

59th General Meeting
17th & 18th of April 2024
Glasgow



Wellbore Positioning Technical Section



The Industry Steering Committee on
Wellbore Survey Accuracy (ISCWSA)

Wellbore Positioning Using 3D Way-point - A Comparative Study

Harald Bolt, DwpD Ltd., Depth Solutions

With acknowledgement and thanks for the cooperation of Andy McGregor,
H&P Inc. for the minimum curvature and ISCWSA calculations

Harald Bolt

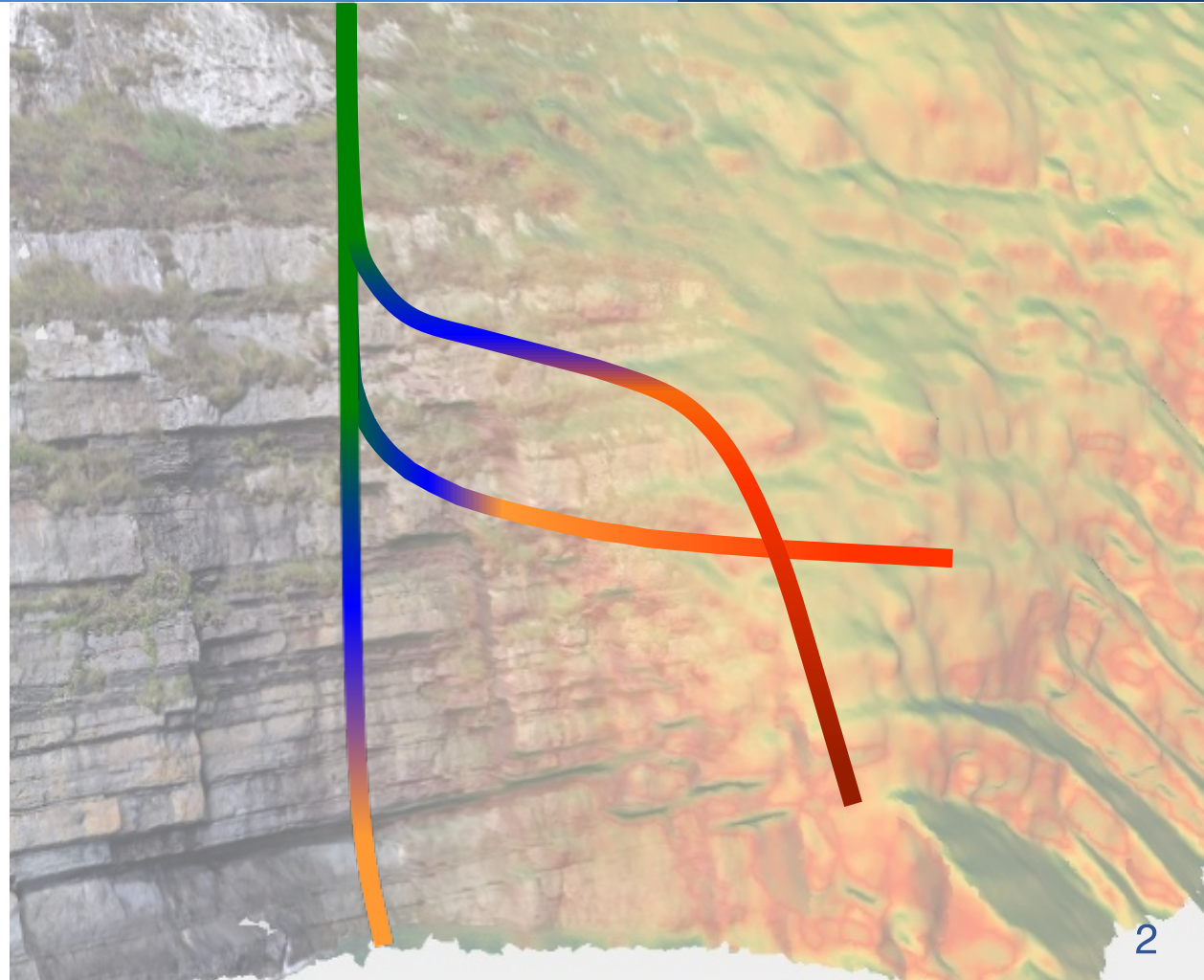
DwpD Ltd, Depth Solutions

Wireline background
Well depth expert
Driller's Way-point Depth (DwpD) inventor
3D Way-point inventor
Well path 3D position and positional
uncertainty advisor, consultant, and trainer

SPE, ISCWSA, SPWLA, EAGE, and GESGB

3D Way-point refers to: International Patent Application
nr. PCT/GB2022/052855, "System for Determining 3-d
Well Position", property of DwpD Ltd., Depth Solutions

DwpD refers to: EU patent 18 715 234.3 and US Patent
11,174,723 "A Method For Determining Well Depth",
property of DwpD Ltd., Depth Solutions





The uncertainty comparative discussion

Increased inclination and azimuth measurement accuracy should result in decreased 3D uncertainty. Without balanced well depth accuracy improvements, there is no improvement.

3D Way-point provides a “balanced” approach to well subsurface position and 3D positional uncertainty.

Industry standard minimum curvature positional and ISCWSA (Rev 5) positional uncertainties are compared to 3D Way-point results.

The (small) differences in well positional results are explained.

3D Way-point positional uncertainties are lower than the equivalent ISCWSA positional uncertainties.

Reduced 3D positional uncertainty diminishes operational risk and improves asset description confidence.



Uncertainty discussion T&C's

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The point is: this is a discussion, not a solution.
It works, but other ways and means are also possible.

The 3D Way-point milking chair principle

The 3 components of 3D position must have balanced accuracies.

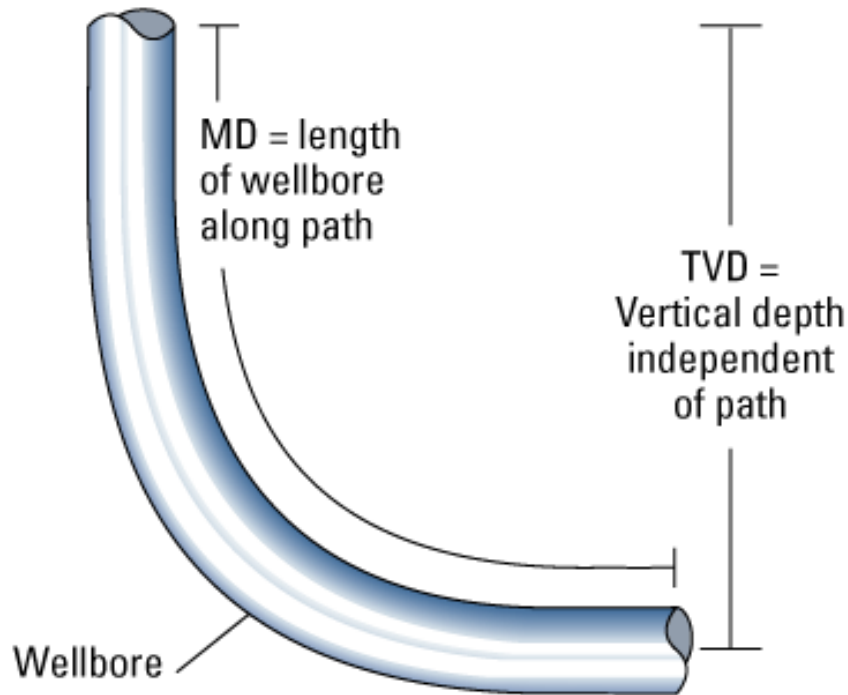


Well geometry, well survey measurement accuracies, and interval spacing determine N, E, and V positional uncertainties.

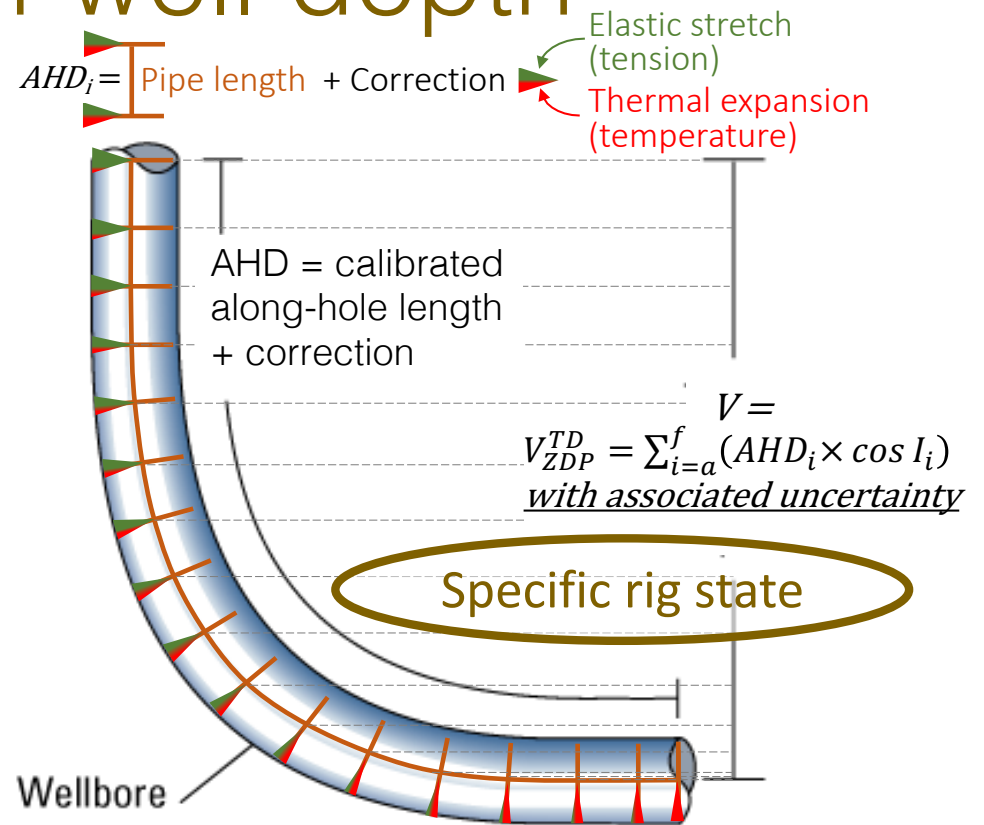


The flavors of well depth

Measured Depth, MD – as we know it



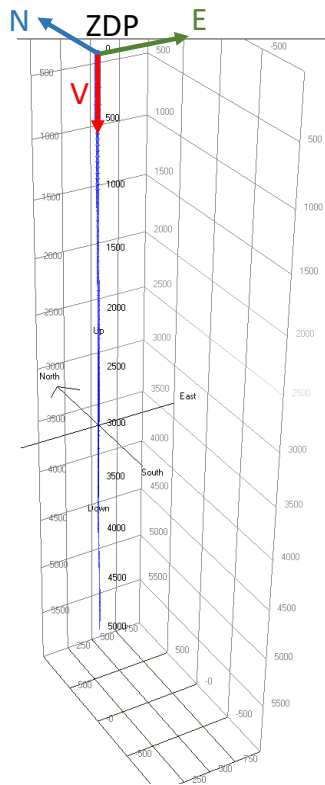
Text and image from Schlumberger, <https://glossary.slb.com/en/terms/m/md>



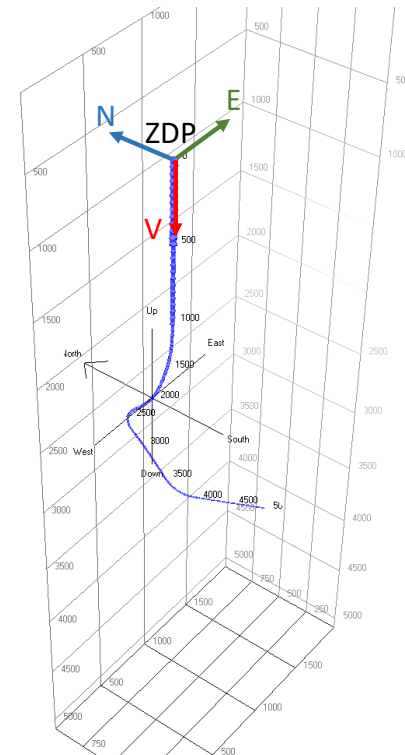
Along-hole Depth, AHD = calibrated and corrected

