EDM

T&D SERVICES

ENVIRONMENTAL SERVICES

PRODUCTS

Overcoming utility infrastructure challenges by merging excellence in engineering, science and technology with a passion for client satisfaction.

Overhead Transmission Structure and Foundation Asset Management – Inspection & Structural Retrofits

Kento Arai (SDG&E®) & Jonathan Jordan, P.E. (EDM International)

AGENDA

- SDG&E's Asset Management Program
- Process Flow
- Case Study
- Conclusion
- Q&A

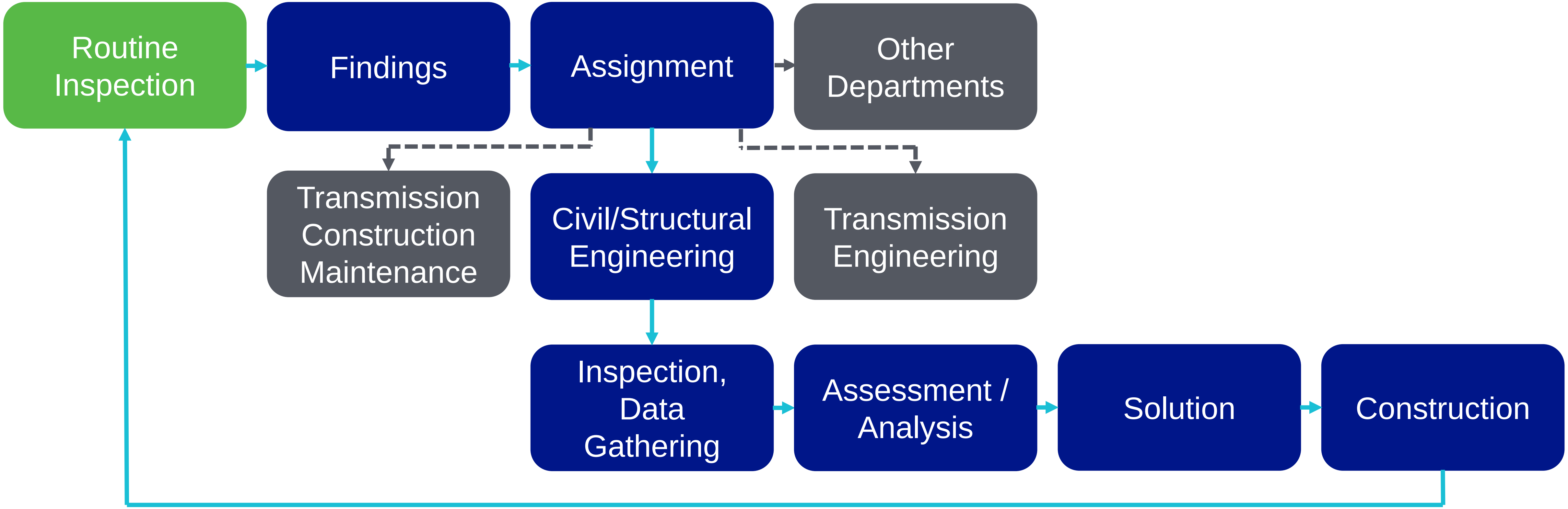
Asset Management – Task Tracker

Importance of Asset Management

- Maintenance of Aging Infrastructure
  - For Safety and Reliability
  - Minimizing Environmental Impact
  - Cost Saving
- Task Tracker – Web based communication tool for Transmission Assets used by Transmission Construction & Maintenance (TCM) group
- Conditions identified and reported through various SDG&E routine inspection programs
  - Part of TCM's Maintenance practice
  - Audited by Regulators
    - California ISO – Transmission Maintenance Support Policy Letter
    - California Public Utilities Commission (CPUC) – G.O. 95 Rule 18

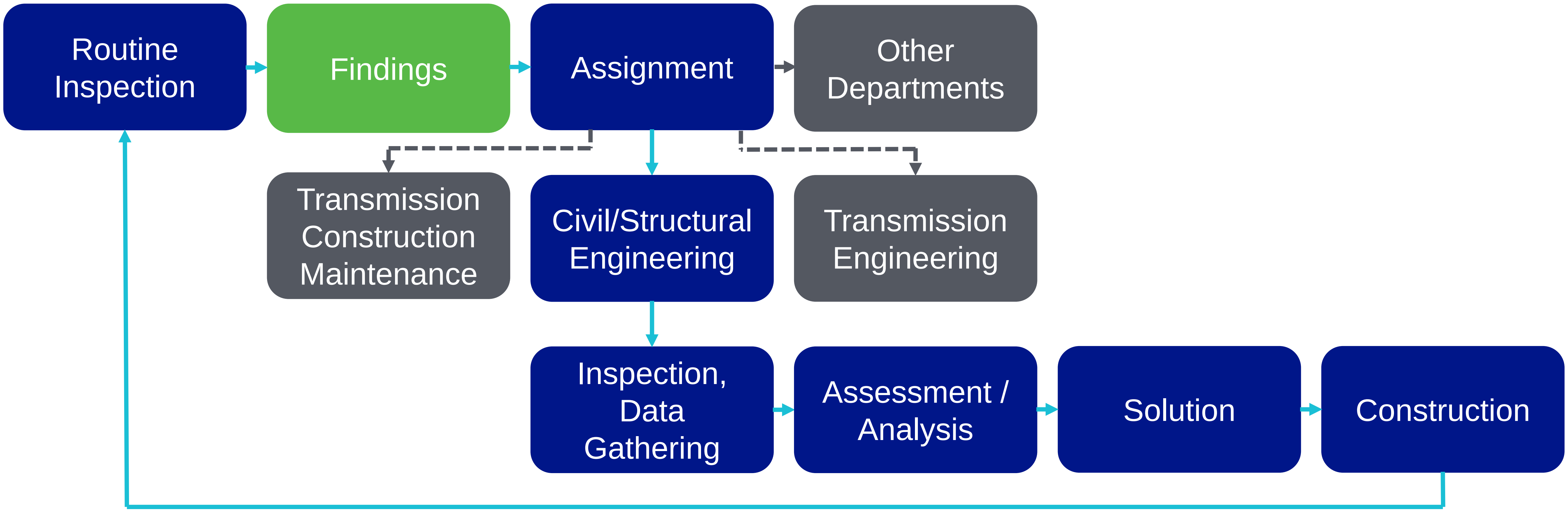
Asset Management Process – Flow Chart

Routine Inspection



Asset Management Process – Flow Chart

Findings



Asset Management Process – Flow Chart

Findings - Examples

Submerged Pier and Stub Angle

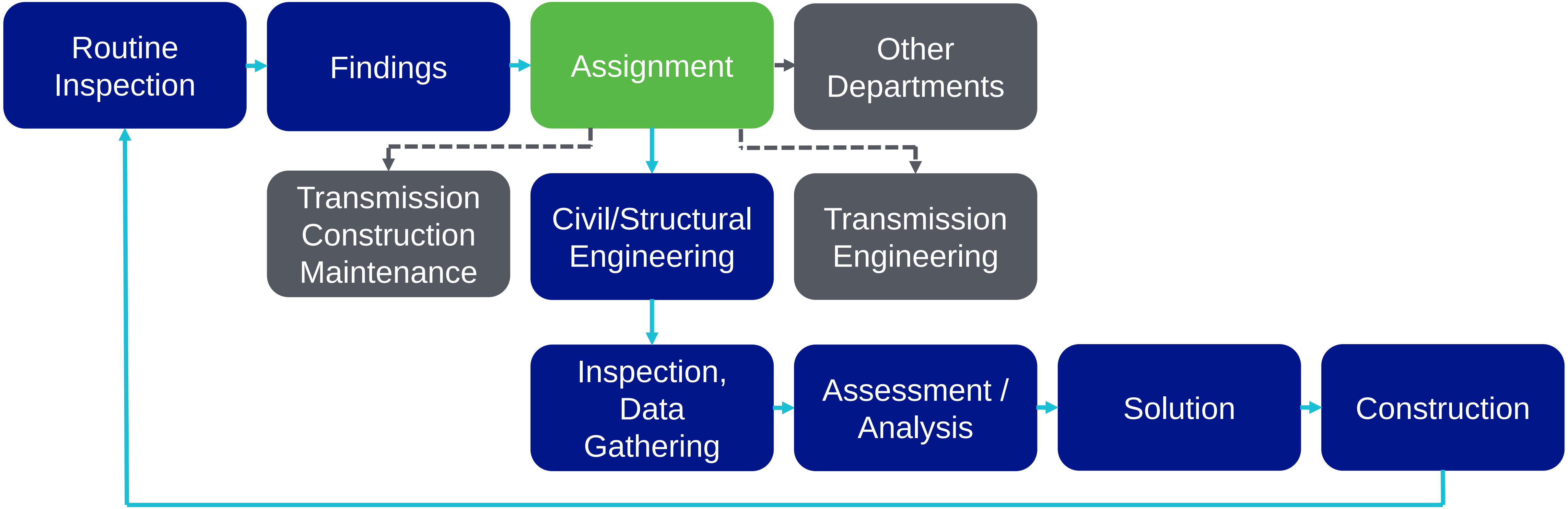
Bullet Holes

Cracked Pier

Damaged Coating

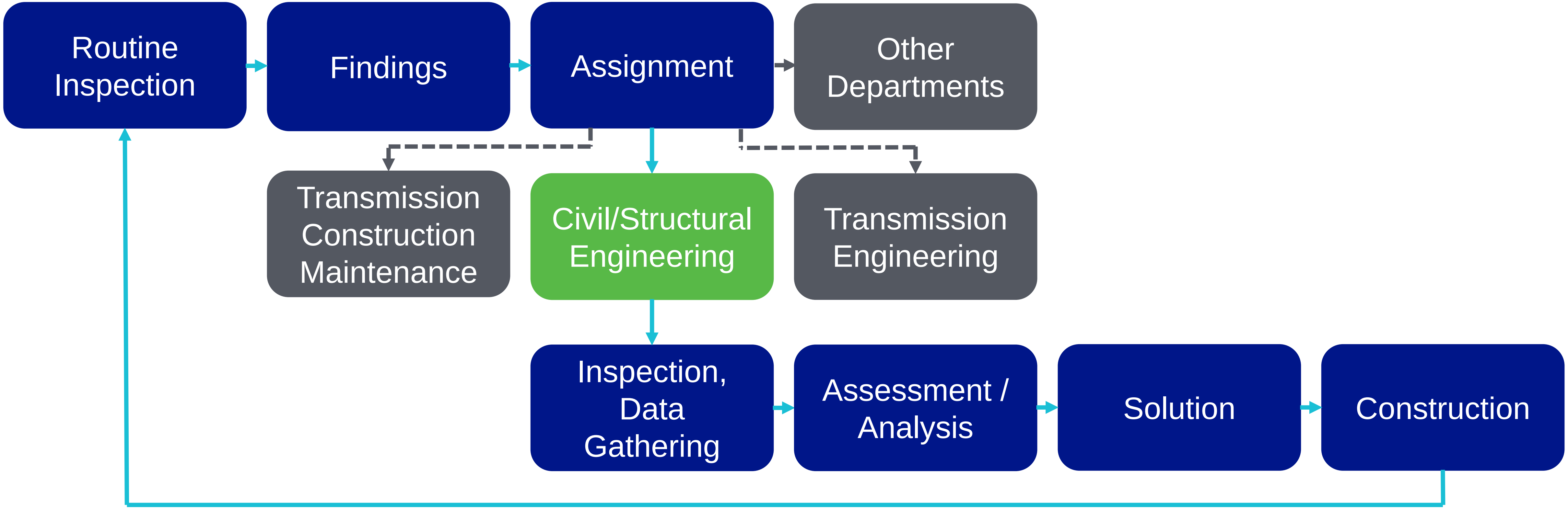
Asset Management Process – Flow Chart

Assignment



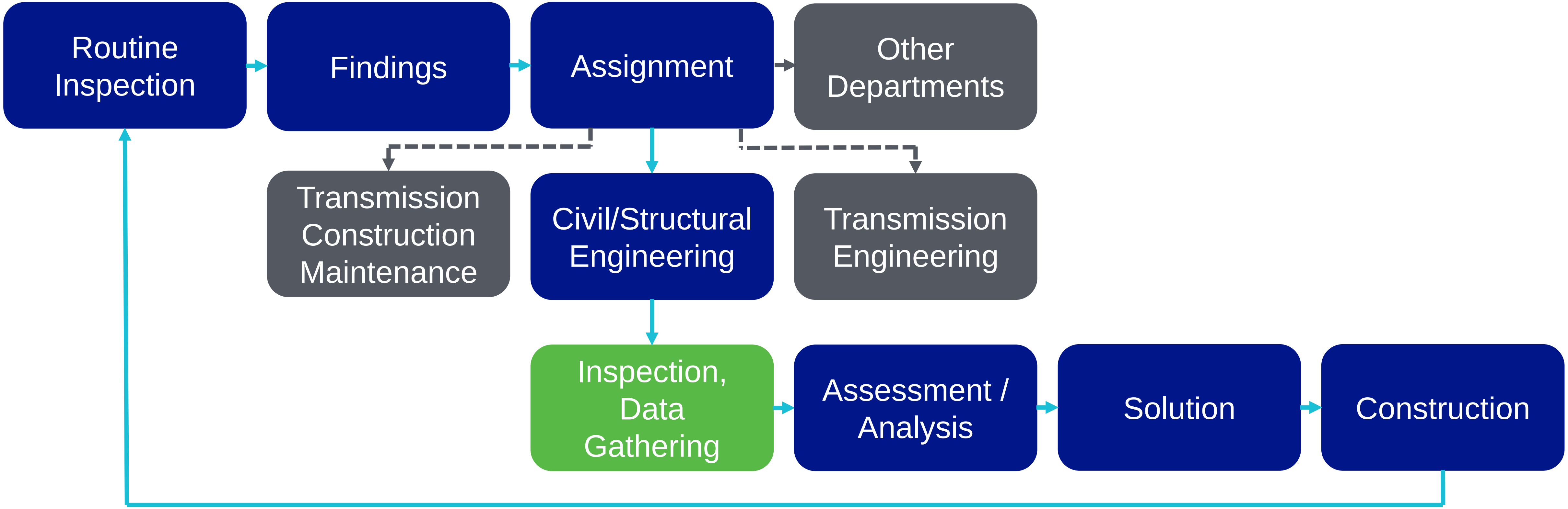
Asset Management Process – Flow Chart

Civil/Structural Engineering



Asset Management Process – Flow Chart

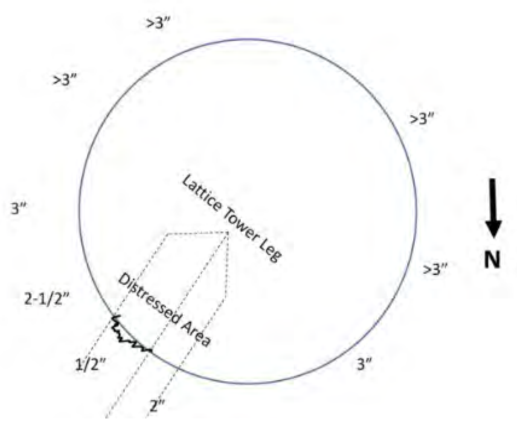
Inspection, Data Gathering



Asset Management Process – Flow Chart

Inspection, Data Gathering

Steel Section Loss



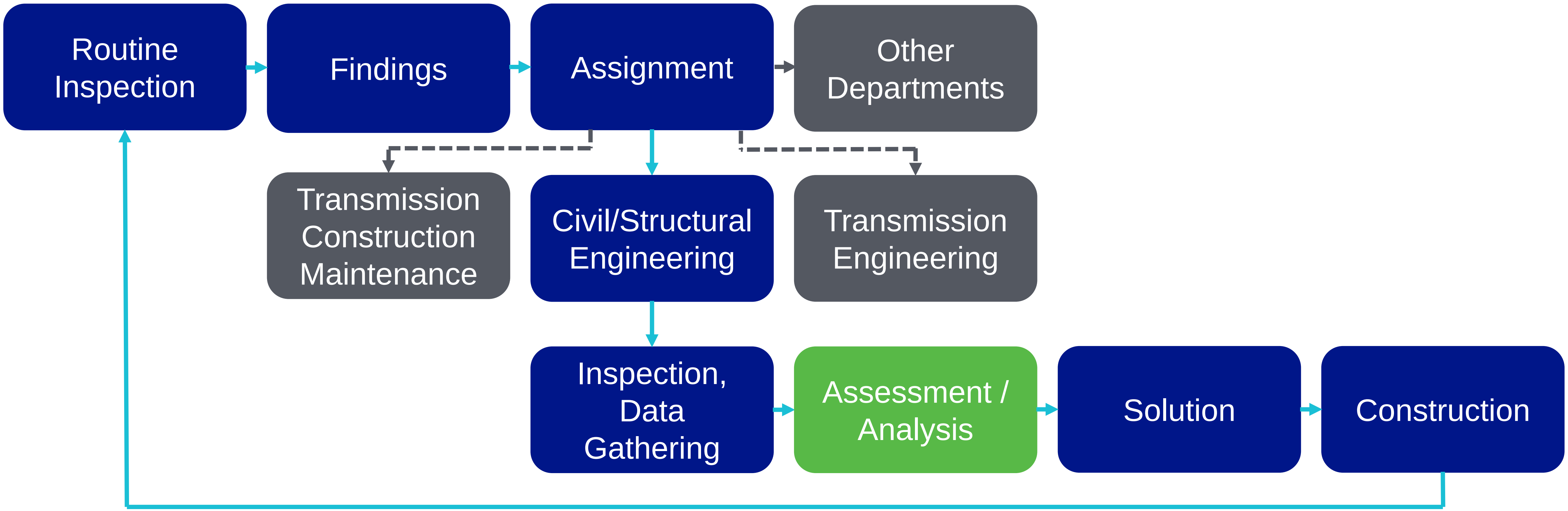
Concrete Cover

Tie Loss

Steel Pitting

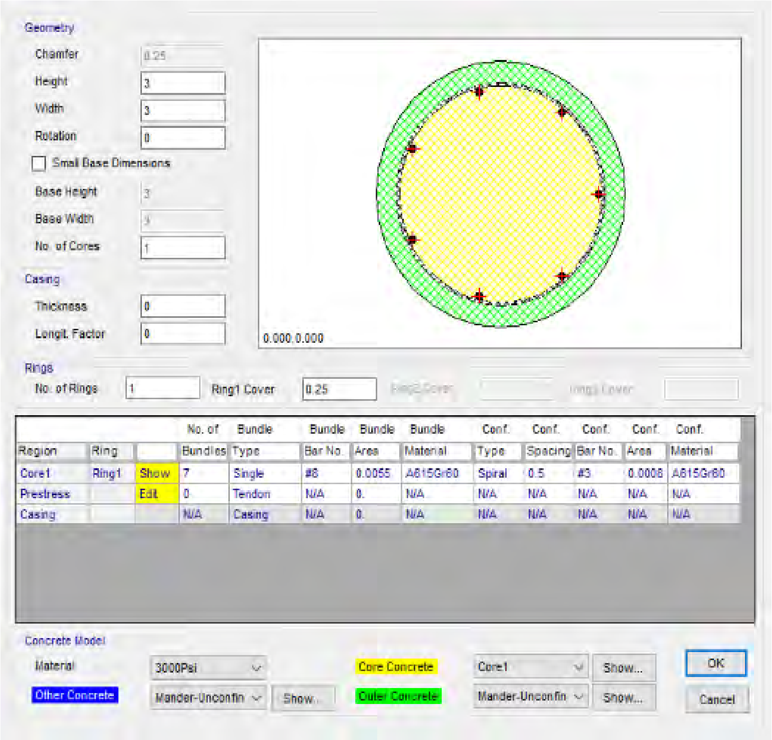
Asset Management Process – Flow Chart

Assessment / Analysis



Asset Management Process – Flow Chart

Assessment / Analysis



Pier Analysis

Check Governing 1/4" Fillet Weld

$M_{cap} := 1362.4\ kip \cdot ft$ — Capacity at 6' above base plate

$d_{out} := 37.61\ in$

$t_{pole} := 0.25\ in$

$t_{plate} := 0.3125\ in$

$A_{pole} := 30.03\ in^2$

$I := 5363.63\ in^4$

$d_{in} := d_{out} - 2 \cdot t_{pole} = 37.11\ in$

$W := 3\ in$ — Plate width

$T_{u\_flat} := t_{pole} \cdot \frac{M_{cap}}{I} \cdot \int_0^{\frac{d_{out}}{2}} d_{out}\, \mathrm{d}d_{out} = 134.736\ kip$ — Tensile force extreme extreme fiber/flat of pole.

$BR := 4 \cdot t_{pole} = 1\ in$

$w := 0.268 \cdot (d_{out} - t_{pole} - 2 \cdot BR) = 9.476\ in$ — ASCE 48-2019 Figure B-2

$ratio := \frac{W}{w} = 0.317$ — Ratio of welded plate to length of flat

$T_{u\_plate} := ratio \cdot T_{u\_flat} = 42.654\ kip$

$T_u := \frac{T_{u\_plate}}{2} = 21.327\ kip$ — Tension per leg of weld

$F_{y\_A572\_50} := 50\ ksi$

$F_{u\_A572\_50} := 65\ ksi$

$F_{y\_A572\_65} := 65\ ksi$

$F_{u\_A572\_65} := 80\ ksi$

$L := 7.14\ in$ — Length of weld per leg

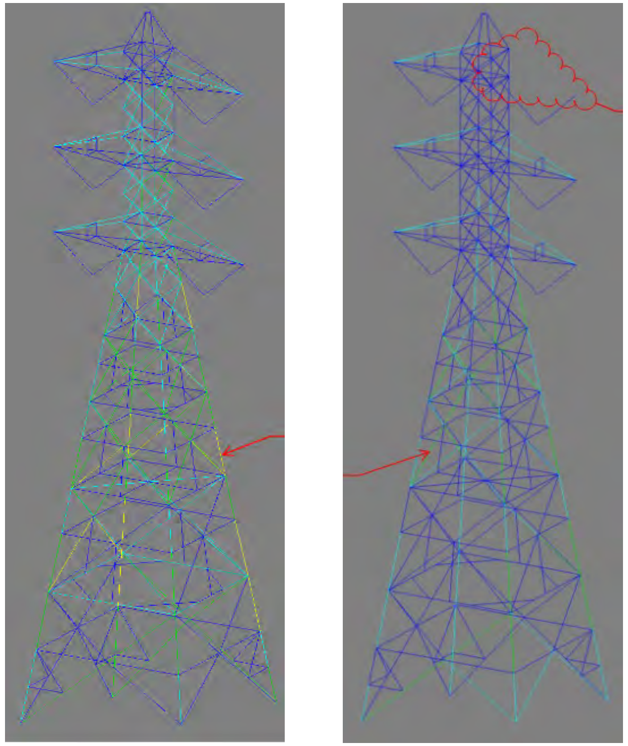
$A_{gv\_50} := L \cdot t_{plate} = 2.231\ in^2$

$A_{nv\_50} := A_{gv\_50}$

$A_{gv\_65} := L \cdot t_{pole} = 1.785\ in^2$

$A_{nv\_65} := A_{gv\_65}$

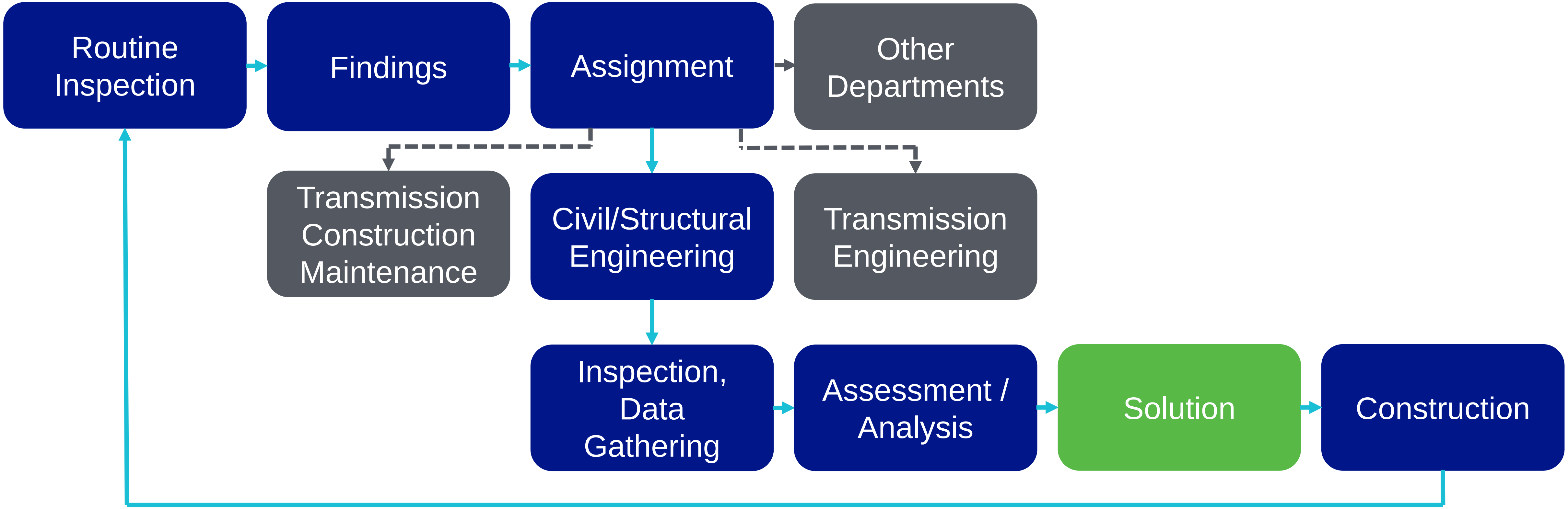
Weld Analysis for Repair



Load Analysis of Tower

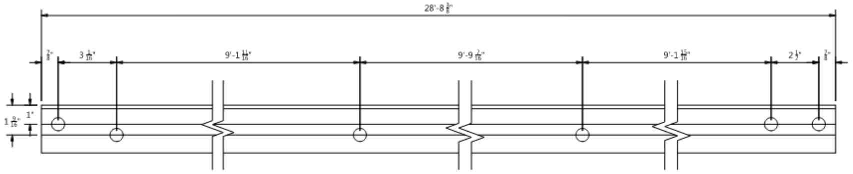
Asset Management Process – Flow Chart

Solution



Asset Management Process – Flow Chart

Solution Example #1 – Tower Member Replacement

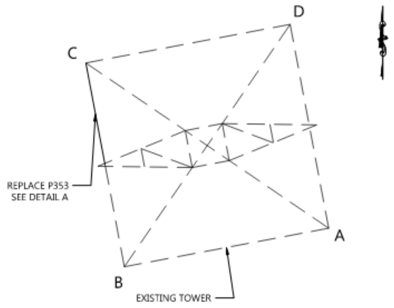


NOTES TO FABRICATOR:

1. ALL BOLT HOLES SHALL BE 11/16"Ø UNLESS OTHERWISE NOTED.
2. MARKS TO BE STENCILED IN MATERIAL.
3. ALL ANGLES SHALL BE ASTM A36.
4. ALL PLATES SHALL BE ASTM A36.
5. ALL BOLTS SHALL BE HEX HEAD AND INCLUDE HEX NUTS AND PAL NUTS.
5. ALL BOLTS SHALL BE ASTM F3125 GR A325 T1.
6. ALL NUTS SHALL BE ASTM A563 GR DH.
7. ALL WASHERS SHALL BE ASTM F436.
8. BOLT QUANTITY INCLUDES EXCESS BOLTS.
9. ALL NEW STEEL SHALL BE HOT DIPPED GALVANIZED, DULL FINISH, FOR FULL WEATHER PROTECTION PER ASTM A123 AND A153.
10. ALL STEEL SHALL BE MELTED AND MANUFACTURED IN THE USA.
11. ALL MATERIAL UTILIZED FOR THIS PROJECT MUST BE NEW AND FREE OF ANY DEFECTS. ANY MATERIAL SUBSTITUTIONS, INCLUDING BUT NOT LIMITED TO ALTERED SIZES AND/OR STRENGTHS, MUST BE APPROVED BY THE OWNER AND EOR IN WRITING.
12. PROVIDE STRUCTURAL STEEL SHOP DRAWINGS TO THE EOR FOR APPROVAL PRIOR TO FABRICATION.

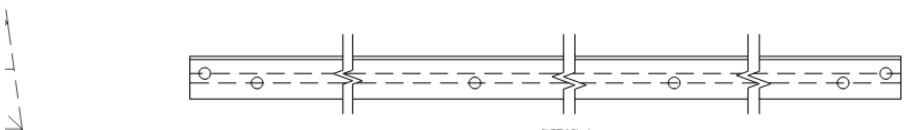
BILL OF MATERIAL

QTY.	DESCRIPTION	LENGTH		MARK
		FEET	INCHES	
1	L 2 1/2 x 2 1/2 x 3/16	28	8 3/8	P353
3	ASTM F3125 GR A325 T1 BOLT - 5/8" Ø	-	2	-
5	ASTM F3125 GR A325 T1 BOLT - 5/8" Ø	-	1 3/4	-
8	PALNUTS - 5/8" Ø	-	-	-
8	ASTM A563 GR DH NUT - 5/8" Ø	-	-	-
3	ASTM F436 WASHER - 5/8" Ø	-	-	-
3	5/8" Ø - 11 SECURITY BREAKOFF NUTS HD GALV.	-	-	504022



NOTES TO CONTRACTOR:

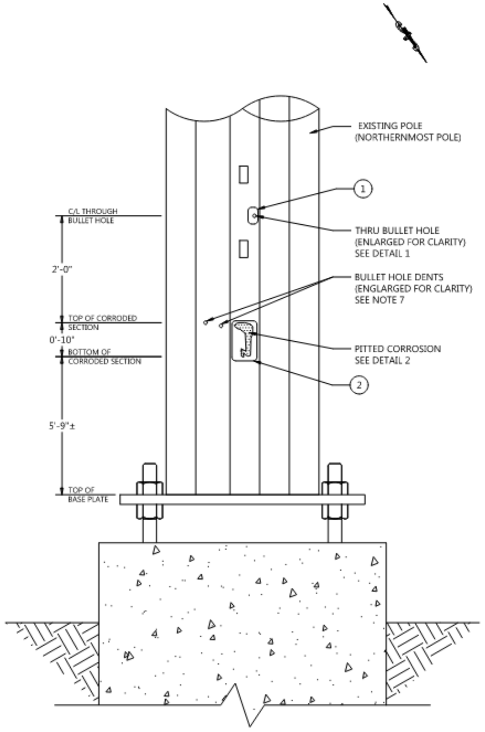
1. IT IS ASSUMED THAT ALL WORK WILL BE PERFORMED BY KNOWLEDGEABLE WORKMEN WITH TOWER CONSTRUCTION EXPERIENCE.
2. THE CONTRACTOR IS RESPONSIBLE FOR OBTAINING ALL REQUIRED PERMITS AND APPROVALS.
3. THE CONTRACTOR SHALL FIELD VERIFY ALL EXISTING CONDITIONS, POSSIBLE INTERFERENCES, AND DIMENSIONS BEFORE PROCEEDING WITH WORK. REPORT ANY AND ALL DISCREPANCIES TO THE EOR AND FIELD PERSONNEL IMMEDIATELY. ANY AND ALL FIELD CHANGES SHALL BE APPROVED AND DOCUMENTED BY THE EOR PRIOR TO FIELD IMPLEMENTATION.
4. WORK SHALL ONLY BE PERFORMED DURING CALM, DRY DAYS (WINDS LESS THAN 10-MPH).
5. OWNER WILL PROVIDE MATERIAL INDICATED IN THE BILL OF MATERIAL.
6. CONTRACTOR SHALL REPAIR ALL DAMAGED PAINTED/GALVANIZED SURFACES. SURFACES SHALL BE WIRE BRUSHED CLEAN AND REPAIRED BY COLD GALVANIZING BRUSH APPLIED PAINT (STOCK # S516004).
7. ALL BOLTED CONNECTIONS SHALL BE SNUG TIGHT.
8. FOR ORIGINAL STRUCTURE DRAWINGS, PLEASE REFER TO BETHLEHEM STEEL CORPORATION DRAWING P27 "35'-0" TYPE "C" LEG EXT'N. 0"-3" TANGENT TOWER 138/230KV D.C. TRANSMISSION LINE"



DETAIL A
MEMBER P353 - PLAN VIEW

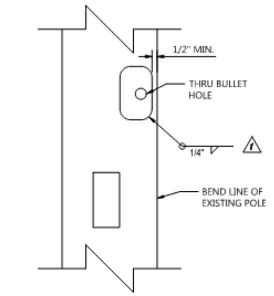
Asset Management Process – Flow Chart

Solution Example #2 – Welded Repair for Corroded Steel Section

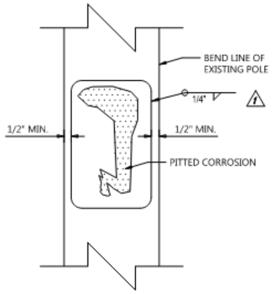


ELEVATION VIEW, FACING WEST

(NOT TO SCALE)



DETAIL 1

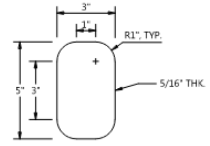


DETAIL 2

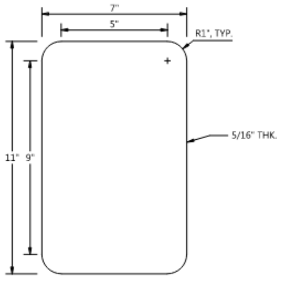
⚠1 BILL OF MATERIAL			
ITEM NO.	QTY.		DESCRIPTION
	INSTALL	ULTIMATE	
1	1		PLATE, 3" X 5" X 5/16"
2	1		PLATE, 7" X 11" X 5/16"

NOTES TO CONTRACTOR:

1. THE CONTRACTOR MUST FIELD VERIFY ALL EXISTING CONDITIONS, POSSIBLE INTERFERENCES, AND DIMENSIONS BEFORE PROCEEDING WITH WORK. REPORT ANY AND ALL DISCREPANCIES TO THE EOR AND FIELD PERSONNEL IMMEDIATELY. ANY AND ALL FIELD CHANGES MUST BE APPROVED AND DOCUMENTED BY THE EOR PRIOR TO FIELD IMPLEMENTATION.
2. ⚠3 THE EXISTING STRUCTURE IS PAINTED. REMOVAL AND ABATEMENT OF PAINT CONTAINING HEAVY METALS MUST BE PERFORMED PRIOR TO THE WORK SHOWN ON THIS DRAWING. AFTER COMPLETION OF REPAIR, PAINT MUST BE RESTORED. CONTRACTOR MUST REPAINT AREA OF REPAIR PER WSP INSPECTION REPORT "R-20240223_TL23052&23007-Z322262-TT16104_SP_1."
3. CONTRACTOR MUST COORDINATE SPECIAL INSPECTION PROVIDED BY OWNER FOR ALL FIELD WELDS.
4. ⚠2 CONTRACTOR MUST PROVIDE FIRE WATCH FOR FIELD WELDING IN ACCORDANCE WITH ESP 113.
5. OWNER WILL PROVIDE MATERIAL INDICATED IN THE BILL OF MATERIAL.
6. PRIOR TO WELDING, THE STEEL MUST BE CLEANED PER SSPC-SP5 TO WHITE BASE METAL. WELDING REPAIRS MUST BE ALTERNATED ON SECTIONS FURTHER APART TO ALLOW FOR COOLING IN ORDER TO AVOID CONTINUOUS HIGH TEMPERATURE HEATING.
7. BULLET HOLE DENTS TO BE REPAIRED USING FIELD PLUG-WELDS TO FILL DENTS. DENTS MUST BE FILLED WITH WELD UP TO SURFACE OF POLE AND GROUND SMOOTH ON SURFACE.
8. ALL WELDS MUST BE IN ACCORDANCE WITH AWS D1.1 AND TE-0042 AT A MINIMUM.
9. WELD STRENGTH, F_{EXX}=80 KSI MIN.
10. ⚠1 ALL PLATES MUST BE ASTM A572 GR. 50. ALL PLATES MUST HAVE A CHARPY V-NOTCH IMPACT VALUE OF 15 FT. LBS. AT -20°F PER PLATE TEST MINIMUM
11. ALL NEW STEEL MUST BE MELTED AND MANUFACTURED IN THE USA. PROVIDE MILL TEST REPORTS FOR OWNER REVIEW.



