Lead Concentration Analysis of Quadrangles 16, 20 and 24, Nevada

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Background and Purpose

The National Uranium Resource Evaluation (NURE) program was established in the 1970s to locate potential uranium resources in the United States (Smith). Stream sediments were systematically sampled and analyzed by quadrangles all across the country. In addition to uranium, the samples were analyzed for other elements, like lead.

This analysis will focus on lead concentrations since the element can be found in a majority of the NURE samples. The concentration of lead will be observed at different distances from known lead mines to see if there is a gradual decrease in concentration with increasing distance from the mine. The discovery of a clear trend in concentration could be useful for land use planning to avoid developing over areas where the lead concentration in soil is above the EPA standard.

Quadrangles 16, 20, and 24 of Nevada were thoroughly sampled during the NURE program and contain hundreds of lead mines, and therefore will be the area of interest in this study.

Data Collection

Datasets from several sources were required for this study.

NURE Sediments: http://mrdata.usgs.gov/nure/sediment/

The NURE sediment data was available in shapefiles through the USGS. It contained the lead concentrations of hundreds of sediment samples as well as the location of each sample. The samples were taken in 1979. This dataset was downloaded and used to determine the various concentrations of lead throughout the area of interest.

Mineral Resources by Quadrangle: http://mrdata.usgs.gov/mrds/select.php

The mineral resource data, available as a shapefile through the USGS, contained the names and commodities of mines by their location in the 1°x 2° quadrangles of Nevada. This dataset was downloaded and used to determine the location of mines that had lead listed as the first commodity. The data was updated in 2015.

Hydrography Dataset: https://viewer.nationalmap.gov/viewer/nhd.html?p=nhd

The NURE samples are stream sediments taken from drainages. The hydrography dataset was available in a shapefile and used to visualize the sources of the data, how the samples were systematically taken, and can also be used to visualize the samples' change in concentration with distance from the lead mines. The dataset began in 2001 and was published in 2016.

Nevada DEM: https://archive.epa.gov/esd/archive-nerl-esd1/web/html/nvgeo_gis3_dem.html#map

The Nevada Digital Elevation Model was used to create a hill shade that added more detail to the study area and helped show the sources of the drainages in the hydrography dataset. The data was published in 1999.

USA Database- States: GEO 327G, Lab 2

This shapefile of the United States was used to locate and visualize the 3 quadrangles used as the area of interest.

Nevada State Boundary:
https://www.blm.gov/nv/st/en/prog/more_programs/geographic_sciences/gis/geospatial_data.html

This shapefile was used to clip data to Nevada's state boundaries. The file was published in 2014.

EPA Lead Standards: https://www.epa.gov/lead/hazard-standards-lead-paint-dust-and-soil-tsca-section-403

This information was used to help locate areas with lead concentrations above the EPA standard, which, for soils, is 1200 ppm. The standard was published in 2001.

Methods

After the datasets were downloaded, they were unzipped and added to Arc Map. All datasets were transformed to be projected in NAD 1983 (2011) Contiguous USA Albers coordinate system, as shown in Figure 1. This projection was used with the USA state polygons to make locating and visualizing the study area on a map easier.
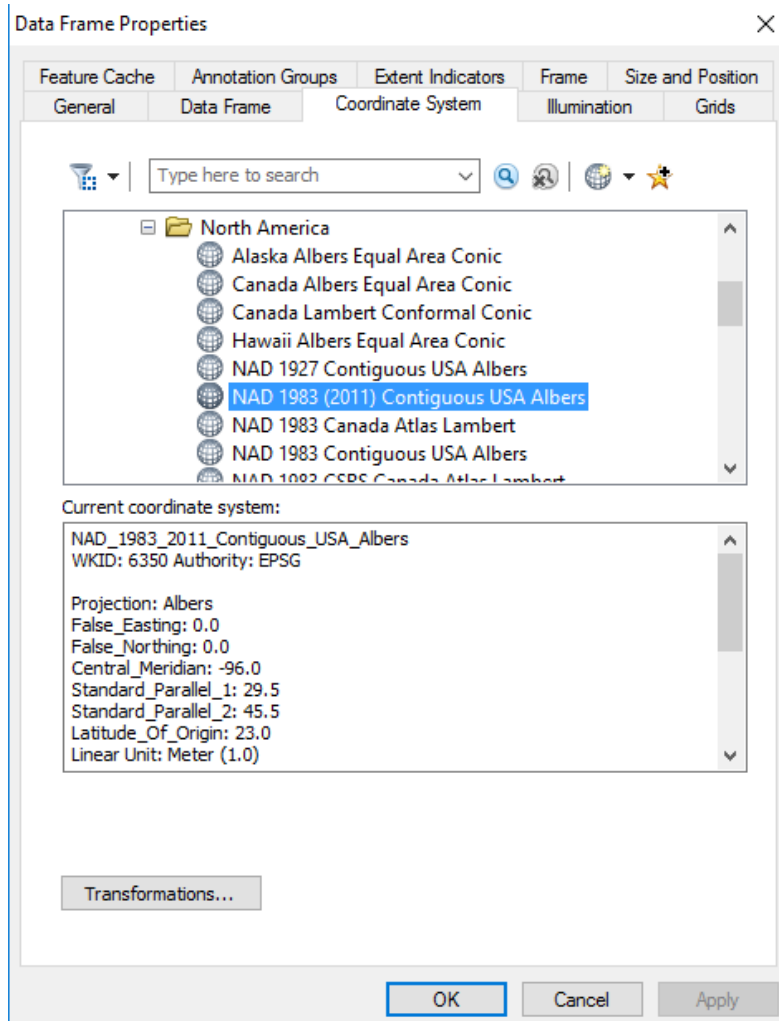
Figure 1. Transformation of data frame to NAD 1983 (2011) Contiguous USA Albers.

