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Submission to the Queensland Floods Commission of Inquiry

11 March 2011

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About DHI

DHI is an independent, not-for-profit international research and consulting organisation with offices in over 25 countries including a long term presence in Australia. Our objectives are to advance technological development and competence within the fields of water, environment and health. DHI has been designated an Advisory Centre for the Global Water Partnership, Collaborating Centre for United Nations Environment Program and the World Health Organization.

DHI is world renowned as the developers of the MIKE suite of advanced water models focused on hydrological, hydraulic and ecological processes. In Australia, DHI have been active as a supplier of advanced water modelling software to the government and private water sectors for over 25 years. Our MIKE 11, MIKE 21 and MIKE FLOOD river modelling systems are the de-facto standard for river flood and hydraulic studies in Australia, and have underpinned hundreds of hydraulic and river flow studies across the nation.

Because of the many years of on-going developments in our models, we are seen by many as industry leaders in the modelling of rivers, floodplains, groundwater systems and eco-hydraulics.

Overview of Our Submission

Our submission covers two main areas: Flood Hazard Risk Assessment and Flood Forecasting and Dam Operations. DHI have considerable experience in developing models and decision support systems covering both these topics, which we believe may be of interest to the Commission as possible technologies that could be introduced in a cost effective manner throughout Queensland, and most particularly in the Brisbane River valley.

Our comments are based on our position as a leading international developer of advanced river modelling tools and decision support systems, and from extensive experience gained in the application of these tools to many hundreds of applications in Australia and around the world.

Flood Hazard Risk Assessment

Flood Risk

In Queensland, like most states in Australia, the responsibility for identifying and communicating flood risk to landholders and communities, generally lies with local authorities. Although detailed flood studies have been undertaken for many parts of Brisbane and SE Queensland, these are generally focussed on large urbanised areas where the economic consequences of floods are significant. Yet flood risks may be apparent in the many smaller, rural communities scattered throughout the State, as has been witnessed in the January 2011 floods. Undertaking detailed flood studies for each and every community would be prohibitively expensive for local councils and also very time consuming. What is required is a rapid assessment that can be applied over a large geographical extent in a short time.

Traditional Methods for Assessing Flood Extent and Risk

The accepted approach for identifying areas of potential flood hazard is to perform a detailed hydraulic model study. This is a rigorous and time consuming undertaking that provides a detailed and accurate assessment of flood behaviour. A traditional flood study typically consists of a number of tasks including:

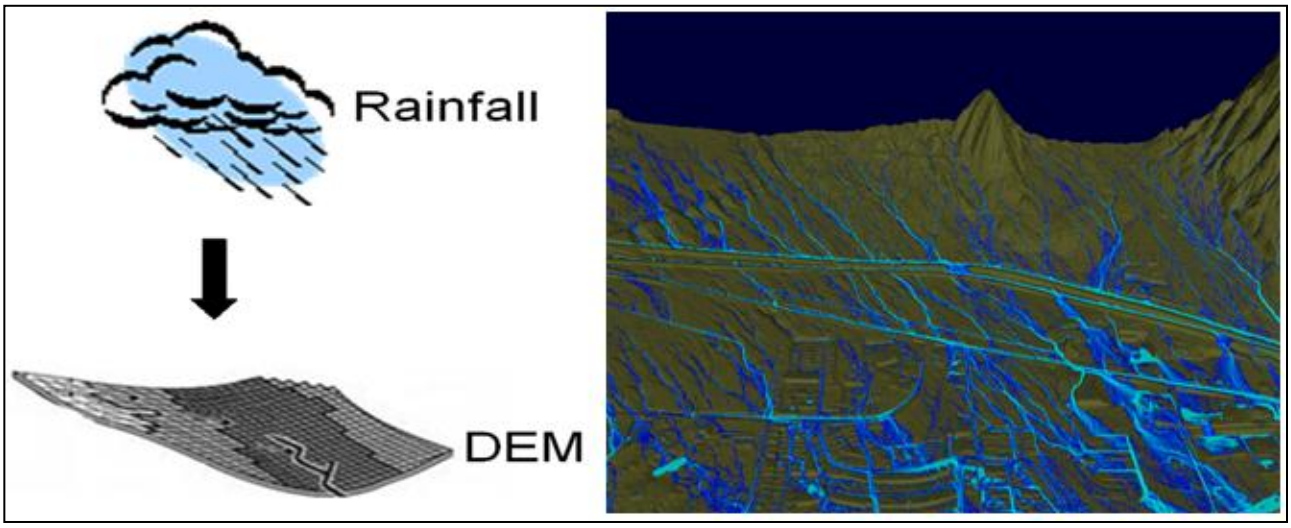
- Review of previous studies;
- Site Inspection;
- Community Consultation;
- Survey Brief and Ground Survey;
- Development of a Rainfall-Runoff Model;
- Development of a Hydraulic Model;
- Model Calibration and Validation;

- Modelling of Design Events;
- Mapping of Flood Extent, Depth, Velocity and Hazard;
- Draft and Final reporting

The time to complete this process will often exceed 12 months and can sometimes run into several years. Because of the nature of such studies councils will typically undertake only a small number of such studies each year, and these are generally confined to limited geographical extents.