4 example 5,000 m well geometries

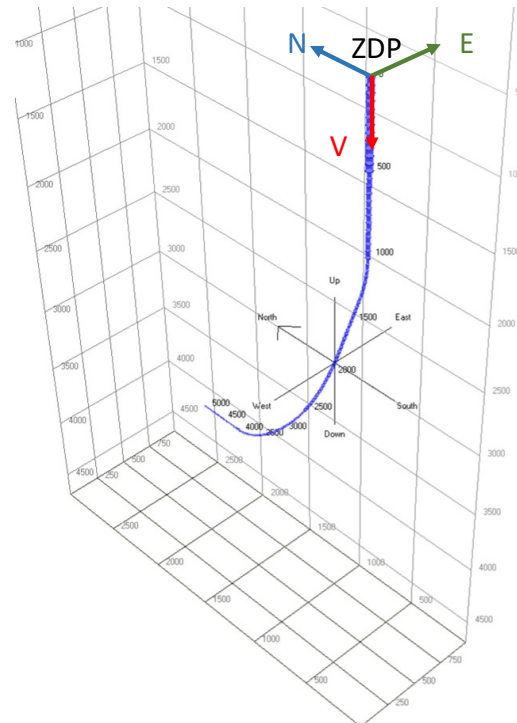
Example vertical well



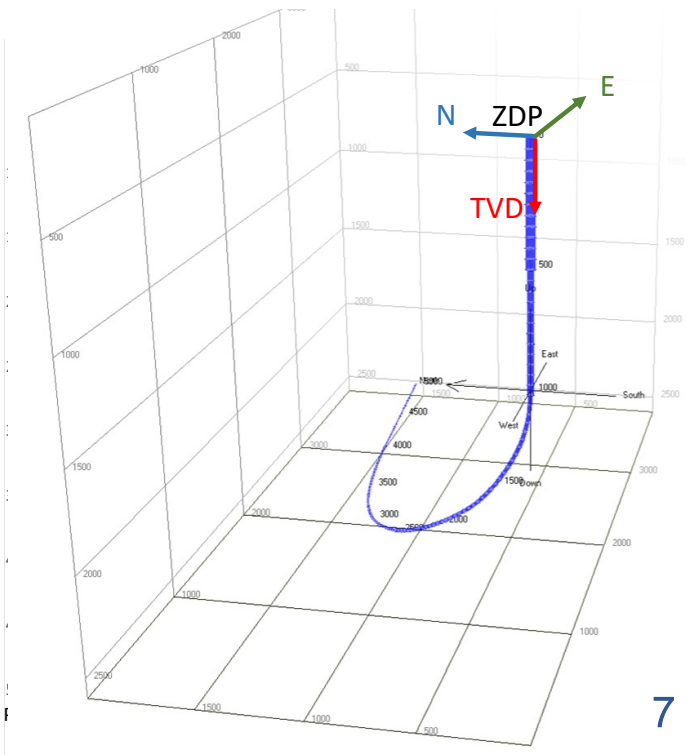
Example deviated well



Example horizontal well

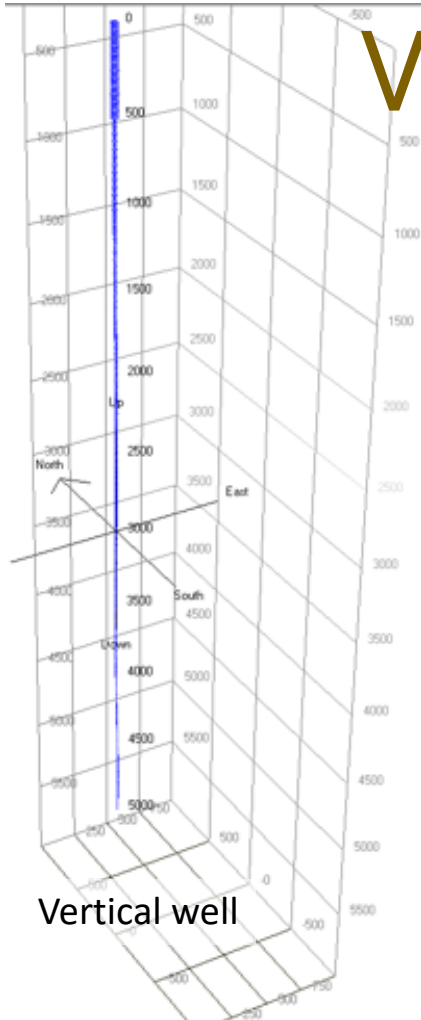


Example S-profile well



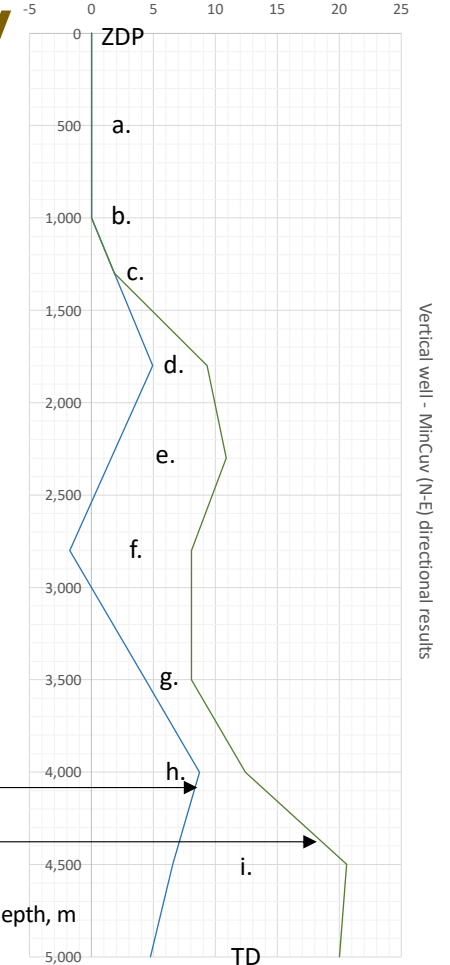


Vertical well geometry



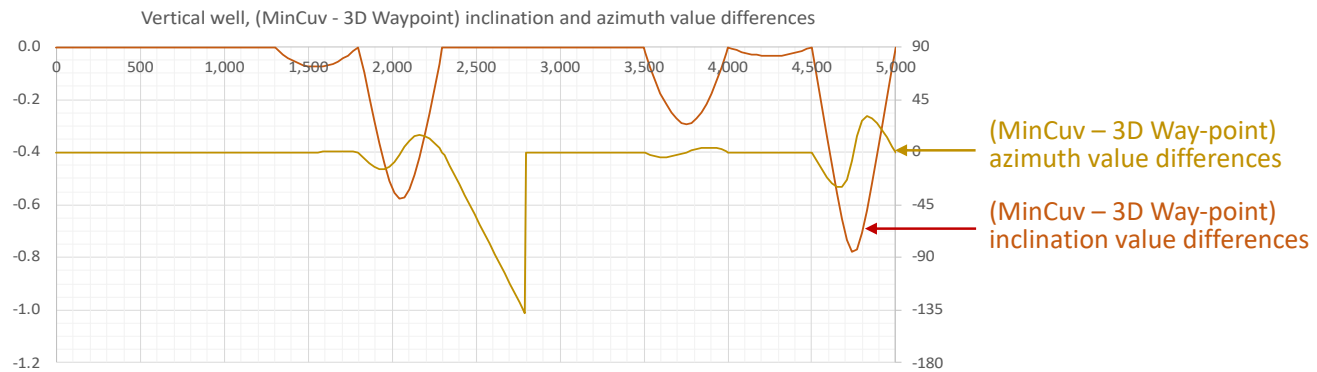
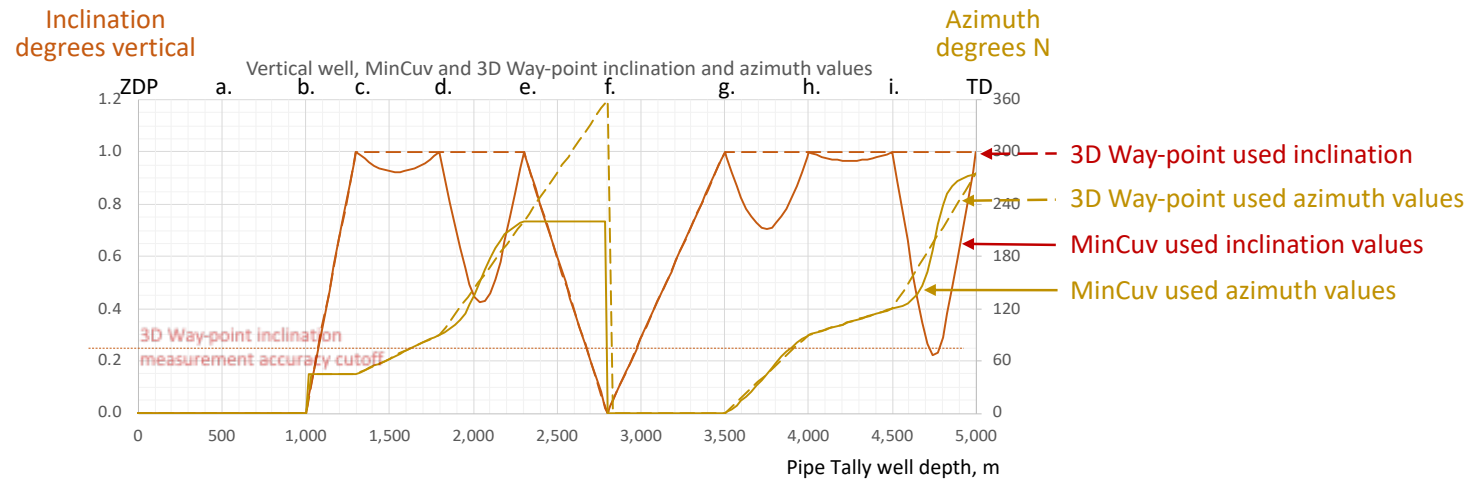
	Pipe tally, m	Incl., deg	Az, deg N
Data	Data	Data	Data
Vertical	0	0	0
a.	500	0	0
b.	1,000	0	0
c.	1,300	1	45
d.	1,800	1	90
e.	2,300	1	220
f.	2,800	0	0
g.	3,500	1	0
h.	4,000	1	90
i.	4,500	1	120
TD	5,000	1	275

MinCuv North and East displacement from ZDP, m



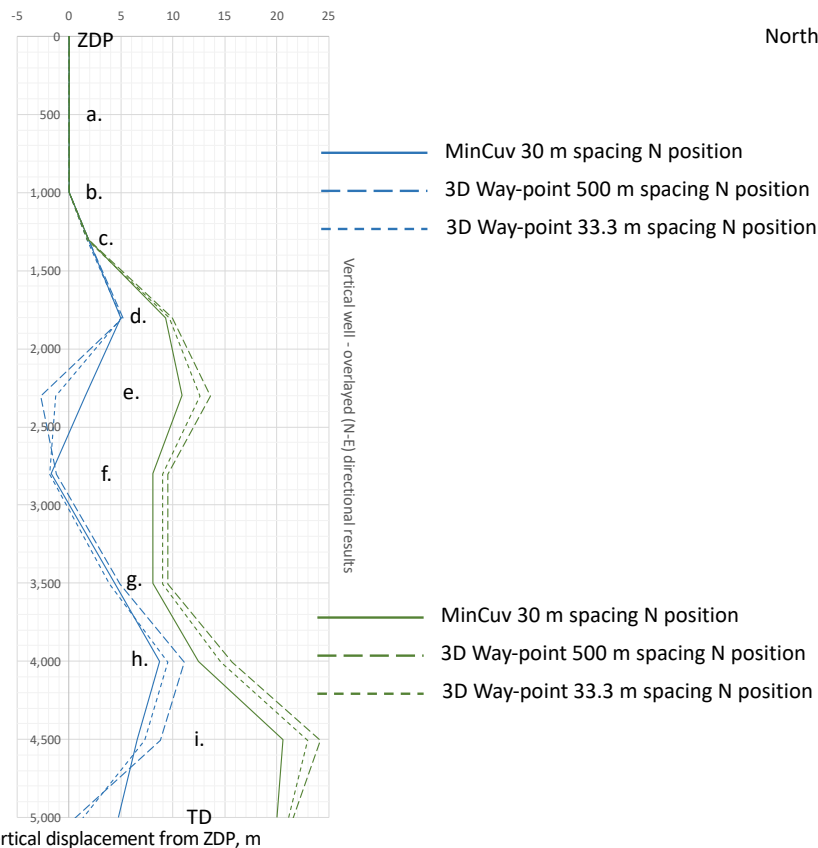
- MinCuv 30 m spacing N position
- MinCuv 30 m spacing E position

