MACMAHON

Darwin City Waterfront Project
Community Infrastructure

Lagoon Flushing System

Operations and Maintenance Manual

December 2008

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Section 1.

Design Philosophy

Section 2.

System Description

2.0 System description

With the construction of the breakwater, the lagoon and marina will form a closed body of water with a relatively constant water level. This body of water varies in depth from zero at the edges to up to14 m deep near the toe of the breakwater. To ensure that the water quality within the lagoon is maintained at an adequate standard, it is necessary to flush it with ocean water.

The water level of the lagoon is kept at about 3.0 m AHD which is too high to rely on tidal flushing to maintain the water quality at the desired level. Therefore the flushing system has been designed to be a solely pumped system without any reliance on tidal effects.

ITT Flygt Limited or their approved subcontractor must be used for repair & maintenance on the pumps, control equipment& stinger screens for warranties to be valid. See warranty for details. ITT Flygt Limited are located at 3 Anictomatis Road, PO Box 447 Berrimah NT 0828. Phone 08 8947 8300 or 131914. Fax 08 8947 2088.

2.1 Pumps & associated equipment

The intake pump station is mounted off Stokes Hill Wharf, adjacent to the Police Jetty (refer Drawing JE02.03-CO-001).

The pump station consists of three submersible pumps mounted on rails, braced to new piles adjacent the wharf. A permanent working platform is mounted above the structure to allow retrieval of the pumps for maintenance (refer Drawings JE02.03-CO-006 and 007).

2.2 Delivery pipe system

Due to the shape of the lagoon, several circulation cells will have to be working together to ensure complete flushing of the water body. Thus it is not possible to have only one pumping delivery point into the lagoon to achieve complete flushing of the lagoon. Three delivery points are used, one near the southern end of the DCEC, one by the swimming pool and the third by the beach section ((refer Drawing JE02.03-CO-001). All three delivery points are on the floor of the lagoon which helps in the mixing of the deeper water.

Although the delivery pipes are flexible enough for these delivery points to be moved, changes to their positions may not be undertaken without first remodelling the system to ensure that the water quality will not be compromised. The current positions have been determined as the optimal positions based on previous modelling, to achieve secondary contact water quality.

Due to the fact that the pipes are passing marine water it can be expected that some marine growth may build up on the walls of the pipes if not maintained. For this reason the pipe system will need to be cleaned on a regular basis.

Consideration was given to chlorine dosing of the line to reduce marine growth, but aside from the problems associated with the chemical dosing itself, it is believed to be inefficient in these sorts of lines unless undertaken at very high doses. This would then lead to environmental problems and hence the option was not pursued further. Instead, provision has been made to clean the line with pigs. Pigging points have been incorporated at the start of the delivery pipes to enable this to be undertaken(refer Drawing JE02.03-CO-007). It is envisaged that pigging would be undertaken using a portable high pressure pump drawing water directly from the lagoon.

Allowance for the delivery pipe to be closed at both ends has been incorporated should future users decide to undertake some form of chemical dosing.

2.3 Outlet structure

The outlet structure from the marina back to the sea, consists of a HDPE outlet pipe through the breakwater from a weir inlet on the marina side to a headwall on the seaward side. The weir acts as a control for the water level in the lagoon. This level is set such that when the flushing system is operating at the desired flow rate the water level in the lagoon will be at its design level, namely +3.0 m AHD. Based on the flows derived above, the level of the weir of the outlet would be at +2.87 m AHD. The weir level can be adjusted, to account for settlement or changes in operation, by installing stop logs on the crest.

The weir inlet to this structure is covered with a safety grille to prevent people accidentally falling into the pit. As such the grille bar spacing has been kept wide to allow minor debris to pass through and not interfere with the operation of the system. The grille has also been angled up at 30 degrees to reduce the chance of debris blocking the grille during operation (refer Drawing JE02.03-CO-004). The structure of the grille has been designed to allow easy raking of debris up on to a maintenance platform. Calculations were undertaken to check what would happen if the grille openings became progressively blocked. Prior to flooding the system, the water level followers would switch off the pumps preventing inundation of the public domain.

