North Shore City Council

Wastewater Pump Station Management for the Next Generation

Presentation to INGENIUM Conference

Palmerston North

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1.0 OVERVIEW AND SUMMARY OF NSCC WASTEWATER PUMP STATIONS

North Shore City Council (NSCC) is New Zealand's fourth largest city and has very popular swimming beaches. NSCC manages its own wastewater system including 85 pump stations with storage and failure of these can lead to the temporary closure of these swimming beaches.

This high consequence of failure has lead to the development of best practice management techniques by North Shore City Council. This lead to implementing the Avantis Computerised Maintenance Management System in 2003 for wastewater pump stations.

Avantis is a powerful and customisable system that allows NSCC to integrate existing and new management practices into the computerised system. It includes the usual features of

- Asset register
- Work history and Costs
- Programmed maintenance
- Statistics Recording
- Condition
- Valuation

In addition, the following examples of NSCC specialised processes were incorporated:

- Hazard tracking
- Risk
- Audits
- Overflows
- Forward work programme

Emphasis has been placed on the ability to get data out of the system easily as business practice moves on to the next generation of asset management which involves the analysis of real time data.

The Avantis system is sufficiently flexible that it will also allow the easy and seamless addition of functions and reporting that may be required by the Local Government Act 2002. This will be the immediate improvement priority. It is anticipated that in the near future additional functionality will be added to assist with:

- Robust auditing procedures
- Integration and tracking of risk management and reliability centred maintenance analysis
- Integration of real time SCADA data returns and the use of these to optimise operations and maintenance.

By implementing the Avantis system and associated processes, and by incorporating both operational and asset management requirements, NSCC has developed a robust platform that will enable and enhance pump station management for the next generation.

