A Method for Estimating Flood Frequencies for Small Basins in Minnesota

Draft 6/12/2018

Wetland restoration requires design features capable of withstanding overflow and runoff events. Computing flood recurrence intervals, otherwise known as flood frequencies, along with other factors can help ensure restoration designs are capable of conveying a varied range of flood flows. While this information is critical for larger wetland restorations, it can be equally important for the restoration of small wetlands. However, existing methods for computing flood frequencies for small basins are either, too time intensive or inaccurate. The tutorial below is intended to provide a quick but reasonably accurate method for estimating flood frequencies for small basins in Minnesota.

Choosing the Correct Approach for Computing Flood Frequency Estimates

There are several methods that can be used for calculating flood frequencies for small basins, from online tools to hydrologic models. The first step in selecting the method you will need is to determine the size and complexity of your project. Larger, more complex or higher risk projects may require a more accurate flood frequency method. Begin by asking yourself the following question:

> "Will the size or complexity of the restoration pose a threat to downstream properties if a breach or failure of the wetland restoration structure occurred?"

If the answer is "yes", a hydrologic model should be developed. Please contact Josh Eash (josh_eash@fws.gov or 612-713-5404) for options. The FWS dam safety program has criteria for inventorying dams on Service-owned lands above a specific size (https://www.fws.gov/policy/361fw2.html; part G.). These same criteria could be a method for estimating the size and complexity of a restoration structure (i.e., Does it exceed FWS Inventory Dam criteria?).

If the answer is "no", the tutorial below should help you compute flood frequency estimates for your restoration.

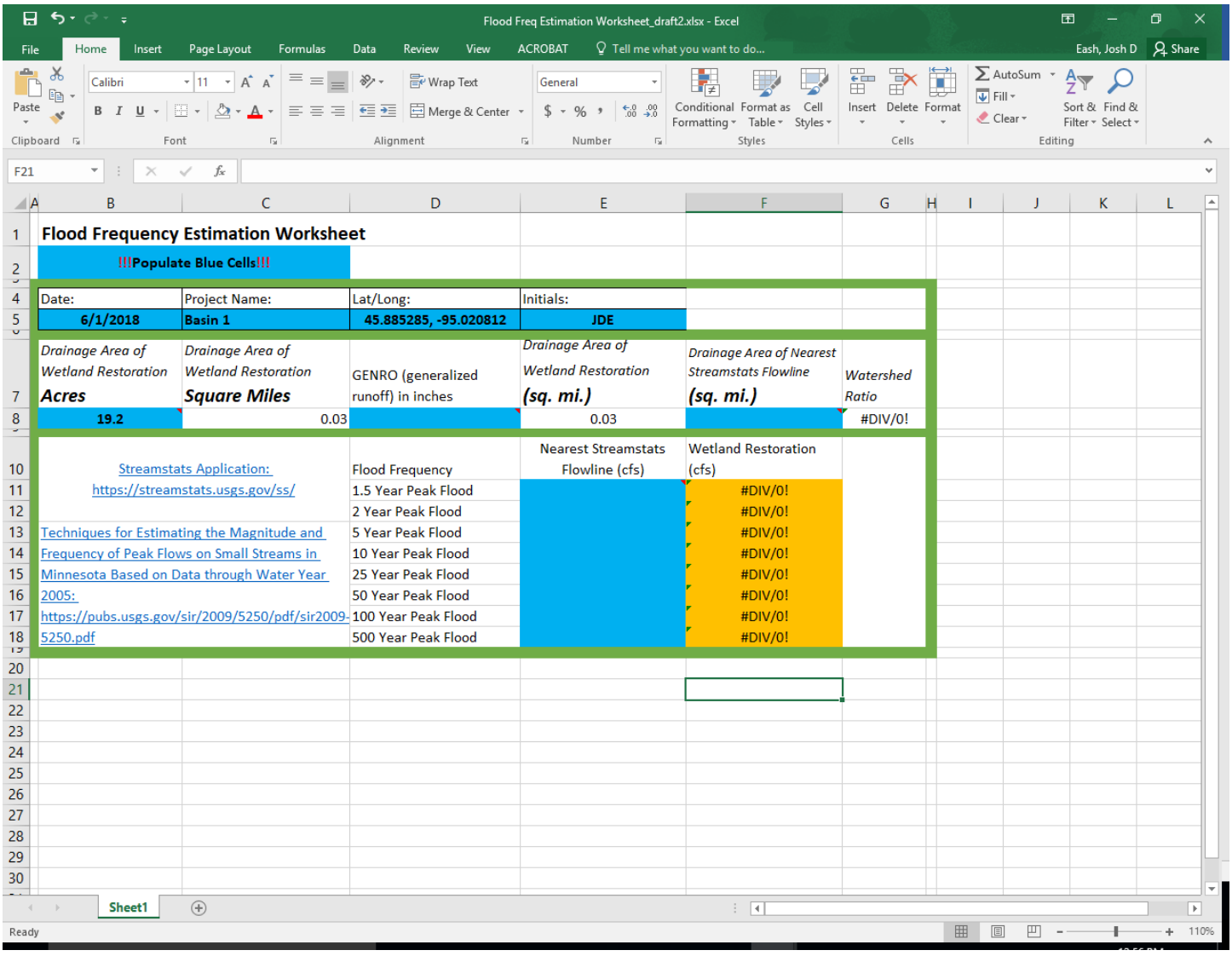
Tutorial

The approach below is based on the USGS StreamStats application (https://StreamStats.usgs.gov/ss/).

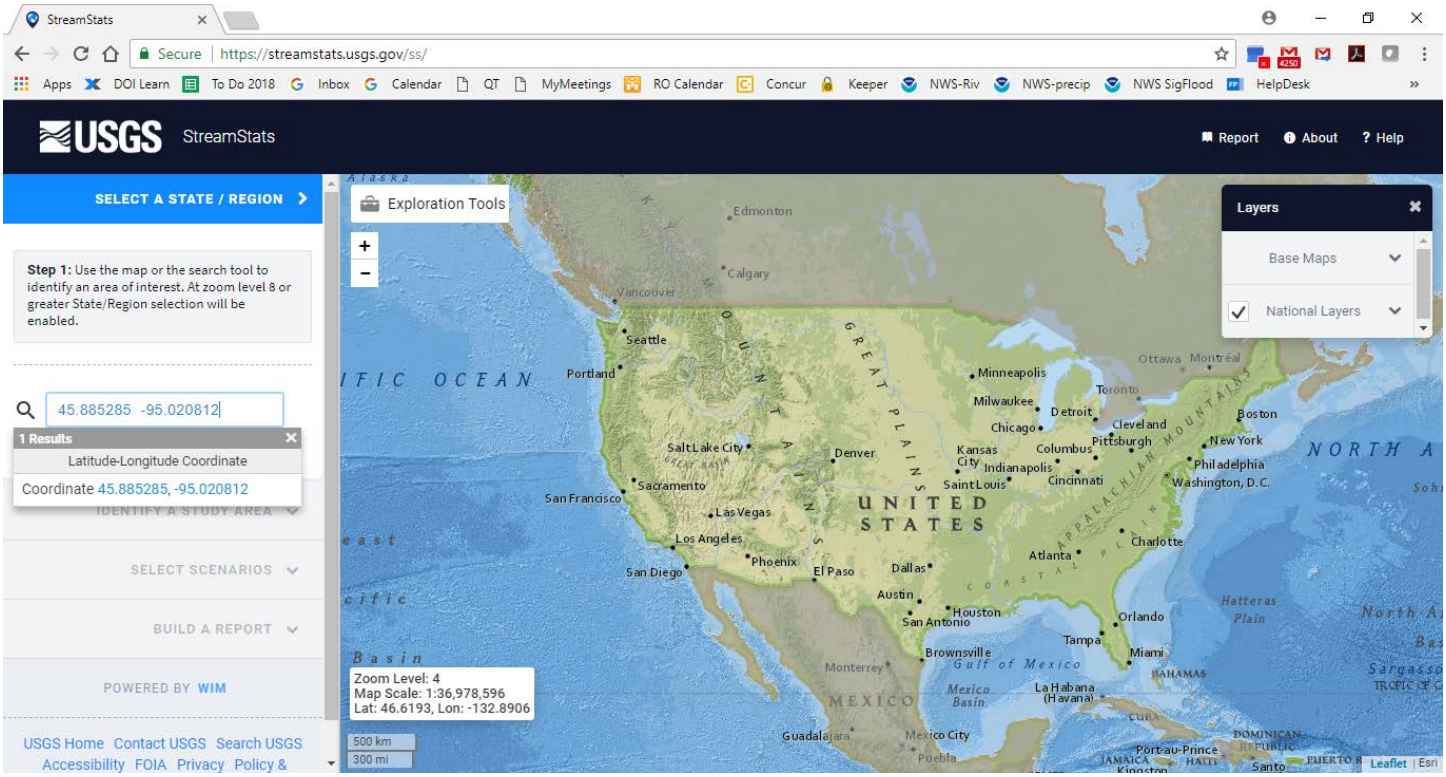
Step 1: Delineate the drainage area of the watershed upstream of your wetland restoration site. The drainage area should be delineated from the location of restoration structure (i.e., ditch plug, weir, dam, etc.). You will likely need to use LiDAR data and ArcGIS to delineate an accurate drainage area (not explained in this tutorial).

Step 2: Open the Flood Frequency Estimation Worksheet and populate the project name, latitude and longitude in decimal degrees*, initials and drainage area (in acres) of the intended wetland restoration:

