Volume 31: Issue 3
July, 2020

LINES & POINTS

www.plsw.org

THE EQUALITY STATE SURVEYOR
PROFESSIONAL LAND SURVEYORS OF WYOMING

P.L.S.W.

President • Brad Neumiller, PLS

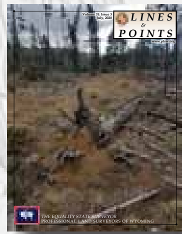
President Elect • Matt Gotham, PLS

Secretary/Treasurer • John “Jack” Studley, PLS

NSPS • Cotton Jones, PLS
Area Director

Mark Corbridge, PLS
Wyoming Delegate

On The Cover



Uprooted B.T. for W/4 of Section 28. (Figure 8)

Photo by Mike Jackson

CONTENTS

Publications Committee

2020 PLSW SUSTAINING MEMBERS

- •Jason Dysthe - Frontier Precision Inc.
- •John Baffert - Surv-KAP, LLC
- •Chris Farnsworth - RDO Integrated Controls
- •Kelly Goff - Underground Consulting Solutions
- •Susan Hall - Trimble
- •Tim Klaben - Berntsen International Inc.
- •Troy Langston - Monsen Engineering

PLSW (Professional Land Surveyors of Wyoming; PO Box 8, Cheyenne, WY 82003) is a statewide organization of Land Surveyors registered to practice in the Equality State of Wyoming. PLSW is dedicated to improving the technical, legal, and business aspects of surveying in the State of Wyoming. PLSW is affiliated with the National Society of Professional Surveyors (NSPS) and the Western Federation of Professional Land Surveyors (WestFed).

Lines and Points is published by the Professional Land Surveyors of Wyoming. Lines and Points is not copyrighted and permission is hereby granted to reprint articles with appropriate credit. The Professional Land Surveyors of Wyoming assume no responsibility for statements made or opinions expressed in this publication. The articles and opinions as put forth in this journal are not necessarily those of PLSW or the Editorial staff of this journal.

Advertising Information

Digital-ready, full-color advertising with payment should be mailed to Lines & Points, P.O. Box 8, Cheyenne, WY 82003.

Advertising rates are as follows:	Year	Issue
Full Page	$810	$210
Half Page	$540	$140
Quarter Page	$310	$80
Business Card	$40	$10
Employment	Free	Free

Special Rates apply for PLSW Chapters and cover placements.

For more information please contact Jack Studley.

PRESIDENT'S MESSAGE

Hello Everyone,

With the summer upon us I hope you are all enjoying the outdoors and finding corners all across the state. Hopefully your chapters are still able to get together at this point as we have all had a rocky start to the year. COVID is still here and affecting everything we around us still at this point and I am not sure that will change any time soon. However things are moving forward and so should the things we are doing. The Field book archive project is up and moving and they are scanning and archiving as they get time. This project could be a great benefit to all the membership being able to access those old field notes and retrace what has been done in the past. If you want more information on this please let us know.

The board has had several discussions concerning the fall tech session, WES format, and how this year will progress. At this point we will be hiring a speaker for the WES convention and are looking at getting more CEU's at that venue. The board has approved to hire the speaker this year at no cost to the membership. We will still be holding a Board of Directors meeting at WES but the annual meeting will not be held there as we are moving it to the fall tech Session Lunch hour. We are looking at how we could recoup funds from the WES Sessions if we continue this format in the future. This will allow for the same 12 credits at the Fall Tech Session and the Annual meeting to have a full Quorum. So at fall tech we will no longer have a board of directors meeting Thursday evening, instead we will hold that meeting a week prior or a week after. It is our hope to create a format that will be maintainable going forward and allow more and better education for the membership. With all of these changes the officers will stay in place until the Annual meeting of 2021 at the fall tech session. If you have any ideas or suggestions I urge you to please contact the Director of your chapter or myself.

I hope you all enjoy the rest of your summer!

Brad Neumiller, PLS

President - Prefessional Land Surveyors of Wyoming

P.S. Just keep looking that stone is here somewhere!

Lines and Points Article Rotation Submission Schedule By Chapter

Responsible Chapter	First Call Date	Last Call Date	Publication Date
West Chapter	THANK YOU!! (SEE "*FIELD NOTES & HIGH RES PHOTOGRAPHY*" IN THIS ISSUE)		
Central Chapter	September 1	September 15	October 1, 2020
South Central Chapter	December 1	December 15, 2020	January 1, 2021
Southeast Chapter	March 1	March 15	April 1, 2021
Upper Platte Chapter	June 1	June 15	July 1, 2021
Southwest Chapter	September 1	September 15	October 1, 2021
Northeast Chapter	December 1	December 15, 2021	January 1, 2022

FIELD NOTES & HIGH RESOLUTION PHOTOGRAPHY

-A POWERFUL COMBINATION FOR THE MODERN DAY SURVEYOR-

By: Mike Jackson, PELS

The first 7 miles of Skyline Drive had just been reconstructed through a cooperative effort between Sublette County and the Central Federal Lands Highway Division (CFLHD). This scenic route was initially constructed by the Civil Conservation Corps (CCC) in the 1930's and begins near the southeastern shores of Fremont Lake. The road winds its way up to Elkhart Park at an elevation of 9,350 feet, a popular trail head for access into the Wind River Mountains in Sublette County. Following Phase I of road reconstruction in 2017, our team was tasked with creating a right-of-way legal description, survey map, and related documentation for final acceptance as a county road.

The subject portion of Skyline Drive traverses three townships; T34N-R109W, T34N-R108W, and T35N-R108W. As a customary practice, corner record research was initially performed for all encumbered sections at the County Clerk's Office. Extensive monumentation had been previously reported in T34N-R108W and T34N-R109W, however, little information was found pertinent to T35N-R108W. The lack of corner records in this township was not surprising due to the fact that the entirety of T35N-R108W is located within the Bridger National Forest, containing no patents. Subsequently, we gathered GLO and BLM records prior to setting out to locate pertinent PLSS corners for our use in completing the legal descriptions and mapping product.

HISTORY

This story specifically deals with the township boundary line between T34N-R108W and T35N-R108W. The chronological history of the PLSS survey is as follows:

1889: The south and west boundary lines of T34N-R108W are originally surveyed by Franklin O. Sawin under contract dated May 13, 1889. Mr. Sawin also completed a partial subdivision of the township. Notably, the SE/4 of Section 6 and the SW/4 of Section 5 are surveyed. The remaining parts of each referenced section remain unsurveyed.

