

**Hello, NACE/SSPC/AMPP**

**Kansas Section**

**Great Bend, Kansas**

# **HOW NOT TO DO CLOSE-INTERVAL SURVEY ON PIPELINES, Revisited**

**March 11, 2026**

**Cal Chapman, P. E.**

NACE-Certified Cathodic Protection Specialist #23357  
Professional Engineer in TX, FL, LA, NM, ND, NY, OK, TN  
Boerne, Texas; Houston, Texas; Columbus, Montana

**With Big Thanks to William M. “Mike” Ames,  
NACE CP Specialist #4343**

# HOW TO PROPERLY PERFORM CLOSE-INTERVAL POTENTIAL SURVEY?

- ▶ See **NACE SP0207-2007**, the standard practice for performance of Close-Interval Potential Survey (or “CIS” for short);
- ▶ Also consult the document **NACE TM0109-2009**, on ACVG, DCVG, C-Scan and similar surveys for coating quality assessment, and for External Corrosion Direct Assessment (ECDA, NACE SP0507-2014) methodologies. **ECDA combines results of both CIS and a second, complementing survey** (usually ACVG or DCVG);
- ▶ Impressed-current cathodic protection systems are vital for (most) CIS and DCVG work.

# WHY DO WE USE CIS?

- ▶ Learning detailed patterns of cathodic protection (CP) effectiveness over complete pipeline length is vitally important;
- ▶ **CIS shows degree of CP, averaged over 10 to 20 feet of line at a time;**
- ▶ **It may show influences or interference patterns related to CP current from other structures;**
- ▶ CIS may help define areas of pipeline with especially poor coatings;
- ▶ CIS may check AC volts as well as DC, but AC study is not as valuable in CIS approach – due to constant power load variations;
- ▶ **CRITICAL:** make sure **ALL DC current sources are PROPERLY MANAGED** for accurate survey results.

NACE MATERIALS  
PERFORMANCE MAGAZINE  
ARTICLE,  
MARCH 2017 –

MATERIAL MATTERS

Common Pitfalls Encountered in  
Close-Interval Potential Surveys

ARTICLE CAME FROM  
PRESENTATION AT NACE  
CENTRAL AREA  
CONFERENCE, NEW  
ORLEANS, AUGUST 2016,  
BY AMES & CHAPMAN



Close-interval potential surveys are useful in determining whether buried metallic pipelines have sufficient CP. Photo courtesy of Chapman Engineering.

Recurring themes have emerged in recent case studies of unsuccessful close-interval potential surveys (CIS), according to a pair of engineering executives often contracted for such work. Mike Ames and Cal Chapman—vice president and president, respectively, at Chapman Engineering (Boerne, Texas)—

CIS often finds such interference patterns if performed correctly.

“You buy CIS to get good data and good value,” Chapman says in a recent interview. “It’s not just to file a report. Several steps are needed to assure that data are going to be valid, useful, and worth the money. They include using

# HOW **NOT** TO DO CIS?

## ARE ALL DC CURRENTS CONTROLLED?

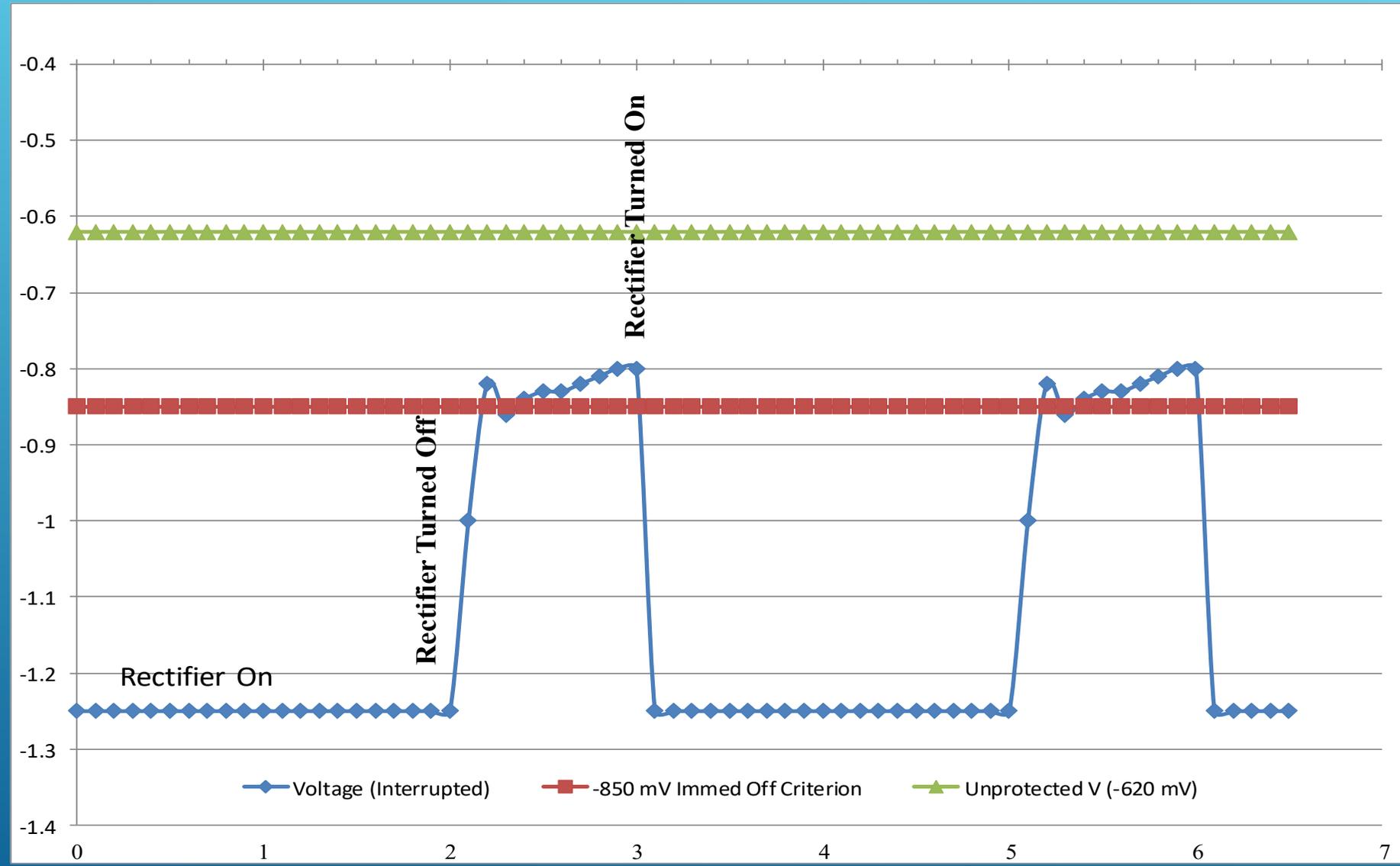
- 1) All DC current sources must be interrupted in synchronized fashion (per SP0207). What sources are known? Unknown?
- 1) A good guide for “System On” DC pipe-to-soil voltage is to obtain readings at -1.8 volts (V) DC to copper/copper sulfate reference cell, or more positive. **When CP is driven harder than this, coating damage may be the result for FBE and similar good-quality coatings (carbon steel metal is assumed);**
- 3) A “must” is to see current-interrupted or “instant-off” P/S voltages at -1.2 VDC or more positive. Based on **evaluation of carbon steel thermodynamic properties** using the Nernst Equation (Dr. Jack Smart, P. E., NACE Fellow, at 2016 NACE Central Area Presentation, New Orleans, LA), **any current-interrupted measurement more negative than -1.2 VDC shows CP current is still being delivered** to pipeline metal during the “off” cycle portion.

# WANTED: CP POLARIZATION SHIFT, "PIPE-TO-SOIL" VOLTAGES VS. TIME

*Gold +0.1 to 0.2 V*  
*Copper -0.1 V*  
*Stainless steel -0.3 to -0.1 V*  
*Old Carbon Steel -0.4 V*  
*All compared to copper/copper sulfate reference cell in soil.*

Are we certain that a carbon steel pipeline is NOT touching any copper metal in common soils?  
Any other metals?

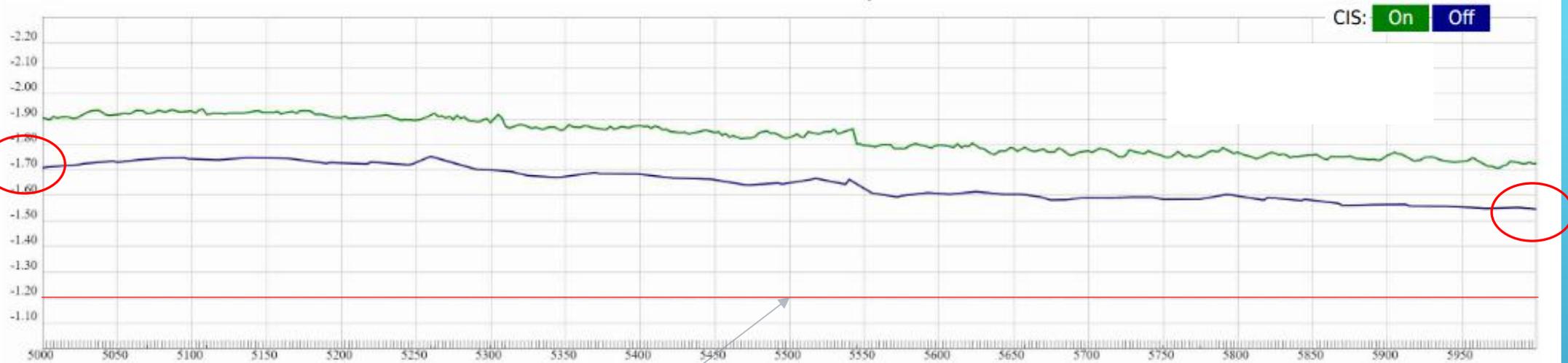
Pipe-to-Soil DC Voltage



Time, seconds

# ARE ALL DC CURRENTS CONTROLLED IN THIS SURVEY?

2018 Close Interval Survey



5110 | 32.26928, -101.96917 | Test s  
tation, Line marker tp sn51+10 fg-1  
933/-1742 ng-1917/-1731 lr-5/-1 nav  
Itas xing ntl (ACV: 2.112V)