The seaward end of the outlet pipe incorporates a "Tideflex" non-return valve to prevent water flowing back into the lagoon during very high tides. Tideflex valves require minimal maintenance due to their elastomer construction. Routine inspections will be required to check the valves.

Marine growth may build up on the walls of the pipe with time. This will need to be cleaned regularly to keep the system operating efficiently. It is envisaged that this cleaning will be undertaken from the downstream end by pulling a pig through.

Section 3

Operation

3.1 Water levels

The system is designed to maintain the level of the water in the lagoon at about +3.0 m AHD under normal conditions. Actual levels will vary across the lagoon due to the required hydraulic grade to drain the lagoon through the outlet and wind / wave set-up.

The water level can be altered by adjusting the height of the weir sill at the outlet. Provision has been made for the inclusion of stop logs on the sill to take up the expected settlement of the breakwater structure which could be as much as 150 mm. At construction the weir sill was set at 2.87 m AHD.

If pumping (inflow to the lagoon) ceases, the level of the lagoon will drop relatively rapidly (approximately 24 hours) to that of the level of the weir sill on the outlet structure. Thereafter the water level will continue to drop more slowly as losses continue through seepage and evaporation.

Rainfall falling directly onto the lagoon and flowing into the lagoon from the building roofs will have negligible effect on the lagoon water level.

During major storms, wave overtopping of the breakwater will cause the lagoon to fill above the design water level. In a cyclonic event, this may fill up to the top of the breakwater wave wall, approximately 5.70 m AHD. After such an event, it will take up to approximately 40 hours to drain the lagoon back to the normal water level. This time period is on top of any time that the subsequent tides are high enough to restrict or cease drainage from the lagoon.

3.2 Pumping

The pumps are designed to pump water into the lagoon continuously (whilst tidal levels allow water inside the lagoon to flow out of the outlet structure). When the external tide exceeds a level of 2.5 m AHD, the flow out of the outlet starts to be throttled and ceases altogether when this level reaches 3.0 m AHD. A sensor in the sea will turn the pumps off when the tide exceeds +2.7 m AHD. A back up sensor in the lagoon will also turn the pumps off when the water level exceeds +3.0 m AHD.

When the receding tide drops below +2.5 m AHD and the level in the lagoon is below +3.0 m AHD, the pumps turn back on again. This sequence will allow the pumps to run on average 90% of the time.

Note the pumps incorporate non-return valves to prevent syphoning of the lagoon if the pumps are switched off when the tide is low.

3.3 Water Quality

The pumping regime will turnover on average 20 % of the total volume of the boating side of the lagoon. This is designed to prevent stratification in the lagoon and to maintain the water quality at a level suitable for secondary contact. Note that as it relies on using water from Darwin Harbour for flushing, the requirements for secondary contact water quality may be compromised at times due to events such as:

- Sediment plumes in the harbour particularly during the wet season.

- Spills (oil or chemical) in the harbour.
- Invasive marine species invasions.
- Blue-green algal blooms.

The flushing system draws water directly from the sea and therefore does not reduce the risk of stingers (box jellyfish) entering the lagoon, in either adult or juvenile form. Similarly the future lock will also allow marine life to enter the lagoon. Therefore, use of the lagoon may have to be limited during their active season, approximately October to May.

Similarly the lagoon cannot be guaranteed to be free from crocodiles (although this is unlikely) and once the lock is operational, there is always the risk that stray sharks may enter the waters. Thus the recreational lagoon will carry a similar risk to using the open sea for similar activities with regard to these issues.

Section 4.

Maintenance

4.1 Water Quality

Test frequency – Monthly
Testing to be undertaken by a certified laboratory and sampling undertaken by qualified personnel.

Water quality is to meet ANZECC guidelines for secondary contact, in particular:

Microbiological characteristics:
The median bacterial content shall not exceed:

- 1000 faecal coliform organisms per 100 mL (minimum of five samples taken at regular intervals not exceeding one month, with four out of five samples containing less than 4000 organisms per 100 mL).
- 230 enterococci organisms per 100 mL (maximum number in any one sample 450 to 700 organisms per 100 mL).

