ERDC/ITL SR-20-4

US Army Corps
of Engineers®
Engineer Research and
Development Center

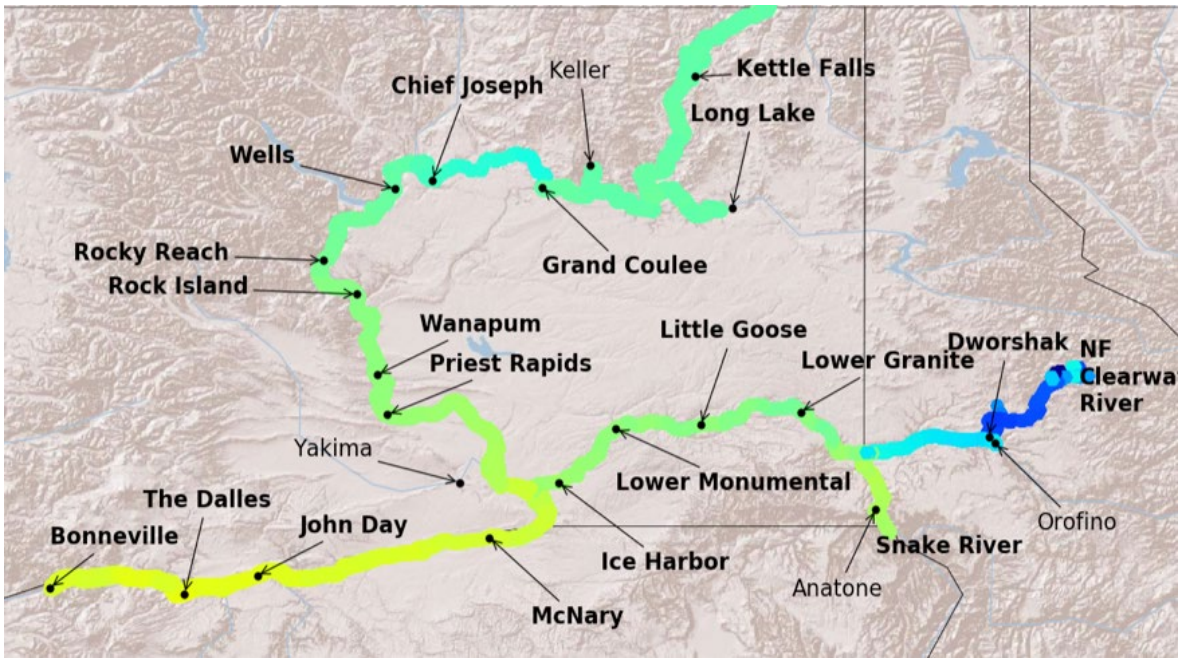
ERDC
ENGINEER RESEARCH & DEVELOPMENT CENTER

# Water Quality Visualization Tools

## A Python Application (1/A)

Corey H. Mize

June 2020






Information Technology Laboratory

**The US Army Engineer Research and Development Center (ERDC)** solves the nation's toughest engineering and environmental challenges. ERDC develops innovative solutions in civil and military engineering, geospatial sciences, water resources, and environmental sciences for the Army, the Department of Defense, civilian agencies, and our nation's public good. Find out more at www.erdc.usace.army.mil.

To search for other technical reports published by ERDC, visit the ERDC online library at http://acwc.sdp.sirsi.net/client/default.

ERDC/ITL SR-20-4
June 2020

# Water Quality Visualization Tool

## A Python Application (1/A)

Corey H. Mize

*Information Technology Laboratory*
*US Army Engineer Research and Development Center*
*3909 Halls Ferry Road*
*Vicksburg, MS 39180-6199*

Final report



Prepared for US Army Corps of Engineers, Portland District
Portland, OR 97204

Under Project No. 7D5KFK

# Abstract

On May 4, 2016, US District Court Judge Simon ordered the US Army Corps of Engineers and two other Action Agencies to produce a comprehensive Environmental Impacts Statement (EIS) by March 26, 2021. To do this, the Columbia River Systems Operation (CRSO) EIS will evaluate and compare a range of alternatives to offset or minimize any remaining unavoidable impacts on the Columbia River System. Due to the unique large system model approach, there is a need to quickly develop and analyze water quality model results. Therefore, there was a need for several visualization tools to assist the CRSO EIS team in promptly analyzing the results and creating publication-ready graphics. To create an easily accessible desktop application for the CRSO EIS team, the Python programming language was used to develop three visualization tools. These three tools are only useful for relatively small data sets. If the team wishes to expand the functionality for larger data sets, it is recommended that model execution and analysis be moved to the supercomputers.

# Contents

# Figures and Tables

## Figures



## Tables

# Preface

This study was conducted for the US Army Corps of Engineers, Portland District, under Project 7D5KFK. Ms. Kathryn Tackley was the technical monitor.

The work was performed by US Army Engineer Research and Development Center (ERDC), Scientific Software Branch of the Computational Science and Engineering Division, Information Technology Laboratory (ITL), and the Water Quality and Contaminant Modeling Branch, Environmental Processes Division, Environmental Laboratory. At the time of publication of this report, Mr. Timothy Dunaway was Chief, Scientific Software Branch, ERDC-ITL; Dr. Jerry Ballard was Chief, Computational Science and Engineering Division, ERDC-ITL; and Dr. Robert Wallace was the Technical Director for Engineered Resilient Systems domain. The Deputy Director of ERDC-ITL was Ms. Patti Duett, and the Director was Dr. David Horner.

Mr. Michael Puhr, Mr. Joshua Church, and Mr. Kevin Walker are acknowledged for their technical contributions to this project. Ms. Tammy Threadgill is also acknowledged for her support of this effort.

The Commander of ERDC was COL Teresa A. Schlosser, and the Director was Dr. David W. Pittman.

# 1 Introduction

## Background

The Columbia River Systems Operation (CRSO) Environmental Impacts Statement (EIS) Water Quality (WQ) team commissioned a tool for the purposes of supporting their efforts to explore fish survival and productivity based on an array of alternatives. The CRSO EIS WQ team was charged with creating, running, and analyzing their water quality models to contribute to the EIS ordered by US District Court Judge Simon on May 4, 2016.

Evaluating these alternatives requires the use of two different models — CE-QUAL-W2 (for the stratified reservoirs) and HEC-RAS (for the isothermal/run-of-river reservoirs). These models must be run for two different constituents, temperature and total dissolved gas (TDG), to then be visualized in three different ways. Because of the size of these data sets and the short timelines the WQ team is facing, they required the creation of a robust and efficient visualization toolset. The Information Technology Laboratory (ITL) was consulted to create three separate visualization tools that can quickly create publication-ready Sankey plots, Stratification heat maps, and Animations. They also required that these tools have options for creating plots that could be tailored for technical or non-technical audiences.[1]

## Objective

The objective of this project was to create three Water Quality Visualization Tools (WQVT) to support the CRSO EIS water quality modelers. These tools needed to satisfy the following requirements:

1. Parse several different file formats.
2. Provide the users with options for customizing the visualizations.
3. Produce publication-ready visualizations.
4. Produce visualizations to be used for public presentations.
5. Produce visualizations of temperature and TDG data.

[1] *Columbia River System Operations Environmental Impact Statement,* mandated by US District Court Judge Simon. In preparation.

## Approach

This application consists of three Python-based visualization tools that have been customized for the CRSO EIS project. The Sankey and Animation generators combine two types of model files. One file is produced from the CE-QUAL-W2 Model (W2), and the other is generated by the HEC-RAS Model (RAS). The Stratification generator only uses the CE-QUAL-W2 model files. Both model file types contain the necessary flow, elevation, temperature, and/or total dissolved gases data that is necessary to create each of these figures.

The remaining sections break down the installation and execution necessary to use each generator listed in Table 1.

Table 1. Tool overview.

| Tool Overview | Details |
|---|---|
| Sankey Plot Generator | Create Temperature or TDG Sankey Diagrams |
| Stratification Figure Generator | Create Temperature Stratification Diagrams |
| Animation Generator | Create Temperature and TDG Animations |

# 2 Installation

The Sankey, stratification, and animation tools are run via an executable. Therefore, there are **no required installation steps** for this application. The executable encapsulates all necessary languages and modules needed to run these tools. If there is no need to manually edit and run the application, skip to Chapter 3 – Quick Start Guide.

*Note: These steps were tested on a Windows OS only.

To manually edit and run the code, complete the following steps:

*Note: If on a restricted, government machine, skip to the next section.

1. Install Python 2.7.
2. Install pip.
3. Use pip install to add the matplotlib, pillow, numpy, image, xlsxwriter, xlrd, plotly (3.4.1 or higher), scipy, and pandas modules.
4. Change directory to the wqvt_setup_utils.zip folder, and pip install the **basemap-1.2.0-cp27-cp27m-win_amd64.whl** wheel file. A more updated version of basemap can be retrieved here: https://www.lfd.uci.edu/~gohlke/pythonlibs/#basemap .

If using a restricted government machine to run Python, the following steps may be required instead of those above.

*Note: There may be no need to install all of these dependencies; this was done with a new install of Python. Therefore, if already in a Python environment, there may be no need to install all of these libraries. However, if attempting to install a library and an error message occurs that implies that a necessary dependency is missing, check the wqvt_setup_utils.zip folder for that missing library before searching for it online.

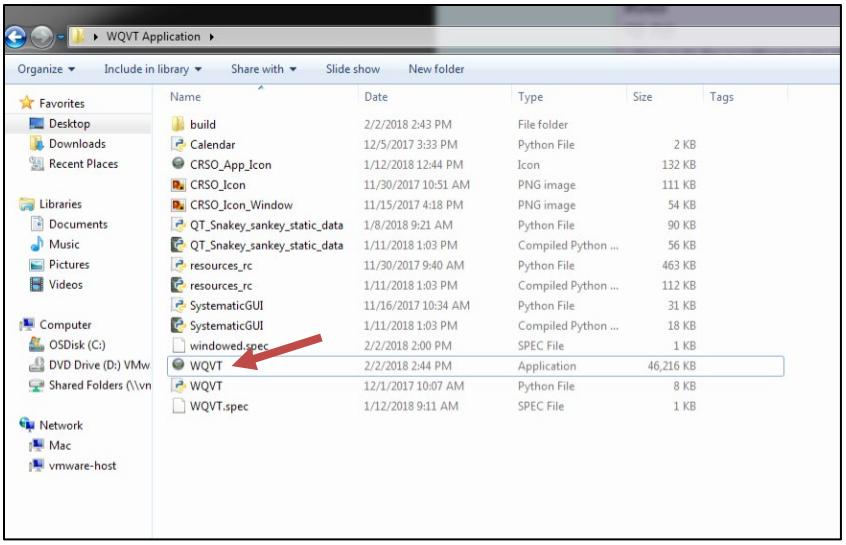
1. Request a Python 2.7 installation (https://aceit.usace.army.mil)
   a. Choose the “Submit Your Request” tab.
   b. Search for “Software Request.”
   c. In the App Portal, search “Python 2” and add “Python Software Foundation Python 2 7.5.6” to Cart.
   d. View Cart and Checkout.

   e. The target should be “Me on machine xxxx,” where xxxx is the machine name.
   f. Hit Next and then Submit.
2. Once Python is installed, pip should already be installed as well. To check for this, open a command prompt and type “pip.” and if the Usage options are populated, then pip is already installed.
3. Then, unzip and download all of the files in the wqvt_setup_utils.zip folder.
4. Change directory to the location where all of the wheel files are located, and use the command “pip install <insert wheel file name>” to install the following wheel files.
   a. pillow-5.3.0-cp27-cp27m-win_amd64.whl
   b. xlsxWriter-1.1.1-py2.py3-none-any.whl
   c. xlrd-1.1.0-py2.py3-none-any.whl
   d. scipy-1.1.0-cp27-none-win_amd64.whl
   e. image-1.5.27-py2.py3-none-any.whl
   f. matplotlib-2.2.3-cp27-cp27m-win_amd64.whl
   g. plotly-3.4.0-py2.py3-none-any.whl
   h. numpy-1.15.3-cp27-none-win_amd64.whl
   i. pandas-0.23.4-cp27-cp27m-win_amd64.whl
   j. basemap-1.2.0-cp27-cp27m-win_amd64.whl

# 3 Quick Start Guide

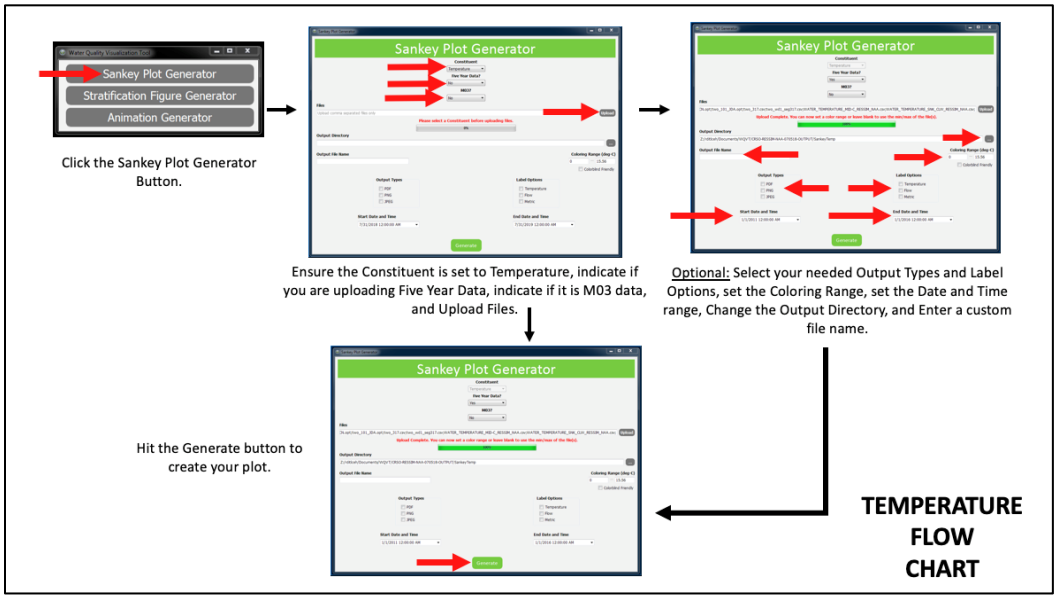
This section provides a flow chart of the possible paths of action for each tool.

## Run executable (First step for tools 1-3)

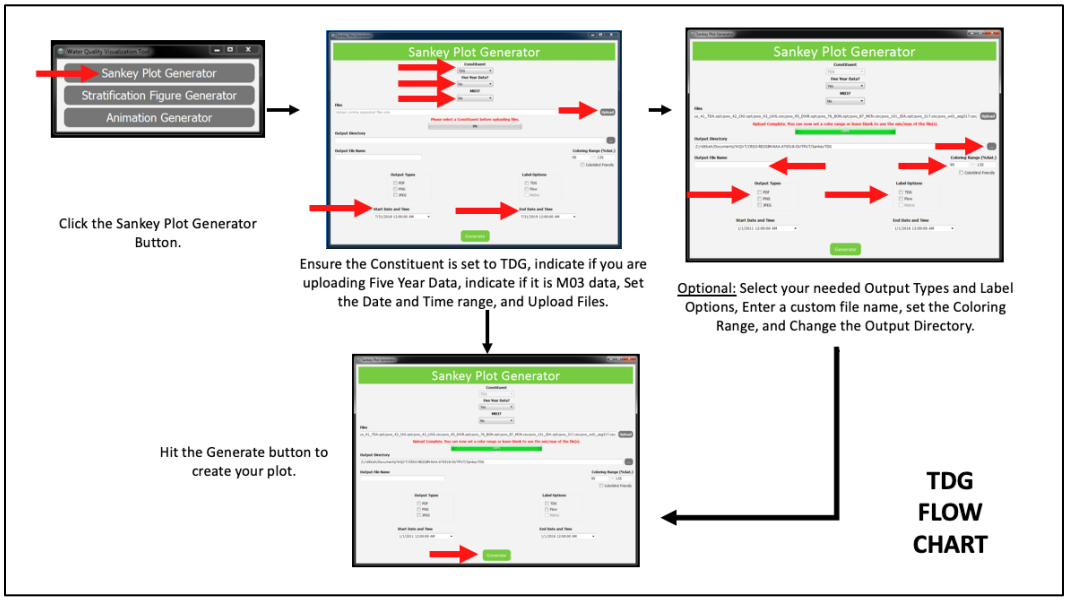



## Sankey plot generator

a. Temperature flow chart

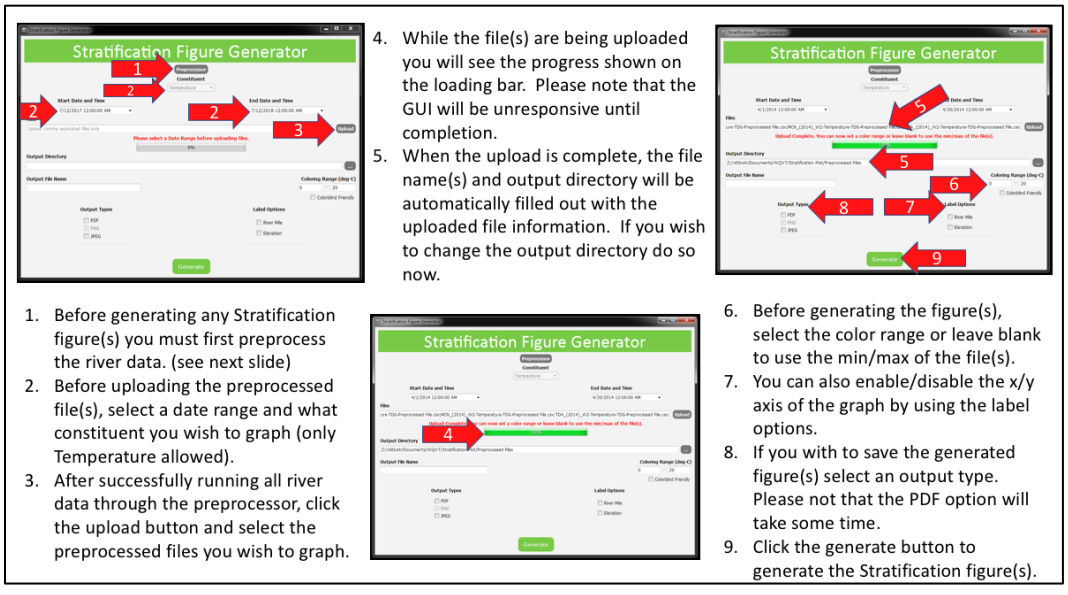


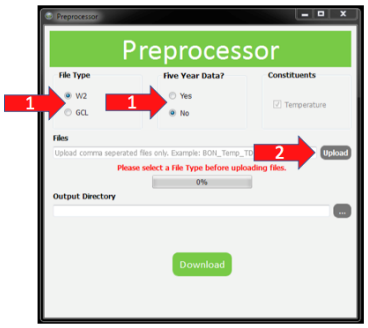
b. TDG flow chart



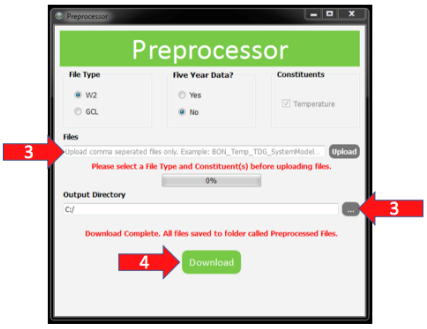

## Stratification figure generator

a. Temperature flow chart (preprocessor below)



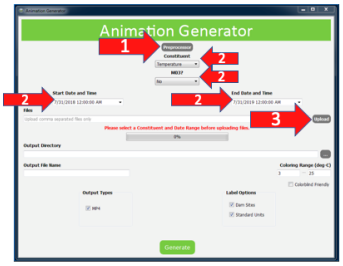



1. Before uploading any file(s), first select what file type you wish to process and indicate if it will be 5 year data. Please note that only the selected file type will be accepted.
2. Click the upload button to select the file(s) you wish to process. Please note that large files may need to be uploaded one at a time to reduce your overall wait. See the project README.txt for specifics about file naming conventions.
3. When the upload is complete, the file name(s) and output directory will be automatically filled out with the uploaded file information. If you wish to change the output directory do so now.
4. Click the download button to download preprocessed file(s). The file names will be cleared when download is pressed. The file(s) will be placed in a "Preprocessed Files" folder in the selected output directory. Please do not rename any preprocessed files.

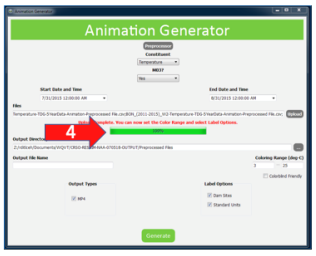


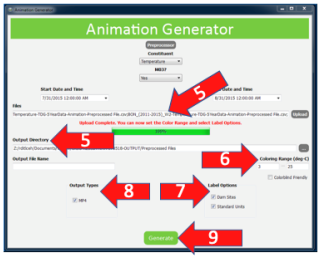

## Animation generator

a. Temperature and TDG flow chart (preprocessor below)

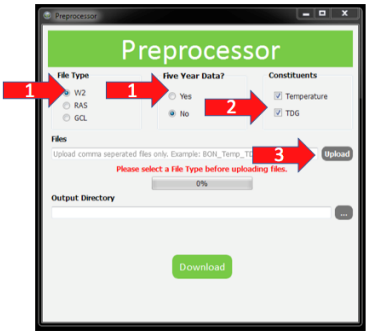



1. Before generating any Animations you must first preprocess the data files. (see next slide)
2. After successfully running all data files through the preprocessor, select a date range, what constituent you wish to animate, and indicate if it is M03 data.
3. Click the upload button and select the preprocessed files you wish to animate.
4. While the file(s) are being uploaded you will see the progress shown on the loading bar. Please note that the GUI will be unresponsive until completion.
5. When the upload is complete, the file name(s) and output directory will be automatically filled out with the uploaded file information. If you wish to change the output directory do so now.

