2006 UT NAIP Absolute Accuracy Pilot Project

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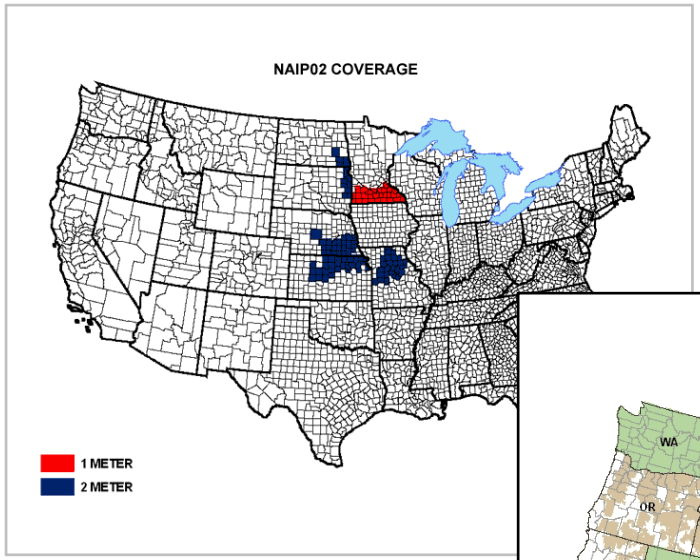
Overview

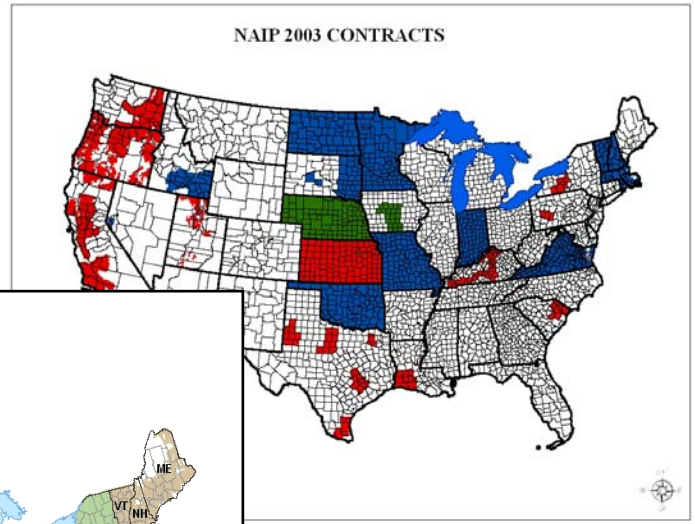
- NAIP Overview
- The Issue at Hand
- Business Case
- Determine Accuracy Requirements
- Acquiring & Maintaining Photo Control
- Comparison of 2004 to 2006 UT NAIP Imagery
- Control Point Database Design
- 2006 UT NAIP Inspection Process
- Supplemental Data
- Pilot Study Results
- National Implementation & Recommendations

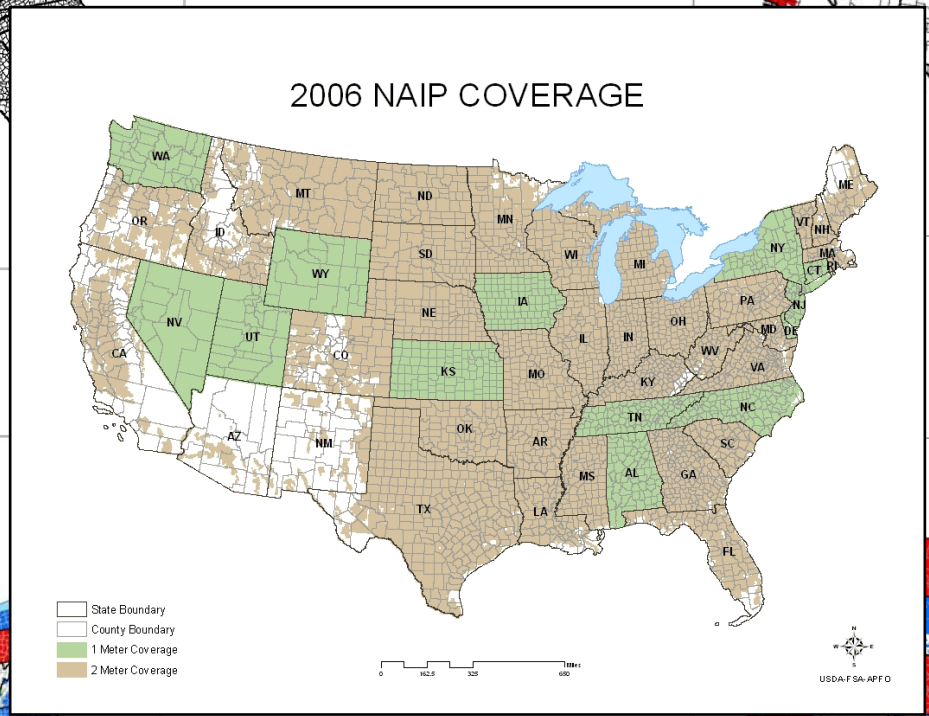
NAIP Basics

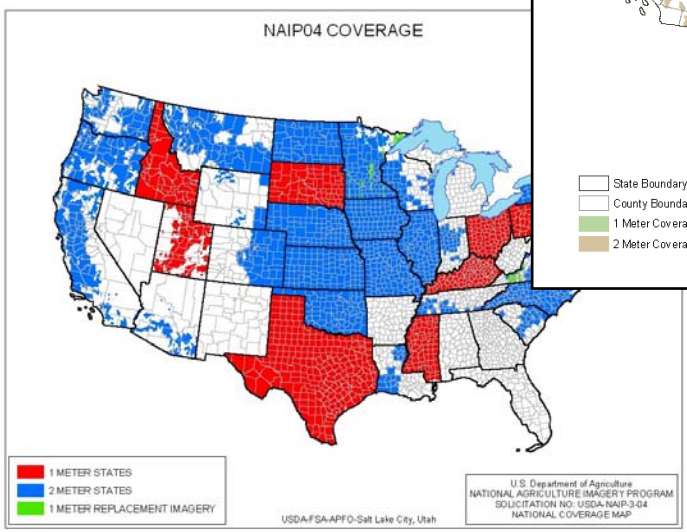
- National Agriculture Imagery Program
- 1 & 2-meter resolution acquisition
- Leaf On (prime growing season)
- DOQQ and Compressed County Mosaic
- Used for compliance, base layer, other
- Funded by FSA & partner organizations
- Currently slated to become the 1-meter portion of Imagery For The Nation

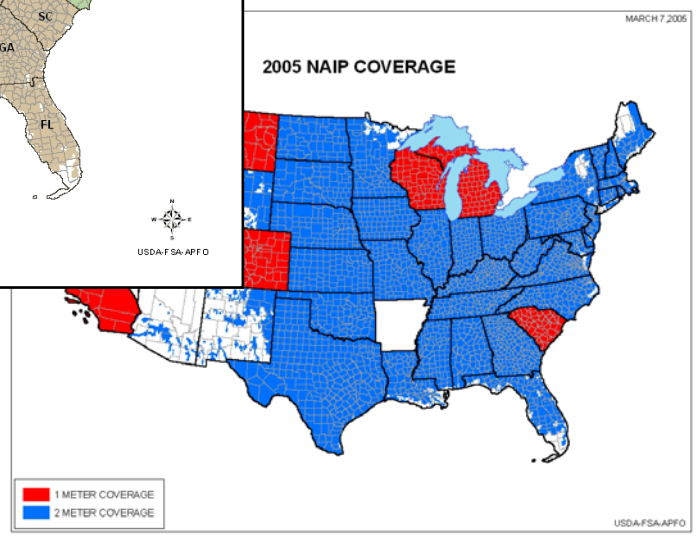
NAIP History











The Issue at Hand

- In the past, NAIP used horizontal accuracy specifications relative to other imagery rather than to true ground control
  - Less accurate as a base layer
    - Less accurate to digitize upon
    - Less accurate to other vector datasets
    - Less appealing to partners
    - Less valuable as a product
- Opportunity arose in UT to move NAIP to absolute accuracy specification

Why move to absolute accuracy? Business Case

- Imagery used as a base layer in GIS
  - Imagery often the most spatially accurate data
    - Digitize on imagery; “most accurate” to true ground
      - Less manipulation of vector data over time to “match” base
      - Alleviate continual horizontal adjustments/workload
    - A more accurate dataset is a more valuable dataset
      - Has more uses and more confidence
    - Attracts more partners = less Federal dollars spent
- Better for meeting customer requirements
- Good business

Approval

- Support for UT NAIP Pilot Project
  - FSA (APFO, WDC & State offices)
  - NAIP partners
  - State GIS office (AGRC)
  - NAIP contractor (North West Geomatics)

Relative and Absolute

- NAIP Relative Accuracy
  - New imagery tied to old imagery
    - ± 5-meter for 1-meter NAIP
    - ± 10-meter for 2-meter NAIP
  - Pro
    - CLU and other SCA data *should* match new imagery since both are tied to the old imagery
  - Con
    - Other data sets *may* not match because they are not tied to the old imagery

Relative and Absolute

- NAIP Absolute Accuracy
  - Pros:
    - Imagery represents reality, not former imagery
    - Don’t use errors and offset from former imagery
    - Imagery would match most other data sets
    - Potentially more NAIP partners
    - Less “maintenance” to CLU datasets after an initial shift
  - Cons:
    - Additional cost and time to acquire control
    - Additional time *may* be needed to produce imagery
    - No nationwide, standardized, photo-identifiable control point database for use in production & inspection
    - Changes to inspection, database, & contracting processes

Determine Accuracy Requirements

- Researching & selecting a standard
  - Industry standards, imagery uses, accuracy requirements, existing standards
- Discussions with USGS
  - Number and distribution of points, methods used with former and existing imagery programs
- Discussions with AGRC & NW Geomatics
  - Number of points and specifications, scheduling, contacts, meetings, emails, and telephone calls
- Discussions with IFTN representatives

Determine Accuracy Requirements

- Reviewed & evaluated standards:
  - NMAS
    - National Map Accuracy Standard
  - ASPRS
    - American Society for Photogrammetry & Remote Sensing
  - NSSDA
    - National Standard for Spatial Data Accuracy
  - IFTN
    - Imagery For The Nation

Determine Accuracy Requirements

- Finally!!!
  - 2006 NAIP UT 1m GSD Requirement
    - **“95% of points tested must fall within six (6) meters of pre-determined quality assurance ground control points”**
  - 2007 NAIP 1m GSD Requirement
    - **95% of well-defined points tested shall fall within 6 meters of true ground**
      - Meets or exceeds NMAS for 1:12000, ASPRS class 2, and Imagery for the Nation (last iteration)

Acquiring & Maintaining Photo Control

- General Workload
  - Standards development
  - Point selection for AGRC
  - Coordination with AGRC and other agencies
  - Finding, evaluating, preparing control points from other sources for use in inspection
  - Database creation
  - Control point inspection
  - Data maintenance
  - Continued research and testing

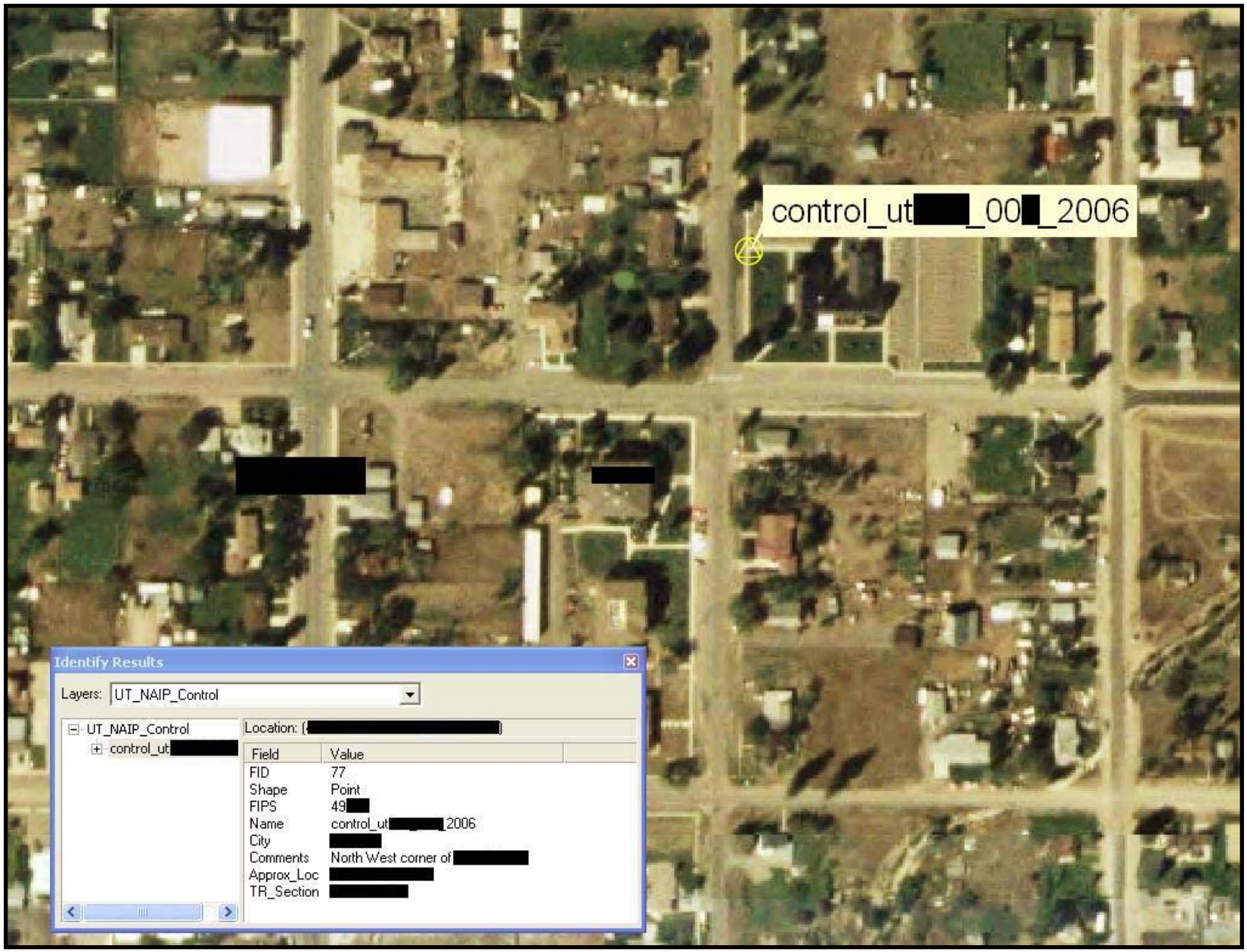
Acquiring & Maintaining Photo Control

- AGRC point selection
  - Researched how others select & acquire control
  - Met with AGRC Surveyor Sean Fernandez
  - APFO selected each of the 87 inspection points and created a simple map and descriptor of each point
  - Field Control Sheet
  - Support Data
    - Photographs (N, S, E, W & Close up view of point)
    - Raw GPS data
    - NGS OPUS report (Online Positioning User System)
    - Maps, sketches, descriptions

