



# **FEWS for CHPS**

## **Design Document**

**April 2007**



Table



Chart

Manual Forecast

Log Browser

Forecast Manager

What-if Scenario

Longitudinal Display

Flood Map Display

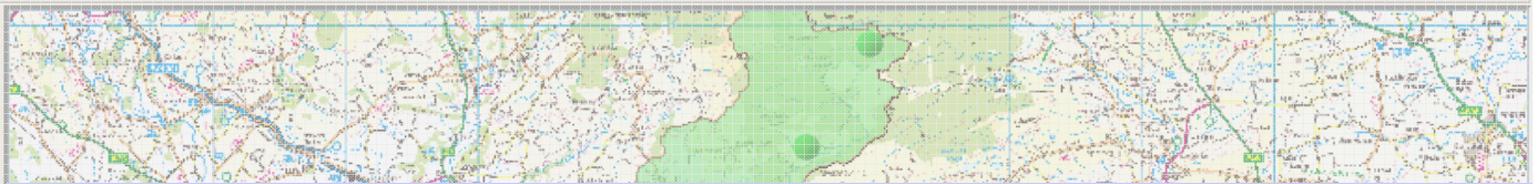


- Hydrological gauges
- Hydrological Forecast Points
- Meteorological gauges
- Catchments

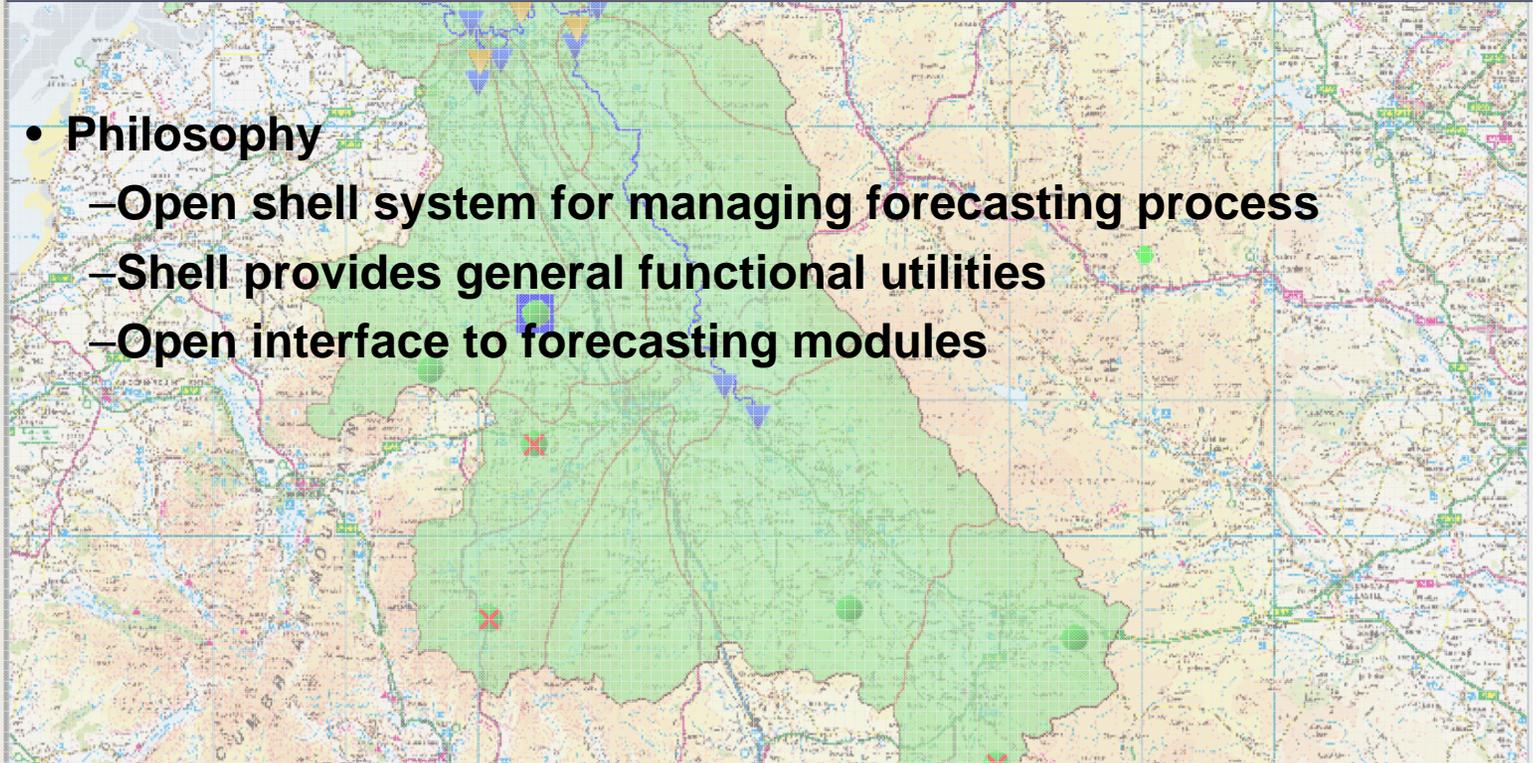
- Aisgill Moor
- Barras
- Brotherswater
- Castlethwaite
- Coalburn
- Cummersdale
- Great Corby
- Green Close
- Greenholme
- Harraby Green
- Holme Head
- Linstock
- Mosedale
- Scalebeck
- Sheepmount
- Skelton
- Temple Sowerby
- Udford
- Ungauged Catchments

- Calculated Discharge
- Simulated Discharge
- Simulated Historical Discharge
- Simulated Forecast Discharge
- Updated Discharge
- Merged discharge
- Typical Profile
- Observed Water Levels
- Simulated Historical Water Levels

1999-01-06 04:00 Eden Floodmap



## DELFT-FEWS- An open shell flood forecasting system



- **Philosophy**
  - Open shell system for managing forecasting process
  - Shell provides general functional utilities
  - Open interface to forecasting modules

< >



# Presentation Agenda

<b>Delft FEWS Standalone System Architecture</b>	<b>4</b>
<b>CHPS FEWS Pilot Software Architecture</b>	<b>5</b>
<b>Delft FEWS Design Approach</b>	<b>6-9</b>
<b>Delft FEWS Configuration</b>	<b>10-17</b>
<b>CHPS FEWS Pilot Setup for NWRFC, NCRFC</b>	<b>18-48</b>



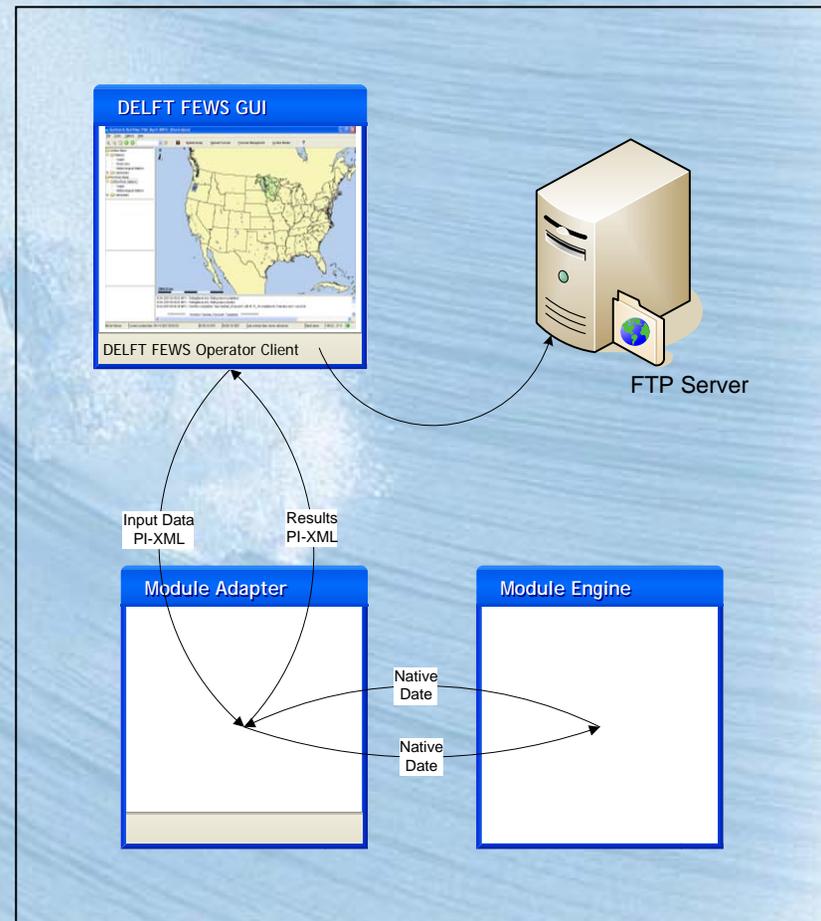
# Stand Alone System

(Distributed system available but not used for Pilot)

