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Tempest™ Hydro-Met Analysis System

White Paper

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The *Tempest* ™ Hydro-Met Analysis System provides a suite of tools for retrieving, storing, validating, analyzing, and displaying hydro-meteorological data.

The figure below shows how the members of the Tempest family fit together: Use an LRGS System to retrieve raw DCP Data. Data is collected from several possible satellite, radio, internet or file links. Then use the DCS Toolkit decoder to convert raw data to time-tagged engineering units. Finally use the Tempest™ Hydro-Met Analysis System to perform all of the tasks shown at the right of the figure:

- Efficiently store your decoded data in a standards-based SQL database,
- View & correct the data graphically using several automated tools,
- Perform automated computations, limit-checking, and alarm notification,
- Generate web-content for your analysts and for public release,
- Export data to your custom applications.

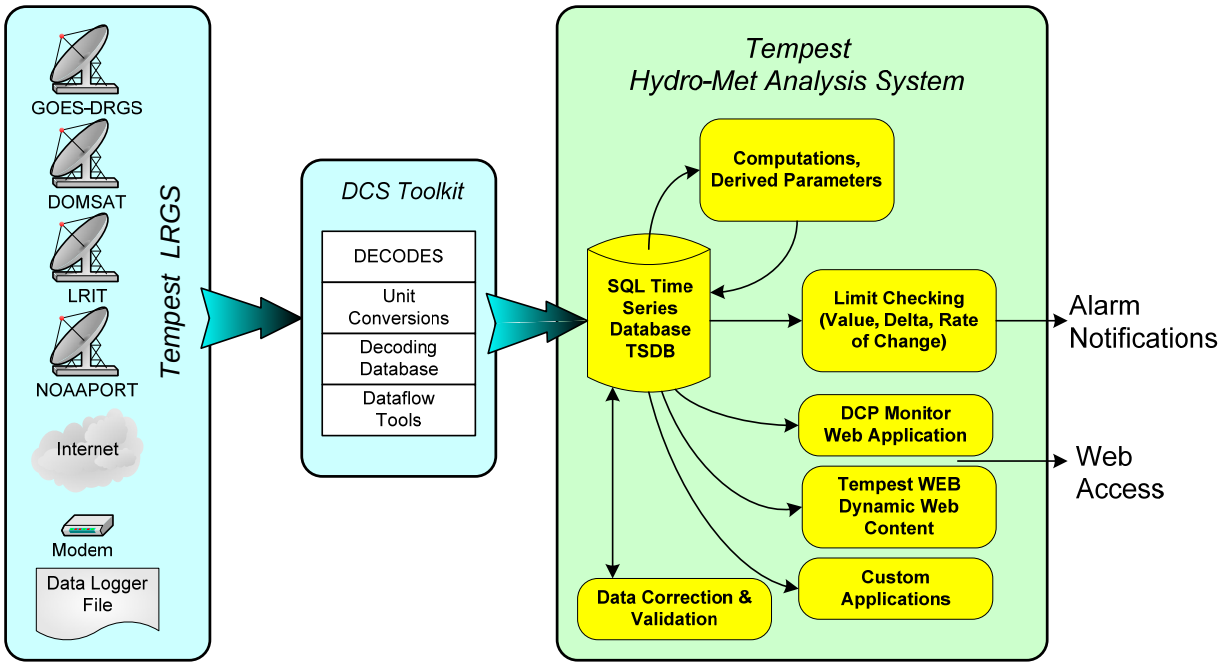

Figure 1: Tempest™ Family of Hydro-Met Data Products.

Time Series Database

The heart of the system is our time-series database. After reviewing the design of several large hydro-met databases in use by the U.S. Federal Government, we designed our system for extreme performance:

- **Standard SQL DBMS**: We currently use PostgreSQL (a full-featured open source database). We have plans to port the system to Oracle and Micrsoft SQL Server in the near future.
- **Accommodate Vast Amounts of Hydro-Met Data**: The data-storage is limited only by the underlying DBMS (terabytes).
- **Efficient, Fast Storage & Retrieval:** Our flexible schema allows the database to grow without adversely affecting the speed of storage & retrieval.
- **Easy to use Table Structures:** Add your own custom applications by using our API or accessing the tables directly.

The following figures show the GUI Time Series Database Editor. Figure 2 shows a list of time-series defined in our database. Figure 3 shows that we have opened the time series for HG (Height of a Gage or 'Stage') at the site named OKMI4.