Acquiring & Maintaining Photo Control

- Control point accessibility
  - Production Control Points
    - 1 meter NAIP 2006 orthoimagery production
    - 1 foot UT imagery (Coverage for approx ¼ of the state)
    - Use for 6-inch imagery for Salt Lake County
    - Data available for public use
  - APFO Inspection Control Points
    - 1 meter NAIP 2006 orthoimagery inspection
    - Data **not** available for public use

Inspection Control Point Sample



Sample Observation Sheet

NAIP 2006 GPS Observation Sheet

Control Station

Station Name ut[redacted]_2006 [redacted]	**State** Utah	**County** [redacted]
Contacts Name Matt[redacted]	**Contacts Phone** (801)[redacted]	
Source Agency AGRC	**Date** 9/15/06	

Rover Receiver

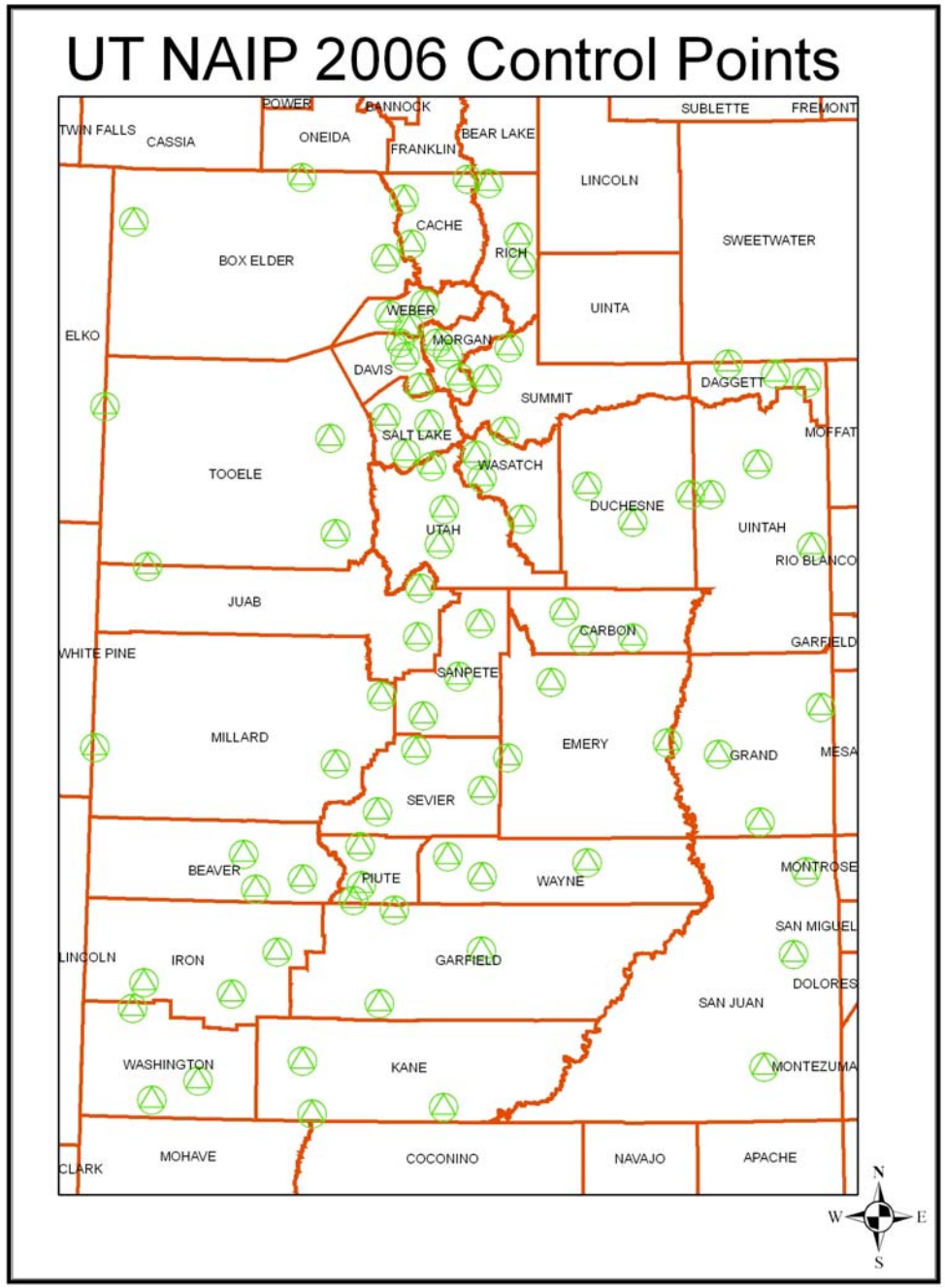
Type Trimble	**Model** 5800	
Serial Number [redacted]	**Antenna Type** 5800	**Antenna Height** 3.72 sft

Monument Description and Comments

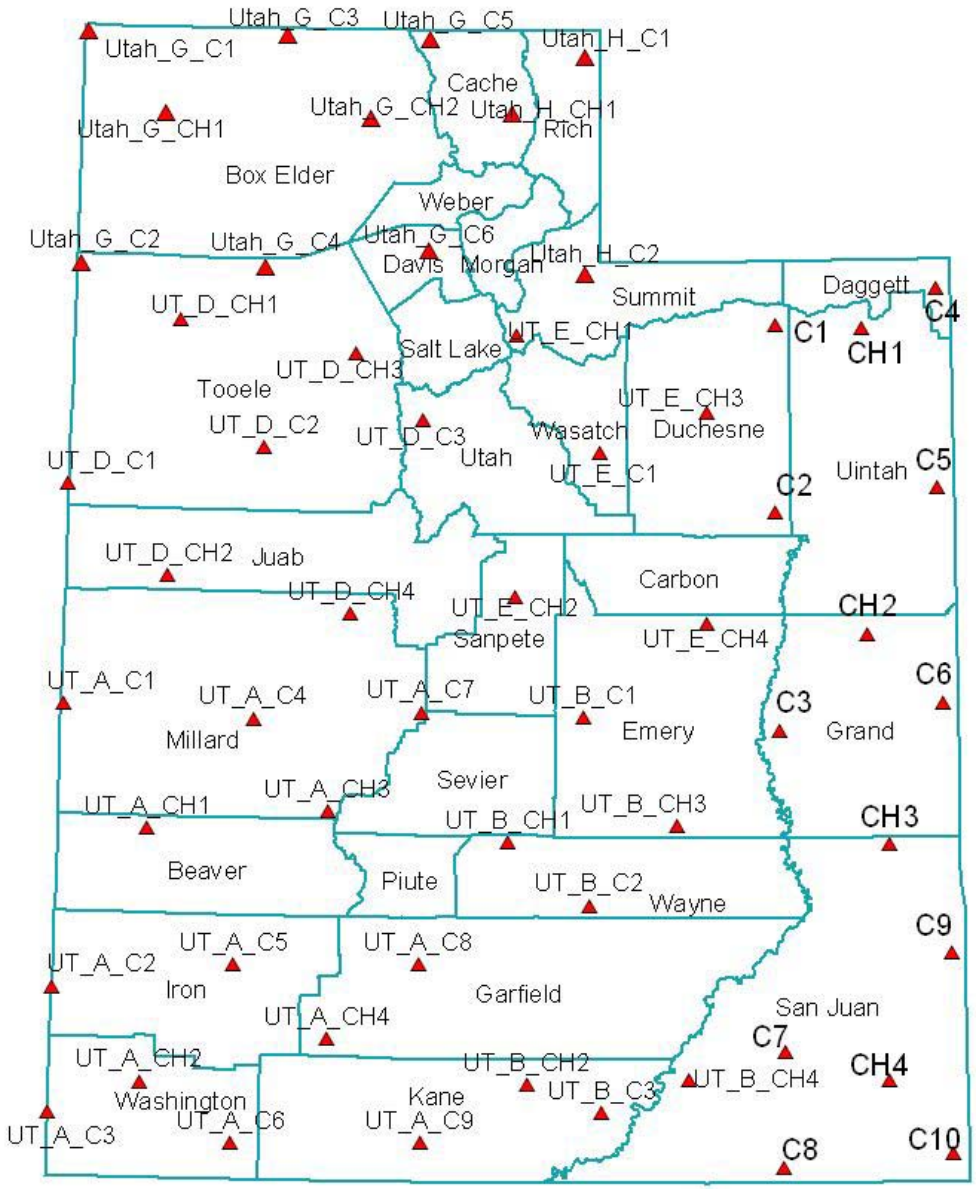
[redacted]–Changed to Southeast corner of church lawn.

Approximate locations of the 87 inspection control points (3 per county)

According to AGRC the points are accurate to within millimeters, others centimeters, and others decimeters. In other words, sub-foot accuracy.



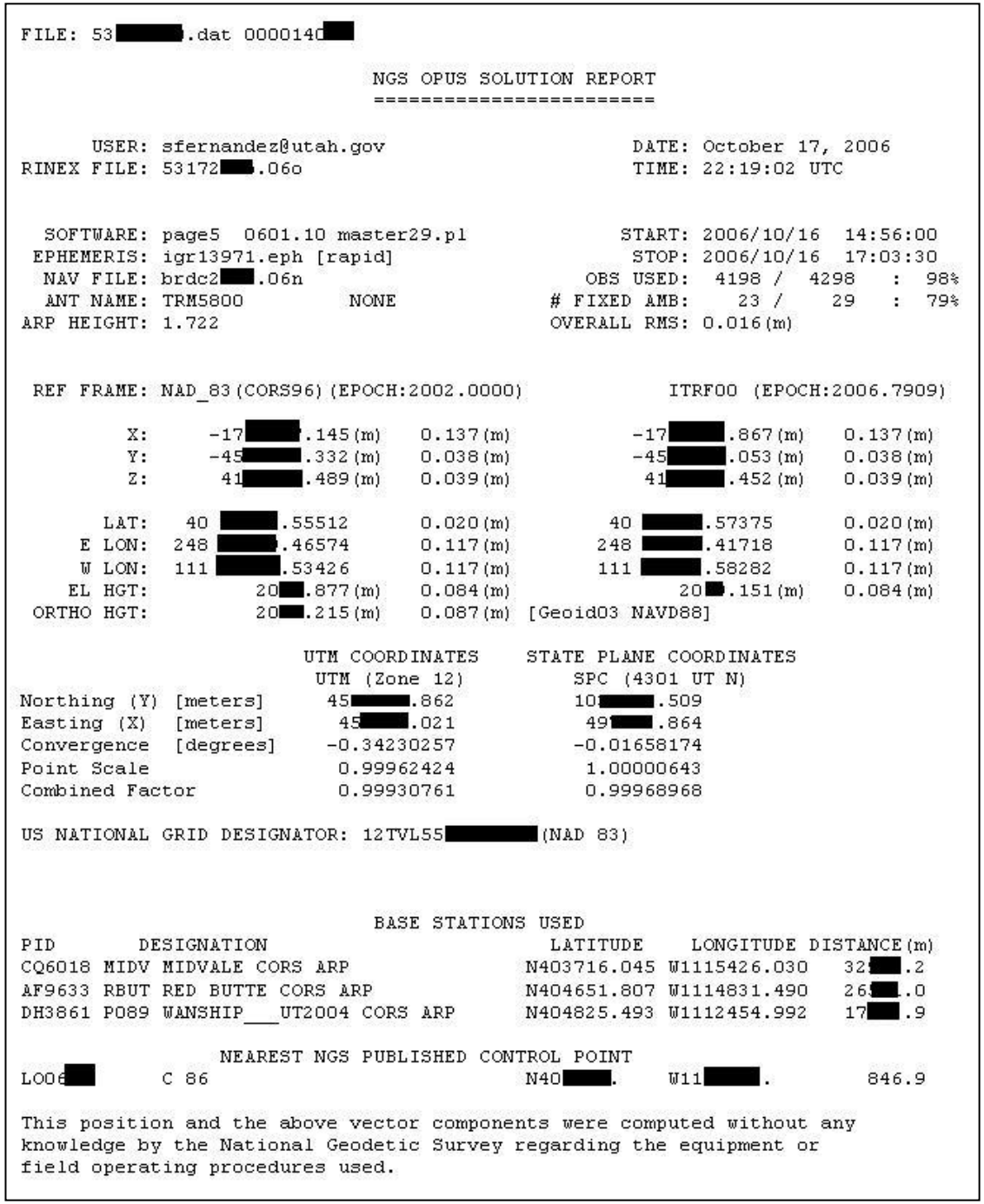
Approximate locations of the 57 production control points



OPUS Sample Report

National Geodetic Survey
Online Positioning User Service

http://www.ngs.noaa.gov/OPUS/



FILE: 53[redacted].dat 000014[redacted]

NGS OPUS SOLUTION REPORT
==========

USER: sfernandez@utah.gov
RINEX FILE: 53172[redacted].06o

DATE: October 17, 2006
TIME: 22:19:02 UTC

SOFTWARE: page5 0601.10 master29.pl
EPHEMERIS: igr13971.eph [rapid]
NAV FILE: brdc2[redacted].06n
ANT NAME: TRM5800 NONE
ARP HEIGHT: 1.722

START: 2006/10/16 14:56:00
STOP: 2006/10/16 17:03:30
OBS USED: 4198 / 4298 : 98%
FIXED AMB: 23 / 29 : 79%
OVERALL RMS: 0.016(m)

REF FRAME:	NAD_83(CORS96)(EPOCH:2002.0000)		ITRF00 (EPOCH:2006.7909)	
X:	-17[redacted].145(m)	0.137(m)	-17[redacted].867(m)	0.137(m)
Y:	-45[redacted].332(m)	0.038(m)	-45[redacted].053(m)	0.038(m)
Z:	41[redacted].489(m)	0.039(m)	41[redacted].452(m)	0.039(m)
LAT:	40 [redacted].55512	0.020(m)	40 [redacted].57375	0.020(m)
E LON:	248 [redacted].46574	0.117(m)	248 [redacted].41718	0.117(m)
W LON:	111 [redacted].53426	0.117(m)	111 [redacted].58282	0.117(m)
EL HGT:	20[redacted].877(m)	0.084(m)	20[redacted].151(m)	0.084(m)
ORTHO HGT:	20[redacted].215(m)	0.087(m)	[Geoid03 NAVD88]	