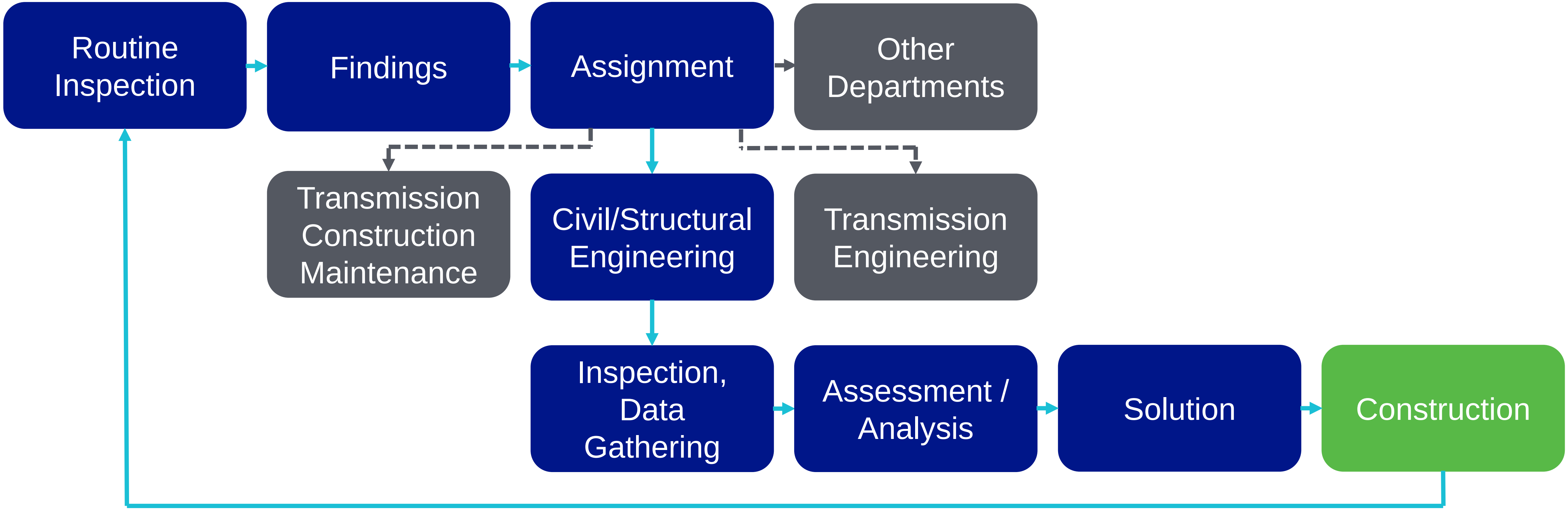
⚠1 ITEM (1) DETAIL



⚠1 ITEM (2) DETAIL

Asset Management Process – Flow Chart

Construction



Asset Management Process – Flow Chart

Construction Example

Preparation

Sand Blasting

Concrete Removal

Asset Management Process – Flow Chart

Construction Example

Weld Repair

Zinc Coating

Mortar Infill

Asset Management Process – Flow Chart

Construction Example

Before

After

Case Studies

Concrete Pier

Steel members and concrete pier analysis

Steel Monopole

Steel arm and hardware analysis

Case Study – Concrete Pier

Inspection & Data Gathering → Assessment / Analysis → Solution → Construction

Case Study – Concrete Pier

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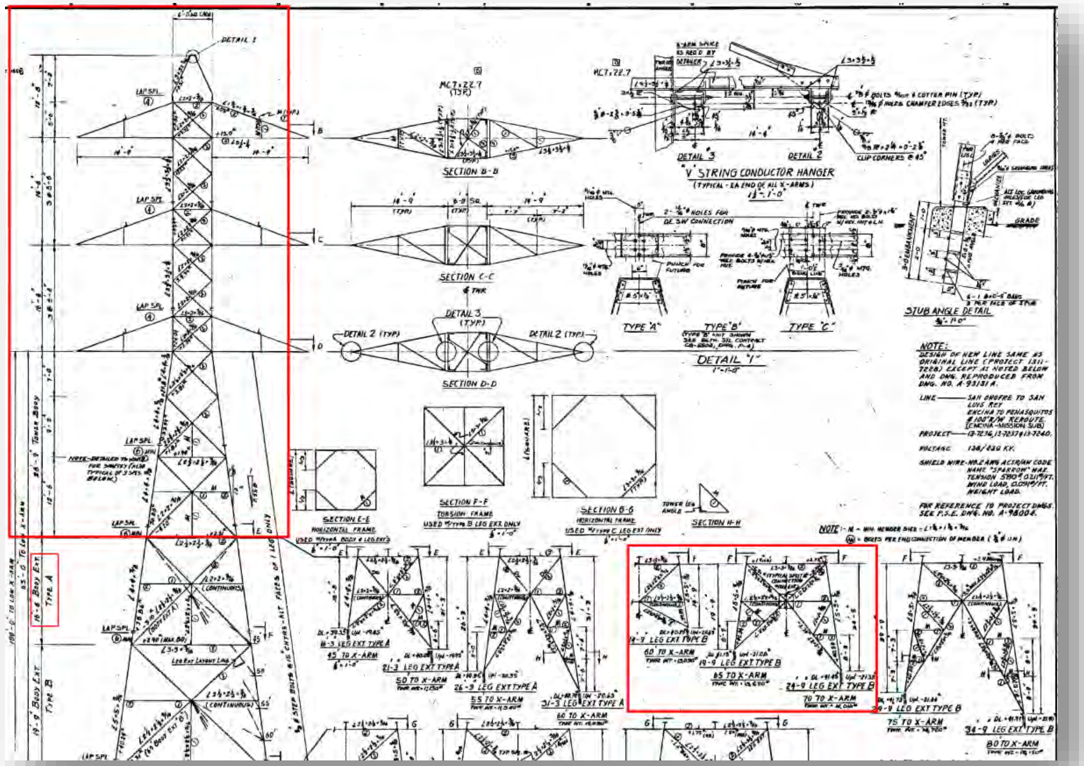
Case Study – Concrete Pier



Inspection & Data Gathering → Assessment / Analysis → Solution → Construction

Case Study – Concrete Pier

Inspection & Data Gathering → Assessment / Analysis → Solution → Construction

Case Study – Concrete Pier

$$T_{wind.uplift.tower} := \frac{V_{wind.tower} \cdot h_{wind.cg}}{a_{tower.footprint} \cdot 2} = 7.127\ kip$$ wind uplift from tower only per leg

$$T_{tot.wind.uplift} := T_{wind.uplift.wires} + T_{wind.uplift.tower} = 31.935\ kip$$ total wind uplift per leg

$$\frac{T_{tot.wind.uplift}}{P_{wind.uplift}} = 1.043$$ close to 1.0, compared very well.

$$\frac{T_{wind.uplift.tower}}{T_{tot.wind.uplift}} = 0.223$$ tower wind uplift is about 25% of the total wind uplift per leg

$$V_{tot.wind} := V_{wind.tower} + V_{wind.wires} = 16.977\ kip$$ total wind base shear of the tower

$$\frac{V_{wind.tower}}{V_{tot.wind}} = 0.286$$ wind shear from tower is about 30% of total wind base shear

therefore:

$$P_{max.downward} := P_{DL} = 41.45 \cdot kip$$ unfactored maximum downward load per leg

$$P_{max.net.uplift} := P_{uplift} = 21.4 \cdot kip$$ unfactored max net uplift per leg

$$n_{bolts} := 5 \cdot 2 = 10$$ total number of bolts at the leg-to-stub splice connection 5 rows and 2 lines

check leg strength at the minimum net section (only four bolts resisting the remaining load in the net section):

$$P_u := P_{max.downward} \cdot \frac{4}{n_{bolts}} \cdot LF = 24.87 \cdot kip$$

$$\frac{P_u}{\left(\frac{F_u \cdot A_{net}}{\Omega_{sf}}\right)} = 0.201$$ <1, ok

$$\frac{P_u}{\left[\frac{F_y \cdot (A_{leg} - A_{lost})}{1}\right]} = 0.266$$ <1, ok

$$\frac{P_{max.downward} \cdot LF}{\left[\frac{F_y \cdot (A_{leg} - A_{lost})}{\Omega_{sf}}\right]} = 0.664$$ <1, ok conservative

check concrete tensile breakout strength of drilled pier:

$$D_{pier} := 30in = 2.5 \cdot ft$$ diameter of pier

$$d_{bar} := 1 \cdot in$$ #8 bars in the pier

$$A_{bar} := \frac{\pi \cdot d_{bar}^2}{4} = 0.785 \cdot in^2$$

$$n_{bar} := 8$$ number of bars in the pier

$$d_{tie} := \frac{3}{8} in$$ diameter of tie

$$s_{tie} := 6in$$ spacing of tie

check concrete shear breakout:

$$D_r := D_{pier} - cover - d_{bar} - \frac{d_{tie}}{2} = 25.813\ in$$ circular diameter of spiral tie at tie center

$$s_{tie} = 6\ in$$ pitch (spacing) of spiral ties

$$\frac{\frac{V_{tot.wind}}{4} \cdot LF}{0.75 \cdot \frac{2}{\pi} \cdot (2 \cdot f_y \cdot A_{tie}) \cdot \left[\frac{1.5 \cdot (e_{stub.top}) - 5in}{s_{tie}} + 2\right]} = 0.482$$ <1 (worst case), ok, with 2.5 extra turns of spiral ties at the top

$$\frac{0.8 \cdot D_r}{1.5 \cdot (e_{stub.top})} = 3.733 \qquad 1.5 \cdot (e_{stub.top}) = 5.531\ in$$

$$\frac{\int_0^{\pi} \sin(\theta)\, d\theta}{\int_0^{\pi} 1\, d\theta} \rightarrow \frac{2}{\pi} \qquad \frac{\left(\frac{\int_0^{\pi} \sin(\theta)\, d\theta}{\int_0^{\pi} 1\, d\theta}\right)}{\frac{2}{\pi}} = 1$$

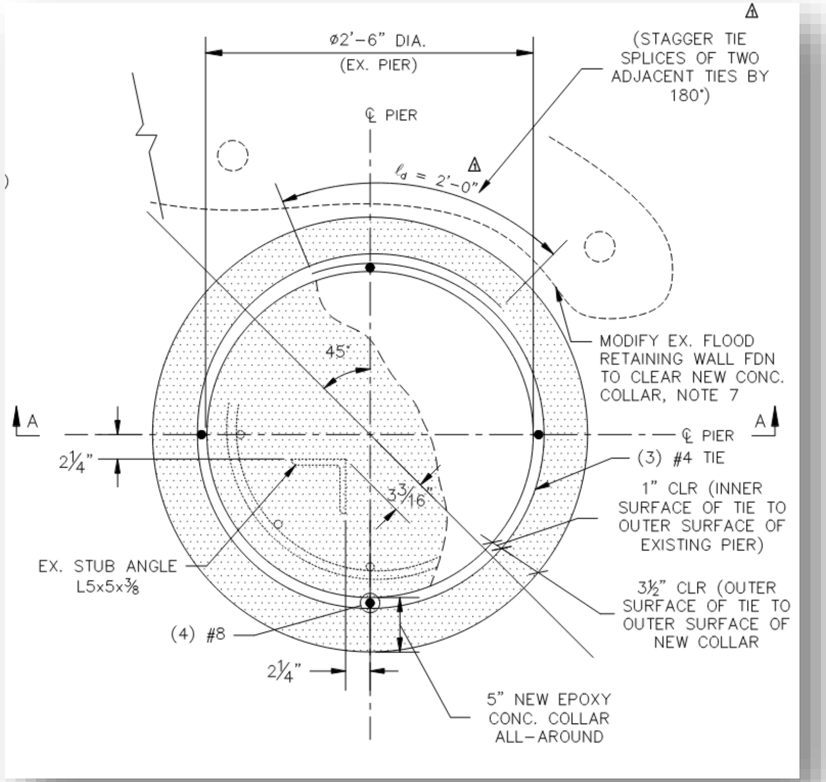
$$\frac{P_{uplift} \cdot LF}{0.75 \cdot f_s \cdot A_{bar} \cdot n_{bar}} + \frac{\frac{V_{tot.wind}}{4} \cdot LF}{0.75 \cdot \frac{2}{\pi} \cdot (2 \cdot f_y \cdot A_{tie}) \cdot \left[\frac{1.5 \cdot (e_{stub.top}) - 5in}{s_{tie}} + 2\right]} = 0.626$$ <1.2, ok

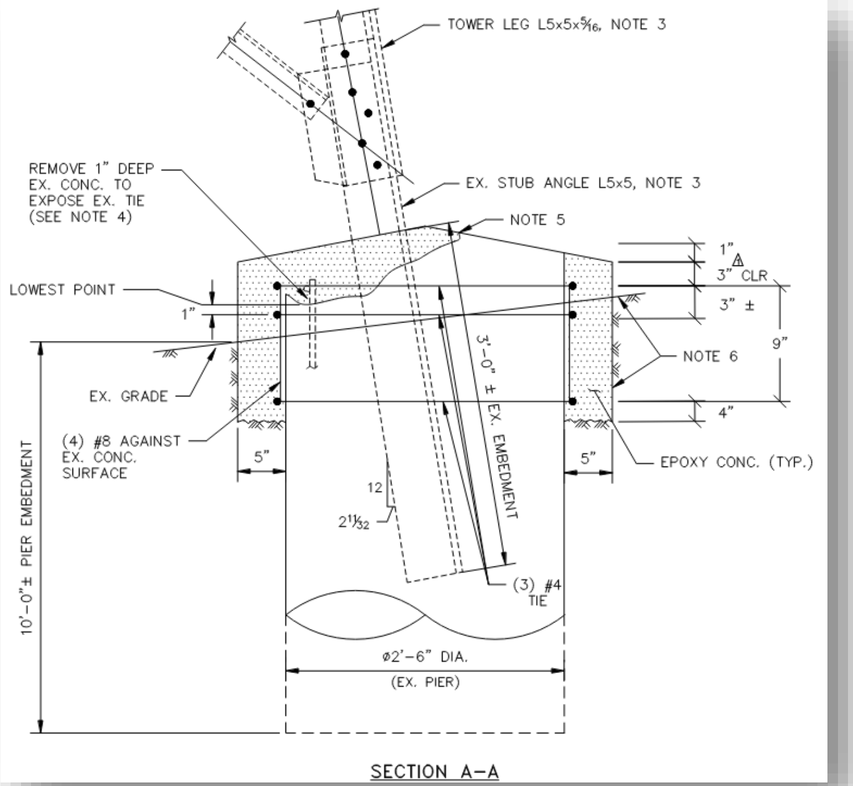
Inspection & Data Gathering → **Assessment / Analysis** → Solution → Construction

Case Study – Concrete Pier

Inspection & Data Gathering → Assessment / Analysis → Solution → Construction

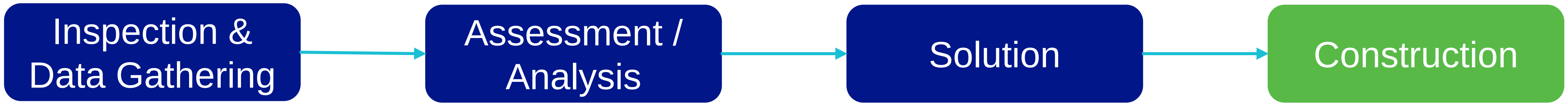
Case Study – Concrete Pier





Inspection & Data Gathering → Assessment / Analysis → Solution → Construction

Case Study – Concrete Pier



Case Study – Concrete Pier

Inspection & Data Gathering → Assessment / Analysis → Solution → Construction

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Inspection & Data Gathering → Assessment / Analysis → Solution → Construction

Case Studies

Concrete Pier

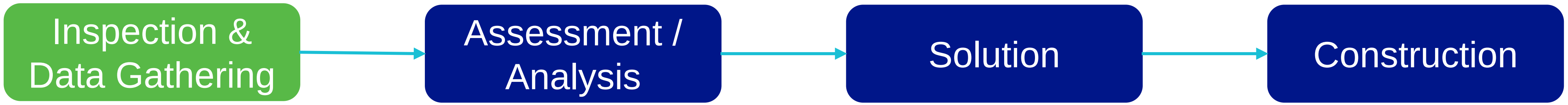
Steel members and concrete pier analysis

Steel Monopole

Steel arm and hardware analysis

SDGE™ EDM

Case Study – Steel Monopole



Case Study – Steel Monopole

Inspection & Data Gathering → Assessment / Analysis → Solution → Construction

Case Study – Steel Monopole

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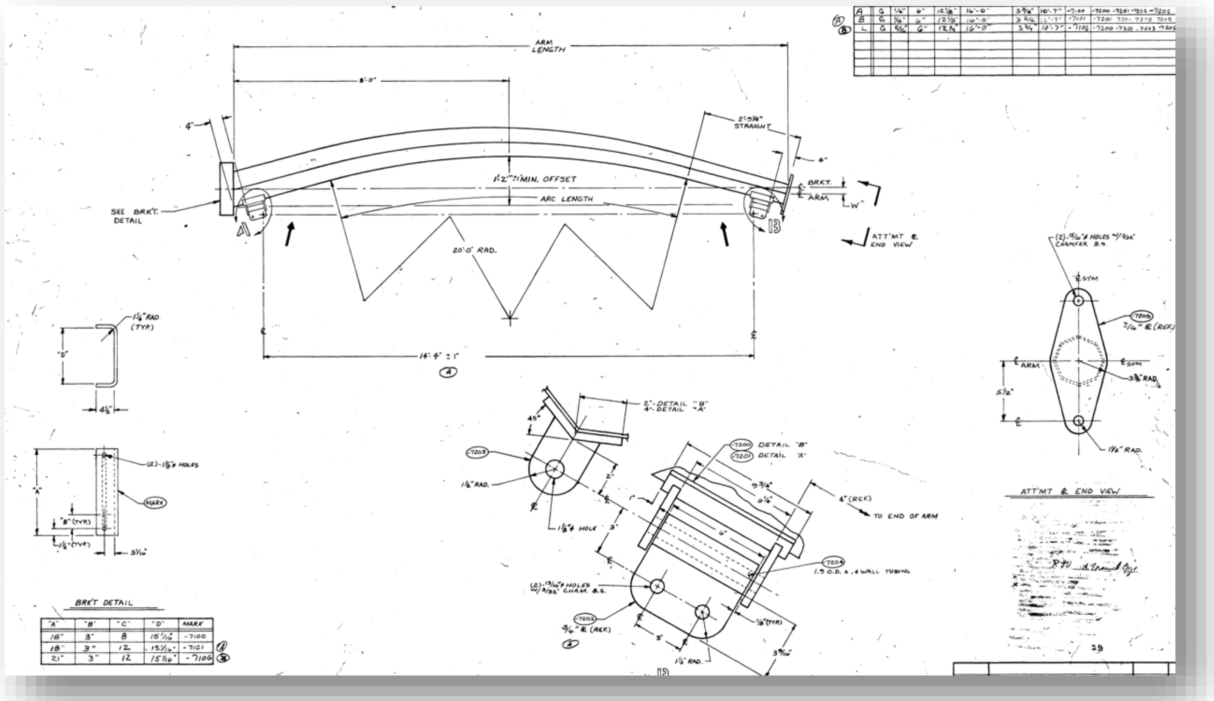
Case Study – Steel Monopole



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SDGE™ EDM

Case Study – Steel Monopole

Inspection & Data Gathering → Assessment / Analysis → Solution → Construction

Case Study – Steel Monopole

Note: Loads in this report include load from counter weights, insulator weight, insulator wind area and jumpers.

LC #	WC #	Load Case Description	Set No.	Phase No.	Attach. Joint Labels	Structure Loads Vert. (lbs)	Structure Loads Trans. (lbs)	Structure Loads Long. (lbs)	Loads from back span Vert. (lbs)	Loads from back span Trans. (lbs)	Loads from back span Long. (lbs)	Loads from ahead span Vert. (lbs)	Loads from ahead span Trans. (lbs)	Loads from ahead span Long. (lbs)	Warnings
1	14	60 deg F (Everyd	1	1	1.1	2141	10	110	873	4	11472	1268	6	-11362	
1	14		2	1	2.1	2143	6	110	873	2	11435	1270	4	-11325	
1	14		3	1	3.1	2154	3	85	884	2	11191	1270	1	-11106	
1	14		4	1	4.1	2136	18	106	868	10	11461	1268	8	-11355	
1	14		5	1	5.1	2146	17	127	877	10	11105	1269	7	-10977	
1	14		6	1	6.1	2140	15	143	871	9	11337	1268	6	-11194	
1	14		57	1	z055:SW1	154	2	-76	58	1	1076	96	1	-1152	
6	1	GO95LT GRD B+ AT	1	1	1.1	1958	2017	113	695	978	17769	1263	1039	-17656	
6	1		2	1	2.1	1960	2015	108	698	976	17635	1262	1039	-17527	
6	1		3	1	3.1	1977	2006	83	710	976	17317	1267	1030	-17234	
6	1		4	1	4.1	1956	2026	95	690	985	17750	1266	1041	-17655	
6	1		5	1	5.1	1977	2022	146	708	987	17041	1268	1036	-16895	
6	1		6	1	6.1	1968	2020	164	701	985	17354	1268	1035	-17190	
6	1		57	1	z055:SW1	135	234	-101	39	114	1704	96	120	-1805	
7	1	GO95LT GRD B- AT	1	1	1.1	1960	-1983	112	695	-966	17773	1265	-1017	-17661	
7	1		2	1	2.1	1961	-1994	108	699	-968	17636	1263	-1027	-17529	
7	1		3	1	3.1	1979	-1996	83	711	-970	17315	1268	-1026	-17233	
7	1		4	1	4.1	1950	-1976	95	687	-957	17752	1263	-1018	-17657	
7	1		5	1	5.1	1972	-1977	145	706	-958	17043	1266	-1018	-16898	
7	1		6	1	6.1	1963	-1977	163	698	-959	17357	1265	-1018	-17194	
7	1		57	1	z055:SW1	135	-227	-101	39	-110	1704	96	-116	-1806	
24	4	KNOWN LOCAL WIND	1	1	1.1	2031	2707	120	766	1310	15805	1265	1397	-15685	
24	4		2	1	2.1	2029	2707	119	766	1309	15751	1263	1398	-15632	
24	4		3	1	3.1	2044	2698	91	776	1309	15486	1268	1389	-15395	
24	4		4	1	4.1	2030	2716	114	762	1317	15784	1268	1399	-15670	
24	4		5	1	5.1	2042	2713	143	772	1318	15365	1270	1394	-15222	
24	4		6	1	6.1	2035	2710	161	765	1316	15633	1270	1393	-15472	
24	4		57	1	z055:SW1	132	316	-104	37	154	1779	96	162	-1883	
25	4	KNOWN LOCAL WIND	1	1	1.1	2033	-2676	120	766	-1299	15807	1267	-1377	-15687	
25	4		2	1	2.1	2031	-2687	119	767	-1301	15751	1264	-1386	-15632	
25	4		3	1	3.1	2046	-2688	91	777	-1303	15485	1269	-1385	-15394	
25	4		4	1	4.1	2025	-2671	114	760	-1292	15787	1265	-1379	-15673	
25	4		5	1	5.1	2037	-2671	142	769	-1292	15368	1268	-1378	-15226	
25	4		6	1	6.1	2031	-2671	161	763	-1293	15637	1267	-1378	-15476	
25	4		57	1	z055:SW1	132	-308	-104	37	-150	1779	96	-158	-1884	
56	12	Uplift (GO95 Lig	1	1	1.1	2023	14	116	756	5	15474	1267	9	-15358	
56	12		2	1	2.1	2029	8	111	759	3	15340	1269	5	-15229	
56	12		3	1	3.1	2045	4	87	774	2	15002	1271	1	-14915	
56	12		4	1	4.1	2017	24	94	749	13	15453	1267	11	-15359	
56	12		5	1	5.1	2039	22	150	770	13	14711	1268	9	-14562	
56	12		6	1	6.1	2029	21	168	762	12	15033	1267	8	-14865	
56	12		57	1	z055:SW1	148	3	-88	52	1	1275	96	1	-1363	

Inspection & Data Gathering → Assessment / Analysis → Solution → Construction

Case Study – Steel Monopole

Note: Loads in this report include load from counter weights, insulator weight, insulator wind area and jumpers.

LC #	WC #	Load Case Description	Set No.	Phase No.	Attach. Joint Labels	Structure Loads Vert. (lbs)	Structure Loads Trans. (lbs)	Structure Loads Long. (lbs)	Loads from back span Vert. (lbs)	Loads from back span Trans. (lbs)	Loads from back span Long. (lbs)	Loads from ahead span Vert. (lbs)	Loads from ahead span Trans. (lbs)	Loads from ahead span Long. (lbs)	Warnings
1	14	60 deg F (Everyd	1	1	1.1	2141	10	110	873	4	11472	1268	6	-11362	
1	14		2	1	2.1	2143	6	110	873	2	11435	1270	4	-11325	
1	14		3	1	3.1	2154	3	85	884	2	11191	1270	1	-11106	
1	14		4	1	4.1	2136	18	106	868	10	11461	1268	8	-11355	
1	14		5	1	5.1	2146	17	127	877	10	11105	1269	7	-10977	
1	14		6	1	6.1	2140	15	143	871	9	11337	1268	6	-11194	
1	14		57	1	z055:SW1	154	2	-76	58	1	1076	96	1	-1152	
6	1	GO95LT GRD B+ AT	1	1	1.1	1958	2017	113	695	978	17769	1263	1039	-17656	
6	1		2	1	2.1	1960	2015	108	698	976	17635	1262	1039	-17527	
6	1		3	1	3.1	1977	2006	83	710	976	17317	1267	1030	-17234	
6	1		4	1	4.1	1956	2026	95	690	985	17750	1266	1041	-17655	
6	1		5	1	5.1	1977	2022	146	708	987	17041	1268	1036	-16895	
6	1		6	1	6.1	1968	2020	164	701	985	17354	1268	1035	-17190	
6	1		57	1	z055:SW1	135	234	-101	39	114	1704	96	120	-1805	
7	1	GO95LT GRD B- AT	1	1	1.1	1960	-1983	112	695	-966	17773	1265	-1017	-17661	
7	1		2	1	2.1	1961	-1994	108	699	-968	17636	1263	-1027	-17529	
7	1		3	1	3.1	1979	-1996	83	711	-970	17315	1268	-1026	-17233	
7	1		4	1	4.1	1950	-1976	95	687	-957	17752	1263	-1018	-17657	
7	1		5	1	5.1	1972	-1977	145	706	-958	17043	1266	-1018	-16898	
7	1		6	1	6.1	1963	-1977	163	698	-959	17357	1265	-1018	-17194	
7	1		57	1	z055:SW1	135	-227	-101	39	-110	1704	96	-116	-1806	
24	4	KNOWN LOCAL WIND	1	1	1.1	2031	2707	120	766	1310	15805	1265	1397	-15685	
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25	4	KNOWN LOCAL WIND	1	1	1.1	2033	-2676	120	766	-1299	15807	1267	-1377	-15687	
25	4		2	1	2.1	2031	-2687	119	767	-1301	15751	1264	-1386	-15632	
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25	4		6	1	6.1	2031	-2671	161	763	-1293	15637	1267	-1378	-15476	
25	4		57	1	z055:SW1	132	-308	-104	37	-150	1779	96	-158	-1884	
56	12	Uplift (GO95 Lig	1	1	1.1	2023	14	116	756	5	15474	1267	9	-15358	
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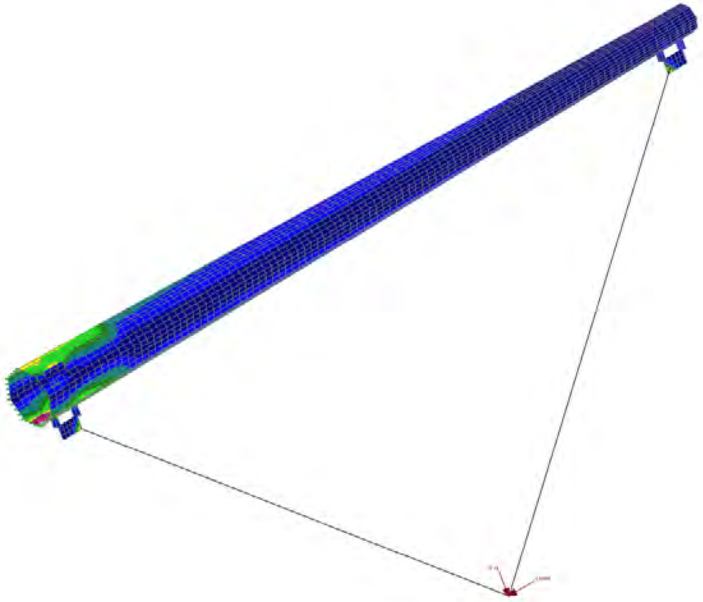
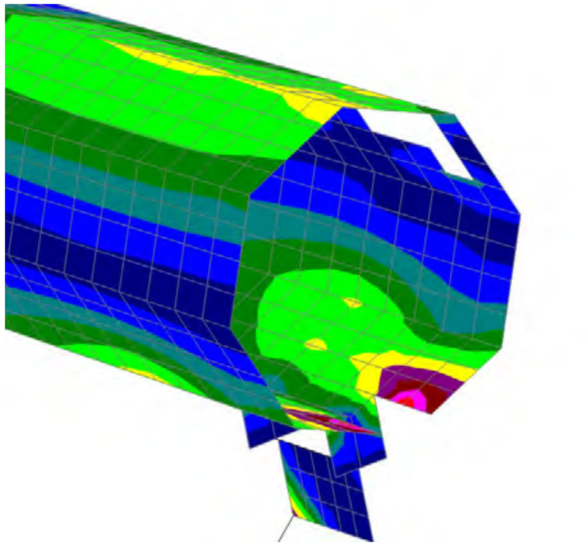
56	12		6	1	6.1	2029	21	168	762	12	15033	1267	8	-14865	
56	12		57	1	z055:SW1	148	3	-88	52	1	1275	96	1	-1363	