1896: The west, east, and south boundaries of T35N-R108W are originally surveyed by Benjamin A. Hart under contract, dated May 23, 1896. Mr. Hart also performed a partial subdivision of the township.

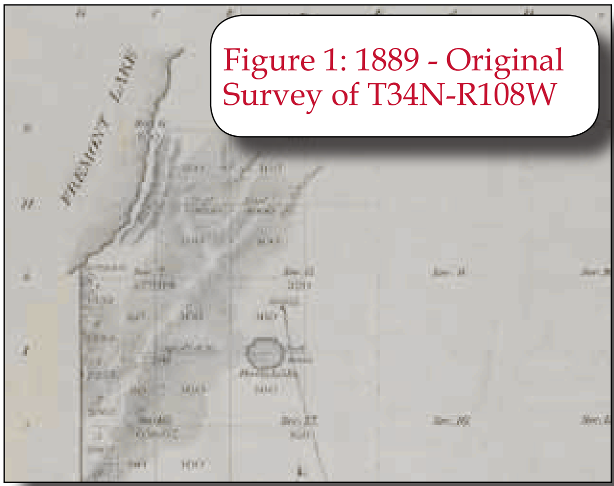


Figure 1: 1889 - Original Survey of T34N-R108W

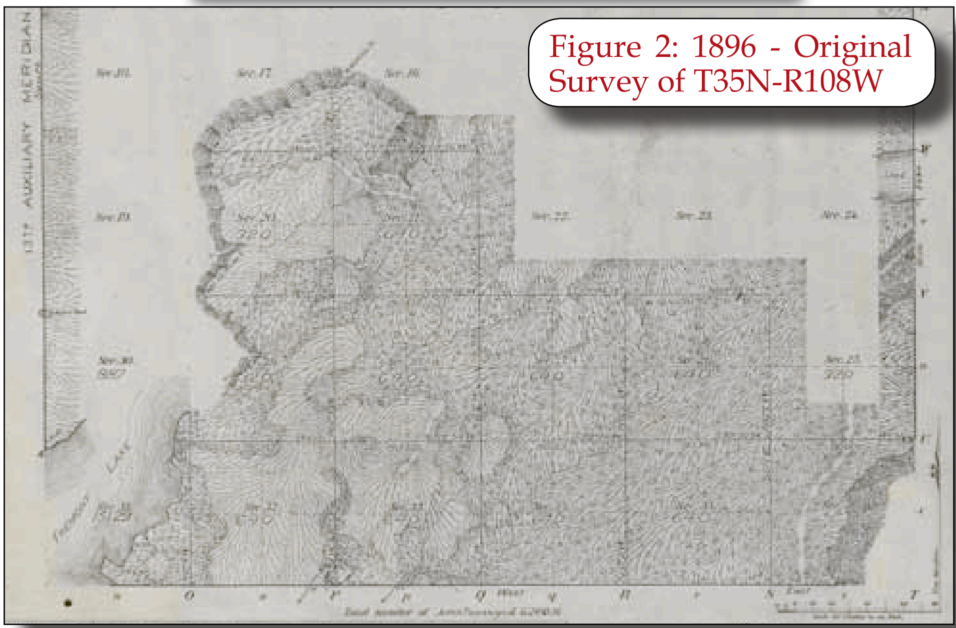


Figure 2: 1896 - Original Survey of T35N-R108W

1917: Hans D. Voigt performs a resurvey of the north boundary line of T34N-R108W and completes the retracement and resurvey for fractional subdivision under contract, dated January 29, 1917. Note that the remaining portions of Section 5 and Section 6 are surveyed at this time.

1962: Andrew Nelson remonumented certain corners within T34N-R108W under special instructions dated May 11, 1959.

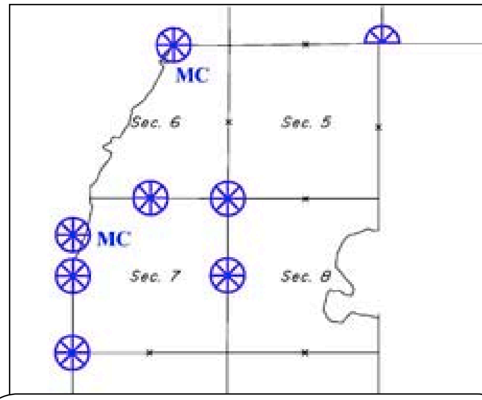


Figure 4: 1962 –BLM Index to Corner Remonumentation without Survey (T34N-R108W)

