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CASE BASED REASONING

REAL-TIME PROBLEM AVOIDANCE

AGENDA

- Conclusion(s)
- Background
  - Goal
  - Example
- Opportunity–Automated Decision Making
  - What is Case Based Reasoning?
- Methodology—How did we evaluate success?
- Results—What is the bottom line?
- Review

CONCLUSION

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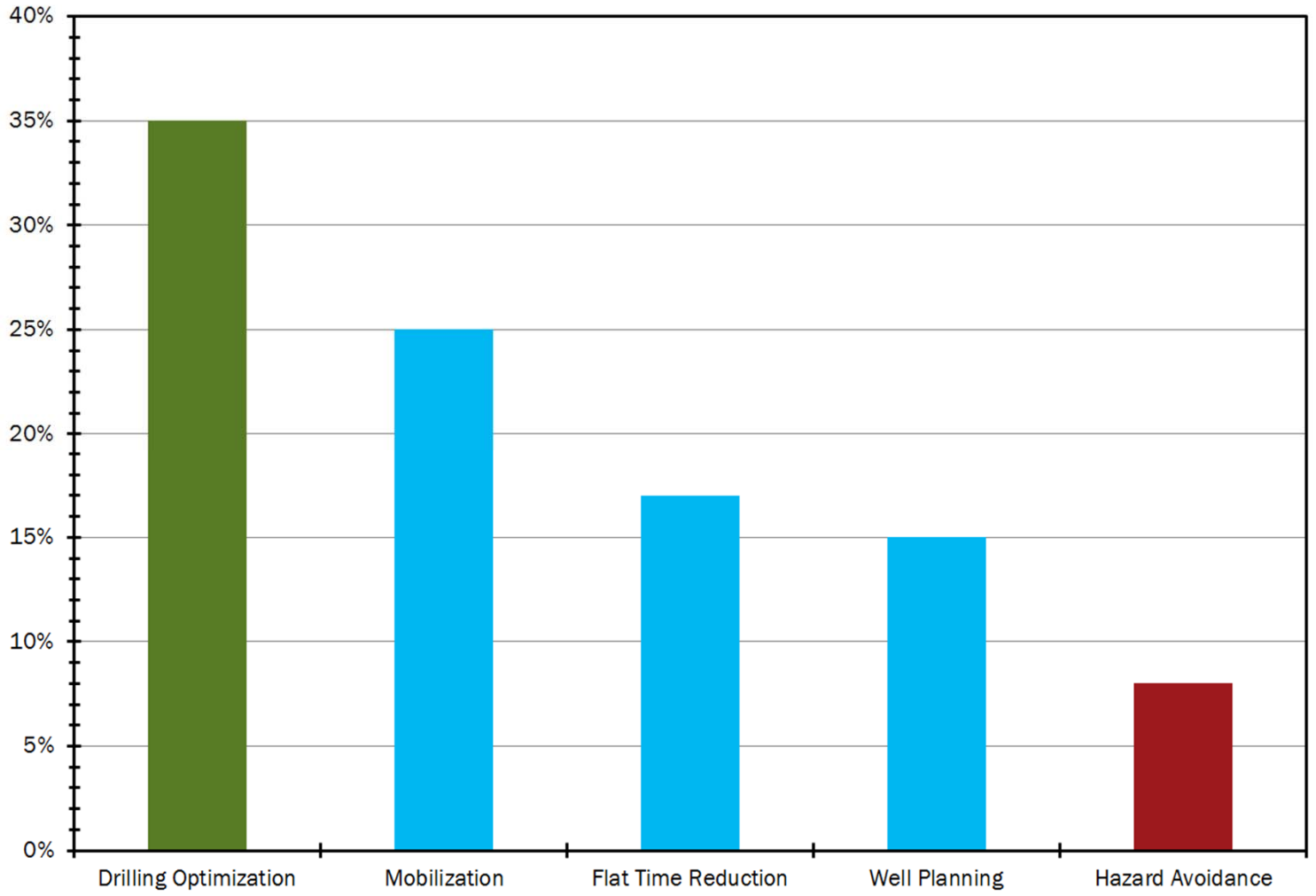
Implementation of a Real-Time Case Based Reasoning system was correlated to significant reduction in non-productive time

VERDANDE™ TECHNOLOGY

*Correlation does not imply causation

GOAL
AFFECT KPIs AND DRIVE VALUE TO INVESTORS



Based on going from 15 days/well to 10 days/well:

Results from DuPriest (SPE 134580) and our Peake Move Process

EXAMPLE

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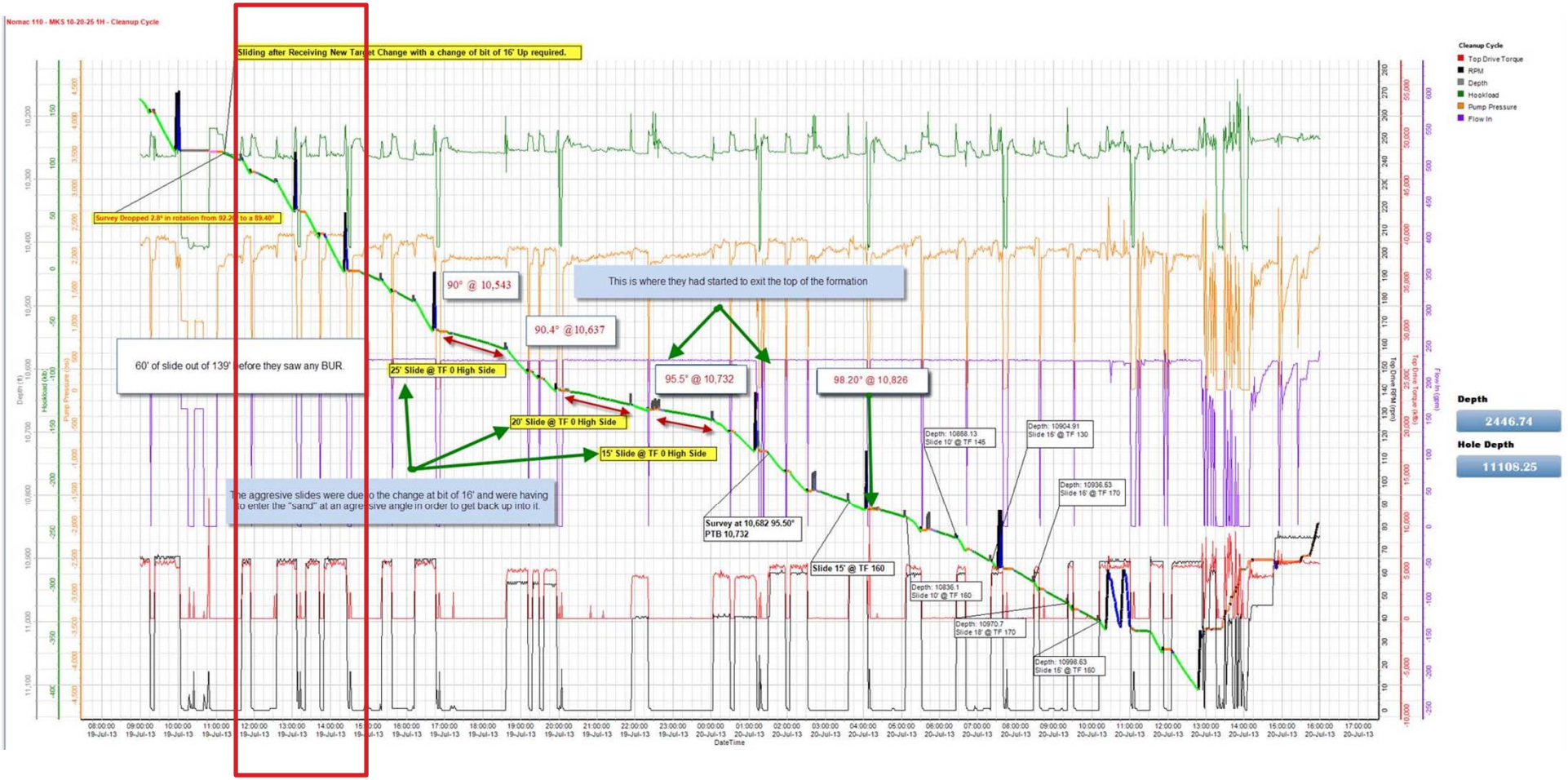
REAL TIME EXAMPLE