	UTM COORDINATES UTM (Zone 12)	STATE PLANE COORDINATES SPC (4301 UT N)
Northing (Y) [meters]	45[redacted].862	10[redacted].509
Easting (X) [meters]	45[redacted].021	49[redacted].864
Convergence [degrees]	-0.34230257	-0.01658174
Point Scale	0.99962424	1.00000643
Combined Factor	0.99930761	0.99968968

US NATIONAL GRID DESIGNATOR: 12TVL55[redacted](NAD 83)

BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)
CQ6018	MIDV MIDVALE CORS ARP	N403716.045	W1115426.030	32[redacted].2
AF9633	RBUT RED BUTTE CORS ARP	N404651.807	W1114831.490	26[redacted].0
DH3861	PO89 WANSHIP___UT2004 CORS ARP	N404825.493	W1112454.992	17[redacted].9

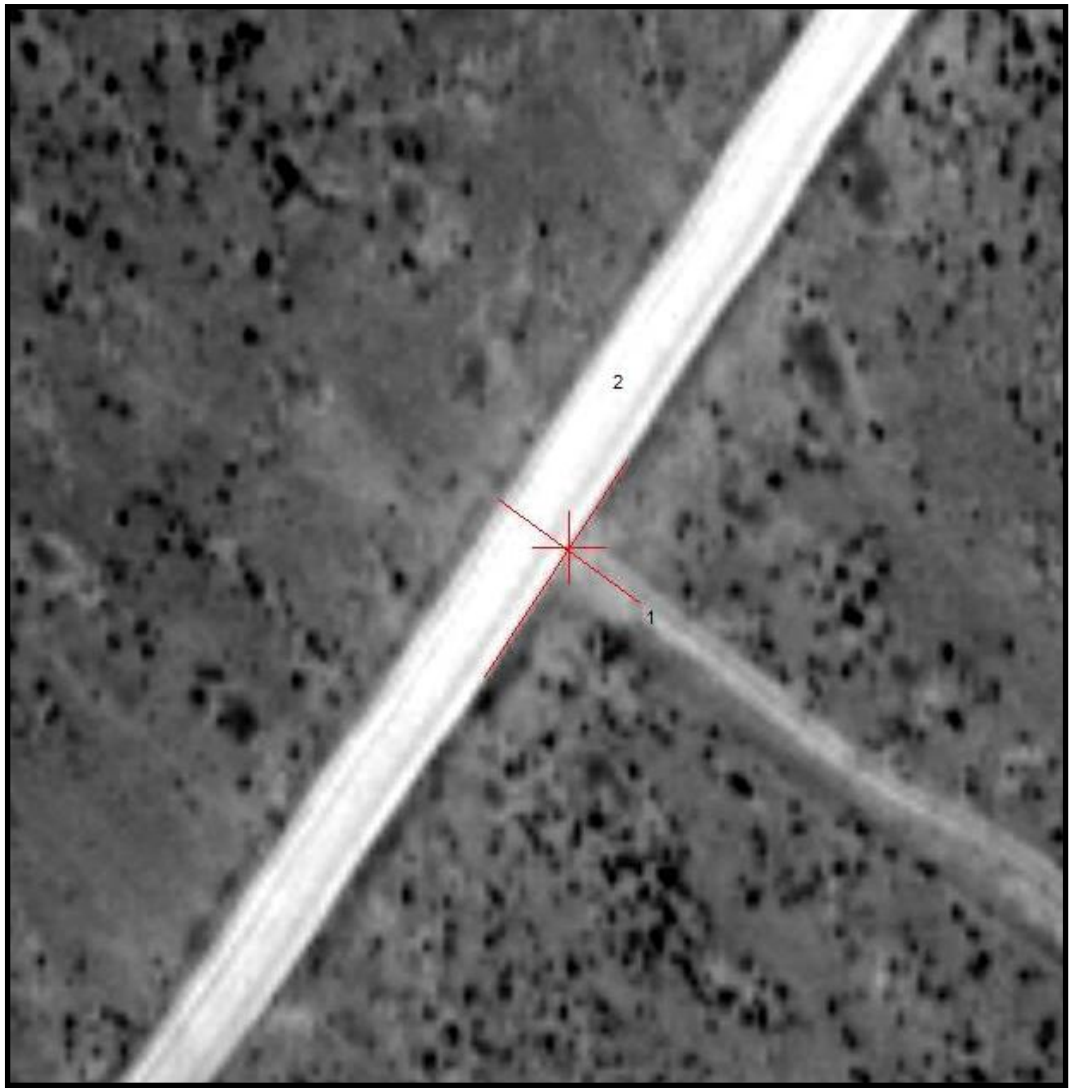
NEAREST NGS PUBLISHED CONTROL POINT

LO0[redacted]	C 86	N40[redacted].	W11[redacted].	846.9

This position and the above vector components were computed without any knowledge by the National Geodetic Survey regarding the equipment or field operating procedures used.