Figure 3: 1917 - Retracement, Resurvey, & Fractional Subdivision of T34N-R108W

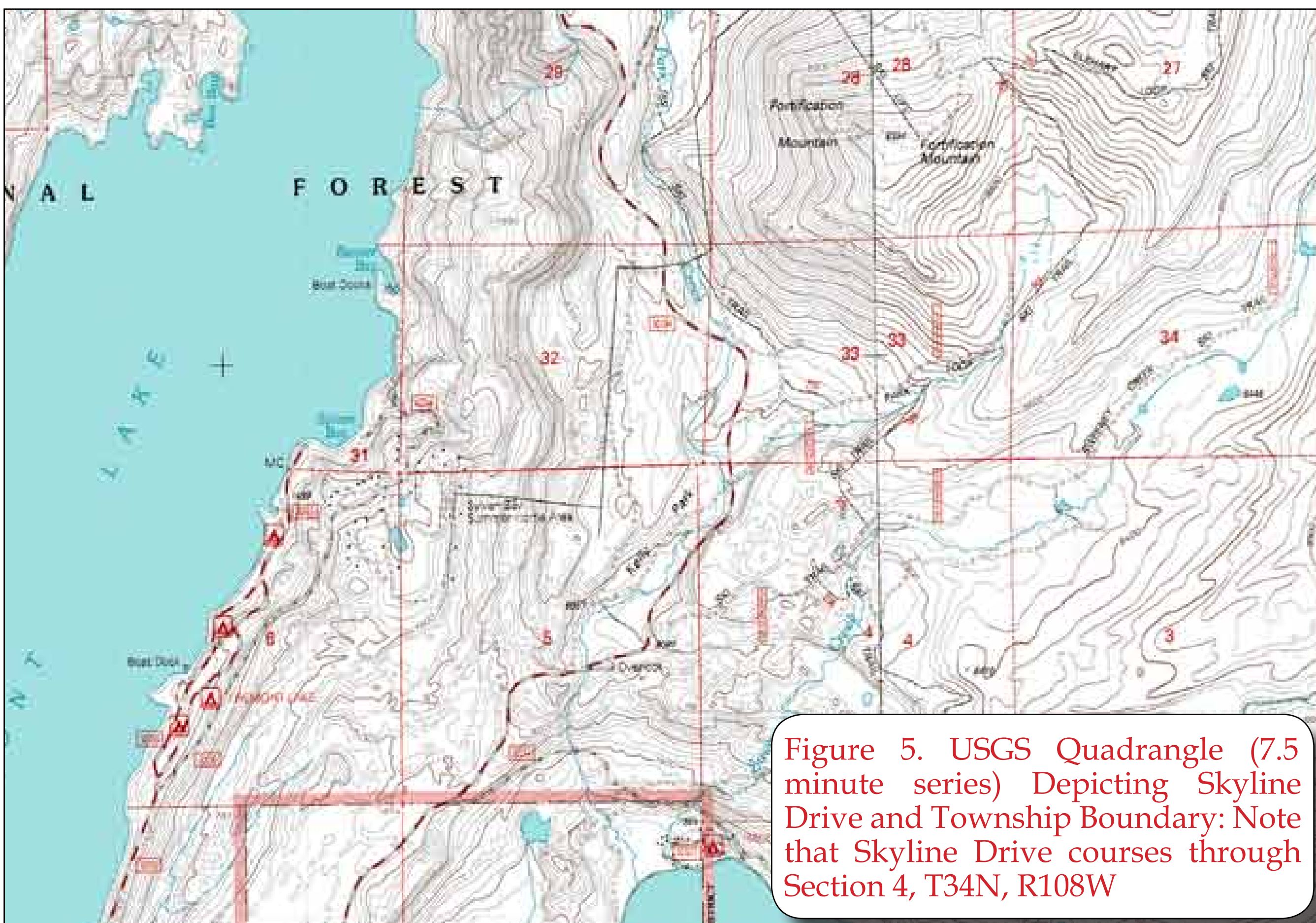


Figure 5. USGS Quadrangle (7.5 minute series) Depicting Skyline Drive and Township Boundary: Note that Skyline Drive courses through Section 4, T34N, R108W

