56th General Meeting
Main meeting 6th of October 2022
Houston

Wellbore Positioning Technical Section

The Industry Steering Committee on
Wellbore Survey Accuracy (ISCWSA)

Stay in Polygon: A Real-Time Lease Boundary Awareness Tool

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Agenda

- Introduction and Objectives
- Workflow
- Lease Boundary and Coordinates Conversion
- Distance to Lease Line (Shapely Library) and Distance to Plan
- Validations and Examples
- Alert Set Up
- Summary, Conclusions, and Q&A

Introduction and Objectives

- Introduction:
  - Every year several occurrences of wellbores crossing lease boundaries are reported. This translates into potentially significant fines and possibly loss of production.

- Objectives: Build a data analytics dashboard tool that…
  - Determines if the survey point is inside or outside the lease boundaries
  - Determine the distance of each survey point to the nearest boundary
  - Can be used for the design purpose using the planned survey
  - Can provide alerts to the drilling team when a well gets close to the lease boundaries
  - Can handle exceptions and honor the rules used in every BU

Current Workflow

1. Get the list of all active wells with available surf. lat. & long.
2. Pull all the lease boundary shape files for each well
3. Get the planned and actual real-time surveys
4. Coordinates conversion to state planes
5. Determine if each survey point is inside the lease using the **shapely** library
7. Determine the distance to the nearest lease boundary and to the plan
8. Send the result to database (and set alerts)
9. Display the results on the web-based vis. tool

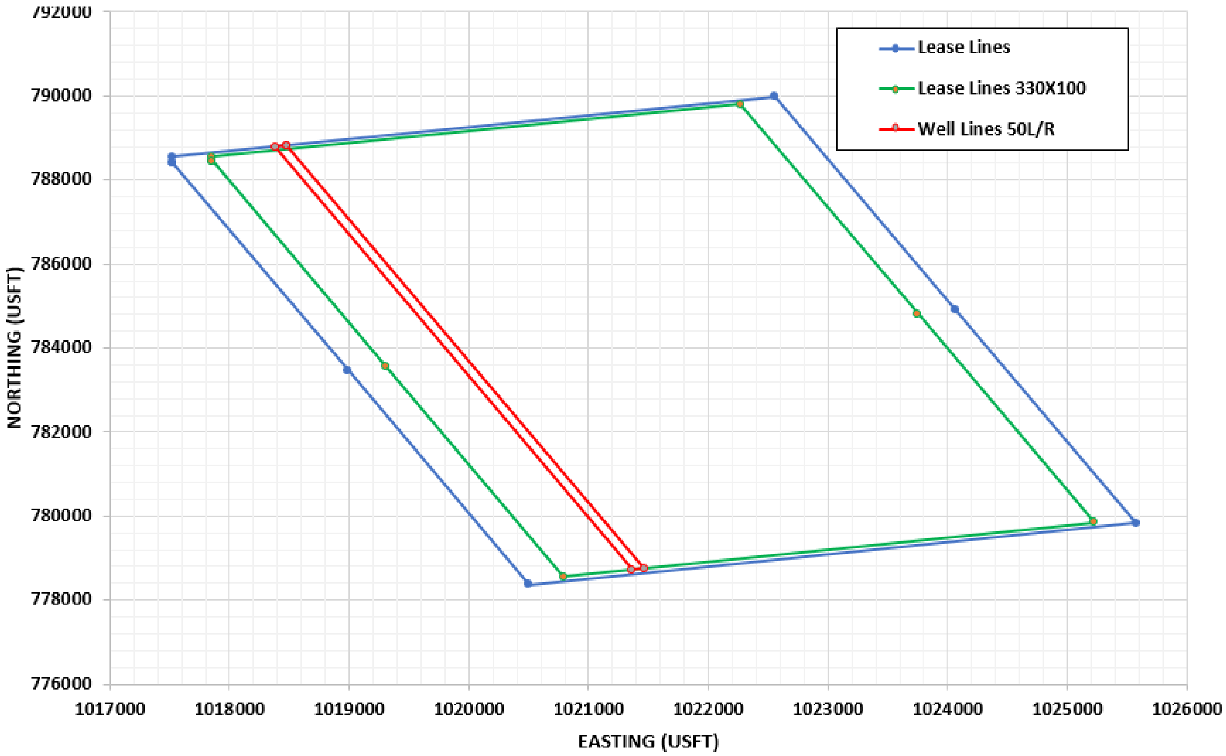
Real-Time Surveys

- Real-Time surveys are obtained via making API calls to the third-party company.
- Surveys are received in JSON format.
- Surveys are processed with quality controls to flag exceptions such as invalid rows or numbers to be deleted or replaced.