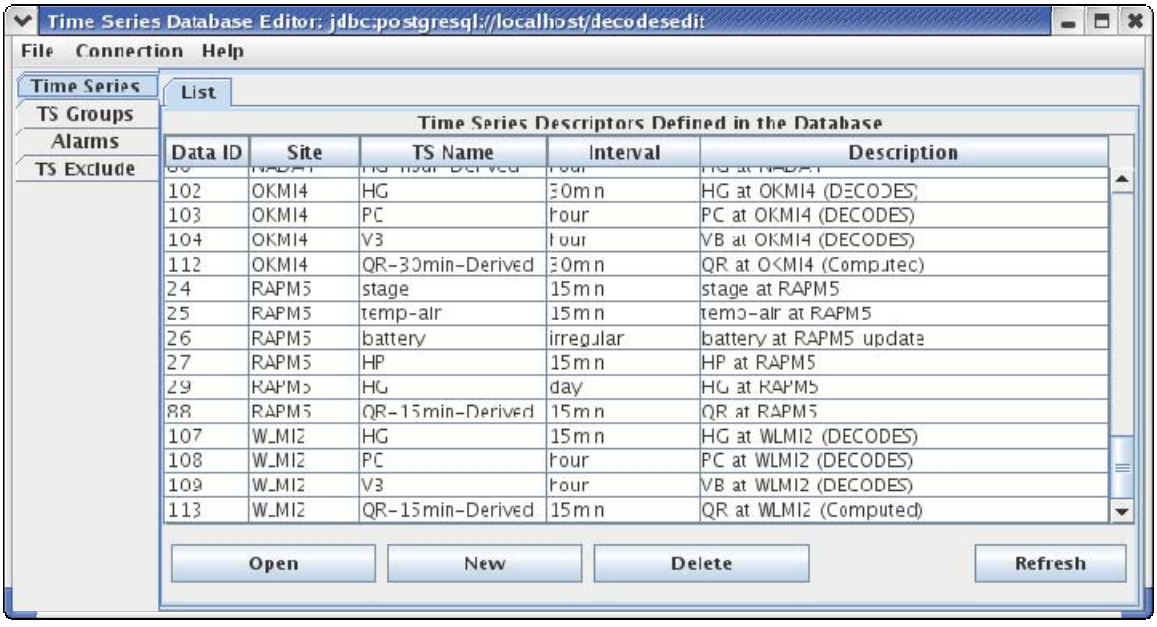

Figure 2: Time Series Database Editor - List Tab.

The following screen shows how you to enter and maintain the 'meta-data' about each of the time-series in the database. This includes the parameter code, periodicity, engineering units, description, limits, alarms, etc.