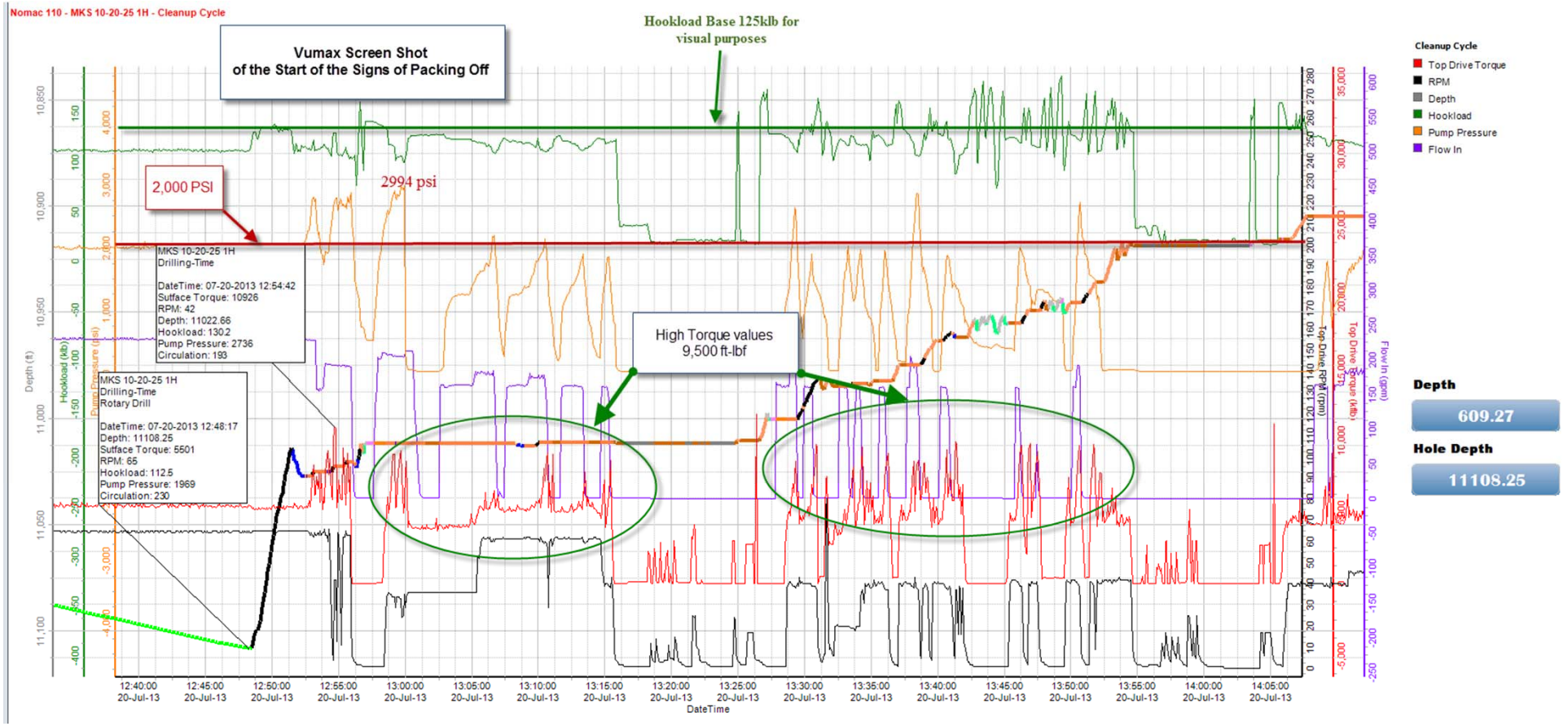
DRILLING OUT OF ZONE



Rig starts getting out of zone at approximately 11:00—All hands on deck!

But, something else starts happening at 12:30.....

REAL TIME EXAMPLE
DRILLING OUT OF ZONE (CONT.)



- Increase in pressure and torque suggest packoff ahead
- Consultant, Superintendent, DOC and Engineer all missed the signs
- Packoff led to sidetrack!!

OPPORTUNITY

EVERY PROBLEM IS AN OPPORTUNITY!