FEWS Explorer  
Main GUI  
Task Running

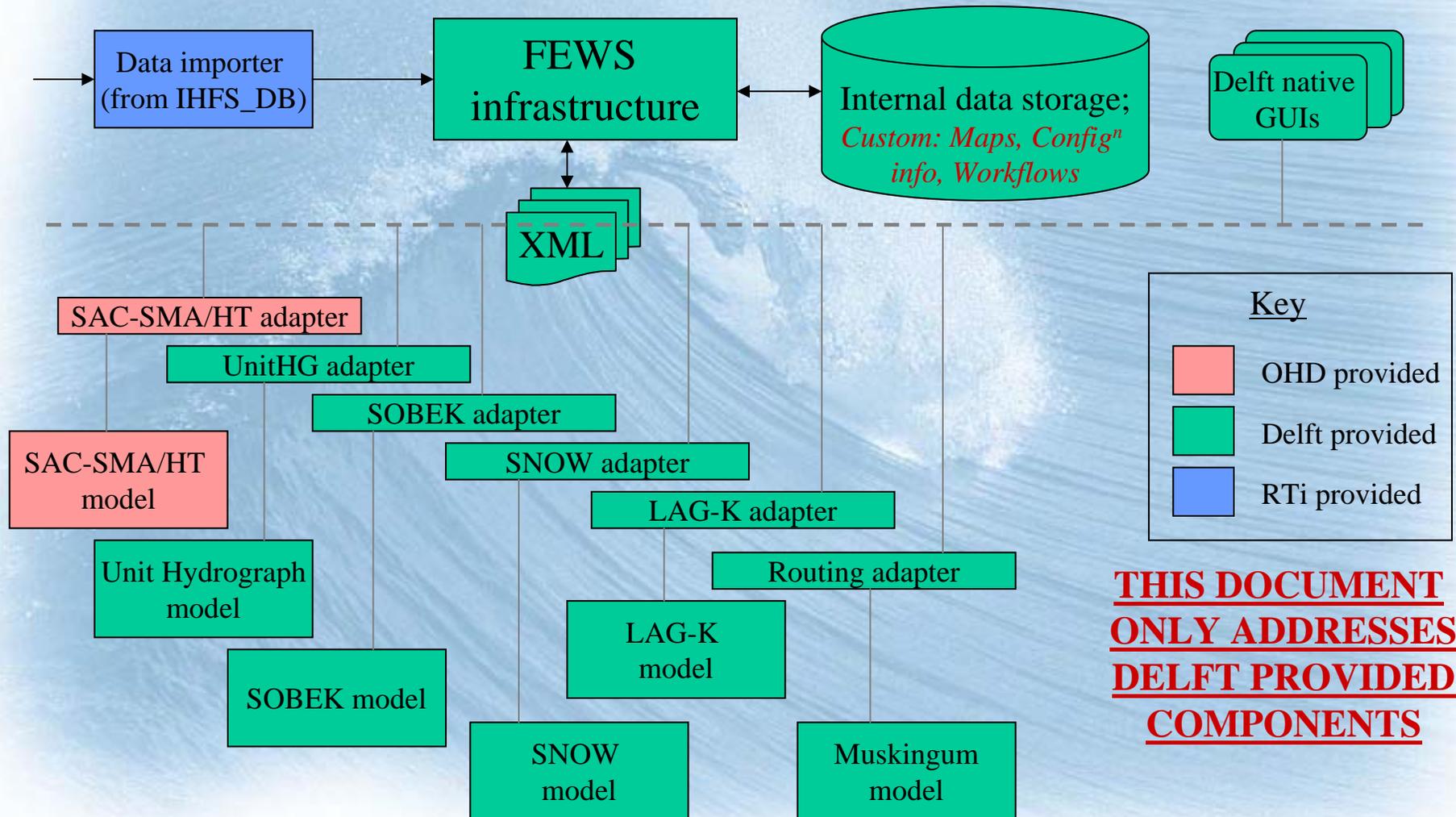
Running models  
Through adapters  
Under control of FEWS-GUI

AWIPS/Linux





# CHPS FEWS Pilot software architecture



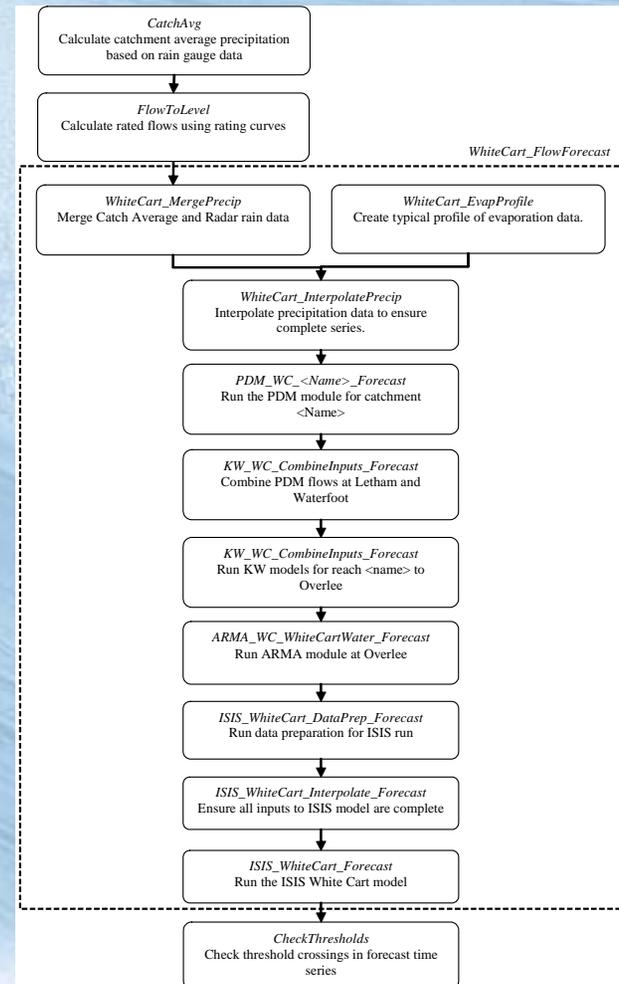
**THIS DOCUMENT ONLY ADDRESSES DELFT PROVIDED COMPONENTS**



# FEWS Approach

## Modular Approach

- **WhiteCart\_Forecast workflow**





# Open interface to models

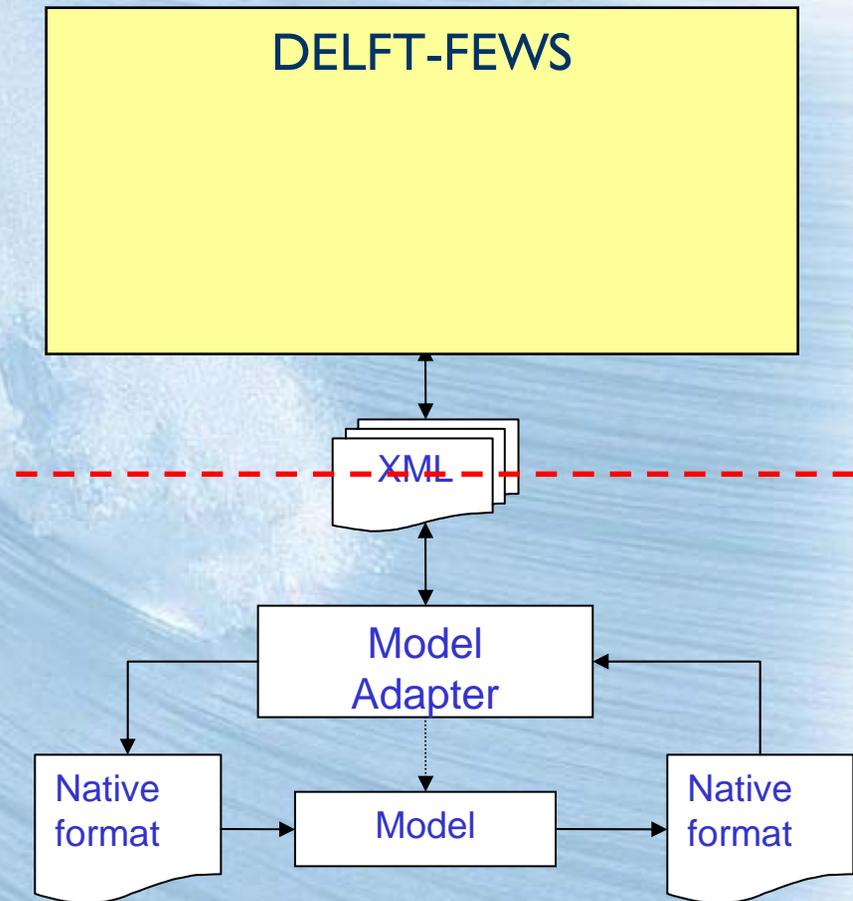
## General Adapter Module

- Published interface (XML)
- Module adapters

## OpenMI adapter

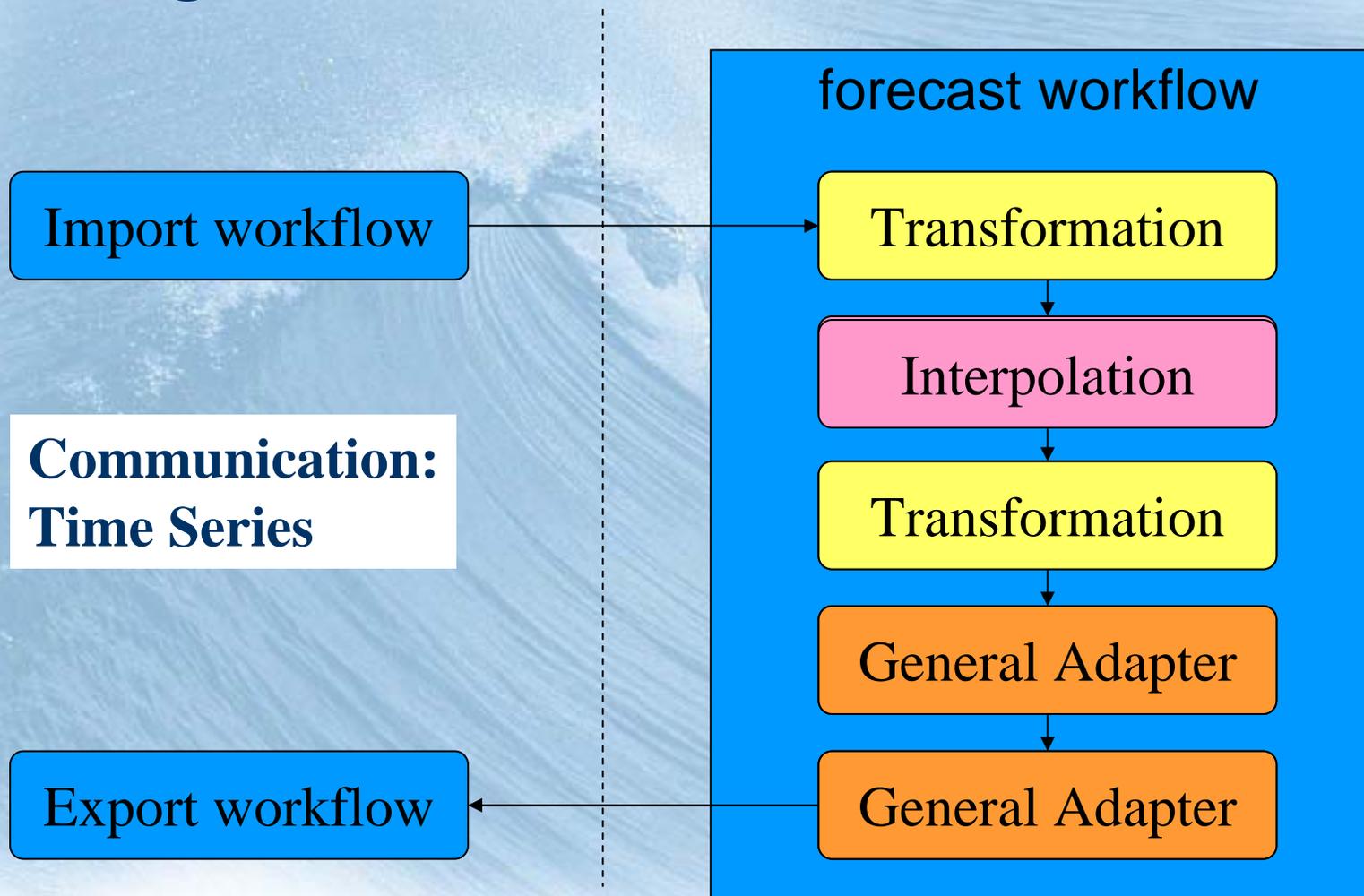
## Philosophy

- No model intelligence in DELFT-FEWS
- Model intelligence vested in model adapter