Vertical well inclination and azimuth

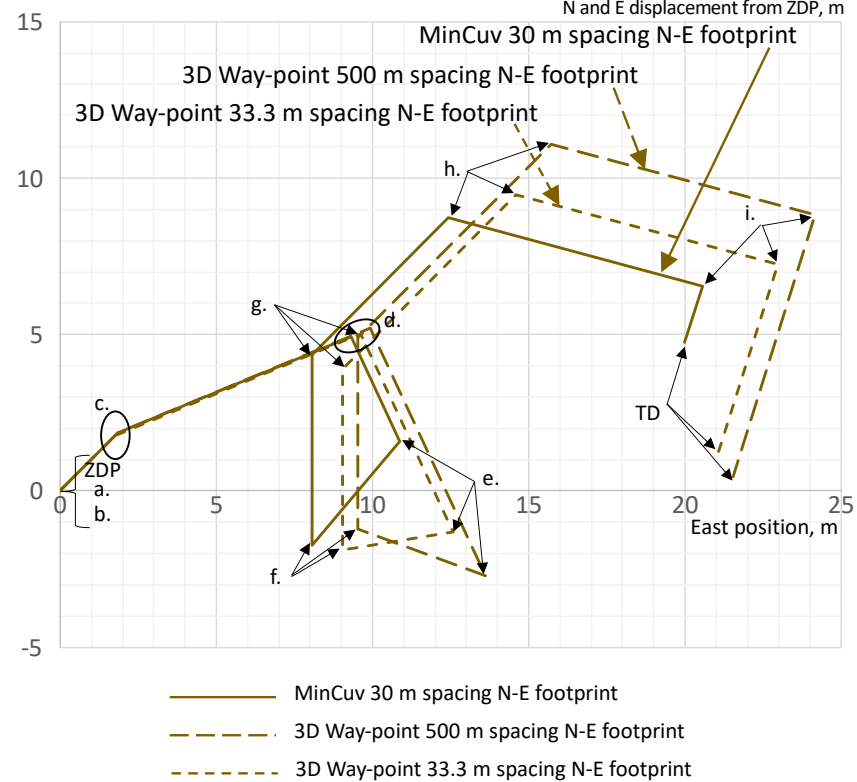


Vertical well positional results

Horizontal North and East displacement from ZDP, m

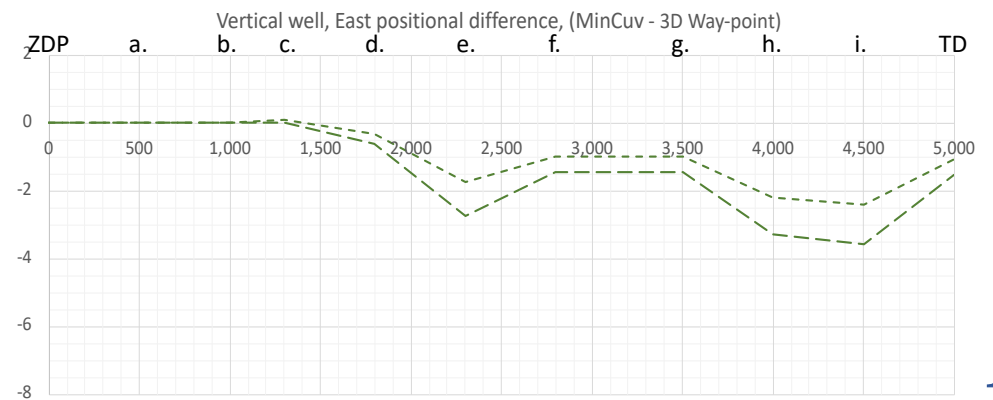
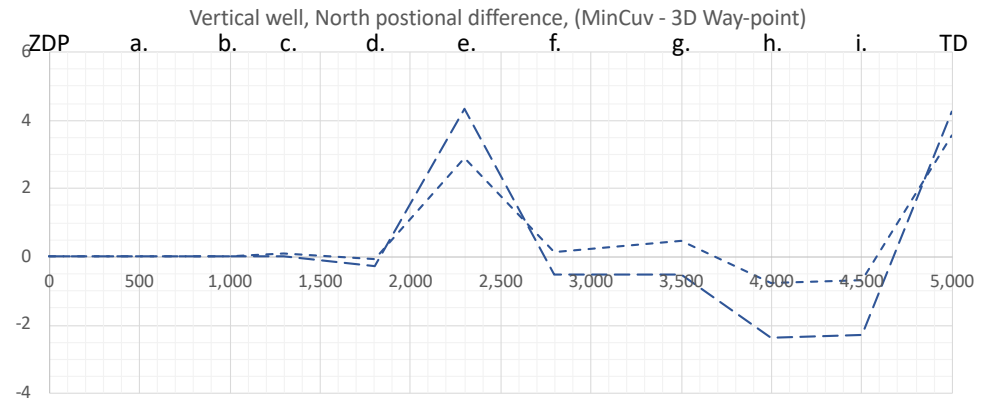
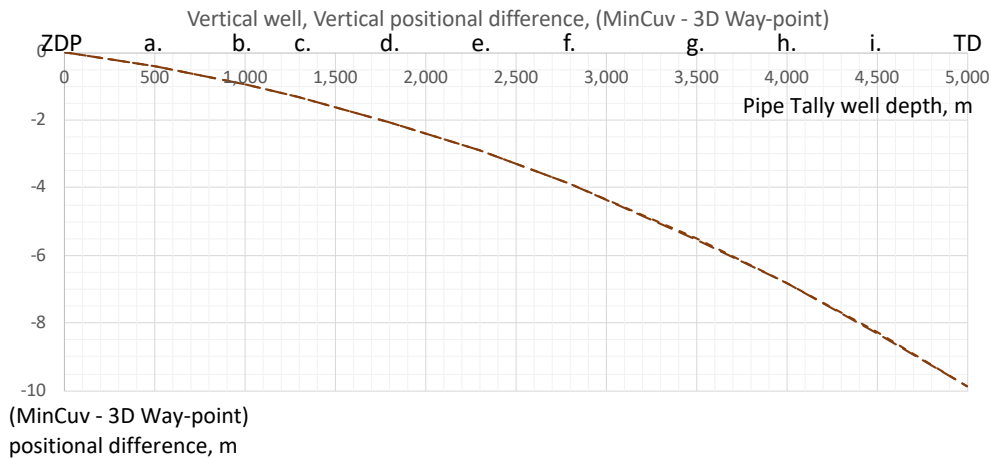


North position, m



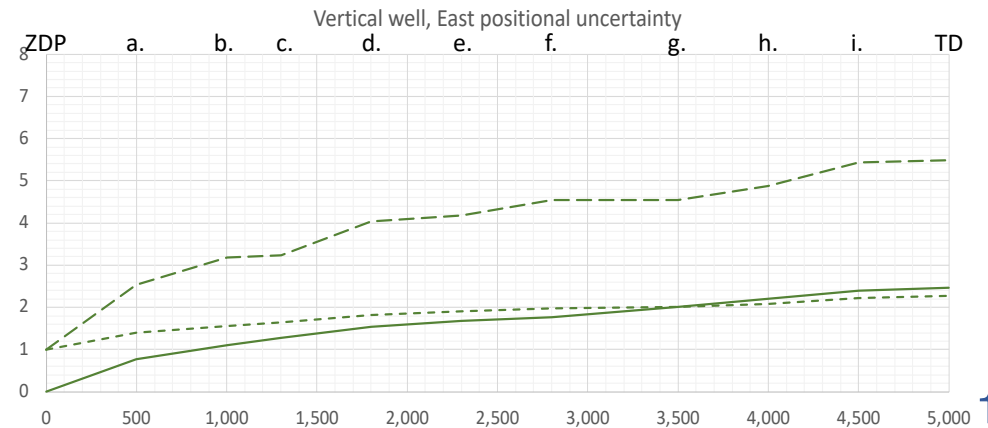
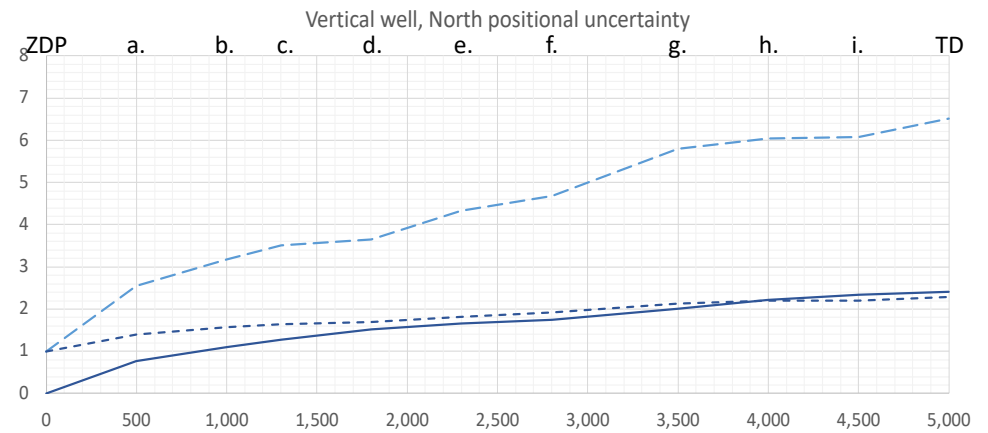
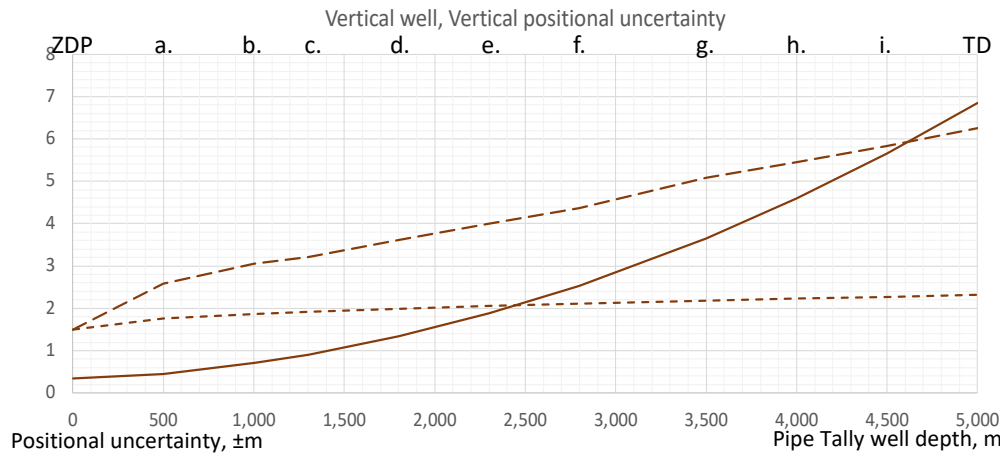