5070 | 32.26920, -101.96899 | Test s  
tation, Line marker tp sn50+10 fg-1  
943/-1749 ng-1922/-1735 lr-5/-2 nav  
Itas xing ntl (ACV: 2.025V)

5310 | 32.26952, -101.96970 | Test s  
tation, Line marker tp sn53+10 fg-1  
904/-1786 ng-1886/-1709 lr+1/+2 (AC  
V: 2.228V)

5300 | 32.26950, -101.96967 | wfg xi  
ng ntl (ACV: 2.180V)

5262 | 32.26945, -101.96955 | Test s  
tation wfg xing fl-1493/-1487 (ACV:  
2.125V)

5260 | 32.26945, -101.96955 | Test s  
tation, Line marker tp sn52+60 fg-1  
902/-1711 ng-1905/-1722 lr+1/+1 (AC  
V: 2.158V)

5545 | 32.26982, -101.97038 | Test s  
tation, Line marker tp sn55+45 fg-1  
839/-1651 ng-1814/-1631 lr+1/10 nav  
Itas xing ntl (ACV: 2.021V), PI

5657 | 32.26975, -101.97075 | navita  
s xing ntl (ACV: 1.7951V)

5655 | 32.26975, -101.97073 | Test s  
tation, Line marker tp sn56+55 fg-1  
786/-1604 ng-1775/-1598 lr+0/+1 (AC  
V: 1.8475V)

5775 | 32.26966, -101.97110 | Test s  
tation, Line marker tp sn57+75 fg-1  
780/-1682 ng-1760/-1581 lr+1/+1 (AC  
V: 1.8328V)

5750 | 32.26968, -101.97103 | wfg xi  
ng ntl (ACV: 1.8198V)

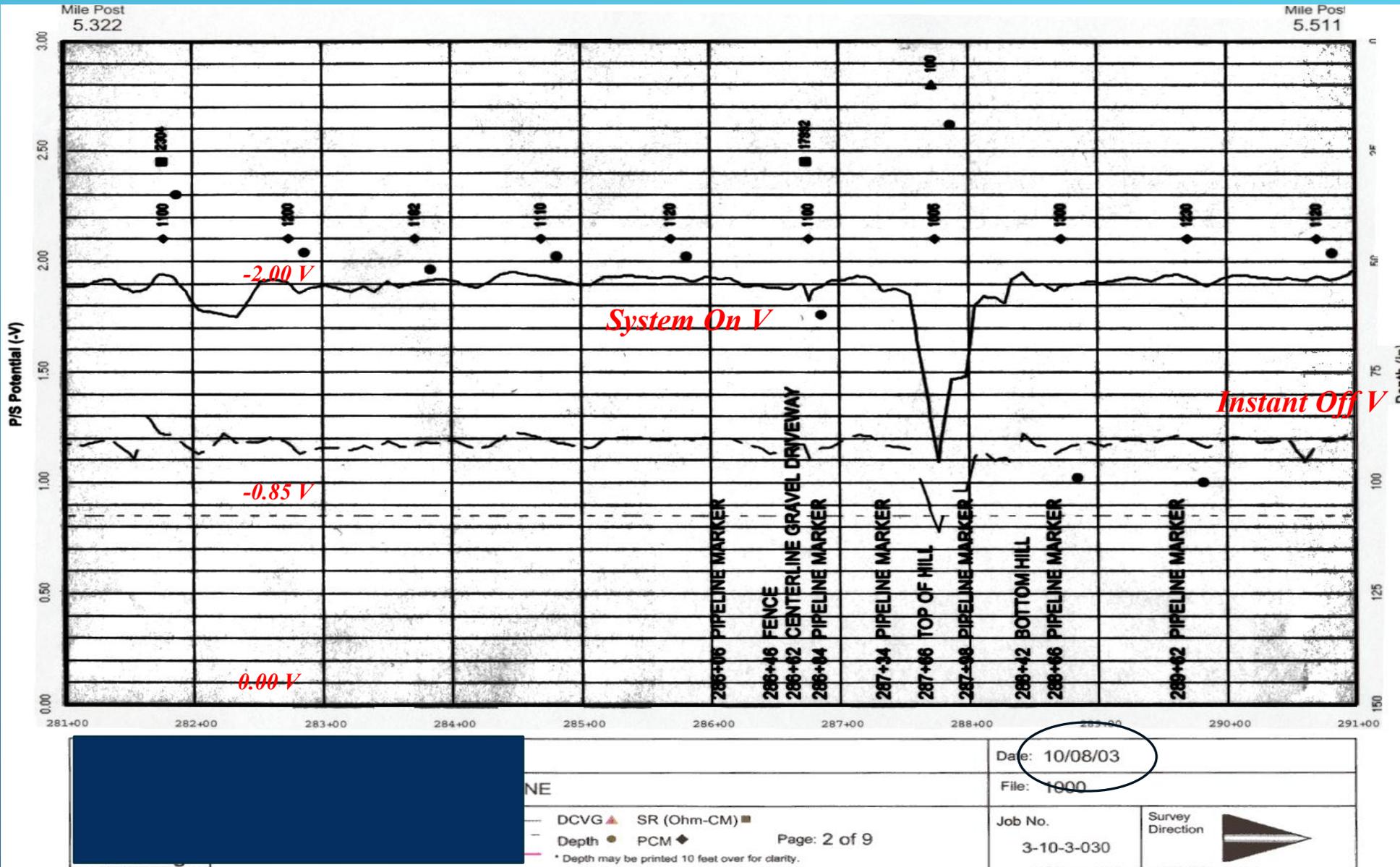
The -1.2 VDC line serves what purpose here?

**ANSWER IS NO!**



# GOOD CIS DATA LOOKS LIKE THIS:

(WHERE ARE WE ON THE GROUND? NO MAP IN 2003.)

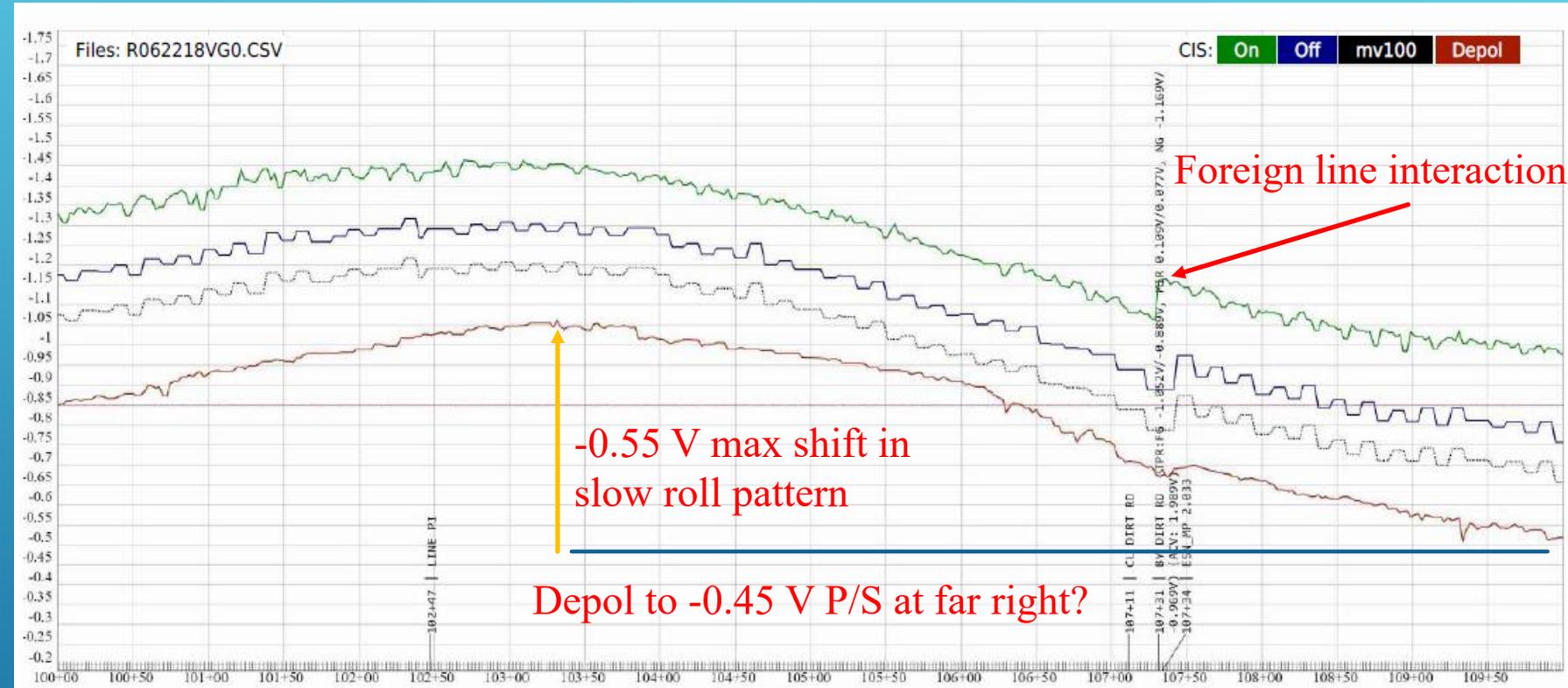


Taking CIS data from multiple years and comparing is high-value. The old ones might not have maps, but patterns will often hold form.

Humans can do this, but new AI-driven techniques may be even better. We humans must still evaluate the AI outputs!

# GOOD CIS DATA CAN LOOK LIKE THIS:

(BUT DOESN'T MEAN "SITUATION NORMAL"!)



Is it possible that target pipeline is touched off to an aluminum irrigation pipeline by some conductor? Old direct-connect mags? Even depolarized data shows a negative shift centered on the orange arrow.

Is AC neutral involved?