Index	Azimuth	DLS	E-W	nclinatior	N-S	TVD	tical Sect	depth
0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	28.8	0	28.8
2	342.26	0.26	-0.16	0.4	0.51	180.8	0.53	180.8
3	331.28	0.3	-0.41	0.59	1.06	251.8	1.14	251.8
4	333.06	0.19	-0.88	0.75	1.95	337.79	2.13	337.8
5	331.48	0.11	-1.45	0.84	3.03	425.78	3.34	425.8
6	326.84	0.08	-2.1	0.81	4.12	513.77	4.59	513.8
7	330.37	0.18	-2.79	0.96	5.27	600.76	5.9	600.8
8	324.93	0.12	-3.55	0.91	6.47	687.75	7.29	687.8
9	330.84	0.14	-4.26	0.83	7.6	775.74	8.59	775.8

Lease Boundaries

- Lease boundaries are defined as closed polygons of an arbitrary shape.
- 330X100 lines and well lines (50 L/R) are also recorded.
- Latitude and longitude for the surface locations are provided in **NAD 27** while lease boundary coordinates are presented in the State Plane (SP) Coordinate Reference System (CRS).



Coordinates Conversions

- **pyproj** library in Python is used for coordinates transformation (conversion). However, EPSG code for each location is needed to implicitly define the CRS.
- **stateplane** library is used to obtain EPSG for each location.
- EPSG for NAD 27 is **4267**.
- Example: consider (long., lat.) = (-103.4, 31.7)

  stateplane.identify(-103.4, 31.7) – 100 = 32039 (EPSG for this location)

  nad27_state = pyproj.Transformer.from_crs(4267, 32039)

  east_spc, north_spc = nad27_state.transform(31.7, -103.4)

  (1,046,343.693, 752,659.949)