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Observation

1. People CANNOT watch everything 24/7
2. Bias and/or Experience influence actions

Opportunity

Automate detection of problems and application of engineering best practices

AUTOMATED DECISION MAKING
3 COGNITIVE MODALITIES

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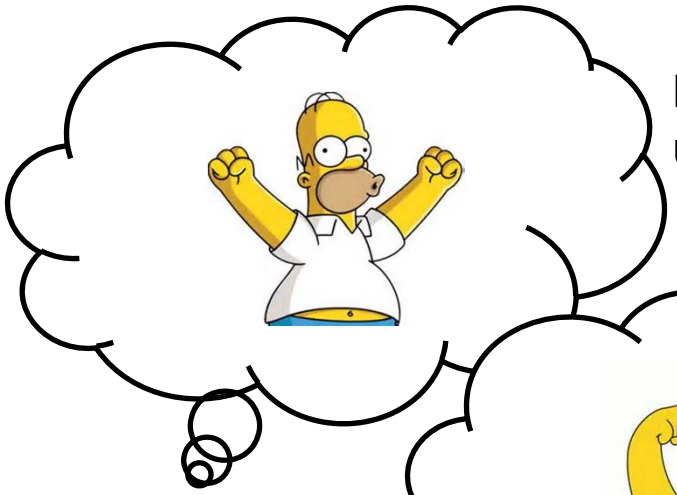
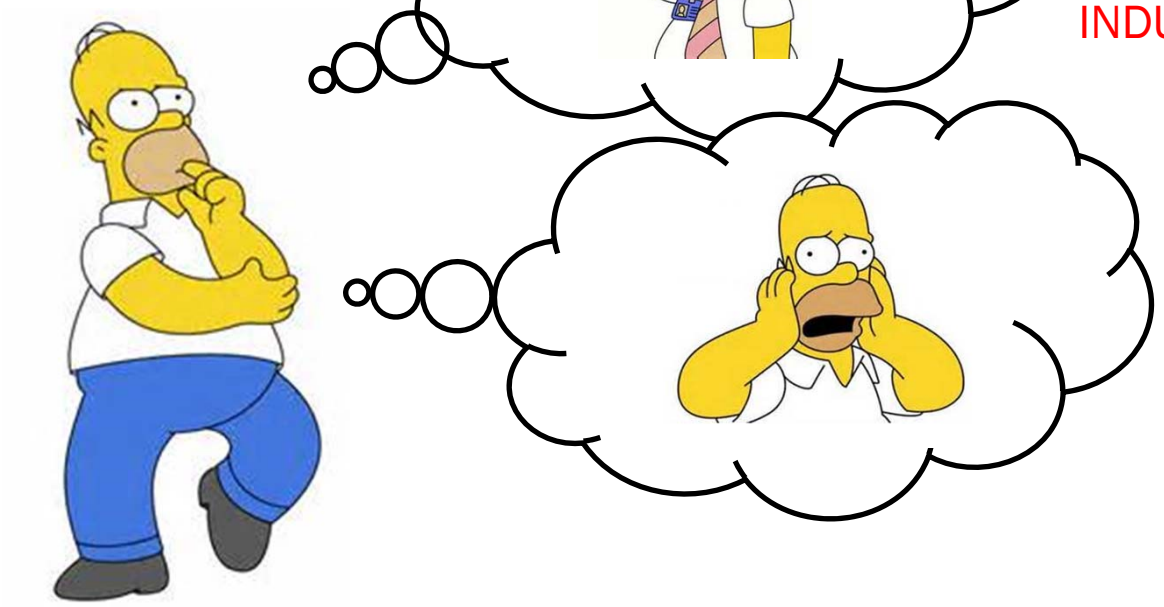
HOW DO ENGINEERS SOLVE PROBLEMS?



Is there a rule, equation or procedure I can use? If so, WOOHOO DEDUCTIVE

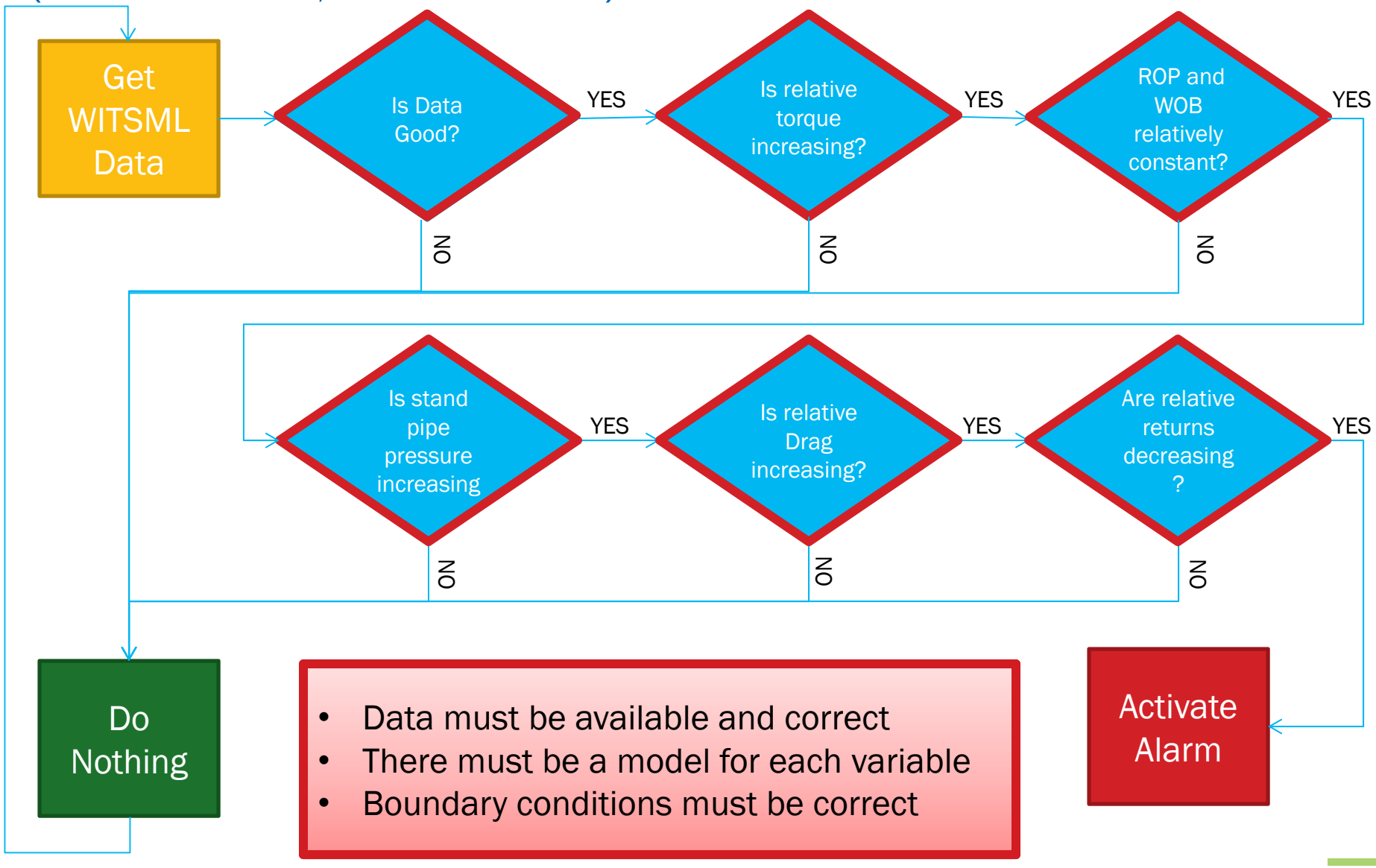
Have I seen something similar before? What worked then? Probably donuts…mmmmm. INDUCTIVE



Gonna have to guess--DOH! ABDUCTIVE

DEDUCTIVE REASONING SYSTEMS

(MACHINE LOGIC, DETERMINISTIC)



- Data must be available and correct
- There must be a model for each variable
- Boundary conditions must be correct

INDUCTIVE REASONING SYSTEMS
(CASE BASED REASONING, PROBABILISTIC)

Problem: Who is Pie Man?

