This describes the GIS workflow for resurveying Patented Mining Claims.

<u>Requirements</u>:

1) Use either QGIS. This workflow used QGIS.

2) PLSS of Townships, Sections, and second level shapefiles. Set coordinates to NAD 84. The latest GIS database available as they are updated from time to time. A 2nd level shapefile from the PLSS has the 1/4 – 1/4 section digitized surveys. Also, 2nd level shapefile includes Mineral Surveys but lumps multiple claims if the Mineral Survey had several claims deeded together.

3) In a newly created line shapefile, add three fields: distance (a number), Azimuth (a number), Bearing (a string) in a shapefile. These fields will be plotted on maps for checking the accuracy of the the shapefiles, surveys, and maps.

<u>Procedure</u>:

1) Download from the GLO the Mineral re-Survey or the original Mineral Survey for the claim.

2) Find the location of the GLO claim or claims in the PLSS files loaded into QGIS.

3) Digitize the claim sides using the Bonito Peak surveys tracing the exactly the green lines. The green lines are from the 2nd level shapefiles. Digitize the lines (the claim sides and tie line) in the bearing direction of the re-survey (or Mineral Surveys) are shown on the mineral survey map from step 1. Note: Digitizing is using the shapefile and not the georeferenced paper map from step 1.

4) Calculate the azimuth using the pseudo Python code (Appendix A) which will calculate the direction of the line from 0-360 degrees. Save this information in the azimuth field of the shapefile. Digitize the claims tie line to the Mineral Location Monument if available. (See note below about grid offset).

5) Calculate the bearing using the pseudo Python code (Appendix B). The results of this step are stored in the bearing field of the shapefile. Output is of the form N-45-30-E (North-45 degrees-30 minutes East).

6) Plot the distance value and the bearing value parallel to the recently digitized claim side lines from step 3.

7) Georefernce the downloaded GLO PDF map of the claim The georeferencing does not have to be an exact scaling. The scaled PDF will be compared with the results in number 8 below.

8) Compare the plotted values from step 6 with the GLO PDF map loaded and georeferenced in step 7.

Notes and/or Problems:

1) Note that this method does not require the recalculation of the the claims boundaries from the metes and bounds survey notes or maps The method uses the existing BLM surveys in the 2nd level shapefiles rather than calculate the distance and bearing on the original Mineral Survey.

2) The re-survey is sensitive to the Grid North rotation factor. This value is the angle between the UTM grid and true north. USGS topo sheets have the grid value on the lower left corner. The Grid North value is the value at the center of the topo map. The Grid North value can be interpreted the same as Magnetic Declination. Values will have to be extrapolated between map centers. See Figure 1. Figure 2 has the extrapolated grid factors for the four quadrangle sheets in the area. North-south grid-factor zone have been further delineated. Claim groups that are re-surveyed will have a grid-factor selected from this map.

3) The elevation of the bearing line, especially at 11,000 feet above sea level make a difference. GIS and coordinate conversion assume that entire world is a smooth ellipsoid. There are no mountains or valleys and the world is assumed to be at sea level. The distance is moved from elevation to sea level and therefore the distance is shorter at sea level.   At 12,000, feet a distance of 1000 foot has a length of around 999 feet 71/2 inches. See Figure 3.

4) The lack of accurate US Mineral Location Monuments in the area. This is the source of the connecting sheet sections being off by just less that ½ mile. The USLM markers are sometimes available in the PLSS data. The BLM has had to resurvey those markers with a good GPS receiver. Using the new locations,f the claims now are placed in the correct sections.

Appendix 1

This calculates azimuth in decimal degrees. The code calculates rise over run and feeds that number into the arctan function to get a angle from 0 degrees to 360 degrees. Zero degrees is north, 90 degrees is due east, 180 is due south, and 270 degrees is due west. This code uses QGIS as the GIS software.

Two special cases are due east and due west. Each are handled because arctan fails in those two directions.

The code rounds the angle to 5 decimals for adequate precision for the next code segment in Appendix 2.

The **"+ or - Grid rotation here"** is where the value of Grid North is substituted. The Grid North value is the value from Figure 2. Use the Grid North value closest to the claims

```
case
    when yat(-1)-yat(0) < 0 or yat(-1)-yat(0) > 0 then
        round( (atan((xat(-1)-xat(0))/(yat(-1)-yat(0)))) * 180/3.14159 + "+ or - Grid rotation here"+
                (180 *
                (((yat(-1)-yat(0)) < 0) +
                (((xat(-1)-xat(0)) < 0 AND (yat(-1) - yat(0)) >0)*2)
                )),5)
    when ((yat(-1)-yat(0)) = 0 and (xat(-1) - xat(0)) >0) then 90
    when ((yat(-1)-yat(0)) = 0 and (xat(-1) - xat(0)) <0) then 270
end
```

Appendix 2

This code calculates the Azimuth in the form of **X-**dd-mm-**Y** where **X** is North for South and **Y** is East or West. The bearing quadrant is determined and N or S is determined as well as the proper E or W. From bearing decimal degrees is determined as and the minutes extracted from the degrees.

This code example uses the numeric field name “Bearing” in the shapefile to calculate the azimuth.

This code is written for QGIS software.

This code have four cases:

- The north-east quadrant where the bearing is used as is.
- The north-west quadrant where the bearing is subtracted from 360.0.
- The south-east quadrant where the bearing is subtracted from 180.0.
- The south-west quadrant where the bearing has 180 subtracted from it.

```
case
    when ((yat(-1)-yat(0)) > 0 and (xat(-1) - xat(0)) > 0) then
        concat('N-', floor("Bearing"), '-',round(("bearing"-floor("Bearing"))*60,0) , '-E')
    when ((yat(-1)-yat(0)) > 0 and (xat(-1) - xat(0)) < 0) then
        concat('N-', floor(360-"Bearing"), '-',round((360-"bearing"-floor(360-"Bearing"))*60,0) , '-W')
    when ((yat(-1)-yat(0)) < 0 and (xat(-1) - xat(0)) > 0) then
        concat('S-', floor(180-"Bearing"), '-',round(((180-"bearing")-floor(180-"Bearing"))*60,0) , '-E')
    when ((yat(-1)-yat(0)) < 0 and (xat(-1) - xat(0)) < 0) then
        concat('S-', floor("Bearing"-180), '-',round((("bearing"-180)-floor("Bearing"-180))*60,0) , '-W')
end
```

This code has a small error in the minute display, however, the angle shown is still correct. The error will show for example N-45-60-E. This angle should be N-46-0-E.

Figure 3 reference: :Lining Up Data in ArcGIS – A guide to map projections, Margaret M. Mahler, ESRI Press, pg 75.