Spatial Representation of Best Management Practices (BMPs) Implemented in Lower Bear River (LBR) Watershed using ArcGIS tools.

Prepared by: Nour Atallah

Submitted to: Dr. David Tarboton

GIS in Water Resources Class

Contents

Abstract

Effective water quality management often occurs by using a holistic system management approach. This approach takes into account the effectiveness of each management practice and the costs of each practice. Some individual practices may not be effective alone but, in combination with others, may provide a key function in highly effective systems. A set of these practices were implemented in Lower Bear Malad River (LBMR) to control the loads of Phosphorus and Sediments caused by several point and non-point sources. This report was prepared to check the effectiveness of the BMPs implemented in the LBMR from 2000 to 2010; the track used in preparing this report started by understanding and visualizing the study area watershed hydrology features using ArcGIS tools and data input such as DEM, NHD, USGS monitoring sites, and land use. After that, time series slider tool has been used to trace the temporal change in water quality among the LBMR. Based on the temporal trend and the visualization of BMPs with time, it is concluded that the implemented BMPs have not reduced the loads of phosphorus, hence not improving the water quality within the watershed. This can be due to couple of reasons, like not targeting the critical areas that contribute to loads, or the type of the implemented BMPs are not the ones that can reduce such loads to the required water quality standards.

Introduction

Spatial representation of best management practices (BMPs) for control non-point sources (e.g., agricultural runoffs) is of important issue to the watershed community managers and coordinators. The spatial tool will provide prospective vision and judgement of how the implementation of BMPs was done spatially within watershed scale and whether the BMPs were targeting the critical areas contributing pollution loads (e.g., nutrients and sediments) to the surface water bodies.

The approach that will be carried on in this Project will start by understanding and visualizing the study area watershed hydrology features using ArcGIS tools and data input such as DEM, NHD, USGS monitoring sites, and land use. The study area is the Lower Bear-Malad River watershed (LBMR). This step will produce the main rivers, slopes, longest path in the watershed, and the dominant nature of the watershed and its elevations. Mapping the land use configuration and visualization will provide an idea of potential non-point sources and their locations within the watershed.

Additionally, I will integrate the main point sources in the Watershed and see the transport of their discharges within the watershed. This will offer a wide understanding of how the watershed quality is affected by point and non-point sources.

Study area

The research will be conducted in the Lower Bear River (LBR) watershed located in Box Elder County located in Northern Utah as shown in Figure 1.

The LBR watershed includes the following waterways: the main Bear River from Cutler Dam to its confluence with Great Salt Lake; the Malad River from the Utah-Idaho state line to its confluence with the Bear River in which these water bodies will be under study. The LBR Watershed is sub-basin of Lower Bear Malad River (LBMR) watershed (HUC 16010204) that is part of Great Basin Region (HUC 1601) as shown in Figure 1.

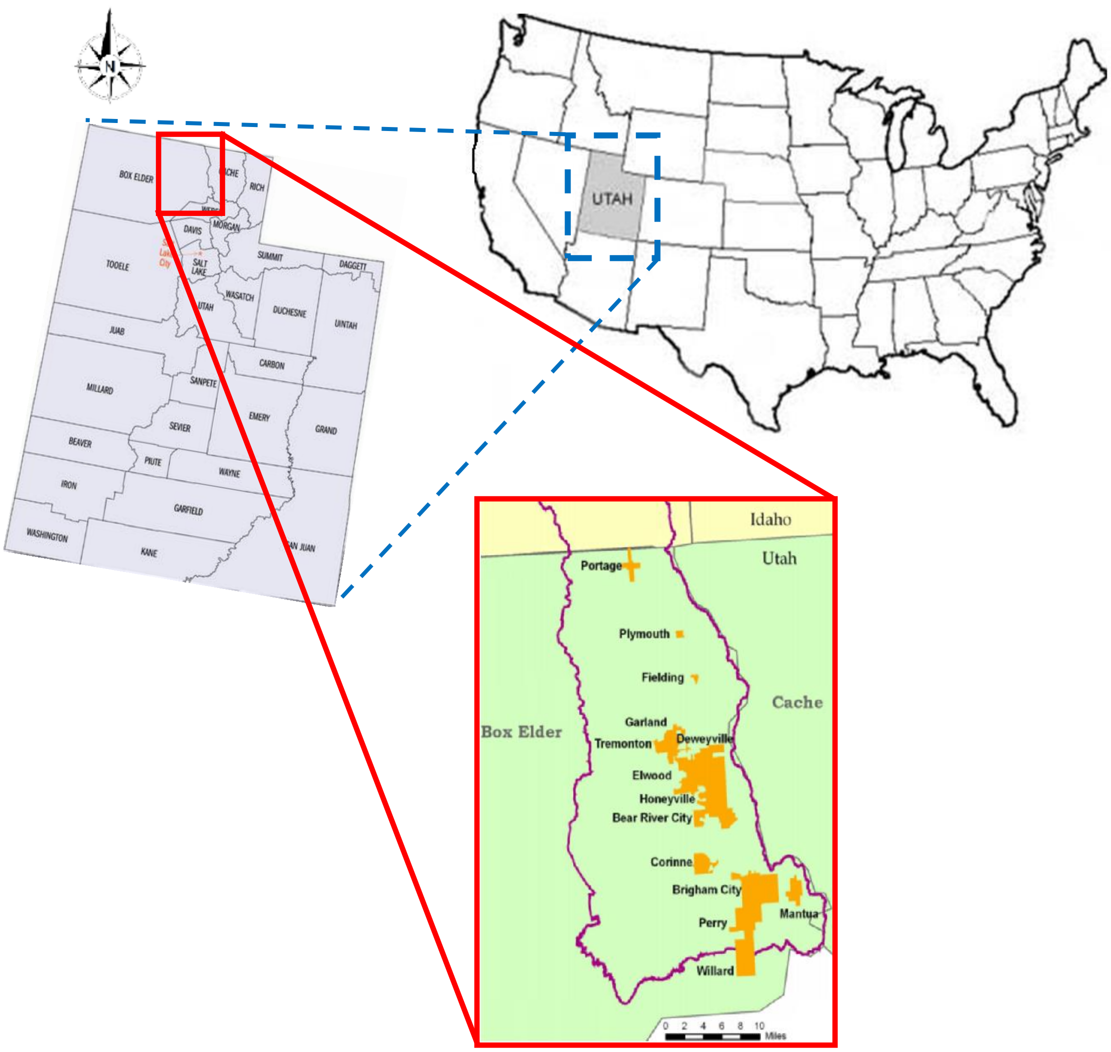


Figure 1. LBMR Watershed

The LBMR watershed includes the main Bear River from Cutler Dam to its confluence with the Great Salt Lake, the Malad River from the Utah–Idaho state line to its confluence with the Bear River, Box Elder Creek from its headwaters to its confluence with Black Slough and the Bear River, along with numerous springs and other small tributaries. The outlet of the watershed is located on the Bear River near Corinne, Utah (USGS 10126000) with Latitude 41°34'35", Longitude 112°06'00" using NAD27 as projection system.