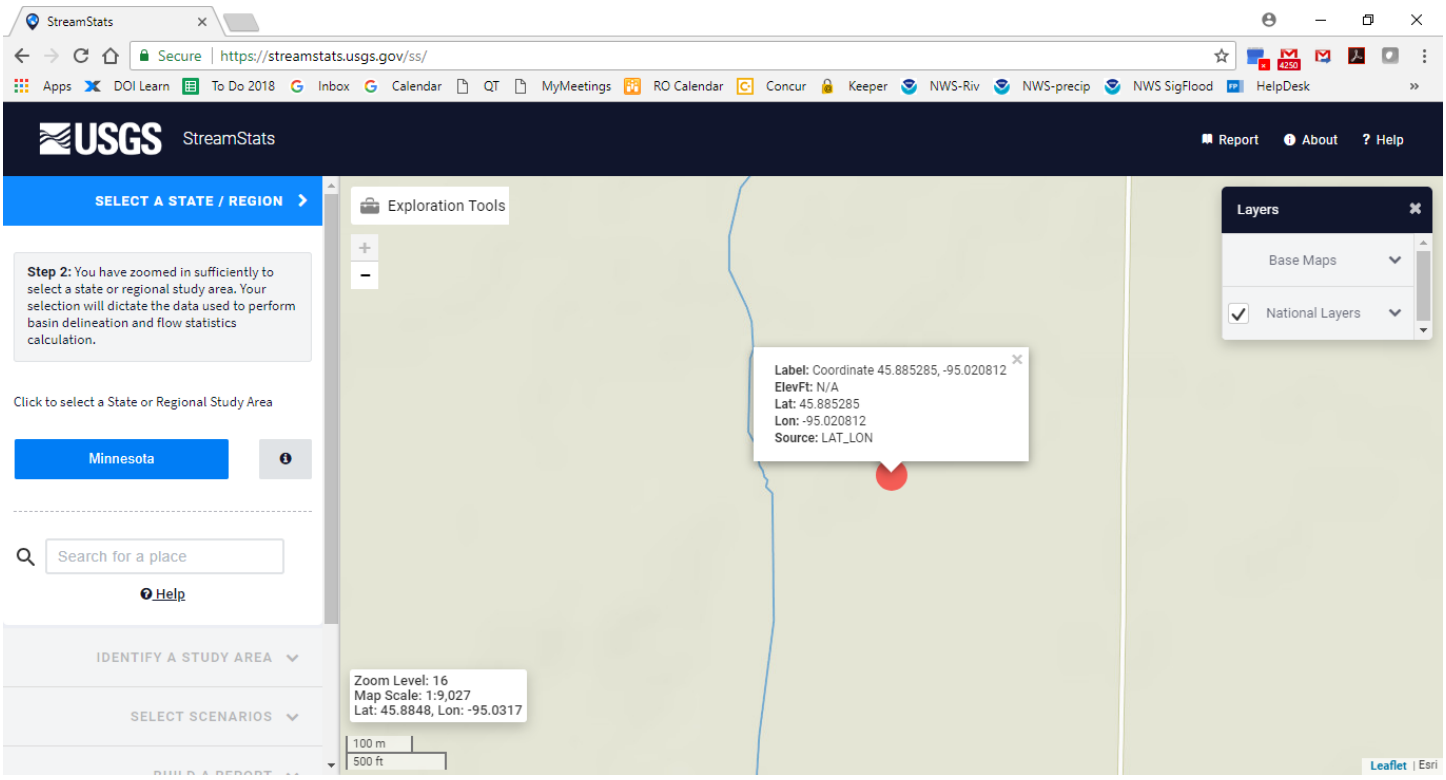
**There are multiple site that will convert degrees, minutes, seconds to decimal degrees, such as https://www.fcc.gov/media/radio/dms-decimal*



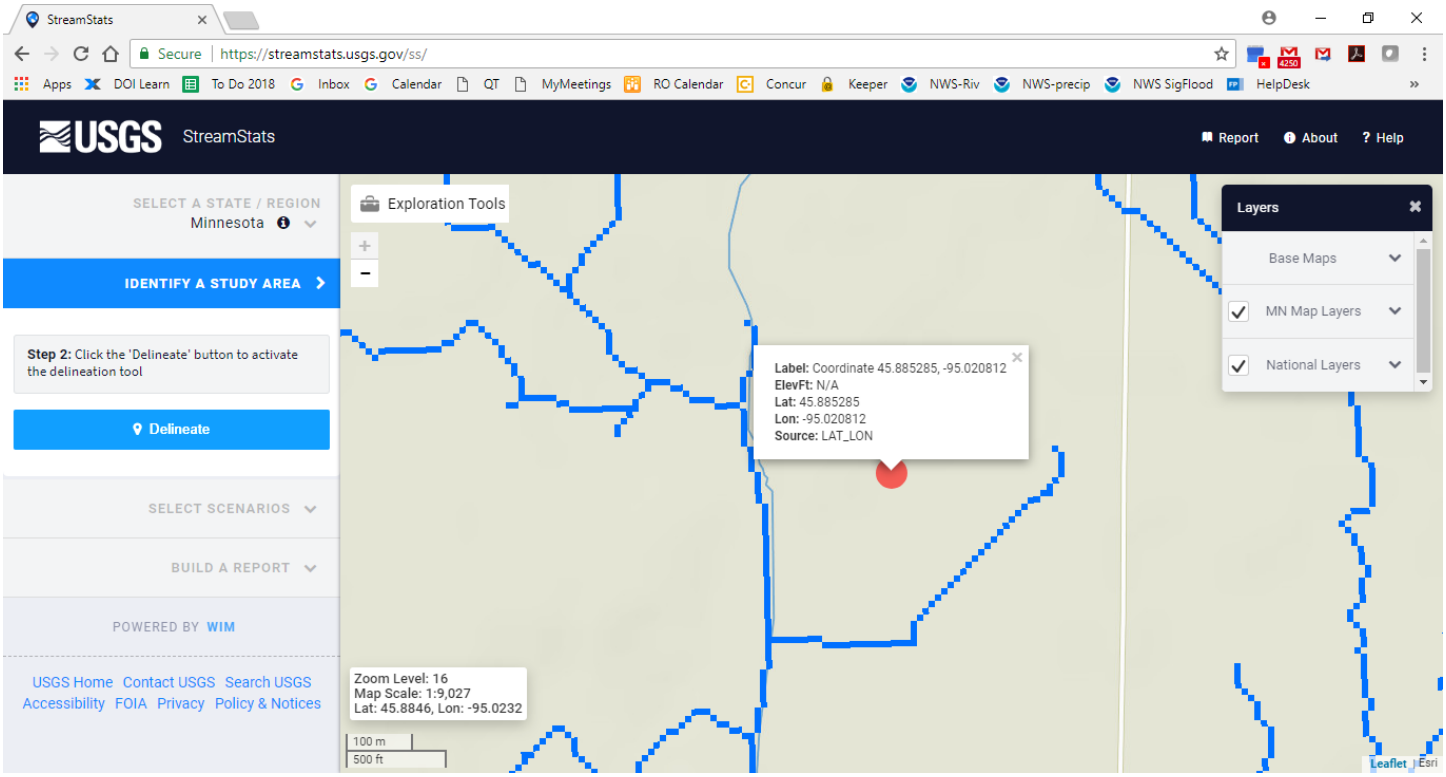
Step 3: Open StreamStats (https://StreamStats.usgs.gov/ss/ and enter lat./long. from worksheet into the location search:



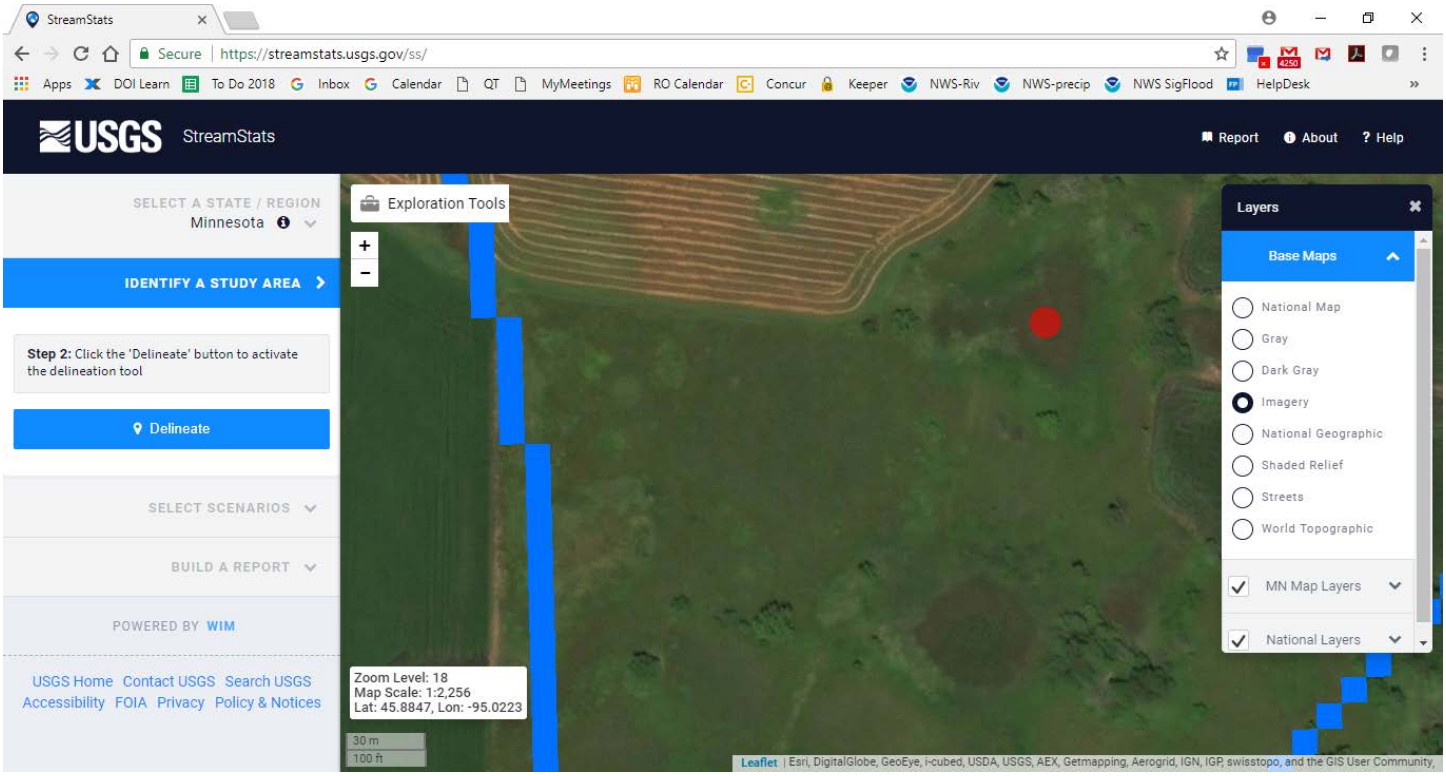
Step 4: The state associated with the lat./long. should appear on the left side of the screen. Select the state (Minnesota):



