<u>Snow Distribution for Utah:</u>

An Alternative Approach to Analysis Accumulation

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Abstract:

This paper highlights a student developed technique to predict snow accumulation volume and resulting spring runoff values using a linear relationship between SWE depths and elevation. Typically in researchers and water managers would use interpolation (like spline) to predict volume of water. Sometimes interpolation doesn't work, particularly when there is not enough data to adequately predict values within a confined area. This is due from too few sites recording data to work with in a specific area. The solution approach to this problem was created using a simple linear relationship of the form $y = mx + b$. This is a type of regression analysis that uses statistical process for estimating the relationships among variables. Using this relationship it is possible to predict volumes of water in a confined area when there are few sites to work with.

After the linear relationship between elevation and SWE was found it was then tested to see if the relationship could be used to predict quantity of spring runoff. Two models were produced, one using SWE values from April 1, the other using seasonal peak SWE values. Both models were then compared to seasonal peak river flow values. It was found that the SWE peak values predicted the spring peak streamflow values better by nearly 4% than using April 1st data. These results lead to the following conclusions: 1) it is possible to predict spring river flow values using the SWE vs elevation relationship with some margin of error, 2) better to compare peak-to-peak values rather than a specific date, 2) the difference between peak SWE and April 1st values could be marginal as peak SWE values typically might occur around that date.

Introduction:

This paper will present information on an alternative practice to obtaining snow water equivalent data based on an elevation model. The goal for this project is to develop a technique that can predict spring runoff with a higher accuracy within a confined area. Snow Water Equivalent (SWE) is the amount of water contained within a snowpack. It can be thought of as the depth of water that would theoretically result if a snowpack melted instantaneously.

As a class we learned that to determine runoff from any precipitation you must use a form of data interpolation. The spline interpolation tool, used in ArcGIS, estimates values using a mathematical function that minimizes overall surface curvature, resulting in a smooth surface that passes exactly through the input points (esri 2012). For our class, this technique utilized multiple sites which engulfed the area of observation (see figure 2 Appendix A).

Interpolation works best when there is sufficient amounts of sites to interrupt data from. Points in between the sites are assigned a value that is based on the relationship and distance to the sites. Essentially, this technique works because there is enough to data to adequately fill in the missing pieces. However, interpolation does not offer a high enough resolution to adequately analysis a smaller confined area. For this project, for example, only seven sites with sufficient data are available. This means when interpolation is used it produces an incomplete model (see figure 3 Appendix A). This is due because interpolation likes to interrupt its data between sites. In figure 3 there are only seven sites with adequate data to work from, which produces an interpolation that does not encompass the entire basin.

It is possible to force the interpolation (in this case spline) to match the basin size, however even this is not advisable. In figure 4 (see Appendix A) the spline interpolation was forced to use the entire basin. Readers familiar with the area should immediately recognize that although the zones near the river produce almost feasible results, a trained eye will note that the prescribed model does not match the basin geographically, which produces results that are infeasible to the actual elevations of the area.

Due to the fact that the interpolation is not completely reliable on all scenarios a new solution technique must be composed that will adequately predict spring runoff due to snowmelt with only seven sites to work with. This paper will describe one such technique, its uses, its flaws and the general rundown on how and where it can be implemented.

Solution Approach: SWE vs Elevation Relationship

The main purpose of this project is to describe a new solution technique that will adequately predict spring runoff without the use of an ArcGIS interpolation tool. The basin chosen for this project represents an ideal location where this technique could potentially be used. Similar locations can be chosen as long as they meet the following requirements: 1) have readily available SWE information, 2) have readily available streamflow data, 3) have readily available elevation data.

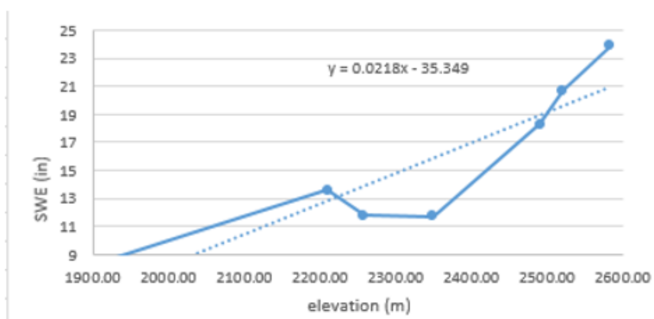
The specific location for this procedure description will be the Logan River Basin (see figure 1 Appendix A). This site was chosen for: 1) it's simplicity as it was used consecutively throughout the class as an example, 2) it is a prime example of a site that only contains limited SWE data. A total of seven sites were found that have readily available SWE data. These sites are 1) Tony Grove RS, 2) Klondike Narrows, 3) Temple Fork, 4) Garden City Summit, 5) Franklin Basin, 6) Usu Doc Daniel, 7) Tony Grove Lake.

SWE data from these sites was acquired through NOAA, the National Centers for Environmental Information (NOAA 2015), and through the department of the Natural Resources Conservation Services (NRCS). SWE data was gathered starting from 2015 and going back to 2010. Streamflow data was acquired through the United States Geological Survey (USGS) services for the Logan River above State Dam, site ID 10109000 (USGS 2015). Streamflow data was gathered from 2015 and going back to 2010 to match the gathered SWE data. For presentation purposes and the explanation of the technique SWE data will be from April 1st 2010. The April 1st day was chosen because it occurs during the time period that is typical of spring runoff. This technique can be used for any date providing there is available SWE and streamflow data available. Later in this paper further research will be presented that used SWE seasonal peak values.

Table 1 (below and Appendix B) shows the gathered SWE data for the Logan River Basin April 1, 2010 for the seven sites. Within the acquired data there can be found: 1) the location of the site, 2) the elevation of the site measured in both ft and meters, 3) and the SWE measured in inches. An x-y plot was generated using the SWE and the elevation data. Using this plot a simple linear relation of the form y = mx + b was generated. This equation is plotted out as the dashed line along the plot.

Table 1: SWE data for Logan River Basin April 1, 2010

SNOTEL Station	Lat	Long	elevation (ft)	elevation (m)	Date	SWE (in)
Tony Grove RS	41.89	-111.57	6332	1929.99	4/1/2010	8.8
Klondike Narrows	41.97	-111.6	7250	2209.80	4/1/2010	13.6
Temple Fork	41.79	-111.55	7406	2257.35	4/1/2010	11.8
Garden City Summit	41.92	-111.47	7705	2348.48	4/1/2010	11.7
Franklin Basin	42.05	-111.6	8170	2490.22	4/1/2010	18.3
Usu Doc Daniel	41.86	-111.51	8270	2520.70	4/1/2010	20.7
Tony Grove Lake	41.9	-111.63	8474	2582.88	4/1/2010	23.9



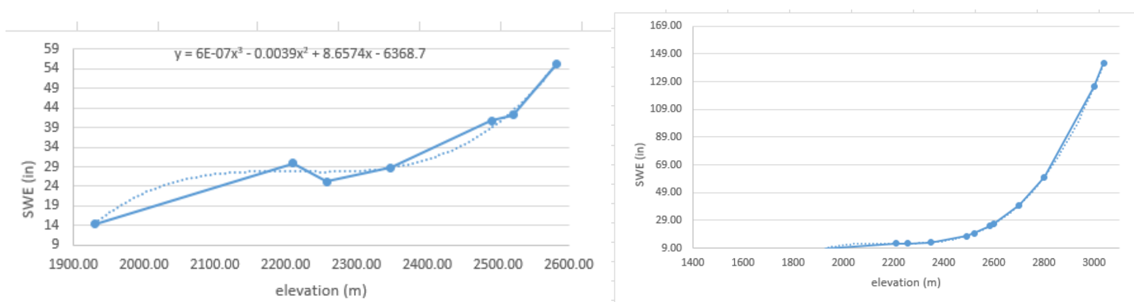
The dashed line represents the linear relationship between the x axis (elevation) and the y axis (SWE). Although the line is not perfect, it is a close enough fit to the plotted data. This linear relationship will be used as the basis to generate the new runoff prediction technique. The foundation of this relationship is as elevation rises so does the SWE value. Higher elevations will have more SWE while lower elevations will have less SWE. This relationship can be noted in the table and the produced plot (see figure 7 Appendix A).

This linear relationship is a simple yet effective form of regression analysis. Regression analysis is a statistical process for estimating the relationships among variables. It includes many techniques for modeling and analyzing several variables when the focus is on the relationship between a dependent variable and one or more independent variables (Regression Analysis 2015).

Additional Analysis: Polynomial

It should be noted that other forms of regression analysis were performed to test their compatibility with the proposed technique of comparing elevation to SWE. For example, figure 5 and 6 (see Appendix A) show the resulting relationship built between elevation and SWE with a third degree polynomial regression analysis. At first glance this type of fit seems to work better than the linear relationship as the tread line more closely matches the plotted results. However under closer inspection one can see that the polynomial fit only works on values within the visible range. Any further and a third degree polynomial begins to rise or dip exponentially. This can be especially seen in figure 4, where any predicated value of SWE within the range of the posted NOAA data seems legitimate, yet at higher and lower elevations the value of SWE beings to rise or fall dramatically and become impractical. Due to the simplistic nature of the linear relationship method found earlier it will be used to determine the volume of SWE and the resulting spring runoff.

Figure 6: Third degree polynomial fit.



Once the linear relationship has been denoted it is possible to begin to build the map of the SWE vs elevation relationship. This was accomplished using the Spatial Analysis > Map Algebra > Raster Calculation tool in ArcGIS. Set the x value as elevation (use the dem, digital elevation model) which will spit out a y value of SWE. However, this technique will produce results that are negative. This is a result of the linear equation. This can be solved using the Raster Calculation tool again by setting the values greater than zero and multiplying by itself. This produces models that do not report any negative values. SWE vs elevation relations results can be seen in figures 7 through 12 (See Appendix A). Models of years 2011 to 2015 were created in a similar fashion using the ArcGIS model builder (see figure 13).

Spring Runoff: SWE Comparison to Streamflow

To test the SWE vs elevation model produced using the above method, the calculated volume results were compared to peak stream flow values to see if it is possible to predict spring runoff using this model. Two models were created. One model using the SWE data from April 1st, and a second model created using yearly SWE peak values. The logic beyond selecting two SWE models is that SWE is a storage value. Snow does not gather than just melt all at once, it has periods of melt mixed in with accumulation, especially at low elevation. Comparing the streamflow with two different values of SWE will help provide better insight into how this snow relates to spring runoff.

The SWE peak value models was created using the proscribed procedure. The difference this time being that instead of selecting SWE values at a specific date, the resulting model was created using peak SWE values recorded during the specified winter period. Models were built from 2010 to 2015.

Both models (April 1st and Peak SWE) were compared to the peak stream flow values using a similar a regression analysis of building a linear relationship of the form y = mx+b. These results can be seen in table 13 and 14 (see below and Appendix B). From the results it was found that the SWE peak values predicted the peak spring streamflow values better by nearly 4% vs using April 1st data. These results suggest the following: 1) it is possible to predict spring river flow using the SWE vs elevation relationship with some margin of error, 2) better to compare peak-to-peak values rather than a specific date, 2) the difference between peak SWE and April 1st values could be marginal as peak SWE values typically might occur around that date.

Table 14: April 1st SWE Values Compared to Peak Stream Flow

Test: April 1st SWE to Peak Flow

Year	SWEVol (ft^3)	PredictFlow (cfs)	RecoredFlow (cfs)	% Difference: (cfs)
2010	7.4E+09	614.01	852	27.93
2011	1.6E+10	1475.01	1630	9.51
2012	7.1E+09	582.81	429	35.85
2013	6.5E+09	522.41	480	8.83
2014	1.2E+10	1123.11	773	45.29
2015	6.4E+09	510.39	545	6.35
			AVG	22.30

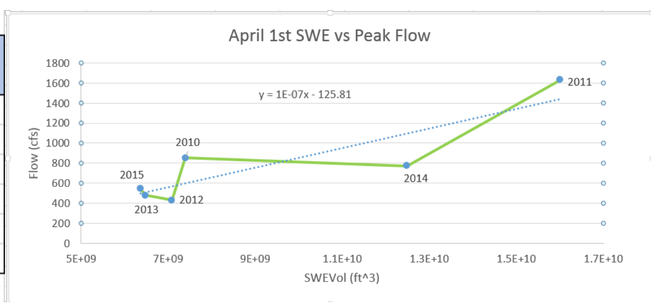
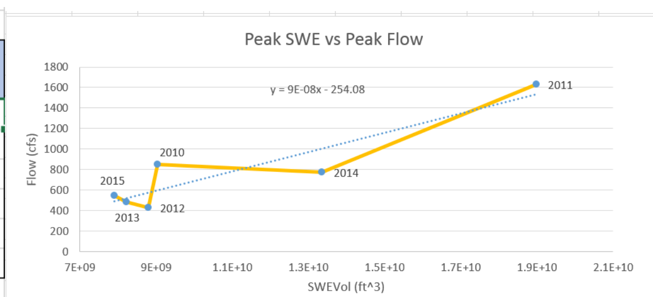


Table 15: Peak SWE Values Compared to Peak Stream Flow

Test: Peak SWE to Peak Flow

Year	SWEVol (ft^3)	PredictFlow (cfs)	RecoredFlow (cfs)	% Difference: (cfs)
2010	9E+09	559.15	852	34.37
2011	1.9E+10	1454.30	1630	10.78
2012	8.8E+09	537.92	429	25.39
2013	8.2E+09	485.57	480	1.16
2014	1.3E+10	948.20	773	22.66
2015	7.9E+09	457.07	545	16.13
			AVG	18.42



Discussion: Model Limitations and Improvements

The proscribed method of comparing SWE to elevation provides better accuracy to results within a confined area vs typical data interpolation techniques. Data for this project was provided by the NRCS from the seven available SNOTEL sites located in the Logan River Basin. Locations that have access to less SNOTEL sites and data may not be able to adequately use the proscribed procedure to its full extent.

This visualizations and calculations for this project all utilized data begging in the year 2010. As data accumulation goes this is a very small timeframe to conduct a proper analysis. With a larger range of data to work with it might be possible to build a linear relationship with an even higher accuracy. This could lead to better predictions of SWE volume and spring runoff. The same procedure described can still be used with ease on a larger time frame.