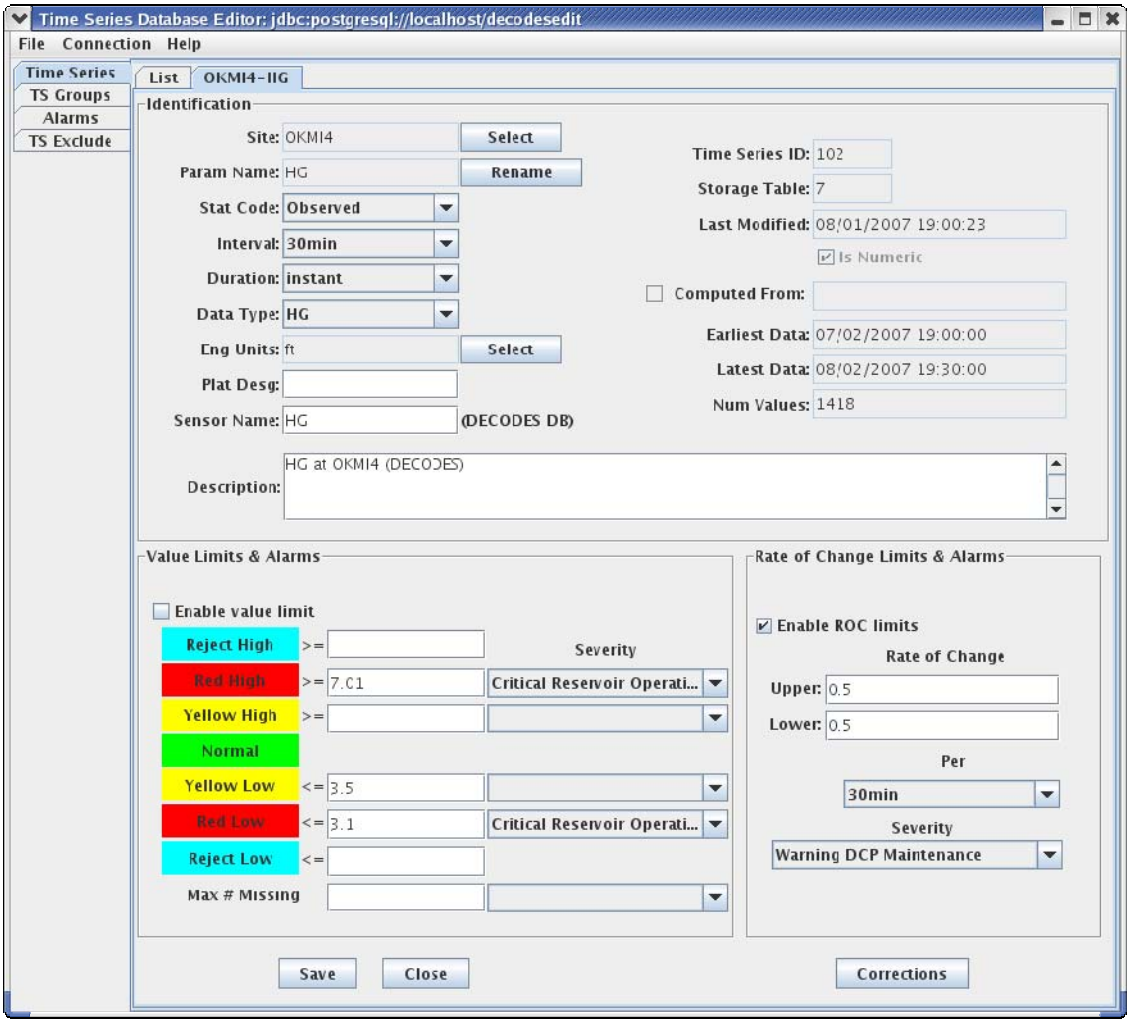

Figure 3: Time Series Database Editor - Edit Tab

Note the area at the bottom of the screen: Here you can easily define value and rate-of-change limits on each parameter. As well as flagging or rejecting values that are out-of-limits, you can cause various types of alarms to be executed, such as sending a text-message or email.

For value limits, we allow yellow (warning) and red (critical) bands above and below the normal range. You can also enter a reject high/low limit (values outside this range are rejected automatically as garbage-data).

Time Series Groups

You will also want to divide your time-series into meaningful groups. Groups are used for selecting parameters to display, alarm assignments, etc. Figure 4 shows a variety of groups that we have defined in our test database.

Some groups show related data-types, like ‘River Stages’, and ‘Battery Voltages’. Some groups represent geographic regions, such as river systems. Other groups represent DCPs relevant to a certain power-plant. Finally, you can also define groups for your technicians that maintain DCPs.

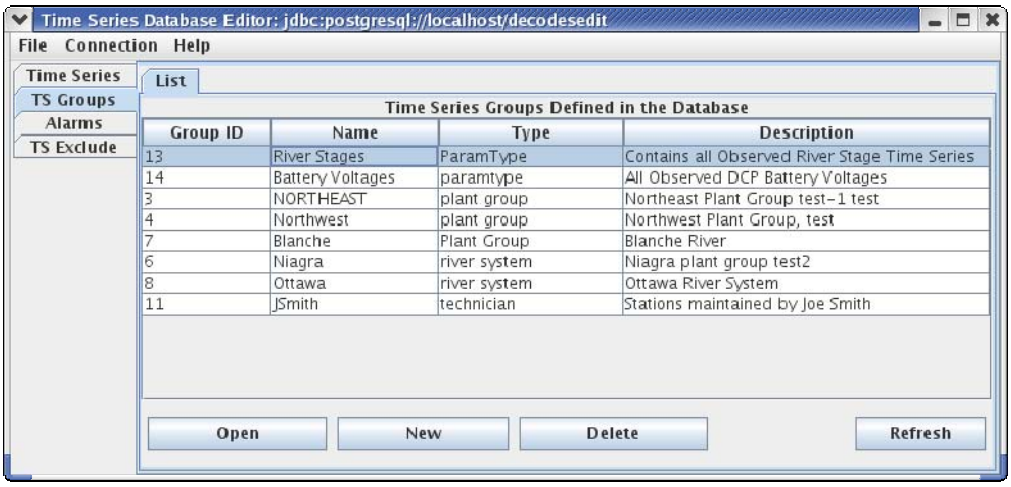

Figure 4: Time Series Groups.

Real-Time Data Ingest

The database is fully integrated with the decoding engine (a.k.a. 'DECODES') contained in the DCS Toolkit. You can run retrieval processes which ingest data directly into the database without the need for intermediate files. This ingest can be done periodically on a schedule, in real-time, or interactively in an ad-hoc manner.

If desired, you can have the ingest process automatically create new time-series as needed for incoming data. This saves a lot of work, especially if you are already using DECODES. Simply run DECODES for a representative period of time (say, a day's worth). It will create time-series as needed for each DECODES platform/sensor.

Later, after your database is set up the way you want, you may want to turn off this feature, or at least restrict it for specific platforms and/or data-types.

For example, suppose you *do not* want to store battery-voltage parameters in the database. Figure 5 shows how you could create a rule that excludes all parameters with data-type 'VB'. The rule will match any site.