6% Match

36% Match

1% Match

57% Match

ABDUCTIVE REASONING SYSTEMS
(ARTIFICIAL INTELLIGENCE, HEURISTIC + RANDOM)

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Sometimes.....

You just have to guess

METHODOLOGY
EVALUATING
CASE BASED REASONING

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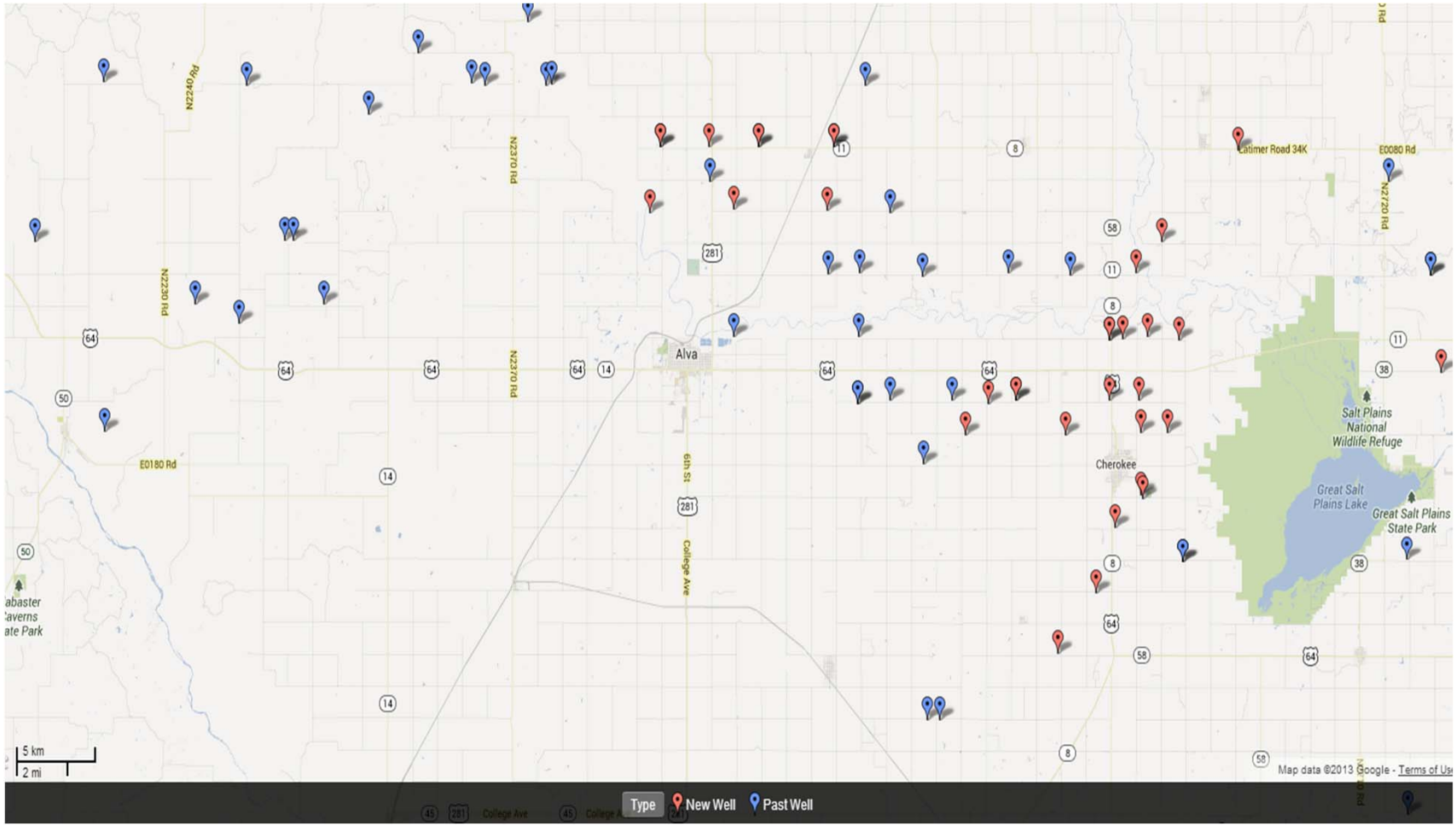
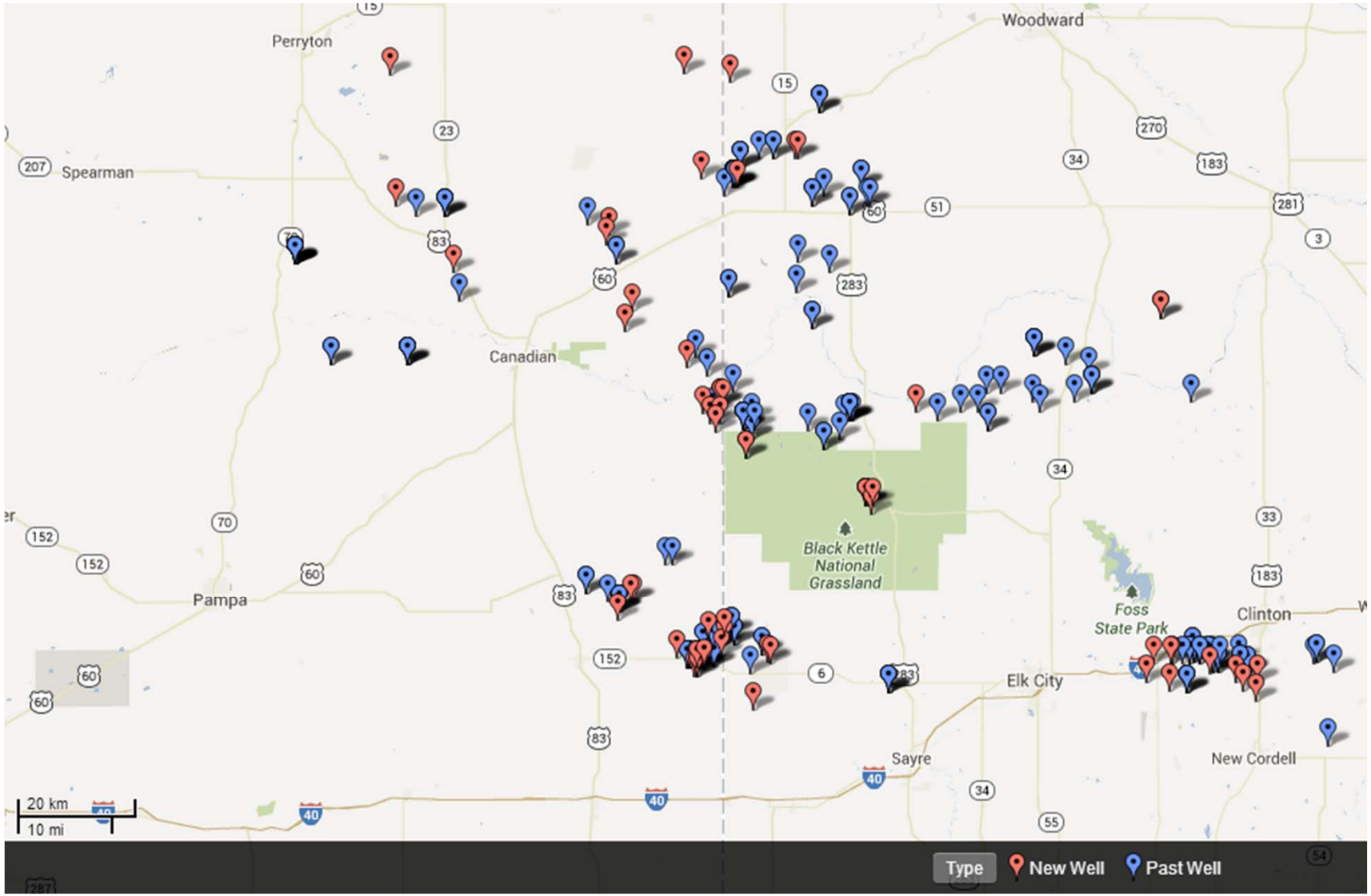
FOLLOW SCIENTIFIC METHOD