The final results support that seasonal SWE peak values work best to predict the seasonal peak streamflow values for the Logan River Basin. Some locations may benefit more from using SWE data from specified date ranges (like April 1st) rather than using peak SWE values as modeling elements such as temperature, elevation, and seasonal length can all affect the quality and quantity of SWE. It is suggested a thorough study of a basin be conducted before the selection of SWE values be considered.

This study was conducted under the assumption that spring runoff would occur at some date later than when the peak SWE values were recorded. The model does not possess the capacity to predict when (the time and date) the peak streamflow will occur. The model only suggests that it is feasible to predict the quantity of the streamflow based on volumes of SWE recorded for that season.

Conclusion:

Interpolation of data works best on a large scale where data is abundant. However, on a finer scale interpolation (such as spline) does not possess the abilities to adequately display results with a high enough resolution. This can be due to the lack of available sites from which to build said interpolation on.

This project's goal was to highlight one solution approach that addresses this problem. The proscribed technique of the linear relationship between SWE to elevation offers a higher resolution of data. From this relationship it is possible to predict volumes of SWE within a confined area with more accuracy than interpolation. Comparing SWE volume to spring runoff offers insight into how snow can affect the streamflow of a specific river. From the model it was found that a SWE volume model composed of seasonal SWE peak values can predict spring runoff at a higher accuracy rather than using a specified date of data accumulation.

Appendix A: Figures

Figure 1: Logan River Basin and Digital Elevation (dem)