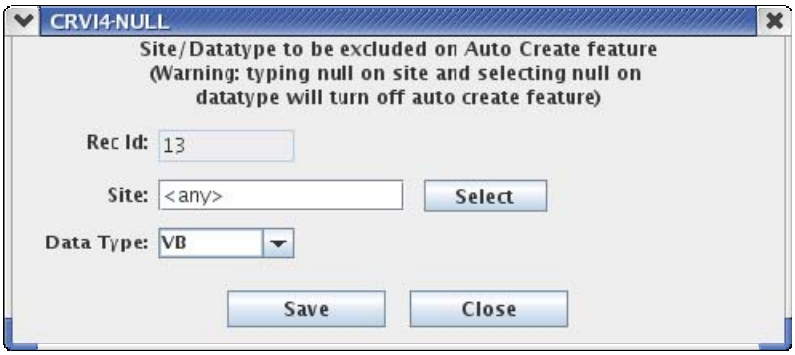

Figure 5: Create Rules to Control how DECODES Auto-Create is Done.

Computations and Derived Parameters

In the past several years, we have worked with the U.S. Geological Survey, the U.S. Bureau of Reclamation, and the U.S. Army Corps of Engineers to develop a powerful computation engine for hydro-met applications. We have incorporated this into our Hydro-Met Analysis System.

The Computation Engine allows you to specify 'Algorithms' and then apply the algorithms to specific 'Computations' on specific time-series. For example, Figure 6 shows the definition for computing Discharge at the site 'KEQI4' by using a table-lookup from a USGS RDB file.

Once this computation is defined and enabled, it will be automatically executed when new stage values are stored in the database. When an insert, update, or delete operation is performed, a trigger is fired which signals the computation engine to perform any dependent computations.

We provide a fairly complete set of initial 'algorithms' including rating-table lookup for discharge and volume, periodic statistics such as min/max/mean/median/std-dev, summing and scaling multiple input points, and others. It is easy to supplement this set with custom Java code. Thus any type of computation can be handled.

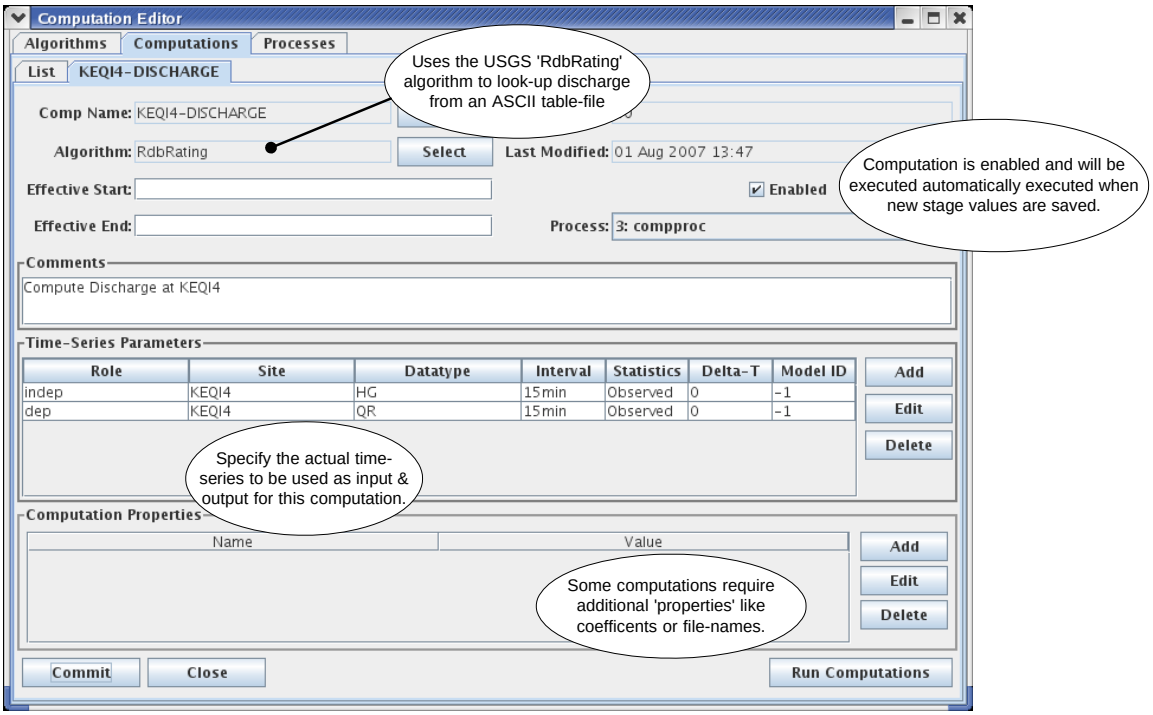

Figure 6: Computation Editor Showing a Stage/Discharge Computation.

