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# TIME SERIES ANALYST

**A Web application for visualizing time series data published on a HydroServer**

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## Distribution

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The Time Series Analyst and all associated source code and documentation are available at the following URL: <http://his.cuahsi.org/>.

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## Disclaimers

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Although much effort has been expended in the development and testing of the software described in this document, errors and inadequacies may still occur. Users must make the final evaluation as to the usefulness of this software for their application.

The Time Series Analyst and this software manual are based upon work supported by the National Science Foundation (NSF) under Grants No. 03-26064, and 06-10075 and by the Inland Northwest Research Alliance (INRA). Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author and do not necessarily reflect the views of NSF or INRA.

## Acknowledgements

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## Technical Support

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There is no formal ongoing support for this freely distributed open source software. However, we are interested in feedback. If you find errors, have suggestions, or are interested in any later versions, please contact:

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## 1.0 INTRODUCTION AND SOFTWARE DESCRIPTION

The CUAHSI Hydrologic Information System (HIS) Project is developing information technology infrastructure to support hydrologic science. One of the major components of the HIS is a software stack called HydroServer that can be used for storing and publishing hydrologic data. HydroServer includes a point Observations Data Model (ODM), which is a relational database schema that was designed for storing time series data, a suite of data loaders and tools for working with ODM, the WaterOneFlow Web services that publish data stored in an ODM database on the Internet in WaterML format, and the capability to publish geographic information systems (GIS) datasets as spatial data services. Using the HydroServer software stack, server administrators can create any number of observational data services published using the WaterOneFlow web services as well as any number of spatial data services published as Open Geospatial Consortium (OGC) services. The Time Series Analyst (TSA) was created as a Web application for visualizing hydrologic time series data hosted within an observational data service on a HydroServer.

### 1.1 GENERAL FUNCTIONALITY

TSA is a web application for visualizing and summarizing time series data stored in ODM databases on a HydroServer. It has a variety of plot types and descriptive statistics coupled with a graphical user interface for selecting data to be analyzed. TSA is a stand-alone web application that can be launched in a specific state by passing parameters to a custom calling interface via the URL string. TSA is capable of connecting to multiple ODM databases on a HydroServer. It supports both ODM 1.0 and ODM 1.1 databases. TSA was designed to use a direct SQL connection to each of the ODM databases on a HydroServer, and uses information stored in the HydroServer Capabilities database (server name, database name, userid, password) for those databases. The ODM SQL Server databases do not have to be connected to the same SQL Server instance.

### 1.2 PLATFORM AND MINIMUM SYSTEM REQUIREMENTS

TSA was designed to be used on HydroServers running Windows Server 2003 or Windows Server 2008 with Microsoft SQL Server 2005 or Microsoft SQL Server 2008. It requires Microsoft IIS as the Web server. In addition, HydroServers must have the Microsoft .Net Framework Version 3.5 installed prior to installing TSA. Instructions for obtaining the .Net Framework Version 3.5 from Microsoft are included in the Installation Instructions section below. TSA also requires one or more ODM databases implemented in Microsoft SQL Server and an instance of the HydroServer Capabilities database. None of the databases have to be on the same physical machine as the TSA Web application; however, the TSA does require a direct SQL connection to the ODM databases and the HydroServer Capabilities database using a SQL Server authentication login.

## 2.0 INSTALLATION INFORMATION

### 2.1 INSTALLATION PREREQUISITES

Prior to installing TSA, you must first install the Microsoft .Net Framework Version 3.5 and Microsoft Internet Information Services (IIS). If you have Microsoft SQL Server 2008 installed, Version 3.5 of the .Net framework will be installed already. The .Net Framework Version 3.5 is free, and is required to run software applications developed in Microsoft's Visual Studio .Net 2008. If you are running Windows Server 2008 R2, the .Net Framework Version 3.5 is included as part of your operating system, and you can add it as a Windows Feature using the Windows Server 2008 Server Manager. If you are running Windows Server 2003, instructions for downloading and installing the .Net Framework Version 3.5 can be obtained from the Microsoft website via the following URL:

<http://www.microsoft.com/downloads/details.aspx?FamilyId=AB99342F-5D1A-413D-8319-81DA479AB0D7&displaylang=en>

Once the .Net Framework Version 3.5 has been installed, you can continue with the installation of TSA.

**NOTE:** Implementing TSA requires that you have an instance of the HydroServer Capabilities database and that you have one or more ODM databases. If you do not already have these prerequisites, please consult the software manuals for each of these components of the HydroServer Software Stack.

#### 2.1.1 SETTING UP A DOMAIN FOR YOUR HYDROSERVER

Prior to installing the HydroServer Web applications – e.g., the HydroServer Website, the HydroServer Map Application, the Time Series Analyst, the WaterOneFlow Web Services, and the HydroServer Capabilities Web Services – you will want to create a domain for your HydroServer. You will need to work with the Information Technology professionals within your organization to help you create a domain. Once a domain has been created for your HydroServer, you can proceed in the setup of the HydroServer software.

