

## XVI. TSTool Code

The South Platte River  
and Alluvial Aquifer

HB 1278 South Platte Groundwater Study



## **HB1278 Memorandum**

From: Steve Malers (Open Water Foundation)  
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Subject: HB 1278 TSTool software use and availability

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### **Introduction**

This memorandum summarizes the use of the TSTool software for HB 1278 data processing and analysis, and availability of software. TSTool (“time series tool”) is a software application developed for the Colorado Water Conservation Board (CWCBC) and Division of Water Resources (DWR) as part of Colorado’s Decision Support Systems (CDSS). TSTool:

- Provides access to a variety of data sources:
  - DWR data in HydroBase, including daily, monthly, and irrigation year (November to October) diversion records by diversion class and total, as well as streamflow data collected by DWR. All published HydroBase tables and views are accessible to TSTool, including structures, water rights, etc.
  - Third-party data included in HydroBase, including streamflow, climate, well, snow, and other data, from a variety of organizations including United States Geological Survey (USGS), National Climatic Data Center (NCDC), Natural Resources Conservation Service (NRCS), and others.
  - Data from web services including DWR, USGS, NCDC, and NRCS. Many organizations are now offering web services to access databases, but these services are slower than using a local HydroBase.
  - CDSS model data and results, including StateCU and StateMod models.
- Automates processing of time series, tables, and other data:
  - Creates useful formats and data products.
  - Helps implement processes that are repeatable and transparent.

Although TSTool initially was developed for CDSS modeling for use by modelers, it is now used to meet a variety of data analysis requirements. It can serve as an initial data review and collection tool, a tool to translate data from one form to another so data can be used with another tool, and as a full analysis tool. TSTool has been used as needed on the HB 1278 project in conjunction with Microsoft Excel, GIS, CDSS models, and to publish results in documentation and the website.

## HB 1278 TSTool Enhancements

Many TSTool enhancements were implemented during the HB 1278 project, with major enhancements noted below. These features were released in TSTool versions 10.12.00 through 10.25.00 and are documented in the TSTool release notes, which are available with the software. Although the enhancements were in response to HB 1278 project requirements, most features have general utility.

- The `AnalyzeNetworkPointFlow()` command was added to perform a historical point flow analysis. Input to the command includes a table to define the network, and time series corresponding to network nodes. Mass balance is performed based on diversion, streamflow, and inflow time series, with output time series created for tracking the water at each network node.
- The ability to configure HydroBase as a “datastore” was added. Datastores provide a more generic database connection, which supports general commands including `ReadTableFromDataStore()`. Datastores use a small text configuration file that allows specific configuration properties to be defined. Datastore configuration files are now distributed with HydroBase for the CDSS and HBGuest HydroBase users. The former allows full integration with TSTool and the latter can be queried with `ReadTableFromDataStore()`. For example, the HBGuest login allows access to the `vw_HBGuest_StructureAssocWDID` view, which describes augmentation plan relationships to structures.
- The `ReadHydroBase()` command was updated to handle all time series data types (similar to the main TSTool window), facilitating bulk processing of time series. Structure type and other attributes can be used to limit the number of time series.
- Reading diversion class time series from HydroBase results in the individual SFUTG parts being set as properties on the time series for later use in processing and output.
- Water level (well elevation) time series in HydroBase that do not have location identifiers previously were not handled. Features were implemented to assign an identifier `LL:LatLong` based on coordinates, so that the time series could be retrieved. This notation also flags the time series so that the identifier issue can be resolved.
- The `ReadTableFromDataStore()` command was updated to allow any SQL select statement. Consequently, TSTool can be used to automate a sequence of HydroBase queries without requiring that the user install other software, such as SQL Server Management Studio.
- Updated several commands to use new WDID columns in HydroBase tables/views. Previously WD and ID were separate columns but recent enhancements have made WDID available, which simplifies processing.
- Station and structure data are assigned as time series properties. For example, if a water level (well elevation) time series is queried, information about the well (depth, location, etc.) is available with the time series for analysis and output.
- The `ReadUsgsNwisGroundwater()` command was added to read groundwater measurements. This allows TSTool to read water levels from USGS web services.
- The `TimeSeriesToTable()` command was added to convert time series to a simple tabular format.

- The WriteTableToDelimitedFile() command was updated to omit comments from the file header, which facilitates use by GIS software. Data fields that contain newlines are also handled to ensure that output can be used in other software such as Excel.
- Time series graphs can now have a y-axis that goes down, suitable for water depth graphs.
- The CalculateTimeSeriesStatistic() command was updated to only consider time series values in part of a year (e.g., irrigation season) and additional statistics were added to compute trend and count values above a threshold (e.g., for a high groundwater cutoff).
- Initial versions of WriteTimeSeriesToJson() and WriteTimeSeriesToKml() commands have been implemented to facilitate creating data formats for the HB 1278 website.
- The ReadTableFromExcel() command was added to read a data table from Microsoft Excel. For example, this is useful when processing a list of locations.
- The ReadTimeSeriesList() command was added to read a list of time series using information from a table.
- The CopyTable(), AppendTable(), JoinTables(), SortTable(), SetTableValues(), SetTimeSeriesPropertiesFromTable() commands and other features were implemented to automate table processing. Commands were also added to manipulate table columns, including simple math and formatting text.
- The ProcessRasterGraph() command was added to automate creation of raster graphs, which color-code daily and monthly time series values to illustrate trends and extremes.
- The CreateTimeSeriesEventTable() command was added to match general event table information (e.g., flood for a place and date) with matching time series, to facilitate annotation of such events on output products.