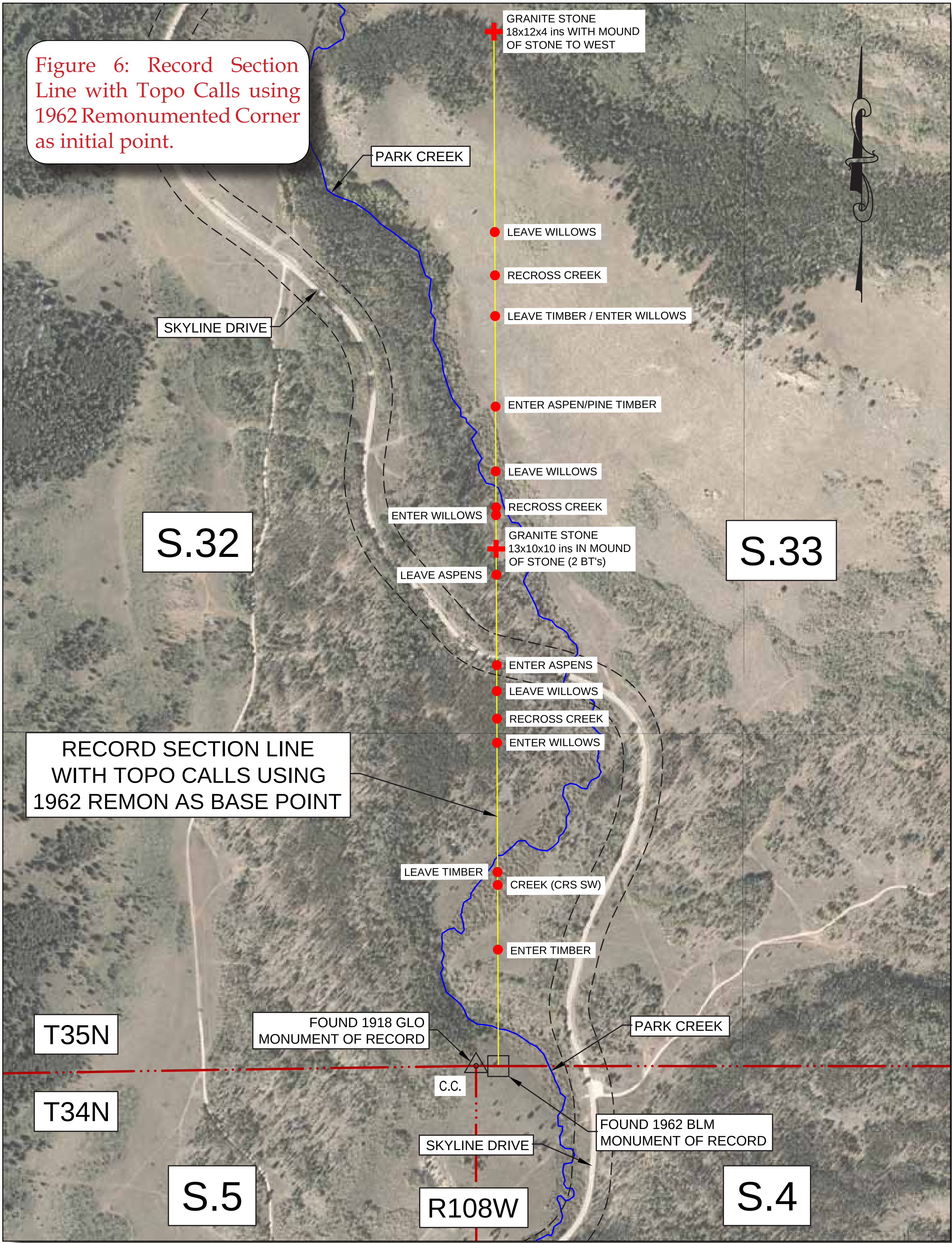


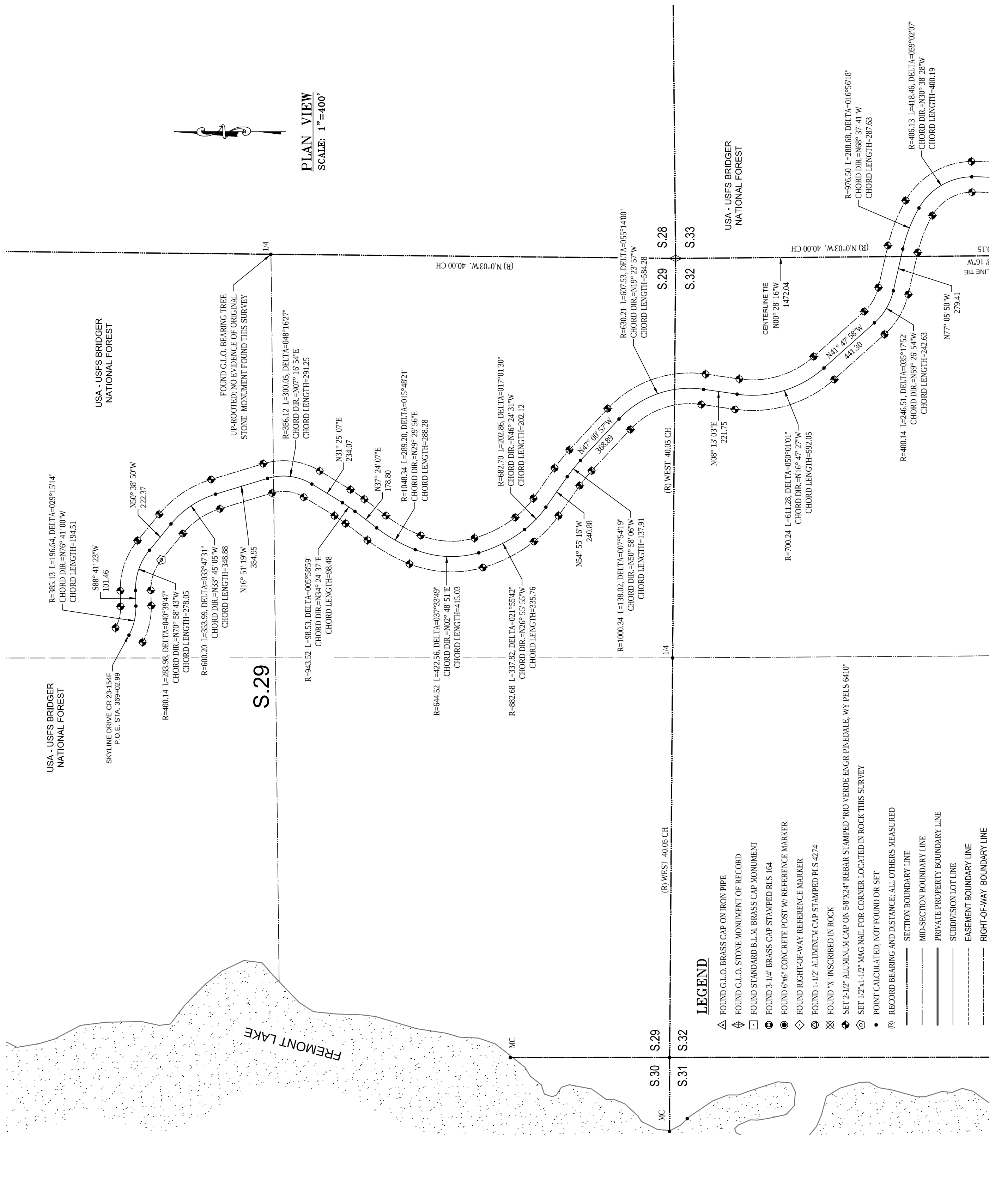
Figure 6: Record Section Line with Topo Calls using 1962 Remonumented Corner as initial point.

THE SURVEY

We began the project by working south to north through T34N-R108W. We were successful in locating every record monument we looked for, generally consisting of brass caps on iron pipe. In our quest to identify aliquot parts and to determine centerline ties, our crew continued northward into Section 5 and located all monuments set by Hans D. Voigt in 1918, as well as the remonumented southwest corner of Section 33.

Prepared with field notes and staking points (based on the recovered monuments along the township boundary line), we began surveying into T35N-R108W. Our initial search for the Benjamin A. Hart monuments yielded nothing. Based on our staking data and record distances, no evidence of monuments, accessories, or bearing trees were found. At this point, I double-checked the record distances and associated staking data. With no apparent blunders in the calculations, I decided to draw the record sections (Sections 32 and 33, T35N-R108W) utilizing the 1896 field notes and included topo call locations along each respective line. I figured I could use the distinguished geographic features in the area to get us back on track.