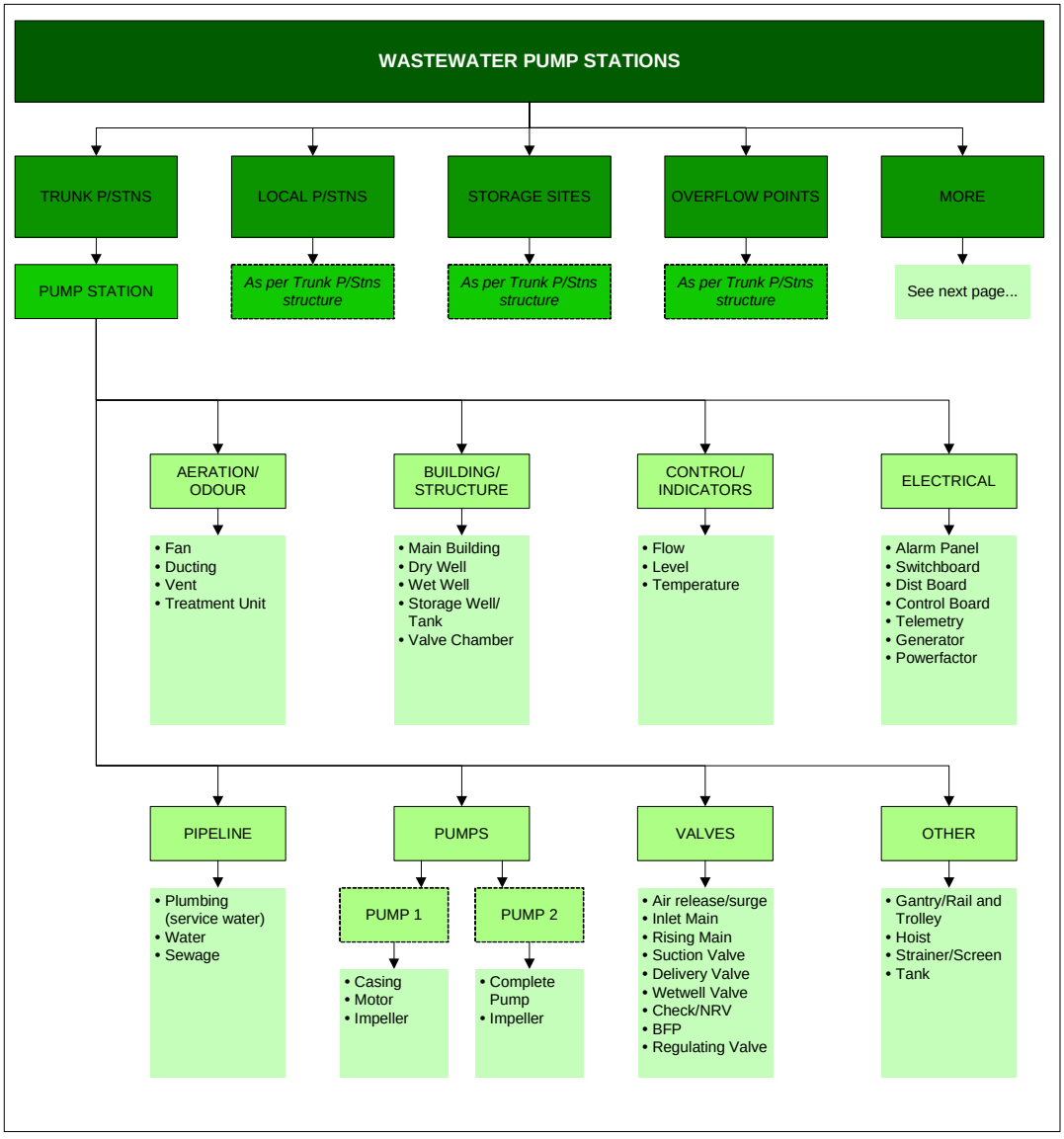
2.0 EXISTING MANAGEMENT PRACTICES

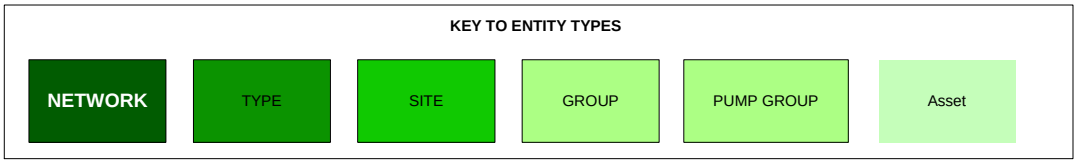
2.1 Asset Register

2.1.1 Hierarchy

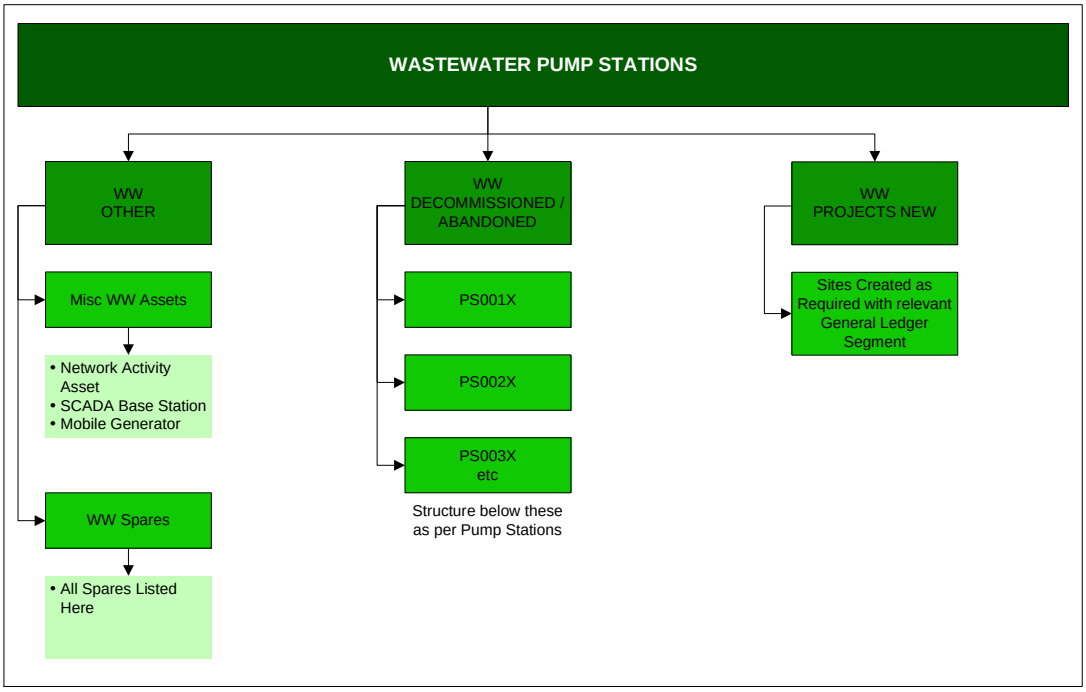
Avantis holds Assets (or Entities as per Avantis terminology) in a hierarchical structure. An Entity Structure was introduced to reflect the structure of the Wastewater Pump Stations and to be generic enough to cater for future expansion if necessary. This is illustrated in the following diagrams.