Vertical well positional differences



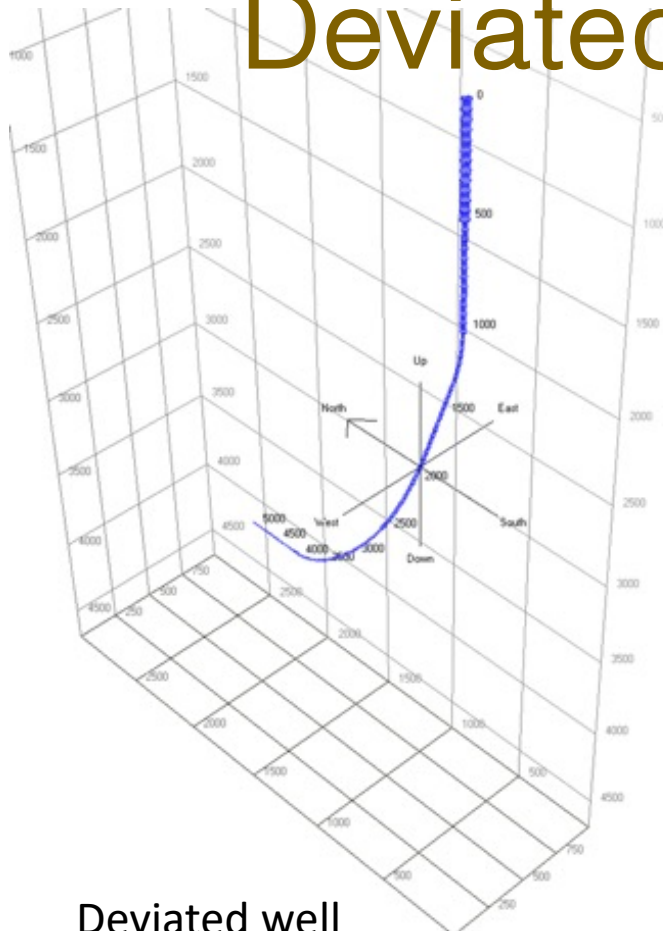


Vertical well 3D positional uncertainties



- ISCWSA 30 m positional uncertainty
- - - - - 3D Way-point 500 m positional uncertainty
- . - . - 3D Way-point 33.3 m positional uncertainty

Deviated well geometry

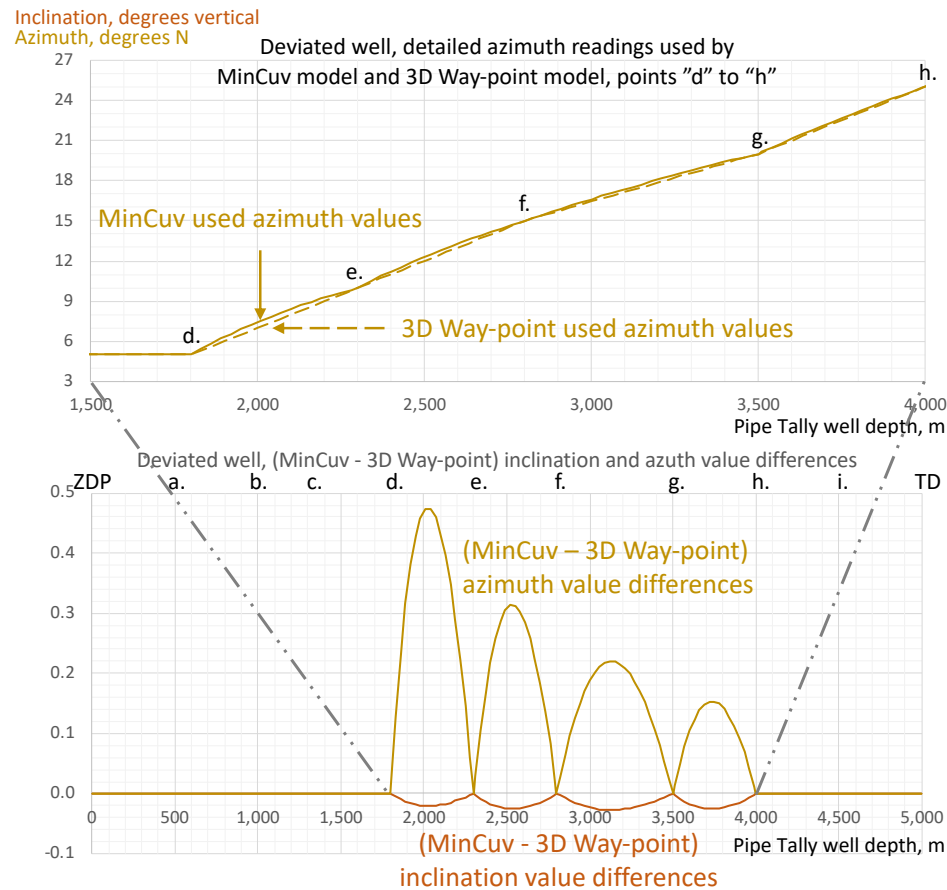


Deviated well

	Pipe tally, m	Incl., deg	Az, deg N
Data	Data	Data	Data
Deviated	0	0	0
a.	500	0	0
b.	1,000	0	0
c.	1,300	20	5
d.	1,800	20	5
e.	2,300	30	10
f.	2,800	40	15
g.	3,500	50	20
h.	4,000	60	25
i.	4,500	60	25
TD	5,000	60	25

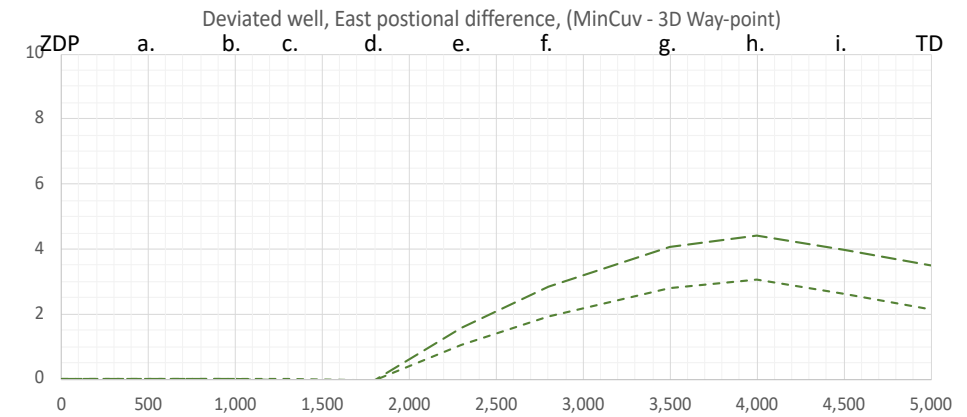
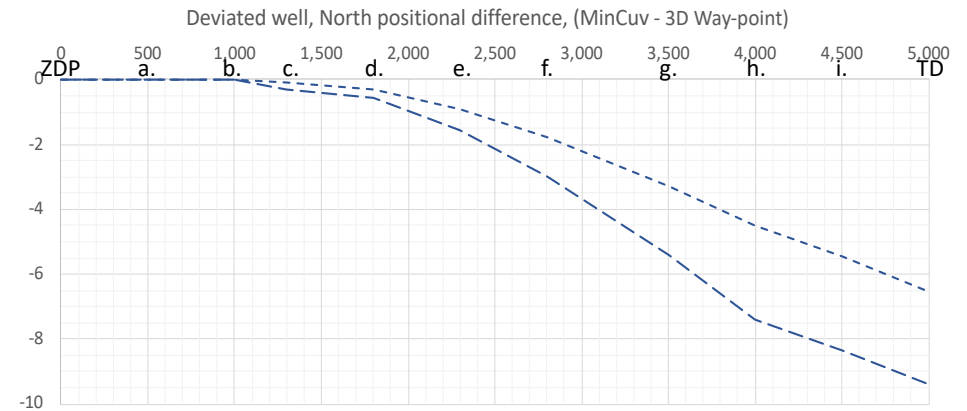
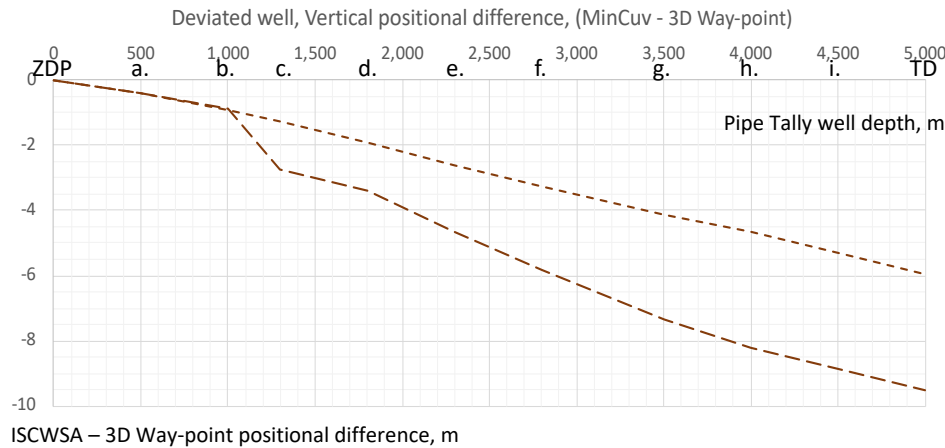


Deviated well inclination and azimuth





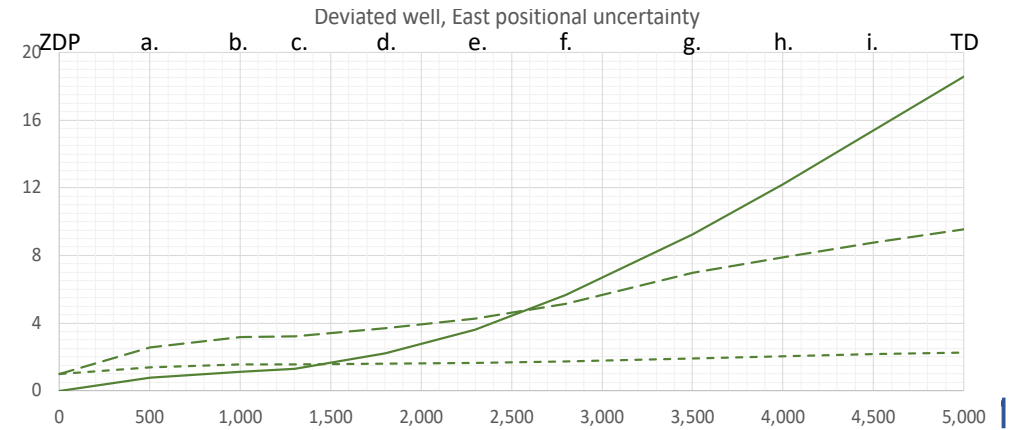
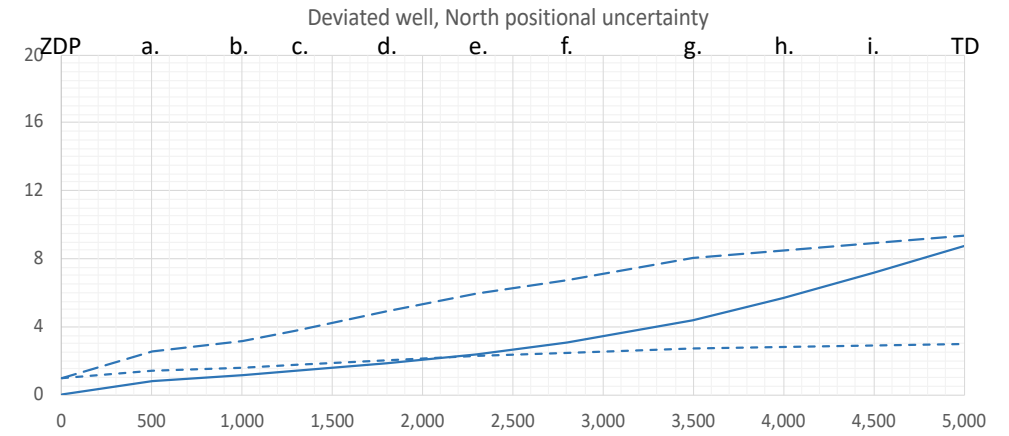
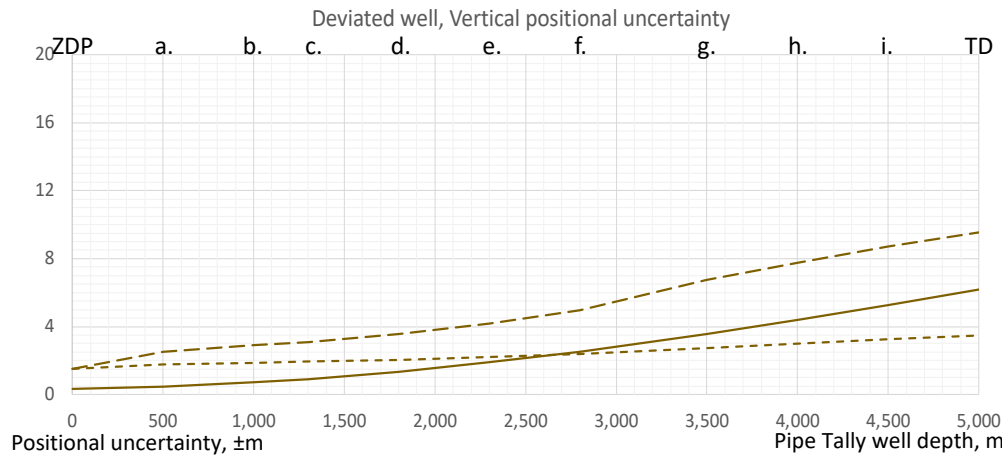
Deviated well positional differences