If so, we have

**dissimilar-metal system.**

**Measure AC butt grounds.**



## PRE-ASSESSMENT, PER NACE SP0207

- ▶ Section 3, **Pre-Job Considerations** – calls for good planning, good understanding of structure network and existing CP, ability to evaluate field data rapidly and make adjustments as needed, etc. Safety aspects;
- ▶ What about depth-of-cover need? Any DCVG in conjunction with CIS? Depolarization run to be done? **DCVG is “Cell-to-Cell” survey;**
- ▶ Accurate mapping? Foreign crossing info and foreign CP system operations known, needing coordinated interruption, etc.?
- ▶ What about PCR’s installed and their effects on interruption?
- ▶ The list goes on. **And if you go to field, then don’t get good data?**  
**Think more budget will show up when the work’s done wrong?**

# CIS PRE-ASSESSMENT, AKA PLANNING?

(PER NACE SP0207)

**What factors affect how a CIS can be set up and performed? Many items on the list.**

If you do CIS with direct-connect mag or zinc anodes, what do you get? Can you interrupt mags at test stations effectively? **LOOK AT ANNUAL CP SURVEY DATA TO GET A SENSE OF PROBLEMS ALREADY THERE.** Look at previous CIS data set(s).

With ICCP systems, how many involved? Good interruption capability at each rectifier? How to prove that before the survey kicks off? Do you need a combination of RMU's and temporary interrupters? Does everything synchronize properly?

**Other bad ideas:**

- ▶ Use untrained or poorly trained personnel, or stray off of pipe centerline;
- ▶ Put half-cells on vegetation debris for LOUSY soil contact, or maybe on **frozen soils;**

**Do you have control of all DC currents involved?**

**Get test data and see what's happening, before the big MOB.**

## OTHER CIS CONCERNS

**Isolation fittings** – used to break the electrical connection between different metallic structures or portions of structures. Used so cathodic protection is applied to KNOWN amount of metal SURFACE AREA, in a hopefully “closed system” type of approach. **Are iso kits working properly?**

**Bonds between different pipelines**, to manage CP influence or interference – done purposely by cooperating operators, and these bonds must be managed same as rectifiers over time, for regulated lines. **Do you learn where they are, how they are working? Measurement history? When do you learn? How to manage?**

**Interference between CP systems and operators** – If a “foreign operator” CP system puts DC current onto your pipes (or vice versa), that’s big trouble, too. **STRAY CURRENT INTERFERENCE. Do you know if such issues are present, pre-survey?**

Is any pipeline metal tied to AC power neutral system? Test by measuring AC voltages on power pole butt grounds, with interrupting rectifiers. **Does copper shift?**

**If copper and steel are tied together, -850 mV Instant-Off is only passing criterion.**

# LOCATION, LOCATION, LOCATION

- ▶ CIS must be done **RIGHT OVER** each pipeline, to keep measurement path length as short as possible (smallest IR drop added to every voltage measurement);
- ▶ So a good pipe locator and operator is needed – easy, right?
- ▶ Yes, easy till a bare steel line running with your well-coated line takes **some of your signal** (it happens), then PI's off into the countryside;
- ▶ It's easy until your good survey lead gets sick, and another person is thrown into mix.

BARE 2-INCH LIES OVER TARGET 4-INCH PIPELINE . . .

PIPE "LOCATE" SIGNAL JUMPS, THEN 2-INCH PI'S AWAY?

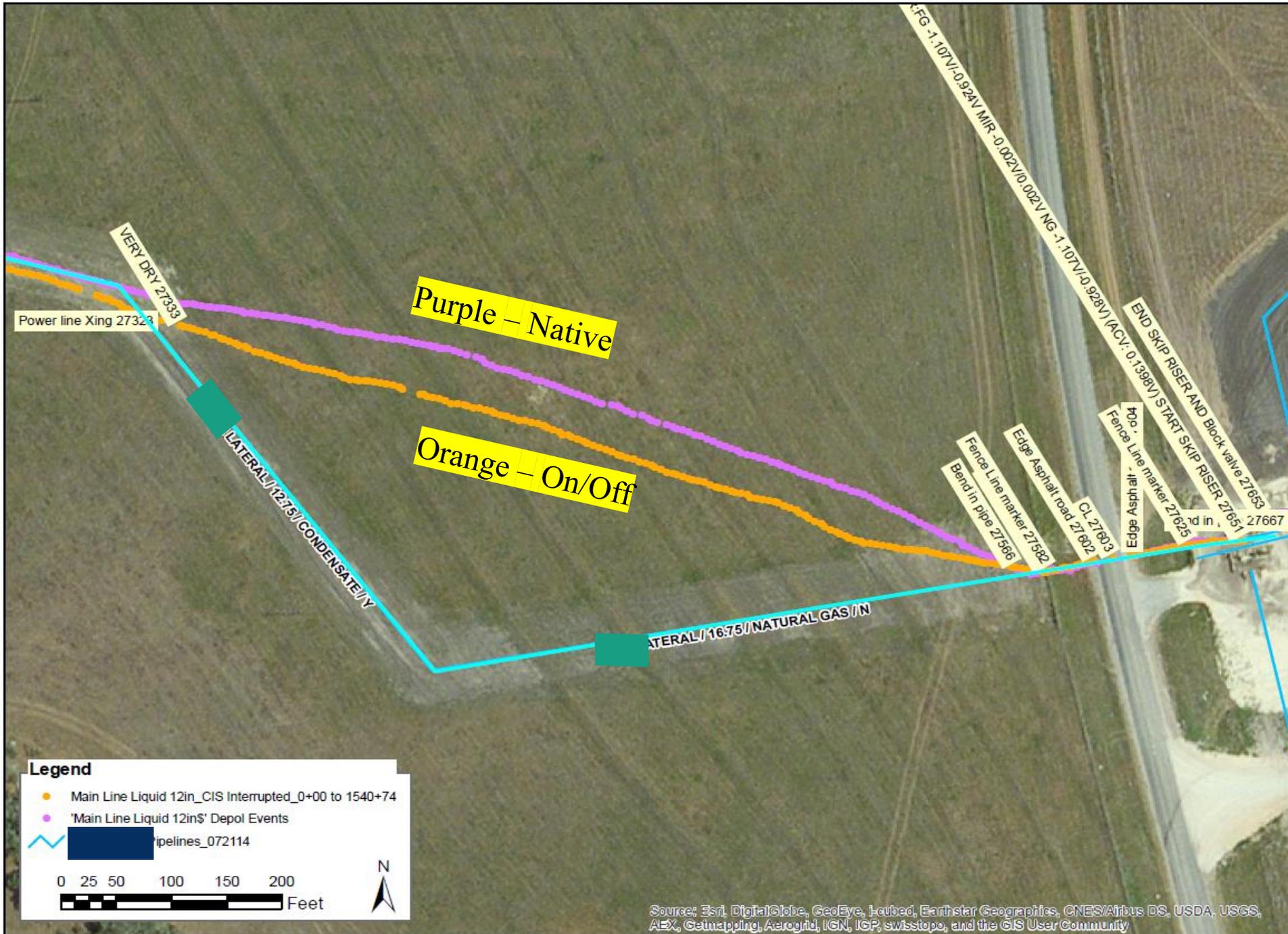


# LOCATION, LOCATION, LOCATION

- ▶ GPS allows good mapping of data, even in near-real-time (has for years now);
- ▶ Think of pipeline surveying as geo-spatial. Pipe stays in the same place. So do test stations (WE HOPE), rectifiers, above-grade valve sets, tees, other appurtenances, and anode beds. **We touch them repeatedly over time;**
- ▶ Mapping data has always been necessary (I say!) – now it's easier than ever to do, and to check. Is your vendor providing accurate and complete mapping of CIS data?  
**YOU CAN VERIFY IF YOU PLOT THEIR DATA.**

## SO WHAT GOES WRONG? (NEXT EXAMPLE)

- ▶ **Fall 2014 – we had lots of work, had to hire in a contract CIS crew;**
- ▶ **Client required our staff CP-1 on site to write permits each AM for contract crew, conduct safety meeting, do documentation;**
- ▶ **After we laid the work out for contract crew, got rectifiers interrupting, our guy rarely saw them through each work day. Too much to do, remember?**



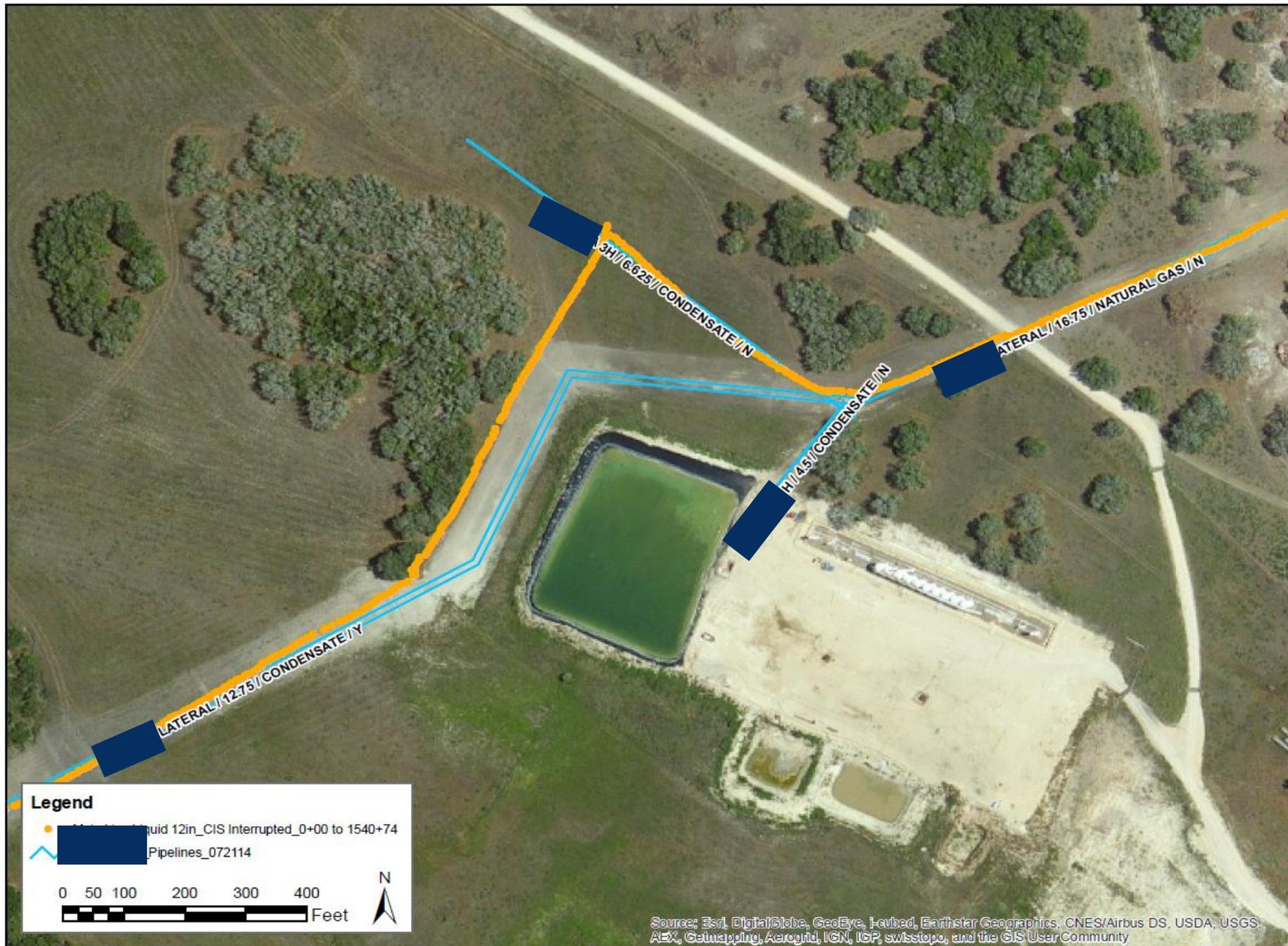
LIGHT  
BLUE IS  
PIPELINE  
ROW ...  
WHERE WERE  
THEY GOING?