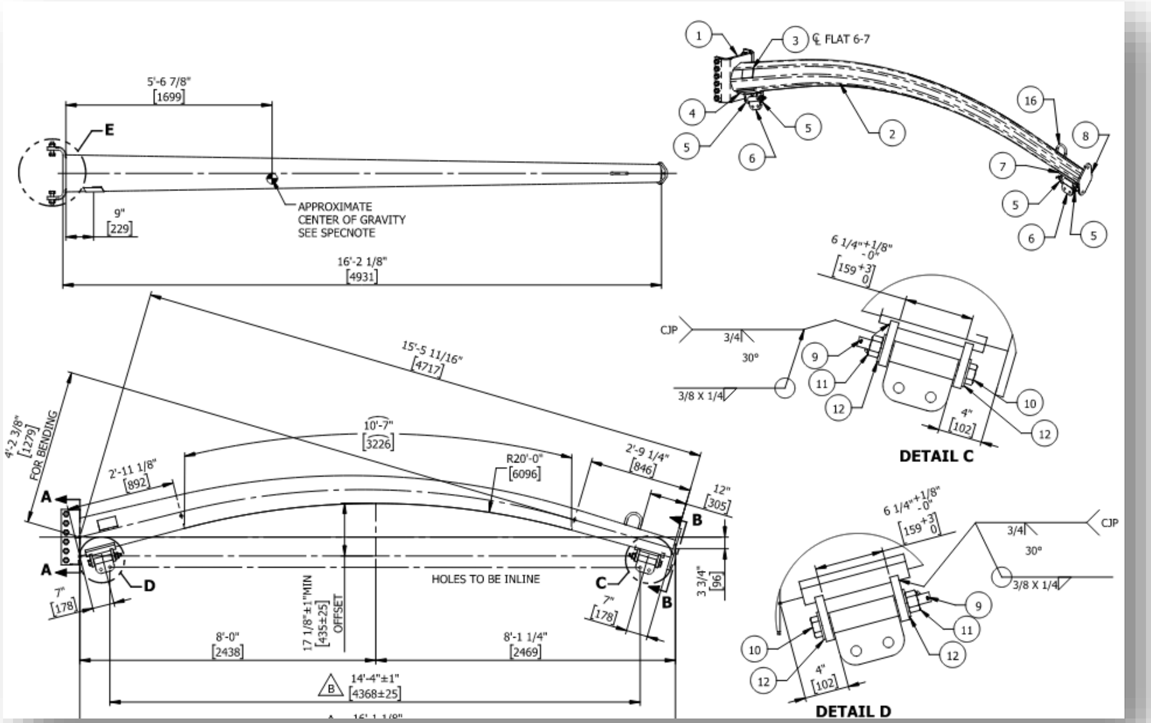


Inspection & Data Gathering → Assessment / Analysis → Solution → Construction

Case Study – Steel Monopole

Inspection & Data Gathering → Assessment / Analysis → Solution → Construction

Case Study – Steel Monopole



Inspection & Data Gathering → Assessment / Analysis → Solution → Construction

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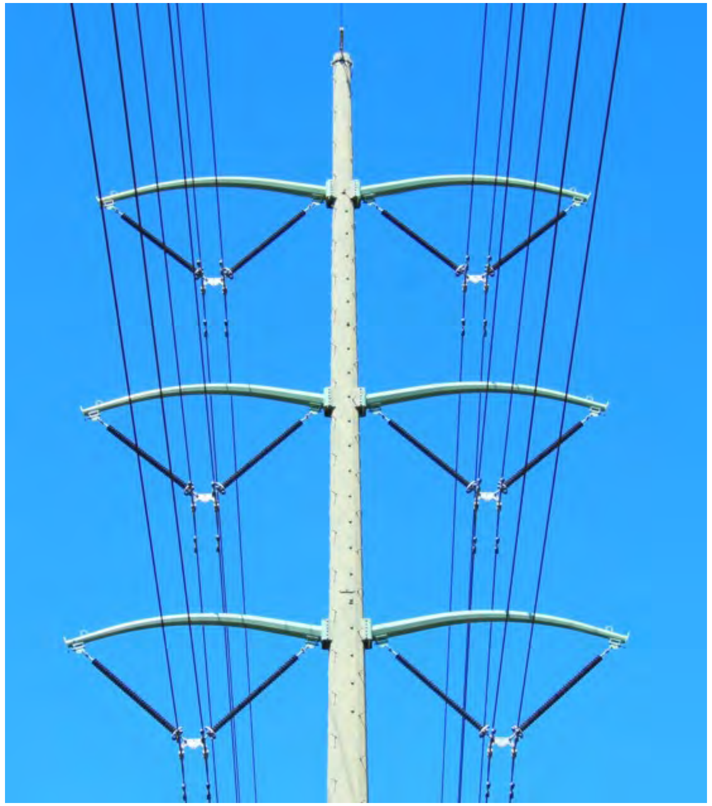


Inspection & Data Gathering → Assessment / Analysis → Solution → Construction

Conclusion

Asset Management of Aging Infrastructure

- The Task Tracker Program is an Asset Management tool used to maintain a safe and reliable Transmission system

- Asset Management Process Flow
  - Provides clear handoffs between various department
  - Sets a standardized framework for all aspect of Civil/Structural related scope

- Task Tracker Counts
  - 16800+ total Task Tracker
  - 960 counts of Civil / Structural Engineering Related Assets
    - 879 Completed
    - 81 Active
  - In the last 5 years, Average of 65 new Task Tracker / year

- Complex Projects
  - Unique engineered solutions
  - Drives solution that minimize cost and environmental impact

Questions

Ameren Composite Poles

August Platt – Standards Engineer

Agenda

- Ameren Introduction
- Composite Pole Use History
- Advantages & Disadvantages
- Pultrusion Process
- Testing
- Design
- Applications & Examples
- Questions

Company Overview

Ameren Missouri

- Electric transmission, distribution, and generation business and a natural gas distribution business regulated by MoPSC
- Serves 1.2 million electric and 0.1 million gas customers
- ~10,000 MW of total generation capability

Ameren Illinois Electric Distribution

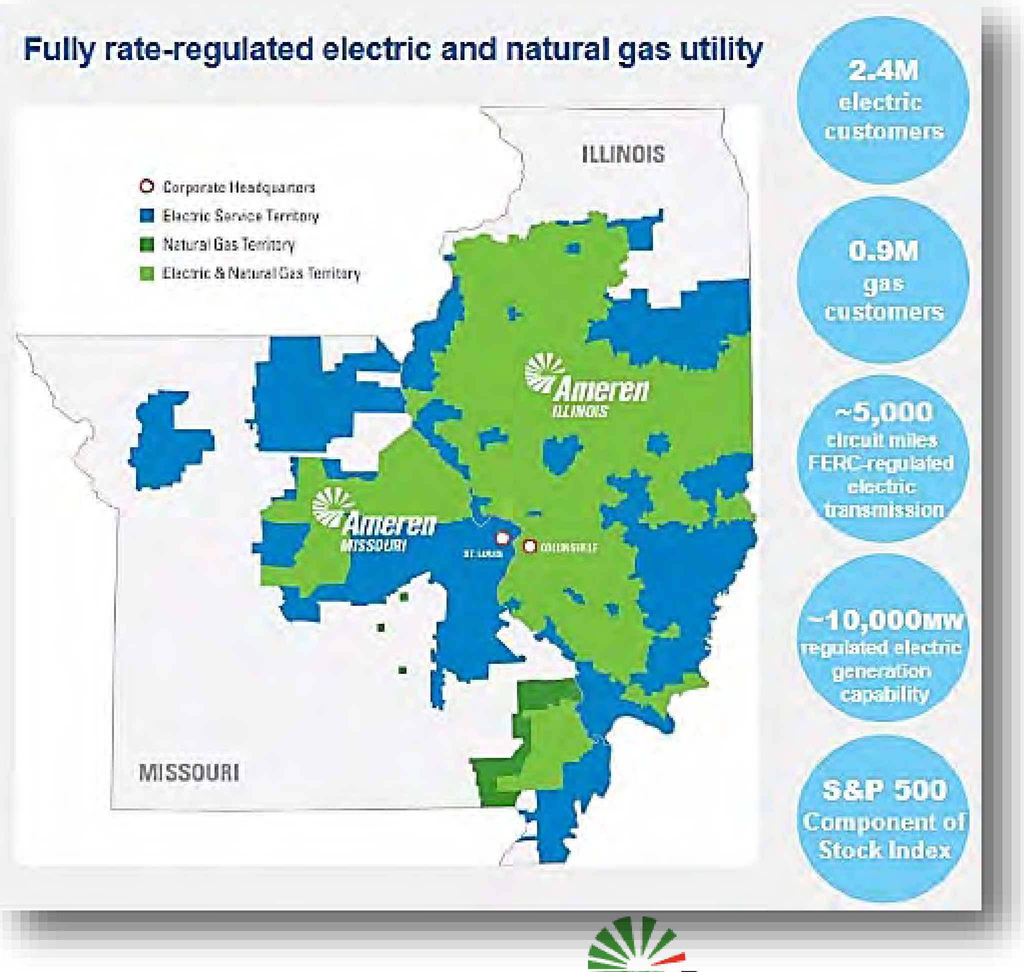
- Electric distribution businesses in Illinois regulated by ICC
- Serves 1.2 million electric customers

Ameren Illinois Natural Gas

- Natural gas distribution business in Illinois regulated by ICC

Ameren Transmission

- Electric transmission businesses of Ameren Illinois and ATXI regulated by FERC
- Ameren Illinois invests in local reliability projects
- ATXI invests in regionally beneficial projects

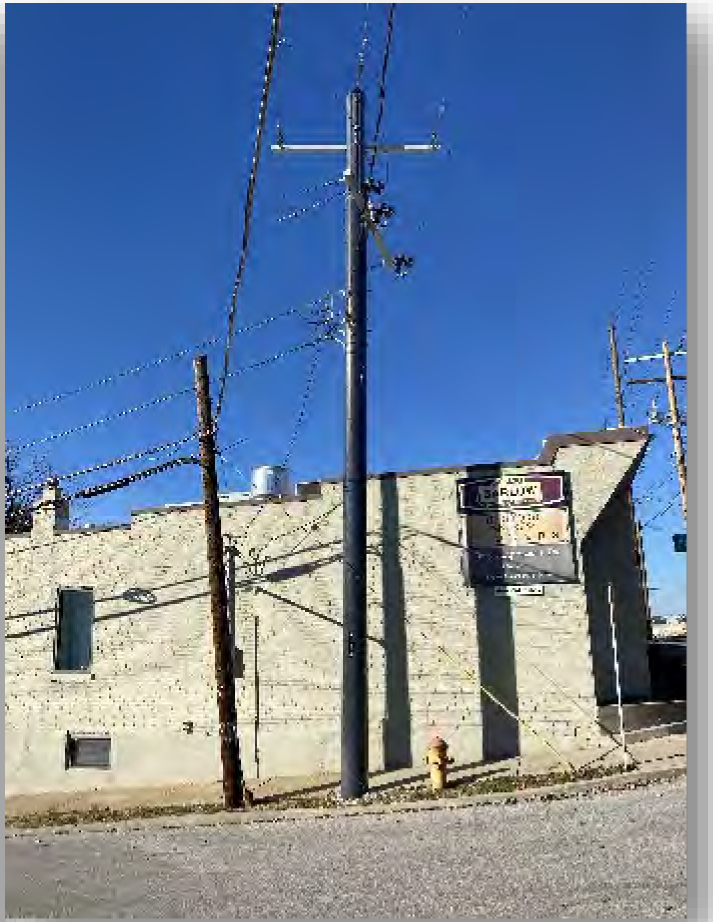


Ameren FOCUSED ENERGY. For life.

Composite Pole History at Ameren

Wood Poles have been used for distribution because of abundance, ease, and cost. This is still the case today at Ameren with over 99% of the poles being wood. Ameren does use Laminated Wood, Steel and Composite poles for Unguyed structures.

As the required Right of Way narrowed, and easements became more difficult to obtain, Ameren began using more unguyed structures which led to the use of Composite Poles 2009.



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Composite Pole History at Ameren

Since 2009 Ameren has installed over 8,600 Composite Poles on its overhead distribution system. Ameren currently uses 12”, 14”, 15” and 17” diameter poles as single-layer and multi-layer constructions.

The use of Composite Poles at Ameren has grown significantly since 2014 when the first proactive program was started, and our designs began incorporating Composite Poles as storm structures.

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Composite Advantages

Lifespan - 60+ years

Maintenance

- UV resistant
- Does not rot or corrode
- No routine maintenance

Safety

- Low conductivity
- Light weight

Environmental

- No toxic chemicals effecting surrounding soil or streams
- Animal resistant (Insect, Woodpecker)
- Enhanced Avian Protection

Copper Theft – Ground wire inside of pole

Prefabrication

- Accurate attachment placement
- Labor Savings

Fire Resistant

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Composite Disadvantages

Climbing

- Unable to use wood pole gaffs

Insert sleeves to prevent crushing

Skin Irritations when drilling

- Special Equipment for attaching hardware
- Carbide Tip Drill Bits for drilling holes

Third party attachments require pole bands

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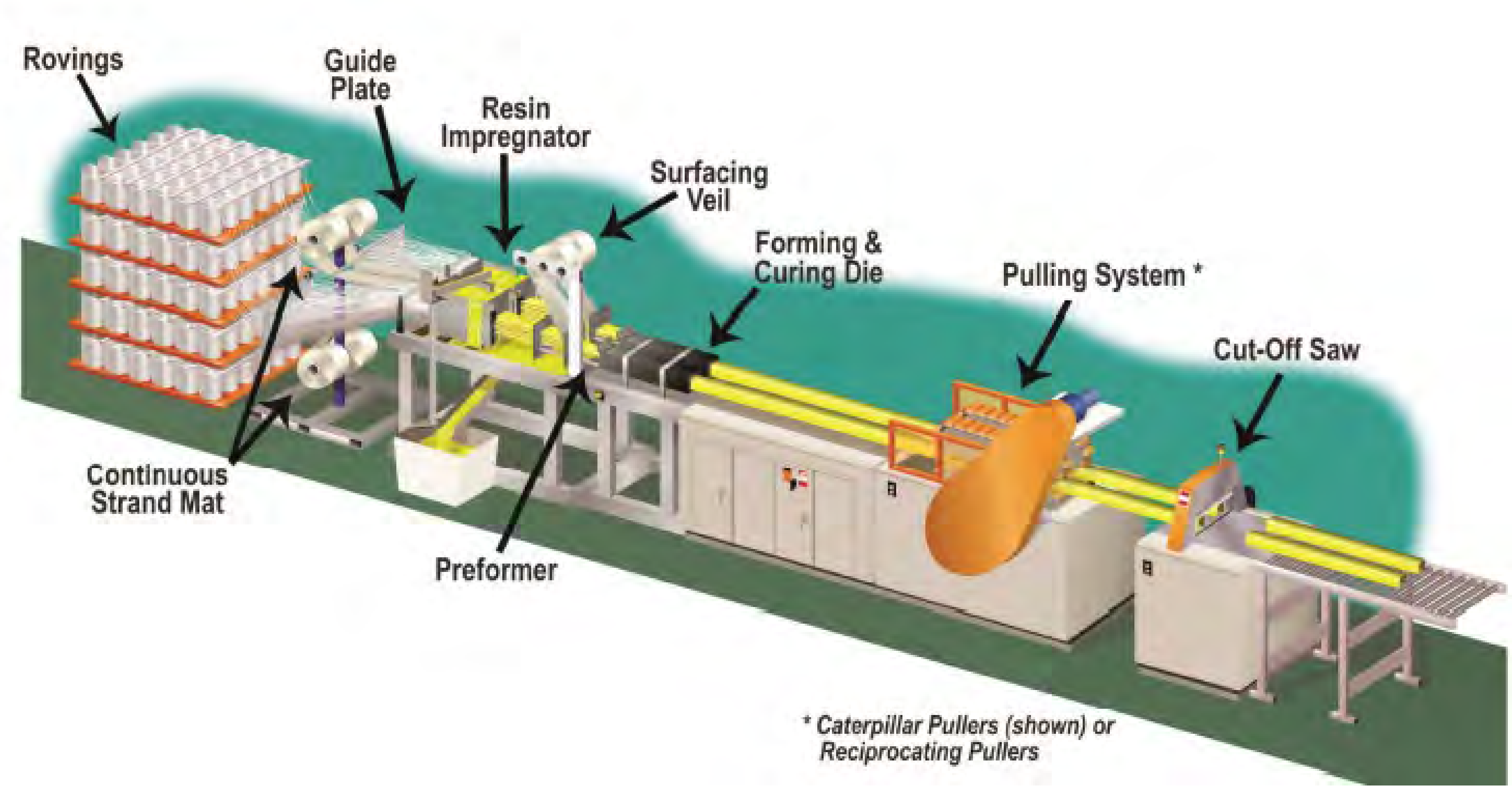
Production Process – Pultrusion



Production Process – Fabrication

Poles Come Fully Assembled Ready for Installation

Pole Nesting for Multi-Layer Structures

Drilling for Devices and Attachments per Ameren Drawings

Composite Sleeves Inserted

Internal Ground Wire Installation

Cap and Baseplate Installation

Below Grade Angle Brackets

Labeling per Ameren Standards

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Framing

Hardware must be non-cleated and conform with pole radius – including third party

Through bolt for any load bearing attachment

Always use carbide or diamond tipped tools

Pole bands can be used with or without integrated through bolt

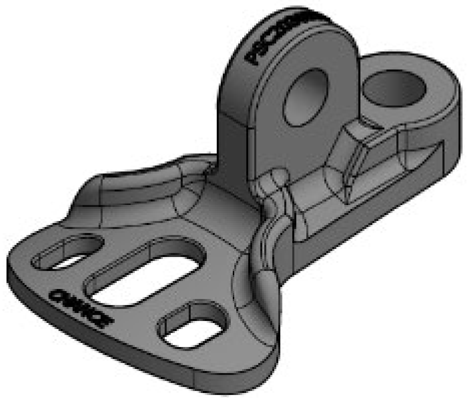
Self-tapping screws can be used for non-load bearing elements; pilot hole required

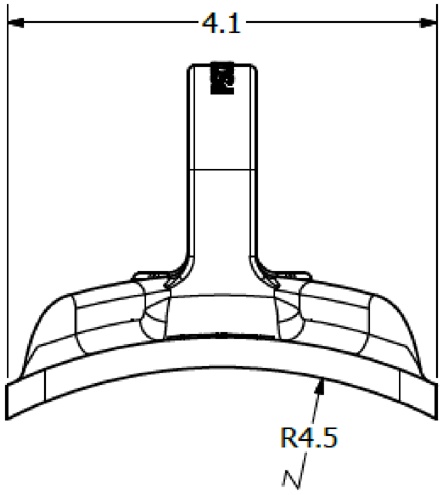
Torque limit of 50 ft-lbs., hand tighten +1/2 - 1 full turn

Curved washers, minimum 3” x 3”

Hole spacing convention:

- No less than 6x diameter of largest hole, 1” holes standard
- No more than 3 holes per 12” height





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Installation

POLE MARKINGS

Information tag is placed 6’ above ground level. Tag is at 0 degrees, which is located directly under the middle phase of the source line. The pole ground wire is always mounted at 45 degrees internal.

Ground line is marked with red tape.

Balance point is marked with yellow tape.

PPE

When drilling or cutting, wear eye protection, dust mask, long sleeves and gloves. The dust created is considered a skin and respiratory irritant and has no proven long term health effects due to exposure. An approved respirator meeting 42 CFR Part 84 standards should be worn if dusty conditions exist.

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Installation

HANDLING

Do not drag the pole. Butt plate shall be protected during install.

Use nylon or fabric straps for lifting poles. Do not use chains, cable or other metal rigging to lift poles.

Take care to prevent damage to the UV protective surface.

Plug any unused holes with Trident rubber plugs.

SETTING

Typical burial depth is 10% of the pole length plus 2 ft.

Backfill lifts shall be every 6”- 8".

Tamp backfill at each lift to assure good compaction. Care should be taken to avoid impacting the pole wall with steel tools during backfill and tamping.

Backfill options include crushed limestone, road crush, pole setting foam, or concrete.

Install 1' of backfill in hole prior to installing the pole.

When pole is set in concrete, use 1” to 2” of expansion material between pole and concrete.

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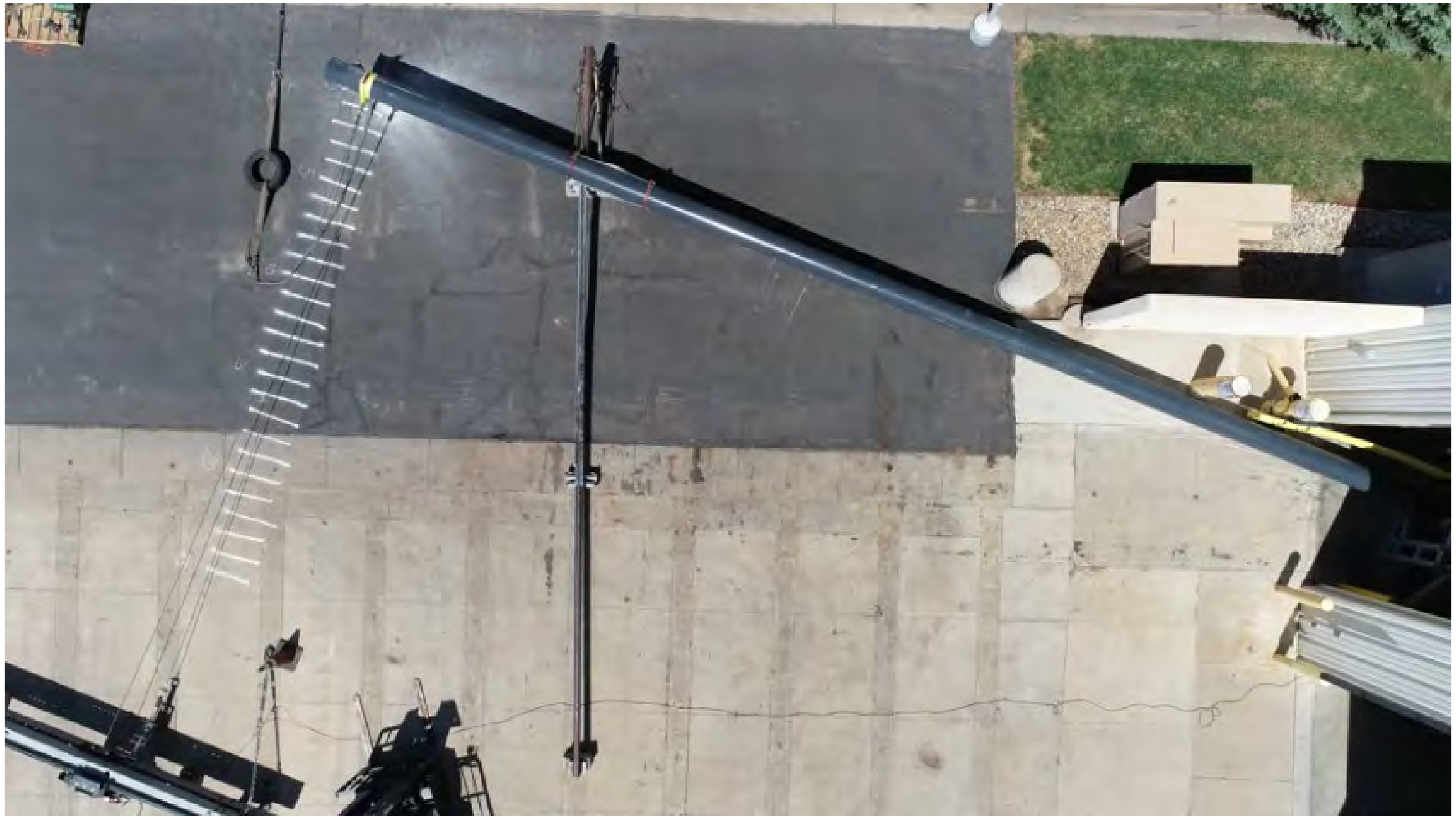
Composite Pole Testing – ASTM D1036



Composite Poles are pultruded to create a high strength product with increased deflection compared to wood poles. This allows for greater absorption of impact during maximum loading.

Composite Pole Testing Results

Test	Module	Section Diameter	Pole Length (ft)	Date Tested	Maximum Load (lbs)	Max Deflection (in.)	Adjusted Deflection "A" (in.)	Moment of Inertia "I"	Modulus of Elasticity (psi)	Equivalent wind pressure (psf)	Equivalent Wind Speed (MPH)
13	14"	13.80	64.98	6/8/2023	8,862	242	231	650	5,311,932	263	321
14	14"	13.80	65.00	6/8/2023	9,493	283	253	650	5,227,567	282	332
15	14"	13.80	65.04	6/8/2023	6,612	198	185	650	4,760,861	196	277
16	14"	13.80	65.00	5/23/2022	8,084	243	232	650	4,594,730	240	306
17	14"	13.80	65.00	6/8/2023	7,417	219	205	650	4,885,020	220	293
18	14"	13.80	65.08	6/8/2023	8,735	252	238	650	4,958,879	259	318

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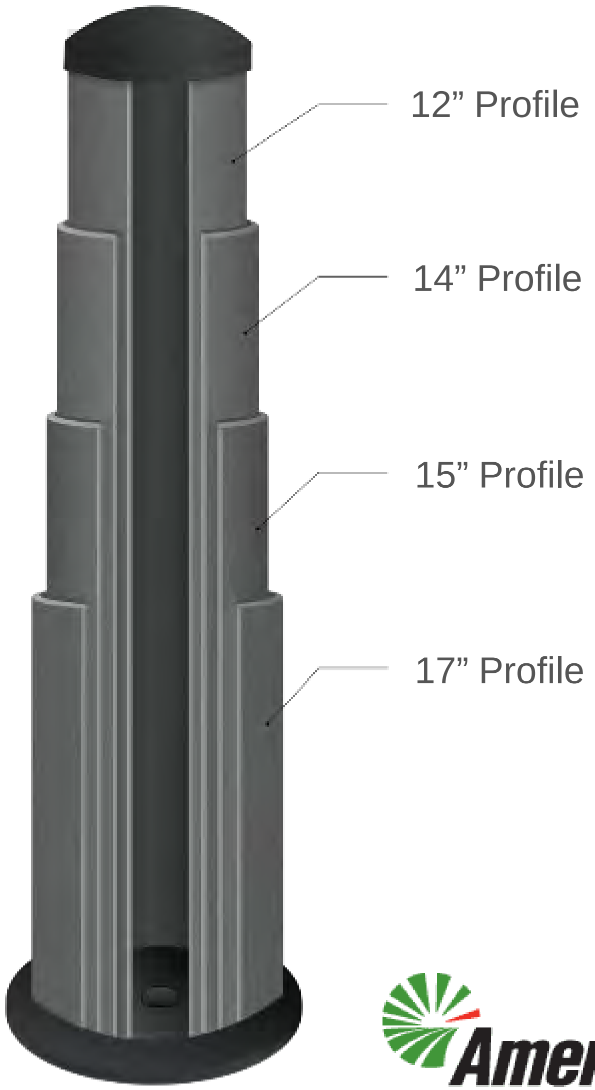
Design

To increase load limits and minimize deflection the diameter of the structure can be increased, or multiple structures will be nested together by Trident.

Single-layer Dual-layer Three-layer Four-layer



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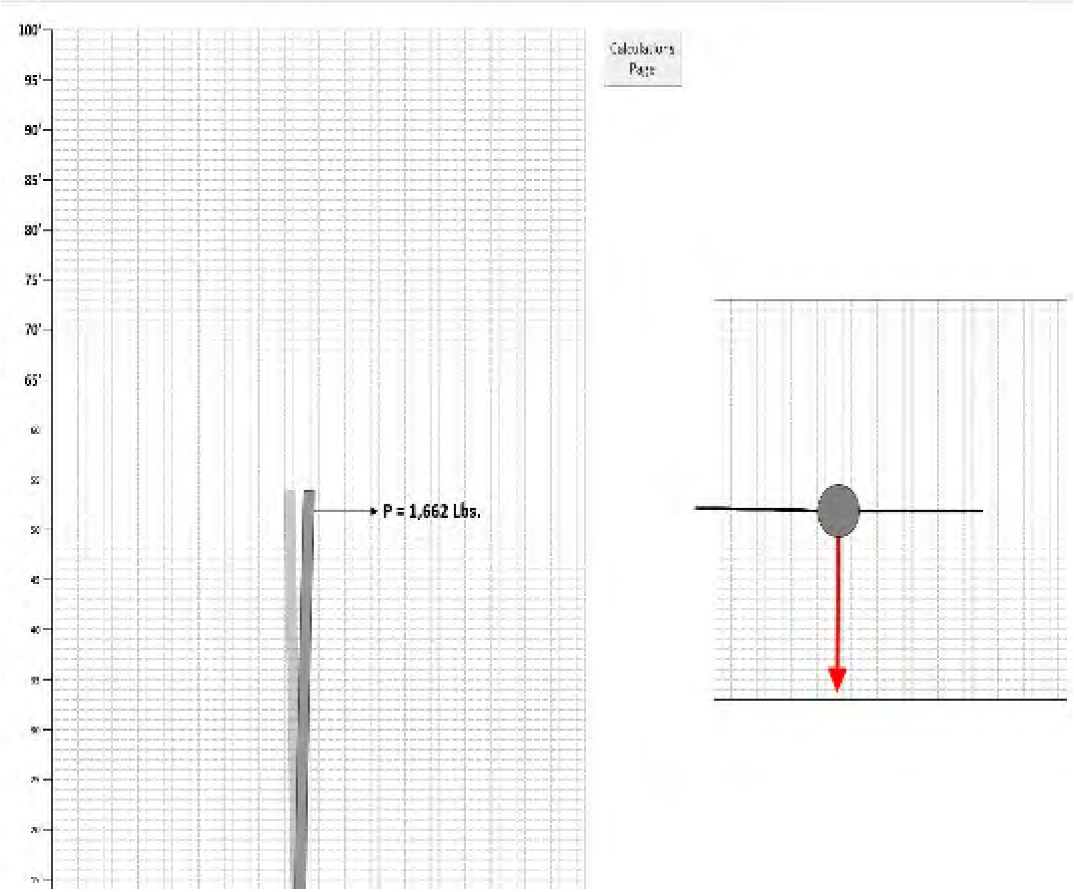
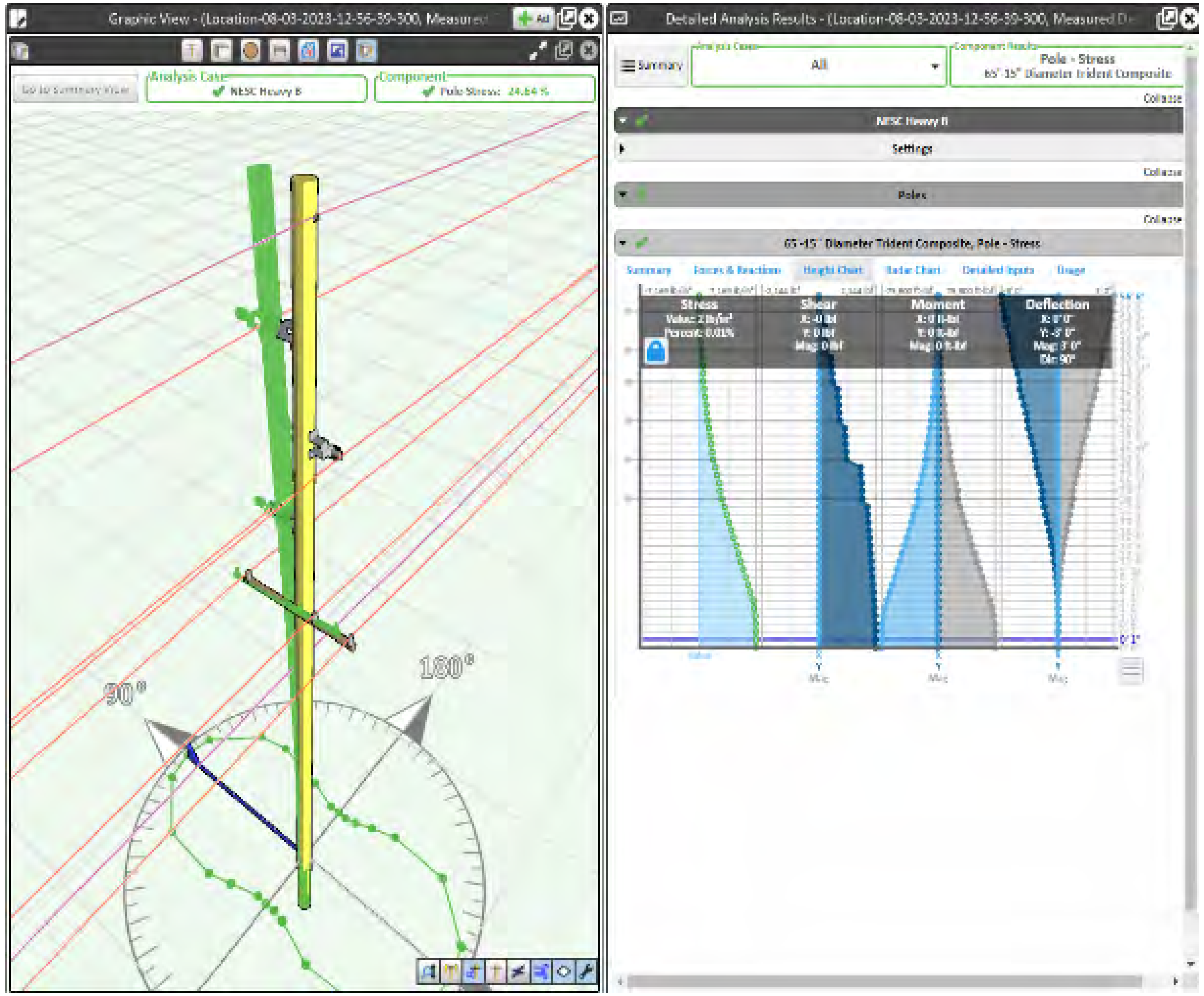
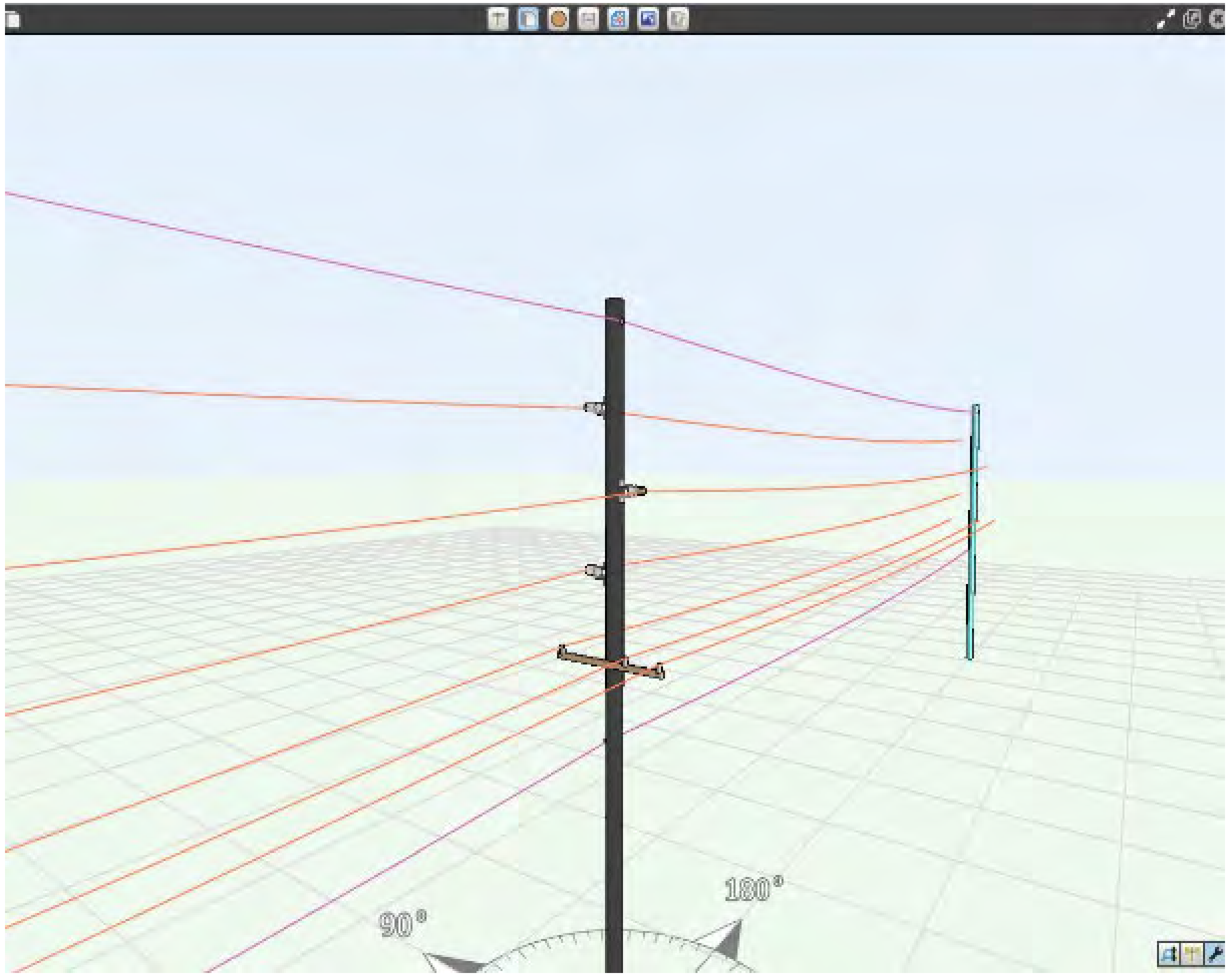
Design Calculator



Design Calculator





Ameren Composite Pole Applications

Example of Tangent Structures

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Ameren Composite Pole Applications

Example of Storm Hardening Structures

Ameren Composite Pole Applications

Example of Partial Guyed Structures

Ameren Composite Pole Applications

Example of Guyed Structures

Ameren Composite Pole Applications

Example of Unguyed Angle Structures

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Example of Switch Structures

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Example of Equipment Structures

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Example of H-Frame Structures

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Ameren Composite Pole Applications

Example of Long Span Structures

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Questions?