Nuisance organisms:

- Macrophytes, phytoplankton scums, filamentous algal mats, blue-green algae, sewage fungus and leeches should not be present in excessive amounts.

Visual clarity and colour:

- The natural visual clarity should not be reduced by more than 20% of the incoming water from the Harbour.
- The natural hue of the water should not be changed by more than 10 points on the Munsell Scale from that of the incoming water from the Harbour.
- The natural reflectance of the water should not be changed by more then 50% from that of the incoming water from the Harbour.

pH:

- The pH of the water shall be within the range 7.0 to 8.5.

Toxic Chemicals:

- Toxic chemicals should not exceed concentrations provided in Tables 5.2.3 and 5.2.4 of the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC 2000)

Nutrients:
The following levels of nutrients shall not be exceeded to ensure that nuisance organisms are not encouraged and natural fauna and flora are not unduly stressed:

Nutrient	Symbol	Limit	
Chlorophyll-a	Chl a	5	µg/L
Total phosphorus	TP	30	µg P /L
Filterable reactive phosphate	FRP	15	µg P /L
Total nitrogen	TN	300	µg N /L
Oxides of nitrogen	NO_x	15	µg N /L
Ammonium	NH_4^+	15	µg N /L
Dissolved oxygen	DO	80 to 110	% saturation

Surface films:

- Oil and petrochemicals shall not be noticeable as a visible film on the water nor should they be detectable by odour.

4.2 Inlet Pipes

The pipes from the pumps to the outlets in the lagoon are to be pigged to remove marine fauna growth. The pig shall be sized to fit the 380mm ID of the pipes. As the pumps are fitted with non-return valves, it is not necessary to remove or isolate the pumps during the pigging operation.
Frequency – Every six months

Method:

- Switch off flushing pumps and lock out.
- Remove covers from the delivery points of the pipes 2 and 3 in the lagoon. (Pipe 1 has no cover).
- Close the air release valve isolating sluice valves on the breakwater (refer Drawing JE02.03-CO-003). Failure to close these during the pigging operation will result in damage to the air valves.

For each pipe in turn:

- At the pump station, check air release valve isolating sluice valve on top of pig entry pipe is open and pressure in the pig entry pipe is stable (no sound of air exiting or entering the air release valve).
- Remove air valve, leaving sluice valve.
- Remove flange from the top of the pig entry pipe.
- Place pig into pig entry pipe and replace flange.
- Connect portable high pressure pump to sluice valve.
- Pressurise the system to push the pig along the pipe. Note time of start of pressurisation.
- Monitor the pressure being applied at all times. Do not exceed a maximum pressure of 1.0 MPa at any time.
- Visually monitor the amount of debris being expelled at the pipe delivery points.
- When pig exits from end of pipe, note time and determine speed of travel of the pig.
- Remove high pressure pump and re-connect air valve.
- Repeat process for other two pipes.

After pigging:

- Replace covers over delivery points for pipes 2 and 3.
- Open the air release valve isolating sluice valves on the breakwater. Failure to open these during normal flushing operation will allow air to build up in the pipes, reducing flow capacity and ultimately lifting the pipes damaging the breakwater.
- Check the air release valve isolating sluice valves on the pig inlet pipes are open.
- Re-start pumps.
- Check sealing on flanges on the pigging points.

4.3 Outlet Structure

Debris on the grille:
The grille must be kept clean at all times.

- At least once a week (period to be re-addressed subject to volume of debris encountered) rake debris off grille onto the concrete platform.
- Immediately bag and remove debris (note debris may contain "sharps" and must be handled with extreme caution).

Debris in the tideflex valve:
The tideflex valve must be kept clear of debris at all times.

- At least once a week and after storm events inspect the tideflex valve at low tide.
- Immediately remove any debris caught in the valve (note debris may contain "sharps" and must be handled with extreme caution).

Outlet pit and pipe:
Every six months clean the pit and outlet pipe. (Note the rate of marine fauna growth in this pipe is unknown and the frequency of cleaning the pipe will need to be re-assessed based on the findings of the initial cleans).