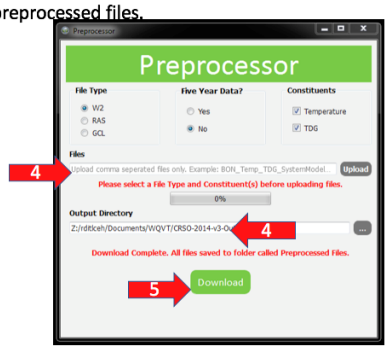



6. Before generating the animation, set the color range or use the defaults.
7. You can also enable/disable displaying the dam sites and using standard units by using the label options.
8. If you with to save the generated animation, leave the MP4 box checked.
9. Click the generate button to generate the Animation.




1. Before uploading any file(s), first select what file type you wish to process and indicate if it will be 5 year data. Please note that only the selected file type will be accepted.
2. You can also select what constituent(s) you wish to extract from the uploaded file(s).
3. Click the upload button to select the file(s) you wish to process. Please note that large files may need to be uploaded one at a time to reduce your overall wait. See the project README.txt for specifics about file naming conventions.
4. When the upload is complete, the file name(s) and output directory will be automatically filled out with the uploaded file information. If you wish to change the output directory do so for the first download, and then do not change the output directory again.
5. Click the download button to download preprocessed file(s). The file names will be cleared when download is pressed. The file(s) will be placed in a "Preprocessed Files" folder in the selected output directory. Please do not rename any preprocessed files.



# 4 Documentation

This section provides detailed instructions for running all of the WQVT. The Sankey, stratification, and animation tools are housed in an executable, but they can be accessed via the command line as well.

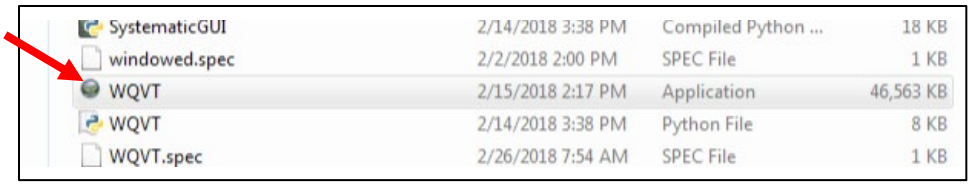
## Sankey plot generator

The Sankey plot is used to visualize the average flow and constituent value of each section of the Columbia, Snake, and Clearwater Rivers over a given time period. The constituents that are currently visualized are temperature and TDG. Each section's width is proportional to its flow, and the color of the section represents either its temperature (degrees) or TDG (saturation). The diagram can be labeled with flow and/or the constituent value, if desired. For temperature, there is also an option to view the values in metric units. The plot will automatically appear in a pop-up window, but it can also be output as a PDF, PNG, and/or JPEG file format for easy addition to papers and presentations.

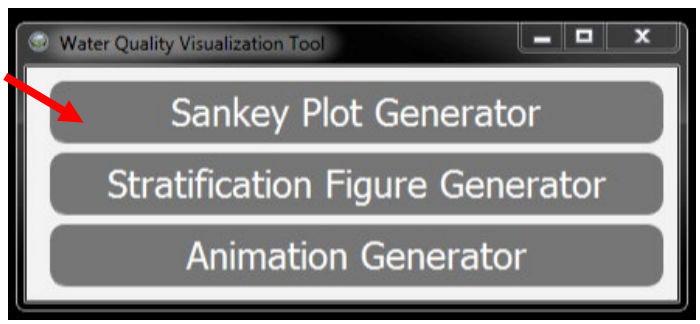
### Temperature

#### STEP 1: Open the executable

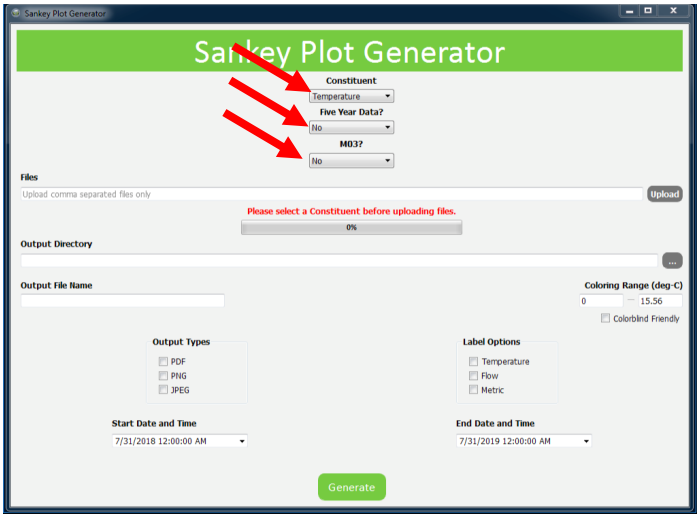
- This may take several seconds to open.




#### STEP 2: Select the Sankey plot generator tool



**STEP 3: Set constituent to "Temperature," indicate if Five Year Data will be used, and indicate if M03 data will be used.**




**STEP 4: Upload all W2 and RAS files at once.**

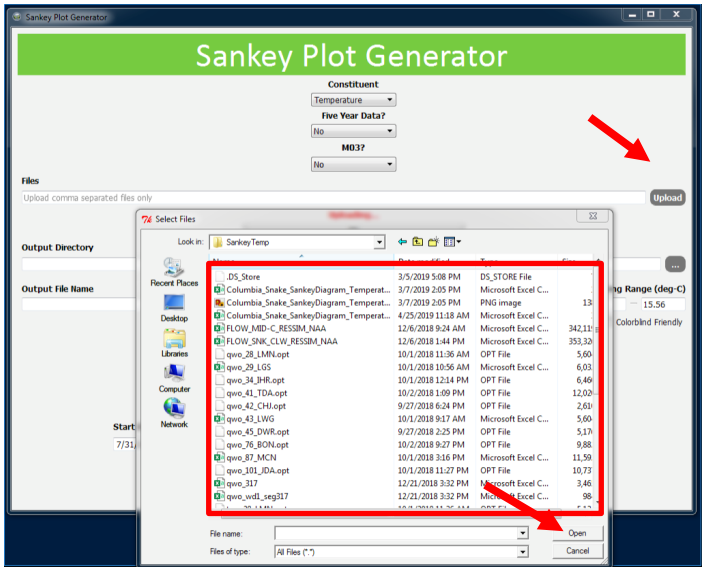
*Items enclosed in brackets [] means that one of each option must be uploaded or one year from the selection must be included in the name.* ***Ensure that only one version of each file is uploaded.***

- It may take several seconds to parse the files. Wait for the progress bar message to indicate the upload is complete.

Table 2 presents the Sankey temperature files.

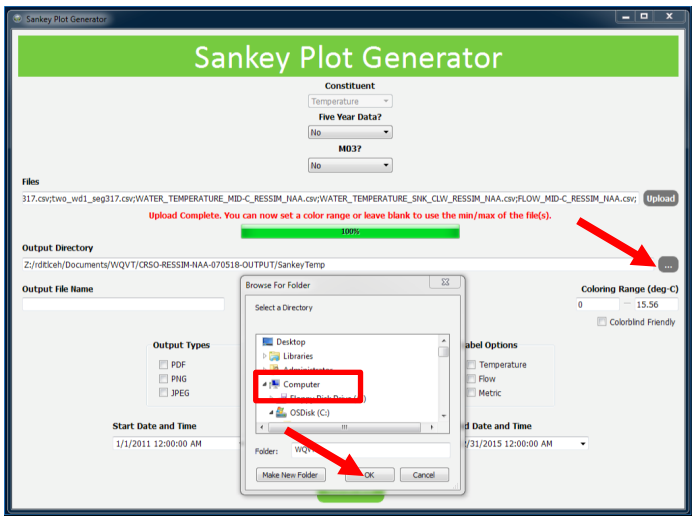
Table 2. Sankey temperature files.

| File Name Contains (1 Year Data) | File Name Contains (5 Year Data) | File Name Extension |
|---|---|---|
| qwo_[28, 29, 34, 41, 42,43, 45, 76, 87, 101, 317, wd1_seg317] | qwo_[28, 29, 34, 41, 42,43, 45, 76, 87, 101, 317, wd1_seg317] | .opt or .csv or .xls |
| two_[28, 29, 34, 41, 42,43, 45, 76, 87, 101, 317, wd1_seg317] | two_[28, 29, 34, 41, 42,43, 45, 76, 87, 101, 317, wd1_seg317] | .opt or .csv or .xls |
| [COLUMBIA, MID-C] and [FLOW, TEMPERATURE] and [2011, 2014, 2015] | [COLUMBIA, MID-C] and [FLOW, TEMPERATURE] | .opt or .csv or .xls |
| [SNAKE_CLEARWATER, SNK-CLW] and [FLOW, TEMPERATURE] and [2011, 2014, 2015] | [SNAKE_CLEARWATER, SNK-CLW] and [FLOW, TEMPERATURE] | .opt or .csv or .xls |



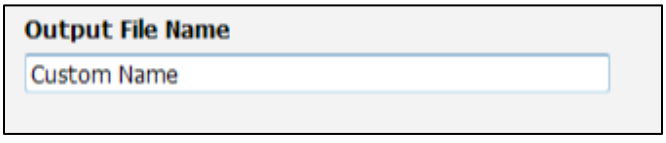

## STEP 5: Optional selections (can skip to STEP 6).

*STEP 5a: Change the output directory.*



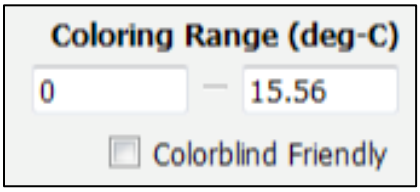

*STEP 5b: Customize the output file name*

- Default Name:
  Columbia_Snake_SankeyDiagram_Temperature_startdate_enddate

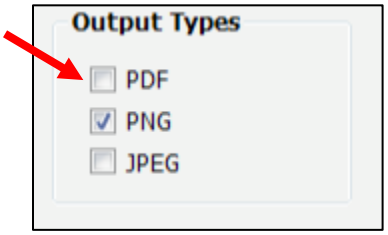


*STEP 5c: Set the temperature coloring range.*

- The values below are the default values for the range, but if both boxes are cleared, the range will be set based on the data's minimum and maximum values.
- Also, check the "Colorblind-Friendly" box if wishing to use a color palette that is readable by colorblind persons.

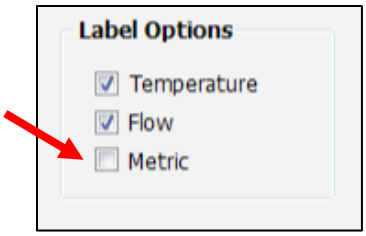



*STEP 5d: Select output types.*

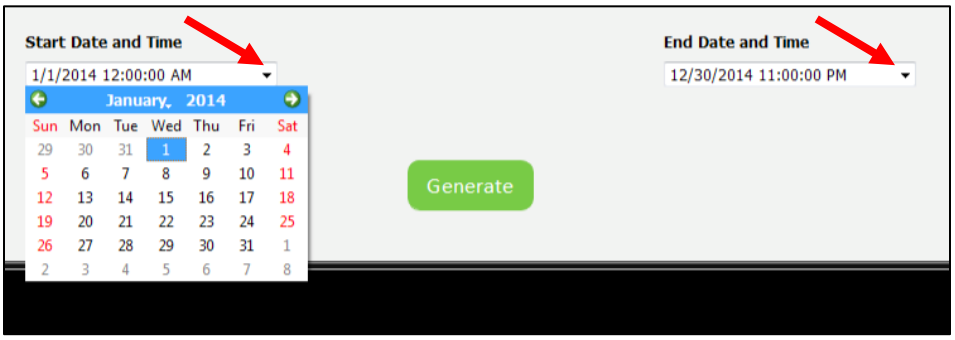



*STEP 5e: Select label options.*

- These options will display the temperature and flow for each section of the river. If the "Metric" box is checked, all values will be displayed in metric units. By default, the values are displayed in standard units.



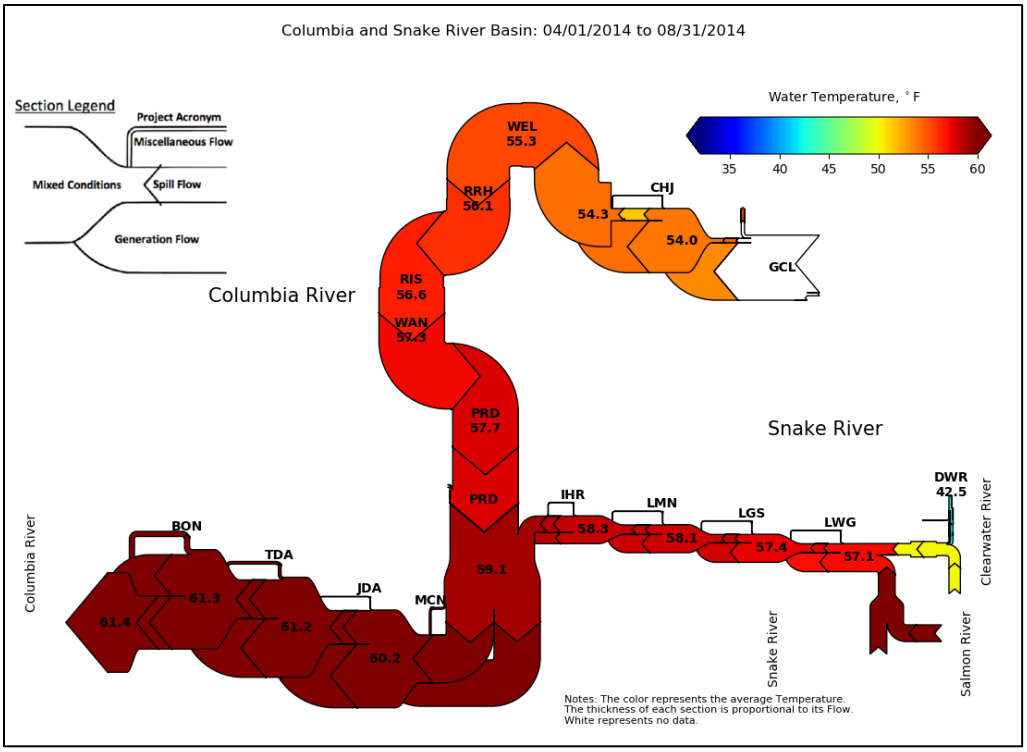
*STEP 5f: Set the start and end date and time.*




**STEP 6: Select the "Generate" button**

- It may take several seconds to generate the figure.

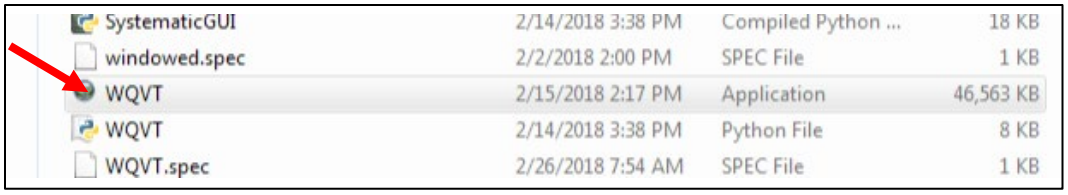

- A Sankey figure will be generated and displayed, and any output files selected will be created.



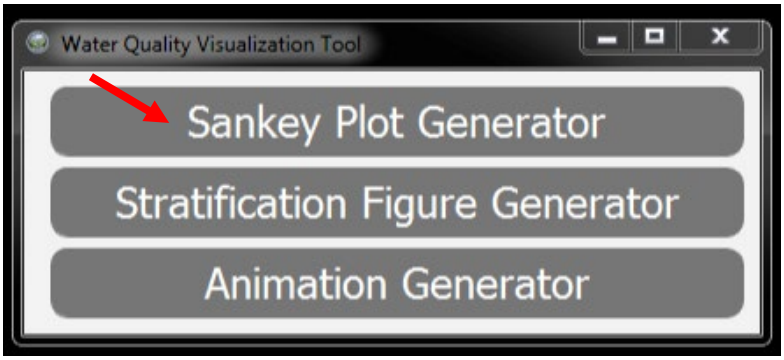
## Total dissolved gases (TDG)

### STEP 1: Open the executable.

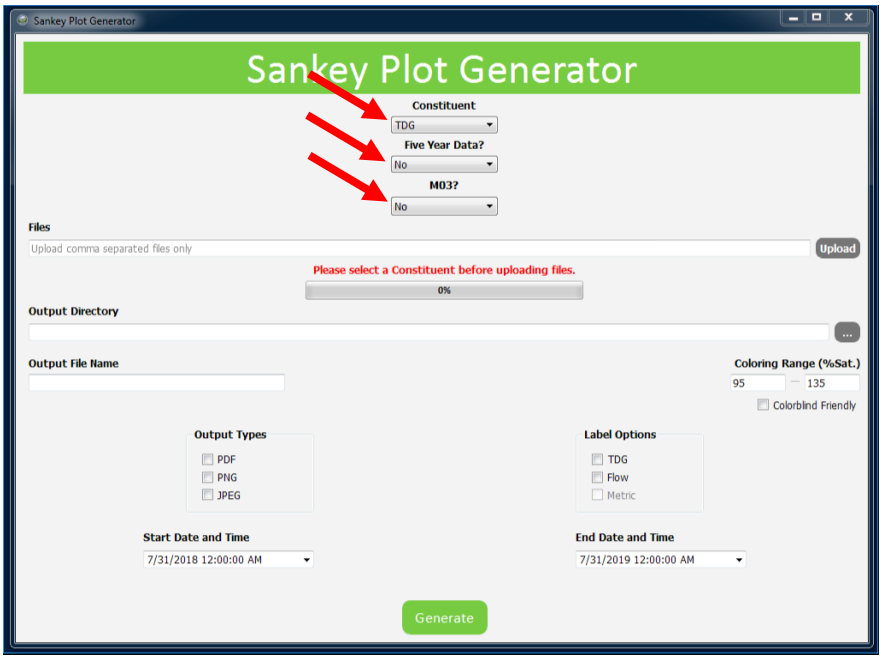
- This may take several seconds to open.




### STEP 2: Select the Sankey plot generator tool.




### STEP 3: Set Constituent to "TDG," indicate if "Five Year Data" will be used, and indicate if "M03" data will be used.



**STEP 4: Upload all W2 files.**

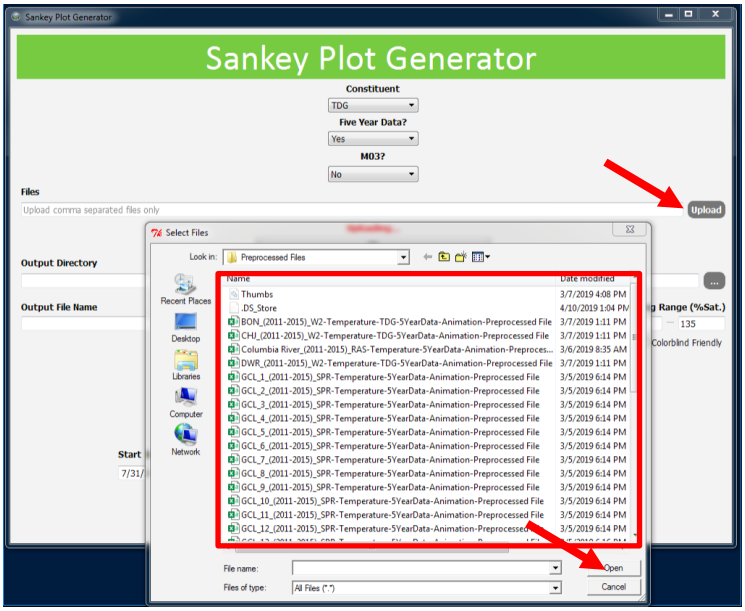
*Items enclosed in brackets [] means that one of each option must be uploaded or one year from the selection must be included in the name.* ***Ensure that only one version of each file is uploaded.***

- It may take several seconds to parse the files. Wait for the progress bar message to indicate the upload is complete.

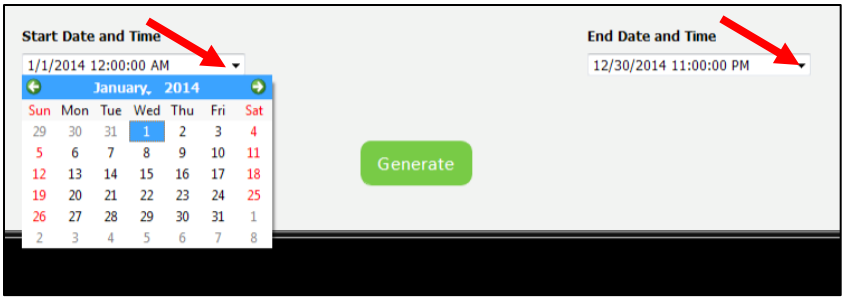
Table 3 presents the Sankey TDG files.

