Cienega Creek Physical Integrity Survey

Appendix Version 1.00

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Prepared by

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Purpose and Scope

This appendix was prepared for the goal of documenting methods associated with data collection, interpretation, quality assurance / quality control, and storage for the geomorphology survey conducted on the Upper Cienega Creek Basin. This appendix references all data collected through March 20, 2002. Given my departure from this project, the goal of this document is to ensure that a reference exists for duplicating these methods on data collected in the Lower Cienega Creek Basin.

This appendix may also serves as a resource for future generations wishing to ensure repeatability of our methods for their own studies so that morphological changes within in the Cienega Creek Basin can be adequately quantified over time. Questions regarding this version of the appendix should be directed to Hans Huth (hans.huth@veridian.com, 520-326-7005 ext 107).

It is recommended that this appendix be supplemented and attached to future reports submitted to the Arizona Water Protection Fund.
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I. Upper Basin Characteristics

The topography of both the Upper and Lower Cienega Creek Basins began to develop during the Basin and Range Disturbance which dates back to the late Tertiary (Robertson, 1991). During this time, the crust of the Earth was separated by high-angle faulting into blocks of various sizes. Some blocks sank relative to others forming lowland areas surrounded by highlands. Movement along the faults continued, and the lowland areas filled with sediment eroded from the highlands. Some lowland areas were completely enclosed by surrounding mountains, and evaporation of saline waters created hundreds of feet of evaporites and clastic materials (Kafri et al., 1976).

During the Pleistocene (Glacial) Epoch, there were several periods when the climate was wetter than it is presently. Increased stream runoff and continued sedimentation resulted in the breaching of many of the closed basins. With the return to arid or semi-arid conditions in recent time, flowing streams were reduced in size or became intermittent. These are the conditions that exist at Cienega Creek today.

Unconsolidated recent alluvium is made up of unconsolidated silt, sand, and gravel deposited along Cienega Creek and its various tributaries. This unit is generally several tens of feet thick and groundwater occurs at shallow depths supporting a variety of riparian phreatophytes.

The elevation of the Upper Cienega Creek drainage drops from approximately 4400 feet at the Gardner Canyon confluence to 4000 feet at the Narrows over a distance of 10 miles. This translates to an average stream slope of approximately 0.0076 along the major stream-length of the Upper Basin.

Since the acquisition of the Resource Conservation Area (RCA) in 1988 by the BLM, perennial flow has been recovering in several areas of the Upper Basin. Approximately one-quarter mile northeast of the Empire Ranch (T19S, R17E, sec18, aca) a small spring produces a three-quarter mile stretch of perennial flow with a negligible flux.

On the eastern side of the basin, Mattie Canyon has several springs, but the respective flows are not significant. Near the confluence of Mud Springs and Cienega Creek, a series of small ponds is present. Mesquite located within this area are being drowned indicating that water levels may be recovering.

Isohyetal rainfall maps obtained from the Arizona Department of Water Resources indicate 16 inches rainfall per year occurring within the Upper Basin. In summertime, moisture from the Gulf of Mexico combines with high-surface temperatures and orographic lifting producing short-lived thunderstorms. These enter the Upper basin through the southeast resulting in precipitation predominantly along the Whetstones or Santa Rita Mountain fronts. Most of the runoff from any one monsoon event is drained through either Gardner Canyon, Empire Gulch, Mattie Canyon, or Spring Water Canyon, and eventually evolves through Cienega Creek (Lomeli, 1995).

Summer monsoons are responsible for approximately 65% of the annual precipitation in southern Arizona, whereas winter precipitation accounts for 35% (Lomeli, 1995). Winter storms originate as Pacific fronts, which follow the prevailing winds to Arizona from the northwest. These are less intense but more widespread and longer in duration. Total annual precipitation for both the upper and lower basins is estimated to be 278,000 acre-feet / yr. with 121,000 acre-feet falling in mountain regions (Simpson, 1983).

The watershed area contributing runoff to the furthest downstream point of Upper Basin (or the Narrows) is 228 mi². This was calculated using the Watershed Tool in ArcInfo using USGS digital elevation maps (DEM) as input for the area of interest. The boundary of the contributing watershed compares well with those calculated by hand in Huth (1998).

The geomorphic survey of the Upper Basin will begin at the confluence of Gardner Canyon and Cienega Creek, and will conclude where Cienega Creek intersects the Narrows (Figure I-A). Given the relative stability of the Upper Basin, this will be considered the “reference” reach upon which physical criteria for the Lower Cienega Creek Basin will be developed.
II. Lower Basin Characteristics

The geologic processes responsible for the topographic formation of the Lower Basin are the same as those discussed for the Upper Basin. Younger alluvial deposits are found along many of the stream channels in the Lower Basin and are composed of unconsolidated silt, sand, and gravel that were deposited primarily by ephemeral stream flow. Stream channels such as Cienega Creek, Mescal Arroyo, and their larger tributaries, have deposits of channel alluvium that are usually less than 100 feet thick (Ellett, 1994). These unconsolidated deposits range in thickness from very thin to about 105 feet at well (D-17-18)17bdb1 (Ellett, 1994). The average thickness for the permeable channel deposits is probably 60 feet (Ellett, 1994).

The elevation of the Lower Cienega Creek drainage drops from approximately 4000 feet at the Narrows to 3200 feet at the USGS Pantano Wash Stream Gauge over a distance of 17.5 miles; this translates to an approximate slope of 0.0087 over the length of the study reach in the Lower Basin.

Fonseca et.al. (1990) reports the average rainfall in the Cienega Creek Natural Preserve to be 14 inches per year, and the mean temperature to be 45° F in January and 80° F in July. Isohyetal rainfall maps obtained from the Arizona Department of Water Resources indicate 16-20 inches of rainfall per year. These numbers are reasonably close to those identified for the Upper Basin.

The watershed area contributing runoff to the USGS Stream Pantano Wash Stream Gauge is 456 mi². This was calculated using the Watershed Tool in ArcInfo and USGS DEMs for the area south of the USGS gauge, and compares well with the 457 mi² area referenced on the USGS website for the same gauge (http://dg0daztcn.wr.usgs.gov/rt-cgi/gen_stn_pg?station=09484600 ) The area of the contributing watershed for the Lower Basin is almost exactly twice that of the area for the Upper Basin. Much of the increase results from the inclusion of Davidson Canyon in the catchment since it contributes an additional 51 square miles of surface water drainage to the USGS Pantano Wash streamgauge.
III. Summary of Return Period Analysis

The following quote is taken from a paper entitled *Regional Relationships for Bankfull Stage in Natural Channels of Central and Southern Arizona* (Moody and Odem, 1999).

Natural stream channels are constructed and maintained by the forces of the water and sediment of the watershed balanced against the resistance of bed and bank materials. Research in other parts of the United States indicate that these complex processes form consistent quantifiable patterns are the basis of the hypothesis of “bankfull flow” defined as the channel forming or maintenance of flow. The bankfull stage corresponds to the discharge at which channel maintenance is most effective, that is, the discharge at which moving sediment, forming or removing bars, forming or changing bends or meanders, and generally doing work that results in the average morphological characteristics of channels. Over the past decade, a system for classifying and assessing rivers has been developed around bankfull channel dimensions (Rosgen, 1994). This system is now widely accepted and used. If bankfull stage can be accurately identified in the field, it provides a common reference point with which to quantitatively describe and classify stream channels.

Moody’s study investigates the hydraulic relationships of natural channels of central and southern Arizona as they relate to bankfull flows. Based on field data collected for sixty-six gauged and un-gauged sites, he divided his streams into 5 hydro-physiographic provinces or regions sharing similar watershed characteristics (e.g. log-linear relationship between bankfull cross sectional area and watershed area). Once streams are grouped into provinces, Moody derives the recurrence interval of respective bankfull floods through an analysis of historical gage data. In his study, Cienega Creek falls in “Province E”. Based on field measurements of bankfull indicators for three gauged sample sites, Moody concludes that bankfull stage (for this Province) has a recurrence interval of 1.5 years (with a range of 1.3 to 1.7 years).

Identification of bankfull flows based on return period data provides one more piece of information that can be used characterize the channel forming processes at Cienega Creek. Accordingly, forty-two years of return period flows for USGS Pantano Wash stream-gauge (09484600) were analyzed via Gumbel, Hazen, and California cumulative probability distributions. The stage associated with 1.3 to 1.7 year return period flows were mapped on a cross section measured at the gauge in order to better defined bankfull stage within this range. Using the slope characteristics of the cross section, it was determined that the 1.3 year return period flows best represented bankfull stage at the gauge. Accordingly, this stage has a cross sectional area of 364 feet (Figure III-A)
This bankfull cross sectional area (364 square feet) may be used to limit the selection of (upstream) bankfull indicators since these are likely to have stages that result in smaller cross sectional areas compared with the (downstream) Pantano gauge. This is significant for those (upstream) reaches of Cienega Creek that are wide and shallow, since these reaches will demonstrate cross sectional areas that are highly sensitivity to the selection of an incorrect bankfull indicator. Thus, the cross sectional area at the gauge may serve as a constraint on the selection of upstream bankfull indicators for those parts of Cienega Creek that are difficult to characterize. For methods and formulas used to derive return periods and cross sectional areas, please review the following spreadsheets.

Spreadsheet Reference: return period data.xls
Worksheet Reference: (Pantano) Gum-Haz-Ca Anl Series

Spreadsheet Reference: all streamgauge data.xls
Worksheet Reference: Pantano Peak

Spreadsheet Reference: gxsec_text.xls
Worksheet Reference: Gauge Data Elevation Tied

USGS streamgauges identified for in basin:

1) Pantanno Wash 09484600
Latitude 32°02'09", Longitude 110°40'37" NAD27,
Datum of gage is 3,205 feet above sea level NGVD29.
http://water.usgs.gov/az/nwis/inventory/?Site_no=09484600

2) Cienega Creek 09484550
Latitude 31°51'51", Longitude 110°34'16" NAD83,
Datum of gage is 4,200.00 feet above sea level NAVD88.
http://water.usgs.gov/az/nwis/inventory/?Site_no=09484550
3) Gage at I10 (Destroyed) 9454560
Latitude: 31.9855556, Longitude -110.5658333
Stateplane: 361205.762132, 1118298.064140, NAD83 / NAVD88
Surveyed in on 17to18m edited
Z = 3562.51 at mouth of gauge vs
# gage datum (feet above NGVD)................. 3560.32
# latitude (ddmss)............................ 315908
# longitude (dddmss).......................... 1103357
IV. Channel Scale Issues

Sheer Stress

Sheer stress is significant to stream morphology in that it impacts the hydraulic radius of the channel. Specifically, sheer stress can be defined as the drag that a stream induces on its channel materials. Mathematically:

\[ \tau = \gamma R S \]

- \( \tau \) = shear stress (Newton / meter²)
- \( \gamma \) = unit weight of water (Newton / meter²)
- \( R \) = hydraulic radius (meters)
- \( = \) (channel cross-section (meter²) / wetted perimeter (meters))
- \( S \) = hydraulic gradient (unitless)

Increased runoff will cause the channel x-sectional area to increase at a greater rate than the wetted perimeter thereby causing the hydraulic radius to grow. Increased runoff may also induce a greater hydraulic gradient. These factors will increase the sheer stress on channel materials.

If channel materials are already in equilibrium with lower average flows (and lower sheer stress), the channel may attempt to achieve a new equilibrium by offsetting the hydraulic radius of the higher flows. For a given cross sectional area, the channel can achieve this by attaining a shallower, wider profile (which is the same as offsetting the increased channel radius via a larger wetted perimeter). This kind of a profile is less likely to contain the suite of physical components that will add to the diversity of the system (and hence, complexity) thus weakening its relative immunity in the seral succession. Channel stability will eventually return, but the channel will be less complex and is more likely to have a wider bankfull width.

These concepts are best understood by computing multiple hydraulic radi for different channel morphologies while keeping cross sectional areas of a hypothetical flow constant- a wider shallow channel will have a lower hydraulic radius than a deep narrow channel. Consequently, a channel can decrease sheer stress (left side of the equation) by decreasing its hydraulic radius (right side of the equation). Doing so results in a narrower, shallower, less complex channel.

Another way of stating this is that channel materials in equilibrium with lower average flows cannot handle higher sheer stress from increased average flows. Consequently, the surplus energy goes into redefining the channel morphology until lower stresses are achieved. As such, channel materials define the acceptable equilibrium sheer stress and consequently also define the channel morphology as a function of average flows. If average flows change, so does the channel morphology. Obviously, average channel flows can be affected by activities at the watershed scale.

Bankfull discharge

A discussion on bankfull stage is included for those who may not be familiar with the term. Bankfull stage corresponds to the discharge at which channel maintenance is the most effective, that is, the discharge at which moving sediment, forming or removing bars, forming or changing bends and meanders, and generally doing work that results in the average morphological characteristics of channels (Dunne and Leopold, 1978). Moody (2/99) identified bankfull discharge for Southern Arizona to be related to the 1.3 – 1.7 yr return period flood. In a separate study, Moody also identified a regression equation which can be used for predicting bankfull stage via a watershed area - bankfull cross-sectional area regression relationship. Bankfull width is considered the width of the channel at water level when it is flowing at bankfull stage.
Stream Channel Stability

A channel can have a stable width even though the stream is migrating laterally at a constant annual rate. Stream width can remain relatively constant where the role of erosion on one bank is compensated with corresponding sediment deposition along the opposite bank. The bankfull width of alluvial channels remains relatively constant and thus becomes one of the most directly observable features used in correlations with selected stream flow magnitudes (Rosgen, 1996). As such, the change in bankfull width over time may be used to measure stream stability. Wider bankfull widths over time are indicative of a channel that has modified its morphology in response to increased flows (as described in the section on sheer stress). Relative indicators of stability for different stream types include:

a) Well defined / stable banks.
b) Presence of interspersed riffles, pools, runs and meanders.
c) Well developed pool depths.
d) Bankfull width to depth ratios that allow bankfull flows to saturate the floodplain while not being too wide and shallow.
V. Establishment of Primary Control Stations via GPS Work Conducted by ADOT

Primary Control Point Network Selection and Installation

The Cienega Creek Physical Integrity Survey is tied into a suite of 32 Primary Control Points installed by ADEQ. Coordinates for these Primary control points were supplied by the Arizona Department of Transportation (ADOT) via a GPS survey conducted in October 2000. The resulting network provides the Physical Integrity Survey with a means for conducting qaqc (quality assurance / quality control) on daily traverses, and also registers our data to the Stateplane Coordinate System. The following table summarizes the coordinate system and projection parameters associated with the Primary (and our own Secondary) Control Point Networks.

Table V-A: Projection and Coordinate System Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
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<td>Projection</td>
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<td>Coordinate System</td>
<td>Stateplane –feet</td>
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<tr>
<td>Zone</td>
<td>Arizona Central (3176)</td>
</tr>
<tr>
<td>Horizontal Datum</td>
<td>NAD-83 (with HARN Adjustment)</td>
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<tr>
<td>Vertical Datum</td>
<td>NAVD-88</td>
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<td>Ellipsoid</td>
<td>GRS 80</td>
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<td>Central Meridian</td>
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<td>CIEN 24B</td>
<td>379203.826</td>
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Figure V-1: Primary Control Point Distribution
The following metadata was supplied with the point information shown in Table V-B:

To all concerned about horizontal control along the A.D.E.Q. Cienega Creek Project,

There are three first order stations and four second order stations being held fixed in the horizontal. The first order stations are as follows: CZ0266-IRENE 1935, FQ0208-PIPE 1960 and CZ1815-PANTANO 1935. VAIL 1935-CZ0258 was let free in the horizontal.

The second order stations held fixed are as follows: CG0338-NEGA 1960, CXG0346-MILEPOST 1962, CG0362-DAVID 1962 and CG1041-SONOITA 1936. PA 12 1960-CG0333 and AMOLE 1960-CG0347 were let free and the horizontal.

The LOCUS project scaling errors were increased to allow for the discrepancies between the second order and the first order control. This did not affect the quality of your data.

To all concerned about vertical control along the A.D.E.Q. Cienega Creek Project,

The vertical control along the north end of the project was based upon CZ0266-IRENE 1935, FQ0208-PIPE 1960 CZ1815-PANTANO 1935, CG0338-NEGA 1960 and CG0346-MILEPOST 1962.

Because of underground pipeline construction along the Southern Pacific railroad easement, the published benchmarks are presumed destroyed. This vertical control “line” is along the south end of the Cienega Creek Project. In an effort to keep the project on schedule and achieve the desired accuracy’s, Howard Whitley recovered some non-published third order benchmarks that were set along and near SR83 from the south edge of the Rincon Valley Quadrangle(49), or from I 10 south along SR83 to Sonota.

I, Donald E. Bloodworth converted the third order N.G.V.D. 1929 elevations to N.A.V.D.1988 elevations using a free program from the N.G.S. called VERTCON VER. 5.2. I held all published vertical control and the “GPS derived” elevation came to within a foot of my converted value. I was only able to hold 43 MDC 1976, not 48 MDC 1976.

The “MDC” bench line was established in 1976. The USGS “NOGLS” bench line was originally established in 1903 and was re-observed in 1946 and 1976. During the 1976 re-observations, differences were found. The differences were great enough to preclude further publishing of the third order line and the “spur lines” in their entirety from the N.G.S. N.S.R.S. database. In my research of the area, I found a P7M JOB2385 that was completed in 1986. In BOOK 2A, page 4, there are notes concerning the vertical differences from the field observations and the elevations of record for the benchmarks used in the Cienega Creek Project. These note coincide with the nearly half of a foot of disagreement with each of the two benchmarks recovered by Howard Whitley, Geodesy Supervisor.

The NGVD1929 elevation for 43 MDC 1976 was 4745.436, after conversion through VERTCON the NAVD 1988 elevation is 4748.25, for a difference of 2.81’.

The NGVD1929 elevation for 48 MDC 1976 was 4748.829, after conversion through VERTCON the NAVD 1988 elevation is 4751.70, for a difference of 2.87’. I was unable to hold this elevation in your network.

Field checks will prove out elevation arguments from the converted benchmarks. These may either be differential levels between control points, STATIC GPS or R.T.K.G.P.S.

To make a long story short, there is only one vertical control holding down the south end of your project.
and it is converted from non-published third order control NGVD29 to NAVD88.
VI. Establishment of Secondary Control Stations

Summary

The primary control-point network provides us with a suite of stations from which the survey can be extended. The resolution of the primary control point network is much too coarse for collection of continuous geomorphology data through the length of the survey. As a result, a secondary control point network was established between all primary control stations. The secondary control point network was created by occupying a primary control point, and then traversing to the next primary control point via a second order traverse. The procedure as executed by an instrument man operating the Zeiss R-50 EDM (gun), and a reflector man (placing reflectors on stations) is briefly summarized here.

1. The instrument man occupies a primary control point (e.g. CIEN1A) and backsights to a reflector located either on another primary control point (e.g. CIEN1B), or previously surveyed secondary control point. The backsight serves as a bearing control on the survey. The instruments man then focuses on the backsight and “zeroes” the circle reading on the instrument to establish a baseline for measured angles.

2. The reflector man establishes a new secondary control point that provides good visibility of (1) the channel, (2) the instrument man, (3) his next secondary control point, and relative assurance of permanence for future surveys. If possible, he will also try to produce a 90-degree angle between himself, the instrument man, and the backsight. This minimizes the negative effects of improper instrument leveling at the instrument man’s station.

3. Once found, he flags the area and checks his location by verifying with the instrument man that the point is indeed visible through the gun. When the instrument man verifies the candidate for the secondary control point, the reflector man installs a two-foot piece of rebar at that location. A yellow cap is placed on the rebar, and a metal tag with the point description is tied at the base. The yellow cap contains a mark, which will be used to center the reflector and will serve as the next station for the gun. The label carries the description for the point. The description defines the bank and point number for the traverse (e.g. LB1 would indicate Left Bank, first point in the traverse).

4. The reflector man installs and levels a reflector on the new point identified by the yellow cap. Leveling takes place via the use of a bipod to generate the highest level of accuracy possible.

5. The instrument man measures the angle to that point, and shoots a distance. Whenever traversing, the instrument man always measures this angle twice- once with the gun in its “face forward” position, and a second time with the gun “flopped”. The average angle and distance produce a coordinate for that station which can then be used as a new station (or “occupy-point”)

6. The reflector man indicates the height of the reflector. The height of the instrument combined with the reported height of reflector results in an elevation for the new station. This information is collected and input into the TDS datalogger connected to the Zeiss R-50 EDM.

7. Having collected the coordinate and elevation for the new point, the instrument man is now free to occupy that new station. The reflector man sets up the backsight on the instrument man’s previous occupy point, and then locates his next secondary control point. The instrument will now use his previous occupy point as his backsight, and will shoot to the next secondary control point using the same techniques discussed above.

This procedure is repeated for as many turning points as required to establish a high-resolution control point network between any two primary control points. Once established, this secondary network is available for collecting high-resolution geomorphology data. Over time, not all stations will survive- some will be disturbed by cattle or washed...
out. However, given the density of the stations installed in both the Upper and Lower Basins, not all need survive. As long as two points can be located within any traverse, future surveys may be registered to this survey.

The above summary ignores many of the finer details required for the accurate installation of the secondary control point network. Details regarding the use of the instrument and datalogger, angle optimizations, and compass rule adjustments follow, and are presented in the form of a manual. This manual defines the methodology employed by our survey, and is presented here to ensure reproducibility of our data. All details presented in this documentation are specific to the following equipment:

Zeiss R-50 Constructor EDM Surveying Instrument
Sokia Wooden Tripod
TDS48 Datalogger

Zeiss R-50 Constructor EDM Instrument Setup

1) Setup: Extend tripod legs to a comfortable height and fix them using the tripod locking screws. Screw the instrument centrally on the tripod head plate with the tribrach screws in mid position.