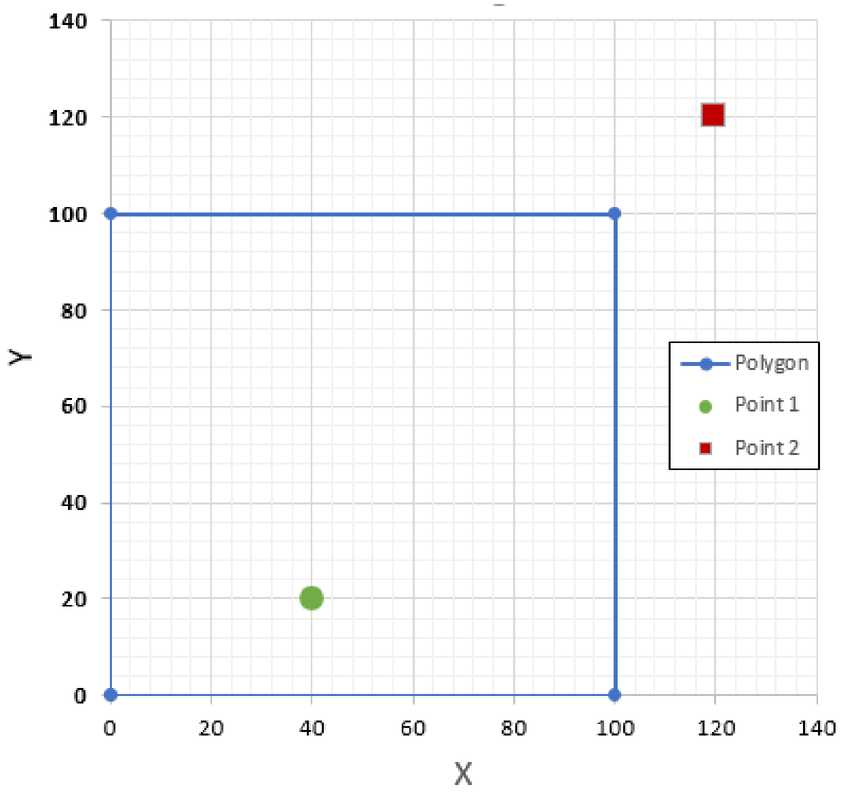
Shapley Library

- We need to know if a certain survey point is inside or outside of a certain lease boundary. Then, determine the distance to the **nearest** boundary.
- **Shapely** library in Python
- Example:

```
poly = Polygon([[0,0], [100, 0],[100, 100], [0,100],[0,0]])
```

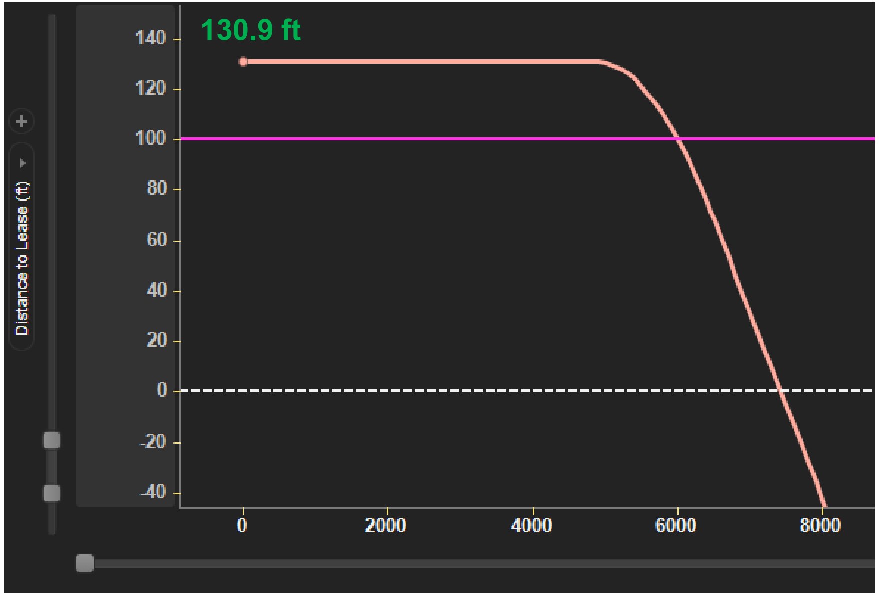
```
p1 = Point([40, 20])

p1.within(poly)
True

poly.exterior.distance(p1)
20.0
```

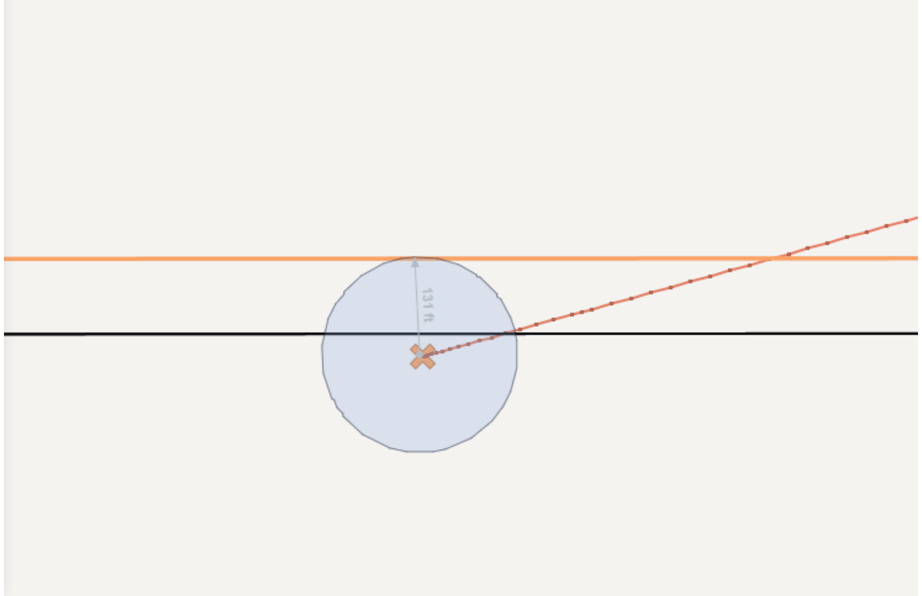
```
p2 = Point([120, 120])

p2.within(poly)
False

poly.exterior.distance(p2)
28.284271247461902
```



