominated by the designer and is to consider operating conditions, surge and shut off head.

5.7.3 HYDRAULIC DESIGN

A number of factors must be considered when designing the inlet and outlet pipework and pumpset layout.

Total pump head is to be based on the flow requirements according to the demands placed on the system. This must take into account available suction pressure and the variation in flow due to average day, peak day demands etc. This can particularly be the case where there is no service reservoir to provide a buffer and the pumping station pumps directly into the system.

This information can generally be obtained from a dynamic model of the system using a computer simulation package such as PIPES++.

In order to minimise energy, but at the same time not oversize pipework and fittings, high local headlosses at the station must be avoided by limiting the velocity through sections of pipework, minimising changes of direction and avoiding other hydraulic losses in fittings, etc.

Minimum station pipework diameter is to be DN100, except for the straight section of pipe connected to the pump inlet which is to be sized in accordance with the pump.

The velocity in the pump suction pipework upstream of the straight section connected to the pump should be no greater than 2m/s. The velocity in the pump delivery pipework downstream of the pump outlet should be between 2m/s and 3m/s.

For end suction pumps, the pump suction pipework should branch from a manifold laid parallel to the building length and outside the building.

The pump delivery pipes, where possible, should connect to a delivery header, again located parallel to the building axis. This can be installed inside or outside the building.

Pipework passing through the concrete floor of a pumping station building should be avoided due to cost, construction difficulty and access for future replacement. Suction and delivery pipes located through a wall rather than the floor is preferred. However, care will need to be exercised to ensure the wall is designed to avoid transmission of noise due to any vibration of the pipework caused by pumping machinery or hydraulic transmission.

Table 5.7.3-1: Maximum Flows for Pumping Station Pipework (Based on DICL K12)

Pipe Size DN	Pump Suction L/s	Pump Delivery L/s
100	14	22
150	35	53
200	65	98
250	103	155
300	154	230

5.8. VALVES

5.8.1 LOCATIONS

Valves are required on the suction and delivery pipework of all pumps in order to provide isolation for the pumps and other equipment. Depending on the layout, these can be located inside or outside the station. Valves are also required to isolate and bypass the strainer and flowmeter.

5.8.2 STOP VALVES

Each pump is to be fitted with an inlet isolation valve and a delivery isolation valve. The delivery valve shall be downstream of the non-return valve to allow isolation of the pump and non-return valve for maintenance.

Suction and delivery isolation valves at the majority of stations will be flanged gate (sluice) valves with resilient seats, non-rising spindle and clockwise closing. The valves will generally be located outside the station direct buried in the ground with a pipe sleeve section over the spindle and a valve box located at ground level. These valves will allow isolation of the inlet and outlet of the pumps to allow maintenance or removal of the pumps for repair or overhaul.

Where the stop valves are located below ground outside the station, the valve surface boxes are to be incorporated into a concrete strip 600mm wide linking all suction valve surface boxes and, where applicable, a separate strip for delivery valves. This is to lessen the chance of them being covered over.

In some cases for pit or building type stations where space is limited, lugged or flanged wafer butterfly valves up to a maximum size of DN250 may be used as suction and delivery isolation valves but must be located within the station or a pit. These valves are compact and generally easy to operate. It is essential that the butterfly valves be either flanged or of the lugged design so that the valve can be retained in position on the flange of the

pressurised pipe to provide pipeline isolation whenever an adjoining section of pipe needs to be removed. Wafer butterfly valves secured between two mating flanges are not to be used.

Butterfly valves up to and including DN150 are to be fitted with a 10 position latching manual lever arm. Butterfly valves DN200 and greater must be fitted with a manual handwheel and gearbox drive.

5.8.3 NON-RETURN (REFLUX) VALVES

A non-return (reflux) valve allows for flow in one direction only. The most commonly used non-return valve is the full (long) bodied swing flap type, however the full bodied tilting disc type is also available. Non-return valves shall be provided on pump deliveries and on any by-pass line around pumping stations.

Non-return valves are required in order to prevent water from running backward through the pump when the pump stops. They also prevent water from recirculating from the duty pump back to any standby pump(s). Non-return valves may be mounted in horizontal or vertical sections of pipe.

Non-return valves are to be installed in the delivery pipework downstream of the pump and upstream of the delivery isolation valves and generally located inside the pumping station pit or building. Flanged long bodied non-return valves or wafer non-return valves are to be used.

For some pumping stations where there is limited space or stations with small diameter pipework, wafer type non-return valves may be used. These can assist in allowing the pumps and pipework fittings to be incorporated into a compact station arrangement.

When using wafer type check valves, care must be taken to ensure that there is space immediately downstream of the check valve to allow for the flap to fully open. Therefore a valve, and in particular a butterfly valve, cannot be located immediately adjacent to a wafer non-return valve. In such cases a short flanged spacer pipe is to be installed between the non-return valve and isolation valve.

5.8.4 DISMANTLING JOINTS

Dismantling joints are to be incorporated in station pipework only where required to allow removal of pumps, valves, non-return valves and flowmeters, etc. Dismantling joints are available in thrust and non-thrust type and the designer is to ensure the appropriate type is used for each particular application.

5.8.5 TAPPING POINTS

Pressure

Tappings for pressure gauges and transmitters are to be either directly tapped into DICAL pipework or connect to tapping bands on the top or side of the pipe via a 10mm (3/8 inch) BSP female thread for pipework up to and including DN200.

For pipe sizes above DN200 15mm (1/2 inch) BSP tappings are to be used. These tappings are to be fitted with stainless steel or bronze ball valves and copper pipe/flexible tubing connected to the instruments. Under no circumstances are globe valves to be used.

Pump Condition Monitoring

Separate tapping points are to be installed on the inlet and outlet of the pump to allow the insertion of a pressure and temperature probe in order to determine pump efficiency. These

tapping points are to be 15mm (1/2 inch) BSP through way gate valves. The tapping points are to be located on straight sections of pipe ideally about two pipe diameters from the pump.

5.8.6 AIR RELEASE VALVES

Air release valves generally used at water pumping stations comprise either automatic air release valves or manual ball valves. Air release valves are used to bleed air from pipes and pump casings (where the pump discharge is not vertical) during commissioning or where air enters the system. If not released, air will cause a flow restriction.

Air valves can also be used to admit air into pipework to assist in draining pipes.

Automatic air valves must incorporate a manual isolation valve (for example, ball valve) between the pipe and air valve.

Both manual and automatic valves are to be located at local high points in the pipework where air may collect. An air trap such as the upward facing branch of a Tee to enable the air to accumulate so it can be released should be installed. The air valve is to be installed on a blank flange fitted to the Tee.

Where located outside the building, manual air release ball valves are to be padlockable in the closed position.

5.8.7 FLOWMETER

An electromagnetic flowmeter is to be installed in the delivery or suction pipework. The flowmeter is to record all pumped flows, along with gravity flows where applicable.

The flowmeter is to be flanged and sized the same diameter as the delivery pipework (i.e. no tapers are to be used) so that the inside diameter of the flowmeter matches that of the pipework.

The flowmeter is to be located so that there is ideally 10 and 5 but no less than 5 clear pipe diameters upstream and a minimum of 2 clear pipe diameters downstream of the flowmeter from any disturbance (for example, valve, tee, bend, change of direction etc.) in the pipework. At least one of the pipe flanges joining the flowmeter must be a dismantling joint or alternatively is to incorporate a gibault joint on the section of pipe adjacent to the flowmeter to allow removal of the flowmeter.

The signal converter and LCD display unit is to be located in the switchboard and readings displayed in flowrate (ML/d) and cumulative total flow (ML).

Where the flowmeter is used for control purposes, it is important to specify the required flow range. This “compresses” the 4-20mA signal to cover only the required range for improved control.

Flowmeters are to be installed according to manufacturer’s instructions and shall incorporate earthing rings or earth connections as required by the manufacturer. Flowmeters shall operate either on 240V AC or 24V DC.

Generally the flowmeter is to be direct buried outside the station. Note that special precautions are needed in terms of corrosion protection when flowmeters are to be buried. A marker is to be laid in the ground to identify that the flowmeter is buried below.

Isolation valves are to be provided upstream and downstream of the flowmeter as well as a valved bypass. The bypass line is required in the event that the flowmeter is isolated and

removed from service. During this time the flow will be directed through the bypass. Under normal circumstances the bypass valve will be shut.

A flushing hydrant is to be installed on the downstream end of the bypass.

Due to the short length of the bypass line, friction losses through this section are likely to be small. The bypass line may be one size smaller than the water main, with a minimum bypass pipe size of DN100.

The only instances where a by-pass may not be needed is where the station is not required to operate on a continuous basis (such as directly to a reservoir) or where the station can be by-passed by temporarily re-directing gravity reticulation to customers by the operation of system valving.

5.8.8 STRAINER ASSEMBLIES

The suction pipework to the pumping station is to be fitted with a strainer assembly to prevent stones and other foreign material entering the pumps and causing damage. The strainer is to be installed above ground or in a below ground pit which is to be provided with drainage and lockable treadplate covers. An inlet valve and outlet valve for the strainer assembly, along with a valved bypass, are to be provided. The bypass will allow the station to function while the strainer is isolated for cleaning or repairs.

With some stations, and particularly the smaller ones, it may be possible to locate the strainer assembly in an aboveground section of pipe. This will allow easy access for cleaning, particularly if a 'Y' type strainer is used where removal of the cover is from the underside. However, such an arrangement must be in keeping with the site and would need to be approved by Hunter Water on a case by case basis.

The strainer is to be fitted with a removable cover which can be safely removed by one person and allow the basket to be withdrawn for cleaning.

The strainer assembly must be installed so that solids fall to the bottom of the strainer basket and can be readily collected when the basket is removed. Where the removable covers are heavy, a support device is to be provided to support the cover and allow it to be swung away in order to remove the basket.

Where the strainer is mounted above the ground, an automatic air release valve fitted with a padlockable manual ball valve is to be provided in the top of a vertical Tee on the downstream section of pipework after the strainer.

The strainer body may be manufactured of iron or steel (with fusion bonded epoxy protective coating), gunmetal or stainless steel. The stainer element (basket) is to be wire mesh or perforated sheet metal manufactured from 316 stainless steel. The size opening is to be 50% of the throughlet of the pump impeller, ie 10mm impeller throughlet (clearance) means 5mm diameter hole in strainer basket.

Care must be taken during the design of the strainer assembly to ensure that the headloss through the strainer does not exceed 1m (10kPa) at the maximum + fire flowrate. If a standard line strainer is unable to satisfy this requirement, then either a larger strainer assembly than the pipe size may need to be installed or two strainers installed in parallel to ensure this headloss requirement is not exceeded.

Pressure gauge tappings are to be fitted upstream and downstream of the strainer assembly with pressure tubing connected to the gauge board in the building or wall of the pit and a

DN150 differential pressure gauge installed with range 0-50kPa. This is to indicate headloss across the strainer.

Isolation valves are to be provided upstream and downstream of the strainer section as well as a valved bypass. The bypass line is required in the event that the strainer is isolated and removed from service. During this time the flow will be directed through the bypass. Under normal circumstances the bypass valve will be shut.

A flushing hydrant is to be installed on the downstream end of the bypass.

Due to the short length of the bypass line, friction losses through this section are likely to be small. The bypass line may be one size smaller than the water main, with a minimum bypass pipe size of DN100.

5.8.9 VALVE PITS

In most cases a separate valve pit is not required as the stop valves are either direct buried or are installed inside the pump pit or the pumping station building.