In addition to the automatic trigger-based approach, you can run your computation interactively in the screen shown in Figure 7. This can be used for testing new computations, or processing historical data that was entered before a computation was defined.

The screen below shows the execution of a single computation, stage/discharge at site 'OKMI4' over a one-month period. The graph and table show computation inputs and outputs.

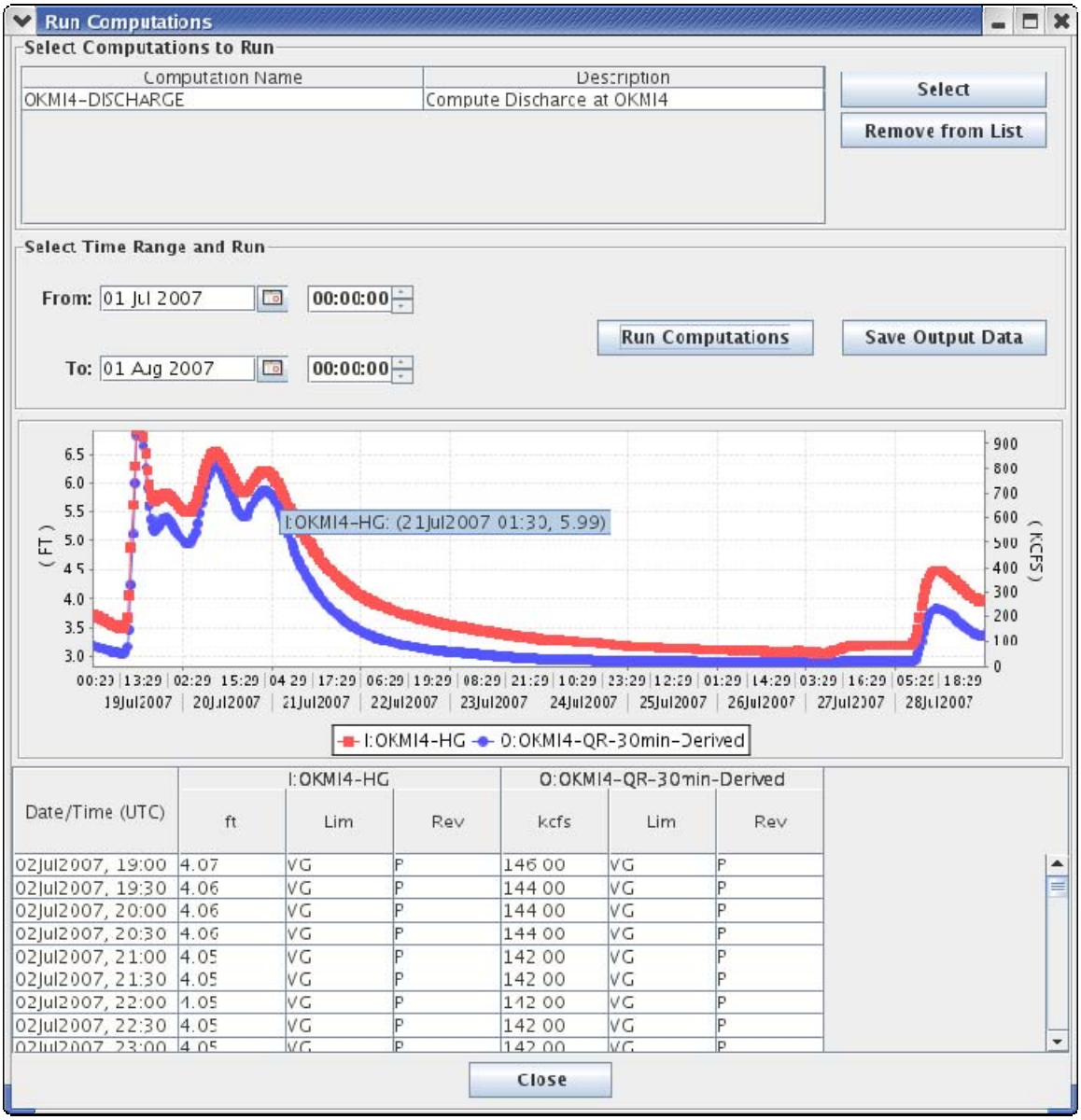

Figure 7: Run Computations Interactively in a GUI.

Limit Checking and Alarm Tracking

Refer back to Figure 3 where you set red/yellow limits on each parameter. Now you need a way to see at a glance whether your time-series values are in or out of limits. The screen shown in Figure 8 answers that need. Here you specify a time-range and a group of time-series that you want to monitor.

The sample screen shows all of my Battery Voltage values for the previous day. The 'Quality Color Bar' shows good values in green, warning-level values in yellow, and critical values in red. Missing values are shown in white.