Table 3. Sankey TDG files.

| File Name Contains (1-Year Data) | File Name Contains (5-Year Data) | File Name Extension |
|---|---|---|
| qwo_[28, 29, 34, 41, 42,43, 45, 76, 87, 101, 317, wd1_seg317] | qwo_[28, 29, 34, 41, 42,43, 45, 76, 87, 101, 317, wd1_seg317] | .opt or .csv or .xls |
| dwo_[28, 29, 34, 41, 42,43, 45, 76, 87, 101, 317, wd1_seg317] | dwo_[28, 29, 34, 41, 42,43, 45, 76, 87, 101, 317, wd1_seg317] | .opt or .csv or .xls |
| dwo_gate[1-10]_seg28 | dwo_gate[1-10]_seg28 | .opt or .csv or .xls |
| dwo_gate[1-11]_seg29 | dwo_gate[1-11]_seg29 | .opt or .csv or .xls |
| dwo_gate[1-12]_seg34 | dwo_gate[1-12]_seg34 | .opt or .csv or .xls |
| dwo_gate[1-25]_seg41 | dwo_gate[1-25]_seg41 | .opt or .csv or .xls |
| dwo_gate[1-3]_seg42 | dwo_gate[1-3]_seg42 | .opt or .csv or .xls |
| dwo_gate[1-10]_seg43 | dwo_gate[1-10]_seg43 | .opt or .csv or .xls |
| dwo_gate[1-20]_seg76 | dwo_gate[1-20]_seg76 | .opt or .csv or .xls |
| dwo_gate[1-24]_seg87 | dwo_gate[1-24]_seg87 | .opt or .csv or .xls |
| dwo_gate[1-22]_seg101 | dwo_gate[1-22]_seg101 | .opt or .csv or .xls |
| dwo_gate[1-5]_seg317 | dwo_gate[1-5]_seg317 | .opt or .csv or .xls |
| [COLUMBIA, MID-C] and FLOW and [2011, 2014, 2015] | [COLUMBIA, MID-C] and FLOW | .opt or .csv or .xls |
| [SNAKE_CLEARWATER, SNK-CLW] and FLOW and [2011, 2014, 2015] | [SNAKE_CLEARWATER, SNK-CLW] and FLOW | .opt or .csv or .xls |

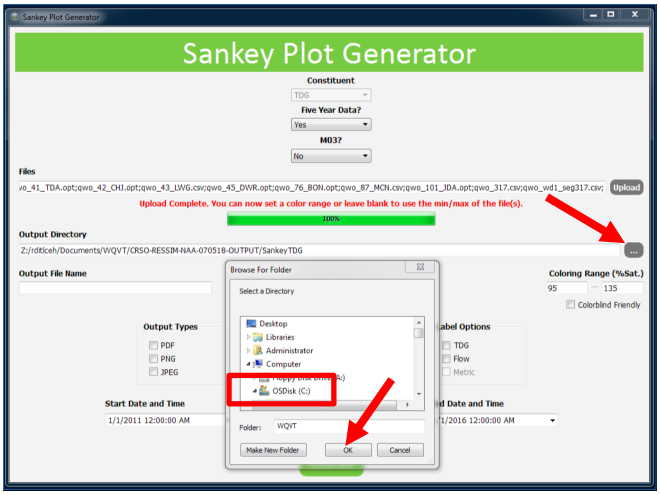



## STEP 5: Set the start and end date and time.



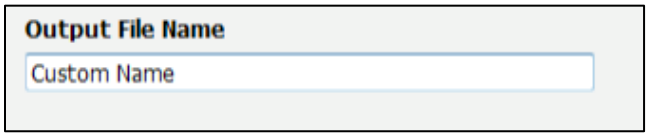

## STEP 6: Optional selections (can skip to STEP 7).

*STEP 6a: Change the output directory.*



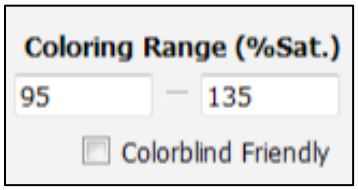
*STEP 6b: Customize the output file name.*

- Default: Columbia_Snake_SankeyDiagram_TDG_startdate_enddate

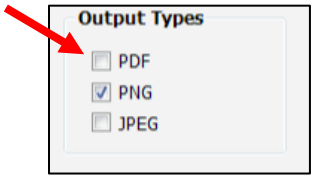



*STEP 6c: Set the TDG coloring range.*

- The values below are the default values for the range, but if both boxes are cleared, the range will be set based on the data's minimum and maximum values.
- Also, check the "Colorblind-Friendly" box if wishing to use a color palette that is readable by colorblind persons.

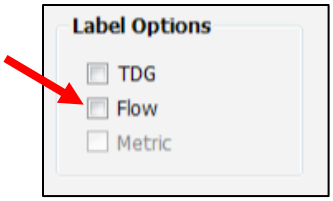



*STEP 6d: Select output types.*




*STEP 6e: Select label options.*

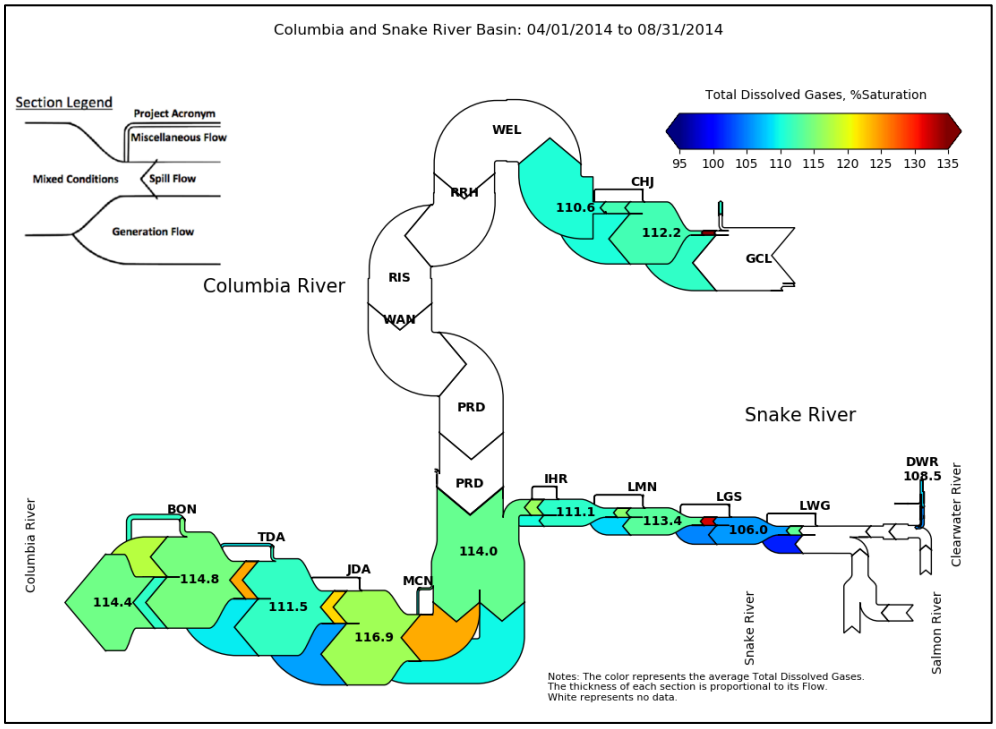
- These options will display the TDG and flow for each section of the river. The "Metric" box is disabled because TDG is in %Saturation and has no other form. By default, the values are displayed in standard units.



**STEP 7: Select the "Generate" button.**

- It may take several seconds to generate the figure.


- A Sankey figure will be generated and displayed, and any output files selected will be created.



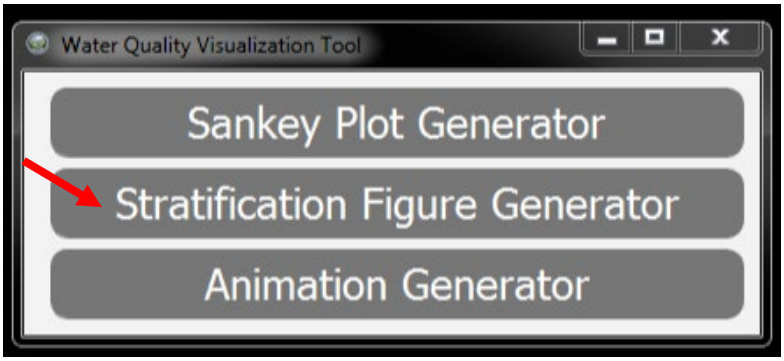
## Stratification figure generator (temperature only)

The Stratification figure is used to visualize the average elevation and constituent value at each river mile for each section of the Columbia, Snake, and Clearwater Rivers over a given time period. The constituent that is currently visualized is temperature. Each section's height is represented on the *y*-axis, the river mile is shown on the *x*-axis, and the colors in each section represent its varying temperature in *degrees*. The diagram can have the *x* and *y* axes labels, if desired. The plot is automatically saved as a PNG and can also be output as a PDF and/or JPEG file format for easy addition to papers and presentations.

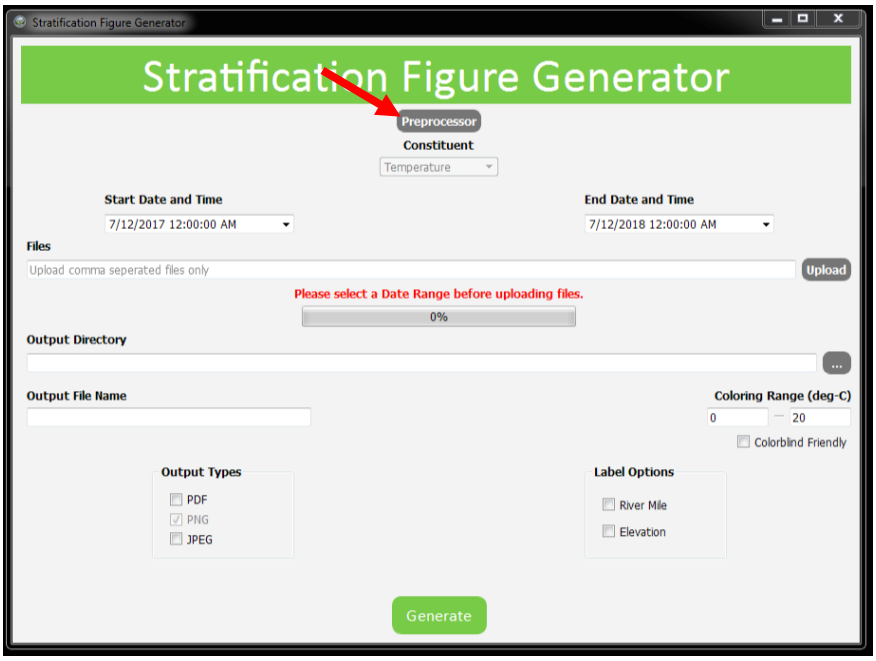
### STEP 1: Open the executable.

- This may take several seconds to open.

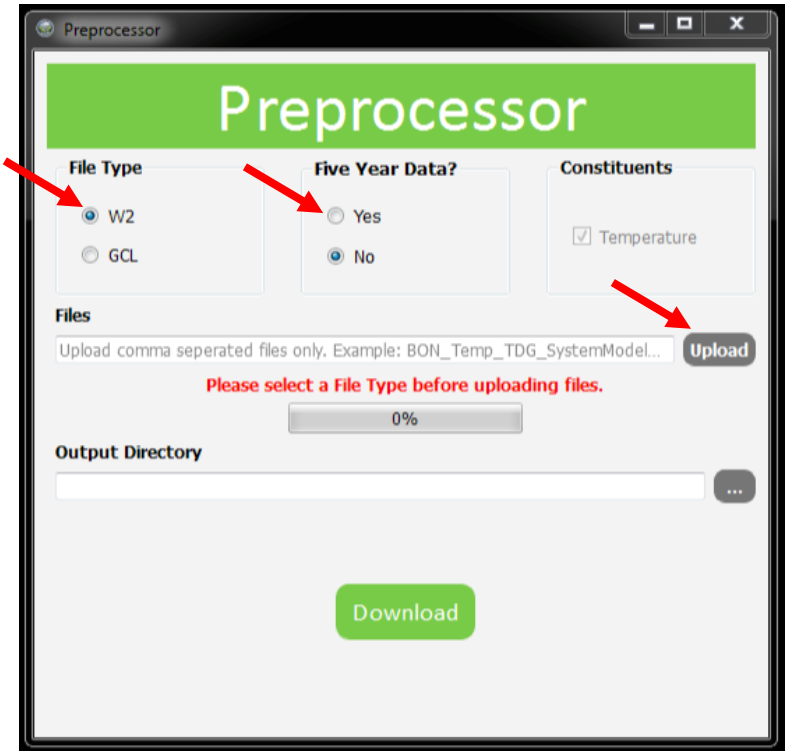

### STEP 2: Select the Stratification figure generator tool.



**STEP 3: Select the preprocessor button.**




**STEP 4: Select a file type (W2 or SPR) and indicate if this is Five Year Data to parse all temperature data from those files.**



**STEP 5: Upload files that match the file type selected.**

*Items enclosed in brackets [] means that one of each option must be uploaded or 1 year from the selection must be included in the name.* ***Ensure that only one version of each file is uploaded.***

- It may take several seconds to parse the files. Wait for the progress bar message to indicate the upload is complete.
- Suggested Upload Procedure: Upload all W2 files and continue through Step 6. Next, upload all but the largest SPR files at once and continue through Step 6. Finally, upload each of the largest SPR files separately going through Step 6 each time.

Table 4 presents the Stratification temperature files.

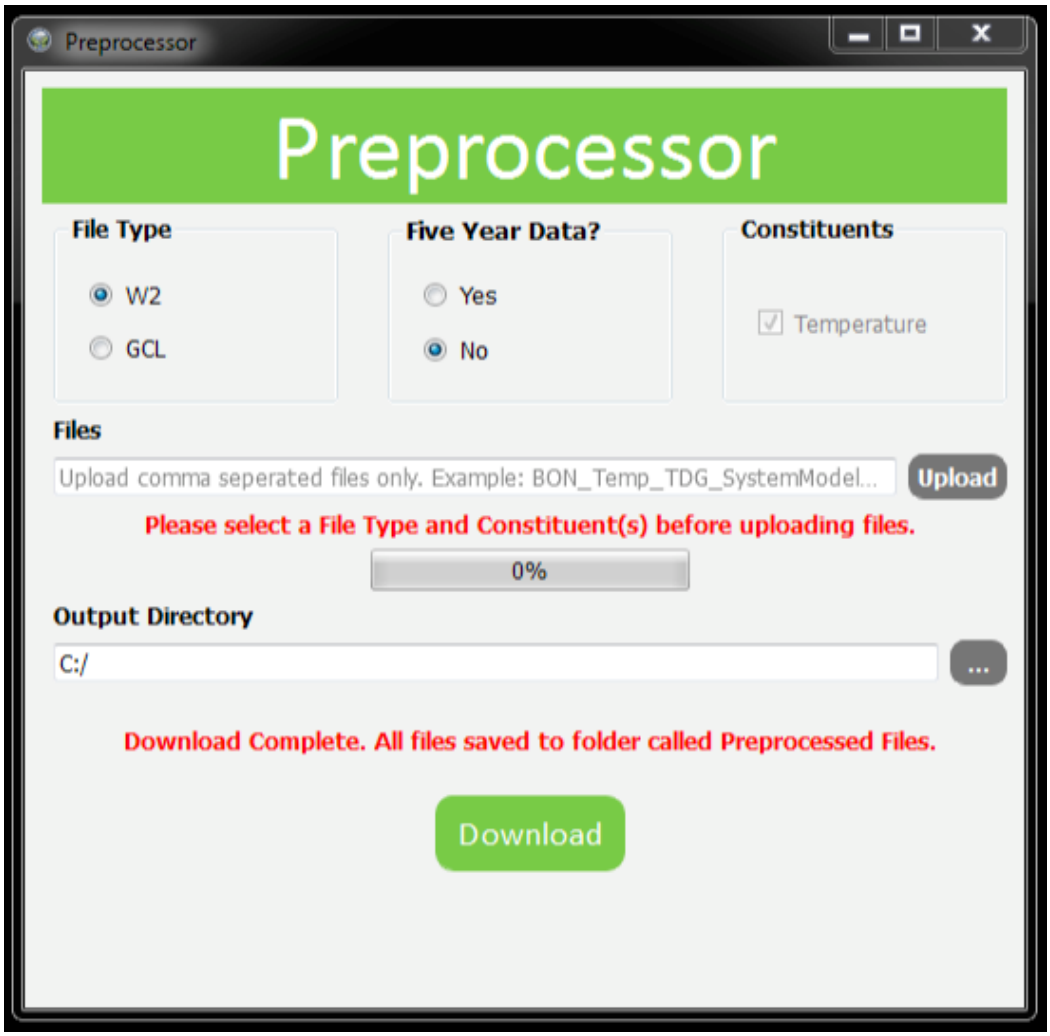
Table 4. Stratification temperature files.

| File Name Contains (1 Year Data) | File Name Contains (5 Year Data) | File Name Extension |
|---|---|---|
| [LWG, LMN, DWR, CHJ, BON, TDA, JDA, MCN, IHR, LGS, LWG] and [2011, 2014, 2015] and spr | [LWG, LMN, DWR, CHJ, BON, TDA, JDA, MCN, IHR, LGS, LWG] and spr | .opt or .csv or .xls |
| spr and [1-25] and _[2011, 2014, 2015] | spr and [1-25] | .opt or .csv or .xls |

**STEP 6: Wait for "Upload Complete" message to appear. Then, if this is the <u>first time</u> to download, change the output directory and hit the "Download" button. This will create a "Preprocessed Files" folder in that directory that will store all of your preprocessed files.**

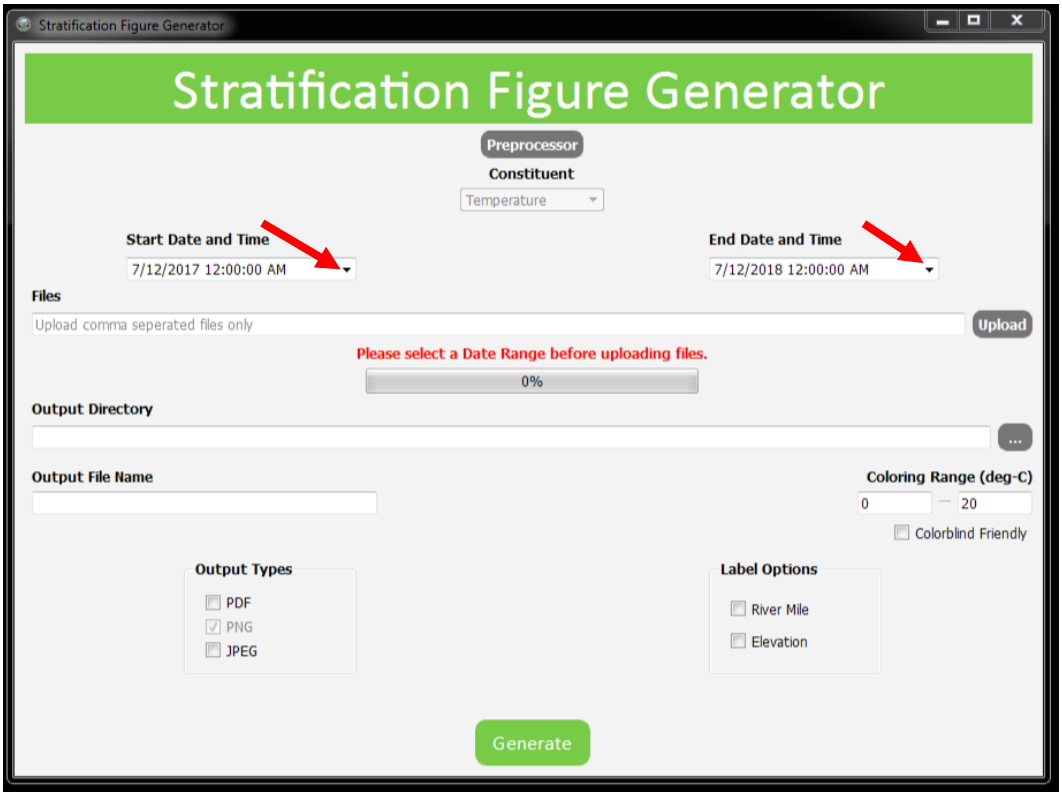
*Every time a file is downloaded <u>after the first time</u>, ensure that the output directory is the same as the first download.*

*Repeat Steps 4-6 until all files needed have been preprocessed, and then, close the preprocessor. DO NOT rename any preprocessed files.*

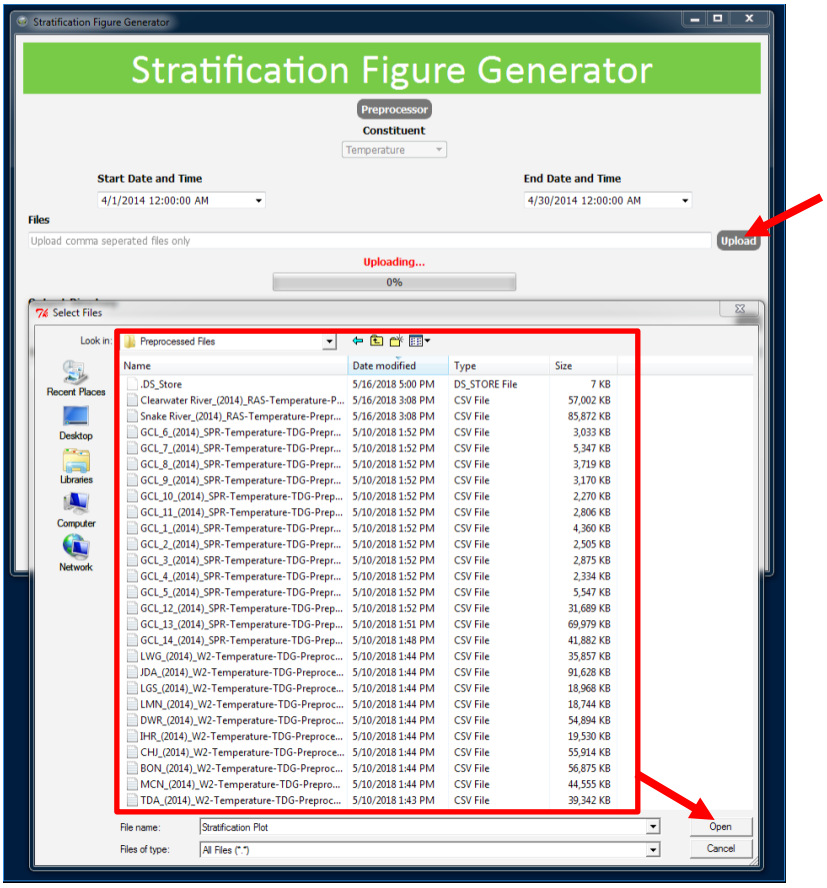


**STEP 7: Set the date range to be viewed.**

*Ensure that the preprocessor is closed before moving on to this step.*

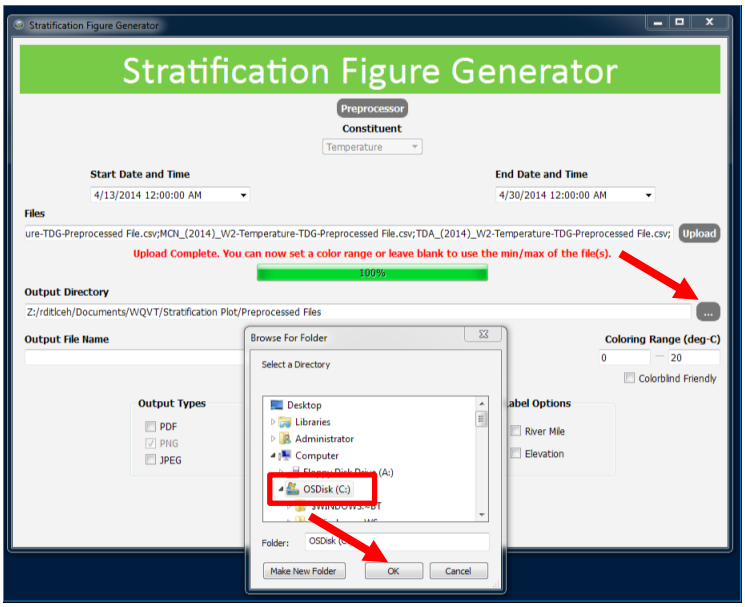


**STEP 8: Upload every preprocessed file for every section to be included in the figures.**



**STEP 9: Optional selections (can skip to STEP 10).**

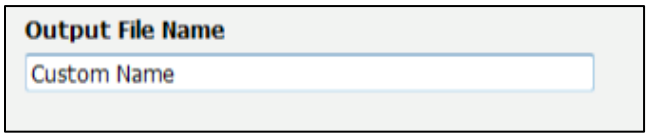
*STEP 9a: Change the output directory.*




*STEP 9b: Customize the output file name.*

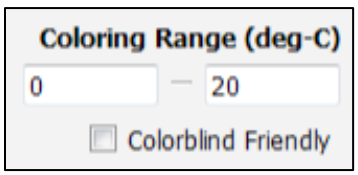
- Default name:

  StratFig_Temp_(MM-DD-YYYY to MM-DD-YYYY)_River Section



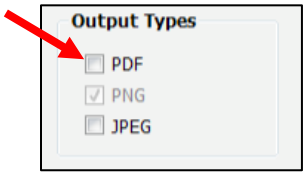

*STEP 9c: Set the Temperature coloring range.*

- The values below are the default values for the range, but if both boxes are cleared, the range will be set based on the data's minimum and maximum values.
- Also, check the colorblind-friendly box to use a color palette that is readable by colorblind persons.