In implementing the HydroServer Web applications, it is helpful to understand the structure of the overall deployment so that each of the pieces can be implemented correctly. The HydroServer Website was designed to be a parent, or root level, application within a domain that you set up for your HydroServer. For example, if you were to create a domain name for your HydroServer called “icewater.usu.edu,” the URL for your HydroServer Website would be at the root level of that domain (i.e., <http://icewater.usu.edu/> would be the URL for your HydroServer Website). Each of the other HydroServer Web applications was designed to be a child application of the HydroServer domain. The following shows how the other HydroServer Web applications would be implemented under the HydroServer Website within the same domain:

<http://icewater.usu.edu/tsa/> - The Time Series Analyst

<http://icewater.usu.edu/map/> - The HydroServer Map application

<http://icewater.usu.edu/HydroServerCapabilities/> - the HydroServer Capabilities Web service

<http://icewater.usu.edu/LittleBearRiver/> - a WaterOneFlow web service for the Little Bear River experimental watershed

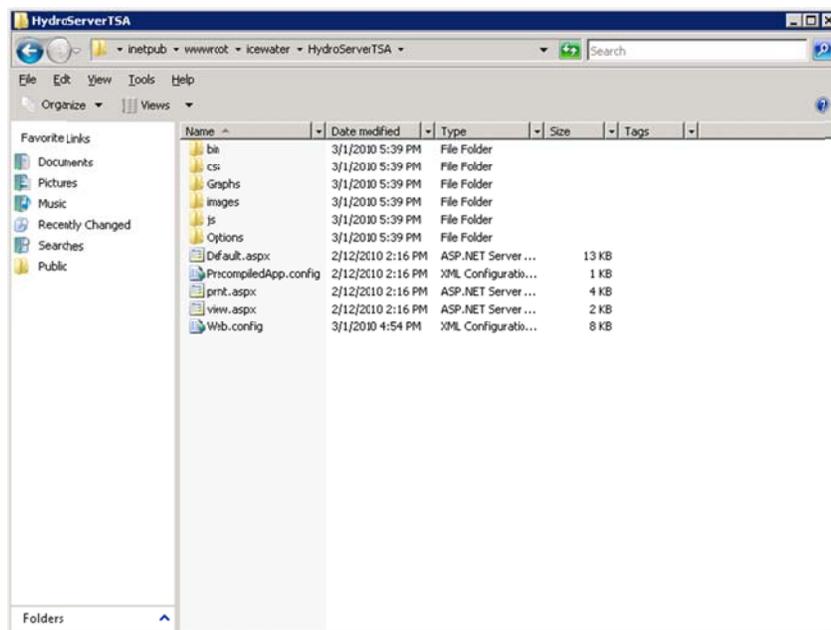
<http://icewater.usu.edu/MudLake/> - a WaterOneFlow web service for data collected within Mud Lake at the Bear Lake National Wildlife Refuge

The above example assumes that your HydroServer is serving as the Web server running Microsoft Internet Information Services (IIS), as the database server running Microsoft SQL Server, and as the GIS server running ArcGIS Server. This doesn't have to be the case, though, and there is quite a lot of flexibility for the components of your HydroServer to be spread across multiple machines and implemented within multiple domains. In general, the HydroServer documentation assumes that you are assembling your HydroServer within a single domain.

## 2.4 INSTALLING AND CONFIGURING TSA

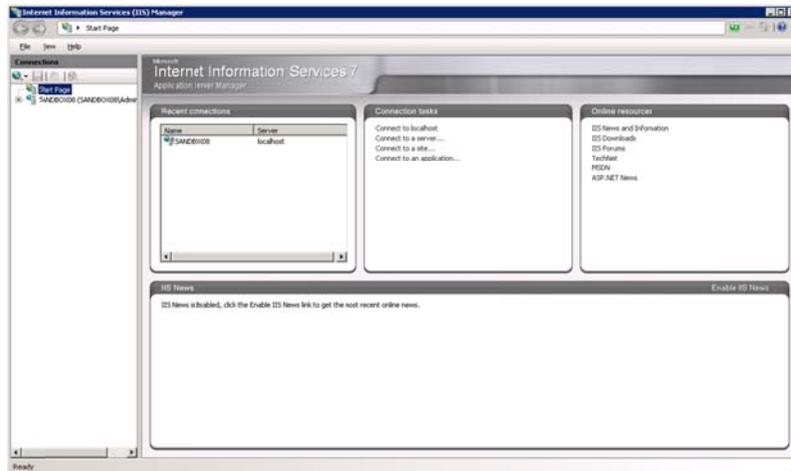
Use the following steps to install and configure TSA. The following steps were written for a web server running Windows Server 2008 and IIS Version 7.0.