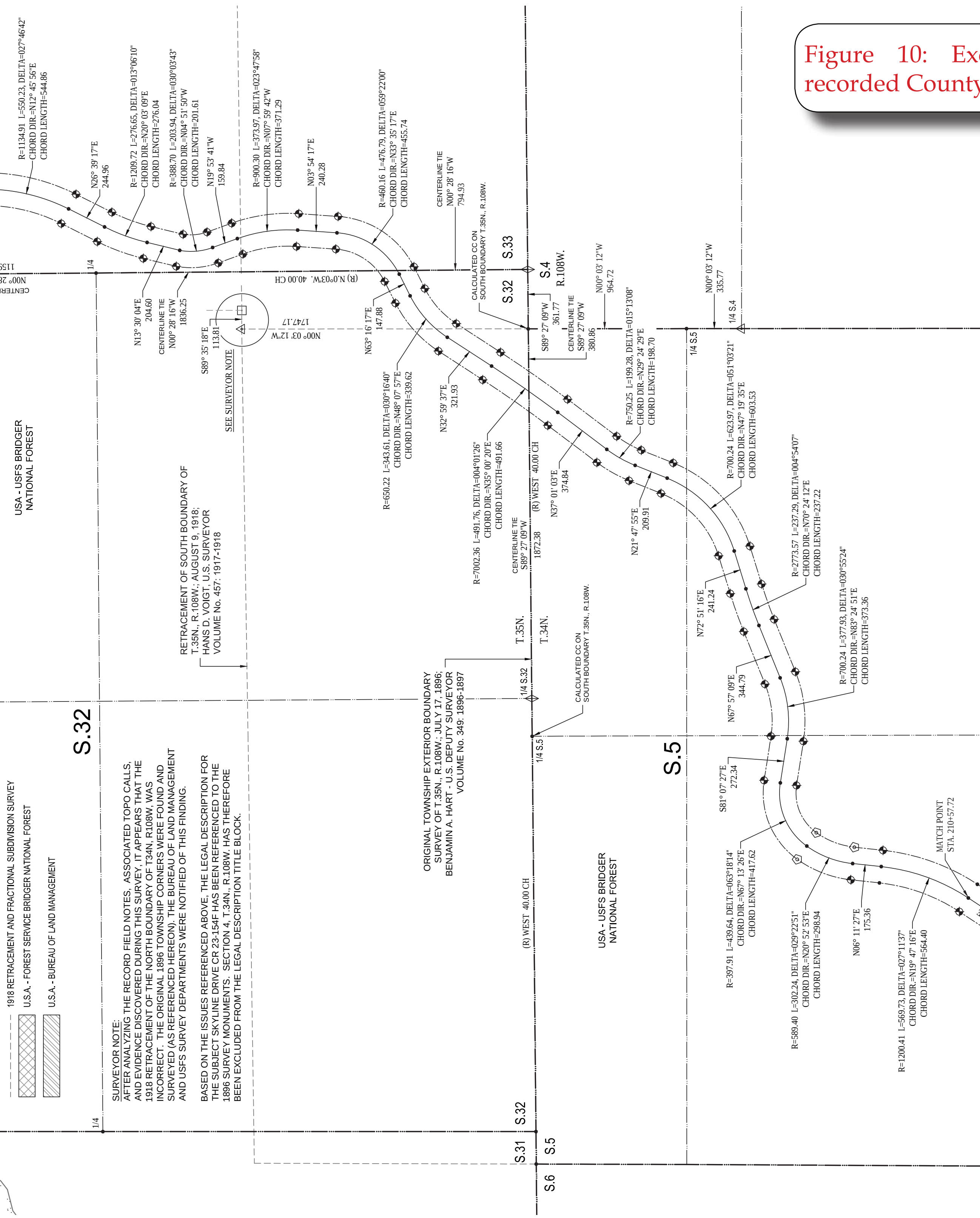
Initially, I used the southwest corner of Section 33, T35N-R108W (1962 remonumentation) as our initial point for staking calculations. After overlaying the record line run by Benjamin A. Hart in 1896, complete with topo calls and relative chainage, I noticed that the aerial photography grossly mismatched the reported field notes. There were 15 individual topo calls made between the southwest and northwest corners of said Section 33, including creek crossings, willow entry/exits, aspen entry/exits, and timber entry/exits. In this 80 chain distance, the field notes indicated that the



RIO VERDE ENGINEERING
PINEDALE, WYOMING
(307) 367-2826
FAX# (307)-367-2546

DRAWN BY: MTJ NOVEMBER 5, 2018 JOB NO. 3567

Figure 10: Excerpt from recorded County Road plat.



MAP OF

SKYLINE DRIVE COUNTY ROAD No. 23–154F

LOCATED IN

SECTIONS 13, 24, & 25, T.34N., R.109W.,
SECTIONS 5, 7, 8, & 18, T.34N., R.108W., AND
SECTIONS 29, 32, & 33, T.35N., R.108W.,
6th P.M., SUBLETTE COUNTY, WYOMING

SHEET 3 OF 3

surveyors crossed the creek (now known as Park Creek) a total of four times. The aerial underlay showed that the section line only crossed the creek three times and none of the willow, aspen, and timber calls were matching either (see Figure 6).

Going back and forth between the 1896 and 1918 field notes and survey maps, I tried to reason why the topo calls weren't correlating with the aerials. After all, Voigt's field notes indicated that he had found the original Hart monuments of record. I finally decided to deviate from holding the initial point at the recovered southwest corner of Section 33. Instead, I attempted to match the record line and topo calls with the aerial photograph underlay. After about 15 minutes, I found what appeared to be a harmonious match between the 15 topo calls and the aerial. The only issue……I had to shift the line off of the initial point approximately 1,760 feet in a S-S-E direction to get there. At this point, we were grasping for straws so I recalculated the staking points from this apparently random position and set out for another monument search in T35N-R108W (see Figure 7)

We started by searching for the northwest corner of Section 33 on an open sage brush hillside. Immediately, we found a well set stone with deteriorated markings 18 feet from our staking point. From this position, we worked south 40 chains and searched for the ¼ corner. After a thorough investigation, we did not find the monument. The field notes indicated that the original granite stone monument was set on solid rock and encircled with a mound of stone. Because the search area was located in the vicinity of a historic camping site, we theorized that the nicely piled mound of stones may have found themselves repurposed for a campfire ring. We then continued south another 40 chains and found a well set granite stone, complete with notches, and the accessory mound of stone alongside for the "true" southwest corner of Section 33. At this point in time, we were pretty excited about the success we were having. We then proceeded west along the township boundary line and found evidence of the original S1/4 corner of Section 32. Eventually, we also discovered remnants of one of the original bearing trees at the W/4 corner of Section 28 (see Figure 8 on the cover and Figure 9), northerly 40 chains, plus or minus, from the northwest corner of Section 33 we had previously found.

RESOLUTION

Based on this compelling evidence, I was confident that we had identified the true township boundary, originally established by Benjamin A. Hart. Understanding that both sets of monuments (1896 and 1918) created a substantial overlap, I put a call into Pat Factor, Land Surveyor for the Bridger-Teton National Forest at the time (and fellow West Chapter member), to explain our situation. After reviewing several exhibits I emailed to her, she agreed that we were onto something and advised me that we should contact Olian Shockley, Land Surveyor for the Bureau of Land Management.