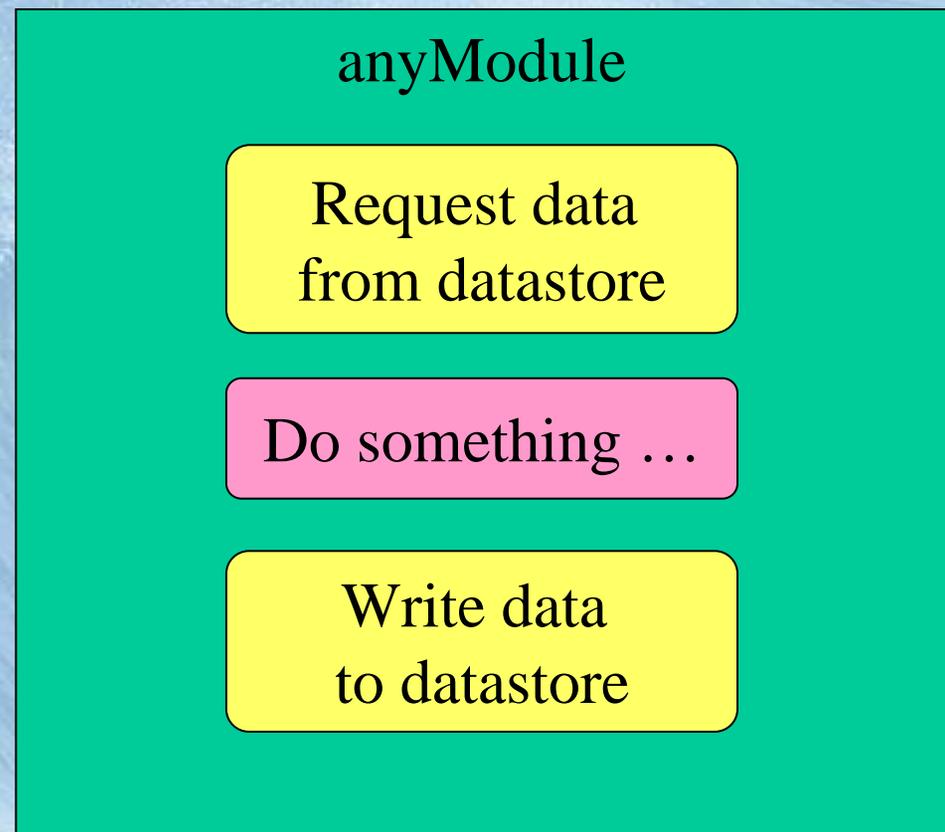


## Running modules in a workflow





## General Module layout





# DELFT FEWS Configuration

## Elements of the DELFT-FEWS configuration

- Main DELFT-FEWS configuration (*config* directory)
- Root configuration
- Layout configuration
  - Icons
  - Maps
- External Modules



# FEWS Configuration

## Main DELFT-FEWS Configuration (Stand Alone: Config directory)

- All configuration in XML format
- Various section
  - RegionConfigFiles                      Locatios, Parameters etc.
  - SystemConfigFiles                      Main system config
  - ModuleConfigFiles                      All “processing” modules
  - DisplayConfigFiles                      Displays
  - WorkflowFiles                              Defintion of workflows



## XML Configuration and XSD Schemas

- Each XML configuration adheres to a XSD schema
- Independent check on correct information
  - Required Items
  - Optional items
  - Types





# Defining Locations

## Locations.xml

<b>geoDatum</b>	WGS 1984																																																				
<b>Comment</b>	Locations - Santiam																																																				
<b>location</b> (61)																																																					
<b>Comment</b>	MAP/MAT locations Santiam																																																				
<b>location</b> (28)																																																					
<b>Comment</b>	Locations -RedRiver																																																				
<b>location</b> (35)																																																					
	<table border="1"> <thead> <tr><th></th><th><b>id</b></th><th><b>name</b></th><th><b>description</b></th></tr> </thead> <tbody> <tr><td>1</td><td>ABRN8</td><td>Abercrombie</td><td>Wild Rice River</td></tr> <tr><td>2</td><td>BKRM5</td><td>Baker</td><td>Stoney Creek</td></tr> <tr><td>3</td><td>SABM5</td><td>Sabin</td><td>Buffalo River Sou</td></tr> <tr><td>4</td><td>HWYM5</td><td>Hawley</td><td>Buffalo River</td></tr> <tr><td>5</td><td>DILM5</td><td>Dillworth</td><td>Buffalo River</td></tr> <tr><td>6</td><td>DDBM5</td><td>Dillworth Local</td><td>Buffalo River</td></tr> <tr><td>7</td><td>FGON8</td><td>Fargo</td><td>Red River</td></tr> <tr><td>8</td><td>HWDN8</td><td>Harwood</td><td>Sheyenne River</td></tr> <tr><td>9</td><td>HICN8</td><td>Hickson</td><td>Red River</td></tr> <tr><td>10</td><td>BJI</td><td>Bemidji AWOS</td><td>Red River Basin</td></tr> <tr><td>11</td><td>CKN</td><td>Crookston Muncpal Airport</td><td>Red River Basin</td></tr> <tr><td>12</td><td>DTI</td><td>Detroit Lakes Airport</td><td>Red River Basin</td></tr> </tbody> </table>		<b>id</b>	<b>name</b>	<b>description</b>	1	ABRN8	Abercrombie	Wild Rice River	2	BKRM5	Baker	Stoney Creek	3	SABM5	Sabin	Buffalo River Sou	4	HWYM5	Hawley	Buffalo River	5	DILM5	Dillworth	Buffalo River	6	DDBM5	Dillworth Local	Buffalo River	7	FGON8	Fargo	Red River	8	HWDN8	Harwood	Sheyenne River	9	HICN8	Hickson	Red River	10	BJI	Bemidji AWOS	Red River Basin	11	CKN	Crookston Muncpal Airport	Red River Basin	12	DTI	Detroit Lakes Airport	Red River Basin
	<b>id</b>	<b>name</b>	<b>description</b>																																																		
1	ABRN8	Abercrombie	Wild Rice River																																																		
2	BKRM5	Baker	Stoney Creek																																																		
3	SABM5	Sabin	Buffalo River Sou																																																		
4	HWYM5	Hawley	Buffalo River																																																		
5	DILM5	Dillworth	Buffalo River																																																		
6	DDBM5	Dillworth Local	Buffalo River																																																		
7	FGON8	Fargo	Red River																																																		
8	HWDN8	Harwood	Sheyenne River																																																		
9	HICN8	Hickson	Red River																																																		
10	BJI	Bemidji AWOS	Red River Basin																																																		
11	CKN	Crookston Muncpal Airport	Red River Basin																																																		
12	DTI	Detroit Lakes Airport	Red River Basin																																																		

```

<!-- Locations -RedRiver-->
<location id="ABRN8" name="Abercrombie">
  <description>Wild Rice River</description>
  <shortName>Abercrombie</shortName>
  <x>-96.783</x>
  <y>46.468</y>
  <z>276.740</z>
</location>
<location id="BKRM5" name="Baker">
  <description>Stoney Creek</description>
  <shortName>Baker</shortName>
  <x>-96.360</x>
  <y>46.740</y>
</location>
<location id="SABM5" name="Sabin">
  <description>Buffalo River South Branch</description>
  <shortName>Sabin</shortName>
  <x>-96.627</x>
  <y>46.776</y>
</location>
<location id="HWYM5" name="Hawley">
  <description>Buffalo River</description>
  <shortName>Hawley</shortName>
  <x>-96.329</x>
  <y>46.850</y>
</location>
<location id="DILM5" name="Dillworth">
  <description>Buffalo River</description>
  <shortName>Dillworth</shortName>
  <x>-96.661</x>
  <y>46.961</y>
</location>
<location id="DDBM5" name="Dillworth Local">
  <description>Buffalo River</description>
  <shortName>Dillworth Local</shortName>
  <x>-96.520</x>

```



# LocationSets

- Allows Defining locations with common properties
- Locations may exist in various “sets”
- Apply operation to set of n locations - rather than n times to 1 location per time

locationSet (29)		locationSetId	locationId
<b>= id</b>			
1	HydroStations	locationSetId (2)	
2	HydroStations_Santiam		locationId (8)
3	Reservoirs_Santiam		locationId (3)
4	HydroStations_RedRiver		locationId (8)
			Abc Text
			1 ABRN8
			2 BKRM5
			3 SABM5
			4 HWYM5
			5 DILM5
			6 FGON8
			7 HWDN8
			8 HICN8
5	Ratings_RedRiver		locationId (8)
6	ExternalForecast_RedRiver		locationId (4)