5.8.10 FLEXIBLE PIPE JOINTS NEAR BUILDINGS

Pipework in the ground leading into and from the pumping station building may have either rubber ring or flanged joints. TYTON-LOK joints at the station are not acceptable. Appropriate restraint such as thrust blocks are to be provided where required.

Where the geotechnical investigation has determined that settlement is likely then to compensate for the possibility of differential settlement of the building and pipework, flexible pipework jointing should be utilised. The designer must determine the manner in which movement may take place and design an appropriate flexible jointing system. This may include flexible bellows which may allow horizontal or vertical movement and may also provide horizontal or vertical restraint depending on which type is selected.

Such items are to be included in the design to ensure that no fracturing of the pipework, joints or building occurs.

5.8.11 WATERHAMMER AND PIPE MATERIAL SELECTION

General

Waterhammer occurs due to a rapid change in pressure in the pipeline caused by a sudden variation in flow velocity. In a pumping system this occurs upon pump start and shut down, the latter usually causing the most severe waterhammer. When a pumping station commences pumping there is a rapid increase in pressure in the pipe. This increase in pressure propagates along the pipeline accelerating the flow until a steady state hydraulic grade line is established.

Problems are most frequently encountered when a pump or pumps fail instantaneously due to, for example, a power failure or when a valve is shut instantaneously. With a rapid cessation of flow through the pump(s) there will be a rapid decrease in the pressure head in the pipeline. In some cases upon shut down the pressure in the main may fall below the vapour pressure of water and separation of the water column in the pipeline occurs. Upon the columns rejoining, large positive pressure surges which may be much greater than the normal operating pressure can occur.

A waterhammer analysis may be necessary to ensure that the material and pressure class of the pipe selected is adequate to sustain the surge pressures developed and also to determine pressure requirements for the design of thrust restraint.

As different material types (even of the same nominal size and class) may cause differing surge pressures to develop, it is recommended that waterhammer analyses be carried out during preliminary design.

Under surge conditions, pressures are generally higher closest to the pumping station. Whilst this has implications for the pipes and thrust restraint, any properties being supplied directly from the pipeline in these locations can be adversely affected. Consideration must be given as to the mitigation of such pressure variations where these will otherwise cause failures.

Whilst pressure within the pipeline is able to be predicted, noise and vibration cannot.

The designer is to assess the impact of waterhammer on adjoining system pipework when pumping into a system and not a reservoir.

Methods of Analysis

There are a number of methods used to analyse waterhammer pressures although computer simulation allows the rapid dynamic analysis of waterhammer. An appropriate computer software package is to be used to carry out a dynamic waterhammer analysis and provide graphical plotting of the HGL maximum envelope.

For further methods of waterhammer analysis refer to Section 4.3.7 of Hunter Water – Water and Sewer Design Manual.

Waterhammer Control

The use of air release valves and other mechanical devices such as slow closing valves are generally considered suitable for pressure control. Enclosed surge tanks pressurised with air or one-way surge tanks are sometimes used. Lowering the rate of approach of separated columns by the use of a bypass (for example, a reflux valve with shaved flap) can also be useful in reducing the maximum pressure developed.

Care must be taken with the selection of mitigation devices as the device may not operate under power fail conditions, may not be properly maintained and may not be capable of providing the intended service in the future.

Often, the most satisfactory method of control is to ensure that the surge pressures which do occur are within the safe working pressure of the pipe selected. This may limit choice of pipe material and/or require adjustment of the pipe diameter to reduce the normal velocity.

5.9. PUMPS

5.9.1 TYPES

These design guidelines are generally aimed towards pumping stations with duties able to be achieved with the use of single stage pumps. High head requirements may be more suited to multi-stage pumps and these are not covered by these guidelines.

There are generally only two types of pumps to be used in the majority of water pumping stations considered under these Design Guidelines. These are:

- Single stage in-line centrifugal pumps. These are predominantly used in pit type stations.
- Single stage end suction centrifugal pumps. This type of pump is typically used in building type stations and, in some cases, pit type stations.

Pumps will be direct driven or close coupled in-line type or direct coupled end suction centrifugal type up to and including 11kW. Over 11kW the pumps will be the direct driven end suction back pull out centrifugal type. A spacer coupling is **not** to be used for the direct driven pumps as it is likely the motor will be removed for overhaul at the same time as the pump.

5.9.2 SIZING OF PUMPS AND PUMPING STATIONS

There is interdependence between trunk main size, pumping station capacity and reservoir storage. The correct sizing of pumping stations is a matter of economics. Historically, the best solution has been to size pumping stations to supply the daily demand constantly over a 20 to 24 hour period. However, with modern computer techniques the designer can vary design criteria to suit individual systems so that the most economical distribution scheme is achieved.

The following factors should be considered when selecting pumps:-

Pump Efficiency. By using the most efficient operating range on the pump curve more economical running costs will be achieved. The investigation should consider running the pump at maximum efficiency during average demand periods as against running during peak demand periods.

For fixed speed pumping the pump will generally operate over a wide range of duties due to varying suction and delivery conditions. Pump efficiency may or may not vary greatly for single pump operation, depending on the variation between maximum and minimum pump head condition.

For variable speed pumping such as to maintain a set delivery pressure, pump speed will vary significantly with demands. The designer must calculate the speed applicable to the operating points and quote the respective efficiencies.

Type of Pumps. Variations in demand may be handled effectively by use of more than one fixed speed pump or variable speed pumps. Many pumps are available with a range of impeller sizes. Meeting future pumping requirements may be possible by changing impeller sizes rather than pumps. This may be an economical solution, however, consideration of a change in motor size to drive a larger impeller may be necessary.

Pump Combinations. Using a number of smaller pumps rather than one larger unit may be an economical alternative. This will allow a smaller pump operating at high efficiency to be used during low demand periods with a resultant saving in running costs. The change from single pumps to multiple pump operation may affect individual pump efficiencies and maintenance costs. This aspect must be satisfactorily resolved to ensure a multiple pump installation is feasible.

Standby Capacity. Standby capacity is normally required as an insurance against pump failure as well as an alternative during maintenance operations. This is necessary where the pumping station is the sole source of supply to an area.

Existing Pumping Station Amplification. Amplification of an existing pumping station may be achieved by increasing the number of pumps, increasing the impeller size on existing pumps or replacing the pumps with larger units. Each alternative should be investigated.

Number of Pumps able to Operate. Standby capacity is required at each pumping station and is to be equivalent to the capacity of the largest duty pump. Most stations will contain two identical pumps, being a duty and a standby pump. For three pumping stations, all pumps will be identical with two being duty pumps and the third being the standby pump.

For two pumping stations, the power supply is to be adequate to allow for the second pump to be operated manually under emergency conditions. For a three pumping station provision is to be made for two pumps to operate whilst the third will operate only when one of the two duty pumps fails or is unavailable.

In some cases Hunter Water may require all three pumps to be able to operate together.

5.9.3 PUMP SELECTION

Selection of the type and size of pump will be determined from the system duty requirement and will determine the final arrangement of the mechanical equipment within the pumping station and the final dimensions of the pumping station.

A pump is required to provide a range of flows over a range of system pressures in order to satisfy system demand criteria, including fire flows. The main criteria when selecting a pump is operating efficiency. Ongoing power costs are greater than those costs associated with lifetime maintenance and hence preference will be given to such a pump.

The designer is to ensure that there is a commercially available pump which satisfies the duty with high efficiency and from at least one supplier.

Selection of a pump suited to the application, requiring an acceptable level of maintenance and efficient in operation is critical to achieving minimum whole-of-life costs. Some previous installations have performed below expectation and pump selection must be undertaken with greater scrutiny. Designers are to liaise with Hunter Water to obtain advice on pump performance, maintenance cost and failure history for use in the preparation of NPV calculations.

Each pump and drive unit is to be suitable for pumping water and for performing the duty throughout the specified range. The operating (flow) requirements are to be determined by the designer and approved by Hunter Water.

Consideration is to be given to:

- System flow and head for initial and ultimate requirements (where applicable)
- Pump efficiency within the normal duty range
- Pump speed
- Standby capacity required
- Best efficiency point to be as close as practical or within the normal operating range.
- Availability of spare parts, supported by adequate local service agent
- Consistency with existing pump brands and models

In cases where customers are supplied directly from the delivery watermain which is subject to start/stop pump operation, customers can experience “pressure spikes”. Under such circumstances, consideration must be given to the slow starting and stopping of the pump.

This may be achieved using “soft” starting, variable speed starting or a slow opening and closing valve.

The designer must consider the operation of that system for when the reservoir is taken offline for maintenance. This can be achieved by the use of a VSD or delivery control valve such that pressure control in the system can be maintained without the reservoir. An NPV analysis is to be undertaken by the designer to compare both options and to consider the other relevant issues such as life span, maintenance requirements and operation.

For variable speed (VS) operation, it is preferable to select a pump with a closed head pressure being significantly higher than the operating pressures as these tend to have a broader efficiency range more suited to VS operation. Similarly, the maximum duty should be to the right of the best efficiency point (BEP) on the pump performance curve so that lower speed operation typical of average demand is closer to the BEP.

If the speed difference between the range of duties is less than 10% then consideration must be given to fixed speed operation.

5.9.4 PUMP MATERIALS AND CONSTRUCTION

Generally pump bodies and bearing housings will be constructed of cast iron. Shafts are to be stainless steel and impellers are to be bronze or stainless steel. Shaft bearings may be oil or grease lubricated. Pumps greater than 11kW are to incorporate fully cast impellers.

Generally pumps will be of the direct driven style as outlined in the Pump Selection clause. That is, the pump shaft will be fitted with bearings and the end of the shaft fitted with a half coupling. The motor shaft will also be fitted with a mating half coupling and the two coupling halves will be joined together with pins and rubbers or a flexible type device, etc.

For lower duty applications involving pumps up to and including 11kW, a close coupled arrangement will be acceptable. This arrangement uses the motor shaft to support the pump shaft via a single coupling which encloses both shafts. Therefore the only bearings supporting the pump stub shaft are those of the motor. Such arrangements are generally used in inline pumps of either 1440rpm or 2900rpm. A common term for such a pump arrangement is a “motor pump”.

Centrifugal pumps are to be of the back pull-out (BPO) style where the bearing housing and mechanical seal assembly, complete with pump shaft and impeller, is able to be unbolted from the pump volute casing and removed as a unit without disturbing the pipework.

Pumps of the direct driven style are to be fitted with renewable wear rings in the front and back of the body and on both faces of the impeller.

All pumps are to be fitted with mechanical seals and are to be of the multi spring arrangement. Seal stationary faces are to be minimum silicon carbide, rotating face to be minimum carbon. Ceramic faces are not acceptable. A water flush to the seal housing is desirable and may be required by Hunter Water in some cases.

Where the suction pressure is greater than 10m and for high pressure applications (eg series pumping) the pump may require a special mechanical seal and this will depend on the rating of the standard seal. The pump casing must also withstand any higher pressures.

Designer must state minimum and maximum suction and delivery pressure.

Internal wetted surfaces of the pump (ie volute casing but excluding impeller and seal ring surfaces) are to be coated with a non-toxic 2 part epoxy paint suitable for potable water. If epoxy coating is not possible, alternative materials of construction such as bronze or stainless steel, are to be considered. As operating efficiency is the major consideration in the pump selection process, if alternative materials are not available then this should be discussed with Hunter Water prior to selecting an alternative less efficient pump which can either be epoxy coated or is available in non-corrosive materials..