As depicted in Figure 10, Skyline Drive does not enter Section 4 if the 1896 monuments are accepted as controlling the township boundary. Alternatively, the opposite is true if the 1918 monuments are accepted. This was a point of particular interest to me, due to the fact that the legal description and county road plat needed to accurately identify all quarter-quarters that would be traversed by the roadway. After speaking with Mr. Shockley, he agreed to perform an independent investigation of the situation on the ground. The information he gathered during that site visit agreed with our

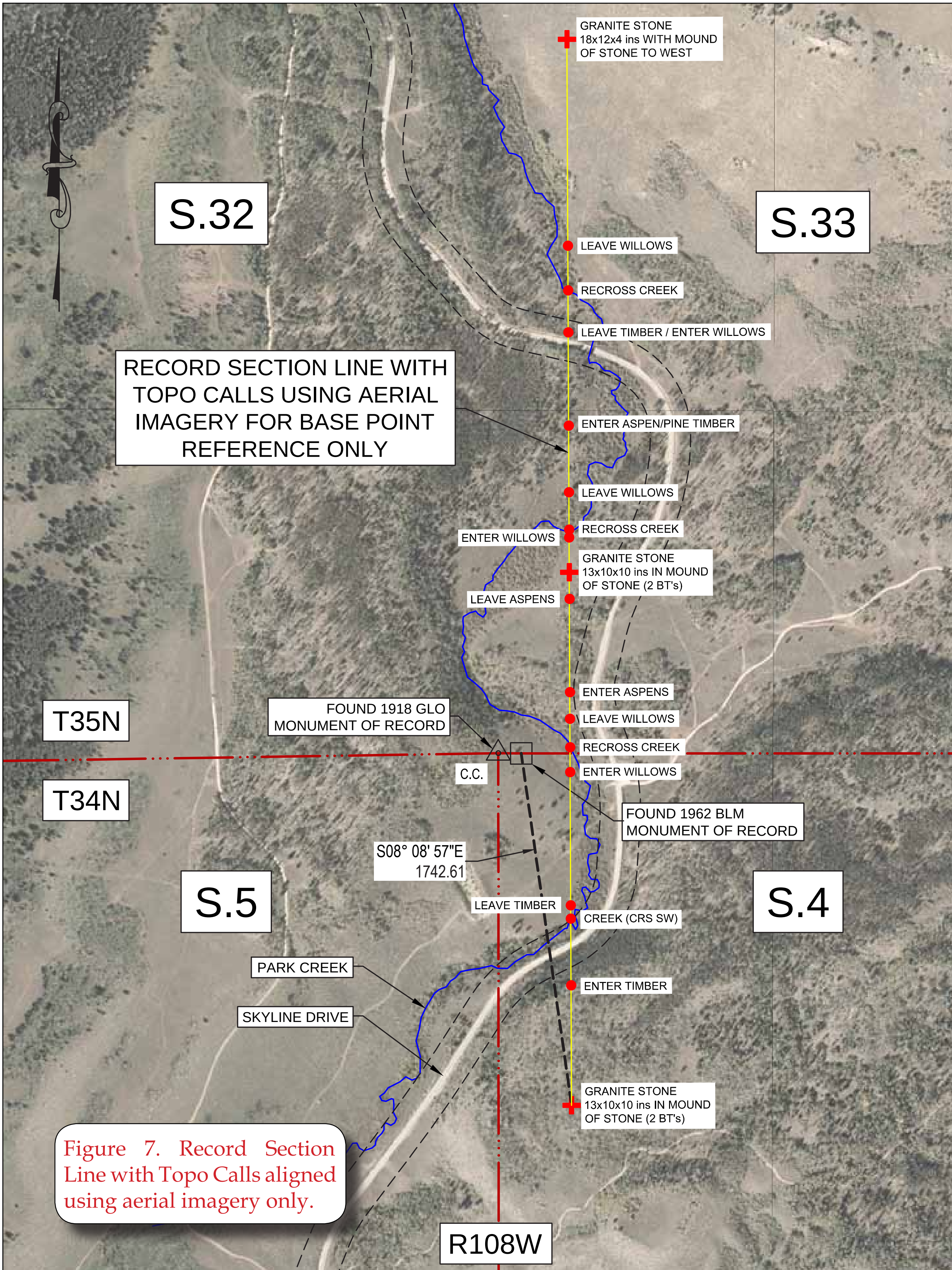


Figure 7. Record Section Line with Topo Calls aligned using aerial imagery only.

findings and after some back and forth dialogue, it was decided by all parties involved, that the plat and legal description should clearly indicate which monuments were found and to what extent each monument controlled. This issue was also presented at one of our regularly scheduled PLSW West Chapter meetings where discussions were held. Comments and opinions offered during that meeting proved to be valuable in deciding how to proceed with the platting of Skyline County Road.

Based on the evidence discovered, we elected to accept the original 1896 monuments set by Hart to prepare the plat and legal description. A surveyor note was included on the face of the plat describing the unique circumstances and evidence found in the field. Additionally, reference ties to the 1918 retracement monuments set by Voigt were also included. Section 4 was therefore excluded from the legal description. Because no private lands currently exist in the referenced township and due to an extensive backlog, it is unlikely that corrective measures will take place on the federal level, at least in the near future.

CLOSING

The tools available to us in this modern day era are vast. The use of aerial photography allows us to easily manipulate stake out data and to review calls made by the original surveyor. Without such tools, in reference to this particular project, it would have been very difficult and time consuming for a surveyor to correlate existing geographic features with the calls made in the original field notes. We normally expect error, but 1,760 feet is out of the ordinary. I am positive that many of you in our field have found success using similar methods and techniques. It just goes to show how this great profession continues to evolve.