Within the Lower Bear River watershed, there are five permitted point source discharges. Four are waste water treatment plants (WWTPs) and one is an industrial source as illustrated in Table 1 that also illustrates the maximum monthly discharge limitations from each point source as stipulated in their UPDES document. They are: Corinne WWTP, Brigham City WWTP, Bear River City WWTP, Tremonton WWTP, and Nucor Steel.

Table 1. List of permitted point sources in the LBR Watershed and the Maximum monthly discharge limitation of the permitted point sources

Point Source	Latitude	Longitude	Flow (MGD)	TSS (mg/L)	BOD_5 (mg/L)	TP (mg/L)
TREMONTON WWTP	41.6984034	-112.16161	2.0	25	25	N/A
BRIGHAM CITY WWTP	41.5241527	-112.04622	6.0	25	20	N/A
BEAR R CITY LAGOONS	41.5997351	-112.14331	10	45	45	N/A
CORINNE LAGOONS	41.5368495	-112.11186	0.07	25	25	N/A
NUCOR STEEL	41.8863124	-112.20440	21	25	N/A	N/A

The LBR TMDL that was released in 2002 indicated that three main point sources (Corinne, Bear River and Tremonton cities) accounted for approximately 3% of the TP load to the Lower Bear River. The remaining 97% is attributed to NPS. Given that the nonpoint source TP loads from NPS are more prominent than the point source contributions, TP effluent standard limits for these point sources considered insignificant in the TMDL but recommended to continue monitoring the TP.

BMPs actions were implemented to control the phosphorus load within the watershed, where the first action was carried out in 2002. Within the period (2002-2010) fifteen different BMPs action were proceeded. Table 2 illustrates the BMPs implemented within the watershed.

Table 2. List of BMPs implemented in the LBR Watershed.

Project Type	X_Projection	Y_Projection	Implementation Year
Riparian Fencing	41.76016	-112.11959	2009
Drain Piping (Irrigation)	41.67290	-112.12693	2008
Feedlot (AFO)	41.60806	-112.11510	2002
Dairy (Solid/Liquid Pits)	41.63647	-112.10856	2002
Dairy (Solid/Liquid Pits)	41.56089	-112.08713	2005
Feedlot (AFO)	41.56576	-112.12244	2008
Dairy (Solid/Liquid Pits)	41.60079	-112.14379	2007
Feedlot (AFO)	41.62406	-112.16670	2002
Feedlot (AFO)	41.62779	-112.17109	2002
Feedlot (AFO)	41.65431	-112.16264	2007
Composting facility	41.65525	-112.15930	2007
Feedlot (AFO)	41.71296	-112.16020	2009
Feedlot (AFO)	41.89303	-112.16817	2005
Runoff Pond (Retention)	41.82568	-112.12724	2009
Dairy (Solid/Liquid Pits)	41.70145	-112.09151	2009

See Annex (A-1) for major LBR watershed features).

Problem statement

The Lower Bear Malad River Watershed (LBMR) suffers from loads of Phosphorus and Sediments loads caused by point and nonpoint sources. A Total Maximum Daily Load (TMDL) study conducted in 2002 recommend several BMPs actions to control and reduce theses loads.

Objectives

The main objective of this project is utilize the tools and the abilities of ArcGIS Pro edition to track the temporal trend of water quality parameters (phosphorus and sediments) at the Lower Bear-Malad River watershed following the implementation of BMPs.

Methodology

Delineate the LBMR Watershed

The watershed tool located in ready to use geoprocessing tools was used to delineate the watershed, the input point (watershed outlet) used by the tool was the USGS 10126000 station, finest data source resolution was selected and the output was the LBMR Watershed (Annex A-2).

Determine the characteristics of the Watershed

A set of geoprocessing tools was used to examine the characteristics of the watershed. Fill impact examination tool enabled us to locate the deepest sink within the watershed, Flow Direction, Slope, and Aspect tools described the nature of topography in the watershed, the Flow Accumulation tool generated the flow accumulation raster which allowed us to identify the contributing area at each grid cell in the watershed domain, and Trace Downstream Tool determined the path water will take from a particular location (Point Sources in our case) to its furthest downhill path. Moreover, land cover raster was used to determine the dominant land cover type within the watershed. Model builder was used to automate the previous processes. Annex B illustrates the characteristics of the watershed.

Determine how water quality has been improved in the watershed over time since BMP's implementation.

First, BMPs parameters like type, location and year of implementation were identified. Second, water quality data was collected using the available data at USGS Water-Quality Data (water.usgs.gov/owq/data.html). Finally, and in order to track how water quality have been changed over the period of 2000-2010, a layer time for BMPs was enabled and time slider tool provided a temporal representation of water quality. See clips captured for more details **(Clips were uploaded on Hydroshare URL:** https://www.hydroshare.org/resource/d8d305f5b8fe4b9eb1b2500383a140f2/**)**

Results and Conclusion

Based on the temporal analysis performed of BMPs, it was obvious that the implemented BMPs for the period of 2002-2010 have not improved the watershed water quality using phosphorus concentration as an indicator. Water quality standards set by the Utah Division of Water Quality used for the analysis are: 0.05 mg P/l for streams (total phosphorous concentration criteria) and 90 mg TSS/l total suspended solids concentration criteria). Figures 2 and 3 show how total phosphorus and total suspended solids concentration varied over the time with the flow.

In details, Figure 2 shows that phosphorus concentration decreased when higher flow rates occurred. On the other hand, Figure 3 indicates that when we are dealing with high rate of flow the concentration of sediments increases. Figure 4 indicates that total phosphorus concentration exceeded the standards over the study period.