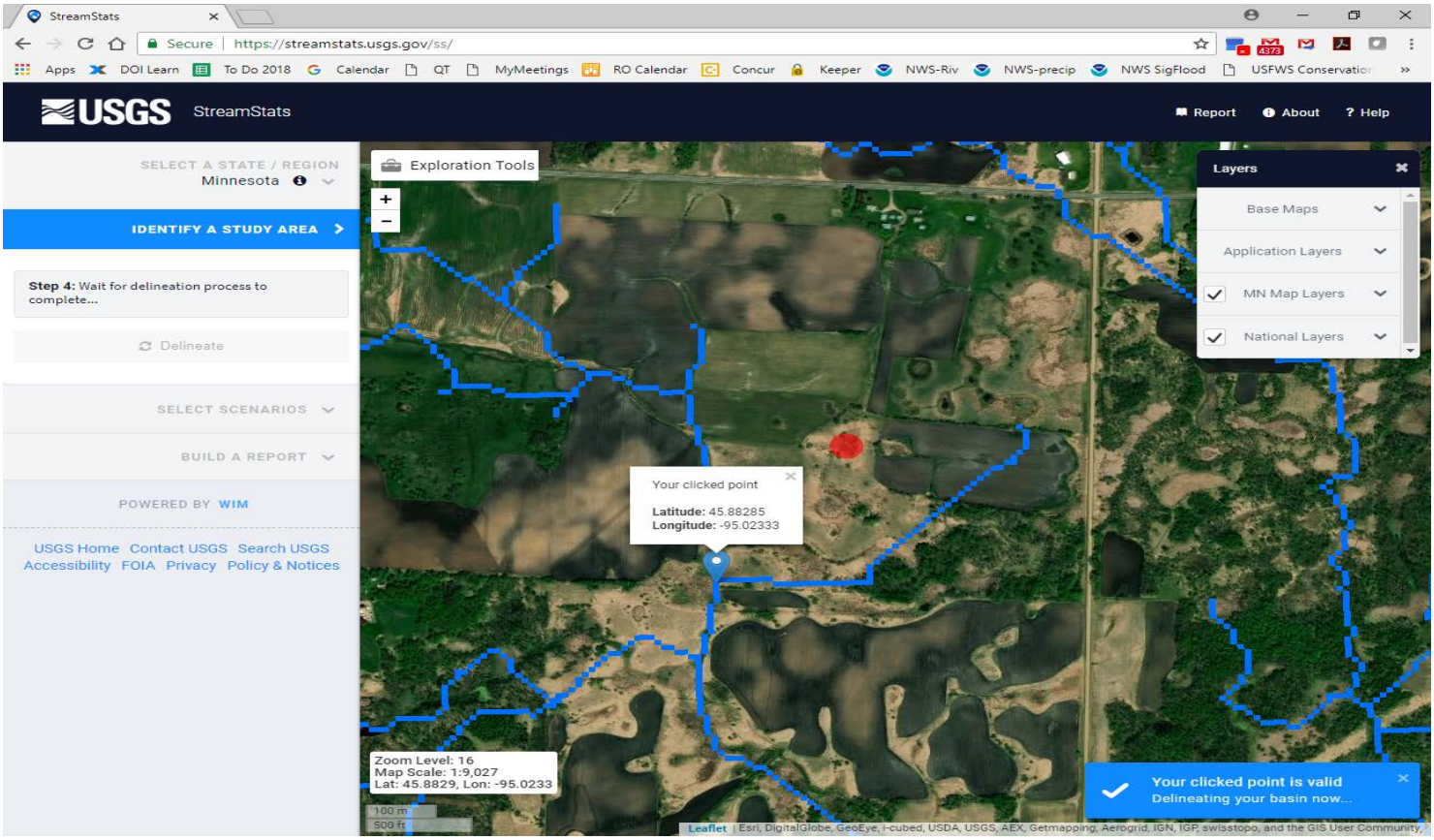
Step 5: After the state is selected, blue stream cells should become visible. If blue stream cells are not initially visible, zoom in until they appear. See the segmented blue lines in the example below. Each cell represents a drainage area.



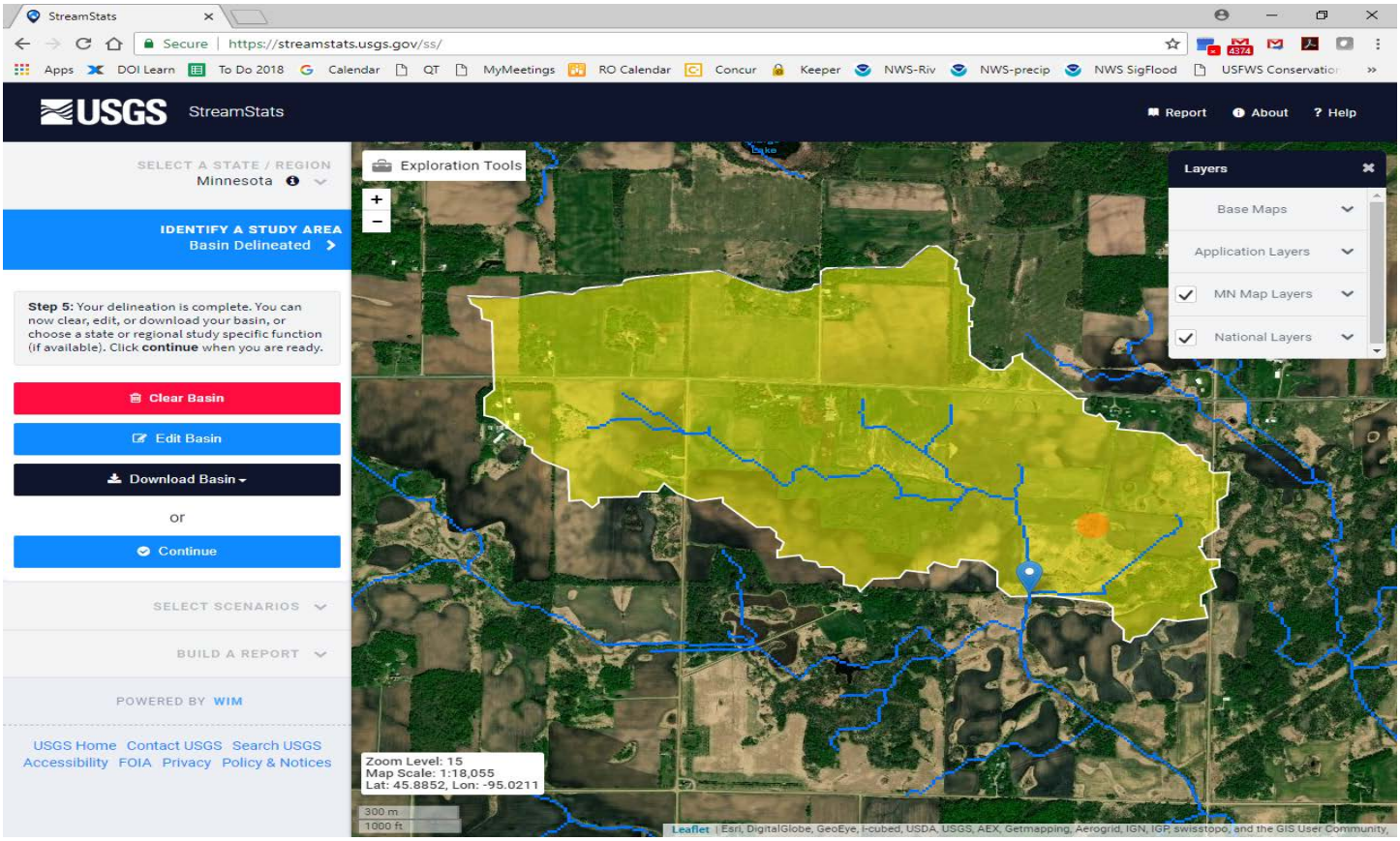
Step 6: Open the Base Map layers on the upper right side of the screen and select Imagery to visually confirm the location of the wetland restoration:



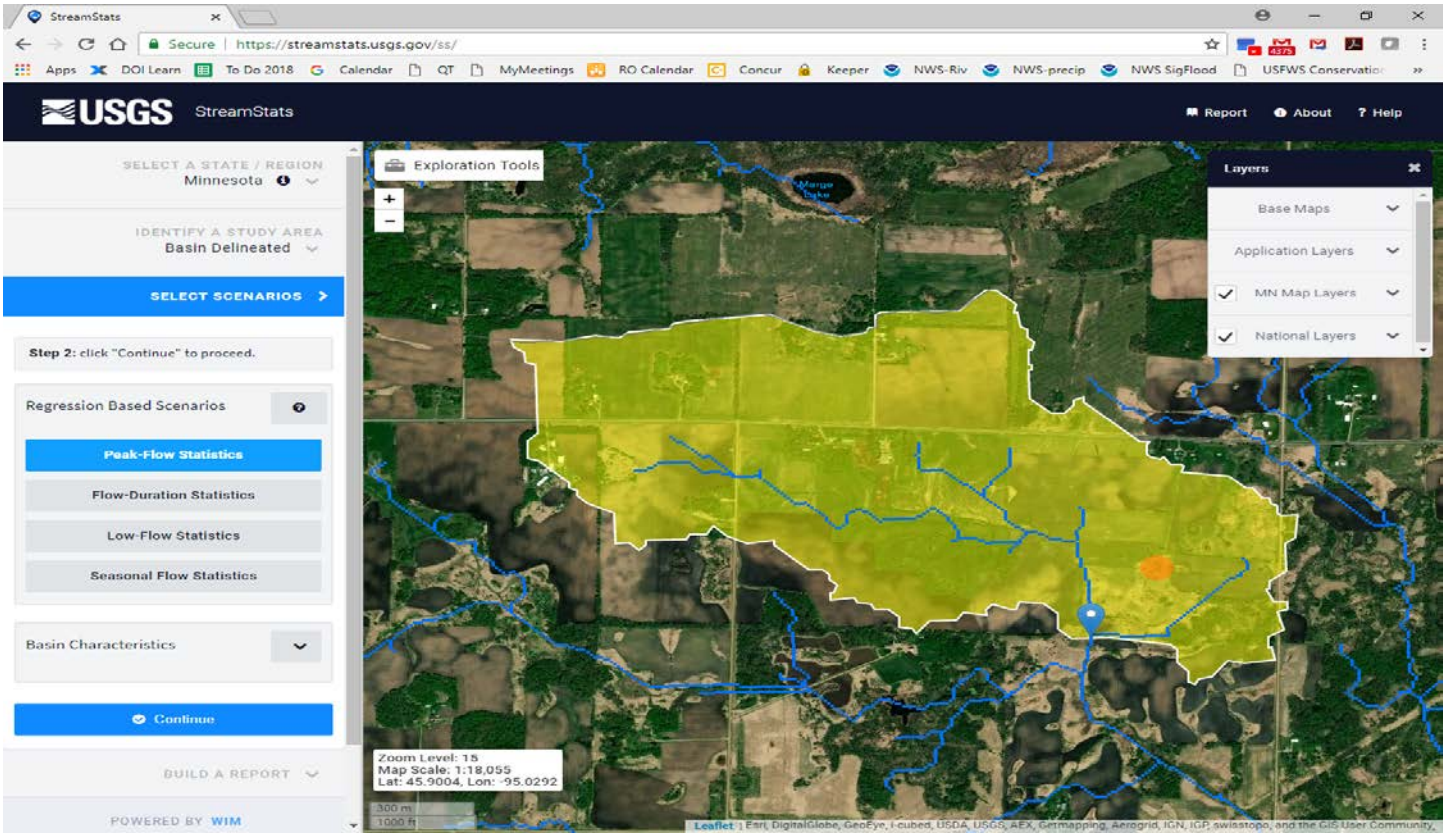
Step 7: Select the Delineate button on the left side of the screen. Select one of the longer blue stream cell segments downstream or adjacent to the wetland restoration. Try to select a longer stream segment without selecting too large of a stream. The drainage area for this initial delineation should be somewhere between 0.1 and 1.0 square miles. The delineation for this Step simply has to be large enough to compute Streamflow statistics (usually greater than 0.1 square miles). It does not need to encompass the restoration site.