# Running a model through the General Adapter

## SACSMA\_GPRO3IU\_Historical 1.00 default.xml

generalAdapterRun	
xmlns	http://www.wldelft.nl/fews
xmlns:xsi	http://www.w3.org/2001/XMLSchema-instance
xsi:schemaLoc...	http://www.wldelft.nl/fews http://fews.wldelft.nl/schemas/version1.0/generalAdapterRun.xsd
general	
activities	
exportActivities	
exportStateActivity	
exportTimeSeriesActivity	
exportFile	inputs.xml
timeSeries Sets	
timeSeries Set (2)	
exportParameterActivity	
executeActivities	
executeActivity	
command	
className	ohd.hseb.fewsadapter.FewsAdapter
arguments	
argument (10)	
timeOut	30000
importActivities	
importStateActivity	
stateConfigFile	%ROOT_DIR%/states/states.xml
importTimeSeriesActivity	
importFile	sacsmaoutput.xml
timeSeries Sets	



## Workflows

**‘hydrologically’ logical sequence of running modules**

- **Multiple modules/steps per segment**
- **Granularity configurable**
  - **Workflow per forecast group**
  - **Workflow per segment**

## Demo

**Amend the Fluvial\_Forecast workflow**

**Provide a “new” workflow that runs the Great Peter Inflow segment only**

•



# Workflows

Follow “Hydrological” order

workflow		
<b>xmlns</b>	http://www.wldelft.nl/fews	
<b>xmlns:xsi</b>	http://www.w3.org/2001/XMLSchema-instance	
<b>xsi:schemaLoc...</b>	http://www.wldelft.nl/fews http://fews.wldelft.nl/schemas/version1.0/workflow.xsd	
<b>version</b>	1.1	
<b>activity (7)</b>		
<b>Comment</b>	Green Peter Segment	
<b>activity (8)</b>		
	<b>runIndependent</b>	<b>moduleInstanceld</b>
1	true	SNOWMELT_GPRO3IU_Forecast
2	true	SNOWMELT_GPRO3IL_Forecast
3	true	SAC SMA_GPRO3IU_Forecast
4	true	SAC SMA_GPRO3IL_Forecast
5	true	GPRO3_WeighTS_Forecast
6	true	UNITHG_GPRO3I_Forecast
7	true	ARMA_GPRO3I_Forecast
8	true	ROUTE_GPRO3_Forecast
<b>Comment</b>	Foster Dam Segment	
<b>activity (9)</b>		
<b>Comment</b>	WaterInn Segment	

Demo: Configure GPRO3 as separate workflow



## CHPS FEWS Pilot

### Current Pilot

- Explore/Demonstrate using FEWS for providing forecasting capabilities
- Explore/Demonstrate modularity of FEWS in delivering this and how this approaches the SOA concept

### Pilot basins/Segments

- Santiam in NWRFC
- Buffalo River and Red River SOBEK model in NCRFC



# CHPS FEWS Pilot

## Main Elements of each basin

### Santiam

- Catchments (Snow, Runoff, UnitHG)
- Reservoirs
- Routing
- Naturals
- Effective locals

### Red River

- Catchments (Snow, Runoff, UnitHG, Frozen Ground)
- SOBEK Routing



# Setting up the CHPS FEWS Pilot

## Approach to configuration

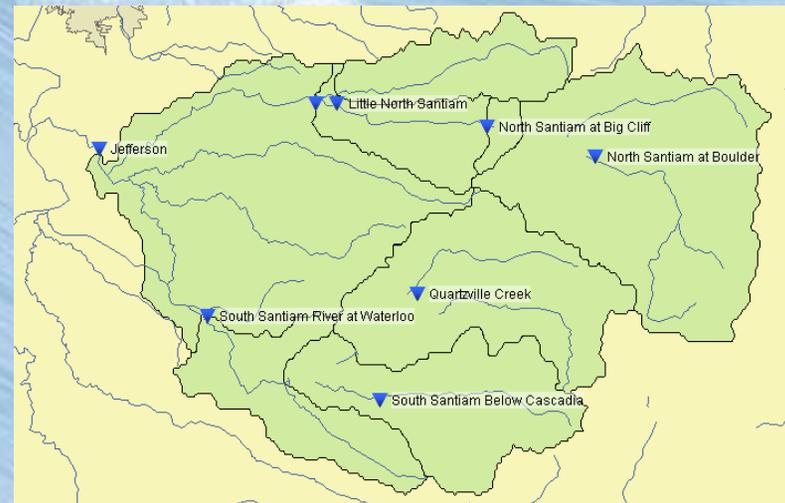
- Static data (Locations, Parameters) *slides 21-23*
- Importing data from external sources *slides 24-25*
- Pre-processors (MAP, MAT) *slides 26-27*
- Models *slides 28-33*
  - SNOW-17, SAC-SMA, UNITHG, SARRESV, SARROUTE, LAG-K, TATUM
- Additional Data handling *slide 34*
- Displays *slide 35*
  - PLOT-TULSA
- MODs *slides 36-38*
- Calibration of models *slides 39-48*



## Static Data

### Locations - Santiam Basin to Jefferson

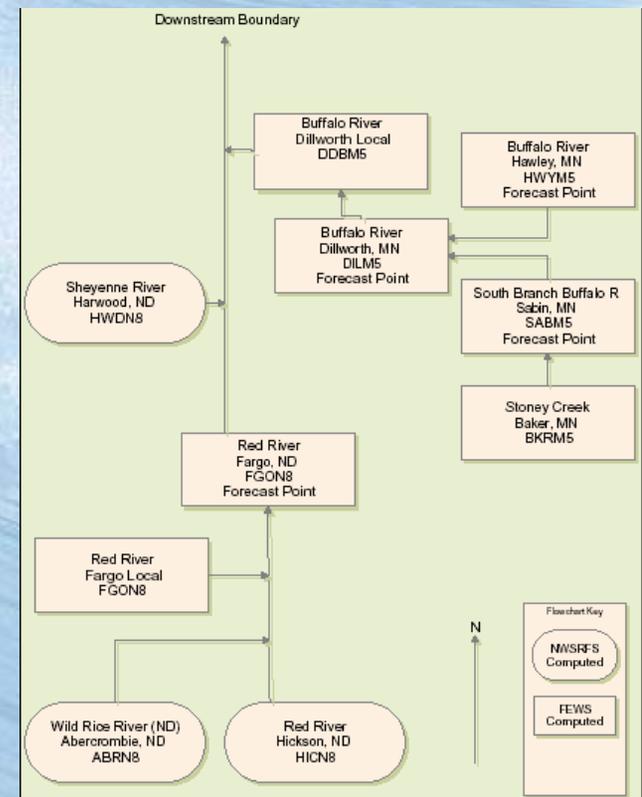
- All locations defined in **SEGMENTS** set up in **FEWS** (some reduction in “dummy locations”)
  - Temp/Precip gages
  - River Gages
  - Reservoirs (3)
  - Catchments (14)



# Static Data

Locations – Buffalo River & Red River  
 All locations defined in SEGMENTS  
 set up in FEWS

- Temp/Precip gages
- River Gages
- Catchments (5)





## Static Data

### Parameter Naming Conventions

- Taken from NWSRFS Convention
- **UNITS are METRIC**
  - Database
  - Displays



## Importing Data

### Process

- Data extracted from IHFSDB (Danny's Program) – XML files
- dropped in Import Folder
- FEWS Reads from there

### Source Type Codes

- All source type codes exported
- Handshake set to import data for specified type codes per location



## Importing Data - Additional

### **SHEF**

- **SHEF Data for NCRFC**
- **Inflows into Red River not calculated in FEWS pilot**
- **MAP – MAT for checking**