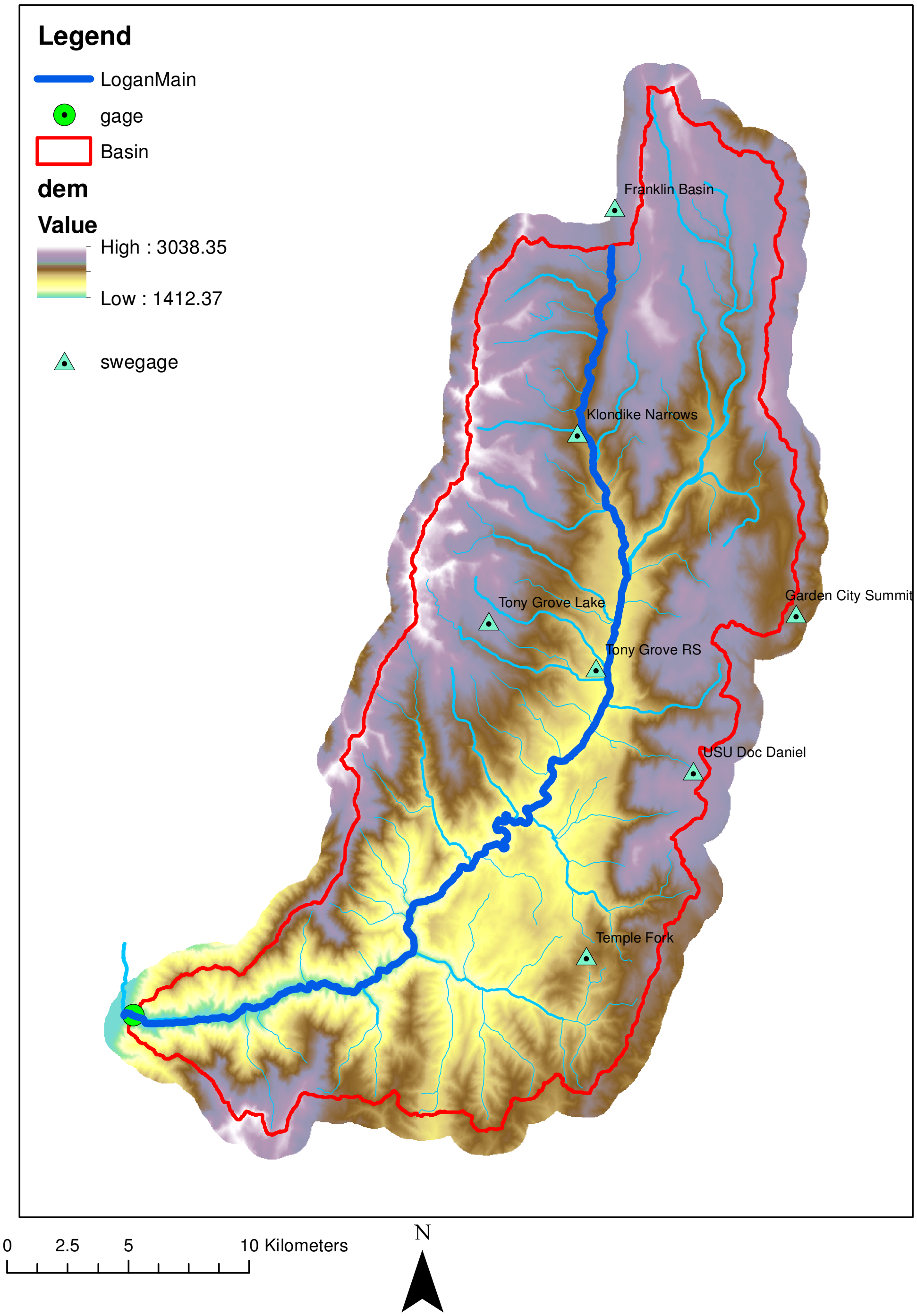


Figure 2: Class technique of Example of Spline Interpolation for Runoff

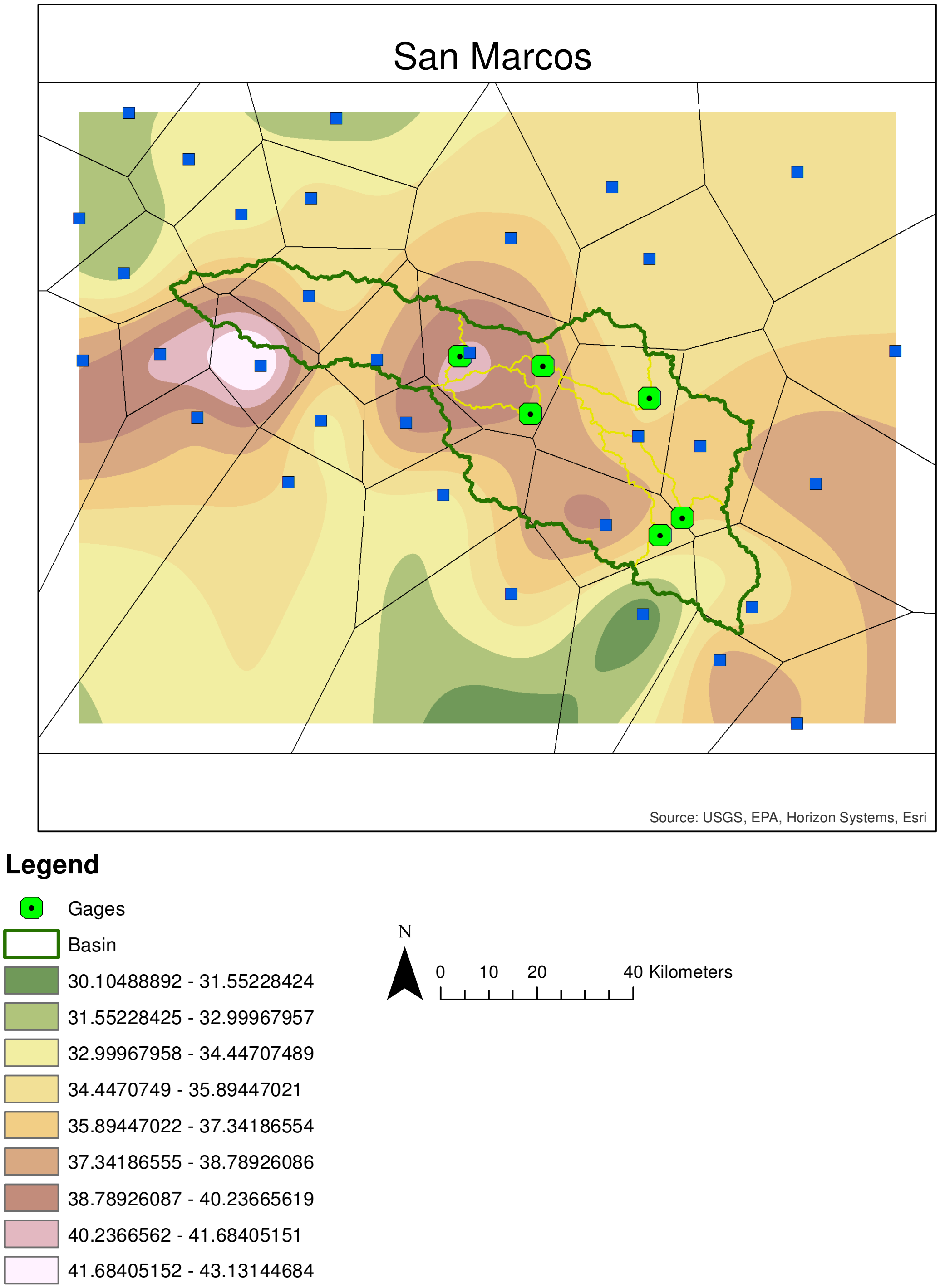


Figure 3: Spline Interpolation Fail. Lack of Sites

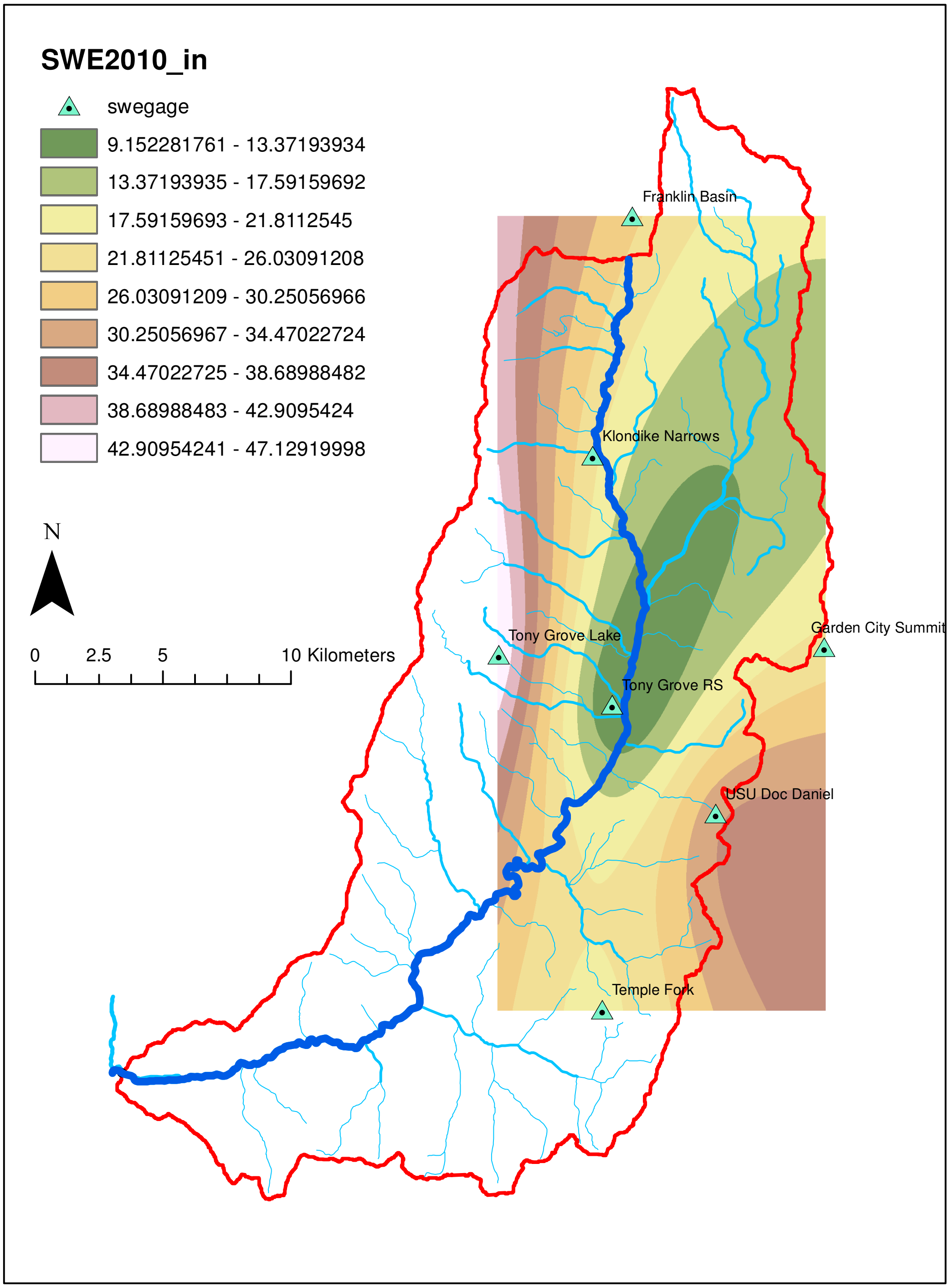


Figure 4: Spline Interpolation Fail. Inaccurate Values of Basin

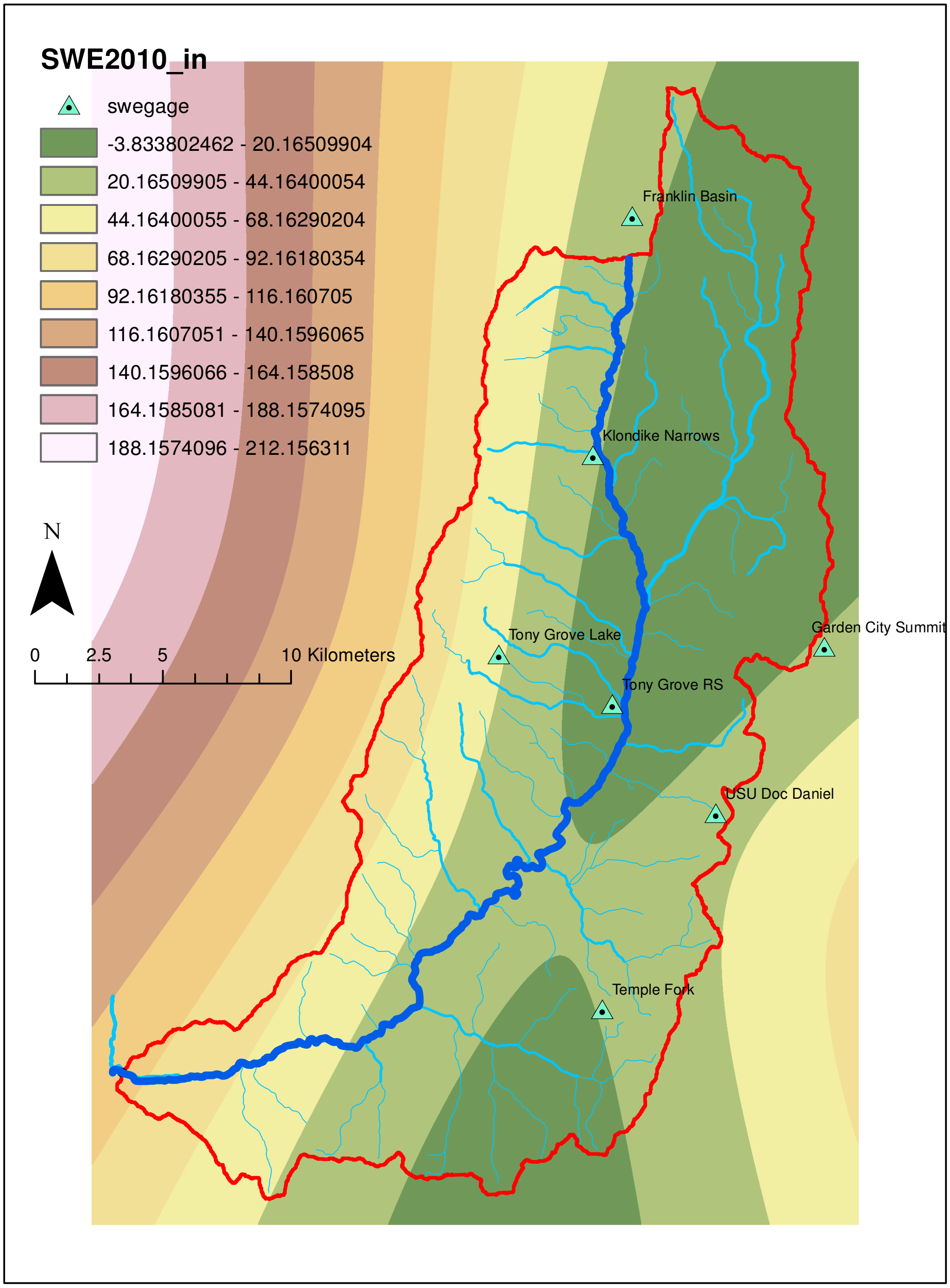


Figure 5: Third Degree Polynomial Line Fit

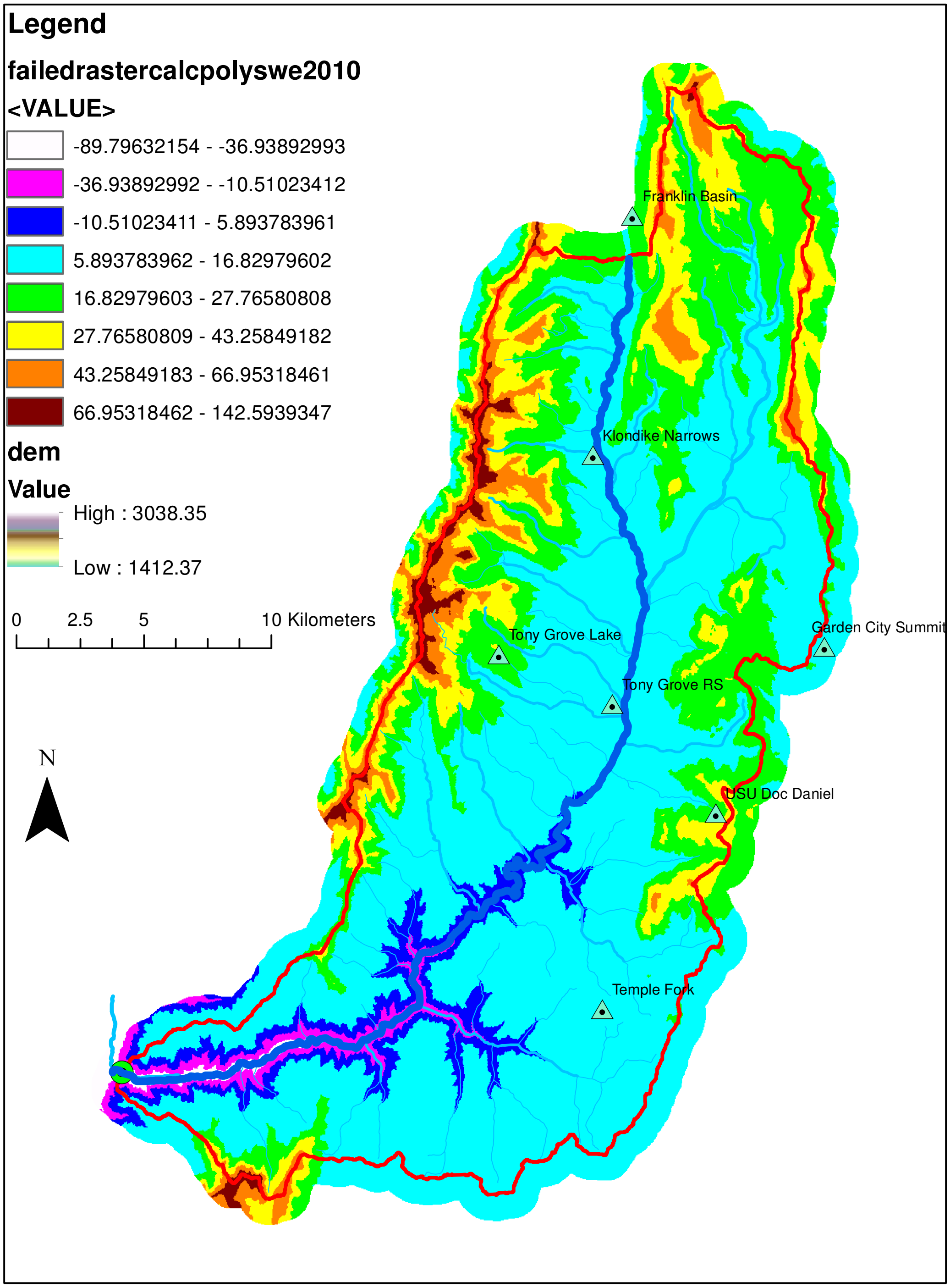
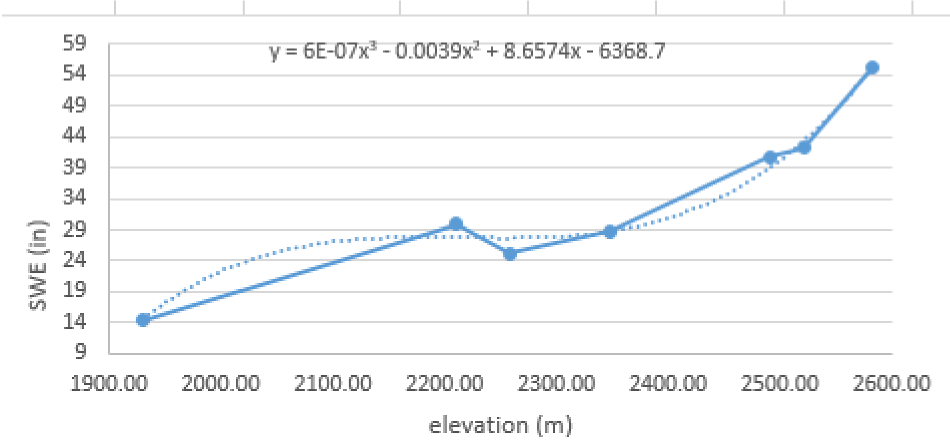


