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October, 2020

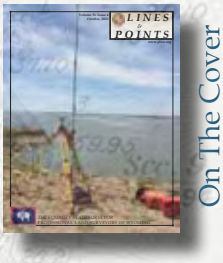
LINES & POINTS

www.plsw.org

THE EQUALITY STATE SURVEYOR
PROFESSIONAL LAND SURVEYORS OF WYOMING

P.L.S.W.

Publications Committee



On The Cover

Base station setup for Boysen Bathymetric Survey

Photo by Tom Johnson

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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).

Advertising Information

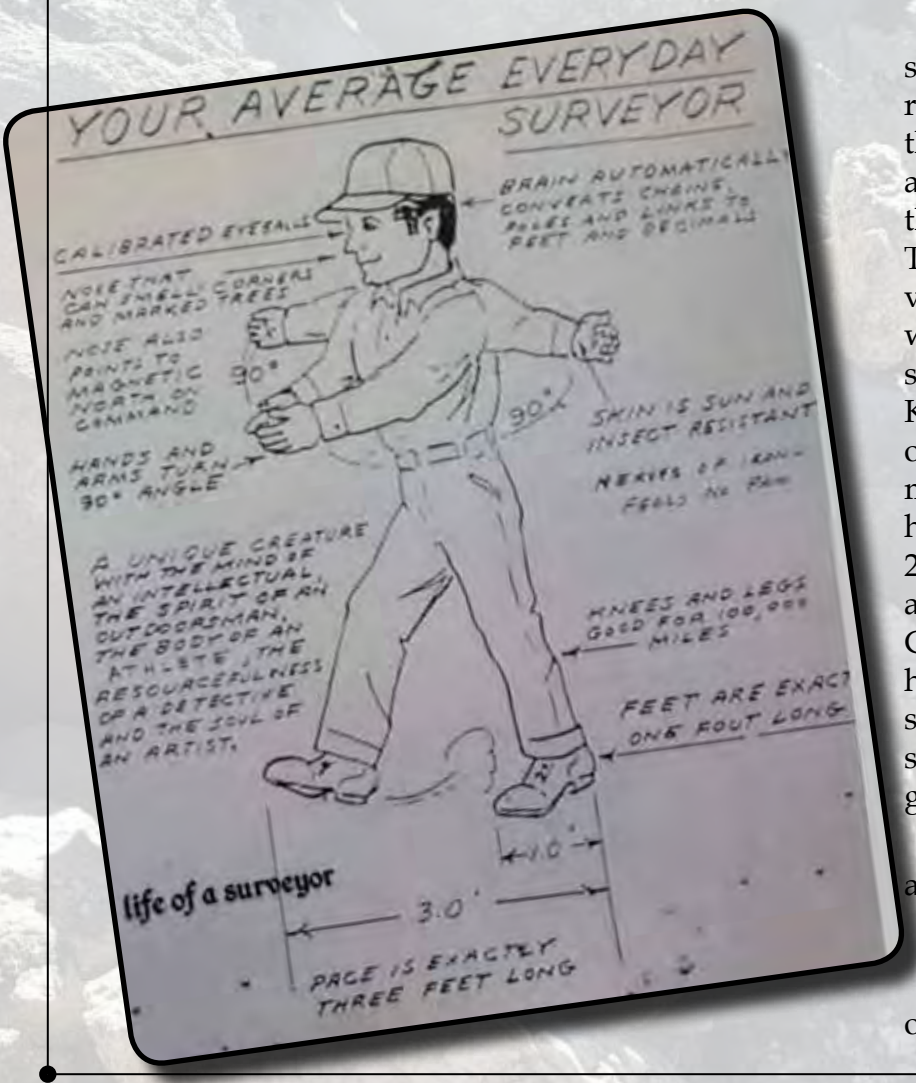
Digital-ready, full-color advertising with payment should be mailed to Lines & Points, P.O. Box 8, Cheyenne, WY 82003.

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



Greetings all,

I hope you are all still well as Fall has snuck up on us once again. Fall tech is just right around the corner and like many other things this year we will be working around all the COVID issues. It has been decided that we will have a hybrid session this year. This consists of a full in person session with vendors, meals and social hour for those who can and want to meet in person. The speaker will be presenting virtually from Kansas City and this allows for the virtual option to be presented to those who can't make the in-person session. While WES has decided to go all virtual for the year 2021! The Survey speaker there will also be a virtual presentation and there will be 8 CEU's available at this venue. The PLSW has pitched in and hired a professional speaker for this so I do hope that everyone signs up and takes full advantage of this great opportunity.

I look forward to visiting with everyone at Fall Tech!

Brad Neumiller, PLS

President - Prefessional Land Surveyors of Wyoming

ANNOUNCEMENTS

CONGRATULATIONS!

The members of the Professional Land Surveyors of Wyoming would like to recognize the achievement of the following new Wyoming registrants:

John Bruckner - Casper, WY	LS 17907
Basil Hanson - Morrison, CO	LS 18008
Steven J. Frisbie - Meridian, ID	LS 18009
Jeremiah O'Dean - Pittsburgh, PA	LS 18068
Robert Loane - Not Listed	LS 18087
Jon Master - Laramie, WY	LS 18099
Garrett Smelker-Arlington, TX	LS 18109
Neil Shultz - Uniontown, PA	LS 18123
Joel Moen - Casper, WY	SI 181

ATTENTION!

SAFETY MANUAL FOR SURVEYORS

NOW AVAILABLE FROM THE SW CHAPTER OF PROFESSIONAL LAND SURVEYORS OF WYOMING

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Special Offer - Only $50 + $2 SHIPPING!