A Rapid Method for Identifying Flood Hazard

DHI have pioneered the application of so called Rapid Flood Hazard Assessments (RFHA) which aims to provide a sufficient level of flood hazard information suitable for emergency and strategic planning purposes. The technique utilizes a two-dimensional computer hydraulic model of the catchment surface, upon which rainfall is directly applied. The surface elevations for the model are usually derived from high resolution airborne laser surveys (ALS, or LiDAR) or other digital elevation models (DEM). The technique removes the need to develop a separate rainfall-runoff model. The two-dimensional model can incorporate various levels of detail, as applicable, including road and rail bridges, flood embankments etc.



Graphical representation of the rain on grid method

The advantages of the RFHA approach are:

- The method is fast, with very little pre-processing needed;
- The technique produces hydraulically consistent flood inundation maps, showing depth, water velocity and hazard (depth x velocity);
- Outputs are highly visible and easily understood by non-specialists
- Animations showing the timeline of the evolution of the flood can be produced, for public awareness and also for consideration of flood evacuation routes

It is stressed that the approach is a simplified one, but it is suitable for an initial assessment of flood risk and the identification of priority areas where more detailed (traditional) investigations are warranted. The method has been applied at various locations in Australia and New Zealand at various scales, including a 4000 sq. km area of the Auckland Region. Our experience has shown the method capable of reproducing the most important aspects of flood behaviour.

Recommendation: The Commission consider Rapid Flood Hazard Assessment of flood prone regions of Queensland where traditional flood studies have either not been conducted or where existing risk maps may be uncertain following the 2010/2011 wet season.

Flood Forecasting and Dam Operations

Description Flood Forecasting Approaches

Flood Forecasting is a technology that has been available for some time. Like weather forecasts, flood forecasts utilise computer models to generate the predictions. Two types of models are generally used:

1. A **rainfall-runoff** model to generate the catchment flows that result from rainfall events
2. A **routing** model that predicts the movement of water once runoff reaches the channel system.

The rainfall-runoff model uses both measured and predicted rainfall, and the resulting flows are then fed to the routing model to simulate and predict flows in the river. There are two main types of routing model:

1. **Hydrological** routing models simulate the flows in the river channel, based on simplified descriptions of the river channel. Due to their simplified approach these models are not equipped to take into account complex effects such as tidal influences or the effects of bridges and other structures. Water level predictions can only be made at existing gauge locations, where a relation between flow and level has been established through site measurements.

2. **Hydraulic** models are based on the physical characteristics of the river channel and can provide very accurate determinations of flow **and levels**. Predicted levels can be generated anywhere along the river, and the model can fully account for tidal and backwater influences, floodplain storage and variable flood propagation speeds.

Current System for Flood Forecasting of the Brisbane River

The current flood forecast system for the Brisbane River is operated by the Bureau of Meteorology (BoM) in association with Seqwater and the City Councils of Brisbane and Ipswich. Because of the presence of Wivenhoe and Somerset Dams, Seqwater plays an important role in the flood predictions as dam operations will directly affect river levels downstream of the dam.

Seqwater relies on rainfall forecasts provided by BoM which are fed into its own Real Time Flood Model (RTFM). The RTFM comprises rainfall-runoff models and a hydrological routing model. The RTFM rainfall-runoff models compute inflows for both Somerset and Wivenhoe dam catchments as well as downstream inflows from the Bremer and Lockyer valley catchments. Dam releases are computed in accordance with the Seqwater Flood Procedure Manual. The hydrological routing model is used to assess the impacts of the proposed release strategy on flows and levels downstream.

Actual and planned dam releases are provided by Seqwater to BoM who utilise these to predict downstream flows, with flood levels calculated from existing rating curves at gauge locations along the river. Brisbane City Council finally utilise these predictions to determine likely inundation extents, based on a database which relates gauge levels to likely inundation extents. The database has been developed from hydraulic model simulations covering a wide range of possible river and flow scenarios.