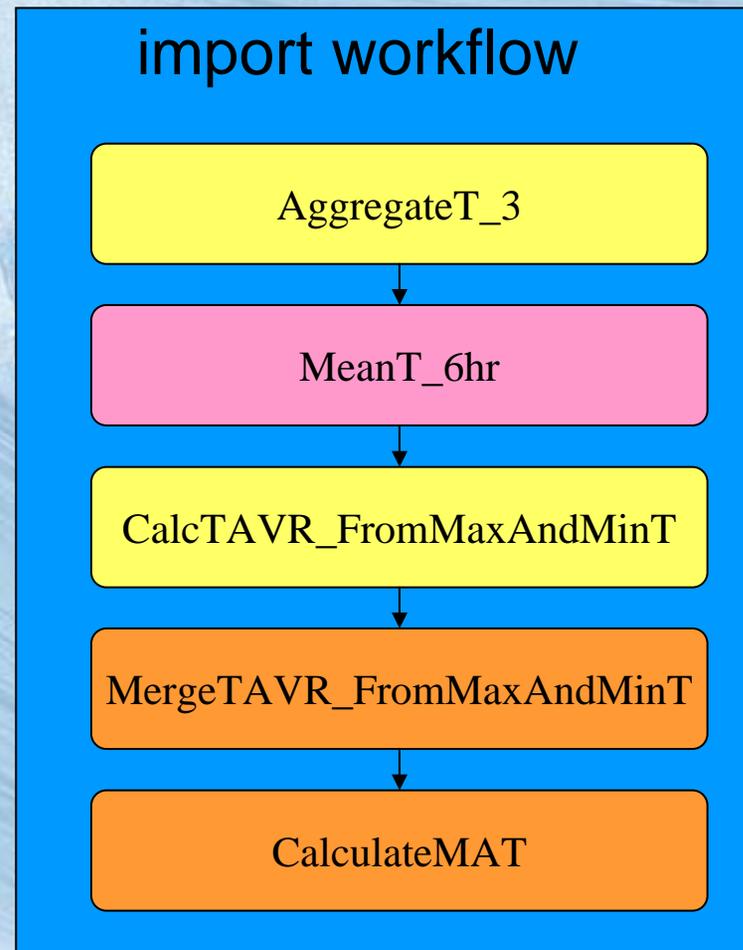
### **MPE (MAPG)**

- **Gridded radar precip fields**
- **Imported through GRIB1 Files**



## Configuring pre-processors

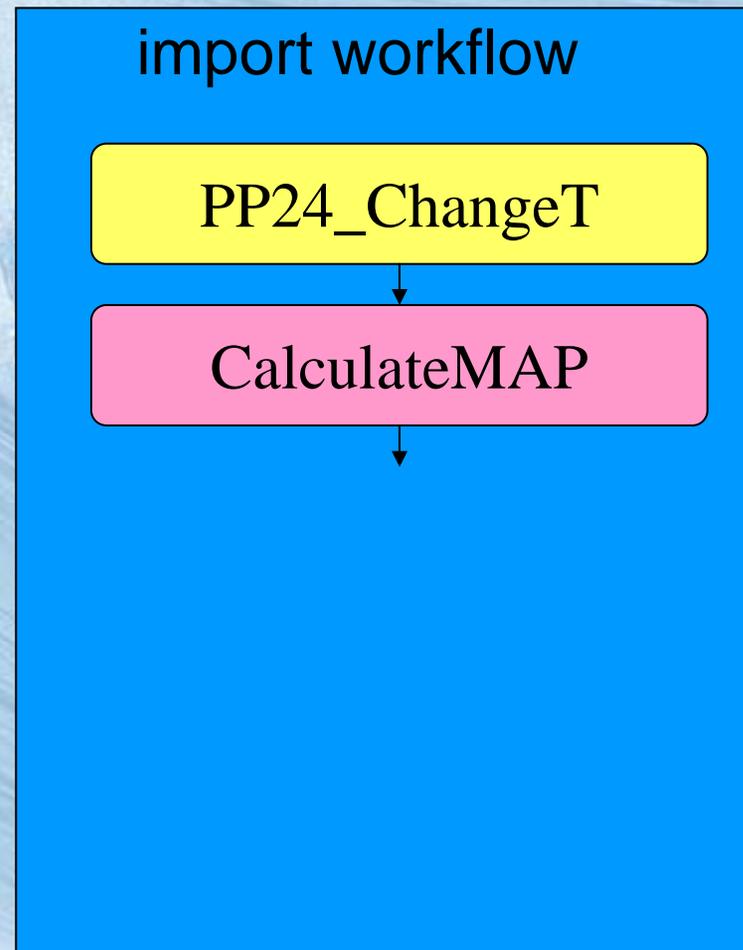
- **MAT**
  - T available at various resolutions
  - 24h data disaggregated
  - 3h data aggregated
  - Merged with 6 hr data
  - MAT calculated
    - Weights (distance)
    - Elevation normalised using temp lapse





## Configuring pre-processors

- **MAP**
  - PP24 used as backup to 6hr
  - MAP calculated as weighted average





## Models - Snow

**NWSRFS: SNOW-17**

**FEWS: SNOWMELT**

- Degree-Day model
- Discrete elevation zones (elevation-areas)
- Inputs
  - MAT & MAP (SNOG not used)
- Outputs
  - SWE, RAIM, SASC





## Models - Runoff

**NWSRFS: SAC-SMA**

**FEWS: SAC-SMA**

- Legacy model migrated
- Adapter developed by Suddha
- Frozen-Ground model (NCRFC)
  
- Inputs
  - RAIM (legacy)
  
- Outputs
  - INFW





## Models - UNITHG

### NWSRFS: UNIT-HG

### FEWS: GammaModel

- Allows UNIT-HG routing
- Same ordinates as NWSRFS
- Inputs
  - INFW
- Outputs
  - SQIN





## Models - Reservoirs

NWSRFS: SARRESV

FEWS: SAMRT

- Simple Resv model
- Area-Elevation
- Spill & setting of Pool elevation and Q-out
  
- Inputs
  - QINE (SQIN)
  - RQOT, FBEL
  
- Outputs
  - SQIN, PELE





## Models - Routing

**NWSRFS: SARROUT, LAG-K, TATUM**

**FEWS: SAMRT**

- Muskingum Routing
- Single parameterisation
  
- Inputs
  - QINE (SQIN)
  
- Outputs
  - SQIN





## Models - Additional

NWSRFS: - FldWav

FEWS: SOBEK

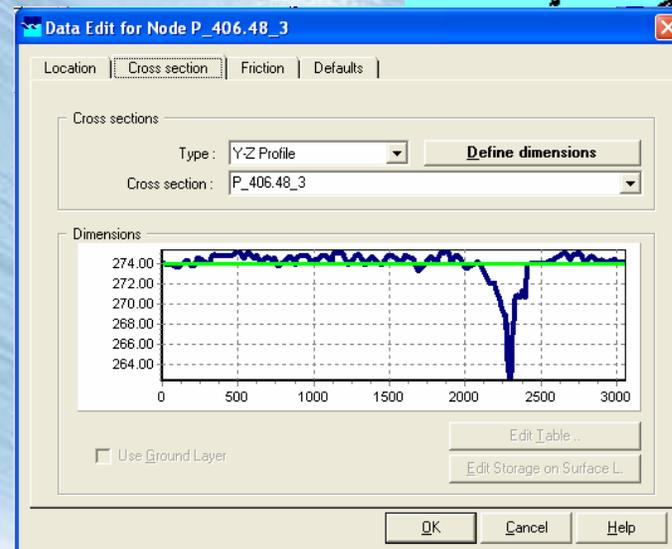
- Hydrodynamic Routing
- Transformed from HEC-RAS model

- Inputs

  - SQIN

- Outputs

  - SQIN, SSTG



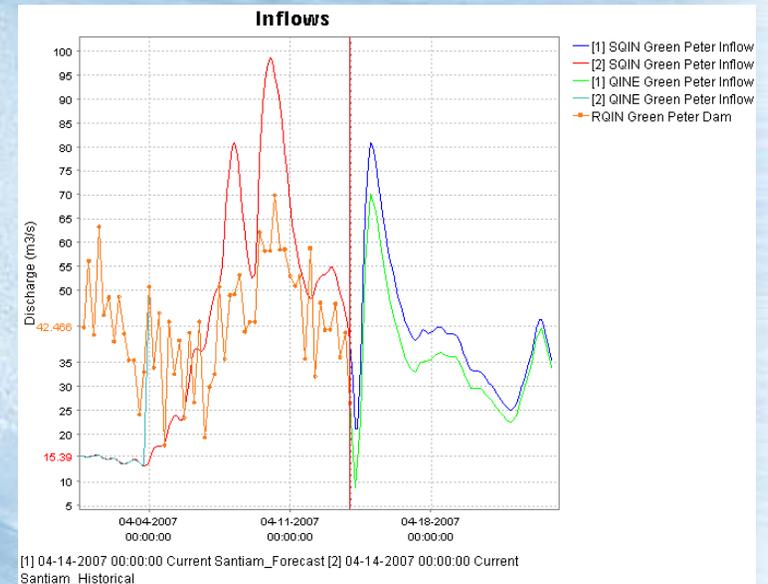


## Additional Data handling

NWSRFS: ADJUST-Q  
FEWS – ARMA Model  
Fixed “blend” rate

NWSRFS – CHANGET, WEIGH-TS,  
ADDSUB  
(confluences, naturals, effective  
locals etc)