Ortho-Production Control

Selecting the point



Control point marker

Ortho-Production Control

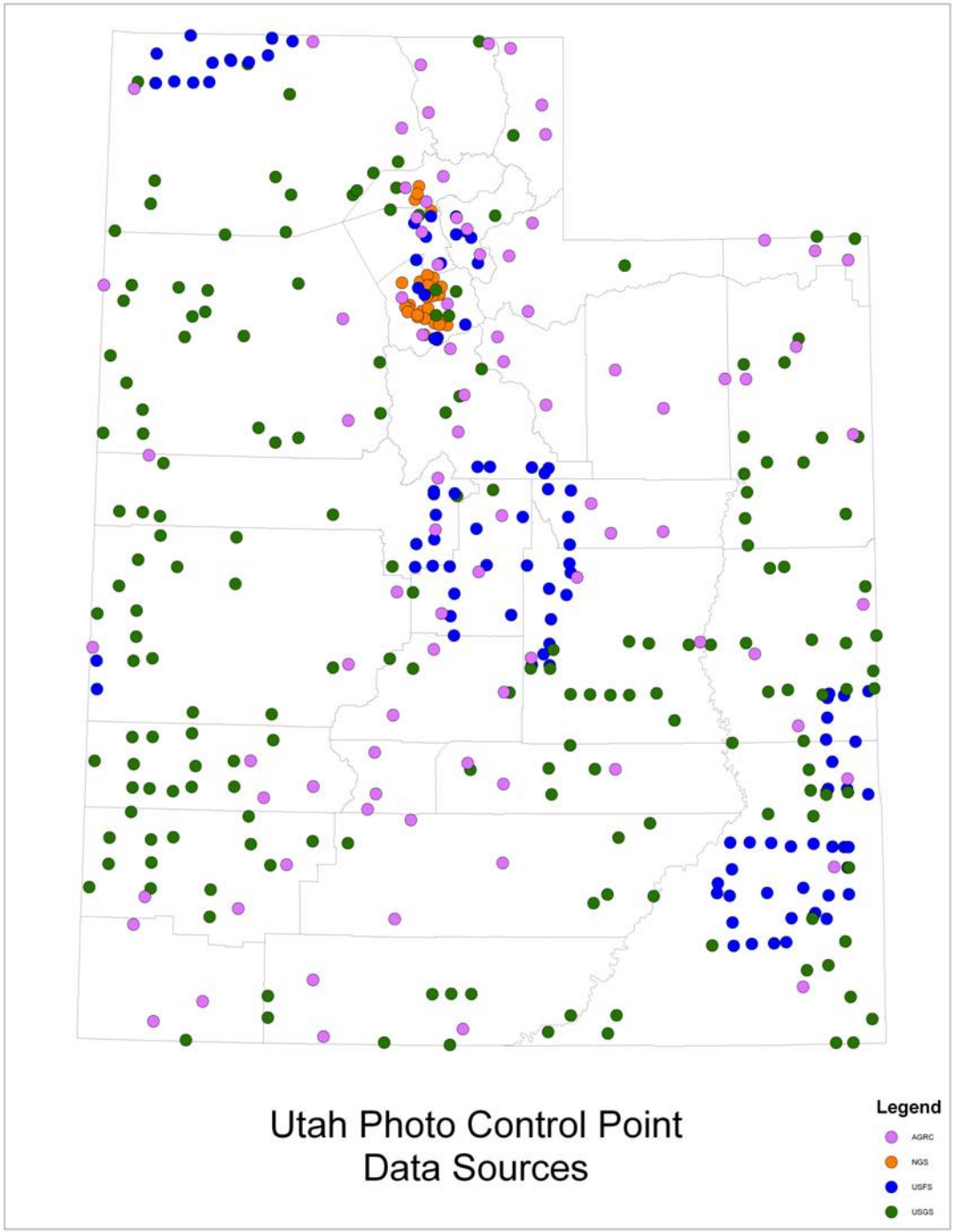
Control point examples

Inspection Control

Control point examples

Inspection Control

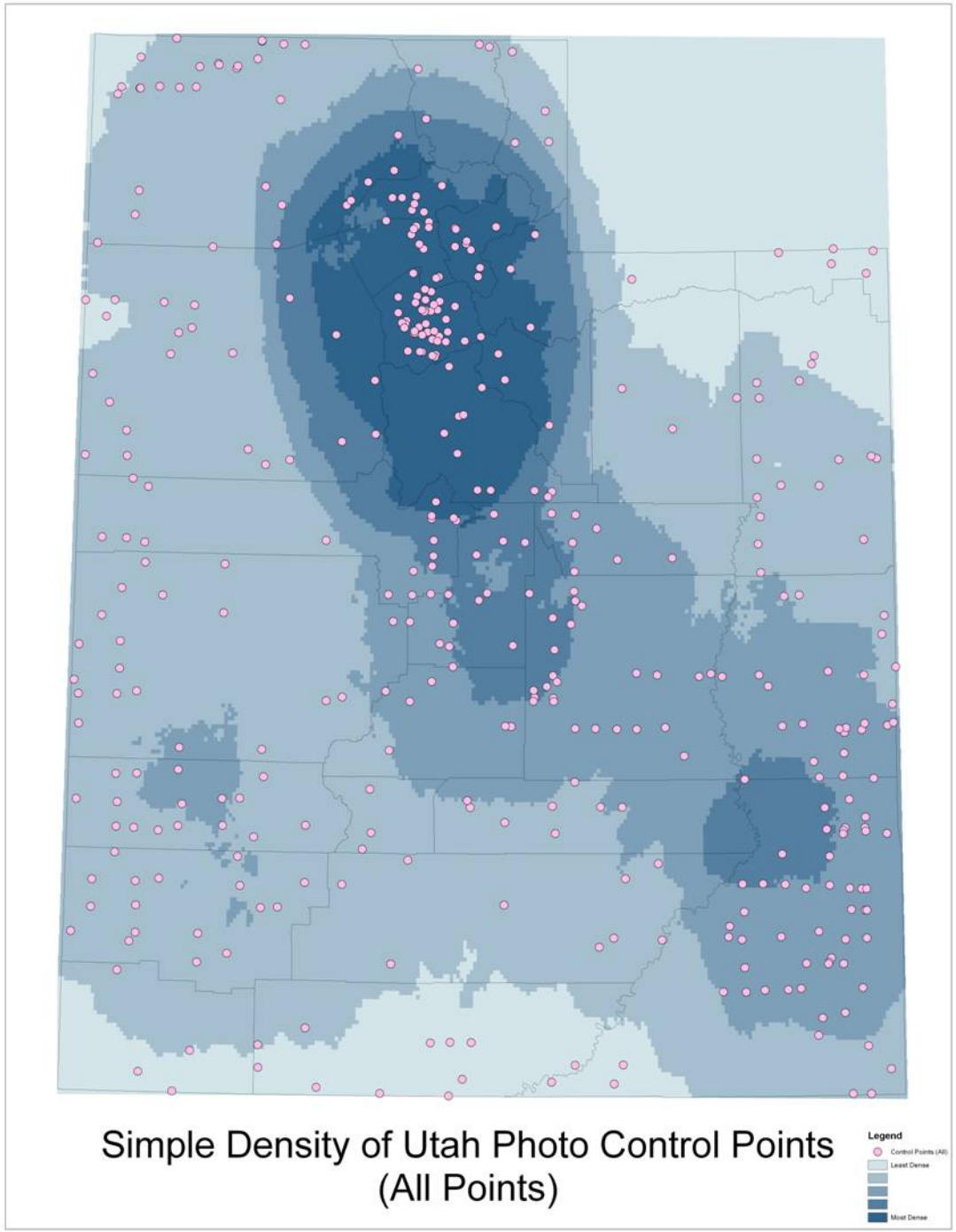
Control point examples

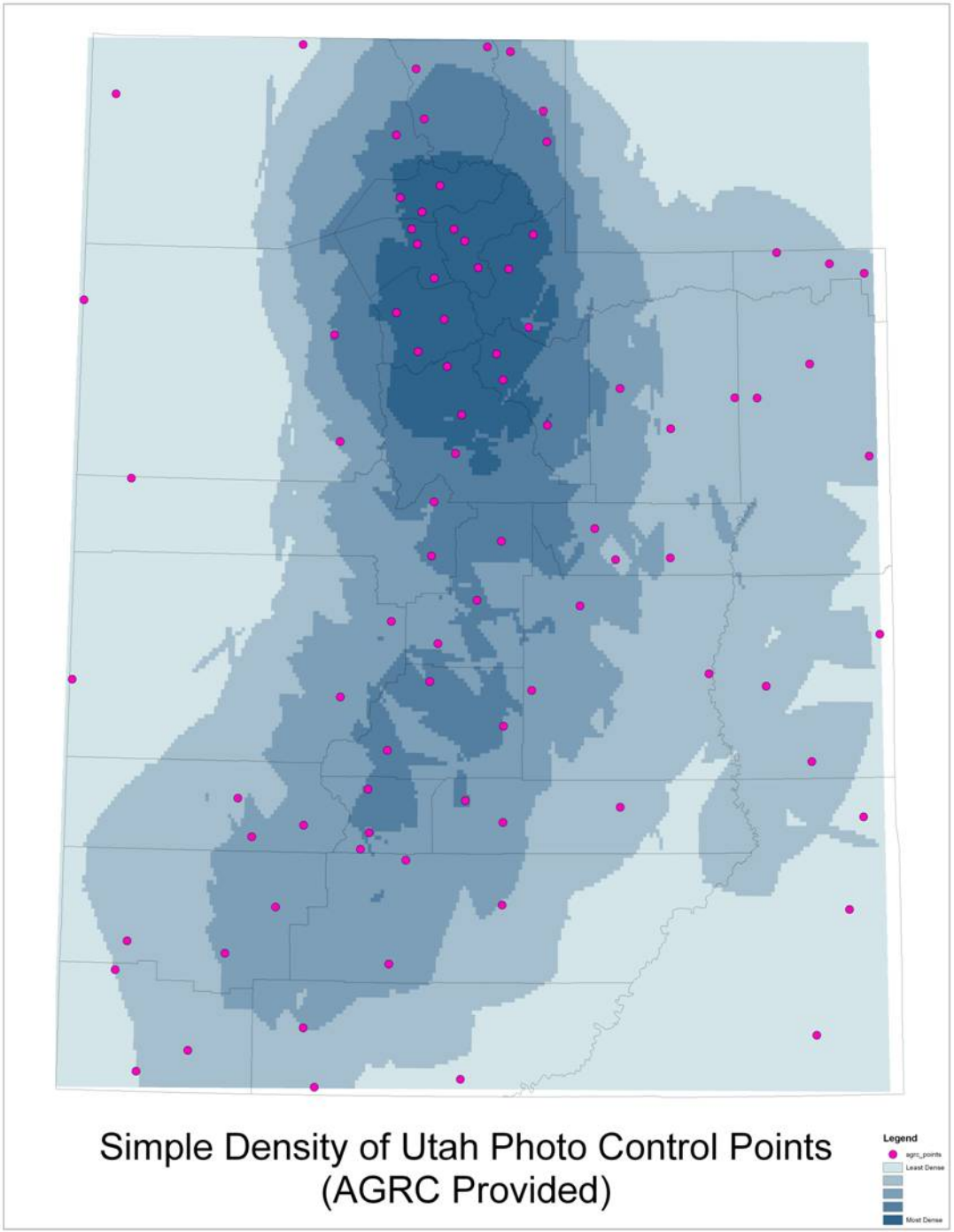


Control Points

- AGRC
  - NGS
    - USFS
      - USGS

Distribution of all control points used for inspection



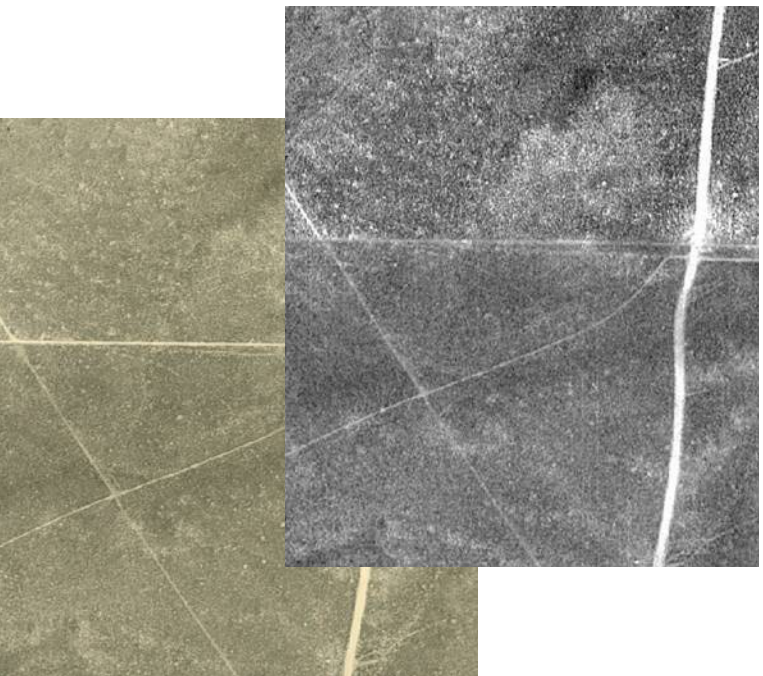


Distribution of AGRC control points used for inspection

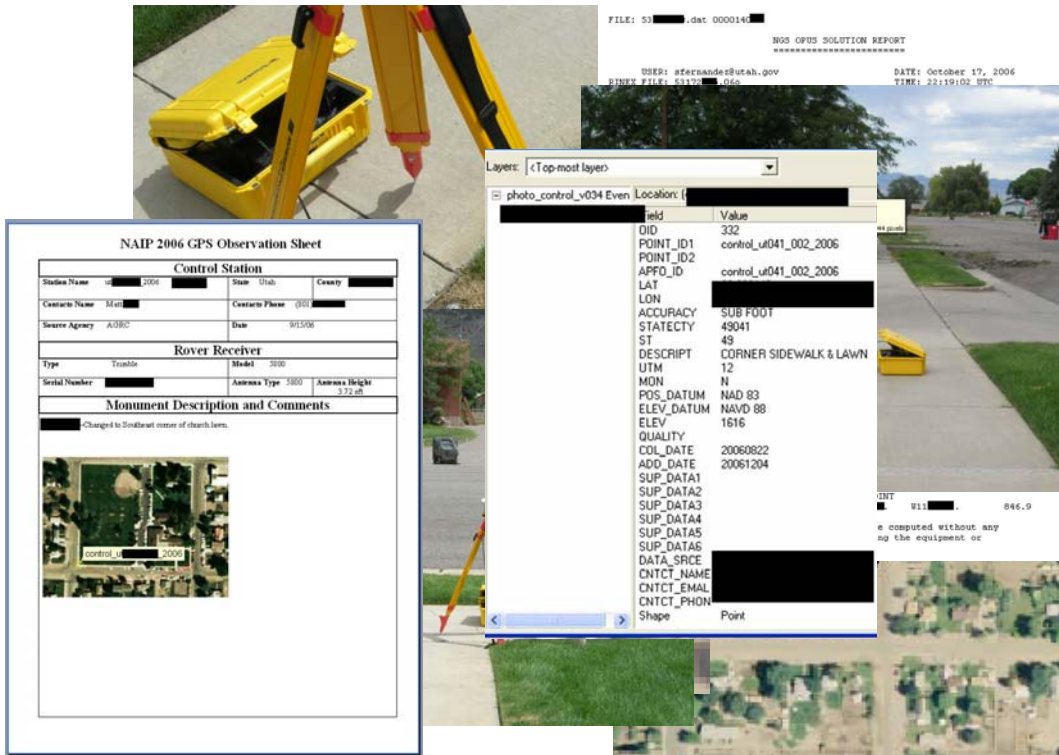
Control Point Database Design

- The connecting factor in the move of NAIP from relative to absolute control specs

Relative



Absolute



Control Point Database Design

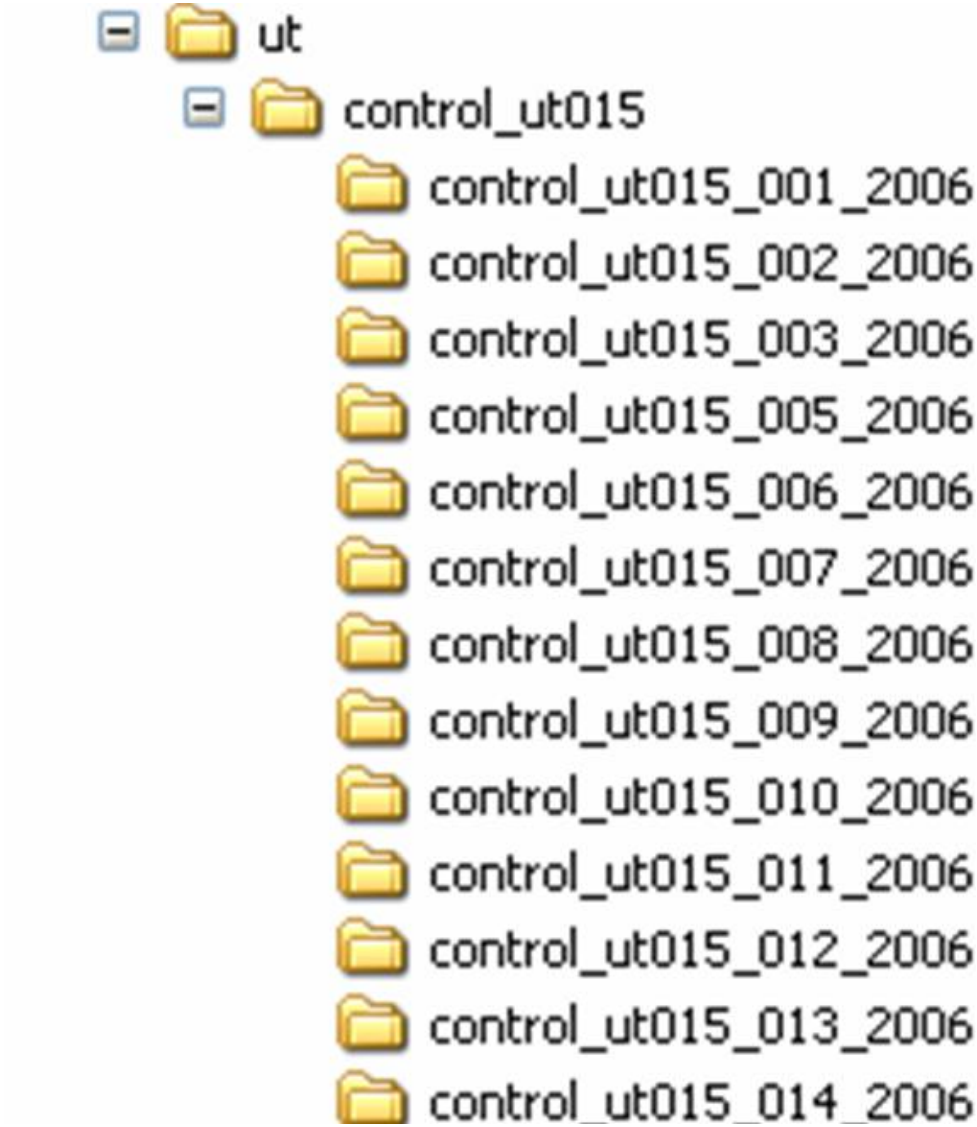
- Control Point Database: database of all photo-identifiable ground control points used for NAIP inspection
  - Start with UT pilot
  - Design geared towards National coverage (long term)
  - Flexibility
    - Can “handle” most data delivery formats
      - Numerous data sources (USGS, USFS, States, NGS, Private, etc.)
      - Accommodating field types and lengths
- Maintained as .dbf this year
  - Future Oracle table
- Capable of adding x,y (lat,lon) “events” into ArcMap
- Not for public disbursement

POINT_ID1: Surveyor named identification of point (String 50)
POINT_ID2: Surveyor secondary identification of point (String 50)
APFO_ID: APFO's point identification name (String 50)
LAT: Latitude in Decimal Degrees (Double 19)
LON: Longitude in Decimal Degrees (Double 19)
ACCURACY: Survey accuracy information for point (String 50)
STATECTY: 5 digit FIPS of where the point is located (String 5)
ST: 2 digit State FIPS of where the point is located (Short 2)
DESCRIPT: textual description location of point (String 50)
UTM: UTM zone of where the point is located (Long 9)
COL_DATE: Original or most recent point collection/visit date (String 50)
MON: Is point monumented (String 50)
POS_DATUM: Positional datum (e.g NAD83) (String 50)
ELEV_DATUM: Elevation datum (String 50)
ELEV: Elevation of point (String 50)
QUALITY: APFO populated quality assessment of point for specific purpose of inspection. Is the point easy to use for inspection? 1=Excellent, 2=Good, 3=Average, 4=Difficult, 5=Recommend Removal from Inspection Database. This field will allow for APFO to keep current a quality inspection point database, based on inspector observations (String 50)
ADD_DATE: Date point added to the APFO control database (String 50)
SUP_DATA1: supplemental data field, including hyperlinks to websites, images, sketches, detailed descriptions, etc. (String 100)
SUP_DATA2: Same as SUP_DATA1 (String 100)
SUP_DATA3: Same as above (String 100)
SUP_DATA4: Same as above (String 100)
SUP_DATA5: Same as above (String 100)
SUP_DATA6: Same as above (String 100)
DATA_SRCE: Source of the control data (USGS, NGS, USFS, etc.) (String 50)
CNTCT_NAME: Name of primary contact for control point (String 50)
CNTCT_PHON: Phone for primary contact for control point (String 50)
CNTCT_EMAL: Email for primary contact for control point (String 50)

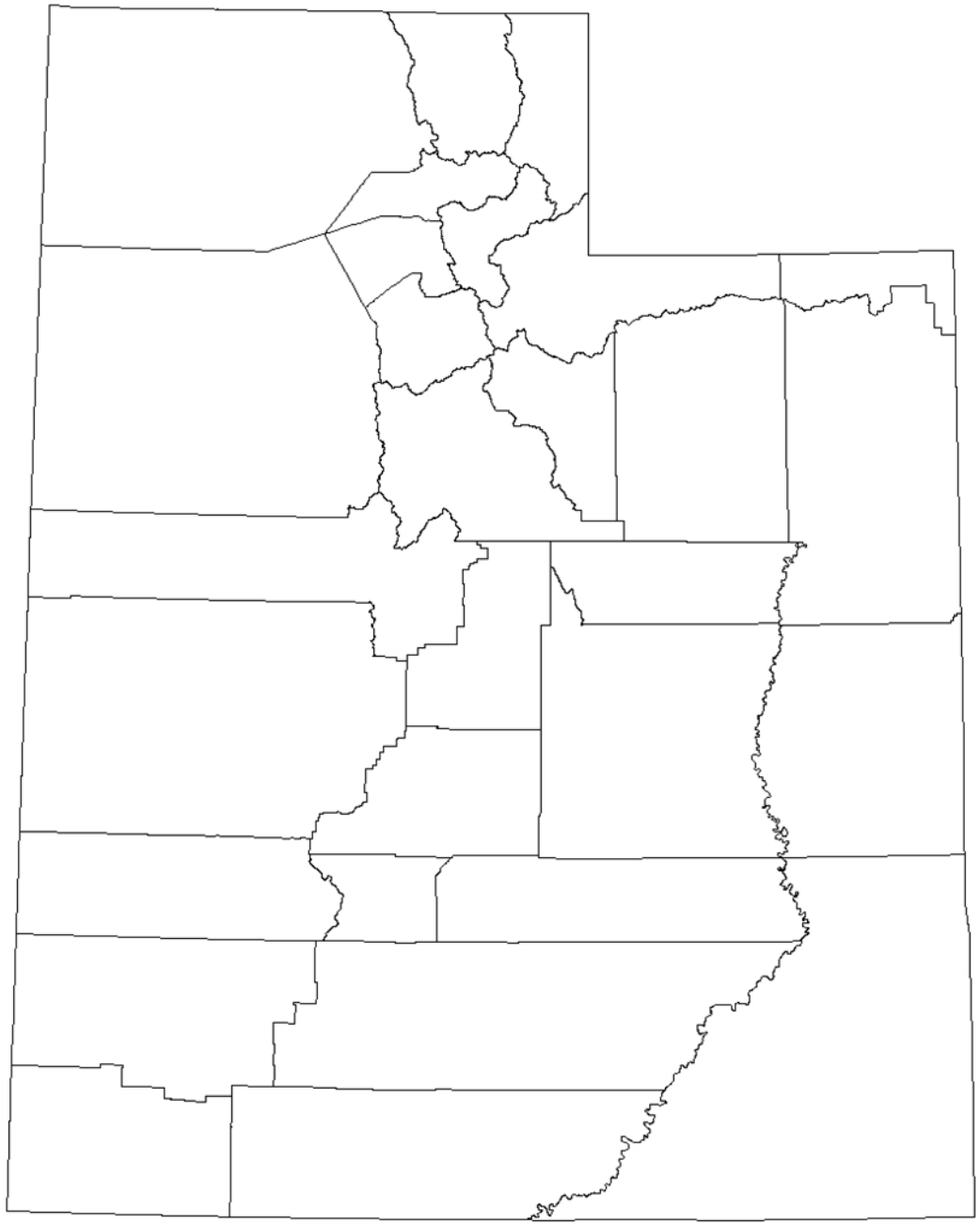
DB Fields

- Critical fields
  - LAT
  - LON
  - DESCRIPT
  - POS_DATUM
  - ACCURACY
  - SUP_DATA
  - DATA_SRCE

