A methodology for determining the precision of well location datasets

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Introduction

- The advent of global positioning satellites and geographical information systems has increased the accuracy of spatial measurements by orders of magnitude.
- The luxury of these accurate measurements may induce us to forget some basic cartographic principles of data precision which govern older spatial datasets.
- A study of 700+ well locations from Iraq show that *data rounding and truncation*, not cartographic datum shifts are the most likely source of well location errors.

Value of Determining Precision

Select “best” well location from several well location datasets

Eliminate duplicate well locations and resulting overposting of well picks

Quantify area of uncertainty around well location for well correlation ties

Process to quantify well location precision

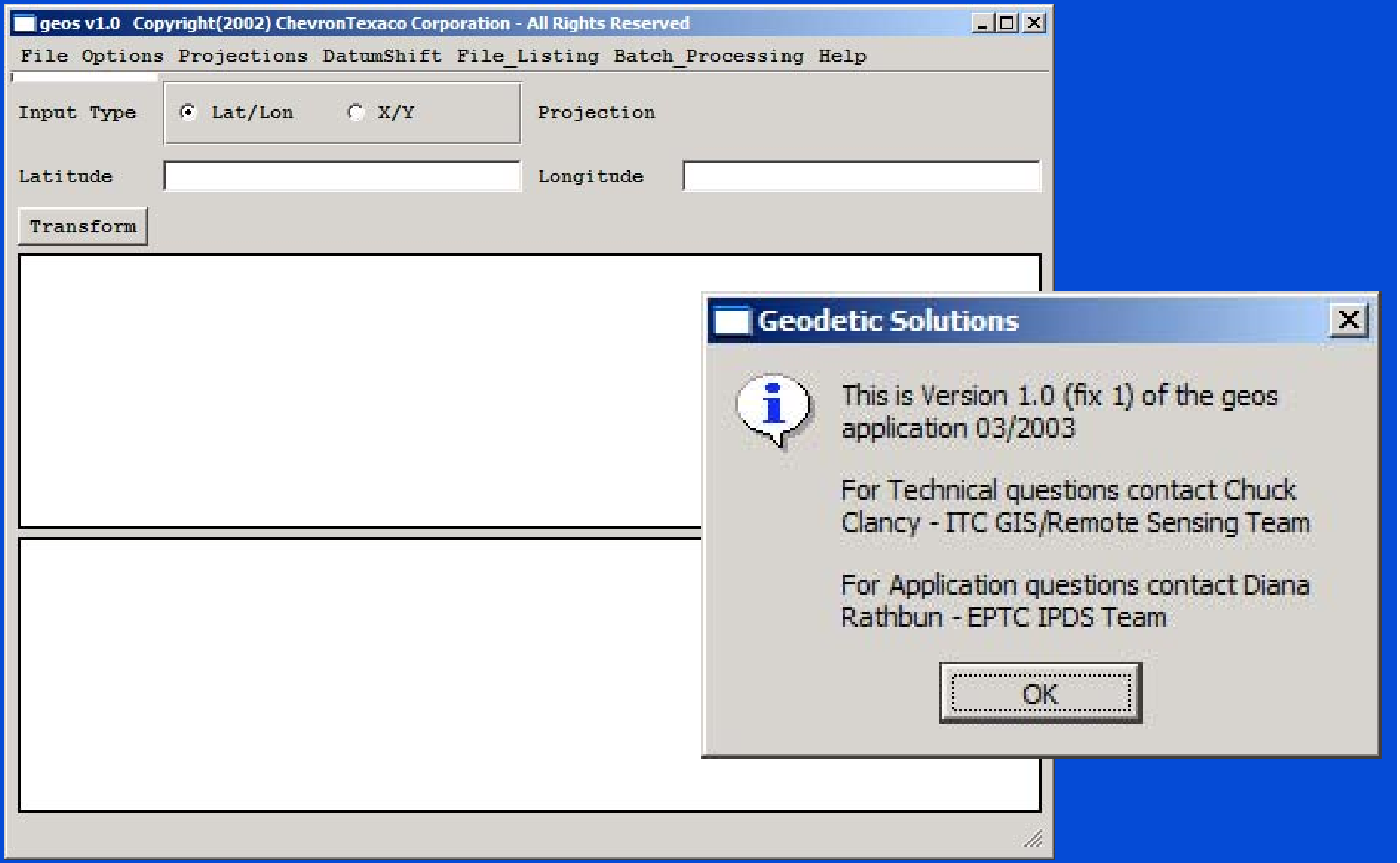
1. Data-entry, reformatting and data storage conversion into a standard dataset

We need to create a standardized spreadsheet so we can line up the fields and compare data!

Standardized Spreadsheet

Refno	OW_well	OW_lat	OW_lon	CRS	X	Y
VB6242	Wellname-1A	36.6111111	41.8861111	IRAQ NAHRWAN (QGPC 1992) UTM38N CM 45E	221483.58	4055958.72
VB5956	Wellname-1	32.3833830	47.3909080	IRAQ NAHRWAN (QGPC 1992) UTM38N CM 45E	724924.81	3585174.50
VB6113	Wellname-10	32.3326128	47.4420454	IRAQ NAHRWAN (QGPC 1992) UTM38N CM 45E	729865.31	3579653.50
VB6114	Wellname-11	32.3617853	47.4222574	IRAQ NAHRWAN (QGPC 1992) UTM38N CM 45E	727929.00	3582846.00
VB6115	Wellname-12	32.3934474	47.3844900	IRAQ NAHRWAN (QGPC 1992) UTM38N CM 45E	724296.00	3586277.00
VB6116	Wellname-13	32.3816007	47.4023507	IRAQ NAHRWAN (QGPC 1992) UTM38N CM 45E	726006.00	3585001.00
VB5957	Wellname-2	32.4424543	47.3282829	IRAQ NAHRWAN (QGPC 1992) UTM38N CM 45E	718889.19	3591594.50
VB5958	Wellname-3	32.3538982	47.4107635	IRAQ NAHRWAN (QGPC 1992) UTM38N CM 45E	726866.88	3581947.00
VB5959	Wellname-4	32.4704527	47.2763682	IRAQ NAHRWAN (QGPC 1992) UTM38N CM 45E	713941.19	3594593.75