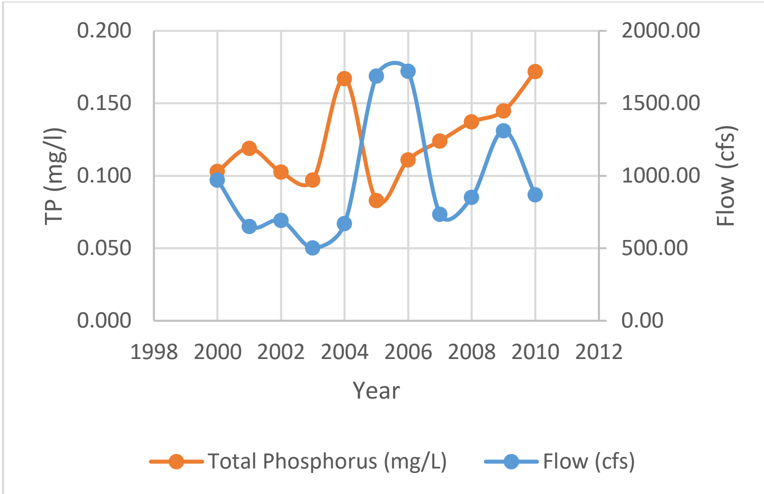


Figure 2. Flow Vs. Total Phosphorus

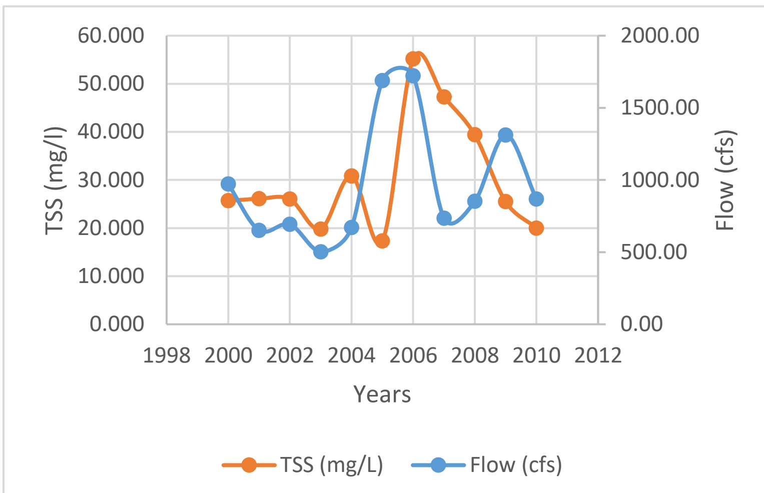


Figure 3. Flow Vs. Sediments

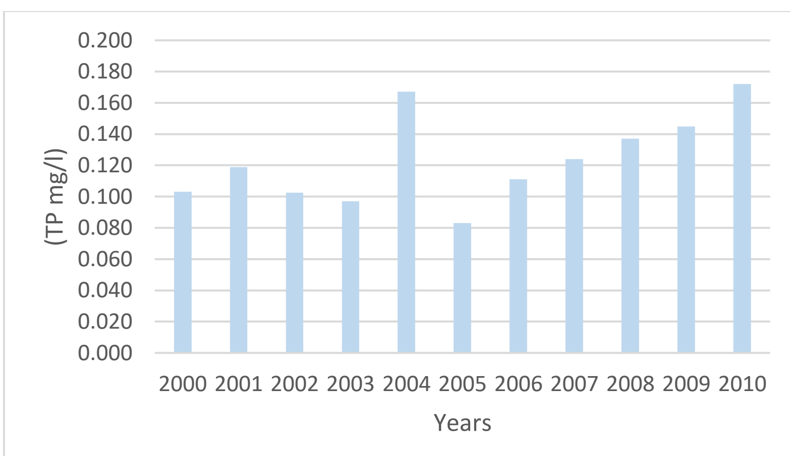


Figure 4. Total Phosphorus (mg/L)

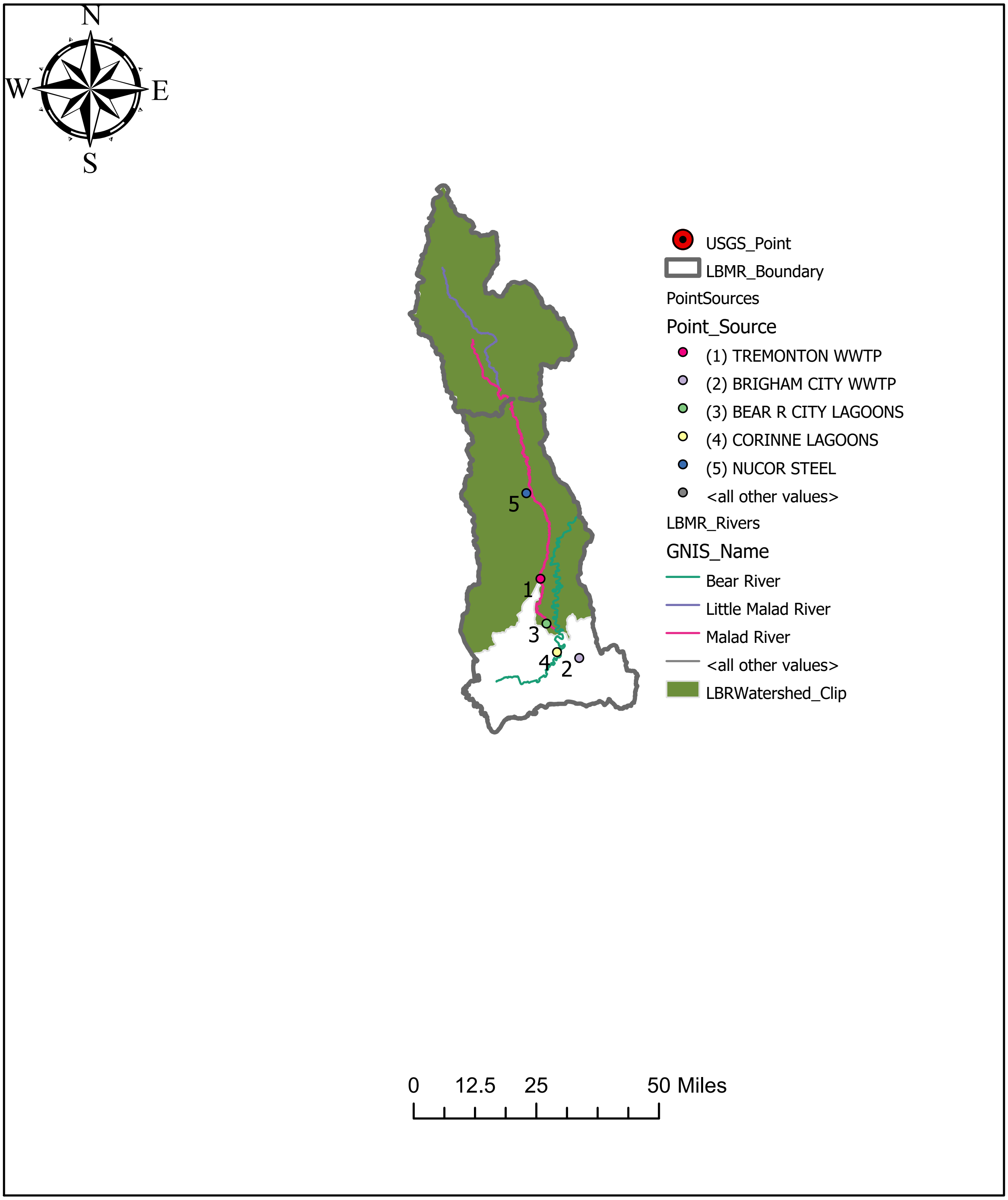
Further outputs regarding the watershed characteristics showed that the deepest sink is located in the eastern edge of the watershed with a depth of 38.12 m. Topographic and hydrologic slope values were close where the maximum hydrologic slope value located in the watershed is 216.67 while the maximum topographic slope value is 185.32. Drainage area of LBMR watershed is 7,029 square miles. The density of all point sources is the Great Salt Lake. The dominant land cover is the Scrub which contributes with about 44% of the total watershed area.