2) Coarse Centering: Set up the tripod roughly above the station point with the tripod head plate horizontal. Use the optical plummet over the toe of your shoe to get the best results. Center the circular mark of the optical plummet above ground mark by moving the instrument on the tripod head plate. Once centered, tighten the instrument in place (don’t over tighten).

3) Coarse Leveling: Adjust tripod legs until circular bubble (fisheye) is centered.

4) Precision Leveling: Align instrument parallel with the imaginary connecting line between two tribrach screws. Turn tribrach screws in opposite directions to level. Repeat by turning the instrument about its vertical axis 90 degrees and leveling with the one remaining tribrach screw. Retain one leveling screw as an axis point and use the remaining two to fine level the instrument. Once leveled, turn the instrument to its original position (-90 degrees) and re-check the leveling. Repeat this process as many times as necessary.

5) Double Check Centering: Once the instrument is level, ensure that the circular mark of the optical plummet is still centered over the benchmark. If it is not, re-center and re-level as discussed above.

6) Focus the Crosshairs: Sight a bright, evenly colored surface and focus the crosshairs by turning the eyepiece. Make sure you are adjusting the focus for the cross hairs rather than the focal length of the scope.

7) Instrument Calibration: Turn the instrument on. Instrument will prompt for calibration- spin instrument around vertical, then horizontal axis. If the instrument is not level, the digits after the coordinate decimal point will be dashes. You will need to turn the instrument off, re-level, and turn the instrument back on.

8) Locate the Backsight Prism: Use the sighting collimator to roughly locate the backsight prism. Lock the coarse adjustment by turning the vertical and horizontal clamp screws. Fine-tune the instrument with the vertical and horizontal tangent screws. Use the telescope to center cross hairs on prism. NEVER over-tighten the adjustment. NEVER attempt to adjust the instrument by hand when the coarse adjustment is tightened.

9) Define Environmental Conditions via Menu Options on the Gun: Always make sure you have temperature, pressure, and the prism constant set correctly before taking measurements- check these as well as instrument level periodically throughout survey.
**TDS 48 Datalogger Setup**

**In the Office:**

1) Go to the main menu and set up a control file in the TDS by selecting (G) OPEN / EDIT JOB and then (G) CREATE NEW JOB. You can add control point coordinates (or points with known GPS coordinates) to this job through (J) EDIT COORDINATES available from the JOB MENU. (NOTE: The main menu of the TDS datalogger will have the following title: &lt;SELECT G to S&gt;).

2) Alternatively, you can download text files containing control point coordinates using the TDS Survey Link Software. When you download (or use the FILE TRANSFER option in the software), a new job is automatically created from the downloaded data.

3) In both cases (OPEN / EDIT JOB / CREATE NEW JOB and FILE TRANSFER), you are creating what is known as a coordinate file (*.CR5), which will house all your calculated coordinates and elevations. This file can be edited directly in the field.

4) For each coordinate file, there is a respective raw data file (*.RW5). This file CANNOT be edited from within the datalogger- this is an account of what you did in the field and is the file used for calculating your foresight coordinates. However, this file can be downloaded to a PC and edited there. Upon uploading back to the datalogger, the coordinate file (*.CR5) can be recalculated using the edited raw data file.

5) Lastly, you will also need to set up your repetitions for the traverse. If you have not already done so, select (J) TRAVERSE option from the main menu in order to bring up the REP softkey. Use this key to bring up the REPETITIONS menu. Then select (L) SET REP MODES. For the Zeiss R-50, specify the following:

   HORIZ ANGLE MODE: Directional
   VERT ANGLE: Multi.dir
   DIST MODE: Multi.dir
   NUMBER OF SETS: 1
   ANGLE TOLERANCE (SEC): 15.00
   DIST TOLERANCE: 0.01
   (MORE)
   SHOOTING SEQUENCE FOR DIRECTIONAL: BS.FS flip BS.FS

Once specified, press the EXIT softkey to bring you back to the TRAVERSE options. Press EXIT again to bring you back to the main menu.

**In the Field:**

1) After setting up the instrument (as described above) and powering up the data-logger, select (G) OPEN / EDIT A JOB from the main menu. (The main menu has a heading of &lt; SELECT G TO S &gt; at the top of the screen. (NOTE: If you see the heading JOB MENU, you are already where you belong).

2) Establishing and Checking the Backsight

   a) From the traverse menu, select the purple shift key and the “0” key in order to enter the backsight menu. Specify the backsight-point, the occupy point, the height of the leveled instrument, and the height of the backsight reflector on the backsight station. Then, press the softkey SOLVE in order to solve for the backsight azimuth.

   b) Focus the instrument on the backsight and set the horizontal azimuth to zero. Ensure that the BS CIRCLE READING OF GUN on the data-logger also reads zero. The instrument is now ready to
check the backsight. Check the backsight by pressing the CHEC softkey. Confirm the backsight-point by (G) shooting the distance. Upon doing so, the datalogger will prompt you to press a key in order to take a shot. After doing so, the data-logger will report your horizontal and vertical error (or the calculated distance to the BS point relative to the known distance).

c) If the errors are small (within a few hundredths of a foot) you have specified the correct occupy point, backsight-point, and instrument / reflector heights. If the errors are large, check the instrument and reflector heights and ensure that these have been entered appropriately in the TDS. Also, make sure that the correct occupy point and backsight-point have been specified. Repeat this process as many times as necessary in order to generate good closure on the backsight.

d) Once the backsight check has been completed successfully, record the vertical and horizontal error in your field-notes. Also, record the horizontal distance shot to the backsight. These notes will help you identify the sources of error in data that has not closed within your tolerances, and are essential to preventing propagation of error in the field.
Conducting a Second Order Traverse Between Primary Control Points

1) After the backsight has been solved and confirmed, and the distance to the backsight has been recorded, you are now ready to traverse. Go to the main menu and select (J) TRAVERSE/SIDE SHOT.

2) Ensure the HI and the HR (relative to the FS) are correct, and press TRAV. The instrument will now prompt me to take shots through the following routine: BS, FS (reverse), BS, FS (set scope right). Take note of the following during BS-FS-BS-FS routine:

- Before shooting the BS, ensure the circle reading of the gun and data-logger are zero and note accordingly in your field notes. If they are not, the instrument tripod legs may have settled into the soil (settling causes the internal compensator to register a new azimuth). Check leveling and optical plummet, re-center on prism, and reset backsight circle to zero on the instrument before proceeding. *Then* shoot the backsight.

- Focus on and shoot the FS and record the horizontal distance measured displayed on the instrument.

- When flipping the instrument and re-shooting the backsight, record the flipped horizontal azimuth. This number should be close to 180 degrees if the instrument is level and if the circle on the gun was set to zero before starting the BS-FS-BS-FS routine (as it should have been).

- Complete the routine by taking one last shot at your foresight with the instrument flipped. Set the scope up right and wait for the data-logger to compute a coordinate for the FS point.

- *If you receive a message stating that there is a horizontal error*, your angle windings were not within 15 seconds of one another (as specified under Angle Tolerance under SET REP MODES). If this happens, *do not accept the data*. Make sure the instrument and reflectors are precisely over their points and level before shooting since these will have an impact on your angle-windings. Refocus on the backsight and *set the instrument circle to zero*. Then, REDO THE TRAVERSE by hitting the TRAV key and repeating the procedure discussed above. Record all revised angle windings in your field notes.

- *If you receive no error message*, you have shot your point successfully. Occupy your foresight and repeat the BS check procedure using your previous occupy point as your backsight. Make sure to record all measurements in your notes.

When checking your backsight, ensure that your back sight check is no greater than two-tenths of a foot. If the backsight check generates an error greater than this, you have a “bust”. *Do not move to your next traverse point until the source of this error is identified and remedied*. You might consider re-leveling the instrument and clearing brush that is obstructing the view between the instrument and the backsight reflector. If this does not solve the problem, consider re-shooting the traverse (occupying your current backsight and re-shooting your current occupy point, traversing, and re-shooting the backsight distance for comparison). The error may result from one of the following:

- *Refraction of light between instrument and prism* – although the prism may be clearly visible, brush may be refracting light causing the distance traveled to be longer than what is real. This will have an effect on the calculated coordinate for the foresight since the distance shot (the hypotenuse used in calculating the Northing and the Easting) is biased.

- *Instrument Setting* – the instrument may settle before or during the shot causing it to come out of plumb with the point in question especially in wet or sandy soils. As such, you may be shooting from a changing coordinate that may not be valid. Furthermore, the angles you are turning will likely be incorrect.

The following page shows the field form used for collecting traverse data.
I. Secondary Control Point Traverse – Cienega Creek Physical Integrity Survey; Traverse from ____ to ____

<table>
<thead>
<tr>
<th>Point</th>
<th>Name</th>
<th>Measurements</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>OP#</td>
<td></td>
<td>HI =</td>
<td></td>
</tr>
<tr>
<td>BS#</td>
<td></td>
<td>HR =</td>
<td></td>
</tr>
<tr>
<td>FS#</td>
<td></td>
<td>HR =</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Permanent FS Point Installed (Y/N)
Circle set to zero on BS (Y/N)
If No, circle reading sent to TDS = (NA) ( )
Reverse Horizontal Angle =

BS# HR =
FS# HR =

Backsight Check
Horizontal Error = Vertical Error =

DATE: PAGE of TOTAL

25
Mitigation of Closure Errors Via Compass Rule Adjustment

Each traverse is completed when a coordinate is surveyed for the closing primary control point. Together with the starting primary control point, these two stations bracket the suite of established secondary control points. This is referred to as a second-class, closed traverse (Moffit and Bouchard, 1982). For more details on the coordinate adjustment method, see section 8-19 in Moffit and Bouchard (1982).

A variety of factors may influence the departure of the calculated coordinate for the closing control point when compared to its original GPS coordinate established by the Arizona Department of Transportation (ADOT). These factors include instrument settling, poor angle definition, poor leveling, and other factors, which can be reviewed in any basic surveying text. Errors associated with closure in latitude (Y) and departure (X) are mitigated using the method of coordinate adjustment. This method evenly distributes the total error associated with a traverse to all points located within that traverse (thus increasing the accuracy of the survey).

Additional details regarding the methodology for downloading data from the datalogger, performing the adjustment, and uploading the adjusted coordinates follow, and are presented in the form of a manual to ensure reproducibility of our results.

Step 1. Downloading Survey Data from the TDS48 datalogger:

Two bounding primary control points identify each traverse. The name of the job is set according to the traverse and takes the form of “XtoX.CRS" in the datalogger. For example, installation of secondary control points between primary control points 1 and 2 can be identified in the data logger by referencing the job called “1to2.CRS." Job files have already been created for all bounding primary points, and are subsequently supplemented with traverse data.

Once a traverse is completed, the data must be downloaded to a PC using the program entitled TDS Survey Link. The following outlines the steps for downloading this data and converting it to a format readable by a spreadsheet.

1. Attach the TDS Survey Link Software Key to the parallel port in the back of the PC.
2. Attach the data logger to the PC using the serial cable.
3. Turn on the data logger and go to the main menu of the TDS48 program.
   - note: the first option of the main menu is: (G) Open/Edit Job.
4. Hit the softkey MORE to bring up the File Transfer option (S).
5. Select (S) and then select the softkey SEND to bring up the menu of available jobs.
6. Highlight the job you are interested in adjusting using the error keys, but do not SELECT yet.
7. Start the TDS Survey Link program on your computer.
8. Under the TRANSFER menu option, select Send/Receive.
9. Highlight the tab RECEIVE on the new window.
10. Check the option: Get filename from the data collector or PC.
11. Select the directory for the downloaded data.
12. Click the RECEIVE button in the program, and click the SELECT key on the data logger.

Your data will now begin downloading. If there are multiple retries with no success, then replace the batteries in the data logger- the transfer will not work unless the batteries are fresh. Also, note that the transfer will not take place unless you use the serial cable provided with the datalogger- a replacement serial cable from Radio Shack will not transmit data. Contact HP if the serial cable is lost.

13. Once downloaded, close the transfer window in the TDS Survey Link program.
15. Under the Input Type, select TDS Coordinates, and choose then choose the file to convert.
16. Under Output Type, select ASCII and type the full path and name the file XtoX.txt.
17. Open the output text-file in a text editor and eliminate unnecessary points from the traverse.
18. Save the changes. If using Quattro, you will need to change the file extension to *.CSV.

Step 2. Generating the Coordinate Adjustment Using a Spreadsheet Template.

The following steps assume that you are using the generic Quattro template created by Hans Huth at ADEQ.

19. Open the Generic Compass Rule Adjustment template in Quattro.
20. Open the CSV file in Quattro.
21. Copy the CSV fields to the worksheet entitled “Generic In” (anchor the paste on cell A3).
22. Cut the last record of the pasted coordinate data (which should = ADOT GPS coordinate)
23. Paste the GPS coordinate in cell A54
24. Copy the second to last record of the pasted coordinate data (= surveyed ADOT coordinate).
25. Paste the surveyed coordinate in cell A55.

Steps 22 and 23 will calculate the closure error and will use the calculated error to generate a new set of secondary control point coordinates. These new coordinates incorporate the coordinate adjustment rule (for second order traverses) into a new coordinate file for the secondary control points. See cell formulas for details on calculations (equations identified from Moffit and Bouchard, 1982).

26. Rename the worksheets entitled Generic In and Generic Out to something unique for the traverse. Then, save the workbook with a name unique to the traverse.

27. Go to the worksheet formerly entitled “Generic Out” and corroborate that the adjusted coordinate for the last surveyed point (the surveyed GPS coordinate) matches the GPS coordinate listed in record A55 of the “Generic In” worksheet. If it does not, there was an error when cutting and pasting data in the “Generic In” worksheet.

28. Delete any extraneous records in the worksheet formerly entitled “Generic Out”.

29. Save that worksheet as an ASCII text (comma delimited) file and give it the name XtoXm.txt. Make sure to include the “m” in the filename since this will distinguish this coordinate file from the unadjusted coordinate file.

30. Change the name of the “XtoXm.txt” file to “XtoXm.asc” This needs to be done so that the Survey Link Program will recognize the file.

Step 3. Upload the Corrected data to the TDS48 Datalogger (for future survey work).

31. Return to the Survey Link program and under CONVERSIONS, select “Convert File Format.”

32. Convert the file from an ASCII type (asc) to a TDS Coordinate file (cr5). Make sure that the new cr5 file is named appropriately with an “m” (e.g. 1to2m.cr5). This will enable you to distinguish the original traverse coordinate file from the coordinate adjusted traverse.

33. Under TRANSFER, select “Send/Receive” and in the new window, select the Send tab.
34. Choose the appropriate CR5 file (the coordinate adjusted one identified with the “m”).
35. In the data logger, navigate to the file transfer menu as specified previously and hit the softkey RECV.
36. In the Survey link program, press the SEND button.

37. Once the file is transferred, corroborate that it is present in the data logger. Go to the main menu, select (G) Open/Edit Job, then (H) Open and existing Job. The file you uploaded should be the last file in the list of jobs available to you to work from. Use the XTOXm.CR5 file of interest for subsequent sideshot work. DO NOT use the XTOX.CR5 file (note the missing “m”) this file contains unadjusted coordinate data.
Summary of Closure Errors for the Traverses Conducted through March 20, 2002.

The conditions at Cienega Creek pose many difficulties for generating an ideal second order traverse. Given poor visibility resulting from the dense foliage, station selection was often limited to points that were located very close to one another, or at angles that were less than optimal (e.g. much greater or less than 90 degrees). In many instances, limits on site selection resulted in locations that were unstable (e.g. marshy, muddy, or very soft ground). Given these conditions, several traverses generated large closure errors relative to the precision of the instruments used.

In order to improve overall accuracy, many traverses were re-surveyed, and field qaqc methods were developed to capture errors on site. The field qaqc methods were maintained, but the practice of re-shooting a traverse did not generate significant gains in accuracy. Consequently, this practice was discontinued, and subsequent errors were mitigated via compass rule adjustments.

Both the surveyed and compass rule adjusted coordinates and elevations are stored in Quattro Pro worksheets specific to each traverse. Only the compass rule adjusted data were used for subsequent geomorphic characterization. It should be emphasized that the horizontal and vertical errors are not significant relative to the goals of the survey. Nevertheless, they are documented and noted for posterity.

Table VI-A: Error Summary on Second Order Traverses

<table>
<thead>
<tr>
<th>Traverse</th>
<th>Error (ft)</th>
<th>Distance Traversed (ft)</th>
<th>Horizontal Error (ft)</th>
<th>Vertical Error (ft)</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1to2</td>
<td>3744</td>
<td>4381</td>
<td>1.17</td>
<td>-0.25</td>
<td>Ephemeral</td>
</tr>
<tr>
<td>2to3</td>
<td>11061</td>
<td>6194</td>
<td>0.56</td>
<td>0.10</td>
<td>Perennial</td>
</tr>
<tr>
<td>3to4</td>
<td>5089</td>
<td>2290</td>
<td>0.45</td>
<td>-0.03</td>
<td>Perennial</td>
</tr>
<tr>
<td>4to5</td>
<td>3481</td>
<td>5778</td>
<td>1.66</td>
<td>0.22</td>
<td>Perennial</td>
</tr>
<tr>
<td>5to6</td>
<td>10107</td>
<td>8389</td>
<td>0.83</td>
<td>0.16</td>
<td>Perennial</td>
</tr>
<tr>
<td>6to7</td>
<td>3366</td>
<td>11311</td>
<td>3.36</td>
<td>0.54</td>
<td>Perennial</td>
</tr>
<tr>
<td>7to8</td>
<td>1641</td>
<td>4217</td>
<td>2.57</td>
<td>0.19</td>
<td>Perennial</td>
</tr>
<tr>
<td>8to9</td>
<td>2683</td>
<td>9714</td>
<td>3.62</td>
<td>0.40</td>
<td>Perennial</td>
</tr>
<tr>
<td>9to10</td>
<td>2780</td>
<td>7896</td>
<td>2.84</td>
<td>0.20</td>
<td>Perennial</td>
</tr>
<tr>
<td>10to11</td>
<td>NA</td>
<td>Not traversed</td>
<td>NA</td>
<td>NA</td>
<td>(11A/B Bearing Check)</td>
</tr>
<tr>
<td>11to12</td>
<td>NA</td>
<td>Not traversed</td>
<td>NA</td>
<td>NA</td>
<td>Ephemeral – cross sections only</td>
</tr>
<tr>
<td>12to13</td>
<td>NA</td>
<td>Not traversed</td>
<td>NA</td>
<td>NA</td>
<td>Ephemeral – cross sections only</td>
</tr>
<tr>
<td>13to14</td>
<td>NA</td>
<td>Not traversed</td>
<td>NA</td>
<td>NA</td>
<td>Ephemeral – cross sections only</td>
</tr>
<tr>
<td>14to15</td>
<td>NA</td>
<td>Not traversed</td>
<td>NA</td>
<td>NA</td>
<td>Ephemeral – cross sections only</td>
</tr>
<tr>
<td>15to16</td>
<td>NA</td>
<td>Not traversed</td>
<td>NA</td>
<td>NA</td>
<td>Ephemeral – cross sections only</td>
</tr>
<tr>
<td>16to17</td>
<td>NA</td>
<td>Not traversed</td>
<td>NA</td>
<td>NA</td>
<td>Ephemeral – cross sections only</td>
</tr>
<tr>
<td>17to18</td>
<td>6427</td>
<td>7391</td>
<td>1.15</td>
<td>0.60</td>
<td>(17A/B Bearing Check)</td>
</tr>
<tr>
<td>18to19</td>
<td>1879</td>
<td>7365</td>
<td>3.92</td>
<td>0.35</td>
<td>Perennial</td>
</tr>
<tr>
<td>19to20</td>
<td>1852</td>
<td>11742</td>
<td>6.34</td>
<td>0.74</td>
<td>Perennial</td>
</tr>
<tr>
<td>20to21</td>
<td>3740</td>
<td>7442</td>
<td>1.99</td>
<td>0.95</td>
<td>Perennial</td>
</tr>
<tr>
<td>21to22</td>
<td>6221</td>
<td>13811</td>
<td>2.22</td>
<td>0.58</td>
<td>Perennial</td>
</tr>
<tr>
<td>22to23</td>
<td>33181</td>
<td>13936</td>
<td>0.42</td>
<td>0.32</td>
<td>Perennial</td>
</tr>
<tr>
<td>23to24</td>
<td>2293</td>
<td>9080</td>
<td>3.96</td>
<td>0.41</td>
<td>(24A/B Bearing check)</td>
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</tbody>
</table>
Suspected Problems with the Primary Control Point Network.

When traversing between control points 19 and 20, we generated poor horizontal closure (1:1879). Our vertical closure was good. Although we perform a coordinate adjustment on all our data to mitigate horizontal errors, we were concerned that the poor closure might propagate through the rest of the survey downstream from control point 20 through control points 24A/24B. Consequently, we decided to approach control point 20 from our primary bearing control points in the lower basin (24A/24B) thus working our way upstream to control point 20.

Using this approach, closure was poor between 24A/24B and 23 (1:2293), and worsened between 23 and 22 (1:need spreadsheet). Given our extensive field qaqc methods, we were concerned that our GPS control may not be accurate. Consequently, we decided to proceed with a first order closure back to 23 for the 23-to-22 traverse. Specifically, we continued the 23-to-22 traverse back to our starting point (23). Doing so resulted in a closure that was an order of magnitude better than that generated by closing on the GPS coordinate for 22. The closure error for the first order traverse to point 23 was 1:33181. This is significant when compared to the closure error for the second order traverse to the GPS coordinate for point 22 (1:need spreadsheet).

We had similar results when generating a first order closure between 22 and 21 (e.g. traversing from 22 to 21, and back to 22). The respective closure error for this first order traverse was 1:6221 – much higher than the closure associated with the second order traverse to the GPS coordinate 21 (1:need spreadsheet).