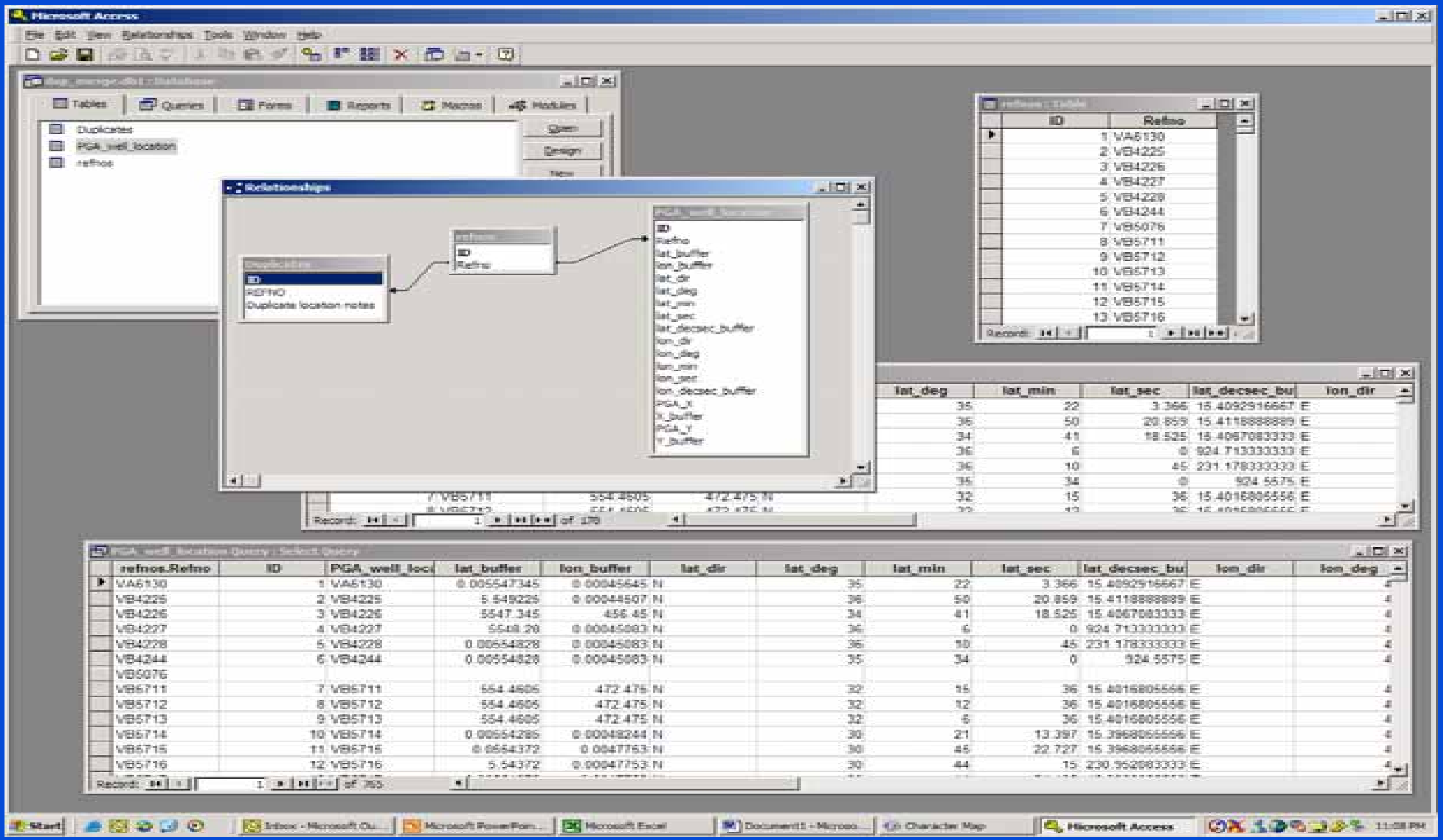
Geos


geos v1.0 Copyright(2002) ChevronTexaco Corporation - All Rights Reserved
File Options Projections DatumShift File_Listing Batch_Processing Help
Input Type
Lat/Lon
X/Y
Projection
Latitude
Longitude
Transform
Geodetic Solutions
This is Version 1.0 (fix 1) of the geos application 03/2003
For Technical questions contact Chuck Clancy - ITC GIS/Remote Sensing Team
For Application questions contact Diana Rathbun - EPTC IPDS Team
OK

Analysis of well location datasets

1. Match wellnames between datasets
2. Use SQL or Access to match wellnames between datasets
3. Create table of OpenWorks REFNOs versus wellnames for external datasets

Microsoft Access



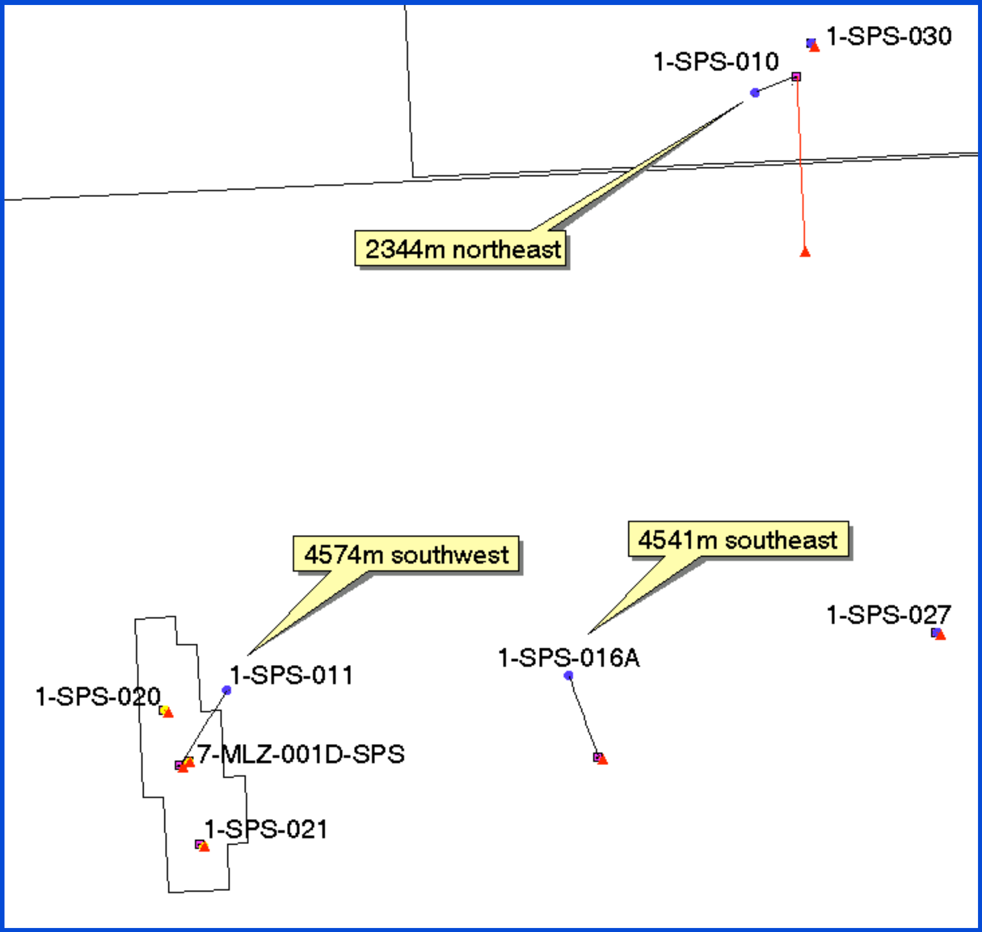
Process to quantify well location precision