The mineral resource and hydrography datasets were available specifically for the state of Nevada so no changes were made at this point. However, the NURE sediment data spanned the entire United States so the clipping tool was used to clip the NURE layer to the Nevada state boundary layer. Next, the Extract by Mask tool was used on the DEM layer to make a new raster that only had elevation values within the Nevada state boundary. Once this new layer was extracted, it was used to create a hillshade using the Hillshade tool shown in Figure 2. The hillshade layer was placed under the Nevada state boundary layer. The state boundary layer was made 70% transparent and the hillshade layer was made 20% transparent.
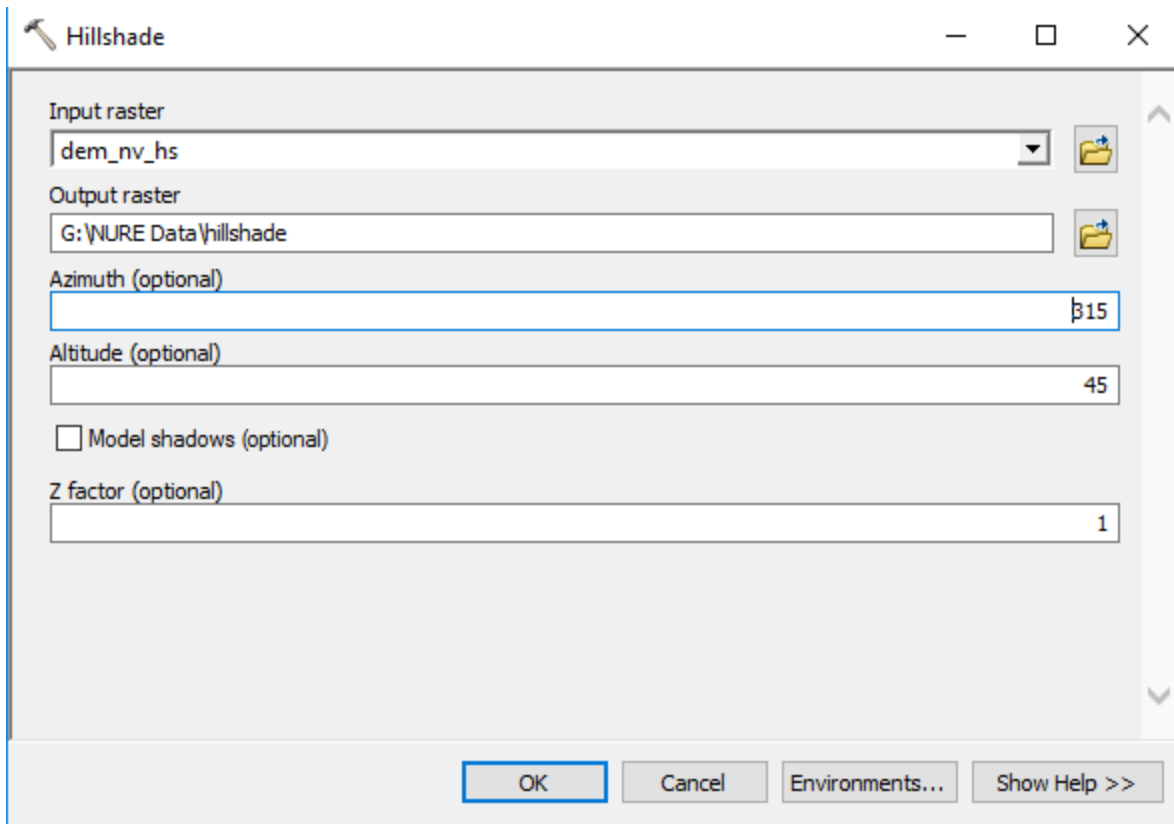
Figure 2. Hillshade tool producing a hillshade of Nevada.