Ameren

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New Zealand utilities increase resilience of their grid and at the same time extend the life of their fleet

by Kris Deuar and Merv Cook

The recent Micro-Stress Pole Testing (MSPT) technology involves safely applying very small pressure to a pole (equivalent to the usual daily wind force) and measuring digitally any pole movement. Movement that is invisible to the naked eye.

Hydraulic Model of the MSPT for Transmission Poles

Platform Model of the MSPT for Distribution Poles

It is a laboratory type of test adapted for field conditions. A mathematically and empirically complex but user friendly computer program collects all the data (such as pole data, wind loading zone, timber species, pole attachments and reinforcement if any, cable data, pole top loading configuration etc) and calculates pole's maximum wind loading and residual strength.

As this technology is very accurate the MSPT can uniquely identify additional surplus of fiber strength in about 95% of all poles, based on natural variability of wood mechanical properties. At the same time it can find deficit of fiber strength in the remaining 5% of all poles.

The MSPT used by Aurora Energy (a relatively small NZ utility) uncovers all hidden, unsafe and dangerous poles, having an impact on planned work and also saves a lot of money by eliminating unnecessary and premature pole replacements.

Its case study shows that overall, the implementation of the MSPT system has been a resounding success with the capex savings of $4.0 million in the 9 months of initial operational use.

Results show that many previously rejected poles are still serviceable. Also, there were many previously passed poles which have been rejected by the MSPT thus improving safety and preventing potentially fatal risks associated with climbing poles.

Case study covers 663 rejected poles and 627 passed poles (inspected originally by the traditional *dig and drill* methodology)

The MSPT has found that out of 663 traditionally rejected poles 317 (48 %) were still serviceable with an average estimated remaining life of about 20 years.

On the other hand, the MSPT has found that out of 627 traditionally passed poles 118 (19 %) were unsafe/unserviceable.

Thank you

Witnessing, Managing and Optimising the Life Cycle of a Humble Distribution Pole.

Author and Presenter

Merv Cook

New Zealand

My Background History

- Born and live on the east coast of North Island of NZ in the province of Hawkes Bay.
- Area known for its apples & wine production, horticulture, farming and forestry sectors.
- Son and Grandson of Electricians
- Love the Outdoors – Hunting & Fishing, all abundant in NZ
- Start of 1964 joined the local Power Board as a Cadet Engineer.
- Retired Dec 2017 after 54yrs continuous service.

Background Continued

- Love challenges – I’m inquisitive and problem-solving by nature.
- Completed Cadetship in Late 1960s
- My Love of outdoors drew me to Line Survey and design in the early 1970s and continued through to late1980s.
- Moved to Asset Management, centred on O/H Asset management.
- Have Wide range of skills and experience outside of Distribution life.

NZ & Company History and Growth

- 1888 first reticulated power to a NZ town and in the southern hemisphere.
- First Electricity in Hawke's Bay in 1892 – still operating today as museum piece.
- 1912 Hastings Council supplied power through Diesel generators , to the towns centre and its water pumps.
- HB Power Board Established in 1924 now NZ's 5th largest.
- Supply from National grid came in 1927 and rapidly spread.
- Expansion of Network ramped up after WW2, with land settlement for pastoral farming by returning Soldiers and continued through the 1970s.

Pole Fleet - Asset Life Story

- Network largely constructed on Australian Hardwood Poles from 1912 up until mid - late 1970s then replaced with a mixture of softwood and concrete poles.
- By mid 1970s in-service pole failures were becoming a concern with multiple failures occurring during weather events.
- Poles were being visually inspected, but these failures continued to occur. – Resulting in significant impacts on Network Performance.
- Network renewals with concrete poles were occurring at the rate of approx. 20 miles per year, but with 2500 miles of line, that would take 125yrs **(now here’s is a problem!)**

The Search for Answers

- There had to be a better way of identifying at risk poles, to reduce the failure rate.
- In 1990 I was introduced to Deuar’s early version of of a mechanical pole testing system at the NZ Forest Research Institute,
- I immediately recognised its potential .
- Company adopted this technology in same year and used it until 1997, four years after Lines inspections and contracting services were contracted out.
- Initial testing saw a condemnation rate of 16.8%, this dropped to under 4% in the second 5yr cycle.
- Technology was heavy and contractors did not like it saving poles and made excuses for not using it.

Pole Fleet - Asset Life Story (Cont.)

- Company moved to Ultrasonic testing, this was used until 2008, but Inservice failures were again becoming a problem near the end of this period.
- In 2008 Dr Deuar demonstrated his new Micro Stress Testing system to the company and we undertook a 294-pole trial of the system.
- A senior pole inspector undertook normal visual inspections of these poles and placed his remaining life estimate on them also, to be able to draw a comparison with the Deuar system RLE.
- Independent consulting engineers were then commissioned to witness and evaluate destructive testing trials on a group of poles tested and evaluated by Dr Deuar.
- Engineer's findings were very positive on the accuracy of the estimations of pole strength against actual strength at point of failure.
- 2009 Company adopted MSPT Testing
- By the end of the 1^{st} 5yr cycle unassisted Inservice failures were eliminated.

The Early Trials

Photo 17: Pole 135134 at failure.

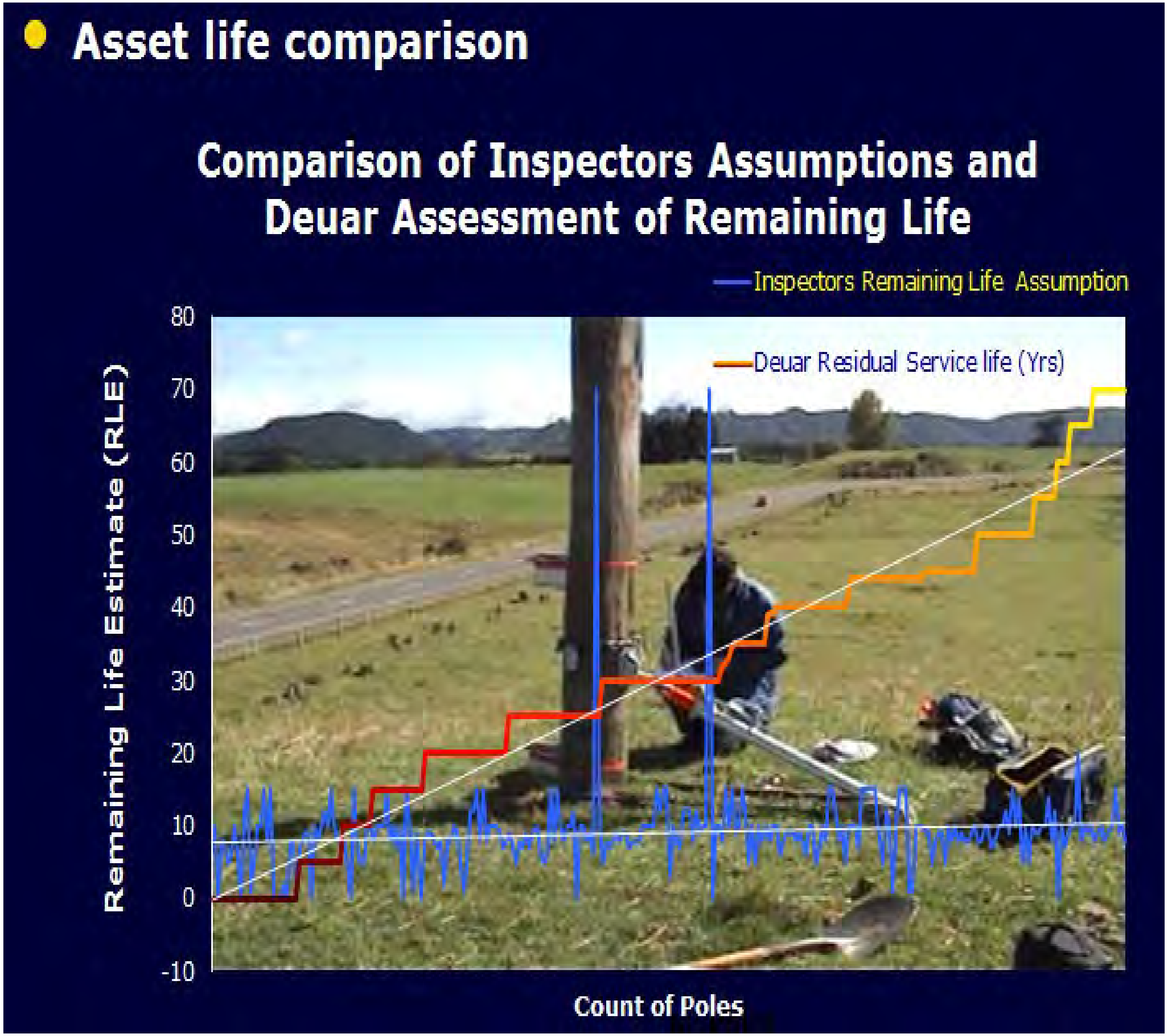
Photo 18: Fracture in base section of Pole 135134.

The Early Trials

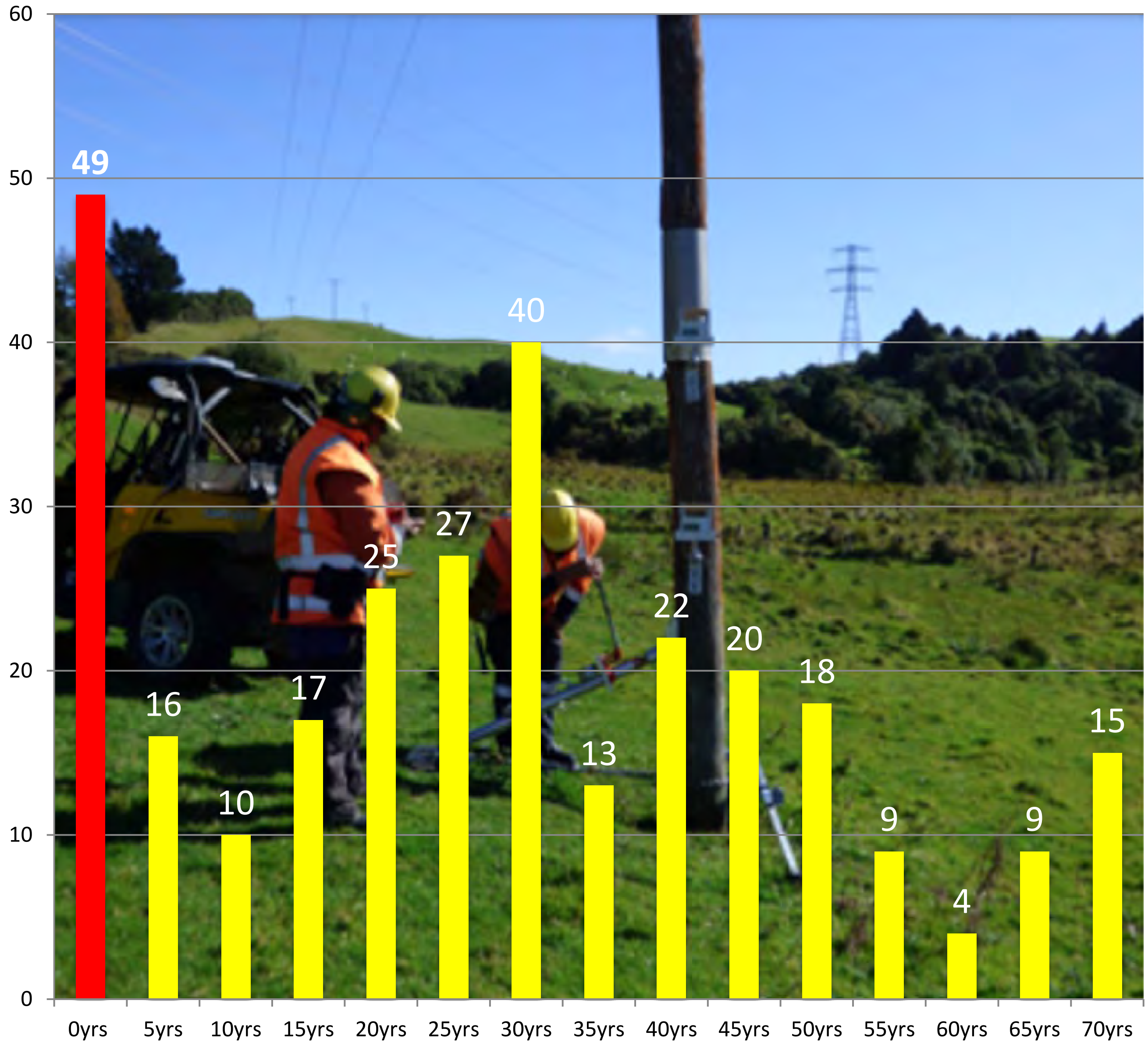
Photo 23: Pole 125668 at failure. Chain highlighted.

Photo 24: Fracture in base section of Pole 125668.

294 Pole Statistical Test Results Data



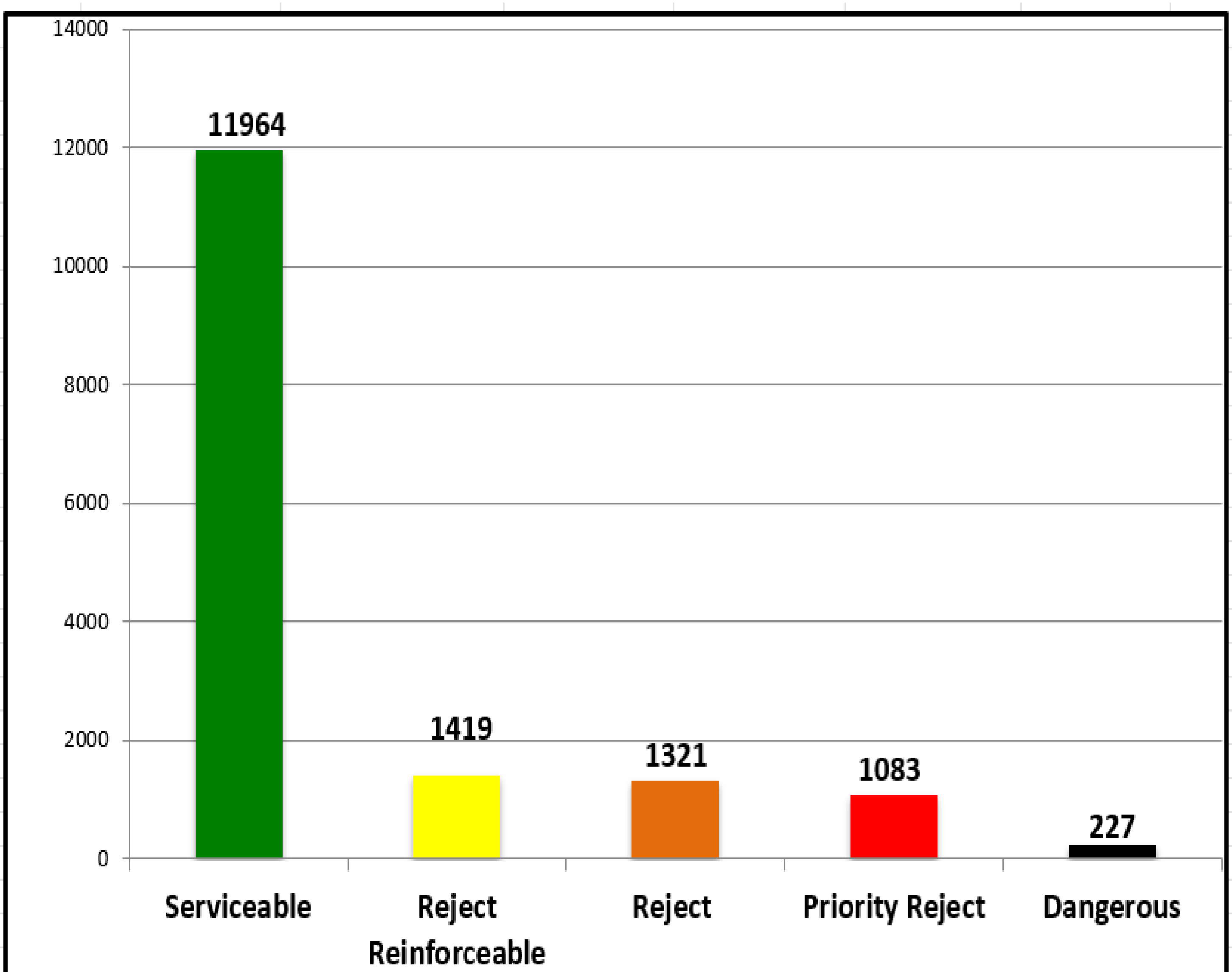
294 Pole Statistical Test Results Data



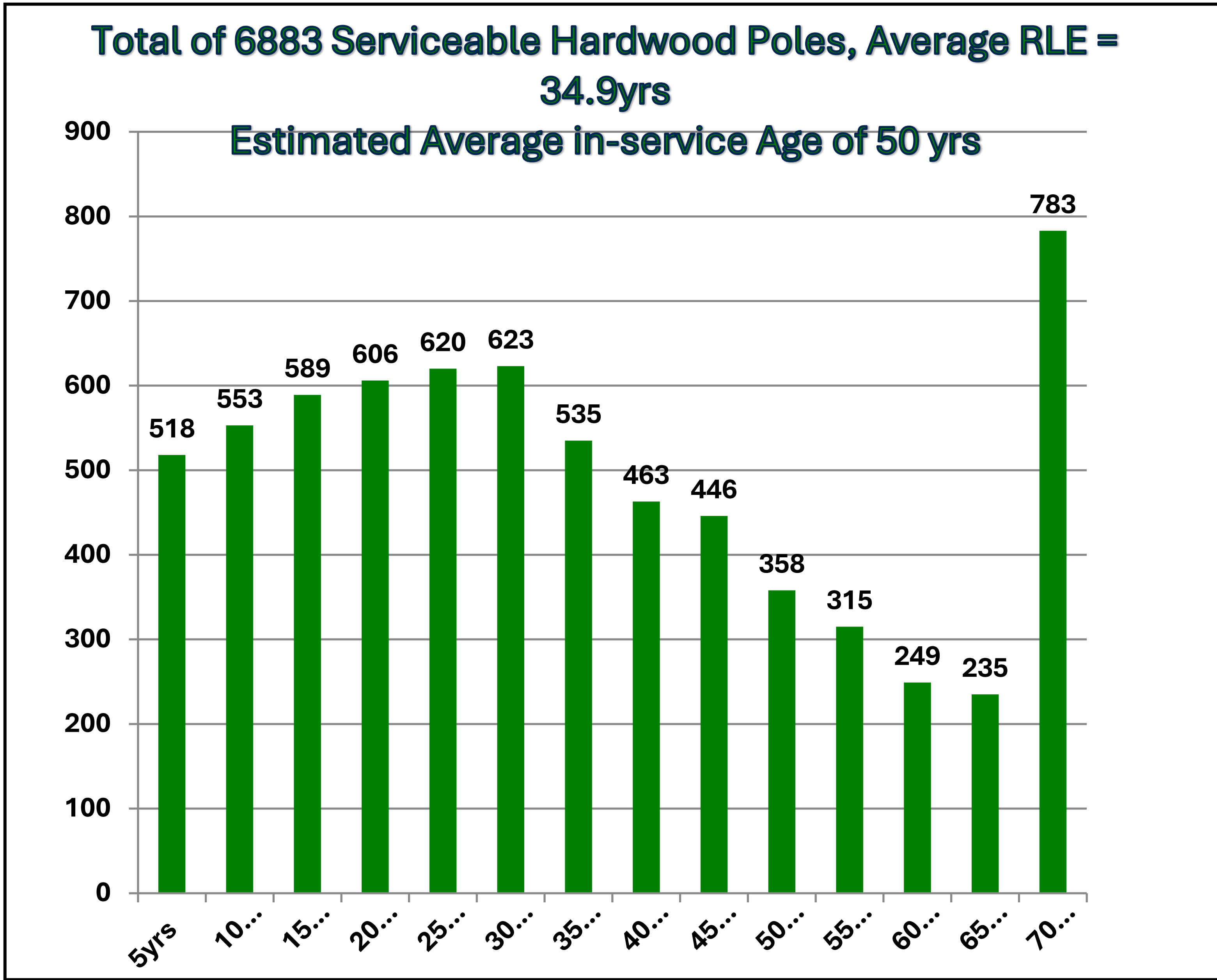
Overall Statistical Test Results Data

Timber Strength Group	Serviceable	Reject Reinforceable	Reject	Priority Reject	Dangerous	Total No Poles Tested
(H/W's S2)	6883	879	874	926	210	9772
%	70.44%	9.00%	8.94%	9.48%	2.15%	
S5 (Larch)	1868	338	292	111	13	2622
%	71.24%	12.89%	11.14%	4.23%	0.50%	
S6 (Pine)	3213	202	155	46	4	3620
%	88.76%	5.58%	4.28%	1.27%	0.11%	
Totals	11964	1419	1321	1083	227	16014
%	75%	9%	8%	7%	1%	

Statistical Test Results Data



Overall Statistical Test Results Data



Benefits Derived from Adoption of MSPT Testing

- Elimination of unassisted in-service Pole failures resulting in improved Network Reliability. SAIDI – SAIFI
- Deferral of Capital expenditure by Asset Life extension (Average 35yrs) from normal perceived 40yr life and over condemnation by visual inspections.
- Ability to accurately identify poles suitable for reinforcement further reducing need for renewals.
- Ability to re-run test parameters with different inputs for potential line upgrades.
- Reduced labour, capital and transport costs resulting from unassisted in-service failures
- Potential to optimise and reduce inspection costs by deferral of testing of poles with significant RLE.
- Potential optimisation of workforce for other projects.

THANK YOU ALL

- Thank you all for this opportunity to present this to you today.
- Love to meet as many of you as I can and have a Chinwag.
- There’s is plenty more that I could have covered, but time is all too short.
- Maybe might even talk you into taking a trip down to our beautiful neck of the woods.

EPRI

ENERGY DELIVERY AND CUSTOMER SOLUTIONS

Rapid Restoration

Enhancing Grid Resilience

Joe Potvin
Distribution Systems - Program Leader

EDM International Conference on Overhead Lines
April 16, 2024

The Challenge

Infrastructure Aging

Structures stressed beyond design criteria, age-related loss of strength, weak spots in the system develop.

O&M Budgets Stretched Further

Requires prioritization of O&M dollars, can’t fix everything right now.

Increased Climate Stresses

Unforeseen, more frequent, or more intense weather stressing system, while customer expectations rising.

What is Resilience, and How Can We Improve It

One perspective, in no particular order…

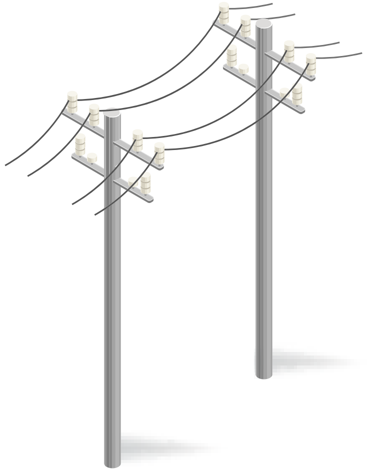
Undergrounding 1

Deploy hardened designs 2

Good vegetation management 3

Good application of inspection and maintenance 4

Applied data analytics 5



1 Strategic deployment of distribution automation

2 Enhanced fault locating

3 Mechanical coordination of overhead lines

4 Adequate resources for and good coordination of mutual assistance

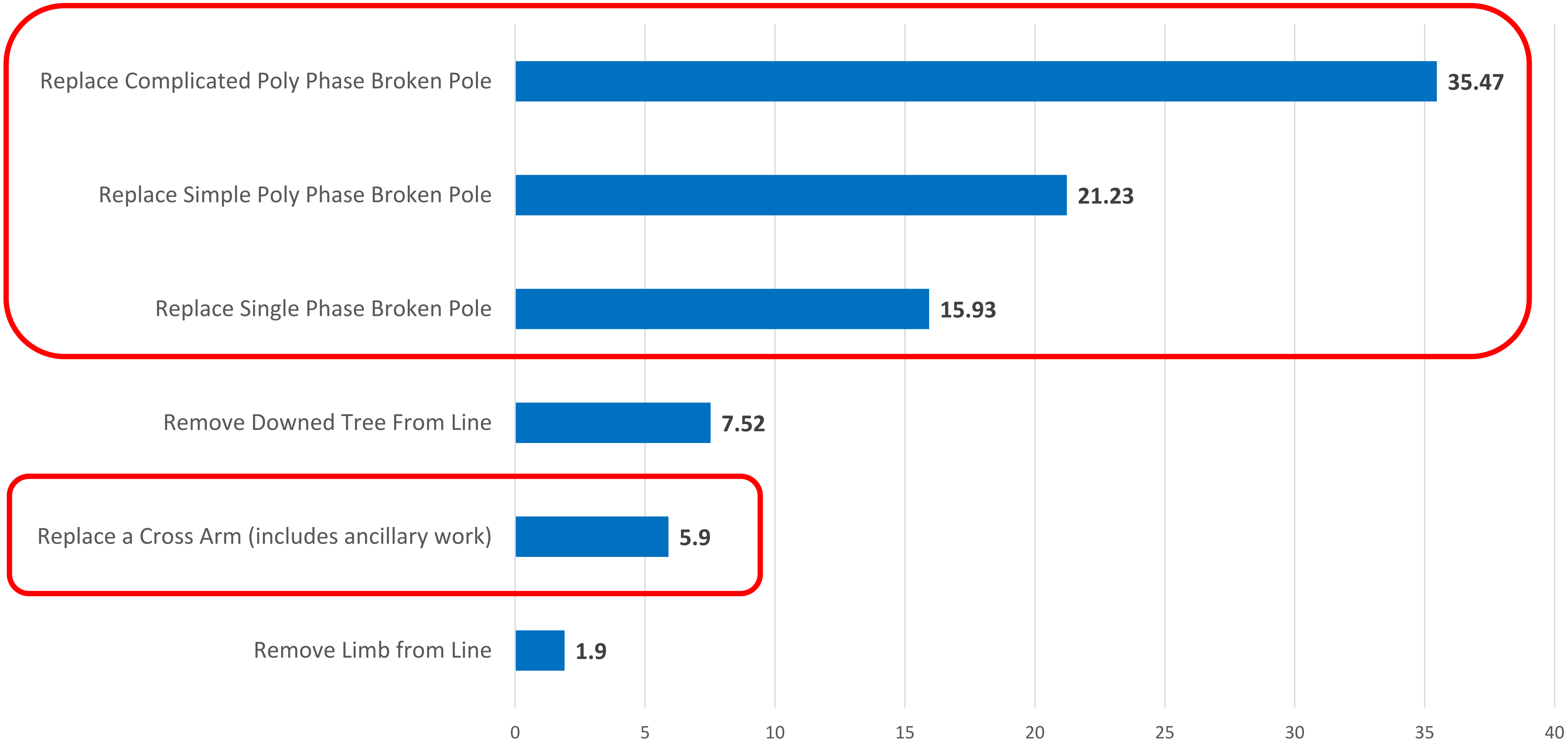
5 Applied data analytics

Prevent Damage

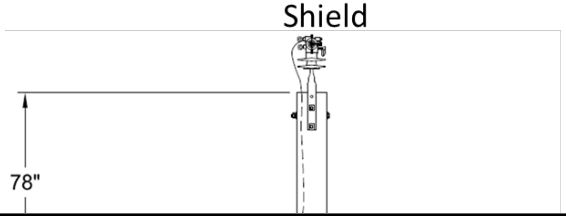
Accelerate Restoration

Average Labor Hours to Complete Repair

Distribution Grid Resiliency: Overhead Structures, EPRI, Palo Alto, CA: 2015. 3002006780.