2. Calculate distance and bearing between datasets

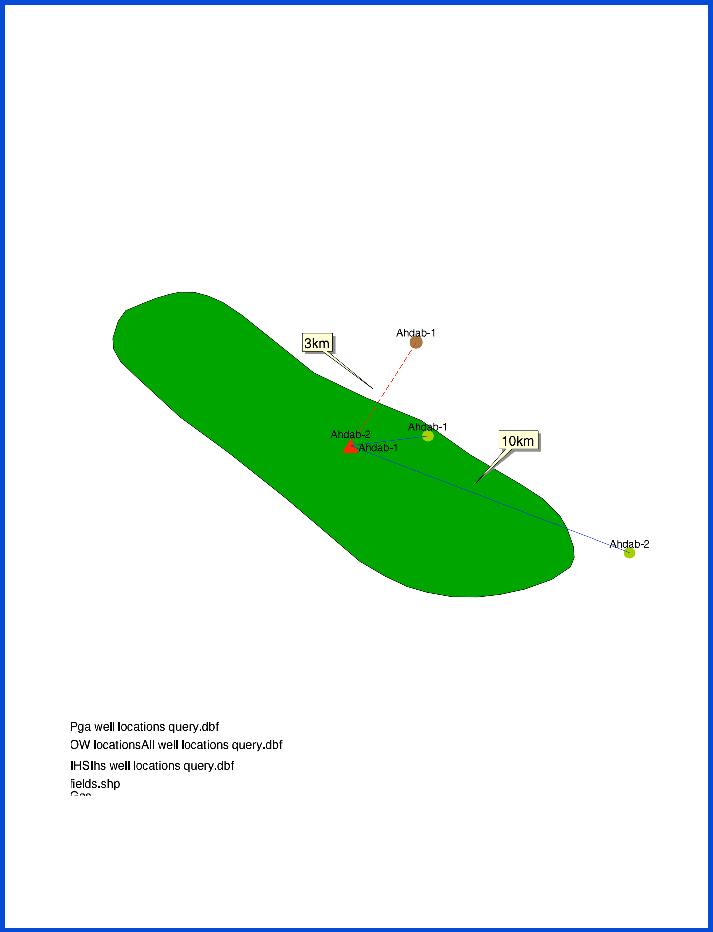
This allows us to differentiate:

1. typographical errors
2. geodetic datum shift errors
3. “close-enough” within tolerance
4. duplicates – exact matches

Distance and Bearing of well location datasets



Distance and Bearing of well location datasets



Data analysis - finding overlapping (duplicate) well locations and typographical errors

- Excel Pivot-table
- Sort dataset by latitude and longitude
- Sort by error distance in meters
- View wells with field outlines

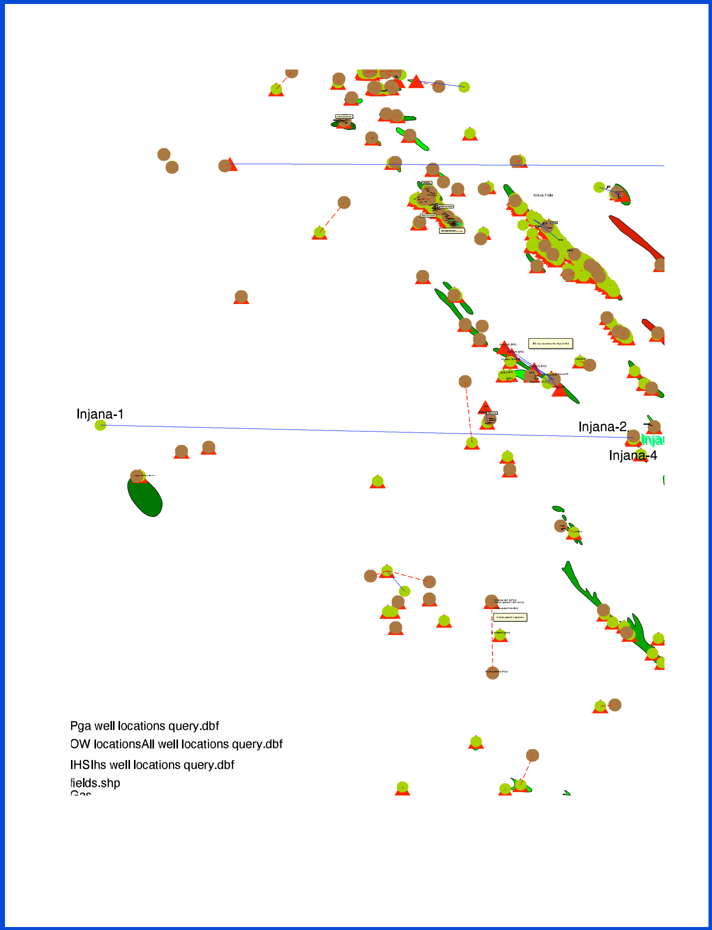
Need to correct the typos in each dataset first, then run geodetic datum and data precision analysis

Example of well location error analysis – Typographical errors

REFNO	Wellname	Latitude	Longitude	Duplicate?
VB6317	Well-1	34.48361111	40.64722222	LAT SAME
VB6318	Well-2	34.48361111	44.6425	LAT SAME

Spot the "heavy-hitters"

Well 368km off due to typo
Use IHS location



Geodesy – know the datum shifts in your area

Datum: Nahrwan 1967

Ellipsoid : Clarke 1880 RGS

Semi-major axis : 6378249.145 meters

Flattening inverse : 293.465

Datum shift parameters:

Nahrwan 1967 to WGS84 (Brown and Root for QGPC 1992)

dX = -250.20 meters

dY = -153.09 meters

dZ = +391.700 meters

(Molodensky transformation – already in ArcGIS as Nahrwan_1967_To_WGS_1984_5)

Map projection:

Universal Transverse Mercator - Zone 38 North

Longitude of Origin : 45 deg 00' E

Latitude of Origin : 0 deg

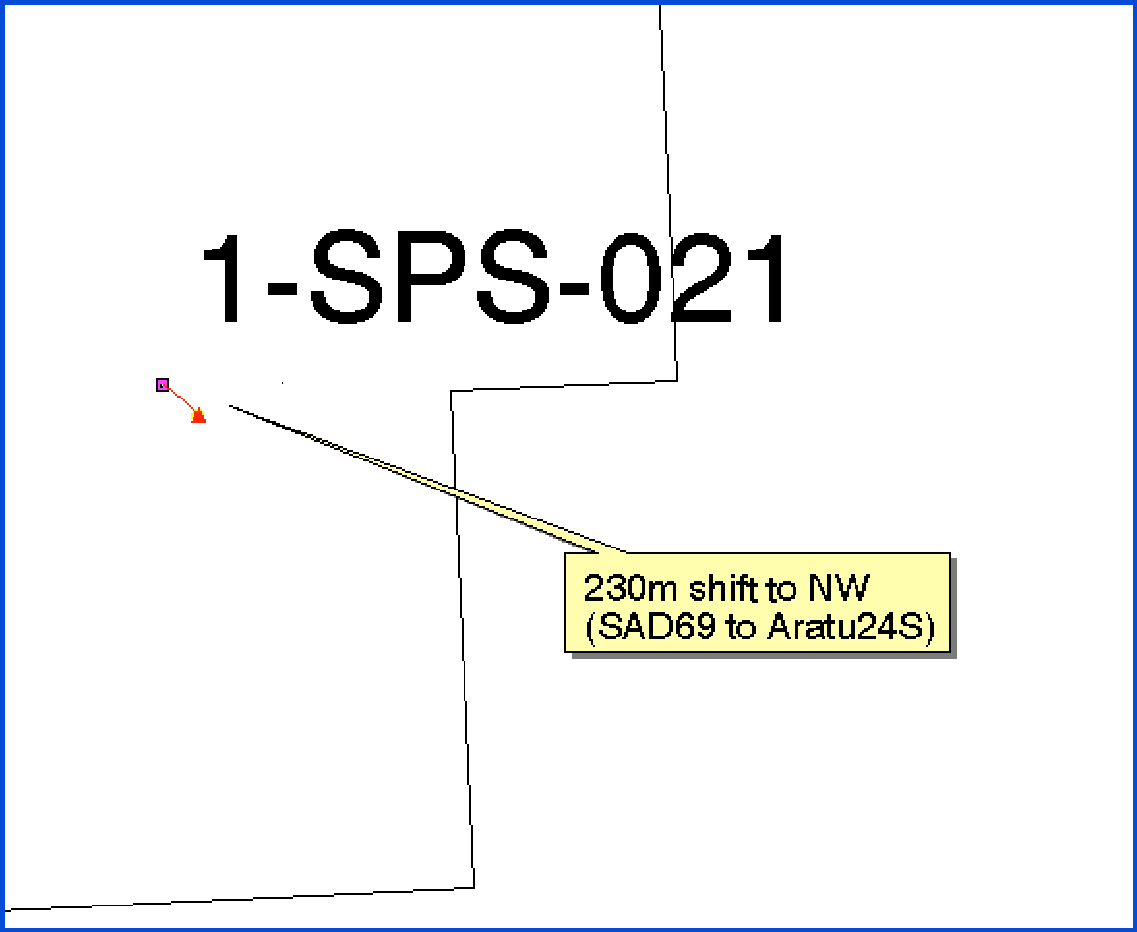
False Easting : 500,000 m

False Northing : 0 m

Scale Factor : 0.9996

Datum / Ellipsoid : Nahrwan 1967 / Clarke 1880 RGS

Datum shift example – Brazil Offshore



Geodetic Parameter Detection and Troubleshooting Using Enhanced Landsat Imagery

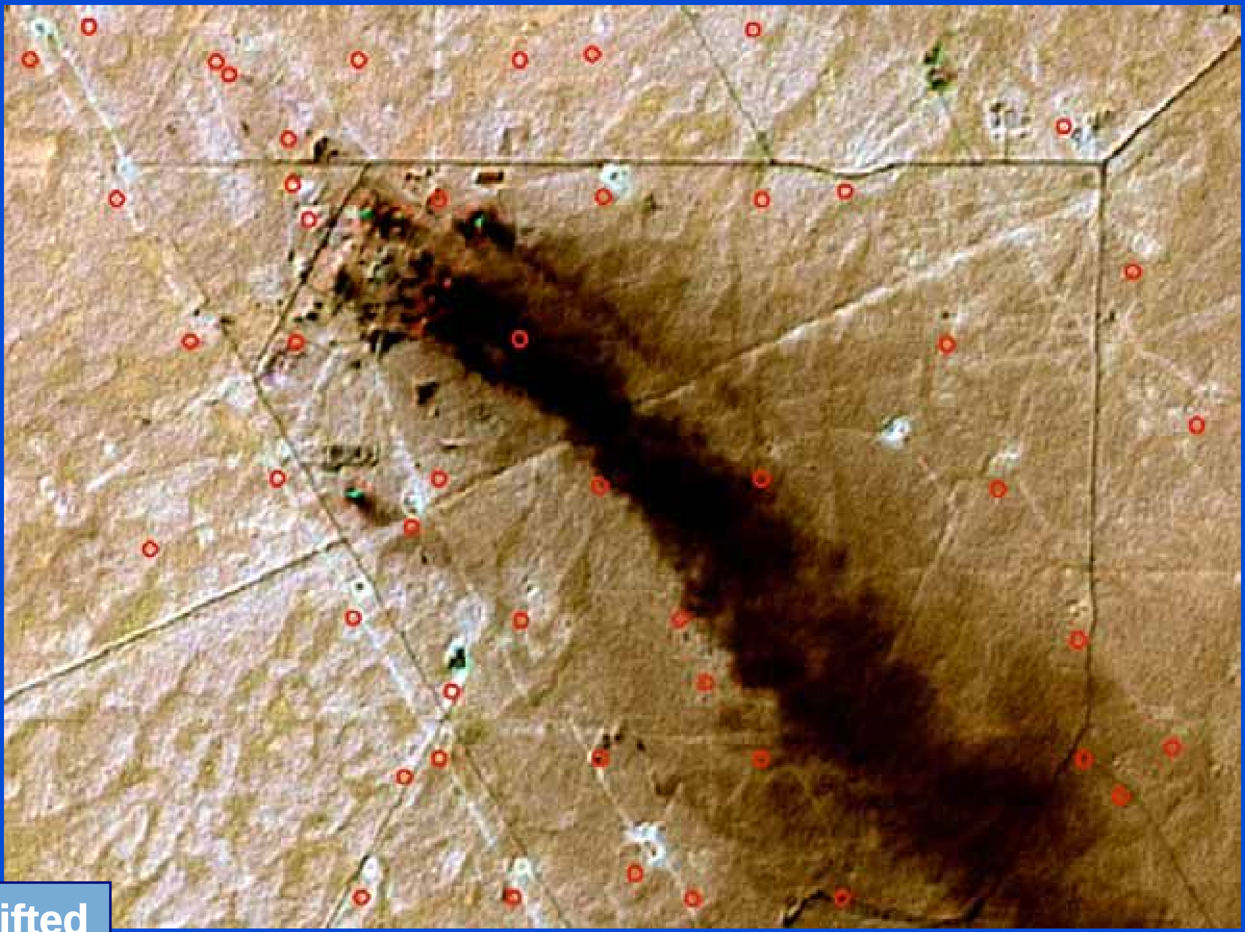


Image Un-shifted

Geodetic Parameter Detection and Troubleshooting Using Enhanced Landsat Imagery

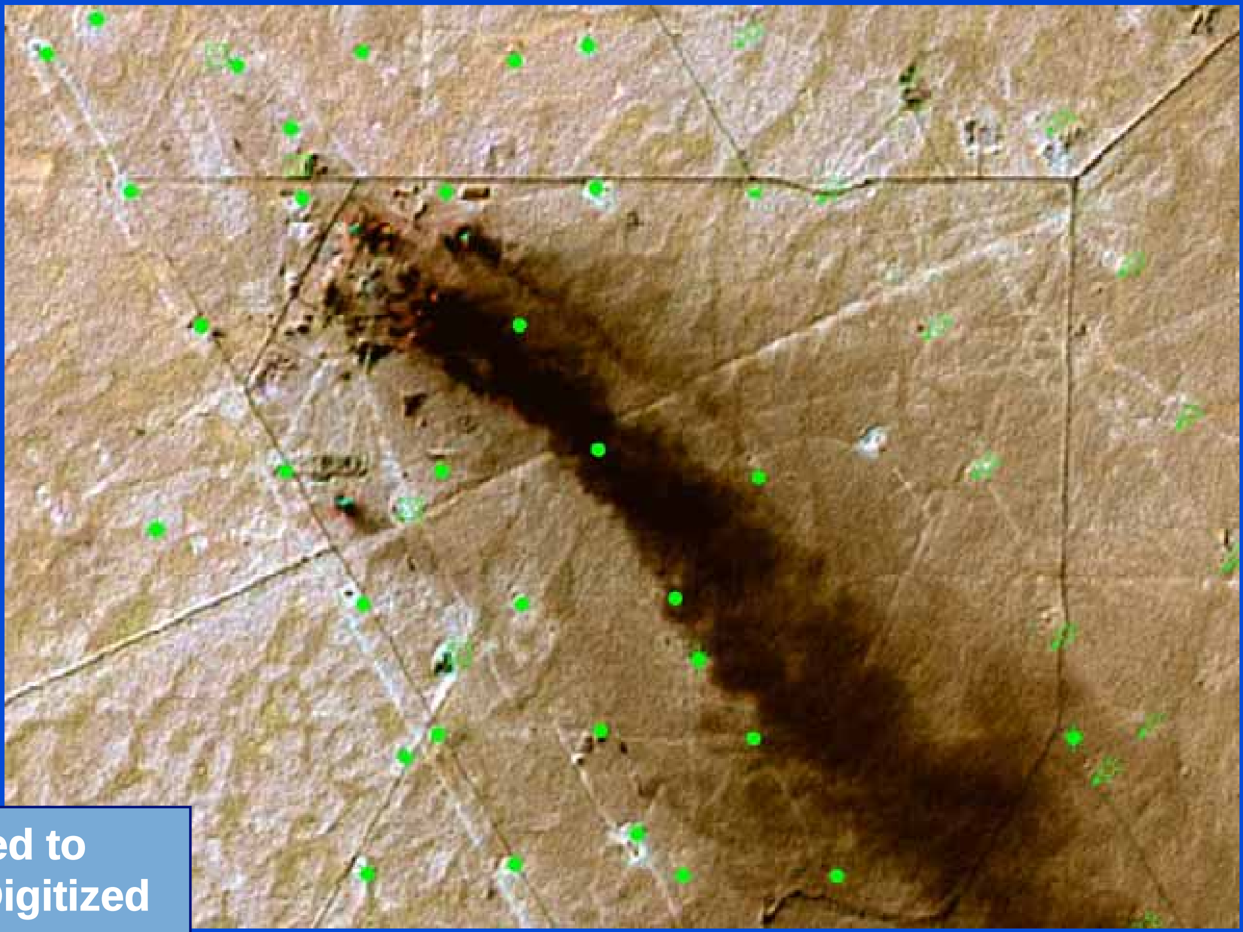


Image Shifted to Nahrwan - Digitized well locations

Geodetic Parameter Detection and Troubleshooting Using Enhanced Landsat Imagery

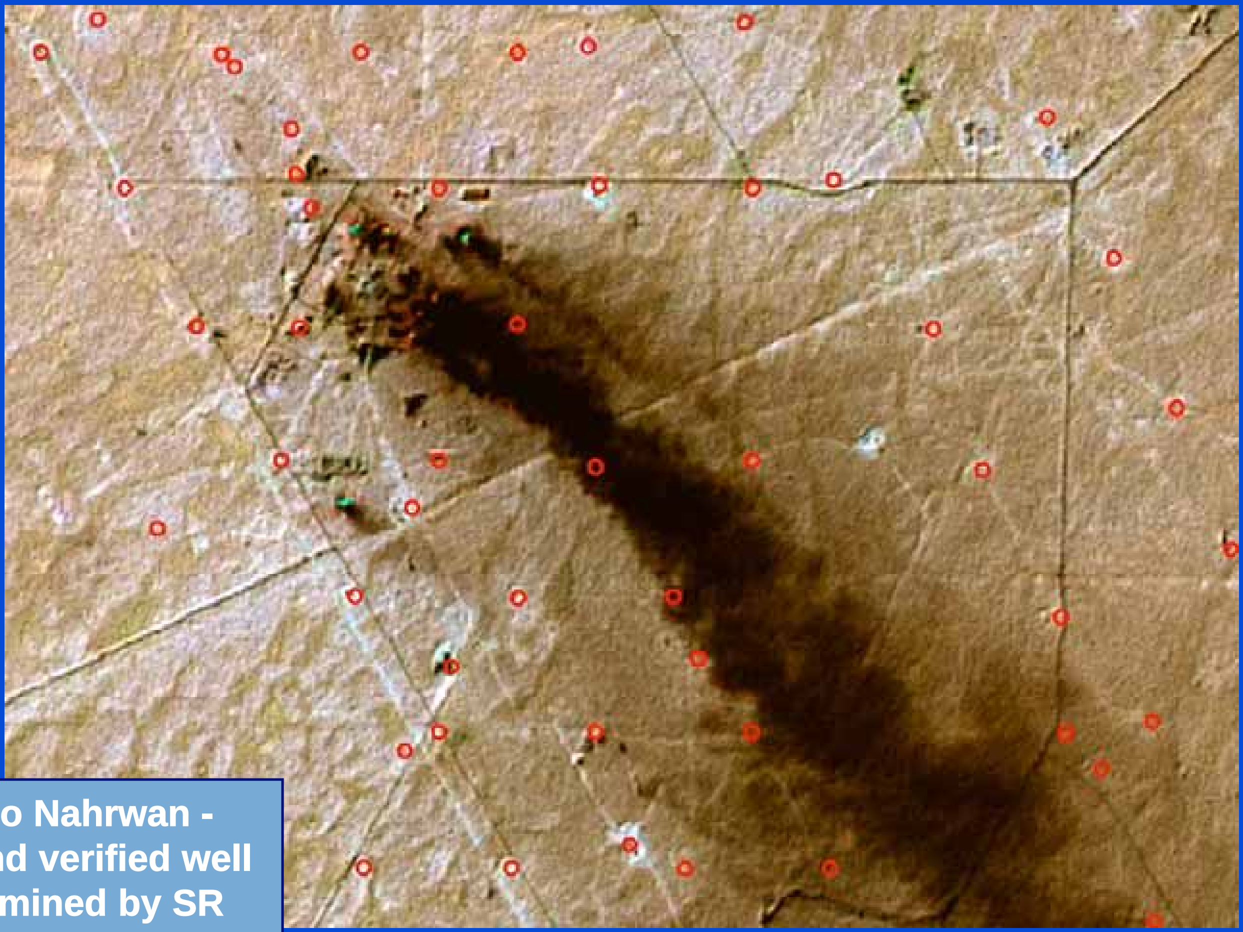


Image Shifted to Nahrwan - 300+ refined and verified well locations determined by SR GIS/RS contractor.

Process to quantify well location precision

3. Data precision analysis

Data rounding and truncation, not cartographic datum shifts are the most likely source of well location errors

IHS Coordinate Quality

IHS ENERGY
ANYWHERE YOU GO, THE POWER TO KNOW.™

Coordinate Quality	Total
Approx to 1 degree	5
Approx to 1 minute	722
Approx to 1 second	146
Approx to 10 minutes	92
Approx to 10 seconds	746
Approx to 20 minutes	2
Approx to 30 minutes	25
Approx to 30 seconds	208
Approx to 45 minutes	2
Approx to 5 minutes	69
Approx to 5 seconds	520
field centre *	1243
field discovery well	2715
platform centre	42
provisional coords	9
Reliable coords	4238
Reliable with datum **	15494
Unreported coords	1
Grand Total	*26316*

- "field centre" coordinates create overposting of well picks in map view
- Unless the data is labeled "Reliable with datum" the well location is suspect

Data Precision Analysis Background

- If the well location coordinates do not reflect the modern GPS standard of sub-meter accuracy, *the well locations were measured using traditional survey methods and/or approximated from maps.*
- For example, if latitude is given as 35.3500000°, it is unlikely that the well was exactly located at by GPS because a location measured by a GPS unit would display greater precision such as 35.3500001°.
- Calculation and digital storage of well locations results in *rounding and truncation* errors *(especially among inexperienced Excel users!)*

Lengths of latitude table

Using the lengths of each latitude and longitude number string for the three data storage formats, an index of lengths of data strings (zeros to right suppressed) versus data precision was built.