1. Extract the "HydroServerTSA" folder from the zip file containing the TSA program files ("HydroServerTSA.zip") to a web application directory on your HydroServer. For this example, I have set up a folder called "icewater" under my "c:\inetpub\wwwroot\" path. Within the "icewater" folder, I have copied the "HydroServerTSA" folder (see the following figure), which contains the application folders and files.



NOTE: In this example, I have put the TSA within a folder called "icewater" within my "c:\inetpub\wwwroot\" folder. I might do this if I were building a HydroServer within a domain called "icewater," e.g., if the URL for my HydroServer was something like <http://icewater.usu.edu>. This folder can also contain the other Web applications that are part of HydroServer, including the HydroServer Capabilities Web service, the HydroServer Website, and the WaterOneFlow web services.

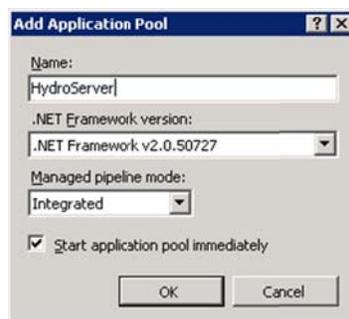
2. Open the Internet Information Services (IIS) Manager by clicking Start → Administrative Tools → Internet Information Services (IIS) Manager. The following window will appear.



3. Expand your server in the tree view at the left of the form by clicking on the plus sign next to its name. Then, expand the “Sites” element by clicking on the plus sign.
4. Since TSA was created in Microsoft Visual Studio 2008, we will first create an Application Pool for running it. In the tree view on the left, right click on “Application Pools” and select “Add Application Pool”. The following window will appear.

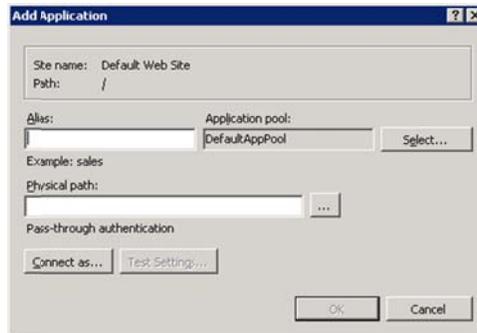


5. Create a name for the Application Pool in the “Name:” text box. For this example, we will call our Application Pool “HydroServer.” Make sure that “.NET Framework v2.0.50727” is selected in the “.NET Framework version:” text box. From the “Managed pipeline mode:” drop down box, select “Integrated.” Ensure that the check box next to “Start application pool immediately” is checked. Your form should look like the following:



NOTE: In this example we are creating an Application Pool called “HydroServer.” We have chosen the “Integrated” Managed pipeline mode because TSA was created using Visual Studio 2008. If we implement other HydroServer web applications (e.g., the HydroServer Capabilities Web Service and the HydroServer Website) that were developed in Visual Studio 2008, we can reuse this Application Pool for those applications.

6. For this example, we will implement TSA under the default website (see note below about setting TSA up under a website other than the default website). Right click on the name of the website (in this example “Default Web Site”) in the tree view and select “Add Application” from the context menu. The following window will open:

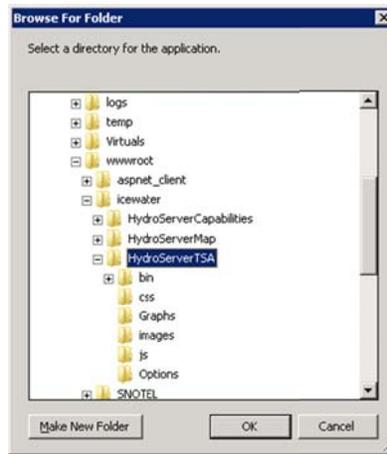


NOTE: TSA was designed to be set up as an application that is subsidiary to a domain within IIS. For example, the URL for TSA will be <http://yourdomain/tsa/>. The domain can be the name of the server in the case that you set TSA up under the default website in IIS, or it can be a domain of your choosing.

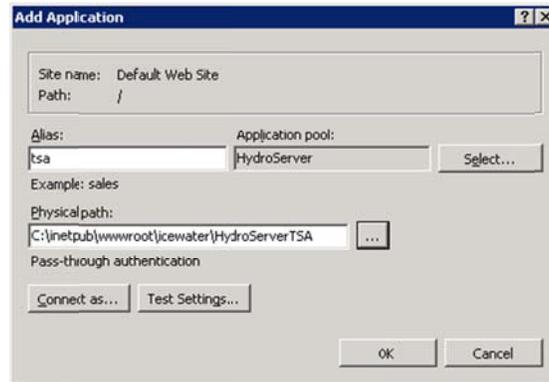
7. In the “Alias” text box, enter “tsa.” Click the “Select” button next to the “Application pool:” box. In the “Select Application Pool” form that pops up, select the “HydroServer” application pool from the “Application pool” drop down list and then click “OK”.