5.9.5 PUMP SPEED

End suction centrifugal pumps for water supply applications are mainly available in 1440rpm (4 pole) and 2900rpm ((2 pole) motor speed. For the same duty 2900rpm pumps tend to be of lower cost, more compact and more efficient when compared to a 1440rpm pump.

Wear is related to rotational speed and therefore lower speed pumps are generally regarded as experiencing less wear and will provide a longer service life than high speed pumps for the same duty. 2900rpm pumps are only to be installed in pumping stations up to a motor size of 11kW. Higher flow and head duties requiring motors larger than 11kW are to be provided with 1440rpm pumps or pumps of a lower speed.

There may be special cases where high speed pumps above 11kW are required due to particular circumstances and written approval from Hunter Water would be required for such applications.

Electric Motors

Motors are to operate on nominal 415V three phase supply. Motors greater than 11kW are to be specified as premium (high) efficiency low noise motors as these provide efficiencies greater than normal motors and are quieter in operation. When costs are taken over the life of the motor the capital cost accounts for only a small portion of the total operating cost of a motor.

High efficiency motors are not always available in the smaller capacity pumps as some may come complete with their own brand of motor, particularly for those which use a close coupled motor.

Motors used in variable speed drive applications are to have Class H insulation.

For the type of pump units covered by these design guidelines, motors will generally be of the two pole and four pole arrangement.

5.9.6 PUMP OPERATION UNDER LOW DEMAND CONDITIONS

Pumps can pump directly into the system and may need to deliver a range of flows over varying demand conditions. In particular, many such pumps may need to operate to provide a very low flow demand. This would be typical of night time operation where a pump is still required to maintain the required system pressure but where the actual demand is minimal or even nil.

In such cases due to the very low or nil demand, it is possible to have the pump running but pumping no water (ie no flow), thereby leading to overheating of the water in the pump casing, causing the water to boil. This can result in a vapour lock and cause damage to the mechanical seal as well as blistering the casing paint and is to be avoided. To overcome such likelihood, a small bypass line is to be installed between the pump delivery and suction pipework.

This bypass line is to be fitted with a solenoid valve. This valve is to be operated by a thermostat sensor mounted directly on the outside of each pump casing. Once the thermostat sensor has operated at a preset temperature (50°C), a signal will be provided which will open the solenoid valve, thereby causing flow from the delivery of the pump back into the suction. If adequately sized this will provide sufficient cooling to prevent water and pump overheating.

Once the pump casing temperature reduces to an acceptable level (30°C) due to an increase in flow as demand increases, the solenoid valve is to close.

The diameter of the bypass line is to be a minimum of 10mm and will depend on pump capacity but should allow around 5% of average pumped flow to pass through, sufficient to provide cooling of the pump.

For variable speed pumps, the minimum speed setting is not to be less than 40% of full speed.

In some cases with small fixed speed pumps where pump operation will occur under no flow conditions, a small diameter permanent bypass is installed incorporating a manual isolating valve.

5.9.7 PUMP PERFORMANCE TESTING AND COMMISSIONING

Acceptance Tests

Pumps to be installed in the stations covered by these design guidelines will be mass produced and will perform generally in accordance with the published performance curve. However, it is possible the performance will be inferior to the curve. Australian Standard AS2417 allows for a positive and negative tolerance whereby the actual pump performance can deviate from the published or tendered performance data. This performance variation may not be significant for some applications but could be more critical for larger pumps.

The designer should consider either not permitting a negative tolerance or specifying a higher duty to ensure the actual pump performance is not below that which is required.

Hunter Water's Technical Specification STS405 for Construction of Small Water Booster Pumping Stations has details on test requirements.

Commissioning and Site Tests

As part of the pump installation process, for direct driven pumps with motors 15kW and over, shaft alignment is to be achieved with the use of laser alignment equipment. Printed results of the alignment are to be submitted to the Superintendent prior to commissioning. Alignment to within $\pm 0.05\text{mm}$ is required.

Upon completion of installation, the equipment is prepared and placed into operation under the same conditions it will operate in practice. Tests are made to ensure all protective devices, and controls are fully operational.

Hunter Water's Technical Specification STS 405 has details of commissioning and site tests.

Performance tests will also be made to verify the designed performance under operational conditions. The designer to specify how this is to be done.

Where commissioning of the station is likely to occur outside peak demand periods, detail special pump operating requirements to verify operation of station at peak demand flows.

Each pump individually is to be operated and the following values measured:

- Suction pressure
- Delivery pressure
- Flowmeter reading

In general terms the difference between the pressure gauge readings will provide the pump boost and the flowmeter will provide the flow. Corrections are to be made to the pressure gauge readings to allow for losses and corrections between the gauge locations and pump. These should then be reported on against the individual pump performance curve. This shall be done for all pumps one at a time for the station or in combination as the total station output may require.

The test results are to be submitted to the Superintendent as part of the requirements for practical completion. Should the results not be in line with the expectations based on required performance and results of factory testing, the contractor is to provide reasons why this is the case and what corrective action is required to ensure compliance with the requirements.

5.10. ELECTRICAL

The electrical components of a pumping station comprise:

- Incoming power supply
- Switchboard containing metering, main switch, pump circuit breakers, pump starters, protection equipment, PLC and telemetry equipment
- Instruments such as pressure transmitters, pressure switches, flowmeter, etc.
- Building lighting and power
- Security system

The pump starters supply power to the pump motors based on a PLC control signal (for example, reservoir level or pipeline pressure). Telemetry provides remote monitoring and control (for example, telemetered reservoir level for pump cut-in and cut-out).

5.10.1 POWER SUPPLY

All pumps covered by these guidelines will operate on a three phase 415V 50Hz (3 phase) MEN power supply. Power is to be supplied by the local Electricity Distributor (ie Energy Australia) directly from the existing distribution system or via an extension/augmentation of the system. This system must be secure in order to minimise disruptions to the pumping system.

The extent of work required by the Electricity Distributor to provide power will depend upon:

1. Power requirement at the pumping station. The supply must be sufficient to operate all pumps, including the standby pump, at the same time..
2. Frequency of pump starts (for example, five per hour etc.)
3. Method of starting (for example, soft starter, direct on line (DOL), VSD, etc.).
4. Power supply system capacity to supply the load without causing an excessive voltage drop on start-up or during running which may affect other customers in the area.

Where the load is small (for example, 4kW) it is likely that supply can be provided from the existing or proposed distribution system. However, if the load is significant (for example, 100kW) then a dedicated substation (transformer) may need to be provided.

This transformer could be pole mounted or pad mounted (kiosk) unit depending on the load and would be connected directly to the Electricity Distributor's 11kV system. Such an arrangement would be provided in order to minimise any local disruption on the 415V supply to other customers (eg flickering of lights etc).

For many new developments, pumping station loadings are often factored in as part of the power reticulation design. In such cases, a connection pillar (in the case of underground supply) is generally provided for future connection of the supply to the pumping station.

The Electricity Distributor needs to be consulted at the earliest possible stage in order to make provision for such a connection.

Recent changes in Electricity Distributor service rules have meant that it is no longer possible for the consumers main (cabling between Electricity Distributor point of attachment and the pumping station switchboard) to be run down the transformer pole. A customer lead-in pole is now required. An overhead connection is made to this pole from the transformer and the consumers main is run down the lead-in pole and underground into the switchboard.

When negotiating with the Electricity Distributor, a Design Information (monopoly) Fee is payable in order for the Electricity Distributor to advise how the power connection can be made and what works will be needed to service the load. This information will also advise whether the works (if needed) will be contestable or non-contestable.

In some cases a dual (duplicate) power supply is desirable as insurance against loss of supply at critical installations. This is a supply by feeders from two independent (or relatively independent) sources (generally zone substations) in the network.

In the event of loss of one supply, manual (or automatic) switching can be provided to enable supply from the second feeder to connect to the station.

5.10.2 SWITCHBOARD

The switchboard is to be located outdoors for a pit type station or indoors in the case of a building. The cabinet for outdoor switchboards is manufactured either from marine grade aluminium or 316 stainless steel and for indoor switchboards is to be painted zinc anneal sheet. Cables are bottom entry for outdoor switchboards and can be either bottom or top entry for indoor switchboards (depending on station layout) although they are generally bottom entry.

In accordance with AS/NZS 3000 Wiring Rules, switchboards are to be located to ensure that minimum clearance requirements for safe personnel access around switchboards are maintained. Similarly, the building is to be provided with sufficient points of egress (building doorways) in compliance with AS/NZS 3000. Accessibility and safety also need to be considered.

The switchboard will comprise various compartments and components to serve many functions. The main compartments are as follows:

1. Metering of incoming power supply
2. Main incomer switch and voltmeter
3. Pump circuit breakers, starters, power, control wiring and ammeters etc.
4. Auxiliaries panel (lighting, GPO's, flowmeter power, etc.)
5. Programmable logic controller (PLC) cubicle
6. Telemetry cubicle

For outdoor switchboards electrical equipment must be secured behind an internal door fitted with a lock that is "81/3" keyed. However, the electricity meters, all instrument displays, station controls and at least one 240V AC power outlet shall be accessible by opening an external door with padlockable handles.

Outdoor switchboards are to incorporate a security system comprising sensors fitted to the external doors. These sensors are to be connected to the PLC and telemetry to raise an alarm as detailed in Hunter Water's specification STS 105.

Metering of Incoming Power Supply

This compartment houses the electricity meters which record kilowatt hours. Some pumping stations are on general tariff whilst other stations are on Time of Use or Maximum Demand tariffs. These latter tariffs have a kWh charge based on the time of day and week (for example, peak, shoulder, off peak) whilst maximum demand has a kVA demand component. Some metering is fully electronic and readings can be made via Electricity Distributor telemetry.

Main Incomer Switch

This provides isolation of the switchboard from the incoming power supply and distributes power to the pump starters and auxiliaries panel. The switch is rated for the maximum station load.

Pump Starters

These comprise individual pump circuit breakers and starters. The circuit breakers are rated for the individual pump motor full load current (FLC). Starters may be soft (electronic) starters, direct on line (DOL), variable speed drive (VSD), star delta, auto transformer, etc. A signal via the PLC will stop and start the pump.

The pump starters also have motor overload (overcurrent), fault trip and phase failure protection where, under certain conditions, power to the motor is automatically switched off to prevent the motor windings overloading and burning out or a potentially lethal condition existing.

Variable speed drives (VSD's) are to be of the variable voltage, variable frequency (VVVF) type with switching frequency adjustable to greater than 16,000Hz. Drives are to be wall or switchboard mounted a minimum of 150mm apart. Motors driven by VSD's are to have Class H insulation and motor cables are to be fully shielded with 360 degree glanding at both ends.

Variable speed drives can generate considerable heat and ventilation requirements for the switchboard enclosure and building must be taken into account during the design process.

Auxiliaries Panel

This provides individual circuit breakers to supply power to various appliances such as power points (GPO's), lighting, security system, flowmeter, fan, etc.

PLC Cubicle

This houses the PLC. The PLC is a control device which is programmed to provide switching under certain input/output events. Wiring connections to and from the PLC are made to racks into which PLC input/output cards are installed. PLC cards can include digital and analog inputs and outputs.

Telemetry

On completion of the Concept Design, the designer is to engage and pay for a Hunter Water approved supplier for design and installation of telemetry and SCADA works to undertake a radio survey and from this to nominate a base station, transmit and receive frequencies and remote terminal unit (RTU) number along with antenna direction/bearing to base, antenna mounting height and antenna size.