To improve the readability of the map, the symbology of the layers was changed. Beginning with the NURE data, the Graduated Symbols option under the Quantities tab was selected to show different lead concentrations with different symbol sizes. "PB_PPM", which is lead concentration in parts per million, was entered into the value field to organize the data into five classes based on lead concentration, as shown in Figure 3. The larger circles represent higher concentrations of lead while the smaller circles represent lower concentrations. This makes it easier to see how lead concentrations change throughout Nevada.
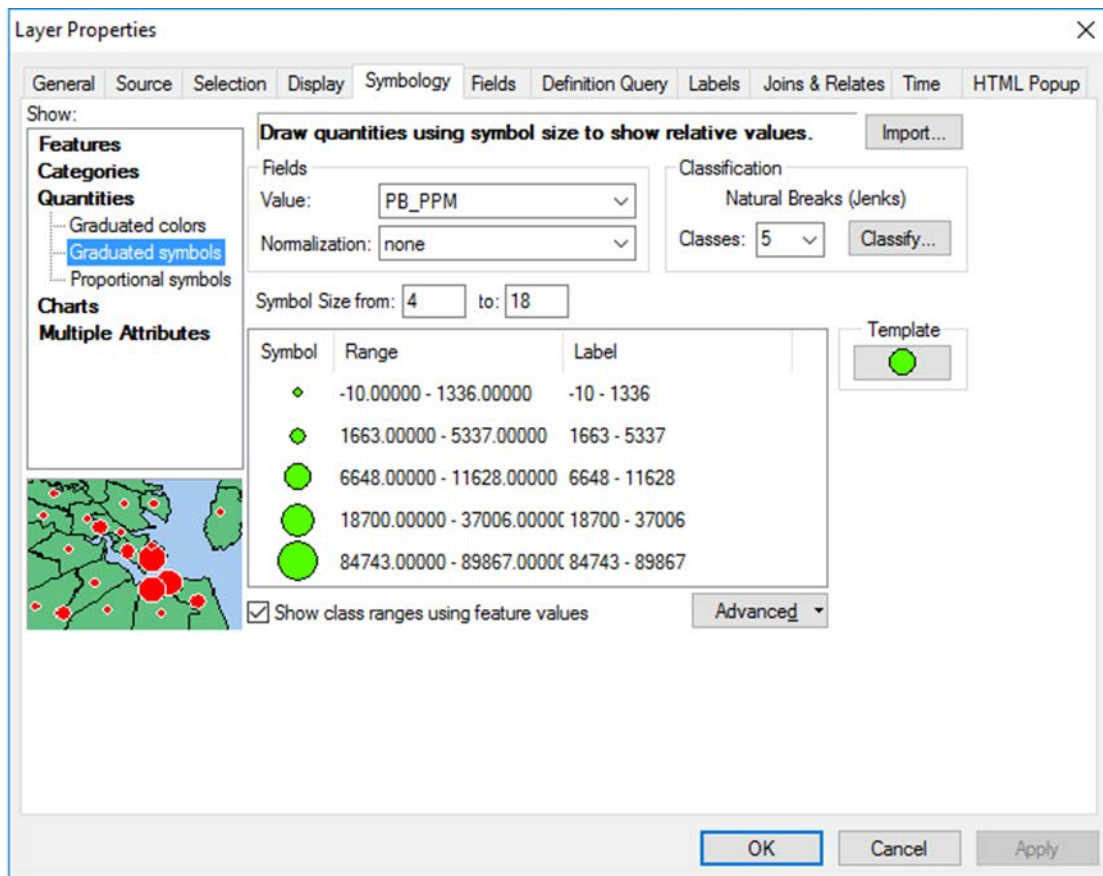
Figure 3. Symbolizing NURE data by lead concentration using graduated symbols.

To further organize the lead concentration data, values less than or equal to 1200 ppm were eliminated. This was done by entering ""PB_PPM" <=1200" into the query of the Exclusion option in the Graduated Symbols category, as shown in Figure 4. While all of the lead concentrations are still present in the attribute table, only those greater than 1200 ppm are visible on the map.
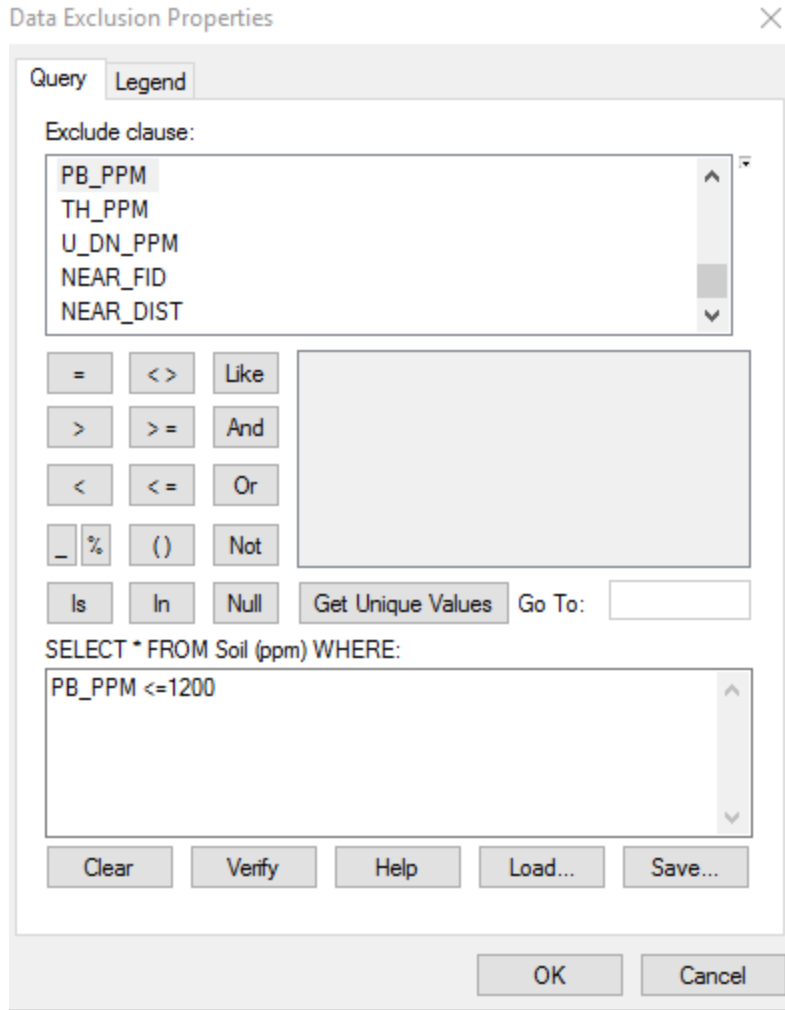
Figure 4. Exclusion option used to exclude lead concentrations less than or equal to 1200 ppm from the map.