NORTH SHORE CITY COUNCIL
CMMS ENTITY STRUCTURE

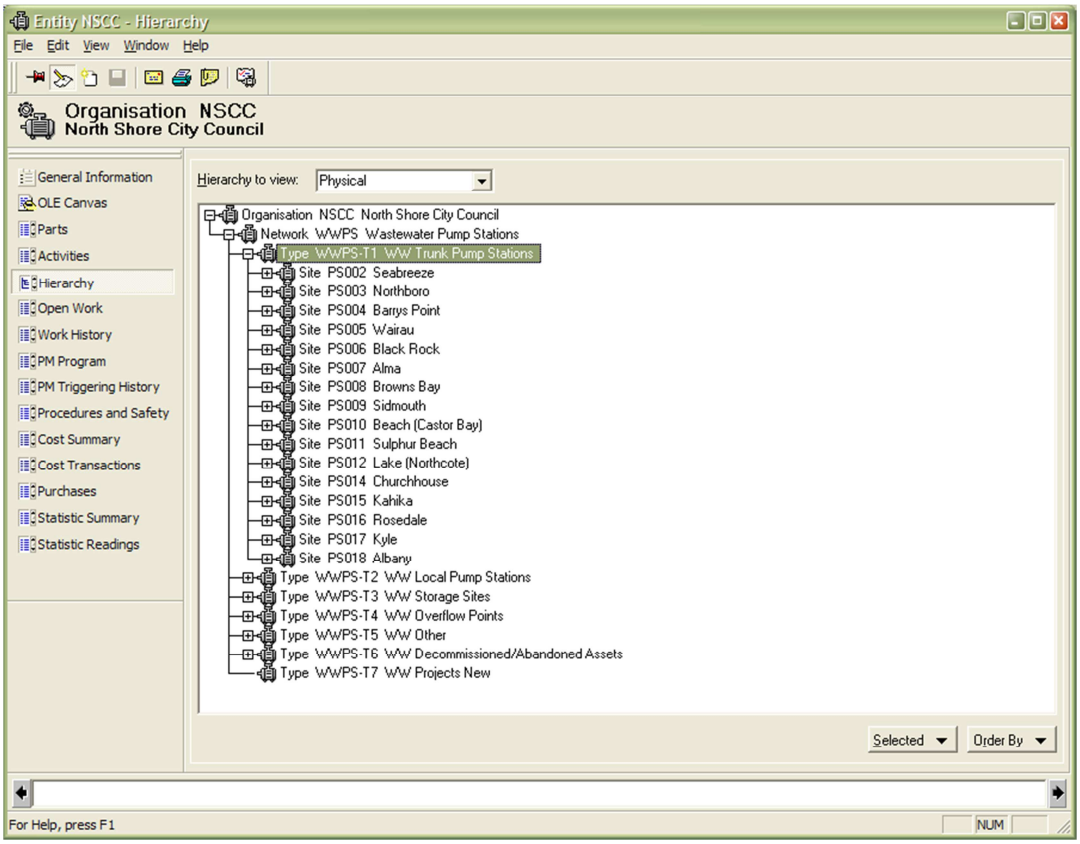




NORTH SHORE CITY COUNCIL
CMMS ENTITY STRUCTURE FOR 'OTHERS'



This hierarchy can be seen in the screenshot below where the Trunk Pump Stations is expanded to show the sixteen trunk pump stations



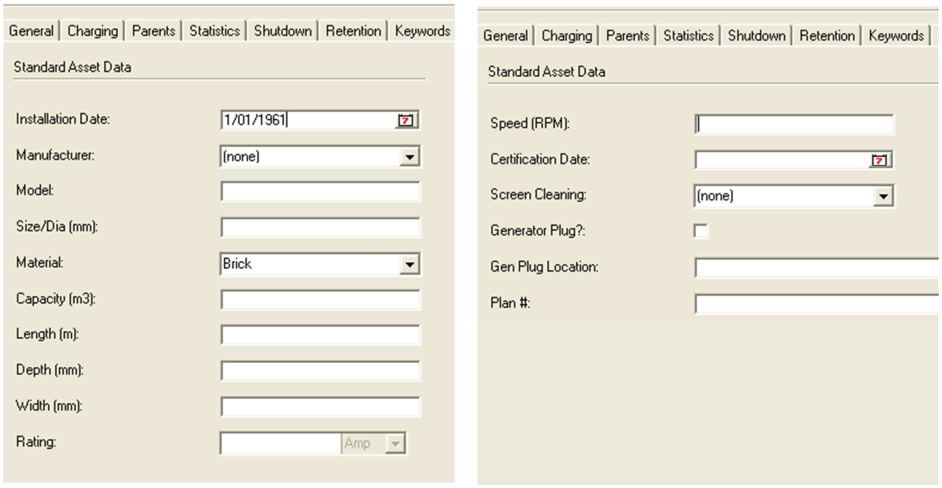
2.1.2 Assets

Because Avantis is a customisable database, meaning that new tables (tabs) and fields can be created and attached to objects were required, this was employed fully to hold the specialised information required for civil engineering assets.

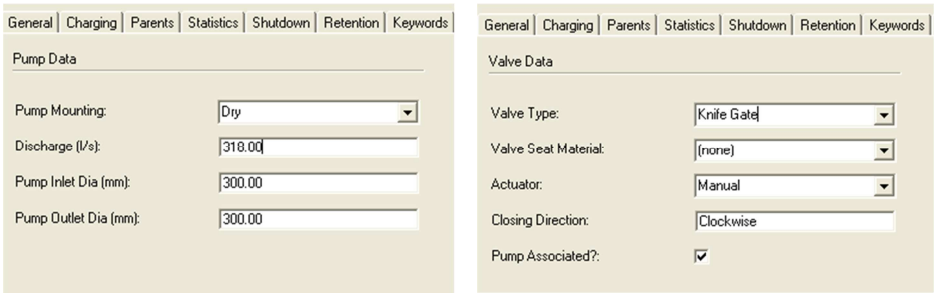
A standard tab was developed for all assets which records information such as Manufacturer, Model, Capacity, Dimensions, and Rating etc. In addition to this, some asset types require additional information to be recorded to effectively manage that type of asset. These included and screenshots of these tabs are shown below:

- Pumps
- Valves
- SCADA
- Storage Tanks

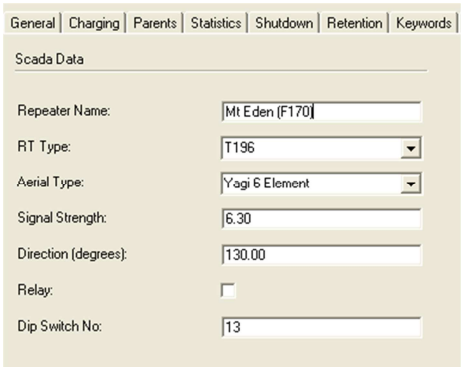
Standard Tab

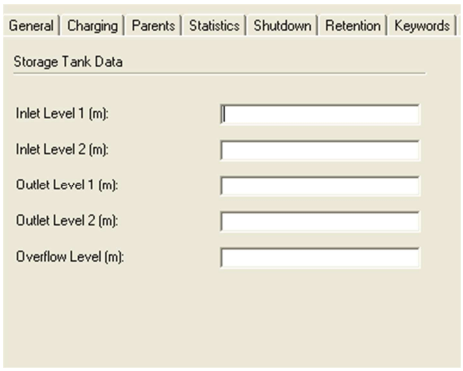


Pump and Valve Tabs

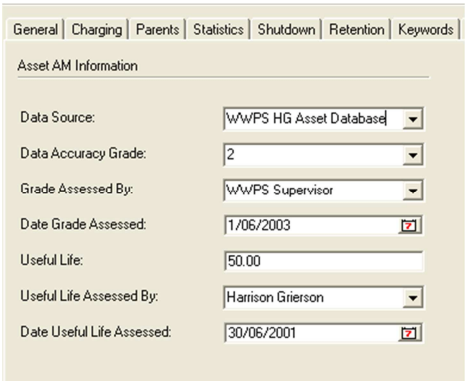


SCADA and Storage Tank Tabs





In addition to the assets physical attributes it is becoming more important with advanced asset management practices to hold non-physical attributes. Therefore, a tab for Asset Management Data was developed. Additional fields can be added to this at any time. Below is an example of the information in this tab:

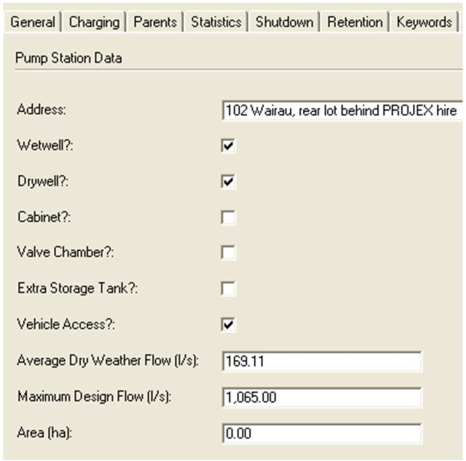


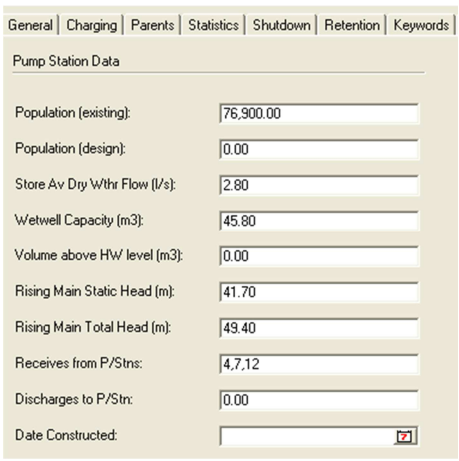
The Data Accuracy Grade, could also be called Data Confidence Grade, was recorded as it is essential to know any assumptions during a decision making process.

The Useful Life of the asset has been held against the asset (as well as the valuation record) to allow the Engineer to alter the Useful Life and enable forecast renewal reporting.

2.1.3 Pump Stations

Additional operational information was also held against the Pump Station Entity. This information related to design parameters, catchment characteristics, flow history data and storage capacity. This type of information is often lost in filing systems or contract files making them difficult to access quickly or maintain. Below are two examples of the type of information held against the pump stations:





2.2 Work History and Costs

NSCC had great foresight when in 1995 they started recording all maintenance in spreadsheets, with costs where available. Work history had also been identified by the asset ID since 2000 when a naming convention was introduced.

This maintenance history was then matched to the correct asset where necessary and imported into Avantis. The import of maintenance history from 1995 has provided the ability to analyse a number of trends including incidence of failure, maintenance cost per pump per year etc.

2.3 Statistics Recording

Statistics can be held against assets and prompt for the field to be completed when certain jobs are undertaken. One example of this is for sludge and grit removal. Every time this work is undertaken the operator must enter the quantity of sludge removed before the work order can be closed.

- Statistics have been created for:
- Amps Readings
- Megger Readings
- Operating Hours
- Power Readings
- Sludge Volume Removed
- Volt Reading
- Water Meter Reading

Because statistics can be rolled up or down, (Avantis function) if a component is swapped to another location the run hours stays with the component as well as still knowing how many hours where done in it's previous installation.

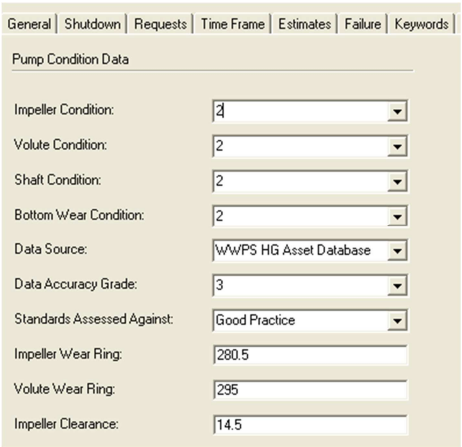
2.4 Programmed Maintenance Scheduling and Costs

Programmed Maintenance (PM) schedules were created for all the regularly occurring tasks such as:

- Weekly / Monthly Inspections
- Sludge and Grit Removal
- Pump Condition Assessment
- Electrical Testing

The PM system creates a work order every month to instruct the Contractor to complete the job and within a given timeframe. The creation of these work orders enables easy reporting on whether the necessary PM work has been completed on time for KPI measurement.

These work orders are customised in the PM template to ensure that the necessary data is collected such as pump lift condition as shown below.

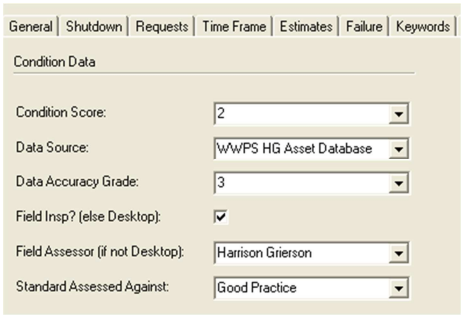


2.5 Condition Data

Condition inspections are time dependent results and therefore were recorded as specific work orders with a Tab for Condition data and data confidence in this Grading.

Holding condition data as a work order allows the condition of an asset to be tracked over time. This information can then be extrapolated to model condition decay curves.

The Data Source and Data Accuracy Grade fields are for differentiating between condition assessments which have been ascertained by specialist material testing or simple visual inspection. It is also important to know the standard that the condition is assessed against (for example NZ Asset Grading Manual or NZ Pipe Inspection Manual) and provision to record this has been made.