Figure 6: Third Degree Polynomial Fit



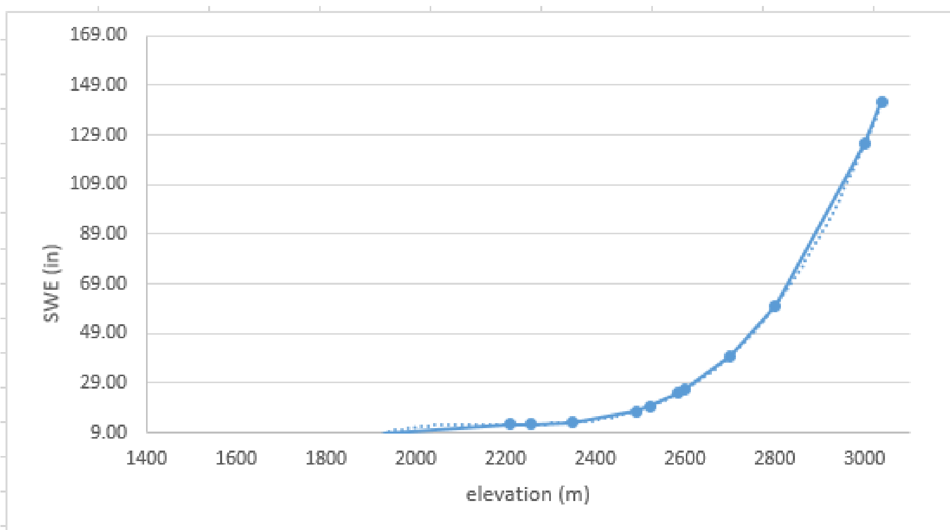


Figure 7: April 1st SWE Accumulation 2010

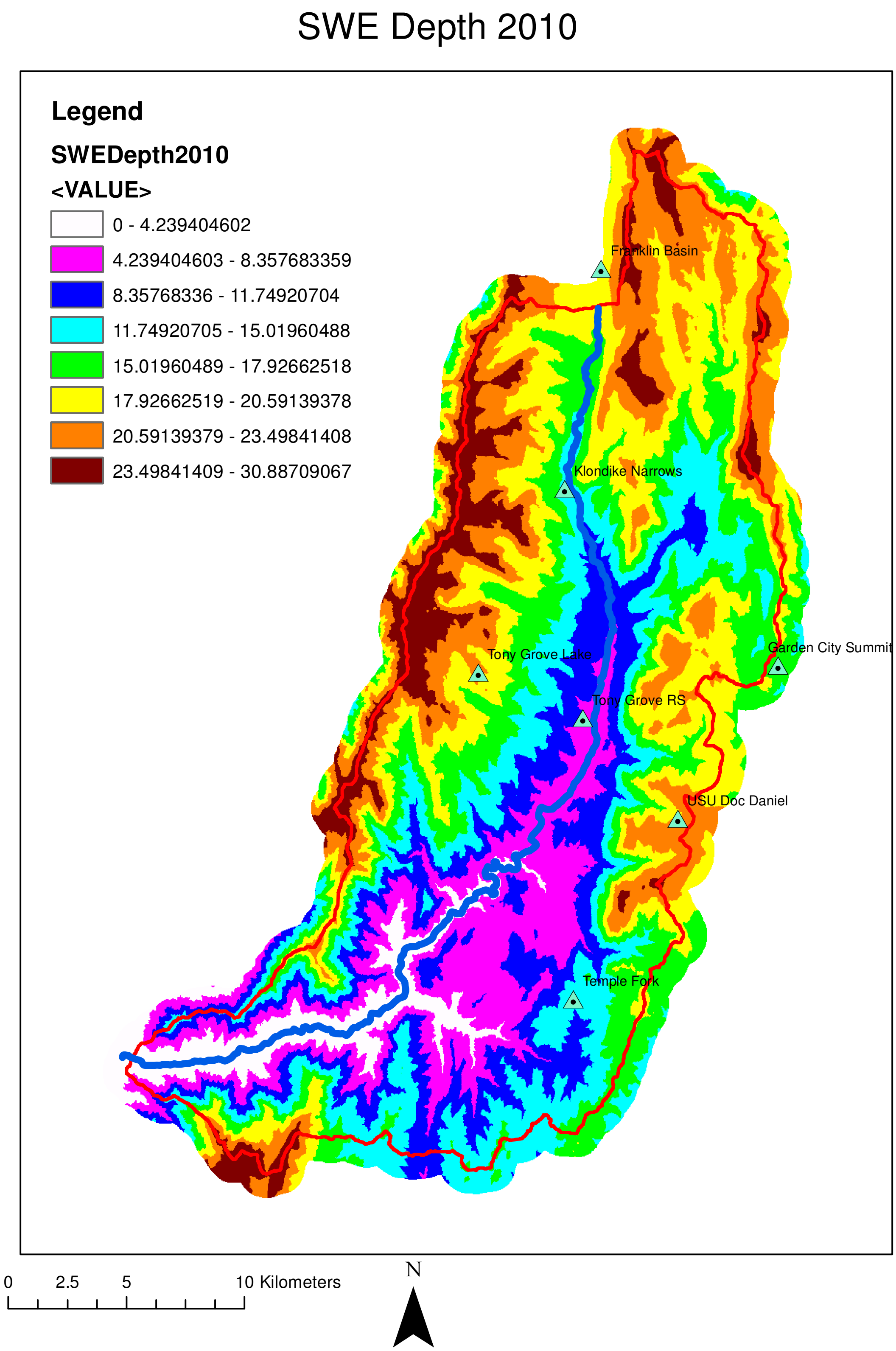


Figure 8: April 1st SWE Accumulation 2011

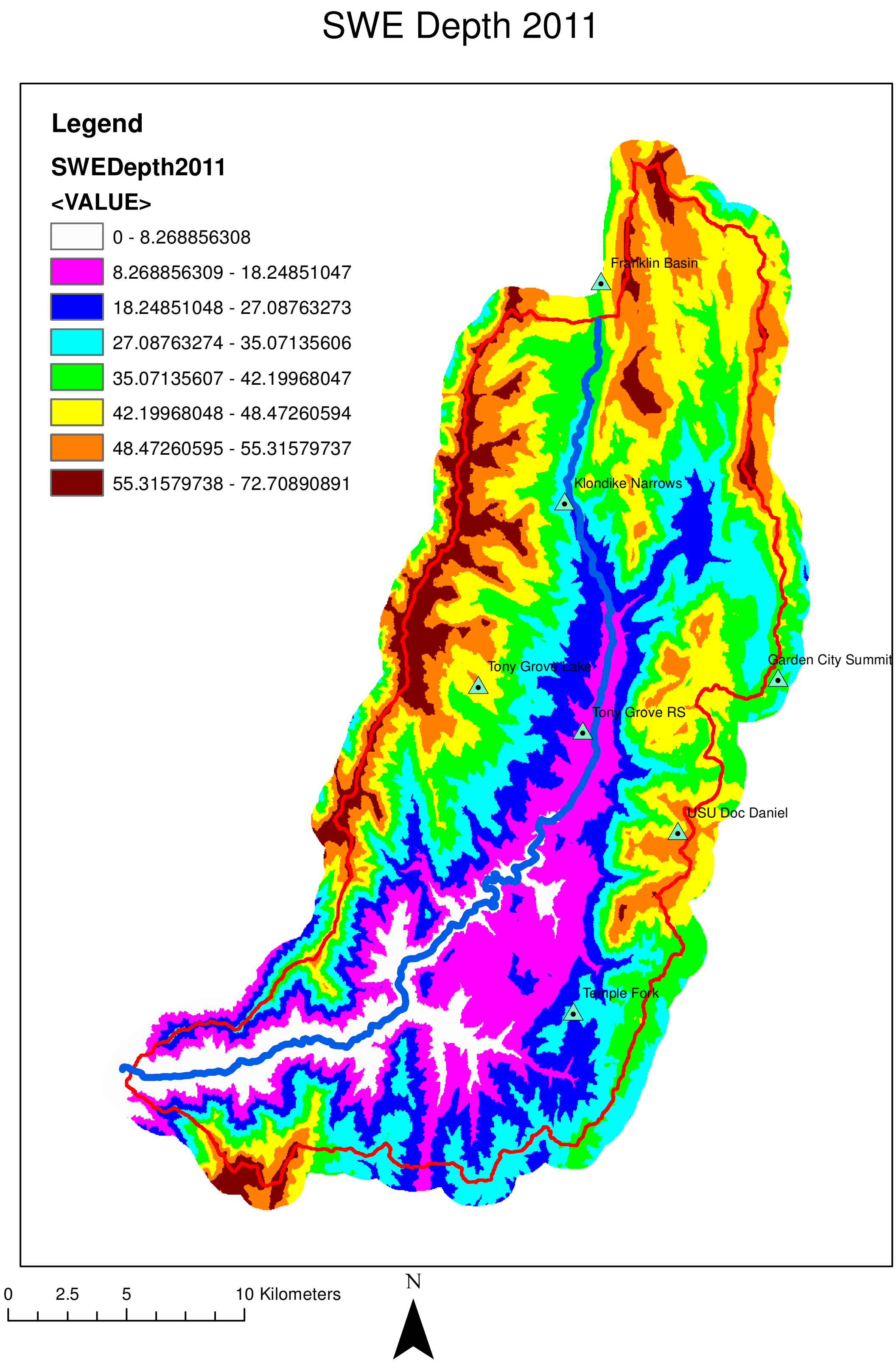


Figure 9: April 1st SWE Accumulation 2012

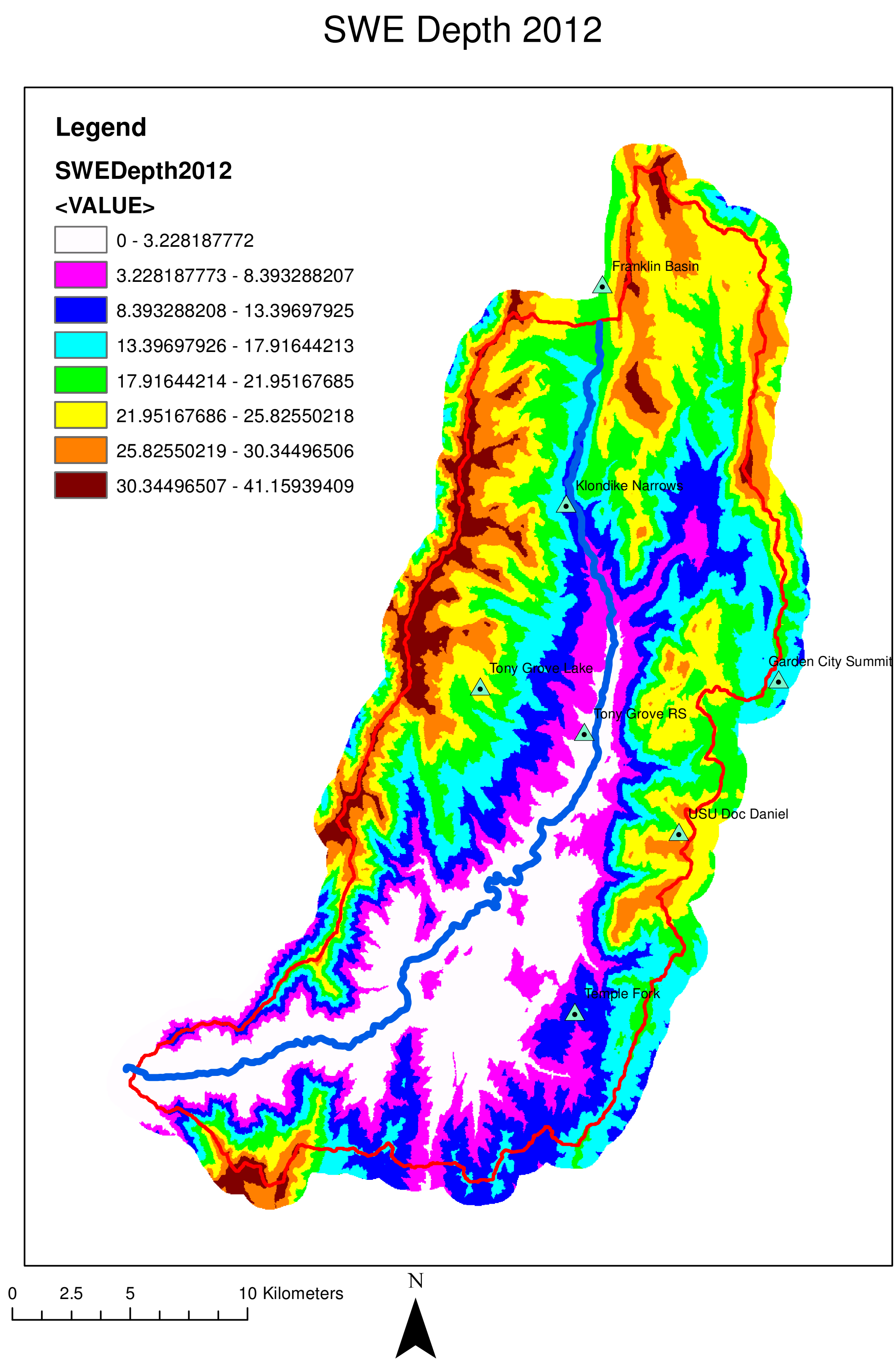


Figure 10: April 1st SWE Accumulation 2013