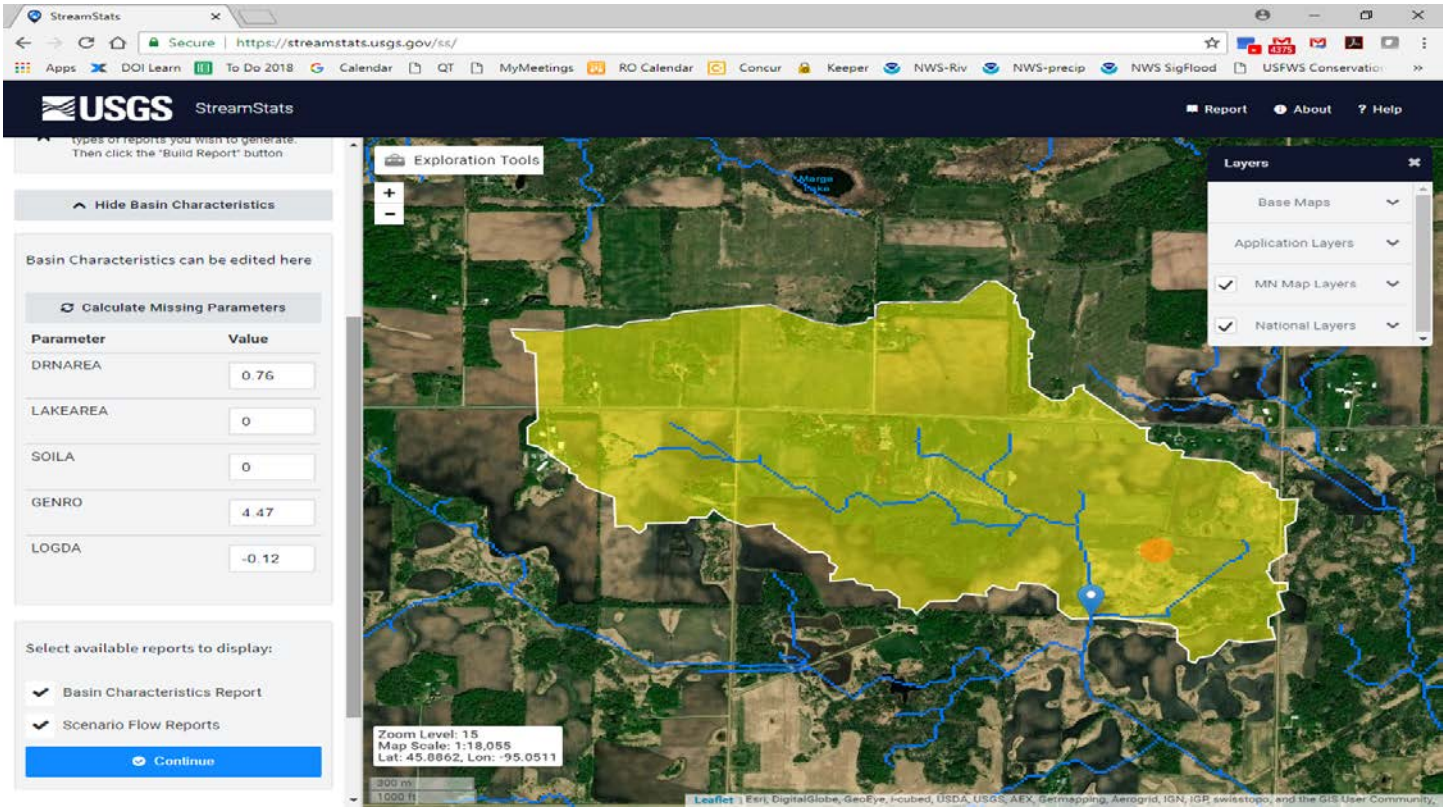
Step 8: StreamStats will delineate a drainage basin based on the blue stream cell you selected. Note: The National Hydrography Dataset can be inaccurate near the headwaters of streams. This is especially true in areas that have been highly modified. Again, for this method, the drainage basin delineation does not need to include the wetland in question it just needs to be large (but less than or equal to 1.0 square miles) enough to compute streamflow statistics. Select Continue.



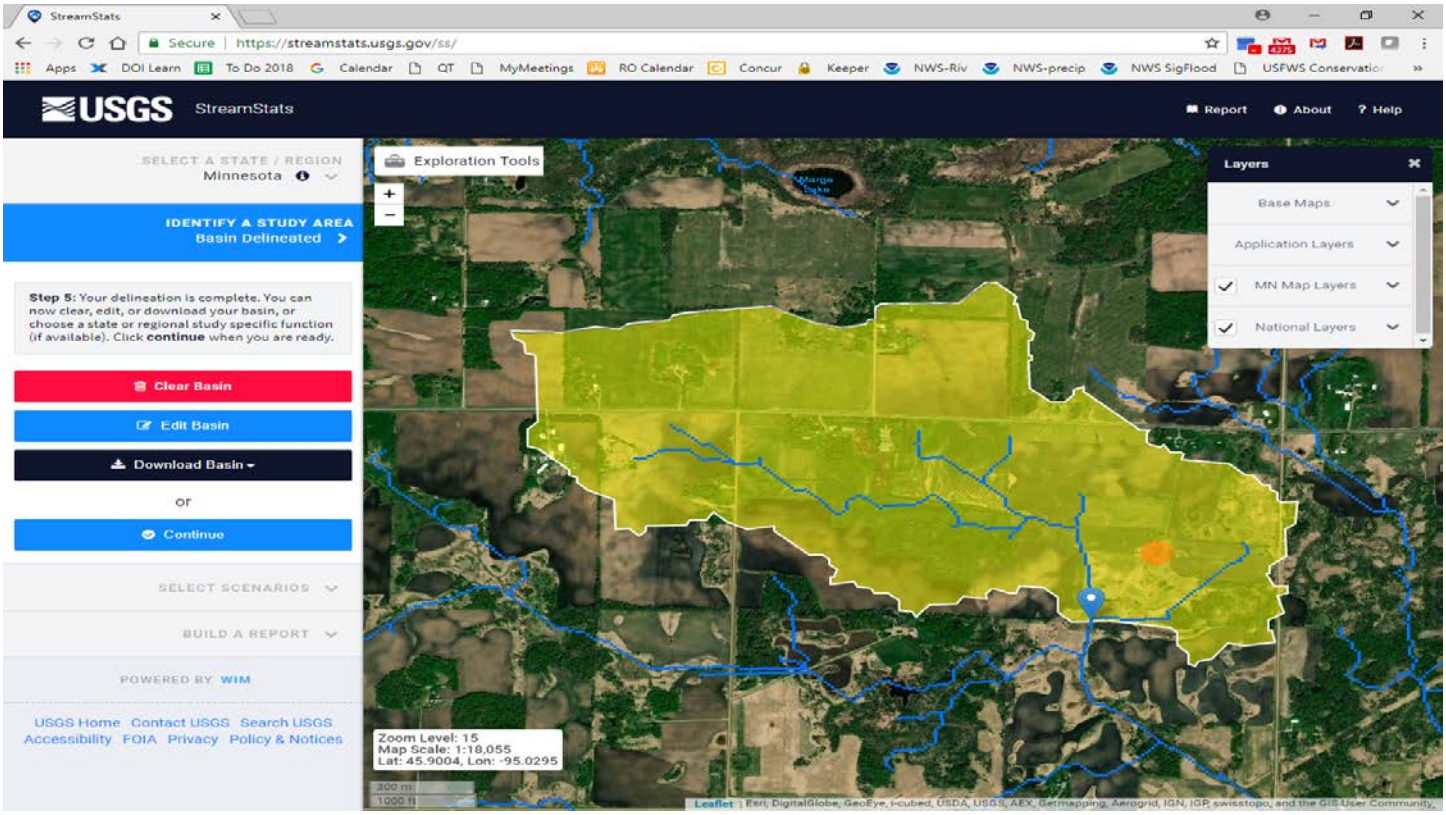
Step 9: On the Select Scenarios page, select the Peak-Flow Statistics button and select continue. If your delineation does not meet the minimum drainage area size, peak flow statistics will not be displayed. Simply go back to the Identify a Study Area tab, Clear Basin and Delineate a larger stream cell segment.



Step 10: Basin characteristics will be displayed along the left side of the screen, note the GENRO (Generalized Runoff) value. Record the GENRO value in the Flood Frequency Estimation Worksheet for future reference.

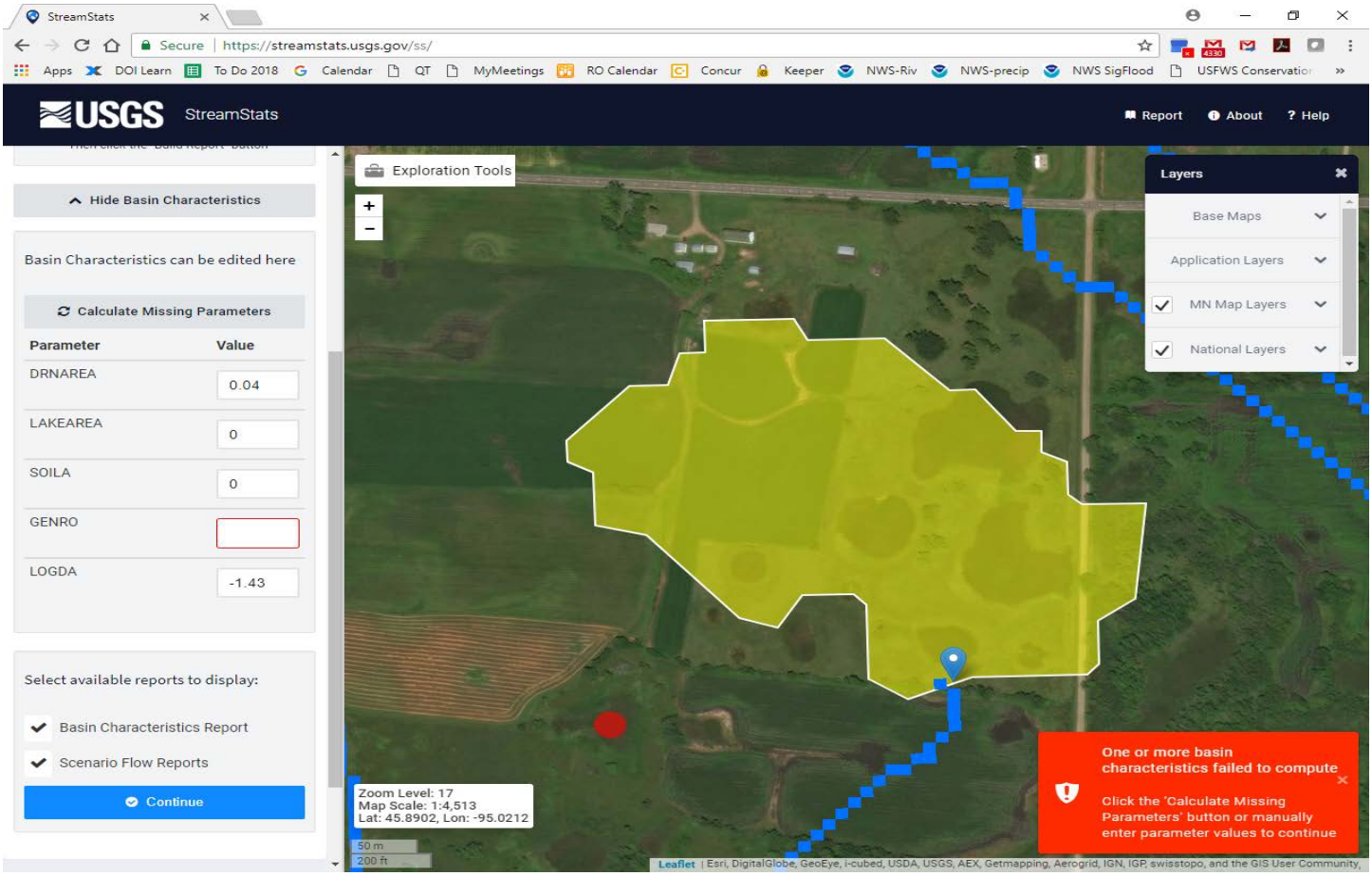


Step 11: Once you have determined the GENRO value, select the Identify a Study Area: Basin Delineated dropdown on the left side of the screen. Select the Clear Basin button to reset.