- (MinCuv - 3D Way-point) 500 m spacing positional difference
- - - (MinCuv - 3D Way-point) 33.3 m spacing positional difference

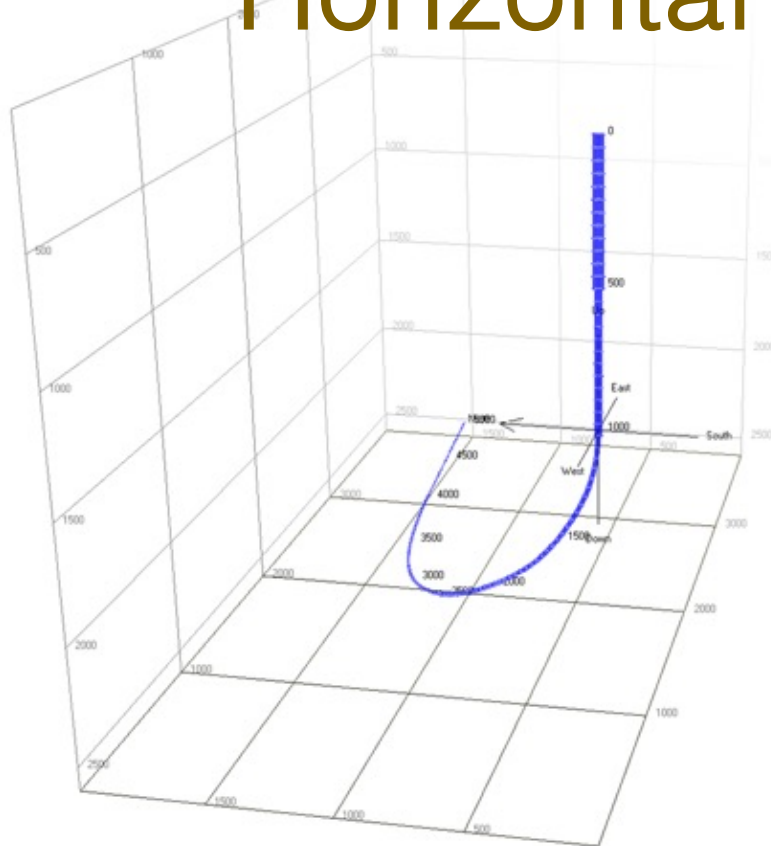


Deviated well positional uncertainties



- ISCWSA 30 m positional uncertainty
- - - 3D Way-point 500 m positional uncertainty
- . - 3D Way-point 33.3 m positional uncertainty

Horizontal well geometry



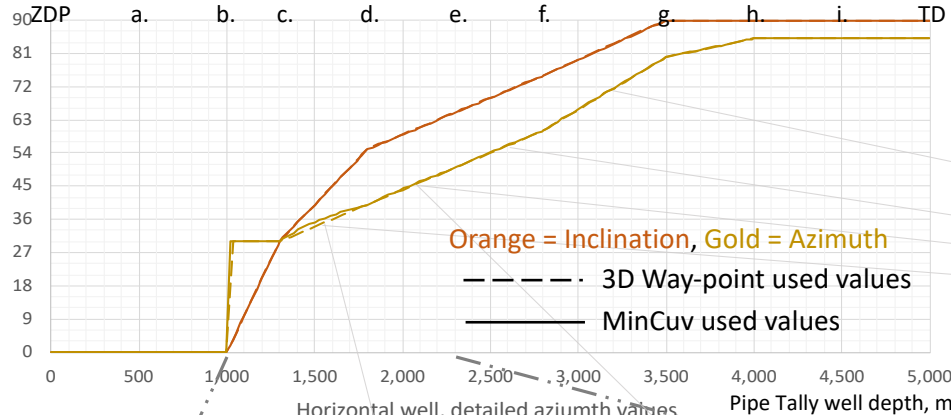
Horizontal well

	Pipe tally, m	Incl., deg	Az, deg N
Data	Data	Data	Data
Horizontal	0	0	0
a.	500	0	0
b.	1,000	0	0
c.	1,300	30	30
d.	1,800	55	40
e.	2,300	65	50
f.	2,800	75	60
g.	3,500	90	80
h.	4,000	90	85
i.	4,500	90	85
TD	5,000	90	85

Horizontal well inclination and azimuth

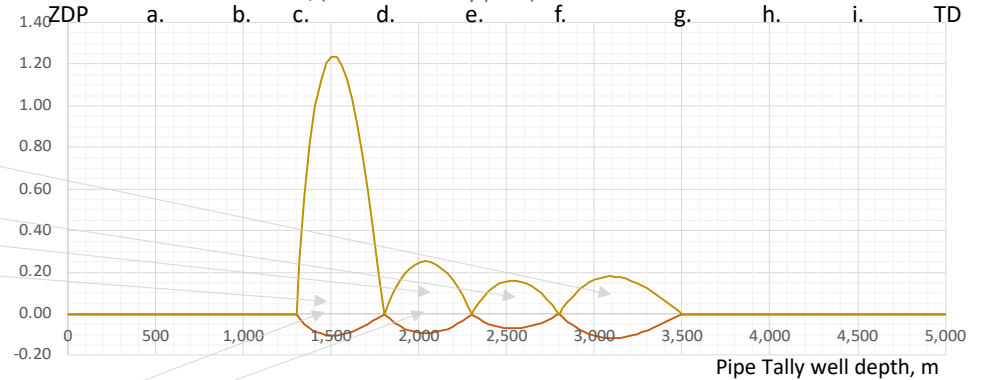
Inclination, degrees vertical
 Azimuth, degrees N

Horizontal well, inclination and azimuth values



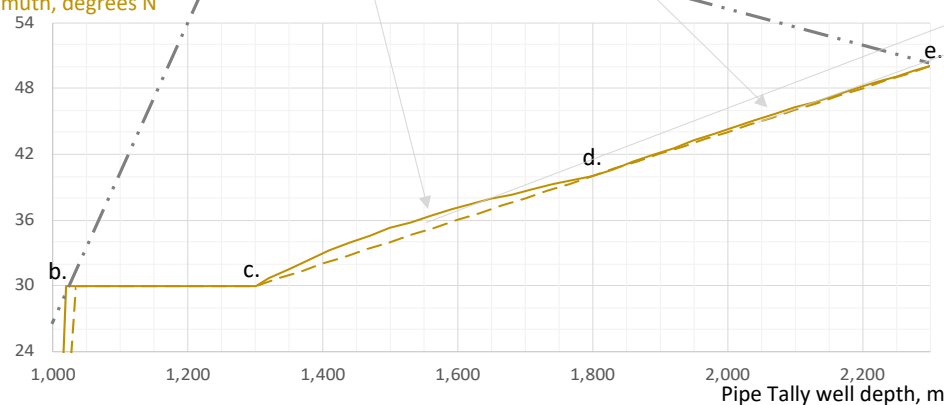
Inclination, degrees vertical
 Azimuth, degrees N

Horizontal well, (MinCuv - 3D Way-point) inclination and azimuth values



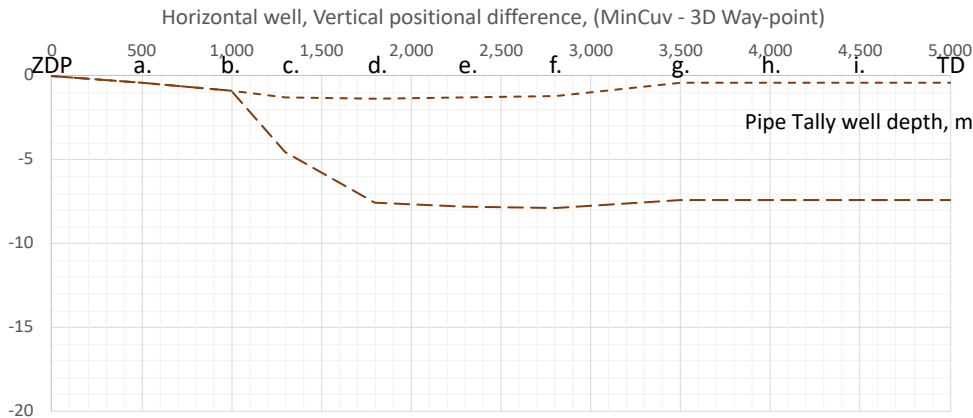
Azimuth, degrees N

Horizontal well, detailed azimuth values

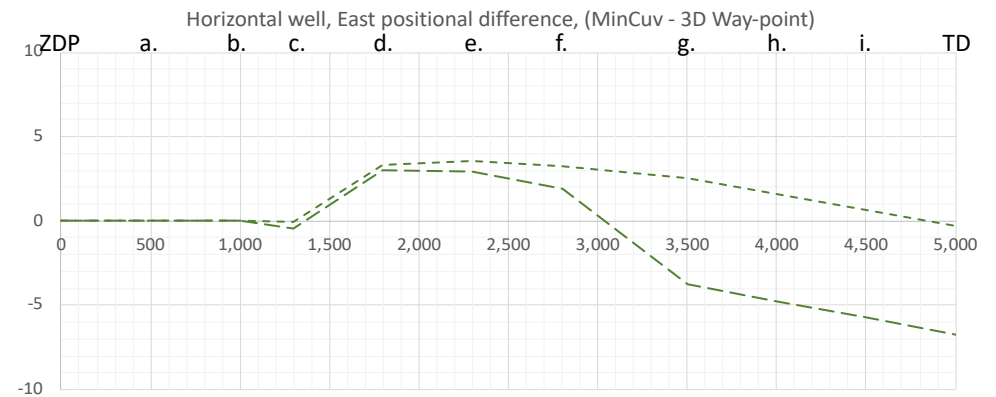
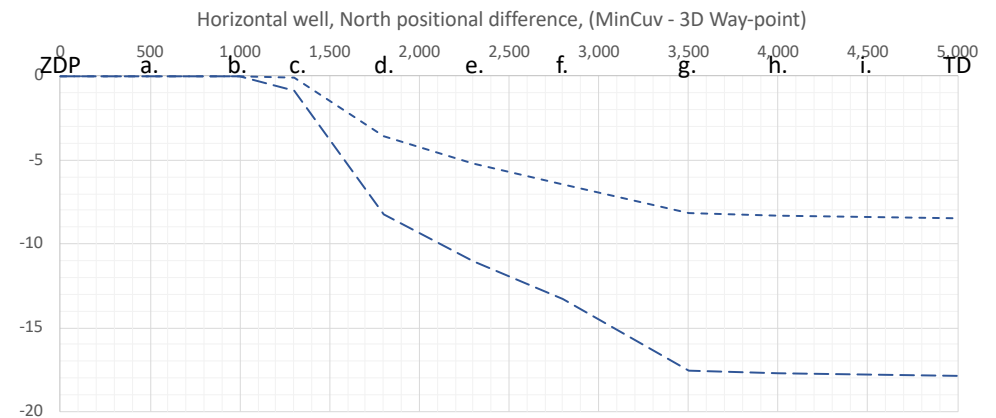