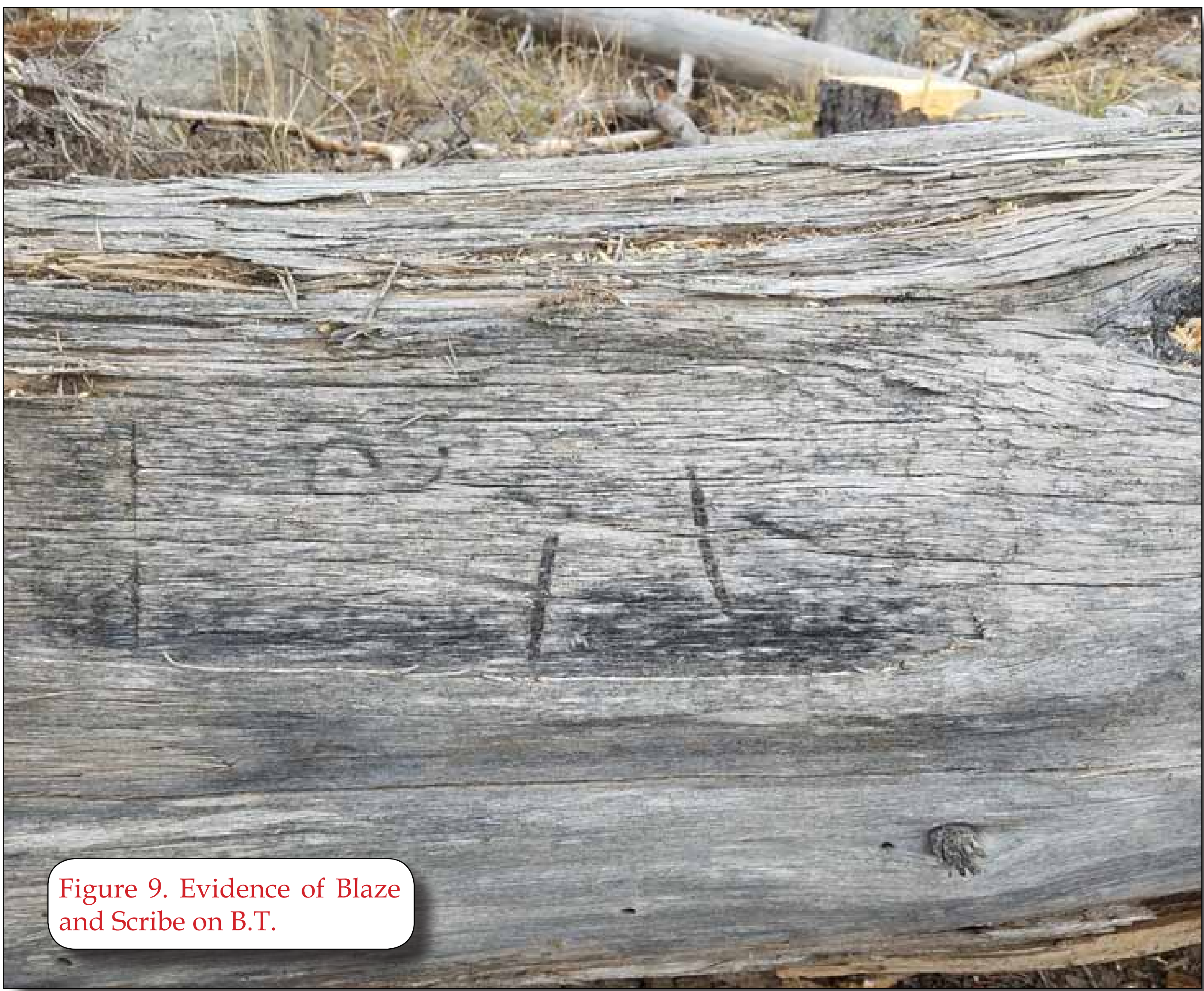


Figure 9. Evidence of Blaze and Scribe on B.T.

A Primer on Transformations and Interpolation Algorithms

by: Herbert W. Stoughton, PhD, PELS, CP

Introduction

There are numerous procedures, techniques, and algorithms available to compute information at specific "locations" which do not have actual/observed values, but are surrounded with values in two-dimensional or three-dimensional space, which hopefully could provide estimated values that "closely" approximate the true value, or nearly the true value, so as to provide an accurate solution. All approaches are only as reliable as the quality of the original data set(s) available to compute the estimated value of the unknown data point. Recall the old computer adage: "Garbage in - garbage out!" In many instances, the old data set may have been compiled from existing data bases, and in many instances these have unknown or uncertain accuracy and precision evaluations for each data point/set. Later, when it is desired to transform these data sets to an upgraded data base, someone is assigned to review the requisite information, which will be a subset of the data points to provide the data for transforming the original data set and, hopefully, not degrade the new data set. In most cases, the quality of the required information desired is considerably better than the quality of the original data set. This causes problems when producing a set of transformation coefficients/information for or at each of the common points. Then, we shall probably find significantly different "shifts". Therefore, to find a "friendly" set of transformation coefficients, which are compatible for the entire data set (or a significant region/area of the data set), requires a subset which covers the entire area of the original data set and, at least, two times the minimum number of points required for a unique solution. The quantity "two times" is not a specific quantity, but is based on personal experience. After the data set coefficients have been computed by a least squares adjustment, inspection of the residuals is required to determine if any of the residuals are numerically large (outliers). Usually, the first (trial) adjustment assumes equal (unit) weights. If one or two data points exhibit abnormal residuals, these points are removed from the adjustment, and the unit weight adjustment is recomputed. When performing these computations, it is often difficult to assign realistic weights for individual data points in the old data set, because most of the estimates of data precision required for weighting are not available. Hopefully, the new data subset is more consistent with respect to accuracy and precision in the data collection. If this is the case, then outliers identified in the adjustment residuals will probably be associated with the points' accuracy and precision in the old data set. If both data sets are older and lacking quality precision information for weighting, then the pool (number) of information for points common in both data bases should be 2.5 or 3 times the minimum required (a personal insight). Unfortunately, there has been relatively little published addressing this aspect of developing suitable transformation coefficients.

The value of a transformation is only as good as the selected transformation function (sensitivity) and the values of the computed coefficient set for that transformation function(s). In many instances there are several transfer functions which would "address" the problem. As will be indicated later herein, some of these transformation functions are unwieldy and uneconomical to utilize. Another problem is that there may be no viable computer software/algorithm available to address the problem.

Following is a brief resume of various types of interpolation and/or transformation functions which have been employed in the past two centuries.

Functions and Programs

1. Two-Dimensional Linear. Sometimes called a profile interpolation. This process requires a series of either equally or irregularly spaced points along the curve or function. Depending upon a number of points, a multi-term polynomial or Fourier Series may mathematically "describe" the curve. The most common usage is to obtain values of the function between published entries in tables. For instance, this interpolation is used in tables of trigonometry, logarithms, and "coordinate projections. Also, this procedure is employed for "profile" depictions.

2. Two-Dimensional Planar, Type I. This is sometimes called a planar interpolation. Data points with specific coordinate positions are plotted on a plane. The most common usage is a topographic survey (stadia - transit, GPS topographic point positioning, etc.). Straight lines connect these data points, and a linear profile interpolation is computed. Then contours for constant value (elevation or gravimetric anomalies) are estimated.

3. Two-Dimensional Planar, Type II. A "map" of points with known positions are plotted. Then an orthogonal grid is superimposed. The grid is usually square, but could be rectangular. The values of data are linearly interpolated and used for modeling. The most common format is to actually lay out the grid and actually observe (collect) data at the grid corners. When information is required for an interior point, a pair of orthogonal lines parallel to the sides of the grid are drawn with their intersection being at the desired point. Then, a linear interpolation is done on each side of the grid between corners. After these four points have been determined, a linear interpolation is performed along the orthogonal lines to the point of intersection. Common usage for this procedure has been borrow pits mapping and areal grading. Before the advent of GPS, this procedure was employed to determine the geodetic position for points on USGS topographic quads, particularly when determining latitude/longitude positions of the theodolite used for astronomic azimuth determinations.