Given the high accuracy of the first order closures encompassing points 22 and 21, we believe that the GPS data associated with control points 22 and 21 is questionable. In reviewing the metadata for the ADOT GPS network, we found that ADOT had documented poor control horizontal and vertical control for the GPS survey in this part of the basin given a lack of first order stations to tie the GPS survey into. As such, we eliminated the GPS data for these two points (22 and 21) from our compass rule adjustments. Instead, we used the data generated from our first order closures.

It is also likely that poor station control also resulted in a biased GPS coordinate for control point 20. Given time constraints, we were not able to complete a first order traverse for this leg of the survey (19 to 20, and back to 19). For the purposes of this study, the horizontal error associated with this leg of the traverse (19-to-20) is not significant, and it is mitigated via a compass rule adjustment on the traverse. All compass rule adjustments throughout the survey have been documented extensively. Both the calculated and compass rule adjusted coordinates have been saved for posterity.
VII. Collection of Geomorphic Data

Summary

Once a secondary control point network is finalized, the instrument man uses these stations to measure the location and elevation of geomorphic features selected by the reflector man. In order to add a geomorphic dimension to the data, a series of lookup codes were developed for the survey. A lookup code is a short three or four letter word that can be used to quickly attribute a feature in the field. In order to carry a lookup code attribute, each feature must conform to a set of rules associated with that code. For example, the code “TOT” stands for “Top of Terrace”. In order for a feature to carry this attribute, the reflector man must place his rod precisely at the edge of the terrace resulting from the oldest historical incision (the highest terrace). When the feature (rather than the reflector) is visible by the instrument man, he/she should double check the placement of the rod and the feature callout to ensure repeatability.

Creation of a Lookup Code Schema

Most features represent either an edge, or a break in slope. Consequently, the reflector man follows respective breaks to guide his placement of the rod for geomorphic characterization. Doing so allows for accurate extrapolation of channel characterization of these features in a GIS.

a) TOT - Top of Terrace - This is the highest terrace resulting from the oldest historical incision. This feature may be between 5 and 20+ feet high. Place the reflector on the edge of the terrace. If the terrace has eroded, place the reflector on the first inflection from the historical floodplain.

b) TOTS - Top of Terrace Source - This is the highest terrace resulting from the oldest historical incision. In order to be listed as "source", this feature must be actively eroding at a greater rate relative to other local terraces. This feature may be between 5 and 20+ feet high. Place the reflector on the edge of the terrace. If the terrace has eroded, place the reflector on the second inflection from the historical floodplain.

c) BOT - Bottom of Terrace - This is the base of the highest terrace resulting from the oldest historical incision. Place the reflector at the first inflection point at the base of the terrace. This may be at the top of an apron, which has formed at base of the terrace. Do NOT call out "Top of Apron". Instead, call out "Bottom of Terrace".

d) OS - On Slope - This characterizes the slope of the apron between the bottom of the terrace and the bottom of the apron. Place the reflector between the inflection point marking the bottom of terrace and the bottom of apron. Take as many "on-slope" measurements as you like in order to capture interesting characteristics of the apron. Aprons may also be characterized for eroding banks.

e) BOA - Bottom of Apron - Required for characterizing the full height of the apron. Place the reflector at the inflection point marking the bottom of the apron, and the active (or historical) floodplain.

f) TOB - Top of Bank (version 1) - May describe a historical bankfull feature that has been abandoned due to subsequent incision and thus is above bankfull; not the same as bankfull. Place the reflector on the inflection point above a bank's apron, and its upstream floodplain or active channel.

g) TOB - Top of Bank (version 2) - May describe a bank near the water's edge that is located beneath bankfull. This example shows the top of bank beneath bankfull near the water's edge. If there is no water in the channel, use LEC or REC for this first bank next to the thalweg. Place the reflector on the inflection point between a bank's apron, and its upstream floodplain.
h) \textbf{FP - Flood Plain} - Describes the level area above bankfull. Always take a floodplain measurement at the base of a bank in order to capture the slope of the bank. Take the measurement at the inflection point where you would instinctively call out "bottom of bank". Take your measurements along any minor inflection points between the "bottom of bank" and the next "top of bank" or bankfull feature.

i) \textbf{BF - Bank Full} - Describes the bank associated with bankfull floods. Use this callout only when you are relatively certain that the bank you are measuring is in fact bankfull. Measure this feature the same way you would measure a "top of bank" feature. (Details regarding indicators for bankfull are available in the original sample plan).

j) \textbf{AC - Active Channel} - Analogous to the floodplain, but located beneath bankfull. Therefore, it cannot be called "floodplain". A lack of vegetation has been observed in the active channel during the course of this survey. Take the measurement at the inflection point where you would instinctively call out "bottom of bank". Take measurements along any minor inflection points between the "bottom of bank" and the next "top of bank" feature.

k) \textbf{LEW - Left Edge of Water} - Take measurements where the water level elevation pooling or running water meets the sediment along the left edge of feature as one faces downstream.

l) \textbf{REW - Right Edge of Water} - Take measurements where the water level elevation of pooling or running water meets the sediment along the right edge of the feature as one faces downstream.

m) \textbf{UWF - Under Water Feature} - Measure significant breaks in slope under pooling or running water.

n) \textbf{LEC - Left Edge Channel} - Analogous to the first top of bank encountered upstream from the thalweg. The difference is that REC and LEC are called out where the channel is ephemeral, and thus are indicators of an ephemeral reach in the GIS when no other indicators are present.

o) \textbf{REC - Right Edge of Channel} - Analogous to the first top of bank encountered upstream from the thalweg. The difference is that REC and LEC are called out where the channel is ephemeral, and thus are indicators of an ephemeral reach in the GIS when no other indicators are present.

p) \textbf{IC - In Channel} - Use this callout when you are dealing with a very wide and shallow ephemeral channel that has no defined thalweg. Use this in place of "active channel" or "floodplain" when you do not know if you are above or below bankfull (thus, you are not certain of whether or not you are in the floodplain or in the active channel). Use MC (mid channel) when predicting the thalweg along the center of a run characterized by IC callouts.

q) \textbf{THAL – Thalweg} – Measured at the deepest point along the main channel (ephemeral or perennial). Avoid measuring multiple thalwegs for braided channels- follow the main channel wherever possible.

r) \textbf{TRIF – Top of Riffle} – Measured at the top of a riffle. Take this measurement where the water breaks and/or a negative change in slope of the thalweg is evident immediately downstream of the point. Measure at least one thalweg downstream of the riffle and prior to the next pool, riffle, or run. If a pool follows the riffle, take at least one measurement in the deepest thalweg of the pool to characterize the depth of the pool.

s) \textbf{TPOL – Top of Pool} – Measured at the top of a pool. Take this measurement where a negative change in slope of the thalweg is evident immediately downstream of the point. Measure at least one thalweg downstream of the top of the pool and prior to the next pool, riffle, or run.

\textbf{NOTE:} In reviewing collected data, many TPOLs measured immediately downstream of TRIFs generate positive slopes to their respective thalwegs. This results from the difficulty of identifying
exactly where the riffle ends and the pool starts. For the purposes of this study, TPOLs should not be called out downstream of riffles. Instead, care should be taken to identify the deepest thalweg downstream of the riffle. Assuming that a LEW or a REW was measured near this thalweg, the GIS can be used to establish the presence (or lack of) a pool downstream of a TRIF feature.

1) **TRUN – Top of Run** – Measured at the top of the run. Take this measurement at the thalweg of a channel where a riffle or pool does not evolved into a pool or riffle respectively.

These are the major features encountered during the course of the survey. The reflector man is not constrained to using these codes alone- he/she can add codes through the traverse if a new repeatable feature is identified. When a new feature is identified, the reflector man creates and identifies the lookup code to the instrument man for record keeping.

The schema used to measure these features must be strictly adhered to in order to ensure repeatability of the results at a future date. This procedure results in a suite of points consisting of a coordinate, an elevation, and a characterization for all features identified by the reflector man. If sufficient care is taken during the measurement and attribution of geomorphic features, the stations can be revisited at a later data for the measurement of movement (e.g. sediment migration). During the course of this survey, extreme care was taken in the placement of the reflector, and selection of a lookup code for characterization of each feature.

Lastly, the following rules should be adhered to when selecting a suite of points for measurement:

1) Always call BOT or BOA if a TOT has been called. Not doing so results in the GIS not having the ability to extrapolate the slope of the terrace.

2) Always call out AC or FP at the point analogous to what would otherwise be called "base of bank". Not doing so results in the GIS not having the ability to extrapolate the slope of the bank.

3) Always call out LEW and REW in at least one area for each run or pool. Not doing so results in the GIS not having the ability to extrapolate the width of these features.

4) Always call out al least one thalweg for each TPOL or TRUN. Not doing so results in the GIS not having the ability to extrapolate the longitudinal slope of these features.

5) Always make sure the TPOLS, TRUNS, and TRIFS are alternating throughout the length of the longitudinal traverse. Skipping, missing, or repeating one of these features biases the length of the previous feature, and thus the GIS loses the ability to extrapolate an accurate feature.

6) In cases where a pool follows a riffle, do not call out TPOL downstream of the riffle. It is difficult to determine where exactly the top of the pool is relative to the slope of the riffle. Instead, measure the thalweg of the pool following the riffle. The presence and depth of the pool can be discovered from this thalweg where measured.

**NOTE:** Rules 1 – 6 above were developed after an analysis of the data in the Upper Basin (1/1/01 – 7/31/01). These rules were developed to prevent data gaps from manifesting in the data collected for the lower basin. Where features in the Upper Basin were not measured, feature extrapolation and corrections were made based on graphed longitudinal profiles. All subsequent changes to the data were documented, and the rules were strictly adhered to for the Lower Basin survey.

The following sections detail the methodology for collecting this data as a manual. This will ensure the repeatability of our results at a future date. This following sections discuss setting up the datalogger and instrument for sideshot work, collecting and attributing feature data, conducting field qaqc on the instrument setup, attributing the survey with pictures, mitigating documented field errors, and digital transcriptions of field datasheets.
Instrument Setup

– see Traverse Notes.

Datalogger Setup

1) From the main menu, select the appropriate compass rule adjusted morph file created for the traverse: (G) OPEN / EDIT JOB and then (H) OPEN EXISTING JOB. When prompted, do not specify the occupy point or backsight point. (NOTE: The main menu of the TDS datalogger will have the following title: <SELECT G to S>).

2) Check the repetitions for the traverse. If you have not already done so, select (J) TRAVERSE/SIDESHOTS option from the main menu in order to bring up the REP softkey. Use this key to bring up the REPETITIONS menu. Then select (L) SET REP MODES. If you haven’t already done so, set the NUMBER OF SETS to 0. This will turn off the multiple shooting sequence, which is not necessary for sideshot work. Once specified, press the EXIT softkey to bring you back to the TRAVERSE options.

Establishing and Checking the Backsight

1) From the traverse menu, select the purple shift key and the “0” key in order to enter the backsight menu. Specify the backsight-point, the occupy point, the height of the leveled instrument, and the height of the backsight reflector on the backsight station. Then, press the softkey SOLVE in order to solve for the backsight azimuth.

2) Focus the instrument on the backsight and set the horizontal azimuth to zero. Ensure that the BS CIRCLE READING OF GUN on the data-logger also reads zero. The instrument is now ready to check the backsight. Check the backsight by pressing the CHEC softkey. Confirm the backsight-point by (G) shooting the distance. Upon doing so, the datalogger will prompt you to press a key in order to take a shot. After doing so, the data-logger will report your horizontal and vertical error (or the calculated distance to the BS point relative to the known distance).

3) If the errors are small (within a few hundredths of a foot) you have specified the correct occupy point, backsight-point, and instrument / reflector heights. If the errors are large, check the instrument and reflector heights and ensure that these have been entered appropriately in the TDS. Also, make sure that the correct occupy point and backsight-point have been specified. Repeat this process as many times as necessary in order to generate good closure on the backsight.

4) Once the backsight check has been completed successfully, record the vertical and horizontal error in your field-notes. Also, record the horizontal distance shot to the backsight. These notes will help you identify the sources of error in data that has not closed within your tolerances, and are essential to preventing propagation of error in the field.

Taking Sideshots

1) Assuming the backsight has been solved and checked, you are now ready to take sideshot. Go to the main menu and select (J) TRAVERSE/SIDE SHOT (or select “EXIT” from the BACKSIGHT menu). You may now begin taking sideshot.

2) Aim the gun at the reflector and press the “SIDES” softkey to take a sideshot. When the shot has been taken, the instrument will prompt you for the height of the reflector, and the descriptor for the feature. Obtain this data from the reflector man, and enter it into the datalogger prior to taking your next shot.
Recommendation for Field QAQC

It is recommended that the backsight be shot as several times when collecting sideshot data. Shoot and record the backsight at the start, during, and at the end of the data-collection taking place from your current occupy point. Attribute these points as “BSC”, which is the lookup for “backsight check”. This is important for capturing physical errors that may take place during the data collection. Specifically, if the tripod is accidentally kicked, or if the circle on the gun is accidentally set to zero when not pointed at the backsight, these points can be used to rotate the data associated with biased locations, and thus become a means of conducting a field based qaqc and saving data that would otherwise be lost.

Check accidental bumps to the tripod by pointing the instrument at the backsight and reading the circle on the instrument. If the circle is no longer set to zero, the difference is the amount the gun has been displaced since your last BSC. Shoot the backsight, relevel and reset the gun to zero on the backsight, and shoot the backsight a second time.

If the tripod is kicked or moved, focus the gun on the backsight reflector, take a BSC reading, reset the circle to zero, and take a second BSC reading. Make appropriate notations so that any errors can be identified, trapped and corrected in a GIS.

Photo Attribution of Sideshot Work

It is recommended that the reflector man carry a digital camera, and periodically take pictures of the channel from surveyed points. When a photograph is taken, information regarding its location, direction, and nature should be relayed to the instrument man for notation. The instrument man will also attribute the picture with a surveyed point number (read from the data logger) so that it can be accurately mapped in a GIS for posterity.

The following page presents the field-form used for collecting and attributing sideshot work in the field.
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<thead>
<tr>
<th>Point</th>
<th>Name</th>
<th>Heights</th>
<th>Comments</th>
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<td>HI =</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BS#</td>
<td>HR =</td>
<td></td>
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**Date:**
ADOT CP Traverse From: To:

**Instrument Man:**
**Reflector Man:**

**Backsight Check**
**Horizontal Error =** Vertical Error =
Identify Marker Photo if taken:
If Market Photo Taken, Reset Picture # to 1.

**Additional Comments / Adjustments:**

**PIC LEGEND**
(Circle all that apply)

- PT = POINT
- LB = LEFTBANK
- RB = RIGHTBANK
- LP = LEFT PIN
- RP = RIGHT PIN
- LT = LEFT TERR
- RT = RIGHT TERR
- THAL = THALWEG
- US = UPSTREAM
- DS = DOWNSTREAM
- BS = BACKSIGHT
- BED = STREAMBED
- LP = LEFT PIN
- RP = RIGHT PIN

<table>
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<tr>
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<th>Comment</th>
<th>Pic</th>
<th>From:</th>
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Digital transcription of all Field Datasheets

All field datasheets should be transcribed digitally to ensure longevity of field notes taken during the sideshot work. Worksheets have been prepared for population of this data, and all data collected through March 20, 2002 has been transcribed to these sheets.
VIII. Use of ArcView (GIS technology) For Creation of Shapefiles from Sideshot Data

Summary

All field data must be downloaded from the TDS48 datalogger on a routine basis. ArcView shapefiles have been chosen as the container for storing respective data. The following details the steps used for downloading data, storing it in a shapefile, modifying the data for corrections made in the field, and using the shapefile as a means for qaqc.

Downloading Sideshot Survey Data from the TDS48 datalogger

Once collection of geomorphic data for a given traverse is complete, the data must be downloaded to a PC using the program entitled TDS Survey Link. The following outlines the steps for downloading this data and converting it to a format readable by a

1. Attach the TDS Survey Link Software Key to the parallel port in the back of the PC.
2. Attach the data logger to the PC using the serial cable.
3. Turn on the data logger and go to the main menu of the TDS48 program.  
   - NOTE: the first option of the main menu is: (G) Open/Edit Job.
4. Hit the softkey MORE to bring up the File Transfer option (S).
5. Select (S) and then select the softkey SEND to bring up the menu of available jobs.
6. Highlight the job you are interested in adjusting using the error keys, but do not SELECT yet. Recall that the job title containing the sideshot work will terminate in an “m” (e.g. “1to2m”).
7. Start the TDS Survey Link program on your computer.
8. Under the TRANSFER menu option, select Send/Receive.
9. Highlight the tab RECEIVE on the new window.
10. Check the option: Get filename from the data collector or PC.
11. Select the directory for the downloaded data.
12. Click the RECEIVE button in the program, and click the SELECT key on the data logger.
13. Once downloaded, close the transfer window in the TDS Survey Link program.
15. Under the Input Type, select TDS Coordinates, and choose then choose the file to convert.
16. Under Output Type, select ASCII and type the full path and name the file XtoXm.txt.

Converting the Downloaded Data to a Shapefile

1. Open ArcView and import the downloaded file as a new table. Before importing, make sure that the text file contains a header row for the data. The header row should read “Northing, Easting, Elev, Desc”.
2. Select VIEW | ADD EVENT THEME from the view menu bar. The table option should point to the imported text file table. The X option should point to the “Easting” field, and the Y option should point to the “Northing” field. When all selections are made, click on “ok”. This will generate a theme in the view from your text file. Note that this is not a shapefile.
3. Convert the theme to a shapefile by selecting THEME | CONVERT TO SHAPEFILE from the view menu. Call the theme XtoXm_edited (replace X with the traverse numbers associated with your sideshot work).
4. Begin editing the new shapefile’s table. Open the table, and then select TABLE | START EDITING from the table menu bar. Create two new fields in the new shapefile’s theme table. Call these fields Mod_desc (string) and Mod_elev (numerical).
5. Populate the records for these fields with exact duplicates of the values found in the “Desc” and “Elev” fields. Use the FIELD | CALCULATE option under the table menu-bar to do this.

6. Review the field data sheets and identify records requiring modification due to errors in the field. Make these modifications in the Mod_desc and Mod_elev fields of the shapefile and document these changes in a text file, which will be stored with the shapefile. For consistency, the text file should be called “XtoX shapefile documentation.txt”

7. Any “Desc” that may be considered unique (e.g. LB7, RB8, CP1, TOPMINNOW HABITAT”) should carry a respective “Mod_Des” value of “COM” for the same record. This will ensure that these values are linked appropriately when checking for lookup outliers in the next step.

8. Identify all the BSC points via creation of a thematic legend for your new shapefile. You must ensure that all points attributed as BSC in fact overlay on their proper control point. Respective control for a given BSC can be identified via review of the field data sheets and associated point numbers. If a given BSC does not overlay on its control point, there was an error during the course of the survey for the respective suite of sideshot points (Either the tripod was accidentally moved, or the circle was not set correctly). In order to fix this, you will need to bracket all points associated with that part of the traverse, and conduct a rotation on the data from within the datalogger. The rotated points will then be downloaded and replaced in the shapefile. All documentation regarding rotations needs to be stored with the original field datasheets.

9. In addition to checking the horizontal placement of a BSC relative its control, also check for errors in elevation. If these are encountered, they must be documented. When encountered, these cannot be mitigated. However, these are typically small (less than ¼ foot vertical) and will not have an impact on analysis associated with this survey.

10. Once all BSC are corroborated in the shapefile, review the data for elevation outliers. If any are found, delete the points from the shapefile. Do this by identifying the associated record in the shapefile’s table, setting the table to edit mode, and deleting that record. All deletions need to be documented in the “XtoX shapefile documentation.txt” file.

11. Lastly, conduct a join between the Mod_elev field of the “Lookup” field of the lookup.txt file, and the Mod_desc field of the shapefile. Do this as follows:
   a. Import the Lookup.txt file as a table.
   b. Open the table for the XtoXm_edited.shp theme.
   c. Highlight the “Lookup” field in the Lookup.txt table.
   d. Highlight the “Lookup” field in the XtoXm_edited.shp theme.
   e. Click on the join button on the table menu bar.

   This will join all the meaning of the lookups in the XtoXm_edited.shp theme to those defined in the Lookup.txt file. All callouts that were entered incorrectly or that do not have a respective lookup definition will appear as blank records. When this happens, you must either (1) supplement the lookup.txt table with the new lookup code, or (2) make a correction to the callout description in the shapefile. All joins and corrections should be made under the Mod_desc field. The “Desc” field should never be edited since it contains the original data from the survey.

12. If changes are made to the lookup.txt file as a result of new lookups being realized, then the lookup table should be saved as a new version (e.g. lookup_v2.txt) with the shapefile. This new version must be used for subsequent lookup joins on future traverses. Note that changes to the lookup.txt file should only be made for valid
repeatable lookups.

13. Add a “Trav” field to the XtoXm_edits.shp theme and populate with the traverse id for the respective data (e.g. “1to2”).

14. Add a “Date” field to the XtoXm_edits.shp theme and populate with the dates from which respective points were measured. These are easily referenced from the digital copies of the field notes.

If all these steps were followed correctly, you should now have a shapefile representing the geomorphic data collected between given traverse points. Your shapefile has been corrected for descriptor outliers and horizontal errors relative to backsight control. Callout corrections are noted under the Mod_desc field and noted in a digital text file which will accompany the shapefile in its directory (XtoX shapefile documentation.txt). Lastly, sufficient data is included with the shapefile for safe merging with other shapefiles.