The designer must then seek approval from Hunter Water for the above.

Telemetry Cubicle

This contains a power supply with battery backup, remote/radio telemetry unit (RTU) which is connected to the PLC, a digital radio and an aerial. The RTU forwards and receives radio signals to and from a base station (for example, Gan Gan, Sugarloaf, etc.) which is connected to the Hunter Water SCADA (supervisory control and data acquisition) system.

This system allows for remote monitoring and control of the pumping station. This is achieved by 2-way communication with the station PLC.

Sample SCADA screen page diagrams are to be provided by the designer as part of the design documentation. Typical diagrams supplied by Hunter Water are to be marked up for the particular installation.

5.10.3 PRESSURE TRANSMITTERS

Suction and delivery pressure transmitters are to be installed at each station. These are to be connected by pressure tubing from a valved pipe tapping to the suction and delivery header pipework respectively. The transmitters are to be mounted on the wall of a pit type station or on the gauge board of a building type station.

The transmitters are to show the reading as an LCD display and be of the type which can be site adjusted if the calibration drifts. The transmitters are to be ranged to suit the operating conditions and must be capable of withstanding the maximum possible working pressures.

5.10.4 LOW SUCTION PRESSURE ALARM

Should the suction pressure to the station drop to a level which is lower than the normal range of pressures likely to be experienced, a signal from the transmitter is to be used to provide a SCADA alarm to advise of a low suction pressure condition. This will allow time for a Hunter Water operative to check out the problem and take remedial action prior to a critical level being reached.

5.10.5 PUMP PROTECTION ON LOW SUCTION PRESSURE

As part of the controls, pump protection is to be provided in the event that there is a pipeline break or a restriction on the suction to the pump which could leave the pump with no water and result in damage. Likewise, the same would apply if a suction valve had been inadvertently closed (ie suction pressure will be zero).

To achieve this protection, pressure switches are to be fitted to the suction pipework of each pump to protect the pump and adjusted to suit the particular installation. These should be set at a minimum of 5m. If this low pressure is reached and sustained for a pre-set time period, the pump is to switch off and an alarm raised on the SCADA.

Only when the set pressure has been restored will the pump become available.

Operation of a pump under manual control shall not bypass the protection equipment. However, facility to override this protection via the SCADA is to be provided.

5.10.6 PUMP PROTECTION ON LOW DELIVERY PRESSURE

In a similar manner to low suction pressure to the pumps, the delivery pressure is to be monitored by the installation of a pressure switch on the delivery manifold. This is to be set such that a pipeline break that will result in low delivery pipeline pressure will allow the pump to switch off and raise a SCADA alarm.

5.10.7 NO FLOW PROTECTION

Provision of No Flow protection will only apply to fixed speed pumps which do not normally experience a no flow condition while the pump is operating. In such cases, No-Flow protection is to be provided for each pump. This protection is required in the event that the pump is operating but no water is being pumped. Such cases are where a delivery valve is closed or the pump shaft has broken etc.

No-Flow protection can be achieved in several ways. A No-Flow paddle type switch can be inserted into the delivery pipe of the pump or by fitting an extended hinge shaft and lever arm to long bodied reflux valves and fitted with a micro-switch or sensor. In both cases the switch or sensor is to be linked to the control system.

After a short time period of pump operation has elapsed and the switch or reflux valve has not operated, the control system is to stop the pump and raise a “No-Flow” alarm.

Reflux valves with lever arms cannot be direct buried and will need to be located in the pumping station or in a pit.

5.10.8 GAUGE BOARD

For pit type stations the pressure transmitters, switches and gauges are to be located on the inside of the pit wall. For building type stations these instruments are to be mounted on a timber gauge board which is to be fastened to the inside wall. The board is to be located in an accessible area which facilitates reading of the gauges and calibration checking and adjustment.

Sufficient isolation valves and test points are to be provided to allow isolation of the pressure transmitters and switches from their respective pressure tubing to enable a test device to be connected via a Tee and valve to check the various calibration and settings.

5.10.9 GENERATOR CONNECTION POINT

All stations are required to incorporate a connection point for an emergency generator. Due to AC power failure from the Electricity Distributor system, a portable diesel driven generator may need to be taken to the site of the pumping station and connected to allow at least one pump to be operated to maintain water supply.

These connection points are to be located external to the station mounted on the external wall of a building or in a lockable enclosure within an outdoor switchboard. Terminal connection points are to be provided for the generator leads and a manual changeover switch in the main switchboard allows changeover from AC power and generator power. This switch will disconnect AC power supply and connect supply from the generator to the pump starter. Likewise, when AC power is restored the connection is to be changed back over via the same switch.

5.10.10 STANDBY GENERATOR

Some stations will require a permanently installed emergency standby generator. This will allow the station to operate in the event of AC power fail. A risk assessment is to be undertaken by the designer in regard to the consequences of power failure at a pumping station in terms of continuity of supply and meeting Hunter Water's licence obligations of a minimum 12m being available to all properties. Where such licence requirements will not be met alternative back up strategies are required to be determined by the designer for incorporation into the design (eg tank, generator, etc.). Refer Hunter Water's Water and Sewer Design Manual Section 2.1.4 Security of Supply.

The designers recommendations are subject to Hunter Water's review and approval.

Such a system will incorporate an automatic load transfer switch which has mains supply after the metering point connected to the switch. Supply to the switchboard and generator connect to this transfer panel. The switch will monitor AC power and on the event of AC power fail the generator will be automatically signalled to start operation and the changeover switch will activate to disconnect mains power from the switchboard and provide generator power to the switchboard and restart the operative pump(s).

Once AC power is restored to the site the switch is to automatically revert back to supply AC power to the switchboard and disconnect generator power and stop the generator.

The generator is to be located adjacent to the station and mounted on a concrete pad. The generator itself is to be enclosed in a weatherproof container type lockable enclosure, soundproofed and complete with fuel tank. The enclosure is to incorporate a bund to collect diesel fuel spillage or engine oil spillage. Cabling between the generator and switchboard is to be belowground in conduits

The generator may be required for fixed speed pumps or variable speed pumps. In each case the generator supplier will need to have a thorough understanding of the operational requirements of the pumping station, the maximum number of pumps to be operated under power outage conditions, along with the details of the load, motor details and characteristics and the starting system.

The generator shall be sized to match the load and method of starting employed at the pumping station. The generator must be a minimum size in relation to VSD's and must have advanced speed control in order to avoid "hunting" of the generator.

Operating noise level limits are to be specified for the generator and will depend on the nature of the particular location and the requirements as set out in the EPA noise control guidelines.

The generator operation is to be regularly checked by test running and operation under power fail conditions.

An Operations and Maintenance Manual is to be supplied.

5.10.11 ELECTRICAL DESIGN DRAWINGS

The electrical design shall include (but not be limited to) the following drawings:-

- Incoming supply and PLC I/O
- General arrangement of switchboards
- Power and Control schematics for all equipment
- PLC I/O Schematics for all equipment

- Telemetry
- Instrument loops
- Typical installation wiring diagrams for each different type and instrument type
- Equipment and cabling layouts
- Light and small power layouts
- PLC layout

Standard outdoor electrical switchboard cabinet assembly (SCA) drawings for wastewater pump stations may be obtained from Hunter Water (standard water pumping station drawings are not available) in electronic format following the determination of pump size and method of starting. These shall be amended by the designer to ensure they are suitable for the specific water pump station. Hunter Water does not have standard indoor SCAs drawings. Alternatively, Hunter Water may be able to provide recent SCA drawings for water pump stations as an example to assist in preparation of the electrical drawings.

5.11. PUMPING STATION OPERATION AND CONTROL

5.11.1 GENERAL

The role of the pumping station in supplying demand within the system must be clearly defined by the designer. This is so that the required method of operation can be described in the specification document and implemented by the programming of the PLC.

All pumping stations will have at least one duty and one standby pump. This is regarded as a duplex pumping station. With a triplex station there would be two duty and one standby pump. In such a case the Duty 1 pump would perform the majority of operation, with the Duty 2 pump providing service in periods of high demand to satisfy the design criteria.

To ensure each pump has approximately equal running hours, pumps are generally rotated weekly to ensure that other pumps are also operated. In the case of start/stop operation such as servicing a reservoir, pumps are generally rotated in duty whenever the duty pump stops. That is, when a pump is next called to operate the next pump in the 'queue' will operate as the duty pump.

A two duty/one standby arrangement can achieve energy savings where the range of duties is broad from minimum demand to maximum demand plus fire flows. Should a single pump be used for a wide range of duties, even with variable speed drive, then it is unlikely that the range of duties will be covered in an efficient manner. For example, the pump may only operate efficiently at maximum demand duty while most of the operation will be undertaken at minimum to average demand conditions.

Under a three pump configuration it is possible to provide average demand duty with one pump only in operation. The second duty pump would only be brought into service when greater than average demand conditions require. This would be where two pumps operating near or at 100% speed would provide maximum demand plus fire flow. In this way, the pump is selected based on maximum efficiency at around average flow. Again, this depends on the spread of flow range required.

Some of the more common control methods are:

- a) Pump operation based on reservoir level
- b) Pump operation based on low suction pressure
- c) Pump operation based on low delivery pressure

- d) Pump operation to maintain a pre-set delivery pressure
- e) Fire flows

5.11.2 PUMP OPERATION BASED ON RESERVOIR LEVEL

This is where a pumping station pumps to a service reservoir and pump operation is controlled by a level switch in the reservoir. The switch signal is forwarded via telemetry from the reservoir to the station PLC and will start the pump when Pump cut-in level in the reservoir is reached. When Top Water Level (TWL) of the reservoir is reached a signal will then be sent to stop the pump. Such a control system would communicate either by radio telemetry or landline between the reservoir and pumping station.

In general terms, pumping to a reservoir will require fixed speed pumping. However, a case could be made for variable speed or a two duty pump arrangement in order to reduce energy due to friction losses, particularly where there is a long pipeline and a significant variation in demand, meaning that the reservoir filling rate can be decreased.

The reservoir control system can have different levels which bring in the first and second pump or can vary the speed of the operative pump. The economics of this must be assessed on a case by case basis using estimated capital (eg larger pumping station building, extra starter and pipework for three pumps, etc.) and operating costs using an NPV assessment.

5.11.3 PUMP OPERATION BASED ON LOW SUCTION PRESSURE

This type of control system would include a pressure switch or transmitter connected to a tapping point on the suction side of the pumps which monitors reticulation system pressure. For example, where a general reduction in suction pressure occurs and a preset low pressure at the pump suction is reached, a signal is sent to the pump to start in order to provide system boost. Only after the inlet conditions to the station return to a preset level will the pump be signalled to stop.

5.11.4 PUMP OPERATION BASED ON LOW DELIVERY PRESSURE

This would be similar to 11.3 except that delivery pressure would be monitored and when it dropped to a preset level (eg due to low upstream pressure) the pump would operate. This would then boost the pressure. When the pressure reached a preset high value, indicating that normal (upstream) system pressure had been restored, the pump would stop.

5.11.5 PUMP OPERATION TO MAINTAIN A PRESET DELIVERY PRESSURE

This system would provide variable speed pressure control where a pressure transmitter connected to the delivery pipe monitors delivery system pressure and supplies a signal to the variable speed controller. This allows the controller to regulate the pump motor speed to maintain the set point delivery pressure. Should the pressure fall (indicating an increase in demand) then the motor speed will increase to maintain pressure and supply a greater flowrate. Conversely, should the pressure rise, generally indicating a reduction in demand, the pump would be signalled to progressively reduce speed.