*STEP 9d: Select output types.*

- PNG is automatically checked to ensure that a figure is created and can be viewed. The other output types are optional.




*STEP 9e: Select label options.*

- These options will display the river mile and elevation on the *x* and *y* axes, respectively, for each figure. By default, the values are displayed in standard units, and both label options are selected.


**STEP 10: Select the "Generate" button.**

- It may take several seconds to generate the figure.


- A Stratification figure will be generated for each section of the rivers where data files were provided, and they will be saved to the output directory selected. Those images can be viewed once this message appears.

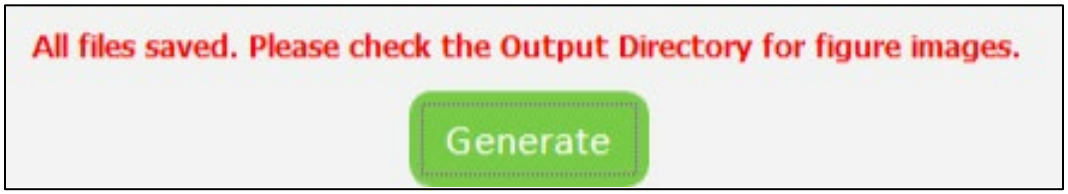


Figure 1 presents Stratification output file names and corresponding example plots.

**Figure 1. Stratification output file names and corresponding example plots.**

| Four Possible Output Files |
|---|
| StratFig_Temp_(MM-DD-YYYY to MM-DD-YYYY)_**Columbia River Upper** |
| StratFig_Temp_(MM-DD-YYYY to MM-DD-YYYY)_**Columbia River Lower** |
| StratFig_Temp_(MM-DD-YYYY to MM-DD-YYYY)_**Clearwater River** |
| StratFig_Temp_(MM-DD-YYYY to MM-DD-YYYY)_**Snake River** |

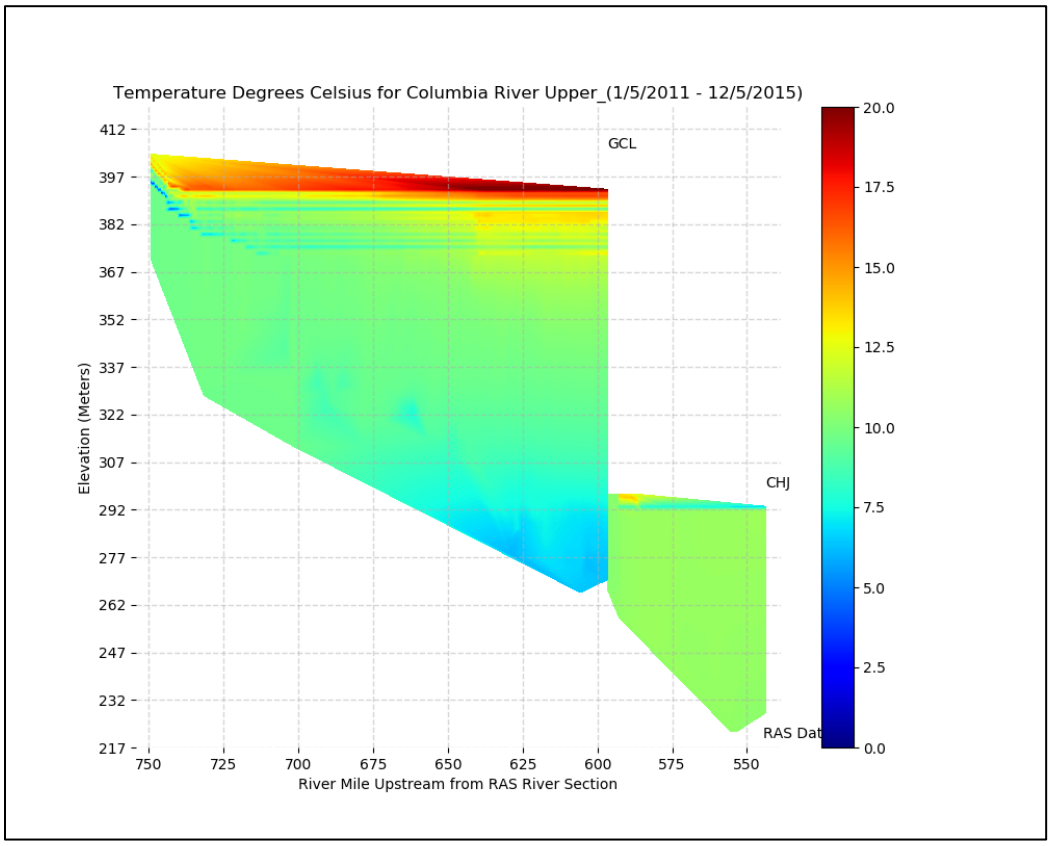
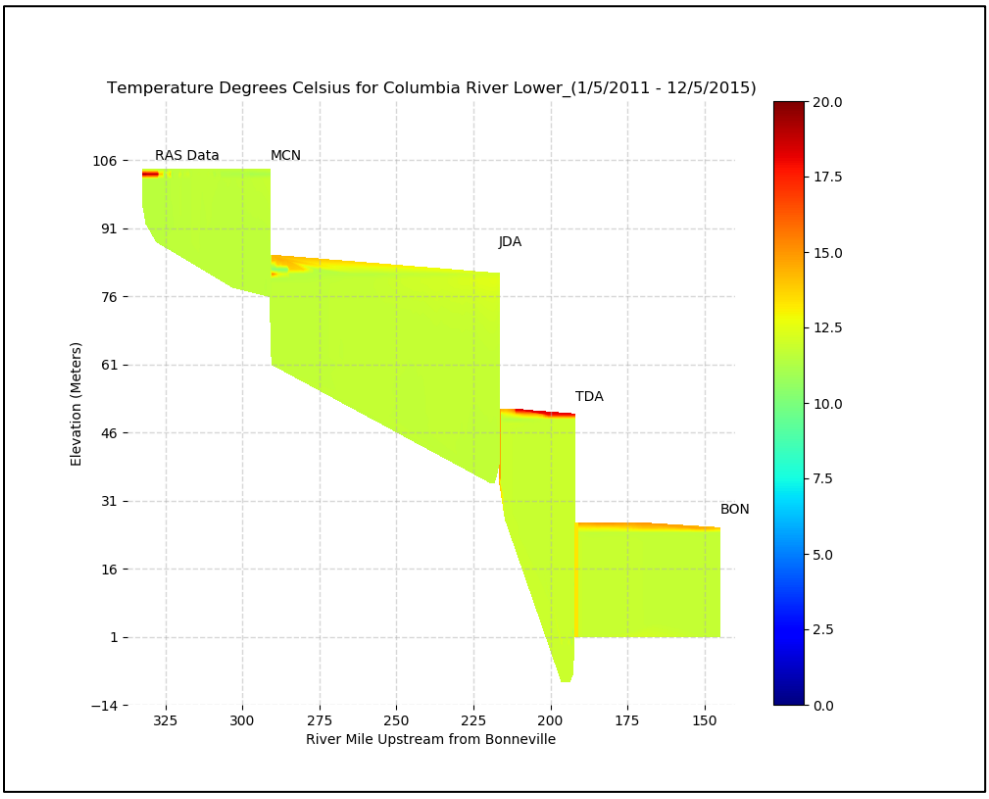


Figure 1 continued.



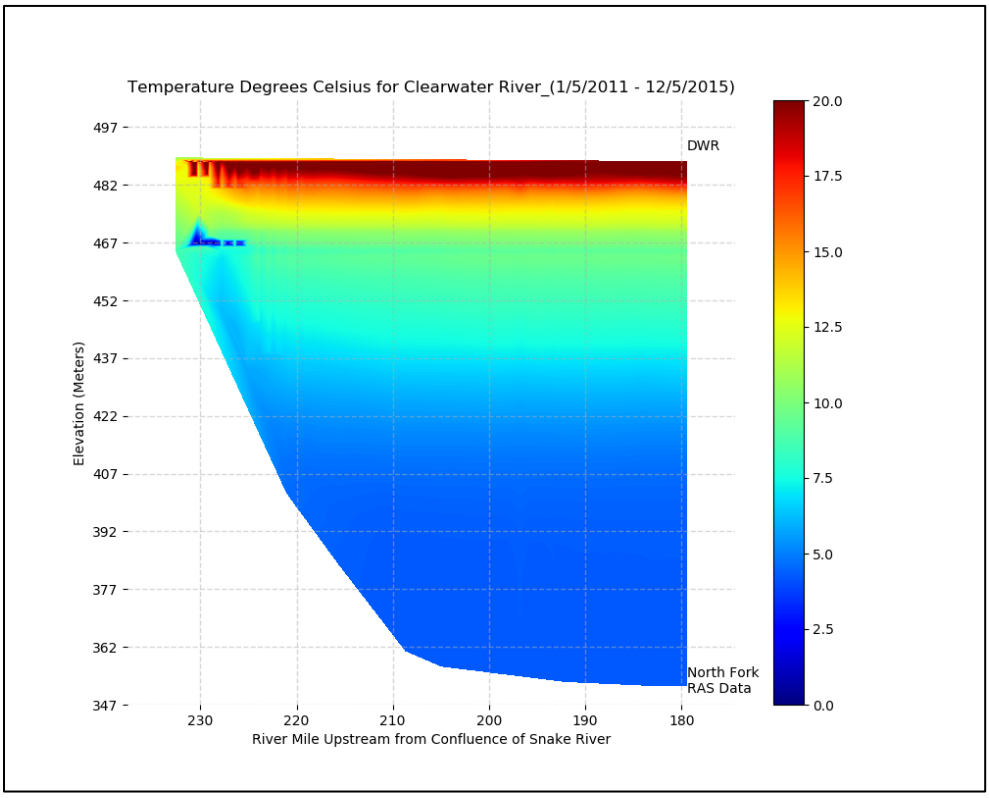
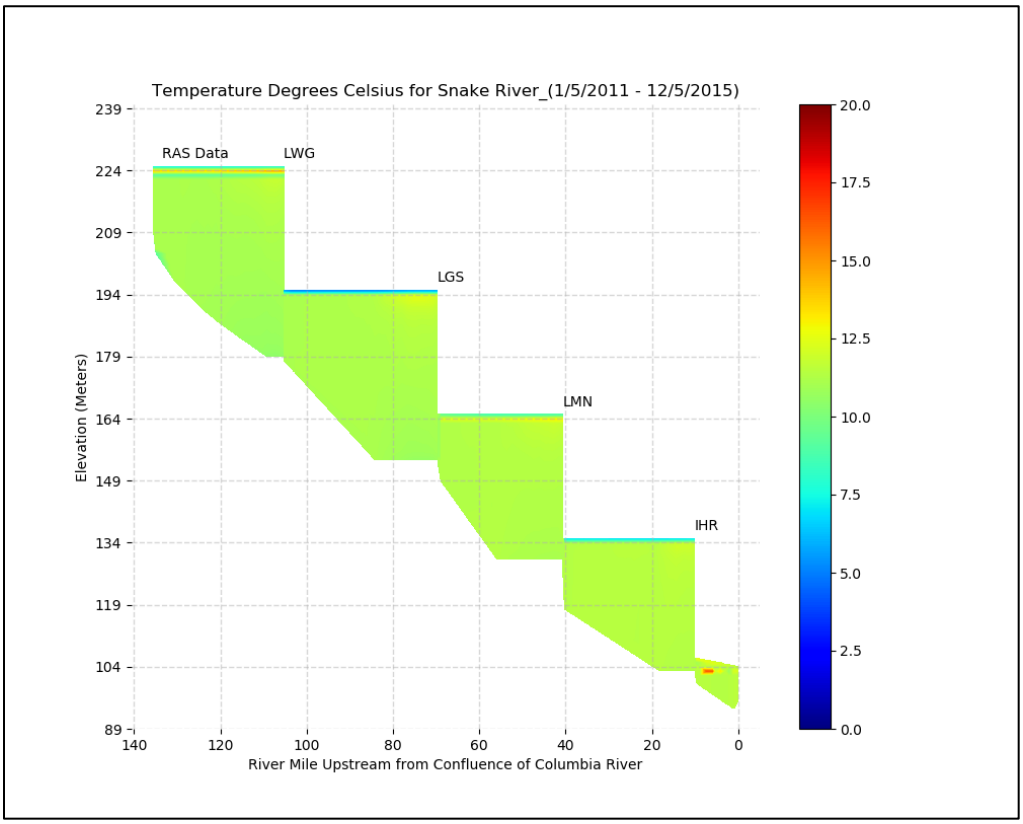



Figure 1 concluded.



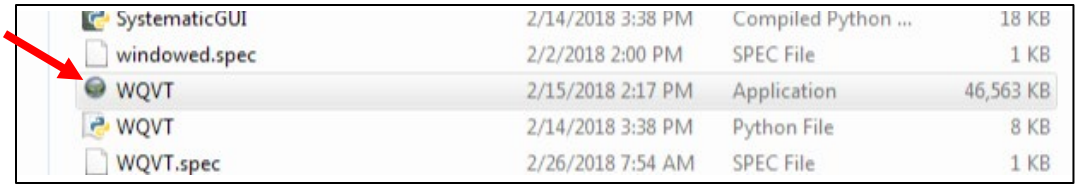

## Animation generator

The animations are used to visualize the depth averaged constituent value per day at each river mile for each section of the Columbia, Snake, and Clearwater Rivers over a given time period. The constituents that are currently visualized are temperature and TDG. Each section's color represents either its temperature degrees or TDG saturation. The diagram can be labeled with the dam sites, if desired. For temperature, there is also an option to view the values in standard units. The plot will automatically appear in a pop-up window, but it can also be output as an MP4 for easy addition to websites or presentations.

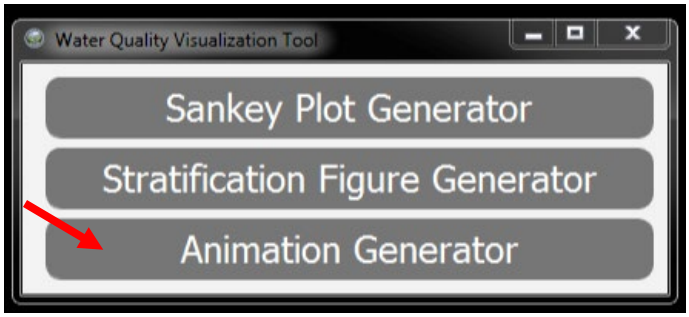
## Temperature

### STEP 1: Open the executable.

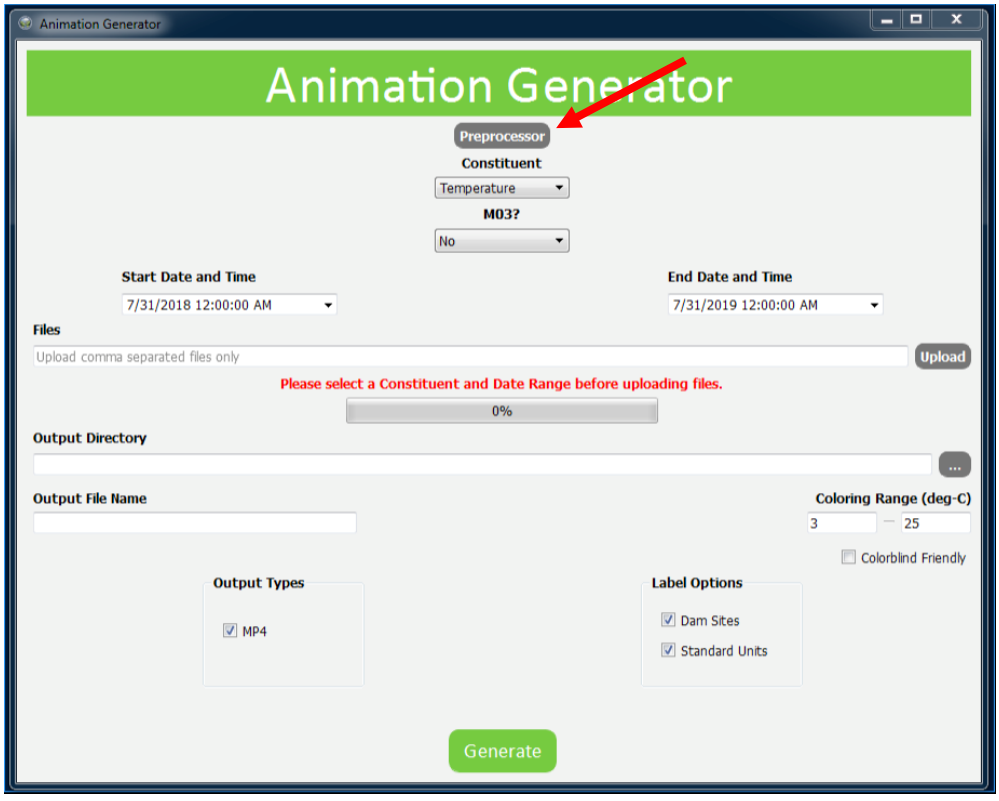
- This may take several seconds to open.