2.6 Valuation Data

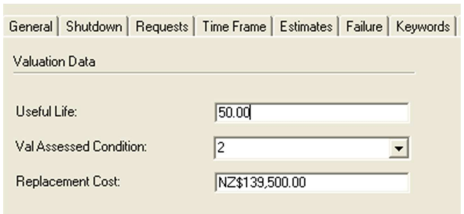
Valuation results are also held as work orders as valuations change over time (depreciated replacement cost decreases with time). The useful life of an asset may also change over time as more information is learnt about a materials performance or testing is done on a particular asset.

The combination of the Valuation and Asset data being in the same database allows reports to be developed for forward projection of valuation and renewal requirements with replacement cost estimates.

The Valuation Tab was setup with minimal information for the implementation but allows for future addition of fields to represent factors influencing valuation such as:

- Design Standards
- Construction Quality
- Material Quality
- Operation Stresses
- Maintenance History
- Performance

Below is a screenshot of the Valuation Tab. The date of the Valuation is recorded in the Standard Work Order fields.



3.0 SPECIALISED PROCESSES

3.1 Hazard Tracking

NSCC had completed rigorous hazard analysis assessments of their pump stations and this data was recorded in Avantis as work orders with Activities to represent each hazard identified. Because an Activity can be used to trigger additional work in Avantis this functionality has been used to track whether a hazard has been rectified or not.

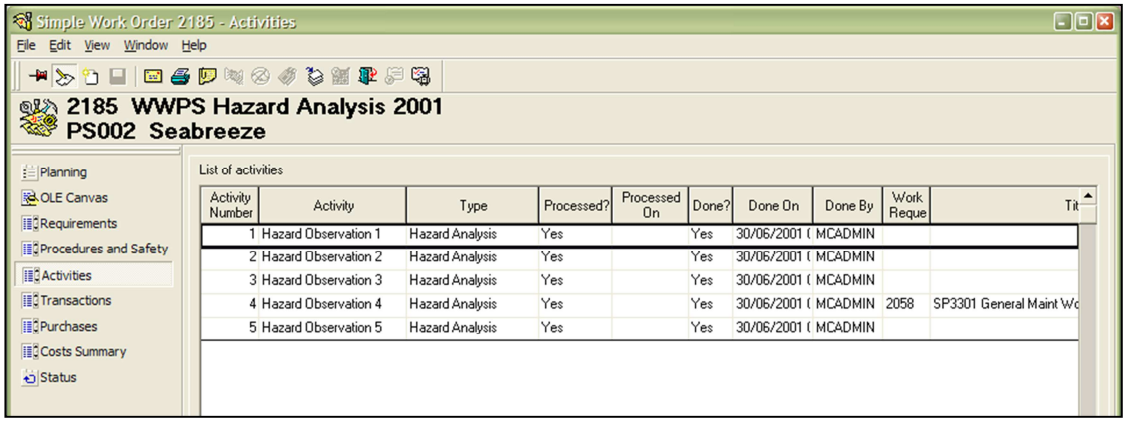
As you can see from the report extract below of the seven hazards identified at this station five have been rectified as they have a follow up Work Request and the a Work Order to show the contractor has started the work and then the Work Order is completed to show the job is finished. The data below is a composite example only, to reflect the type of results available.

	Reference	Action	Priority	Recommendation	Work Request No.	Work Order No.	WO Completed
1	5.2: Caught in/on/between - Protruding Objects	Isolate	High	Fit guards over pump/motor couplings			
2	6.1: Slip/Trip/Fall - On the same level	Eliminate	Low	Remove redundant concrete plinth in dry well	2095	13178	Yes
3	7.6: Ergonomic - Ventilation	Minimise	High	Install warning signs (refer sheet 1A for details)	2093	13176	Yes
4	7.7: Ergonomic - Temperature	Eliminate	Low	Provide O & M manual at station	2094	13177	Yes
5	8.3: Other - Lifting Equipment	Eliminate	Med	Test and display SWL on monorail	2062	2086	Yes
6	8.4: Other - Hygiene	Eliminate	High	Install complying backflow unit on potable water supply to station.			
7	8.5: Other - Safe Working (Equipment Lock-Out)	Isolate	High	Provide lockable pump isolators for pump motors on MCC.	2076	12589	Yes

Therefore, monitoring the status of the need for any follow up work resulting from investigations is very easy for the Pump Station Engineer and for auditing purposes.

Additional work requests and work orders can be issued as funding becomes available or as work is bundled together.

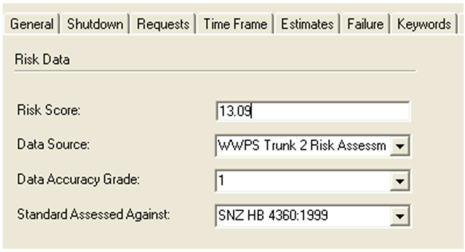
Below is an example of how a work order appears with the list of hazards identified.



3.2 Risk Scores

Risk Scores are held as work orders as the Risk Score can change over time as work is done to reduce the risk or situations change and risk increases.

Therefore the Risk Scores are held in a Risk Tab as shown to the right. The tracking facility used for Hazard Rectification is also used for tracking changes in the Risk Score.