AND ALL  
CONTRACTOR  
GAVE US  
WAS THEIR  
DATA FILE  
AND GRAPH,  
NOT THE  
MAPPING!

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

## SO WHAT GOES WRONG?

- ▶ The blue line is target pipeline (2 lines, actually);
- ▶ The orange route is the current-interrupted survey pass – PATH LAID OUT BY THEIR GPS CALLS attached to each data point! (They did not give us maps with their survey results, by the way.)
- ▶ We also needed a depolarized survey pass, done a couple of weeks later. Was that done properly? See the purple route. They missed the pipeline **again**. Accident? Purposeful? Repeat the mistake, on the same line?
- ▶ Turns out, they did this a bunch of times – moving faster.



AND THEY MISSED AGAIN. IN THIS CASE, THEY ADDED LENGTH TO THE PIPE AND SURVEY.

**THEN WE FOUGHT.**

**CHAINAGE COMPLETELY WRONG.**

# NEXT: THREE STEEL PIPELINES, TWO ICCP SYSTEMS, & PIPES BONDED TOGETHER AT THREE POINTS OVER 33 MILES

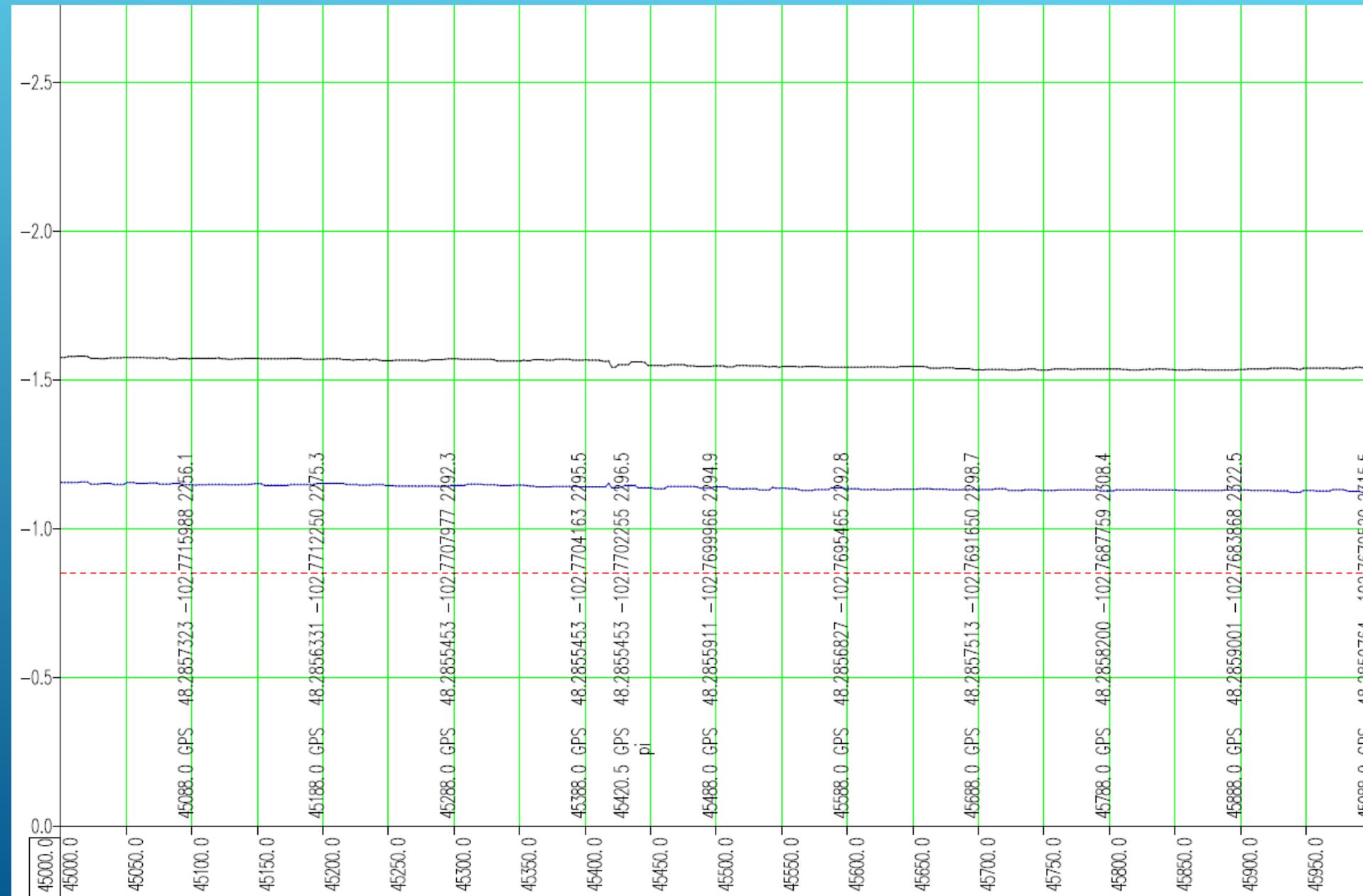


# SO WHAT GOES WRONG?

## THREE PARALLEL LINES, BONDING, COMMON CP

- ▶ Contract survey company surveyed all three lines in one pass, in 2010, AND with no current measurements at bonds. This was counter to NACE SP0207 approach. You get averaged voltage for each reading, combining three pipe metals with every touch.
- ▶ In 2014, operator hired a different CP firm to do CIS on same three lines. Result? That contractor did it same substandard way as 2010 provider!
- ▶ In 2015, our firm did CIS on each of the three lines independently, finally giving operator **DEFENSIBLE** results, and **practical recommendations**.
- ▶ The operator really paid for three CIS runs in five years – no in-house technical expertise to say, **“Let’s get it done right the first time.”**

# NORTH DAKOTA CIS DATA, 2010



Nice and pretty straight-line outputs on the graph, thanks to all three pipes getting “averaged together.” And there is no guide at -1.2 VDC.

**THIS DEFECT WAS NOT FOUND BY 2010 CIS; SHOULD IT BE?**



Major anomaly – coating damage & gouge – identified by C-Scan COATING CONDUCTANCE survey, October 2012

# WHAT OTHER DC CURRENT SOURCES MIGHT BE INVOLVED?

- ▶ Is there a bad isolation kit in system? Could it tie well pad to pipeline? Pipeline to facility?
- ▶ Are there bonds on target pipeline? Find them, AND MEASURE CURRENT FLOWS, DIRECTIONS;
- ▶ Is there another type of galvanic interference involved, and no one understands it?
- ▶ Is a pipeline CP system accidentally tying pipe metal to AC power grid neutral wiring? This may mix together **tens to thousands** of structures when it happens.

## **WHAT ARE OPTIONS FOR REGULATED PIPELINE TESTING, RELATED TO EXTERNAL CORROSION & INTEGRITY?**

**For external corrosion understanding, we use “External Corrosion Direct Assessment” (ECDA), or “In-Line Inspection” (ILI, using “smart pigs”). And we might even do both, depending on RISK for particular pipeline.**

**Another option is hydro-testing, but that is huge expense and NOT PREDICTIVE.**

**How frequently are these assessments needed? Again, depends on risk, but three-year to seven-year frequency often involved.**

# WHAT ON/OFF CYCLE TO CHOOSE?

- ▶ Ask CIS vendors what they recommend as “on/off cycle” for interruptions. What is “miles per day” goal? Always the same?
- ▶ We were asked a ways back, “Can you please interrupt 8 on, 2 off, where your CP systems may influence us?”
- ▶ Opinions vary. But to maximize your crew’s work speed, AND STILL MAINTAIN DATA QUALITY, will you take 10 seconds at each point? Nope.
- ▶ We typically go 2/1, 3/1, maybe 5/2. Can you safely get two cycles, even three every 10 seconds? Improve data quantity AND quality this way . . .