To conclude, the watershed water quality in terms of total phosphorus concentration has not improved in the period between 2000 and 2010. The implementation of different BMPs with time have shown no significance reduction in the loads received by the two main water bodies in the LBR. Even though that the number of BMPs have increased with time, yet the reduction is not significant to tell if these BMPs were effective or not. We can refer to this insignificant reduction in phosphorus loads to couple of reasons, like not targeting exactly the critical areas (main sources of nutrients) that contribute to phosphorus loads, or that the type of the implemented BMP is not the one that can reduce such loads to attain the required water quality standards.

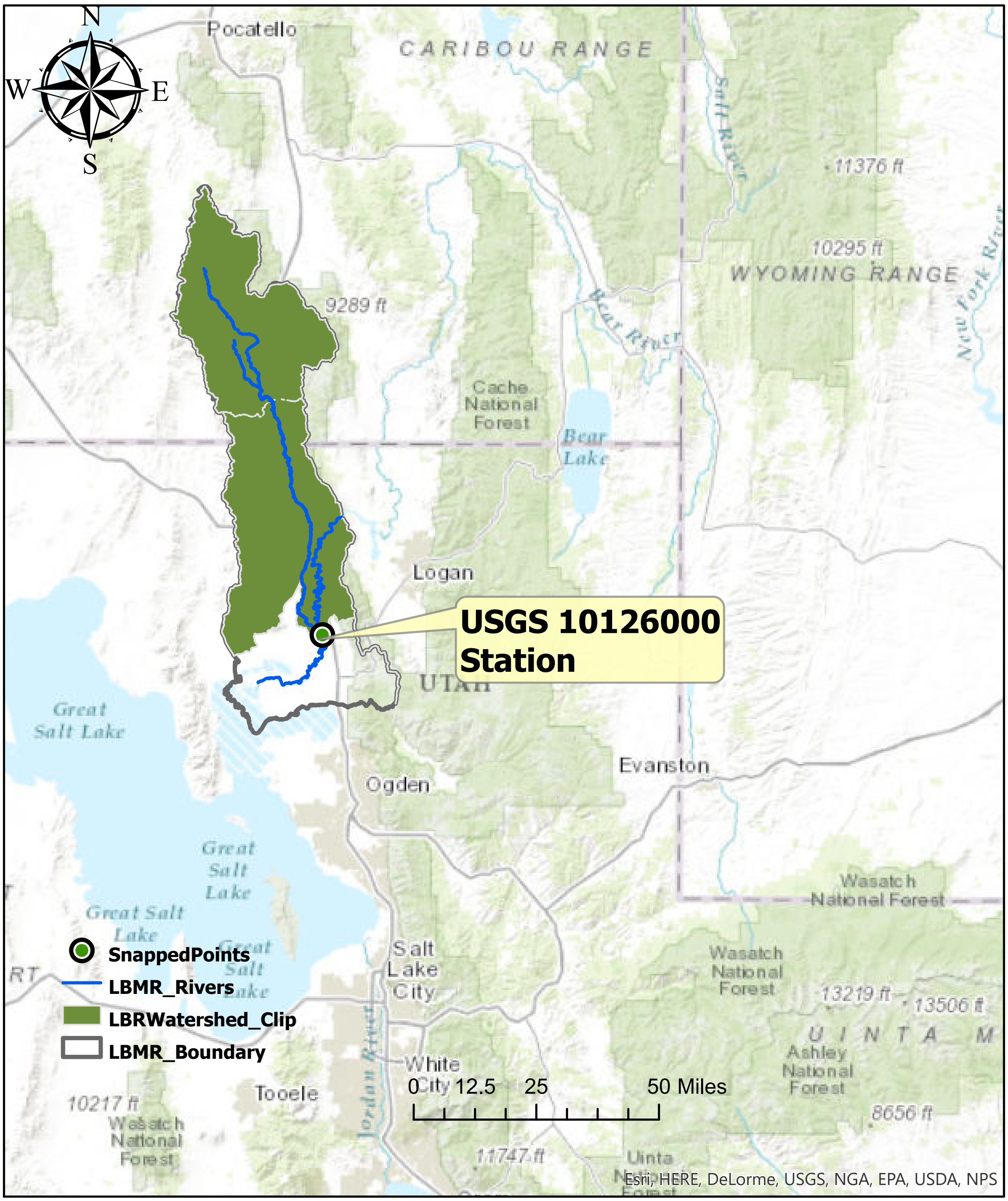
We can also conclude that spatial representation of BMPs and tracking the water quality trend temporally using the available tools and packages in ArcGIS Pro (time slider and spatial analysis tools) have shown it is evident that using ArcGIS in water quality management of watershed is of great value and asset. It saves times and efforts when you have the right and accurate data.

