Performance of RTFM

Introduction

The Real Time Flood Operations Model (RTFM) is known as FLOOD, which is a mnemonic for *Flood Level Observations and Operations of Dams*. The system was developed by the Department of Natural Resources in 1994 as part of the Brisbane River and Pine River Flood Study.

The system consists of two integrated modules:

- FLOOD-Col,
- FLOOD-Ops.

FLOOD-Col is the data capture module whilst FLOOD-Ops is the data analysis module. The system is accessed through a Graphical User Interface (GUI) that allows the operator flexibility in managing the system. The modelling system was developed under a Unix operating environment using OSF/Motif GFUI under the X Window system.

In 20??, The system was ported to a LINUX operating environment and is currently running on PCs (specs?)

FLOOD performs the following tasks;

It automatically and continuously,

- Collects, filter sand stores hydro-meteoroligic data in real time,
- Evasluates the spatial and temporal distribution of antecedent catchment soil moisture conditions on a daily basis,

Upon operator initiation.

- Assigns temporal and spatial distributions of forecasted rainfall and forecasted rainfall for extension into the future,
- Generates files from databases suitable for use in hydrologic modelling,
- Performs hydrologic routing of stream flows in an integrated environment,
- Provides estimates of storage performance and resulting downstream releases,
- Prepares summary output in textual and graphical format for storage operation and resulting downstream flood flows/levels.

Radio Telemetry Stations

The primary source of raw data for the system is rainfall, river height and lake level sensors located within and around the relevant catchments. Rainfall sensors consist of standard tipping bucket rain gauges attached to a data logger. The river height and lake level sensors vary in type and model but include shaft encoders, wet pressure transducers and dry pressure transducers. Refer to Section xx for more details.

The sensors are attached to encoder/radio transmitters that send radio signals containing an accumulated value using a standard Automated Local Evaluation in Real Time System (ALERT) style radio signal. This has become the adopted standard for flood warning networks adopted by the Bureau of Meteorology. A system of repeater stations is installed within the catchment to ensure the signals reach the base station located on top of the building housing the Flood Operations Centre.

System Architecture

FLOOD was designed as two major sub-systems; data collection and data analysis. The FLOOD modelling system was developed as a fully integrated system as it automatically associates data collected and process models with catchment spatial information.

Data Collection

Data collection is completely independent to data analysis within the FLOOD system. Data collection is performed on a sensor by sensor basis. Signals sent form the field arrive randomly at the FOC base station and are relayed to the computer hardware platforms serial port via a decoder. The system enables the serial port to receive the incoming sensor information which consists of a sensor identification number and an accumulated sensor value. The signal is read, decoded, accepted or rejected, filtered, validated and then stored in a sensor database. All information is stored in the data base even if it is considered ‘trash’ data.

A sensor details database contains details of each sensor, including:

- Sensor name
- Identification number
- Type of sensor
- Calibration information
- Alarm thresholds
- And rating curve information if applicable.

Filtered data obtained from the sensors can be viewed in a textual or graphical format. Facilities for viewing groups of sensors are available. The types of information that can be viewed or edited include height, discharge, rainfall pluviographs, rainfall hyetographs, lake levels and dam volumes.

No issues where observed with the RTFM data collection module during this event. Some sensors stopped reporting during the course of the event, but this related to issues with the field sensors and not the data collection module. Some sensors also required re-calibration during the event as they where repaired or the data started ‘drifting’.

Data Analysis

The data analysis system has been developed around the concepts of regions, processes and cases.

Regions

Regions are spatial areas such as catchments located above a stream gauging station, which can be assigned various input definitions and process modules depending upon the nature of the region. For example, a sub-catchment is assigned a soil moisture accounting process and a runoff-routing model process, whereas a reservoir region is assigned only a reservoir routing process. A region’s relationships with neighbouring regions are defined for each process associated with the region.

The regions database contains the following information;

- Extent and location of sub-areas within regions, and regions within catchments,
- Connectivity of sub-areas within regions, and regions within catchments,
- Processes associated with each region,
- Process module input definitions.

Figure X shows the region layout adopted in the FLOOD system.

Process

A Process is a computational model of a physical mechanism. Examples as stated include soil moisture accounting, runoff-routing, reservoir routing and hydraulic routing.

Soil Moisture Accounting Model

The Soil Moisture Accounting Model is used to provide an indication of the catchment wetness at the commencement of a flood event. Relationships have been derived which relate conceptual soil moisture storage volumes with rainfall loss rates.

The FLOOD system contains a number of different process models which perform similar functions. For example the Soil Moisture Accounting Module consists of several different model types which are:

- Antecedent Precipitation Index (API)
- Resdiual Baseflow Index
- SACRAMENTO Model

In this event the API model was used to derive initial estimates of rainfall loss rates during the early period of the flood event. These estimates were then modified as initial stream rises were detected and event loss rates could be then assessed by matching the timing and rate of rise.