## **TSTool Application for HB 1278**

TSTool command files were developed to automate data processing and allow reproduction of the analysis in the future. The command files, input, and results are maintained with specific HB 1278 analysis files (e.g., historical streamflow time series were analyzed as a work task). Specific applications of TSTool in the HB 1278 project are listed below.

- Water level (well elevation) data processing – query water level time series from HydroBase, analyze data, and create products
- Streamflow time series processing – query streamflow time series from HydroBase and USGS web services, analyze data, and create products
- Diversion and recharge time series processing – query diversion records from HydroBase, analyze data, and create products
- Climate data – query climate data from HydroBase and the Regional Climate Center web services, analyze data and create products
- Historical point flow analysis – read network data definition from Excel and time series from HydroBase and DWR web services, perform the point flow analysis, and create data products
- HydroBase queries – SQL queries were run by TSTool to facilitate analysis of HydroBase tabular data, such as determining well counts

- CDSS dataset creation – query HydroBase and other data sources and create model files for the consumptive use (StateCU) model
- CDSS model results – automate processing of CDSS model results
- Prepare data for website – format time series and other data for website visualization

Various HB 1278 report appendices and project memos focus on specific analysis tasks. TSTool command files are included in documentation where appropriate.

## **TSTool Availability**

TSTool is one of the core CDSS software tools and can be downloaded from the CDSS website:

<http://cdss.state.co.us/software/Pages/TSTool.aspx>

Source code for TSTool is not currently available on the above website. However, the State of Colorado is evaluating moving CDSS software to open source licensing and as that process moves forward it is expected that TSTool source code will be made available similar to other open source software projects. Questions about TSTool relevant to the State of Colorado can be directed to Ray Alvarado at the Colorado Water Conservation Board ([ray.alvarado@state.co.us](mailto:ray.alvarado@state.co.us)). Technical questions about TSTool software can be directed to Steve Malers at the Open Water Foundation ([steve.malers@openwaterfoundation.org](mailto:steve.malers@openwaterfoundation.org)).

## **Comments, and Concerns, and Recommendations**

The TSTool software as a component of CDSS has provided a useful tool to access and process water resources data for the HB 1278 study. TSTool, in conjunction with other CDSS components, including HydroBase, DWR web services, and the StateCU model have been leveraged to increase the efficiency of the HB 1278 team and perform analysis tasks in a way that can be repeated in the future as additional data are made available. The following recommendations, comments, and concerns are made based on the experience of the HB 1278 project, focusing on the role of TSTool:

1. The “data-centered” approach that is standard for CDSS modeling encourages a repeatable data analysis process and this approach has been utilized on the HB 1278 project where appropriate. It is recommended that such an approach continue to be used as follow-up to HB 1278 occurs. For example, it may be appropriate to include some of the HB 1278 analyses in SPDSS modeling to provide system-wide evaluation of important questions or perhaps the State can repeat the an analysis to support administration.
2. Many TSTool software enhancements needed for the HB 1278 project were implemented with project funding, resulting in new software functionality that facilitated the efforts of the team. It is recommended that the State utilize and build on these enhancements for other projects. For example, new features to filter diversion records by water class will be useful in other projects. At the same time, TSTool has not yet been updated to fully handle the new diversion coding standards.

3. The capabilities and data provided by CDSS are extensive. However, the complexity of HydroBase and CDSS model data sets is challenging for those who are unfamiliar with the database and tools. It is recommended that effort be continued to make water data and tools more accessible and understandable to a wider audience.
4. TSTool software originally was developed for CDSS modelers but over time it increasingly has been used by a wider audience, including consultants, government agencies, and other organizations. However, within DWR there is limited use. While DWR staff are primarily focused on water administration and the tools associated with those tasks, the administration of water increasingly involves evaluating the river system in space and time (and in the future, also water quality). TSTool software provides functionality that is not available in other DWR tools but which is useful to DWR staff and could increase efficiency. Consequently, it is recommended that DWR staff be given training on the use of TSTool (and potentially other CDSS tools), in particular to utilize software features that support their work activities. An example use is automating the retrieval and analysis of historical diversion records, including quality control.
5. The HB 1278 project depended heavily on the HydroBase database. Although the team was effective in accessing and processing data, there were times where HydroBase contained data errors that required additional updates. It is recommended that the State consider using TSTool more for HydroBase quality control, in particular using TSTool's automation and data check features. In addition to checking HydroBase itself, this will help ensure that CDSS components that use HydroBase function as expected with HydroBase outside of DWR.