- Switch off flushing pumps and lock out.
- Wait for the water level in the lagoon to drop below the level of the inlet weir.
- Remove the grille from the pit.
- Observe all OH&S requirements for working at heights, working adjacent deep trenches and working in confined spaces.
- Remove sediment and debris from base of pit.
- Remove tideflex valve from downstream end.
- Check valve for damage or signs of wear.
- Clean the inside of the outlet pipe by manually pulling a pig through the pipe. (Note scrapping the pipe is not recommended due to potential damage to the pipe).
- Inspect the joint in the centre of the pipe for signs of leakage (sediment intrusion). Report and such evidence immediately.
- Replace tideflex valve.
- Replace grilles.
- Re-start pumps.

4.4 Drainage of the Lagoon

The lagoon is not designed to be drained once it is filled. Should this be required to be undertaken in the future it will be necessary to provide portable pumps as no infrastructure is provided for this purpose.

4.5 Flushing System Pumps

Refer to folder 2 – Lagoon Flushing System Darwin City Waterfront - Flygt

4.6 Lagoon Flushing System – Statement of Maintenance Requirements – ITT Flygt

Statement of Maintenance Requirements is located on next page.

DCWF Project
Lagoon Flushing System
Statement of Maintenance Requirements

ITT Water and Wastewater
Australia Limited
ACN. 000 832 922

3 Anictomatis Road
Berrimah NT 0828
PO Box 447
Berrimah NT 0828 Australia
Tel: +61 8 8947 8300
Mobile: 0400 372 216
Fax: +61 8 8947 2088
Email: duncan.price@itt.com

9 January 2009

The purpose of this document is to explain the maintenance requirements of the Lagoon Flushing System pumps and control equipment that form part of the Lagoon flushing System at the DCWF project, to ensure that extended warranty period requirements are met and system performance is maintained within its design parameters. This document is intended to form part of the operation and maintenance documentation.

Inspection and servicing of the pump units and switchboard shall be as per the ITT Flygt Installation Care and Maintenance Manual for model 3202 pump, in particular page 22 (please refer to attached ICM manual), with the following additions:

- Intermediate service intervals will be 6 monthly
- Care will be taken to inspect the external special coatings for any sign of damage or corrosion
- Excessive marine growth will be removed by shot blasting and special coatings reinstated where necessary
- Stinger screens will be cleaned by high pressure blasting or other means if necessary to ensure the apertures are free from obstruction
- The rising main air release valve and pressure gage will be inspected for serviceability

Notes:

- The pump controller is equipped with a GSM modem to alert designated personnel via SMS of any failures with pump or control equipment; ITT W&WW recommend that this function is utalised by the operator.
- All service and repair work is undertaken by a workshop and personnel authorised by ITT W&WW (please refer to the Statement of Warranty & Conditions document).

Regards,

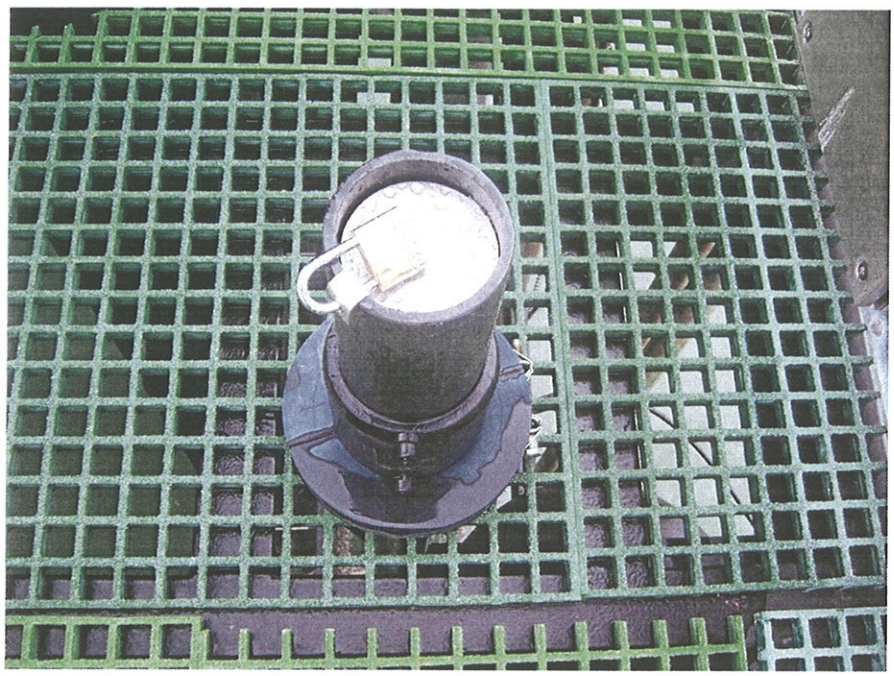
Duncan Price
Branch Manager
ITT Water and Wastewater Australia Limited