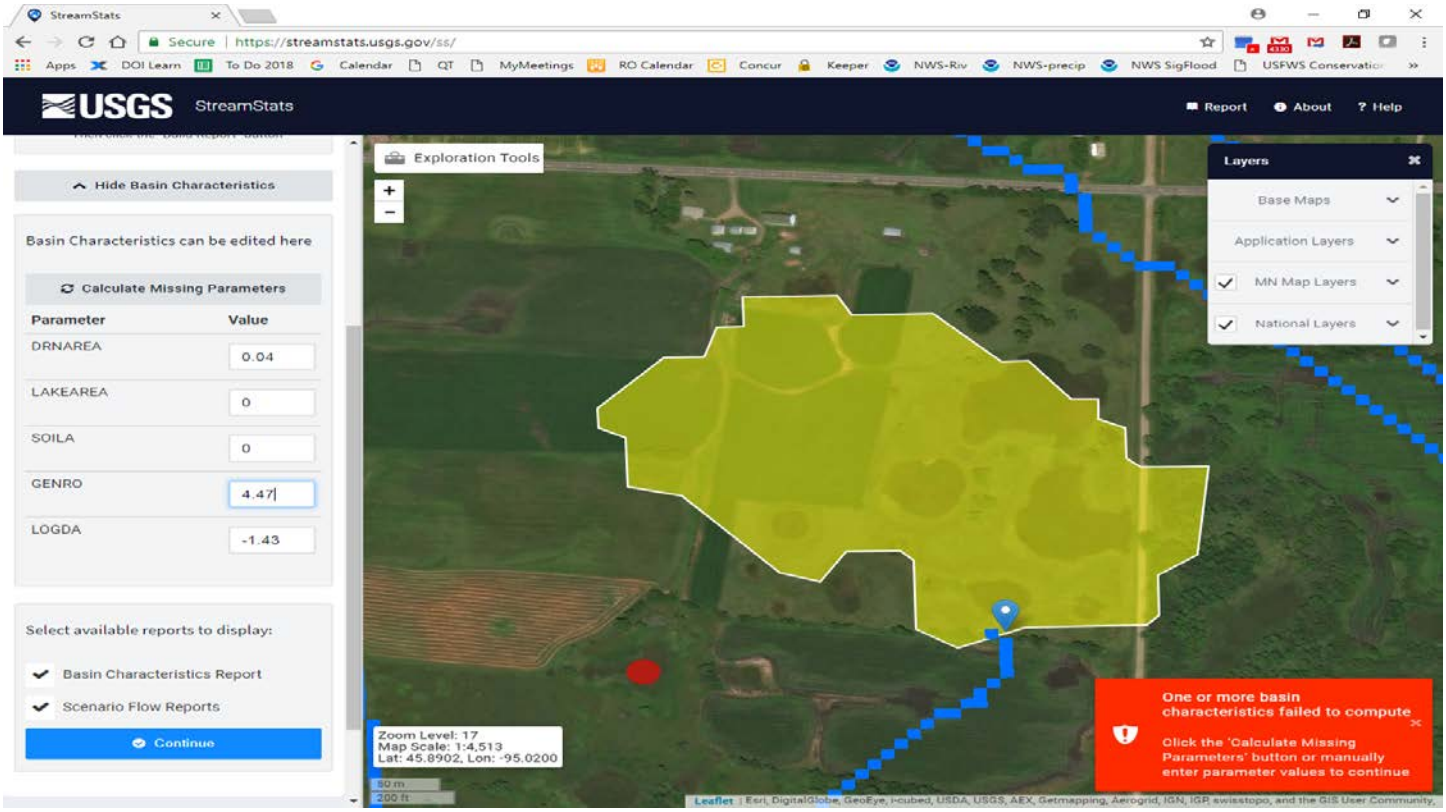


Step 12: Select the Delineate button and select a point on a blue stream cell equal to your wetland restoration drainage area. This will be a trial and error method. The objective of this Step is to match the Streamstats delineated area as close as possible to your restoration site drainage area. This will help ensure the 'drainage area ratio' in your Flood Frequency Estimation Worksheet is as close to '1.0' as possible. Delineation points should be selected at your restoration outlet (if a blue stream cell is present) or on an adjacent blue stream cell. Trial and error drainage areas can be viewed by selecting: Continue, Peak-Flow Statistics, Continue. If the drainage area is too small or too large, clear the basin and re-delineate accordingly.

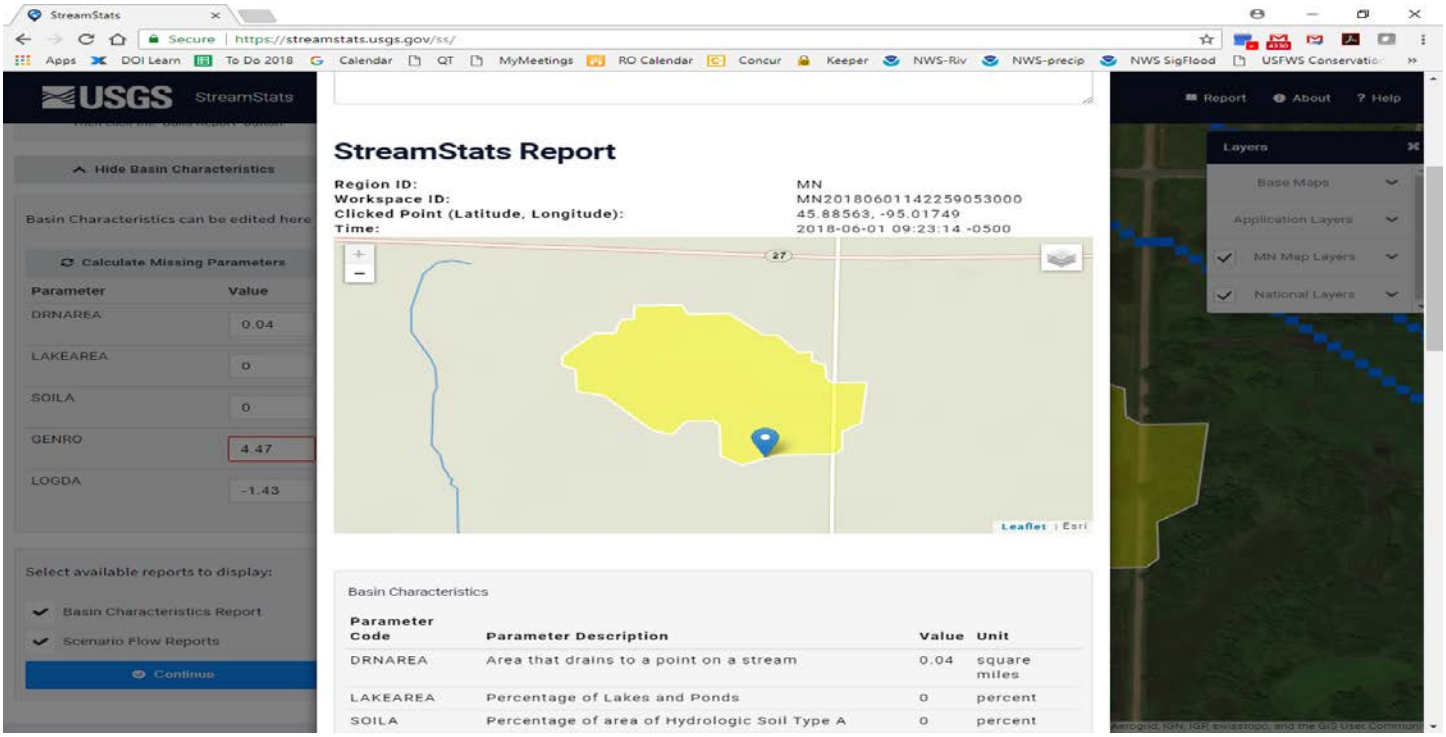
If your wetland restoration drainage area is less than 25.6 acres (0.04 sq mi), select the upper most blue stream cell nearest to your restoration site (see example below). The upper most cell of all blue stream cells in StreamStats have a drainage area of 0.04 sq mi.



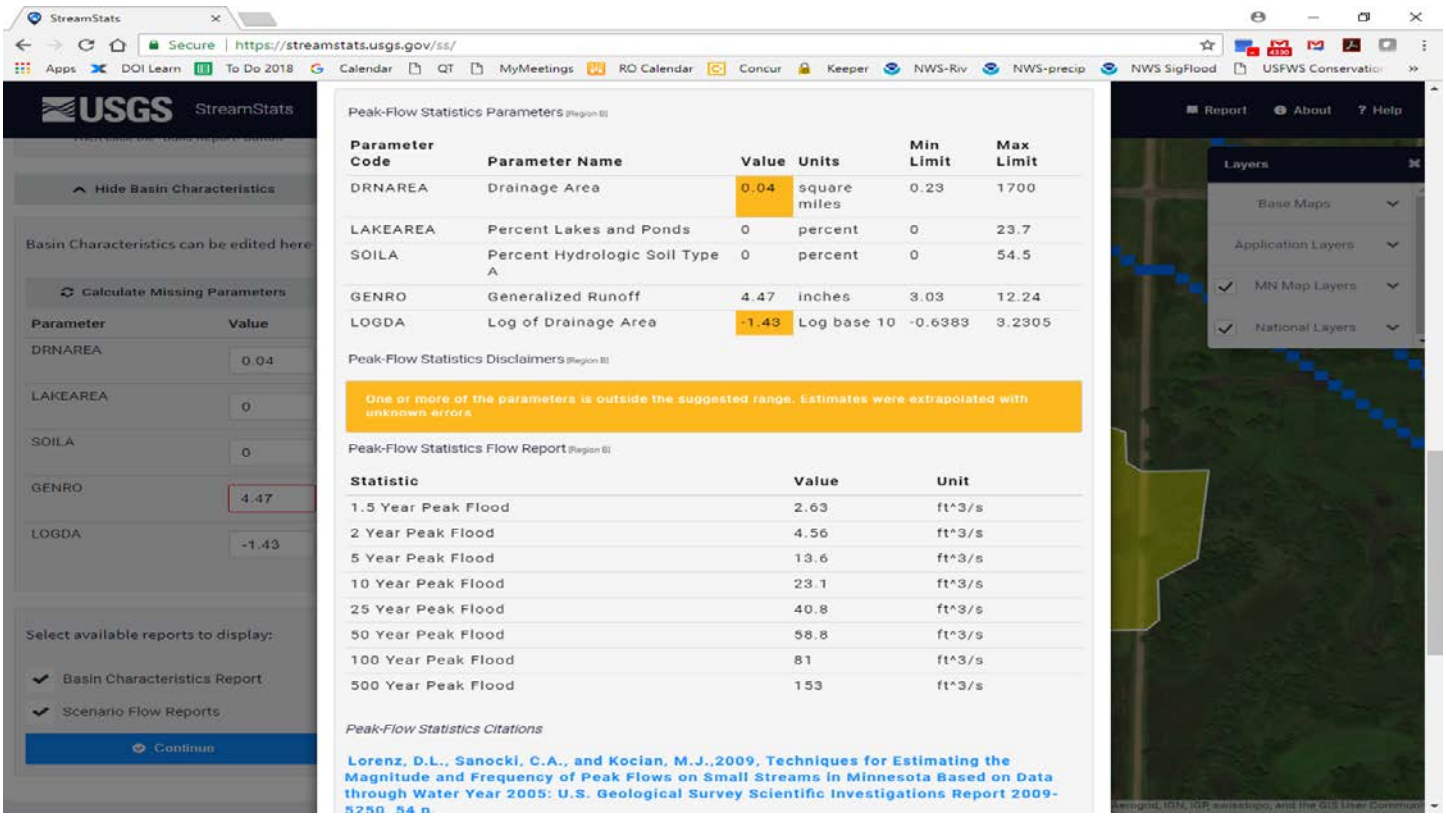
Step 13: If the drainage basin delineation you select is of sufficient size, Peak-Flow Statistics will be computed and you can follow the Steps below. However, if your drainage basin delineation is too small, you will get a red error warning and the GENRO value will be left blank. If this is the case, click on the GENRO field and manually enter the value recorded during the previous Steps.



