During the past decade Bronson has acquired considerable technical expertise and project management experience in hydrodynamics-related areas in the coastal and estuarine environment.

Bronson currently manages MHL’s Flood group, which involves the flood data capture network for the New South Wales coast ranging from Eden in the south to the Tweed River in the north. He has managed a range of projects for both government and private organisations.

Bronson is a Senior Engineer with MHL with experience in numerical and physical modelling of hydrology, hydrodynamics and ocean conditions. He is currently involved in real-time flood modelling and warning systems for Lake Macquarie City Council, Hastings Municipal Council, Manly, Warringah and Pittwater councils through the Floodwatch and LagoonWatch projects.

Bronson’s work history has involved a significant amount of contact with clients and colleagues in both a management role and as technical collaborator and adviser. Some of the projects managed by Bronson include:

- Kogarah Bay Decision Support Tool for Prioritising Remediation Works
- Wallis Lake Foreshore Flooding Assessment
- Manly Golf Course Flood Investigation
- Manly Lagoon Flood Assessment
- Kore Creek Flood Assessment
- Booral (Karuah River) Flood Assessment
- Cabbage Tree Creek Flood Assessment
- Inverell Flood Scoping Study
INNOVATIVE DATA ANALYSIS AND DELIVERY: WHERE IS IT HEADING?

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"The impact of climate variability on the national economy is the greatest single influence beyond the state of the economy" ¹

INTRODUCTION

Effective management of aquatic ecosystems requires a sound understanding of ecosystem processes and the indicators that reflect the system condition at any time. In general these complex processes are not easily monitored by a single variable but rather require a combination of different measurements and their subsequent analysis to derive a meaningful management tool. In raw form measured data has limited value to environmental managers who require simpler interpreted information that can be derived from the application of analytical tools.

Data may be used in a variety of ways, including storing for later use, near real-time download for compliance checking or warning and more recently for presentation and incorporation into decision support systems. Adding value to hydrographic data is an important step in bridging the gap between environmental data collection and the management of environmental systems. Manly Hydraulics Laboratory (MHL) has a vast amount of experience in data collection and adding value through application of analysis and interpretive presentations in a variety of ways that focus on the clients needs.

Recent advances in analytical tools and more affordable monitoring systems provide a range of opportunities for the development of 'smart' tools that can assist managers make timely decisions on a range of issues. These applications include development of sampling triggers, assessment of flushing and water quality, alert systems for flood evacuation, and assessment of the status of intermittently closing coastal lagoons to assist in entrance management procedures, and inputs into Australian and Global climate models.

This paper examines the real time hydrographic data collected by MHL and provides examples of innovative applications of analytical and presentation tools that provide an interpretation of environmental conditions in near real time to assist management decisions.

Table 1 Average annual cost (in millions of dollars) of Australian natural disasters for the period of 1967 to 1999, excluding death or injury costs (BOM, 2003)

<table>
<thead>
<tr>
<th>State</th>
<th>Flood</th>
<th>Severe Storms</th>
<th>Cyclones</th>
<th>Earthquakes</th>
<th>Bushfires</th>
<th>Landslide</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSW</td>
<td>128.4</td>
<td>195.8</td>
<td>0.5</td>
<td>141.2</td>
<td>16.8</td>
<td>1.2</td>
<td>484.1</td>
</tr>
<tr>
<td>Australia</td>
<td>314.0</td>
<td>284.4</td>
<td>266.2</td>
<td>144.5</td>
<td>77.2</td>
<td>1.2</td>
<td>1087.5</td>
</tr>
<tr>
<td>Proportion of total %</td>
<td>28.9</td>
<td>26.2</td>
<td>24.5</td>
<td>13.3</td>
<td>7.1</td>
<td>0.1</td>
<td>100</td>
</tr>
</tbody>
</table>

¹ See Table 1 (Stone)
Data Collection and management

With aquatic disciplines, data collection forms an essential component of problem solving and planning; project system designs; operations; early warning systems; and predictive models. Management decisions affecting estuaries or coastlines require a sound knowledge of the baseline and event driven conditions of indicator variables.

MHL operates a network of over 900 automatic environmental data collection stations throughout NSW, which include telemetered time series recordings of rainfall, water level, flows, water quality, ocean water levels (tides), barometric pressure, wind, and near-shore and estuarine wave heights. Specific water quality variables measured include chlorophyll-a, pH, dissolved oxygen, turbidity, temperature and salinity. The network of gauges is linked to MHL's computer system where the data is maintained in databases and may be presented in web graphics of the raw data or subjected to a range of analysis for decision support tools.

To improve knowledge of an aquatic system and enable better-informed management decisions, it is imperative that collected data is properly archived in an accessible manner. MHL maintains a database of 10,000 years of data that is readily accessible. Data management is an important component of effective environmental programs that is often overlooked, and as consequence limits the expansion of knowledge.