Eventually, shapefiles associated with these individual traverses will be merged into a master shapefile (e.g. merge_032002.shp) from which further analysis can take place. This was the methodology employed for generating the survey shapefiles included with this report and used for subsequent analysis discussed below.
IX. Generation of Thalweg Cover For QAQC Filter on Descriptors / Elevations

Summary

As discussed in this report, the geomorphic diversity of a system is an indicator of stability and is also important for buffering the sheer stress imposed on channel materials from low probability flow events. For this reason, a theme representing the dimension and diversity of riffles, pools and runs is important for demonstrating the diversity (or lack of) channel features.

A thalweg theme may be developed for anchoring feature lengths, depths, and widths. This theme will represent the deepest elevation of the main channel as defined by the survey data, and thus will define the main flow line of the channel. As such, it must contain all points defined as THAL, TRIF, TPOL, TRUN, TFALLS, GW, (and MC for ephemeral reaches). Segment lengths extrapolated from this theme can be used to calculate feature lengths and slopes, and can also be used to conduct qaqc on elevation and feature descriptions.

Only start the delineation of the thalweg theme when all the data for the reach of interest has been collected, converted into a “merged” shapefile, and undergone thorough qaqc as described in the prior sections of this appendix. For the shapefiles associated with this report, the parent shapefile used for feature extraction was “032002_merged.shp” and represents all of the (qaqc’d) data collected through March 20, 2002. Feature extraction only took place on points related to the Upper Basin given that the survey for the Lower Basin was still in progress.

Create a Thalweg Theme

1) Start a new ArcView project. Add the “merged” shapefile containing all qaqc’d data.

2) Open the “merged” shapefile table and select all those points, which have a Mod_desc field containing the values THAL, TRIF, TPOL, TRUN, TFALLS, GW, and MC. (Recall that the Desc field contains those values recorded in the field, and the Mod_desc field is a modification of the Desc field based on error flags in your field notes).

3) Create a new shapefile from these selected records (e.g. select THEME | CONVERT TO SHAPEFILE). When prompted, name the new shapefile thal_pts.shp.

4) Repeat steps (2) and (3) using the features identified as LEW and REW to create a lew_rew.shp theme.

5) At a scale of 1:250, use the ArcView line tool to delineate the thalweg making sure to connect all the points in the thal_pts.shp theme that make up the main channel (There may be some thalwegs recorded for tributaries or side channels - do not include these in your delineation). Use the lew_rew.shp theme to keep your thalweg line within the surveyed baseflow regime.

- Use your best judgement to follow the meander of the channel when points are far in between. If necessary, consider reprojecting the thal_pts.shp and lew_rew.shp theme to UTM, Zone 12 NAD 27 (y-shift of -3200000 meter). This will allow you to overlay the points on USGS topographic tiffs available on the ADEQ server. The overlay can help guide your meander where data is not recorded. Use these tiffs only when absolutely necessary since the USGS data on which these are based can be inaccurate.
6) Convert the completed line work to a shapefile and call it \textit{thal.shp}.

\begin{center}
\includegraphics[width=\textwidth]{image.png}
\end{center}

\textit{Snapping the “thal.shp” theme to the “thal_pts.shp” features}

Although it may not be apparent at a scale of 1:250, you’ll notice at tighter scales that the thalweg line is not “snapped” to the point cover. In other words, the nodes for the thalweg theme are not directly mapped to the feature points in the \textit{thal_pts.shp} theme. This is a required step that will enable future spatial joins between these two themes.

1) Telnet to your ARCINFO workspace on the ADEQ server

\begin{verbatim}
Telnet 159.87.9.25
\end{verbatim}

2) Login and then Launch ArcInfo

\begin{verbatim}
arc
\end{verbatim}

3) Create a workspace in your home directory called arcwork

\begin{verbatim}
cw arcwork
\end{verbatim}

4) Change your workspace to arcwork

\begin{verbatim}
w arcwork
\end{verbatim}

5) FTP the \textit{thal_pts.shp} and \textit{thal.shp} themes into the arcwork workspace. Use the WS_FTP95LE manager on your
NT Desktop to do this, or any other FTP manager.

The following commands are issued from within ArcInfo-

6) Convert the uploaded ArcView *thal.shp* themes to an ArcInfo line cover
   
   `shapearc thal thal_ai line`

7) Build and clean the line topology for the arcinfo line
   
   `build thal_ai line`
   `clean thal_ai line`

8) Follow the same procedure for the ArcView *thal_pts.shp* theme
   
   `shapearc thal_pts thal_pts_ai point`
   `build thal_pts point`
   `clean thal_pts point`

9) Launch arcedit
   
   `ae`

10) Issue the following commands from within arcedit to snap the nodes in the thal_ai cover to the points in the thal_pts_ai cover.
   
   `ec thal_ai`
   `sc thal_pts_ai`
   `ef arc`
   `sf arc label`
   `sel all`
   `snapping closest 1`
   `snap`
   `save`
   `quit`

11) You are now back at the arcinfo prompt. Convert the thal_ai cover to the shapefile.
   
   `arcshape thal_ai line thal_new`

12) You may now exit ArcInfo, and ftp the new *thal.shp* theme to your working NT directory for use within ArcView.

13) From within ArcView, do a select by theme using the new thalweg theme (*thal_new.shp*) to select the points in the thal_pts.shp theme. If the snapped worked correctly, all the points in the *thal_pts.shp* file (that fall under the *thal_new.shp* theme) should be selected. Unselect these features in *thal_pts.shp* since the selection was just a check.

14) Use the Point and Polyline extension to break the *thal_new.shp* file into segments and call the output shapefile *thal_new_seg.shp* (P/PL Tools | Polyline to Segments). When prompted, do not carry over any of the original fields for the shapefile. Call the output shapefile *thal_new_seg.shp*.

15) Use the Point and Polyline extension to add lengths (P/PL Tools | Polyline Add Length) to the *thal_new_seg.shp* theme. This will add lengths to each of the segments created from your original nodes definition when you build the shapefile.
16) Use the View Precision extension to set the precision of the view to 5 decimals (“P” available from the view menu bar, then ‘5’).

17) Use the Point and Polyline extension to set the view precision to 5 decimals (P/PL Tools | View Set Coordinate Precision), and then add locations (P/PL Tools | Polyline Add Coordinate) to all the segments in the new thal_new_seg.shp theme. This will add coordinates to the thal_new_seg.shp theme. The coordinates will be for the top and bottom nodes of each segment. The respective table for this shapefile should now look like this:

18) Use the MILA Utilities extension to add XY locations to the thal_pts.shp theme (MILA Utilities | Add Coordinates). After doing so, review the associated table for this theme. You’ll notice that you now have a unique location field (use either X or Y) on which to join the surveyed features in the thal_pts.shp theme to the upstream node of the thal_new_seg.shp. Also notice that the MILA extension defaults to a precision of 5. This is the reason we set a precision of 5 in the PP/L Tools. The precision of the coordinates added via these separate extensions must match for future joins to work between these two shapefiles (next step).

19) You will now want to join the feature descriptions from the thal_pts.shp theme to the thal_new_seg.shp theme. The join should take place between the location for the upstream node of each segment in thal_new_seg.shp, and the location for each point in the thal_new.shp theme. Use caution here since the upstream node as defined in the seg_new.shp is actually the bottom node. Also, do not attempt a spatial join between the shape fields of these two themes. This will not be effective since it will match attributes for the upstream and downstream points in the thal_pts.shp theme to each arc in the thal_new_seg.shp theme (We only want the upstream point to be matched).
20) Wherever a match is found, the join will add the feature description (Mod_desc field in the thal_pts.shp theme table) to line segment in the thal_new_seg.shp theme. This will provide a means of extracting feature lengths for each feature in the thal_pts.shp theme.
21) Since not all segments are linked to features, you will need to complete the analysis using a spreadsheet. Specifically, you will have to add unlinked segment lengths (or those segments with no value in the Mod_desc field) to the lengths calculated for those features that are linked (or those segments that are defined by a Mod_desc value). As such, dump the (joined) table associated with the `thal_pts.shp` shapefile into a text file for use with a spreadsheet.
X. Initial Extrapolation of Measured Feature Lengths and QA/QC of Feature Callouts

Summary

Given the presence of interpolated thalweg nodes between surveyed features, the distance encompassed by these nodes between surveyed features (e.g. TRIF, TPOL, TRUN) needs to be accounted for when extrapolating feature lengths for these features (riffles, pools, and runs).

Extrapolation of Distances Between Measured Features

1) Import the text file generated from the ArcView dump into a spreadsheet workbook (analysis.xls). This spreadsheet now contains the same table attributes for the thal_new_seg.shp theme. Notice that the spreadsheet contains an ordered list of all the segments for the delineated reach. Where a segment node was snapped to a surveyed feature point (in the thal_pts.shp), you’ll notice that a description (i.e. Mod_desc) and an elevation (i.e. Mod_elev) has been carried over to that segment.

2) The only fields you’ll need in the new spreadsheet are the Line_id, Length, Mod_desc, and Mod_elev. Delete all the others, and copy the Length field to a new field called “Dist to next node”.

3) Add a new field called “Dist to Prior Desc”. This field should carry the summed distance between measured features. The result of this addition can be used to attribute the Line ID (thus, the feature) with a correct length. Standard spreadsheet conditional formulas (if: then) may be written in Excel to make these calculations go quickly. You should now have a spreadsheet that looks something like this:
4) Copy only those Line_ID records that have associated features to a new spreadsheet. Include the downstream length for the Line_ID into a new field called “DS_FT”. The DS_FT field should contain the downstream distance to the next measured feature as interpreted from calculations in your prior spreadsheet. Your new spreadsheet should look something like this:

| A   | B         | C         | D         | E         | F         | G         | H         | I         
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Line_ID</td>
<td>Length</td>
<td>Mod_desc</td>
<td>THAL</td>
<td>DIST NODE</td>
<td>DIST PRIOR DESC</td>
<td>DS_FT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 1973</td>
<td>42.73</td>
<td>4422 474</td>
<td>THAL</td>
<td>109.66</td>
<td>336.53</td>
<td>1187.47</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 1960</td>
<td>72.13</td>
<td>4415 664</td>
<td>THAL</td>
<td>72.13</td>
<td>774.27</td>
<td>1187.47</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 1936</td>
<td>46.2</td>
<td>4404 254</td>
<td>THAL</td>
<td>46.2</td>
<td>1187.47</td>
<td>1038.37</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>74.69</td>
<td>4367 855</td>
<td>THAL</td>
<td>74.69</td>
<td>1036.57</td>
<td>187.47</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 1784</td>
<td>55.59</td>
<td>4387 853</td>
<td>THAL</td>
<td>55.59</td>
<td>1487.47</td>
<td>1541.84</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 1774</td>
<td>214.16</td>
<td>4363 356</td>
<td>THAL</td>
<td>214.16</td>
<td>1541.84</td>
<td>837.65</td>
<td></td>
<td></td>
</tr>
<tr>
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<td>4390 012</td>
<td>THAL</td>
<td>59.58</td>
<td>837.65</td>
<td>834.49</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 1759</td>
<td>130.48</td>
<td>4376 562</td>
<td>THAL</td>
<td>130.48</td>
<td>834.49</td>
<td>1251.29</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 1740</td>
<td>139.65</td>
<td>4367 974</td>
<td>THAL</td>
<td>139.65</td>
<td>1251.29</td>
<td>538.28</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11 1734</td>
<td>191.76</td>
<td>4364 799</td>
<td>THAL</td>
<td>191.76</td>
<td>538.28</td>
<td>1296.91</td>
<td></td>
<td></td>
</tr>
<tr>
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<td>4367 908</td>
<td>THAL</td>
<td>301.03</td>
<td>1296.91</td>
<td>1988.73</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13 1712</td>
<td>02.17</td>
<td>4347 634</td>
<td>THAL</td>
<td>02.17</td>
<td>1988.73</td>
<td>82.17</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14 1711</td>
<td>222.83</td>
<td>4341 617</td>
<td>THAL</td>
<td>222.83</td>
<td>82.17</td>
<td>224.54</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15 1708</td>
<td>57.59</td>
<td>4342 608</td>
<td>THAL</td>
<td>57.59</td>
<td>224.54</td>
<td>107.86</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16 1706</td>
<td>63.36</td>
<td>4339 471</td>
<td>THAL</td>
<td>63.36</td>
<td>107.86</td>
<td>83.36</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17 1705</td>
<td>24.91</td>
<td>4394 465</td>
<td>THAL</td>
<td>24.91</td>
<td>83.36</td>
<td>51.02</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18 1703</td>
<td>21.85</td>
<td>4352 214</td>
<td>TRIF</td>
<td>21.85</td>
<td>51.02</td>
<td>21.85</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19 1702</td>
<td>7.44</td>
<td>4342 117</td>
<td>THAL</td>
<td>7.44</td>
<td>21.85</td>
<td>7.44</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 1701</td>
<td>9.48</td>
<td>4342 167</td>
<td>TPOL</td>
<td>9.48</td>
<td>7.44</td>
<td>9.48</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21 1700</td>
<td>27.35</td>
<td>4340 673</td>
<td>THAL</td>
<td>27.35</td>
<td>9.48</td>
<td>53.22</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22 1680</td>
<td>9.36</td>
<td>4342 002</td>
<td>TPOL</td>
<td>9.36</td>
<td>53.22</td>
<td>9.36</td>
<td></td>
<td></td>
</tr>
<tr>
<td>23 1697</td>
<td>19.65</td>
<td>4341 317</td>
<td>TRUN</td>
<td>19.65</td>
<td>9.36</td>
<td>19.65</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24 1695</td>
<td>72.04</td>
<td>4342 729</td>
<td>THAL</td>
<td>72.04</td>
<td>19.65</td>
<td>72.04</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5) If all the steps were followed correctly, you should now have a table of segments identified by a Line_ID. The feature identifying each segment is referenced via the Mod_desc field. The Mod_elev field identifies the starting elevation for each segment. Finally, the ds_ft field identifies the length to the next measured feature point (or the distance to next point having a measured elevation). Note that this next feature point may in fact be a thalweg rather than a riffle, pool, or run. For this reason, the ds_ft field may not representative of the full length of a geomorphic feature (e.g. the total length of a riffle, pool, or run).
QAQC of Feature Callouts and Measured Point Elevations

1) The longitudinal profile derived from this data is now used to conduct qaqc on the feature called out for a given point. With respect to this project, the following quality control analysis was conducted within the analysis.xls workbook (via qaqc_thal, qaqc_thal_summary, qaqc_zoom, and qaqc_full worksheets).

- Repeated features where identified along the course of the thalweg. For example, if two consecutive “TRUNS” were identified in the ordered data, the second TRUN was renamed THAL since it is more likely the thalweg of the first TRUN called out during the survey. Also, where repeated features are located very close together, they may have resulted from two different reflector-men measuring the same feature at different times.

- Where TRIFS and TFALLS evolve into TPOLS, the TPOL was renamed THAL. This was necessary when it was discovered that many of the features identified as TPOL generated positive slopes to their respective downstream thalweg. This is nonsense relative to the definition of a TPOL, and probably resulted from uncertainty as to how to measure pools when they evolve from ripples or falls. The actual presence of the pool downstream of these features can be derived from slope and water level elevation downstream of these features.

- The locations of the TPOL features were modified according an analysis of the graphed longitudinal profile. In many cases, the top of the pool was moved back one point (e.g. to the prior thalweg) in accordance with what the graphed profile indicated was a reasonable point.

- All changes to the data were recorded in a qaqc worksheet in the analysis.xls workbook. Reasons for the changes were documented, and all original descriptors were maintained in their original field (Mod_desc).

2) The corrected feature length field (ds_ft), and the modified feature descriptors resulting from the review of the longitudinal profile (qaqc) can now be linked back to the thal_new_seg.shp theme. Export the spreadsheet table containing the new fields to a text file, and then import this text file as an ArcView table.

3) Join the line_id field of the new table to the line_id field of the existing thal_new_seg.shp theme. All fields from the new table will carry over to the attributes for the thal_new_seg.shp theme.

4) Convert this theme to a new shapefile (e.g. thal_arc_final.shp), and delete any repeated or unnecessary table attributes from the new shapefile. Note that the original point shapefile (thal_pts.shp) must also carry the new qaqc fields for the descriptors if it is to be used for additional analysis. Join to and convert this theme to a new shapefile thal_pts_final.shp.

This is the procedure that was employed to create the shapefiles thal_arc_final.shp, and thal_pts_final.shp included with this report. Again, note that the field “ds_ft” is the distance to the next measured point (e.g. TPOL to THAL), which is not necessarily the distance to the next major geomorphic entity (e.g. TPOL to TRIF). Discussion of the methodology used to extrapolate full feature lengths and slopes from analysis.xls follow in this report. At this point, what should be understood is that both the thal_pts_final.shp and thal_arc_final.shp contain qaqc’d features from which further analysis can take place.
XI. Creating Feature Width and Water Level Elevation Shapefiles

Summary

Widths and depths of features can have an impact on the biological integrity of representative reaches throughout the survey. Features that are very wide and shallow at baseflow are more likely to contain higher water temperatures and lower dissolved oxygen. Consequently, the distribution of baseflow widths and water level can be used to assist in the evaluation of the relative conditions for biological habitat in a given stream.

In order to identify feature widths and water level elevations at baseflow, the survey was involved in measuring the left and right edge of all water features (identified via a LEW and REW). When used in conjunction with feature elevations (i.e. TRIF, TPOL, TRUN, and THAL), distributions for the width and depths of these features can be extrapolated. The following details the methodology employed to extrapolate feature depths.

Creating a Feature’s Width Shapefile

1) Start a new project with a view containing the lew_rew.shp and thal_arc_final.shp themes.

2) Begin extrapolating the width of the thalweg using the lew_rew.shp theme. Use the line tool to draw a width at a right angle across the thalweg. Make sure that one of the nodes of the arc defining the width is near a lew or rew point. Draw as many widths as is necessary to capture changes in the width of the channel along the traverse. If possible, draw at least one width for each major feature identified (i.e. TRIF, TPOL, TRUN, and TFALL).

3) Once all the widths have been attributed, convert the resulting line graphics into a theme called width.shp
4) In order to join the water level elevations from the `lew_rew.shp` theme, you will need to snap your `width.shp` theme to the `lew_rew.shp` theme. The output theme should be `width_snapped.shp`. For details on snapping a line theme to a point theme, please see the previous section (Snapping the “thal.shp” theme to the “thal_pts.shp” features steps 1 – 12).

**Adding Water Level Elevations to the Feature Widths Shapefile**

1) You must now join the two themes (`width_snapped.shp` and `lew_rew.shp`). This join is much simpler than the one conducted for the thalweg theme. Simply join the `shape` field of `lew_rew.shp`, and the `shape` field of `width_snapped.shp`. This will generate a spatial join (or a join based on the geographic location of the intersection). The `width_snapped.shp` theme should now contain both the width and water level elevation of the point (in the `lew_rew.shp` theme) it was originally snapped to.

2) Use the “theme intersection to points” extension to generate a point theme from the intersection between the `thal_arc_final.shp` theme and the `width_snapped.shp` theme. Call the output theme `width_pts.shp`. Note that we now have a point theme that overlays precisely on the thalweg theme, and that this point carries attributes of both the width theme (`width_snapped.shp`), and the upstream feature as defined in the thalweg theme (`thal_arc_final.shp`). The new `width_pts.shp` theme is a logical theme from which to extrapolate feature widths, depths, and lengths at baseflow.

3) Delete all unnecessary fields in the `width_pts.shp` theme. You should have something that looks like this:

![Image of ArcGIS interface](image)

This was the procedure used to generate `width_pts_final.shp` and `width_arc_final.shp` included with this report.
XII. Creating Feature Length Shapefiles

Summary

As discussed previously, the initial feature lengths derived in the previous section represent the distance between two measured (or surveyed) points. Since one of these points may be a thalweg, this distance may not represent the total length of a major feature such as a pool or a run. Consequently, all THAL arcs must be incorporated into the closest major upstream features so that the total lengths of these features can be derived. This is accomplished via the union command.

Creation of a Parent Theme from which to Extrapolate Major Feature Lengths

1. Select any records in the thal_arc_final.shp which contain a blank or a THAL value under the qaqc field and convert these records to a new shapefile called thals.shp.
2. Select any records that have blank values in the qaqc field of thal.shp and populate these with the value “THAL”.
3. Use the Point and Polyline extension to consolidate all the arcs in thals.shp and call the output thals_cons.shp.
4. Go back to the original thal_arc_final.shp theme and select records not containing THAL or blank under the qaqc field. Convert these records to a new shapefile called majors.shp.
5. Use the viewless merge extension to merge the thals_cons.shp and majors.shp theme to create a new theme call merge.shp. This new shapefile contains the major feature arcs and the consolidated thalweg arcs, and will serve as the parent theme from which consolidated riffle, pool, and run arcs will be created. These consolidated arcs will be composed of the original major feature arc (e.g. TRIF, TPOL, TRUN), and the consolidated downstream arc (e.g. THAL).

Derivation of Riffle Lengths from the Parent Merge.shp Theme

1. Select records attributed as TRIF and THAL from the qaqc field of the merge.shp theme and create a trif.shp theme from the selected features.
2. Add the thal_pts_final.shp theme to your project.
3. Use the legend editor to create thematic legends for both the trif.shp and thal_pts_final.shp themes. The thematic legends should be based on the unique values of the qaqc field of these themes.
   a) On the trif.shp theme, color descriptor THAL as red, and descriptor TRIF as blue. Set the thickness of the TRIF arcs to 2.
   b) On the thal_pts_final.shp theme, color descriptor THAL points as red (size 8), and descriptor TRIF points as blue (size 10). All other points can be hidden.