4. Conformal Coordinate Transformation, Type I. This transformation is sometimes called the three parameter transformation. In this instance, the two reference systems (orthogonal coordinate axes) are parallel to each other. Then the transformation is simply a linear "shift" in three-dimensional space.

5. Conformal Coordinate Transformation, Type II. This transformation is sometimes called a six parameter transformation. A set of data points in one reference system with a finite subset of these points in a second system, requires all the points be transformed to the second reference system. The six parameters are three orthogonal linear translation and three rotation elements. It is required to find coefficients for the linear translation and rotation between the two systems. A minimum of six data points must be common

in both systems. However, as indicated above, more points are desirable, because of the possible uncertainty of the available information. If more than the minimum number of points are available, a simultaneous least squares adjustment is performed to determine the most probable set of coefficients. Then, inspection of the residuals will identify outliers, which can be removed to improve this transformation function. This procedure was frequently used in analytical photogrammetry.

6. Conformal Coordinate Transformation, Type III. This transformation is an expansion of the Conformal Coordinate Transformation, Type II, except that an additional parameter has been added. Therefore, it is sometimes called a Seven Parameter Transformation. The seventh parameter is called linear / scale, or simply scale. This transformation adequately addresses the problem of the data points being transformed between two systems whose linear "scale" dimensions are not equal. For instance one system may be in feet and the second in meters. Or there are two different definitions of the meter or foot units. Another example is when the two systems are on different conformal map projections which have two different scale factors.

7. Mather Transformation. This special transformation was proposed by R.S. Mather and utilizes geo-center motion. It introduces the factors of tectonic plate motion (continental drift), isostatic rebound, subsidence, and temporal motions. As indicated by the geophysical factors, this transformation is dedicated to measuring geophysical phenomena, usually encompassing sizeable land areas.

8. Kringing. This procedure is a method to build a two-dimensional or three-dimensional function from a set of finite points. The original applications were in geo-statistics. The procedure is now widely used in the domain of spatial analysis. The transformation/interpolation function is also know as: Gaussian Process Regression, Kolmogorov Wiener Prediction, and Best Linear Unbiased Prediction. [For additional information go to Wikipedia - "kringing". This reference is not for those who have little or no calculus.]

9. Kalman Filtering. The process has been used in continuing operating navigation systems. The procedure takes the "best" information available to initialize (the position). As new data/observations are collected from the sensors, the procedure updates the results. One author has stated that the process is a recursive solution

to Carl Friedrich Gauss's original least squares problem. The process can accommodate input and output observed data from multiple sensors, and through a data processing algorithm, filters, smooths, and/or predicts, information (real time or near real time solutions). One of the major applications is in inertial navigation systems (both marine and aerial).

10. Bursa - Wolf Transformation. A seven parameter transformation - three linear translation parameters, three rotation parameters, and the scale parameter. It is very similar to the Conformal Coordinate Transformation, Type III, but does not enforce the condition of conformality. M. Bursa (Czechoslovakia) and Helmut Wolf (Germany) collaborated in devising this transformation. It is one of the most popular transformation algorithms available, because of its simplicity.

11. Co-location (or Collocation). This is considered the most inclusive transformation procedure. It permits inclusion of not only position, rotational, and scalar parameters, but gravimetric and other geophysical parameters. Also, epochal data can be collected or observed for inclusion. Furthermore, the data points need not have all data elements. The computer program is a data processing/computing "hog". Because of its complexity, it is considered only for the most sophisticated interpolation/transformation problems. The algorithm is well suited for unevenly or irregularly spaced (geometrical and epochal) data points.

12. Multiquadric Interpolation. A least squares program to predict data values from unevenly and irregularly spaced (in two - and three - dimensional space) data points. It works very well for two-dimensional and three-dimensional transformation and interpolation problems employing the same algorithm and program. The algorithm searches the data set for a subset of the nearest "data point" neighbors to the unknown point. The analyst can select any number of neighbors to employ in the interpolation. Applications have been for topographic, geoid, and gravity anomaly contouring; gravity and deflection of the vertical interpolation; and gravity (earth tides) and marine tidal predictions. Some years ago, European geodesists compared the Collocation and Multiquadric procedures. While the solution employing collocation was considered the absolute, the researchers found that the multiquadric solution provided very good comparative results in much less time, and at considerably less cost (use of computer resources). One of the other benefits was the multiquadric procedure did not require a high cost ("giant/super") computer. In one instance, it was necessary to publish the magnitude of gravity for an INS (inertial navigation standardization) calibration/test pedestal. Unfortunately, a geodetic quality relative gravimeter was not available at the time of the survey. The multiquadric interpolation was used. Later, when a gravimeter was available, the observed value of gravity agreed to the interpolated value less than 0.1 mgal. A remarkable feat!

13. Polynomial Interpolation. This procedure employs a set of "general form" polynomial equations. For each problem, a set of unique coefficients have been calculated from actual comparisons between two systems. When the problem is stated, the coefficients for the two systems are identified and inserted into the polynomial. Reviewing "coefficient sets" reveals that the numerical values of the coefficients can be negative, zero, or positive. Unfortunately, some of these coefficient sets are not very reliable, because the data set contained very few common points or were unevenly spaced through the data set "region". In one instance the polynomial coefficients were based on a one point comparison located on the edge of the region for the data set. The most common use of the polynomial transformation is in the U.S. state plane coordinate (NAD83) systems and the DMA-WGS84 datum transformations for countries around the world (reference: the DMA/NIMA technical manual which is available on line).

14. Molodensky Transformation. This transformation (actually three different transformations) was developed by the Russian geodesist M.S. Molodensky (c. 1962). The Standard Molodensky transformation is a five parameter transformation. The parameters are changes in x, y, z; the change in the semi-major axis; and the change in the flattening. The Abridged Molodensky transformation is a simplification of the Standard Molodensky transformation. The equations do not contain the ellipsoid heights of the points to be transformed. The Molodensky-Badekas transformation is a seven parameter conformal transformation. This latter transformation was used almost exclusively by NIMA (National Imagery and Mapping Agency, formerly DMA).

LINES AND POINTS
P.O. BOX 8
CHEYENNE, WY 82003

Please Recycle