Enhancements in data delivery

Hydrographic data is used by people in a wide range of disciplines, often in unexpected places. For example, an entomologist may need to look at tidal data to determine the likelihood of mosquito outbreaks in wetlands in relation to public health management decisions. It is therefore important that data is collected and presented in such a way as to make it available and accessible for multifunctional use.

Data capture, analysis and delivery has been enhanced recently in recent years, due to developments in:

- Smart, accurate more robust and multifunctional solid state sensors
- Communication advances with telemetry, cellular phones, and satellites
- The speed and capacity of computers
- The integration of data with simulation models
- Quality Assurance systems in place

Real time or near real time data acquisition and analysis has been developed and made available to clients to assist their decision-making. This information can be displayed in many formats, however MHL has had the most success by displaying this information over either over the web or as part of a early warning alert system via:

- Automated Facsimiled alarm
- Automated SMS alarms
- Automated Email alarms
- Automated Voice alarms

The web provides the capability for clients and/or the public to examine the data and draw their own conclusions about system status. Models and analytical tools may be used to predict future trends or events and enhancements can be readily developed by interfacing with a variety of software packages and displaying outputs on a web page. These services are particularly relevant during storm and flood events or where the data forms a critical input to operational processes.
Converting Data to Information – ‘Value Adding’

In a publication entitled “At what Price Data?” produced by the National Committee on Coastal and Ocean Engineering of the Institution of Engineers, Australia it is noted that data is a relative measure, not absolute; but relative to a selected level of accuracy. Data is only meaningful when correctly interpreted by a competent practitioner, experienced in the specific fields of data collection and interpretation.

The “next step” in the use of collected data is its integration into a decision support system to allow a more relevant overview of the system by environmental managers. The availability and enhancement of the data has a vital role in well-informed management decisions.

This type of ‘value adding’ to data requires good understanding of system response, which is developed through a model with well-established inputs and outputs and a clear understanding of model limitations and possible errors. To get the best possible results for use by environmental managers it is important to have a good knowledge of how to apply the model and relevant presentation of simplified outputs.

The following section outlines a few examples of MHL projects that have involved the development of analytical tools that enhance hydrographic data to assist clients with management decisions.

CASE STUDIES

Camden Haven Floodwatch System

The Camden Haven River enters the ocean near North Haven on the NSW north coast approximately 285 km north of Sydney and 25 km south of Port Macquarie. The river has a catchment area of 720 km², which extends 32 km to the west and 25 km north to south. The estuary consists of two lakes, Watson Taylors Lake to the south and Queens Lake to the north (Figure 1).

The Camden Haven Floodwatch System is comprised of a suite of computer programs and field instrumentation linked together to monitor and predict water levels for the more effective management of potential flooding in the lower reaches of the Camden Haven River.

The system involves extracting real-time water level, rainfall, flow, ocean tide and wave height data and running a numerical model to develop future predictions through a web browser interface (Figure 2). Based on these future predictions the system sends alarms to various people using SMS, Web pages, e-mails and faxes. A remote user can access the MHL computer to examine the collected data and model predictions as well as control recovery of the data and distribution of the results by facsimile.

The lower reaches of the Camden Haven River run between Watson Taylors Lake and the ocean with a connection to Queens Lake via Stingray Creek approximately mid-way. In order to model the behaviour of the Camden Haven River at Laurieton it was necessary to model water levels in Watson Taylors Lake, Queens Lake and the ocean. This was done via a hydrology model producing flow into the lakes and a box model producing flow between the lakes and the ocean. The ocean is modeled using predicted tides and tidal anomalies. Laurieton water levels were then determined by estimating the hydraulic gradient along the river.
The computer model is used to predict water levels for 12 hours in advance for two different scenarios of combined environmental conditions (rainfall and ocean water levels). The two scenarios are:

1. Abating Conditions – assumes no more rainfall. The tail water level is the predicted tide plus a tidal anomaly over the next 12 hours.
2. Persisting Conditions – assumes average rainfalls for the previous six hours will continue for the next six hours and tailwater conditions determined from the predicted tide plus a tidal anomaly for the next 12 hours.

Figure 1. Camden Haven catchment map
LAURIE TON WATER LEVELS, CAMDEN HAVEN
Average Rainfall, peak = 0mm at 1930hrs 14/03/2004
Persisting Conditions, peak = 0.41m at 03:45hrs 15/03/2004
Abating Conditions, peak = 0.4m at 03:45hrs 15/03/2004

Figure 2 Camden Haven – model output displayed on web

Lake Conjola Decision Support System

Management of estuaries in NSW has increasingly incorporated the aim of reducing the level of interference with the natural opening and closing regime of estuaries. State Government policy is to allow the entrances to open and close in as near a natural pattern as possible. However, the presence of low-lying assets surrounding some of the estuaries and the fact that many coastal villages are still un-sewered introduces flooding and water quality issues that drive the pressure to manipulate the entrance conditions, usually in the form of mechanically removing the entrance constriction.