Supplemental Data Storage Convention



Order Control
Points Added



Inspection Process

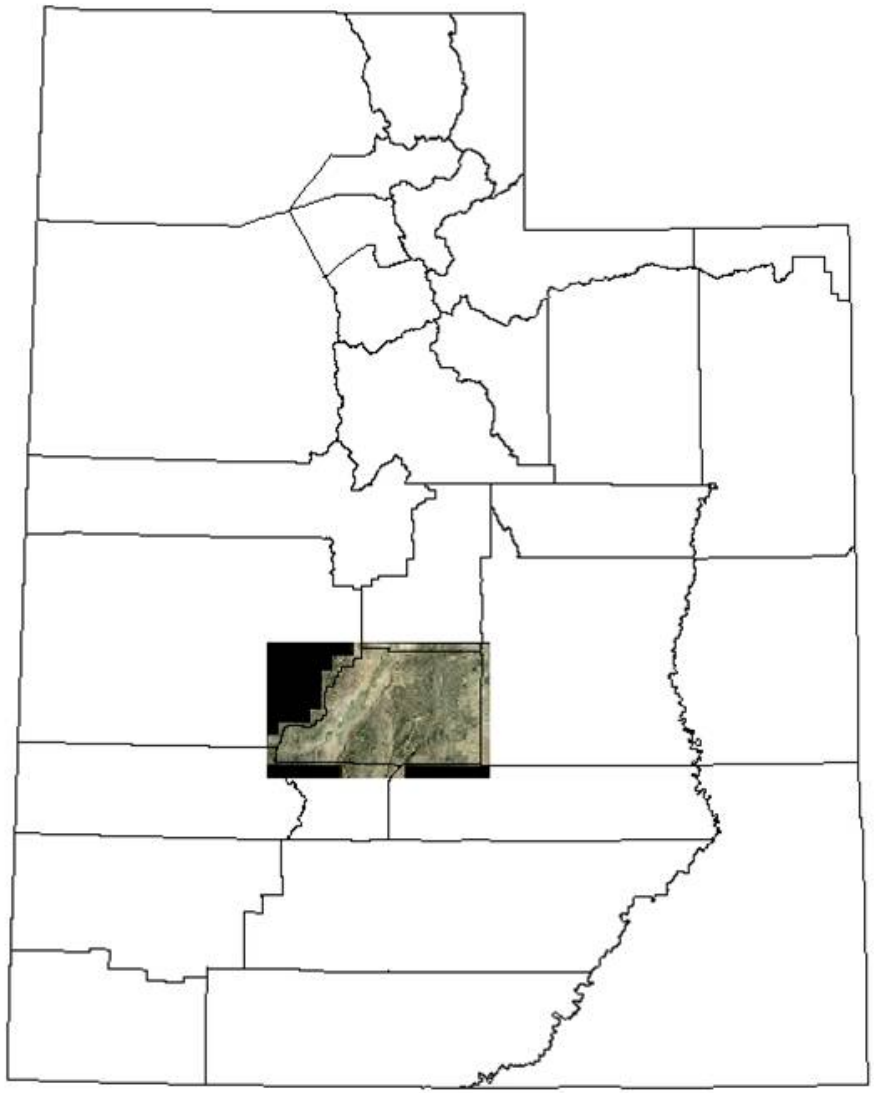
- Parameters
  - Inspect for horizontal accuracy only
  - Off-line process (local computer)
    - first year
  - 3 independent inspectors
  - Inspect State as a whole
    - Inspect all points (410)
    - Subset results later

Inspection Process

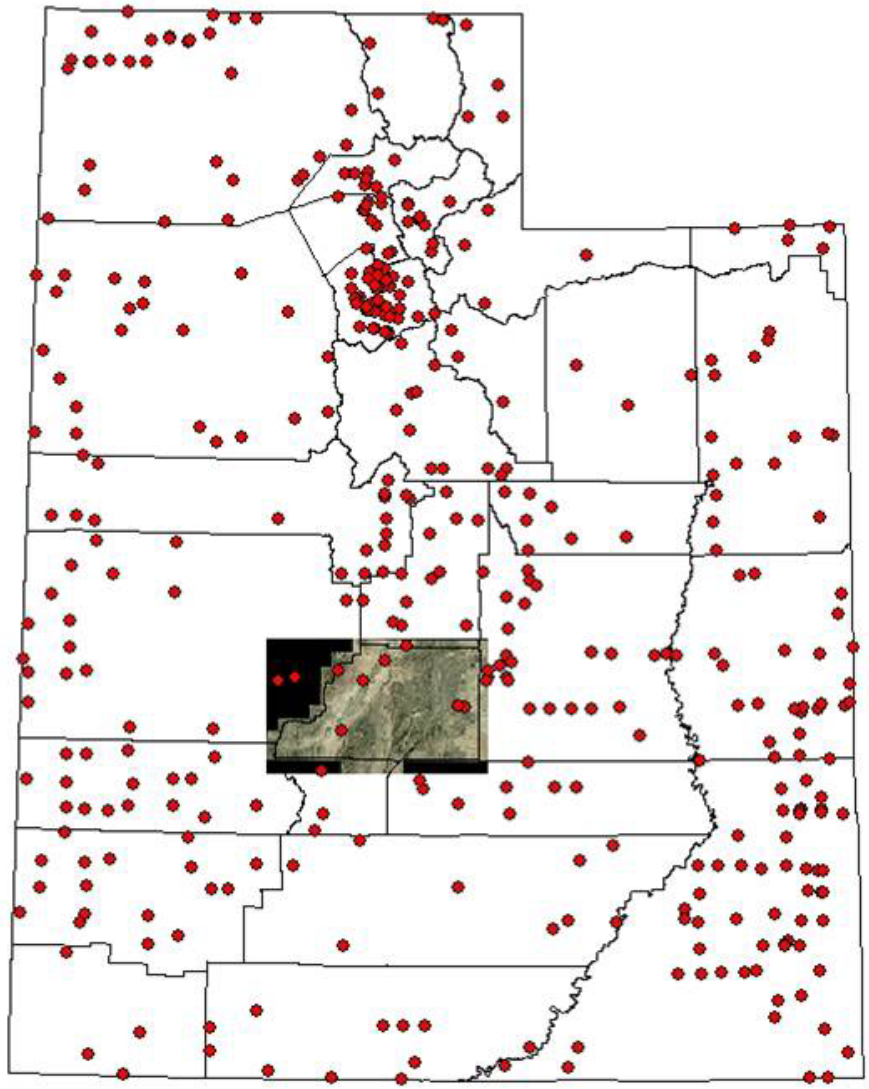
- Methodology
  - Inspection performed using ArcGIS 9.1
  - Add imagery (Compressed County Mosaic) & overlay control points
  - Overlay inspection shapefile and create points
    - Two fields to populate
      - POINT_ID1 (attribute transfer tool to populate)
      - QUALITY (evaluate quality of each point for inspection)
  - Use “Point Distance” tool
    - Creates distances table for distance from control point to its associated inspection point
  - Determine whether imagery meets specifications…

Inspection Process (Example)