ANNEX (A): Watershed Delineation and Major Features

LBMR Watershed Main Streams

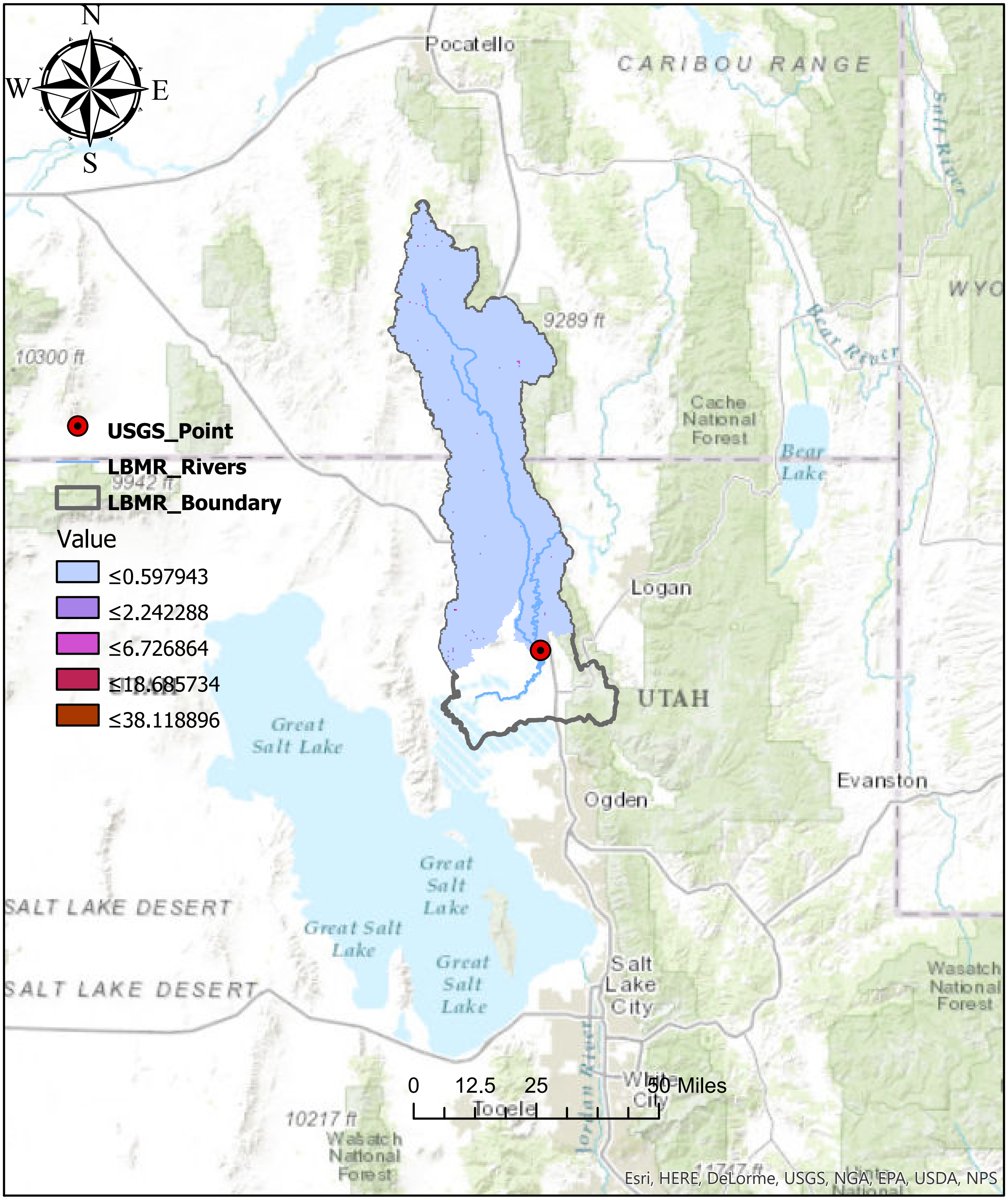


LBMR Watershed Delineation

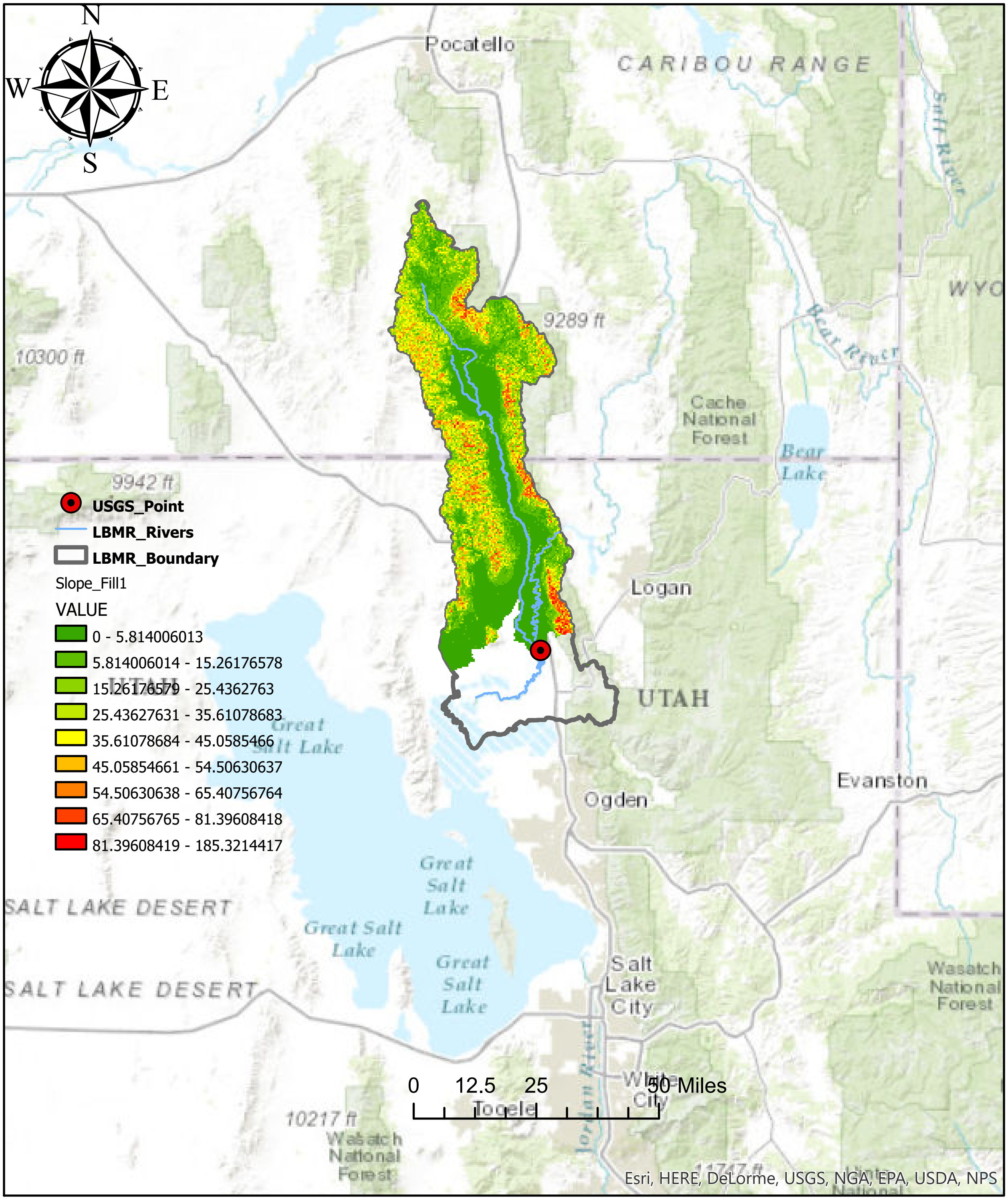