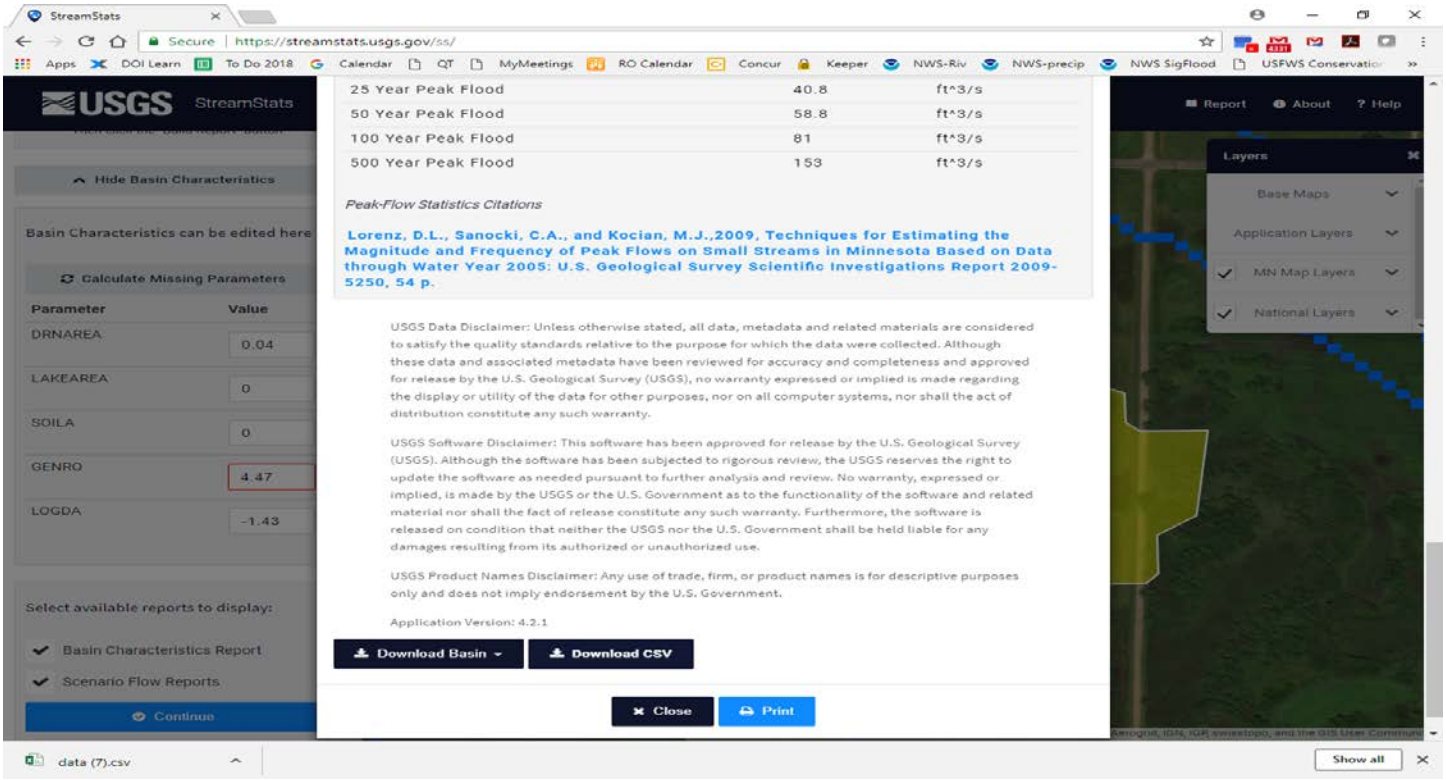
Step 14: Select continue and a StreamStats report will be generated. The report can be labeled and saved for future reference.



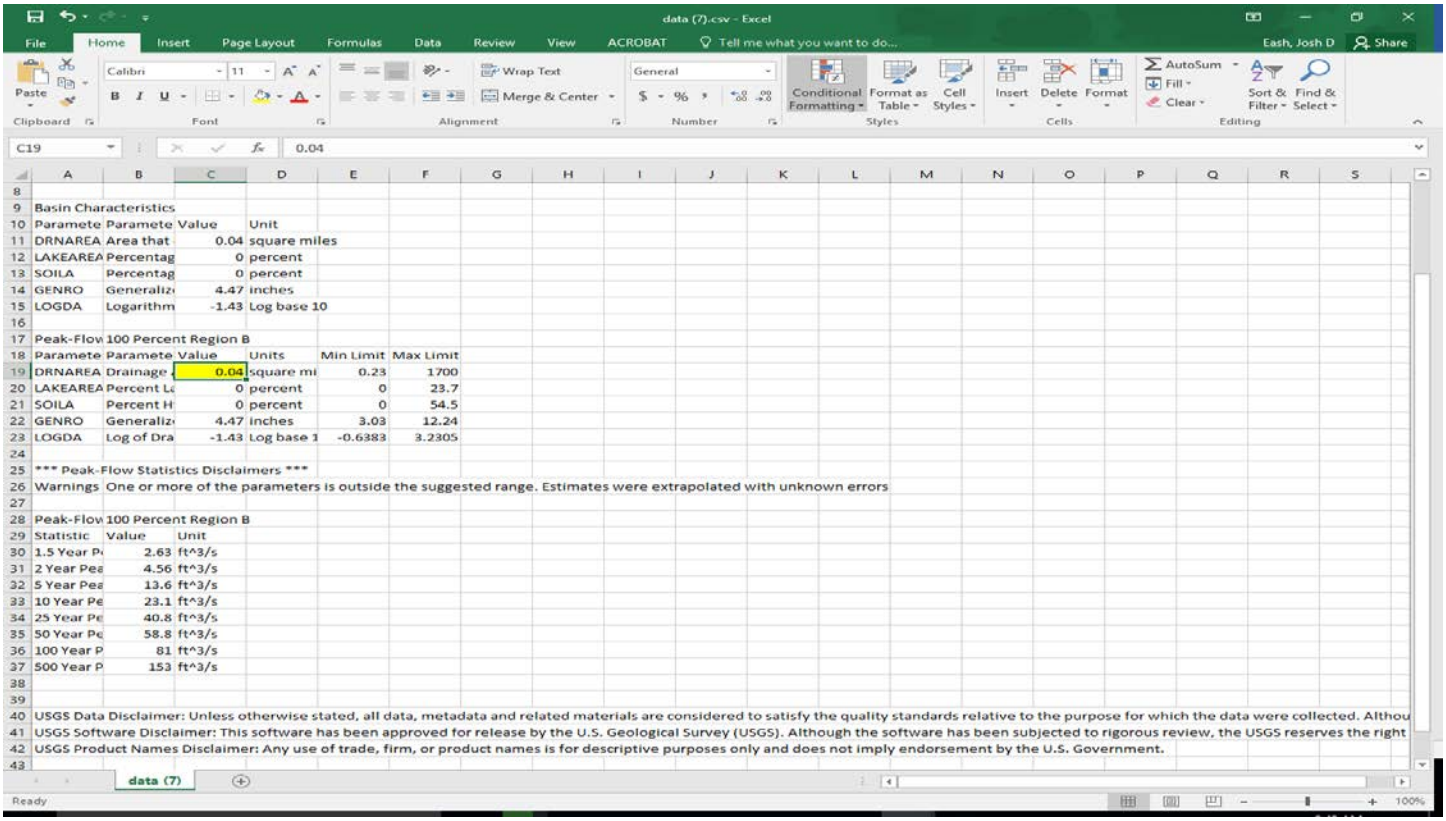
Step 15: Scroll down on the report to view the drainage area and flood frequency statistics:



Step 16: Scroll down to the bottom of the report and select the Download CSV button. All data from the report will be downloaded in a spreadsheet format:

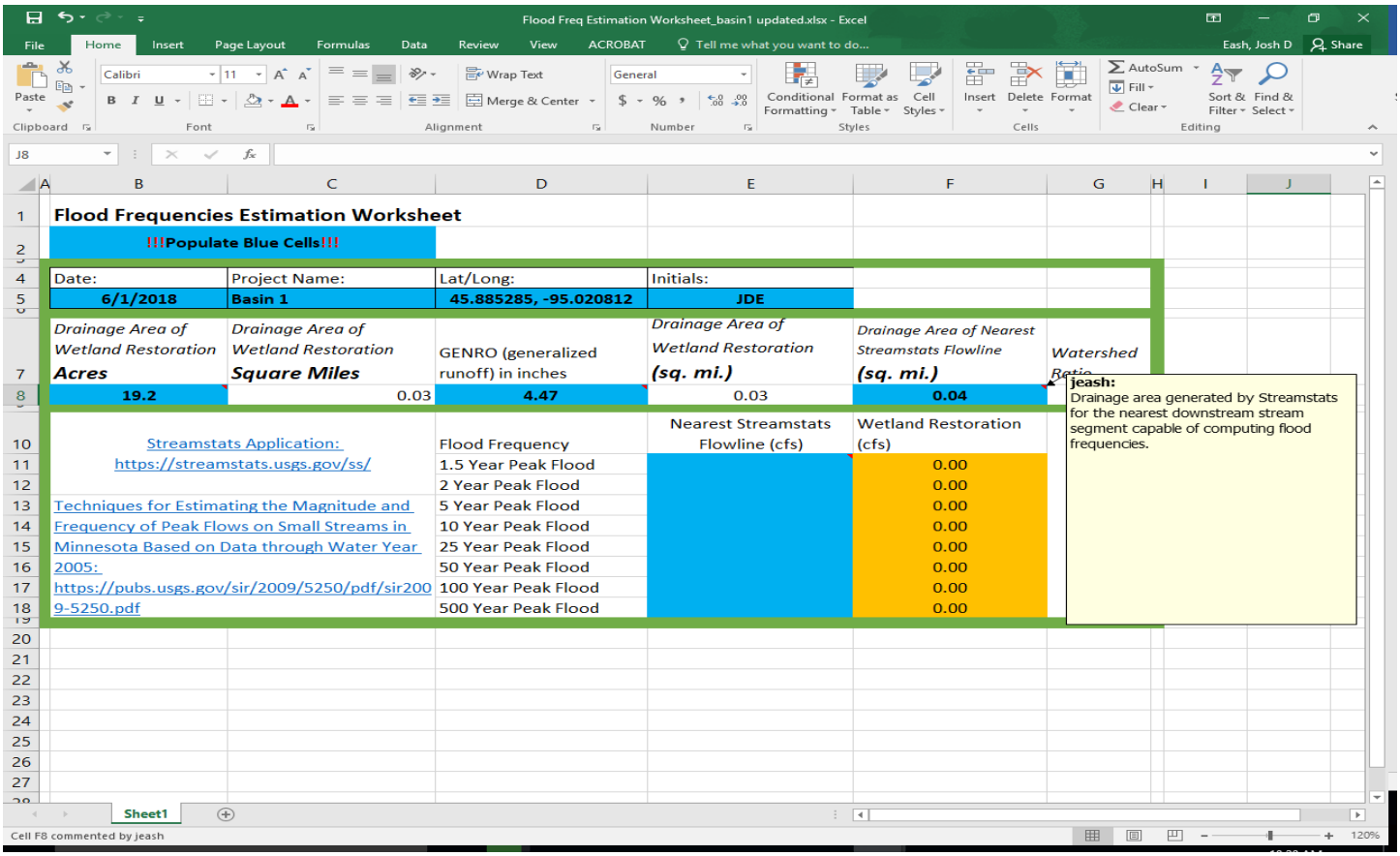


Step 17: Open the CSV file. Find the drainage area:



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
8																			
9	Basin Characteristics																		
10	Paramete	Paramete	Value	Unit															
11	DRNAREA	Area that	0.04	square miles															
12	LAKEAREA	Percentag	0	percent															
13	SOILA	Percentag	0	percent															
14	GENRO	Generaliz	4.47	inches															
15	LOGDA	Logarithm	-1.43	Log base 10															
16																			
17	Peak-Flow	100 Percent Region B																	
18	Paramete	Paramete	Value	Units	Min Limit	Max Limit													
19	DRNAREA	Drainage A	0.04	square mi	0.23	1700													
20	LAKEAREA	Percent La	0	percent	0	23.7													
21	SOILA	Percent H	0	percent	0	54.5													
22	GENRO	Generaliz	4.47	inches	3.03	12.24													
23	LOGDA	Log of Dra	-1.43	Log base 1	-0.6383	1.2305													
24																			
25	*** Peak-Flow Statistics Disclaimers ***																		
26	Warnings	One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors																	
27																			
28	Peak-Flow	100 Percent Region B																	
29	Statistic	Value	Unit																
30	1.5 Year P	2.63	ft^3/s																
31	2 Year Pea	4.56	ft^3/s																
32	5 Year Pea	13.6	ft^3/s																
33	10 Year Pe	23.1	ft^3/s																
34	25 Year Pe	40.8	ft^3/s																
35	50 Year Pe	58.8	ft^3/s																
36	100 Year P	81	ft^3/s																
37	500 Year P	153	ft^3/s																
38																			
39																			
40	USGS Data Disclaimer: Unless otherwise stated, all data, metadata and related materials are considered to satisfy the quality standards relative to the purpose for which the data were collected. Althou																		
41	USGS Software Disclaimer: This software has been approved for release by the U.S. Geological Survey (USGS). Although the software has been subjected to rigorous review, the USGS reserves the right																		
42	USGS Product Names Disclaimer: Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.																		
43																			

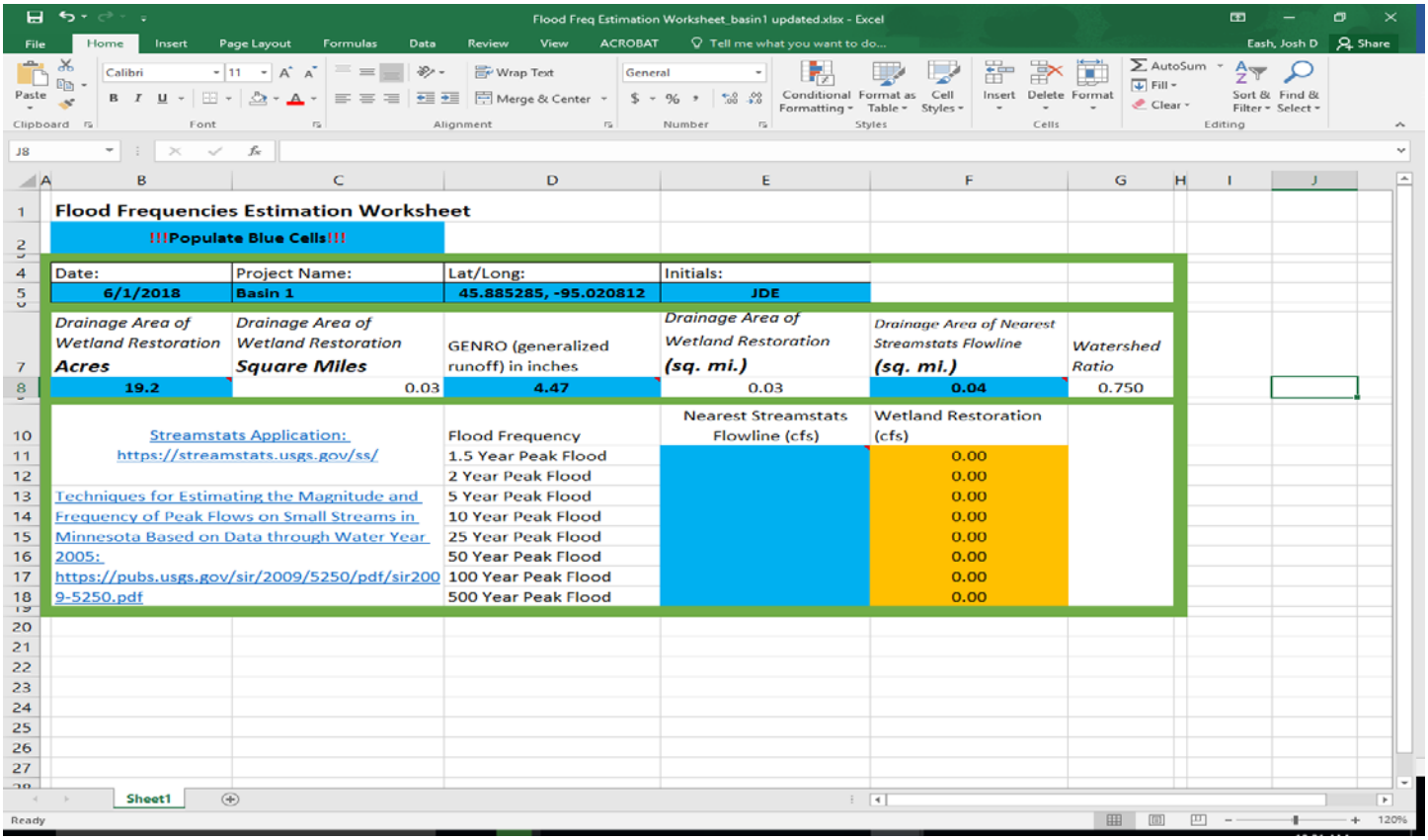
Step 18: Enter the drainage area from the StreamStats report into the Flood Frequency Estimation Worksheet:



	B	C	D	E	F	G	J
1	**Flood Frequencies Estimation Worksheet**						
2	**!!!Populate Blue Cells!!!**						
4	Date:	Project Name:	Lat/Long:	Initials:			
5	**6/1/2018**	**Basin 1**	**45.885285, -95.020812**	**JDE**			
7	*Drainage Area of Wetland Restoration* ***Acres***	*Drainage Area of Wetland Restoration* ***Square Miles***	GENRO (generalized runoff) in inches	*Drainage Area of Wetland Restoration* ***(sq. mi.)***	*Drainage Area of Nearest Streamstats Flowline* ***(sq. mi.)***	*Watershed Ratio*	
8	**19.2**	0.03	**4.47**	0.03	**0.04**		
10	Streamstats Application: https://streamstats.usgs.gov/ss/		Flood Frequency	Nearest Streamstats Flowline (cfs)	Wetland Restoration (cfs)		
11			1.5 Year Peak Flood		0.00		
12			2 Year Peak Flood		0.00		
13	Techniques for Estimating the Magnitude and		5 Year Peak Flood		0.00		
14	Frequency of Peak Flows on Small Streams in		10 Year Peak Flood		0.00		
15	Minnesota Based on Data through Water Year		25 Year Peak Flood		0.00		
16	2005:		50 Year Peak Flood		0.00		
17	https://pubs.usgs.gov/sir/2009/5250/pdf/sir200		100 Year Peak Flood		0.00		
18	9-5250.pdf		500 Year Peak Flood		0.00		

jeash:
Drainage area generated by Streamstats for the nearest downstream stream segment capable of computing flood frequencies.

Step 19: This will generate the Watershed Ratio between the StreamStats drainage area and the wetland restoration drainage area:



Flood Freq Estimation Worksheet_basin1 updated.xlsx - Excel

Flood Frequencies Estimation Worksheet

!!!Populate Blue Cells!!!