### STEP 2: Select the Animation generator tool.

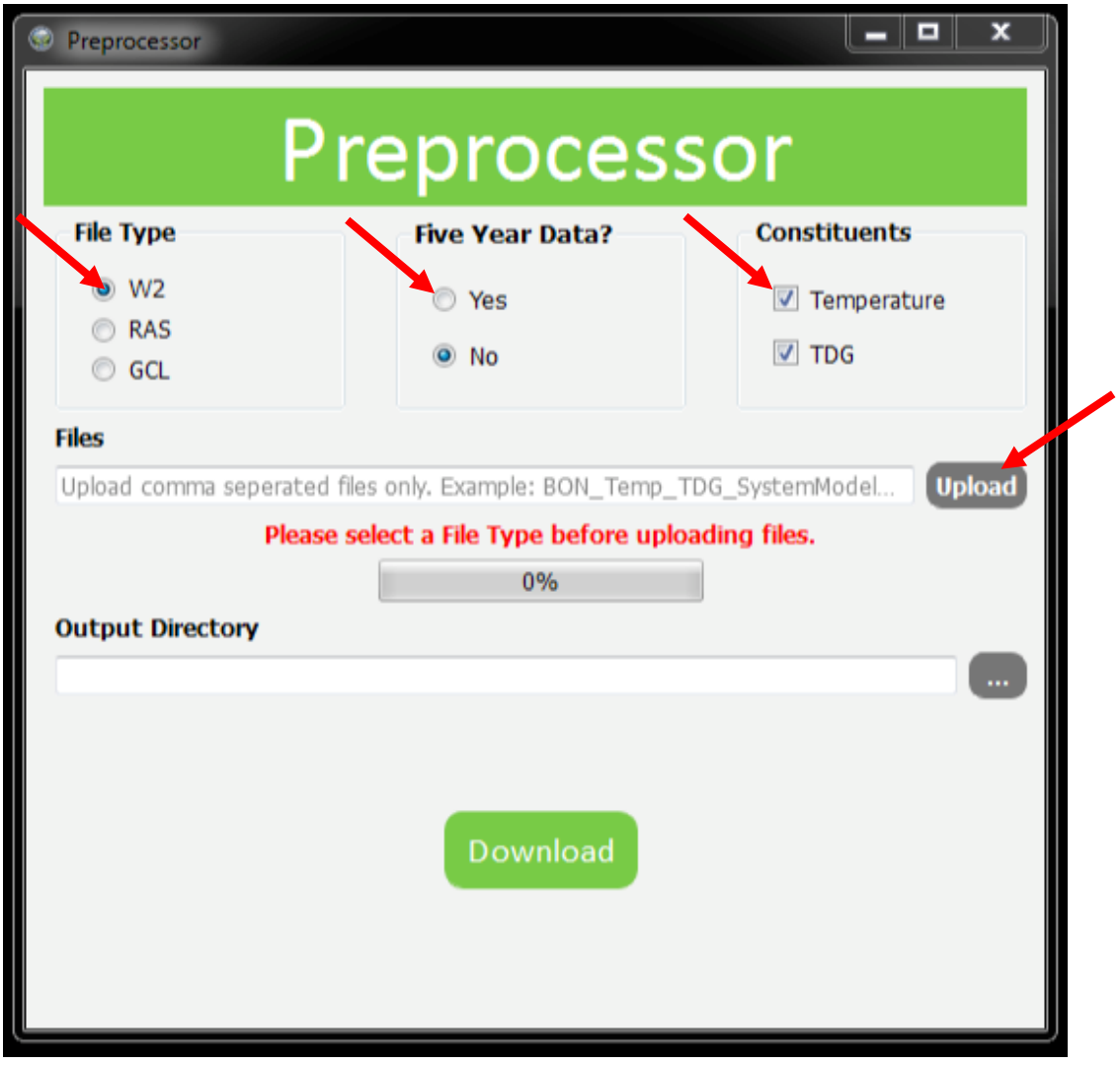



### STEP 3: Select the preprocessor button.



**STEP 4: Select a file type (W2, RAS, or SPR) and indicate if this is Five Year Data to parse all temperature and/or TDG data from those files.**

*Note: If parsing a RAS file, temperature data will be the only data in the file since RAS files do not contain TDG data. Also, if parsing for both temperature and TDG on all files, the preprocessor will need to be run only once. If parsing for temperature only, the preprocessor will have to be run again to look at TDG data.*



**STEP 5: Upload files that match the file type selected.**

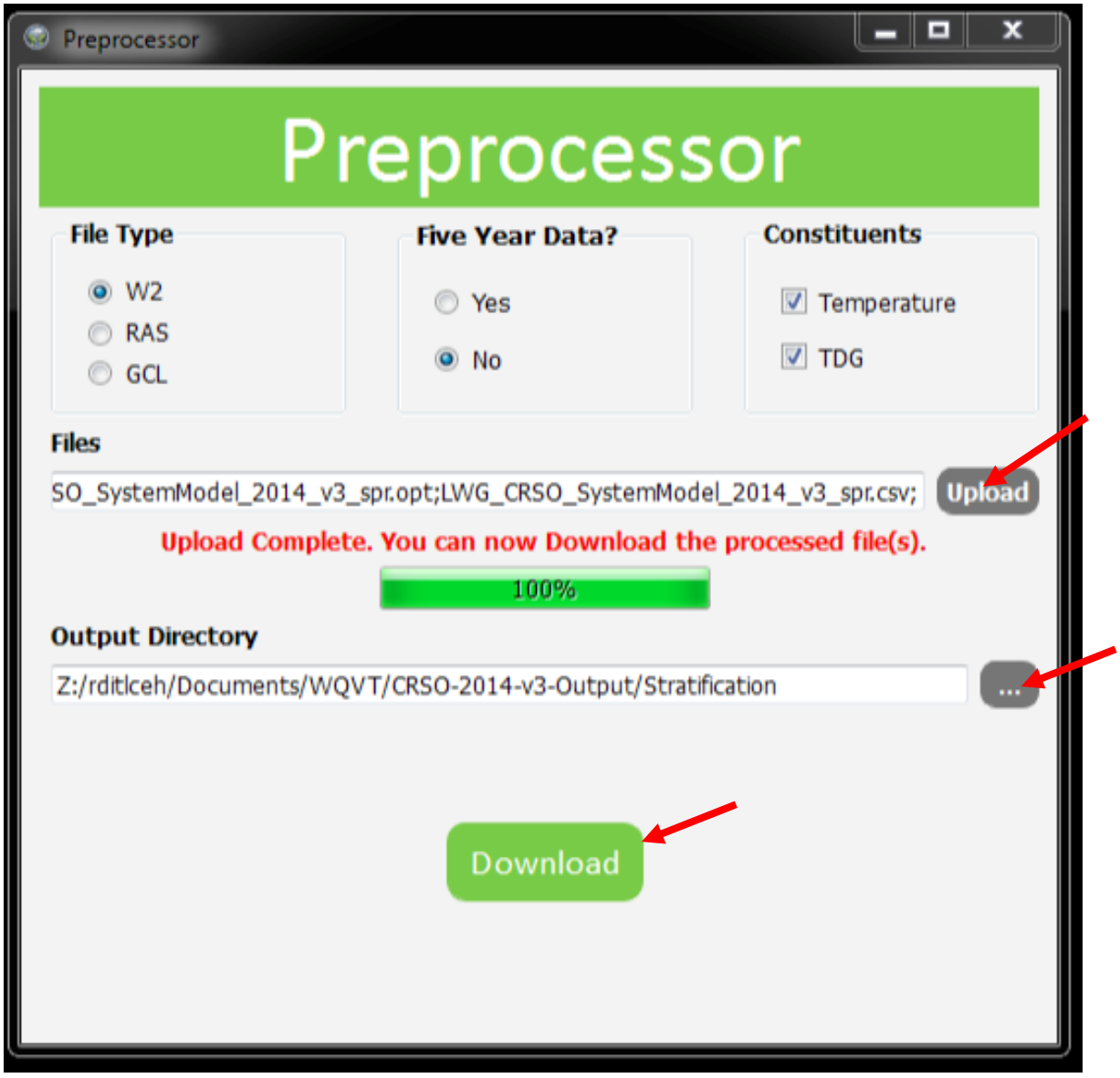
*Items enclosed in brackets [] means that one of each option must be uploaded or one year from the selection must be included in the name.* ***Ensure that only one version of each file is uploaded.***

- It may take several seconds to parse the files. Wait for the progress bar message to indicate the upload is complete.
- Suggested upload procedure: Upload all W2 files and continue through Step 6. Next, upload all RAS files and continue through Step 6. Then, upload all but the largest SPR files at once and continue through Step 6. Finally, upload each of the largest SPR files separately going through Step 6 each time.

Table 5 presents the Animation temperature files.

Table 5. Animation temperature files.

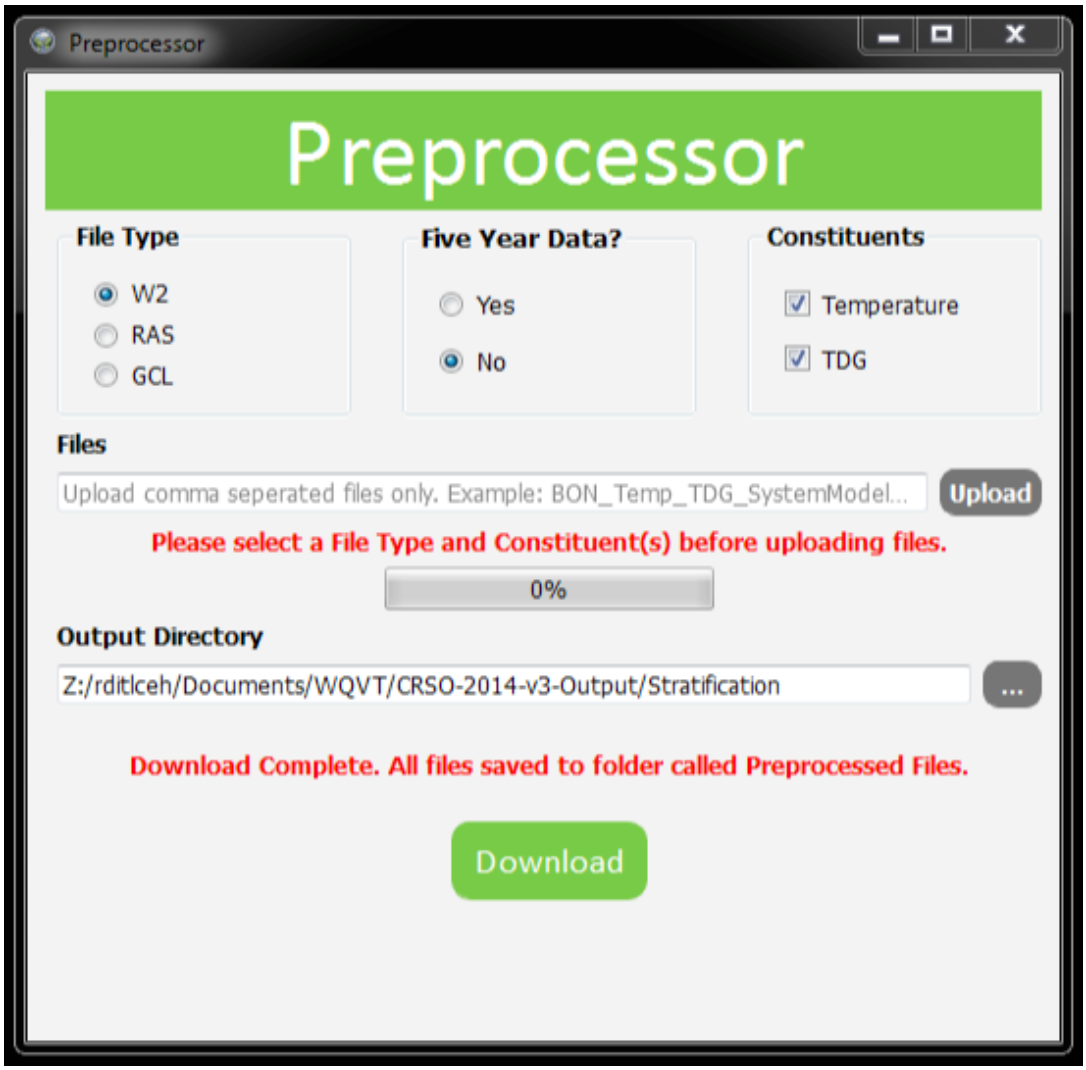
| File Name Contains (1 Year Data) | File Name Contains (5 Year Data) | File Name Extension |
|---|---|---|
| [LWG, LMN, DWR, CHJ, BON, TDA, JDA, MCN, IHR, LGS, LWG] and [2011, 2014, 2015] and spr | [LWG, LMN, DWR, CHJ, BON, TDA, JDA, MCN, IHR, LGS, LWG] and spr | .opt or .csv or .xls |
| [COLUMBIA, MID-C] and TEMPERATURE and [2011, 2014, 2015] | [COLUMBIA, MID-C] and TEMPERATURE | .opt or .csv or .xls |
| [SNAKE_CLEARWATER, SNK-CLW] and TEMPERATURE and [2011, 2014, 2015] | [SNAKE_CLEARWATER, SNK-CLW] and TEMPERATURE | .opt or .csv or .xls |
| spr and [1-25] and _[2011, 2014, 2015] | spr and [1-25] | .opt or .csv or .xls |


Preprocessor
Preprocessor
File Type
W2
RAS
GCL
Five Year Data?
Yes
No
Constituents
Temperature
TDG
Files
SO_SystemModel_2014_v3_spr.opt;LWG_CRSO_SystemModel_2014_v3_spr.csv;
Upload
Upload Complete. You can now Download the processed file(s).
100%
Output Directory
Z:/rditlceh/Documents/WQVT/CRSO-2014-v3-Output/Stratification
...
Download

**STEP 6: Wait for "Upload Complete" message to appear. Then, if downloading for <u>first time</u>, change the output directory and hit the "Download button." This will create a "Preprocessed Files" folder in that directory that will store all of the preprocessed files.**

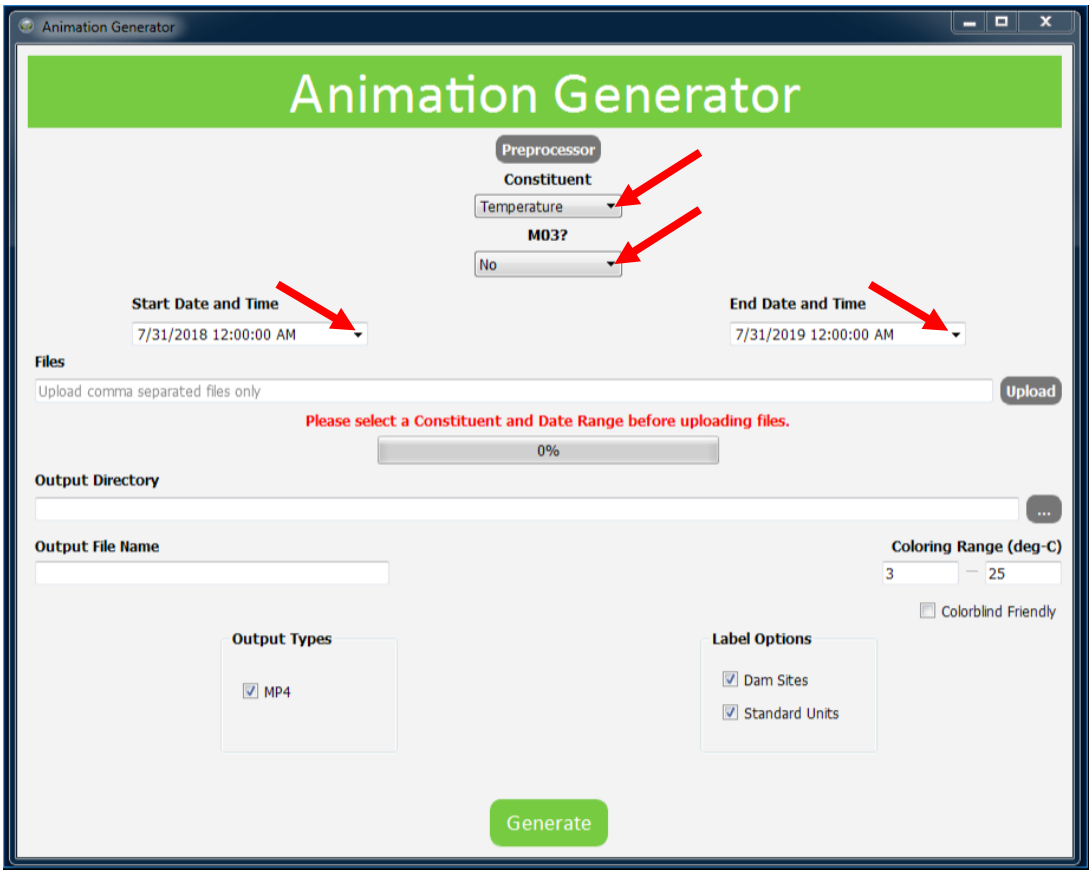
*Every time a file is downloaded <u>after the first time</u>, ensure that the output directory is the same as the first download.*

*Repeat Steps 4-6 until all files needed have been preprocessed, and then close the preprocessor. DO NOT rename any preprocessed files.*

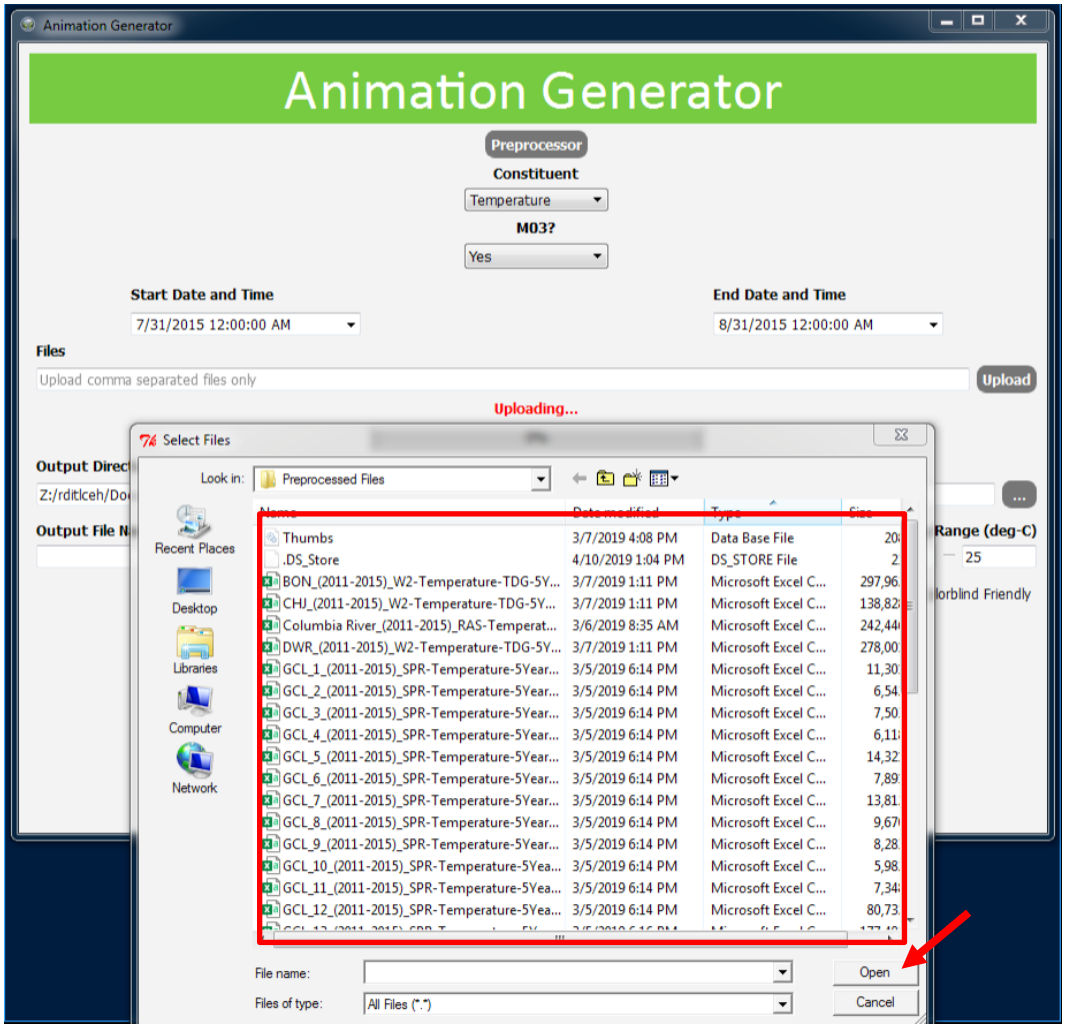


**STEP 7: Set the date range, constituent type that you want to view, and indicate if it is M03 data.**

*Ensure that the preprocessor is closed before moving on to this step.*

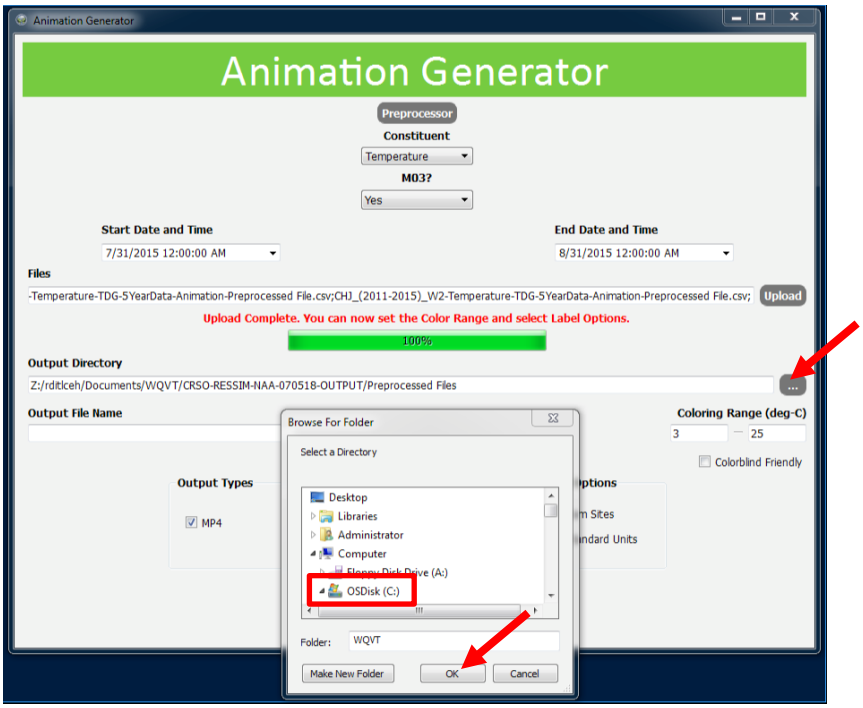


**STEP 8: Upload every preprocessed file for every section to be included in the animation.**



**STEP 9: Optional selections (can skip to STEP 10).**

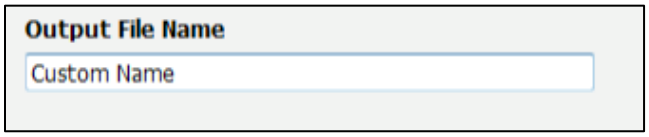
*STEP 9a: Change the output directory.*




*STEP 9b: Customize the output file name.*

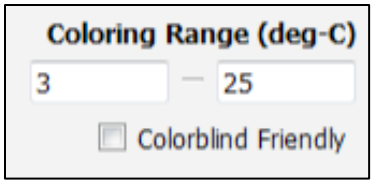
- Default name:

  <River(s)>_Animation_Temperature_ startdate_enddate



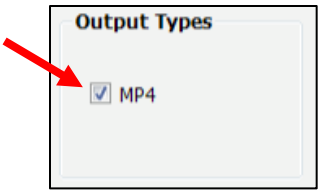

*STEP 9c: Set the temperature coloring range.*

- The values below are the default values for the range, but they can be changed if a different range is preferred.
- Also, check the "Colorblind Friendly" box to use a color palette that is readable by colorblind persons.