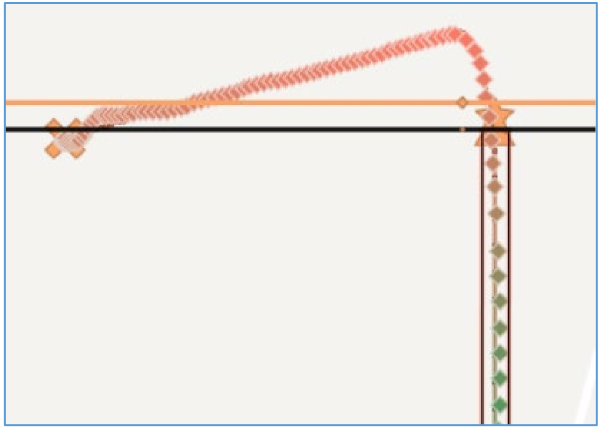
Model Validation

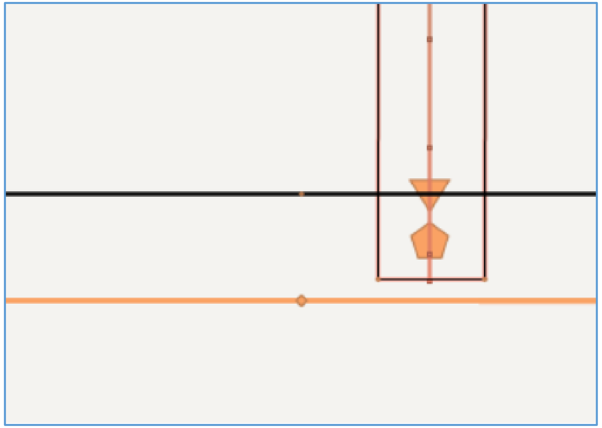
- Publicly available tools such as google maps could be used for tool validation (130.9 ft vs. 131 ft).





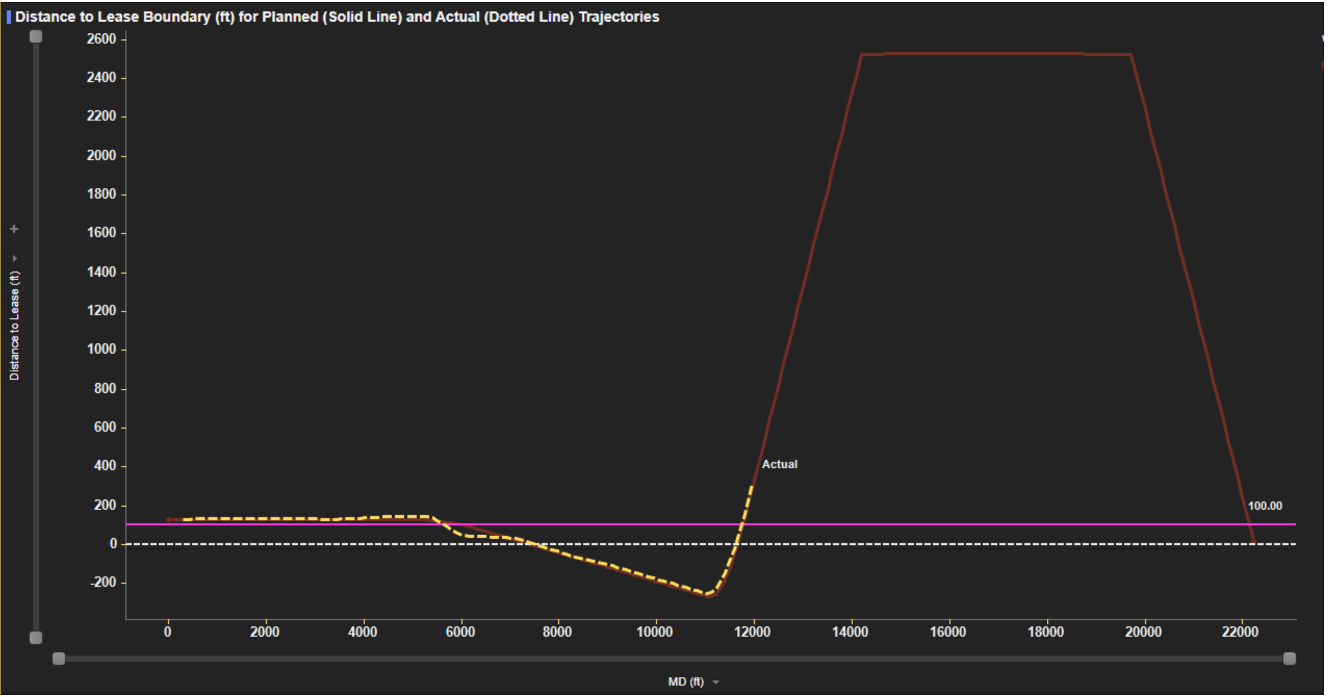
Definitions (For Texas)