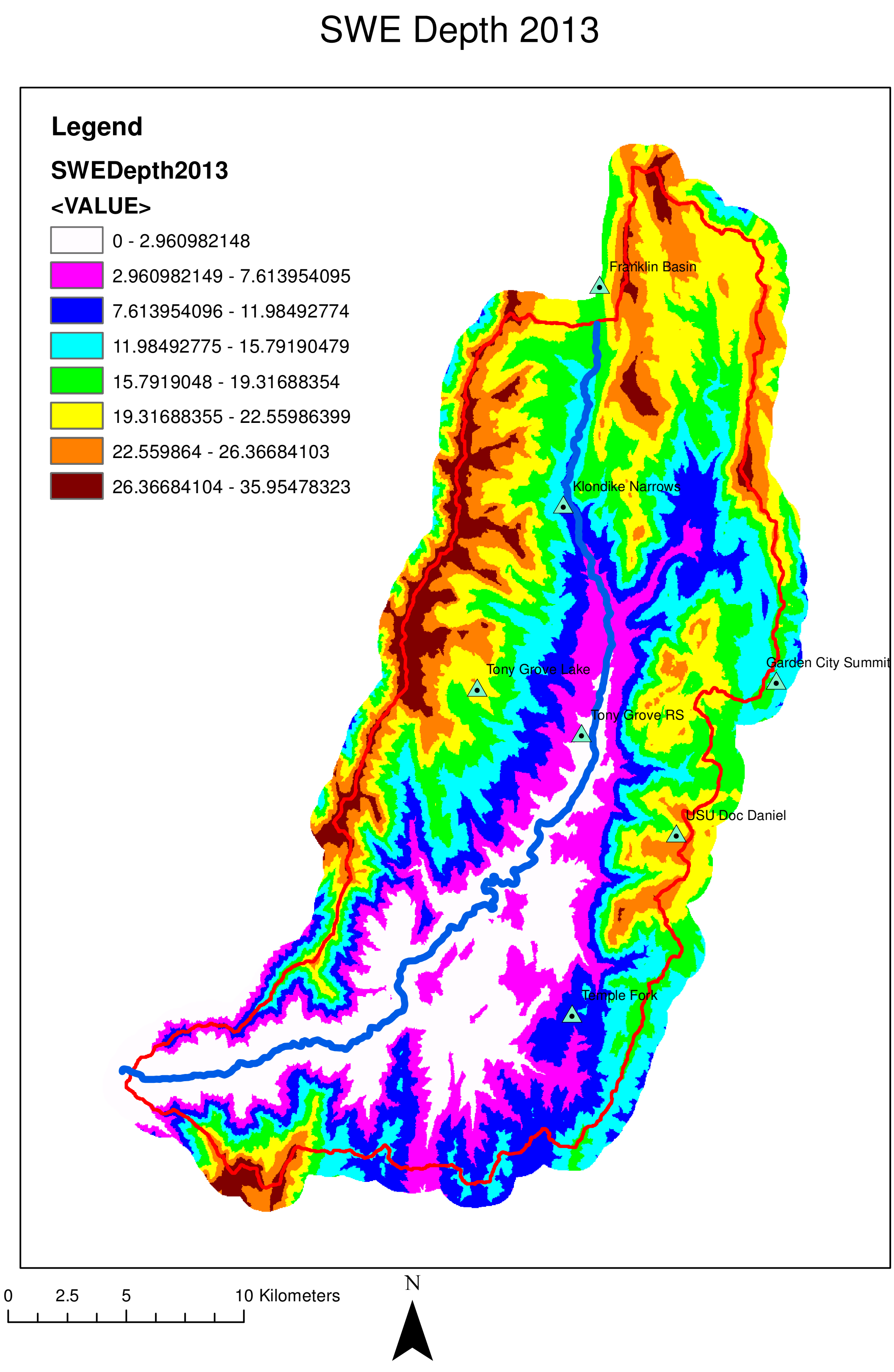


Figure 11: April 1st SWE Accumulation 2014

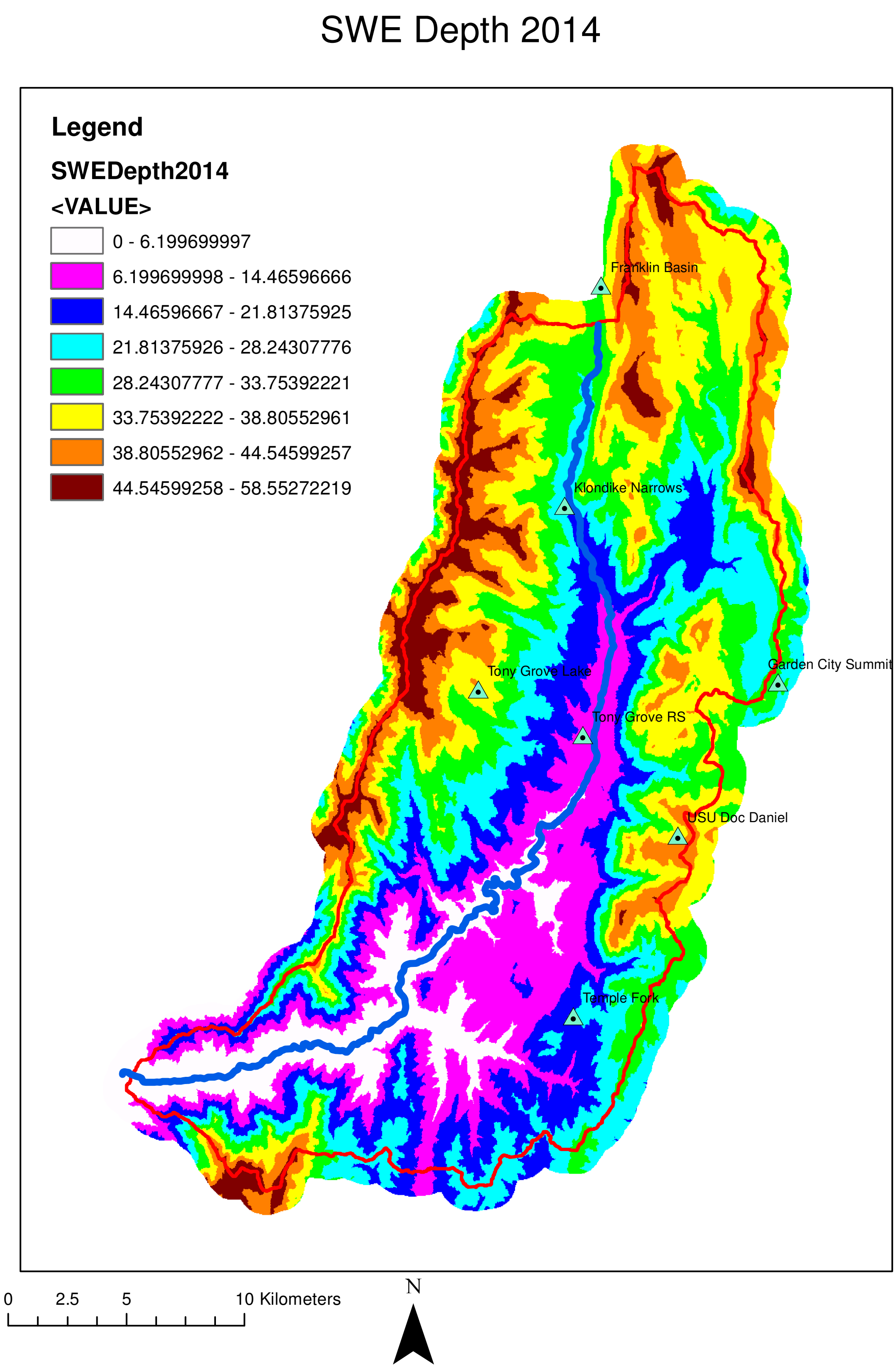


Figure 12: April 1st SWE Accumulation 2015

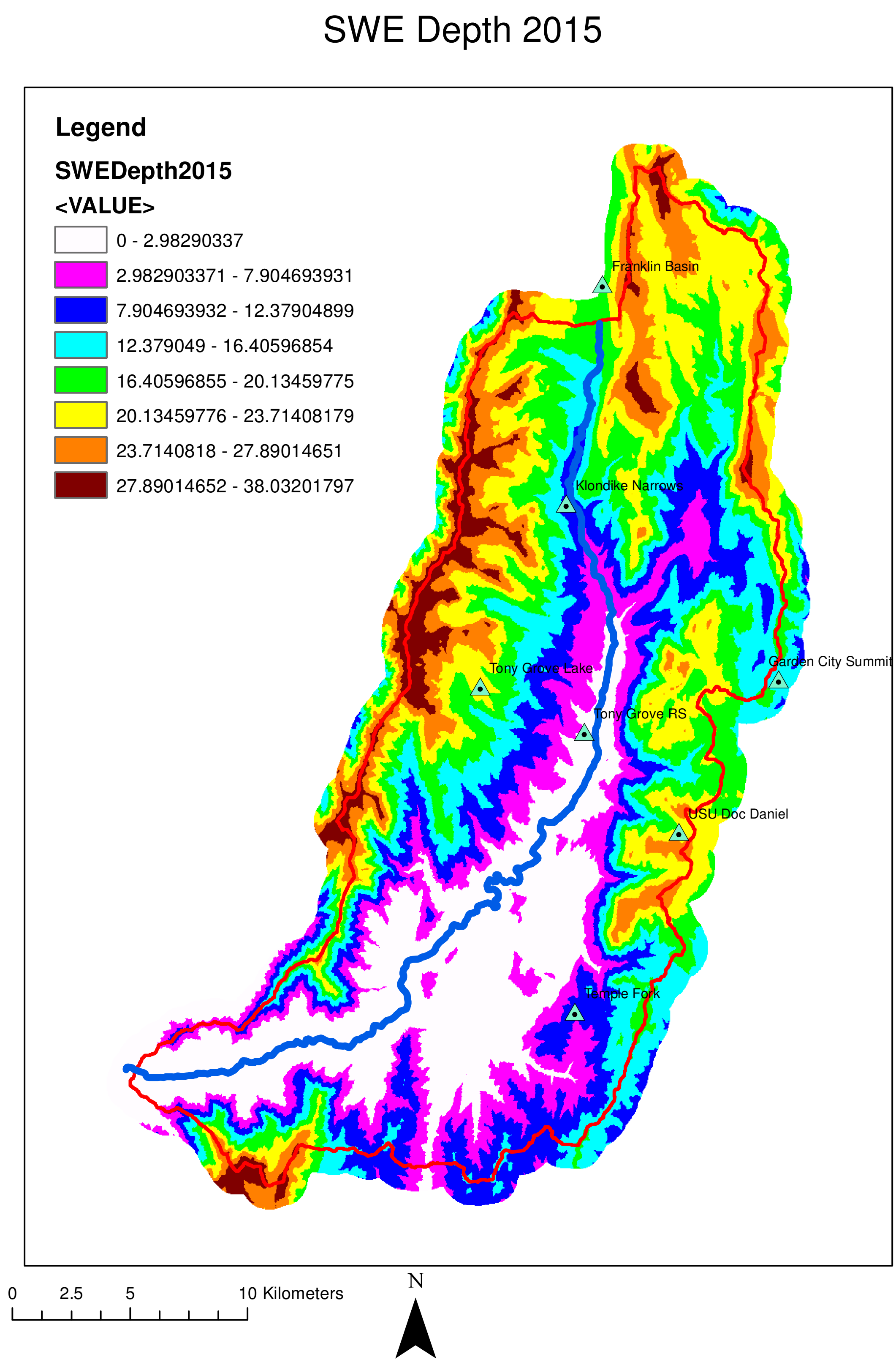


Figure 13: Model Builder

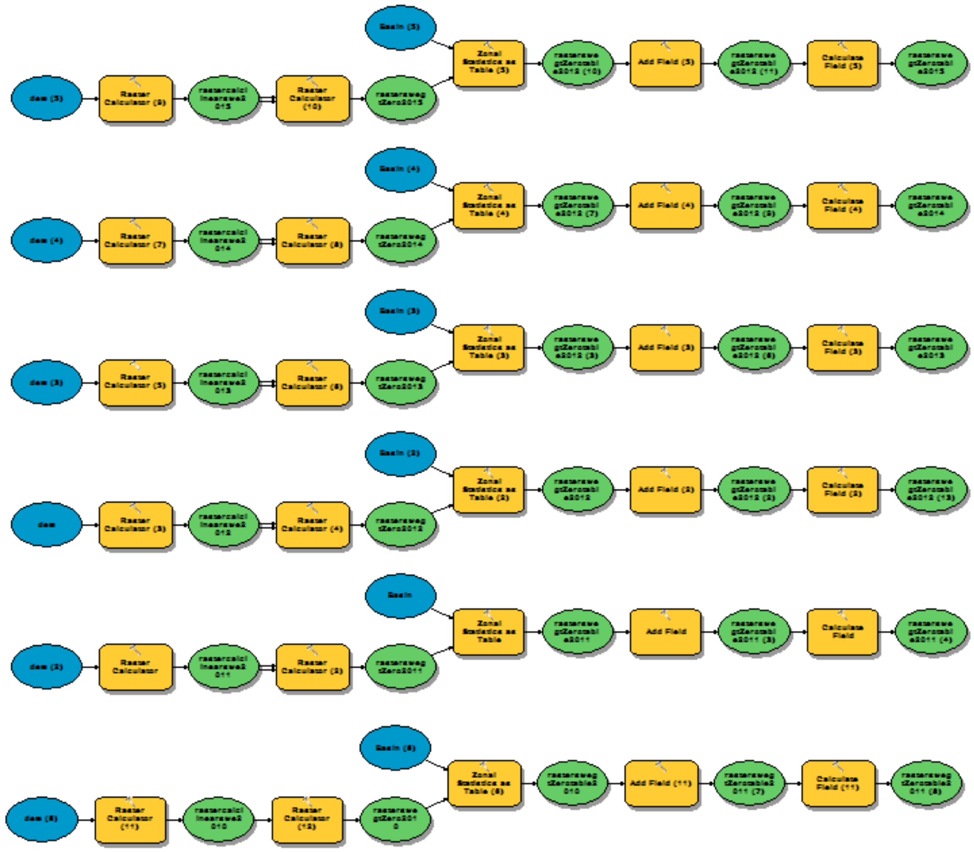


Figure 14: SWE Peak Accumulation 2010

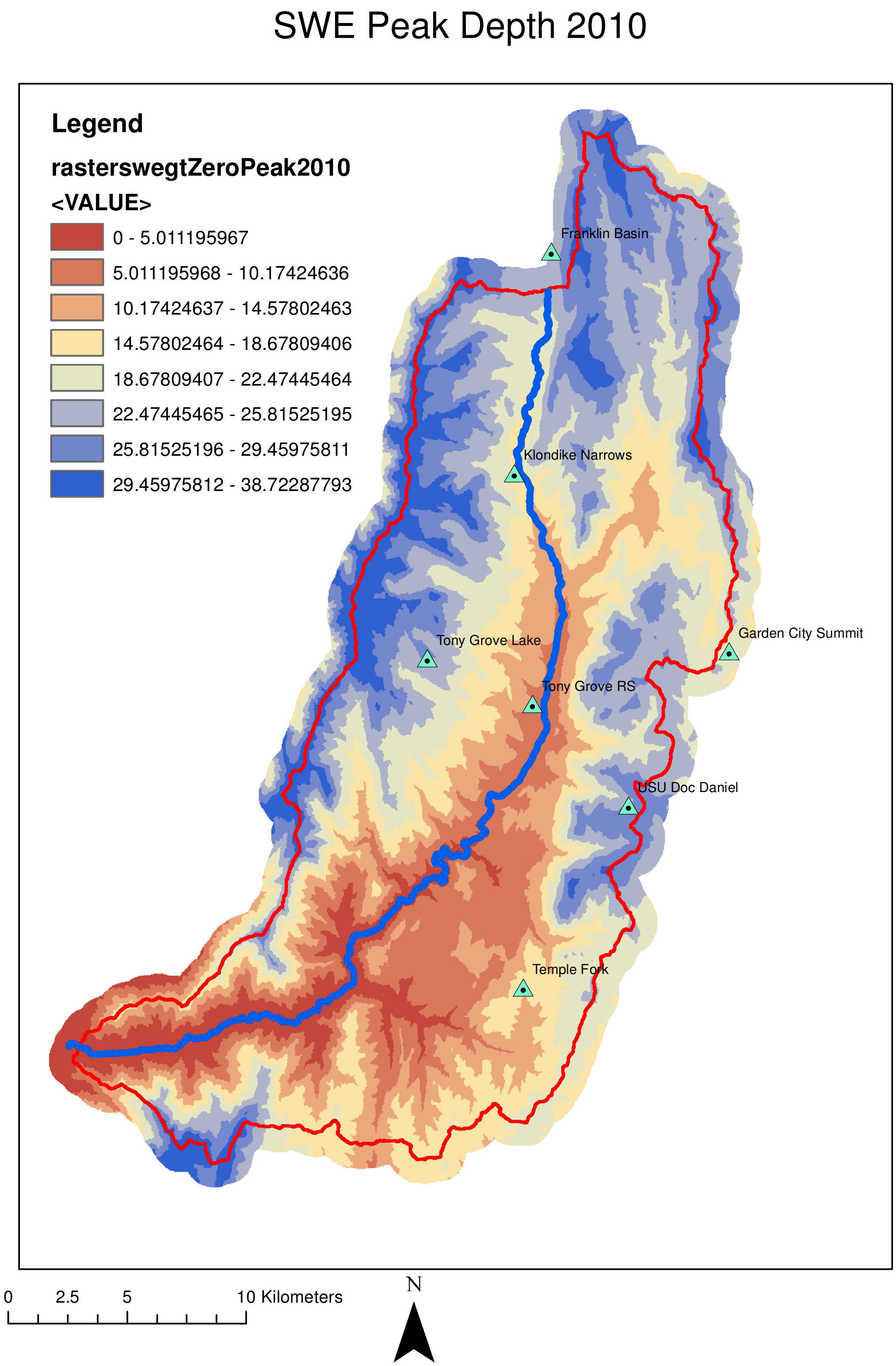