ANNEX (B): Watershed Characteristics

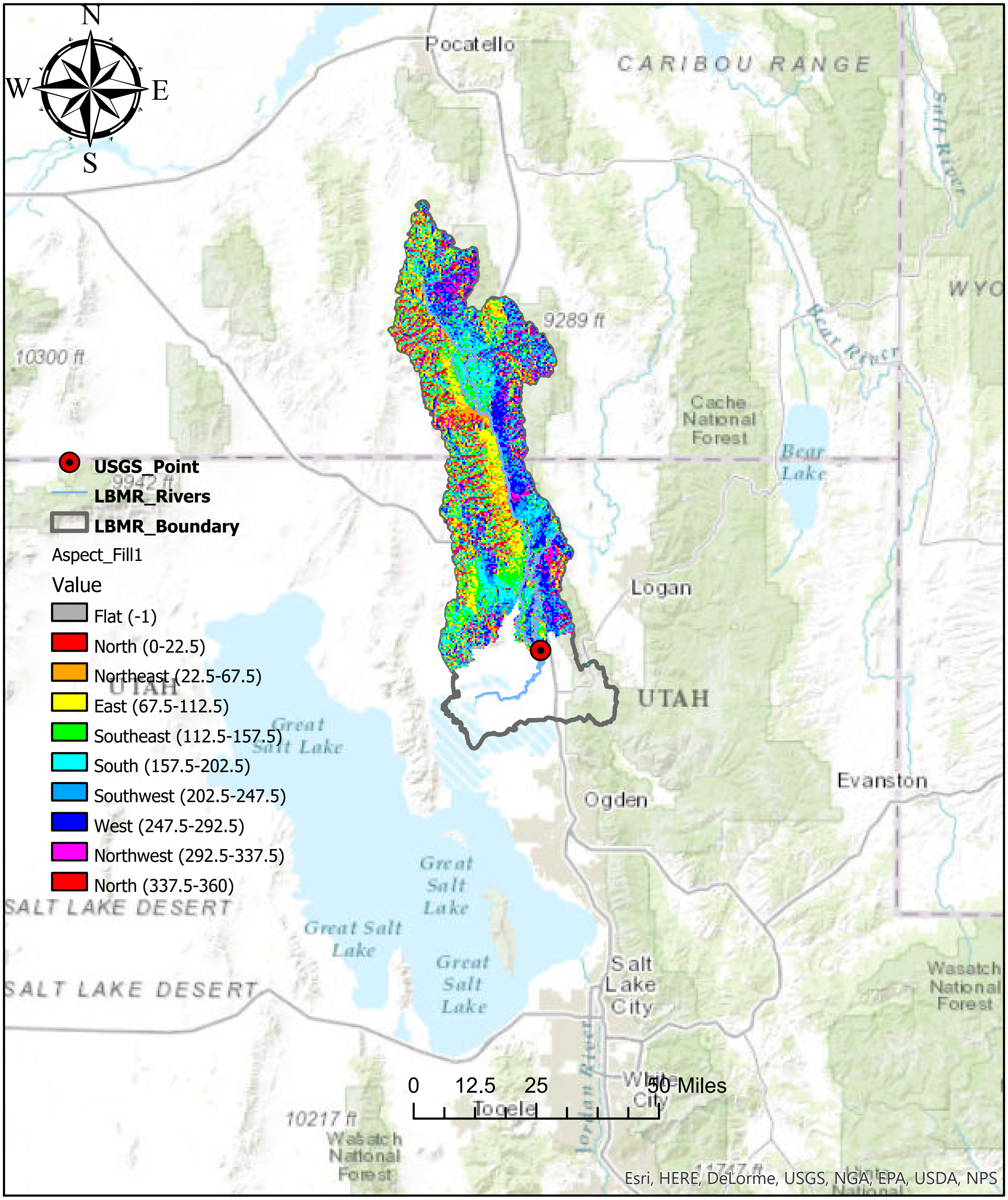
Fill Impact Examination



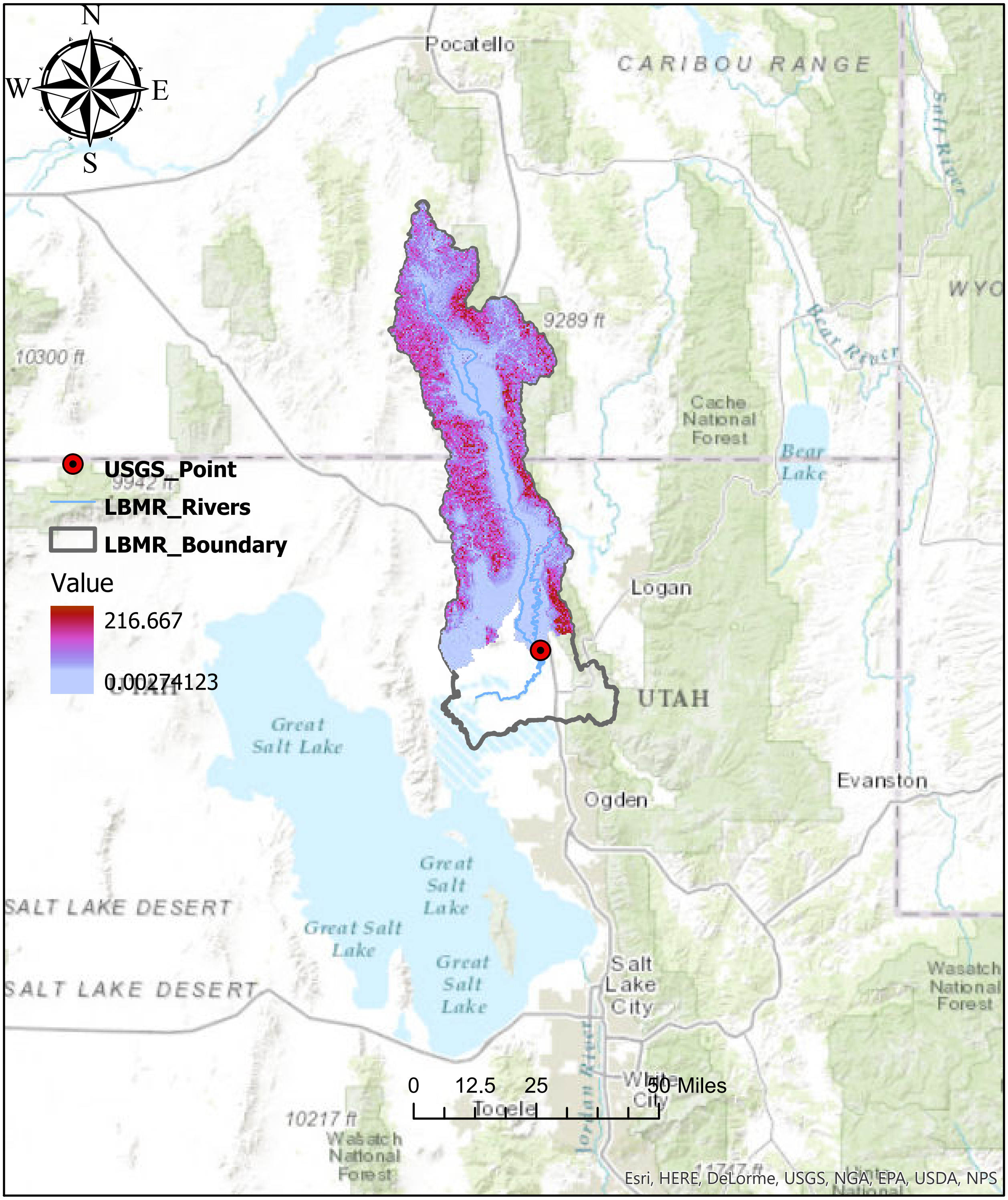
LBMR Watershed Topographic Slope Values