Table xx Loss Rate Estimates of Regions - 5 January 2011

Region	**API Initial Loss (mm)**	**Sacramento Initial Loss (mm)**	**Sacramento Continuing Loss (mm/hr)**
Upper Brisbane River			
COO	28.0	26.5	3.5
LIN	22.6	13.6	3.3
EMU	30.7	25.2	2.1
CRE	33.3	29.6	3.3
GRE	29.2	23.7	3.9
Middle Brisbane River			
WDI	31.8		2.8
Stanley River			
SDI	22.2	12.3	2.5
Lockyer Creek			
HEL	30.4	25.0	4.0
TEN	24.1	0.0	3.5
LAI	14.8	0.0	4.3
GAT	29.3	21.8	3.6
LYO	28.8	20.9	4.2
Bremer River			
WAL	27.8	28.1	2.9
KAL	24.1	0.0	2.0
AMB	27.6	0.0	2.0
PUR	34.3	0.0	2.1
IPS	33.4	0.0	2.0
Lower Brisbane River			
SAV	34.2	37.3	3.0
MTC	33.1	33.0	3.8
JIN	33.5	34.0	3.8
POG	33.6	33.4	3.8
ENO	30.3	25.2	1.2
BUL	33.2	26.6	4.2

Relationships derived by the Bureau of Meteorology that link API and initial loss rate have been utilised. These equations are of the following form:-

Somerset Dam

IL = ????

Wivenhoe Dam

IL = ????

North Pine Dam

IL = ????

The continuing loss rates were varied throughout the event to ensure that the overall shape and volume of the flood event was being matched to an acceptable level.

Runoff-routing Models

An event based runoff-routing model similar to that described by Mein, Laurensen and McMahon (1974) was used to model the surface runoff from a region. The model consists of concentrated storages distributed over the region which have a non-linear storage-discharge relationship. The implementation of the model originated as WT42 (Shallcross, 1987) but was re-written in ANSI C for the inclusion of in the FLOOD system and to accommodate improved data structures required to access data in real time. The model was also modified to operate in a manner which allowed separate regions to be run as a series of linked cascading models. This formulation of the models allows for more effective use of spatially varying data.

The runoff-routing models were calibrated to up to ten historical flood events and have been used to successfully simulate operational floods in February 1999, March 1999, February 2001, February 2010 and March 2010.

Table xx Region Runoff-Routing Model Parameters

Region	**Kc**	**m**
Upper Brisbane River		
COO	43.6	0.8
LIN	20.6	0.8
EMU	37.2	0.8
CRE	34.3	0.8
GRE	20.1	0.8
Middle Brisbane River		
WDI	108.5	0.8
Stanley River		
SDI	60.3	0.8
Lockyer Creek		
HEL	15.0	0.8
TEN	19.0	0.8
LAI	42.1	0.8
GAT	61.9	0.8
LYO	53.9	0.8

Bremer River		
WAL	44.0	0.8
KAL	34.0	0.8
AMB	35.0	0.8
PUR	49.0	0.8
IPS	15.7	0.8
Lower Brisbane River		
SAV	40.0	0.8
MTC	47.0	0.8
JIN	29.4	0.8
POG	19.3	0.8
ENO	9.1	0.8
BUL	10.5	0.8

Base-flow Models

During the February and March 2010 flood events, a base flow ‘model’ was introduced to assist in the assessment of the timing of release closure sequences. This was done to add some consistency to the assessment and provide a catalogue of recession constants applicable to the various dam catchments.

The base flow model has the form:-

Base Flow = ((Base Flow at t-1)xBR) + (BCx(ModelCatchment Inflow at t)^BM))

Where:

t= Current Time Step
BR = Base Flow Recession Constant (~0.90 or less than unity)
BC = Surface Runoff Factor (~0.004)
BM = Power (~1.0)

Reservoir Routing Models

The reservoir routing models incorporated into the FLOOD system are based on level pool routing algorithims. The models for Somerset Dam and Wivenhoe Dam are complicated by the fact the dams are operated conjunctively to maximise the flood mitigation benefits of the overall system and so therefore they have been adapted to reflect the gate configurations of each particular dam.

The gate operations module incorporated into FLOOD is an adaptation of a stand alone computer program known as WIVOPS that incorporates the flood operation objectives described in the October 2004, Version 6 of the ‘Manual of Operational Procedures for Flood Mitigation for Wivenhoe Dam and Somerset Dam’.

WIVOPS was modified in May 2005 to incorporate the Stage I auxiliary spillway works as defined in the Wivenhoe Dam Alliance Report entitled,’ Design Discharges and Downstream Impacts of Wivenhoe Dam Upgrade’, Report Number Q1091, June 2004.

The WIVOPS configuration incorporated into the FLOOD system does not fully reflect the revised operational strategies of the current Version 9 of the Manual which considers the latest revision of design flood hydrology of Somerset Dam.

Therefore, inflow estimates have to be extracted from the FLOOD system and imported into customised gate operation spreadsheets for use in determining appropriate gate operation strategies in accordance with the latest manual.

Case

A Case is an event based sequence of processes applied to a number of regions. Generally, all regions are included in a case, which is identified by a unique case name. The following items are required to define a Case and are entered through the case edit mode:

- Name and description of Case,
- Simulation start time, time_now, simulation finish time and computational time step,
- Rainfall to time_now,
- Rainfall loss model type and required rainfall loss rates and spatial distribution,
- Forecast rainfall duration, depth, spatial and temporal distribution,
- Regions included in Case,
- Hydrologic model routing parameters,
- Reservoir start volume and operating procedure.