Horizontal well positional differences



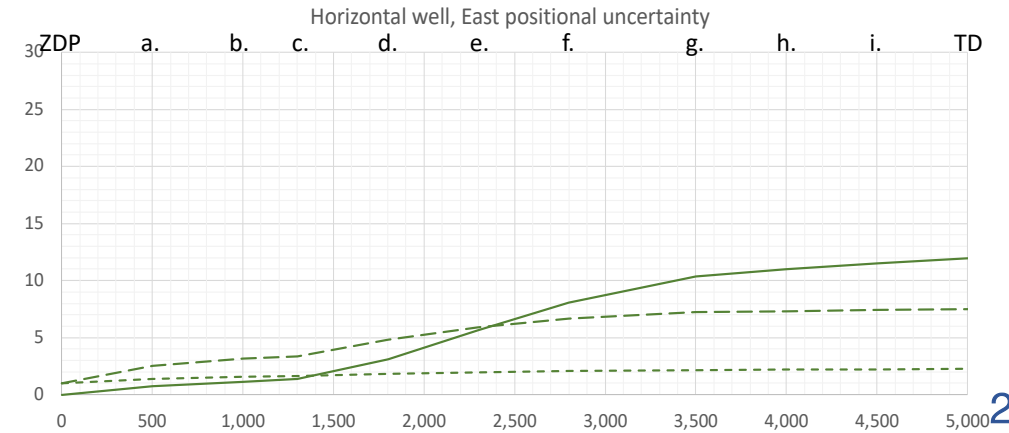
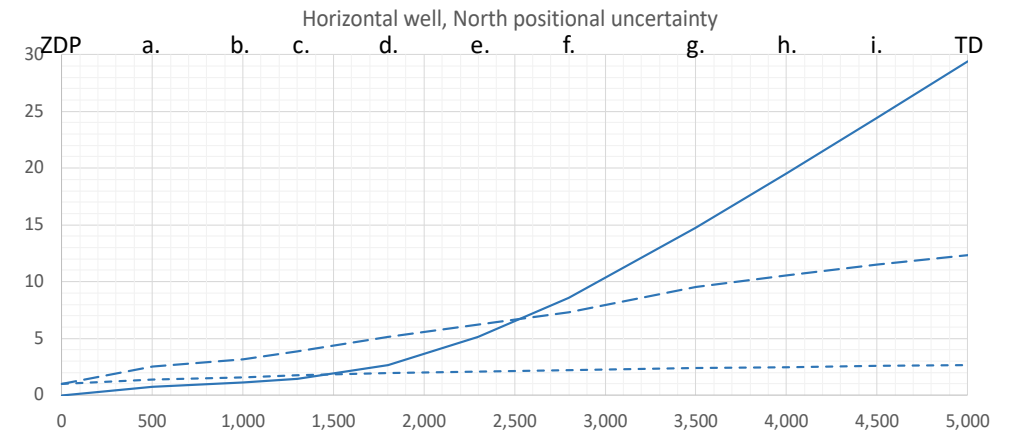
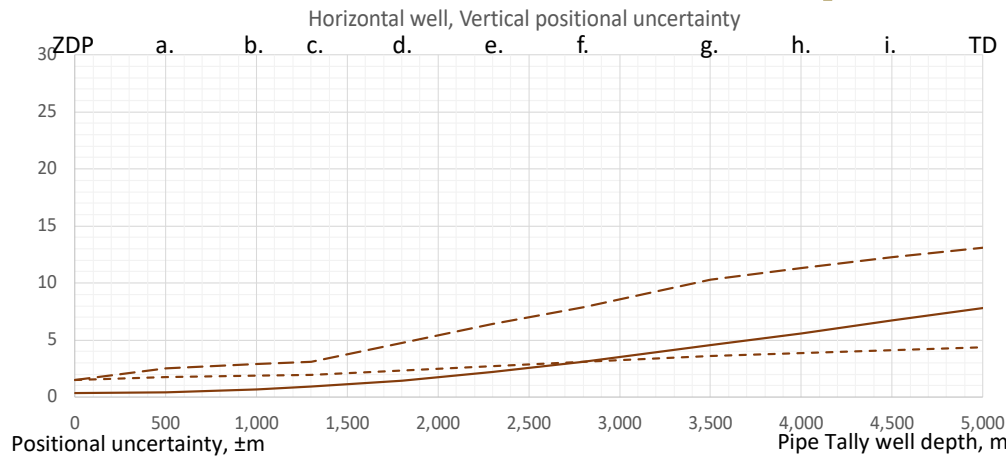
ISCWSA – 3D Way-point positional difference, m



- (MinCuv - 3D Way-point) 500 m spacing positional difference
- (MinCuv - 3D Way-point) 33.3 m spacing positional difference

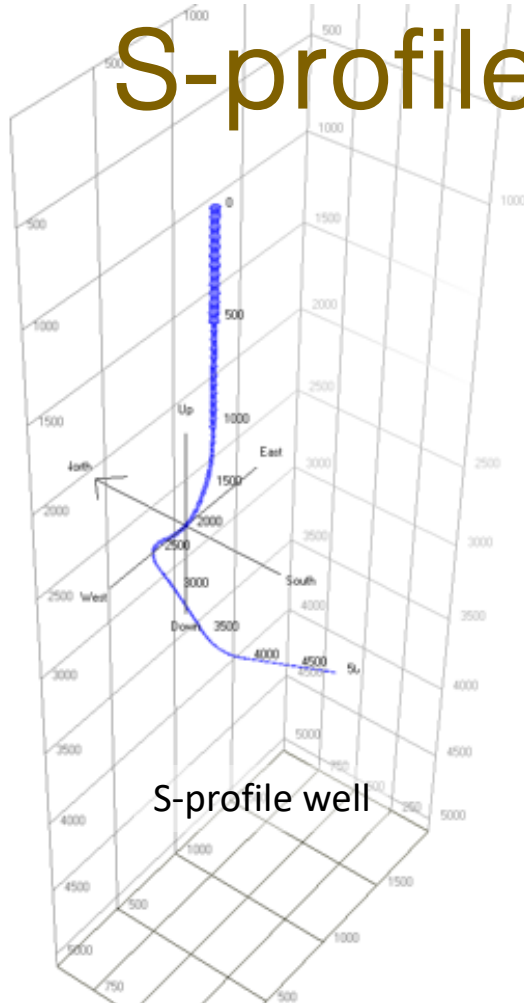


Horizontal well positional uncertainties



- ISCWSA 30 m positional uncertainty
- - - - 3D Way-point 500 m positional uncertainty
- . - . - 3D Way-point 33.3 m positional uncertainty

S-profile well geometry



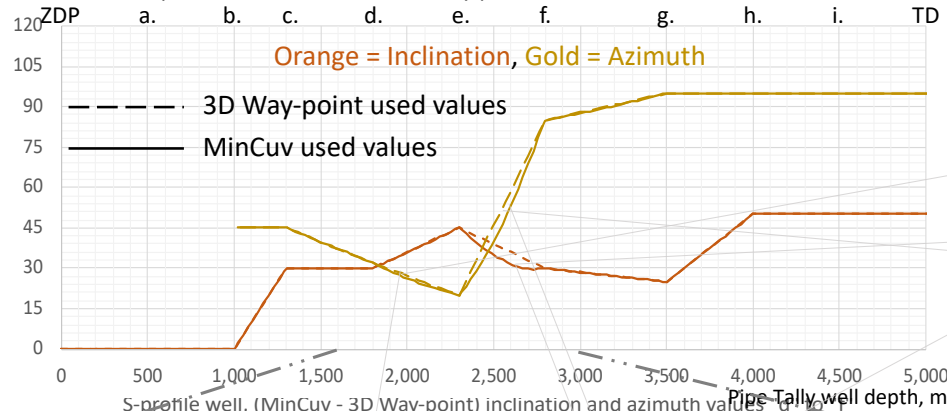
3D Position	Pipe tally, m	Incl., deg	Az, deg N
Data	Data	Data	Data
S-profile	0	0	0
a.	500	0	0
b.	1,000	0	0
c.	1,300	30	45
d.	1,800	30	32
e.	2,300	45	20
f.	2,800	30	85
g.	3,500	25	95
h.	4,000	50	95
i.	4,500	50	95
TD	5,000	50	95



S-profile well inclination and azimuth

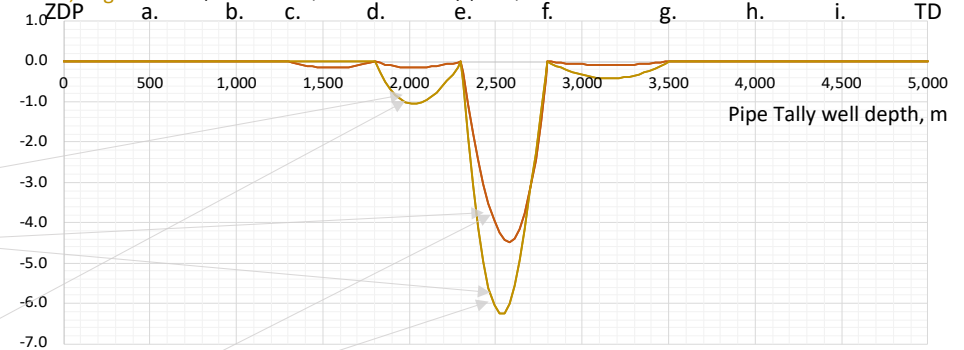
Inclination, degrees vertical
 Azimuth, degrees N