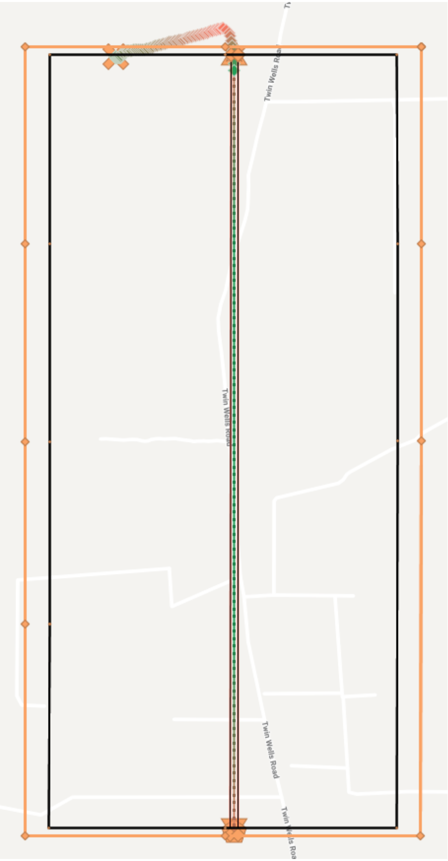




- **Surface Hole Location (SHL)** – Surface Coordinated (Usually, NAD 27 for US Land).
- **Penetration Point (PP)** – Location at which the upper formation is planned to be penetrated with respect to a given Field Rule.
- **First Take Point (FTP)** – Upper location in the wellbore that can be legally perforated.
- **Last Take Point (LTP)** – Lower location in the wellbore that can be legally perforated.
- **End of Terminus (EOT)** – The location of the projected total depth of the well cannot exceed this point.