# THIS GRAPHING SHOWS A TWO-ON, ONE-OFF CYCLE

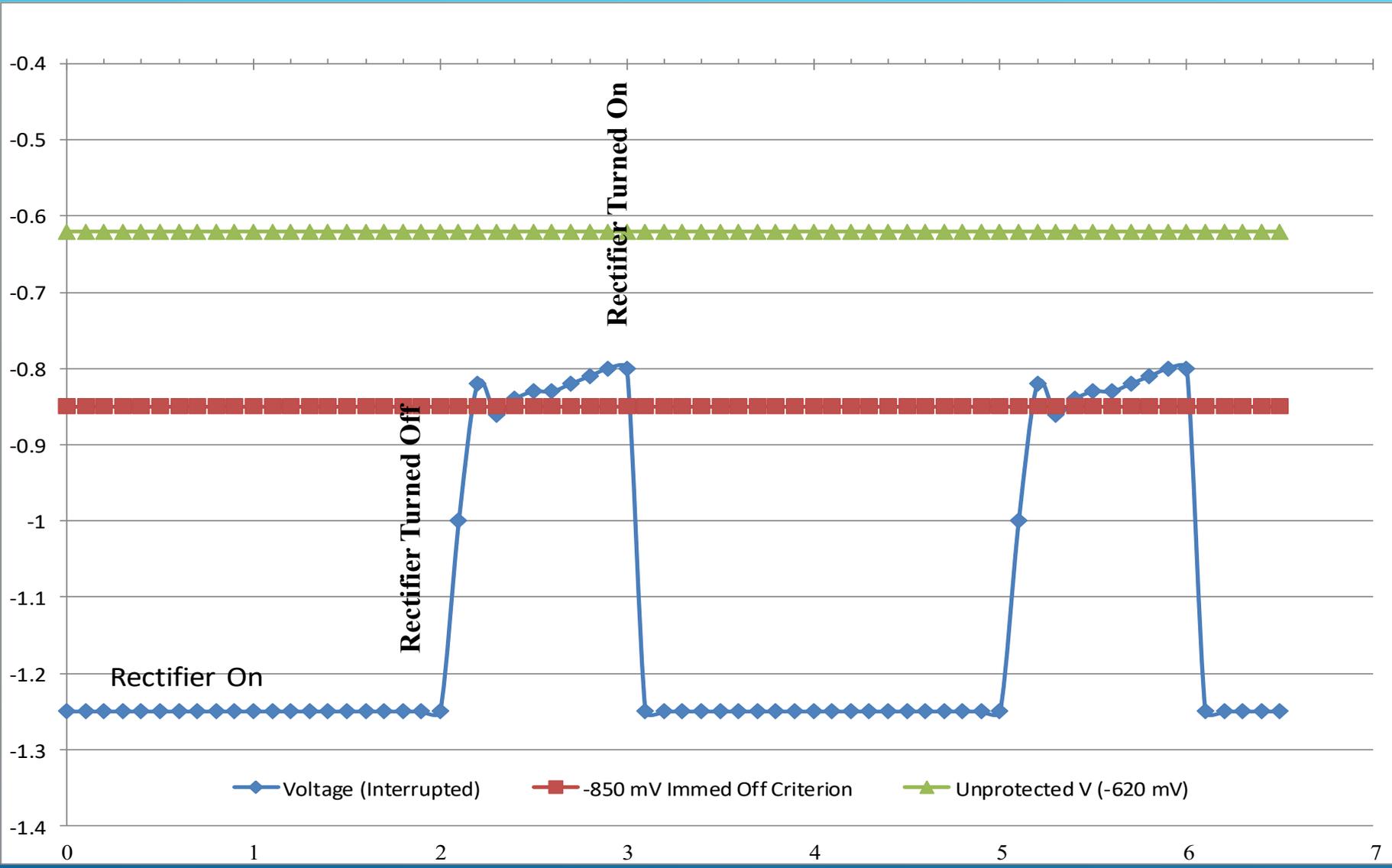
Gold +0.1 to 0.2 V

Copper -0.1 V

Stainless steel -0.3 to -0.1 V

Old Steel -0.4 V

Pipe-to-Soil DC Voltage

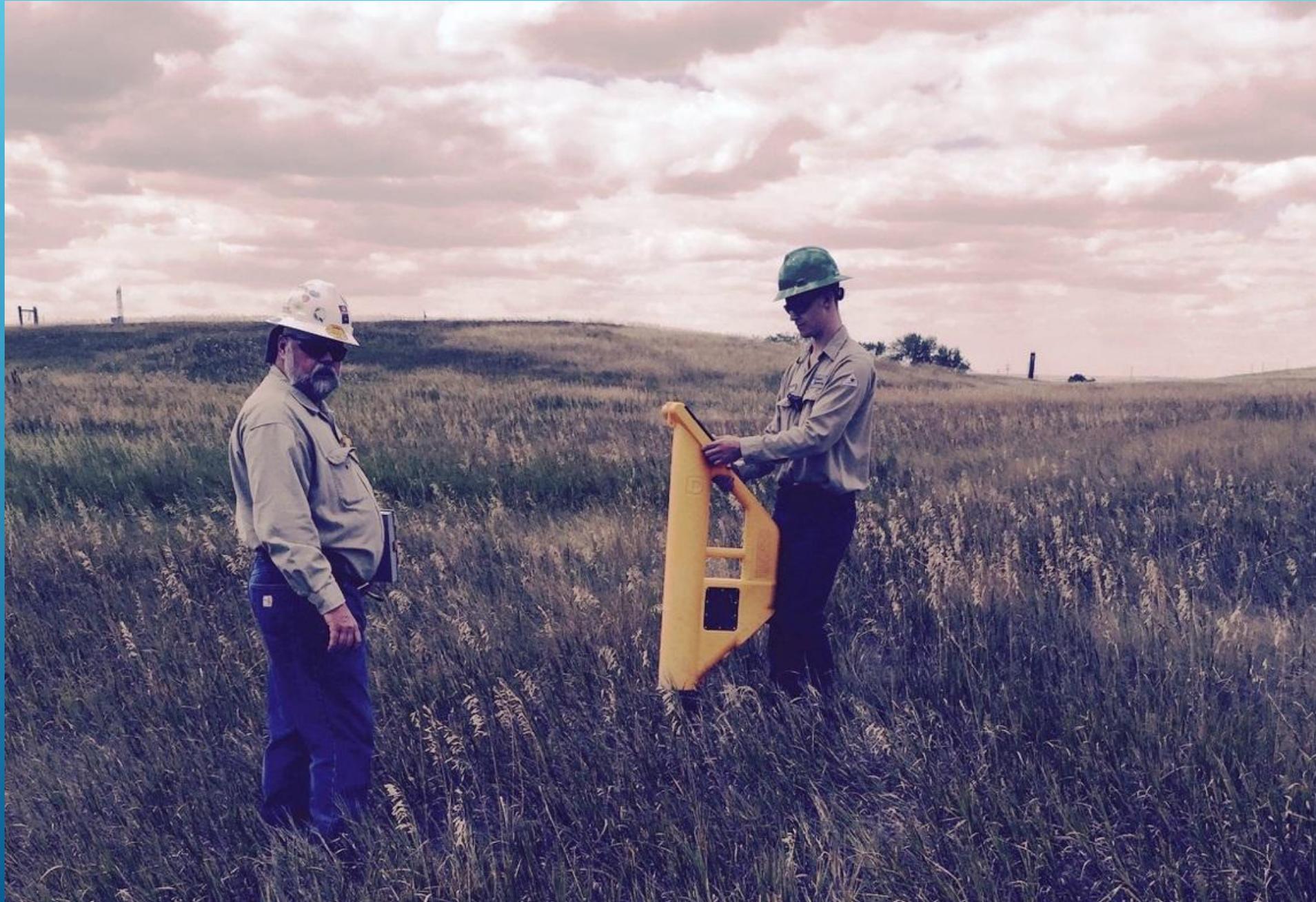


Time, seconds

# WHAT ON/OFF CYCLE TO CHOOSE?

- ▶ Do you go to “fast cycle” – often 0.8 second on, 0.2 second off? Do you get an honest “instant-off” or are you too early (more negative)?
- ▶ This is tempting for fast crew speed over the ground. But it may lead to poor soil contact (rushing the pole plant). One vendor got 20 miles a day on west Texas pipe! Value delivered? **Bad . . . Or none.**
- ▶ DO YOU NEED TO WATER RIGHT-OF-WAY? **How important is pre-assessment and layout of the CIS based on local conditions?!**
- ▶ **Fast-cycle may not read “instant off” voltage within the time window of contact, for every touch;**
- ▶ **What if AC mitigation is present? PCR’s discharging? What’s advantage of PCRX? Costs and benefits?**

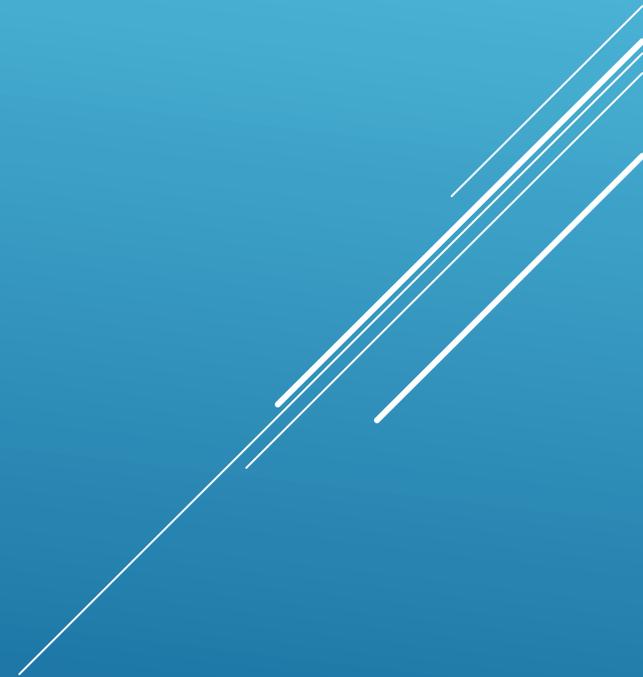
# WHAT DOES RIGHT-OF-WAY LOOK LIKE?