You should now have something that looks like this:
4. Put the `trif.shp` theme in edit mode (i.e. THEME | start editing), and start consolidating all downstream THAL into their upstream TRIF arc. Do this by selecting arcs you wish to consolidate with the arrow tool, and then use the EDIT | UNION FEATURES command to consolidate the arcs. This will consolidate downstream arcs into their upstream counterpart. When doing this, make sure that the View Zoom is set so that no small downstream thalwegs are missed during the consolidation.
5. If the consolidation worked, the previously defined red thalweg arc will turn to a blue trif arc.
6. Consolidate all arcs where necessary and then double-check the entire length of the trif theme to ensure that no arcs were missed in the consolidation. (Thalweg arcs may be missed as a result of their small length at the given scale of the view). Save your work periodically.

7. Use the point and polyline extension to add lengths to the arcs in the trif.shp theme. This theme now contains the total length of the features identified by trif.

8. Convert the trif.shp to trif_final.shp once all lengths have been added to the qaqc’d data.

The consolidated trif arcs should terminate at the start of the next TRUN or TRIF. Accordingly, the trif arcs in the trif_final.shp theme are attributed with the length of the riffle and its respective downstream pool. The pools were consolidated into the riffle features when qaqc on the survey data revealed questions regarding the methodology employed for identifying pools downstream of riffle (specifically, where they should be measured). The actual presence of a pool downstream of a riffle can be derived from the depth of baseflow water for the riffle (discussed in the next section).

This procedure can be easily repeated for “trun” and “tpol” features to create trun_final.shp and tpol_final.shp themes. Note that the tpol_final.shp theme represents those pools that are not directly associated with upstream riffles. During the course of our survey, these were encountered frequently.
XIII. Identification of Feature Slopes

Feature slope can serve as an important indicator of sedimentation when changes are measured over time. When pools are impacted by sediment, their thalwegs may rise, and their slopes may flatten. For the purposes of this study, two classes of downstream slope have been identified for each major feature. Class 1 identifies the slope to the first measured downstream thalweg. This represents the first break in slope downstream of the major feature. Class 2 identifies the slope to the deepest point of the features, and is identified by the first point having a downstream positive slope.

Both class 1 and class 2 slopes were derived for the major features (trif, tpol, trun) identified in the analysis.xls Excel workbook. Details regarding the formulas used for deriving these slopes are available by reviewing the cell contents of worksheets identified by a “5” (e.g. (5) SLOPE POOL, (5) SLOPE RUN, and (5) SLOPE TRIF-POL.) The filtered results for each major feature are summarized in the worksheets identified by a “6” (e.g. (6) trif-pol slope summary, (6) trun slope summary, and (6) tpol slope summary). Note that the worksheets identified by a “6” contain only those records for which feature-slope calculations were possible. All line-ids containing empty values for respective slope calculations were deleted from these worksheets. These were used for generating tables for shapefile joins discussed in the next section.

Note that the feature description cells used for the slope analyses originate from the “qaqc_thal_summary” located in the same workbook. This worksheet contains the qaqc descriptors for the thalweg (which include TRIF, TPOL, TRUN descriptors) that resulted from a review of the graphed longitudinal profile. The review and values associated with the workbook only apply to the longitudinal profile of the Upper Basin.

On the worksheets identified by a “5”, qaqc filters were written to ensure that slopes are calculated only for those major features that have at least one measured downstream thalweg. Additional filters ensure that the downstream thalweg of a major feature demonstrates a negative slope. These qaqc filters trap errors in feature and elevation callouts that may have bypassed other qaqc methods, and thus ensure the quality of the data for the resulting shapefiles. Details regarding these filters may be reviewed by studying the respective cell formulas in those worksheets identified by a “5”.

It is highly recommended that the analysis.xls spreadsheet be used as a template to conduct similar qaqc and slope extractions for data collected in the lower basin. This will ensure consistency in the methods used for deriving information from the survey data.
XIV. Creating Slope, Depth, and Width Shapefiles for Riffles, Pools, and Runs

Summary

Baseflow width to depth ratios can provide important information about habitat for aquatic species. Reaches with very shallow and wide baseflow are likely to contain higher temperature water (and subsequently lower dissolved oxygen) relative to reaches with narrow / deep baseflow. Slope may serve as an indicator of relative sedimentation. Methods for extrapolating these characteristics for riffles, pools, and runs for the creation of respective ArcView shapefiles are presented here.

Procedure

1. The tpol_final.shp theme contains line id’s that can be used for joining to maximum depth data in the analysis.xls spreadsheet. Convert the tpol_final.shp theme to a new tpol_feat.shp theme. Delete all fields in the new theme except for line_id, length, and Mod_elev. Create an alias for the Mod_elev - call it tpol_thal_elev. This field represents the elevation of the thalweg measured at the point called out (or qaqc’d) as TPOL (or top of pool).

2. Open the analysis.xls spreadsheet and export the (6) tpol_slope_summary worksheet to a text file called pool_depths.txt. Import this text file as a table into your ArcView project.

3. Establish a join between the line_id field of pool_depths.txt table, and the line_id field of the tpol_feat.shp theme. The target for the join should be the tpol_feat.shp theme. The max_depth field resulting from the join represents the maximum depth of the pool as identified via the spreadsheet filters in analysis.xls Excel workbook (previous section). In other words, max_depth represents the elevation at the first measured point where the slope of the pool is identified as changing from negative to positive.

4. Import the width_pts_final.shp theme and convert it to width_pts_wle.shp. Delete all the fields in the new theme except for width, Mod_elev, primary, Mod_desc, and date.

5. Join the width_pts_wle.shp theme to the tpol_feat.shp theme via the shape field. This will generate a spatial join between the points in width_pts_wle.shp, and the arcs in tpol_feat.shp. The join will result in the creation of a new field called Distance. This field represents the relative distance between an arc in tpol_feat.shp, and the closest (water level elevation) point in width_pts_wle.shp. The join will also tie in the water level elevation (Mod_elev field) and the width (width field) of the width_pts_wle.shp theme to the tpol_feat.shp theme.

6. Create an alias for the joined Mod_elev field in the tpol_feat.shp theme. The alias should read “wle” (water level elevation).

7. Create a new numeric field in the tpol_feat.shp theme called “bsflw_dpth”. This field will carry the maximum baseflow depth of the pool. Calculate this field by subtracting the max_depth field from the wle field.

8. Review and identify records that contain unusable values for baseflow depth (under the bsflw_dpth field). You may encounter the following when reviewing these depths.

Negative values. This may result from one or both of these factors:

   a) The spatial resolution of the points in the width_pts_wle.shp theme is much coarser than the arcs defining the tpol_feat.shp theme. As a result, the join between the width_pts_wle.shp and tpol_feat.shp is linking points that were located far away from their respective pools. If those water level elevation points were located downstream of an abrupt elevation change (e.g. a riffle), then they may generate a negative depth. Studying the Distance field in the tpol_feat.shp theme will corroborate this. This field identifies the distance between an arc and its respective joined water level elevation point.
b) The water level elevation (recorded as lew or rew during the course of the survey) may be incorrect due to a bad rod elevation callout by a reflector-man in the field.

*Extreme Positive Values:* This is a consequence of the deepest thalweg (determined via inverse slope determination) not being identified within five measured downstream features, or within the length of the feature itself. Either these records should be excluded from further analysis, or a depth may be assumed based on review of the analysis.xls worksheets. In this study, these were excluded from further analysis only with respect to inverse slope and baseflow depth measurements.

*Empty Values:* Some features will contain empty values in the bsflw_dpth field. These results when the qaqc filters in the analysis.xls Excel workbook identify the next thalweg as either having a positive slope, or not existing at all. Since these empty records result from a prior qaqc filter, they should be excluded from further analysis.

9. Select records in the *tpol_feat.shp* theme that satisfy criteria for further analysis (i.e. select the records that do not fall within the categories described in (8) above as well as any other criteria you may specify). Convert the selected records to a new theme called *tpol_depths_final.shp*. This new shapefile may now be used to generate thematic maps on baseflow depth, feature width, and slope.

10. Repeat this procedure for the run and pool features via use of the *trif_final.shp* and *trun_final.shp* themes.

*NOTE:* As discussed previously, the *trif_final.shp* created for this report has downstream pools embedded in its arc. Therefore, resulting values bsflw_dpth field will represent the maximum depth of downstream pools. Additional criteria can be established to characterize these pools (as being deep, shallow, or non-existent).
XV. Creating a Picture Hotlinks Project

Summary

A Nikon CoolPix 800 Digital Camera was used to collect digital images of the site in the field. Each image was attributed with a location by identifying its respective surveyed point number, and its relative location to that point. In this way, pictures “hotlink” project could be developed from which images could be recalled simply by clicking on respective points in the project.

Attributing photos in the Field

The sideshot field datasheet contains a fields for recording (1) point numbers for each image, (2) a “from” field identifying where the image was taken from, and (3) a “to” field identifying what direction the picture was taken. For instance, if picture (PIC) “1” is identified as having been taken from “THAL” to “US” relative to point 165, it should be understood that the image was taken while standing in the closest thalweg of the channel (THAL) relative to point 165 and facing upstream (US). If photo “2” is identified as having been taken from “PT” to “LB” relative to point 175, it should be understood that the image was taken while standing on point (PT) 175 while facing the left bank.(LB). Using this schema enables pictures to be associated with survey points in the GIS.

Summarizing Field Photo Data in a Spreadsheet

In order to add pictures to the pictures.shp theme, data for each image was tabled in a spreadsheet. The spreadsheet contains a minimum of four fields summarized below:

- PATH - the full path or directory housing the image of interest
  - (e.g. D:\CIENEGA\PICTURES\1TO2\021302\ )
  - (set up your directory structure so that pictures are stored by traverse /date as shown)
- FILE - the file name of the image as it will be stored in its directory (e.g. DSCN00001.JPG)
- DESCRIPTION - draft field notes regarding the image
- FINAL DESCRIPTION - the description as it will be viewed by the public
- PRIMARY - the primary id for the point number associated with the picture (e.g. 1TO2 - 1321)

The PATH and FILE fields will provide information as to where the image can be found when recalled from within the GIS. The PATH field is kept separate from the FILE field in order to facilitate the copying of PATH text through the table since these are typically repeated for a given suite of pictures. The FINAL DESCRIPTION field will provide information as to the relative location and direction from which the image was taken. The PRIMARY is required to join all this information to the latest survey shapefile via a join, and is populated with the image’s respective point data as recorded in the field data sheets.

Generation of a Pictures.shp Theme in ArcView

Once this information was tabled, it was imported into ArcView as a table, and joined to the shapefile containing the latest survey data via the PRIMARY field (e.g. 032002_merge.shp). Joined records are then selected and used to create a new pictures.shp theme. The only fields required in the new theme are the FINAL DESCRIPTION and PATH field. The PATH field should contain both the path and filename for the image associated with the respective point (e.g. D:\CIENEGA\PICTURES\1TO2\021302\DSCN0001.JPG). The FINAL DESCRIPTION field was renamed SITE.

The new pictures theme was then edited to reflect the locations from which the images were taken as accurately as possible. Specifically, if a picture was linked to point 165, but the description of an image identifies it as having been taken from the closest thalweg relative to point 165, then the pictures.shp theme was edited such that the point was moved to the respective thalweg (as identified by other points in the survey theme). Overlaying the pictures theme on USGS topographic tiffs can sometimes help with placement of images as well. Obviously, if the image was taken directly from point 165, no edit to the location of that point took place in the pictures.shp theme.
**Creating the Hotlink Script**

Once the `pictures.shp` theme was completed, the following script was added to the project:

```plaintext
// Hotlink Target Script:
theVal = SELF
'see if the value of the field is not null
if (not (theVal.IsNull)) then
  ' if the file listed in the field exists, launch the viewer
  if (File.Exists(theVal.AsFileName)) then
    ' use the path to the video player executable
    System.Execute("d:\cienega\programs\Sputnik\spi\spi.exe  "++theVal)
  else
    ' if the file doesn’t exist, tell the user
    MsgBox.Warning("File "+theVal+" not found.","Hot Link")
  end
end
```

This title of this script was changed to “pictures hotlink”, and is used for launching the freeware “Sputnik” JPEG viewer as the hotlink behavior for the `pictures.shp` theme. Note how Sputnik is identified as the target of the script behavior above (in red). This can be modified to point to any jpeg viewer you wish to use—Sputnik was chosen for this project given its small size and fast loading time. The script is compiled by clicking on the check button, and is then ready for use by any shapefile as a hotlink behavior.

**Setting the Hotlink Properties on the Pictures.shp Theme**

The theme properties for the `pictures.shp` theme were then set. Under the “hotlink” option in the table of contents for the theme properties, the Field option was set to “Path”, and the Predefined Action was set to “Link to User Script”. Lastly, “pictures hotlink” was selected as the user defined script (discussed above).

Given these steps, the project will now allow the user to select the `pictures.shp` theme in the table of contents of any view, and then use the lightening button to bring up pictures as they relate to that point (via Sputnik). The path of the picture will appear in the title bar of the Sputnik view. Since the traverse and date of the image is embedded in the path, both the relative location and time of year is implicitly shown with the picture.

**NOTE:** if the pictures associated with the shapefile are moved, the PATH field of the `pictures.shp` theme must be updated accordingly or the hotlinks will cease to work. This applies not only to absolute paths, but also to drive letters.
XVI. Generating Cross Sections from XYZ Data

Summary

The Rosgen System for classifying rivers requires the collection and analysis of cross sectional data for reference reaches. The Cienega Creek Physical Integrity Survey collects this data in XYZ format through the use of Zeiss R-50 EDM (total station). In order to graph this data as a cross section profile in Excel, XY data for each surveyed Z needs to be converted to distance between elevations. The attached scripts create a cross section text file, and a shapefile from points selected from the master survey shapefile. The modeled cross section calculates distances between points using the simple Pythagoras theorem.

Instructions for d:\cienega\lin\myxsecs\xsec.apr

1. Select the shapefile from which you'll be extracting points by clicking on it (it will generated a 3d box effect around the shapefile when it is selected). NOTE: Selecting a shapefile is not the same as activating a shapefile for the view (e.g. via a check). The script will not work unless you have only the 1to8merge shapefile selected. Having more than one shapefile selected, or having the wrong one selected confuses the script since it does not know which is the target shapefile for the selection of cross section points.

2. Zoom in on the cross section you are interested in modeling by using the magnifying glass.

3. You will need to select the points of interest one at a time and in order. Use the "select" tool to highlight the first point you are interested in. Then, click on the box with the pin in the upper left hand side of the menu. NOTE: The view must be active in order for you to see the custom buttons in the upper right hand side of the button bar. No pins will be displayed in the view. By “pinning”, the shapefile is being created one point at a time in the memory of the computer.

4. Repeat step (3) as many times as necessary. You can use the pan tool to move the view if your cross section is off screen, and use the magnifying glass tool to distinguish points that are very close to one another. IF YOU MAKE A MISTAKE- just save the shapefile as described in (5) and start over. It doesn’t matter where you save it or what you call it (I’ll find and delete them later).

5. When you are done, hit the save button that is located to the right of the pin tool. Name and save the cross section in the directory named d:\cienega\lin\myxsecs\shape_out\. I will use these later to generate watershed areas.

6. Lastly, hit the cross section button to the right of the save button. This will generate a "dbf" file that has the cross section data in the right format. Take the default name and don’t worry about where it saves the file. This file will be overwritten each time you generate a new cross section.

7. You should now see an object called "Table X" under the table view. To get to the table view, you need to go to the main table of contents and select “TABLES”.

8. Your target table (e.g. TABLE XX) needs to be exported to a text file. If there’s more than one table in the contents, select the one that has the highest number. Double click it to see the contents.

9. Now, you will need to export that table to a text-file. In the file menu, select "file | export" and choose the "delimited text" option. Save the file to the directory named d:\cienega\lin\myxsecs\text_out\. These will go into your cross section program.

10. To avoid confusion, delete the table after it has been exported to a text file- you don’t need this table anymore and it will not be overwritten by the script. Do this by closing the table (click on small x in upper right hand corner), selecting the table from the TABLES view, and hitting the delete key.

11. Repeat steps 1 through 10 as many times as necessary.
Tips for Use of Project

1. Don’t use spaces and non-alphanumeric characters for output filenames. Instead, use underscores.

2. Keep the filename schema as short as possible- this will save you time in the long run (e.g. use 1to2_1 instead of 1to2_xsec_1).

3. The projection of the created shapefile will be different from USGS topo and the 1to8merge shapefile. If you want to see it, select it from the views table of contents, activate it, and then zoom to the extent of the shapefile. When you are done reviewing it, select the 1to8merge shapefile and zoom back to its extent. DON’T FORGET TO DO THIS LAST STEP- the script uses the selected shapefile as the target from which to select cross section points. If the wrong target is selected, you will have trouble selecting points from that shapefile.

4. Delete any tables that are currently in the project.

(Scripts follow)
1. Script: Create the Source Shapefile

'////////////////////////////////////////////////

'Get Target Theme Table

theProject = av.GetProject
theView = theProject.FindDoc("CrossSection")
theFTab = theView.GetActiveThemes.Get(0).GetFtab

' Table1 contains X, Y and ID fields.
' Get the fields to copy from aVTab

xF = theFTab.FindField( "Easting" )
yF = theFTab.FindField( "Northing" )
idF = theFTab.FindField( "Point" )
elevF = theFTab.FindField( Mod_elev )
descF = theFTab.FindField( Mod_desc )

if (theView.FindTheme("myXsec.shp") = nil) then

' Create an FTAB and get its fields

myFTab = FTab.MakeNew( "myXsec.dbf".AsFileName, POINT )
myFTab.AddFields( {idF.clone, xF.clone, yF.clone, elevF.clone,
descF.clone} )

else

' Only add the records

myFTab = theView.FindTheme("myXsec.shp").GetFtab

end

pointFF = myFTab.FindField( "point" )
shapeFF = myFTab.FindField( "shape" )
northingFF = myFTab.FindField( "Northing" )
eastingFF = myFTab.FindField( "Easting" )
elevFF = myFTab.FindField( Mod_elev )
descFF = myFTab.FindField( Mod_desc )

' copy each row in the VTab to the new FTab for selected records

for each i in theFTab.GetSelection

' Get the values from theFTab

x = theFTab.ReturnValue( xF, i )
y = theFTab.ReturnValue( yF, i )
id = theFTab.ReturnValue( idF, i )
elev = theFTab.ReturnValue(elevF, i)
desc = theFTab.ReturnValue(descF, i)

' Create the next row and add values

newRec = myFTab.AddRecord
myFTab.SetValue( shapeFF, newRec, x@y )
myFTab.SetValue( pointFF, newRec, id )

'// these lines are causing error - fields are nil
myFtab.SetValue( northingFF, newRec, y)
myFtab.SetValue( eastingFF, newRec, x)
myFtab.SetValue( elevFF, newRec, elev)
myFtab.SetValue( descFF, newRec, desc)
end

if (theView.FindTheme("myXsec.shp") = nil) then
  theView.AddTheme( FTheme.Make( myFTab ))
end
2. Script: Create Longitudinal Output Files

'---------------------------------------------------------------------

'Get Target Theme Table

theProject = av.GetProject
theView = theProject.FindDoc("CrossSection")
theFTab = theView.GetActiveThemes.Get(0).GetFtab

' Table1 contains X, Y and ID fields.

' Get the fields to copy from aVTab

xF = theFTab.FindField("Easting")
yF = theFTab.FindField("Northing")
idF = theFTab.FindField("Point")
elevF = theFTab.FindField(Mod_elev)
descF = theFTab.FindField(Mod_desc)

if (theView.FindTheme("myXsec.shp") = nil) then

' Create an FTAB and get its fields

myFTab = FTab.MakeNew( "myXsec.dbf".AsFileName, POINT )
myFTab.AddFields( {idF.clone, xF.clone, yF.clone, elevF.clone, descF.clone} )
else

' Only add the records

myFTab = theView.FindTheme("myXsec.shp").GetFtab
end

pointFF = myFTab.FindField( "point" )
shapeFF = myFTab.FindField( "shape" )
northingFF = myFTab.FindField("Northing")
eastingFF = myFTab.FindField("Easting")
elevFF = myFTab.FindField(Mod_elev)
descFF = myFTab.FindField(Mod_desc)

' copy each row in the VTab to the new FTab for selected records

for each i in theFTab.GetSelection

' Get the values from theFTab

x = theFTab.ReturnValue( xF , i)
y = theFTab.ReturnValue( yF , i )
id = theFTab.ReturnValue( idF , i )
elev = theFtab.ReturnValue(elevF, i)
desc = theFtab.ReturnValue(descF, i)

' Create the next row and add values

newRec = myFTab.AddRecord
myFTab.SetValue( shapeFF, newRec, x@y )
myFTab.SetValue( pointFF, newRec, id )
' these lines are causing error - fields are nil

myFtab.SetValue( northingFF, newRec, y)
myFtab.SetValue( eastingFF, newRec, x)
myFtab.SetValue( elevFF, newRec, elev)
myFtab.SetValue( descFF, newRec, desc)
end

if (theView.FindTheme("myXsec.shp") = nil) then
theView.AddTheme( FTheme.Make( myFTab ))
end
3. Script: Create Cross Section Output File

'Script: Create Cross Section Output File

theProject = av.GetProject
theView = theProject.FindDoc("CrossSection")
theTheme = theView.FindTheme("MyXsec.shp")

for each t in theView.GetActiveThemes
    if(t.IsActive) then
        t.SetActive(false)
    end
end

theTheme.SetActive(true)
for each t in theView.GetActiveThemes
    p = FALSE
    if (t.Is(FTHEME).Not) then
        if (t.CanExportToFtab.Not) then continue end
        def = av.GetProject.MakeFileName("theme", "shp")
        def = FileDialog.Put(def, ".shp", "Convert " + t.getName)
        if (def = NIL) then return NIL end
        anFTab = t.ExportToFtab(def)
        shpfld = anFTab.FindField("Shape")
    else
        tbl = t.GetFTab
        attribVis = FALSE
        for each f in tbl.GetFields
            if ((f.IsVisible) and not (f.IsTypeShape)) then
                attribVis = TRUE
                break
            end
        end
        shapeVis = tbl.FindField("Shape").IsVisible
        if ((attribVis and shapeVis).Not) then
            continue
        end
        def = av.GetProject.MakeFileName("theme", "shp")
        def = FileDialog.Put(def, ".shp", "Convert " + t.getName)
        if (def = NIL) then return nil end
        shpfld = (tbl.FindField("Shape")).IsVisible
        WasNotVisible = TRUE
        else
            WasNotVisible = FALSE
    end
end
' see if the view is projected
thePrj = theView.GetProjection
if (thePrj.IsNull.Not) then
    p = MsgBox.YesNoCancel("ArcView has detected that your view is projected.++++
    "Do you want the new shapefile to be saved in the projected units?","Convert", FALSE)
    if (p = Nil) then return nil end
end

' if the user wants to project the shape, use ExportProjected
if (p) then
    anFTab = tbl.ExportProjected(def, thePrj, tbl.GetSelection.Count > 0)
else
    anFTab = tbl.Export(def, Shape, tbl.GetSelection.Count > 0)
end

if (anFTab.HasError) then
    if (anFTab.HasLockError) then
        MsgBox.Error("Unable to acquire Write Lock for file " + def.GetBaseName,""
    else
        MsgBox.Error("Unable to create " + def.GetBaseName,""
    end
    return nil end
end

if (WasNotVisible) then
    shpfld.SetVisible(FALSE)
end
end

' build the spatial index
anFTab.CreateIndex(shpfld)

' don't add the projected shapefile to the view -
' it won't show up if you do!
if (p.Not) then
    if (MsgBox.YesNo("Add shapefile as theme to the view?", "Convert to Shapefile",true).Not) then continue end
    create a theme and add it to the View
    fthm = FTheme.Make(anFTab)
    theView.AddTheme(fthm)
else
    MsgBox.Info("Since your view is projected, the projected data" ++
    "will not be added to the view. It has been saved on disk.++
    "Convert")
end

' bring the View to the front
theView.GetWin.Activate
end

' //////////////////////////////////Create DBF File //////////////////////////////////

'Calculates distance from origin, or first point selected
theProject = av.GetProject
theView = theProject.FindDoc("CrossSection")
theFtab = theView.FindTheme("MyXsec.shp").GetFtab
Count the total number of records

theFBitmap = theFTab.GetDefBitmap
theFBitmap.SetAll
totRec = 0
for each i in theFBitmap
    totRec = totRec + 1
end

Create a New Table

myFile =
FileDialog.Put("d:\Cienega\lin\myxsecs\text_out\output.txt".AsFileName,"*.*","File")
theVTab = Vtab.Makenew(myFile,dbase)
myTable = Table.Make(theVTab)

How do I name the table in the table view?
'Not yet resolved.