For a variable speed drive operation with more than one pump (for example, triplex station) it is important that the second pump is called to operate only when the Duty 1 pump is operating near or at 100% (maximum) speed and the pressure is dropping. A pressure drop generally indicates that the duty pump is unable to satisfy demand. After calling Duty 2 pump into service, Duty 1 pump must maintain full speed regardless of the speed of the Duty 2 pump.

The Duty 2 pump should initially operate at a starting speed whereby total flow from the station is immediately increased. That is, time should not be wasted for the pump to come in at a low cut-in speed and progressively ramp up until it provides an increase in total flow.

Duty 2 pump will vary its speed in order to maintain the setpoint pressure. Duty 2 pump will eventually progressively reduce its speed to its cut-in speed once demand has reduced. After running for a preset period of time at minimum speed, Duty 2 pump will cut-out.

5.11.6 PUMP OPERATION TO FACILITATE SHUTDOWNS

It is sometimes necessary to isolate a section of the water supply system to undertake maintenance, such as scouring of reservoirs or repair of water main breaks. In these situations the pump station flow and head may change and the operation of pumps at fixed speed may not be acceptable due to resulting high pressures. The use of variable speed drives shall therefore be considered at all pumping stations to facilitate shutdowns.

For pumping stations where variable speed drives are not otherwise required (eg: to maintain a set pressure) undertake a NPV assessment to compare the additional cost for installation of variable speed drives against the additional operation, maintenance and risk cost should variable speed drives not be installed. Prepare the NPV assessment in consultation with Hunter Water, with consideration of costs of risks including:

- Temporary measures to maintain supply to customers (eg: rezoning, tankers) during reservoir scouring and maintenance;
- Loss of supply to customers should shut down of the pump station be required as a result of a water main break.

Provide variable speed drives to the pumps if the NPV analysis finds that this is the least NPV cost option.

It should be noted that in a shutdown scenario, adjustment of pump speed would be undertaken manually by the Corporation and therefore does not need to be regulated by the PLC program.

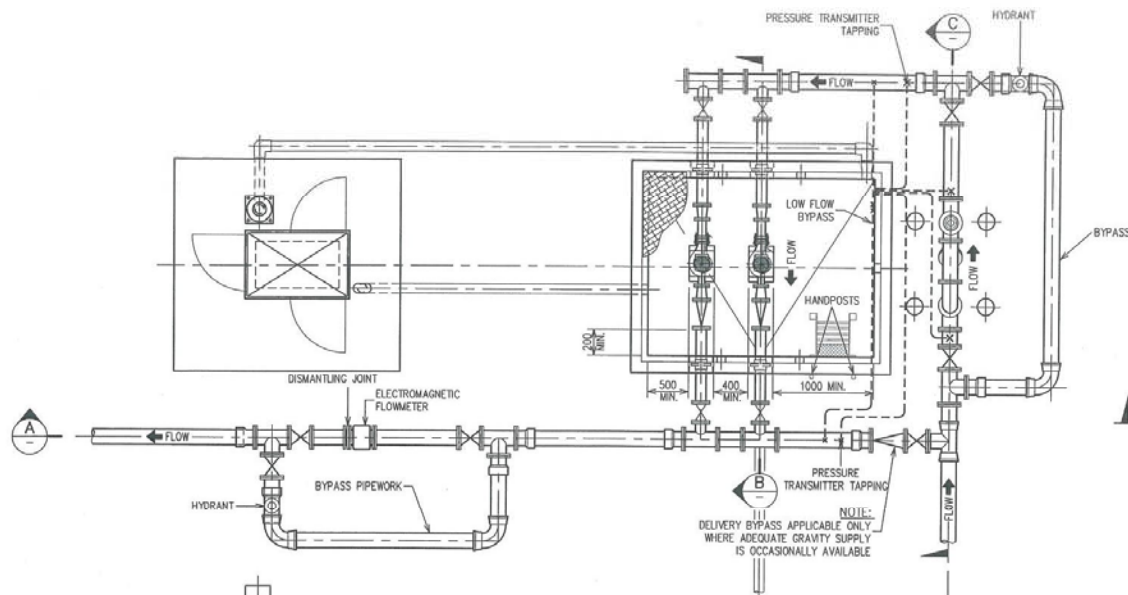
5.11.7 FIRE FLOWS

On occasions a dedicated pump may be required for fire flow demand rather than achieve fire flow capacity using the normal reticulation pump or pumps. Low pressure would generally be used as the trigger for pump operation.

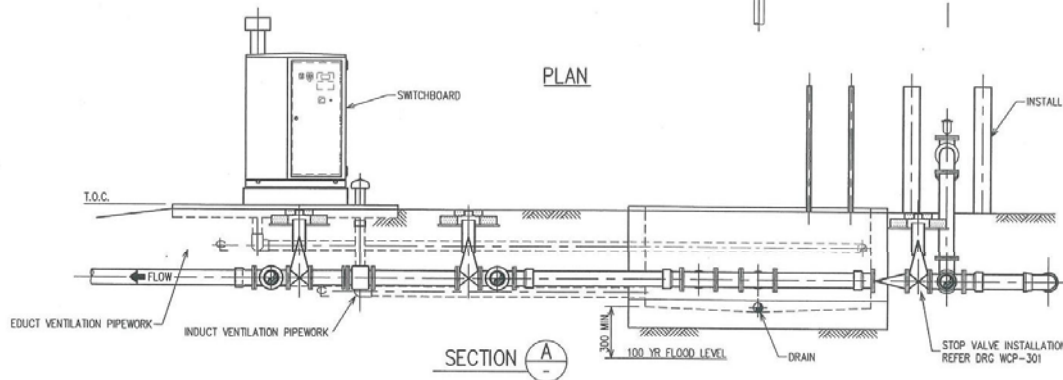
Any dedicated fire pump must be provided with a DOL starter. Electronic or variable speed drive starters are not permitted on dedicated fire pumps.

APPENDIX A

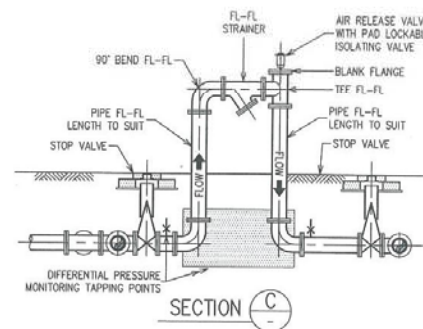
PIT TYPE WATER PUMPING STATIONS - TYPICAL ARRANGEMENTS



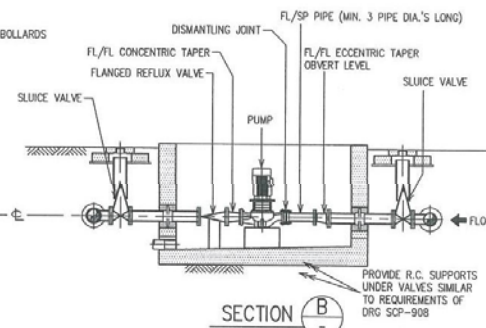
PLAN



SECTION A



SECTION C



SECTION B

- NOTE:
1. DRAWINGS ARE TYPICAL AND NOT TO BE USED FOR DESIGN PURPOSES - USE AS A GUIDE ONLY
 2. BYPASS PIPEWORK MAY NOT BE REQUIRED REFER GUIDELINES
 3. BYPASS PIPEWORK MAY BE SMALLER DIAMETER, REFER GUIDELINES
 4. EDUCT AND INDUCT VENTILATION REQUIRED FOR PUMPS SKW & ABOVE
 5. THRUST RESTRAINT NOT SHOWN

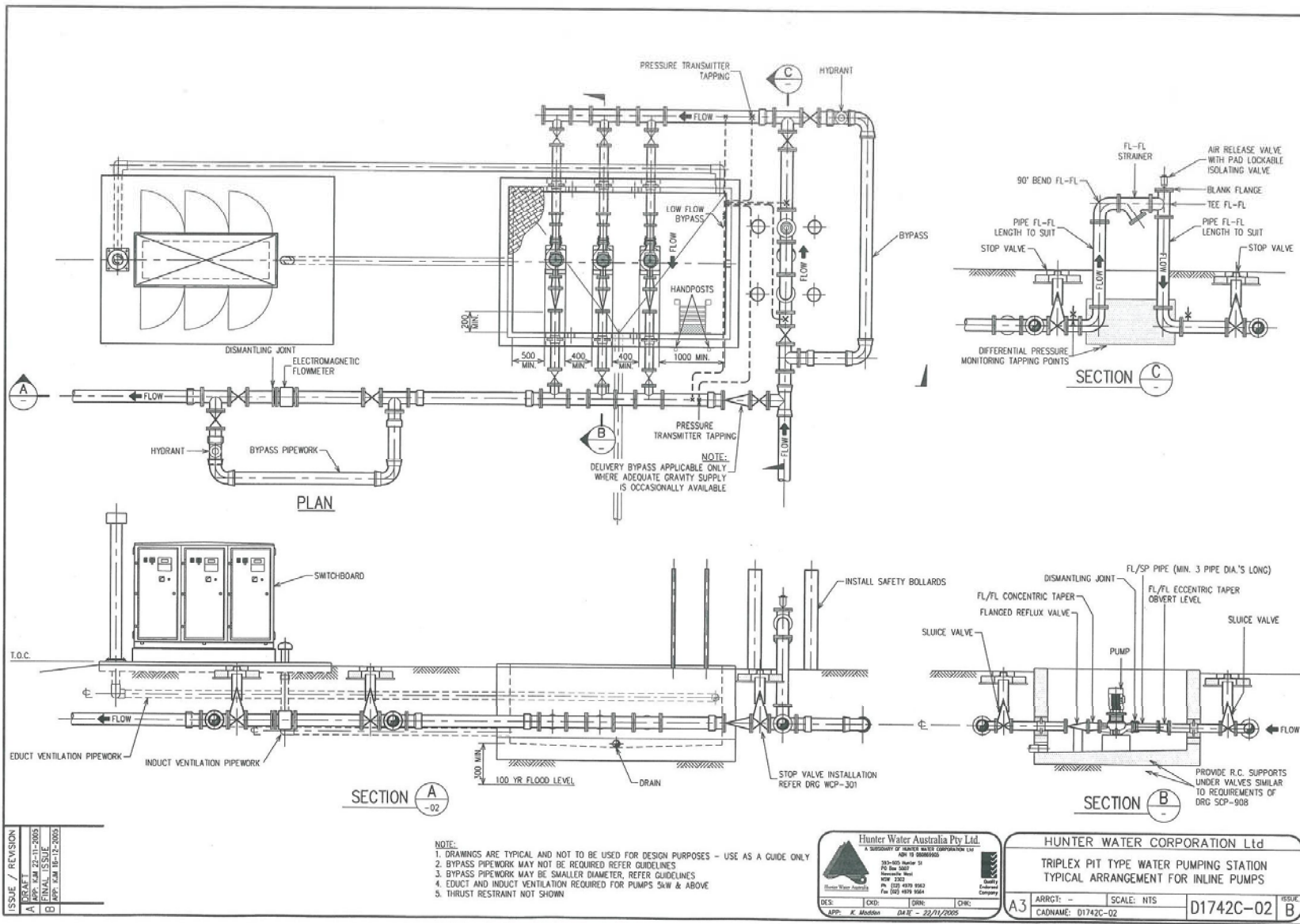


HUNTER WATER CORPORATION Ltd

DUPLEX PIT TYPE WATER PUMPING STATION
TYPICAL ARRANGEMENT FOR INLINE PUMPS

A3 ARRGT: - SCALE: NTS D1742C-01 ISSUE B
CADNAME: D1742C-01

ISSUE / REVISION	DATE
1. DRAFT	23/11/2005
2. APP. CAM	23/11/2005
3. CHECKED	23/11/2005
4. APP. CAM	23/11/2005



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 4. EDUCT AND INDUCT VENTILATION REQUIRED FOR PUMPS SW & ABOVE
 5. THRUST RESTRAINT NOT SHOWN