Potential Areas for Improvement

Use of Hydraulic Models for Flood Forecasting in Real Time

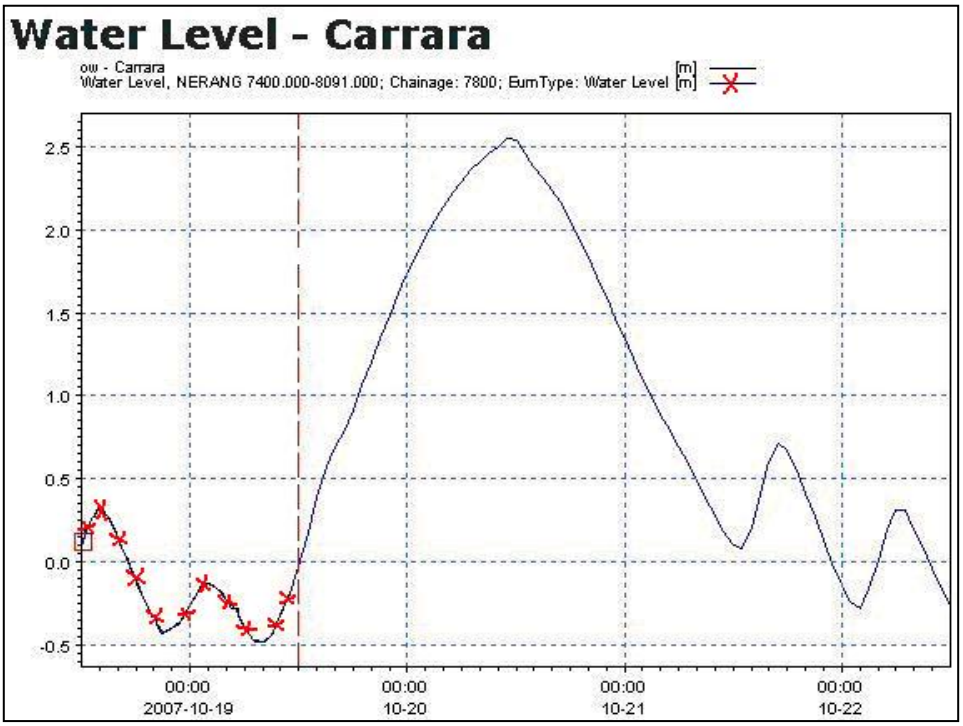
The 2011 flood event has highlighted the need for improved forecasting of the flood impacts downstream of Wivenhoe Dam. At present flood level predictions are possible only where existing flow gauges are located, and these are based on rating curves. At the City gauge, the rating curve is affected by tidal influences, which complicates the prediction of the water levels at this location.

While there appeared to be general appreciation of the fact that many parts of the city would be inundated during the January 2011 event, forecast levels reported in the media were mostly related to the City Gauge, which is far

removed from the upstream areas that were worst affected. Notwithstanding the availability of prepared flood extent maps from BCC, it is evident that there is a general problem with residents relating their own flood risk to the widely publicised predicted heights at the City Gauge.

Using a hydraulic model as the basis for flood forecast predictions would allow water level forecasts to be issued anywhere along the river, including tributary creeks and rivers such as the Bremer and Oxley. The RTFM model used by Seqwater could benefit from the incorporation of an updated hydraulic model, as this may give more confidence in predicting the effects of dam releases on downstream water levels, particularly in the Brisbane urban area. Hydraulic model predictions can be compared to real time water level measurements and the model "self –corrected" to improve the accuracy of forecasts. A hydraulic model will also lend itself to producing flood extents in real time based on the forecast water levels.

The use of hydraulic models as the basis for flood forecasting is well established worldwide and DHI have experience from many installations, including in Australia (Gold Coast, Sydney), New Zealand (Waikato, Canterbury) and overseas (Bangladesh, India, China, UK, Italy, US).