Next, to differentiate lead mines from other mines, the mineral resource layer was symbolized by commodity to show only the mines that had lead listed under "commodity 1". This was done using the Categories tab under symbology where "commod1" was entered in the value field, as show in Figure 5. Now, only the mines that primarily produce lead are visible on the map.
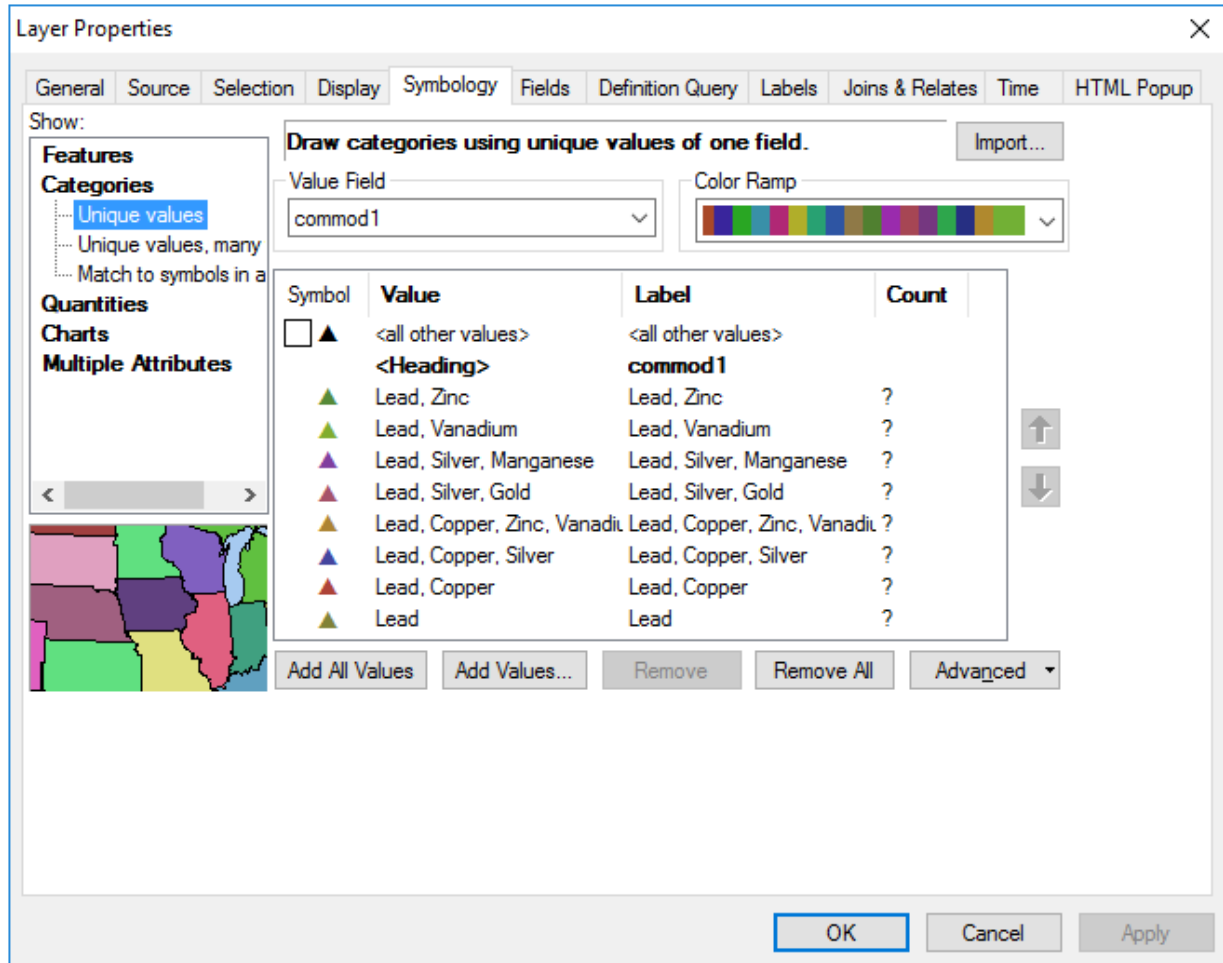
Figure 5. Selecting and symbolizing mines that have lead as commodity 1.