- Make Observations
- Form Hypothesis
- Conduct Experiment
- Evaluate Hypothesis

AREA #1

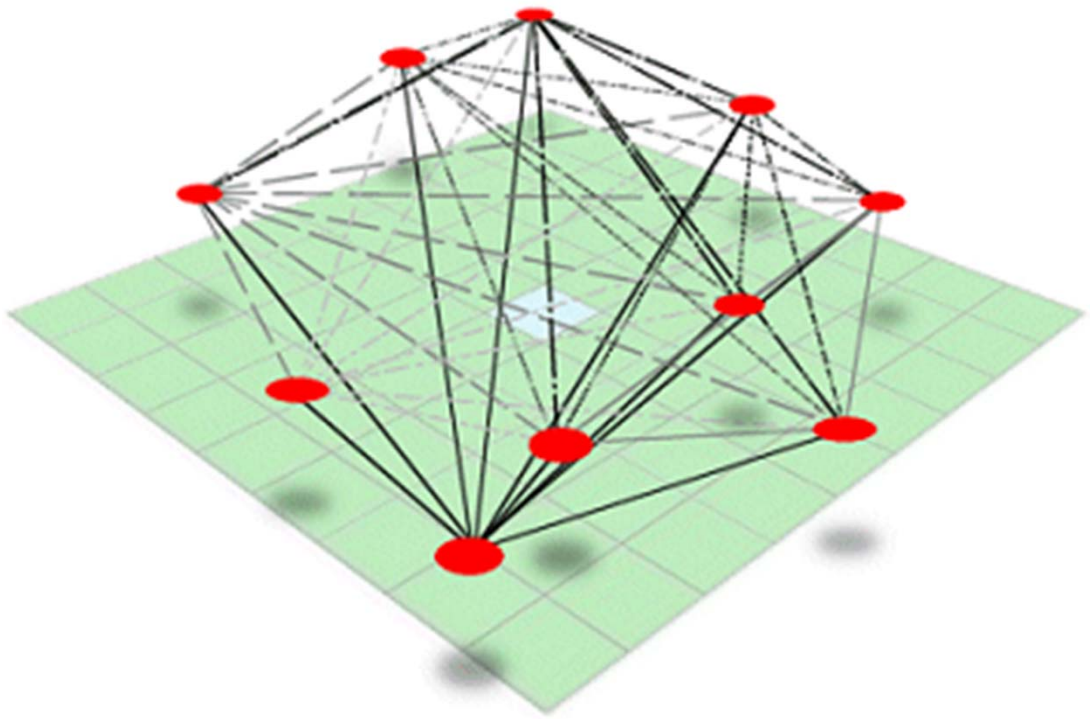

Alva
Cherokee
Salt Plains National Wildlife Refuge
Great Salt Plains Lake
Great Salt Plains State Park
Latimer Road 34K
E0080 Rd
N2720 Rd
N2370 Rd
N2240 Rd
N2230 Rd
E0180 Rd
6th St
College Ave
5 km
2 mi
Map data ©2013 Google - Terms of Use
Type
New Well
Past Well

AREA #2


Perryton
Woodward
Spearman
Canadian
Black Kettle
National
Grassland
Foss
State Park
Clinton
Pampa
Elk City
Sayre
New Cordell
20 km
10 mi
Type
New Well
Past Well