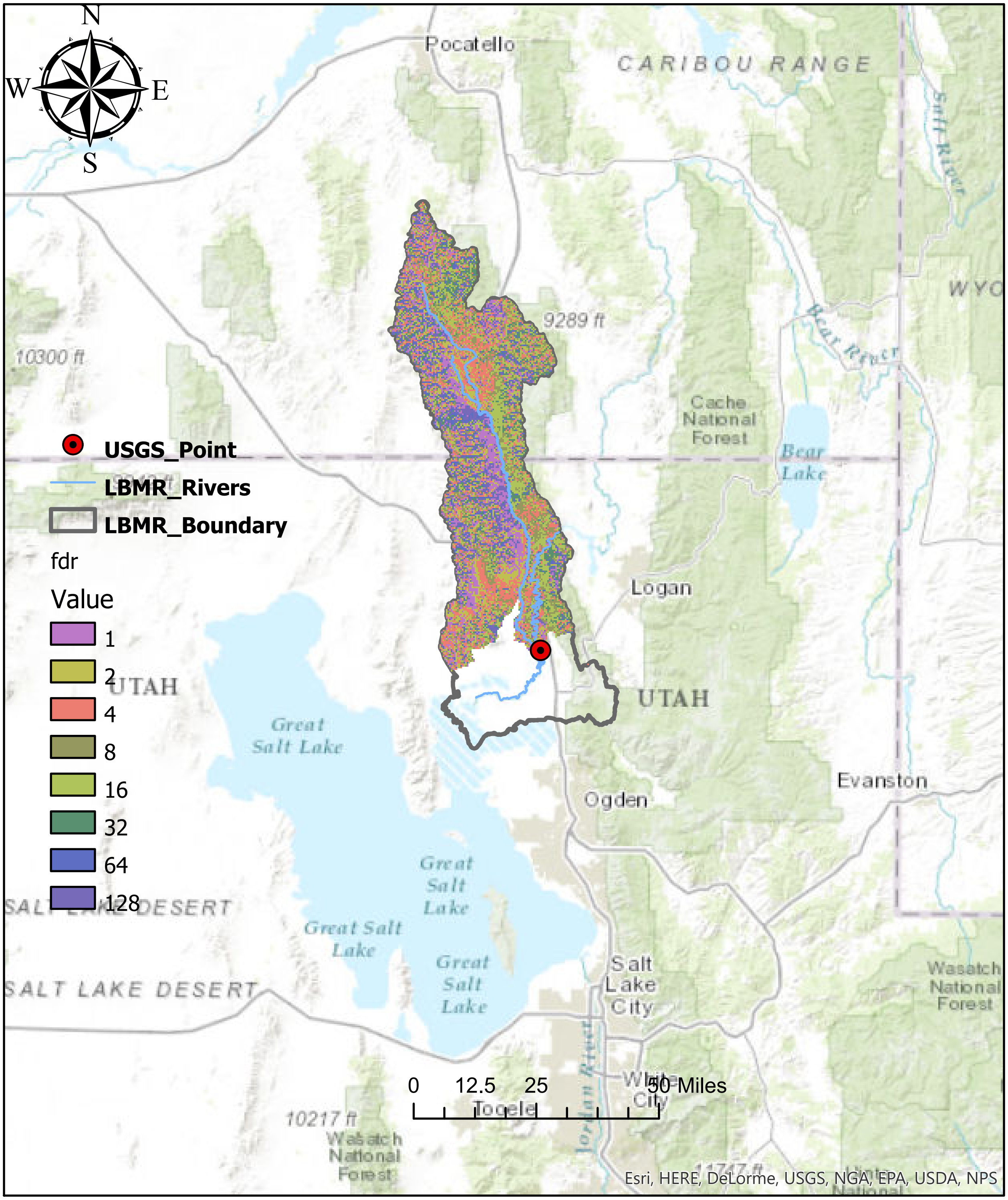
LBMR Watershed Aspect Values



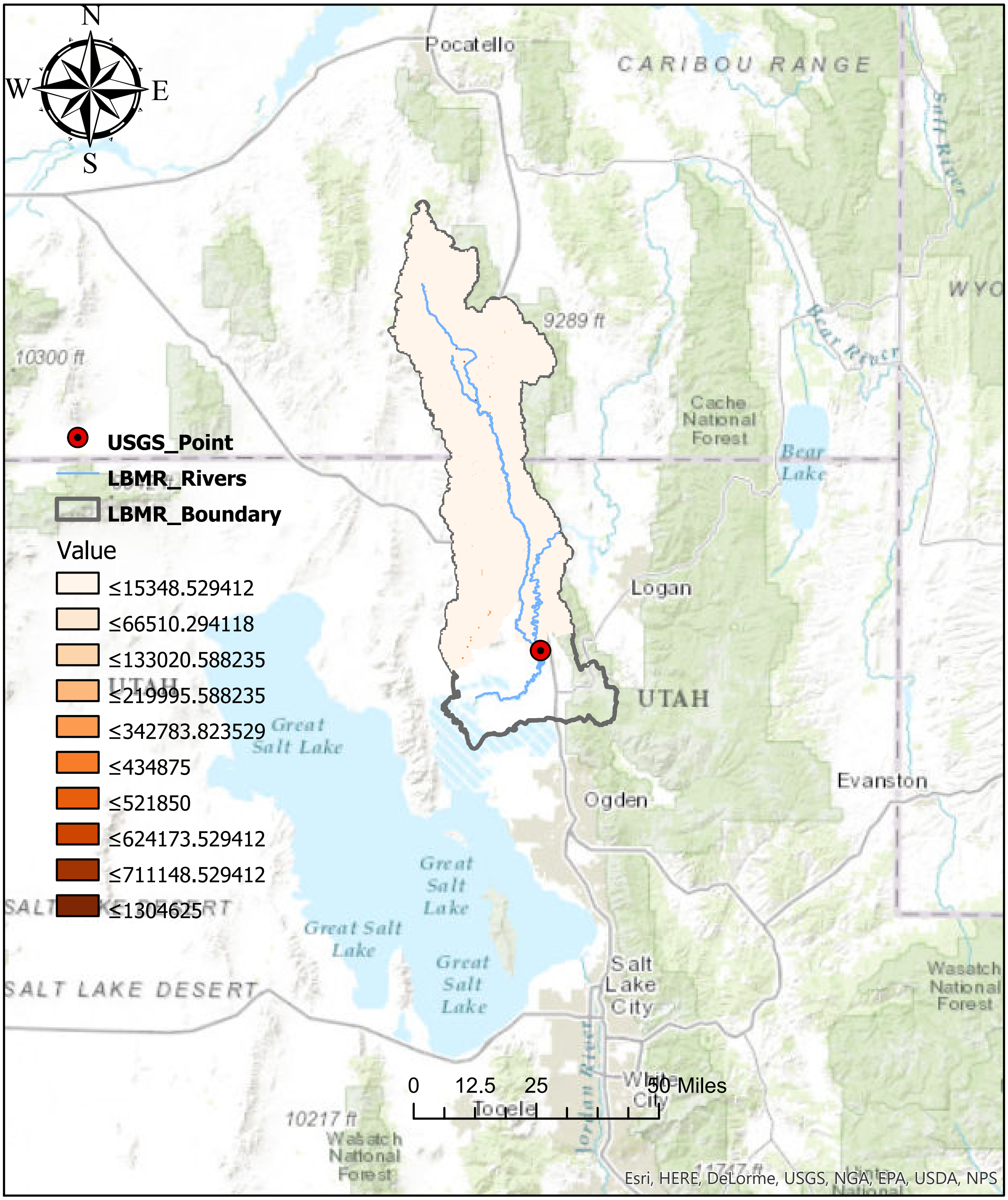
LBMR Watershed Hydrologic Slope Values