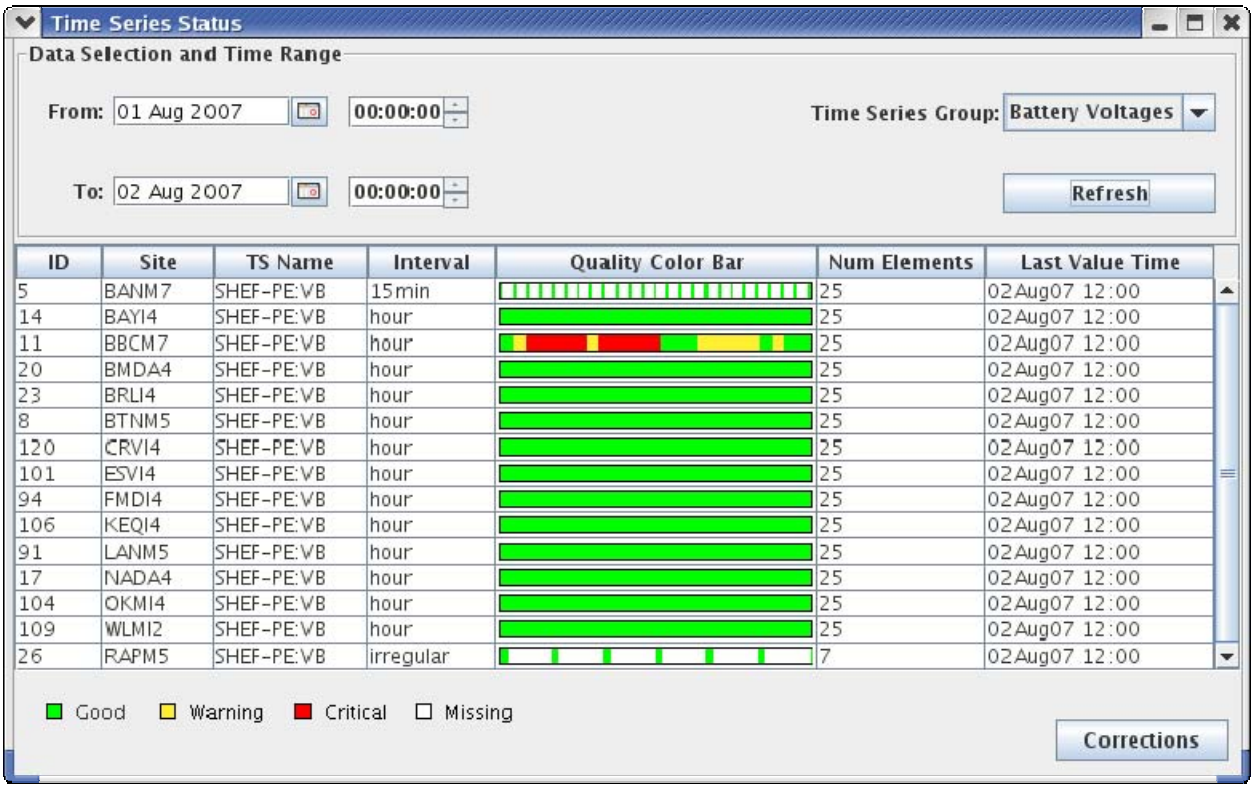

Figure 8: Time Series Status Screen.

Now refer once again back to Figure 3 and notice the 'Severity' assigned to each of the defined limits at the bottom of the screen. Each *Severity* corresponds to one or more *actions* that can be taken. For example, the Severity 'Critical Reservoir Operations' might cause an audible alarm to sound and might Text-Messages to the cell-phones of critical personnel.

Conversely, the severity 'Warning DCP Maintenance' is less severe, indicating a possible problem on a DCP. This might just send email to maintenance personnel.

Automated Data Correction Tools

Any data that arrives via sensors in the field must be quality-controlled. You need automated tools to view the data and correct it if necessary. The screen shown in Figure 9 provides these tools.

The screen below shows us correcting the stage value for site ‘OKMI4’. You can display this point along with a set of ‘reference points’. We are displaying our data against the stage value from ‘BRLI4’.

The screen shows the data graphically and in table-form. The tools at the right allow you to correct data via interpolation, keyboard-entry, or adding a constant. You also set the review level here to one of Provisional, Reviewed, or Approved.