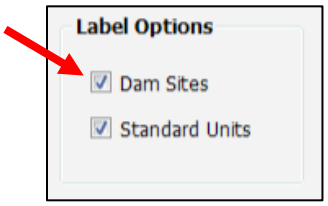
*STEP 9d: Select output type.*

- MP4 is automatically checked to generate a movie of the interactive animation. However, to generate the interactive animation faster, uncheck the MP4 box and only view the animation without saving it.




*STEP 9e: Select label options.*

- These options will label the site of each dam and ensure that the animation is generated in standard units. Uncheck the "Standard Units" box to view the animation in metric units, and/or uncheck the "Dam Sites" box to not see the dam site labels.




**STEP 10: Select the "Generate" button.**

- It may take several seconds to generate the figure.


- An animation figure will pop up when the generation is complete, and an MP4 file will be saved to the output directory if the checkbox was selected.

Figure 2. Presents Animation temperature output file names and corresponding example plots.

Figure 2. Animation temperature output file names and corresponding example plots.

| Three Possible Output Files |
|---|
| Columbia and Snake Rivers_Animation_Temperature_ startdate_enddate.mp4 |
| Columbia River_Animation_Temperature_ startdate_enddate.mp4 |
| Snake River_Animation_Temperature_ startdate_enddate.mp4 |

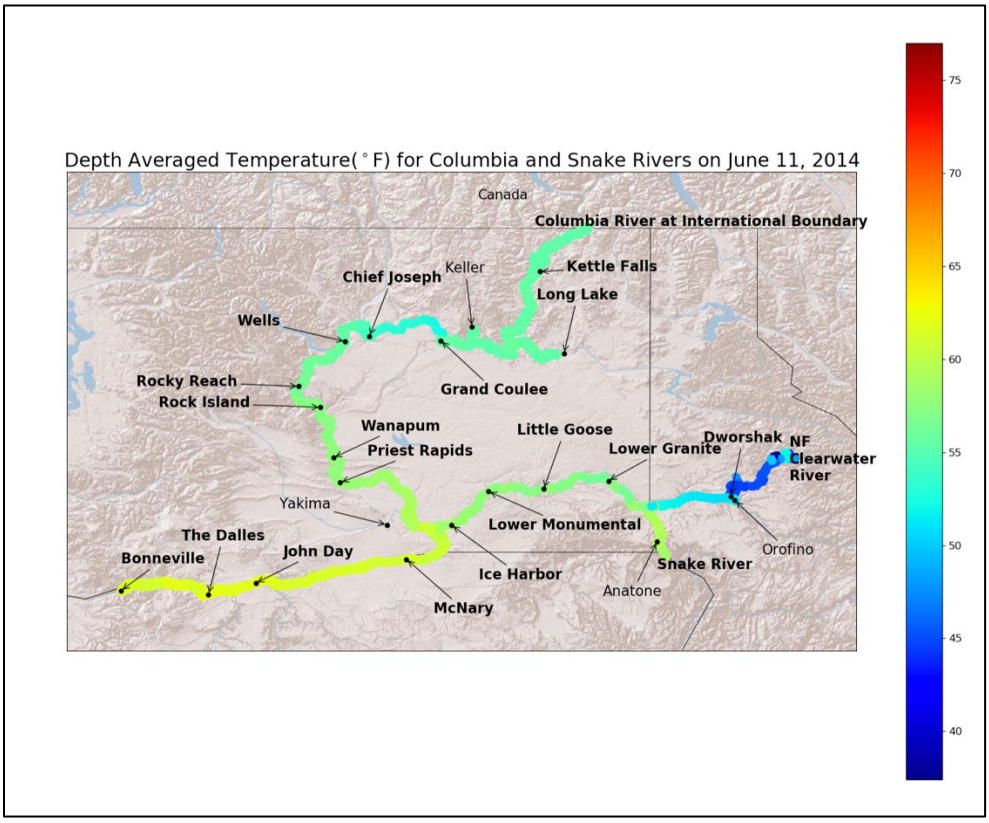
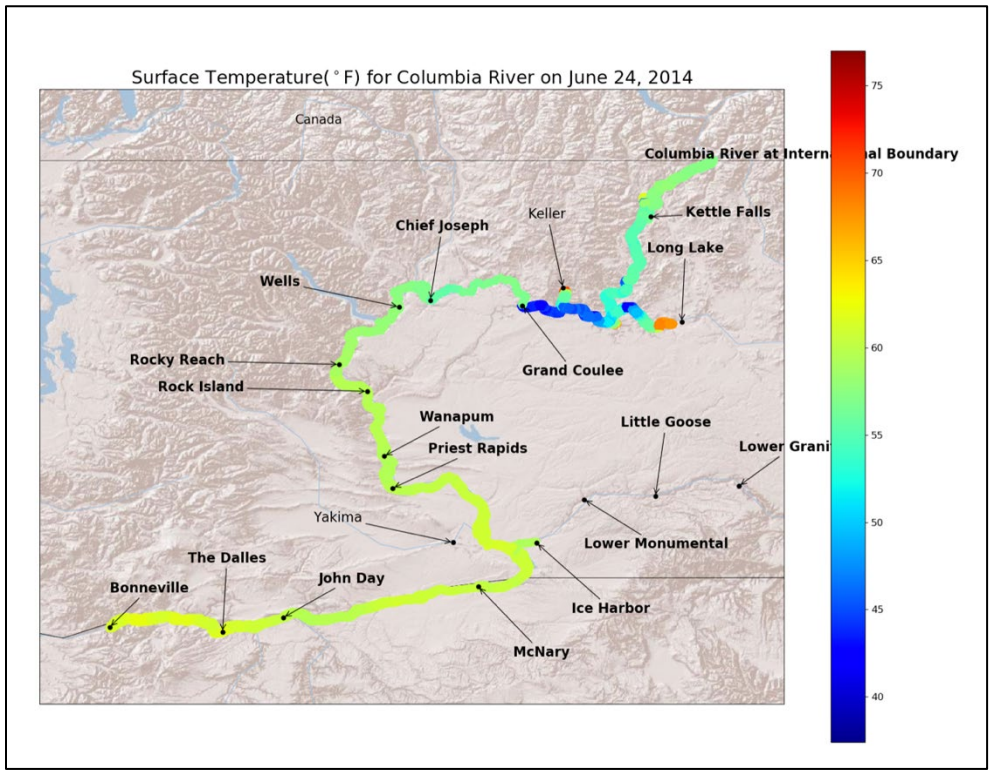
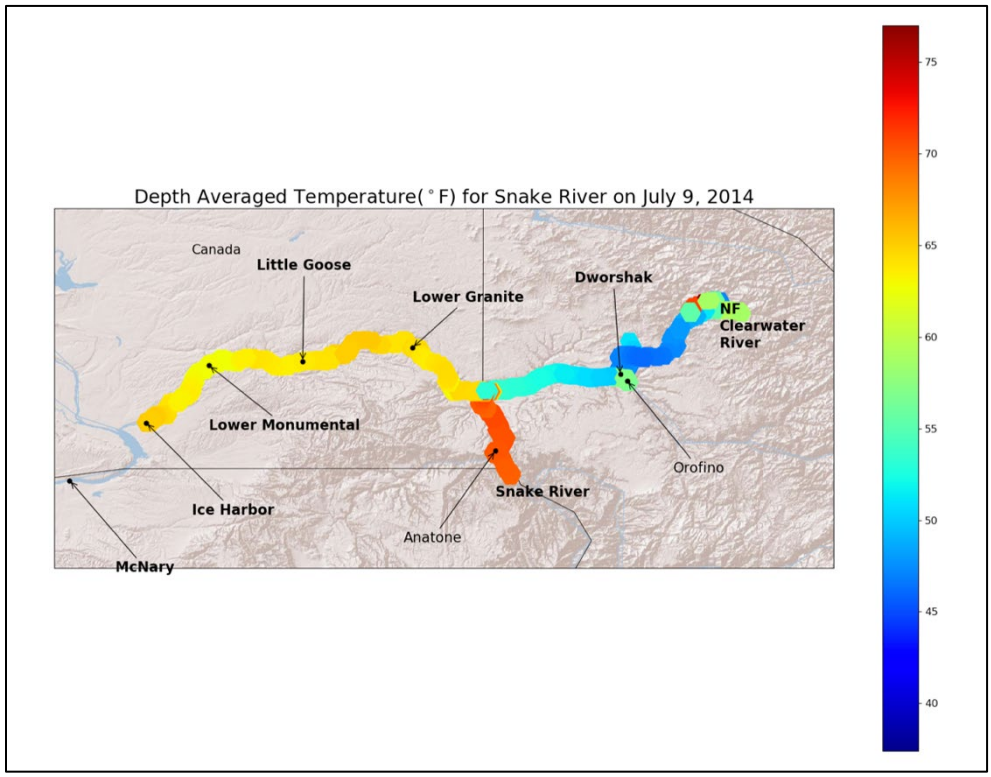


Figure 2 concluded.

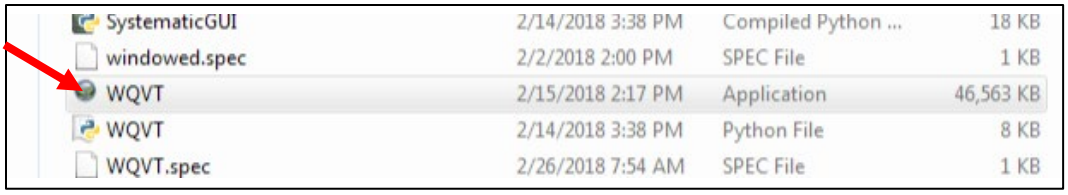


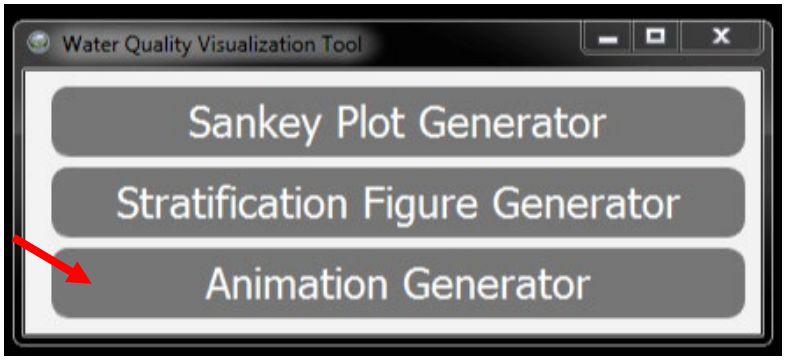
## TDG

### STEP 1: Open the executable.

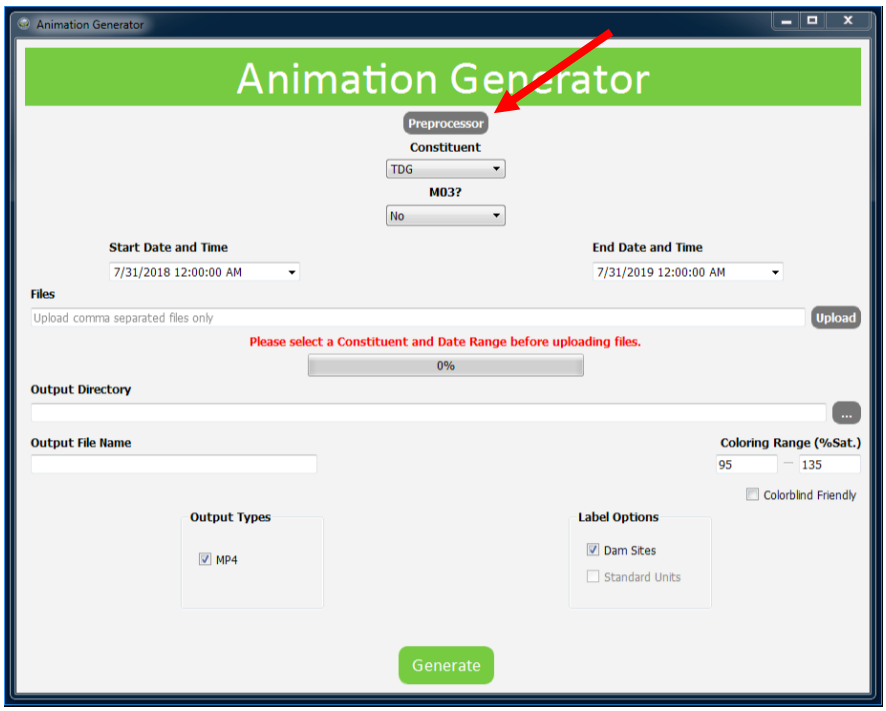
- This may take several seconds to open.




### STEP 2: Select the Animation generator tool.




### STEP 3: Select the preprocessor button.



**STEP 4: Select a file type (W2 or SPR) to parse all temperature and/or TDG data from those files.**

*Note: If parsing a RAS file, temperature data will be the only data in the file since RAS files do not contain TDG data. Also, if parsing for both temperature and TDG on all files, the preprocessor will have to be run only once. If parsing for TDG only, the preprocessor will have to be run again to look at temperature data, and the parsing of the RAS files must be verified.*

**STEP 5: Upload files that match the file type selected.**

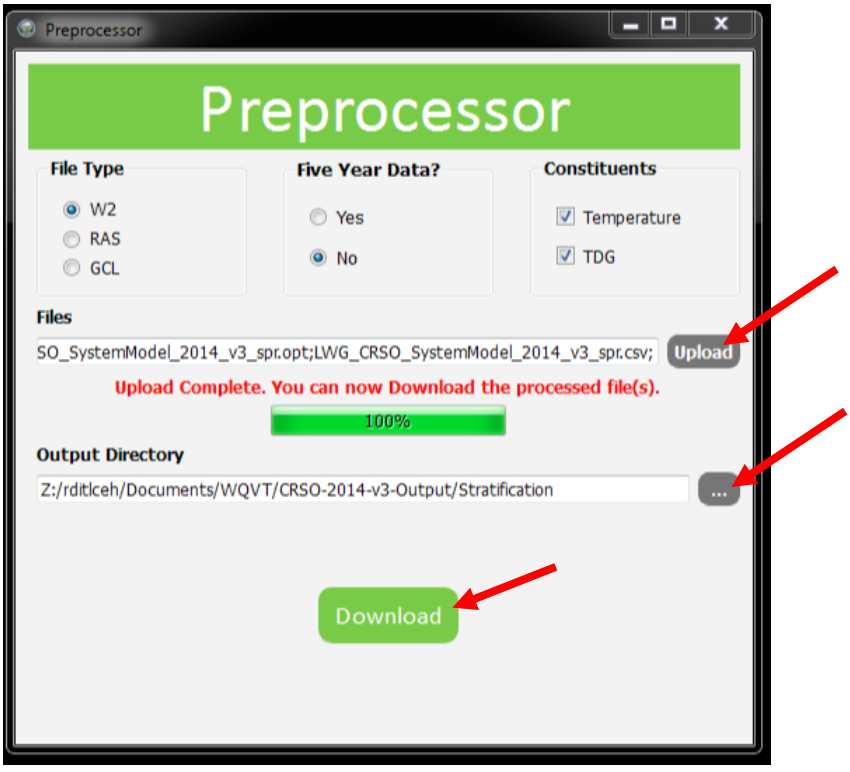
*Items enclosed in brackets [] means that one of each option must be uploaded or one year from the selection must be included in the name.* ***Ensure that only one version of each file is uploaded.***

- It may take several seconds to parse the files. Wait for the progress bar message to indicate the upload is complete.
- Suggested upload procedure: Upload all W2 files and continue through Step 6. Next, upload all but the largest SPR files at once and continue through Step 6. Finally, upload each of the largest SPR files separately going through Step 6 each time.

Table 6 presents the Animation TDG files.

Table 6. Animation TDG files.

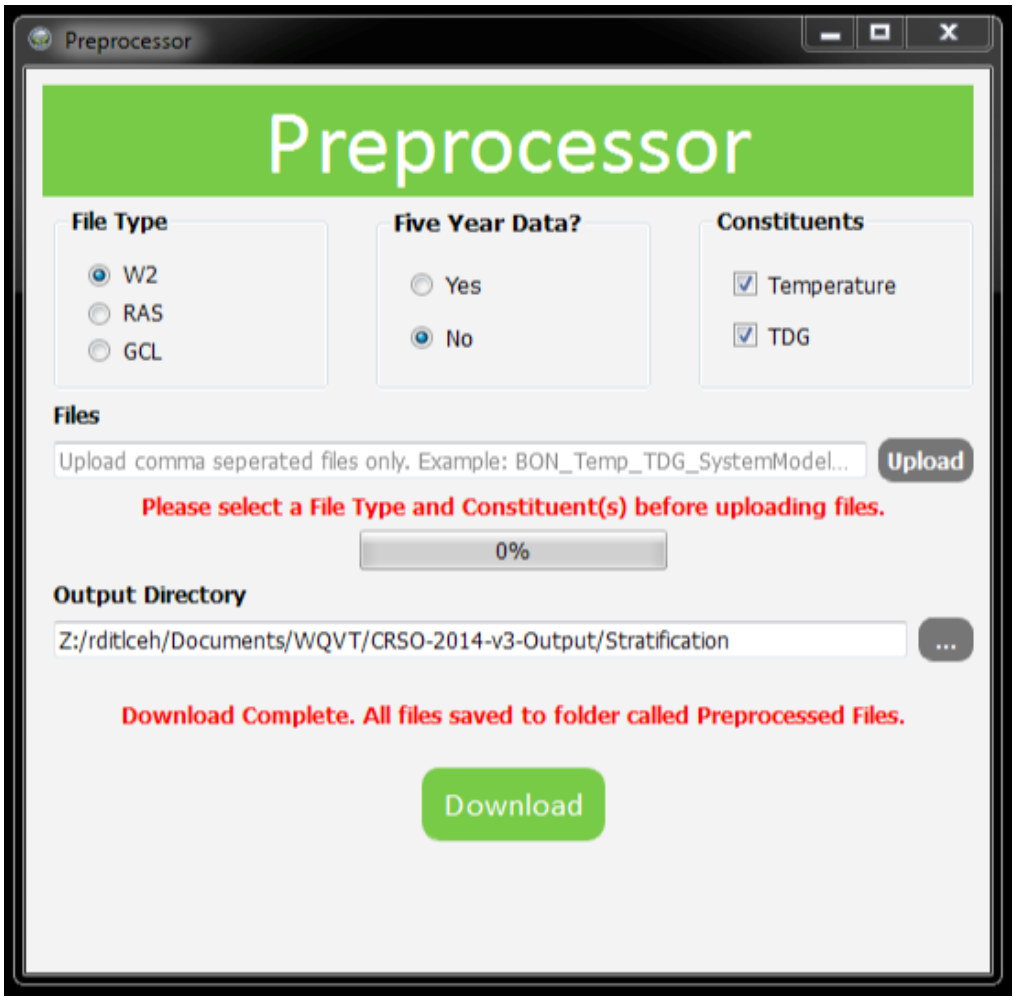
| File Name Contains (1 Year Data) | File Name Contains (5 Year Data) | File Name Extension |
|---|---|---|
| [LWG, LMN, DWR, CHJ, BON, TDA, JDA, MCN, IHR, LGS, LWG] and [2011, 2014, 2015] and spr | [LWG, LMN, DWR, CHJ, BON, TDA, JDA, MCN, IHR, LGS, LWG] and spr | .opt or .csv or .xls |
| spr and [1-25] and _[2011, 2014, 2015] | spr and [1-25] | .opt or .csv or .xls |



**STEP 6: Wait for "Upload Complete" message to appear. Then, if downloading for the <u>first time,</u> change the output directory and hit the "Download" button. This will create a "Preprocessed Files" folder in that directory that will store all of the preprocessed files.**

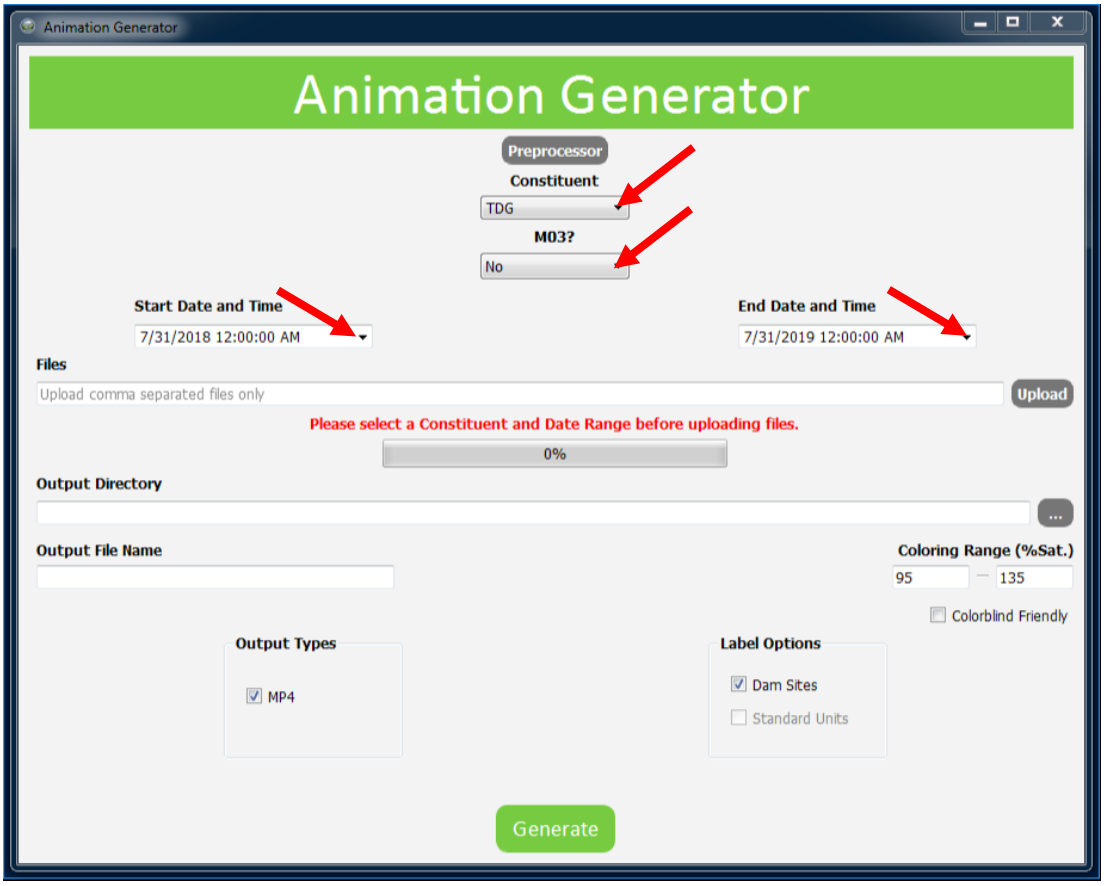
*Every time a file is downloaded <u>after the first time</u>, ensure that the output directory is the same as the first download.*