4.7 Vandal Proof Measures

There are 2 forms of vandal proof measures incorporated into the flushing system. These are the locking nuts on the air valves and the lockable cap on the distilling tube. The locking nuts are located on the handle of the air valve as shown in the drawing below. Ensure these are tight and have not been removed.



The distilling tube lockable cap has a pad lock. The lock will need to be lubricated quarterly to ensure it does not get ceased shut in the salt air. This cap and lock is shown in the below photo.



Section 5

Emergency Actions

Chemical spills:
Pumps to be stopped manually if water quality in the harbour is compromised. Currently the Darwin Port Corporation monitor spills in the Harbour.

- The operator is to approach the DPC to arrange for immediate notification of such events.
- The operator is responsible to manually turn off the pumps when alerted to a spill. To do this all 3 pump switches in the control cabinet need to be turned to the off position. Section 7 includes a photo of the control cabinet and switches and their location.
- After the pumps have been shut down, the extent and effect of the spill are to be evaluated.
- Pumps to be restarted as soon as DPC consider the spill is safely contained or suitably diluted and the operator can determine that any remaining pollutant will not be a problem for the lagoon.

Section 6

Warranty

DCWF Project
Lagoon Flushing System
Statement of Warranty & Conditions

ITT Water and Wastewater Australia Limited
ACN. 000 832 922

3 Anictomatis Road
Berrimah NT 0828
PO Box 447
Berrimah NT 0828 Australia
Tel: +61 8 8947 8300
Mobile: 0400 372 216
Fax: +61 8 8947 2088
Email: duncan.price@itt.com

9 January 2009

The purpose of this document is to explain the limitations and conditions of the 10 year extended warranty period covering the pump and control equipment that forms part of the Lagoon flushing System at the DCWF project and is intended to form part of the operation and maintenance documentation.

The extended warranty period was supplied as a condition of the contract for the supply of the pumping and control equipment between ITT W&WW and Macmahon Contractors for an additional up front fee that was collected at the time of supply of the equipment. This warranty extension is valid for use by the end-user once the equipment is handed over by Macmahon Contracting.

In addition to the standard ITT W&WW warranty document (please find attached) the following conditions apply:

ITT W&WW undertakes to remedy faults in products sold by ITT W&WW provided that:

- The fault is due to defects in design, materials or workmanship;
- The fault is reported to ITT W&WW or ITT W&WW representative during the guarantee period;
- The product is used only under conditions described in the care and maintenance instructions and in applications for which it is intended;
- The monitoring equipment incorporated in the product is correctly connected;
- All service and repair work is done by a workshop & personnel authorized by ITT W&WW.
- Genuine Flygt parts are used
- Storage should be in accordance with the care and maintenance manual.
- The equipment is installed and commissioned in accordance with the manufacturer's recommendations as outlined in the Installation, Operation and Maintenance Manual
- The equipment is operated and maintained in accordance with the Operation and Maintenance Manual.

In addition to the above as per ITT Flygt's Installation Care & Maintenance manual page 22 Service / Inspection clause (see attached manual) all equipment should be subject to half yearly inspection, by ITT Flygt authorised personnel, to inspect the pumps and coatings. Any cost associated with this including repainting will be to client account.