To help better display the drainage data, the symbology of the drainages was changed to symbolize by length. The option "Graduated Colors" under the Quantities tab was selected and "LENGTHKM" was entered in the value field. Next, a blue color scheme was selected to help with the visualization of the stream drainage areas on the map. The streams are now symbolized by their length in kilometers, divided into five classes. Originally, one of the reasons for changing the drainage symbology was to remove some of the shorter drainages to further declutter the map. However, NURE sediments were sampled on both short and long drainages so the hypothesis could not be tested if a specific drainage length was removed. Even after the change in symbology, the map was very cluttered. Therefore, three of the state's quadrangles were sampled, as shown in Figure 6, and observed at a larger scale.
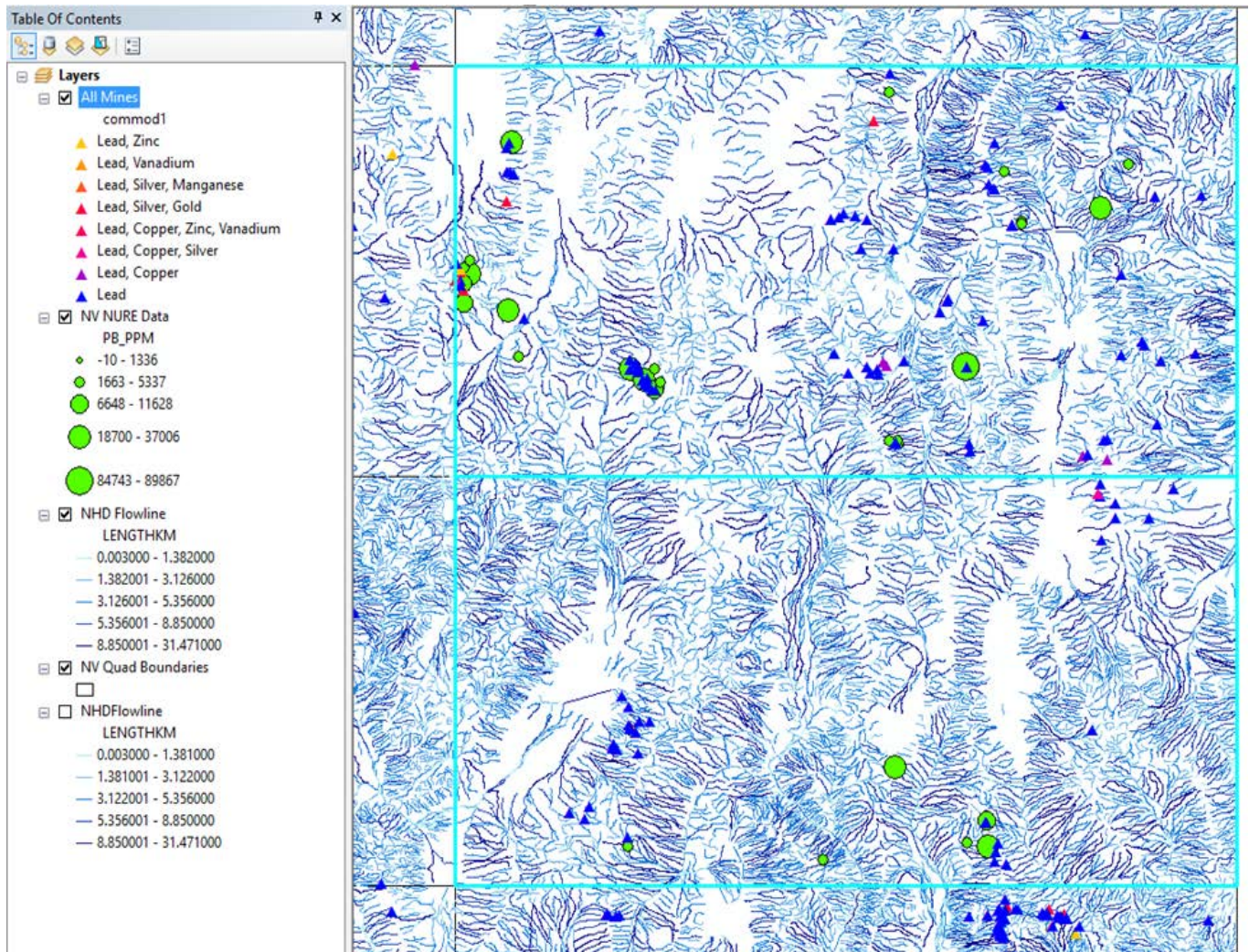
Figure 6. Selection of three quadrangles to become new area of interest.