Learning from Testing: Installation Practices



Built according to specification

After test

No damage sustained to crossarm or arm, wires captured

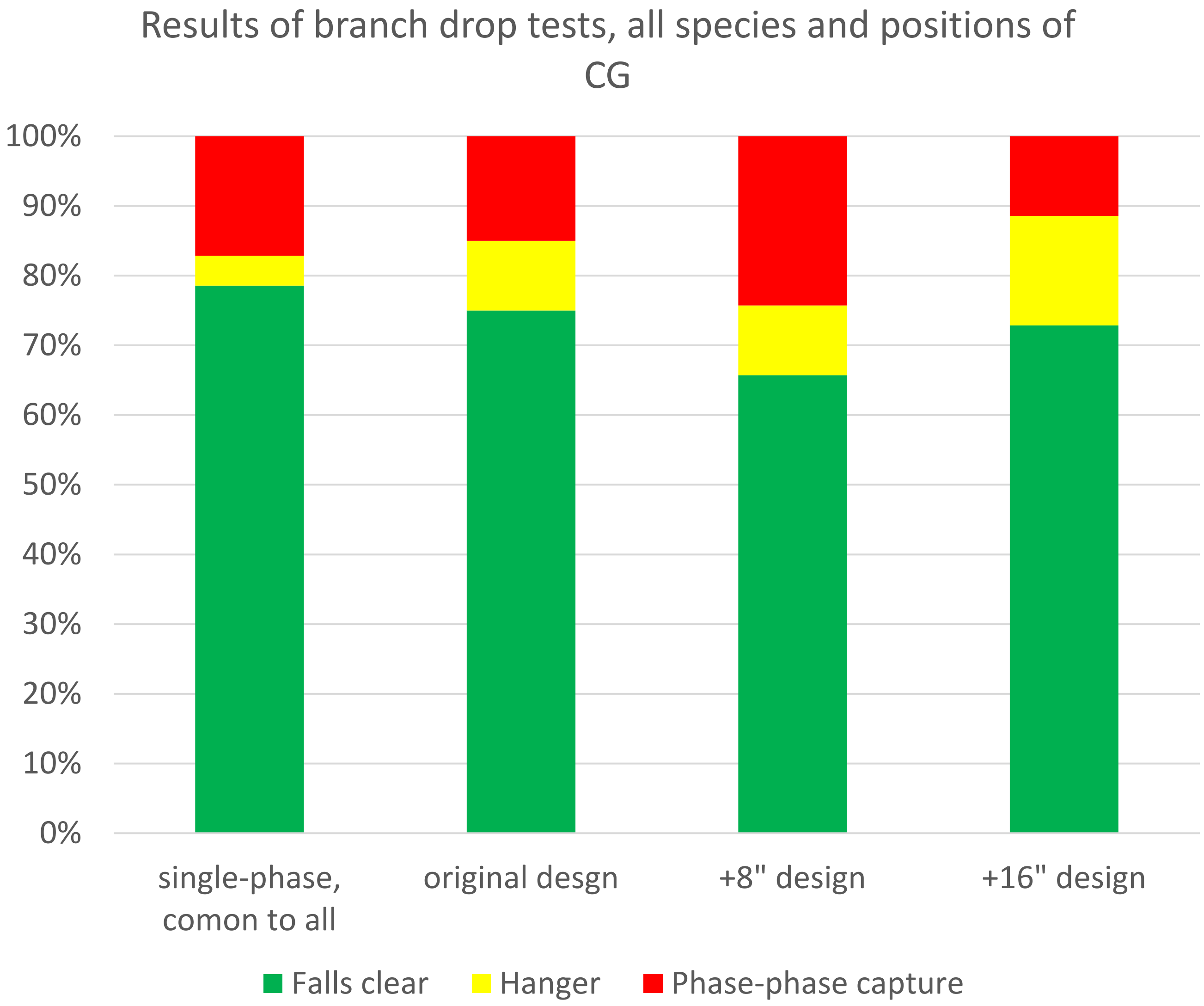
Test 2 – Same structure design

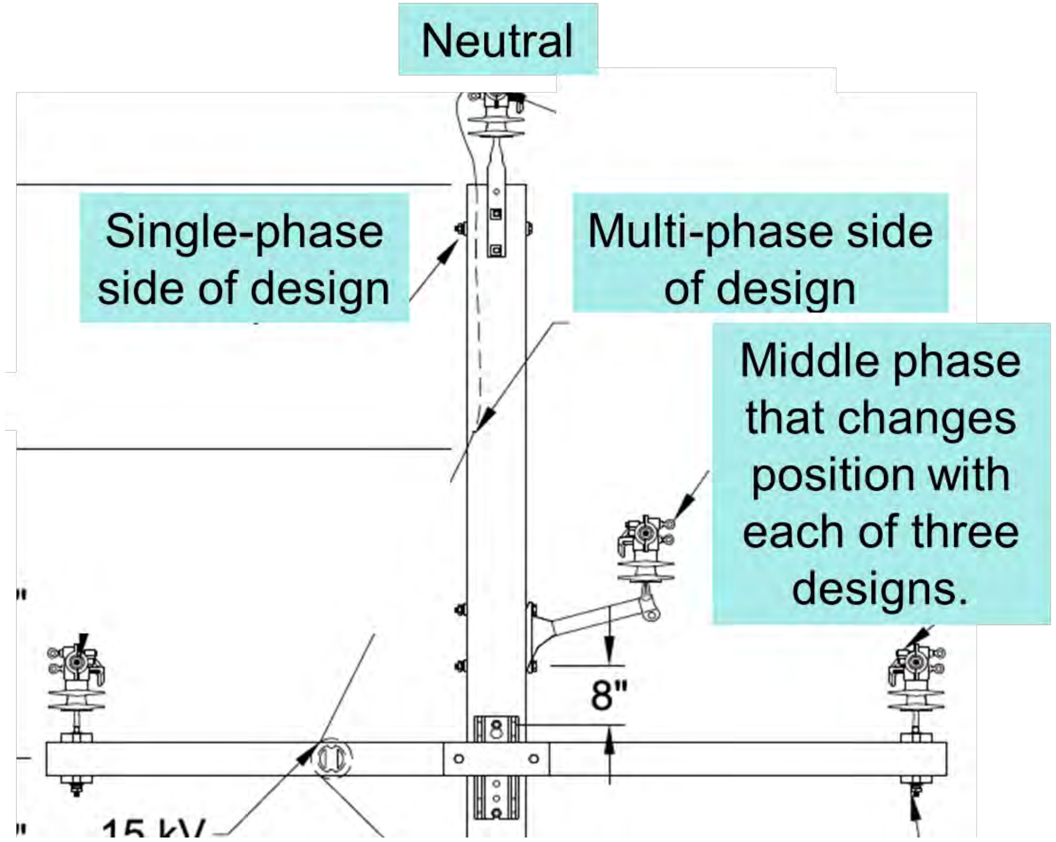
Familiar Result?

Increasing vise-top clamping force decreases slip, increasing pole break risk

Learning from Testing: Not Just Mechanical Damage

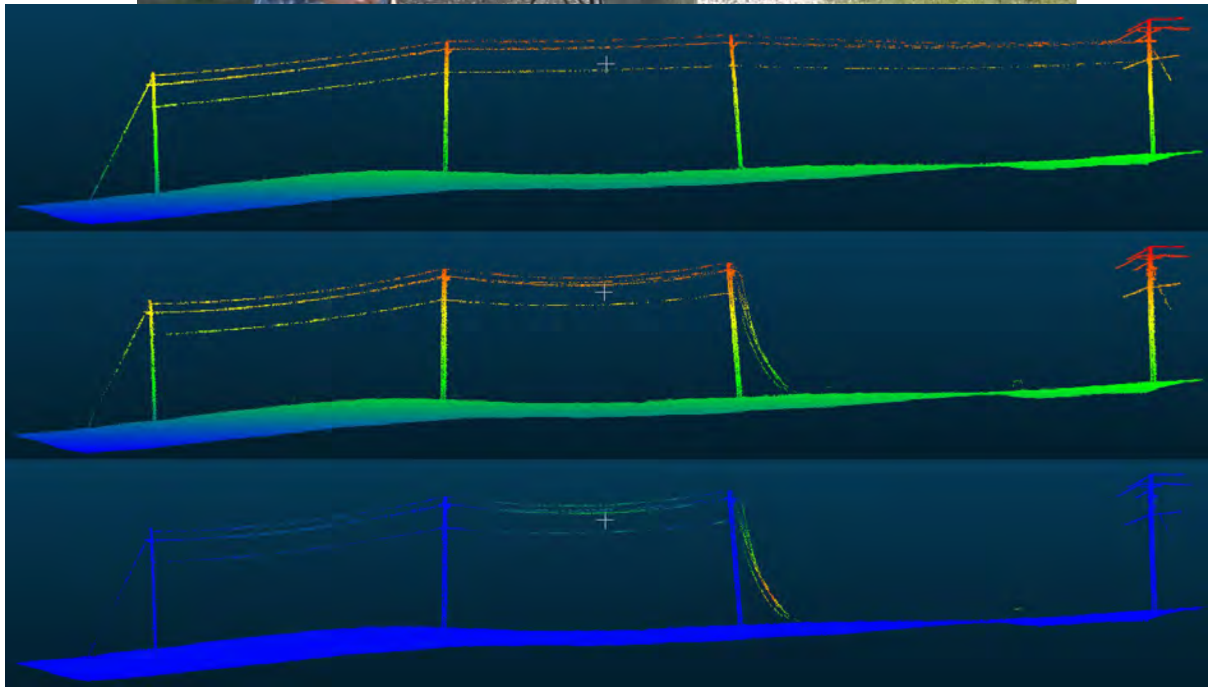
Finding from Testing: Not Just Mechanical Damage





What about Inspection and Maintenance?

- Design basis requires maintaining pole strength
- Advanced inspection technologies
- Digital twins



Example: Optimize inspections with automation

Hypothesis:

Automation provides the greatest opportunity for safe, fast, low-cost, and high-quality inspections.

Autonomous Data Collection

Autonomous Data Interpretation

The Future: Emerging Technologies

- Enhanced wood poles
- Alternative pole materials
- Improved inspection and maintenance
- Online condition monitoring

TOGETHER…SHAPING THE FUTURE OF ENERGY®

www.epri.com

Utility Practices in Wildfire Mitigation

The Cooperative Perspective

The Energy to Thrive™

Jordan Ambrogi

April 16th, 2024

EDM International Conference
on Overhead Lines

CORE
ELECTRIC COOPERATIVE

First, Some Context...

- Forest fires now result in 3 million more hectares of tree cover loss per year compared to 2001
  - In CO, all of the 20 largest fires have occurred since 2001 (4 of 5 since 2018)
- As of 2020, WUI makes up 9.4% of the land area of the contiguous United States, but 32% of all housing nationwide. – USFS
- Litigators becoming increasingly aggressive in pursuing damages from utilities

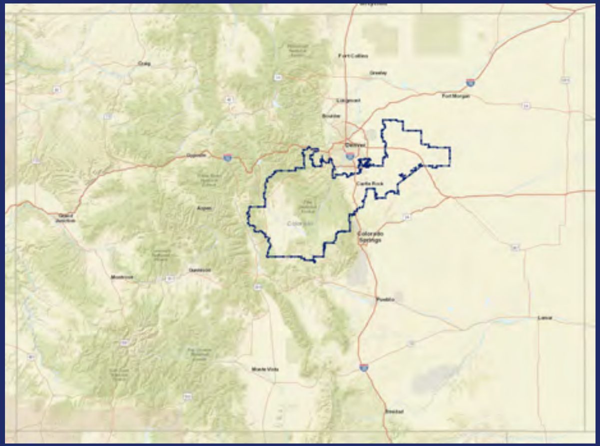
Objectives in Wildfire Mitigation

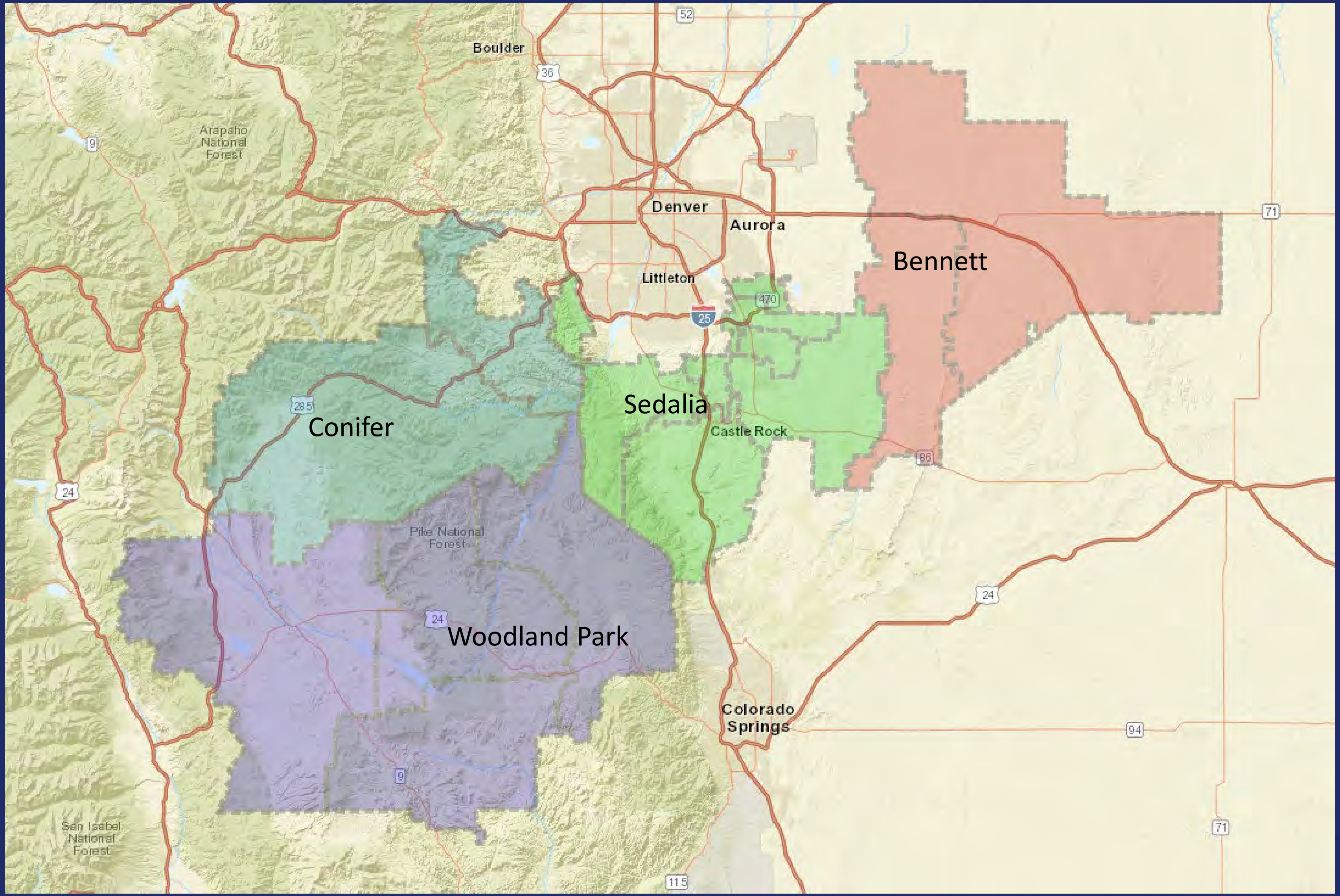
- Protect human life and property
- Prevent damage to critical infrastructure, including utility assets
- Avoid bankruptcy!

Know Your Territory/System

- Environmental Risk Drivers
- Systemic Risk Drivers
  - Common ignition sources
- Business Risk from Wildfire
- High-Risk Communities
- Fire Protection Districts
- Statewide Risk Assessments

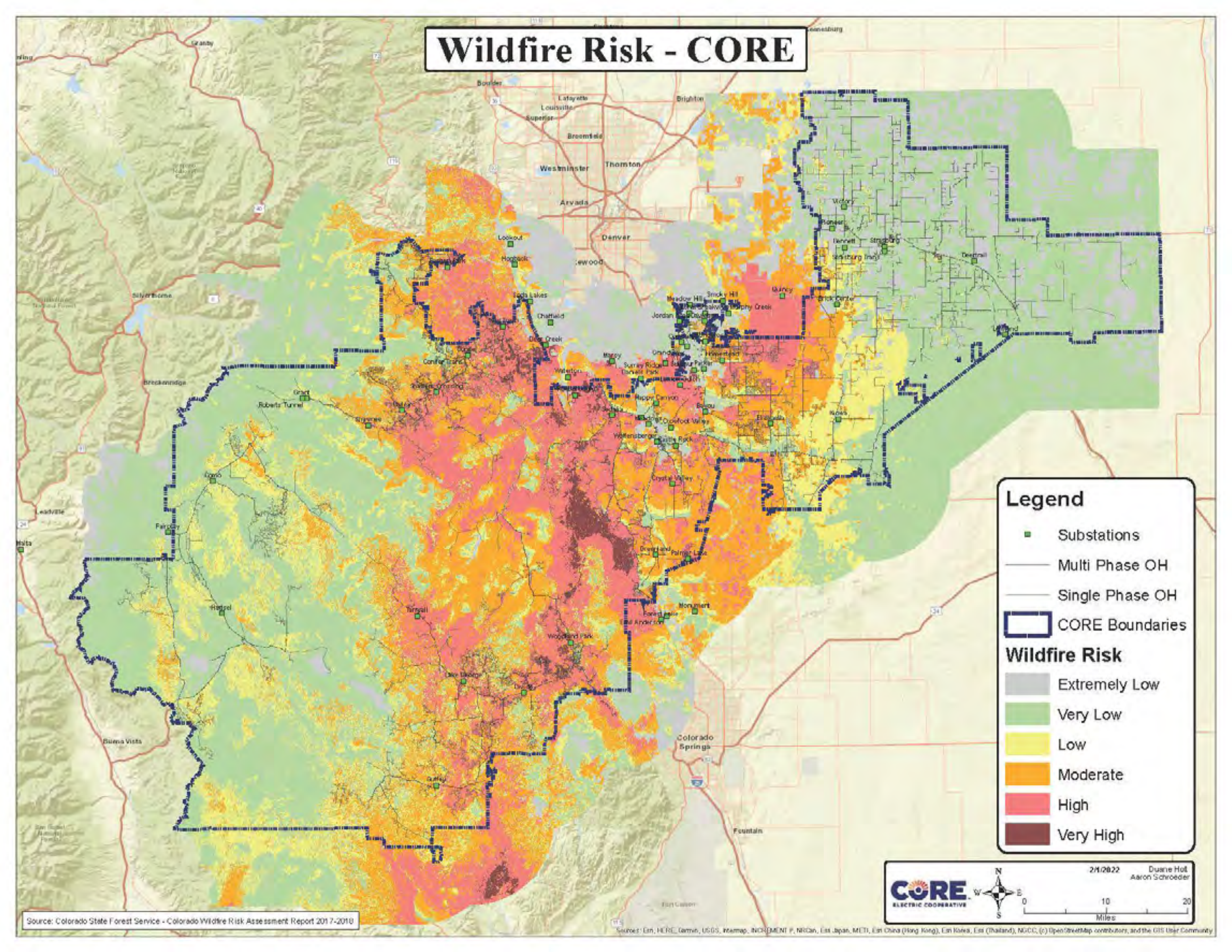
CORE Service Territory





- 5,000 square miles
- 5,000 miles of OH line
- 180,000 meters
- 375,000 members
- Some of the highest wildfire risk in the state

Wildfire Risk



Wildfire Risks

- Environmental Risk Drivers
  - Vegetation (extent, type, health)
  - Terrain (steep slopes, soil type, access)
  - Weather/climate (drought, high winds, lightning)
  - Population Density (WUI)
- Systemic Risk Drivers
  - Contact from objects (trees, animals, vehicles, etc)
  - Equipment failure/contamination
  - Equipment contact (wire-to-wire)
- Business Risk from Wildfire
  - Loss of service, internet, communications
  - De-energization and impedance to restoration

Stay Aware, Be Ready to Respond

- Situational Awareness
  - Seasonal Forecasts, Daily Weather
  - Load ratings, age, and health of equipment
  - Active fires in the region
- Operational Procedures
- Alternate Relay Settings
- Public Safety Power Shutoffs (PSPS)

Stay Aware, Be Ready to Respond

- Situational Awareness
  - DTN WeatherSentry, Technosylva FireRisk
  - Fireguard
  - Cameras: Pano AI, FTS360
- Operational Procedures
  - Work on energized lines limited during High Wind or Red Flag Warnings
  - Increased awareness for potential ignitions
- Alternate Relay Settings
  - Activated when DTN Level 3 or 4 overlap with Red Flag or High Wind warnings

Be Proactive Wherever Possible

- Inspections and Maintenance
- Vegetation Management
- System Hardening
- Improve reliability *and* mitigate wildfire risk

Inspection Programs

- Overhead Distribution Line Inspections
  - 4-year cycle, patrolled by both foot and drones
  - Defects are ranked by severity, prioritized for repair and standardization
- Transmission Line Inspections
  - Every year on 44kV, every three on 115kV
  - Performed by helicopter and drone, LiDAR every other inspection
- Wood Pole Inspections
  - Poles inspected on a 15-year cycle, above and below ground
  - Poles are passed or rejected, restored or replaced

Vegetation Management Plan

- Task Cycle
  - 6 years in Sedalia, Conifer, Woodland Park; 4 years in Bennett
  - Created from a reliability-based perspective, trim proactively based on species
  - Remove dead or dying trees
  - Clear 10-feet around poles with equipment that could spark/cause ignitions
- Mid-Cycle inspections
  - Take place in the 4th year from trimming, looking for hazardous conditions that should not be left another two years (dead or damaged trees, encroachment)
- Leveraging Technology
  - Overstory scans and analysis (hazard tree ID, encroachment risk scores)

System Hardening

- Construction Standards
  - Poles designed to withstand high winds and snow loads
  - 10-foot cross-arms improve spacing between conductors
  - Replacing copper-weld and open-wire secondary
  - Strategic undergrounding in high-risk areas
  - Cover-up of energized parts
- System Protection
  - Replacing OCR’s with Trip-Savers and Versa Tech protection devices
  - Fire settings at the substation level
  - Continuous evaluation of relay settings and new technology

How Do We Pay For All This?!

- Mitigating for wildfire improves reliability (in most cases)
  - Find the efficiencies between programs
- Delayed maintenance and reactive work lead to higher costs
- Start with a pilot
- Apply for Grants
  - Federal and State programs
  - Partner with community organizations with common goals

It Doesn’t Have to Happen In A Day…

- Describe your Plan
- Document strategies and explain rationale (address risk)
- Track pertinent metrics and ascertain trends
- Report on progress of ongoing projects and accomplishments
- Remain a Learning Organization

Metrics and Reporting

- Red Flag Warning days
- Number of days where Fire Settings are implemented
- Progress of various programs
- Number of ignitions associated with CORE equipment
- Pertinent outages

Continual Improvement

- Conducting Event Analysis on every ignition
  - Determining root causes
  - Identifying patterns
  - Recommending mitigations and taking action
- Piloting new technology for better fault detection and operation
- Investing in advanced Risk Forecasting software
- Developing a PSPS Program
- Learning from our peers and implementing good utility practices
- Engaging with Academia to drive research

In Summary

- Know your territory, know your system
- Stay aware, be ready to respond
- Be proactive wherever possible
- Apply for grants, and engage your community
- Document your strategies and track progress
- Requires a thoughtful and wholistic approach

Ignition Prevention on Overhead Power Lines:

ASSESSING AND MITIGATING RISK FROM WILDLIFE

2024 International Conference on Overhead Lines: Design, Construction, Inspection and Maintenance
April 16, 2024
Fort Collins, Colorado

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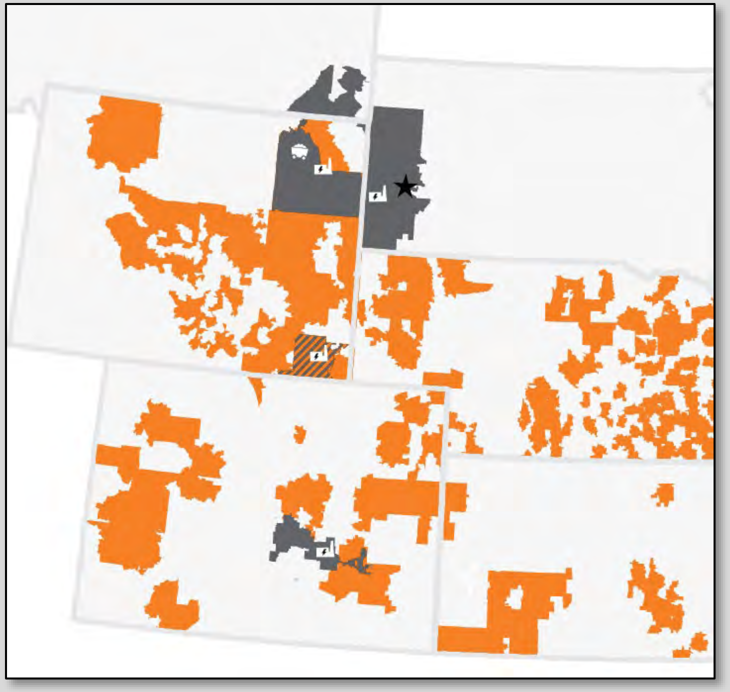
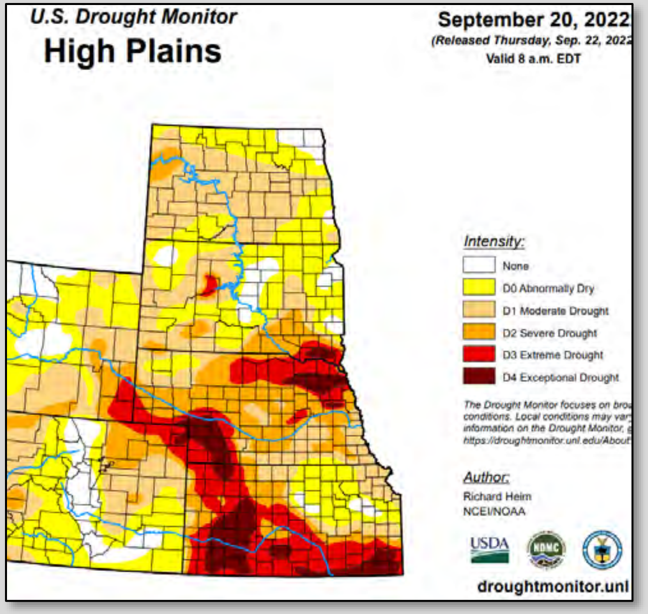
EDM
reliability & innovation

BHE Overview

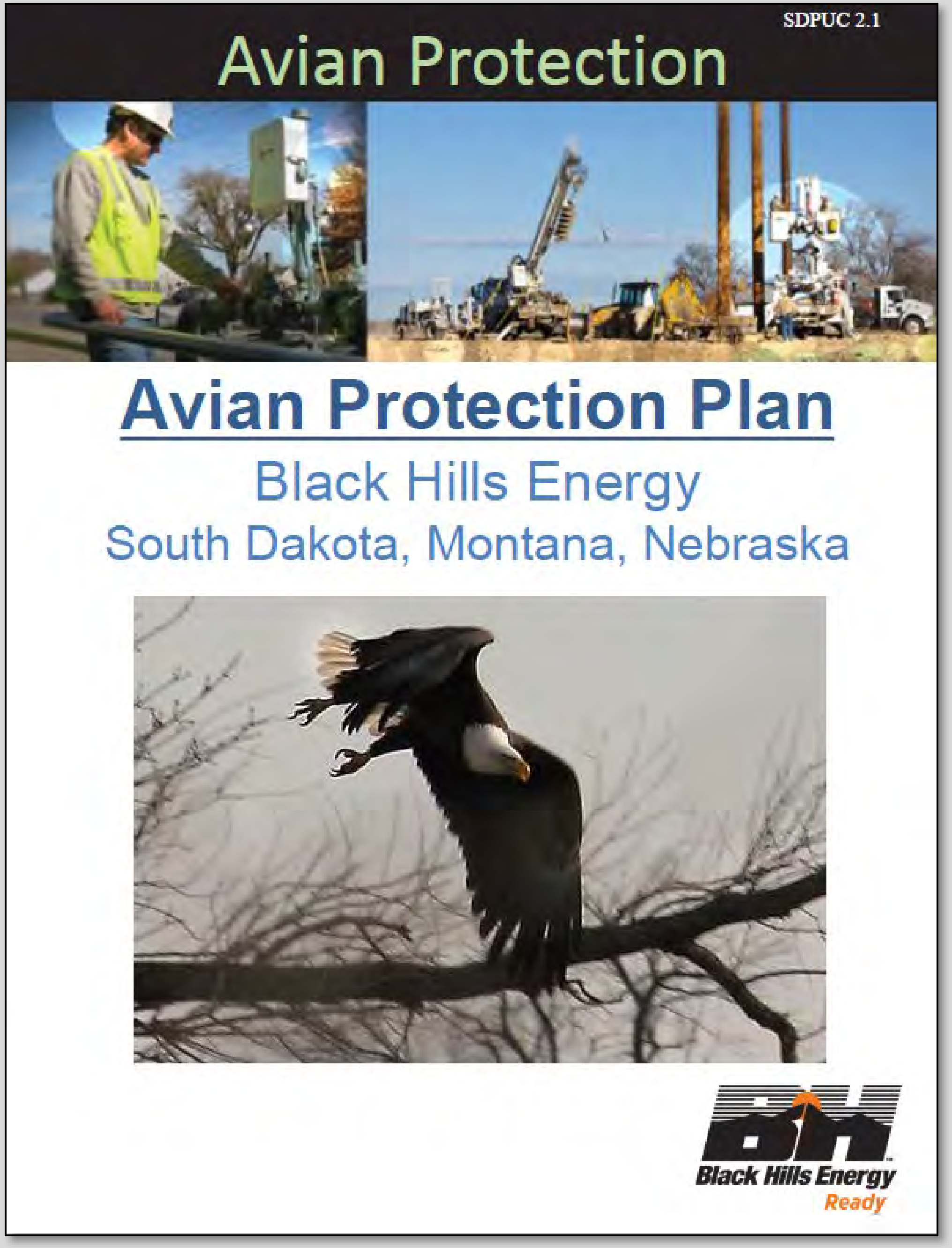
- Black Hills Energy (BHE) is a utility company based in Rapid City, South Dakota that serves over 218,000 electric customers in Colorado, Montana, South Dakota, and Wyoming.
- Our system has 8,900 miles of electric transmission and distribution lines as well as electric generation assets.
- BHE works each day to enhance the safety and reliability of the electric utility system. This includes taking proactive steps to maintain and upgrade the system.
- Current environmental conditions in our service territory pose a challenge to safe operations.





System Investments Example

- 2011 Avian Protection Plans (APP)
- All new facilities will be built to avian-friendly standards and BHE will retrofit infrastructure per Avian Power Line Interaction Committee (APLIC) Guidelines.
- BHE found there is a strong business case for proactively making sensible and appropriate infrastructure investments.



Ignition Prevention on Overhead Power Lines

IDENTIFICATION OF IGNITION RISKS

- There is inherent fire risk near electric infrastructure, but the risk is dependent on equipment and surroundings.
- Could wildlife electrocution be an important ignition risk that could be strategically mitigated?
- BHE partnered with EDM International, Inc. (EDM) to analyze our system and identify equipment with highest potential for fire risk.

Presentation Goals

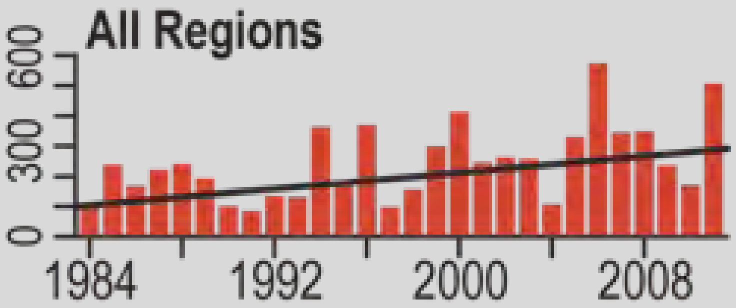
- Describe key elements of this emerging issue to the best of our current understanding
- Scale wildlife ignition risk using multiple approaches and best available data
- Discuss strategy to identify poles at greatest risk of wildfire ignition via wildlife electrocution
- Illustrate how careful analysis leads to focused and cost-effective risk mitigation

1 WILDLIFE, POWER LINES & FIRE

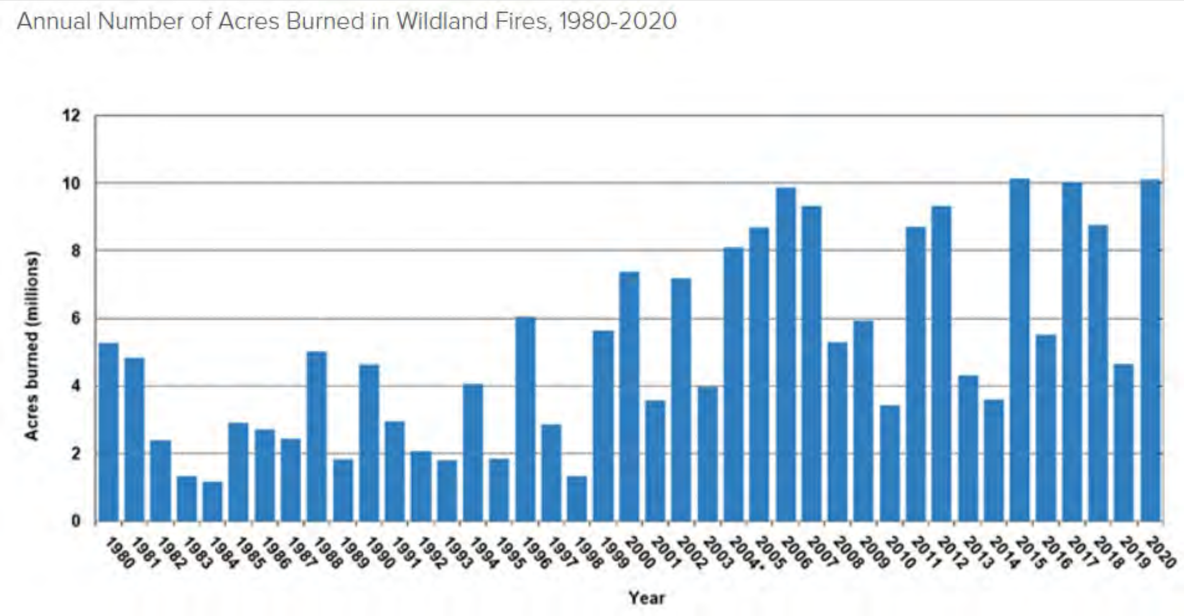
Increasing Wildfire Risk

RISK EXACERBATED BY CLIMATE CHANGE

- Number of large fires doubled, 1984-2015
- Acres burned in big fire years has roughly doubled
- Models: +1°C ambient temperature will increase burned area up to 600%



Source: Center for Climate and Energy Solutions



Source: Insurance Information Institute: Facts + Statistics: Wildfires

Google Alert Data Scrape

DWYER ET AL. (2020)

- Alerts monitored, 2012-2018
- 46 bird electrocution fires
- Concentrated in Mediterranean California and Western Forested Mountains

The New York Times

Like a Bird on a Wire That Starts a Wildfire

Researchers found dozens of incidents where birds fell to the ground after being electrocuted on power lines, and sparked fires. They also proposed steps to prevent such incidents.

Charred and feathered: Hawk and snake spark 40-acre fire in Montana

BY SARAH KEARTES AUGUST 25 2017

Firefighters in Montana have uncovered the cause of a fire that burned some 40 acres of grassland earlier this week. The blaze was sparked by a series of unfortunate events – involving a snake, two power lines and an accidental avian arsonist.