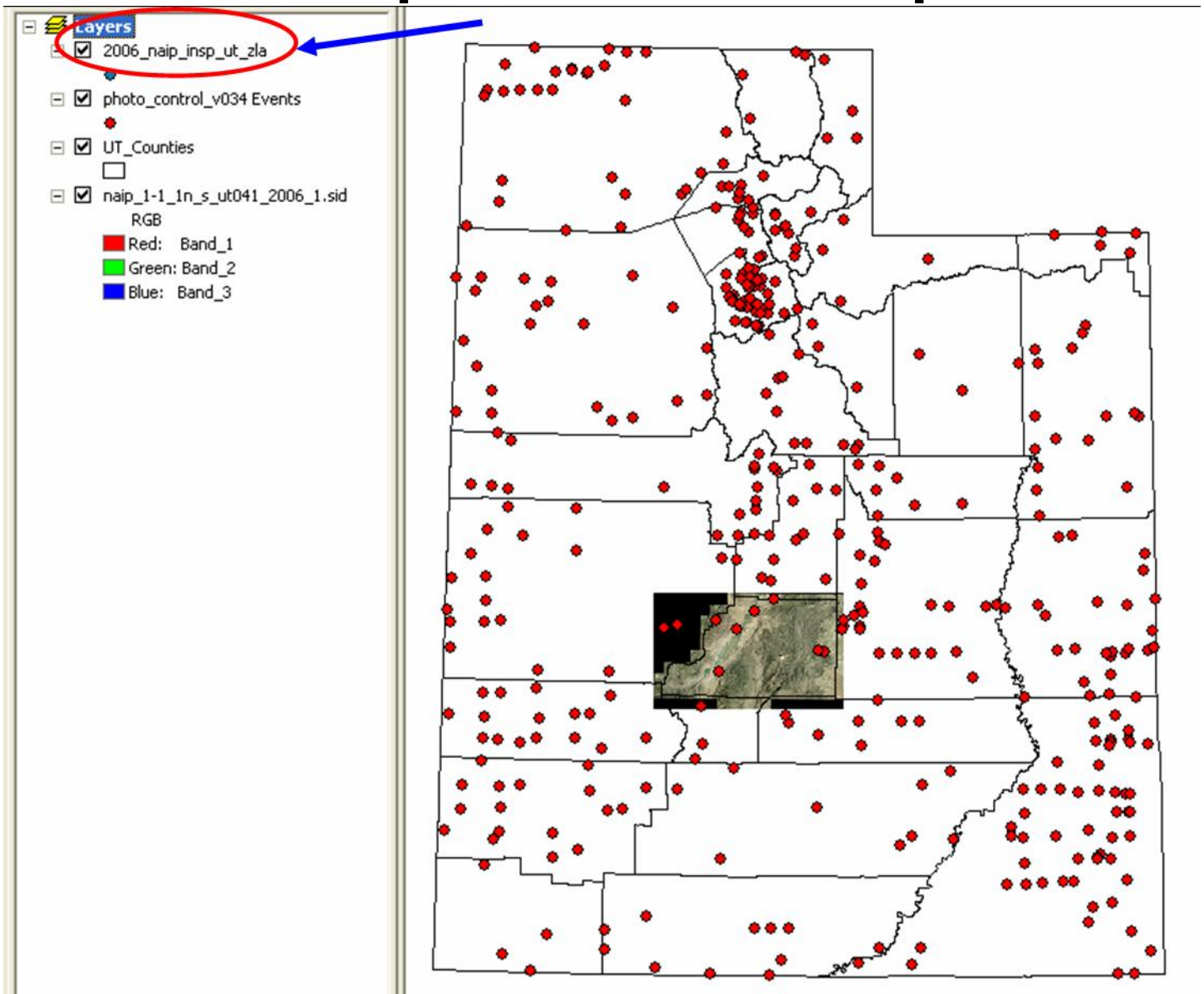
Add Imagery



Add Control Data and Display X,Y

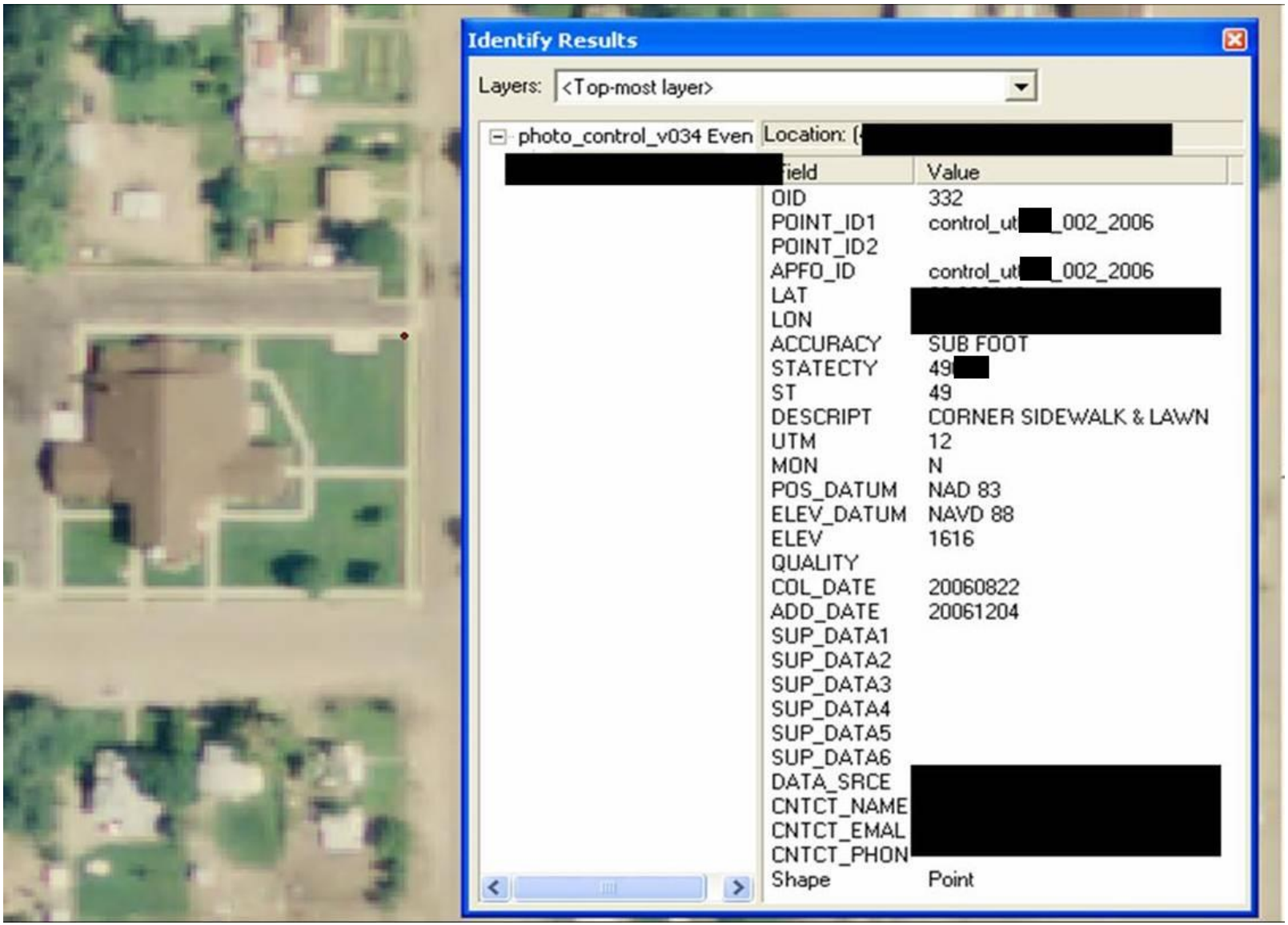


Add Inspection Shapefile



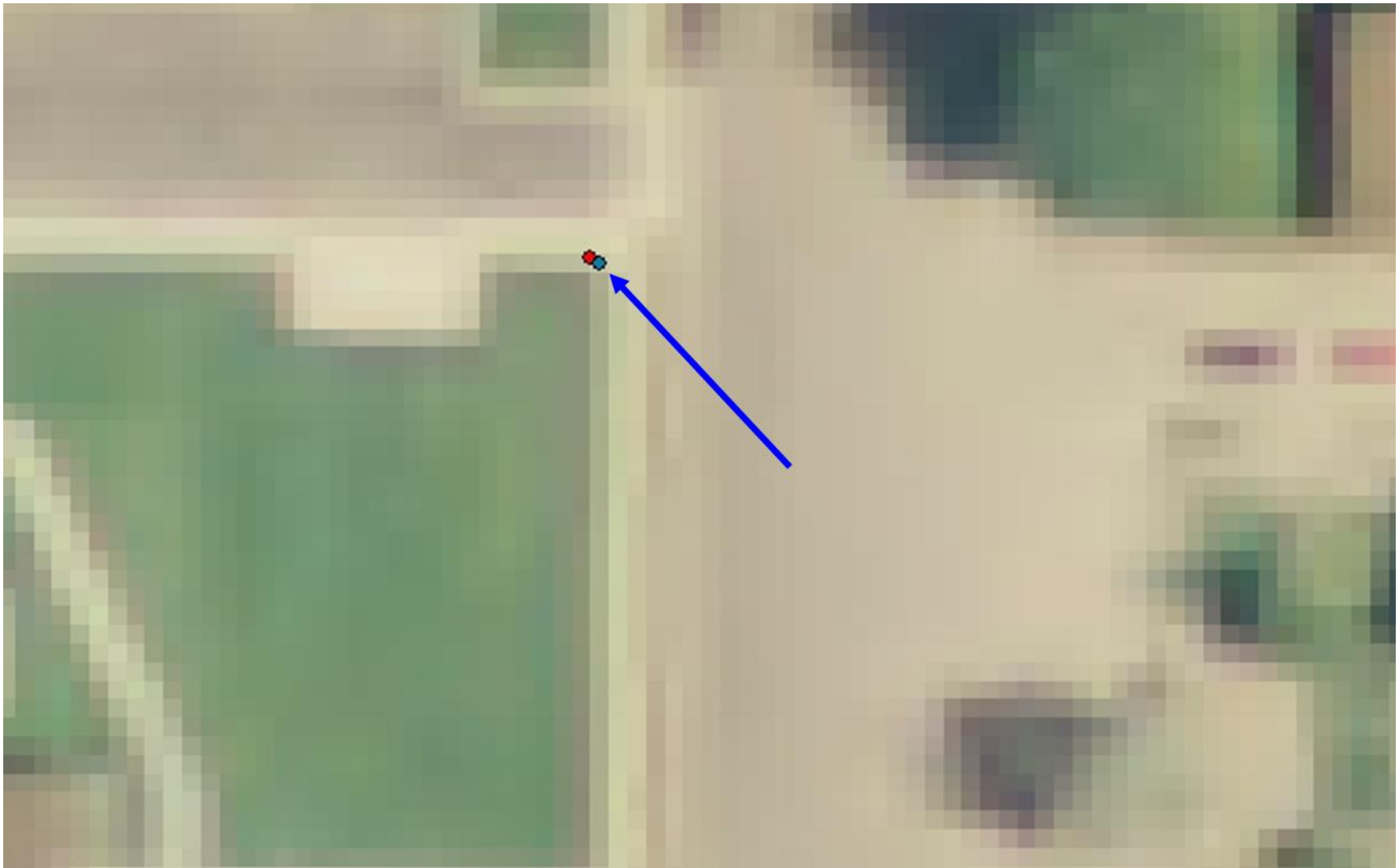
Zoom to a Control Point

ID the Photo Control Point



Check SUP_DATA

Create Inspection Point



Move on to Next Point

Run Point Distance Tool

ArcGIS

- Append
- Buffer
- Clip
- Dissolve (Aggregation)
- Erase
- Identity
- Intersect
- Merge
- Multipart to Singlepart
- Near
- Point Distance
- Union

What is geoprocessing?

Overview

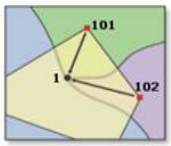
Point Distance *(ArcInfo only)*

Open Tool

NOTE: This tool only works with an ArcInfo license.

Point Distance computes the point-to-point distance between each point in a feature class or layer to all points in the same or different feature class or layer, within a specified search radius. This tool is another Analysis tool used in calculating proximity.

Learn more about the Point Distance tool

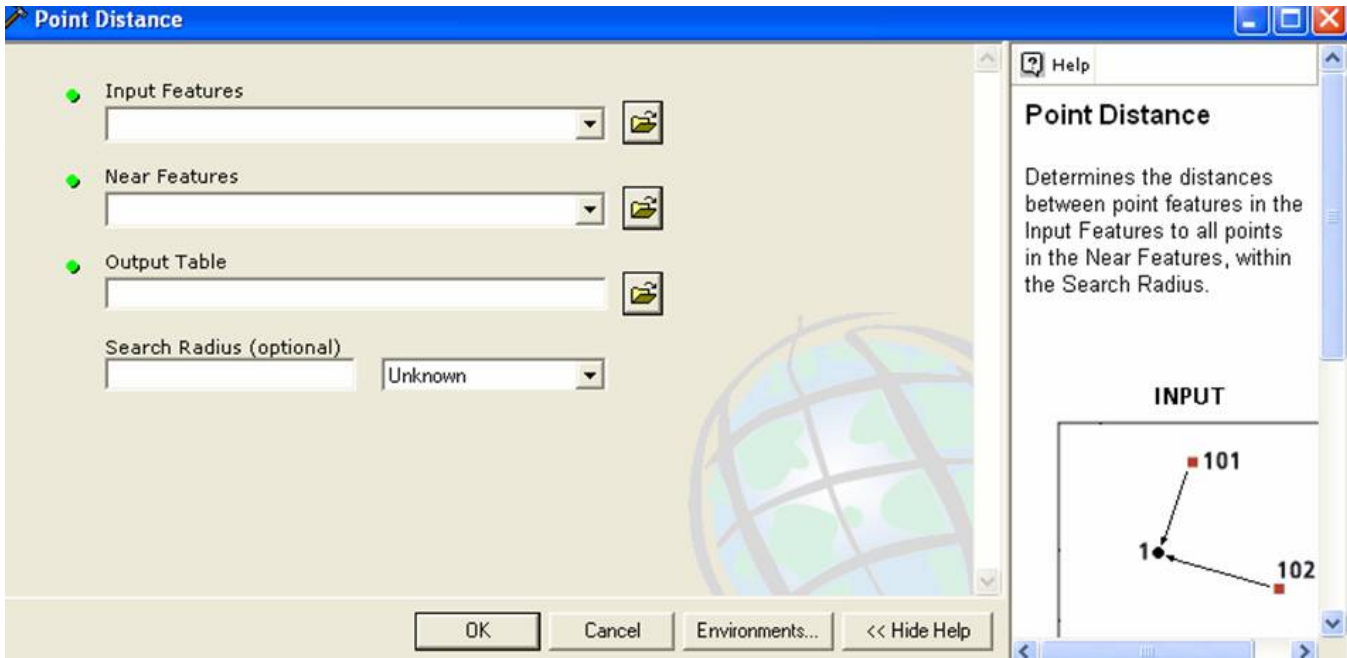


INPUT

input_FID	output_FID	Distance
101	1	65
102	1	83

OUTPUT TABLE

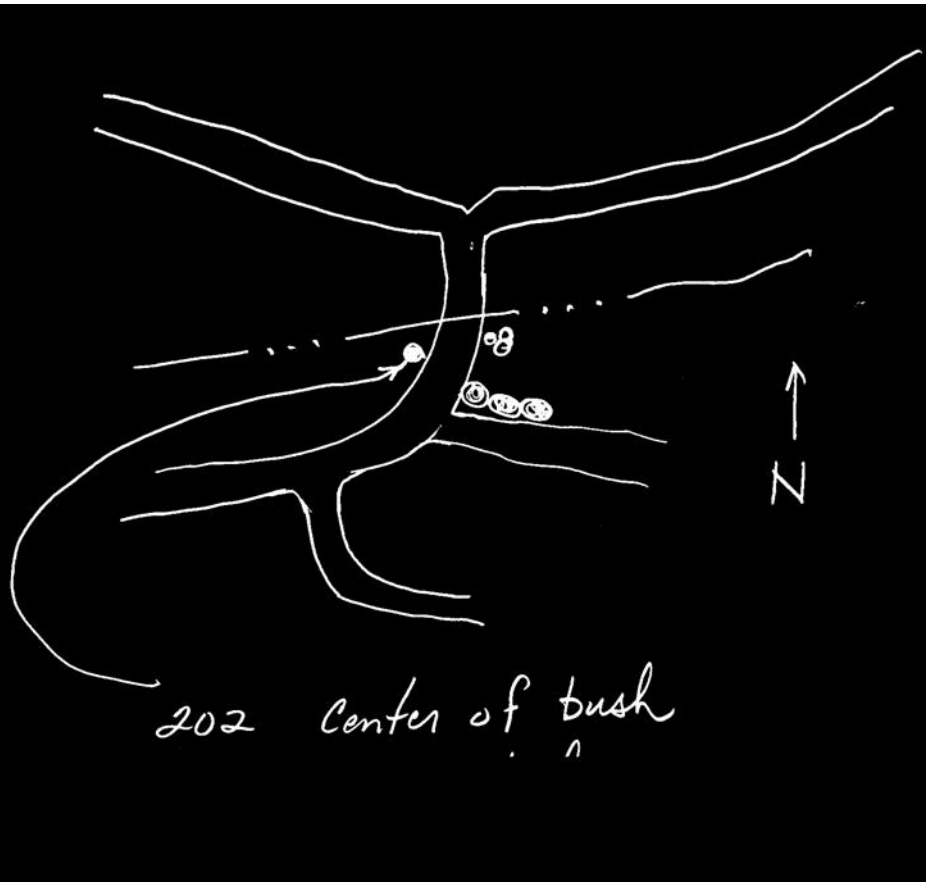
- POINTS IN FEATURE CLASS A
- POINTS IN FEATURE CLASS B

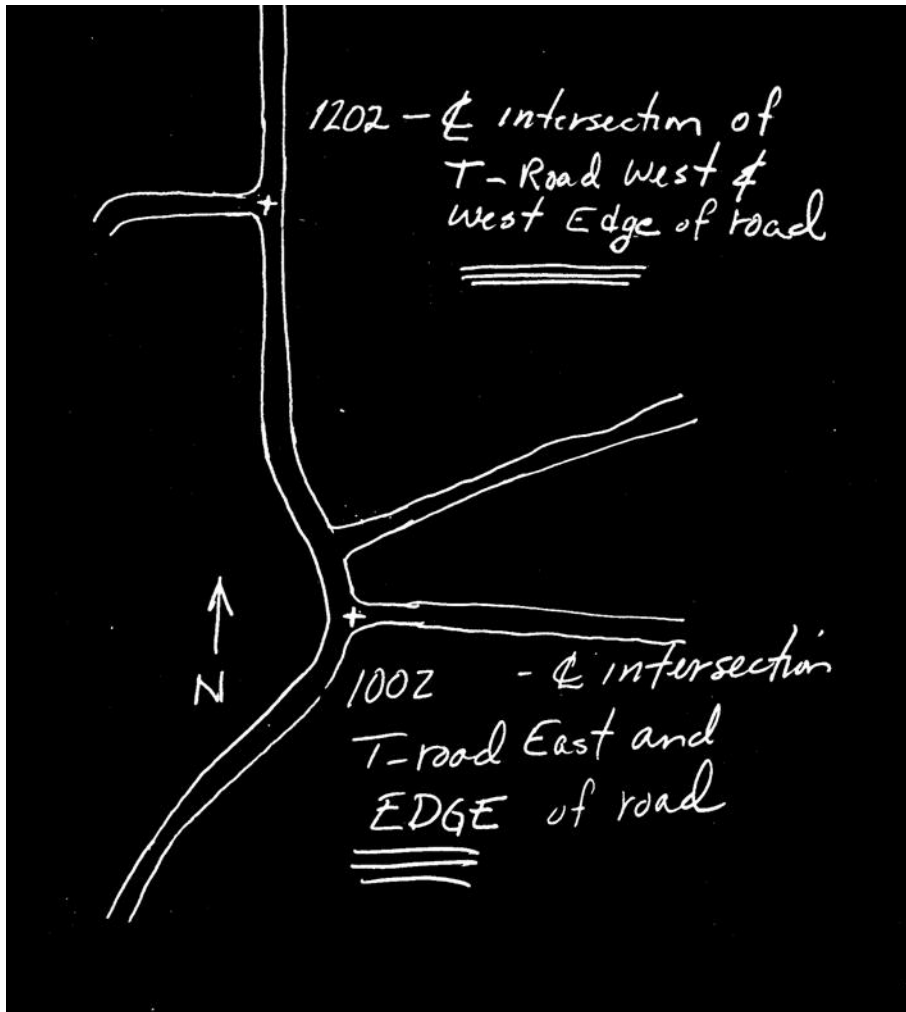


SUP_DATA SAMPLES

- Without supplemental data for the control points, one is left only with a short description…usually not sufficient