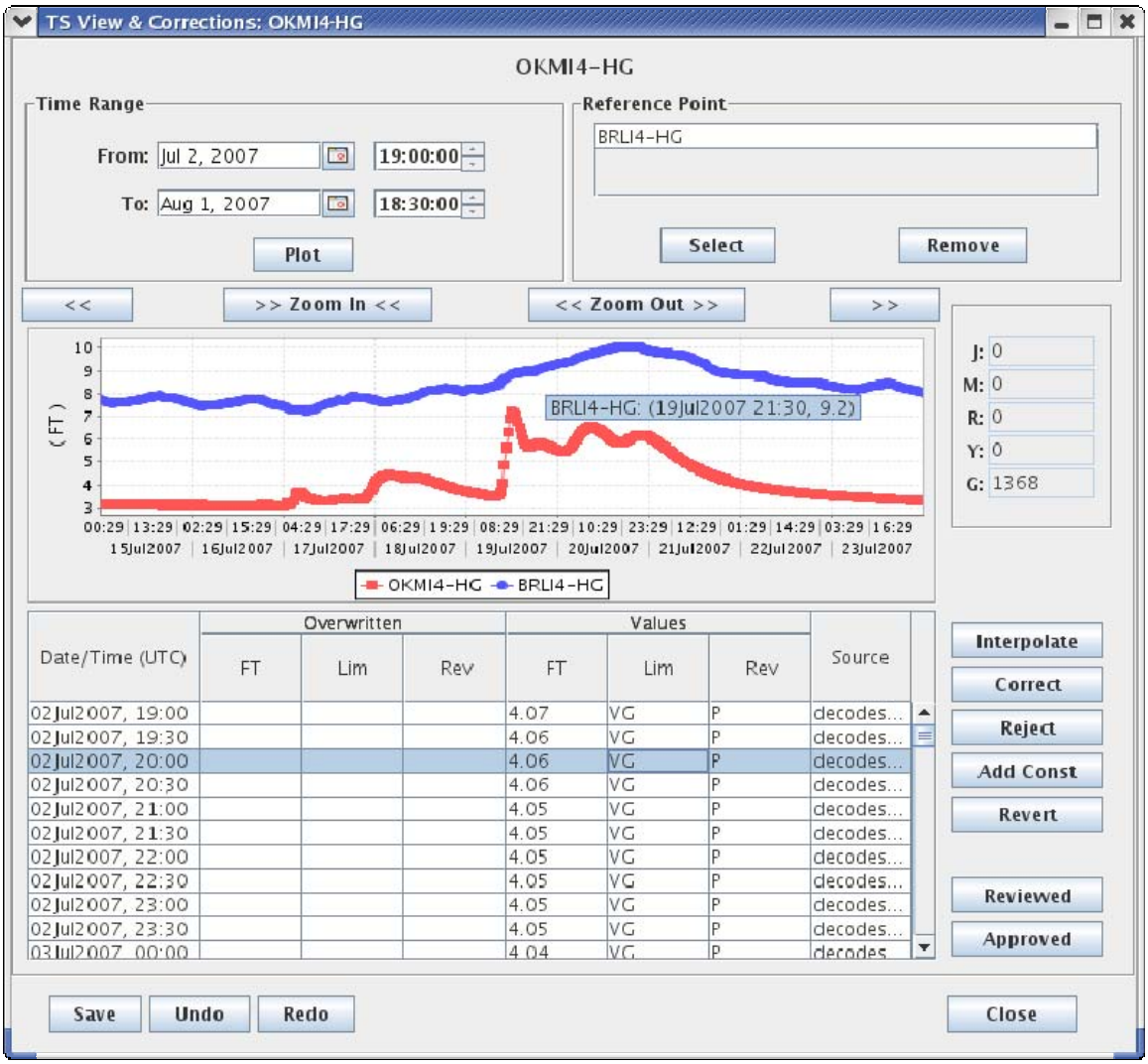

Figure 9: Time Series Corrections Screen.

DCP Monitor

The Hydro-Met Analysis System contains a web-based tool to help you maintain your DCP network. This tool is called the 'DCP Monitor' and is currently in use by several Federal U.S. Agencies. The following two figures show the text-based and graphical screens.