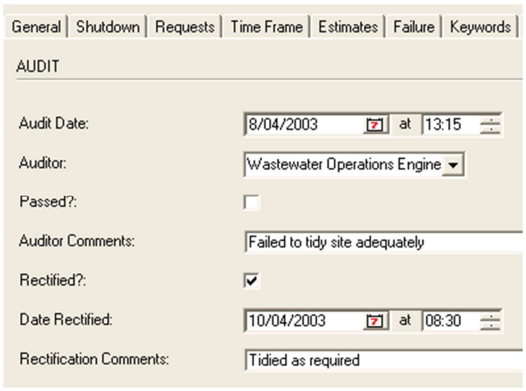


If a pump station receives a high risk score because it had no generator plug the Engineer would issue a work request from the Risk Work Order for installation of the generator plug. This creates an auditable trail so that when a new Risk Score is calculated for the pump station it is clear why it has changed.

Please note that supporting information from the Risk Score formula is also held in the Description Tab so the score for each factor is available for further investigation if required.

3.3 Audit Results

The Contract Supervisor is required to carry out random audits of the Contractor's performance. These audits are recorded against the Work Order which represents the work done. Once a Work Order is created the relevant party (Contractor or Contract Supervisor) can add the Audit Tab and record the details of the audit which will then be available for reporting on the Contractor's Performance. An example of this Audit Tab is shown below.



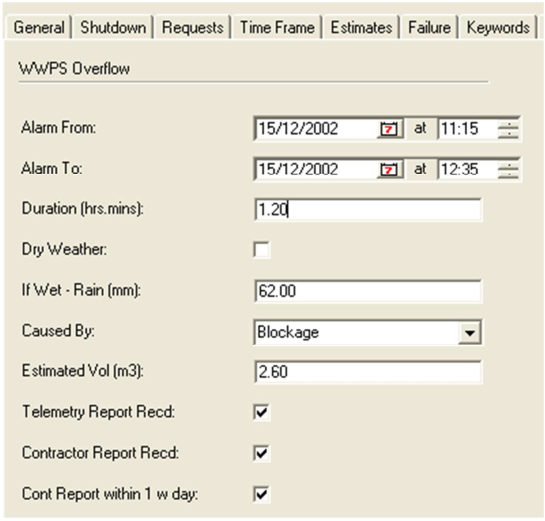
3.4 Overflow Records and Analysis

Wastewater Overflows can occur in the Network. These are recorded for analysis in the future and to prove compliance with key performance indicators for the Contractor and Community Outcome reporting.

A specific Overflow Tab was developed to record the information required. Part of the Add-On is completed by the Contractor and part is completed by the Pump Station Engineer.

Below is an image of how the Overflow Tab appears in Avantis.

The information can now be easily analysed including the standardised 'Caused By' field.

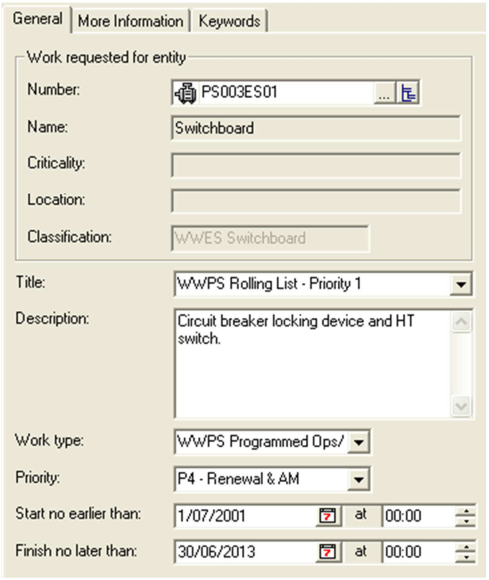


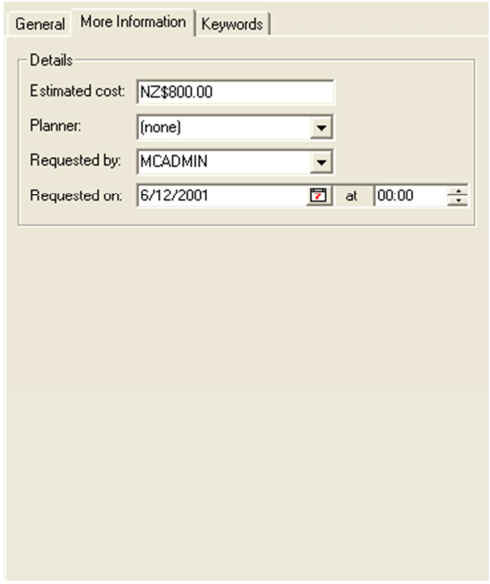
3.5 Forward Work Programme

NSCC previously utilised a MS Access database to record work that had been identified by the Contractor but required programming for budget or timing purposes. Internally at NSCC this database was referred to as the 'Rolling List'.

This database has been superseded by the implementation of Avantis therefore all the outstanding Rolling List items were entered into Avantis as Work Requests (not Work Orders). Work Requests identify the asset requiring maintenance, a description of the maintenance required, a priority ranking and an estimate of the cost involved.

This allows reporting to analyse the potential workload for a Contractor and for budgeting purposes. This includes totalling value of work per pump station and by priority. The Pump Station Engineer can then issue the work requests in a formal process that records approval for work, work completion by Contractor and final payment.





4.0 REPORTING

Avantis has an in built simple reporting tool called Cabinets. A user is able to customise these to include any fields required and necessary parameters for fine tuning a query. Also, the data from cabinets is able to be exported straight to MS Excel for further manipulation if required. This makes cabinets great for day to day queries on the database and finding specific information.

However, cabinets do have limitations in that they are not able to calculate formulas, groupings or summaries and are limited on the number of tables per query.

Therefore, crystal reports were also developed in the following areas to provide greater analysis tools and more expansive reporting:

- Quality Assurance
- Contract Management
- Operational Management
- Asset Management
- Entity Management

4.1 Quality Assurance

Quality Assurance reports were developed to monitor Work Order creation by the Contractor specifically for NSCC processes.