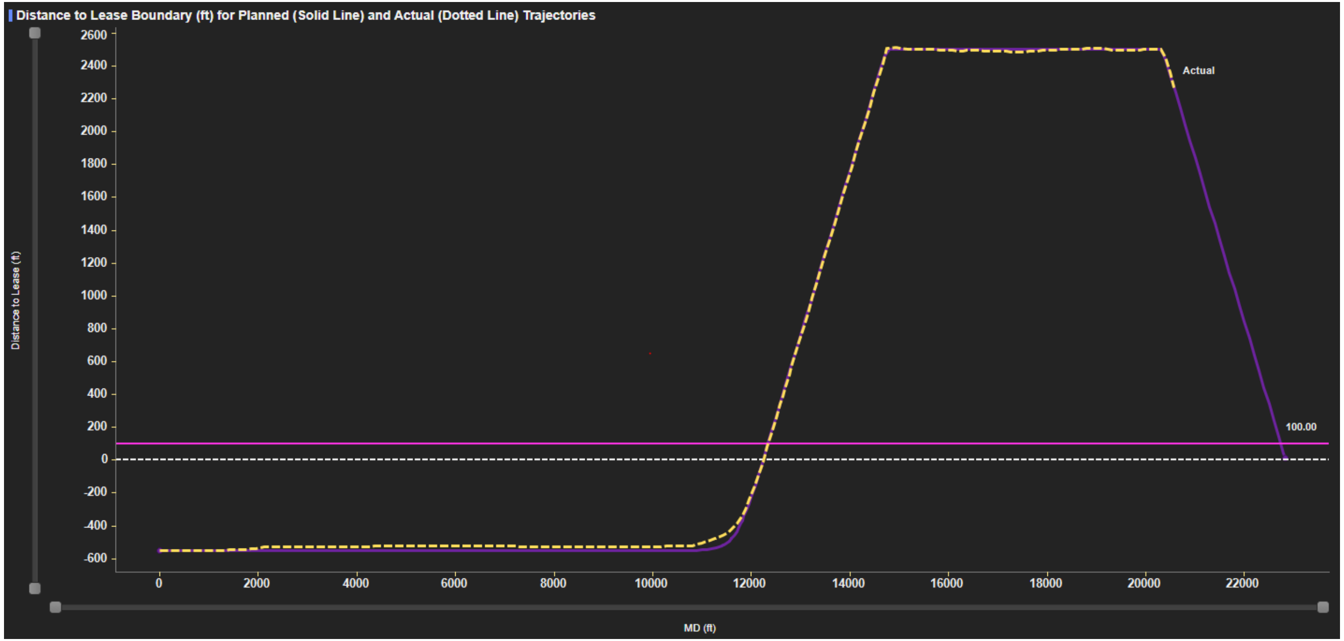
Example 1





- Points outside of the boundary are shown with negative values.

Example 2



- Note that depending on the state and rules, SHL can be outside of the lease lines.

Distance to Plan - The Discrete Boundary Model (DBM)

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Study of Distance Computation between Objects Represented by Discrete Boundary Model