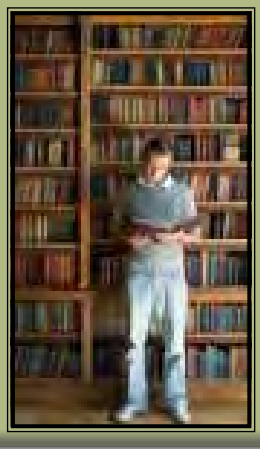
CD CONTAINS ENTIRE 206 PAGE MANUAL IN BOTH "WORD" AND ADOBE ".pdf" FORMATS THAT CAN BE EDITED AND ADAPTED FOR YOUR PARTICULAR USE

Contact Secretary/Treasurer: Olian T. Shockley
Olian_Shockley@msn.com or phone 307-875-0146

APPLY NOW FOR A PLSW SCHOLARSHIP

If you are attending college with the intent of pursuing a career in Land Surveying in Wyoming, we want to give you money!

A Scholarship Application is available on our website http://www.plsw.org



LINES AND POINTS ARTICLE ROTATION SUBMISSION SCHEDULE BY CHAPTER

Responsible Chapter	First Call Date	Last Call Date	Publication Date
Central Chapter	THANK YOU!! (SEE "*2017 BOYSEN BATHYMETRIC*" IN THIS ISSUE)		
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

P.L.S.W. TECHNICAL SESSION

November 5TH & 6TH, 2020 • RAMKOTA HOTEL • CASPER, WYOMING

GENERAL INFORMATION

PRE-REGISTRATION:

FEE: $125 PLSW Members
$75 PLSW Affiliate Members
$200 Non-Members

A $20 late registration fee will be added to all registrations received after October 12, 2020.

AGENDA

November 5TH	7:00 a.m. - 8:00 a.m.	Registration
	8:00 a.m. - 12:00 p.m.	Seminar
	12:00 p.m. - 1:00 p.m.	Luncheon
	1:00 p.m. - 5:00 p.m.	Seminar
	5:00 p.m. - 9:00 p.m.	Social Hour
November 6TH	7:00 a.m. - 7:45 a.m.	Breakfast Buffet
	8:00 a.m. - 12:00 p.m.	Seminar

LOCATION AND LODGING

A block of rooms has been reserved at the **Ramkota Hotel, 800 N. Poplar**, Casper, Wyoming until October 21st. Rate: $85 per night. Telephone: 307-266-6000.

PROFESSIONAL DEVELOPMENT HOURS

12 Professional Development Hours will be awarded for the entire seminar.

FOR MORE INFORMATION, CONTACT:

Paul Svenson 307-266-2524
Bill Fehringer 307-995-2620

Understanding What State Plane Coordinates Really Mean

This course begins with how projections work, followed by geodetic concepts. The latter is an essential part of learning how to deal with grid–to–ground issues. Then various strategies for communicating the issues and how stakeholders work with the published surveying information will be covered. All of these strategies apply equally to communicating and computing within a surveying organization or between surveying organizations. You may want to bring a calculator.

So you're a Surveyor! Why don't your measurements ever agree with those from the Descriptions of another surveyor?

In this course, we will cover elementary principles of measurements and statistics so that surveyors can analyze their work, compare to current/historic measurements and after making educated assumptions about the technology & methods used by the other parties, state whether any discrepancy is within reasonable measurement limits. Also why it is prudent to state on your surveys what the uncertainties are in your stated quantities.

Integrating Small Unmanned Airborne Systems (sUAS) Into a Geospatial Business

In this course you will learn about: Types of UAS, understand some of the applications and potential new customer areas possible with UAS, company operations and management of personnel including training that must be understood and integrated into the business before using UAS, about the photogrammetric differences with UAS as compared to conventional photogrammetry, How the FAA is regulating the process of flying a UAS.

Joseph V.R. Paiva, PhD

Joseph V.R. Paiva, PhD is CEO of GeoLearn LLC, an online education company. Joe's experience goes back to instrument man, to party chief for an engineering firm, & partner in a surveying-engineering business. He taught surveying courses in the civil engineering department at the University of Missouri-Columbia for 11 years. He moved on to R&D at Sokkia, beginning as a consultant, designing the software workflow for the SDR 2, SDR20 series & SDR 33 Electronic Field Books. While at Sokkia he managed a development team who worked on software for the PC as well as software & hardware for GPS & total stations. He moved on to similar duties at Trimble. He began in the UAS world at Gatewing in Belgium, eventually becoming its COO. He continues to teach college courses at State Technical College of Missouri.

For in-person attendees: Our presenter, Joseph Paiva, will present live from a studio at his business in Kansas City. When questions from the audience arise, they will be directed to a moderator at the podium who will relay them to Joe.

For virtual attendees: You will register in a two step secure process to attend the event virtually on the Zoom webinar interface. If you have questions, you will write them at any time in your Q&A. The moderator in Casper will then relay them to Joe. You will need a computer connected to the Internet with a minimum speed of about 10. Also there will be random questions to be answered onscreen along with connection time monitored to ensure you are actively engaged.

Registration, questions, etc.: Register as you always do with PLSW. The fee is the same whether in person or virtual. Contact us with questions as well. We'll also keep tabs on the schedule and registration, and send notification to the virtual attendees about a demo/training webinar for those who are uncertain about their ability to use the technology. We will keep the information coming, if you have questions please email:

Sami at *sami@cepi-casper.com*
or
Bill at *billf@cepi-casper.com*

* * * *There is not a box to indicate on the mail-in registration if you would like to do In-Person or Virtual. So please write it on the email line so we know how to get you the appropriate information.