Multiplying the latitude and longitude data precision for each well location coordinate by the lengths of a degree of latitude and longitude at each latitude, an estimate of the maximum rounding error in meters is calculated.

Latitude	Meters/deg	Meters/sec
0-1	110,567	30.71
1-2	110,568	30.71
2-3	110,569	30.71
3-4	110,571	30.71
4-5	110,574	30.72
5-6	110,578	30.72
6-7	110,582	30.72
7-8	110,586	30.72
8-9	110,592	30.72
9-10	110,598	30.72
10-11	110,605	30.72
11-12	110,612	30.73
12-13	110,620	30.73
13-14	110,628	30.73

Decimal Degrees

Interval	**Format**	**Meters per degree**	**Precision (m)**	**Length**	Degree%
DD	36	**100,000**	100000.00	2.00	1
DD.D	36.5	**100,000**	10000.00	4.00	1/10
DD.DD	36.55	**100,000**	1000.00	5.00	1/100
DD.DDD	36.555	**100,000**	100.00	6.00	1/1000
DD.DDDD	36.5555	**100,000**	10.00	7.00	1/10000
DD.DDDDD	36.55555	**100,000**	1.00	8.00	1/100000
DD.DDDDDD	36.555555	**100,000**	0.10	9.00	1/1000000

Degrees Minutes Seconds

Interval	**Format**	**Meters per degree**	**Precision (m)**
10 minutes	36:30	**100,000**	16666.67
1 minute	36:35	**100,000**	1666.67
10 seconds	36:30:30	**100,000**	277.78
1 second	36:30:35	**100,000**	27.78
.1 second	36:30:35.5	**100,000**	2.78
.01 second	36:30:35.55	**100,000**	0.28
.001 second	36.30:35.555	**100,000**	0.03

Easting/Northing (X/Y Coordinates)

The possible error distance in meters due to lack of data precision can be calculated directly from the length of the X and Y coordinates.

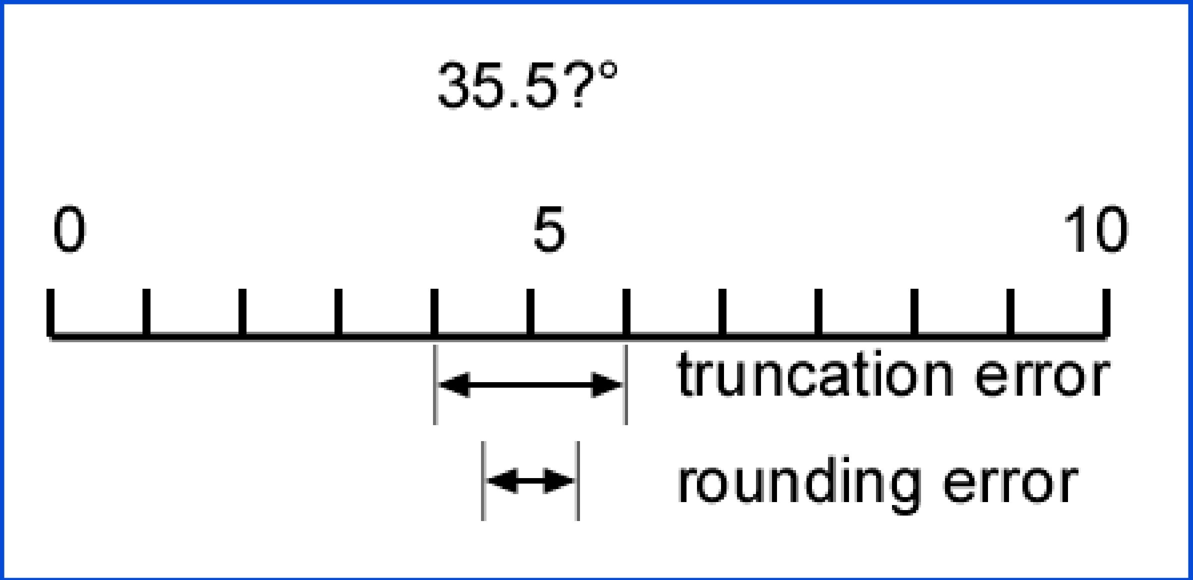
Format	**Precision (m)**
500000	100000
550000	10000
555000	1000
555500	100
555550	10
555555	1
555555.5	0.1
555555.55	0.01
555555.555	0.001

Example calculation of degree length

For example, for a well location in DMS which only has precision to the minutes scale (Latitude = 36° 20' 00"), the possible rounding/truncation error is equal to 1/60th of the length of a degree of latitude at 36° 20' (or ±1 minute precision).

At this latitude the length is 90,166m, the length of a minute is 1502m and the maximum possible rounding error of the location is 3005m.

Rounding versus Truncation



Truncation looses a unit of precision,
rounding has rules for data precision, but...

Rounding versus Truncation – 35.5°

Lat	Lat truncated	Lat rounded
35.44	35.4	35.4
35.45	35.4	35.5
35.46	35.4	35.5
35.47	35.4	35.5
35.48	35.4	35.5
35.49	35.4	35.5
35.50	35.5	35.5
35.51	35.5	35.5
35.52	35.5	35.5
35.53	35.5	35.5
35.54	35.5	35.5
35.55	35.5	35.6
35.56	35.5	35.6
35.57	35.5	35.6
35.58	35.5	35.6
35.59	35.5	35.6
35.60	35.6	35.6
35.61	35.6	35.6