Figure 15: SWE Peak Accumulation 2011

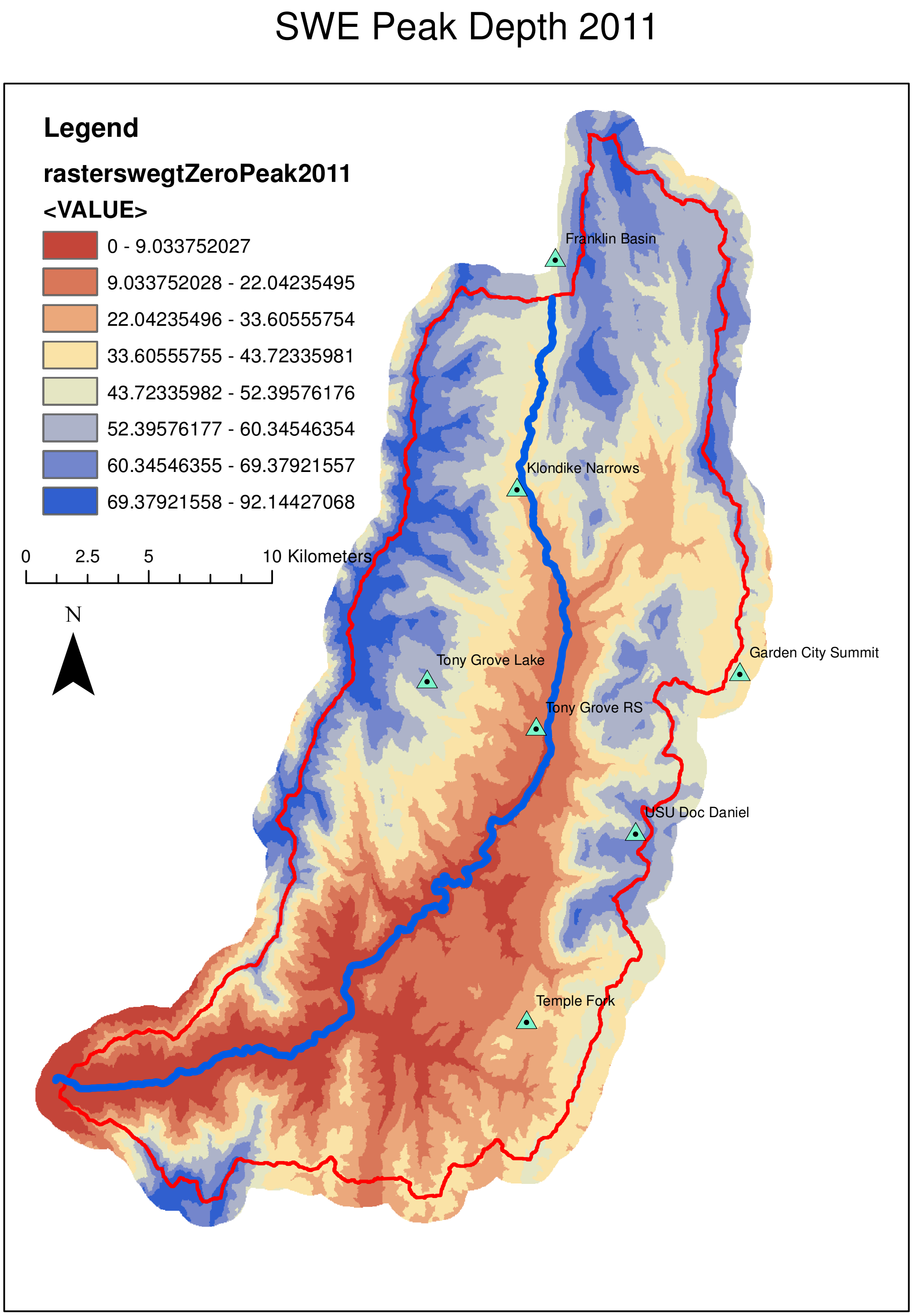


Figure 16: SWE Peak Accumulation 2012

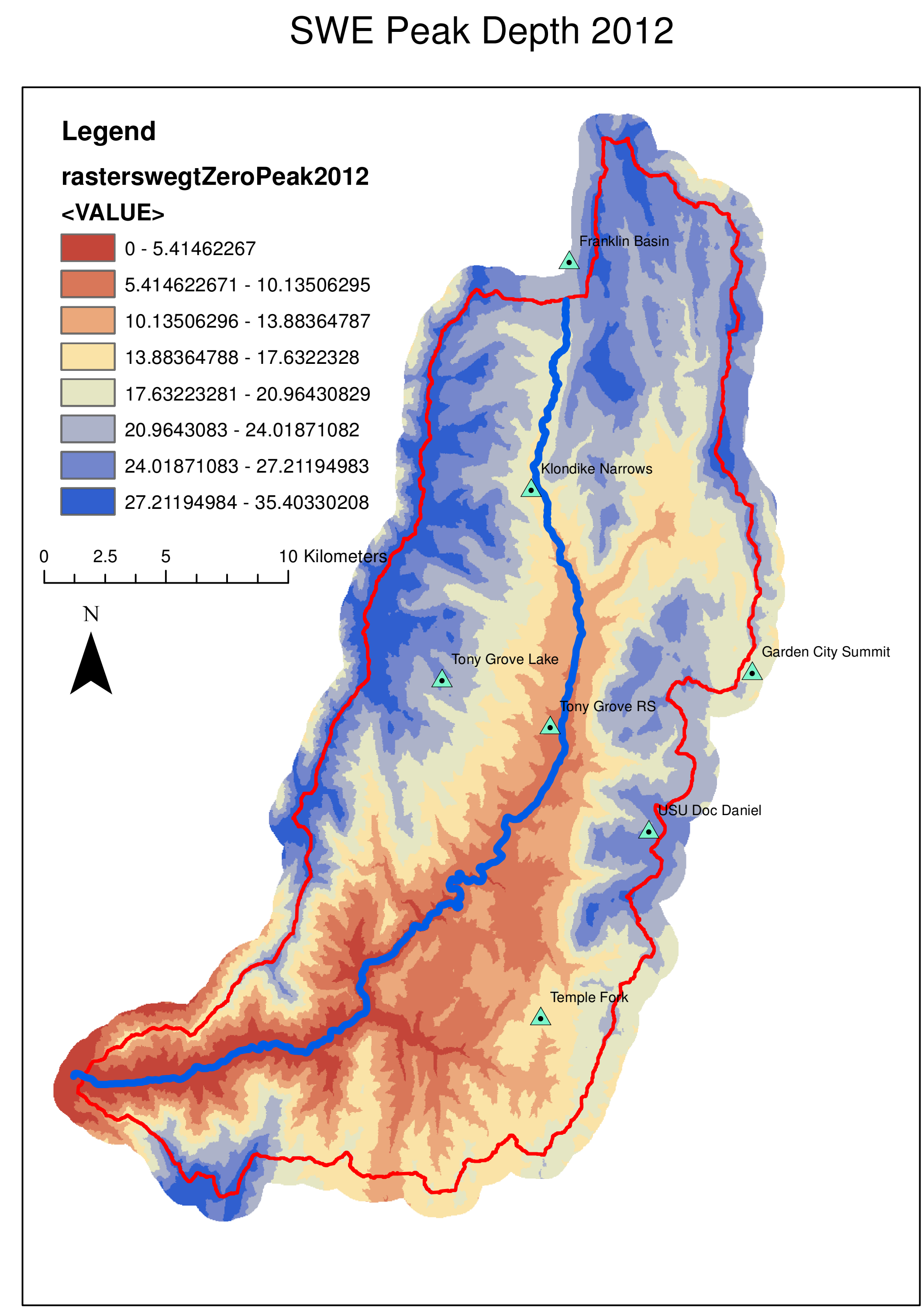


Figure 15: SWE Peak Accumulation 2013

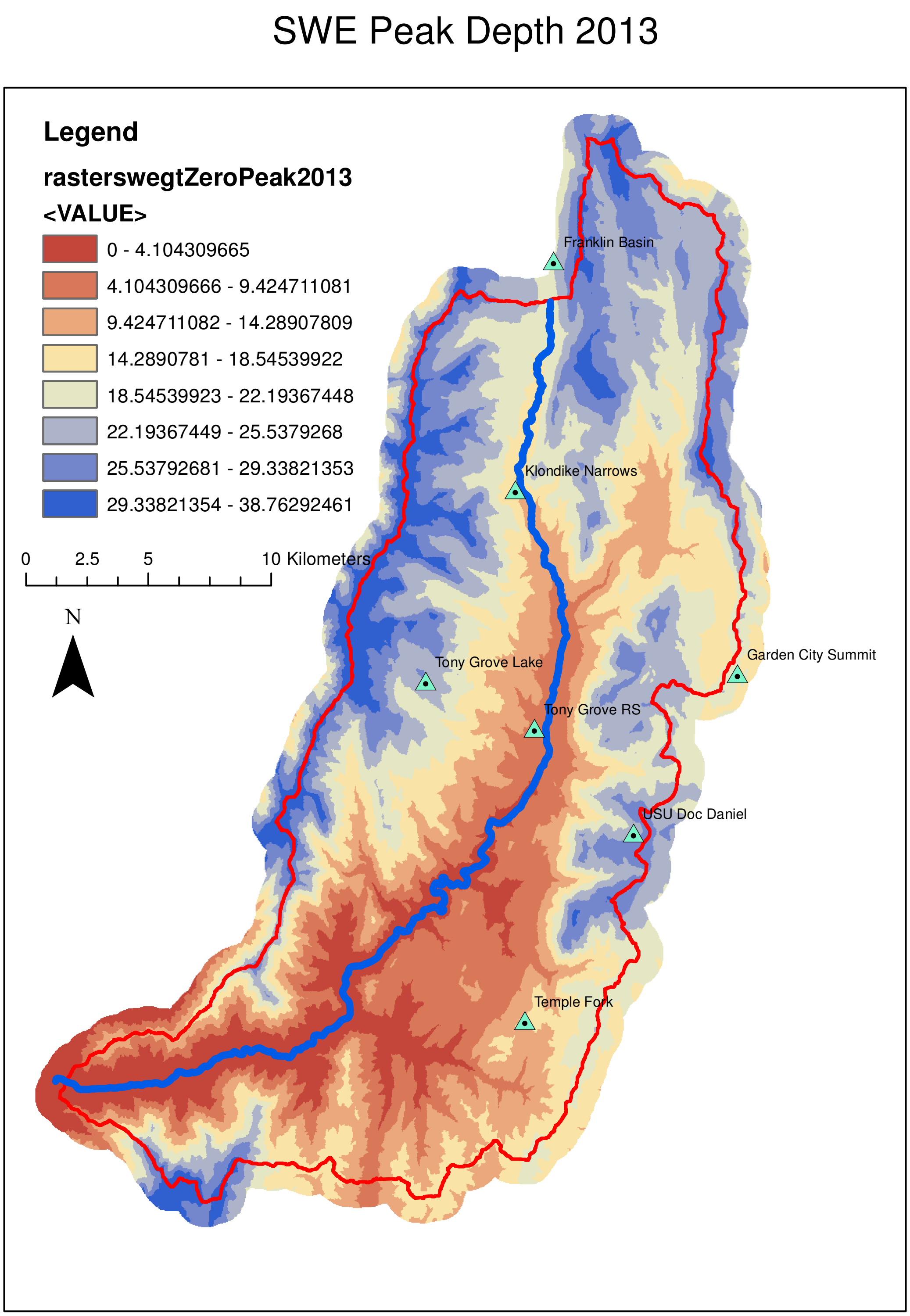


Figure 18: SWE Peak Accumulation 2014

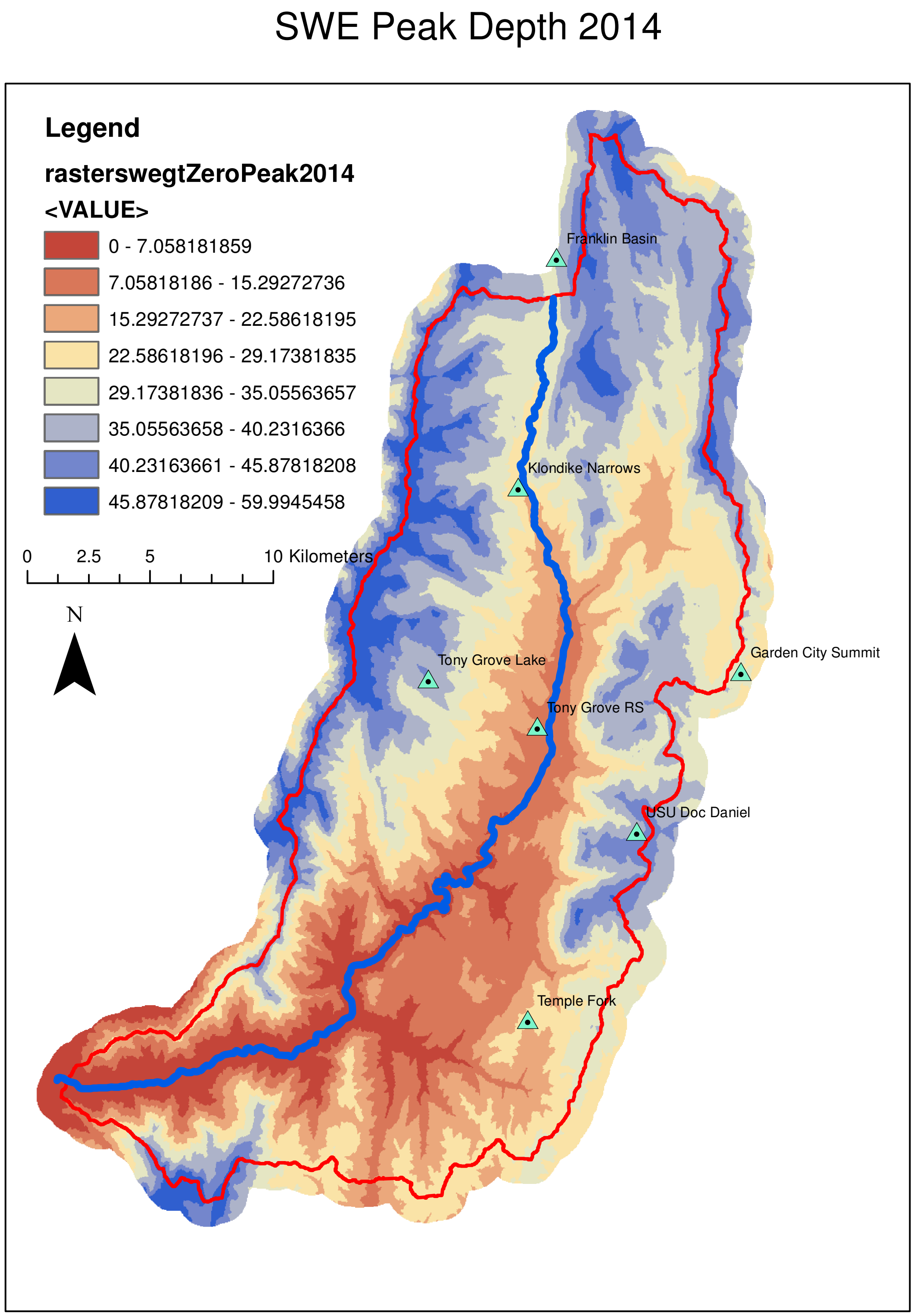
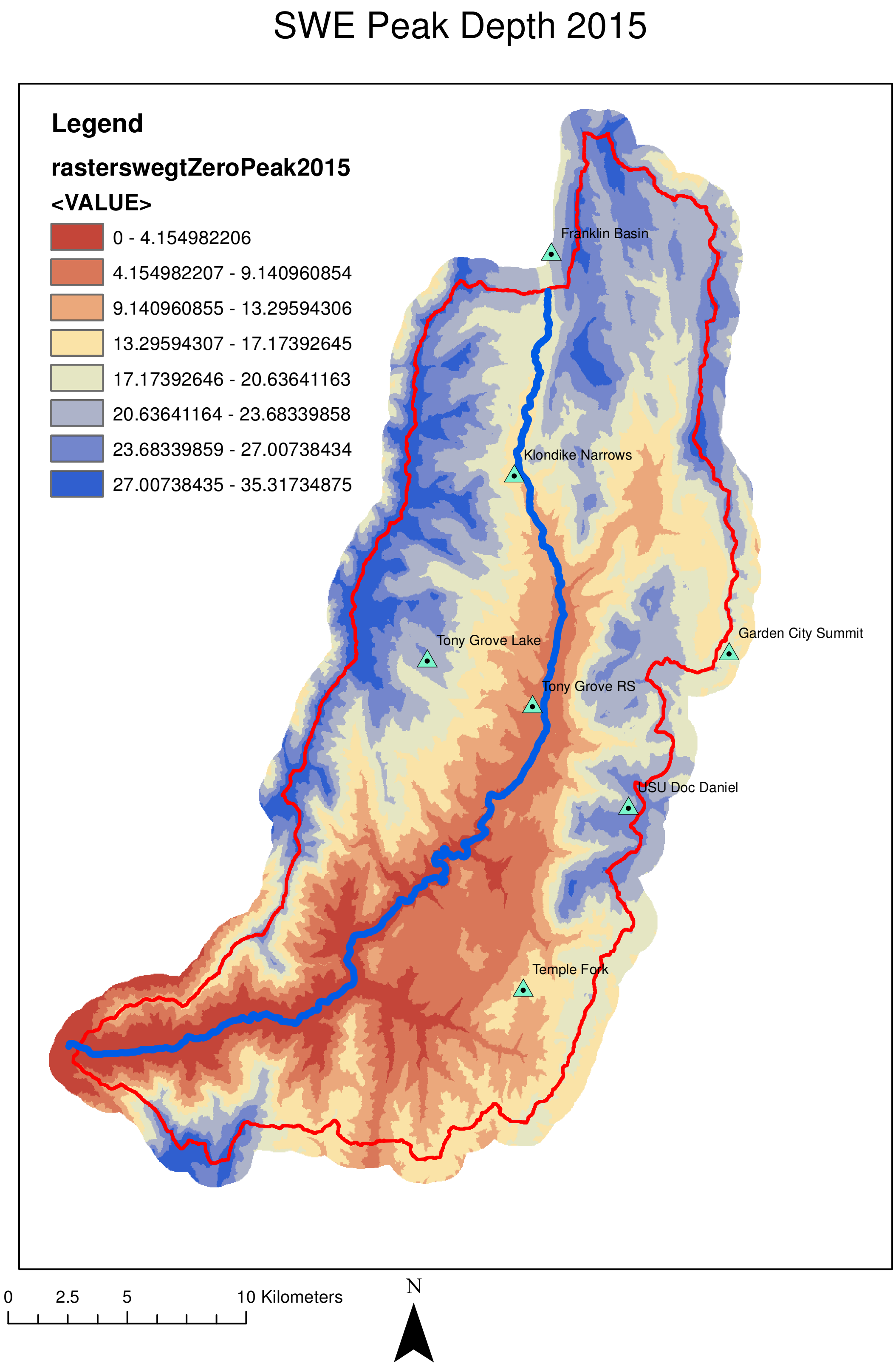