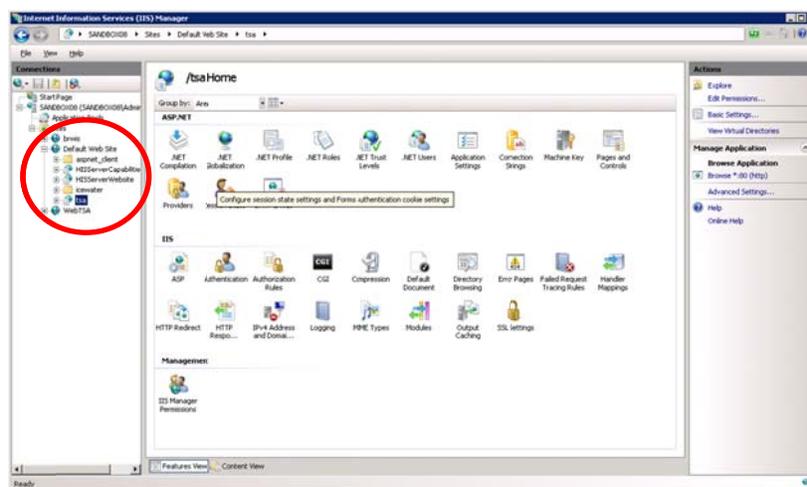
8. Click the navigate button next to the “Physical path:” box. The following window will open. Navigate to and select the folder where you extracted the TSA application files (e.g., “c:\inetpub\wwwroot\icewater\HydroServerTSA”). Then click the “OK” button.



9. Your “Add Application” form should now look something like the following. Click the “OK” button to complete this step.



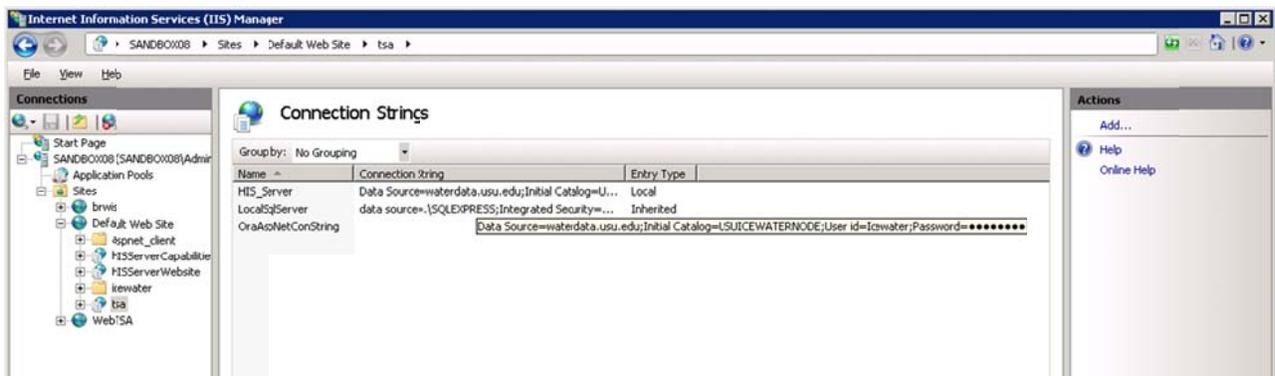
10. You will now notice that an application called “tsa” has been created under your website.



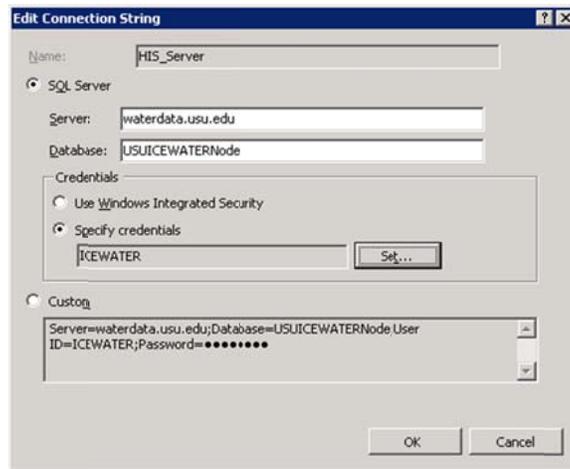
NOTE: The process for setting up TSA under a different website is the same as setting it up under the default website. However, you must first have created the website in IIS before you can do this. In the example above,

since I implemented TSA under the default website on a machine called “sandbox08.uwrl.usu.edu”, my TSA will have a URL path of <http://sandbox08.uwrl.usu.edu/tsa/>. If I wanted my TSA to have a different URL, I would first have to set up an appropriate domain name and then set up a website in IIS to handle that domain name. For example, I could register a domain name called “icewater.usu.edu” and have it pointed at this same machine. I would then create a website in IIS called “icewater” that would handle the “icewater.usu.edu” domain. Then, I would follow the steps above to set up TSA under the “icewater” website in IIS. The path for my TSA would then be <http://icewater.usu.edu/tsa/>. If you wish to register alternate domain names for your HydroServer, you will need to work with the individuals in charge of your IT infrastructure.