You can register online: https://forms.gle/froCKgSXSfRrDxWCA

Again thank you for your understanding during this transition .

T-O ENGINEERS

T-O Engineers is seeking a motivated Survey Department Manager to build our practice and mentor our existing survey staff in our Cody, Wyoming office. We are currently offering a $12,500 hiring incentive to the successful candidate. This is an opportunity to build both a team and a practice with an established firm that is committed to the area and the profession. Candidates can expect to work alongside engineers and planners to support ongoing survey demands and will have the freedom to pursue other surveying opportunities to grow the Cody business. We have a robust staff of licensed professional surveying staff to assist this leader for our Wyoming market.

The ideal candidate will have a professional network in Wyoming and have ability to grow our existing survey practice in this market. The successful candidate will have a Wyoming PLS license or the ability to become licensed in Wyoming within six months. Key traits for this position are strong communication, leadership, and organizational skills; team player; and the ability to work outdoors and in a professional office environment on a wide variety of projects. Professional appearance and conduct is required in the field and office. The successful candidate will also work closely with Survey Staff in our other offices in Idaho, Utah, and Washington.

The pay range for this position is $90,000 to $105,000 per year, depending on experience. Position Requirements & Responsibilities Include:

- Wyoming PLS or the ability to become licensed in Wyoming within six months
- Ability to lead business development and marketing in Wyoming
- PLS in other states a strong plus
- Strong communication, organization, and mathematical skills
- Ability to work outdoors and in a professional office environment
- Strong skills using AutoCAD / Civil 3D
- Trimble Business Center, GPS/RTK and Robotic Total Station experience required
- Self-motivated, team-oriented individual willing to listen
- Ability to work on challenging projects in a team environment

Employee Benefits

- Flexible Schedule, 1/2 Day Fridays
- Paid Holidays & Paid Time Off (PTO)
- Medical, Dental, Vision, and Life Insurance
- Flexible Spending Account
- 401 (K) Retirement Plan with Employer Match
- Discretionary Profit Sharing

2017 Boysen Bathymetric

by Tom Johnson, PLS , CFedS

A NEW EXPERIENCE:

One of the most interesting jobs of my career began in the Spring of 2017. One of our clients had contracted with an out-of-state environmental firm to work with them on a sedimentation study for Boysen Reservoir in north central Fremont County. The environmental firm (OSEF) gathered all the available data for the reservoir to determine their needs for sedimentation modeling of this 19,600 acre reservoir. They determined that the U.S. Bureau of Reclamation (USBR) had done a sedimentation survey in 1994, and that was the latest available information for the bathymetry of the reservoir. OSEF determined that it would be best to have an up-to-date survey rather than base their modeling on 23 year old information. Apex has worked with OSEF on prior projects and they contacted Apex to inquire about our capabilities to do the work. After some research into sounding equipment that would interface with our terrestrial GPS units we put together a scope of services and a cost range to present to the client. The project was approved and Apex spent a large part of late April, May, June and into July, setting control and surveying cross sections and localized bottom topo of the reservoir. The project was wrapped up in July and was transmitted to the environmental firm for their use. Of course no project of this scope happens without some events to spice up the tale.

BACKGROUND:

Boysen Reservoir has existed at least in a smaller scale since before 1910. Mr. Asmus Boysen notoriously acquired a lease of some 640 acres on the Wind River Indian Reservation for mining purposes around 1905. Mr. Boysen was ultimately responsible for the first Boysen dam near the entrance to the Wind River Canyon in Fremont County. In 1907 Mr. Boysen formed the Big Horn Power Company with the intent to create power from hydraulic means. The dam that was constructed during those early years provided electricity into the 1930's. The old dam was removed in favor of the new, larger dam ultimately completed upstream in 1952. The current reservoir is described as 20 miles in length and 5.5 miles wide at its widest point.

SCOPE:

The 1994 survey produced a bathymetric map with a 5 foot contour interval across the reservoir. We had enough detail of how the past survey was done to see that they had cross sectioned at approximately 500 foot intervals. By the time I determined the past surveyors cross section frequency I had already proposed that we would be shooting for a 500 foot between our cross section lines. We would survey the cross sections east to west, and vice versa, zig-zagging across the reservoir. The GPS equipment was set to auto record a shot every 100 feet on the cross section lines. To make sure that we got data

as close as possible to the shoreline we separately navigated parallel to shore while recording shots on a 50 foot interval. We agreed to deliver the point file survey data to the OSEF as well as a contour map. Our scope specifically called out that we were not proposing a shoreline survey, but we would use a publicly available shapefile for the shoreline and correct that in areas that we determined to be inaccurate.

We had some problems right at the beginning of the work on this project and had to send some equipment in due to radio communication problems. During that period we used another of our Viva sets which are essentially identical to one another.

EQUIPMENT:

It was determined early on that we would have a two man crew working from a boat. The GPS equipment used for the project was one of our Leica Viva model differential GPS receiver sets, each equipped with Pacific Crest radios. Our base battery set up would have been sufficient to power the base throughout our work day on the water, but, as an extra level of comfort, we also connected a small solar panel to help maintain the battery.