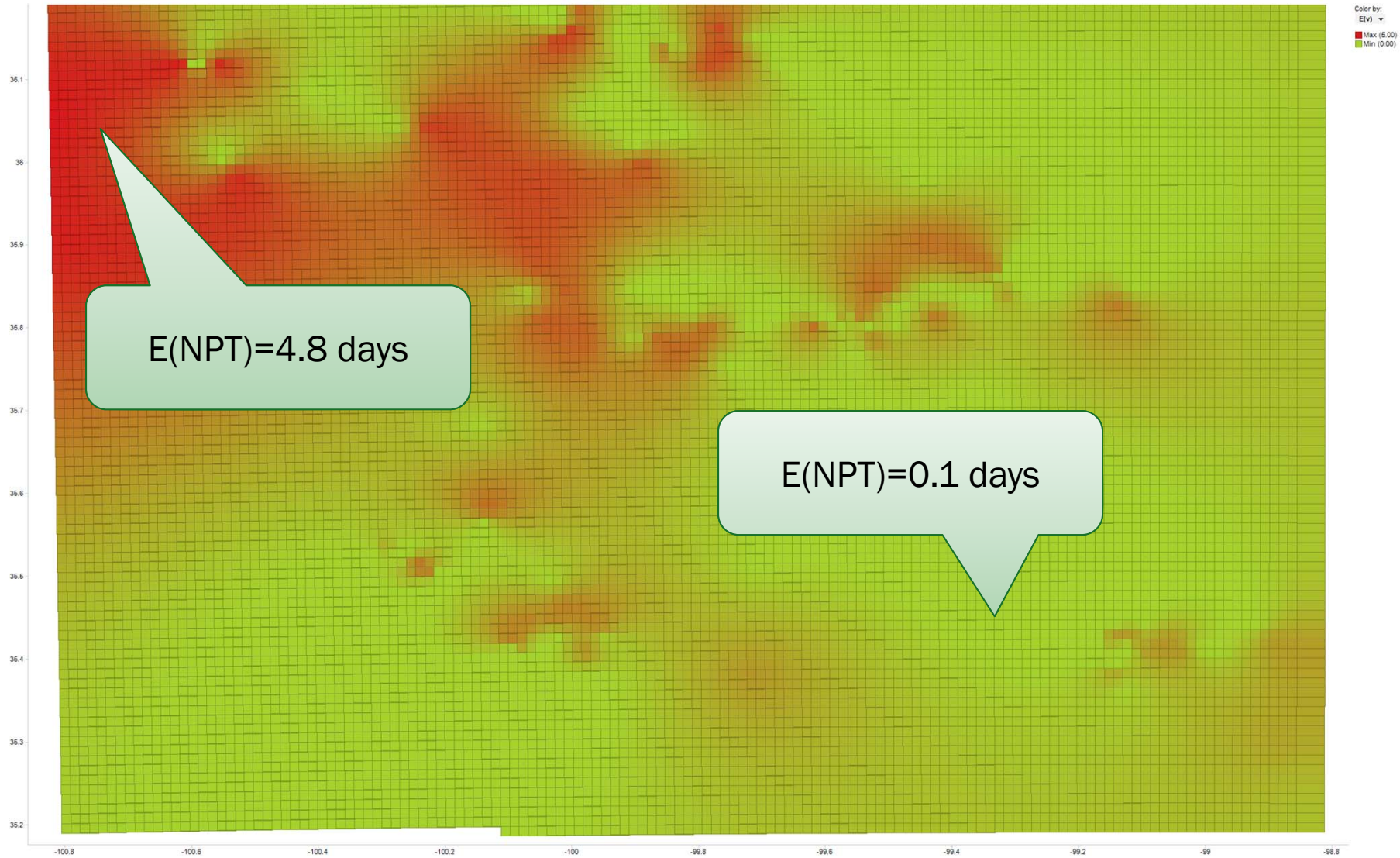
GEOSPATIAL ESTIMATION OF NPT

1. **Normalize Data**
   - Exponentially Distributed
   - Orthogonal Coordinate System
2. **Establish Spatial Variance (variogram)**
   - Exponential Variance about Point of Interest as a Function of Distance
3. **Perform Unbiased Weighted Averaging (Kriging)**
   - Solve LU Decomposition of Sparsely Populated Matrix



- **Considers points across three dimension space**
- **Returns values for all points in space constrained by grid**
- **Affected by zero or null values**
  - Probability Matrix applied after

EXPECTED NPT



CAVEATS

- A negative event or outcome cannot be proven
- An objective approach is to determine a probabilistic expectation of a future event based on past outcomes.
- If we assume that problems are highly correlated to WHERE we are drilling, then a geo-spatial estimation is appropriate.
- If there is only one change to the system, we may correlate the difference in performance to that change
- Drill Edge is not a probability tool, it is a similarity tool