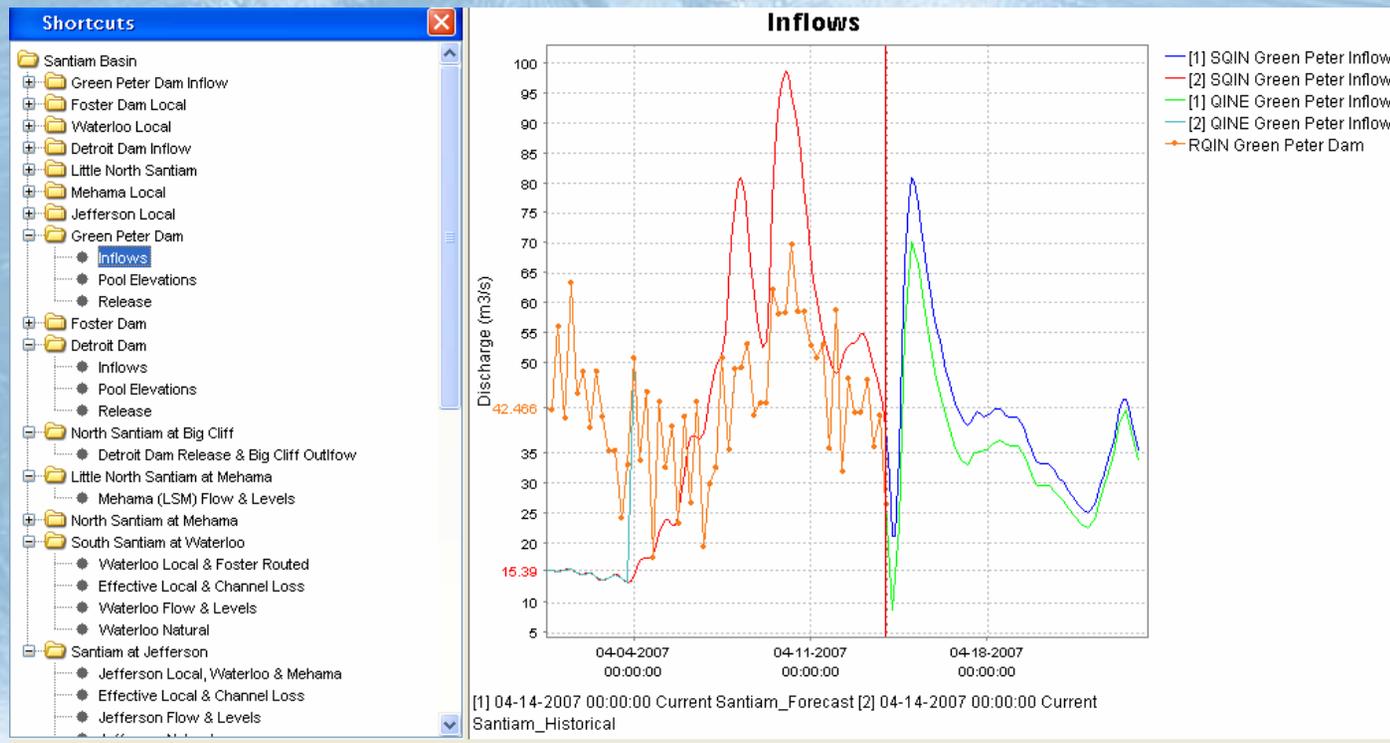
FEWS – Transformation Module



# Displays

Available through pre-configured displays

- On the fly displays also available





# MODS (I)

Available as What-if scenarios

Configured changes allowed to

- MAP & MAT
- FMAP & FMAT
- FBEL, RQOT
- QIN

Changes

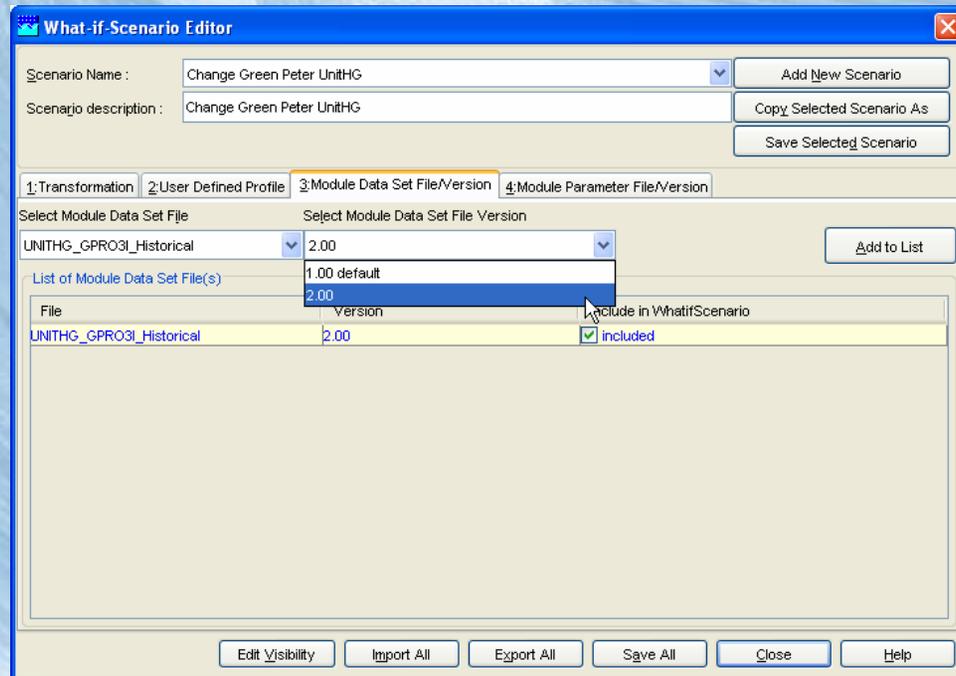
- Arithmetic operators
- Typical profiles



## MODS (2)

### Changes to model parameters

- Multiple parameterisat sets available
- Selection of parameter set version





## **MODS (3)**

### **NWSRFS: MODS**

### **FEWS: What-If scenarios**

- **Need to be selected explicitly to run with forecast**
- **not possible to set validity data**
- **less interaction with model parameters**



# Model Calibration

**Historic dataset**

**1948-2005**

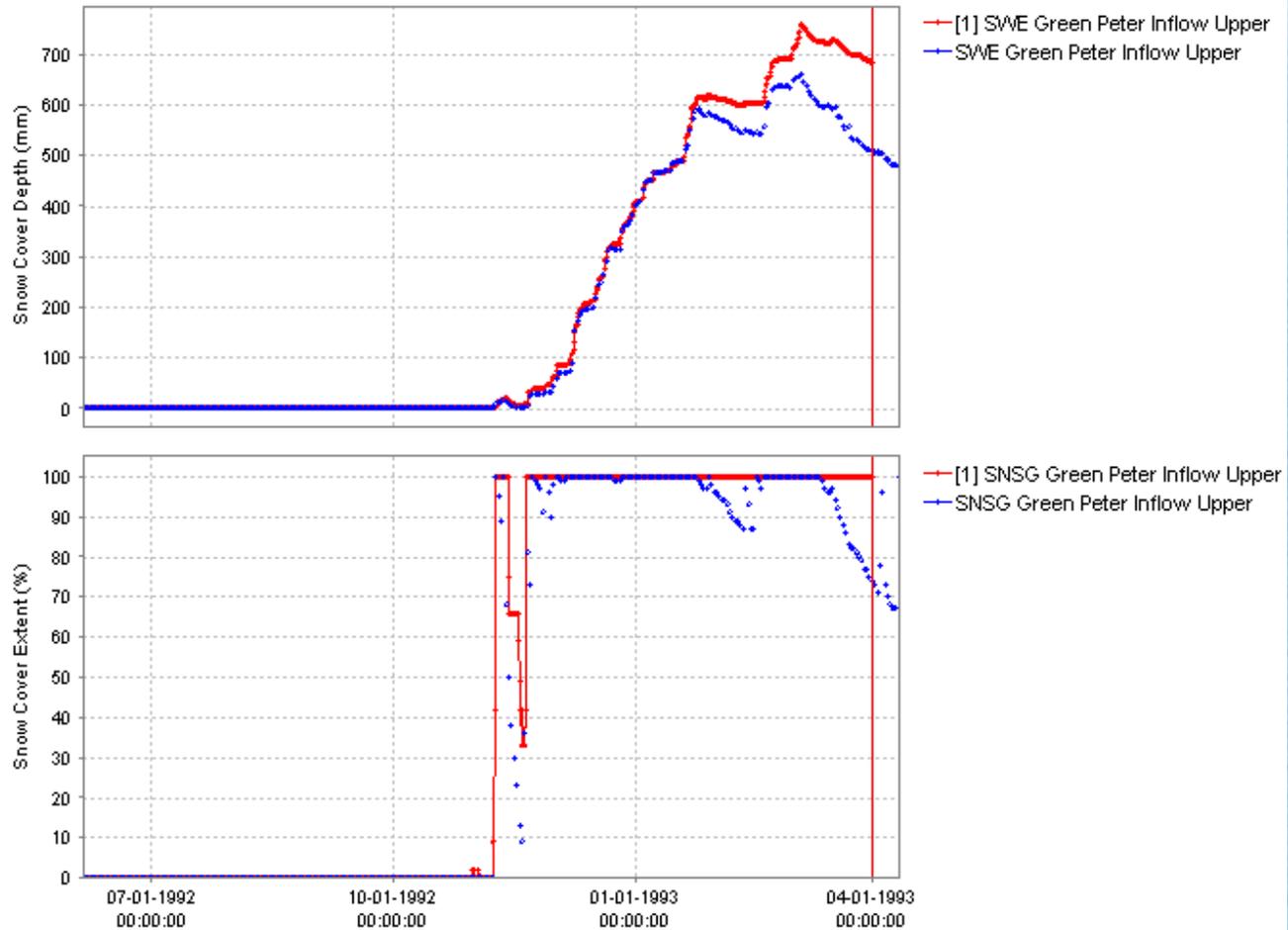
**(contiguous for smaller period)**

**Concentrated on Snow models**

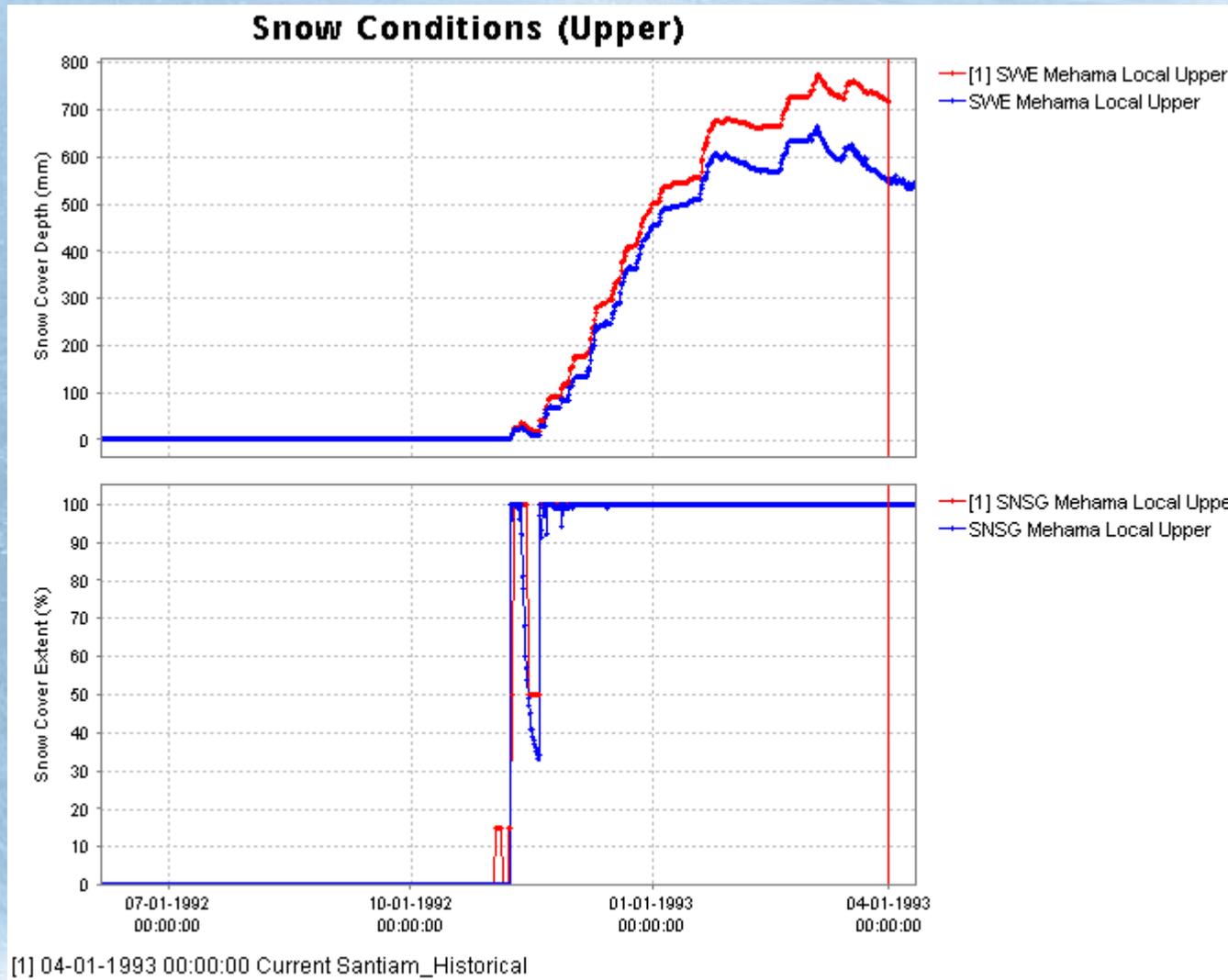
- **“Translation” of parameters from SNOW-17**
- **UNIT-HG, SAC-SMA same as in NWSRFS**
- **Reservoirs – mainly geometric data – translation of some data required (volume –elevation vs area elevation)**
- **Routing models – simple parameterisation**
- **SOBEK model – (very) rough**