The newly purchased sounding equipment was the SonarMite Milspec echo sounder. The boat put to use for this is a Mirrocraft open bow fishing boat equipped with a 40HP Evinrude motor. A brand new heavy thrust Minn Kota trolling motor was also included in our gear as an emergency measure in case the gas motor failed us. In order to mount the sonar equipment to the side of the boat I fabricated a pole and clamp apparatus that allows the sensor antenna to be mounted to a repurposed GPS rod attached to a recycled trolling motor mount that I had saved for no good reason at the time. The dealer of the sonar equipment markets a mount much like this but I was able to put this together at no added cost and it was just as functional. During use, the pole can be raised and lowered, as well as tilted into the boat to be

cradled in the lap of team member two while traveling at higher speeds. The fabricated pole and clamp was mounted to the port side of the boat at about the halfway point along the gunnel whale. Some other equipment used which proved helpful was a 1990's era Humminbird fish finder (upgraded toward the end of the project) with a bottom alarm, a Garmin GPSMAP 64st model recreation grade GPS receiver attached to the boat's dash with a Ram mount bracket, and a previously out-of-service android cell phone which was used to interface with the sounding gear to change settings.

A few things we did to assure safety of our equipment included taping the battery compartments closed on the smart antenna, a lanyard tied off to the rover radio antenna and a safety chain attached to the entire mount/pole/gps/sonar setup. Since all of this was poised over the edge of the boat, we were not going to risk losing anything into the water. Cellular communications from the boat on literally all parts of the reservoir were good, which also added a level of safety.

Since the boat surveying commenced on the second of May and ended in Mid July the work wardrobe ranged from heavy winter clothing to short sleeves, but wide brimmed hats and life jackets were in use throughout.

CONTROL SURVEY:

A total of 7 control point/check point pairs were established around the east and west sides of the reservoir. Control monuments were positioned to make them handy to the boat docks that were expected to be put in use, as well as to assure coverage of all points on the reservoir. In the end we only used 4 of the 7 for reasons to be elaborated on further on in this article.

Each control point was monumented with a 2" dia. Aluminum cap set on a 5/8"X24" rebar stamped with the control point designation, except for control point "BOYS 4" for which an existing concrete monument of unknown origin was used.

When Apex was determining the scope for the project we asked the OSEF if they preferred that we try to match any existing horizontal or vertical control. They did not consider that to be necessary. Each of our control points were occupied for a minimum of 2 hours time and the data processed through OPUS (the National Geodetic Surveys Online Positioning User Service) the final control system was compiled

using all 7 OPUS positions, left uncorrected to ground surface (though averaged scale/elevation/combined factors were determined. From an elevation standpoint this provided us with OPUS derived elevations with a NAVD88 GEOID 12B basis, but it was not relatable to the elevation basis used by USBR for the levels of the reservoir.

As the survey progressed from day to day, I monitored (online) the reported water elevations from the USBR and stream flow information for the Wind/Bighorn River. I determined that, if possible, I wanted to survey in a benchmark for the reservoir so that I could compare the water surface levels that I was coming up with to the data being reported on the USBR website (i.e. https://www.usbr.gov/gp-bin/arcweb_boyr.pl). In order to do this, I contacted the USBR office in Mills, WY and received information on an existing benchmark on the dam. I tied that benchmark during June, 2017.

RESERVOIR SURVEY:

Day one of survey from the boat (BSD 1) was May 3, 2017. This day was spent determining our process for setting up the Base, launching/loading the boat, and operating the combined GPS and sonar gear from the boat. On this day we calibrated the sonar gear to the local conditions and ran some east-west cross sections across the reservoir from just north of Fremont Bay to just north of Badwater Bay. The water level in the reservoir had been brought down in anticipation of expected high runoff with melting snow in the mountains, on this date it was 4706 feet (relative to BM on dam). An elevation of 4713 feet is considered to be the minimum safe launch level at the Fremont Bay concrete boat dock, but I was familiar with the old dock (basically from the beach) and we launched from there.

We found that having the boat "captain" monitor the Garmin 64ST receiver on the dash was a good way to keep on a general east-west course while traveling back and forth across the reservoir. When we reached shore the "captain" would create a waypoint and then navigate along the shoreline to a point 500 feet from that waypoint before making a sharp turn and heading back across the lake, starting a new cross section.

We launched from the old dock for the first two days and collected cross section data in an area from about 0.5 mile south of the Fremont Bay concrete dock to about 0.4 mile north of where the Sand Mesa lateral dumps into the reservoir (Sand Mesa campground). It became very apparent early on that with the reservoir level as low as it was, there were areas of reservoir that would be too shallow to survey until later in the spring when the water would be closer to normal levels. In fact we dragged bottom at one spot, about ¼ mile from the east shoreline, and experienced a short period of desperation while pulling up the motor and maneuvering to deeper water.

Another hazard encountered was floating debris coming into the reservoir on this south side. The reservoir was becoming murkier and some of the larger floating debris was large tree branches. On one of these two days a tree had washed ashore across our dock. When we came in at the end of the day we had to disembark a few yards out into the water to drag the tree out of the way. The tree was too large to move by hand, so I had to unhook the boat trailer and use the truck and a rope to pull the log out of the way. Once done I could hitch back up to the trailer and back in to load the boat.

After this we launched from the Brannan Boat dock near the north end of the reservoir for two days. During this time we surveyed from the Dam south toward the Sand Mesa drain. The surveys on these days were across the most narrow (near the dam) and the widest parts of the reservoir. We were able to navigate west into the Cottonwood Bay area, limited again by how shallow the water level became as we worked west and south.