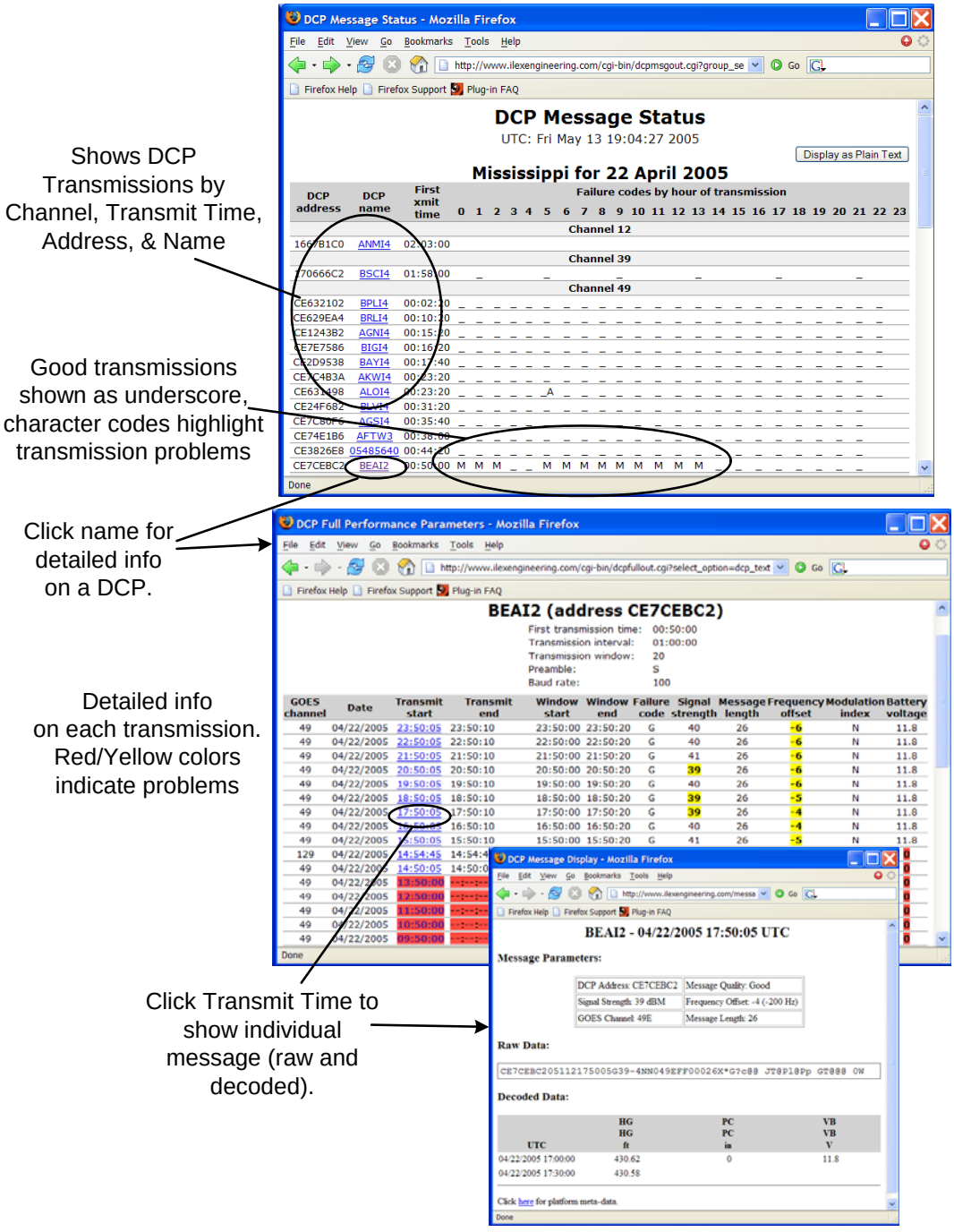

Figure 10: DCP Monitor Text-Based HTML Screens.

Figure 11: DCP Monitor - Graphic Time-Slot Viewer.

Web Content

The above sections describe how you collect, QC, correct, maintain, and compute your time-series data. Finally, you need a way to generate web-content for your hydrologists and meteorologists; and if desired, for the public at-large. The 'Tempest Web' module performs this function.

Tempest Web can generate many types of web-displays:

- Time Series Plots: Multi-variable/Multi-Axis
- Tabular Displays
- Excel-compatible data downloads
- Wind speed/direction plots
- Bar charts: Multi-variable/Multi-Axis
- Graphical Gages (e.g. Dashboard-type displays)

For each display, time series can be selected individually or by group.

Commonly-viewed plots can be generated on a schedule and stored as HTML files for very fast display. Ad-hoc reports (e.g. where the user enters individual time-series and specific time-ranges) are generated dynamically using JSP (Java Server Pages) technology.

You can customize the appearance of the web displays by adding your own organization's header, footer, logo, links, etc.

Coming soon: integration with Google™ Maps for showing clickable locations of your gages on either a map or satellite image overlay.

Summary

With the addition of the Hydro-Met Analysis System, the Tempest™ product family provides a complete solution:

- Data collection from a wide variety of satellite, internet and other sources,
- Decoding engine that can handle any DCP currently using the GOES DCS, as well as a wide variety of EDL (Electronic Data Logger) files,
- Real-time Ingest into Time Series Database,
- Automated rate-of-change and value limit checking,
- Automated computations for rating curves, periodic statistics, multi-variable and other algorithms,
- Graphical data editing and correction,
- Automated alarms and notification system,
- Web content generation, graphical or tabular, interactive and 'canned',
- Interfaces to other popular Hydro-Met products.

Furthermore, our solution runs on a wide variety of platforms including Linux, Windows, and Solaris. The real-time software is 100% Java, making it easy to host on new platforms and architectures.

For more information, contact us at: *info@ilexeng.com*