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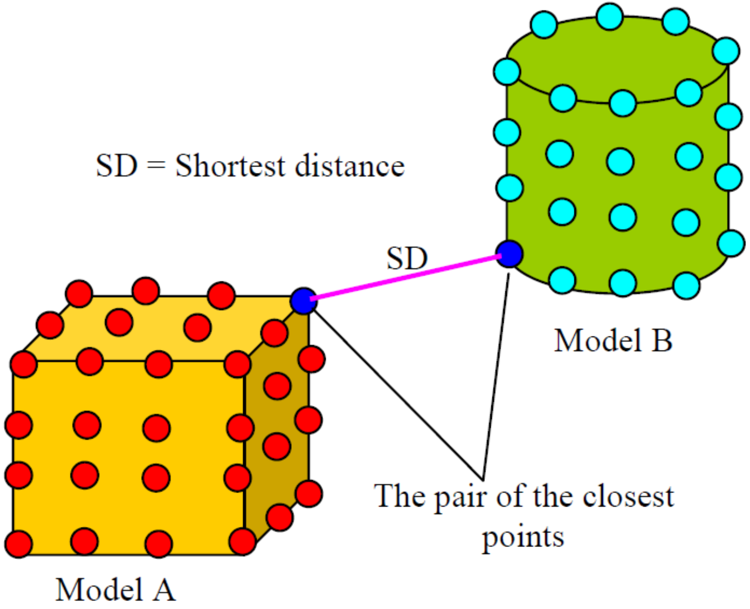
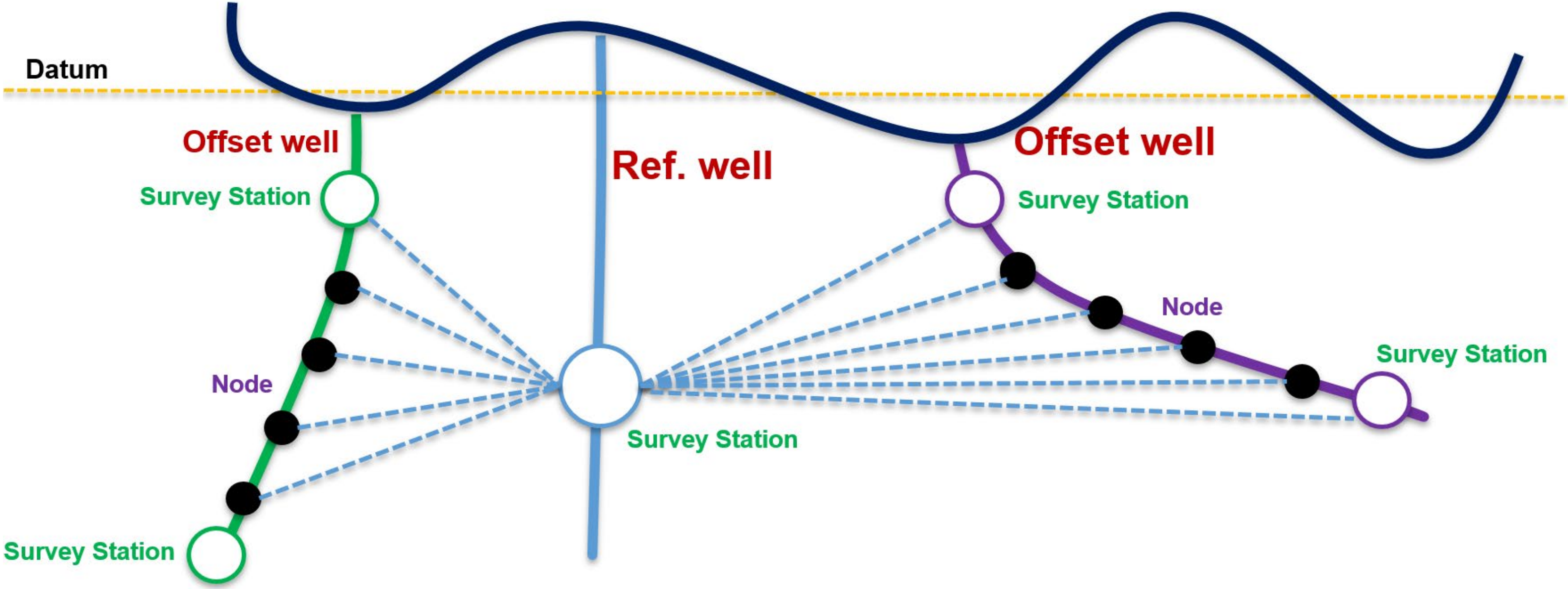
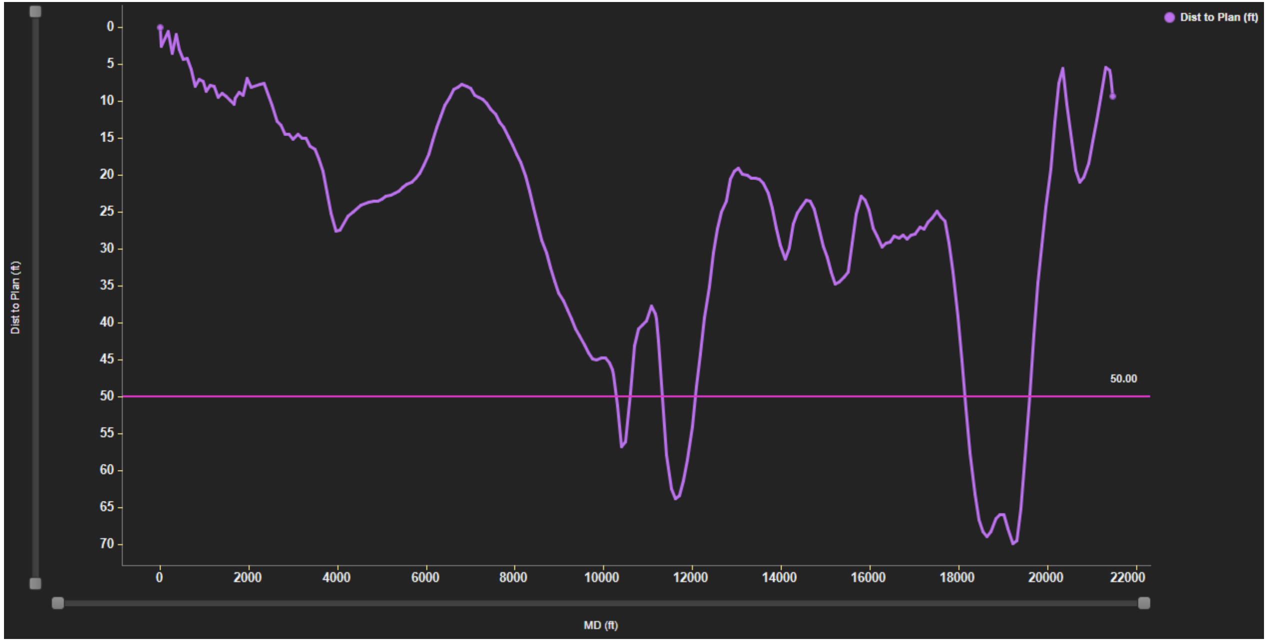