These reports ensure that:

- Key fields for NSCC processes are always completed
- Order of date entry is logical
- Work Orders are Closed formally
- Work Orders are not created against decommissioned assets

4.2 Contract Management

A contract management report was developed to automatically calculate the Contractor's KPI Score each month for Work Completion Timeframes, Health and Safety, Safety Audits and Programmed Maintenance Completion.

A second report was also developed to check the Contractor's monthly claim against the value of the work orders entered into the database. This operates as a check of the Contractor's data entry being complete and up to date. It is envisaged that in the future the Contractor will be able to base their claim on the output from Avantis.

A report which provides an overview of the Programmed Maintenance completed was also developed. This provides the feedback on the PM work orders to provide the following types of information:

- H & S Accidents
- Graffiti Identified and Removed
- Volume of Sludge and Grit Removed
- Megger Test Results
- Pump Lift Inspection Results including Impeller Measurements
- Annual Status Check Results
- Annual Quality Check Results

4.3 Operational Management

Most Operational Management reports have been developed as Avantis Cabinets as these are simple day to day queries. These cabinets included:

- Work Completed
- Priority One Work Orders (Telemetry Callouts)
- Wastewater Overflows

4.4 Asset Management

An Asset Management Cabinet was developed to allow simple analysis of hazard, risk, valuation and condition work orders.

In the future, once both the Contractor and NSCC are more familiar with the database it is intended to develop Crystal Reports for the following asset management data:

- 20 Year Forward Renewal Projection
- 20 Year Forward Valuation Projection
- Condition Trend Analysis
- Expenditure Analysis on Work Type
- Failure Analysis on Asset Type

4.5 Entity Management

Some simple reports for management of the asset data were also developed to assist with quality assurance on asset data and standardised reporting of assets within pump stations. This includes:

- Checking for Missing Data
- An overview of the assets within a pump station
- An annual summary of asset decommission and acquired during the previous year

5.0 FUTURE – NEXT GENERATION

The immediate future of pump station practice and analysis will be driven by the requirements of the Local Government Act 2002, and resource consent considerations. In general this will require increased reporting of service levels, and any asset failure incidents that have environmental effects. All reporting will require the ability to be audited.

The further application of risk management principles and reliability centred maintenance practice are also logical extensions of current pump station management practice.

Leveraging data from real-time alarm systems and integrating this into asset systems and operations and maintenance practice is an area that offers many benefits in the optimisation of work practice and maintenance scheduling.

This future practice described below is not restricted to Avantis CMMS as discussed in this presentation, but can be applied without too much difficulty to any combination of asset management system and real-time SCADA alarm system. It is therefore hoped that the discussion of the topic below will be of assistance to all local authority asset managers and engineers working in the pump station management field.

5.1 LGA2002

To achieve Local Government Act 2002 compliance by July 2006 local authorities will need to have the following in place for major asset activities:

1. Community agreed levels of service and performance measures that support the Community Outcomes (customer service KPIs and measurement of service levels achieved).
2. An assessment (or model) of asset demand and capacity of current assets to meet demand. Capacity forecasting will be required to enable asset acquisition strategies to be developed.
3. Asset acquisition and disposal strategies to meet assessed demand, and agreed levels of service. Development of the asset acquisition and disposal strategies will require expenditure forecasting.
4. Asset renewal strategies that incorporate the results of service level delivery models; risk assessment (particularly for high criticality assets), condition assessment and demand forecast models. Expenditure forecasts will be required to be developed from the asset renewal strategies.
5. Asset operations and maintenance strategies that delivery the agreed service levels. Management of the service delivery contracts will include service level performance measurement and auditing, to ensure results reported can be supported. Expenditure forecast will be required to be developed from the asset operations and maintenance strategies.
6. An asset or activity management plan that summarises all the asset service delivery and lifecycle management issues and develops well supported expenditure and revenue forecasts. Expenditure forecasts will be required for asset maintenance, renewal, replacement and any new asset capacity required. If non asset solutions are to be used to deliver levels of service then any costs associated with these solutions must also be identified.
7. Input into Councils Development Contribution Policy.
8. An accurate asset register, with data at required confidence levels, and the ability to demonstrate robust and auditable processes for keeping the asset register at the required standard of accuracy – including the timely addition of assets from capital expenditure projects and developer vesting. The required asset register accuracy requirements (including asset condition assessment) are higher for critical assets.
9. An accurate calculation asset valuation and depreciation that accounts for asset condition and remaining life.

These requirements will be used as the basis for the development of future processes and data management within Avantis. This will ensure Avantis continues to meet the increased requirements for:

- automation of the service level delivery reporting
- data capture
- asset register updating and data confidence levels
- asset valuation
- operations and maintenance tracking
- reporting processes

5.1.1 Data Confidence

Planning Assumptions and Data Confidence have been highlighted in the International Infrastructure Management Manual as shown in the excerpt below:

<table>
<tr><th>AM Attribute</th><th>'Basic' AM Planning Criteria</th><th>'Advanced' AM Planning Criteria</th></tr>
<tr><td>Planning Assumptions and Confidence Levels.</td><td>AM Planning should:
List all assumptions and provisos under which the plan is prepared.
Indicate the degree of confidence of the reliability of data underpinning the AMP; particularly:
data on condition of assets;
data on performance of asset;
accuracy of asset inventory; and
Demand/growth forecasts.

Confirm the remaining useful lives of assets.