The fire raged for an hour near Rainbow Dam Road in the town of Great Falls, and with the local landscape extremely dry at this time of year, it took the work of several crews to put out the flames. But it wasn't until officials spotted a dead hawk lying on the singed ground that the story came together.

Bird on wire sparks wheat field fire

Birds to blame for several recent fires

Challenges to Understanding Issue

- Availability of direct evidence
- Reporting and publicity
- Potential liability issues
- Diverse fields of expertise
- Nevertheless…a picture is emerging

Animal Incident as Thermal Event

- Electrocution, expulsion fuse operation is “thermal event”
- Thermal event characteristics vary, some have ignition potential
- Each thermal event is a roll of the dice.
- Some incidents would result in multiple thermal events

NOT BHE SYSTEM

Mechanism

DIRECT IGNITION

NOT BHE SYSTEM

youtube.com

Mechanism

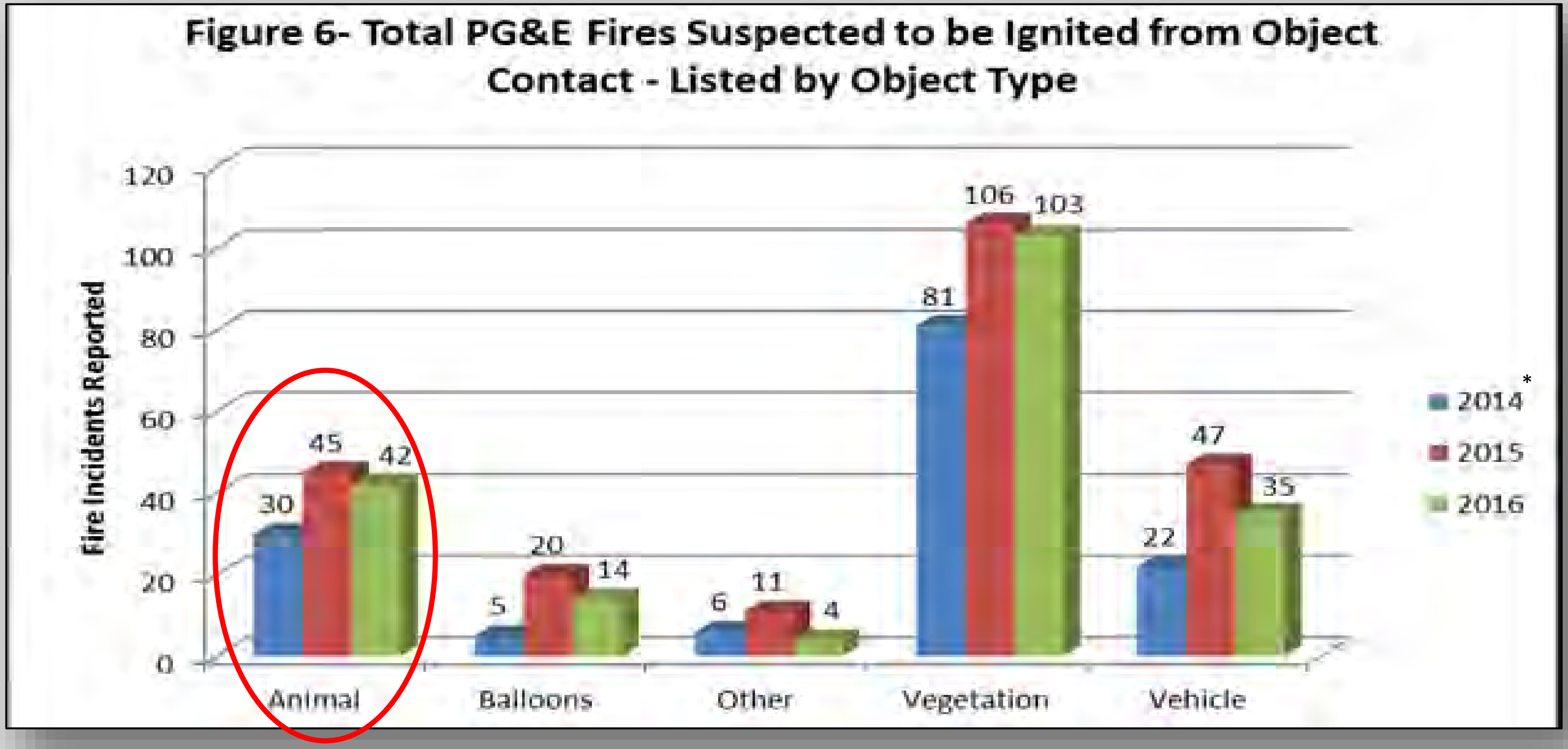
EXPULSION FUSE OPERATION

NOT BHE SYSTEM

ALSO…

NESTS AND CONDUCTOR SLAP

PG&E Fire Stats



*June-December, only

- California Public Utilities Commission, public data
- 410 reported ignitions/yr
- 46 reported wildlife ignitions/yr
- **11% of reported PG&E power line ignitions caused by wildlife**

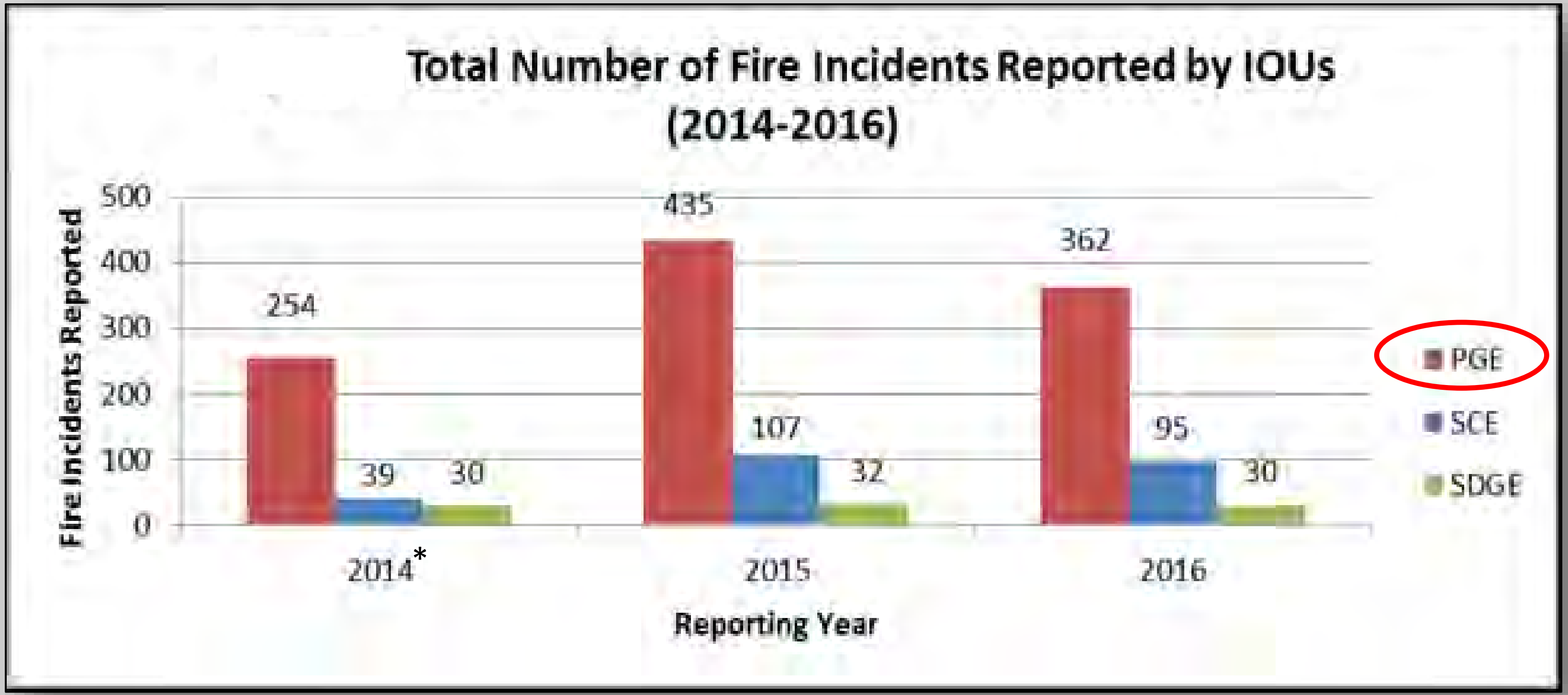
Beale Air Force Base, 2017

- Dwyer et al. (2019) data
- 7 reported ignitions caused by power lines
- 5 reported wildlife ignitions
- **71% of BAFB power line ignitions caused by wildlife**

Susceptibility Varies

POSSIBLE FACTORS

- Number of Poles
- Geography
- Habitat/wildlife
- System age
- System design
- Field practices
- Mitigation



*June-December, only

2 SCALE OF WILDLIFE IGNITION RISK

Recorded Electrocutions

BHE OUTAGE RECORDS 2015-2020

- 491 wildlife outages/year
- 38% unknown animals
- 35% mammals
  - Squirrels
  - Raccoons
- 27% birds
  - European Starling
  - Rock Pigeon
  - Sparrows (incl English)
- 7,020 Distribution line miles
- Detected electrocutions averages **0.07 per mile** each year

Estimated Electrocutions, from BHE Data

ACCELERATOR: ELECTROCUTION DETECTION STUDIES

- BUT…many electrocutions are undetected—fault current not large enough
- Just 6% (Kemper et al. 2013) or <10% (Dwyer and Mannan 2007) of avian electrocutions trigger system protection and cause interruptions.
- Detection rate should be similar for other wildlife
- Multiply 0.07 detected wildlife faults per mile by 10.0-16.7
- A better estimate of the wildlife electrocution rate would be **0.7-1.17 per mile** each year
- Across BHE's ~2000 circuit miles in high fire areas, that would be **>1,400 to >2,340 thermal events** each year due to wildlife contacts.
- Is this too high to be credible?

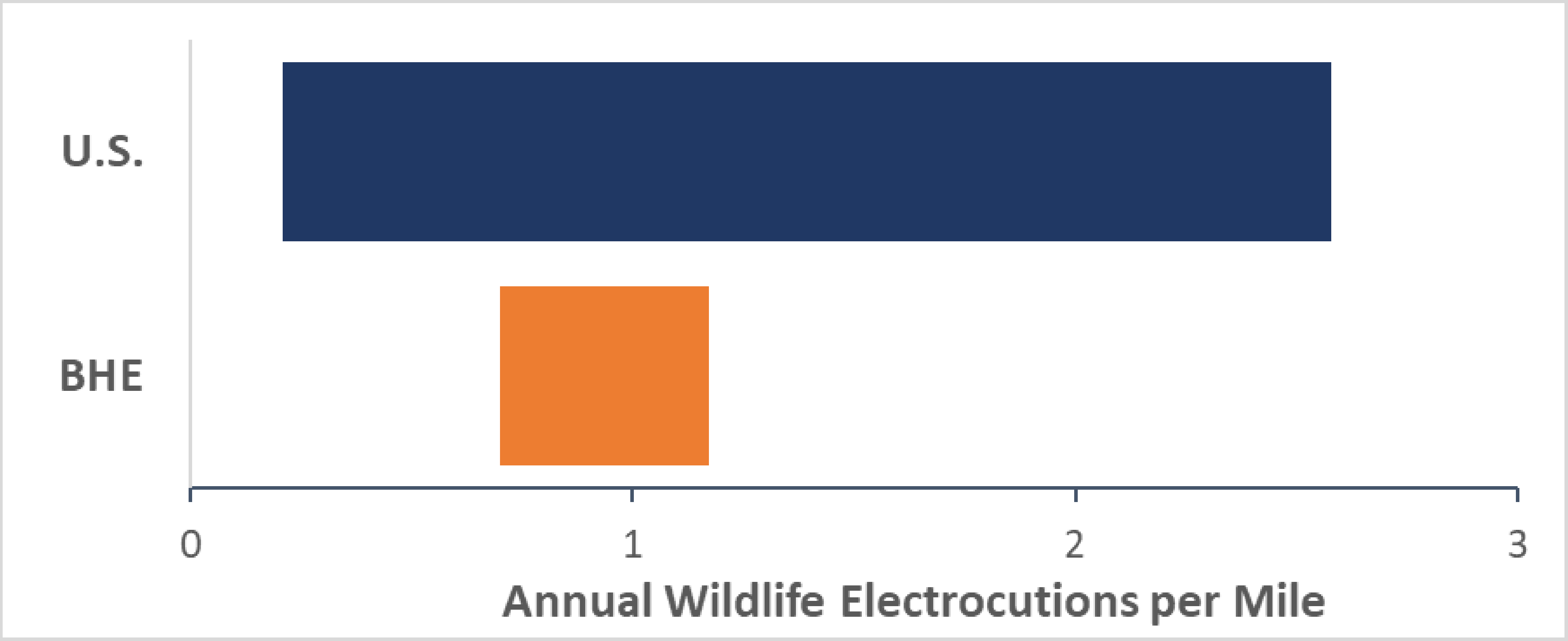
Estimated Electrocutions Across U.S.

META ANALYSIS OF NORTH AMERICAN BIRD MORTALITY STUDIES

- Median estimate of 0.03 avian electrocutions/pole, annually (Loss et al. 2014), which equates to ~0.6 avian electrocutions per mile (95% confidence interval: 0.10-1.24).
- BUT…birds comprise only 48% of wildlife outages for U.S. utilities (EPRI data)
- Based on this proportion, a better estimate of the wildlife electrocution rate would be ~**1.25 per mile** each year (CI: 0.21-2.58).
- Across BHE's ~2000 circuit miles in high fire areas, that would be **>2,500 thermal** events (CI: 420-5,160) each year.

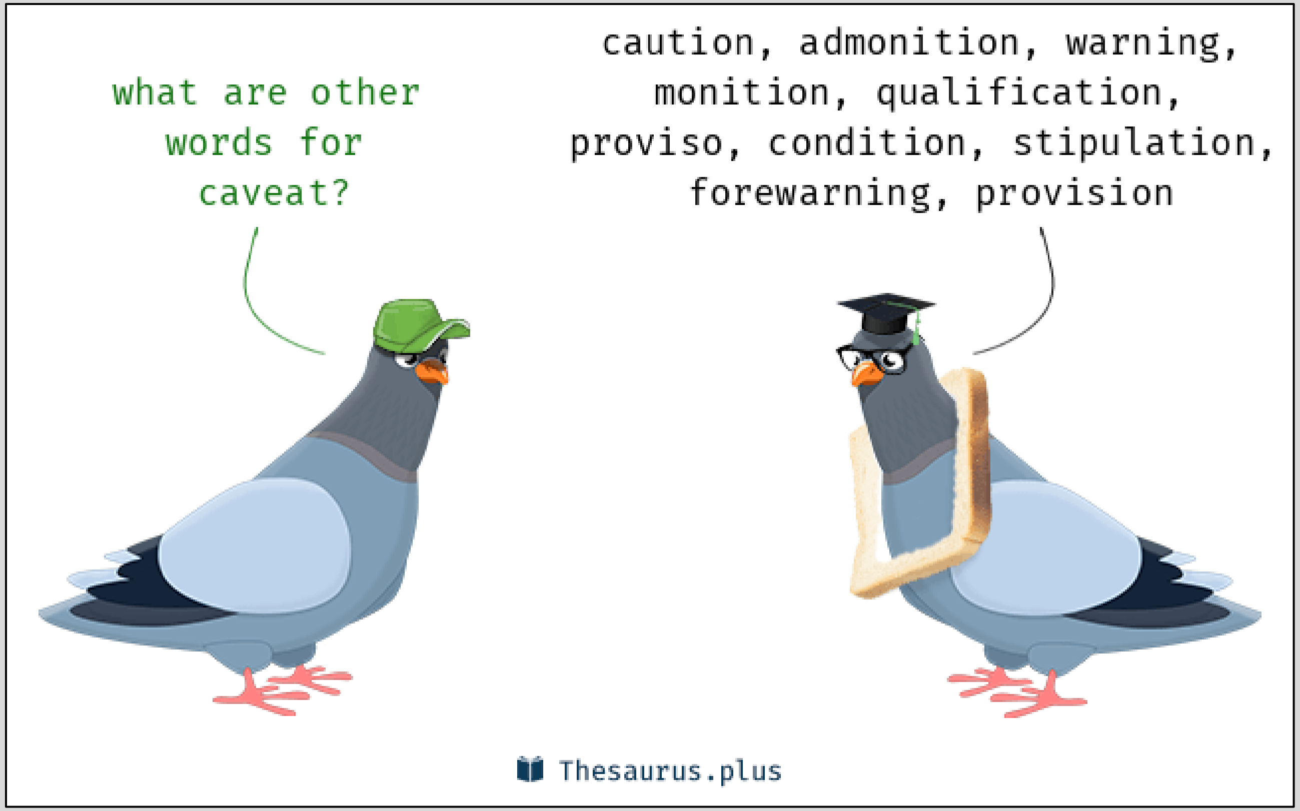
Interpretation

- Both estimates converge around 1 electrocution/mile, annually
- U.S. estimated range brackets the BHE estimated range—lends credence
- BHE estimate is on the low end
- 2011 APPs, revised design/construction/mitigation practices?



Caveats Are Many…

- Both estimates are pieced-together from a range of resources
- Small studies, limited datasets, across species/ systems/ regions
- Assumptions and connections inexact, imprecise, subject to study biases
- Low confidence in the accuracy of either number

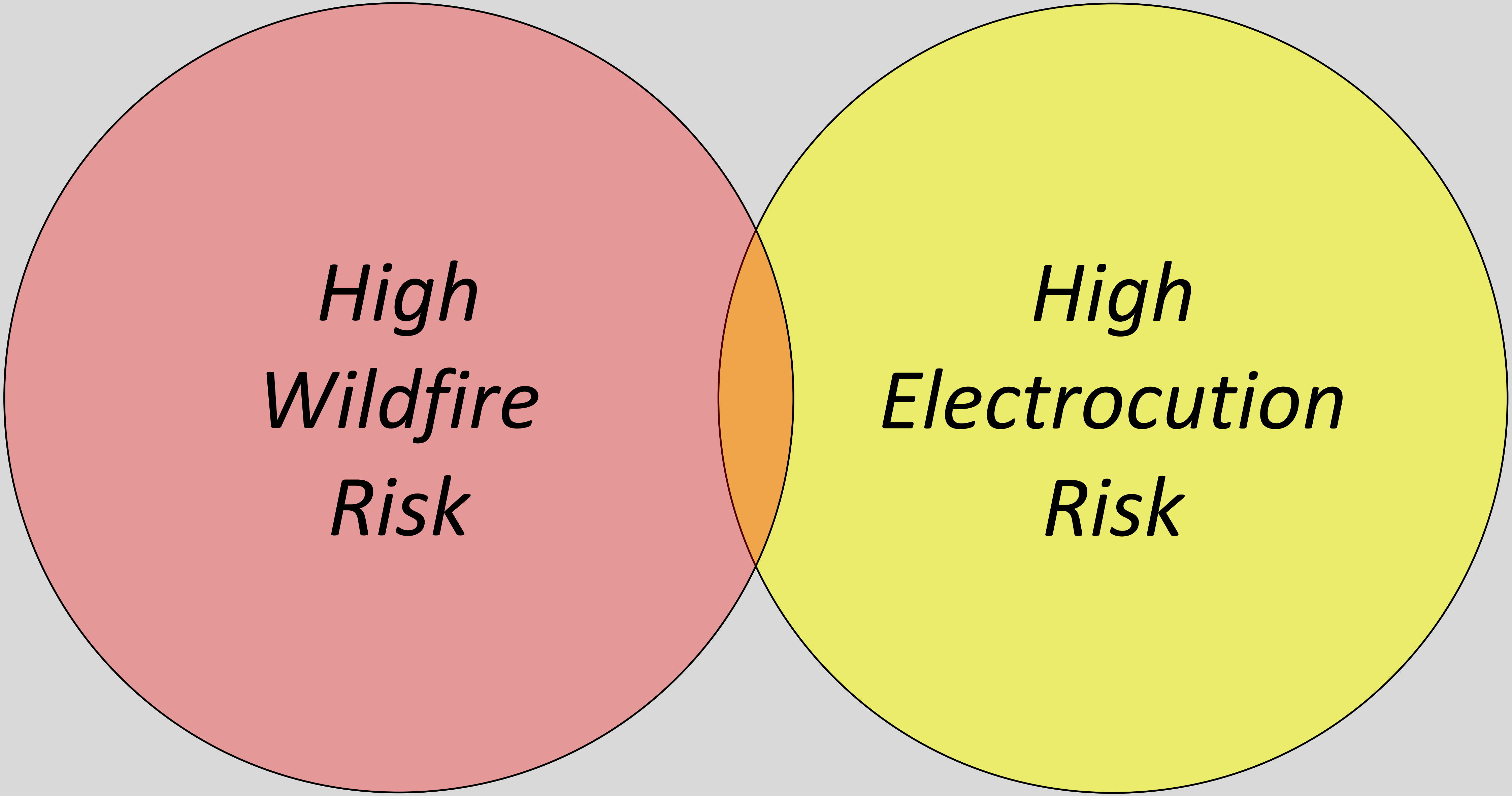


And Yet...

- Independent datasets, convergence is remarkable
- We believe:
  - Wildlife electrocution is far more common than widely acknowledged
  - Electrocution is underappreciated ignition risk that can be mitigated.
- Benefit to starting the conversation
- Additional research will help develop more accurate and nuanced estimates

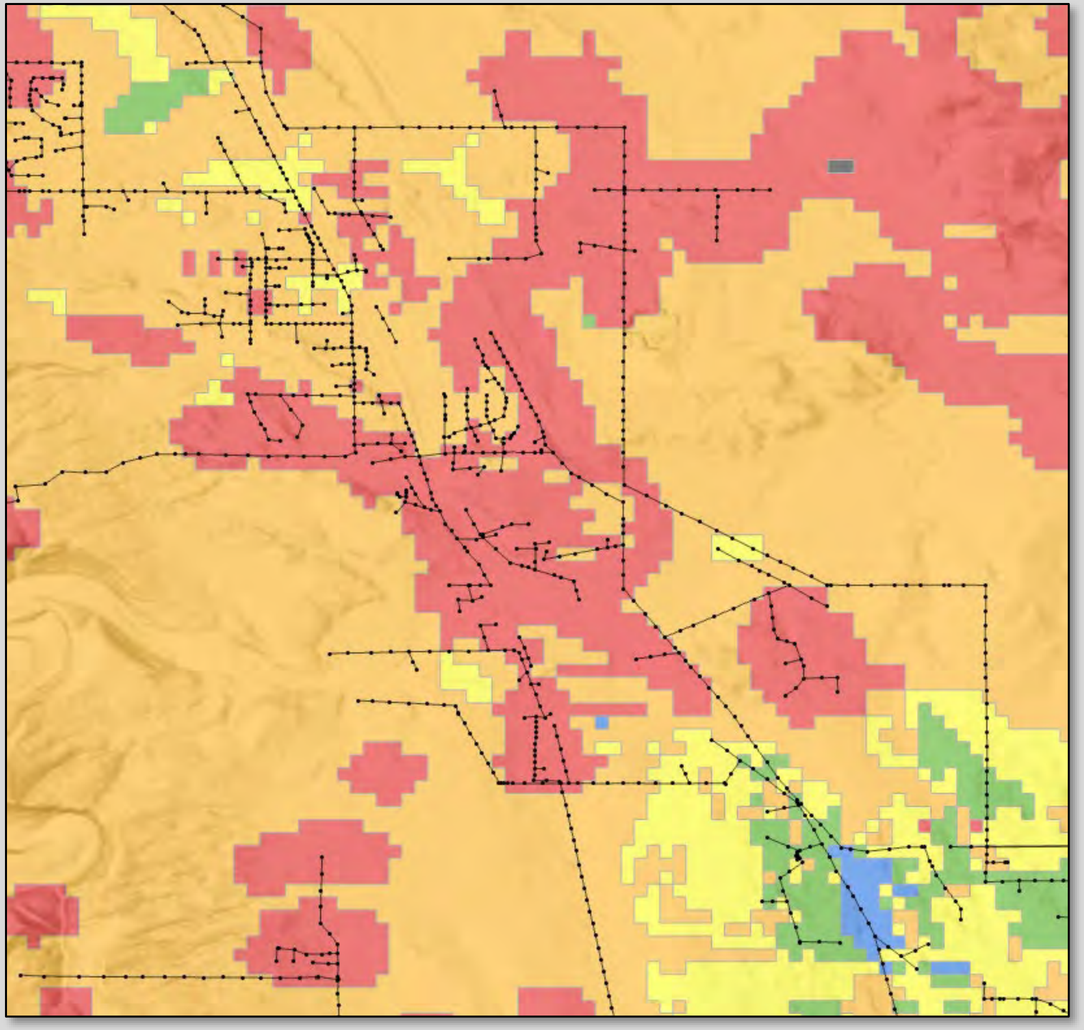
3 PINPOINTING BHE RISK

High Wildlife Ignition Risk Poles



BHE Wildfire Risk Modeling

- Geospatial model of Hazardous Fire Areas (HFA's)
- Fire potential: initiation, spread, intensity, difficulty to control
- Impact potential: population, natural resources, BHE assets
- 6 levels of risk, "zero" to "very high"
- Conservative delineation: 38% is high (■) or very high (■)



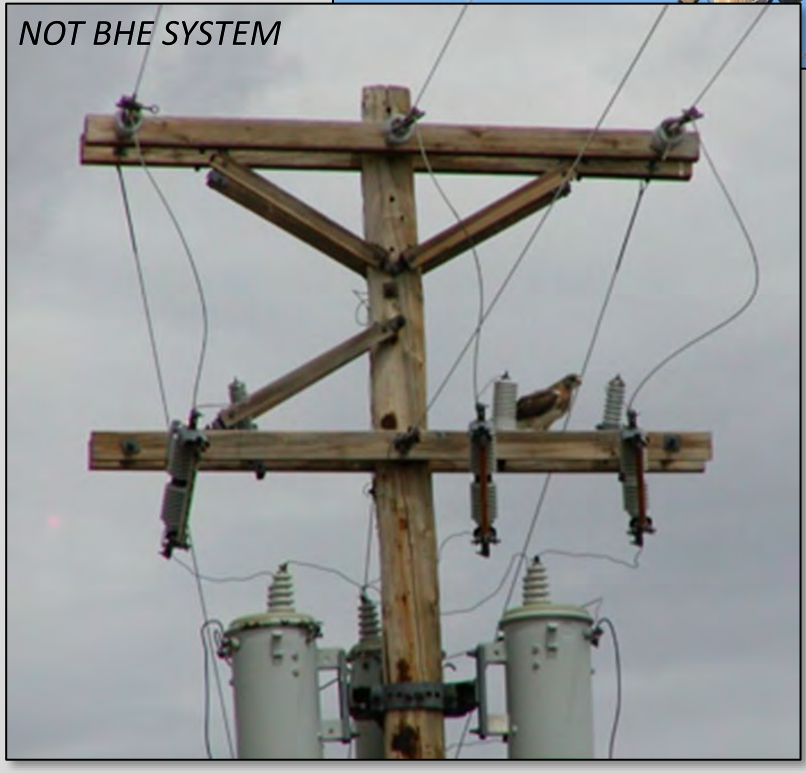
Electrocution Risk Modeling

DWYER ET AL. (2013)

- Electrocution risk factors are:
  - Number of phases
  - Number of jumpers
  - Presence of high grounds (Y/N)
  - Habitat (Y/N)
- Electrocution risk increases w/ pole complexity in favorable habitat
- Risk Index 0.00-1.00
- High risk ($\geq$0.40) pole is 5.25x-8x more electrocution-prone than low risk (<0.40) pole (Mojica et al. 2022, Dwyer and Mojica 2022)

$$Y = -0.93167 + (0.09048 \times \#\ jumpers) + (0.14506 \times \#\ conductors) + (0.53203 \times grounding) - (0.55151 \times habitat)$$