Failure to comply with these requirements will render warranty void unless, due to the nature of the warranty claim, such voiding of warranty is prevented by law, regulation, act and / or ordinance.

Hence, the guarantee does not cover faults caused by deficient maintenance, improper installation, incorrectly executed repair work or normal wear and tear.
Flygt assumes no liability for bodily injuries, material damages, consequential or economic losses beyond what is stated above.

Regards,

Duncan Price
Branch Manager
ITT Water and Wastewater Australia Limited

ITT | Flygt

FLYGT

Statement of Warranty for ITT WWW Limited

The warranties provided by ITT WWW Limited in Australia in this Statement of Limited Warranty apply only to Equipment originally purchased for your use, and not for resale, from ITT WWW.
The term "Equipment" means any parts manufactured by ITT WWW or other manufacturers (as per the following table) or any combination of Equipment.

1. **Warranty.** ITT WWW warrants that all equipment is free from defects in materials and workmanship and conforms to the manufacturers equipment brochures. ITT WWW calculates the expiration of the warranty period from the date on your invoice, the warranty period varies depending on the product as per the following table unless ITT WWW informs you otherwise in writing.
2. During the warranty period ITT WWW will provide warranty service for the Equipment and will manage and install engineering changes that apply to the Equipment. Depending on the Equipment, the service may be "On-site Repair" at your location or "Carry in Repair" ITT WWW 's service location.
3. When a service involves the exchange of Equipment or part, the item ITT WWW replaces becomes its property and the replacement becomes yours. Replacement parts assume the remaining warranty of parts they replace. They may not be new but will be in good working order.
4. If the Equipment does not function as warranted during the warranty period, ITT WWW will repair or replace it without charge. If ITT WWW is unable to do so, you may return it to the place of purchase and your money will be refunded.
5. **Warranty Service.** To obtain warranty service for the Equipment you should contact your reseller or call ITT WWW. You may be required to present proof of purchase.
6. It is your responsibility to: (a) Follow the problem determination, problem analysis and service request procedures that ITT WWW provide. (b) to insure for loss of, or damage to, any Equipment in transit when you are responsible for transportation charges, even if ITT WWW arranges transportation at your request.
7. The purchaser is liable for the correct installation and operation of the goods supplied, as determined by the Statutory Authorities concerned, and the certified information provided by ITT WWW including all protective sensors supplied as standard, relative to that portion of the goods so protected, and including other resulting failures
8. **ITT WWW undertakes to remedy faults in equipment sold by ITT WWW provided:**
   - The fault is due to defect in design, material or workmanship.
   - The fault is reported to ITT WWW or the authorized reseller during the warranty period.
   - That the product is used only under the conditions described in the care and maintenance instructions and in applications for which it is intended.
   - That the monitoring equipment, if incorporated in the product, is correctly connected.
   - That all service and repair work is done by a workshop authorized by ITT WWW.
   - That genuine Flygt parts are used.
   - The undertaking does not cover faults caused by deficient maintenance, improper installation, incorrectly executed repair work or normal wear and tear.
   - ITT WWW reserves the right to alter performance, specification or design.

1. These warranties are in addition to any rights you may have under Australia's Trade Practices Act or other legislation which cannot be excluded or limited, and replace all other conditions and warranties that may otherwise be implied.
2. Warranty Period Table relating to specific products unless otherwise specified.

B & Ready Pumps	12 months	* LL Pumps	12 months	M&C Equipment	24 months
* C & N Pumps	12 months	* PL Pumps	12 months	JWC Muffin Monster	12 months
D Pumps (Vortex)	12 months	M Pumps	12 months	PWO Pumps	12 Months
F Pumps	12 months	Mixers	12 months		
H Pumps – Slurry	12 months	Aeration Equipment	Per Contract		

* All C, N, PL & LL Pumps which are operated in conjunction with a Flygt FMC Pump Controller or MAS Monitoring Unit will have their standard warranty periods shown above doubled.

Section 7

Photos

Section 8

As-Built Drawings