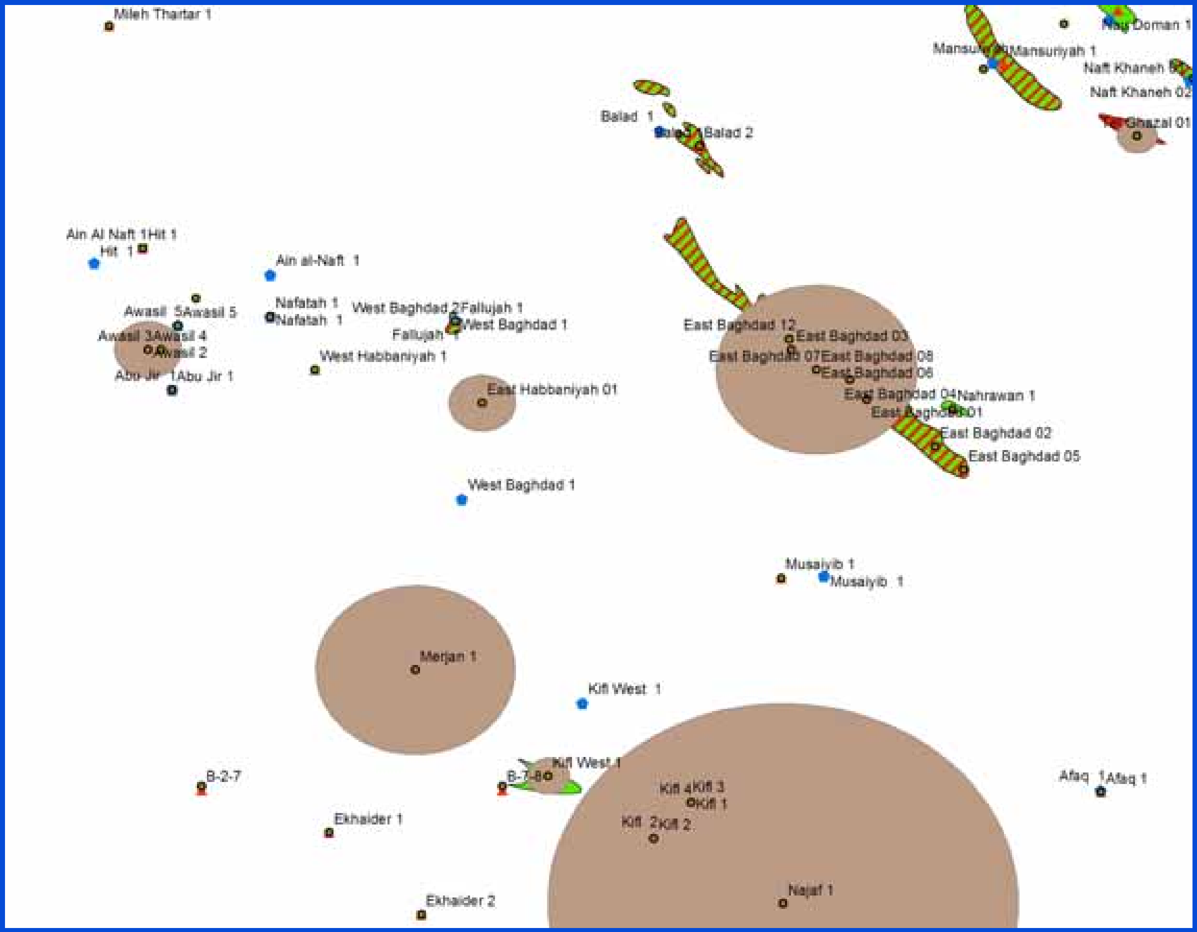
The magnitude of the effects of data rounding and truncation are the same.

If we don't know the rules (rounding or truncation) that were applied to the dataset - the effects indistinguishable.

Generate a number to quantify the amount of data precision in meters

Look for the heavy-hitters so you can label the locations with quality flags before interpretation.

Buffer features in ArcGIS

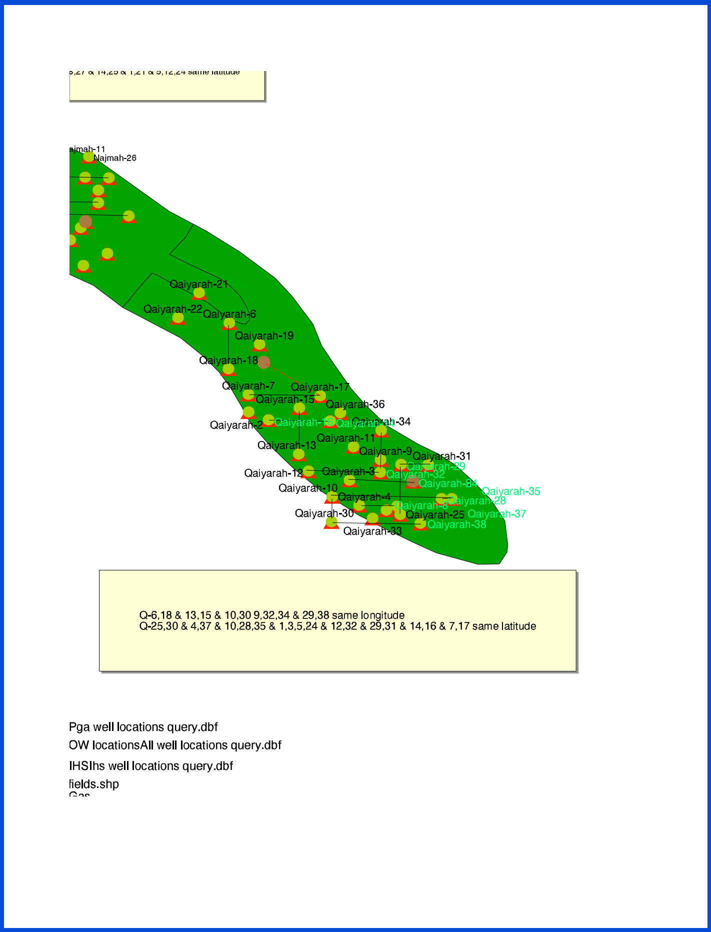


Types of duplicate well locations

- Wells where both latitude and longitude are identical
  - "Field-center coordinates"
  - Copies of previous wells
- Wells where either latitude and longitude are identical
  - Precisely measured well-spot pattern?
  - Moved well X or Y location to prevent duplicate wells?

Duplicate wells locations example

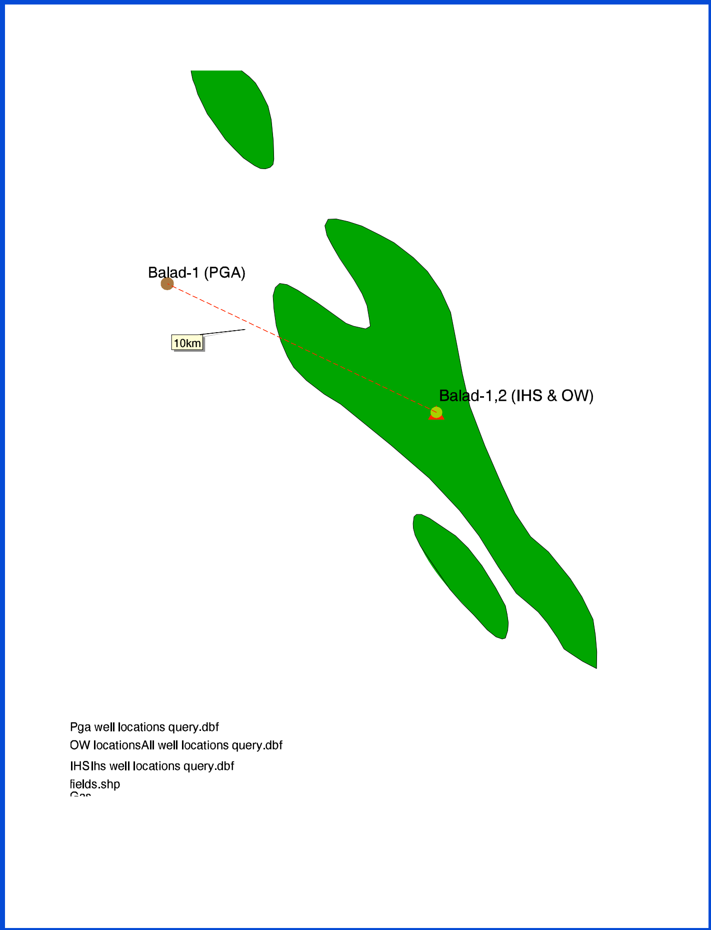
1. Sort the well location spreadsheet by latitude
2. Subtract one cell by the next cell to identify duplicates
3. Repeat process for longitude
4. Create a sub-table of duplicate well locations for a field
5. Display the map view and add annotation and lines tying each duplicate well location