*Repeat Steps 4-6 until all files needed have been preprocessed, and then, close the preprocessor. DO NOT rename any preprocessed files.*

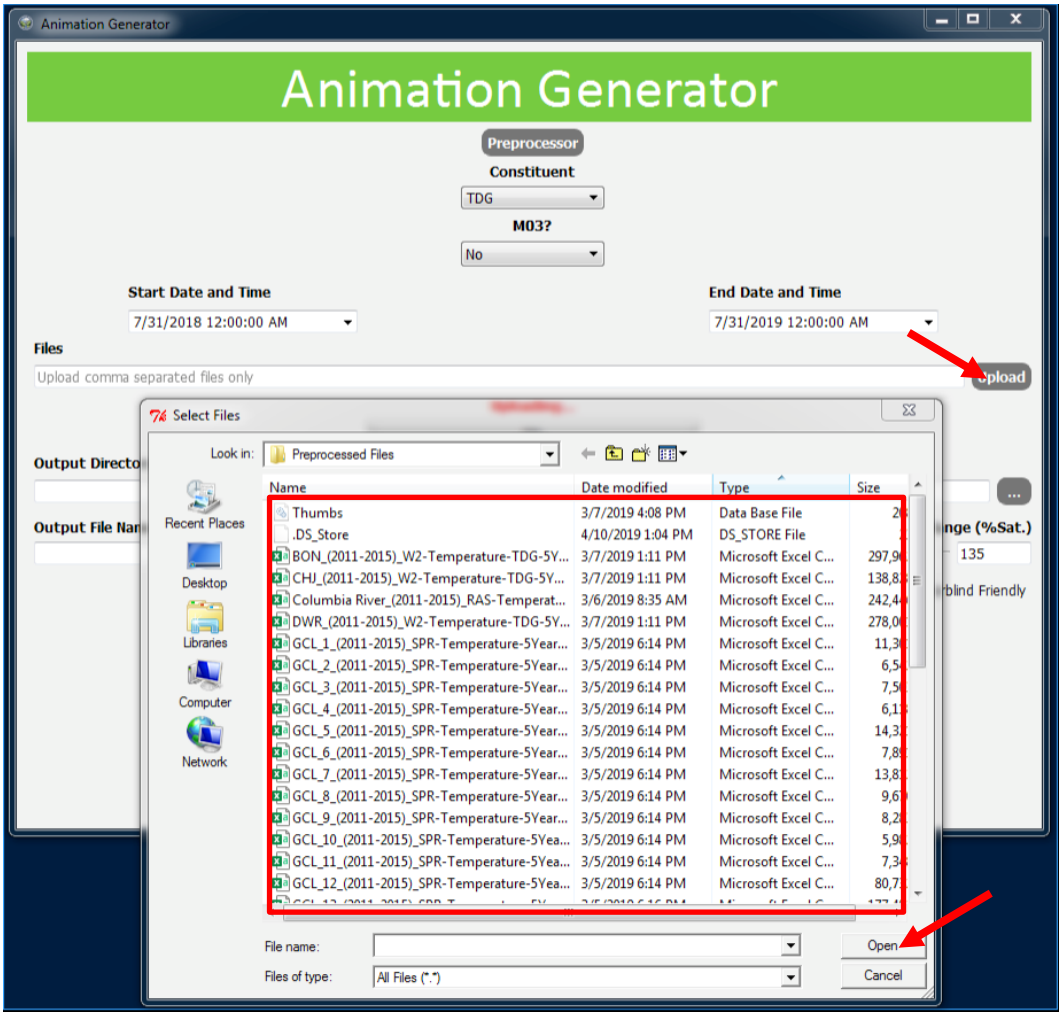


**STEP 7: Set the date range and constituent to be viewed.**

*Ensure that the preprocessor is closed before moving on to this step.*

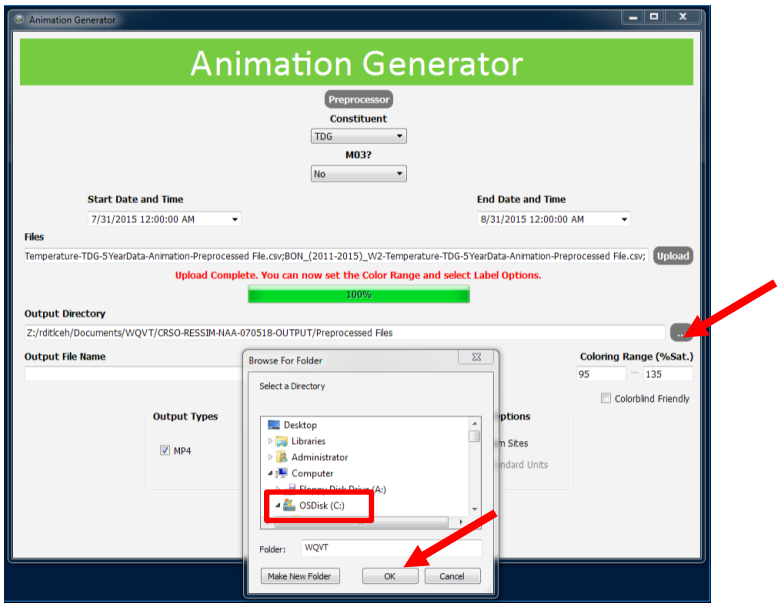


**STEP 8: Upload every preprocessed file for every section to be included in the animation.**



**STEP 9: Optional selections (can skip to STEP 10).**

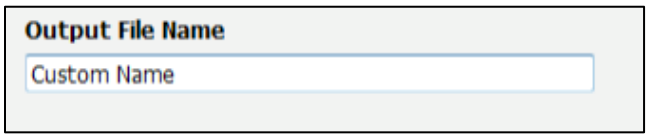
*STEP 9a: Change the output directory.*




*STEP 9b: Customize the output file name.*

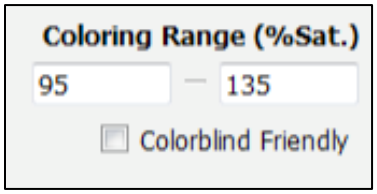
Default Name:

<River(s)>_Animation_TDG_ startdate_enddate



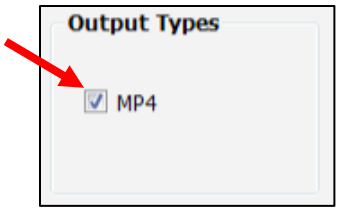

*STEP 9c: Set the TDG coloring range.*

- The values below are the default values for the range but can be changed if a different range is preferred.
- Also, check the "Colorblind Friendly" box to use a color palette that is readable by colorblind persons.



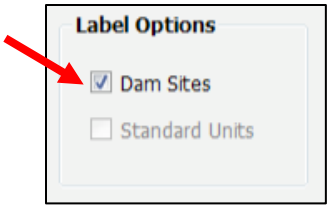
*STEP 9d: Select output type.*

- MP4 is automatically checked to generate a movie of the interactive animation. However, to generate the interactive animation faster, uncheck the MP4 box and only view the animation without saving it.




*STEP 9e: Select label option.*

- This option will label the site of each dam. Uncheck the Dam Sites box to not see the dam site labels.




**STEP 10: Select the "Generate" button.**

- It may take several seconds to generate the figure.


- An animation figure will pop up when the generation is complete, and an MP4 file will be saved to the output directory if the checkbox was selected.

Figure 3 presents Animation TDG output file names and corresponding example plots.

Figure 3. Animation TDG output file names and corresponding example plots.

| Three Possible Output Files |
|---|
| Columbia and Snake Rivers_Animation_TDG_ startdate_enddate.mp4 |
| Columbia River_Animation_TDG_ startdate_enddate.mp4 |
| Snake River_Animation_TDG_ startdate_enddate.mp4 |

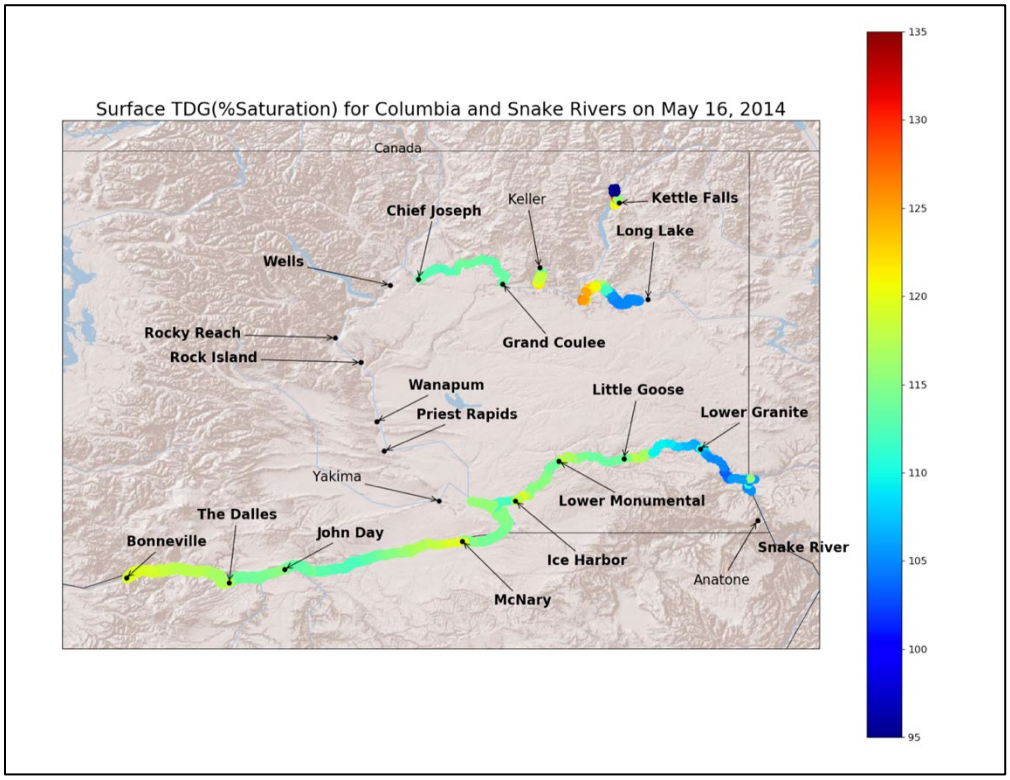
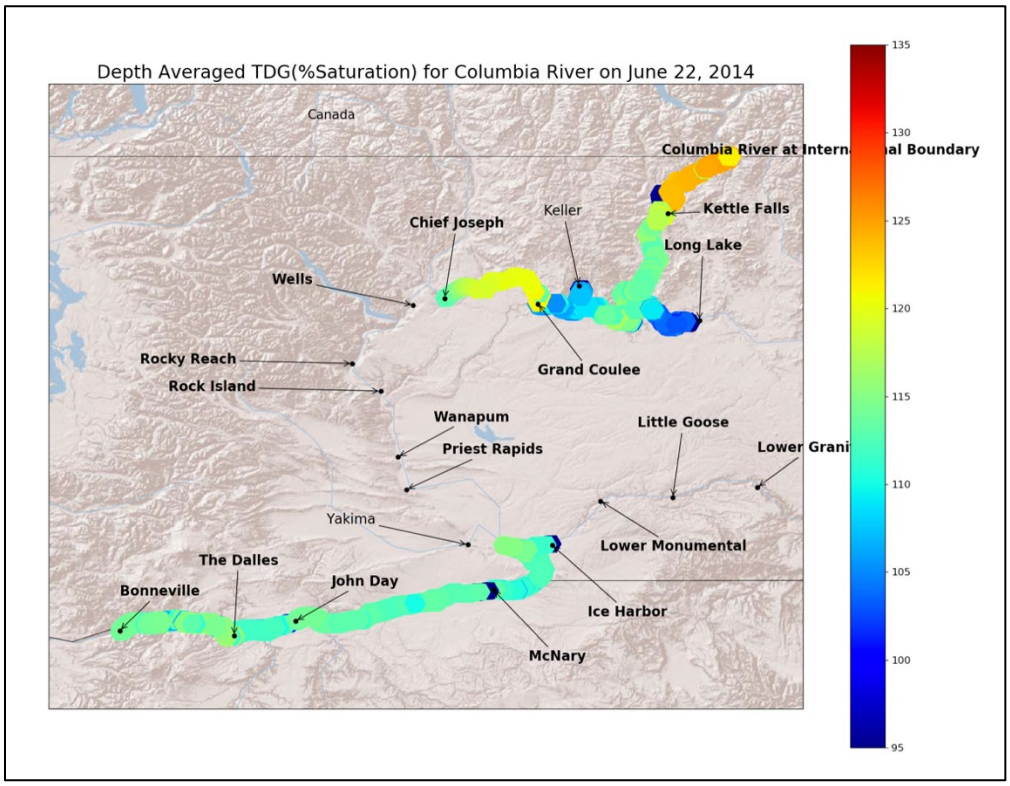
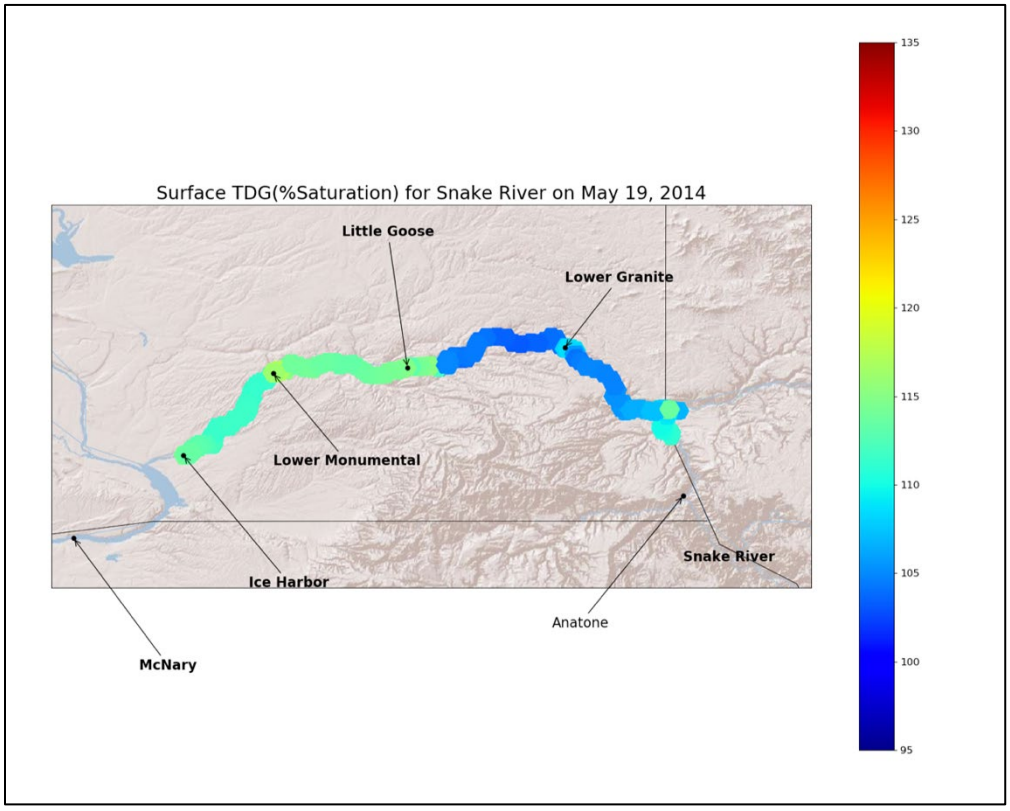


Figure 3 concluded.



# 5 Troubleshooting

This section outlines some of the known issues that can occur while using the WQVT set.

## Sankey plot generator issues

The tool being used may go into a "Not Responding" mode. The files may take several minutes to upload and be parsed or generate. The flow calculations may be incorrect if the wrong options are selected before upload. The user may specify a time range that is not in the data or may forget to upload a necessary file.

Table 7 presents the Sankey issues overview.

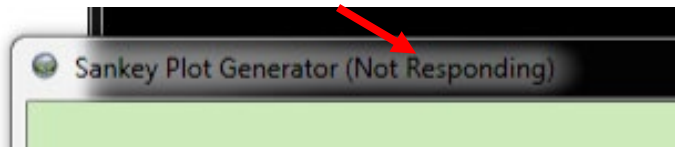
Table 7. Sankey issues overview.

| Issue | Details |
|---|---|
| "Not Responding" | GUI manipulation while figure is displayed or files are being parsed could cause this issue. |
| Upload Time | Excessive time needed to parse large files and/or a large number of files. |
| Generation Time | Excessive time needed to generate figure due to large amount of data being displayed. |
| Flow Calculations Error | Flow calculations for connected sections are not within a certain tolerance. |
| Time Range Error | The start and/or end dates are not set within the bounds of the data. |
| Missing Section | There are missing data files for sections of the river system that must be included to create the figure. |

"Not Responding"

This error may occur for several different reasons. However, the most common reasons are the following:

1. The user attempts to generate a new figure while there is a figure already displayed.
2. The user attempts to upload new files while there is a figure already displayed.
3. When large files are uploaded, parsing time may be long and cause the application to freeze temporarily.




### Prevention

1. Ensure that the figure window is closed before trying to generate a new figure.
2. Ensure that the figure window is closed before trying to upload new files.
3. Ensure there is no unnecessary data in the files that make them excessively large.

### Solutions

1. Close the application and restart.
2. Close the application and restart.
3. Wait for the parsing to complete and it should resolve itself. Otherwise, close the application and restart.

Upload Time

This issue may occur when there are many large files uploaded to create the figure. The amount of time that it takes to parse each of these files cannot be avoided. However, if the file names take longer than 5 minutes to appear in the “Files” box, restart the application.

Generation Time

This issue may occur when there is a large amount of data needed to create the figure. The amount of time that it takes to create the figure cannot be avoided. However, if the figure takes longer than 5 minutes (10 minutes for multi-year figures) to appear, restart the application.

Flow Calculations Error

This error may occur when the “TDG” or “Temperature” Coloring Option was not set correctly before uploading files. This occurs because the flow files were parsed for temperature flow instead of TDG flow or vice versa.

### Prevention

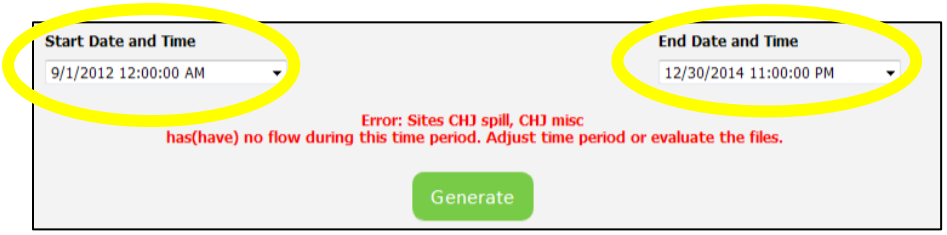
Ensure that the diagram coloring option is set to the desired figure type before uploading any files.

### Solution

Close the figure, ensure the proper diagram coloring option is selected, and re-upload the files.

Time Range Error

This error may occur when the "Start Date and Time" and/or "End Date and Time" are not set within the bounds of the file date ranges. This occurs after selecting the "Generate" button because that is when the data are parsed for the time period.




### Prevention

Ensure that the "Start Date and Time" and the "End Date and Time" are set to dates and times that fall within the data's time and date range before selecting the "Generate button."

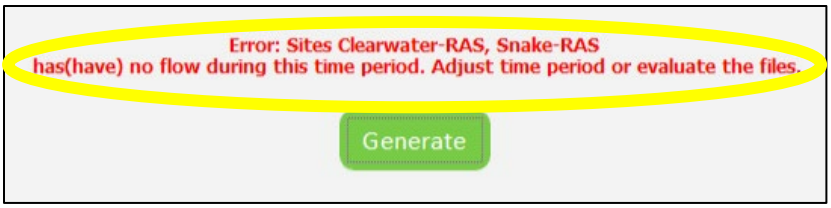
### Solution

Adjust the dates and times to be within the data's time and date range and select the "Generate" button.

Missing Section

If the files are evaluated and there are data during this time, ensure that all needed files have been uploaded because this error may also occur when there are needed sections missing from the data. These sections may be contained in separate files (W2), or there may only be one file missing that contains all of the needed sections (RAS). This error occurs after selecting

the “Generate” button because that is when every needed section is checked for.




#### Prevention

Ensure that all necessary files are uploaded before selecting the “Generate” button.