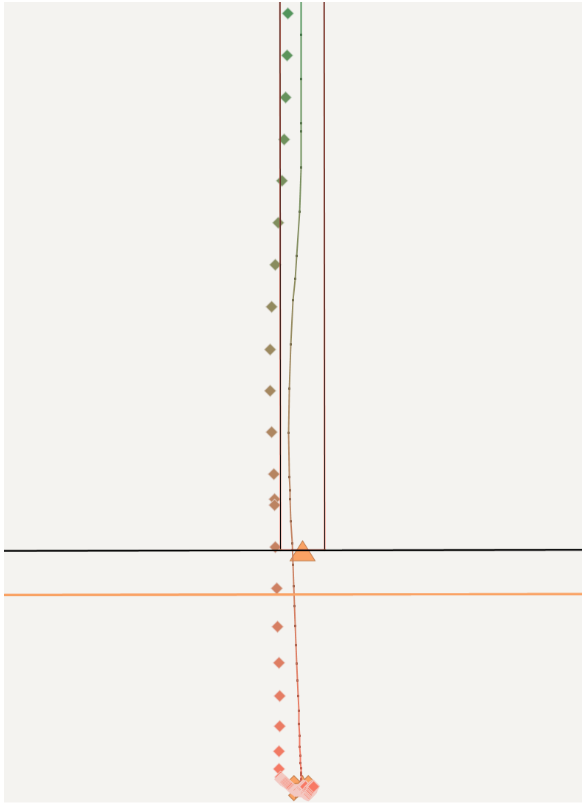
DBM Implementation



- In this case, offset well is the actual survey vs. reference well (planned survey).
- Surface location uncertainty is ignored for simplicity.

Example for Distance to Plan





Setting Up Alerts

send_alert	email_list	lease_alert_ft	dist_to_plan_...	Previous_Depth	Current_Depth
				22714.23	22714.23
				20580.00	22802.00
				0.00	15784.13
				11963.00	13237.00
				4230.63	6734.10
				22055.19	22055.19
				0.00	1484.00
				11130.73	11287.12
				9139.87	10752.34
				8770.60	9911.68
				1545.00	1885.00
				0.00	0.00
				20646.06	20646.06
				0.00	0.00
				1531.93	3392.49
YES	ali_karimi@oxy.com, jonathan_lightfoot@oxy.com	50.00	100.00	0.00	0.00
				437.90	437.90
				16484.79	18642.89
				10327.87	10327.87
				1515.99	1515.99
YES	ali_karimi@oxy.com,	50.00	80.00	14159.90	21564.84
NO	ali_karimi@oxy.com,	50.00	75.00	9736.00	10308.00
YES	ali_karimi@oxy.com, jonathan_lightfoot@oxy.com	75.00	60.00	0.00	19375.00
				3897.31	6569.71

Alarm Setup

Well API10: 4231744214

Send Alert: YES

Email: ali_karimi@oxy.com,

Dist. To Lease Trigger: 50

Dist to Plan Trigger: 80

Submit

- Currently, email alerts can be set up for each well according to the desired threshold.

Summary and Conclusions

- A real-time tool was developed to monitor distance to the lease boundaries and also planned well.
- Real-time directional surveys are provided via API calls.
- Shapley and pyproj python libraries are used.
- DBM model is implemented to obtain distance from the plan.
- Customized alerts could be set up.
- The tool was tested for several wells and could successfully provide warnings.
- Could significantly reduce lease violation incidents and associated cost.

Thank you!

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