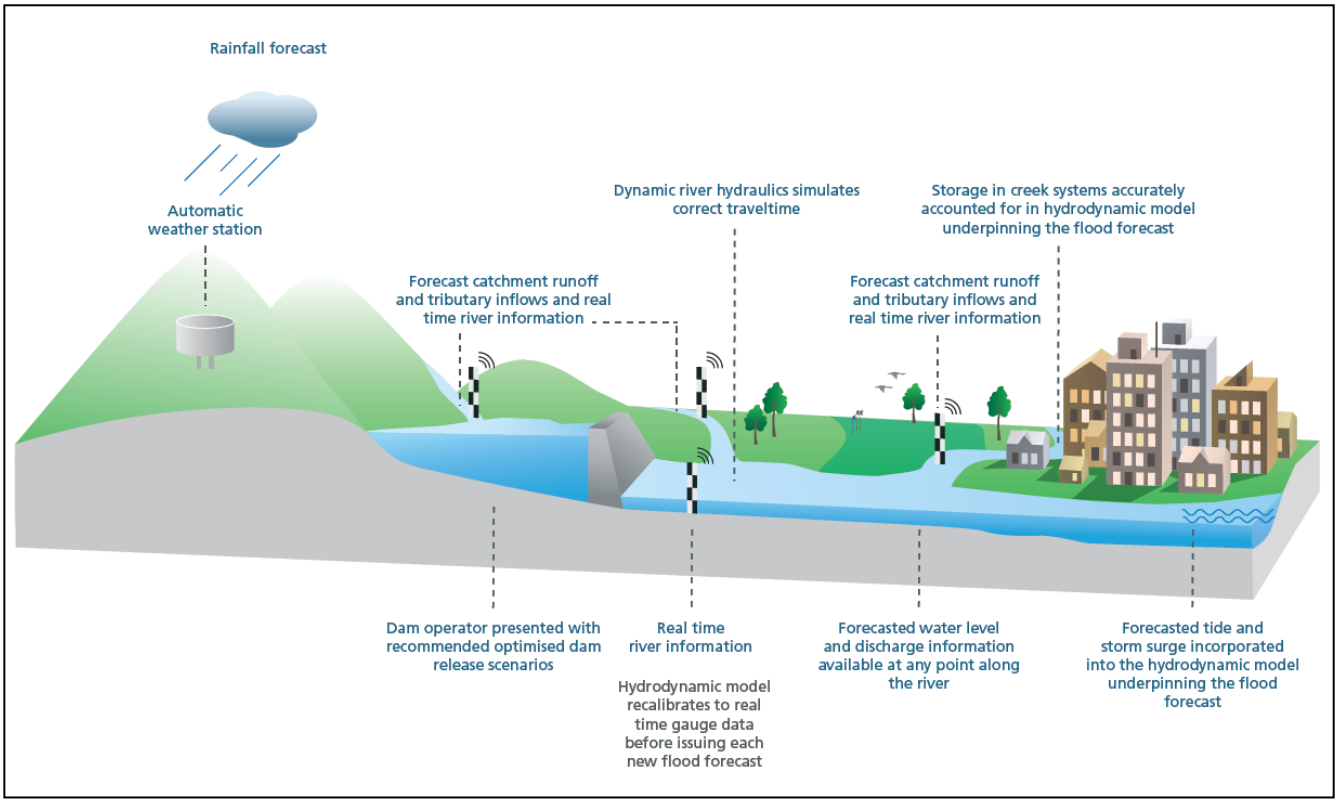
Example output from Gold Coast Flood Forecast System. Note model self-correction in hindcast period (gauge readings shown as red crosses)

Real Time Optimization of Dam Releases

A second area where flood operations in Brisbane may be improved is in the operation of the Wivenhoe and Somerset dams during flood events. The current operations are based on static rules that have been developed based on statistical analyses of the "best" release strategies covering a wide range of probable situations. This is normal practice and is probably applied for the operation of all dams in Queensland.

Recent advances in modelling and optimization technologies now allow the possibility for undertaking an assessment of the "best" release strategies in real time, taking full account of current and forecast river conditions and rainfall, which could deviate from historical norms. Utilizing a hydraulic model at its core, the optimization could for example determine the best release strategy for the next 3 hours based on forecast rainfall, catchment and downstream tributary inflows and tidal conditions, by balancing downstream flood impacts with the all important dam safety. DHI is currently engaged by State Water NSW to implement such a

system, termed Computer Assisted River Management (CARM) for the entire Murrumbidgee River system in NSW. In this case the system will optimize dam releases to minimise these releases while at the same time meeting flow and level targets downstream. The CARM system can be run in a fully automatic mode or manually by the river operators. The system has been demonstrated in a Proof of Concept which indicated historical dam releases could be significantly reduced. Similar systems are already in operation in South Africa.



Concept Diagram of Computer Assisted River Management

Streamlining Operations

The forecasting system for the Brisbane River is a complicated process of data exchange between four different agencies. Holistically speaking, dam operations and flood forecasting are intrinsically linked, as the former has a major impact on the latter. The forecasting and dam release optimization system described above lends itself to a streamlined operation and eliminates the need for manual data exchanges between different organisations during floods. The operations protocol would of course need to take due cognisance of the regulatory responsibilities of the relevant organizations (BoM, Seqwater, BCC, ICC)