On the basis of the preceding assumptions and confidence of underlying data, provide a level of precision, or confidence, on the forecasts of renewal and maintenance expenditure for the asset network.</td><td>AM Planning should:
List all the assumptions and provisos in the AMPs, and note key assumptions regarding AM planning in the organisations strategic plans.
Have degrees of confidence on the reliability of data as follows:
<table>
<tr><th></th><th>Critical Assets</th><th>Non Critical Assets</th></tr>
<tr><td>Physical Inventory data</td><td>Grade 1</td><td>Grade 2</td></tr>
<tr><td>Condition data</td><td>Grades 1 or 2</td><td>Grades 1, 2 or 3</td></tr>
<tr><td>Performance data</td><td>Grades 1 or 2</td><td>Grades 1, 2 or 3</td></tr>
<tr><td colspan="3">(Grades are contained in Section 4.4.6 of the Manual)</td></tr>
</table>
</td></tr>
</table>

Data confidence has been incorporated into the Avantis asset register and all condition data held. As performance data is added to Avantis (if appropriate) this will also be attributed with a confidence grade.

Reporting from Avantis will easily allow scrutiny as to the overall confidence levels in Critical and Non-Critical Assets, and the development of programmes to improve data confidence where necessary. The incorporation of data confidence grades into the Avantis asset register also allows for reporting of weighted confidence bands in Activity Management Plans.

5.1.2 Level of Service Reports

The agreed Community Outcomes developed for LTCCP's and included in the Annual Plan must be supported from the ground up. This means that the high level Community Outcomes are supported by practical, measurable and auditable performance measures at the operational level.

As Community Outcomes are developed and finalised the reporting requirements for these will be scrutinised and processes and reporting implemented in Avantis where required.

5.1.3 Optimisation of Expenditure

Work completed within Avantis is categorised as Reactive Maintenance, Programmed Maintenance, Renewals, New Capital or Asset Management.

This data combined with Action Taken, Failure Mode and Time Stamping will allow all work completed to be analysed and evaluated versus alternative technologies and renewal vs. maintenance.

Work grouping opportunities also allow for optimisation of expenditure.

5.1.4 Financial Projections

Robust financial projections will be able to be developed as a comprehensive history of expenditure is recorded. These financial projections can be developed and fine tuned by trending historical data and analysis of alternatives for both operation and capital expenditure.

Operational

A combination of risk analysis (asset criticality), lifecycle analysis and operational history will allow optimisation of the reactive vs. programmed maintenance split.

Analysis of SCADA reporting incorporated with risk and use of storage will also allow for analysis of the management of service delivery and optimising this for the least expenditure.

Investigation of alternative technologies combined with prudent risk management have the potential to optimise service delivery outcomes and expenditure.

Renewal

The asset inspection history analysed against lifecycle data, maintenance history and risk would allow for an optimised forecast of renewal needs.

New Capital

The need to evaluate alternative technologies as per the LGA2002 can be supported by the known performance of existing assets as recorded in Avantis.

5.2 Reliability Centred Maintenance Analysis

A review of maintenance policies to incorporate Reliability Centred Maintenance (RCM) would allow NSCC to target their maintenance to the assets that require it most for on-going reliability of the system.

Pump stations operate in different modes and the expenditure should be targeted to avoiding the consequence of failure when this consequence is significant. Those assets that do not have a significant consequence of failure are not targeted for programmed maintenance and are only maintained following failure.

An analysis of Hidden Functions within a pump stations operation and control system and recording of these into Avantis would allow greater understanding of these Functions and therefore the opportunity to manage these proactively. Hidden functions such as sensors can be the cause of significant failures if not managed well.

5.3 Real Time Data Integration and Analysis

North Shore City Council has recently installed a SCADA system that has increased the ability to monitor of the pumps stations. The SCADA system is linked to the CITECH HMI which records the history of pump station actions in a database. The Avantis CMMS system

has the ability to store pump and other equipment statistics and then use the statistics to trigger preventative maintenance actions.

5.3.1 Linkages to SCADA

North Shore City Council plans to interface the SCADA system with the Avantis CMMS system. Avantis has built in interfaces to the Intouch HMI system, but in the case of CITECH the interface will have to be adapted. Initially it is intended that data transfer be one way from the SCADA system to Avantis, to allow the automated recording of statistics, and subsequent triggering of maintenance actions. Ultimately the linkage may become two-way, and allow triggering of SCADA operational programmes and actions from the Avantis maintenance system.

5.3.2 Summarised Statistics Recording

Initially the recording of summarised statistics will be of the most benefit as it will allow analysis reports that incorporate pump usage, power usage and possibly summarised station flows collected from meters. This information could be invaluable when used for the calculation of maintenance interventions, reliability centred maintenance also adjusting asset life based on plant usage.

5.3.3 Triggering PM off Statistics

The triggering of preventative maintenance from statistics provides opportunities to optimise maintenance schedules, and ensure that necessary maintenance is not missed.

The use of statistics in the preventative process also provides further opportunity to complete maintenance process analysis and optimisation.

6.0 CONCLUSION

Daily asset operation and maintenance, operational optimisation and asset management improvements, when coupled with the immediate requirements of the Local Government Act 2002 require robust and well implemented Asset Systems and supporting processes.

Any asset system implementation and associated processes or updating must also have an eye to the future requirements. In the case of the NSCC Avantis implementation the system is sufficiently flexible and has been implemented to easily allow:

- Enhanced reporting for LGA2002 requirements
- Robust auditing procedures
- Integration and tracking of risk management and reliability centred maintenance analysis
- Integration of real time data returns and the use of these to optimise operations and maintenance

The Avantis system meets NSCC requirements for current operational and asset management practice and the improvements outlined in this paper will be implemented when time and resources allow. Meeting LGA2002 requirements will be the immediate priority.