S-profile well, MinCuv and 3D Way-point inclination and azimuth values

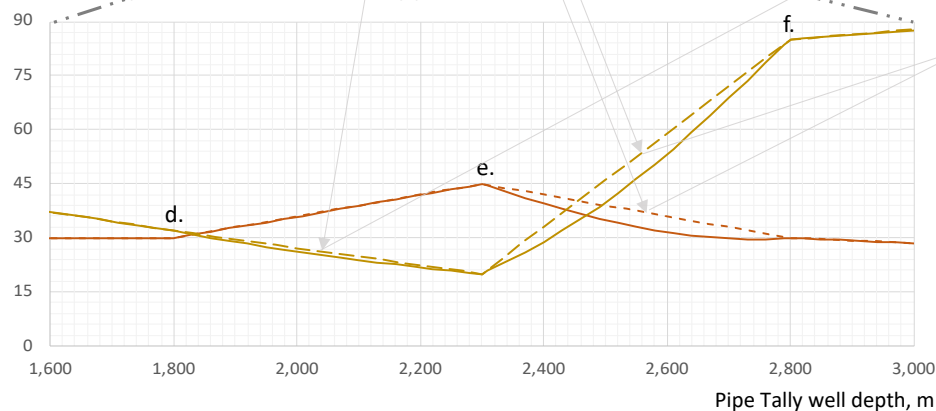


Inclination, degrees vertical
 Azimuth, degrees N

S-profile well, (MinCuv - 3D Way-point) inclination and azimuth values

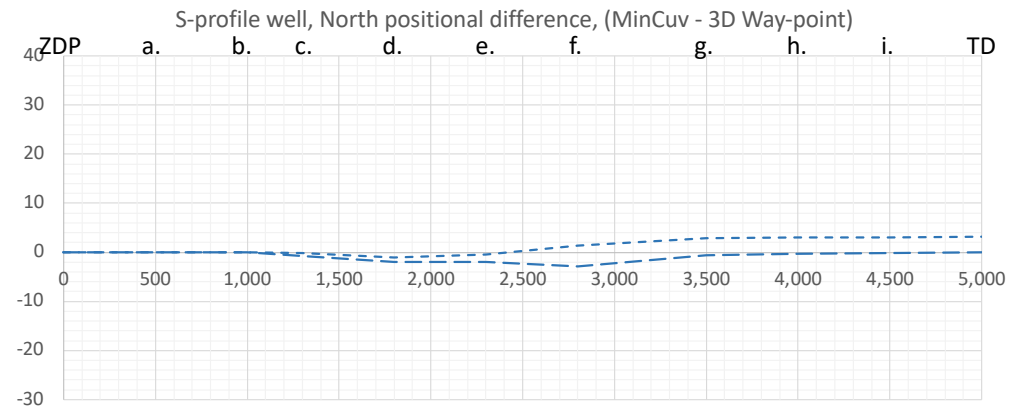
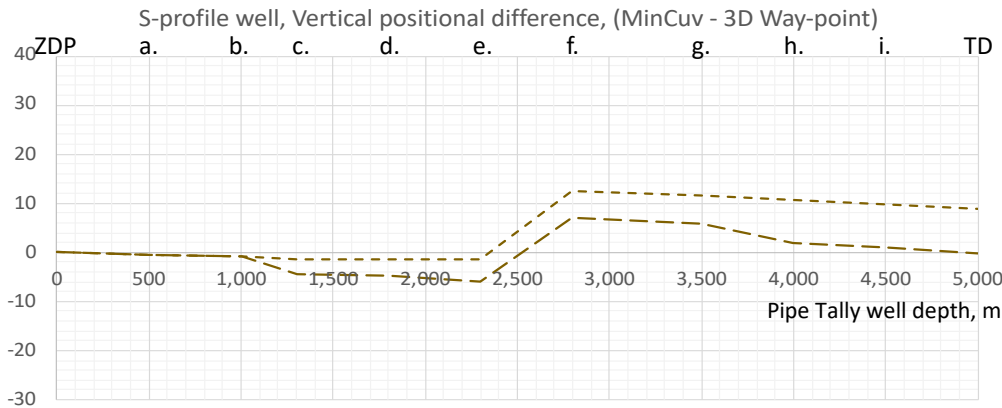


S-profile well, (MinCuv - 3D Way-point) inclination and azimuth values



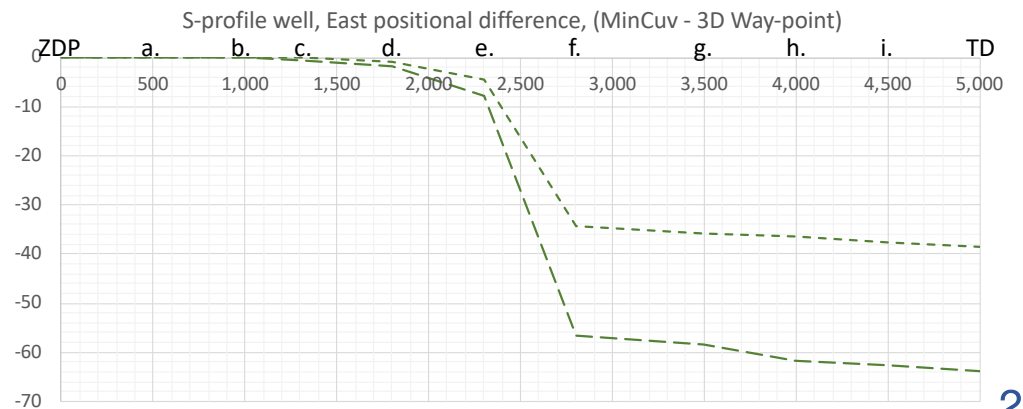


S-profile well positional differences



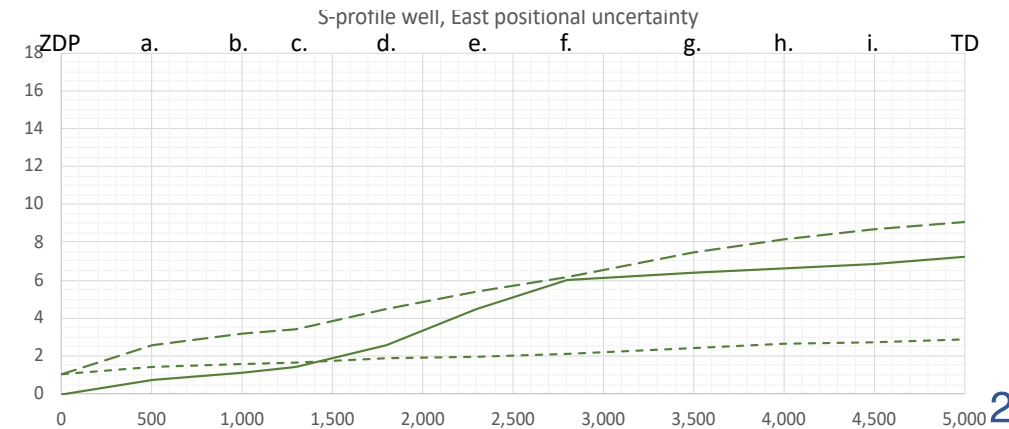
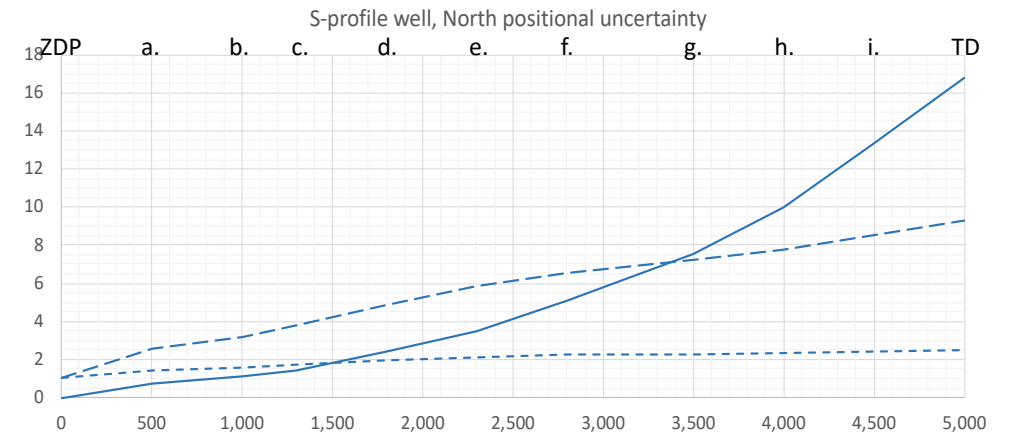
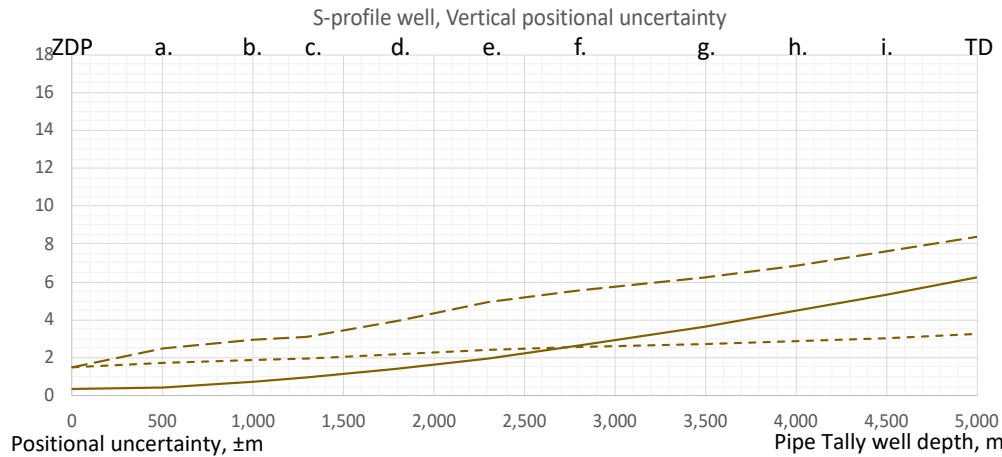
ISCWSA – 3D Way-point positional difference, m

- — — — — ISCWSA - 3D Way-point 500 m spacing positional difference
- - - - - ISCWSA – 3D Way-point 33.3 m spacing positional difference





S-profile well positional uncertainties



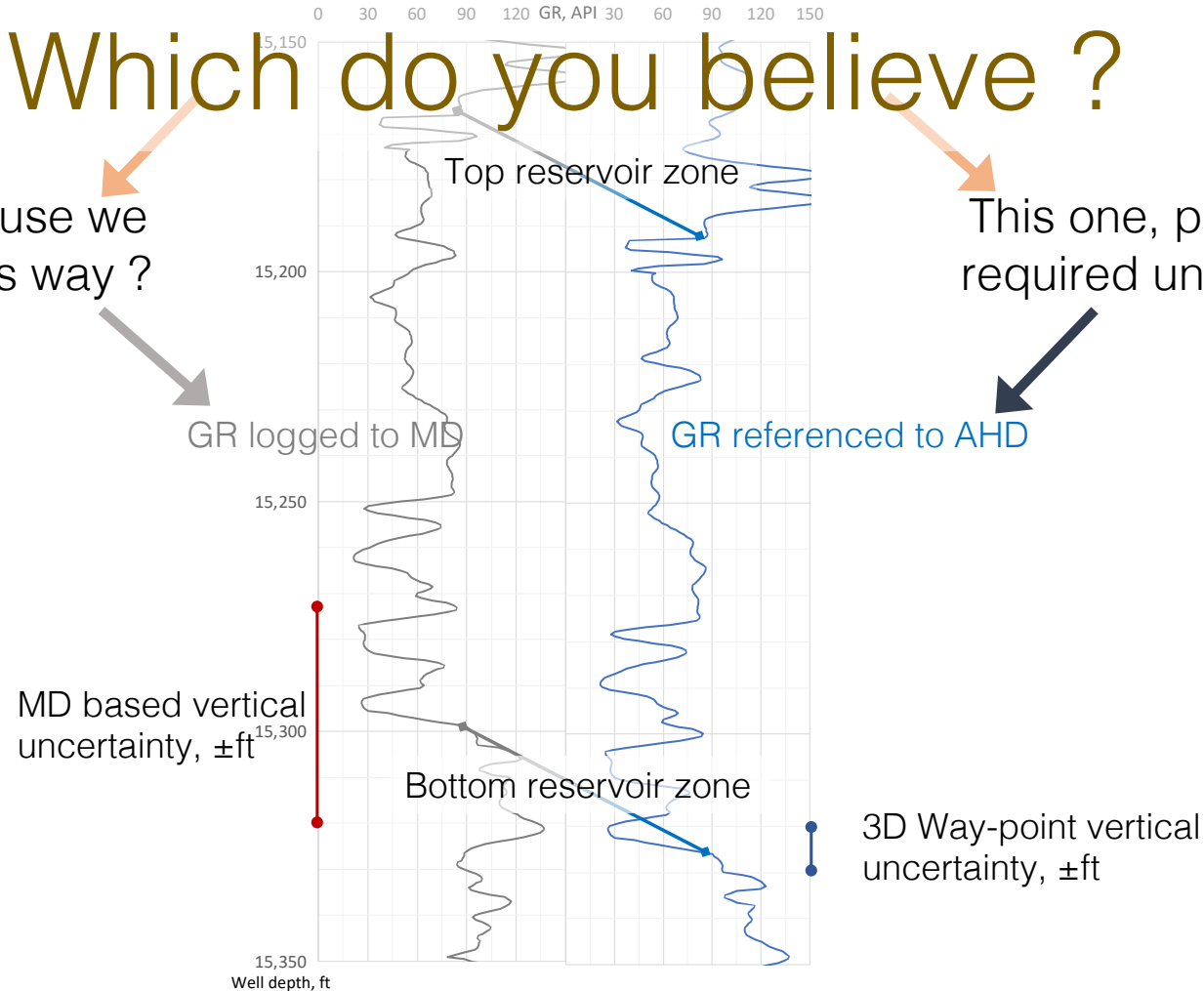
- ISCWSA 30 m positional uncertainty
- - - - - 3D Way-point 500 m positional uncertainty
- · - · - 3D Way-point 33.3 m positional uncertainty



Which do you believe ?