MHL was commissioned to undertake the synthesis and review of available information and develop a final decision support structure in a form that could be easily accessed and used in a practical sense to manage the estuary entrance. The Lake Conjola decision support system was developed following an Entrance Management Study, which found that closure of the lake entrance to the ocean occurs periodically and causes deterioration of water quality and increases flood risk to local low-lying areas. The decision support system monitors the tides in the lake and alerts Council when the entrance channel has shoaled to a point that intervention is required to prevent closure.

The system makes use of a relationship that was discovered between the tidal constituent M2 and the constriction of the entrance based on observations and records of rainfall and storm events (see figure 2). As the entrance begins to be constricted by sand deposition the M2 constituent in the lake is reduced. Long-term monitoring of the tidal range recorded by a water level recorder in the entrance channel therefore provides an easy means of detecting shoaling of the entrance.
Figure 3 Lake Conjola trigger conditions superimposed on pot of M_2 versus time

Within the decision support system various trigger levels have been set which indicate the state of the system and required actions to prevent closure. The system provides advance warning of entrance closure so that the essential activities that must be carried out prior to dredging can be carried out to enable dredging to commence before closure is imminent. It is important to initiate the entrance works at the appropriate time; that is in time to finish the works before closure but not prematurely because a flood may scour the channel naturally.

The system is hosted on the Internet and displays a rolling assessment of M2 tidal constituent against time (Figure 3); offshore wave height, period and direction; and rainfall. Selected Council officers are notified via email, fax or SMS when M2 reaches key trigger levels so that appropriate action can be taken.
Figure 3. Lake Conjola decision support tool - Web display for entrance management

**HWSS - Pipe flow monitoring**

MHL is responsible for the presentation of flow monitoring data at a number of commercial businesses. Our clients include universities, nightclubs, schools, and industries. Previously water consumption was monitored in blocks, which left the user with no information about when and where the water use was taking place. MHL installs a flow meter on the nominated water pipes, with a small data logger and cell phone for telemeter contact. This enables us to present a time series plot of the flow (see figure 4). This enables our clients to undertake water saving programs targeted to specific areas or times to minimise water consumption in the peak usage periods.
**Sydney Water Corporation Rainfall Alarm System**

MHL has been collecting sewer level, velocity and flow data over the past four years to allow Sydney Water to model Sydney’s sewer system. MHL has over 60 rainfall gauges that are situated across Sydney that are used in this modeling process. Previously this data has been provided with no interpretation or analysis of the data.

Sydney Waters main interest in sewer modeling is in the behavior of the sewage system under wet weather conditions. The strong interest in wet weather performance has placed an emphasis on the capturing of good quality wet weather flow data. To achieve this MHL has developed an alarm system to inform Sydney Water and all project contractors when a defined ‘wet weather event’ has started. This allows the field staff to ensure all monitoring equipment is fully functional and recording high quality data.

The alarm system implemented works as such. Each of the rainfall stations located across Sydney is set to send an alert message to MHL when 10mm of rainfall has been recorded in a 24-hour period. This information is logged at MHL until such time as a predetermined number of stations within a set catchment area have all recorded 10mm of rain in the 24-hour period. At this time alarm notices of a declared ‘wet weather event’ on the above criteria are sent to each of the people nominated for that catchment as either SMS, fax or emails.

All this information can be accessed from a password protected MHL website that allows the users to add, edit or remove alarm contact details for any combination of the preset catchments. As a management tool for Sydney Water the website also allows the user to check the listings of rainfalls sites and determine in which catchment they fall and the location and boundaries of this catchment within the greater Sydney area (see figure 5). A log of all alarms sent is also available to ensure each desired recipient has received the notification of the ‘wet weather event’ for their catchments.
The future of data capture and presentation

It is difficult to postulate and crystal ball gaze for where data capture and presentation will be in the near future, but with an eye to the past and present some ideas come to mind;

- Greater variety in sensors
- Better remote sensing
- Redundant systems
- Self-calibrating systems
- Lower power consumption
- Higher frequency sampling
- Continuous data on the net
- Increased data requirements
- Automated decision (not support) tools
- Real-time data editing and real-time quality assurance procedures
- Interaction with other interstate and global systems, such as world climate and data monitoring
- Multi-functional applications
- Replacement of existing or traditional systems
- A change in development and planning regulations
- Increased development
- Higher losses, increased damage.
Conclusion

Data collection is an important component in the management of aquatic ecosystems. The advent of cheaper and more reliable monitoring systems and the Internet enables environmental managers to obtain more relevant information about their systems through the use of interpretive tools. A number of examples of Decision Support Tools that demonstrate the value of enhancing data for environmental managers has been presented. Further work on understanding systems responses to input (measured) variables will allow the development of more client tailored tools that will benefit the environment and public health.

References


McLean, McPherson and Hinwood, A decision support tool for prioritising remediation works in catchment/estuarine bay systems, Modeling and Simulation Society of Australia and New Zealand (MODSIM), July 2003