We used the Tough Creek boat dock to launch from for BSD 5 and 6. On these days we were able to tie together the north and south surveyed areas, survey as far west into Cottonwood Bay as was going to be possible, and to run along the shorelines, mostly on the east side of the reservoir. We had determined that if we can get data along the shorelines at 5-8 feet we would use our predetermined outside perimeter of the reservoir

and "daylight" our contours to that. I had initially planned to be able to launch from the Cottonwood Bay boat dock for some of that area, but the water levels remained lower than the published safe launching level. As it turned out, we were able to access the Cottonwood Bay area adequately by launching from the east side of the reservoir.

BSD 7 was used to complete the shoreline traverse on the northern portion of the reservoir. We launched from the Brannon boat dock and traveled along approximately 18 miles of shoreline. By this date the water levels in the reservoir had come up to 4717 feet and we were able to fill in the areas between the Boysen Marina and Tamarask campgrounds and the islands off of those locations which we had skipped earlier due to shallow water. At this date we were just past the first week of June. Since inflow into the reservoir was at its peak and, even as far north as Tough Creek, the floating debris was getting heavier and heavier. We held off a couple of weeks to let the situation improve not only for safety, but for water clarity and to be able to access the shallow locations we had not managed to get to on the south side of the reservoir.

The Wind River valley experienced record flooding during the spring and early summer of 2017. The Riverton Valley Irrigation District (RVID) diversion became threatened and the main canal overflowed and washed out its banks just ¼ mile from the headgate. Irrigation water was interrupted to the farmers dependent on RVID for

a few weeks. The effect of the high water caused us to abort what would have been BSD 8 on June 30 because the road to the Fremont Bay boat dock was flooded.

We re-commenced our boat survey on July 13. We used this day to fill in the areas of Badwater, and Muddy Creek Bays that we could not access in early May. We also were able to survey a good distance against the shoreline from Muddy Creek Bay south to the mouth of Poison Creek Bay, and cross section into Poison Creek Bay and the main part of the reservoir near the mouth of that Bay. We launched at the concrete Fremont Bay Boat dock this time, and our base was set up on BOYS 4, about 0.9 mile northwest of the dock. We found that we had some radio communication limitations as we approached the causeway (U.S. Highway 26) on the south end of our project area. It was apparent that, to finish, we would need to use a different control point for our base.

On BSD 9 we set our base up on BOYS 3. This point was located on the east side of the reservoir, south of Poison Creek Bay. Because we still wanted to dock at the Fremont Bay boat dock, we started the day by pulling the boat into BOYS 3, setting up and then driving back to Fremont Bay on the west side of the reservoir to launch the boat. This is a 20 mile round trip. Nobody wanted any trouble at the base if you have to drive 20 miles to check on it, and trouble at the base while we were on the water could involve as much as 3 miles of boat travel on this particular day just to get back to the truck. Luckily we had no trouble at all this day, and very little trouble during the project as a whole. We finished the cross sections and ran line against the shoreline as far south as the causeway (U.S. Highway 26), and what we had missed between the causeway (U.S. Highway 26) and the mouth of Poison Creek Bay. The water level on this date was 4727'. This level is 2 feet above the USBR figure of 4725 "active level" for the reservoir and 5 feet below flood.

The level of the reservoir between the start of our survey and the last day (May 3-July 14) rose 21 feet. At the beginning of BSD 9 we were not sure that we would be able to survey all the way to the causeway (U.S. Highway 26), which was part of the reason I was not willing to attempt to use the

causeway boat dock. If we had used that dock it would have cut considerable mileage from our trip from base point to boat launch point. Commercial mapping of the reservoir refers to the area around the causeway as being "sediment filled". It was actually helpful that the reservoir was above the active level as it allowed us to more easily navigate the "sediment filled" areas. If one were to look at our cross sections lines from that day one would see a spot north of the causeway (U.S. Highway 26) where our cross section lines on both east and west sides approach a spot about 1200 feet off the east shoreline and veer away at 90 degrees. This is a shallow spot onto which a large tree had beached itself. I could still spot that tree out there when crossing the causeway two years later.

The office portion of this work was routine during the days of survey. At the end of the field day I would download the days data and back everything up. A quick review of the expected coverage was made to determine if any data points of the cross sections were not recorded. There were a few locations that we had to revisit to fill in some data, but, as a whole, it all went very well.

As the project progressed I monitored the areas coverage to make sure we were indeed collecting cross sections on the entire project area, namely the entire reservoir north of the causeway (U.S. Highway 26).

A PART OF THE WHOLE

Once the final shots were taken the entirety of the project was mapped and the data was packaged and delivered to the OSEF. This was done by the beginning of August of 2017.

After that I was not in touch with the OSEF again on the subject of the Boysen study. I learned afterward that the modeling report entitled "Water Quality Compliance Analysis for the Long Range Development Plan at Moneta Divide, Wyoming"-"A Hydrologic, Hydrodynamic and Water Quality Study of the Boysen Reservoir Watershed" was published in April 2018, by the OSEF. This document was 637 pages in length, and one could imagine the technical detail that it provided. Our survey was only a small part of the study. Given the choice of working in the field to survey the bathymetry of the reservoir, or the months of research and development of hundreds of pages of text, graphs and figures, I would pick the surveying as the more enjoyable part.