This one, because we
always do it this way ?

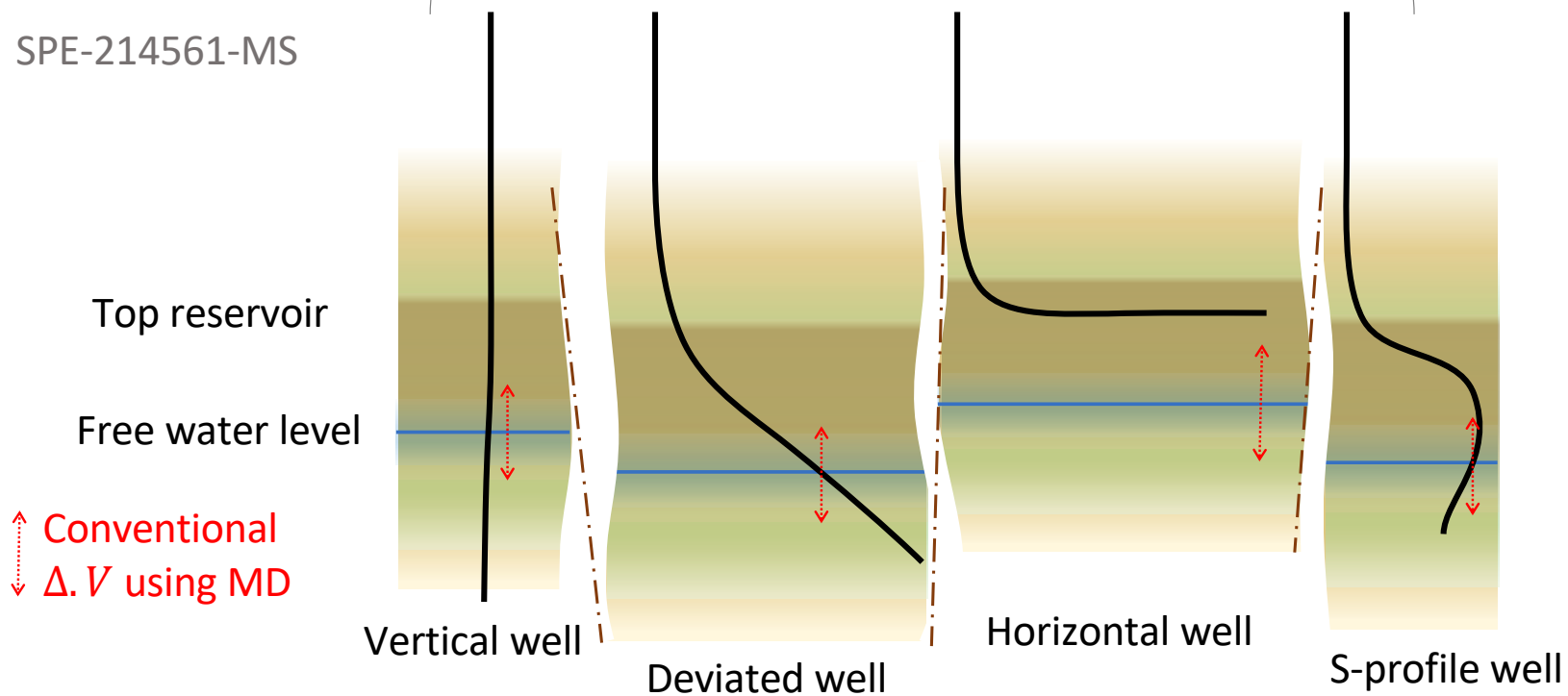
This one, provided to
required uncertainty ?



$\Delta.V$ and asset interpretation using MD

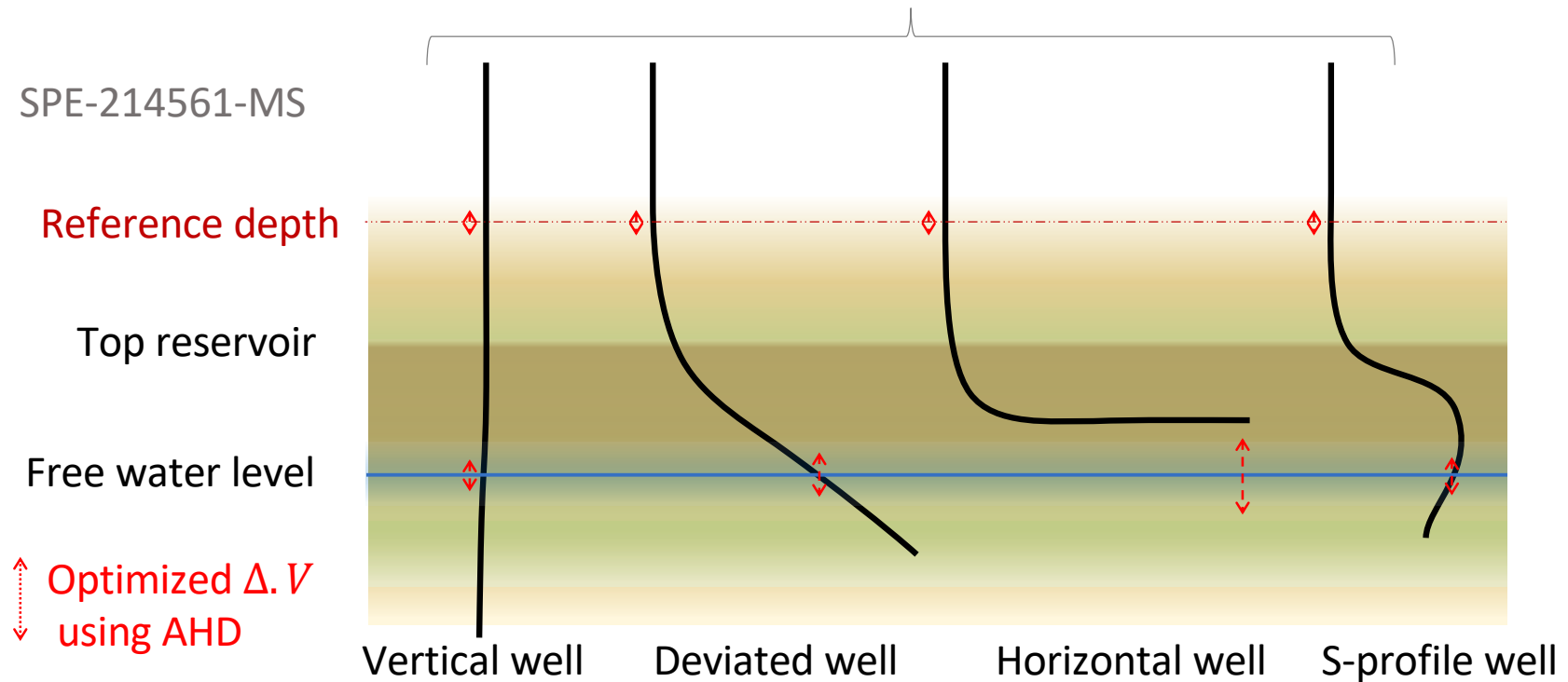
$\Delta.V$ based on Measured Depth (MD)

SPE-214561-MS

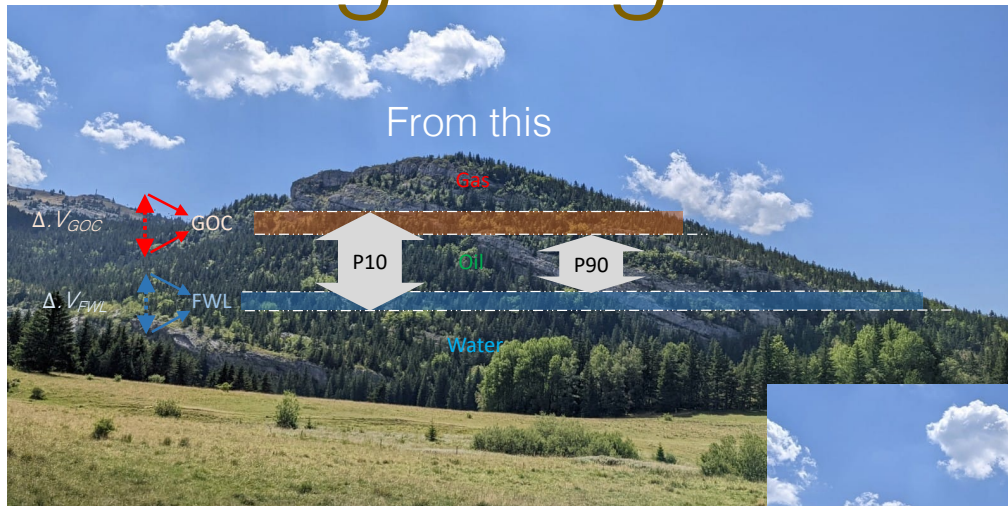


$\Delta.V$ and asset interpretation using AHD

$\Delta.V$ based on AHD

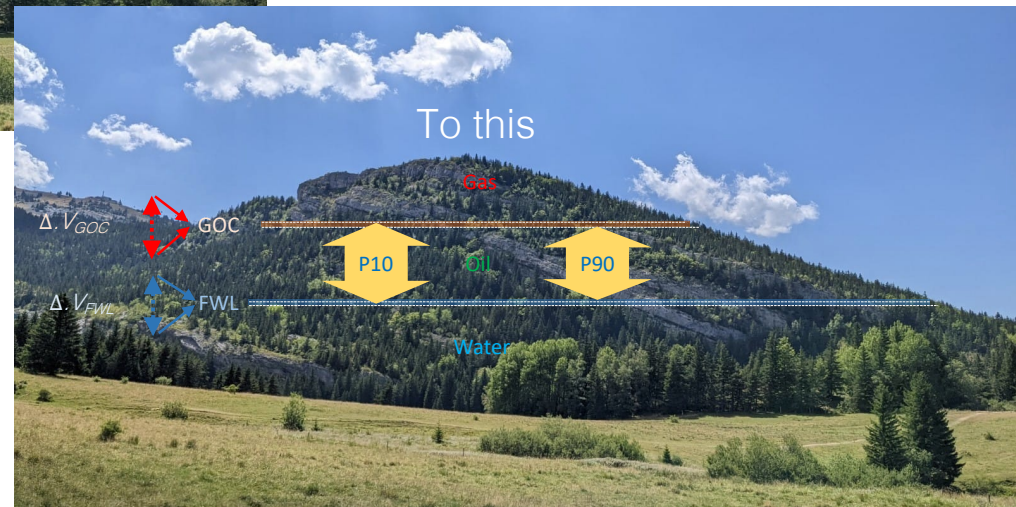


Actual geologies and real uncertainty



Requirements set out what is needed

Specifications deliver the results





The uncertainty comparative take-aways

3D Way-point (using 33 m intervals) 3D positional results are essentially identical to minimum curvature results.

Any 3D positional differences are explained by:

1. AHD vs. MD, and
2. inclination and azimuth model implementation.

Well depth based on AHD (versus MD) is a key accuracy component.

3D Way-point provides a “balanced” approach to well subsurface position and 3D positional uncertainty.

Increased accuracy in well depth, inclination, azimuth measurements, and reduction of survey interval length, reduce 3D positional uncertainties.

3D Way-point positional uncertainties, directly expressed as $\Delta.N$, $\Delta.E$, and $\Delta.V$, are significantly lower than the equivalent ISCWSA positional uncertainty.

Reduced 3D positional uncertainty diminishes operational risk and improves asset description confidence.

And certainly ?

Comments

Questions

Critique

Suggestions