Figure 19: SWE Peak Accumulation 2015



Appendix B: Tables and Plots

Table 1: April 1st SWE data for Logan River Basin April 1, 2010

SNOTEL Station	Lat	Long	elevation (ft)	elevation (m)	Date	SWE (in)
Tony Grove RS	41.89	-111.57	6332	1929.99	4/1/2010	8.8
Klondike Narrows	41.97	-111.6	7250	2209.80	4/1/2010	13.6
Temple Fork	41.79	-111.55	7406	2257.35	4/1/2010	11.8
Garden City Summit	41.92	-111.47	7705	2348.48	4/1/2010	11.7
Franklin Basin	42.05	-111.6	8170	2490.22	4/1/2010	18.3
Usu Doc Daniel	41.86	-111.51	8270	2520.70	4/1/2010	20.7
Tony Grove Lake	41.9	-111.63	8474	2582.88	4/1/2010	23.9

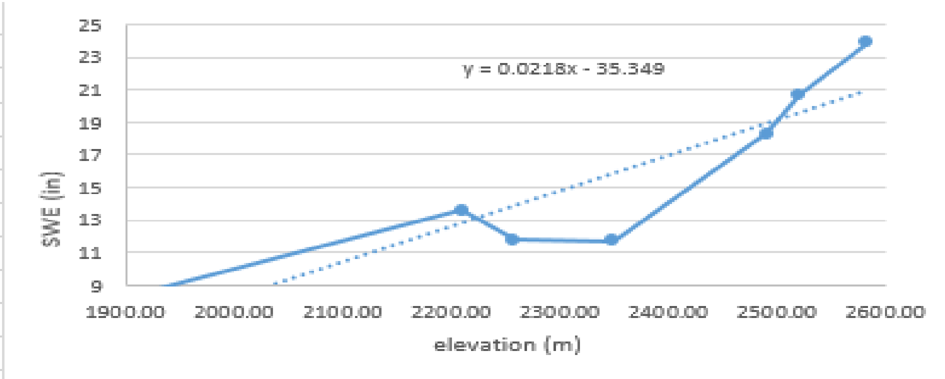


Table 2: April 1st SWE data for Logan River Basin April 1, 2011

SNOTEL Station	Lat	Long	elevation (ft)	elevation (m)	Date	SWE (in)
Tony Grove RS	41.89	-111.57	6332	1929.99	4/1/2011	14.4
Klondike Narrows	41.97	-111.6	7250	2209.80	4/1/2011	29.9
Temple Fork	41.79	-111.55	7406	2257.35	4/1/2011	25.2
Garden City Summit	41.92	-111.47	7705	2348.48	4/1/2011	28.7
Franklin Basin	42.05	-111.6	8170	2490.22	4/1/2011	40.8
USU Doc Daniel	41.86	-111.51	8270	2520.70	4/1/2011	42.2
Tony Grove Lake	41.9	-111.63	8474	2582.88	4/1/2011	55.3

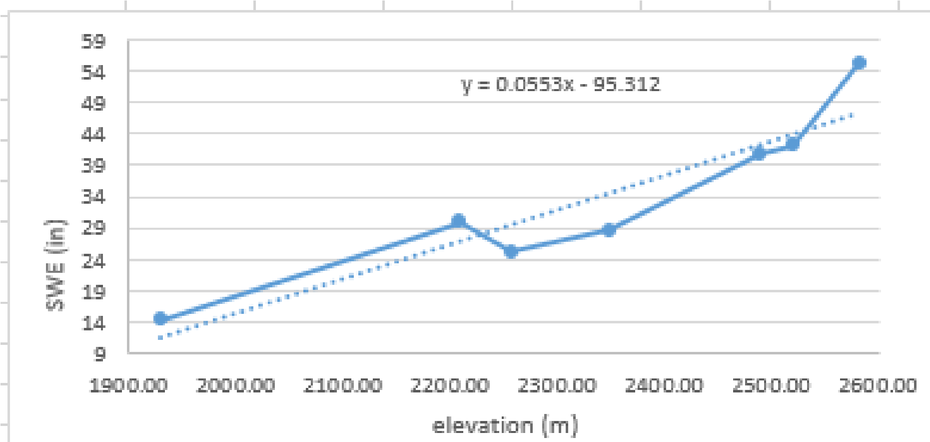


Table 3: April 1st SWE data for Logan River Basin April 1, 2012

SNOTEL Station	Lat	Long	elevation (ft)	elevation (m)	Date	SWE (in)
Tony Grove RS	41.89	-111.57	6332	1929.99	4/1/2012	0
Klondike Narrows	41.97	-111.6	7250	2209.80	4/1/2012	12.1
Temple Fork	41.79	-111.55	7406	2257.35	4/1/2012	12.7
Garden City Summit	41.92	-111.47	7705	2348.48	4/1/2012	12
Franklin Basin	42.05	-111.6	8170	2490.22	4/1/2012	17.2
USU Doc Daniel	41.86	-111.51	8270	2520.70	4/1/2012	23
Tony Grove Lake	41.9	-111.63	8474	2582.88	4/1/2012	27.3

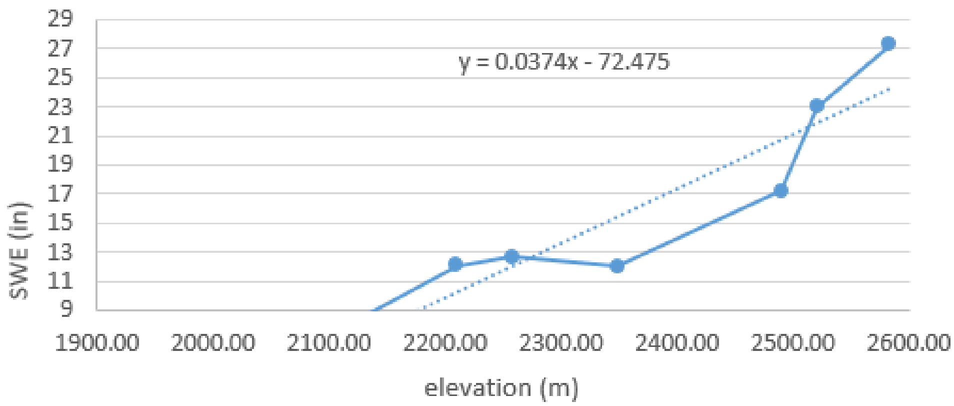


Table 4: April 1st SWE data for Logan River Basin April 1, 2013

SNOTEL Station	Lat	Long	elevation (ft)	elevation (m)	Date	SWE (in)
Tony Grove RS	41.89	-111.57	6332	1929.99	4/1/2013	0.2
Klondike Narrows	41.97	-111.6	7250	2209.80	4/1/2013	11.4
Temple Fork	41.79	-111.55	7406	2257.35	4/1/2013	11.1
Garden City Summit	41.92	-111.47	7705	2348.48	4/1/2013	13.6
Franklin Basin	42.05	-111.6	8170	2490.22	4/1/2013	16.8
USU Doc Daniel	41.86	-111.51	8270	2520.70	4/1/2013	21.4
Tony Grove Lake	41.9	-111.63	8474	2582.88	4/1/2013	21.1

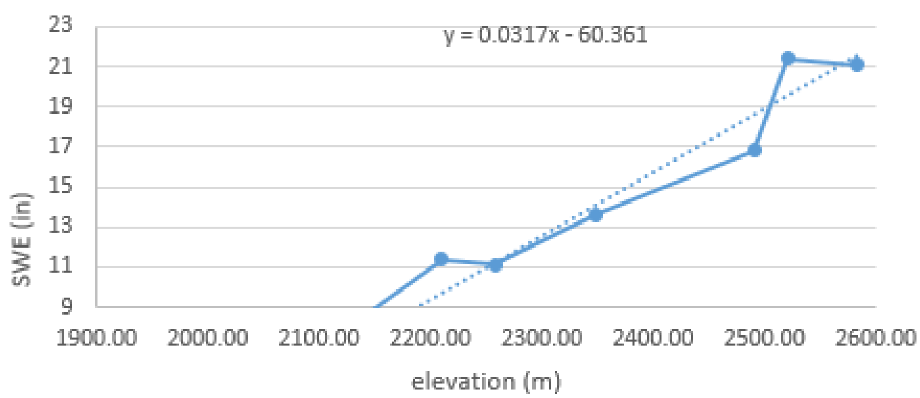


Table 5: April 1st SWE data for Logan River Basin April 1, 2014

SNOTEL Station	Lat	Long	elevation (ft)	elevation (m)	Date	SWE (in)
Tony Grove RS	41.89	-111.57	6332	1929.99	4/1/2014	9.8
Klondike Narrows	41.97	-111.6	7250	2209.80	4/1/2014	22.9
Temple Fork	41.79	-111.55	7406	2257.35	4/1/2014	20.9
Garden City Summit	41.92	-111.47	7705	2348.48	4/1/2014	23.3
Franklin Basin	42.05	-111.6	8170	2490.22	4/1/2014	26.9
USU Doc Daniel	41.86	-111.51	8270	2520.70	4/1/2014	33.2
Tony Grove Lake	41.9	-111.63	8474	2582.88	4/1/2014	46.9

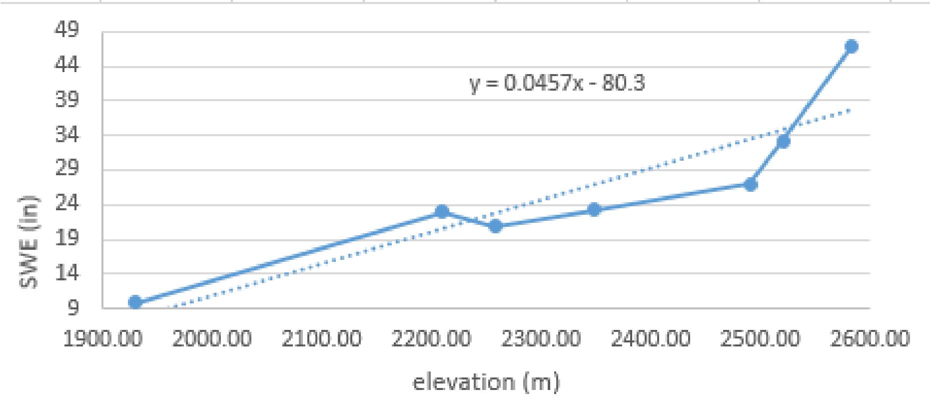


Table 6: April 1st SWE data for Logan River Basin April 1, 2015

SNOTEL Station	Lat	Long	elevation (ft)	elevation (m)	Date	SWE (in)
Tony Grove RS	41.89	-111.57	6332	1929.99	4/1/2015	0
Klondike Narrows	41.97	-111.6	7250	2209.80	4/1/2015	11
Temple Fork	41.79	-111.55	7406	2257.35	4/1/2015	8.5
Garden City Summit	41.92	-111.47	7705	2348.48	4/1/2015	10.5
Franklin Basin	42.05	-111.6	8170	2490.22	4/1/2015	18
USU Doc Daniel	41.86	-111.51	8270	2520.70	4/1/2015	18.8
Tony Grove Lake	41.9	-111.63	8474	2582.88	4/1/2015	25.4