- Next, we need to tell TSA how to connect to the HydroServer Capabilities SQL Server database. Make sure that the TSA application is selected in the tree view at the left of the IIS Manager window. Under the “ASP.NET” icon group in the middle section of the IIS Manager form, double click on the “Connection Strings” icon. This will open the connection strings editor within the IIS Manager.



- Double click on the “HIS\_Server” line. The following form will open:

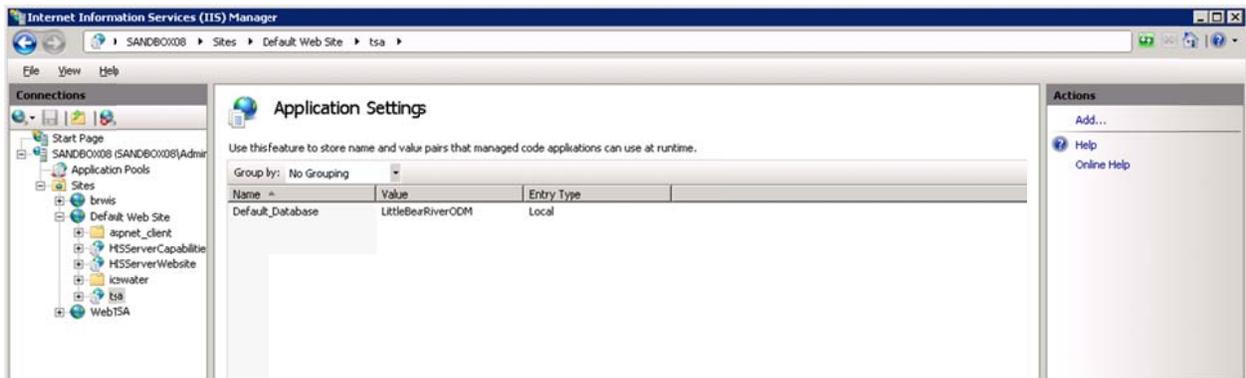


- On this form, you need to edit the items to match the location and user credentials for your HydroServer Capabilities database. Using the figure above, fill in the appropriate values for your database and server. In this example, I am connecting TSA to a HydroServer Capabilities database called “USUICEWATERNode” on a SQL Server machine called “waterdata.usu.edu.” I have created a SQL Server user with read only access to that database called “ICEWATER.” To specify your SQL Server username and password, click the

“Set” button next to the “Specify credentials” radio button and text box. You will notice that the connection string for your database is automatically created for you in the text box at the bottom of the form. Click the “OK” button when you are finished.

NOTE: Since TSA is a public web application, you want to make sure that you create a SQL Server user within your HydroServer Capabilities database that has read only access for use in specifying the connection from TSA. You can do this within SQL Server Management Studio.

14. Next, we need to set a default database to which the TSA will connect if no database is specified in the URL. Click on the TSA application in the tree view to return to the main icon view in the IIS Manager. Double click on the “Application Settings” icon. This will open the application settings editor in IIS:



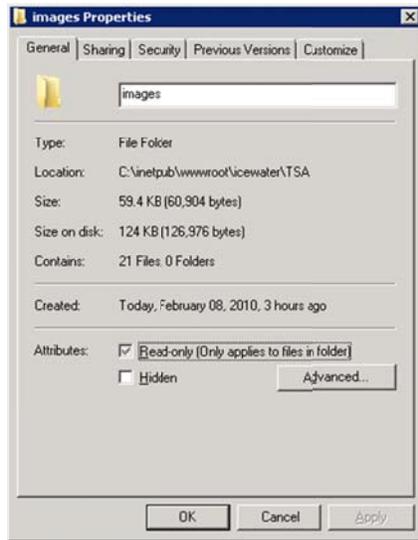
NOTE: Although TSA can connect to any number of ODM databases on your server, it needs a default database to which it should connect in the case that a user simply types the URL of the TSA into a browser. For example, <http://icewater.usu.edu/tsa/> will connect TSA to whatever the default database is, whereas <http://icewater.usu.edu/tsa/default.aspx?Database=MudLakeODM> will connect TSA to an ODM database called “MudLakeODM.”