SUP_DATA SAMPLES





SUP_DATA SAMPLES

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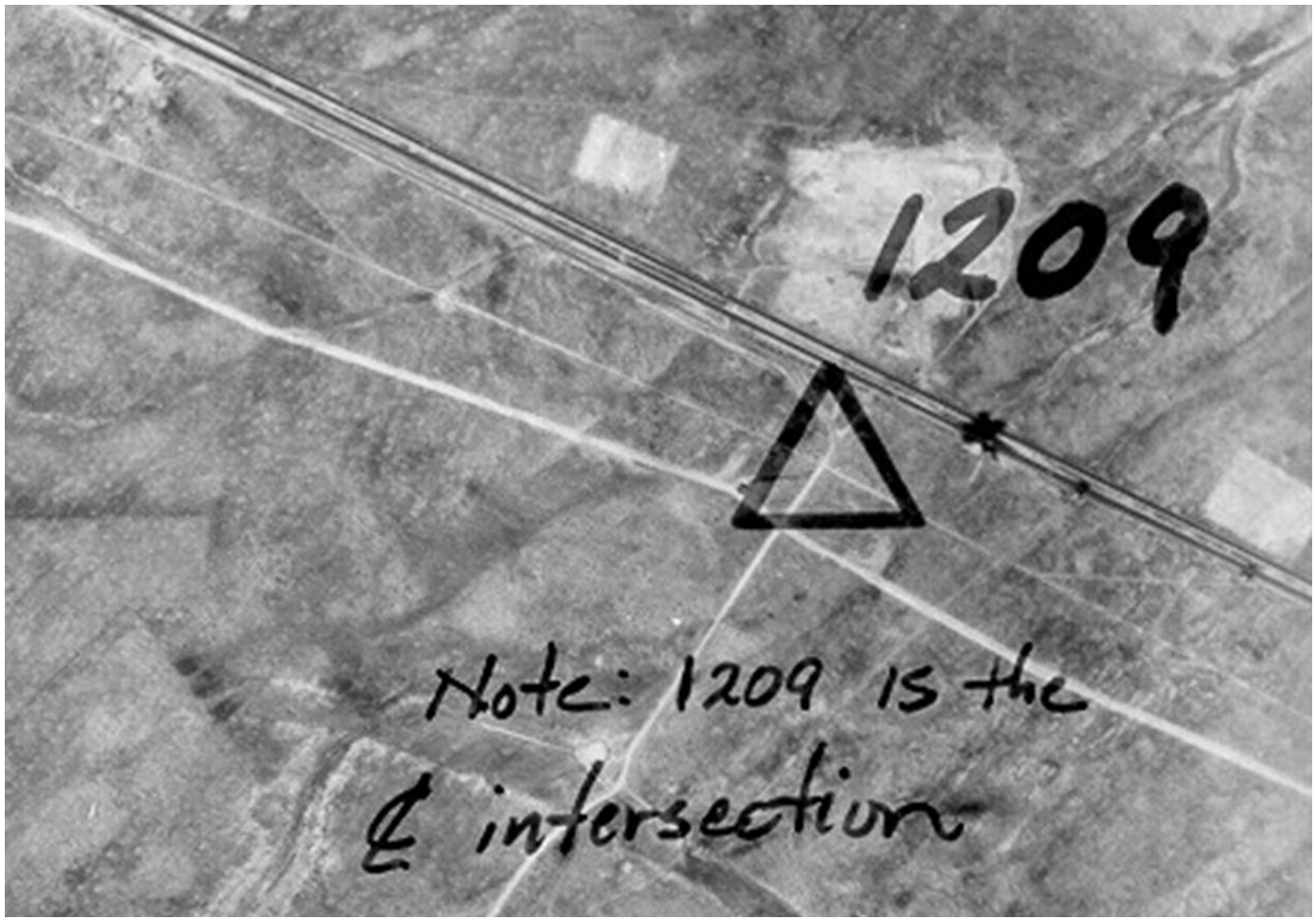


SUP_DATA SAMPLES

The NGS Data Sheet

See file dsdata.txt for more information about the datasheet.

DATABASE = Sybase ,PROGRAM = datasheet, VERSION = 7.42
1 National Geodetic Survey, Retrieval Date = NOVEMBER 20, 2006

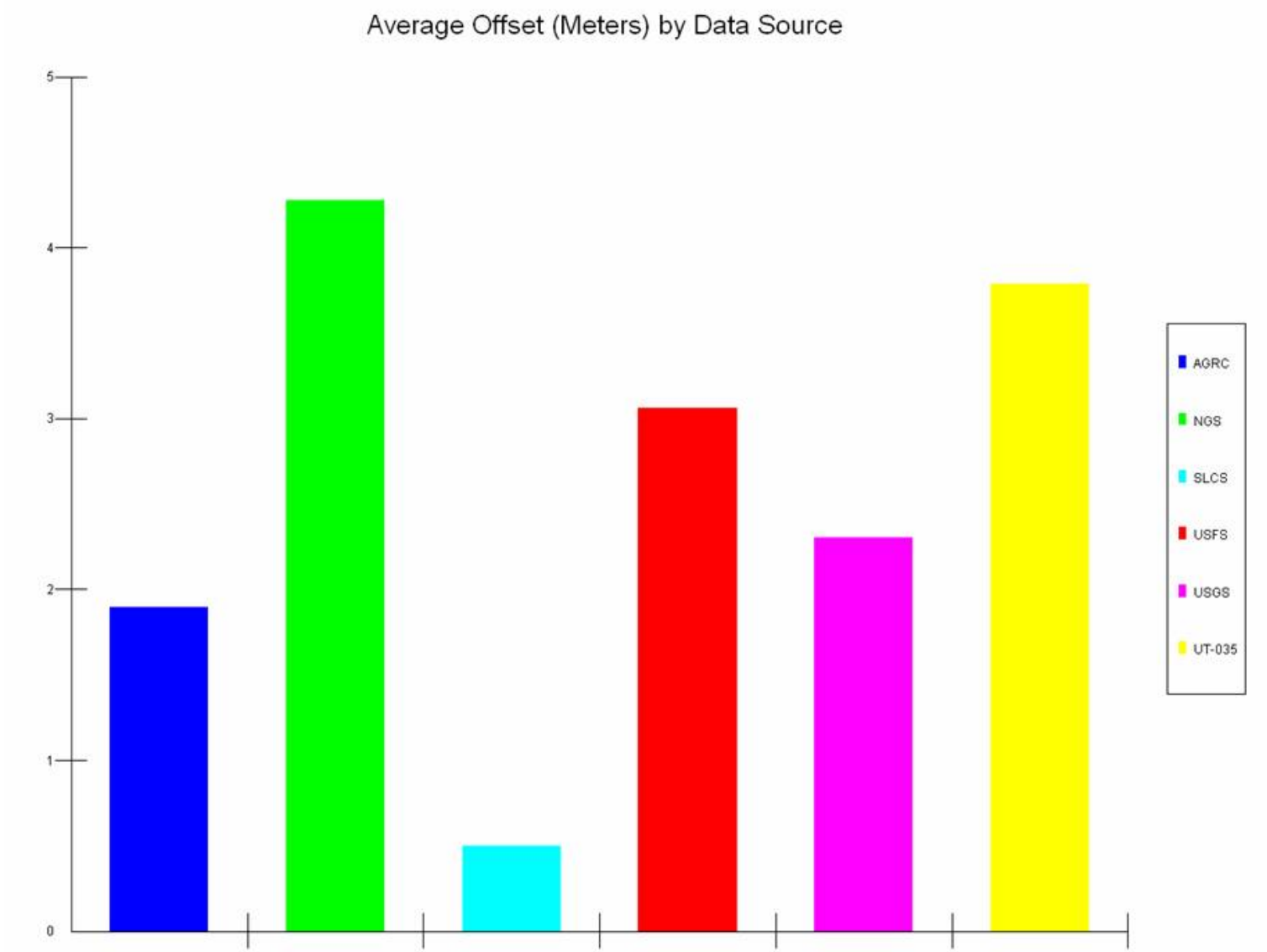
```
DESIGNATION -  OGDEN DEL MONTE FOOD PROD TANK
PID         -  [redacted]
STATE/COUNTY-
USGS QUAD   -

                    *CURRENT SURVEY CONTROL

* NAD 83(1994)-  [redacted]                    ADJUSTED
* NAVD 88     -

LAPLACE CORR-          8.66  (seconds)        DEFLEC99
GEOID HEIGHT-        -16.79  (meters)         GEOID03

HORZ ORDER  -  THIRD

.The horizontal coordinates were established by classical geodetic methods
.and adjusted by the National Geodetic Survey in November 1997..
.The Laplace correction was computed from DEFLEC99 derived deflections.

.The geoid height was determined by GEOID03.

;                        North          East      Units Scale Factor Converg.
;SPC UT N      -  [redacted]                        MT  0.99995697   -0 19 53.5
;UTM  12       -  [redacted]                        MT  0.99968695   -0 39 39.1

                    SUPERSEDED SURVEY CONTROL

 NAD 83(1994)-  [redacted]
 NAD 83(1986)-
 NAD 27      -

.Superseded values are not recommended for survey control.
.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.
.See file dsdata.txt to determine how the superseded data were derived.

_U.S. NATIONAL GRID SPATIAL ADDRESS:  [redacted]
_MARKER: 51 = TANK

 HISTORY     - Date     Condition        Report By
 HISTORY     - 1963     FIRST OBSERVED   CGS
 HISTORY     - 1965     GOOD             CGS
 HISTORY     - 1973     GOOD             NGS

                    STATION DESCRIPTION

'DESCRIBED BY COAST AND GEODETIC SURVEY 1963 (JCC)
'THE STATION IS THE CENTER OF THE TOP OF A 174 FOOT HIGH WATER
'TANK.  IT IS ABOUT 1 MILE EAST OF U.S. HIGHWAY 84 AND NEAR THE
'EAST END OF THE TOWN OF OGDEN.

                    STATION RECOVERY (1965)

'RECOVERY NOTE BY COAST AND GEODETIC SURVEY 1965 (JJC)
'THE INTERSECTION STATION WAS RECOVERED.  THE TANK IS PAINTED GREEN
'ON ITS TOP AND BOTTOM WITH THE CENTER PORTION OF THE TANK PAINTED
'BLACK.

                    STATION RECOVERY (1973)

'RECOVERY NOTE BY NATIONAL GEODETIC SURVEY 1973 (DLS)
'STATION RECOVERED AS DESCRIBED IN GOOD CONDITION.
'
'AIRLINE DISTANCE AND DIRECTION FROM NEAREST TOWN
'IN TOWN.

*** retrieval complete.
Elapsed Time = 00:00:00
```

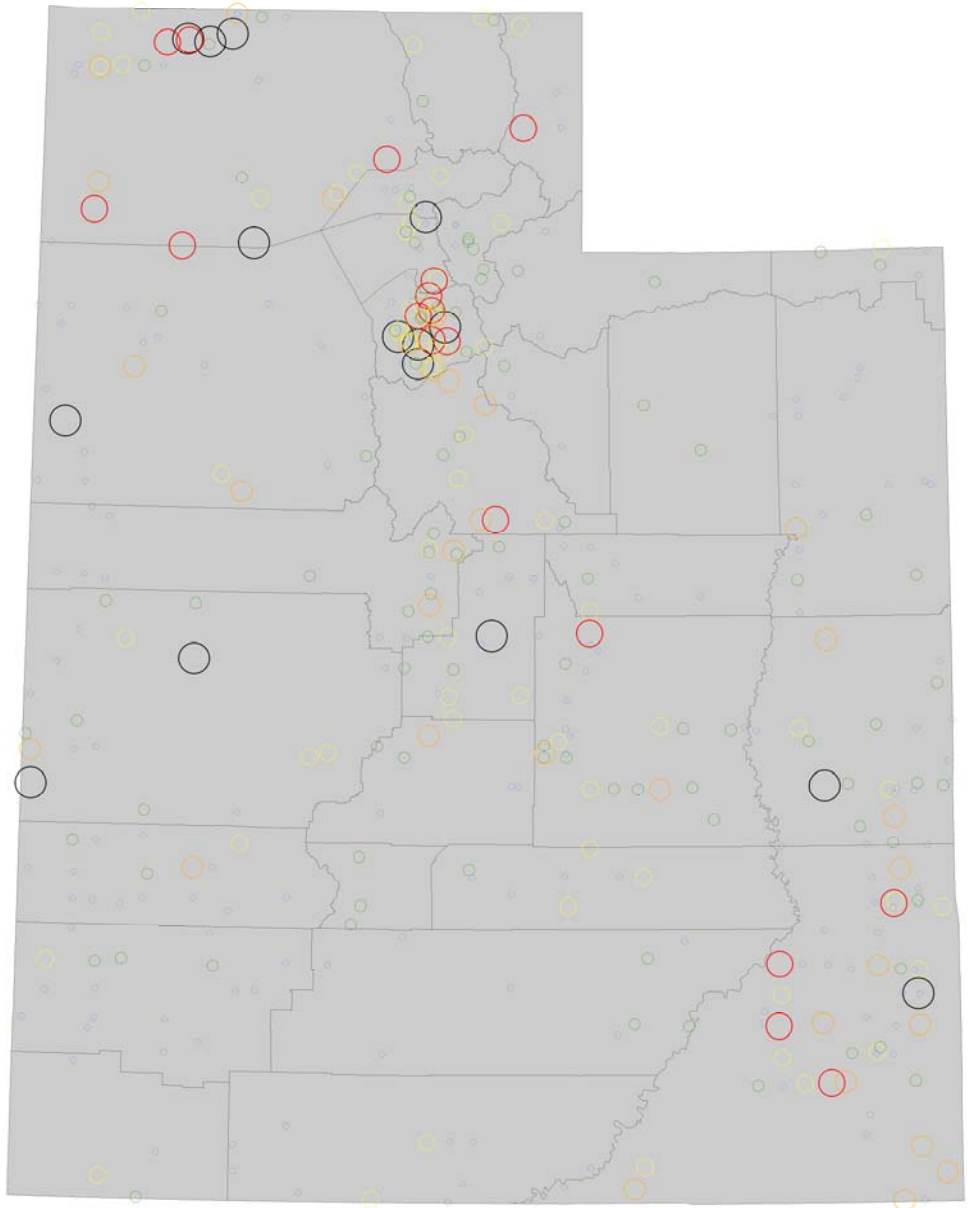
2006 NAIP UT Inspection Results

Inspector 1

- 405 of 410 points inspected
  - 5 points omitted; lack of ground feature ID
- RMSE = 3.26m
- Mean offset = 2.56m
- 96.30% of locations in tolerance (+/- 6m)
  - Dataset met requirements
- AGRC points only – 98.9% in tolerance
- Highest quality points – 99.1% in tolerance

Inspector 1


Average Offset (Meters) by Data Source
5
4
3
2
1
0
AGRC
NGS
SLCS
USFS
USGS
UT-035