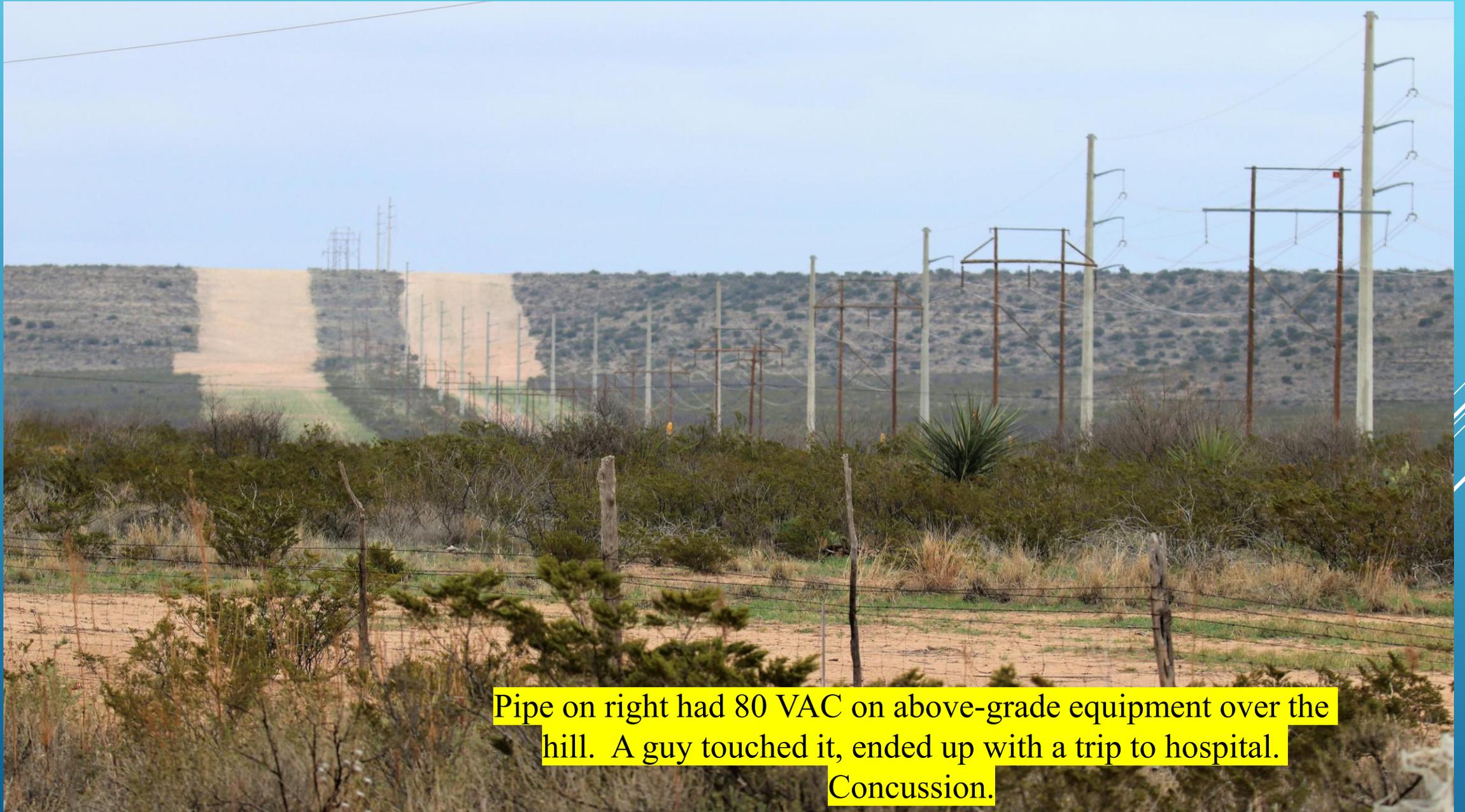
# WHAT DOES RIGHT-OF-WAY LOOK LIKE?



Yes, there is a pipeline in here!



# WHAT DOES RIGHT-OF-WAY LOOK LIKE?



Pipe on right had 80 VAC on above-grade equipment over the hill. A guy touched it, ended up with a trip to hospital. Concussion.

# What Goes Wrong, Next Example

## AC Neutral Power Grid Combines Various CP Systems and Metal Families.

One example: operator near Midland had -13 VDC pipe-to-soil on his pipeline. How?

(And we've seen -37 volts DC on another pipeline, same type of situation!)

The answer is:

# ANNUAL SURVEY PIPE-TO-SOIL OF -13 VDC:

TS at -13.0 VDC to portable ref cell.

Our operator's large-diameter pipeline passes through voltage field – but why a negative shift?

Conventional Anode Bed at +13 VDC

Oil Well Casing with ICCP System

10 amps applied by casing CP system with 13 V driving.

Both the well casing rectifier negative/structure and our operator's CP system are accidentally tied to AC neutral grid. This makes well casing metal and pipeline metal common with one another. Risks of big negative shift? Pipe metal damage. Is this an outside current source to operator pipeline? Yes; with tie to AC neutral, many current sources likely added.

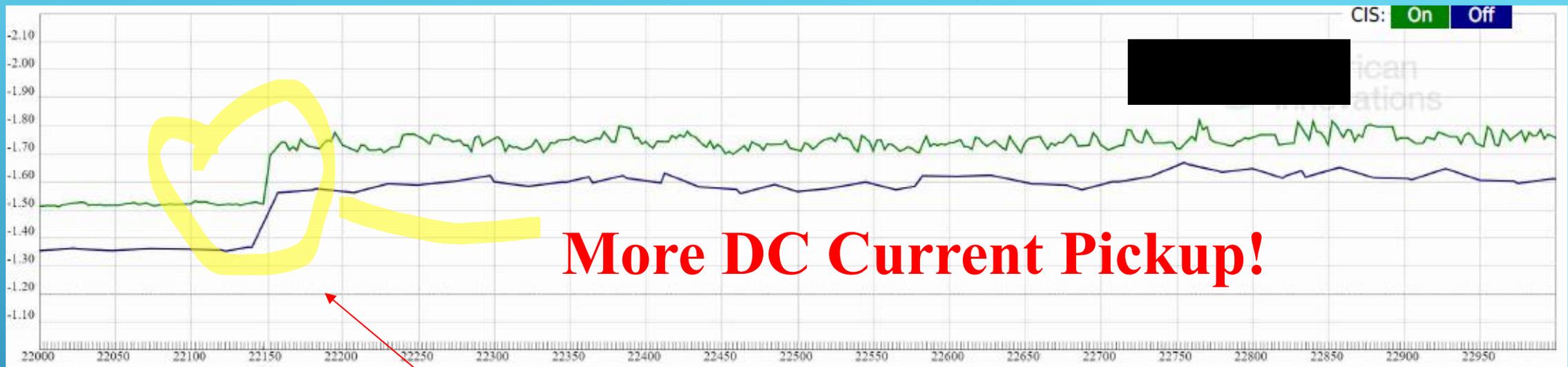
# How Many Well Pads with CP? How Many Pipelines in the Area?