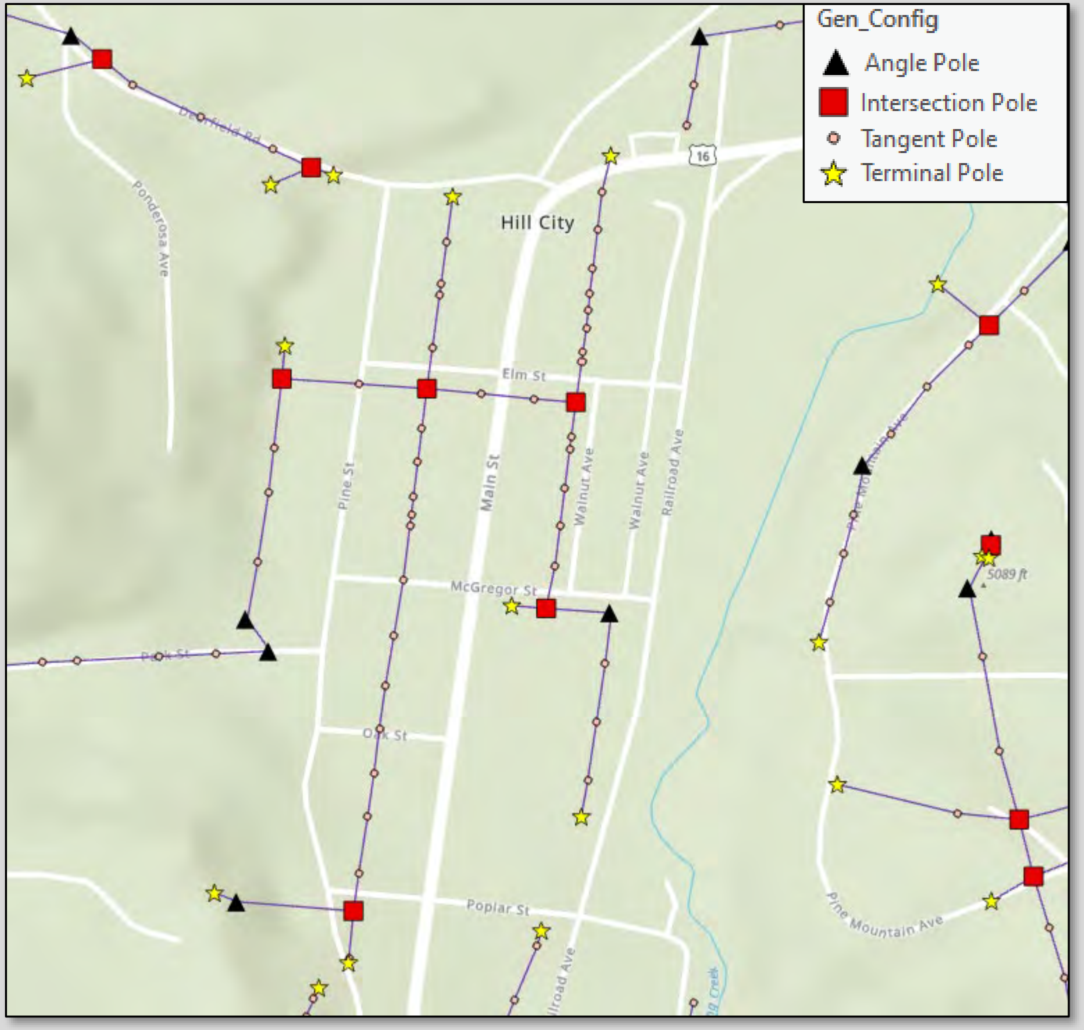
$$Risk\ Index = 1/(1 + EXP(-Y))$$



GIS Electrocution Risk Analysis

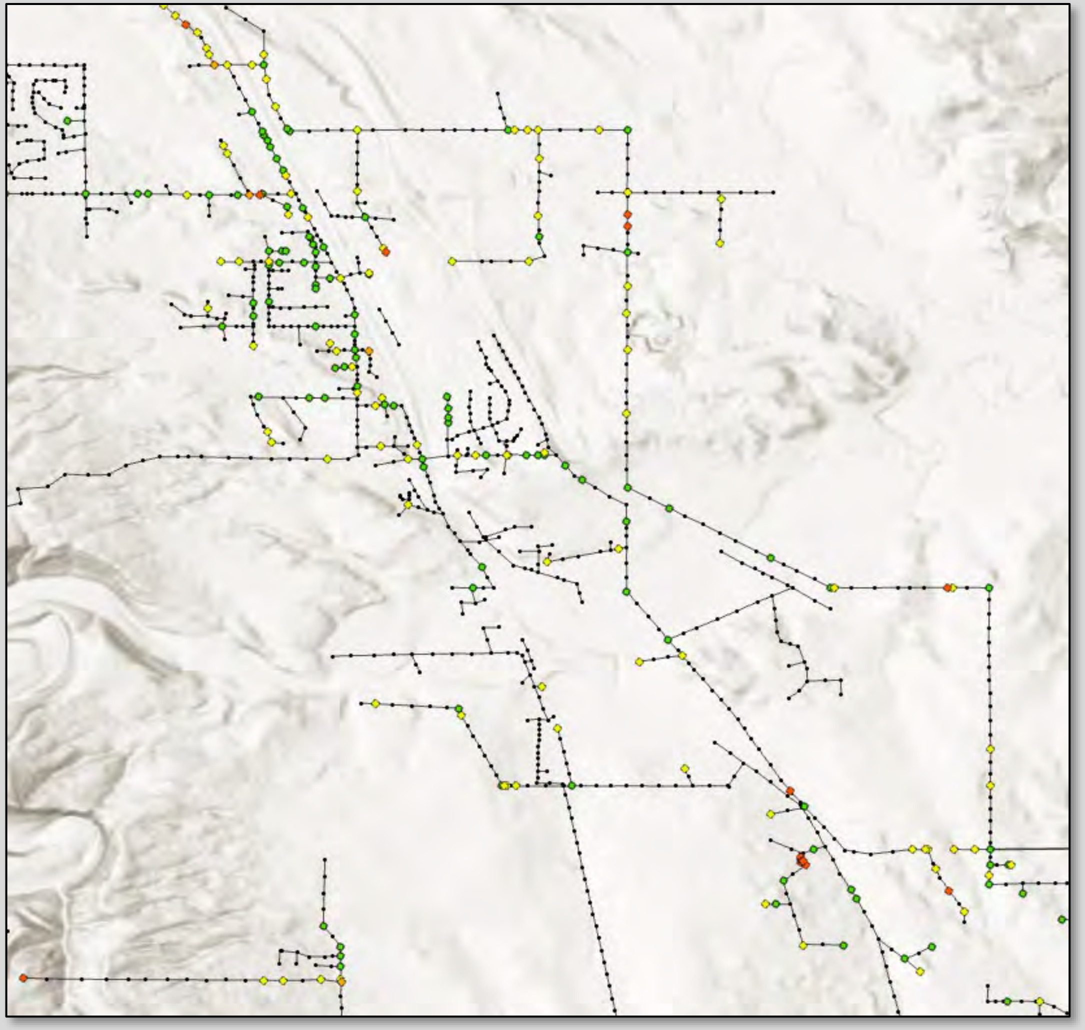
DESKTOPPING A FIELD PROCESS

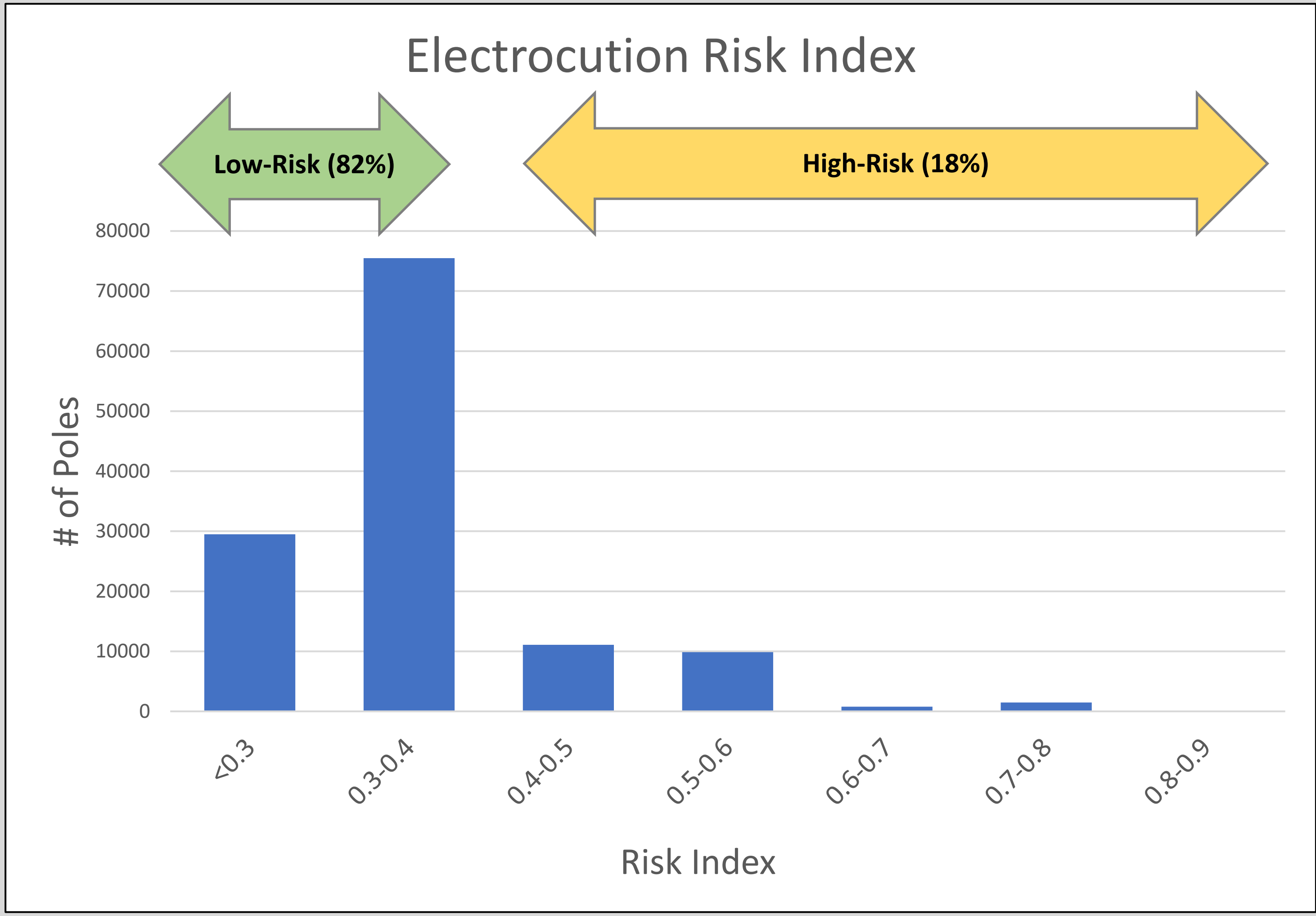
- Scale up and batch!
- # Phases—known
- # Jumpers—estimated
  - Primary jumpers derived from line angles & number of associated spans
  - Stingers from type and number of equipment
- Grounding—estimated
  - Pole material
  - Equipment associated with high grounds
- Habitat—yes, all but “barren”
- Imperfect…but efficient.



GIS Risk Analysis Results

BHE DATA





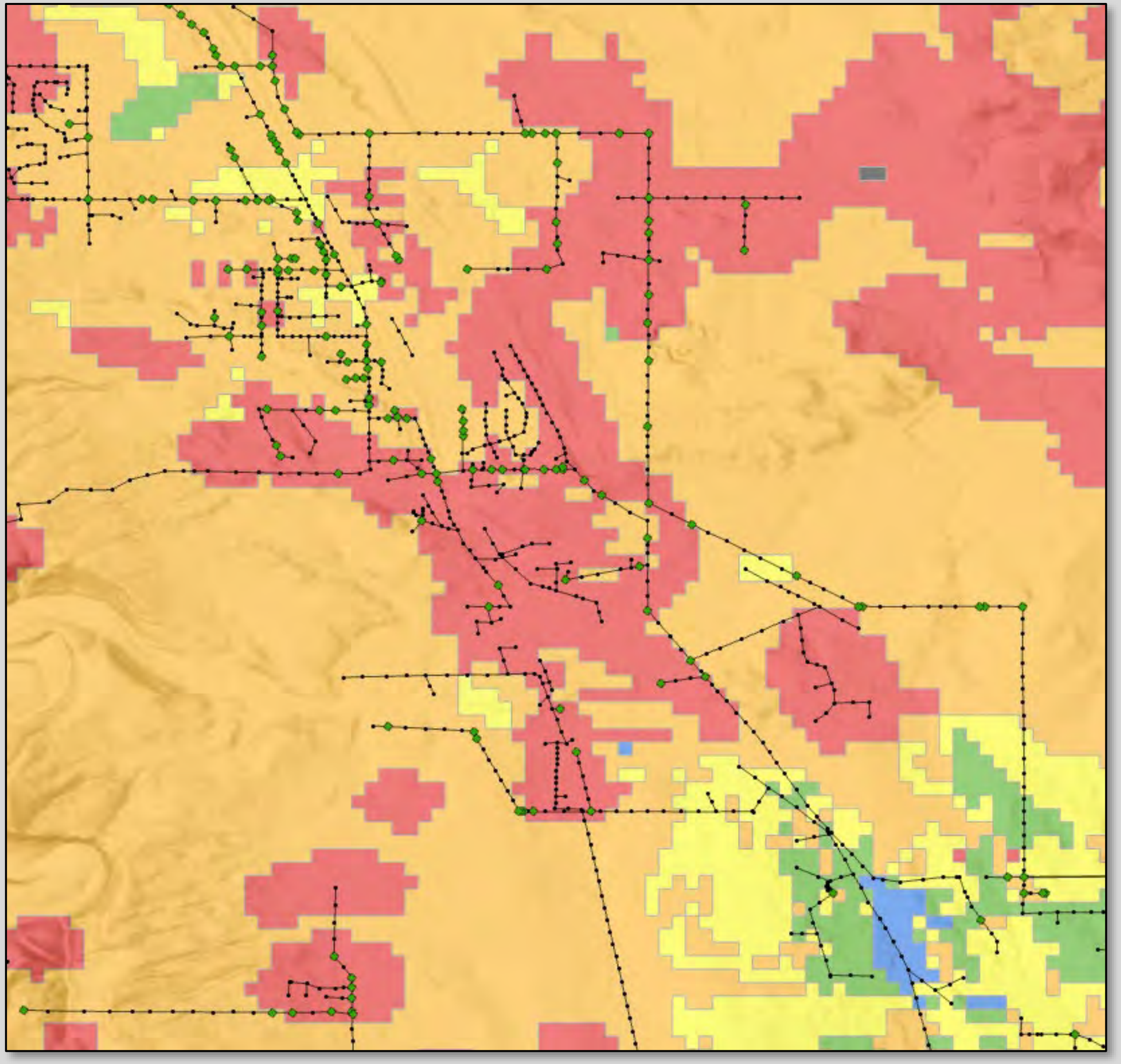
Wildfire Risk (HFA) Class		
Zero-Moderate	**High**	**Very High**
62%	24%	14%

Electrocution + Fire

BHE DATA

Electrocution Risk (rows) by HFA Zone (columns)

Bin	≤Moderate	High	Very High	
<0.3	19.2%	3.0%	0.8%	30.9%
0.3-0.4	31.8%	16.9%	10.2%	
0.4-0.5	5.8%	1.9%	1.0%	
0.5-0.6	4.4%	2.0%	1.3%	
0.6-0.7	0.3%	0.1%	0.1%	
0.7-0.8	0.6%	0.3%	0.2%	
0.8-0.9	0.0%	0.0%	0.0%	
	62.2%	***4.3%***	***2.6%***	



Results Validation

FIELD ASSESSMENT OF 3,254 BHE POLES

- Uncertainties of GIS-based electrocution risk assessment
  - Primary configuration
  - Completeness of system GIS (arresters)
  - Work practices (grounding)
  - Existing mitigation (insulation)
- Modeled RI was generally higher than field RI because of existing mitigation
- Successfully identified
  - High electrocution (& ignition) risk poles
  - Low electrocution (& ignition) risk poles
- Model fallible for single poles, very effective for aggregate groups: identify circuits with many high risk poles.
- Future projects could improve model predictions by:
  - Incorporating existing retrofitting assumptions into model
  - Developing regional models based on field observations

RISK INDEX (P)	Three-Phase Equipment Poles	All Other Poles
GIS	0.55	0.40
Field	0.45	0.36
	N = 819	*N* = 2,435

Focused Mitigation

- Wildlife-friendly spacing
- Mitigation through insulation
- UL 94 V-O products
- IEEE 1656 tested

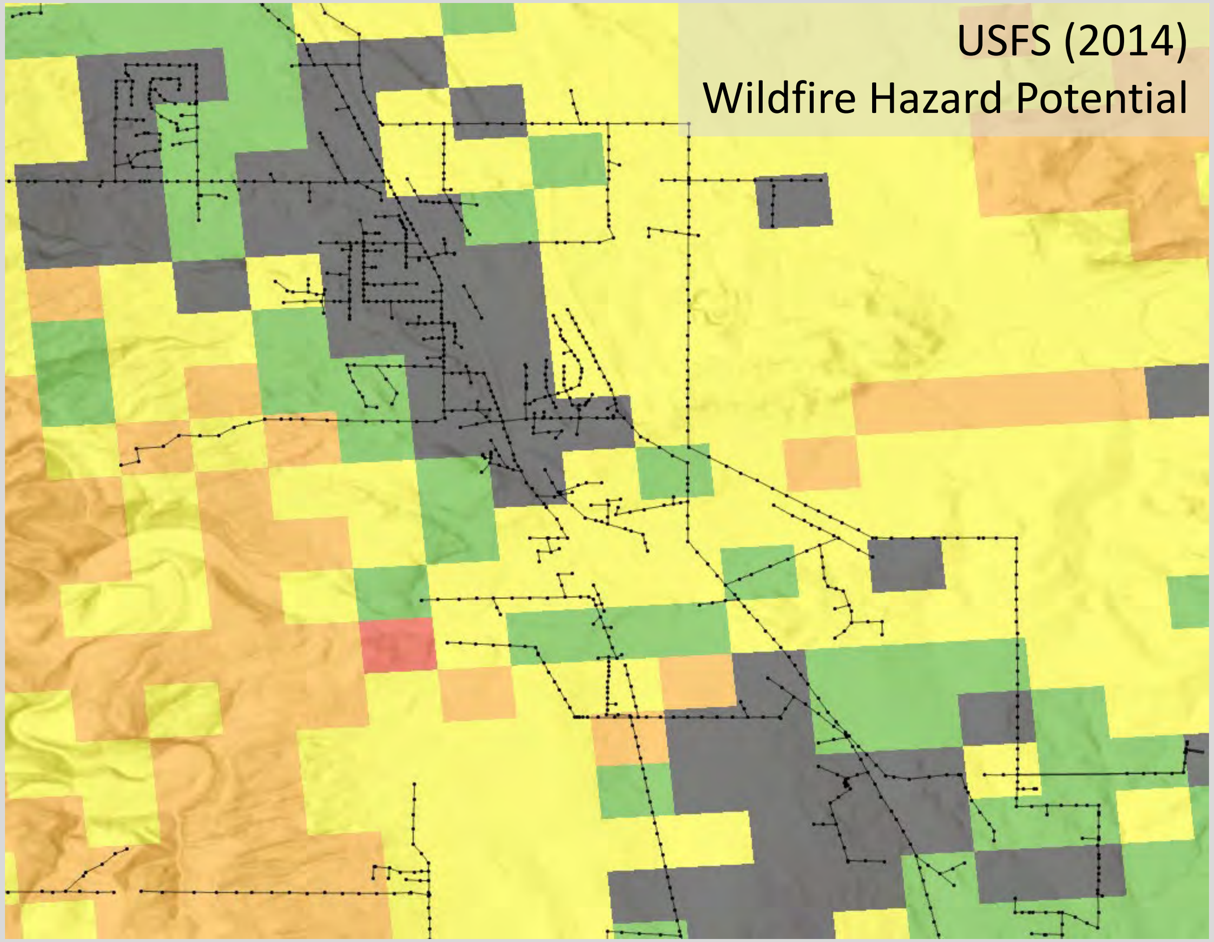
4 VALUE OF KNOWLEDGE

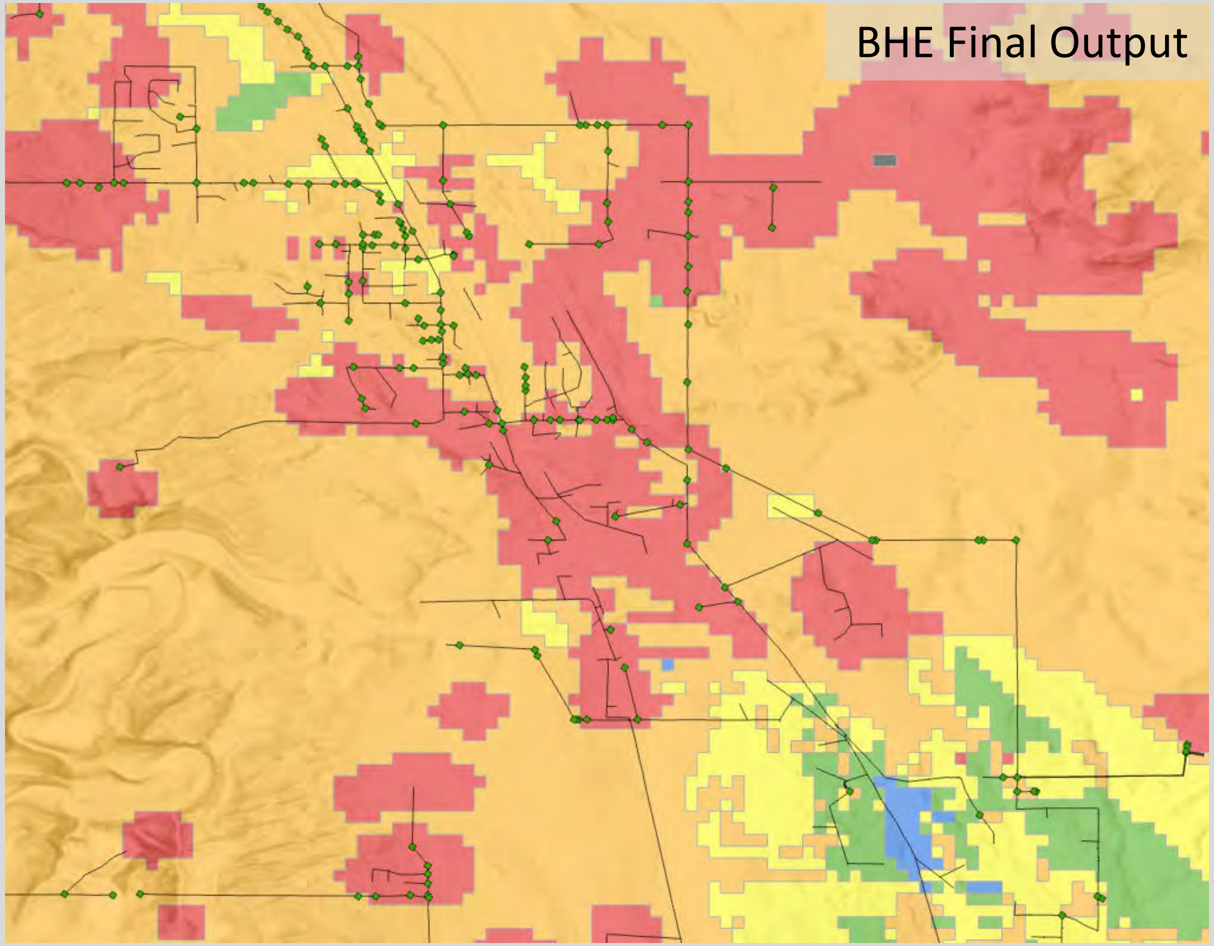
Best Wildlife Ignition Risk Mitigation Guidance

BEFORE PROJECT/AFTER PROJECT

- Generic, coarse fire model
- No pole guidance

- Granular fire model tailored to BHE
- High risk poles prioritized





Ignition Prevention on Overhead Power Lines

IMPLEMENTATION AFTER IGNITION RISK OUTCOMES

- BHE is using results and insights from this project to refocus resources to efficiently reduce wildfire potential in and around its service territories.

- A pilot retrofitting project is planned for a selection of high-risk poles near Rapid City, SD to scale costs, level of effort, time to operationalize, and potential pitfalls.

- Learnings from the pilot program will help BHE better plan and budget for future high-risk pole retrofitting in HFA High or Very High-risk categories.

Ignition Prevention on Overhead Power Lines

WORK TO REDUCE FIRE IGNITION RISK

- BHE developing a proactive program to retrofit equipment across all service territories.
- BHE established wildfire risk evaluation requirements within the internal Distribution System Integrity Program (DSIP) and for siting work.
- This project has helped BHE focus its efforts on a small minority of poles that, when mitigated, can disproportionately improve reliability, enhance wildlife conservation, and reduce fire ignition risk.

QUESTIONS?

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"A Realistic Painting of an Electrocuted Pigeon Starting a Wildfire"
DALL-E 2

Xcel Energy

Wildfire Equipment Standards at Xcel Energy

Presented by: Travis Johnson

Manager, Electric Distribution Standards

April 16, 2024

HISTORY OF WILDFIRE STANDARD

- Research and Field Experience
  - Resiliency improvements
  - NESC Grade B Construction
  - Fiberglass crossarms
  - Ties and Insulators
  - High impedance faults
  - Lightning damage
  - Tree impacts
- Standard development
  - Fusing
  - Arresters
  - Conductor
  - Structure

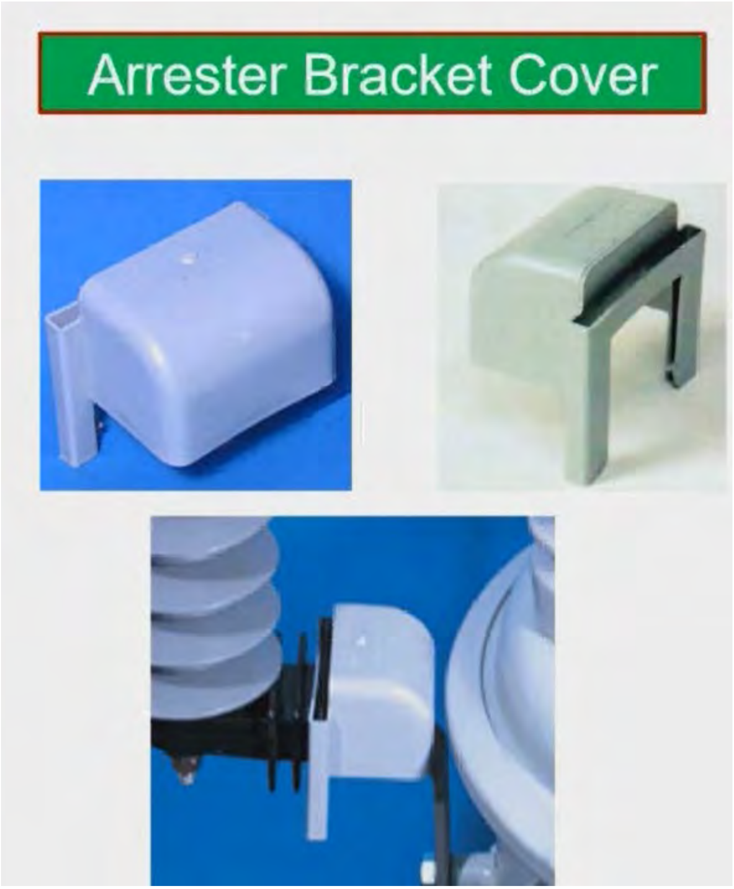
DISTRIBUTION WAY OPERATIONAL EXCELLENCE

BUSHING COVERS

- Non-flammable wildlife guards
  - Self extinguishing
  - Replace all existing bushing guards
  - Transformers, reclosers, terminal poles
  - UL V0 rating

WILDFIRE MITIGATION WILDLIFE GUARDS

- Arrester bracket cover
- Install over arrester first arrester skirt
  - Slip on fit
  - UL V0 rating



WILDFIRE MITIGATION CUTOUT COVERS

- Cutout Cover
  - Cutout guard with stabber
  - UL V0

WILDFIRE MITIGATION
ELF – COOPER/EATON

- ELF – current limiting fuse (Cal Fire)
  - No expulsion
  - Drop open like regular gate
- Different for 15kV and 25kV systems
  - 17.2kV rating on label
  - 23kV rating on label
- Amp sizes:
  - 6A to 50A for 15kV
  - 6A to 30A for 25kV
- Covers transformers and small taps

- Replace all porcelain cutouts

ELF – PRICE & COORDINATION

Xcel Energy®

- Replace all porcelain cutouts with polymer cutouts
  - Better reliability

- 15 kV Transformer fusing
  - 6A will fuse a 25 kVA
  - Coordinates with a 15A K-link upstream
- 25 kV Transformer fusing
  - 6A will fuse a 50 kVA
  - Coordinates with a 15A K-link upstream

DISTRIBUTION WAY OPERATIONAL EXCELLENCE

SMU20 FUSE – COOPER/EATON

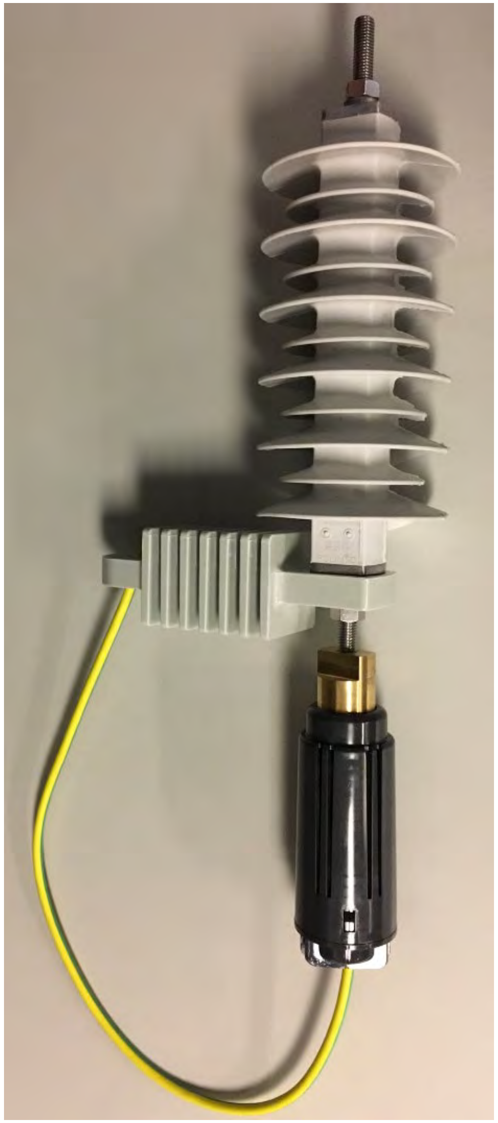
- Power fuse cutouts
  - 15kV (labeled 17kV)
  - 25kV (labeled 27kV)
- Different sized cutout body
  - 15kV 1005888
  - 25kV 1005889
  - Same end pieces
- Same Mat ID as UG fuses
- Chosen for large amperage taps and all capacitors

DISTRIBUTION WAY OPERATIONAL EXCELLENCE

WILDFIRE ARRESTER

Xcel Energy

- ABB Cal Fire Arrester
- Black isolator takes it offline before it fails. Measure leakage current, fires isolator if critical current exceeded.
- Red indicator means the arrester has failed
- No visible open, indicator slides down lead which must remain straight for 6” when mounted

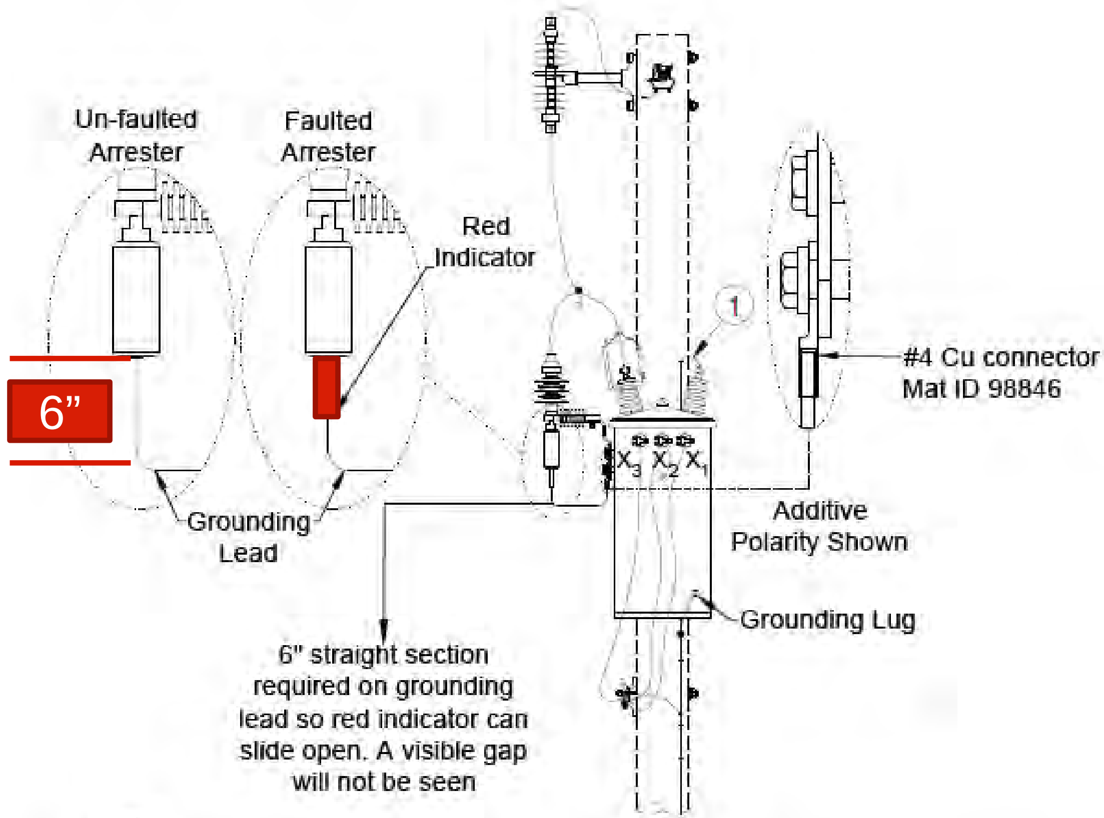


DISTRIBUTION WAY
OPERATIONAL EXCELLENCE

TRANSFORMERS

- Change fusing and arrester
- Tank mounted
- Ground lead must be kept straight for 6”
- Can be tipped a maximum of 45 degrees
- Red Indicator
  - Has a catch and can’t be pushed back in
  - Don’t push back in, would close the gap

WILDFIRE ARRESTER INSTALLATION ON TRANSFORMERS



Notes:

1. Connect the H2 bushing to pole ground with #4 Cu.
2. Install #4 Cu wire from X_2 secondary bushing to transformer tank grounding stud as shown.
3. Ground transformer tanks to system neutral.
4. Provide wildlife protection on transformer primary bushing and arrester.
5. See circuit diagrams on page E-201.