Personal Thoughts and Impressions About State Plane Coordinate Systems and Proposed Legislation

Herbert W. Stoughton, Ph.D., P.E.,P.L.S., C.P.
Geodetic Engineer

Personal Background and Experiences

I received my formal academic course work in surveying, mapping, and geodetic engineering at the University of Michigan under Ralph Moore Berry, Professor of Geodetic Engineering; and Waldo R. Tobler, Professor of Geography. Professor Tobler's lectures addressed the cartographical, mathematical foundations and their development. In many ways the topics complimented and extended the works of Dr. Oscar Sherman Adams (USC&GS); Charles Henry Deetz (USC&GS); Paul D. Thomas (USC&GS and US Navy); and John P. Snyder (USGS). Professor Berry's approach discussed applications of plane coordinate systems for practicing land surveyors, survey engineers, and civil engineers based upon his 1930's and 1940's work experiences as a land surveyor and civil engineer in municipal government and private practice and employment as a geodetic engineer at the USC&GS. The late Lansing G. Simmons (USC&GS) considered Professor Berry's knowledge and experience using conformal plane coordinate systems and applications made him an excellent spokesman and proponent. In the 1960's, Berry gave the keynote address on plane coordinate systems to the Canadian Institute of Surveying.

As a student, I had a "front row seat" when Berry developed the special Michigan State Plane Coordinate system and legislation (NAD 27), which employed the "Michigan-Clarke 1866" reference ellipsoid. Later, he designed the multi-zone conformal plane coordinates system for the Great Lakes employing the Hotine Skew Orthomorphic projection; and a set of algorithms which simplified computing the map projection scale factor based solely on plane coordinates (Lambert conformal conic, transverse Mercator, and Hotine skew Mercator). The Great Lakes' system cover mapping from the Lake of the Woods to the Gulf of the St. Lawrence with only four map projection zones! In the late 1960's, Berry took an active interest in MOLDS and the multi-cadastre discussions. Very early in his studies, he recognized the importance of the need for a coordinate reference system upon which to "place" the collected data, and would minimize ambiguities in positioning demographic information. His studies into multi-zone state plane coordinate systems for a single state led him to conclude (for that time and available data processing hardware and software) there might be problems in the "overlap zone" between a pair, or more, of existing plane coordinate systems. Therefore, although Michigan adopted and enacted a three zone Lambert conformal conic state plane coordinate system, he also recommended that Michigan should have a single zone map projection for state-wide GIS programs. Therefore, in Michigan he developed the Michigan GEOREF [Geographic Reference System] system employing the Hotine Skew Orthomorphic projection (for the entire state), which is still used. As a consultant, he designed a single zone Hotine Skew Orthormorphic projection for the design and construction of the railroad from Washington, D.C. to Boston (AMTRAK). Later, he and I co-authored a paper employing a more detailed sale factor algorithm applied to the UTM systems (published in Survey Review).

Professional Activities and Experiences

It was during Professor Berry's creation of the Michigan state plane coordinate legislation for NAD 27, that I studied the draft "model law" published in USC&GS Special Publication No. 235 [Hugh C. Mitchell and Lansing G. Simmons; The State Plane Coordinate System (1945/1974)]. Later, a subsequent model law appearing in James Stem's publication [State Plane Coordinate System of 1983; NOAA Manual NOS NGS 5] was proposed. By 1980, I was being asked to author and present seminars on state plane coordinates and legislative initiatives. SAMSOG (Surveying and Mapping Society of Georgia) asked me to address the issue of "marrying" the proposed NAD SPC legislation for 1983 with the previously enacted NAD27 system (which had been actively implemented and used), Which James Stem had not addressed in his publication. It was my quasi-legal position, that if the older version of the SPC legislation had been employed in legal documentation (i.e. real property descriptions, proclamations, etc.), then its use could rightly continue, and that there should be a grace period in which projects which had been

initiated under the older system, could continue to develop the project until their completion. SAMSOG adopted the proposal, and submitted the legislation to the state legislature, where is was approved and enacted.

Also, it was during the development of the NAD 83 that states were asked if wanted to modify the NAD27 systems. I was approached by the land surveyor societies of Montana, Nebraska, and Wyoming to offer proposed modifications to the NAD 27 systems in lieu of "changing times". For Montana and Nebraska, my first recommendation was to change the two-zone Lambert conformal conic to a single zone Lambert conformal conic. I proposed this approach because I believed that in the future all data processing (computations, conversions between GP's and PC's, and applications) would be performed on digital computers. The second reason was the impending "explosion" (my perception) of the application of multi-purpose cadastre and geographic information systems encompassing entire states. Multi-zone SPC systems offered the opportunity of the GIS user to encounter computational impediments when working in multiple zones on a single project. Having nearly two decades of experience with surveyors and engineers having difficulties of addressing zone-to-zone relationships, it was conceivable that the GIS community would have even more problems of implementing a "seamless" interface at zone boundaries.

The third innovation was to place the parallels of secancy (intersection of the reference ellipsoid with the projected conical surface at the northerly and southerly state boundaries. This meant that all the scale factors across these states would be less than unity. The reasoning for this was two fold: (1). The original reasoning to have the minimum scale factor be larger than 1:10,000 was promulgated by the USC&GS to encourage engineers and surveyors (in the mid 1930's) to accept and adopt usage of state plane coordinates. By this is meant that if the user disregarded (accidently or intentionally) the scale factor computation, the inherently induced systematic error would be of the same order of magnitude as those accidental errors which were inherent in traverse surveys executed with an engineer's transit and a steel chain/tape. Since everything in the 1970's was being performed with digital computers, the problem of addressing scale factors could be directly addressed without any problems. In many map projections, cartographers identify the scale factor at a point