Quadrangles 16, 20, and 24, identified using the attribute table, were selected as the area of interest. The quadrangles were exported and made into their own layer. Using the clipping tool, all of the other data layers were clipped to fit this new area of interest.

The following observations were made at the larger scale shown in Figure 6:

A. Almost all of the highest concentrations of lead are near mines that have only lead listed under Commodity 1.
B. Some mines that have lead listed under Commodity 1 are not near any high concentrations of lead.
C. Lead concentrations go from the highest range to the lowest range over a relatively short distance.

After these observations were made, it became clear that there was no trend showing a gradual decrease in lead concentration with increasing distance from a lead mine.

To further explore the data and search for other possible trends, the NURE data was separated by source. The sources of the NURE data were soil, stream, playa, volcanic, talus and other. In the attribute table, the data was selected by type, as shown in Figure 7, and each type was exported and made into its own layer.

Figure 7. Selection of samples with "soil" as the source.

Next, each layer was symbolized as before. The Graduated Symbols option under the Quantities tab was selected to show different lead concentrations with different symbol sizes. "PB_PPM" was entered into the value field to organize the data into five classes based on lead concentration. No concentrations were excluded from the map in these layers because some samples, like those with "stream" as the source, have very small concentrations. If low concentrations were to be excluded, the stream samples would not be visible on the map.

The following observations were made once the NURE data was sorted and symbolized by source:

    D. The highest concentrations of lead had either soil or "other" as the source.
    E. Stream was the most abundant source but, with the exception of a few, all of the samples were in the lowest concentration range (-10 to 17965 ppm).
    F. The points with volcanic, playa or talus as the source were sparse and in the lowest concentration range.

Figure 9 is the final map of this data.

Discussion

Observation A confirms the assumption that the highest concentrations of lead in the NURE samples are located near lead mines. Observation B is most likely due to the extent of the NURE samples and mining areas. If there are no high concentrations of lead near a known lead mine, the sediments in that area may not have been sampled by the NURE program.

Observation C disproves the idea that lead concentrations gradually decrease with distance from a lead mine. The data shows a more random distribution of lead concentrations with no clear trend. This is most likely due to the scattered locations of the mines and NURE samples. The NURE samples were not systematically taken at various distances from the lead mines, restricting the extent to which a trend can be observed or predicted. In addition, there are clusters of lead mines that interfere with identifying a change in lead concentration with distance away from other mines and cause skewed results.

Conclusion

A clear trend of gradually decreasing lead concentrations with distance from known lead mines was not observed. However, knowing lead concentrations at various locations can be used to avoid lead exposure since lead is toxic above certain concentrations. The current EPA standard considers lead concentrations in soils toxic at 1200 ppm. Figure 8 shows the locations in the area of interest where lead concentrations are above the 1200 ppm standard.

References

Smith, S.M., 1997, National Geochemical Database: Reformatted data from the National Uranium Resource Evaluation (NURE) Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) Program, Version 1.40 (2006): U.S. Geological Survey Open-File Report 97-492, WWW release only, URL: http://pubs.usgs.gov/of/1997/ofr-97-0492/index.html, accessed Nov. 28, 2016.

Figure 8. Lead concentrations above 1200 ppm.