# Do you have the only pipe in the neighborhood?



# BAD CIS DATA, SEPT. 2018, WEST TEXAS

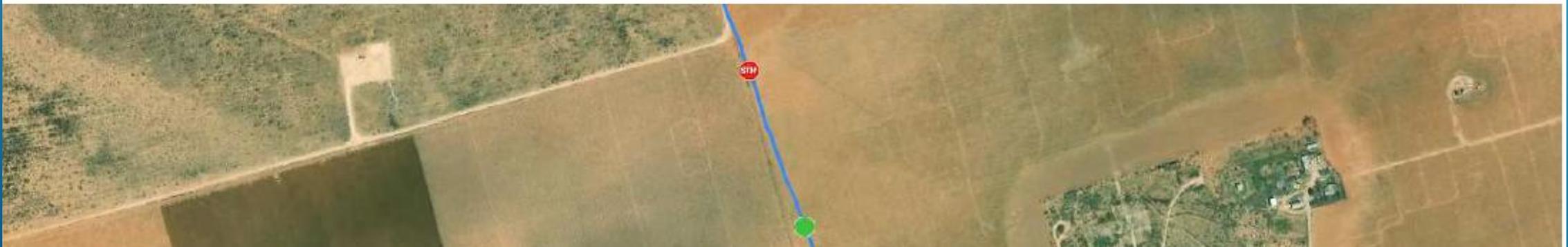


**More DC Current Pickup!**

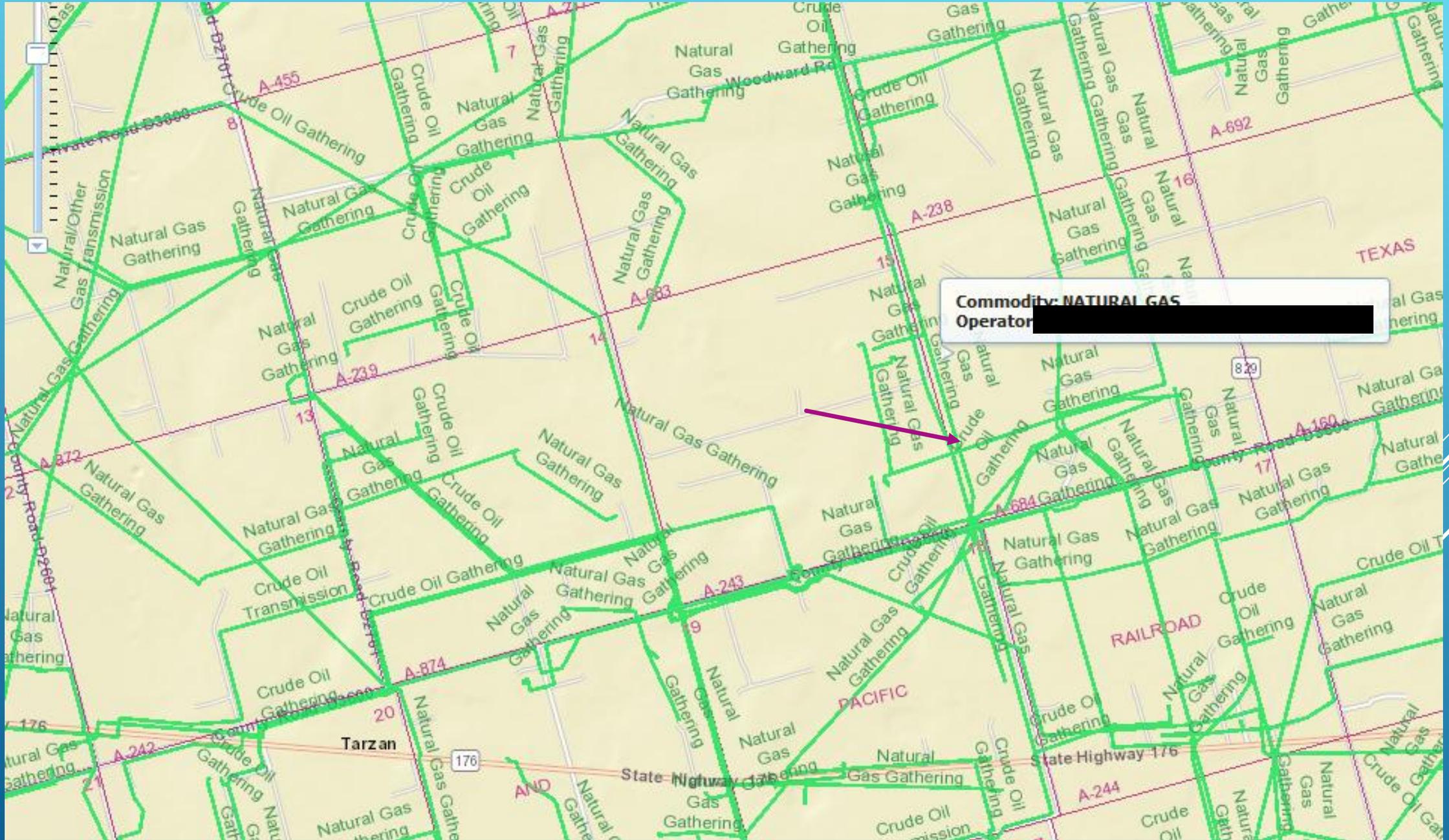
The -1.2 VDC line serves what purpose here?

```
22152 | 32.32145, -101.91  
nd express 12 pcc2mw p:  
(ACV: 5.145V)  
22147 | 32.32145, -101.91  
nd express 12, Test station  
marker tp ts#8 pcc2mw ps-1518  
(ACV: 5.849V)
```

Contractor interrupted one rectifier pushing 0.8 amp, for 8.5 miles of 12-inch pipe. Already other current sources involved at left, if "Instant off" is -1.3. Then a 200-mV new jump?



# WE'VE GOT A CURRENT JUMP W/FOREIGN.



# ***HOW TO SEE DC CURRENT JUMPS?***

An up-and-coming survey addition is software and IN-FIELD display to show operator where survey voltages make big changes.

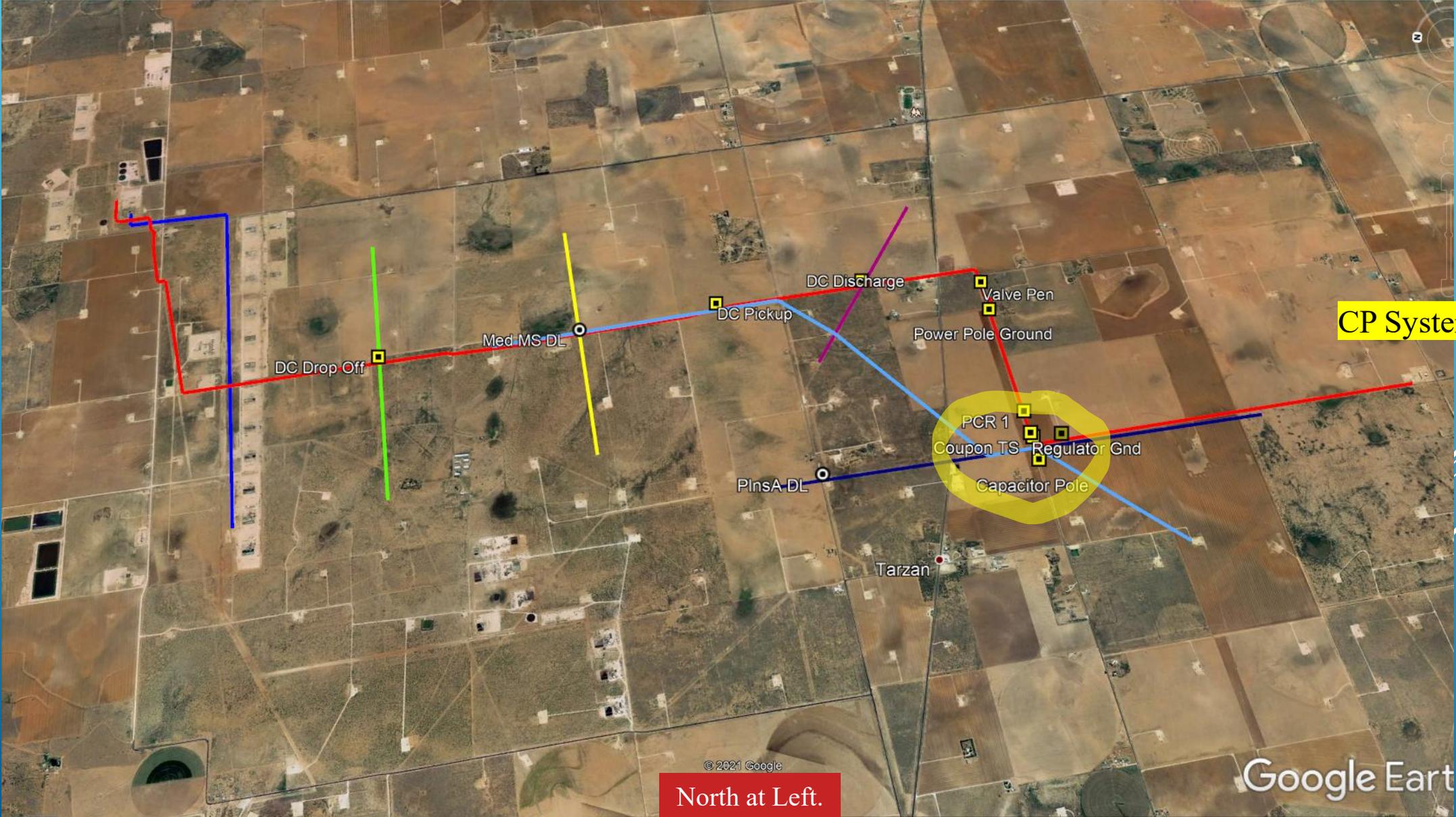
Can you study this further right then and there? Maybe. Very helpful when it can be done.

What to do? DCVG – looking at cell-to-cell voltages over pipe and then to side of pipe, “side drains” indicating currents coming on or going off. Current flows and Voltages Are INTER-TWINED!

Read the voltage fields! And find related mapping!

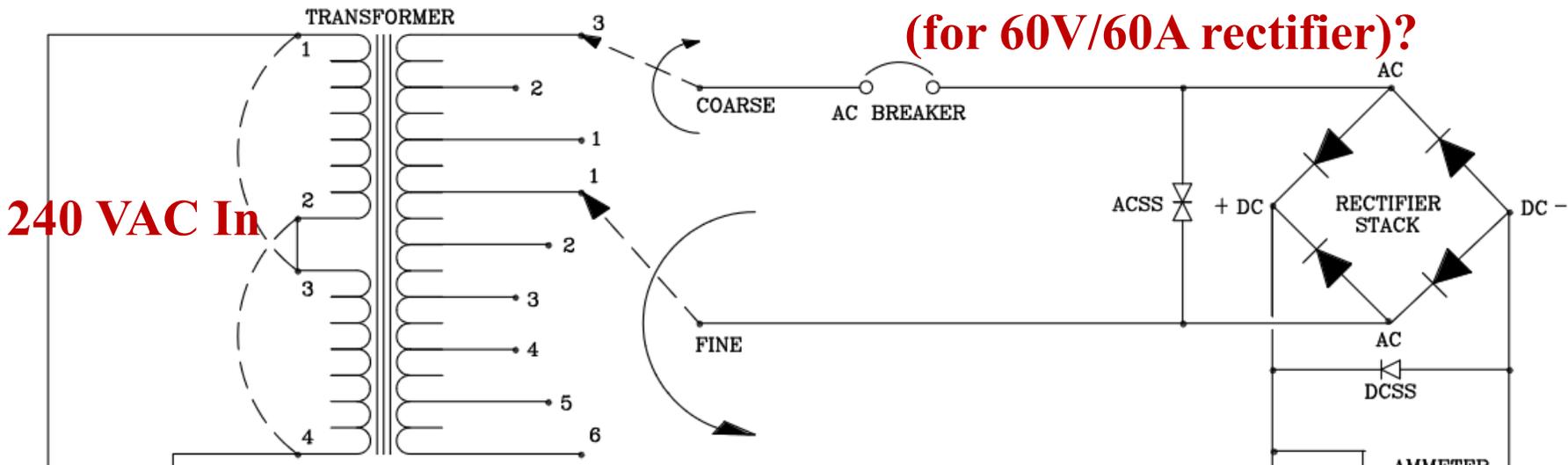
**If you have PCR's and AC mitigation, they can give current in “off” cycles.**

# CAPACITORS IN AC POWER DISTRIBUTION CAUSING ~~INDUCED~~ CONDUCTIVE AC LOAD ON PIPELINE



At C1 F2, 4 VAC to secondary  
(for 60V/60A rectifier)?

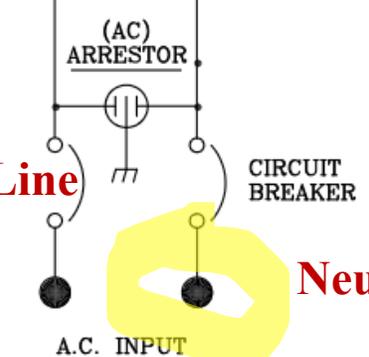
240 VAC In



Isolation

CONNECTIONS SHOWN ARE FOR HIGHER PRIMARY VOLTAGE, FOR LOWER PRIMARY VOLTAGE REMOVE LINK BARS FROM 2 & 3 ON TAP BOARD AND PLACE ONE ON 1 & 3 AND THE OTHER ON 2 & 4.