as a distortion. In conformal map projections, the scale factor at each individual point is a constant (value) and does not change with the azimuth of a unit elemental length from that point. If the scale factor varies with the azimuth for a unit elemental length from that point, then the word distortion is appropriate and Tissot's indicatrix is a graphical indicator of that distortion in azimuth from the center of the ellipse situated at the point (this indicatrix is a circle for conformal projections). In conformal map projections, the scale factor at each point is different, but for short linear surface distances, the change in scale factor appears to change in a linear fashion in every direction without introducing changes affecting the accuracy of the linear distance at the sensitivity of the instrumentation's capabilities. This approach to selecting the parallels of secancy produced this "rule-of-thumb" insight: distances on the reference ellipsoid are always longer than the projected distances of the grid reference system, and vice-versa. This approach produced another "rule-of-thumb" insight. In Montana and Nebraska, all surface lands are above the reference ellipsoid (and geoid). This means that reducing the surveyed (ground) distance to the reference ellipsoid means the length of the projected ground surveyed distance onto the reference ellipsoid will always be shorter. Therefore, the combined reduction of ground to ellipsoid to map projection will always be a shortening of the surveyed length. In the older project designs, if the parallel of secancy was inside the working area of the state, then, for the Lambert systems, the scale factor south of the southerly secant and north of the northerly secant would exceed unity. A similar condition occurs in the for the transverse Mercator project but in the north-south direction (but not meridional). This could cause an interesting anomaly if the reduction factor for surveyed lengths from the earth's surface to the reference ellipsoid was the inverse, or nearly the inverse, of the scale factor, then, the total correction would be unity. This problem occurs with sufficient frequency, that surveyors and engineers not fully understanding the subject, will arrive at the conclusion the "combined factor" is unity. Therefore, my proposals for Montana and Nebraska for the NAD 83 state plane coordinate systems' designs were developed to eliminate this problem.

When the Professional Land Surveyors of Wyoming proposed adoption of the state plane coordinate legislation for NAD 83 (no NAD 27 legislation had been enacted), I was asked to modify the model law (in Stem) to address implementing the transverse Mercator system. The transverse Mercator system has some very

interesting and useful attributes, which have not been discussed in the general geodetic or cartographic literature. One of the attributes is that with the judicial definition of each zones' fundamental constants, it is possible to have one-to-one linear transformations between two or more zones. This approach even can be applied between multiple reference ellipsoids having the same flattening (square of the first eccentricity) are employed. One application would design a state plane coordinate system which would have a one-to-one relationship with a UTM system. These approaches were not employed in the Wyoming NAD 83 system. In the NAD 27 systems, the same x-coordinate of the zone's central meridian was 500,000 feet, and the y-coordinate of the "base" parallel was 0.000 feet. In the NAD83 system the x-coordinate of the central meridian for each zone was uniquely assigned, and the y-coordinate was defined a non zero value. This meant, that for any point in the overlapping working areas of an adjacent pair of zones, inspection of the two sets of plane coordinates for a point in the two zones would be readily identifiable.

In my opinion, publications S.P. 235 and NOS/NGS 5 have been very successful in educating the land surveying and engineering professions to accept and adopt the proposed reference systems. If the "model law" is to be seriously modified from the previous versions/philosophy, then I have definite concerns. First, the perceived audience of engineers, surveyors, mappers, and a small cadre of attorneys, is a minority of the population implementing and using state plane coordinates. The other audience includes the entire GIS community, the associated political administrators, legislators, and the non-surveying grade GPS industry. Nowhere in this latter audience are there in depth mathematical and technical publications describing the intricate relationships of geophysics, geodesy, cartography, and law. In my opinion, a majority of the enacted legislation is benign in this discussion not requiring significant modification, and should be retained in any future legislation.

Review of both model laws (NAD 27 and NAD 83) reveals a strong parallelism which only would change if the state desires to migrate from the older system(s) and its defining constants to another system or reconfiguration addressing modern applications and needs. When these proposals, and modification of the existing statute, are presented to legislators, there should be minimal problem of "selling the proposed modification".

Recommendations and Courses of Action

In my opinion, the two most important issues to be addressed are: (1) "field survey accuracy" requirements, and (2) the issue of metadata - geodetic reference systems.

1. In the two previous versions of the model law, there has been incorporated rigorous minimum field survey accuracy standards / requirements. The issue is that in each version, the requirements addressed only for the technology available at the instance of enactment. In other words, the available technology for both NAD 27 and NAD 83 (1980), was to extend geodetic control employing terrestrial surveying mensuration (traverse, triangulation, and trilateration) technology. I would estimate that less than one-quarter of the surveyors and technicians collecting geodetic positional information have little, if any, knowledge of the classical, traditional geodetic surveying methodologies. Therefore, I believe that this section in the model law addressing the minimum requirements for positional accuracy, rather than minimum surveying field procedures to achieve those tolerances, be rewritten.

2. The second major issue concerns the issue of redefining geodetic reference systems and metadata. When recently inspecting the GPS-OPUS (in this case a RS (rapid static) solution), I can extract the geodetic reference frame and epochal information needed for the metadata. If surveyors employ other broadcasting "master" sites to execute relative positioning, then the "metadata" for that "master" station could be different. In my opinion, the subject of documenting metadata and subsequently writing an appropriate statement has not been sufficiently addressed, even at the elementary level. I personally conferred with several local land surveyors who are still employing single phase GPS receivers and state HARN's, and who have personally established sub HARN's to accommodate their personal GPS survey requirements. In my opinion, the era between the publication of the NAD 83 general adjustment and 2020 (or later) requires detailed analysis and documentation of every local areal readjustment and "publication" in order to comprehend the epochal transitions of geodetic positions of every geodetic point having a "NAD 83" reference "tag" and the associated NSRS and ITRF positions.