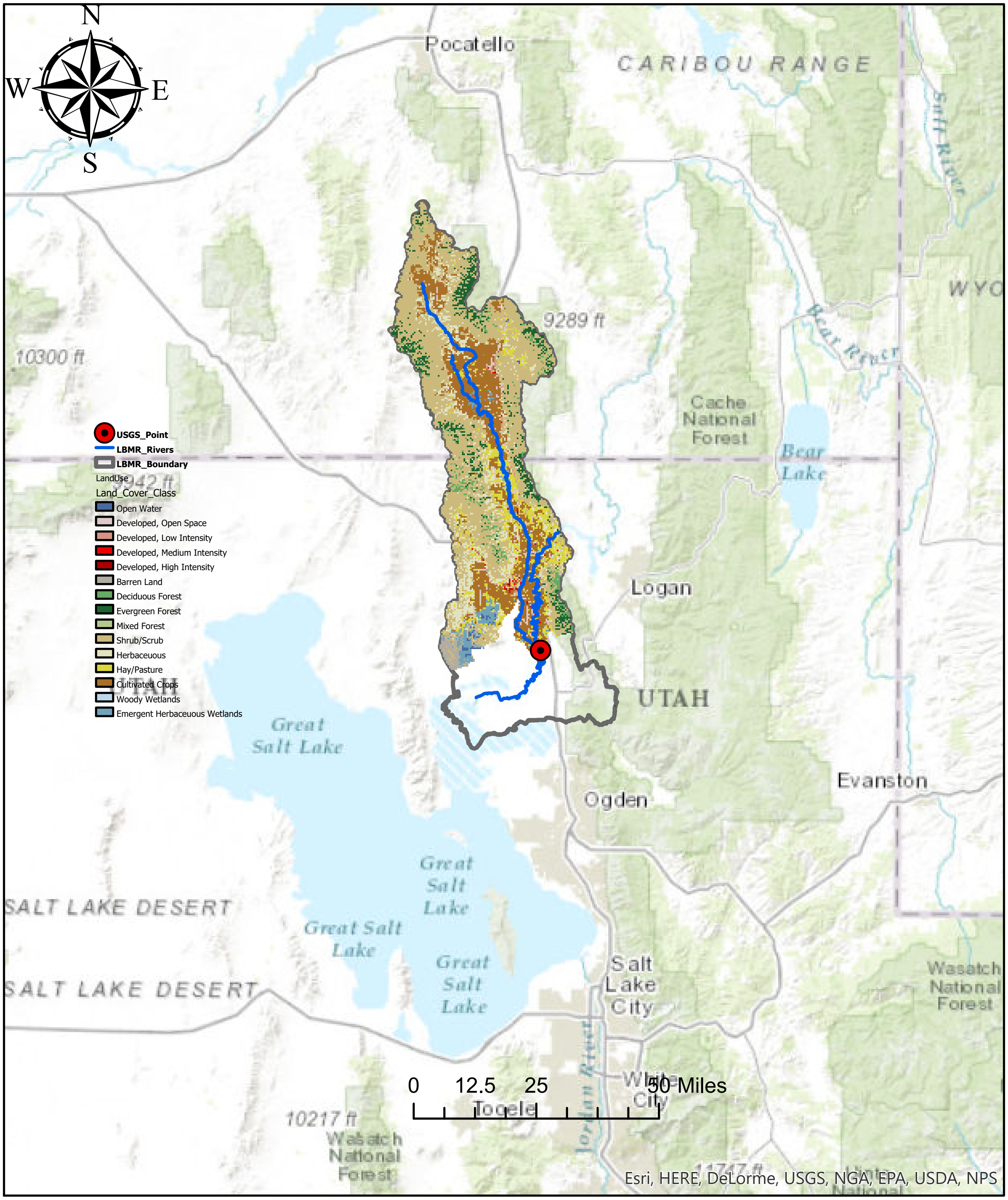
LBMR Watershed Flow Direction



LBMR Watershed Flow Accumlulation



LBMR Watershed Land Cover Distribution



Source Points Trace Line

Model Builder