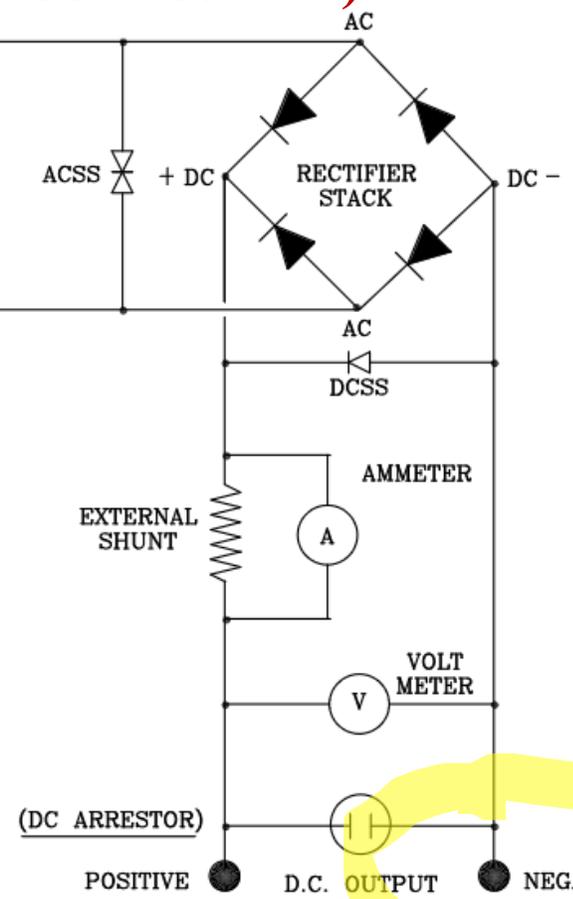
Where is an Electrical Ground?



Neutral

Does transformer isolate?

CONNECT NEGATIVE TERMINAL TO STRUCTURE TO BE PROTECTED. (PIPELINE, TANK, ETC.)



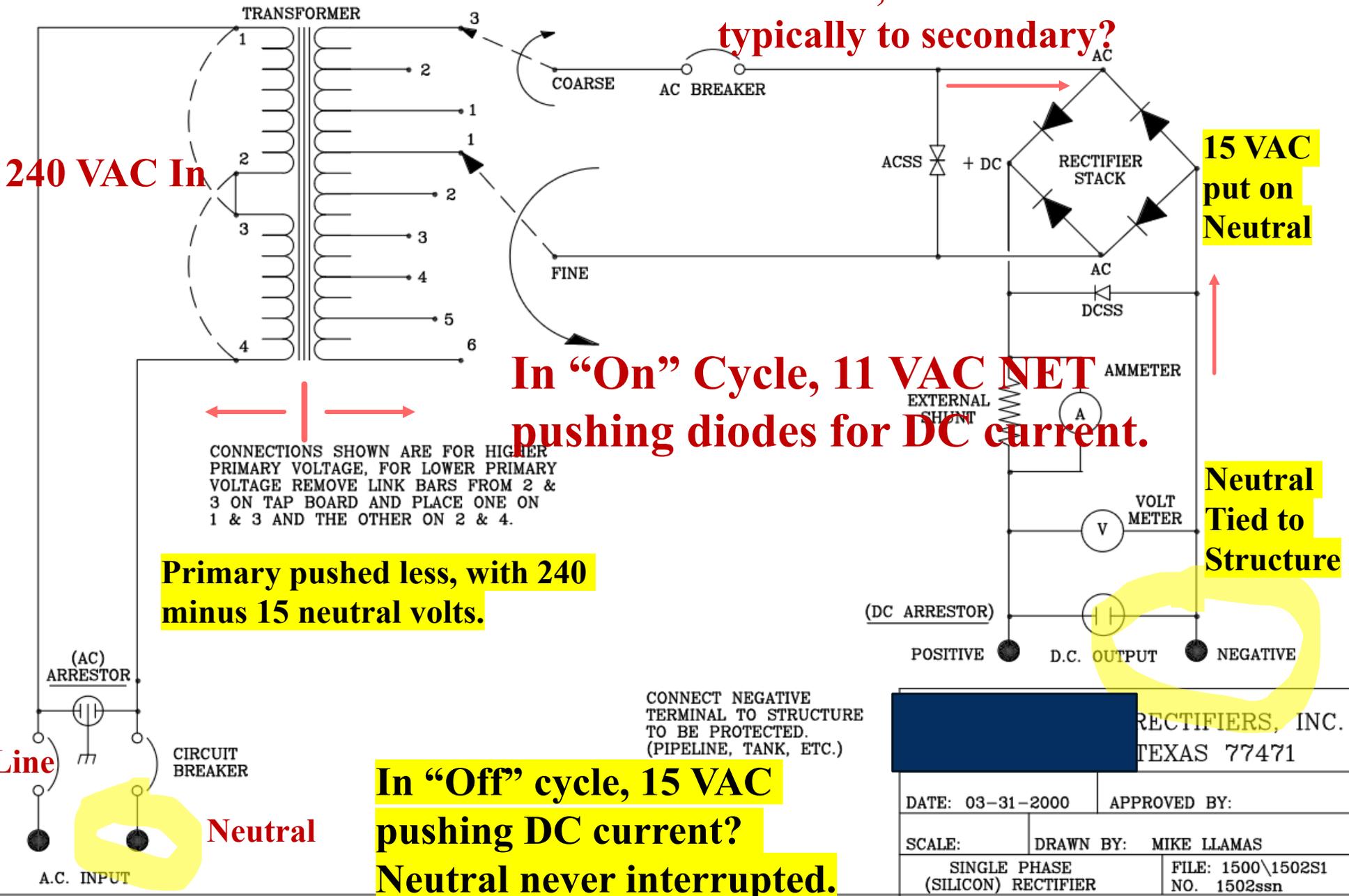
RECTIFIERS, INC.  
TEXAS 77471

DATE: 03-31-2000	APPROVED BY:
SCALE:	DRAWN BY: MIKE LLAMAS
SINGLE PHASE (SILICON) RECTIFIER	FILE: 1500\1502S1 NO. 1502ssn

RECTIFIER SCHEMATIC INFORMS US ON MOST OF THESE CIRCUIT PORTIONS. IS THERE ZERO CURRENT FLOW IN "OFF" CYCLE?

240 VAC In

At C1 F2, 4 VAC typically to secondary?



CONNECTIONS SHOWN ARE FOR HIGHER PRIMARY VOLTAGE, FOR LOWER PRIMARY VOLTAGE REMOVE LINK BARS FROM 2 & 3 ON TAP BOARD AND PLACE ONE ON 1 & 3 AND THE OTHER ON 2 & 4.

Primary pushed less, with 240 minus 15 neutral volts.

In "On" Cycle, 11 VAC NET pushing diodes for DC current.

In "Off" cycle, 15 VAC pushing DC current? Neutral never interrupted.

WE HAD 18 VAC ON AC NEUTRAL A MILE AWAY.

IS THERE ZERO CURRENT FLOW IN "OFF" CYCLE?

15 VAC put on Neutral

Neutral Tied to Structure

Line Neutral A.C. INPUT

From NACE “IMPACT” Study of March 2016, page 2:

**“15 to 35 percent of the annual corrosion damage can be saved through use of available corrosion control practices.” *GOOD-QUALITY PRACTICES, PLEASE!***

These practices SHOULD include:

- Regular surveys of below-grade infrastructure using NACE-standard methods, whether related to cathodic protection, coating assessment, or similar approaches (**This is CIS need!**);
- Data gathering and review, especially using trend comparisons over time when the same points are surveyed year in and year out (annual CP survey work);
- Comparison of data sets [**CIS!**] through use of well-defined standards for corrosion protection. When deficiencies are found, invest in corrective action so that good metal is kept in place!

**Fine Print: NOTE THAT COSTS OF PRODUCT LOSS, ENVIRONMENTAL RESPONSES, AND HEALTH IMPACTS ARE NOT INCLUDED IN THE NACE IMPACT STUDY COSTS! *\$2.3 TRILLION PER YEAR IN CORROSION DAMAGE . . . AROUND THE WORLD. (AS OF 10 YEARS AGO.)***

# How Do We Track Down AC Neutral Involvement with a Pipeline? A Rectifier? A Facility?

## Three basic steps to take:

1. With rectifier(s) interrupting, measure both the DC structure-to-soil AND the AC structure-to-soil at a test station, rectifier bond point, or above-grade metal device. Record those measurements. We want AC to be zero or low millivolts, and DC reads to show protection;
2. Go to AC power pole at least 100 meters (330 feet) away from rectifier and any local power drop your company is using. Find copper wire coming down pole to the underground copper “butt plate.” Measure on copper to portable reference cell for “On” and “interrupted” DC voltages, AND for AC voltage. We want near-zero AC volts on AC neutral and about -0.1 VDC on the copper with NO interruption changes. If copper is more negative than -0.1 and shows shift with CP current, then your pipeline is tied in with AC neutral – somewhere. If you test on multiple butt grounds, the changes in CP levels may point toward the neutral tie-in/CP source;
3. Measure on rectifier negative bond to pipeline for AC current in “interrupted” cycle, and see if it is non-zero. Measure on positive lead to find DC current flow in “off.”

# WHAT DOES RIGHT-OF-WAY LOOK LIKE?



**THANK YOU, NACE/SSPC/AMPP!**

Questions?

**And remember, the only bad question is the  
one not asked . . .**

**Also, “Normal” is the Outlier.**

**Cal Chapman, P. E. (TX, FL, LA, ND, NM, NY, OK)**  
NACE-Certified Cathodic Protection Specialist #23357  
[cal@chapmanengr.com](mailto:cal@chapmanengr.com)

**With Thanks again to Mike Ames, NACE CP Specialist #4343  
and Senior Corrosion Technologist #4343**