3. Because of the chronology of establishing the state HARNS after the original adjustment and publication of NAD83, and the subsequent

small areal regional adjustments could produce an administrative "nightmare". I believe that the statistical and numerical theories have been developed which can provide accurate transformation parameters between various epochs of CORS, HARNS, and other GPS reference stations within the absolute and relative uncertainties inherent in the original observations. I believe that there is sufficient statistical and numerical analysis theory, supported by the computational technology, which could produce transformation algorithms which could provide geodetic accuracies, and hopefully improve map grade transformations. If this approach can be validated, then future modifications of state plane coordinate legislation previously enacted can be implemented.

4. The section in the two current model laws (NAD 27 and NAD 83) addressing the field procedures, terrestrial technology, and subsequent data reduction should be removed. The section should be rewritten to permit the surveyor to utilize available technology producing better than minimal stipulated geodetic positions. The positional tolerances are required by the civilian community, and would not impact those positional survey requirements required by the geodetic, geophysical, military, and other highly specialized communities. The quantification of minimal acceptability would be statutorily stipulated by accepted statistical analysis provided during the survey reduction computations. Since this approach is in the statute, and is independent of the technology used to collect the requisite positional data, the need to change the minimum positional standard is moot!

5. The portion of the model laws previously cited that identifies the geodetic reference system and datum can be so written that when there is a transition to a later edition of geodetic reference frame systems and/or geodetic datum, it can be implemented without legislative fiat. The procedure is to incorporate in the legislation a statement which states that "from time to time the NOAA, NGS, or it successor, shall from time to time update the national spatial reference system now known as the North American Datum 2022 and directly referenced to the International Terrestrial Reference Frame XXXX (ITRF XXXX). Periodically, the international geodetic and geophysical communities update the current ITRF to reflect periodic changes in the earth's rotation and other geophysical phenomena (i.e. continental drift/migration). When these changes have been approved at international congresses, the proclamation contains the specific time

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STS						$125				$130	
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and date of implementation. At that time, the National Geodetic Survey shall implement these changes. Prior to implementation in the United States, the National Geodetic Survey shall have published in the Federal Register notification of the implementation and the numerical values of the ITRF and the corresponding civilian datum." In this manner the continuity of the civilian datum (now known as NAD 83) will be seamless with future civilian datums. Also, the National Geodetic Survey, or its successor, will maintain/generate the transitional parameters between successive pairs of earth reference geodetic/geophysical parameters. This approach may seem novel. However, announcements appearing in the Federal Register are official.

6. By implementing these recommendations, there is a continuum, because the actions which took place have been identified and recognized in the legislation, and the proposed resulting transition could occur. The NAD83 reference ellipsoid is identical to the International Union of Geodesy and Geophysics' GRS80 (Geodetic Reference System 1980) [announced at Canberra, Australia, December 1979]. There does not appear to be any pending redefinition of the geometric elements (semi-major axis, semi-minor axis, and the two eccentricies). The volumes of GNSS data observed does not appear to indicate a need to modify the current reference ellipsoid.

Hints to Authors

LINES & POINTS

Dear Readers:

The editors of Lines & Points wish to convey our gratitude to the numerous authors who have contributed photographs, technical and professional articles, and other information to be incorporated into the quarterly journal. In recent years, the assembly and redaction of the submitted materials has taken on considerable technical application of the various English language compilers, office suites, and "publishing suites". This means that the communication and transfer of information and materials arrive at the editors' desktops in a multitude of formats and styles, which sometimes are not compatible with the PLSW personal computers.

We, the editors, are setting forth some simple rules for submitting materials which, hopefully will simplify your efforts and make the transition to the published version simpler and less time consuming.

1. If you have any questions or comments, please contact S. Dennis Dawson, Publications Comm. Chm., (dennieandbarb@gmail.com) or Michael A. Flaim, Editor-in-Chief (mike.flaim@bresnan.net).

2. If an article contains any illustrations, photographs, graphs, or other graphics, please transmit them as separate individual files. You may also include the illustrations within your manuscript, but the image integrity/quality is degraded seriously when attempting to extract them from the manuscript to create a published digital image. The Editor-in-Chief states that a much better digital resolution is obtained from the separate, individual illustrations submitted.

3. All submissions (electronic and snail mail) should be sent to S. Dennis Dawson (4005 Snyder Avenue; Cheyenne 82001). It is recommended a second copy be sent to Mike Flaim (1212 Southwest Drive; Cheyenne 82007).

4. It is strongly recommended that all submissions be transmitted six weeks prior to the publication deadline. The publication deadlines are: 1 January; 1 April; 1 July; and 1 October, annually.

5. Lines & Points is the official publication for the Professional Land Surveyors of Wyoming. Therefore, hence forth there will be incorporated in the publication all formal announcements pertaining to official business of the organization and other announcements. This includes announcements for the Annual Meeting; state-wide membership meetings; seminars; and the Fall Technical Session. These announcements are to be submitted to the PLSW Secretary/Treasurer John J. Studley (PLSW; Attn.: Mr. Jack Studley; P.O. Box No. 8; Cheyenne 82003) (jklz0318@gmail.com), at least four weeks prior to the publication deadline in which the announcement will appear. The PLSW Secretary/Treasurer will circulate the announcements to the Publication Comm. Chm.; the Editor-in-Chief; and the PLSW Board of Directors.

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