Locations of Lead Concentrations above the EPA Standard of 1200 ppm
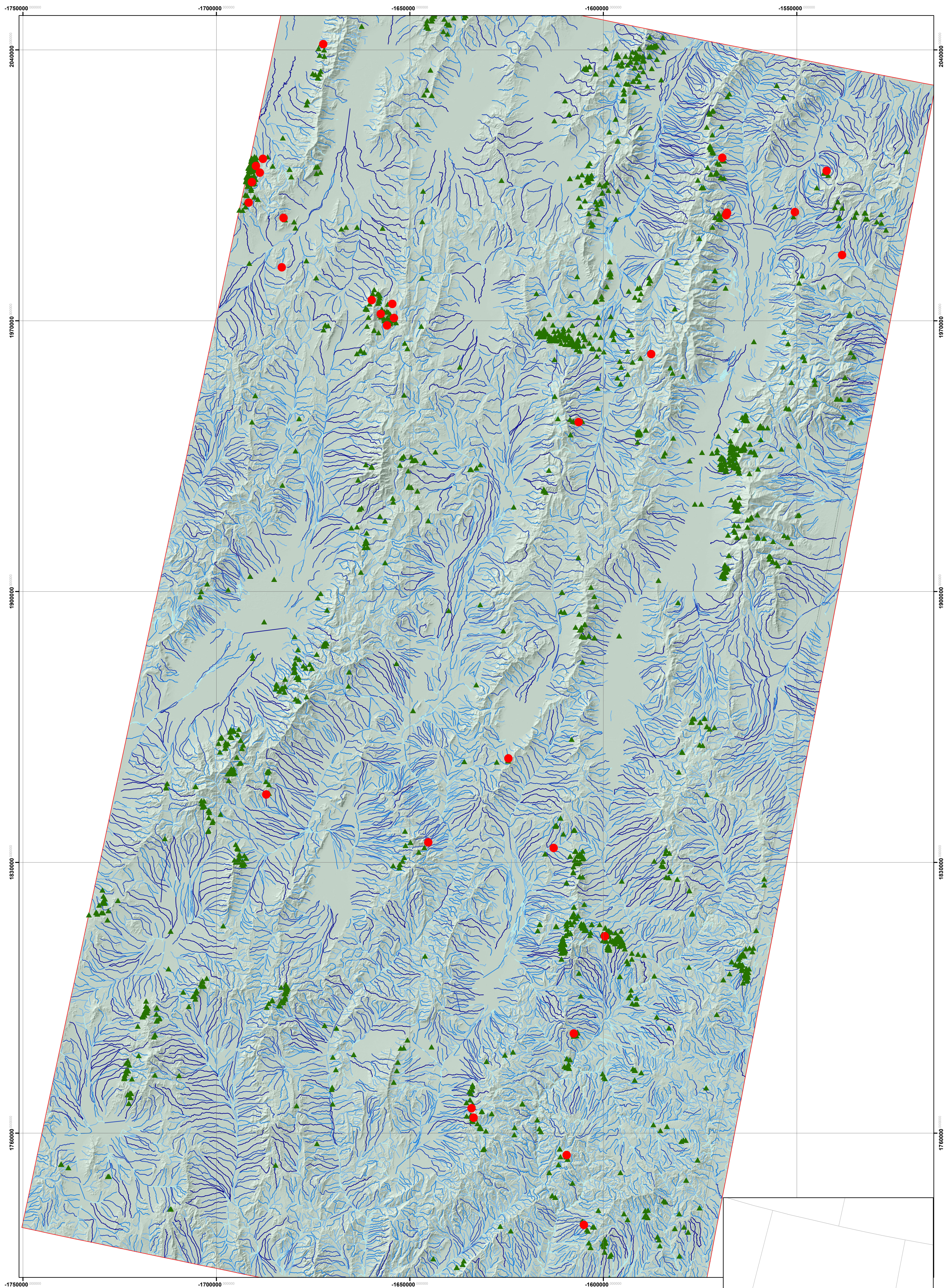
Legend

● Pb Concentrations > 1200 ppm

▲ Lead Mines

Area of Interest

Drainages by Length (Km)

— 0 - 1
— 2 - 3
— 4 - 5
— 6 - 8
— 9 - 22

0 5 10   20   30   40   50 Kilometers
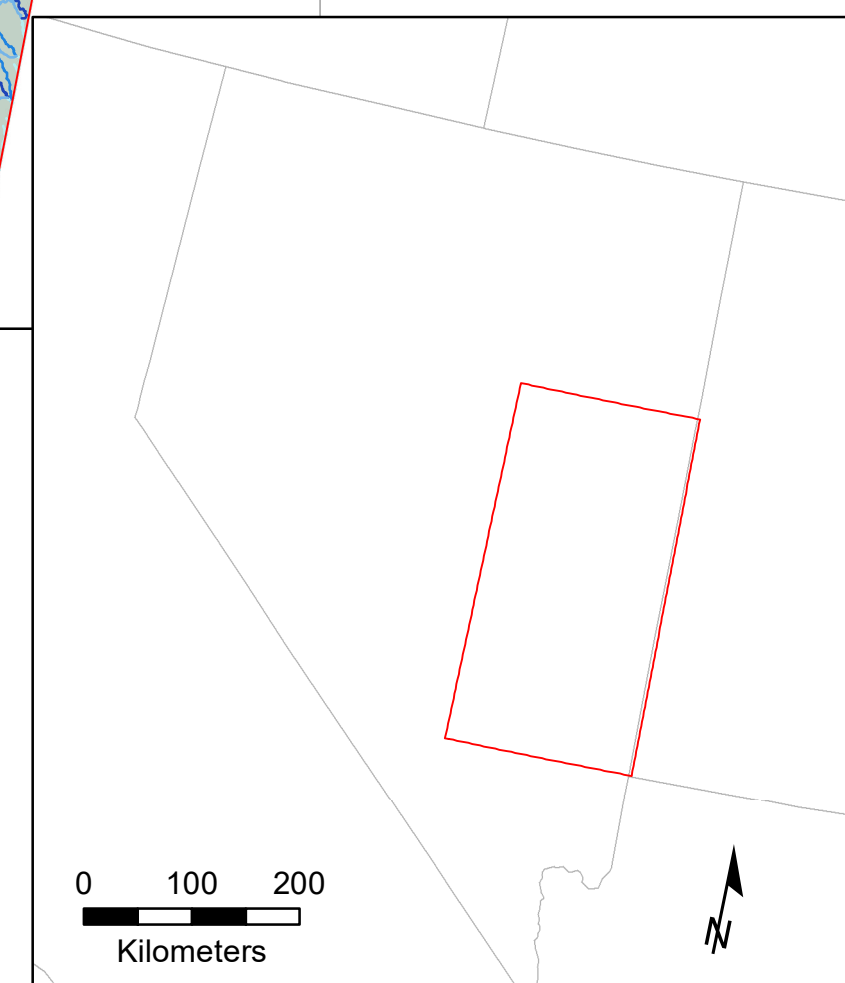
1:500,000