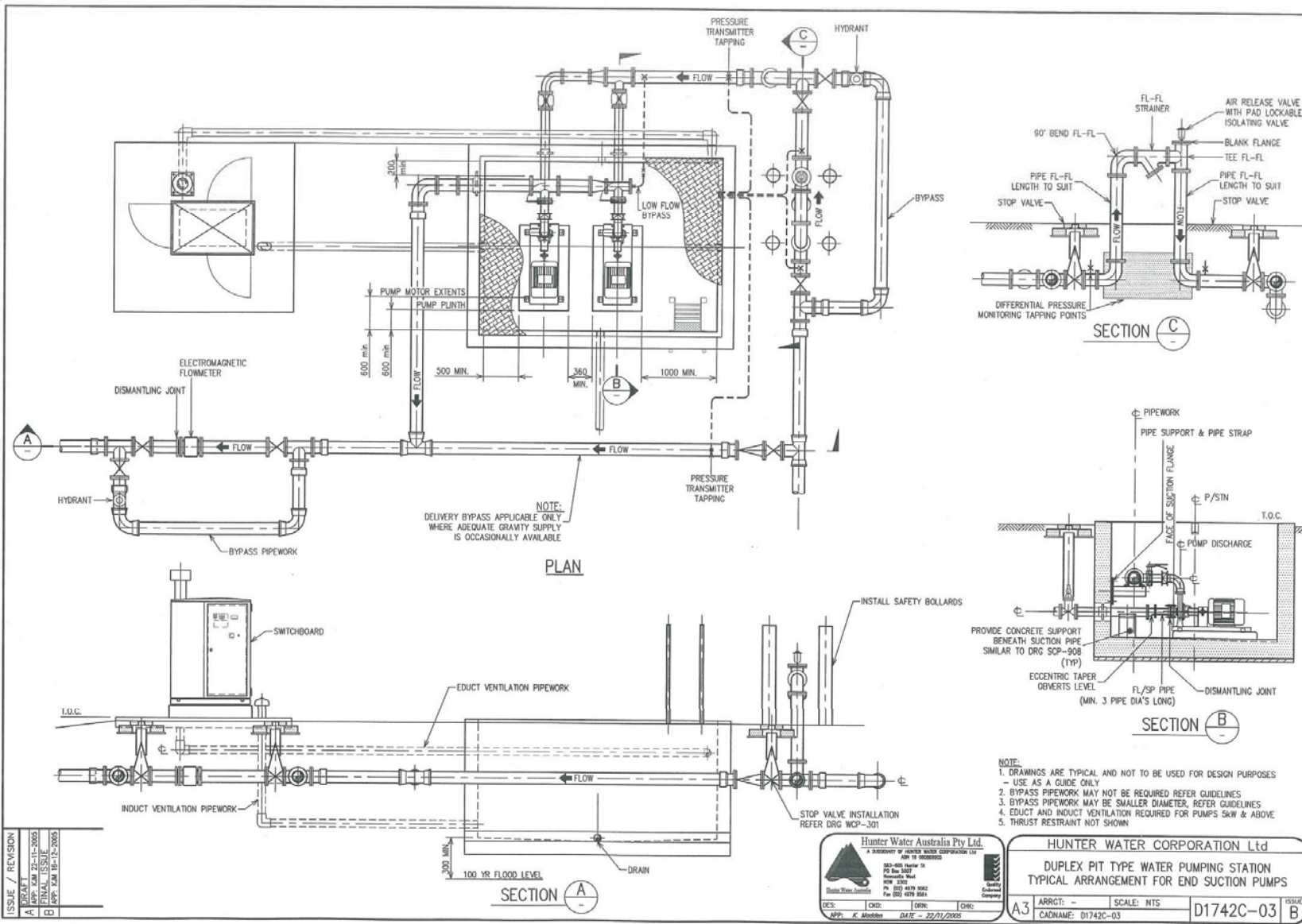
Hunter Water Australia Pty Ltd.
A SUBSIDIARY OF HUNTER WATER CORPORATION LTD
100-105 Hunter St
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Newcastle NSW 2300
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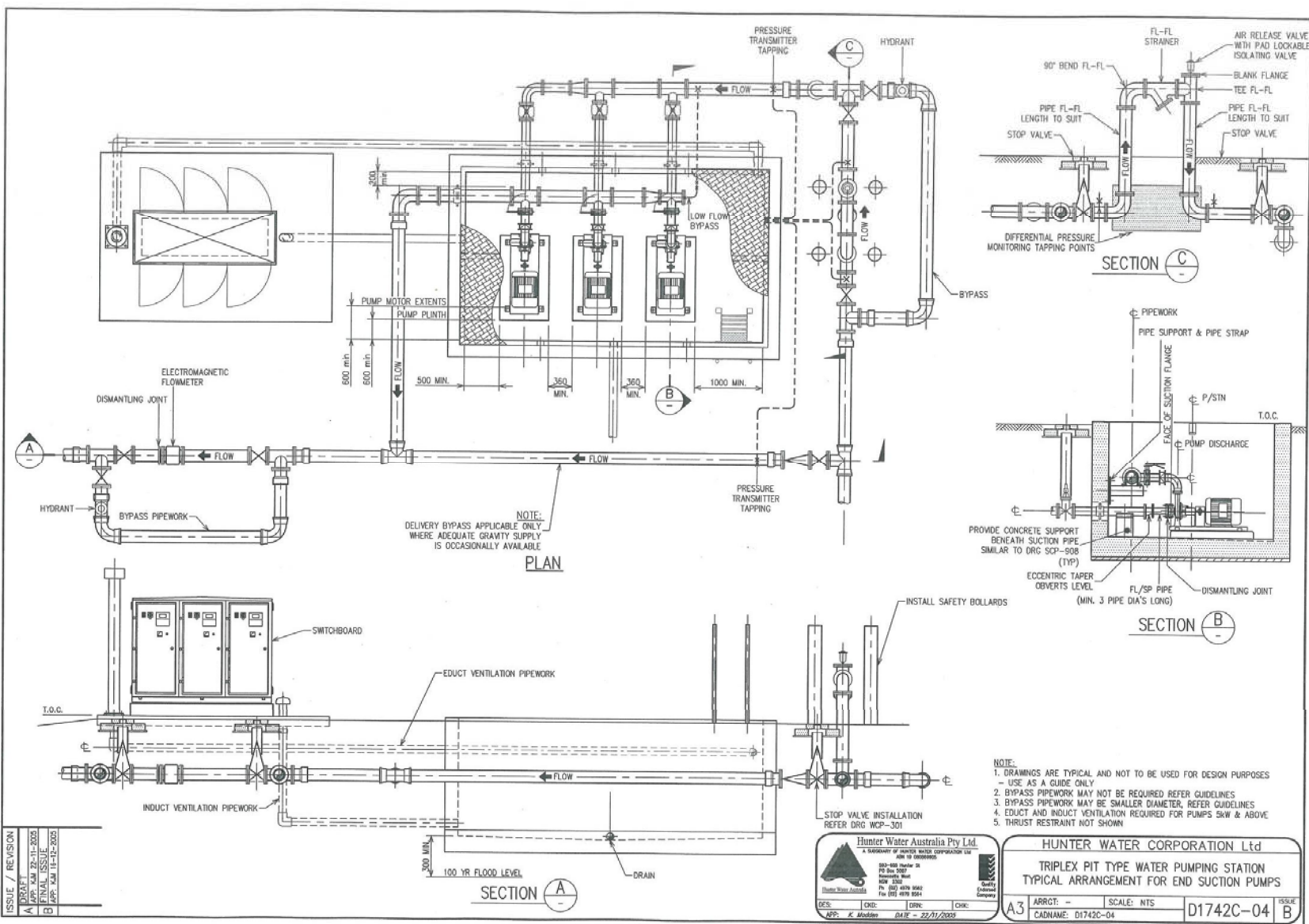
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APP: K. Middleton DATE: 22/11/2005

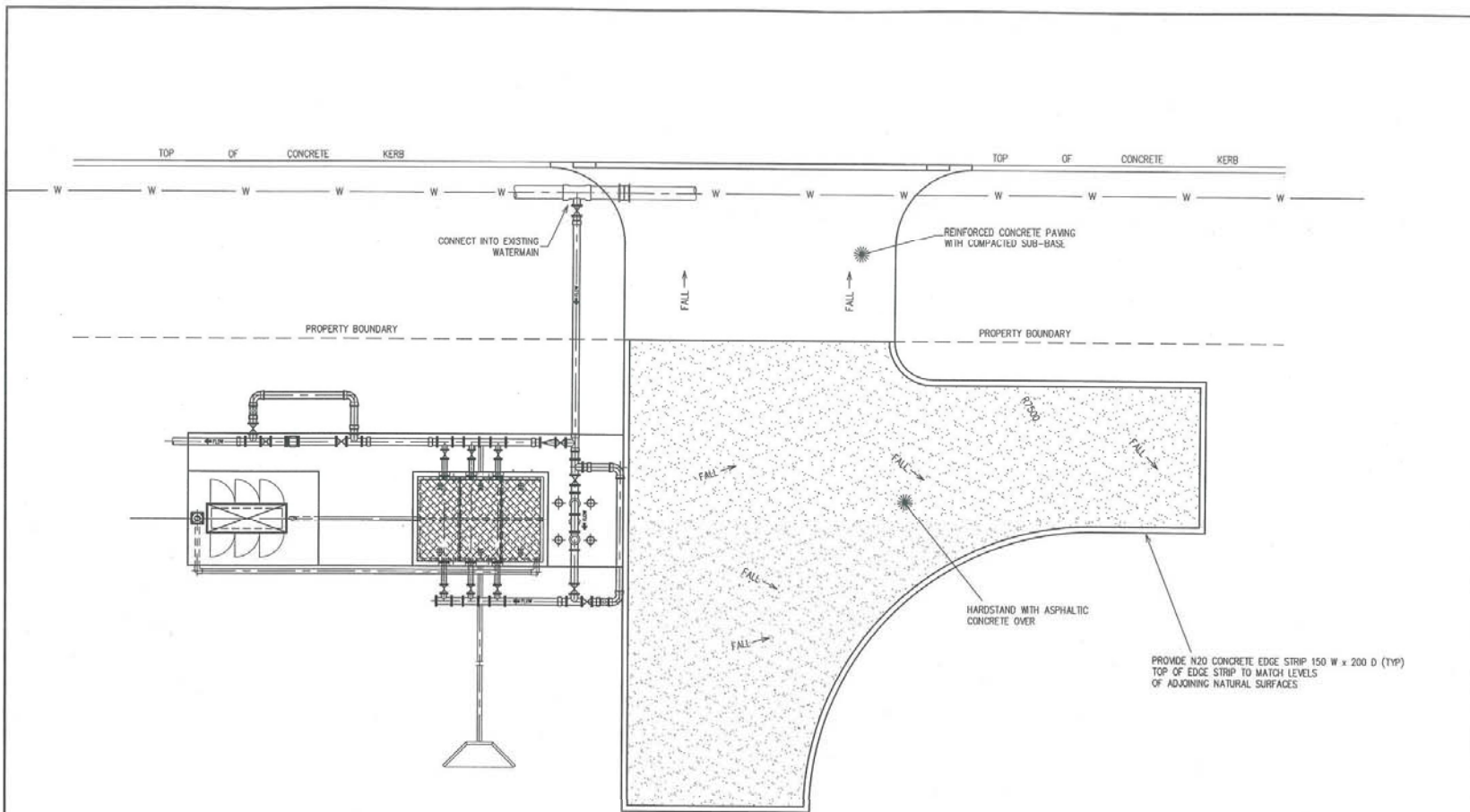
HUNTER WATER CORPORATION LTD

**TRIPLEX PIT TYPE WATER PUMPING STATION
TYPICAL ARRANGEMENT FOR INLINE PUMPS**

A3 ARRGT: - SCALE: NTS D1742C-02 ISSUE: B







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V	ISSUE
W	ISSUE
X	ISSUE
Y	ISSUE
Z	ISSUE