Create fields in VTab

'f1 is for location
'f2 is for elevation
'f3 is point description

f1 = Field.Make("XY",#FIELD_FLOAT, 15,3)
f2 = Field.Make("Z",#FIELD_FLOAT, 15,3)
f3 = Field.Make("DESC",#FIELD_CHAR, 5,5)

Add fields to the VTab

theVTab.AddFields({f1,f2,f3})

transfer records from FTab

theNorthing = theFTab.FindField("Northing")
theEasting = theFTab.FindField("Easting")
theElevation = theFTab.FindField(Mod_elev)
theDesc = theFTab.FindField(Mod_desc)

for each rec in theFtab
    rec = theVTab.AddRecord
    if (rec = (totRec-1)) then
        ' since distance is calculated from origin, always
        ' use the origin Northing1 and Easting1
        Northing1 = theFtab.ReturnValue(theNorthing, 0)
        Easting1 = theFtab.ReturnValue(theEasting, 0)
        Northing2 = theFtab.ReturnValue(theNorthing, rec)
        Easting2 = theFtab.ReturnValue(theEasting, rec)
        Elevation = theFtab.ReturnValue(theElevation, rec)
        'do trigonometric conversion / assignments here
        FinalDesc = theFtab.ReturnValue(theDesc, rec)
FinalCoordinate = (((Northing2 - Northing1)^2) + ((Easting2 - Easting1)^2))^0.5

FinalElevation = Elevation

theVTab.SetValue(f1, rec, FinalCoordinate)
theVTab.SetValue(f2, rec, FinalElevation)
theVTab.SetValue(f3, rec, FinalDesc)

break
else
if (rec = 0) then
    FinalCoordinate = 0
    FinalElevation = theFtab.ReturnValue(theElevation, rec)
    FinalDesc = theFtab.ReturnValue(theDesc, rec)
else
    ' since distance is calculated from origin, always
    ' use the origin Northing1 and Easting1
    Northing1 = theFtab.ReturnValue(theNorthing, 0)
    Easting1 = theFtab.ReturnValue(theEasting, 0)
    Northing2 = theFtab.ReturnValue(theNorthing, rec)
    Easting2 = theFtab.ReturnValue(theEasting, rec)
    Elevation = theFtab.ReturnValue(theElevation, rec)
    'do trigonometric conversion / assignments here
    FinalDesc = theFtab.ReturnValue(theDesc, rec)
    FinalCoordinate = (((Northing2 - Northing1)^2) + ((Easting2 - Easting1)^2))^0.5

    FinalElevation = Elevation

    theVTab.SetValue(f1, rec, FinalCoordinate)
    theVTab.SetValue(f2, rec, FinalElevation)
    theVTab.SetValue(f3, rec, FinalDesc)
end
end

theVTab.Export ( myFile.asString.asFileName, DText, FALSE )
oldTheme = theView.FindTheme("MyXsec.shp")
theView.DeleteTheme(oldTheme)
4. Script: Generate Cross Section Shapefile for Selected Shape

' /////////////////Create DBF File ///////////////////

'Calculates distance from origin, or first point selected

theProject = av.GetProject
theView = theProject.FindDoc("CrossSection")
index = 0
for each t in theView.GetActiveThemes

theFTab = theView.GetActiveThemes.Get(index).GetFtab

'filename identification
theFTabSrcName = theFTab.GetSrcName
theFileNameString = theFTabSrcName.GetName
theFileNameStringTokens = theFileNameString.AsTokens(".")
theFileNameString = theFileNameStringTokens.Get(0).AsString

'Count the total number of records

theFBitmap = theFTab.GetDefBitmap
theFBitmap.SetAll
totRec = 0
for each i in theFBitmap
    totRec = totRec + 1
end

'Create a New Table

myFile = FileDialog.Put(theFileNameString.AsFileName,"*.*","File")
theVTab = Vtab.Makenew(myFile,dbase)
myTable = Table.Make(theVTab)

'Create fields in VTab

'f1 is for location
'f2 is for elevation
'f3 is point description

f1 = Field.Make("XY",#FIELD_FLOAT, 15,3)
f2 = Field.Make("Z",#FIELD_FLOAT, 15,3)
f3 = Field.Make("DESC",#FIELD_CHAR, 5,5)

'Add fields to the VTab

theVTab.AddFields({f1,f2,f3})

'transfer records from FTab

theNorthing = theFTab.FindField("Northing")
theEasting = theFTab.FindField("Easting")
theElevation = theFTab.FindField(Mod_elev)
theDesc = theFTab.FindField(Mod_desc)

for each rec in theFtab

rec = theVTab.AddRecord
    if (rec = (totRec-1)) then
        ' since distance is calculated from origin, always
        ' use the origin Northing1 and Easting1
Northing1 = theFtab.ReturnValue(theNorthing, 0)
Easting1 = theFtab.ReturnValue(theEasting, 0)

Northing2 = theFtab.ReturnValue(theNorthing, rec)
Easting2 = theFtab.ReturnValue(theEasting, rec)

Elevation = theFtab.ReturnValue(theElevation, rec)

' do trigonometric conversion / assignments here

FinalDesc = theFtab.ReturnValue(theDesc, rec)

FinalCoordinate = (((Northing2 - Northing1)^2) + ((Easting2 - Easting1)^2)).sqrt

FinalElevation = Elevation

theVTab.SetValue(f1, rec, FinalCoordinate)
theVTab.SetValue(f2, rec, FinalElevation)
theVTab.SetValue(f3, rec, FinalDesc)

break

else

if (rec = 0) then

FinalCoordinate = 0
FinalElevation = theFtab.ReturnValue(theElevation, rec)
FinalDesc = theFtab.ReturnValue(theDesc, rec)

theVTab.SetValue(f1, rec, FinalCoordinate)
theVTab.SetValue(f2, rec, FinalElevation)
theVTab.SetValue(f3, rec, FinalDesc)

else

' since distance is calculated from origin, always
' use the origin Northing1 and Easting1

Northing1 = theFtab.ReturnValue(theNorthing, 0)
Easting1 = theFtab.ReturnValue(theEasting, 0)

Northing2 = theFtab.ReturnValue(theNorthing, rec)
Easting2 = theFtab.ReturnValue(theEasting, rec)

Elevation = theFtab.ReturnValue(theElevation, rec)

' do trigonometric conversion / assignments here

FinalDesc = theFtab.ReturnValue(theDesc, rec)

FinalCoordinate = (((Northing2 - Northing1)^2) + ((Easting2 - Easting1)^2)).sqrt

FinalElevation = Elevation

theVTab.SetValue(f1, rec, FinalCoordinate)
theVTab.SetValue(f2, rec, FinalElevation)
theVTab.SetValue(f3, rec, FinalDesc)

end

end

end
theVTab.Export ( theFileNameString.asFileName, DText, FALSE )
index = index + 1
end
5. **Script: Generate Longitudinal Shapefile for Selected Shape**

' /////////////////Create DBF File /////////////////

'Calculates distance from origin, or first point selected

```vba
theProject = av.GetProject
theView = theProject.FindDoc("CrossSection")
index = 0
for each t in theView.GetActiveThemes
    theFTab = theView.GetActiveThemes.Get(index).GetFtab

    'filename identification
    theFTabSrcName = theFTab.GetSrcName
    theFileNameString = theFTabSrcName.GetName
    theFileNameStringTokens = theFileNameString.AsTokens(".")
    theFileNameString = theFileNameStringTokens.Get(0).AsString

    'Count the total number of records
    theFBitmap = theFTab.GetDefBitmap
    theFBitmap.SetAll
    totRec = 0
    for each i in theFBitmap
        totRec = totRec + 1
    end

    'Create a New Table
    myFile = FileDialog.Put(theFileNameString.AsFileName, "*.*", "File")
    theVTab = Vtab.Makenew(myFile, dbase)
    myTable = Table.Make(theVTab)

    'Create fields in VTab
    'f1 is for location
    'f2 is for elevation
    'f3 is point description
    f1 = Field.Make("XY", #FIELD_FLOAT, 15, 3)
    f2 = Field.Make("Z", #FIELD_FLOAT, 15, 3)
    f3 = Field.Make("DESC", #FIELD_CHAR, 5, 5)

    'Add fields to the VTab
    theVTab.AddFields({f1, f2, f3})

    'transfer records from FTab
    theNorthing = theFTab.FindField("Northing")
    theEasting = theFTab.FindField("Easting")
    theElevation = theFTab.FindField(Mod_elev)
    theDesc = theFTab.FindField(Mod_desc)

    for each rec in theFtab
        rec = theVTab.AddRecord
        if (rec = (totRec-1)) then
            ' since distance is calculated from origin, always
```
' use the origin Northing1 and Easting1
Northing1 = theFtab.ReturnValue(theNorthing, rec-1)
Easting1 = theFtab.ReturnValue(theEasting, rec-1)

Northing2 = theFtab.ReturnValue(theNorthing, rec)
Easting2 = theFtab.ReturnValue(theEasting, rec)

Elevation = theFtab.ReturnValue(theElevation, rec)

' do trigonometric conversion / assignments here
FinalDesc = theFtab.ReturnValue(theDesc, rec)

FinalCoordinate = theVTab.ReturnValue(f1, rec-1) + (Northing2 - Northing1)^2 + (Easting2 - Easting1)^2).sqrt
FinalElevation = Elevation

theVTab.SetValue(f1, rec, FinalCoordinate)
theVTab.SetValue(f2, rec, FinalElevation)
theVTab.SetValue(f3, rec, FinalDesc)

break

else

if (rec = 0) then

FinalCoordinate = 0
FinalElevation = theFtab.ReturnValue(theElevation, rec)
FinalDesc = theFtab.ReturnValue(theDesc, rec)

theVTab.SetValue(f1, rec, FinalCoordinate)
theVTab.SetValue(f2, rec, FinalElevation)
theVTab.SetValue(f3, rec, FinalDesc)

else

' since distance is calculated from origin, always
' use the origin Northing1 and Easting1
Northing1 = theFtab.ReturnValue(theNorthing, rec-1)
Easting1 = theFtab.ReturnValue(theEasting, rec-1)

Northing2 = theFtab.ReturnValue(theNorthing, rec)
Easting2 = theFtab.ReturnValue(theEasting, rec)

Elevation = theFtab.ReturnValue(theElevation, rec)

' do trigonometric conversion / assignments here
FinalDesc = theFtab.ReturnValue(theDesc, rec)

FinalCoordinate = theVTab.ReturnValue(f1, rec-1) + (Northing2 - Northing1)^2 + (Easting2 - Easting1)^2).sqrt
FinalElevation = Elevation

theVTab.SetValue(f1, rec, FinalCoordinate)
theVTab.SetValue(f2, rec, FinalElevation)
theVTab.SetValue(f3, rec, FinalDesc)

end

end

end
end

theVTab.Export ( theFileNameString.asFileName, DText, FALSE )
index = index + 1

der

end
Creating Attribute Shapefiles for Cross Section Data

Summary

Rosgen Type I and II channel attributes were derived by Dr. Lin Lawson through the use of spreadsheets supplied by Dave Rosgen’s company (Wildland Resources). Respective cross-section attributes were tabled in an Excel workbook (xsec.xls) so they could be joined to the thalweg cover for Cienega Creek. The worksheets found in xsec.xls are as follows:

- a) Forwarded by Lin ver1 – First (incomplete) set of attributes forwarded by Dr. Lawson.
- b) Forwarded by Lin ver2 – Second (incomplete) set of attributes forwarded by Dr. Lawson.
- c) Lins comments on missing info – Information regarding missing data in forwarded tables.
- d) My obs on forwarded data – Hans’ observations on data in forwarded tables.
- e) xsec – Summarized cross sections attributes containing a Line_pt_join field showing where the cross section was located in the thalweg cover for the Upper Basin.

The xsec worksheet in xsec.xls was then exported as a text file, and imported into ArcView as a table. A point cover representing the cross section attributes was created based on a join between the “primary” attribute field in the thal_pts_final.shp theme, and the Line_pt_join field of the newly imported xsec table. The resulting records from the join were exported as a new theme entitled xsection.shp.

Based on information in the comments field of xsection.shp, several cross section records were excluded from further analysis (e.g. not enough data points to characterize). The remaining points were used to create a new theme called xsec_pt_final_rev.shp.

The xsec_pt_final_rev.shp theme served as the master from which arcs in the thal_arcs_final.shp theme could be attributed with respective cross-section attributes. This was done by simply joining the attributes in xsec_pt_final.shp to those arcs located upstream of a given cross section, and downstream of the next upstream cross section. The resulting arc shapefile (carrying the attributes of the cross section data) was entitled xsec_arc_final_rev.shp. In the image below, the xsec_arc_final_rev.shp theme is shown as Level 1 Rosgen Characterization in the view’s table of contents.

The resulting arc theme is important for statistically summarizing features in other themes based on stream type, width to depth ratio, or any other attribute found in the table for xsec_arc_final_rev.shp theme (an arc copy of the xsec_pt_final_rev.shp theme). This may by subselecting data in other themes based on
attributes in xsec_arc_final_rev.shp (via “theme | select by theme”) and then summarizing the characteristics of the subselected features (via “table | summarize”).

One important summary involves the use of the xsec_arc_final_rev.shp to sub-select and statistically summarize conditions by Level II stream type. By doing so, reference conditions (for those Level II stream types found at Cienega Creek) can be derived. The use of a reference reach concept enables Level II stream type classifications to be completed for similar areas in Arizona without requiring extensive on-site data collection. Specifically, this data will enable the agency to compare data for other reaches in the state to those reference data collected at Cienega Creek. Where other reaches in Arizona (of the same Level II type) do not compare well to those of Cienega Creek, factors affecting those reaches (e.g. sediment) may be researched, identified, and mitigated.
XVIII. Metadata for Published Shapefiles

Projection / Datum Information

All shapefiles for this project were created from survey data derived tied into stations installed by the Arizona Department of Environmental Quality, and surveyed by the Arizona Department of Transportation (ADOT). As such, they are in the same datum and projection of the ADOT stations. Respective shapefiles are stored in subdirectories identified as /state (for Stateplane). That projection is as follows:

Table XVIII-A: Metadata for Shapefiles Located in the /state Directory

<table>
<thead>
<tr>
<th>Projection:</th>
<th>Transverse Mercator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coordinate System:</td>
<td>Stateplane –feet</td>
</tr>
<tr>
<td>Zone</td>
<td>Arizona Central (3176)</td>
</tr>
<tr>
<td>Horizontal Datum:</td>
<td>NAD-83 (with HARN Adjustment)</td>
</tr>
<tr>
<td>Vertical Datum:</td>
<td>NAVD-88</td>
</tr>
<tr>
<td>Ellipsoid:</td>
<td>GRS 80</td>
</tr>
<tr>
<td>Central Meridian:</td>
<td>-111.916667</td>
</tr>
<tr>
<td>Reference Latitude:</td>
<td>31</td>
</tr>
<tr>
<td>Scale Factor:</td>
<td>0.9999</td>
</tr>
<tr>
<td>False Easting:</td>
<td>213360</td>
</tr>
<tr>
<td>False Northing:</td>
<td>0</td>
</tr>
</tbody>
</table>

Through the use of ArcView’s projection utility, selected shapefiles were reprojected to UTM for use with USGS quadrangle topographic maps. These shapefiles are stored in subdirectories identified as /utm and carry the following projection properties:

Table XVIII-B: Metadata for Shapefiles Located in the /utm Directory

<table>
<thead>
<tr>
<th>Projection:</th>
<th>Transverse Mercator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coordinate System:</td>
<td>UTM-meter</td>
</tr>
<tr>
<td>Zone</td>
<td>Zone 12</td>
</tr>
<tr>
<td>Horizontal Datum:</td>
<td>NAD-27 (meter)</td>
</tr>
<tr>
<td>Vertical Datum:</td>
<td>NAVD-88 (feet)</td>
</tr>
<tr>
<td>Ellipsoid:</td>
<td>GRS 80</td>
</tr>
<tr>
<td>Central Meridian:</td>
<td>-111.916667</td>
</tr>
<tr>
<td>Reference Latitude:</td>
<td>31</td>
</tr>
<tr>
<td>Scale Factor:</td>
<td>0.9996</td>
</tr>
<tr>
<td>False Easting:</td>
<td>500000</td>
</tr>
<tr>
<td>False Northing:</td>
<td>-3200000</td>
</tr>
</tbody>
</table>

Metadata for the individual shapefile attribute tables follows:
**Theme: 032002_merge.shp**

Location: /cienega/publish_shapefiles/0_master/

Author: Hans Huth
Date of Creation: 3/20/02
Type: Point

Description: This theme contains all the survey data collected through March 20, 2002. Records in this shapefile are generated via a merge of all the individual shapefiles created from each survey job (located in /Cienega/survey/arcview/). Corrections based on field note comments, lookup code joins, and survey rotations have been incorporated into this shapefile. To date, this theme has acted as the master from which other shapefiles included with this report are derived. As of March 20, 2002, this shapefile contains 7913 records.

Known Issues:

1. Dates associated with secondary control point installation as well as the BEHI stations have not yet been entered in the “Date” field. These can be referenced from the field notes.

2. The “confidence” field has not yet been populated with metadata regarding backsight check errors. It should be noted that 99.9% of the backsight checks associated with this survey are under 0.20 feet horizontal, and 0.10 vertical. This is sufficiently accurate for the purposes of this study. Nevertheless, the “confidence” field has been added to the shapefile so that all data regarding the survey can be stored with the shapefile. Backsight check errors may be reviewed from the field notes.

3. Descriptor code corrections based on a review of the longitudinal profile of the thalweg (see analysis.xls Excel Workbook) are not embedded in this shapefile. Those corrections are listed under the “qaqc” field in shapefiles derived from this “master” shapefile.

Field Primary: This field contains a unique id for the point. This id is generated from the concatenation of the traverse id (field “Trav”) and the point id (field “Point”).

Field Point: This field contains the point number recorded by the datalogger for a given traverse job.

Field Easting: This field contains the surveyed Easting coordinate.

Field Northing: This field contains the surveyed Northing coordinate.

Field Mod_elev: This field contains the surveyed elevation. This field incorporates field note corrections.

Field Mod_Desc: This field contains the description lookup code. This field incorporates corrections based on field notes, and code modifications to ensure adequate joins with the lookup code table.

Field Elev: This field contains the unaltered surveyed elevation as it was recorded in the field.

Field Desc: This field contains the unaltered description lookup code as it was recorded in the field.

Field BEHI_work: This field identifies respective records as having been collected during the course of a BEHI station installation.
Field Date: This field contains the date that the point was measured.
Field Confidence: This field contains error data associated with the measurement in the point based on backsight check information recorded in the field notes.

Field Other: This field contains any other information regarding the collection of the data point.

Field ModDescOld: This field identified whether a modification was made to the Desc lookup field based on notes taken in the field, or based on errors from the use of callouts that are not part of the lookup code table.
Theme: thal_arc_final.shp

Location: /cienega/publish_shapefiles/1_lengths_and_rep_widths/

Author: Hans Huth
Date of Creation: 6/5/02
Type: Arc

Description: Contains all discrete arc segments used for delineating the thalweg of the Upper Basin. This theme was built by interpolating the thalweg channel using the points in the thal_pts_final.shp theme. Arc segments are snapped to the points identified in the thal_pts_final.shp, and selected attributes from thal_pts_final.shp are joined to this theme. Segments interpolated between points are preserved as unique records each carrying a Line-id.