NAD 1983 (2011) Contiguous USA Albers
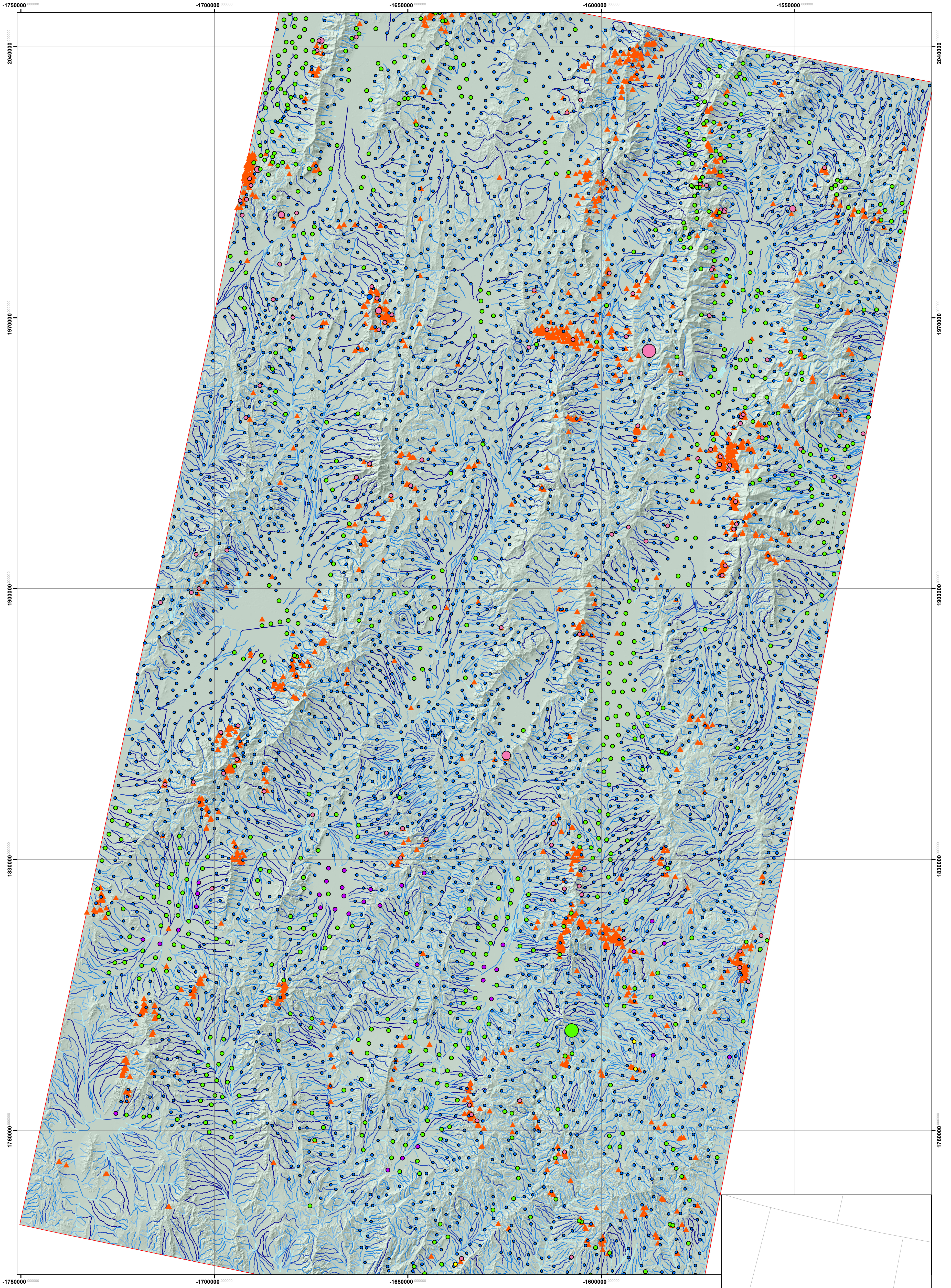
0   100   200
Kilometers

Figure 9. Lead concentration by source.

Lead Concentration by Source, Nevada

Legend

Soil (ppm)
- -10 - 17965
- 17966 - 35941
- 35942 - 53916
- 53917 - 71892
- 71893 - 89867

Volcanic **Other** **Talus** **Playa** **Stream** ▲ **Lead Mines** **Drainages by Length (Km)**

Area of Interest
- 0 - 1
- 2 - 3
- 4 - 5
- 6 - 8
- 9 - 22

0 5 10 20 30 40 50 Kilometers

1:500,000

NAD 1983 (2011) Contiguous USA Albers

0 100 200 Kilometers