#### Solution

Re-upload all files and be sure to include the files that contain the missing sections, then select the “Generate” button.

## Stratification figure preprocessor and generator issues

The tool being used may go into a “Not Responding” mode. The files may take several minutes to upload and be parsed or generate. Uploading the wrong files or downloading the preprocessed files to different locations can also be an issue. The “Not Responding” and upload time issues are also applicable to the preprocessor.

Table 8 presents the stratification issues overview.

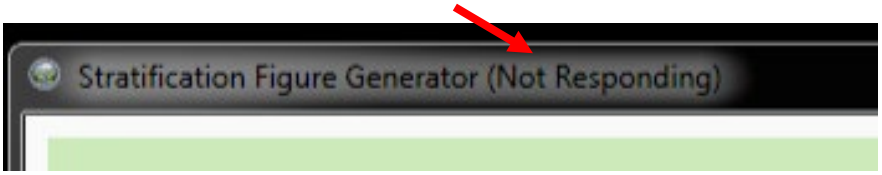
Table 8. Stratification issues overview.

| Issue | Details |
|---|---|
| “Not Responding” | GUI manipulation while parsing files could cause this issue. |
| Upload Time | Excessive time needed to parse large files and/or a large number of files. |
| Generation Time | Excessive time needed to generate figure due to large amount of data being displayed. |
| Uploading Non-Preprocessed Files | The generator will not parse non-preprocessed files. |
| Preprocessed Files Missing | Changing the Output Directory after the initial preprocessed file download. |

"Not Responding"

This error may occur for several different reasons. However, the most common reasons are the following:

1. If the user attempts manipulate any part of the interface while files are being uploaded, the application may freeze temporarily.
2. When large files are uploaded, parsing time may be long and cause the application to freeze temporarily.




**Prevention**

1. Do not attempt to change any options or upload new files while the current files are still being processed.
2. Ensure there is no unnecessary data in the files that make them excessively large.

**Solutions**

1. Wait for the parsing to complete, and it should resolve itself. Otherwise, close the application and restart.
2. Wait for the parsing to complete, and it should resolve itself. Otherwise, close the application and restart.

Upload Time

This issue may occur when there are many large files uploaded to create the figure(s). The amount of time that it takes to parse each of these files cannot be avoided. However, if parsing takes longer than 5 minutes, restart the application.

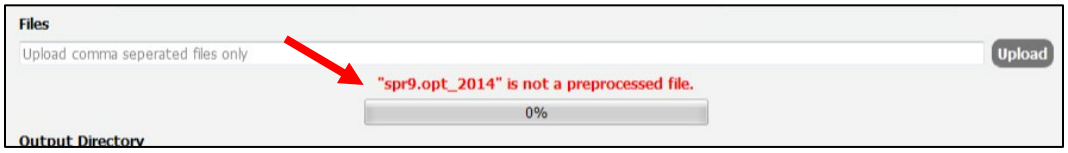
Generation Time

This issue may occur when there is a large amount of data needed to create the figure(s). The amount of time that it takes to create the figure(s) cannot be avoided. However, if the figure(s) take longer than 5 minutes

(10 minutes for multi-year figures) to generate and save, restart the application.

Uploading Non-Preprocessed Files

This issue will occur when a non-preprocessed file is uploaded to the generator. To prevent this issue, ensure that all files that are uploaded have been run through the preprocessor first. This issue should not affect the generation of the stratification plots, but any data that were uploaded via a non-preprocessed file will not be displayed.




Preprocessed Files Missing

If the preprocessor folder is missing files that were supposed to have been uploaded for preprocessing, they may have been accidently stored in a different location. This error will occur if the output directory was changed after the initial download. Before downloading any preprocessed files, select the output directory that will house the “Preprocessed Files” folder for all files. After the first download, the output directory cannot be changed or there will be multiple “Preprocessed Files” folders that only contain some of the necessary files.

## Animation preprocessor and generator issues

The tool being used may go into a “Not Responding” mode. The files may take several minutes to upload and be parsed or generate. Uploading the wrong files or downloading the preprocessed files to different locations can also be an issue. The “Not Responding” and upload time issues are also applicable to the preprocessor.

Table 9 presents an overview of animation issues.

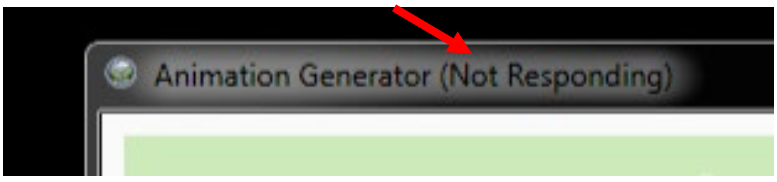
Table 9. Animation issues overview.

| Issue | Details |
|---|---|
| "Not Responding" | GUI manipulation while parsing files could cause this issue. |
| Upload Time | Excessive time needed to parse large files and/or large number of files. |
| Generation Time | Excessive time needed to generate the animation due to large amount of data being displayed. |
| Uploading Non-Preprocessed Files | The generator will not parse non-preprocessed files. |
| Preprocessed Files Missing | Changing the Output Directory after the initial preprocessed file download. |
| Connection Closed by Remote Host | Occurs when the application cannot connect to the internet to create the map background. |

"Not Responding"

This error may occur for several different reasons. However, the most common reasons are the following:

1. The user attempts to generate a new figure while there is a figure already displayed.
2. The user attempts to upload new files while there is a figure already displayed.
3. When large files are uploaded, parsing time may be long and cause the application to freeze temporarily.




**Prevention**

1. Ensure that all figure windows are closed before trying to generate a new figure.
2. Ensure that all figure windows are closed before trying to upload new files.
3. Ensure there is no unnecessary data in your files that makes them excessively large.

**Solutions**

1. Close the application and restart.
2. Close the application and restart.
3. Wait for the parsing to complete, and it should resolve itself. Otherwise, close the application and restart.

Upload Time

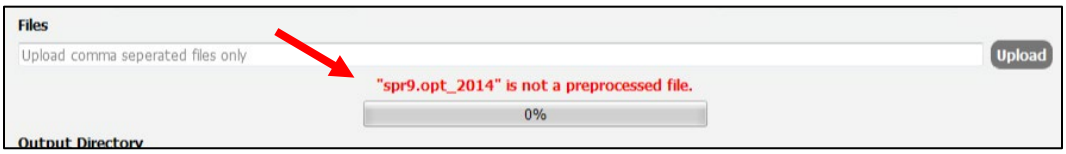
This issue may occur when there are many large files uploaded to create the figure. The amount of time that it takes to parse each of these files cannot be avoided. However, if parsing takes longer than 5 minutes, restart the application.

Generation Time

This issue may occur when there is a large amount of data needed to create the figures. The amount of time that it takes to create the figure cannot be avoided. When generating the figure, it will generate faster if it is not being saved (mp4 checkbox). However, if the figures take longer than 5 minutes (10 minutes for multi-year figures) to generate and save, restart the application.

Uploading Non-Preprocessed Files

This issue will occur when a non-preprocessed file is uploaded to the generator. To prevent this issue, ensure that all files that are uploaded have been run through the preprocessor first. This issue should not affect the generation of the animation, but any data that were uploaded via a non-preprocessed file will not be displayed.




Preprocessed Files Missing

If the preprocessor folder is missing files that were supposed to have been uploaded for preprocessing, they may have been accidently stored in a different location. This error will occur if the output directory was changed

after the initial download. Before downloading any preprocessed files, select the output directory that will house the “Preprocessed Files” folder for all files. After the first download, the output directory cannot be changed or there will be multiple “Preprocessed Files” folders that only contain some of the necessary files.

Connection Closed by Remote Host

After selecting the “Generate” button to create the animation, if an error appears in the command line window that mentions “remote host,” ensure that there is a connection to the internet, and select the “Generate” button again. If this problem persists, close and restart the application and try again.

# 6 River Section Breakdown

| Upper Columbia River System | | |
|---|---|---|
| Section Name | Section Abbreviation | Section Number* |
| Grand Coulee | GCL | 317 |
| Chief Joseph | CHJ | 42 |

| Lower Columbia River System | | |
|---|---|---|
| Section Name | Section Abbreviation | Section Number* |
| McNary | MCN | 87 |
| John Day | JDA | 101 |
| The Dalles | TDA | 41 |
| Bonneville | BON | 76 |

| Middle Columbia River System | | |
|---|---|---|
| Section Name | Section Abbreviation(s) | Section Number* |
| Wells | WEL | 515.4887 |
| Rock Island | RIS | 453.4 |
| Rocky Reach | RRH | 473.712 |
| Wenatchee | WAN | 415.1 |
| Priest Rapids | PRD | 395.6788 |
| Yakima | KIOW | 0.188 |

| Snake River System | | |
|---|---|---|
| Section Name | Section Abbreviation | Section Number* |
| Lower Granite | LWG | 43 |
| Little Goose | LGS | 29 |
| Lower Monumental | LMN | 28 |
| Ice Harbor | IHR | 34 |
| Snake-RAS | (WHBI, HCDI, ANQW) | 147.85 |

| Clearwater River System | | |
|---|---|---|
| Section Name | Section Abbreviation(s) | Section Number* |
| Dworshak | DWR | 45 |
| Clearwater-RAS | (PEKI, ORFI, LEWI) | 1.97 |

*The section number is the site of the dam at the most downstream part of that section. If the section number is an integer, that means the file is a W2 model file. If the section number is a float, that means the file is a RAS (HEC-RAS) model file.

# 7 Summary and Recommendations

This manual presented three visualization tools to be used by the CRSO EIS WQ team. The Sankey plot generator produces a large block diagram whose sections are sized based on their flow and colored based on their constituent value. The Stratification figure generator creates a temperature heat map for each major division of the rivers. The Animation generator creates animations of each section of the rivers for both temperature and TDG.

Since these models produce such large datasets and this project was restricted to being a desktop application, these tools are not as fast as they could be. Also, the speed of running the models that produce the data required for these visualization tools could also be increased. If this project is continued, it is recommended that the models and the visualization of the resulting data be moved to the high performance computers to increase the speed of analysis.

# Appendix: Constituents and Abbreviations

The following table is taken from *CE-QUAL-W2 Postprocessors Users' Manual: A Users' Manual for Using the MATLAB Developed Software* (in preparation).

| Constituent | Option 1 | Option 2 | Option 3 | Option 4 | Units |
|---|---|---|---|---|---|
| Ammonium | NH3 | NH4 | NH_3 | Ammonium | mg/L |
| Phosphate | PO4 | PO4 | PO_4 | Phosphate | mg/L |
| Nitrate-Nitrite | NO3 | NO3_NO2 | NO_3 | Nitrate-Nitrite | mg/L |
| Carbonaceous BOD5 | BOD-5 | BOD | BOD | BOD | mg/L |
| Carbonaceous BOD5-1 | BOD-51 | BOD51 | BOD1 | BOD1 | mg/L |
| Carbonaceous BOD5-2 | BOD-52 | BOD52 | BOD2 | BOD2 | mg/L |
| Carbonaceous BOD5-3 | BOD-53 | BOD53 | BOD3 | BOD3 | mg/L |
| Carbonaceous BOD5-4 | BOD-54 | BOD54 | BOD4 | BOD4 | mg/L |
| Carbonaceous BOD5-5 | BOD-55 | BOD55 | BOD5 | BOD5 | mg/L |
| Carbonaceous BOD5-6 | BOD-56 | BOD56 | BOD6 | BOD6 | mg/L |
| Total Carbonaceous BOD (Ultimate) | BOD-U | CBOD | BODU | Carbonaceous_Ultimate_BOD | mg/L |
| Total Inorganic Carbon | TIC | Inorganic_carbon | TIC | Total_Inorganic_Carbon | mg/L |
| Alkalinity | ALK | ALK | ALK | Alkalinity | mg/L |
| pH | pH | PH | pH | pH_ | SU |
| Total Organic Carbon | TOC | TOC | TOC | Total_organic_carbon | mg/L |
| Dissolved Organic Carbon | DOC | DOC | DOC | Dissolved_organic_carbon | mg/L |
| Particulate Organic Carbon | POC | POC | POC | Particulate_organic_carbon | mg/L |

| Constituent | Option 1 | Option 2 | Option 3 | Option 4 | Units |
|---|---|---|---|---|---|
| Total Organic Nitrogen | TON | TON | TON | Total_organic_nitrogen | mg/L |
| Dissolved Organic Nitrogen | DON | DON | DON | Dissolved_organic_nitrogen | mg/L |
| Particulate Organic Nitrogen | PON | PON | PON | Particulate_organic_nitrogen | mg/L |
| Total Kjeldahl Nitrogen | TKN | Total_Kheldahl_Nitrogen | TKN | Total_Kjeldahl_Nitrogen | mg/L |
| Total Nitrogen | TN | TN | TN | Total_nitrogen | mg/L |
| Total Phosphorus | TP | TP | TP | Total_phosphorus | mg/L |
| Total Organic Phosphorus | TOP | TOP | TOP | Total_organic_nitrogen | mg/L |
| Dissolved Organic Phosphorus | DOP | DOP | DOP | Dissolved_organic_phosphorus | mg/L |
| Particulate Organic Phosphorus | POP | POP | POP | Particulate_organic_phosphorus | mg/L |
| Chlorophyll-a | CHL_A | CHLA | CHL-A | Chlorophyll_a | ug/L |
| Temperature | TEMP | T2 | T | Temperature | $^{o}$C |
| Velocity 'U' | U | vel | U | Horizontal_velocity_[U] | m/s |
| Flow | flow | Q | FLOW | Flow | cms |
| Short Wave Solar Radiation | SRON | sron | SRON | SRON | W/m$^2$ |
| Equilibrium Temperature | EXT | ext | ET | ET | $^{o}$C |
| Depth | DEPTH | Depth | DEPTH | Depth | m |
| Ice Thickness | ICETH | iceth | ICETH | Ice_Thickness | m |
| Model Time Step | dlt | time step | DLT | Time Step | s |
| Water Surface Elevation | elws | Elevation | ELWS | Water_Surface_Elevation | m |
| Width | WIDTH | Width | WIDTH | width | m |
| Shade | SHADE | Shade | SHADE | shade | |
| Dissolved Oxygen | Dis_Ox | DO | DO | Dissolved_oxygen | mg/L |

| Constituent | Option 1 | Option 2 | Option 3 | Option 4 | Units |
|---|---|---|---|---|---|
| Total Dissolved Solids | TDS | TDS | TDS | TDS | mg/L |
| Generic Constituent | GC | GEN | G_CONST | Salinity | mg/L |
| Generic Constituent 1 | Gen1 | GEN1 | GEN1 | Tracer | mg/L |
| Generic Constituent 2 | Gen2 | GEN2 | GEN2 | Age | mg/L |
| Generic Constituent 3 | Gen3 | GEN3 | GEN3 | Coliform | mg/L |
| Inorganic Suspended Solids | ISS | Inorg_SS | ISS | ISS | mg/L |
| Inorganic Suspended Solids 1 | ISS1 | Inorg_SS1 | ISS1 | ISS1 | mg/L |
| Inorganic Suspended Solids 2 | ISS2 | Inorg_SS2 | ISS2 | ISS2 | mg/L |
| Inorganic Suspended Solids 3 | ISS3 | Inorg_SS3 | ISS3 | ISS3 | mg/L |
| Dissolved Silica | DSI | dsi | SIO2-diss | Dissolved_silica | mg/L |
| Particulate Silica | PSI | psi | PSI | Particulate_silica | mg/L |
| Iron | fe | FE | FE | Total_iron | mg/L |
| Labile DOM | ldom | LDOM | LDOM | Labile_DOM | mg/L |
| Refractory DOM | rdom | RDOM | RDOM | Refractory DOM | mg/L |
| Labile POM | lpom | LPOM | LPOM | Labile_POM | mg/L |
| Refractory POM | rpom | RPOM | RPOM | Refractory_POM | mg/L |
| Algae | ALG | ALG | ALG | Algae | mg/L |
| Algae 1 | Algae_1 | ALG1 | ALG1 | Alg_1 | mg/L |
| Algae 2 | Algae_2 | ALG2 | ALG2 | Alg_2 | mg/L |
| Algae 3 | Algae_3 | ALG3 | ALG3 | Alg_3 | mg/L |
| Zooplankton | ZOO | zoo | ZOO | zooplankton1 | mg/L |
| Labile DOM-P | ldomP | LDOMP | LDOMP | LDOM_P | mg/L |

| Constituent | Option 1 | Option 2 | Option 3 | Option 4 | Units |
|---|---|---|---|---|---|
| Refractory DOM-P | rdomP | RDOMP | RDOMP | RDOM_P | mg/L |
| Labile POM-P | lpomP | LPOMP | LPOMP | LPOM_P | mg/L |
| Refractory POM-P | rpomP | RPOMP | RPOMP | RPOM_P | mg/L |
| Labile DOM-N | ldomN | LDOMN | LDOMN | LDOM_N | mg/L |
| Refractory DOM-N | rdomN | RDOMN | RDOMN | RDOM_N | mg/L |
| Labile POM-N | lpomN | LPOMN | LPOMN | LPOM_N | mg/L |
| Refractory POM-N | rpomN | RPOMN | RPOMN | RPOM_N | mg/L |
| Algal Production | APR | APR | APR | Algal_production | mg/L |
| Total Algal Biomass | ATOT | ATOT | ATOT | Total_algae | mg/L |
| Dissolved Oxygen Saturation | DOS | DOS | DOS | Oxygen_%_Gas_Saturation | % |
| Total Suspended Solids | TSS | TSS | TSS | Total_suspended_Solids | mg/L |
| Total Inorganic Suspended Solids | TISS | TInorg_SS | TISS | Total_Inorganic_Suspended_Solids | mg/L |
| Carbon Dioxide | CO2 | CO2 | CO2 | CO2 | mg/L |
| Bicarbonate | HCO3 | HCO3 | HCO3 | HCO3 | mg/L |
| Carbonate | CO3 | CO3 | CO3 | CO3 | mg/L |

# Acronyms and Abbreviations

| | |
|---|---|
| CRSO | Columbia River System Operations |
| EIS | Environmental Impacts Statement |
| RAS | HEC-RAS Model |
| TDG | Total Dissolved Gases |
| WQVT | Water Quality Visualization Tools |
| W2 | CE-QUAL-W2 Model |
| **Columbia River** | |
| BON | Bonneville |
| CHJ | Chief Joseph |
| DSC | Downstream Columbia |
| GCL | Grand Coulee |
| JDA | John Day |
| KIOW | Yakima |
| MCN | McNary |
| PRD | Priest Rapids |
| RIS | Rock Island |
| RRH | Rocky Reach |
| TDA | The Dalles |
| WAN | Wanapum |
| WEL | Wells |
| **Snake River** | |
| IHR | Ice Harbor |
| LGS | Little Goose |
| LMN | Lower Monumental |
| LWG | Lower Granite |
| **Clearwater River** | |
| DWR | Dworshak (45) |

# Unit Conversion Factors

| Multiply | By | To Obtain |
|---|---|---|
| cubic feet | 0.02831685 | cubic meters |
| degrees Fahrenheit (F) - 32 | (5/9) | degrees Celsius |

# REPORT DOCUMENTATION PAGE

*Form Approved*
*OMB No. 0704-0188*



| 1. REPORT DATE | 2. REPORT TYPE | 3. DATES COVERED *(From - To)* |
|---|---|---|
| June 2020 | Final Report | |

**4. TITLE AND SUBTITLE**
Water Quality Visualization Tools: A Python Application (1/A)

**5a. CONTRACT NUMBER**

**5b. GRANT NUMBER**

**5c. PROGRAM ELEMENT NUMBER**

**6. AUTHOR(S)**
Corey H. Mize

**5d. PROJECT NUMBER**
7D5KFK

**5e. TASK NUMBER**

**5f. WORK UNIT NUMBER**

**7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)**
Information Technology Laboratory
US Army Engineer Research and Development Center
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

**8. PERFORMING ORGANIZATION REPORT NUMBER**
ERDC/ITL SR-20-4

**9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)**
US Army Corps of Engineers, Portland District
333 SW First Ave.
Portland, OR 97204-3440

**10. SPONSOR/MONITOR'S ACRONYM(S)**
USACE NWP

**11. SPONSOR/MONITOR'S REPORT NUMBER(S)**

**12. DISTRIBUTION/AVAILABILITY STATEMENT**
Approved for public release; distribution is unlimited.

**13. SUPPLEMENTARY NOTES**

**14. ABSTRACT**
On May 4, 2016, US District Court Judge Simon ordered the US Army Corps of Engineers and two other Action Agencies to produce a comprehensive Environmental Impacts Statement (EIS) by March 26, 2021. To do this, the Columbia River Systems Operation (CRSO) EIS will evaluate and compare a range of alternatives to offset or minimize any remaining unavoidable impacts. Due to the unique large system model approach, there is a need to quickly develop and analyze water quality model results. Therefore, there was a need for several visualization tools to assist the CRSO EIS team in promptly analyzing the results and creating publication-ready graphics. To create the most accessible desktop application for the CRSO EIS team, the Python programming language was used to quickly create three visualization tools. These three tools are only useful for relatively small data sets. If the team wishes to expand the functionality for larger data sets, it is recommended that model execution and analysis be moved to the supercomputers.

**15. SUBJECT TERMS**
Columbia River Watershed, Environmental impact Statements, Environmental management, Environmental protection, Information visualization, Python (Computer program language), Water quality

| 16. SECURITY CLASSIFICATION OF: | | | 17. LIMITATION OF ABSTRACT | 18. NUMBER OF PAGES | 19a. NAME OF RESPONSIBLE PERSON |
|---|---|---|---|---|---|
| a. REPORT | b. ABSTRACT | c. THIS PAGE | | | Corey H. Mize |
| Unclassified | Unclassified | Unclassified | SAR | 75 | 19b. TELEPHONE NUMBER *(Include area code)* 601-634-7346 |