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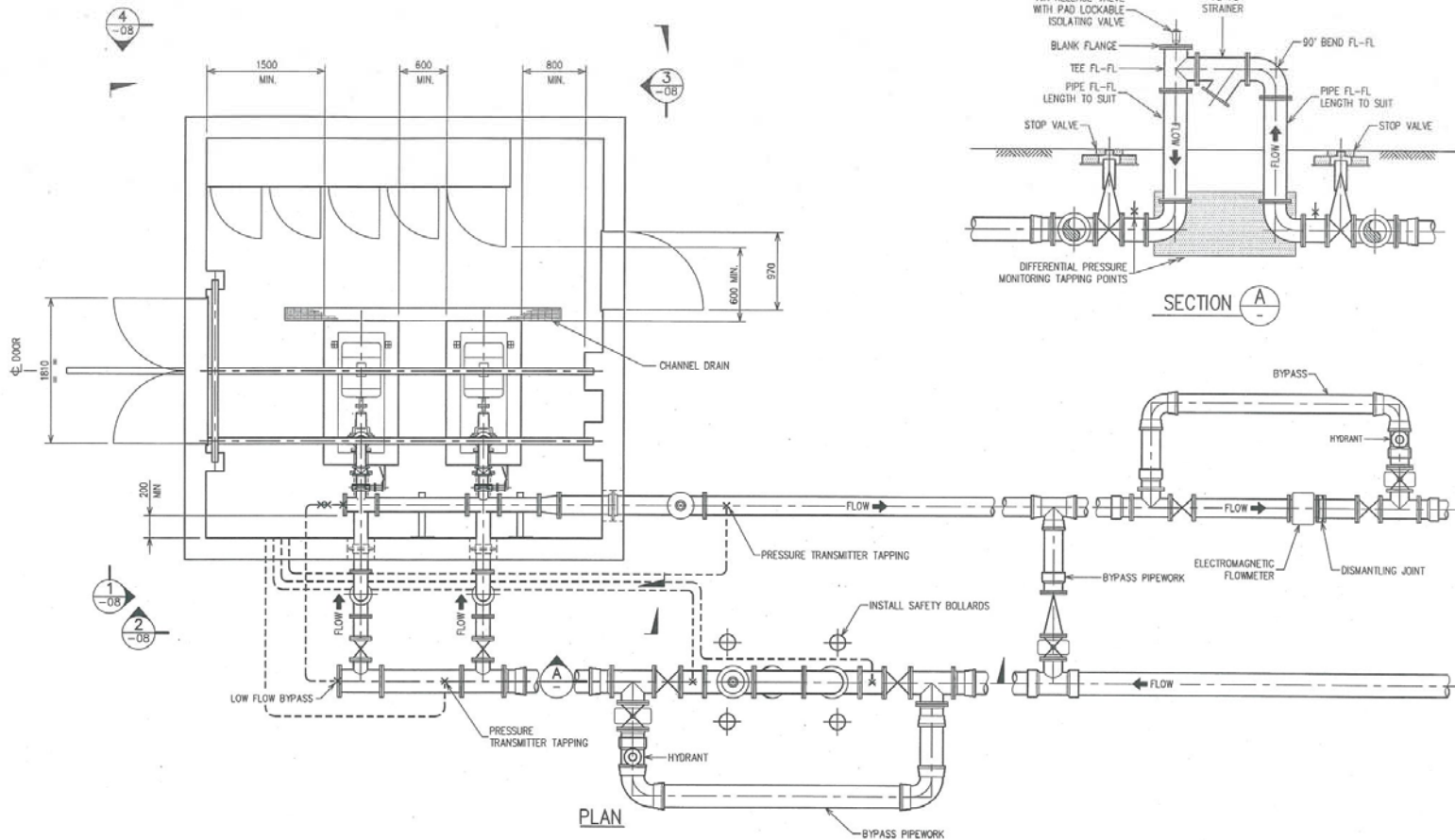
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 APP: K. Johnston 04/11/2008

HUNTER WATER CORPORATION LTD
PIT TYPE WATER PUMPING STATION
TYPICAL SITE LAYOUT

A3 ARROT: - SCALE: NTS D1742C-05
 CADNAME: D1742C-05

APPENDIX B

BUILDING TYPE PUMPING STATIONS - TYPICAL ARRANGEMENTS



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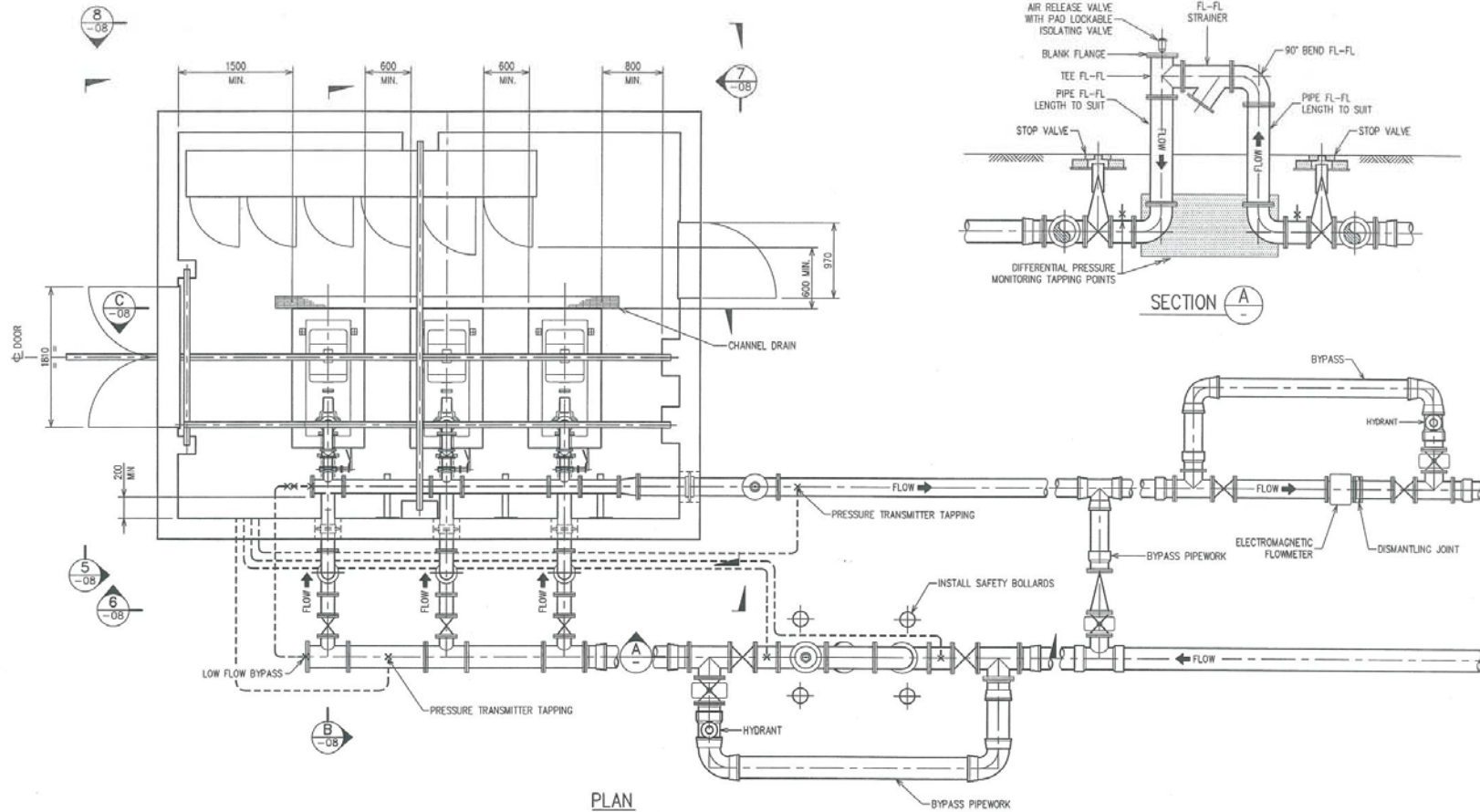
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 3. BYPASS PIPEWORK MAY BE SMALLER DIAMETER, REFER GUIDELINES
 4. THRUST RESTRAINT NOT SHOWN

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APP: K. Modder DATE: 22/11/2005

HUNTER WATER CORPORATION Ltd
 BUILDING TYPE WATER PUMPING STATION
 DUPLEX TYPICAL ARRANGEMENT

A3 ARROW: - SCALE: NTS
 CADNAME: D1742C-06 D1742C-06 B



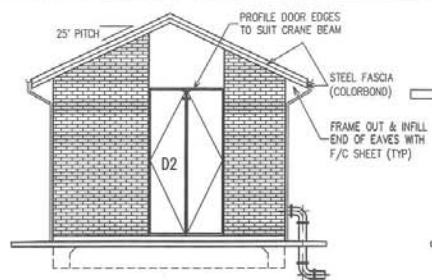
- NOTE:
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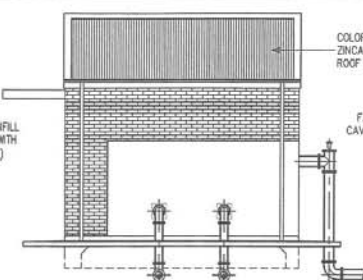
HUNTER WATER CORPORATION Ltd
 BUILDING TYPE WATER PUMPING STATION
 TRIPLEX TYPICAL ARRANGEMENT

A3 ARRGT: - SCALE: NTS
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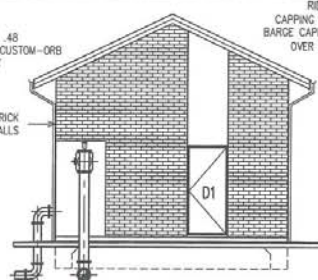
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 A DRAFT 23-11-2005
 B FINAL ISSUE 23-11-2005
 C APP. 10-12-2005



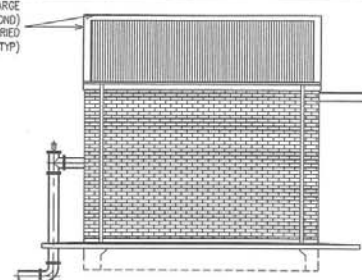
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ELEVATION 2
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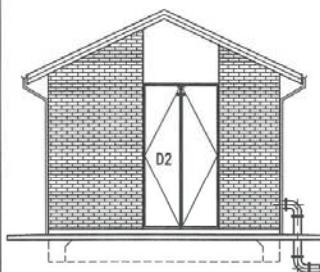