15. You will notice that there is only one item in the list of application settings called “defaultDatabase.” Double click on this item. The following window will open:

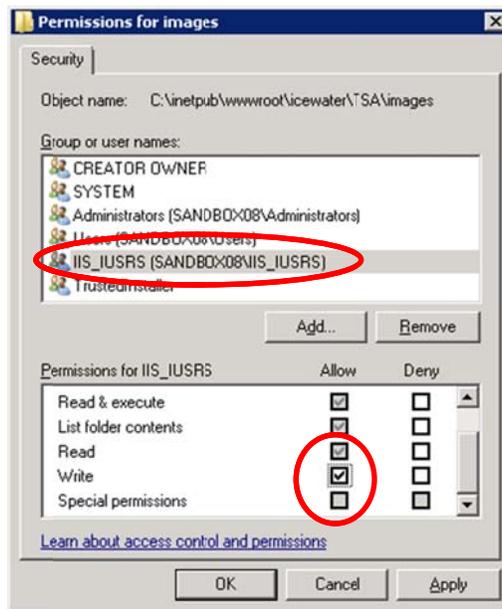


16. You need to set the “Value” of this application setting to the name of one of the ODM databases that is listed in the ODMDatabases table of your HydroServer Capabilities database. The listing of the ODM database in your HydroServer Capabilities database must exist before it can be used here. In this example, the value of this setting is “LittleBearRiverODM.” Type the name of the ODM database that you want to be the default database for TSA in the text box under “Value:”. Do not change the text in the “Name:” text box.

17. As a last step, we need to ensure that the TSA has the correct Windows privileges. When a user views data in the TSA, it creates the images of the plots that are shown in the browser. These images are written temporarily to the “images” directory within the TSA application directory. Because of this, TSA must have write access to the “images” directory. In IIS, expand the TSA application in the tree view on the left. Right click on the “images” folder and click “Edit Permissions” in the context menu that pops up. The following window will appear:



18. Click on the “Security” tab and then click the “Edit” button under the “Group or user names” box. The following window will appear:



19. Scroll down in the list of Group or user names and select the “IIS\_IUSRS” user by clicking on it. Then, in the “Permissions for IIS\_IUSRS” box at the bottom of the form, scroll down and make sure that the

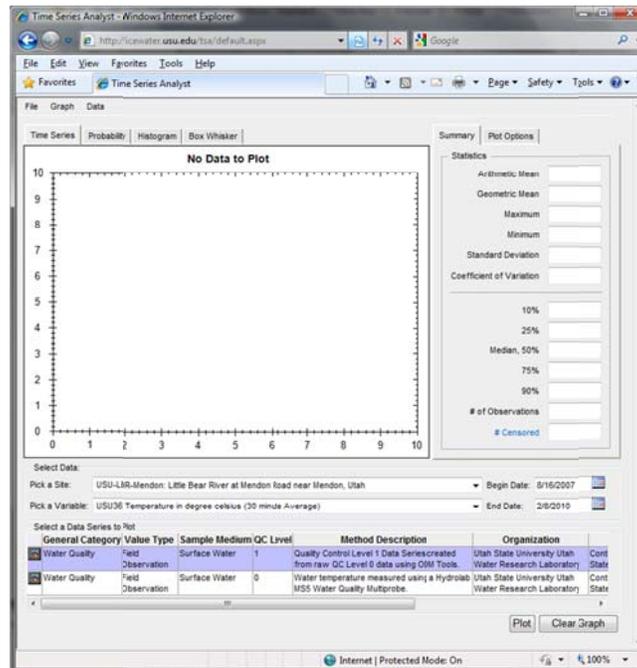
“IIS\_IUSRS” user has “Write” access by clicking on the check box next to “Write” in the “Allow” column (see above). Click “Apply” and then “OK.”

20. Click the “OK” button on the properties window for the “images” folder to close it.
21. Congratulations! Your TSA setup is now complete. You should be able to navigate to your TSA in a web browser. For this example, the URL would be <http://sandbox08.uwrl.usu.edu/tsa/>.