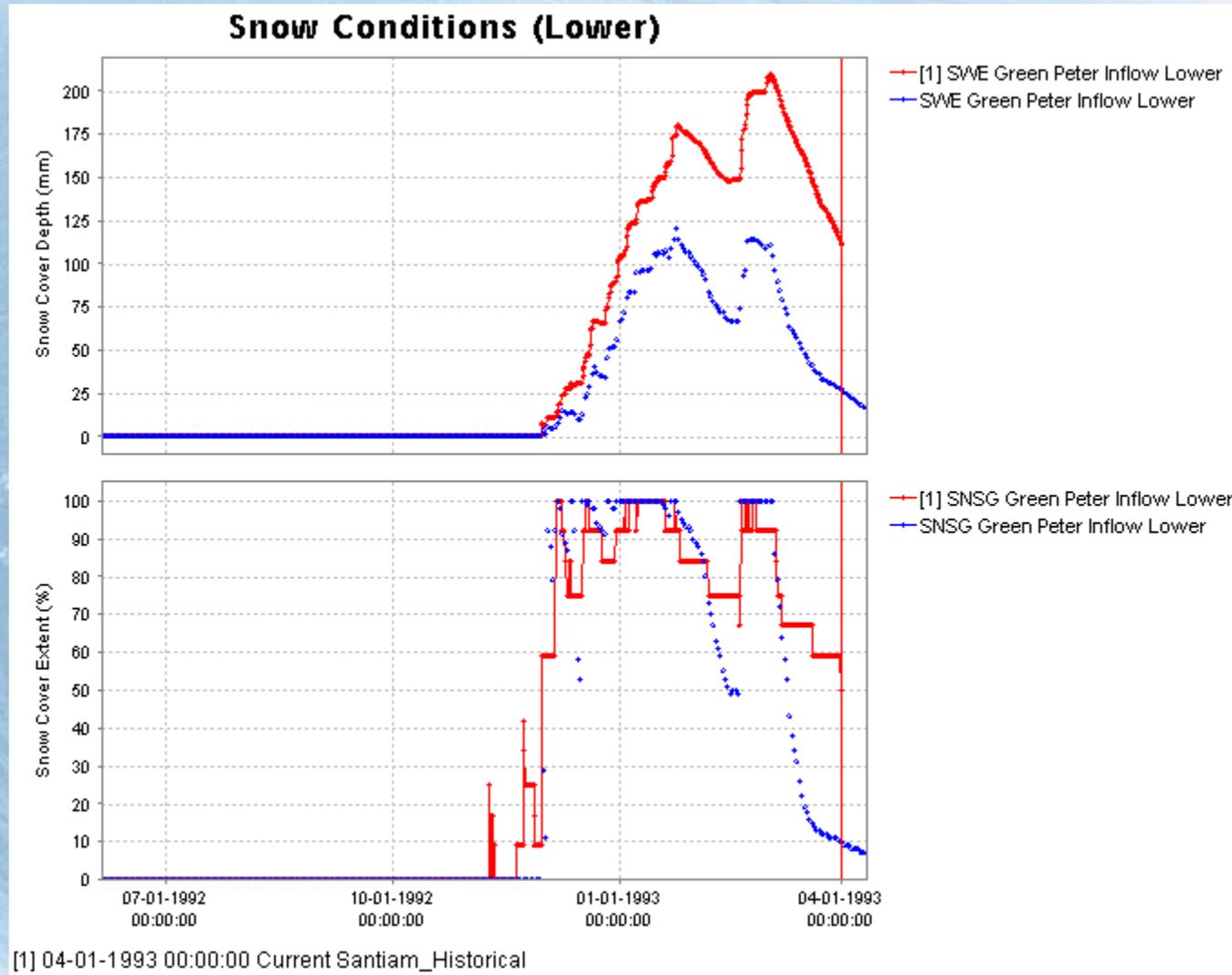


### Snow Conditions (Upper)



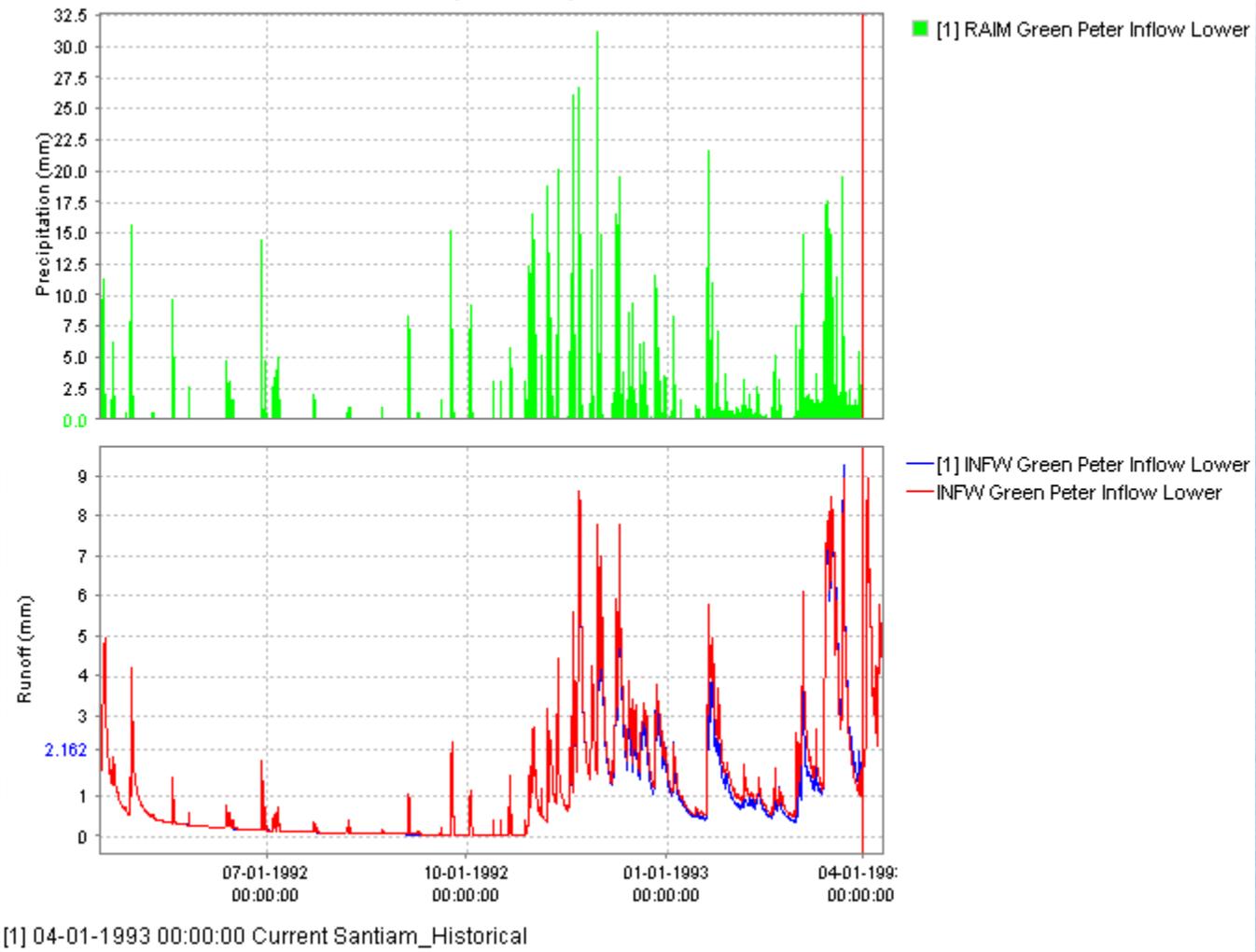
[1] 04-01-1993 00:00:00 Current Santiam\_Historical