Known Issues: None

Field Line_id: A unique identifier for each segment in the theme.

Field Length: The length (in feet) of each segment (or record) in the theme.

Field Ds_ft: This field will only contain a value if there is a join between the top node of a segment, and a point in thal_pts_final.shp theme. It represents the distance in feet between the top node of the segment, and the next point in the thal_pts_final.shp theme as one follows the meander of the thalweg. Thus, it incorporates the intermediary lengths of interpolated segments between major features (such at GW, TRIF, TPOL, TRUN, THAL, TROS, and TFALLS).

Field Ds_del_z: This field will only contain a value if there is a join between the top node of a segment, and a point in thal_pts_final.shp theme. It represents the elevation change in feet between the top node of the segment, and the next point in the thal_pts_final.shp theme as one follows the meander of the thalweg. Thus, it incorporates the intermediary lengths of interpolated segments between major features (such at TRIF, TPOL, TRUN, THAL, TROS, and TFALLS). The elevation change is based on values found in the Mod_elev field.

Field Mod_elev: This field will only contain a value if there is a join between the top node of a segment, and a point in thal_pts_final.shp theme. It represents the edited feature elevation (in feet) for top node of the segment. Some of these values are based on corrections made in the field.

Field Mod_desc: This field will only contain a value if there is a join between the top node of a segment, and a point in thal_pts_final.shp theme. It represents the edited feature description for the top node of the segment. Some of these are based on corrections made in the field.

Field Qaqc_desc: This field will only contain a value if there is a join between the top node of a segment, and a point in thal_pts_final.shp theme. It represents the qaqc’d description for the top node of the segment based on a review of the longitudinal profile of the thalweg. The longitudinal profile is available in the Excel Workbook analysis.xls.
Theme: thal_pts_final.shp

Location: /cienea/publish_shapefiles/1_lengths_and_rep_widths/

Author: Hans Huth
Date of Creation: 6/5/02
Type: Point

Description: This cover represents Upper Basin points in the 032002_merge.shp theme exhibiting a “Mod_Desc” value of GW (groundwater), TFALLS (top of falls), TRIF (top of riffle), TPOL (top of pool), TRUN (top of run), and TROS (top of Rosgen Structure). Therefore, it represents that part of the survey that delineates the main channel. This theme serves as a source for the delineation of the thalweg and the creation of thal_arcs_final.shp arc theme.

Known Issues: None

Field Line_id: This field represents the respective arc segment in thal_arcs_final.shp for which the point is acting as a top node to the arc of that theme.

Field Length: This field represents the respective length of a segment in the thal_arcs_final.shp theme where the respective point record is joined to the top node for the arc in that theme.

Field Ds_ft: This field represents the distance (in feet) to the next major feature along the meander of thalweg. Major features include GW (groundwater), TFALLS (top of falls), TRIF (top of riffle), TPOL (top of pool), TRUN (top of run), and TROS (top of Rosgen Structure).

Field Ds_del_z: This field represents the distance (in feet) to the next major feature along the meander of thalweg. Major features include GW (groundwater), TFALLS (top of falls), TRIF (top of riffle), TPOL (top of pool), TRUN (top of run), and TROS (top of Rosgen Structure).

Field Mod_elev: This field represents the edited feature elevation (in feet) for the point. Some of these values are based on corrections made in the field.

Field Mod_desc: This field represents the edited feature description for the point. Some of these values are based on corrections made in the field.

Field Qaqc_desc: This field represents the qaqc’d description for the point based on a review of the longitudinal profile of the thalweg. The longitudinal profile is available in the Excel Workbook analysis.xls.

Field Primary: This field is a unique id for point and was created by concatenating the survey point number with the Traverse Id.

Field Trav: This field identifies the traverse bounding the point.

Field Behi_work: This field identifies the point as having been collected during the measurement of a cross section for a respective BEHI station.

Field Date: This field identifies the date on which the point was measured.

Field Other: This field is reserved for additional comments.
Theme: width_arc_final.shp

Location: /cienega/publish_shapefiles/2_widths_and_representative_points/

Author: Hans Huth
Date of Creation: 6/5/02
Type: Arc

Description: This theme contains arcs representing the width of the main channel. This theme was derived from the width.shp theme created by Dr. Lin Lawson. Dr. Lawson interpolated widths along the thalweg for the Upper Basin based on the lew_rew.shp point theme. Hans Huth completed the theme by snapping each arc to at least one LEW/REW feature, and then joining respective attributes from the lew_rew.shp theme (including point-ids and water level elevations). Dr. Lawson’s parent shapefile can be found in /cienega/intermediate_shapefiles/feature_widths/ and is called width.shp

Known Issues: None

Field Line_id: This field contains a unique segment id for each delineated width.

Field Width: This field contains the width (in feet) of each delineated segment.

Field Primary: This field contains the primary key of the point used to delineate the width, and also identifies the survey point used to generate a water level elevation for the segment.

Field Point: This field identifies the LEW or REW point (in the lew_rew.shp theme) to which the width segment was snapped.

Field Mod_elev: This field identifies the elevation (in feet) of the LEW or REW point to which the width segment was snapped.

Field Mod_Desc: This field represents the description of the point (LEW or REW) to which the width segment was snapped.

Field Date: This field represents the date that the associated LEW or REW point of a given width segment was measured.
**Theme:** width_pts_final.shp

**Location:** /ciengena/publish_shapefiles/2_widths_and_representative_points/

**Author:** Hans Huth  
**Date of Creation:** 6/5/02  
**Type:** Point

**Description:** This theme represents the intersection of width arcs in width_arc_final.shp theme relative to the thal_arc_final.shp theme as a collection of points along the thalweg.

**Known Issues:** None

**Field Line_id:** This field identifies the segment line-id in the width_arc_final.shp theme responsible for the intersection of the thal_arcs_final.shp.

**Field Width:** This field identifies the width of the channel at the point as determined from the respective segment in the width_arc_final.shp theme.

**Field Mod_elev:** This field identifies the water level elevation as determined from the Mod_elev field for the respective width segment in the width_arc_final.shp theme.

**Field Primary:** This field identifies the unique-id of the point used for deriving the width of the channel for the respective width segment in the width_arc_final.shp theme.

**Field Mod_Desc:** This field identifies the description of the point used for deriving the width of the channel for the respective width segment in the width_arc_final.shp theme.

**Field Date:** This field identifies the date of the measurement of the point used for deriving the width of the channel for the respective width segment in the width_arc_final.shp theme.

**Field Line_id:** This field identifies the Line_id of the width segment in width_arc_final.shp intersecting the thalweg at the given point.

**Field Ds_ft:** This field represents distance between the major upstream and downstream feature bounding the point. This field will contain a number only if a width segment in the width_arc_segment.shp intersects a major feature segment in the thal_arc_final.shp theme (e.g. one attributed as TRIF, TRUN, TFALLS, etc….)

**Field Ds_del_z:** This field represents the elevation change between the major upstream and downstream feature bounding the point. This field will contain a number only if a width segment in the width_arc_segment.shp intersects a major feature segment in the thal_arc_final.shp theme (e.g. one attributed as TRIF, TRUN, TFALLS, etc….)

**Field Mod_elev:** This field represents elevation of the major feature upstream of the point. This field will contain a number only if a width segment in the width_arc_segment.shp intersects a major feature segment in the thal_arc_final.shp theme (e.g. one attributed as TRIF, TRUN, TFALLS, etc….)

**Field Qaqc_desc:** This field represents the description of the major feature upstream of the point. This field will contain a description only if a width segment in the width_arc_segment.shp intersects a major feature segment in the thal_arc_final.shp theme (e.g. one attributed as TRIF, TRUN, TFALLS, etc….)
**Theme: trun_final.shp**

Location: /cienega/publish_shapefiles/3_full_feature_lengths/

Author: Hans Huth  
Date of Creation: 6/5/02  
Type: Arc

Description: This theme represents the full length of runs. It differs from the `thal_arc_final.shp` theme in that calculated lengths include downstream thalweg arcs summed to the next TRIF, TRUN, TPOL, or TFALLS.

Known Issues: None

Field Line_id: Identifies the major feature arc (from `thal_arcs_final.shp`) containing the TRUN feature. This arc has all downstream arcs consolidated into its length up to the next TRIF, TRUN, TPOL, or TFALLS.

Length: This field describes the full length (in feet) of a given TRUN segment.

Field Mod_elev: This field describes the elevation (in feet) of a segment’s upstream TRUN node.

Field Mod_desc: This field contains the description for the upstream node of a segment.

Field Qaqc_desc: This field represents the qaqc’d description for the top node of the segment based on a review of the longitudinal profile of the thalweg. The longitudinal profile is available in the Excel Workbook `analysis.xls`. Where Qaqc_desc and Mod_desc are different from one another (within the same record), qaqc was executed for the point defining the upstream node of the segment.
Theme: trif_final.shp

Location: /cienega/publish_shapefiles/3_full_feature_lengths/

Author: Hans Huth
Date of Creation: 6/5/02
Type: Arc

Description: This theme represents the full length of riffles. It differs from the thal_arc_final.shp theme in that calculated lengths include downstream thalweg arcs summed to the next TRIF, TRUN, TPOL, or TFALLS.

Known Issues: Riffle length incorporates any downstream pools. See instructions on developing this shapefile for additional details.

The fields for this theme are identical to those for the trun_final.shp theme, but specific to riffles rather than runs.
Theme: tpol_final.shp

Location: /cienega/publish_shapefiles/3_full_feature_lengths/

Author: Hans Huth
Date of Creation: 6/5/02
Type: Arc

Description: This theme represents the full length of pools. It differs from the thal_arc_final.shp theme in that calculated lengths include downstream thalweg arcs summed to the next TRIF, TRUN, TPOL, or TFALLS.

Known Issues: Pools in this theme may not be a consequence of riffles, and thus are not representative of what is classically identified as a pool (or part of a riffle-pool sequence).

The fields for this theme are identical to those for the trun_final.shp theme, but specific to pools rather than runs.
Theme: run_feat.shp

Location: /cienega/publish_shapefiles/4_feature_depths_slope_width/

Author: Hans Huth
Date of Creation: 6/5/02
Type: Arc

Description: This theme contains water level, baseflow depth, feature width, and full feature length attributes for arcs characterized as runs. These arcs can be thought of as having an upstream node identified as TRUN.

Known Issues: Under the bsflw_dpth field (baseflow depth), you may encounter very large, negative, or empty values. Please see the instructions regarding the creation of this shapefile for details as to why these were generated. It is recommended that records containing questionable values be filtered prior to using the data for analysis (as they are in the “final” versions located in the same directory).

Field Line_id: Identifies the major feature arc (from thal_arcs_final.shp) containing the TRUN feature. This arc has all downstream arcs consolidated into its length up to the next TRIF, TRUN, TPOL, or TFALLS.

Length: This field describes the full length (in feet) of a given TRUN segment.

Field Trun_thal_elev: This field describes the elevation of the upstream node of the segment at its thalweg (measured as TRUN).

Field Max_depth: Assuming the maximum depth of a run is derived at the point where the slope of the profile changes from negative to positive, this number represents the elevation (in feet) at the run’s maximum depth.

Field Dist_2_brk: This field describes the length (in feet) between a segments’ upstream TRUN node, and the next point identified as THAL (thalweg).

Field Delz_2_brk: This field describes the elevation change between a segments’ upstream TRUN node, and the next point identified as THAL (thalweg).

Field Slp_2_brk: This field describes the slope between a segments’ upstream TRUN node, and the next point identified as THAL (thalweg). This has also been identified in this report as a class 1 slope.

Field Dist_2_inv: This field describes the length (in feet) between a segments’ upstream TRUN node, and the deepest point identified as THAL (thalweg).

Field Delz_2_inv: This field describes the elevation change between a segments’ upstream TRUN node, and the deepest point identified as THAL (thalweg).

Field Slp_2_inv: This field describes the slope between a segments’ upstream TRUN node, and the deepest point identified as THAL (thalweg). This has also been identified in this report as a class 2 slope and assumes that the maximum depth of a run is derived at the point where the slope of the profile changes from negative to positive.

Field Distance: This field represents the distance (in feet) between a run segment, and the width arc used to derive feature width and water level elevation. Large distances indicate that the width arc used to attribute the run segment was located far away from the respective run. This field can be used to filter questionable results in the bsflw_dpth field (See “Known Issues” topic above).

Field Width: Identifies the width of the run. This is derived via a spatial join of the
Field Wle: Identifies the baseflow water level elevation of the run. This is derived via a spatial join of the `width_pts_final.shp` theme.

Field Primary: Identifies the unique id of the point used to identify the water level elevation of the run.

Field Mod_desc: Identifies the description of the point used to identify the water level elevation of the run.

Field Date: Identifies the date of measurement for the point used to identify the water level elevation of the run.

Field Bsflw_depth: Calculated by subtracting values in the Max_depth field from those in the Wle field.
**Theme: rif_feat.shp**

Location: /cienega/publish_shapefiles/4_feature_depths_slope_width/

Author: Hans Huth  
Date of Creation: 6/5/02  
Type: Arc

Description: This theme contains water level, baseflow depth, feature width, and full feature length attributes for arcs characterized as riffles. These arcs can be thought of as having an upstream node identified as TRIF.

Known Issues: Riffle lengths incorporate downstream pools. See instructions on developing this shapefile for additional details. Under the bsflw_dpth field (baseflow depth), you may encounter very large, negative, or empty values. Please see the instructions regarding the creation of this shapefile for details as to why these were generated. It is recommended that records containing questionable values be filtered prior to using the data for analysis (as they are in the “final” versions located in the same directory).

The fields for this theme are identical to those for the run_feat.shp theme, but specific to riffles rather than runs.
**Theme: pool_feat.shp**

Location: /cienega/publish_shapefiles/4_feature_depths_slope_width/

Author: Hans Huth  
Date of Creation: 6/5/02  
Type: Arc

Description: This theme contains water level, baseflow depth, feature width, and full feature length attributes for arcs characterized as pools. These arcs can be thought of as having an upstream node identified as TPOL.

Known Issues: Pools in this theme may not be a consequence of riffles, and thus are not representative of what is classically identified as a pool (or part of a riffle-pool sequence). Under the bsflw_dpth field (baseflow depth), you may encounter very large, negative, or empty values. Please see the instructions regarding the creation of this shapefile for details as to why these were generated. It is recommended that records containing questionable values be filtered prior to using the data for analysis (as they are in the “final” versions located in the same directory).

The fields for this theme are identical to those for the run_feat.shp theme, but specific to pools rather than runs.
**Theme: run_depths_final.shp**

Location: /cieneba/publish_shapefiles/4_feature_depths_slope_width/

Author: Hans Huth  
Date of Creation: 6/5/02  
Type: Arc

Description: This theme contains water level, baseflow depth, feature width, and full feature length attributes for arcs characterized as runs. These arcs can be thought of as having an upstream node identified as TRUN. This shapefile contains filtered records from the parent theme run_feat.shp. Specifically, this is a duplicate of run_feat.shp. However, any records with the following attributes were removed:

- **Bsflw_depth = “”**: Excluded. This indicates that the run feature did not pass qaqc filters developed in the analysis.xls Excel workbook.

- **Bsflw_depth > 10**: Excluded. This is a consequence of the deepest thalweg not being identified within five measured downstream features. As such, the max depth is recorded as 0 in the analysis.xls workbook, and the depth (calculated as WLE – MaxDepth) is extreme.

- **Bsflw_depth < 0 feet**: Excluded. Negative depths are not reasonable. This results when the water level elevation measurement is not located near the arc characterizing the run.

- **Distance > 20 feet**: Excluded given that the water level elevation measurement is not located near the arc characterizing the run.

Known Issues: None

The fields for this theme are identical to those for the run_feat.shp theme.
Theme: rif_depths_final.shp

Location: /cieneiga/publish_shapefiles/4_feature_depths_slope_width/

Author: Hans Huth
Date of Creation: 6/5/02
Type: Arc

Description: This theme contains water level, baseflow depth, feature width, and full feature length attributes for arcs characterized as riffles. These arcs can be thought of as having an upstream node identified as TRIF. This shapefile contains filtered records from the parent theme rif_feat.shp. Specifically, this is a duplicate of rif_feat.shp. However, any records with the following attributes were removed:

Bsflw_depth = “” : Excluded. This indicates that the riffle feature did not pass qaqc filters developed in the analysis.xls Excel workbook.

Bsflw_depth > 100: Excluded. This is a consequence of the deepest thalweg not being identified within five measured downstream features. As such, the max depth is recorded as 0 in the analysis.xls workbook, and the depth (calculated as WLE – Max_Depth) is extreme.

Bsflw_depth < 0 feet: Excluded. Negative depths are not reasonable. This results when the water level elevation measurement is not located near the arc characterizing the riffle.

Distance > 20 feet: Excluded given that the water level elevation measurement is not located near the arc characterizing the run.

Known Issues: Riffle lengths incorporate downstream pools. See instructions on developing this shapefile for additional details.

The fields for this theme are identical to those for the run_final.shp theme, but specific to riffles rather than runs.
**Theme:** pool_depths_final.shp

**Location:** /cienega/publish_shapefiles/4_feature_depths_slope_width/

**Author:** Hans Huth  
**Date of Creation:** 6/5/02  
**Type:** Arc

**Description:** This theme contains water level, baseflow depth, feature width, and full feature length attributes for arcs characterized as pools. These arcs can be thought of as having an upstream node identified as TPOL. This shapefile contains filtered records from the parent theme pool_feat.shp. Specifically, this is a duplicate of pool_feat.shp. However, any records with the following attributes were removed:

- **Bsflw_depth = “”:** Excluded. This indicates that the pool feature did not pass qaqc filters developed in the analysis.xls Excel workbook.
- **Bsflw_depth > 100:** Excluded. This is a consequence of the deepest thalweg not being identified within five measured downstream features. As such, the max depth is recorded as 0 in the analysis.xls workbook, and the depth (calculated as WLE – Max_Depth) is extreme.
- **Bsflw_depth < 0 feet:** Excluded. Negative depths are not reasonable. This results when the water level elevation measurement is not located near the arc characterizing the pool.
- **Distance > 20 feet:** Excluded given that the water level elevation measurement is not located near the arc characterizing the pool.

**Known Issues:** Pools in this theme may not be a consequence of riffles, and thus are not representative of what is classically identified as a pool (or part of a riffle-pool sequence). Under the bsflw_dpth field (baseflow depth), you may encounter very large, negative, or empty values. Please see the instructions regarding the creation of this shapefile for details as to why these were generated. It is recommended that records containing questionable values be filtered prior to using the data for analysis.

The fields for this theme are identical to those for the run_final.shp theme, but specific to pools rather than runs.
Theme: xsection.shp

Location: /cienega/publish_shapefiles/5_cross_sections/

Author: Hans Huth
Date of Creation: 6/17/02
Type: point

Description:

Known Issues:

Field
Theme: xsec_pt_final_rev.shp

Location: /cienega/publish_shapefiles/5_cross_sections/

Author: Hans Huth
Date of Creation: 6/17/02
Type: point

Description:

Known Issues:

Field
**Theme: xsec_arc_final_rev.shp**

Location: /cienega/publish_shapefiles/5_cross_sections/

Author: Lin Lawson / Hans Huth
Date of Creation: 6/17/02
Type: arc

Descriptions: This theme attributes all reaches in the Upper Basin with data derived from cross section analysis. These attributes may by be used to sub-select data in other themes (via “theme | select by theme”). Sub-selected records may then be statistically summarized (via “table | summarize”) in order to generate reference conditions based on the selection parameters (e.g. Level I stream type).

Known Issues: One important summary involves the use of the xsec_arc_final_rev.shp to sub-select and statistically summarize conditions by Level II stream type. By doing so, reference conditions (for those Level II stream types found at Cienega Creek) can be derived. The use of a reference reach concept enables Level II stream type classifications to be completed for similar areas in Arizona without requiring extensive on-site data collection.

The weakness in this theme results from there being few Level II characterizations incorporated in its attribute table (since it is incomplete). There should be at least one Level II reference reach established for each Level I stream type identified. In practice, multiple reference reaches are usually required, one for each change in channel material encountered for a given Level I stream type (e.g. establish a reference reach for a C3 (D50 particle size is cobble) and for a C4 type (D50 particle size is gravel)).

Metadata: Lin in progress
XIX. 19th Century Observations Of Cienega Creek and Surroundings

THE BUTTERFIELD OVERLAND MAIL- 1857 – 1869:

Its organization and operation over the Southern Route to 1861;
Subsequently over the Central Route to 1866 and under Wells, Fargo and Company in 1869

by ROSCOE P. CONKLING and MARGARET B. CONKLING

VOLUME 11

El Paso to Tucson- Cienega Springs, the next station twenty-four miles northwest from San Pedro, was located in what is now Pima County, in township 16, range 17, and in the northeast corner of section 30. Extensive ruins of this station may be seen on a slight elevation on the north side of Pantano Wash, a quarter of a mile west of Irene siding on the old El Paso and Southwestern railroad (now Southern Pacific), the tracks of which are laid directly over the station site. The location is on the property of the Empire Land and Cattle Company. The bridges of both branches of the railroad and the new concrete bridge for Highway 80, cross Pantano Wash slightly over a quarter of a mile west form the mail station ruin. A store and a gasoline station located on the highway which follows along the bluff a short distance north of the station site, has been named Cienega station.

The station buildings which were large and commodious were all adobe structures. The buildings were destroyed by fire sometime during the year following the abandonment of the route by the Butterfield interests, for it was described in ruins in the report of Colonel Edward E. Eyre of the First California Volunteers, in July, 1862. Later travelers over the route reported the discovery of a fabulous treasure among the ruins from that time to the present have engaged the attention of the treasure hunter.