Example of duplicate well locations – Field center coordinates

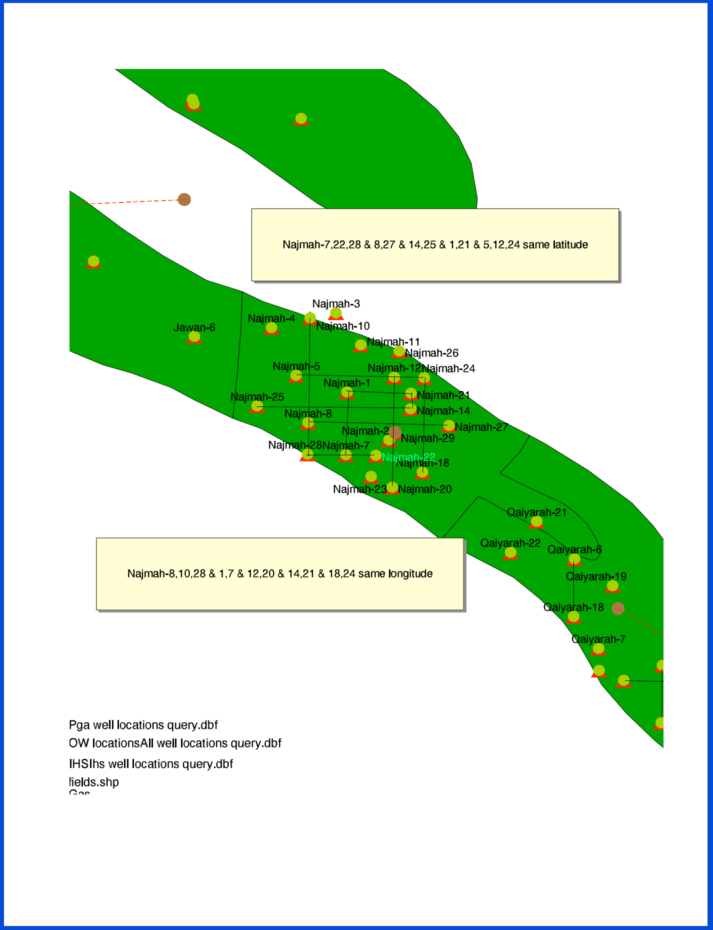
REFNO	Wellname	Latitude	Longitude	Duplicate?
VB6273	Well-1	33.89166667	44.20833333	LAT/LON SAME
VB6274	Well-2	33.89166667	44.20833333	LAT/LON SAME

Use PGA for Well-1?



Example of duplicate well locations – Offset wells

REFNO	Wellname	Lat	Lon	Notes
VB6361	Well-1	35.9	43.1375	LON SAME
VB6365	Well-5	35.90416667	43.12083333	LON SAME
VB6366	Well-7	35.88333333	43.1375	LON SAME
VB6367	Well-8	35.89166667	43.125	LON SAME
VB6368	Well-10	35.91944444	43.125	LON SAME
VB6370	Well-12	35.90416667	43.15277778	LON SAME
VB6371	Well-14	35.89583333	43.15833333	LON SAME
VB6372	Well-18	35.87916667	43.1625	LON SAME
VB6373	Well-20	35.875	43.15277778	LON SAME
VB6374	Well-21	35.9	43.15833333	LON SAME
VB6375	Well-22	35.88333333	43.14722222	LAT SAME
VB6377	Well-24	35.90416667	43.1625	LON SAME
VB6378	Well-25	35.89583333	43.10833333	LAT SAME
VB6380	Well-27	35.89166667	43.17083333	LAT SAME
VB6381	Well-28	35.88333333	43.125	LON SAME



Process to quantify well location precision

4. Generate Comments/Remarks; generate Actions to perform on dataset to create load file

Sit down with geologist working the area, look at output from the data analysis and write comments

Comments to Actions and REMARKS

Comment	**Count**
No change	443
Unresolvable	37
Rounded IHS, keep OW	36
None rounded, PGA as alternate location, confirm later with field maps or satellite imagery	35
Duplicate locations, need to find map of field or confirm with satellite imagery	26
PGA rounded, keep OW	12
OW rounded, no IHS or PGA, no other source	12
IHS rounded, keep OW	11
Rounded OW, use IHS	9
PGA well copy	8
None rounded, look to the satellite imagery for location	8
OW, IHS rounded, unresolvable	7

OpenWorks data model – WELL_MASTER

PREFERRED_SURF_LAT
PREFERRED_SURF_LON
PREFERRED_X_COORD_SURF(IE1)
PREFERRED_Y_COORD_SURF(IE2)
PREFERRED_BH_LAT
PREFERRED_BH_LON
PREFERRED_X_COORD_BH(IE3)
PREFERRED_Y_COORD_BH(IE11)
ORIG_X_LON
ORIG_Y_LAT
ORIG_BH_X_LON
ORIG_BH_Y_LAT

WELL_ID
DATA_ACQ_CO_ID
DATA_ACQUISITION_TYPE
DATA_SOURCE *
WELL_NAME_FREE(IE5)
PLOT_NAME
ORIG_CRS_ID *
ORIG_BH_CRS_ID
REMARK *

See also WELL_MASTER_ALT

What is the value of this exercise?

- Need to determine from multiple set of well location which location will be used in OpenWorks
- Need to identify duplicate well locations tied to different wells (i.e. “field center coordinates”)
- Need to quickly identify typographic errors
- Need to estimate precision quality of well locations

Notes - Word Document
(double-click to open)

A methodology for determining the precision of well location datasets

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Landmark Certified Customer Support – ZMap+™, StratWorks™

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Data Management Overview

The advent of global positioning satellites and geographical information systems has increased the accuracy of spatial measurements by orders of magnitude. The luxury of these accurate measurements may induce us to forget some basic cartographic principles of data precision which govern older spatial datasets. A study of 700+ well locations from Iraq show that data rounding and truncation, not cartographic datum shifts are the most likely source of well location errors.

Data analysis was used to select the "best" well location from several well location datasets. We also wanted to eliminate duplicate well locations and the resulting overposting of picks. Quantification of the area of uncertainty around well location was used to label the well locations used for stratigraphic correlations.

For those of us old enough to remember traditional land surveying methods will remember that many of the well location coordinates were approximated or proposed coordinates and were used for final coordinates on field prints of well log headers. We had to keep in mind the precision of the well locations.

There was a lot of data, so we needed an automated solution, or at least an automated presentation of the data analysis. This allowed us to combine the data analysis results with our knowledge of the area to make choices about which dataset to use for each well location. This study identified which well locations from five vendor datasets was input into the OpenWorks database (one set of well locations that is used in SeisWorks and StratWorks interpretations). There was a need to identify duplicate well locations tied to different wells (i.e. "field center coordinates"), identify typographic errors and estimate the precision quality of the well locations.

Before undertaking a data management project, there are some "givens" that govern the process. The business unit owns the data. There is no IT group doing data cleanup "behind-the-scenes". Each request for data management needs a statement of the value, agreed workplan and charge code. In addition, each business unit is responsible for data standards such as consistent wellnames, log curve name and filing reference numbers.