RESULTS

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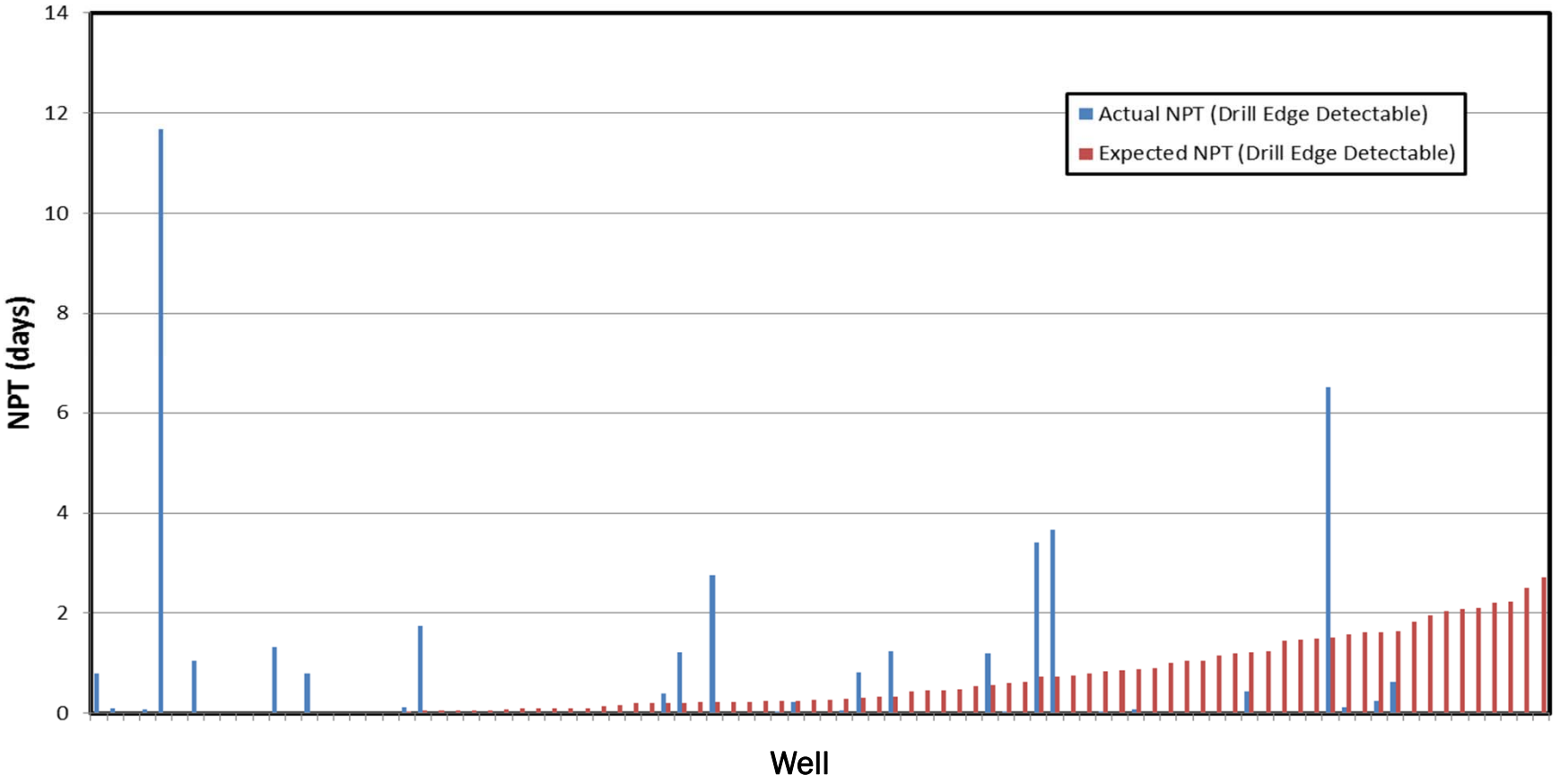
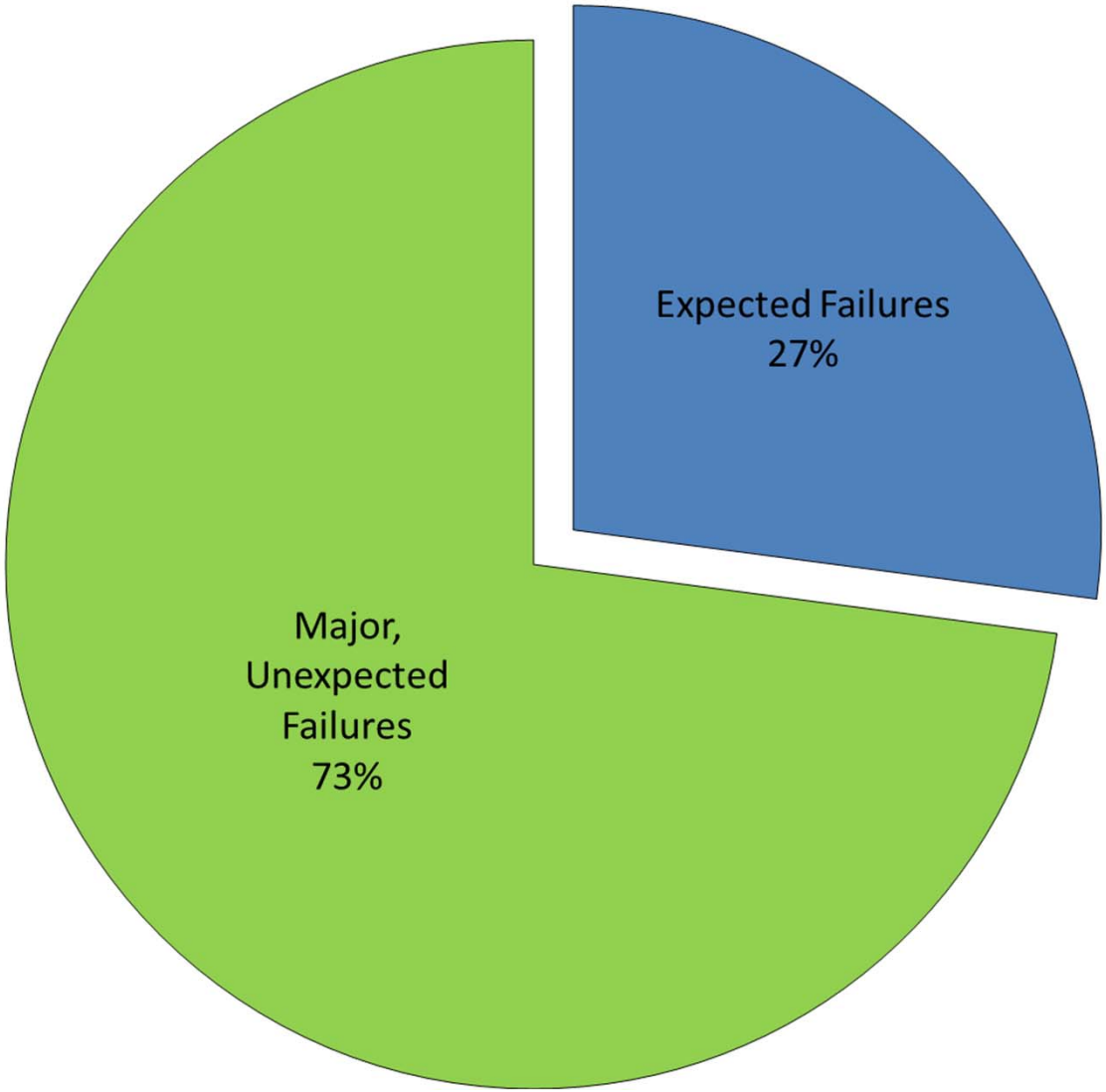
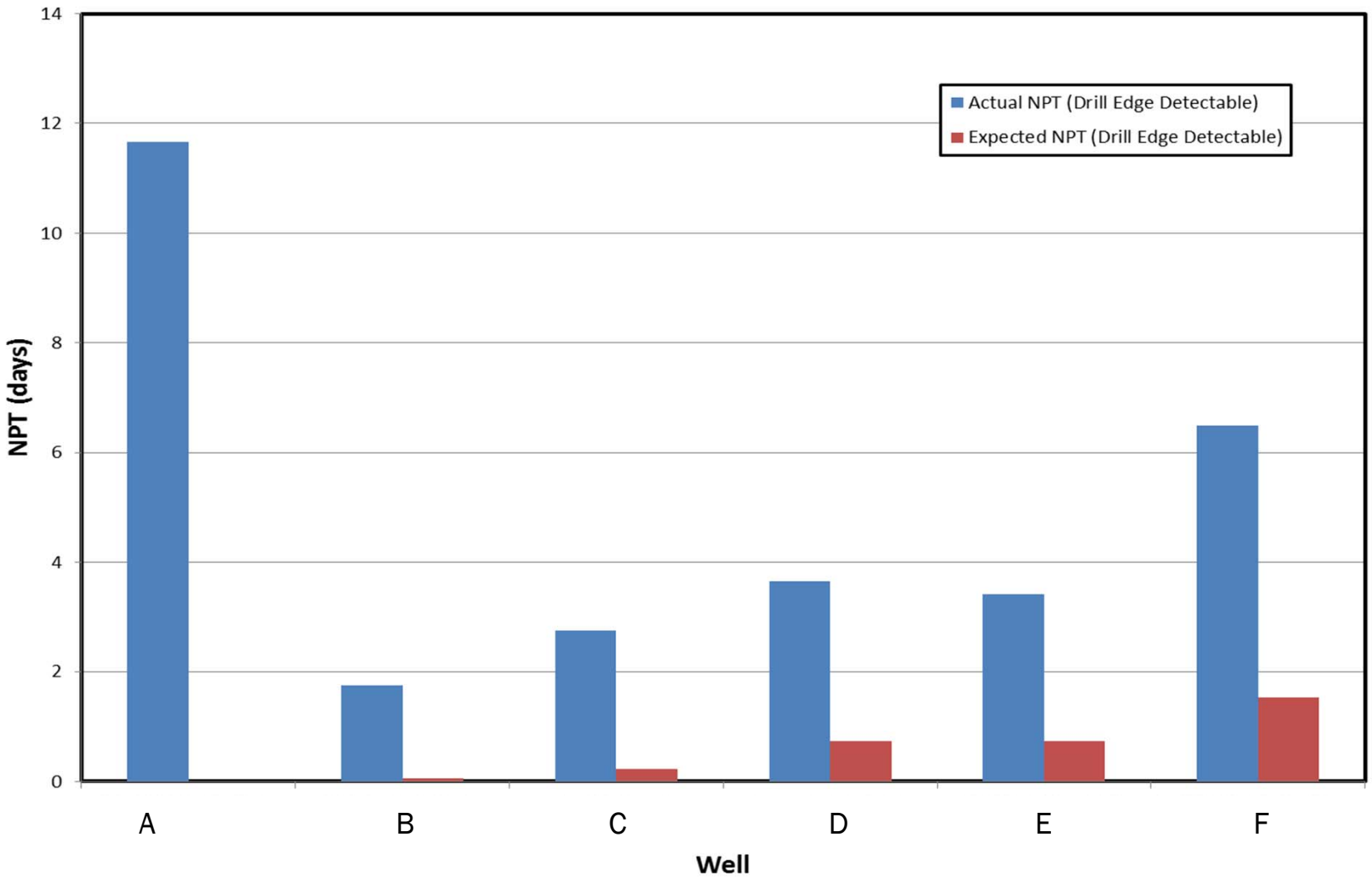
MOST WELLS HAVE MUCH LOWER NPT THAN EXPECTED