The Spanish word "cienega" meaning a marshy place, was evidently applied by the early Spanish explorers to almost any water source. The designation of Cienega springs at this point on the old trail evidently referred to the small stream which flows through Davidson's Canyon and empties into the south side of Pantano Wash a short distance south of the station site, and which was the source of the station water supply. This little stream of sweet cool water which now sinks and disappears in the dry bed of this great wash or torrent bed, probably flowed more abundantly in 1858 than now.

The mail road from Cienega station plunged down again into the dry bed of Pantano Wash which it followed for about a quarter of a mile west and then made the ascent of the bold and steep bank on the west side of the wash to the broad plain that slopes west gently towards the Santa Cruz river. Both the railway and the highway bridges span Pantano Wash at this congested point on the topography of the country. Emerging on the broad plain the mail road traversed it in the same general northwest direction to Tucson through the old Vail ranch as that now followed by the railroads and the highway.
Wednesday, October 31st. It rained considerable last night, but towards morning the moon shone bright and although it did not look very clear, it abstained from rain. There was considerable division about starting, but I thought it was well understood that we were to be off early this morning. Our oxen had strayed considerably, & it was late before we had found them. Captain said those that chose might go on, & the rest stay. Two of P. B. Co.'s, including the captains, started a little before 10 o'clock, and our waggon rolled out the 1st from our encampment, about 1/2 past 11 o'clock. The road was extremely heavy for the first 4 or 5 miles, being over sandy soil, much, to me, resembling the valley of Rio Grande. Leaving this, we ascended a very heavy hill & got on harder ground, the country still rolling. We could see 4 wagons following us, winding their way through the hills. We followed an Indian trail which brought us to the foot of the mountains, in the niches of which, from the greeness of the trees & c., I think there must be water. We passed another horse left to himself on the road, which makes 5, between horses and mules, have been left since the encampment at this edge of salt lake. We also passed a couple of large encampments, one of which was a large Indian one, and the other either Indian or Mexican Army. The road was pretty good after we got out of the bottom. Coming into a rough country and a narrow valley, we got up on some of the adjoining hills, and, not seeing camp, we determined to wait for our wagons & camp for the night. It was about dusk when it came up. Mr. Brower rode up and said that their wagons were only about 2 or 3 miles back, & he came on to find some of the head wagons.

Here we were, along in our glory in the midst of an Indian country, with late Indian signs all around us; in fact, the two of our boys that were with the waggon were certain that they saw 5 Indians on one of the hills. They might possibly have been antelopes, or some other Californians, but they thought they were Indians, as there was no water about. We hobbled the two oke of our oxen that generally stray the most, & tied our horses close to the tent. We ate supper by moonlight, which consisted of jerked beef and sour beans, & some hard bread, & after being sure all our arms were in order, we made our beds as comfortably as possible. We lay down, leaving ourselves to the protection of that kind Providence that so often has guarded us before. It began to cloud up as we retired, with a fair prospect of rain. An ox belonging to the Pine B. Co. passed us, keeping in the road, no doubt in search of water. Distance 2 miles.

Thursday, November 1st. Our oxen had not left the valley, our horses were where we tied them, & we had a prospect of a fine morning. After a good breakfast, we made an early start, seeing the fires of the other boys behind. The road was hard for the oxen & even when over the hills, the chaparral was so thick that it took considerable care to miss the large mezauites, & c. We arrived at camp at 10 o'clock & found Vice's Miller's, & the other Pine Bluff wagons that came ahead. The mule train had just left. The water was in marshes, coming from springs, & a little brackish. The whole of the wagons got up before noon, & it was decided that we should stay for the day. Just about dinner time, some of the Missourians somehow or other set fire to the prairie, which soon spread with the rapidity of lightening. It commenced on the opposite side of the branch about 1/4 mile off. Our oxen were on the other side also, & our first efforts were directed towards them, & we ran as men never ran before. The grass, or rather, cane, was some 6 ft. high, & where I crossed it, it was extremely warm from the fire. It crossed the branch and we now had to look for our wagons, & c., which we moved near the branch where the grass had previously been burnt. Such a scrambling and pulling of wagons & letting down tents, & c., was never seen. The wind was blowing high & towards us. It did not go out till some time after dark.

We here strike Colonel Cook's trail, which the guide says has not been traveled since Cook went over it, the emigrants taking another route going around the mountain (That is, south of the Whetsone and Santa Rita ranges, to the town of Santa Cruz, below the border and thence down the Santa Cruz Valley to Tucson, where they again met Cooke's road.) Some mules were left here, having given out. We had a social meeting last evening, the 1st in some time, & there was considerable attendance. Colonel Watson was in the chair and the performance opened with "Banjo." Mr. Corny's "My Native Land" & "You'll Remember Me" were excellent, & Mr. Monell's "Irish Gentlemen" brought forth bursts of laughter. Colonel Watson gave us the "New Hat" [?] which also created laughter. I recited the "Battle of Waterloo" & sung "Stop dat Knocking." We broke up, all well pleased, the captain mounting guard. No. 3 left their ox that gave out & which subsequently fell into the Pedro, not having got up since they pulled him out. They ended his misery by shooting him. One of the No. 1's ox is unfit for work & no doubt will soon be left. Distance 8 miles.
(Eccleson also discusses his observations of the San Pedro, San Xavier del Bac, and Tucson ("a tolerable Mexican town composed of Mexican adobes and a few Indian huts").)
June 11th. Camped last night about 10 miles this side of the San Pedro. Hobble our mules, stationed our guard, and retired to rest our guard as usual. Started at daylight this morning. Traveled 8 miles and stopped at the de los Pinos Creek (Cienega Creek) for breakfast. The water is clear and beautiful, but slightly alkaline. The valley is a delightful looking place and its cool water, green foliage and scrubby trees look like a paradise to the weary traveler over the hot and parched up plain. He feels loth [sic] to leave here and wonders why it is not the home of some peaceful happy family. One could here retire from the care and strife and deception of the cold world and glide smoothly down the stream of life in the bosom of his own family, and not doubt would it soon be inhabited were it not for the hostile Indians. They seem to be the curse of the country. They will not cultivate the land and become civilized themselves, and they will not allow anyone else to settle here. We are now within 30 miles of Tucson and will probably be there before dark this evening.
Chapter IX (Continued) - By Mrs. Granville Oury 1865

November 5th - Yesterday afternoon, we travelled about fourteen miles, camped in sight of the canyon, which contains the "Dragoon Springs," a place where Indians are always found. None of our party ventured into the springs. We started at twelve, beautiful moonlight. I felt quite comfortable, but the others all complained loudly of the bitter cold. After an unsuccessful attempt to coax myself to sleep, I surrendered my cozy nest to Addy, muffled myself up in a blanket and shawl and drove 'til daylight, through a long, deep ravine, the foremost wagon got a wheel completely smashed, which detained us for some time. It was one of Tully's. Mr Aguirre came to the rescue, as the wheel could not be replaced here and we must proceed, he transferred three thousand pounds of his load to his three wagons, then tied a long pole in the place of the missing wheel and proceeded.

This delay made it late when we got to camp and we were so hungry that we concluded to substitute "flapjacks" for biscuit, as the quicker process, which we ate with molasses. After breakfast, Addy baked a nice lot of bread and then indulged in a bath in the "Rio San Pedro."

I almost felt tempted to do likewise, as it is intensely hot today, but they tell me the water is very cold. There is a station here and ten men are posted to watch for the Indians. Well, unless we meet with some misfortune, two more nights will conclude this tedious and trying journey, and tomorrow we reach the much dreaded Cienega, where about three months since a whole family were murdered, save two little children who were taken captive and for whom the officers proposed to give old "Francisco" in exchange.

November 11th, Tucson - I just run back now for nearly a week and finish up this imperfect record of my long, long, tedious journey which is at last ended.

... We were all still awake when the order to "hitch up" was given and we were soon underway again. Sleep soon overcame me and for a while I became oblivious to all danger. After a drive of sixteen miles they halted and allowed the poor boys to take a short nap. Started again two hours before daylight and about nine arrived safely at the "Cienega." We dispatched breakfast hurriedly in order to give time for a little sleep, but poor Addy found that the tire on one wheel was loose and must be wedged, the ambulance must be greased, so that by the time all these jobs were concluded it must be twelve, the hour for starting, and the long dreaded "Cienega" to pass. We took the precaution to send five men ahead to reconnoiter, the wagon kept in close file, our ambulance in the center. Eugene had a very fine field glass which he used frequently. "Coronado", the elder brother and husband of the lady, was ubiquitous, here, there, everywhere, constantly on the lookout. He and his wife were both very much frightened, but strange to say, notwithstanding the fact that it is the most "Indian" looking place on the globe and death and danger seem to be lurking behind every pile of rocks, yet I never once felt the least afraid, but kept the curtains up and my head out, gazing at all the strange sights, perhaps because I have never seen or felt the real danger, as many of them have. Frequently, the road ran through a narrow pass, when huge rocks on each side rose to immense height, completely willing us in. Behind these walls, whole bands of Apaches could secret themselves, and by firing down on travelers from above, else rushing out suddenly from in front or behind a train, they could annihilate at the first fire almost the entire party. But, thanks to some good fortune or fate, we were spared throughout the whole journey, even the site of a hostile Indian.

Coming through the "Cienega" I saw for the first time the far famed giant cactus or "Saguarro," and they really look like giant sentinels posted in every quarter throughout these awe-inspiring wilds. They grow very tall and straight, with arms branching out on every side about half-way up, and their favorite locality is on the top or side of a bare rock, where there is no soil to nourish them, and having very short, slender roots, it will always be a mystery to me how they manage to retain their hold, particularly in high winds, as they are much smaller at the base then elsewhere. Yet they never lose this balance, but stand there erect for ages, defying wind and sun, the most vigorous and flourishing growths to be found in the land, entirely independent or rain or soil.
(NOTE: These paragraphs are in reference to Sonoita Creek- another tributary to the Santa Cruz located southwest of Cienega Creek. I'm including these observations since the date and time of incision is noted, and probably gives a good indication as to when incision started taking place at Cienega Creek. Notice that the italicized descriptions would be very applicable to Cienega Creek. Also note that the mechanism suggested for the downcutting of Sonoita Creek is reasonable for Cienega Creek. Specifically, there are cienegas surrounding Cienega Creek that are at significantly higher elevations than the downcut creek. This suggests that there are clay layers that may have been incised by the action of the creek itself.)

... My camp was pitched near the house of Sr. Isauro Quiroz, the most important citizen of Sonoita and a man of some reading. Both he and his family delighted in showing me hospitality and attentions; he accompanied me to the place in which I was most interested here, the beginning of the Sonoita River. Stone artifacts had been found there many feet below the surface. The river has receded of late years and brought about some changes in the landscape. Formerly there existed a series of cienegas (swamps) immediately above the rise of the river, extending back for about three miles. They were in reality the river itself which, during its capricious subterranean course, found itself obstructed at Sonoita and spread out into swamps. The water filtered through at one place in a narrow channel which it cut through the gravelly, clayish deposit, thus forming the beginning of the river which flows on after this without embankments.

*During the night of August 6, 1891, after a heavy rain, the water carried off a hard barrier, about twenty meters wide, which had been retaining the swamps, and widened the channel, making it recede about a kilometer. The swamps dried up in three years, but the surface is undermined in places and a man and his horse are said to have inadvertently fallen into a cavity caused by the former action of the water. Where there had been before only a llano, a forest of mesquite trees sprang up, which is visible to anyone who enters Sonoita from the east. An interesting circumstance in the receding of the river and the widening of its channel is that it brought to light aboriginal artifacts, mostly consisting in metates (grinding stones) and their attendant rubbing stones. Also many sea-shells were found there, which were used as ornaments by the primitive people.*

I found this channel to be about two hundred and fifty feet broad and from eighteen to twenty feet deep. The objects that had been discovered here could no longer be accounted for, one metate only was left and it was still lying at the bottom. According to the location of the find, as pointed out to me by Sr. Quiroz, the artifacts must have been about twenty feet below the surface. I found a metate of a light-colored stone imbedded in the embankment twelve feet below the surface, and also took along the other one that was lying at the bottom of the channel.
OVERSTOCKING THE RANGES IN SOUTHERN ARIZONA DURING THE 1870'S AND 1880'S

The Arizonian, Vol II, Number 1, Spring, 1961

By J.J. Wagoner

Stock ranching has always been a frontier industry and has served a place of primary importance in the advancement of western civilization. In the Southwest, two phases of development seem to predominate: (1) The merging of the northward expansion of the Spanish and Mexicans and the westward movement from the Atlantic Cost; and (2) the adaptability of the industry to an arid country which for the first time gave the cattleman an opportunity for land utilization that the farmer could not easily supplant.

Both phases permeate the entire history of the cattle industry in southern Arizona, but the second became more important with the rapid influx of population after the subjugation of the Apaches in 1870s. It is the purpose of this paper to show how the grasslands of Arizona (namely the area south of Gila River) became fully stocked by the mid-1880s, and obviously overstocked with the process of vegetative destruction well underway by 1890.

As background to subsequent development it should be mentioned that most of the herds in Arizona Territory during the 1870s were driven in from Texas and California to supply the federal troops and Indians with beef. Advertisement in the Arizona Citizen would indicate that the business was lucrative. Requests for bids to furnish several thousand head to the army or the Bureau of Indian Affairs were not uncommon.

... Patrick Hamilton, a one man Territorial Chamber of Commerce, wrote in his Resources of Arizona that the native grasses were inexhaustible and could support a cattle population of over seven and one half million head. The evidence, however, indicates that the depletion of Arizona's ranges was contemporaneous with the development of ranching. Unfortunately, the primary objective of cattleman was numbers; overstocking resulted from the unrestricted use of Federal land before the cattle census reached a fifth of the figure that Hamilton considered a reasonable estimate.

... The erosion which resulted from overgrazing in the valleys of Southern Arizona occurred over a considerable time, and the details of the process have seldom been recorded. But the change from aggradation and the building of floodplains to channel-trenching can be placed in the 1880's in most of the important valleys, though many tributaries were not affected until the nineties. Since the changes were initiated at slightly different time in the various localities, it seems imperative to trace the early development of the cattle industry in each of the main areas of settlement.

The Santa Cruz Valley was the center of the first American occupation. In 1870, there were few cattlemen in this area. ... In the early 1870's however, the number of livestock in the valley increased more rapidly.

... Another region which was once covered with good growth of grass is the Rillito Valley, a tributary of the Santa Cruz. The river course was indefinite and lined by an almost continuous growth of cottonwood, ash, walnut, and willow trees. These conditions prevailed until after 1872 at which time the United States Army post was moved from Tucson further east, near which natural grasses could be cut for hay. A few years of such cropping, as well as overgrazing by cattle that were brought in during the 70's resulted in the destruction of the root grasses. The effect of settlement in the valley was to increase the rapidity of runoff and thus the length of dry seasons. The stage was set for the first drastic erosion of the 90s.

The next general area of occupation was east of Tucson between the Santa Rita and Whetstone Mountains. This broad rolling land has few streams, but is fortunate at having permanent water at the base of the Santa Ritas. There are also many natural reservoirs and springs. So in spite of the harsh winter winds and powerful summer heat, several large ranches were located in these lands by the 1880. Among them was the Empire Ranch of Vail, Hislop and Harvey, the so-called "English boys" which was grazing 5000 head. Another was the Cienega Ranch which has 1000 cattle plus 23,000 sheep. Edward R. Vail described this
region as being a succession of meadows thickly covered with sacaton and salt grass in 1880. The mesquite had not yet taken over the country, but grew in gulches were it checked erosion.


All the ranges were being overgrazed with none held in reserve for lean years. By 1891, cattle production has reached a peak in the Arizona Territory. In that year, there were nearly 721,000 head on the tax rolls. It is the opinion of men who understood the methods of listing property in those days that there were at least twice that number on the grasslands.

The day of reckoning came in 1891 when ranchmen were faced with a severe drought. Without rain, there was no grass and soon very little water. Many cattle died, especially in May and June of 1892; but not until the second summer had passed without rain did ranchmen realize how truly the ranges were overstocked, and that livestock had to be removed. During September and October, thousands of cattle were moved to pastures in Texas, the Indian Territory, Kansas, California, Nevada, and as far north as Oregon.

The exodus and fatalities continued until the rains came in July, 1893. Conservative estimates places the losses at fifty percent, and some ranchman said it ran as high as 75%.

Needless to say, these events sobered the cattle owners of Arizona. They learned many things from their personal observations and experiences which proved to be valuable to the livestock business in later years.

One change was the establishment of ranching on a permanent basis. More surface wells and windmills were erected to render available many ranges theretofore considered unusable.... Experienced, resident cattlemen began to consolidate their holdings into larger companies. They pooled their resources in order to artificial water and to market their cattle more profitably.... Many cattlemen leased forest lands in order to secure more grass.... They came to realize that overgrazing was truly an evil. Their attitude switched to the point that after the turn of the century, the Arizona Cattle Growers' Association consistently advocated the administration of the public domain under Federal control similar to the operation and supervision of the national forest reserves by the Forest Service.

They had to wait until 1934, however. The Taylor Grazing Act of that year was passed to provide for regulated control of the unappropriated grazing lands and thus stabilized the livestock industry which was dependent upon the public range.
Many changes have taken place in the basin landscape since the first Europeans explored the Upper Santa Cruz Basin. Erosion has lowered the base level of the Santa Cruz River, and the basin is adapting to it. Early settlers found the flow in the Santa Cruz river adequate for their needs, and Smith (1910) showed the water table in the Tucson area higher than the streambed in 1908. Davidson (written communication, 1969) showed that the water table ranged from about 20-70 feet below the streambed along the Santa Cruz River in 1940-64. The increase in withdrawal of water by pumping accounts for the lowering of the water table, but the exact causes of the erosional activity are not known.

Previous workers agree that the most recent arroyo cutting and lowering of the channel streambeds in the Santa Cruz River basin began about 1890. Leopold (1951) discussed the journals of early explorers and travelers in the Southwest and compared early photographs with more recent ones taken at the same place. He concluded that the vegetation changes in the 50 years between 1895 and 1946 were not significant, and that the vegetation changes that most effected erosional activity possibly occurred before 1895. Hastings and Turner (1965, p 288) discussed the changes in vegetation and stated:

To the extent that arroyo cutting accurately reflects changing vegetative conditions it is possible to be more precise. Arroyo cutting began along many of the streams of the desert region in August, 1890. One can infer, then, that by 1890, the vegetation had been altered enough to affect runoff, but it is an uncomfortable inference, resting as it does on the unproven assumption that a change in the vegetal cover inaugurated arroyo cutting.

Hastings (1958-59, p 35) discussed three theories of what caused the changes in the landscape: (1) the introduction of cattle, which upset the biological balance of the soil and things that grow on it, (2) a tilting of the land surface that caused the gradient of local streams to increase, and (3) climatic changes- less rain, change in rainfall pattern, and change in intensity of storms. Hastings and Turner (1965) stated that the event that may have triggered arroyo cutting was an imbalance between infiltration and runoff caused by a combination of climatic variation and cattle grazing.
... Father Kino's account of the valley near Tucson is of colored by his enthusiasm and missionary zeal, but his statements imply conditions very unlike those of the present. In 1692, he found 800 persons at San Xavier del Bac, 12 miles south of Tucson. In January, 1967, there were at the same place "beginnings of good sowings and harvests of wheat," and in November of the same year, he counted in the rancheria and the environs 6000 persons and "found even bread, fresh and very good." In October, 1699, he counted 1000 persons in the rancheria of San Xavier del Bac and states: "The fields and lands for sowing were so extensive and supplied with so many irrigation ditches running along the ground that the father visitor [Antonio Leal] said they were sufficient for another city like Mexico." Of San Cosme del Tucson, probably located just west of the present city of Tucson, he said that it had "splendid fields." Similarly, he states that he counted 200 men representing 200 families at San Agustin del Oyaut (Oiaur), probably between Jaynes and Rillito. At Santa Catalina del Cuytoabagum he found 300 men representing 300 families. This rancheria was probably near the present Picacho. In April, 1700, after erecting the foundation of a church and beginning a mission at San Xavier del Bac, Kino states that the mission "will be able to have throughout the year all the water it may need, running to any place or workroom one may please, and one of the greatest and best fields in all Nueva Bicaya."

The purport of these statements is that at the beginning of the eighteenth century, about 20 years after the palo verde which Huntington examined had sprouted, the flood plain of Santa Cruz River was without a deep channel and had a permanent stream, else the Indians with their primitive wooden tools would not have been able to divert the water into ditches, nor would the water have lasted all the year. It should be remembered also that the cutting of the channel trench has facilitated the flow of ground water at the present time. There must, then, have been much more water available at the present in 1700 to cause the river to flow all year round. The extensive settlements down the river from Tucson are also significant, for, unless the floods were stronger and more frequent then now, 200 families could not live by primitive agriculture, between Jaynes and Rillito, nor could 300 families live near Picacho. The narrative of Kino thus adds force to the arguments of Huntington that there was once a wetter climate in southern Arizona. One of these periods of slightly wetter climate appears to have been during the time of the missionaries. The first effect on topography of a change to drier conditions came between 1880 and 1890, when changes in the channel of streams took place in widely scattered localities in the Southwest. In northern Arizona, Gregory (USGS Professional Paper 93, p 130-131) has been able to fix the dates when a number of streams began to cut trenches. These dates range from 1880 to 1894, but the most extensive work was done in the late 1880s.
XX. References

(References for ver 1.00 still need to be supplemented with Moody, Rosgen, Fonseca et al (1990), Dunne and Leopold (1980), Huth 1998. Final version of references will be delivered in appendix ver 1.01 to be delivered with contracted shapefiles for the lower basin.


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