2006 NAIP UT Horizontal Offsets

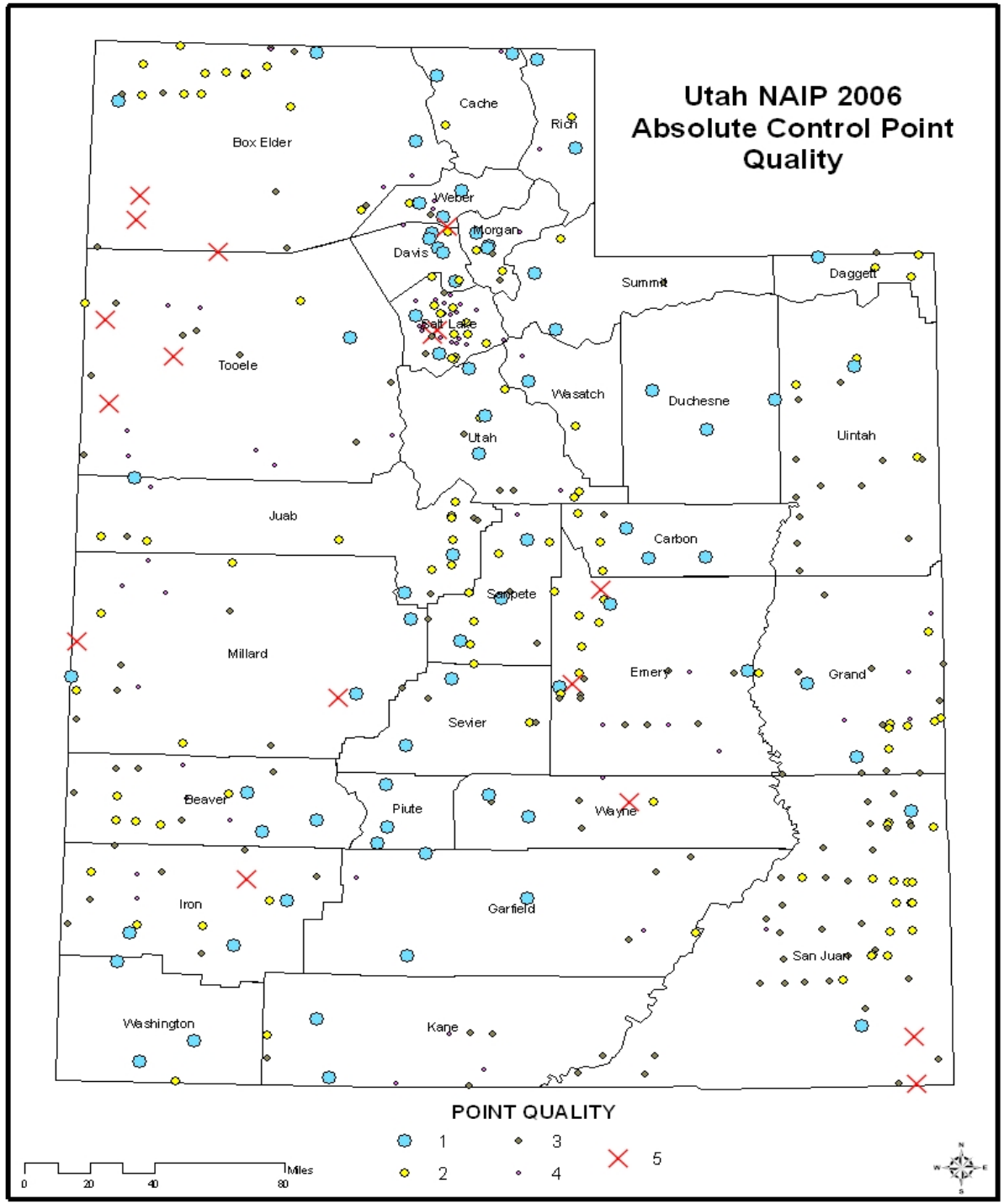
This map depicts the accuracy of the 2006 NAIP UT imagery using color and size coded sets of circles. Each circle represents a horizontal accuracy inspection location using a photo identifiable inspection control point to measure horizontal offset of the imagery. The larger the circle, the greater the offset. In other words, cirlces that are large and black do not meet the outlined horizontal accuracy specifications (+/- 6 Meters).

Legend
Distance (In Meters)

<2.0
2.0-3.0
3.0-4.0
4.0-5.0
5.0-6.0
>6.0

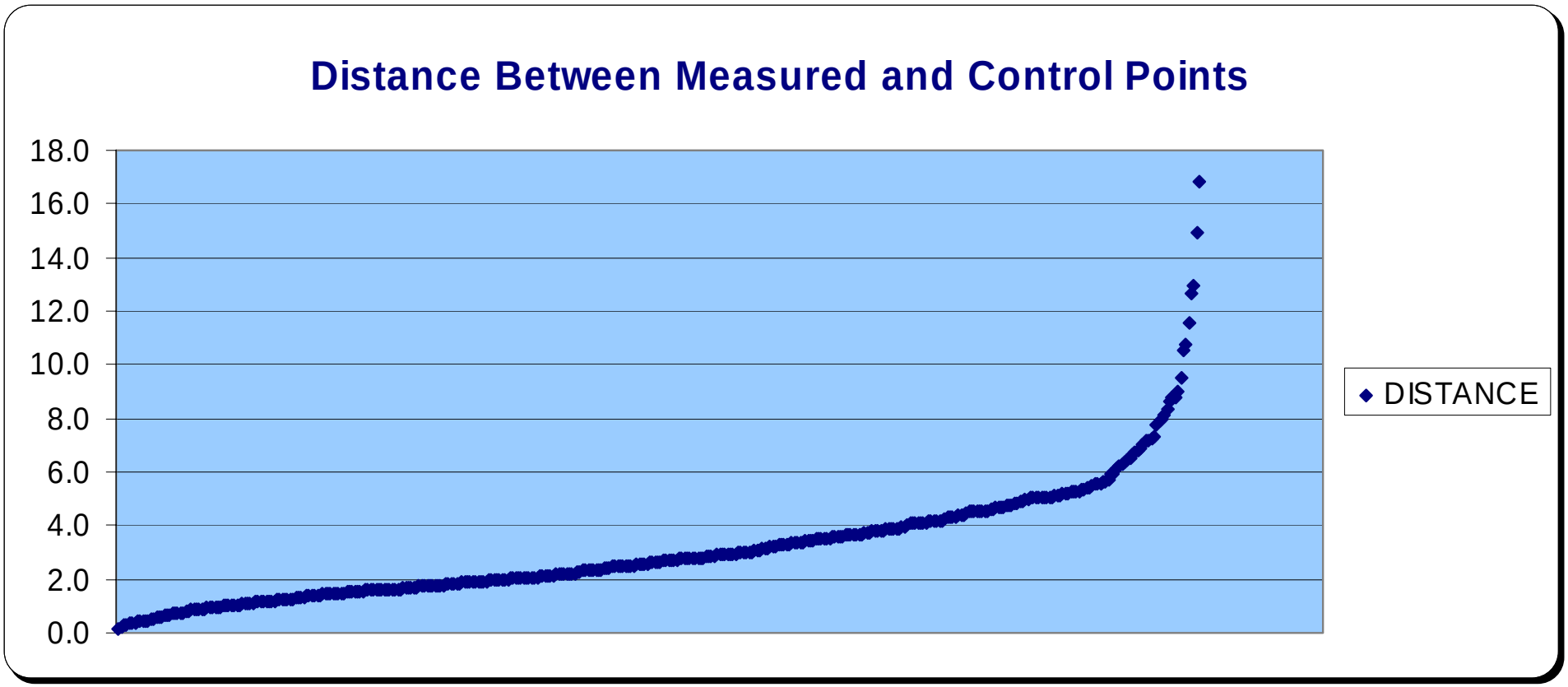
Inspector 2

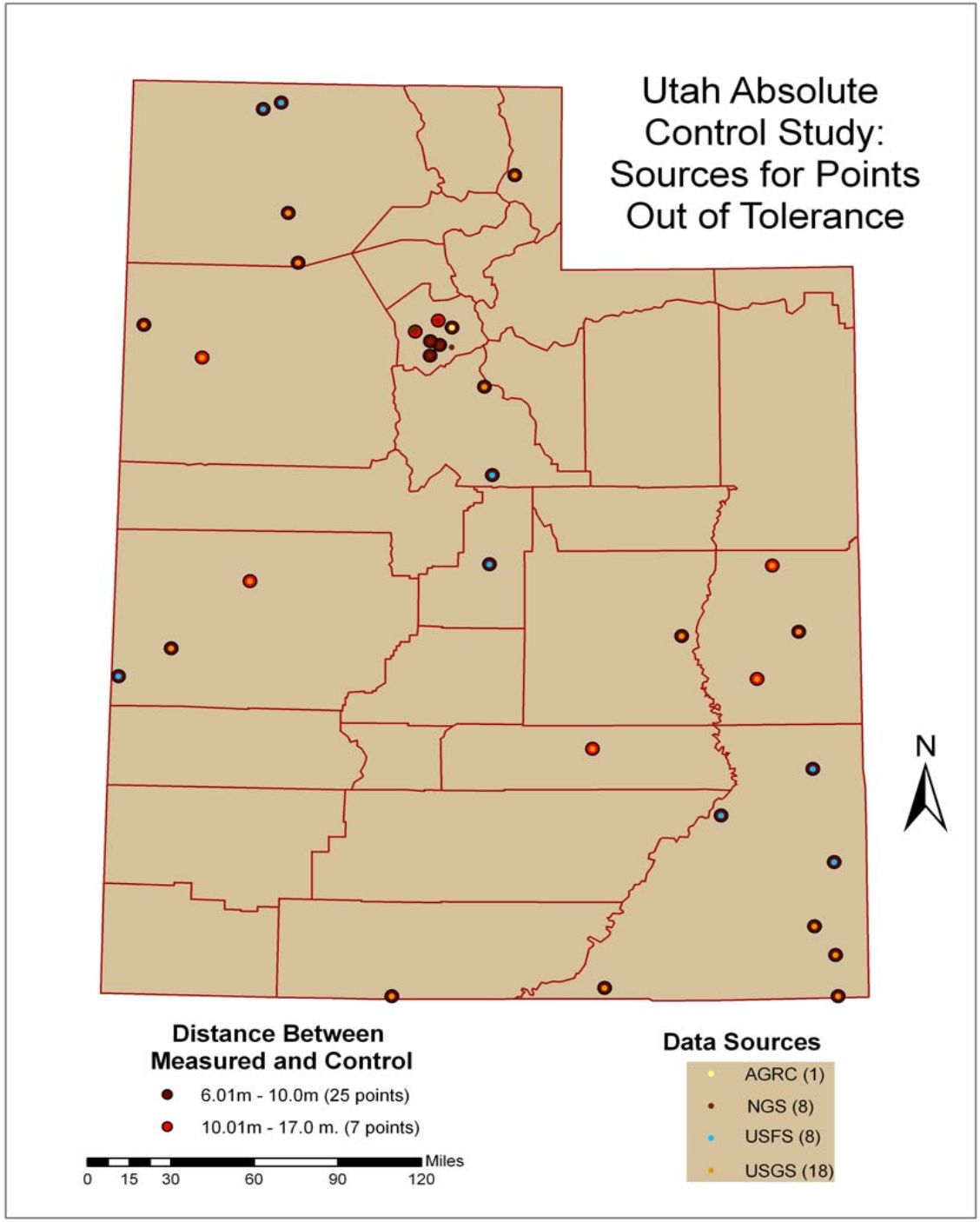
- 400 of 410 points inspected
  - 10 points omitted; lack of ground feature ID
- RMSE = 3.09m
- Mean offset = 2.35m
- Standard Deviation = 2.01m
- Median = 1.91m
- 96.25% of locations in tolerance (+/- 6m)
  - Dataset met requirements
- Points with the greatest offsets occurred in remote areas


Utah NAIP 2006
Absolute Control Point Quality
Box Elder
Cache
Rich
Weber
Morgan
Davis
Summit
Daggett
Salt Lake
Tooele
Wasatch
Duchesne
Uintah
Utah
Juab
Carbon
Sanpete
Millard
Emery
Grand
Sevier
Beaver
Piute
Wayne
Iron
Garfield
San Juan
Washington
Kane
POINT QUALITY
1
2
3
4
5
0
20
40
80
Miles

Inspector 3

- 404 of 410 points inspected
  - 6 points omitted; lack of ground feature ID
- RMSE = 3.85m
- Mean offset = 3.14m
- Standard Deviation = 2.30m
- Median = 2.65m
- 91.34% of locations in tolerance (+/- 6m)
  - Dataset did not met requirements


Distance Between Measured and Control Points
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
DISTANCE


Utah Absolute Control Study: Sources for Points Out of Tolerance
N
Distance Between Measured and Control
6.01m - 10.0m (25 points)
10.01m - 17.0 m. (7 points)
0 15 30 60 90 120 Miles
Data Sources
AGRC (1)
NGS (8)
USFS (8)
USGS (18)

Comparison of Inspectors' Results

- Inspector 1 Versus Inspector 2 Selected Points
  - 258 points selected by the inspectors were within one meter of each other
  - The average distance between Inspector 1 and Inspector 2 selected points was 1.12 meters, which is only slightly larger than the size of one pixel
  - Indicates that Inspector 1 and Inspector 2 *independently* chose spatially similar points throughout the inspection process
- Inspector 2 Versus Inspector 3 Selected Points
  - 190 points selected were within one meter from each other.
  - The average offset was 1.76 meters (closer to two pixels)
- Inspector 1 Versus Inspector 3 Selected Points
  - 189 points selected were within one meter from each other.
  - The average offset was 1.75 meters (closer to two pixels)

National Implementation & Recommendations

- Oversight:
  - acquisition
  - scheduling
  - coordination
  - maintenance
  - data entry
  - inspection
  - standards
  - research

National Implementation & Recommendations

- Nail down the control point database design. Bring the present state of the database to a “final” or end state format
- Develop a procedure to standardize and test for validity new control points prior to being entered into the database
- Develop a schedule and procedure to test and validate current points to ensure continued viability for use as control
- Develop active plan and procedure to acquire through partnerships, existing datasets, or procurement, new control points to ensure continued population of valid control
- Further develop and standardize/automate the absolute horizontal accuracy inspection process within the inspection architecture

NAIP and APFO Links

USDA - Farm Service Agency - Aerial Photography Field Office
www.apfo.usda.gov

UT NAIP 2006 Control Point Summary Report
www.apfo.usda.gov
-Select “Support Documents”
-Select “White Papers”

Download data from the Geospatial Data Gateway
http://datagateway.nrcs.usda.gov/

Purchase data from the USDA Aerial Photography Field Office
Email: apfo.sales@slc.usda.gov or Telephone: 801-975-3503

Viewing data online:
Web browser - http://gdw.apfo.usda.gov/naip/viewer