MAJOR FAILURES REPRESENT 73% OF ALL APPLICABLE DOWNTIME



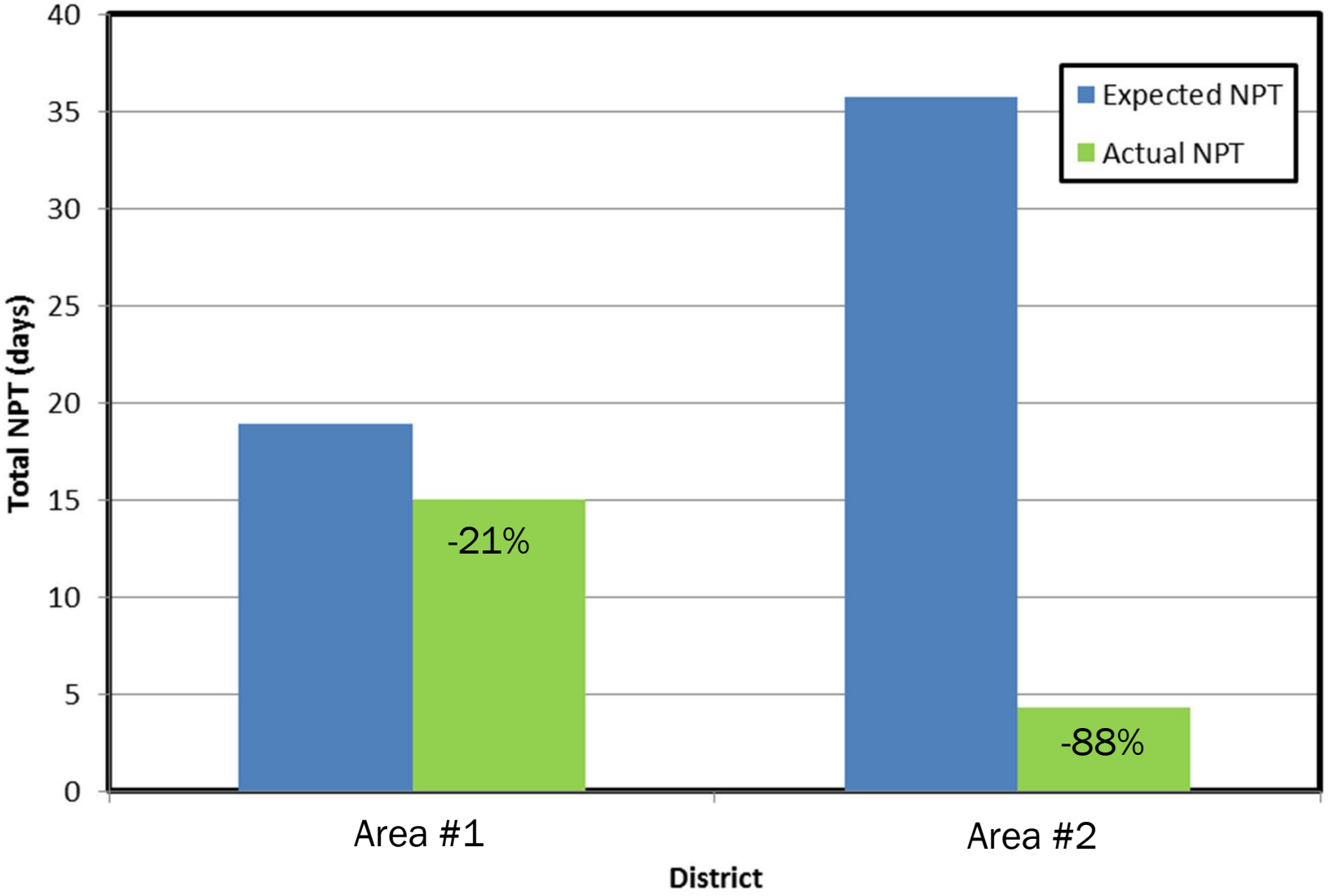
SOME WELLS WITH NPT SIGNIFICANTLY HIGHER THAN EXPECTED



4 OF 6 MAJOR FAILURES (21 DAYS) WERE PREVENTABLE

Well	Actual	Expected	Days Notice	# Warnings	Comment	Avoidable?
A	11.7	0	6	14	Rig/Sup Disregarded Warnings	YES
B	6.5	1.52	0	0	Rig took action before agents triggered. No pressure/rate data from pumps available to trigger agents. Rig was pumping 7000 gal/day to compensate for losses	NO
C	3.66	0.74	7	11	Warned of Stuck Pipe. Rig did not agree with diagnosis.	YES
D	3.4	0.74	5	7	Warned in advance. Rig did not agree with diagnosis	YES
E	2.75	0.22	8	18	Tight Hole noted as early as 8/4. Occurred while tripping in.	YES
F	1.75	0.05	0	0	Stuck Pipe/Tight Hole. No agents were triggered	NO

CORRECTING FOR PREVENTABLE FAILURES—IMPROVEMENT IS CLEAR



VALUE

- Estimated 15-37 Rig Days Saved

CONFOUNDING VARIABLES

- **Study is not blind**
  - Control Groups are required

System In Use Driller informed it IS	System In Use Driller informed it IS NOT
System NOT In Use Driller informed IT IS	System NOT in Use Driller informed it IS NOT

- **Rigs may improve because someone is watching**
  - Recall factory lighting study
- **Rigs may improve because they think they will**
  - Placebo affect
- **Rigs may improve because of better engineering/drilling practices**
  - Additional input not accounted for

REVIEW

- **Conclusion(s)**
  - NPT decreased
  - Success is dependent on:
    - Communication
    - Acknowledgment and Action by RIG
    - Evaluation by ENGINEERS

QUESTIONS??
THANK YOU

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