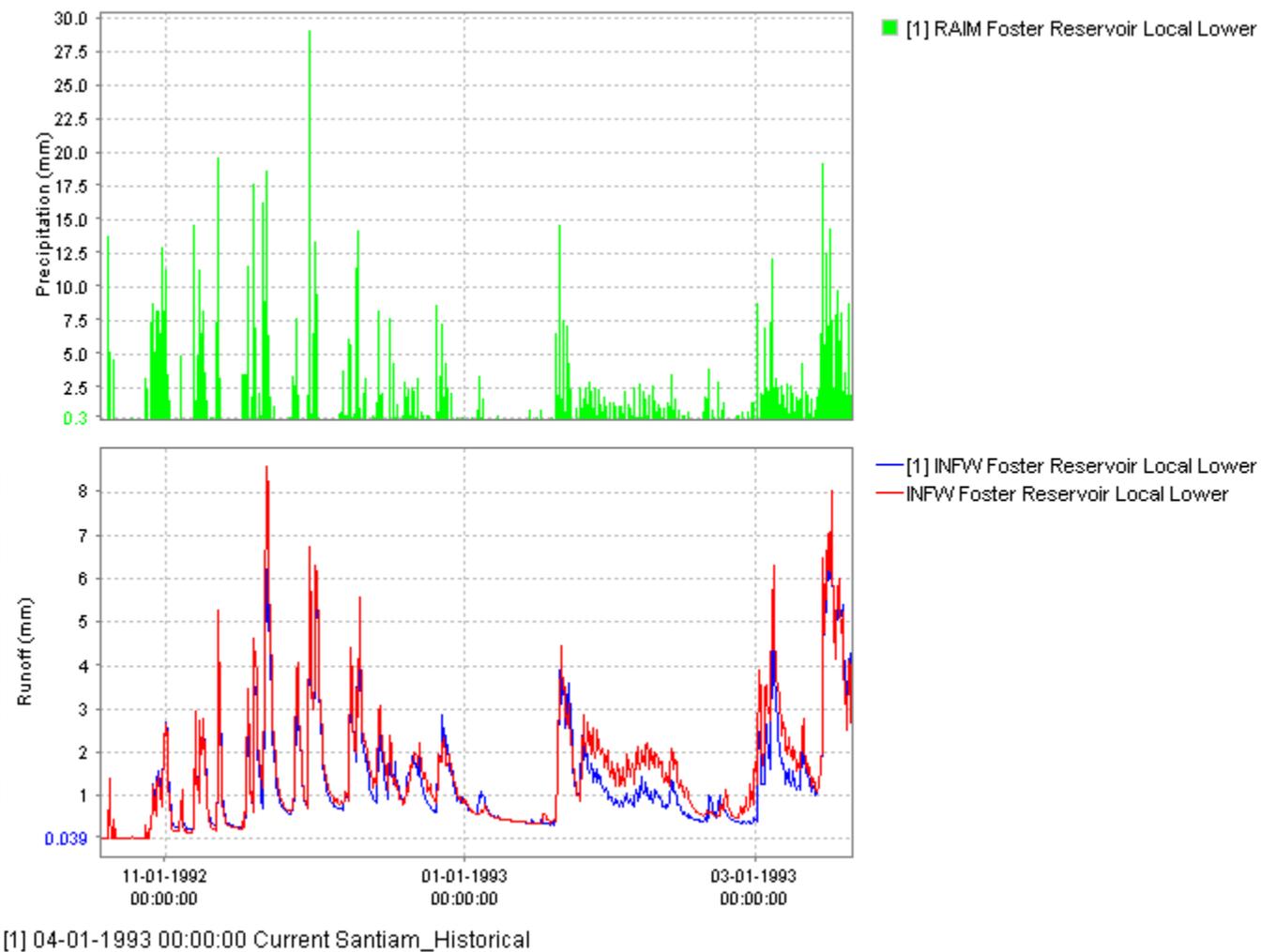


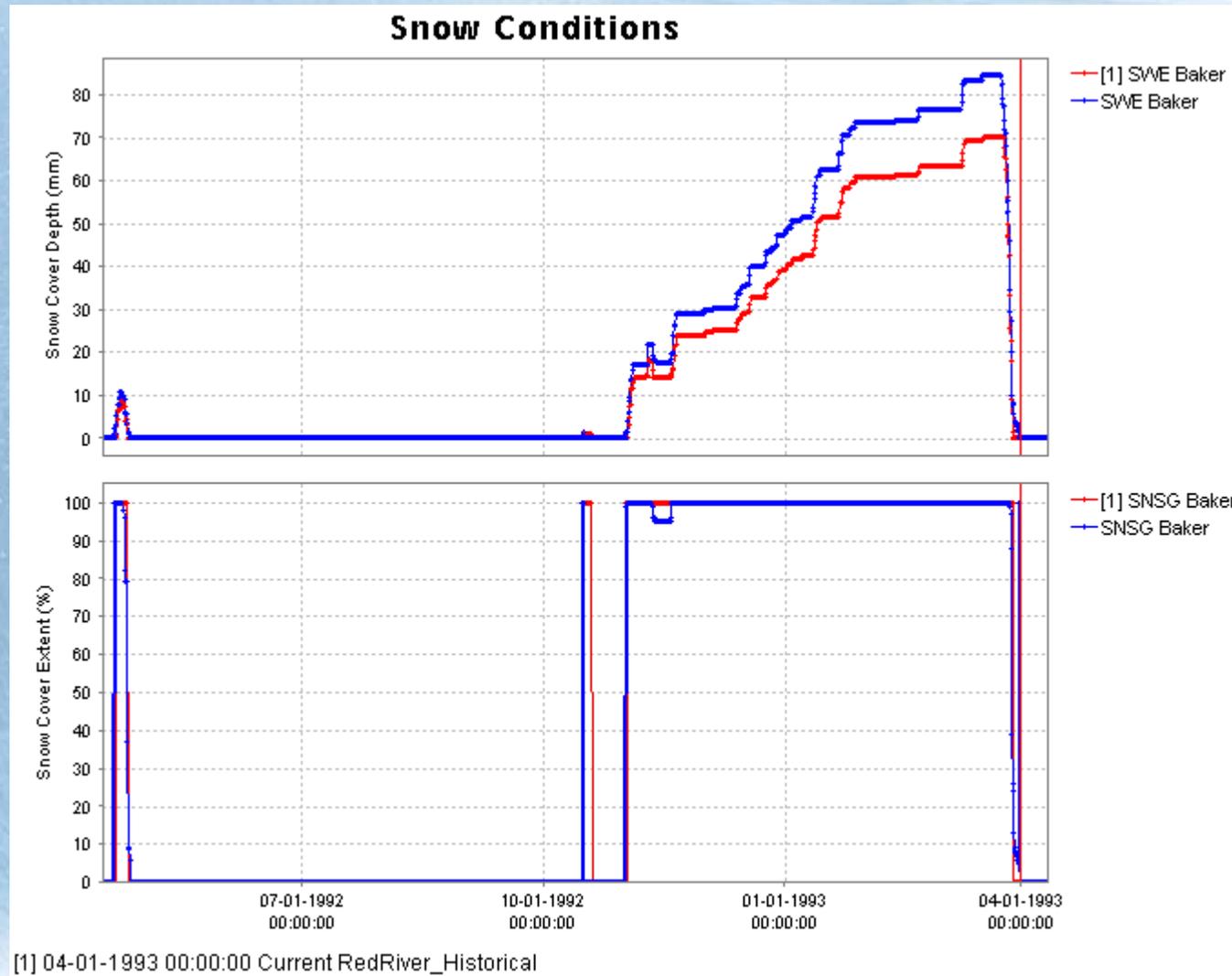
### Runoff (Lower)





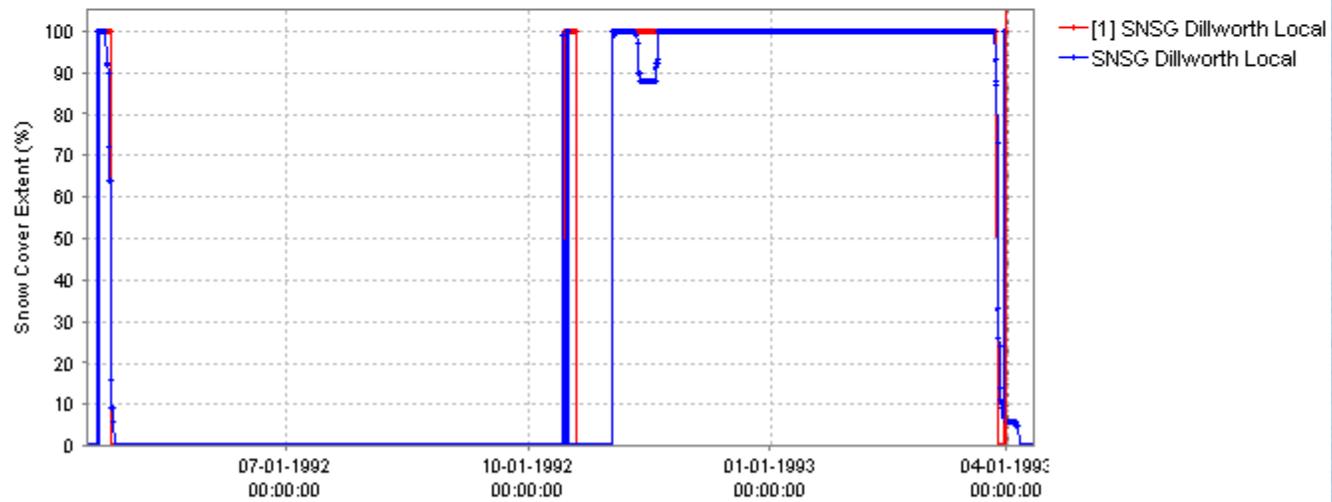
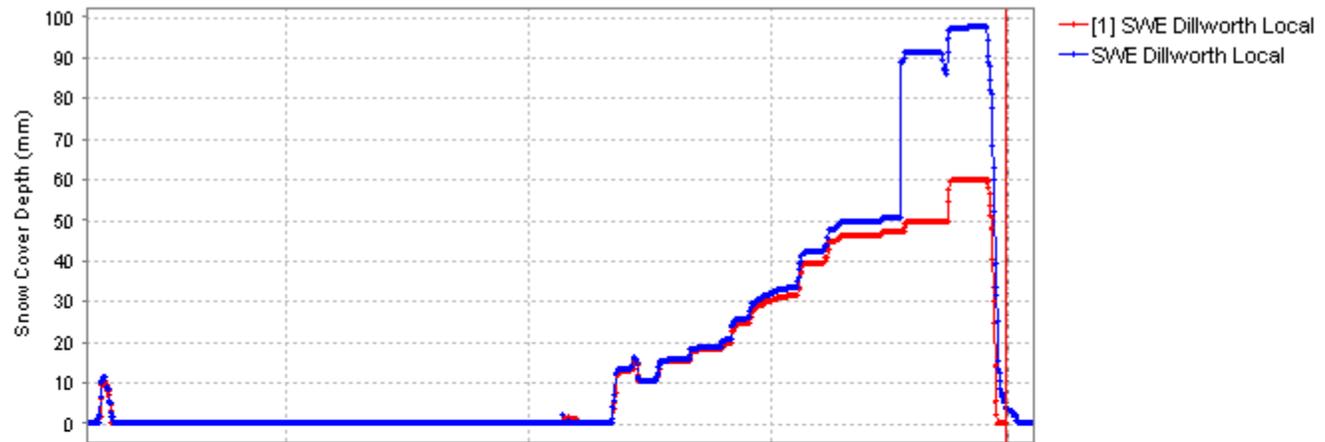
### Runoff (Lower)







### Snow Conditions



[1] 04-01-1993 00:00:00 Current RedRiver\_Historical



### Runoff