ELEVATION 3
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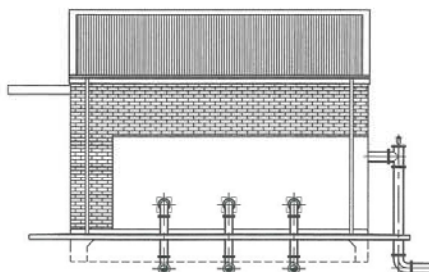


ELEVATION 4
-06

DUPLIX PUMPING STATION



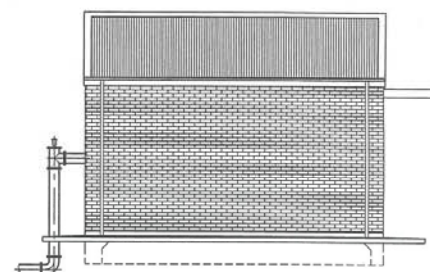
ELEVATION 5
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ELEVATION 6
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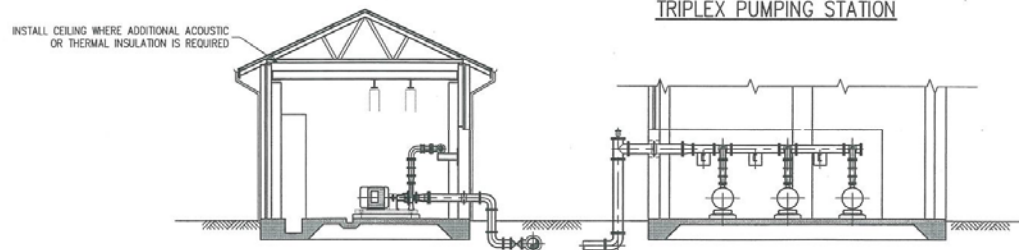


ELEVATION 7
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ELEVATION 8
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TRIPLEX PUMPING STATION



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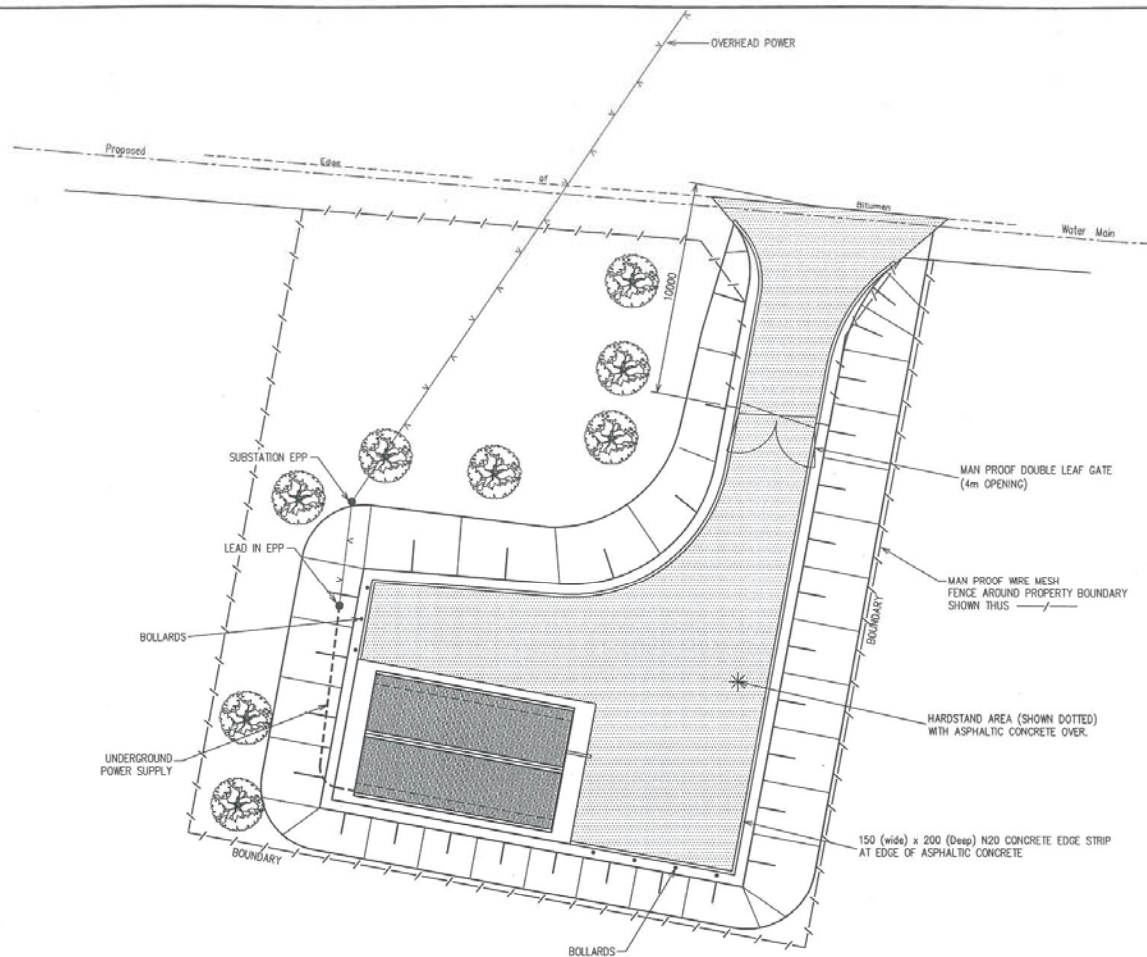
TYPICAL PUMPING STATION SECTIONS

NOTE:
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HUNTER WATER CORPORATION Ltd			
BUILDING TYPE WATER PUMPING STATION			
DUPLIX & TRIPLEX ELEVATIONS & TYPICAL SECTIONS			
APP: K. Madden	CHK: J. Smith	DATE: 22/11/2005	SCALE: NTS
A3	ARROT: -	CADNAME: D1742C-08	D1742C-08

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DES: TTT | ORG: TTT | CHK: DCK | CHK: TTT
 APP: K. Madden | DATE: 22/01/2009

HUNTER WATER CORPORATION Ltd
 BUILDING TYPE WATER PUMPING STATION
 TYPICAL SITE PLAN LAYOUT

A3 | ARRGT: - | SCALE: N.T.S. | ISSUE: B
 CADNAME: D1742C-09 | D1742C-09

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Z	22/01/2009

APPENDIX C

EXAMPLE OF NET PRESENT VALUE (NPV) CALCULATION

EXAMPLE OF PRESENT VALUE ANALYSIS

Factors considered are:

- (a) Building type pumping station structure costs and life
- (b) Pumping machinery (including switchgear and ancillary items) life, replacement and maintenance costs.
- (c) Pump running costs over the life of the station.

DATA

Base Year 2000

Pumping rate 45L/s

Total Head 36 m

Pumping Station Structure Sized to ultimate flows and pumps.
including pipework 100 years economic life. Cost \$200,000.

Pump duty 45 L/s @ 36m, fixed speed pumps with 30 kW motors, small duplex
pumping station

40 years economic life. Cost \$30,000

Pump efficiency 65%

Switchboard 30 years economic life. Cost \$40,000

Telemetry 15 years economic life. Cost \$5,000

Maintenance costs

Pumping station and pumps Cost \$6,000 pa. (Station Maintenance \$2,000 pa; each
pump \$2,000)

Average daily pumping hours 10 hrs

Power cost refer to Appendix 1A of the Design Manual Section 1

CALCULATIONS

Determine annual pumping costs from:

$$\$/\text{year} = \frac{0.0098 \times Q \times H \times c \times t}{\text{eff}}$$

Where

Q	=	pumping rate (L/s)
H	=	total pumping head (m)
c	=	cost of electricity kWh (\$) (refer Appendix 1A)
t	=	duration of pumping per year (hrs.)
eff	=	pump efficiency

$$\begin{aligned}
 H &= \text{Friction losses at 45 L/s} + \text{Static head} \\
 &= 21 + 15 \\
 &= 36 \text{ m} \\
 \text{Annual pumping cost} &= \frac{0.0098 \times 45 \times 36 \times 0.1245 \times 10 \times 365}{0.65} \\
 &= \$11,099 \text{ pa.}
 \end{aligned}$$

DETERMINE PRESENT VALUE

(i) Running Costs

The Present Value Factor (PVF) of \$1 per annum for n years at discount rate r per annum is calculated from the formula:

$$\text{PVF} = \frac{1 - (1 + r)^{-n}}{r}$$

$$\begin{aligned}
 \text{Running Costs 2000 - 2099} &= \frac{\$11,099 \times [1 - (1 + 0.07)^{-100}]}{0.07} \\
 &= \$158,375
 \end{aligned}$$

(ii) Maintenance Costs

$$\begin{aligned}
 \text{Maintenance Costs 2000 - 2099} &= \frac{\$6,000 \times [1 - (1 + 0.07)^{-100}]}{0.07} \\
 &= \$85,616
 \end{aligned}$$

(iii) Replacement Costs

The present value (PV) of \$1, n years hence, which is discounted at discount rate r per annum is calculated from the formula:

$$\text{PV} = \frac{1}{(1 + r)^n}$$

$$\begin{aligned}
 \text{Present value of pump} \\
 \text{replacement 2000-2099} &= \$30,000 \times [(1 + 0.07)^{-40} + (1 + 0.07)^{-80}] \\
 &= \$2,137
 \end{aligned}$$

$$\begin{aligned}
 \text{Present value of switchboard} \\
 \text{replacement 2000-2099} &= \$40,000 \times [(1 + 0.07)^{-30} + (1 + 0.07)^{-60} + (1 + 0.07)^{-90}] \\
 &= \$6,036
 \end{aligned}$$

$$\begin{aligned}
 \text{Present value of telemetry} \\
 \text{replacement 2000-2099} &= \$5,000 \times [(1 + 0.07)^{-15} + (1 + 0.07)^{-30} + (1 + 0.07)^{-45} \\
 &\quad + (1 + 0.07)^{-60} + (1 + 0.07)^{-75} + (1 + 0.07)^{-90}] \\
 &= \$2,836
 \end{aligned}$$

Item	Cost \$	Calculation of Present Value	Present Value \$		
			Capital	Running	Replacement
Pumping Station					
Civil Costs					
100 years life	200,000		200,000		
Pumps			30,000		
Switchboard			40,000		
Telemetry			5,000		
Running Costs	11,099pa	@ 7% over 100 years		158,375	
2000-2099					
Maintenance Costs	6,000pa	@ 7% over 100 years		85,616	
2000-2099					
Ultimate Pumps 30 years life	30,000	discounted @ 7% over 100 years			2,137
Ultimate Switchboard 30 years life	40,000	discounted @ 7% over 100 years			6,036
Ultimate Telemetry 15 years life	5,000	discounted @ 7% over 100 years			2,836
			275,000	243,991	11,009

TOTAL PRESENT VALUE = \$530,000

NOTES:

1. Present value analysis is to allow different efficiencies for each pump considered.
2. Hours of pump operation is to be calculated based on daily demand.
3. Present value analysis is to allow for variation in pump duty with variable speed operation.
4. Currently Hunter Water adopts an discount rate (r) of 7 % for present value analysis. The analysis should also be carried out for discount rates of 4 % and 10 % in order to determine the effect of variations in the adopted rate.
5. Power cost may increase with each year. Refer Appendix 1A.