Date:	Project Name:	Lat/Long:	Initials:
6/1/2018	Basin 1	45.885285, -95.020812	JDE

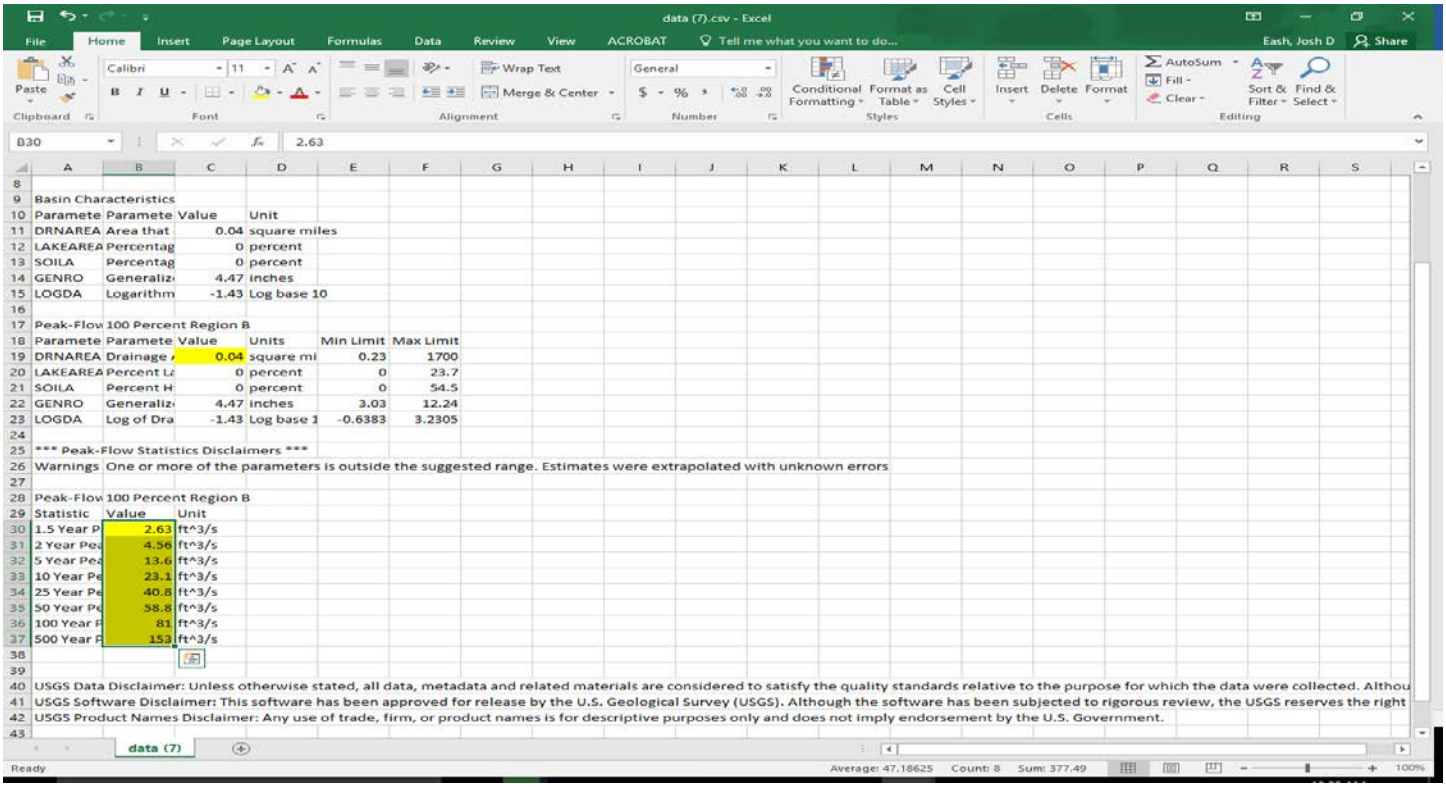
Drainage Area of Wetland Restoration ***Acres***	*Drainage Area of Wetland Restoration* ***Square Miles***	GENRO (generalized runoff) in inches	*Drainage Area of Wetland Restoration* ***(sq. mi.)***	*Drainage Area of Nearest Streamstats Flowline* ***(sq. mi.)***	*Watershed Ratio*
19.2	0.03	4.47	0.03	0.04	0.750

Streamstats Application: https://streamstats.usgs.gov/ss/

Techniques for Estimating the Magnitude and Frequency of Peak Flows on Small Streams in Minnesota Based on Data through Water Year 2005: https://pubs.usgs.gov/sir/2009/5250/pdf/sir2009-5250.pdf

Flood Frequency	Nearest Streamstats Flowline (cfs)	Wetland Restoration (cfs)
1.5 Year Peak Flood		0.00
2 Year Peak Flood		0.00
5 Year Peak Flood		0.00
10 Year Peak Flood		0.00
25 Year Peak Flood		0.00
50 Year Peak Flood		0.00
100 Year Peak Flood		0.00
500 Year Peak Flood		0.00

Step 20: Return to the StreamStats Report CSV worksheet and copy the flood frequency streamflow values for the 1.5 through 500 Year Peak Flood:



data (7).csv - Excel

Basin Characteristics			
Paramete	Paramete	Value	Unit
DRNAREA	Area that	0.04	square miles
LAKEAREA	Percentag	0	percent
SOILA	Percentag	0	percent
GENRO	Generaliz	4.47	inches
LOGDA	Logarithm	-1.43	Log base 10

Peak-Flow	100 Percent Region B				
Paramete	Paramete	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage A	0.04	square mi	0.23	1700
LAKEAREA	Percent La	0	percent	0	23.7
SOILA	Percent H	0	percent	0	54.5
GENRO	Generaliz	4.47	inches	3.03	12.24
LOGDA	Log of Dra	-1.43	Log base 1	-0.6383	3.2305

*** Peak-Flow Statistics Disclaimers ***

Warnings: One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors

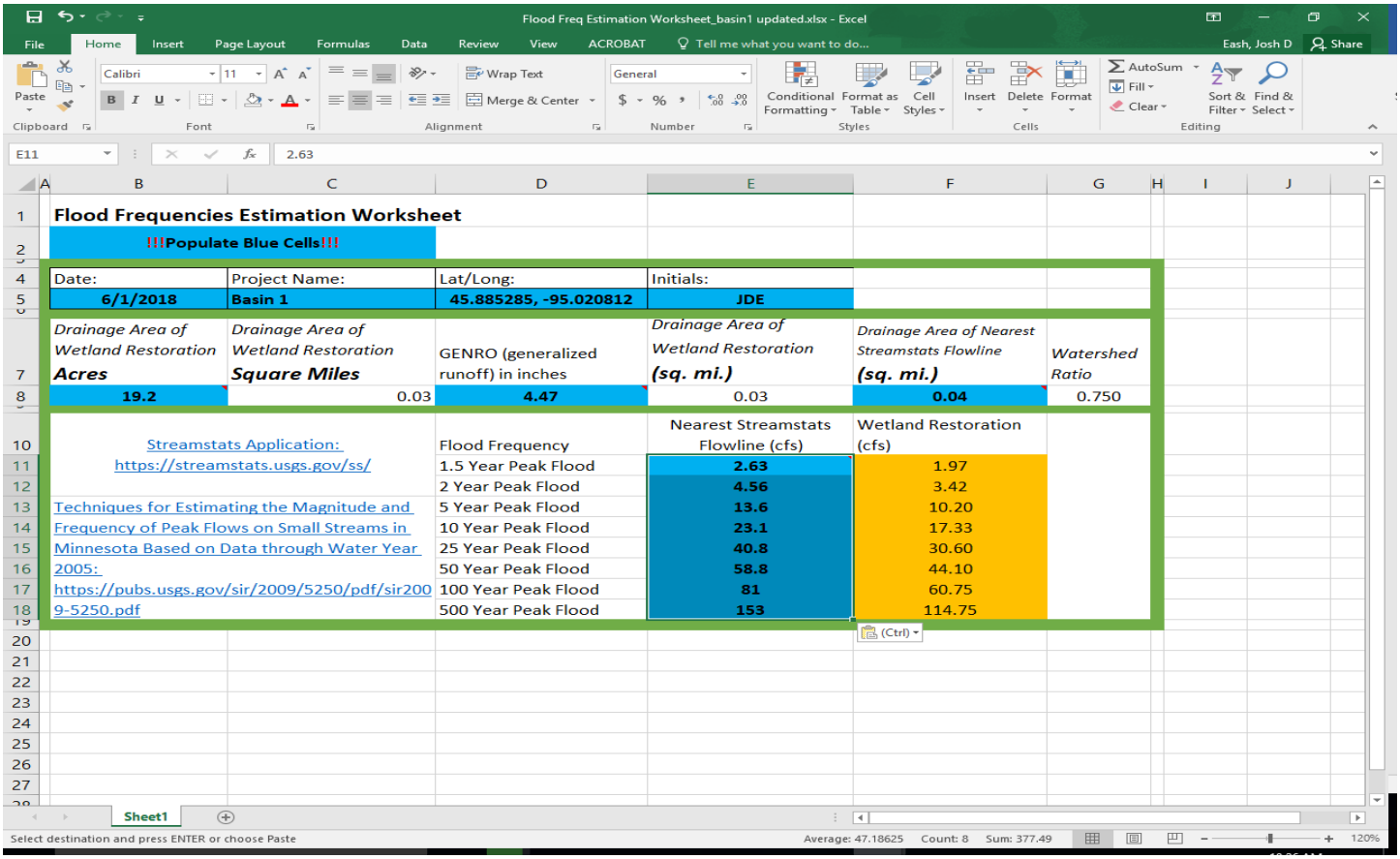
Peak-Flow	100 Percent Region B	
Statistic	Value	Unit
1.5 Year P	2.63	ft^3/s
2 Year Pea	4.56	ft^3/s
5 Year Pea	13.6	ft^3/s
10 Year Pe	23.1	ft^3/s
25 Year Pe	40.8	ft^3/s
50 Year Pe	58.8	ft^3/s
100 Year P	81	ft^3/s
500 Year P	153	ft^3/s

USGS Data Disclaimer: Unless otherwise stated, all data, metadata and related materials are considered to satisfy the quality standards relative to the purpose for which the data were collected. Althou

USGS Software Disclaimer: This software has been approved for release by the U.S. Geological Survey (USGS). Although the software has been subjected to rigorous review, the USGS reserves the right

USGS Product Names Disclaimer: Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

Step 21: Paste the streamflow values into the Flood Frequency Estimation Worksheet in cell F7 to F14. This will generate estimated flood frequencies for the wetland restoration site (highlighted in orange):



Flood Freq Estimation Worksheet_basin1 updated.xlsx - Excel

Flood Frequencies Estimation Worksheet

!!!Populate Blue Cells!!!

Date:	Project Name:	Lat/Long:	Initials:
6/1/2018	Basin 1	45.885285, -95.020812	JDE

Drainage Area of Wetland Restoration ***Acres***	*Drainage Area of Wetland Restoration* ***Square Miles***	GENRO (generalized runoff) in inches	*Drainage Area of Wetland Restoration* ***(sq. mi.)***	*Drainage Area of Nearest Streamstats Flowline* ***(sq. mi.)***	*Watershed Ratio*
19.2	0.03	4.47	0.03	0.04	0.750

Streamstats Application: https://streamstats.usgs.gov/ss/

Techniques for Estimating the Magnitude and Frequency of Peak Flows on Small Streams in Minnesota Based on Data through Water Year 2005: https://pubs.usgs.gov/sir/2009/5250/pdf/sir2009-5250.pdf

Flood Frequency	Nearest Streamstats Flowline (cfs)	Wetland Restoration (cfs)
1.5 Year Peak Flood	2.63	1.97
2 Year Peak Flood	4.56	3.42
5 Year Peak Flood	13.6	10.20
10 Year Peak Flood	23.1	17.33
25 Year Peak Flood	40.8	30.60
50 Year Peak Flood	58.8	44.10
100 Year Peak Flood	81	60.75
500 Year Peak Flood	153	114.75

Step 22: Save all work as documentation of your methods.

The resulting flood frequency values can be used for designing wetland restorations. Streamstats will indicate the standard errors associated with any calculations. However, calculations for drainage areas for very small basins or manually entered GENRO values will have an 'unknown errors'.

Please contact Josh Eash (josh_eash@fws.gov or 612-713-5404) with questions.

For additional information on Flood Frequency Estimation in Minnesota:

Lorenz, D.L., Sanocki, C.A., and Kocian, M.J., 2009, Techniques for Estimating the Magnitude and Frequency of Peak Flows on Small Streams in Minnesota Based on Data through Water Year 2005: U.S. Geological Survey Scientific Investigations Report 2009-5250, 54 p.