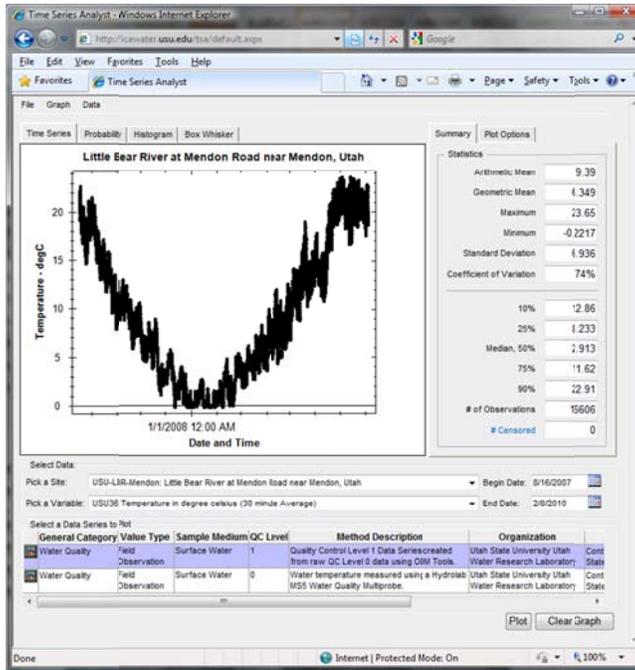
## 3.0 USING THE TIME SERIES ANALYST

TSA enables you to visualize time series data from any of the ODM databases hosted on a HydroServer. With TSA, you can create a variety of plot types and descriptive statistics. The following is a brief tutorial for how to use the TSA.

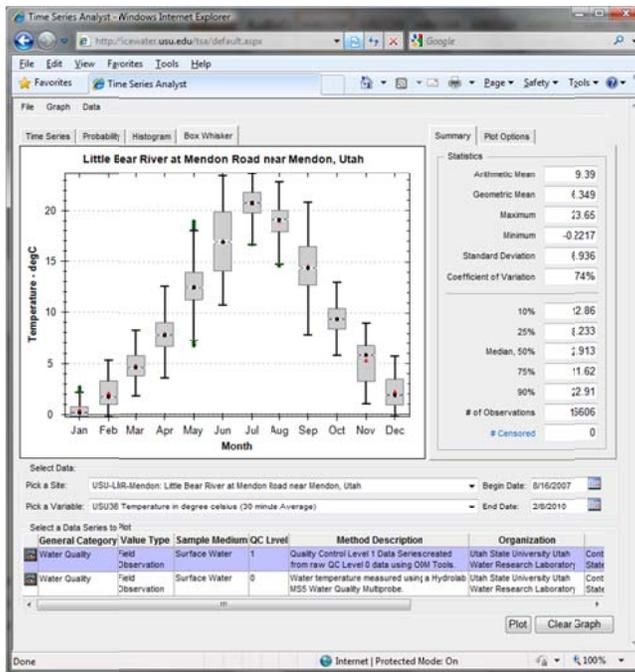
1. Open TSA in a web browser by typing in the URL for the TSA on your server. For this example, we will use <http://icewater.usu.edu/tsa/>. TSA will open with a connection to the default database that you set in the configuration steps above.



2. By default, TSA opens with a blank plot window. You will notice that near the bottom of the form, you can select a site, a variable, a begin date, an end date, and a data series to be plotted. Select a site from the “Pick a Site” drop down. You will notice that when you pick a site, the list of variables is updated to only list those variables that have data at that site. Next, select a Variable from the “Pick a Variable” drop down. You will notice that the list of available data series at the bottom of the form is updated when you select a variable. This list will contain all available time series for the site and variable combination that you have selected.
3. Make sure that one of the data series at the bottom of the form is selected by clicking on it (it should turn blue when selected). Click the “Plot” button at the bottom of the form to generate a plot of the time series that you have selected. After a moment, TSA will display a time series plot for the data that you have selected.



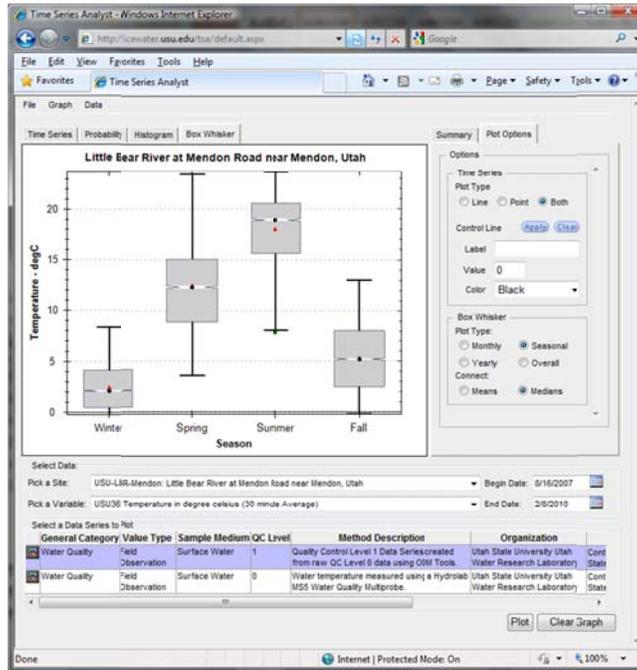
- At the top of the form, there are 4 tabs for the different plot types that TSA can create. If you want to view a Probability, Histogram, or Box and Whisker plot rather than the time series, click on one of the tabs at the top of the form.