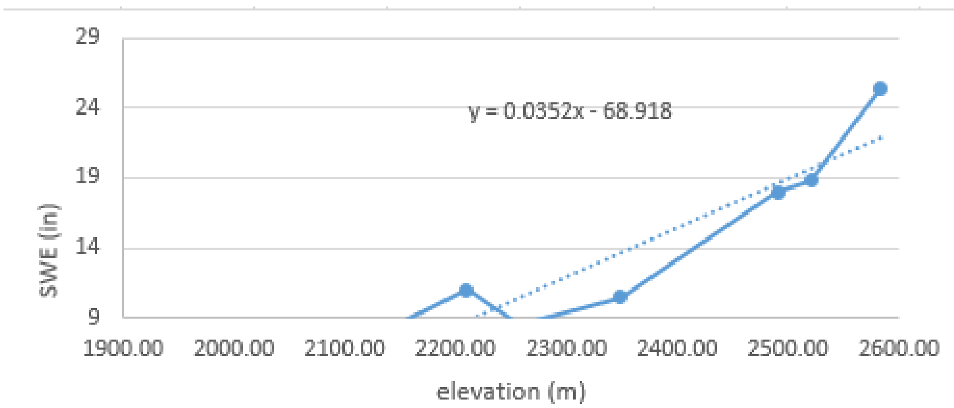


Table 7: Peak SWE data for Logan River Basin April 1, 2010

SNOTEL Station	Lat	Long	elevation (m)	SWE (in)
Tony Grove RS	41.89	-111.57	1929.99	10.10
Klondike Narrows	41.97	-111.6	2209.80	16.30
Temple Fork	41.79	-111.55	2257.35	14.40
Garden City Summit	41.92	-111.47	2348.48	14.90
Franklin Basin	42.05	-111.6	2490.22	21.70
Usu Doc Daniel	41.86	-111.51	2520.70	26.80
Tony Grove Lake	41.9	-111.63	2582.88	28.90

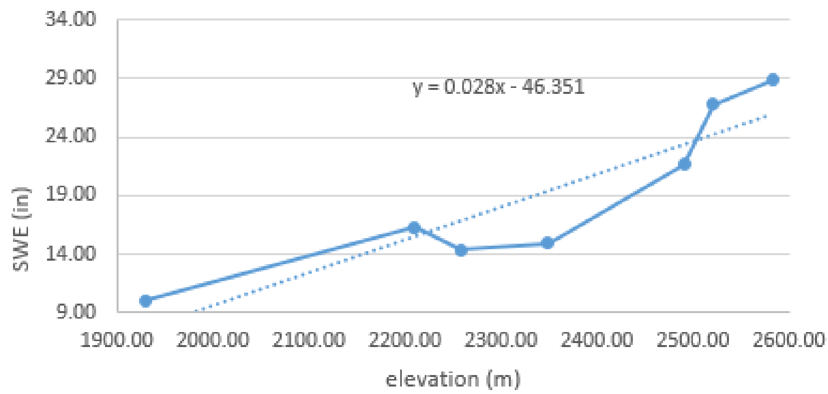


Table 8: Peak SWE data for Logan River Basin April 1, 2011

SNOTEL Station	Lat	Long	elevation (m)	SWE (in)
Tony Grove RS	41.89	-111.57	1929.99	15.00
Klondike Narrows	41.97	-111.6	2209.80	33.80
Temple Fork	41.79	-111.55	2257.35	29.00
Garden City Summit	41.92	-111.47	2348.48	31.10
Franklin Basin	42.05	-111.6	2490.22	52.40
USU Doc Daniel	41.86	-111.51	2520.70	53.80
Tony Grove Lake	41.9	-111.63	2582.88	66.20

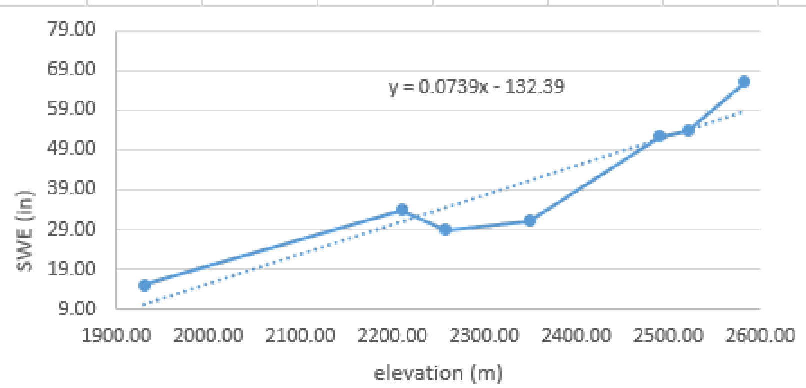


Table 9: Peak SWE data for Logan River Basin April 1, 2012

SNOTEL Station	Lat	Long	elevation (m)	SWE (in)
Tony Grove RS	41.89	-111.57	1929.99	11.70
Klondike Narrows	41.97	-111.6	2209.80	15.50
Temple Fork	41.79	-111.55	2257.35	14.30
Garden City Summit	41.92	-111.47	2348.48	13.70
Franklin Basin	42.05	-111.6	2490.22	18.90
USU Doc Daniel	41.86	-111.51	2520.70	24.60
Tony Grove Lake	41.9	-111.63	2582.88	29.70

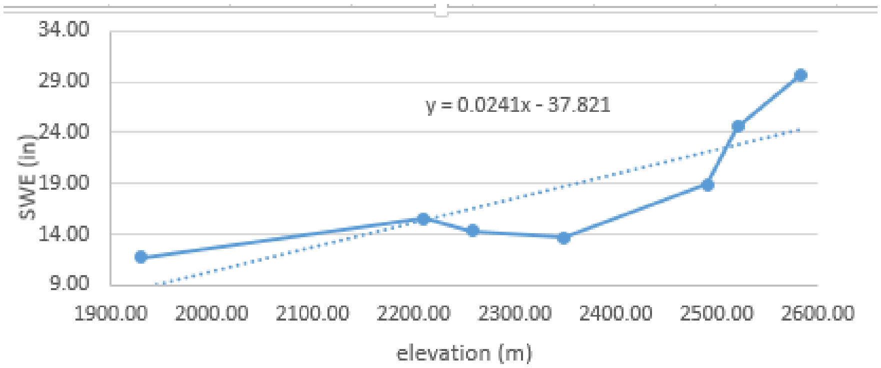


Table 10: Peak SWE data for Logan River Basin April 1, 2013

SNOTEL Station	Lat	Long	elevation (m)	SWE (in)
Tony Grove RS	41.89	-111.57	1929.99	6.30
Klondike Narrows	41.97	-111.6	2209.80	14.30
Temple Fork	41.79	-111.55	2257.35	12.90
Garden City Summit	41.92	-111.47	2348.48	16.00
Franklin Basin	42.05	-111.6	2490.22	20.60
USU Doc Daniel	41.86	-111.51	2520.70	27.70
Tony Grove Lake	41.9	-111.63	2582.88	24.20

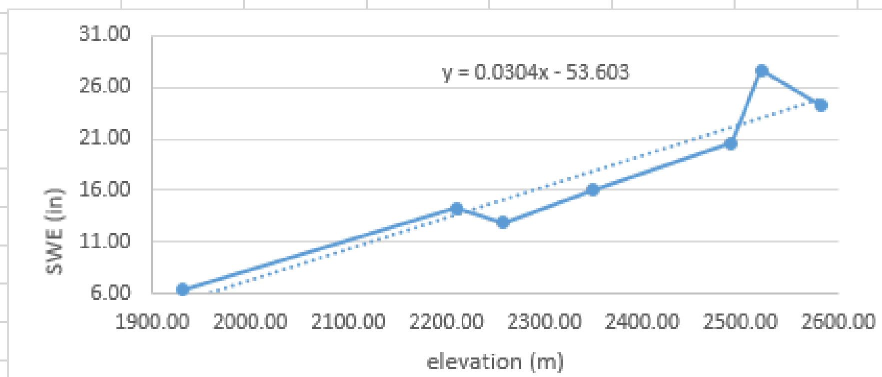


Table 11: Peak SWE data for Logan River Basin April 1, 2014

SNOTEL Station	Lat	Long	elevation (m)	SWE (in)
Tony Grove RS	41.89	-111.57	1929.99	13.50
Klondike Narrows	41.97	-111.6	2209.80	23.20
Temple Fork	41.79	-111.55	2257.35	21.60
Garden City Summit	41.92	-111.47	2348.48	24.20
Franklin Basin	42.05	-111.6	2490.22	28.00
USU Doc Daniel	41.86	-111.51	2520.70	37.80
Tony Grove Lake	41.9	-111.63	2582.88	48.50

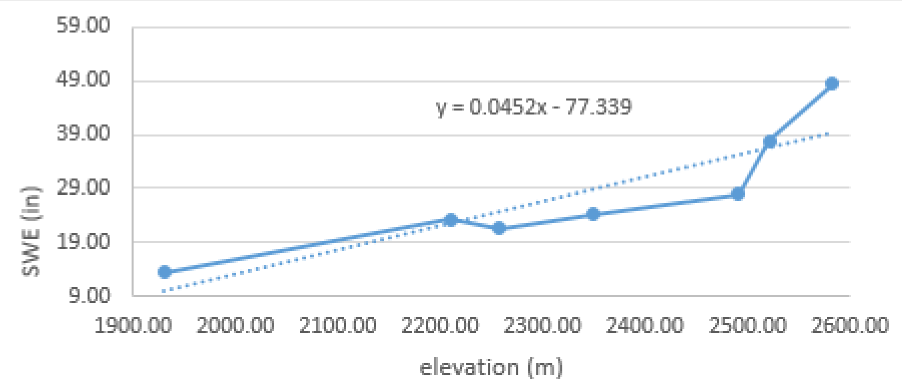


Table 12: Peak SWE data for Logan River Basin April 1, 2014

SNOTEL Station	Lat	Long	elevation (m)	SWE (in)
Tony Grove RS	41.89	-111.57	1929.99	7.00
Klondike Narrows	41.97	-111.6	2209.80	16.80
Temple Fork	41.79	-111.55	2257.35	11.80
Garden City Summit	41.92	-111.47	2348.48	12.50
Franklin Basin	42.05	-111.6	2490.22	20.30
USU Doc Daniel	41.86	-111.51	2520.70	19.90
Tony Grove Lake	41.9	-111.63	2582.88	27.60

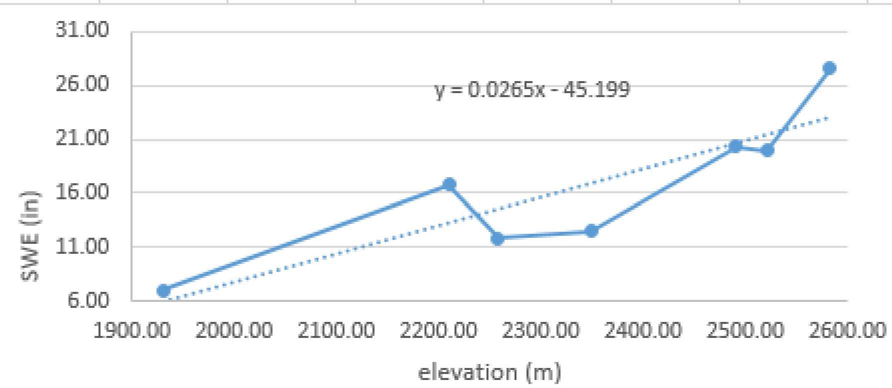


Table 14: April 1st SWE Values Compared to Peak Stream Flow

Test: April 1st SWE to Peak Flow				
Year	SWEVol (ft^3)	PredictFlow (cfs)	RecoredFlow (cfs)	% Difference: (cfs)
2010	7.4E+09	614.01	*852*	27.93
2011	1.6E+10	1475.01	*1630*	9.51
2012	7.1E+09	582.81	*429*	35.85
2013	6.5E+09	522.41	*480*	8.83
2014	1.2E+10	1123.11	*773*	45.29
2015	6.4E+09	510.39	*545*	6.35
			AVG	22.30

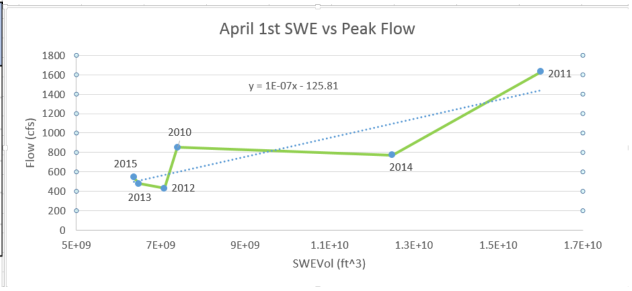
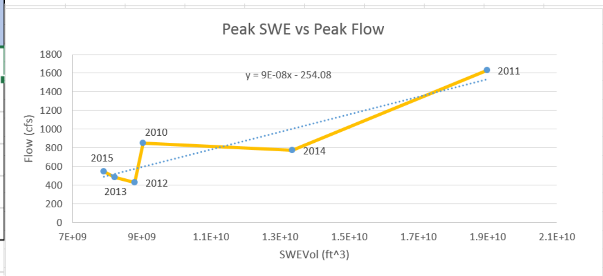


Table 15: Peak SWE Values Compared to Peak Stream Flow

Test: Peak SWE to Peak Flow				
Year	SWEVol (ft^3)	PredictFlow (cfs)	RecoredFlow (cfs)	% Difference: (cfs)
2010	9E+09	559.15	*852*	34.37
2011	1.9E+10	1454.30	*1630*	10.78
2012	8.8E+09	537.92	*429*	25.39
2013	8.2E+09	485.57	*480*	1.16
2014	1.3E+10	948.20	*773*	22.66
2015	7.9E+09	457.07	*545*	16.13
			AVG	18.42



References:

- NOAA. (2015, November 23). *National Centers for Environmental Information*. Retrieved from http://www.ncdc.noaa.gov/cdo-web/search;jsessionid=997399D3716B664163F5164E2C230D39

- *Esri. (2015, August 11) How Spline Works.* ArcGIS Resources. Retrieved from http://resources.arcgis.com/EN/HELP/MAIN/10.1/index.html#//009z00000078000000

- USGS. *USGS 10109000 LOGAN RIVER ABOVE STATE DAM, NEAR LOGAN, UT*. Retrieved from < http://waterdata.usgs.gov/usa/nwis/uv?site_no=10109000>

- Regression Analysis. (2015, November 13). In Wikipedia. Retrieved 23 Nov October 2015. https://en.wikipedia.org/wiki/Regression_analysis