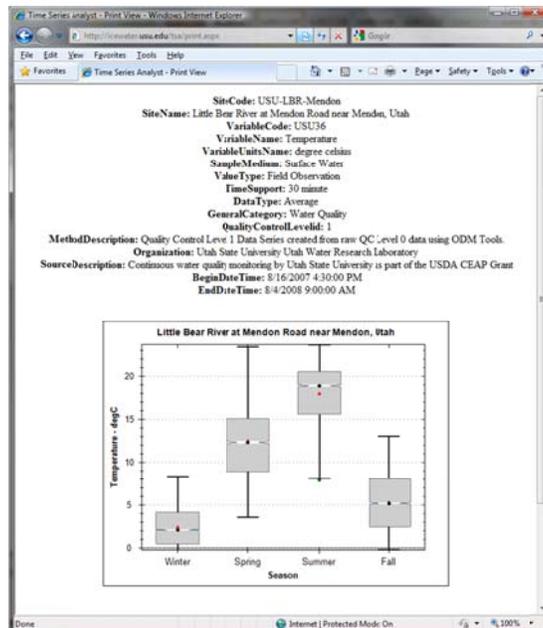
- On the right side of the form, you will notice that summary statistics are given for the time series that you have selected. These statistics are updated each time you click the "Plot" button. For the same time series that you just plotted, you can subset the data by setting a different Begin Date or End Date. When

you click the “Plot” button again, both the plot and the summary statistics will reflect whatever time window you have chosen.

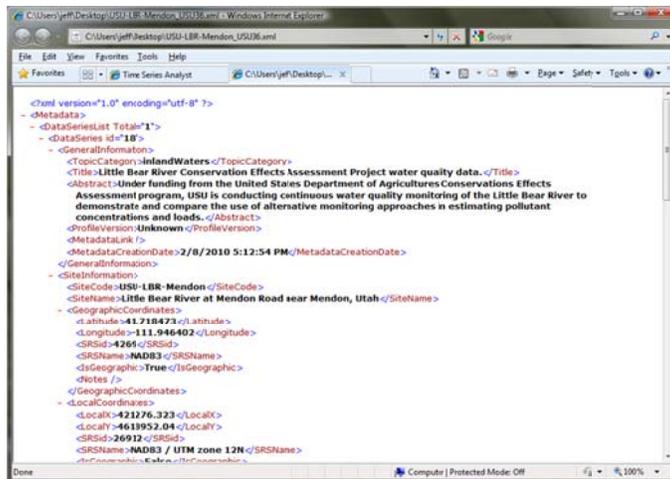
6. On the right side of the form above the summary statistics, you will notice that there are two tabs for switching between the summary statistics and the plot options. When you click on the “Plot Options” tab, you can change a few of the options associated with the plots. For example, you can switch from a monthly box and whisker plot to a seasonal box and whisker plot.



7. At the top left of the form, you will see three pull down menus – File, Graph, and Data. On the File menu, you can select “Print View” to get a printable view of the plot with its associated metadata.



- On the “Plot” menu, you can redraw (Plot) or Clear the current plot, and on the “Data” menu you can choose “View” to see the data as an HTML table, “Export myDB” to export the data as a comma separated values file, and “Export Metadata” to export an XML file containing the full metadata description of the data that you have just plotted.



## 4.0 THE TIME SERIES ANALYST CALLING INTERFACE

TSA can be launched in a specified state by passing parameters to the application in the URL string. This is especially useful for launching the TSA from a map of monitoring site locations, etc. The following parameters, which are attributes of a time series stored in an ODM database, are supported in the URL string:

- Database:** Specify which ODM database to connect to.
- SiteCode:** Specify which ODM SiteCode should be selected.
- VariableCode:** Specify which ODM VariableCode should be selected.
- MethodID:** Specify a MethodID for the data series to be selected.
- QualityControlLevelID:** Specify a QualityControlLevelID for the data series to be selected.
- BeginDate:** Specify a beginning date for selecting the data series.
- EndDate:** Specify an ending date for selecting the data series.
- PlotGraph:** True or False indication of whether ODM TSA should plot the graph when it is launched.

A fully specified URL for the TSA might look something like the following:

<http://icewater.usu.edu/tsa/default.aspx?Database=LittleBearRiverODM&SiteCode=USU-LBR-Mendon&VariableCode=USU6&MethodID=28&SourceID=1&QualityControlLevelID=2&BeginDate=1/1/2008&EndDate=1/31/2008&PlotGraph=True>

The ODM TSA will also accept subsets of the parameters in the URL. For example:

<http://icewater.usu.edu/tsa/default.aspx?Database=MudLakeODM>

<http://icewater.usu.edu/tsa/default.aspx?Database=LittleBearRiver&SiteCode=USU-LBR-SFUpper>