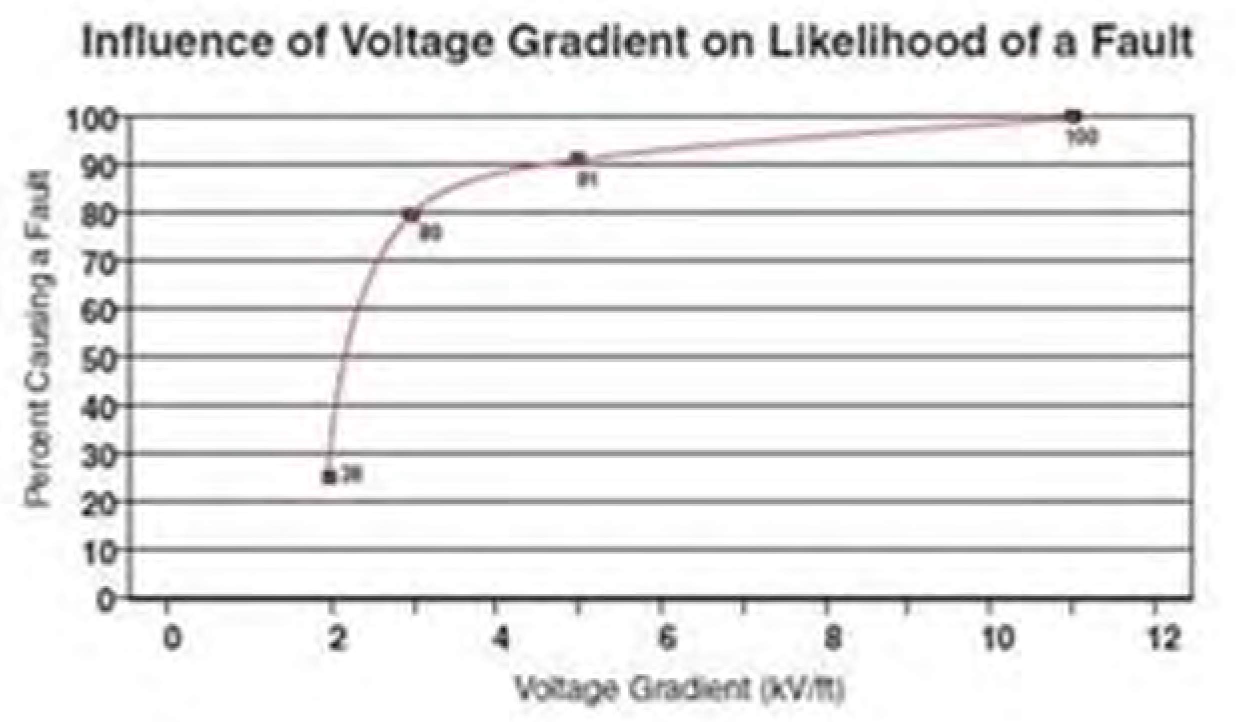
SPACING AND FAULTS

Xcel Energy®

- Branches across the line
  - Increase spacing

- Phase to phase
- 24.9 / 4’ = 6.2 kV/ft
- 13.2 / 4’ = 3.3 kV/ft

- Phase to neutral
- 14.4 / 7’ = 2.1 kV/ft
- 7.62 / 7’ = 1.1 kV/ft

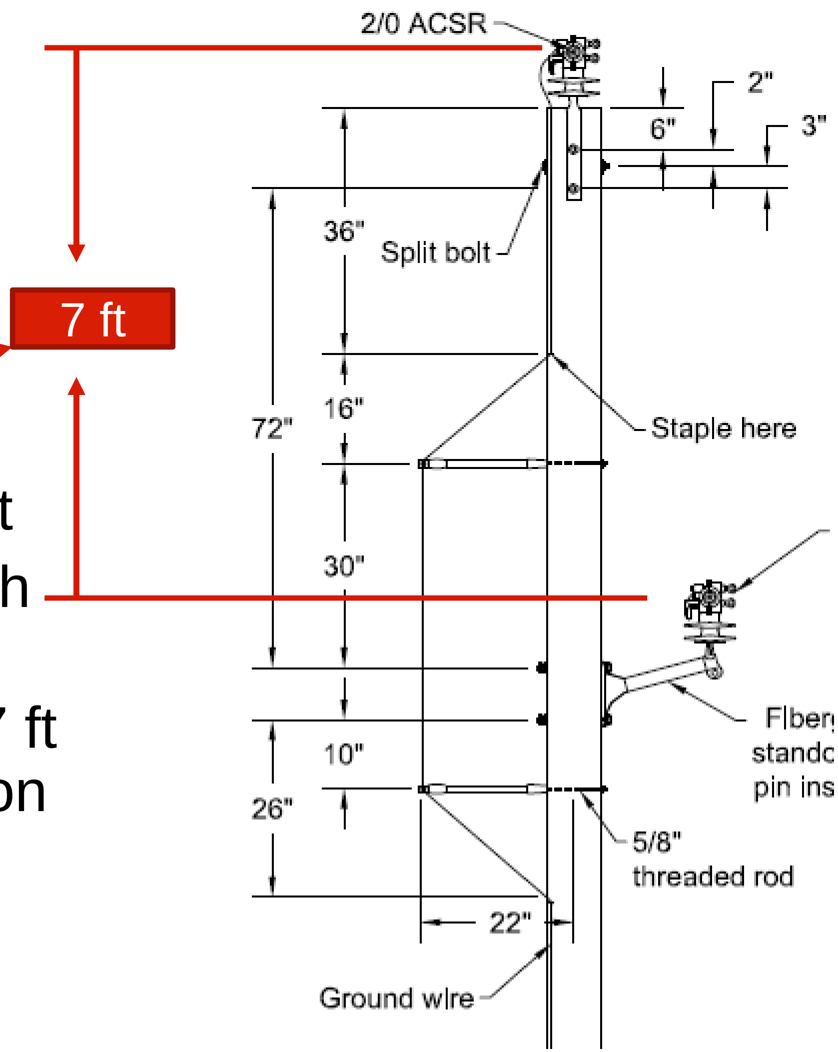


SINGLE-PHASE CONSTRUCTION

Xcel Energy®

- Conductor size
  - Neutral high
  - 2/0 ACSR for strength
  - Neutral and phase wire

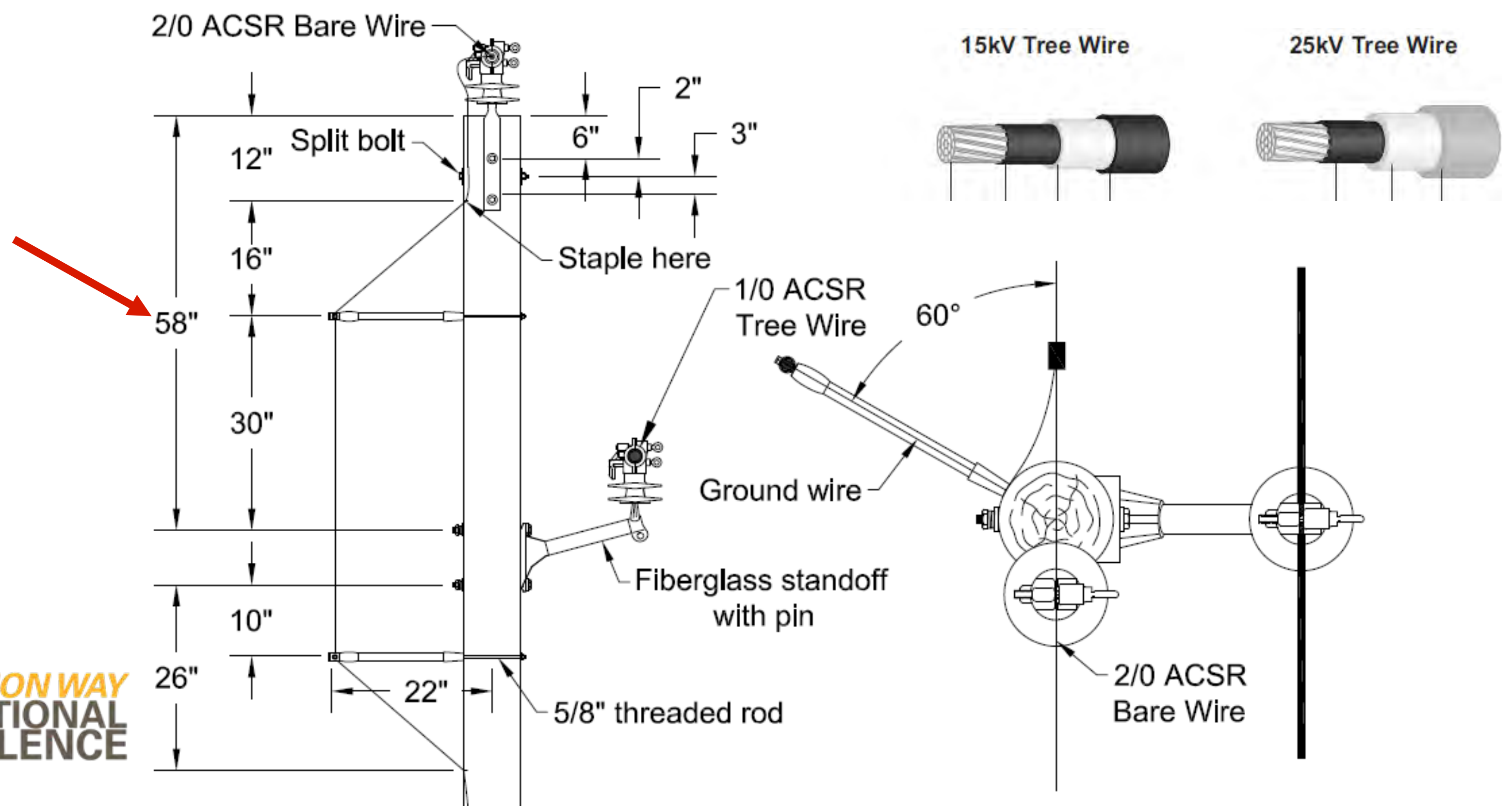
- Spacing increased
  - 84” (7 ft)
  - 14.4kV / 7 ft = 2.05 kV/ft
  - Small chance of char path and arcing
  - No guarantee they stay 7 ft apart when a tree leans on line



DISTRIBUTION WAY
OPERATIONAL EXCELLENCE

SINGLE PHASE CONSTRUCTION

- Covered conductor
  - Insulated for system voltage
  - 2/0 ACSR neutral for strength, 1/0 ACSR tree wire phase wire
  - Less spacing if tree wire

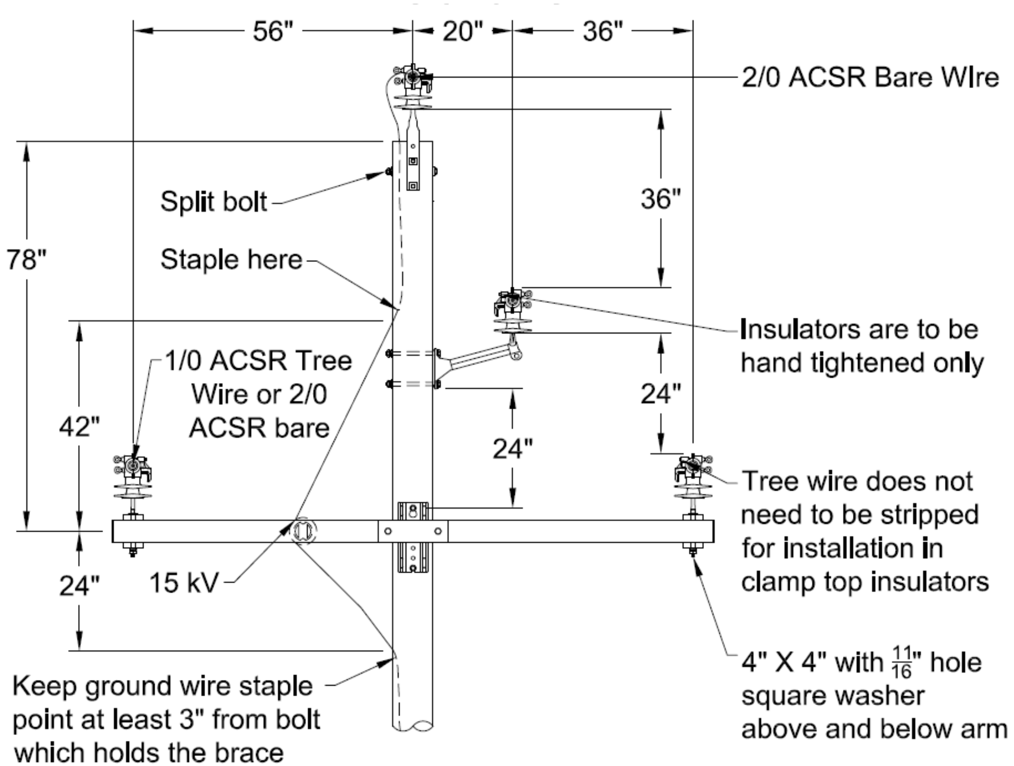


DISTRIBUTION WAY
OPERATIONAL EXCELLENCE

THREE-PHASE CONSTRUCTION

Xcel Energy

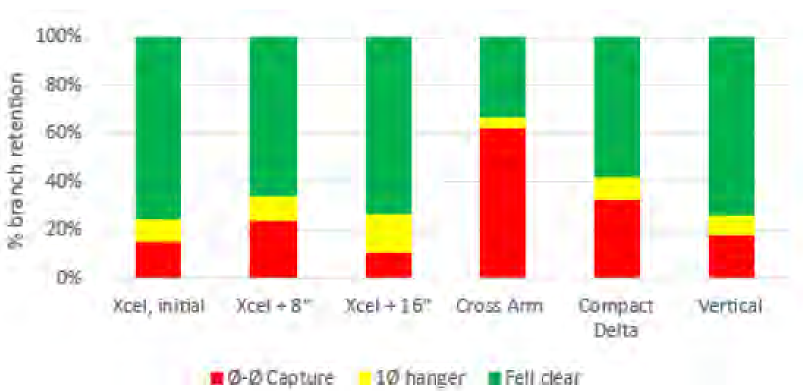
- Conductor size
  - Neutral high
  - 2/0 ACSR neutral and phase wire
  - Phase to phase spacing problem
- Spacing increased
  - 84” (7 ft) diagonal
- Center phase on
  - Road-side
  - Treeless (Less tree side)
  - Downhill side

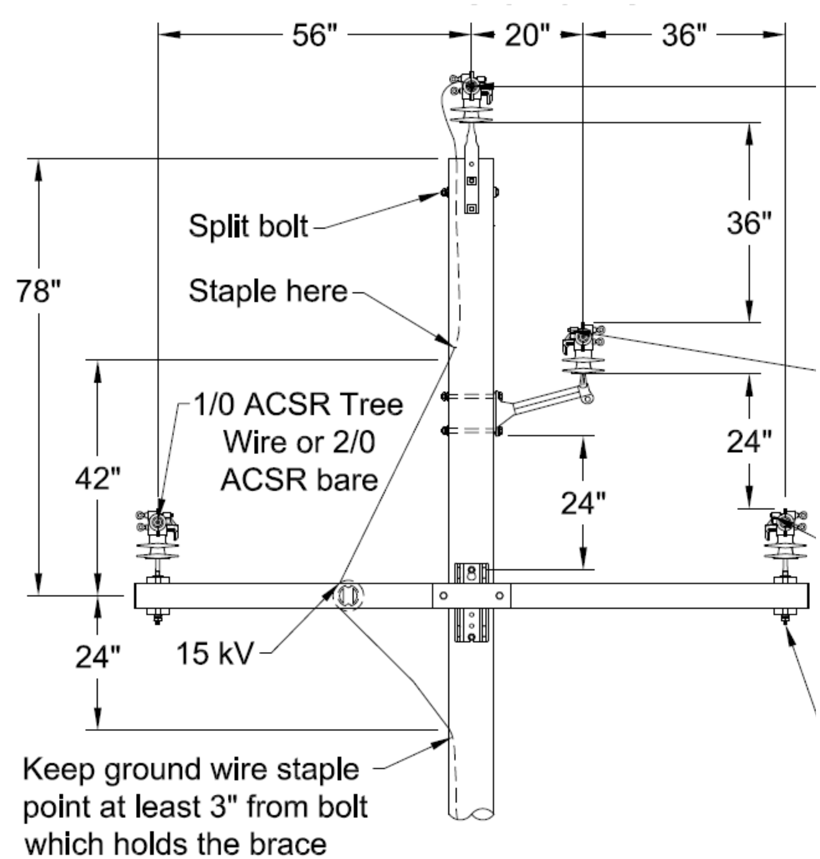


DISTRIBUTION WAY OPERATIONAL EXCELLENCE

THREE-PHASE CONSTRUCTION

- Conductor size
  - Neutral high
  - 2/0 ACSR neutral and phase wire
  - Trees on single phase side
  - Phase to phase spacing problem
- Branch testing
  - >50% flat configuration
  - <15% for raised





THREE PHASE CONSTRUCTION

Xcel Energy®

- Medium Angle, Heavy Angle, Deadend and Tap
  - Raised center phase
  - Clamp top to hold jumpers
  - Use covered jumpers
  - Make connection to tails

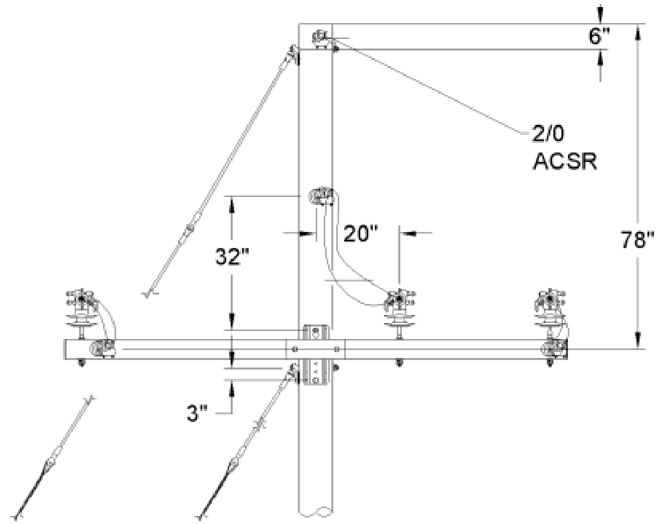
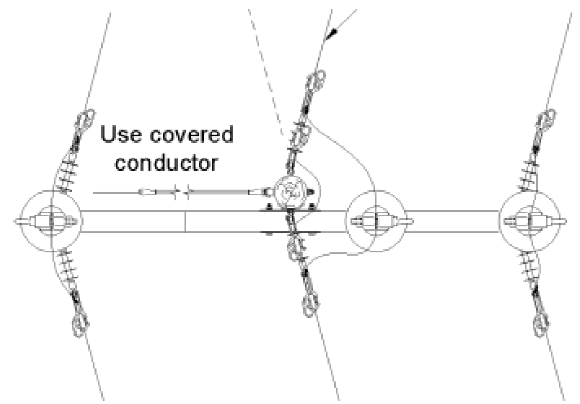


FIGURE 1
15 kV and 25 kV



DISTRIBUTION WAY
OPERATIONAL
EXCELLENCE

TREE WIRE COMPONENTS

- Tangent Pole
  - Single Phase
  - Center phase on 3-phase structures
- Size
  - 15” long
  - 2” diameter rod (heavy duty)

- Mat ID - 1014040

INSULATORS - MAT ID 1014337

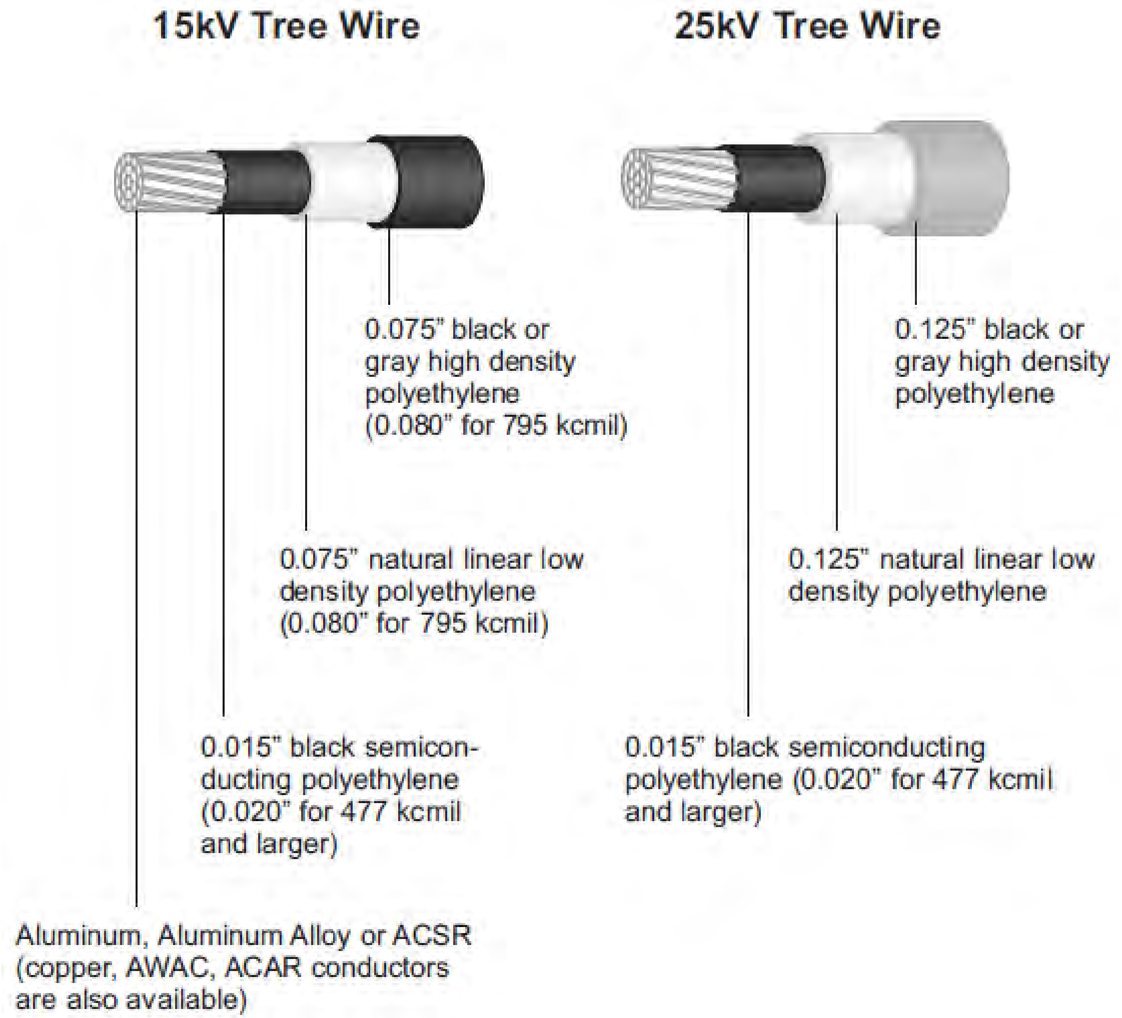
- Insulator Performance
  - Wanted some give
    - Didn’t want to break pole
    - Didn’t want to break crossarm
    - Wanted to retain the conductor in the air
  - Wanted one insulator for simplicity
    - Ceramic jaws for both bare and tree wire
    - 25kV rated
  - Tested at EPRI
    - Conductor ran a few feet
    - Didn’t break pole or arm
    - Conductor stayed contained

INSULATOR INSTALLATION

- Insulator Installations on Pins
  - Tighten till you hit the mastic
  - Mastic gets the air out of the top of the insulator
  - You can then turn it ½ turn more
  - If it doesn't line up (pole top pin or bracket) get another insulator and try again
  - Use the one that didn't work on an arm pin
  - Don't use any strap wrench
  - If you overtighten then over time the plastic can crack and the insulator fail

TREE WIRE CONSTRUCTION

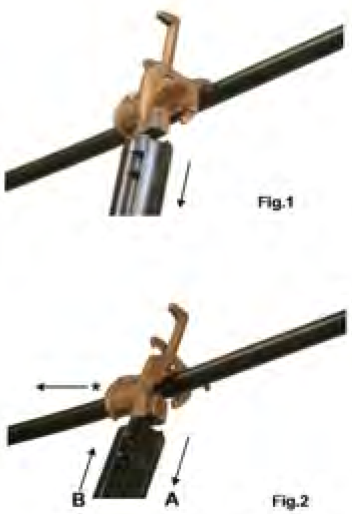
- Tangent
  - 25% more expensive than regular bare construction
  - 1/0 ACSR for tap wire size
  - Has insulation
    - Still considered bare
- Mat ID
  - 15kV 1014190
  - 25kV 1014191



DISTRIBUTION WAY OPERATIONAL EXCELLENCE

STRIPPING TOOLS

- One on the left for stick work
- One's on the right for rubber glove work



Ripley Fixed Conductor
Stripping Tool
WS Series*
www.ripley-tools.com

Ripley Adjustable
Stripping Tool
WS-55
www.ripley-tools.com

Speed Systems
Adjustable Tool
Model 2900
www.spdsystems.com

QUESTIONS?

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  - Travis.n.Johnson@xcelenergy.com
  - Office 303-571-3662
  - Cell phone 970-290-3816

“No fires, no fires, no fires.”

SDG&E Management, 2008

2024 International Conference on Overhead Lines

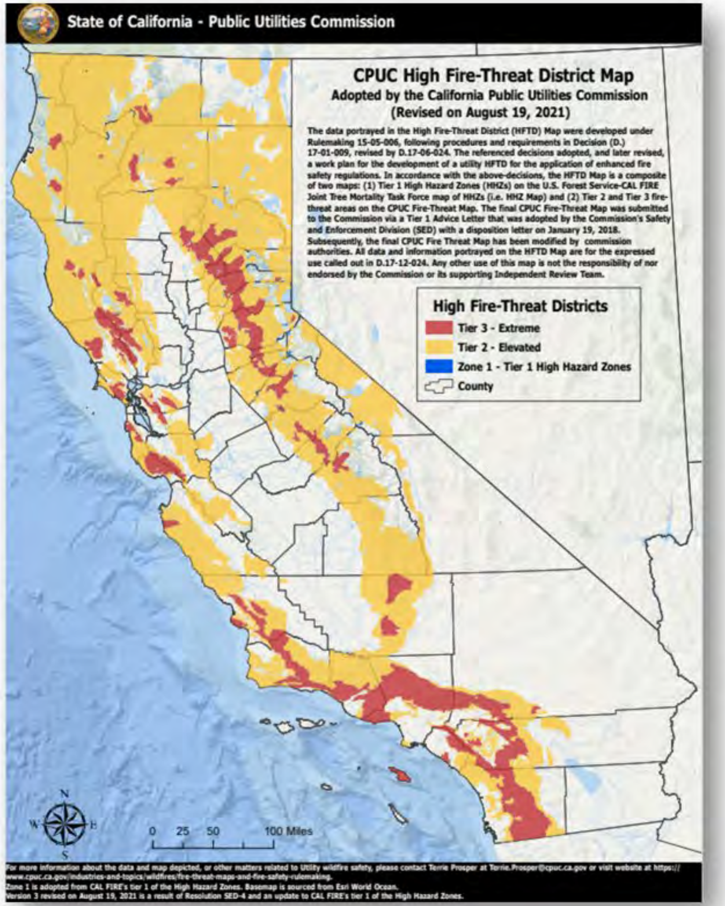
Design, Construction, Inspection, Maintenance

WILDFIRE MITIGATION STRATEGIES

As goes California...

- CPUC High Fire Threat District Map adopted 2019 (Rulemaking 15-05-006)
  - Fire history
  - Fire Threat (CAL FIRE)
  - FHSZ (CAL FIRE and others)
  - Comminutes at Risk (USFS)
  - Tree Mortality

- Requires:
  - Veg clearances
  - Conductor spacing
  - Enhanced inspections
  - Patrol requirements
  - Timeline for correction of defects



As goes California…

Largest wildfires 1932 - 2021

Top 20 Largest California Wildfires

	FIRE NAME (CAUSE)	DATE	COUNTY	ACRES	STRUCTURES	DEATHS
1	**AUGUST COMPLEX** *(Lightning)*	August 2020	Mendocino, Humboldt, Trinity, Tehama, Glenn, Lake, & Colusa	**1,032,648**	935	1
2	**DIXIE** *(Powerlines)*	July 2021	Butte, Plumas, Lassen, Shasta & Tehama	**963,309**	1,311	1
3	**MENDOCINO COMPLEX** *(Human Related)*	July 2018	Colusa, Lake, Mendocino & Glenn	**459,123**	280	1
4	**SCU LIGHTNING COMPLEX** *(Lightning)*	August 2020	Stanislaus, Santa Clara, Alameda, Contra Costa, & San Joaquin	**396,625**	225	0
5	**CREEK** *(Undetermined)*	September 2020	Fresno & Madera	**379,895**	858	0
6	**LNU LIGHTNING COMPLEX** *(Lightning/Arson)*	August 2020	Napa, Solano, Sonoma, Yolo, Lake, & Colusa	**363,220**	1,491	6
7	**NORTH COMPLEX** *(Lightning)*	August 2020	Butte, Plumas & Yuba	**318,935**	2,352	15
8	**THOMAS** *(Powerlines)*	December 2017	Ventura & Santa Barbara	**281,893**	1,060	2
9	**CEDAR** *(Human Related)*	October 2003	San Diego	**273,246**	2,820	15
10	**RUSH** *(Lightning)*	August 2012	Lassen	**271,911 CA / 43,666 NV**	0	0
11	**RIM** *(Human Related)*	August 2013	Tuolumne	**257,314**	112	0
12	**ZACA** *(Human Related)*	July 2007	Santa Barbara	**240,207**	1	0
13	**CARR** *(Human Related)*	July 2018	Shasta County & Trinity	**229,651**	1,614	8
14	**MONUMENT** *(Lightning)*	July 2021	Trinity	**223,124**	28	0
15	**CALDOR** *(Human Releated)*	August 2021	Alpine, Amador, & El Dorado	**221,835**	1,005	1
16	**MATILIJA** *(Undetermined)*	September 1932	Ventura	**220,000**	0	0
17	**RIVER COMPLEX** *(Lightning)*	July 2021	Siskiyou & Trinity	**199,359**	122	0
18	**WITCH** *(Powerlines)*	October 2007	San Diego	**197,990**	1,650	2
19	**KLAMATH THEATER COMPLEX** *(Lightning)*	June 2008	Siskiyou	**192,038**	0	2
20	**MARBLE CONE** *(Lightning)*	July 1977	Monterey	**177,866**	0	0

There is no doubt that there were fires with significant acreage burned in years prior to 1932, but those records are less reliable, and this list is meant to give an overview of the large fires in more recent times. This list does not include fire jurisdiction. These are the Top 20 regardless of whether they were state, federal, or local responsibility.

*Numbers not final.

CAL FIRE

10/24/2022

As goes California...

Most destructive wildfires 1991 - 2021

Top 20 Most Destructive California Wildfires

	FIRE NAME *(CAUSE)*	DATE	COUNTY	ACRES	*STRUCTURES*	DEATHS
1	CAMP *(Powerlines)*	November 2018	Butte	153,336	18,804	85
2	TUBBS *(Electrical)*	October 2017	Napa & Sonoma	36,807	5,636	22
3	TUNNEL - Oakland Hills *(Rekindle)*	October 1991	Alameda	1,600	2,900	25
4	CEDAR *(Human Related)*	October 2003	San Diego	273,246	2,820	15
5	NORTH COMPLEX *(Lightning)*	August, 2020	Butte, Plumas, & Yuba	318,935	2,352	15
6	VALLEY *(Electrical)*	September 2015	Lake, Napa & Sonoma	76,067	1,955	4
7	WITCH *(Powerlines)*	October 2007	San Diego	197,990	1,650	2
8	WOOLSEY *(Electrical)*	November 2018	Ventura	96,949	1,643	3
9	CARR *(Human Related)*	July 2018	Shasta County, Trinity	229,651	1,614	8
10	GLASS *(Undetermined)*	September 2020	Napa & Sonoma	67,484	1,520	0
11	LNU LIGHTNING COMPLEX *(Lightning/Arson)*	August 2020	Napa, Solano, Sonoma, Yolo, Lake, & Colusa	363,220	1,491	6
12	CZU LIGHTNING COMPLEX *(Lightning)*	August 2020	Santa Cruz, San Mateo	86,509	1,490	1
13	NUNS *(Powerline)*	October 2017	Sonoma	54,382	1,355	3
14	DIXIE *(Under Investigation)**	July 2021	Butte, Plumas, Lassen, & Tehama	963,309	1,311	1
15	THOMAS *(Powerline)*	December 2017	Ventura & Santa Barbara	281,893	1,063	2
16	CALDOR *(Under Investigation)*	September 2021	Alpine, Amador, & El Dorado	221,774	1,003	1
17	OLD *(Human Related)*	October 2003	San Bernardino	91,281	1,003	6
18	JONES *(Undetermined)*	October 1999	Shasta	26,200	954	1
19	AUGUST COMPLEX *(Lightning)*	August 2020	Mendocino, Humboldt, Trinity, Tehama, Glenn, Lake, & Colusa	1,032,648	935	1
20	BUTTE *(Powerlines)*	September 2015	Amador & Calaveras	70,868	921	2

"Structures" include homes, outbuildings (barns, garages, sheds, etc) and commercial properties destroyed.
This list does not include fire jurisdiction. These are the Top 20 regardless of whether they were state, federal, or local responsibility.
*Numbers not final

3/27/2024

As goes California…

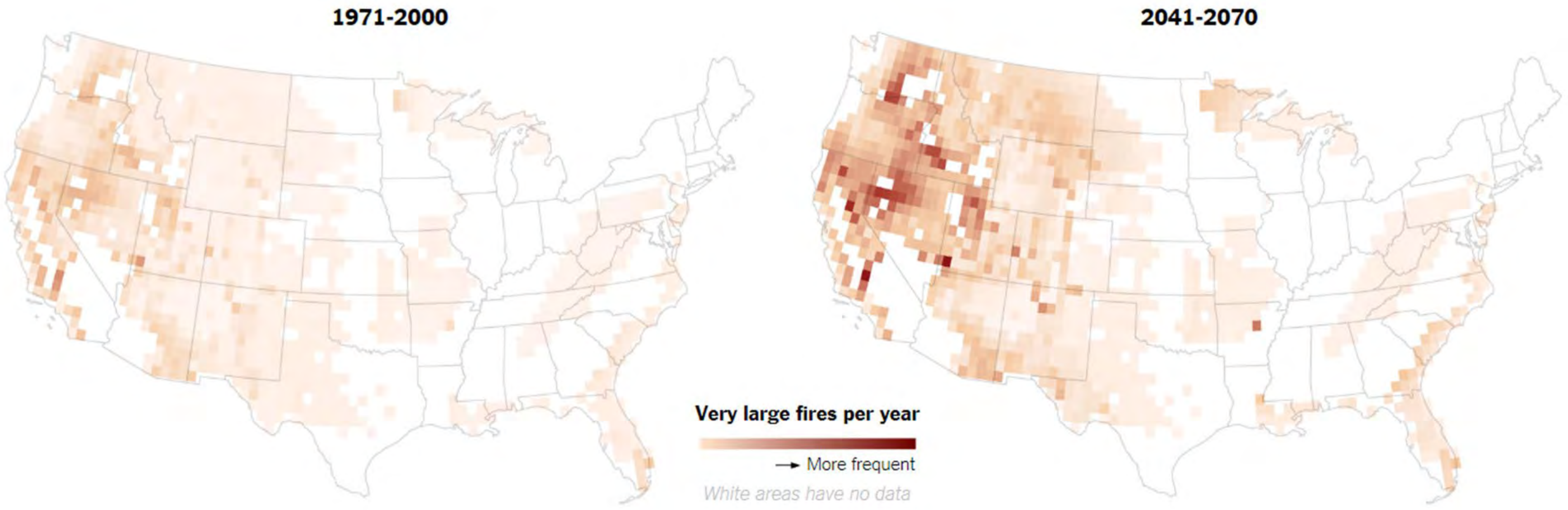
Deadliest wildfires 1933 - 2020

Top 20 Deadliest California Wildfires

	FIRE NAME (*CAUSE*)	DATE	COUNTY	ACRES	*STRUCTURES*	DEATHS
1	CAMP FIRE (*Powerlines*)	November 2018	Butte	153,336	18,804	85
2	**GRIFFITH PARK** (*Unknown*)	October 1933	Los Angeles	47	0	**29**
3	**TUNNEL - Oakland Hills** (*Rekindle*)	October 1991	Alameda	1,600	2,900	**25**
4	**TUBBS** (*Electrical*)	October 2017	Napa & Sonoma	36,807	5,636	**22**
5	**NORTH COMPLEX** (*Lightning*)	August 2020	Butte, Plumas, & Yuba	318,935	2,352	**15**
6	**CEDAR** (*Human Related*)	October 2003	San Diego	273,246	2,820	**15**
7	**RATTLESNAKE** (*Arson*)	July 1953	Glenn	1,340	0	**15**
8	**LOOP** (*Unknown*)	November 1966	Los Angeles	2,028	0	**12**
9	**HAUSER CREEK** (*Human Related*)	October 1943	San Diego	13,145	0	**11**
10	**INAJA** (*Human Related*)	November 1956	San Diego	43,904	0	**11**
11	**IRON ALPS COMPLEX** (*Lightning*)	August 2008	Trinity	105,855	10	**10**
12	REDWOOD VALLEY (*Power Lines*)	October 2017	Mendocino	36,523	543	9
13	**HARRIS** (*Undetermined*)	October 2007	San Diego	90,440	548	**8**
14	**CANYON** (*Unknown*)	August 1968	Los Angeles	22,197	0	**8**
15	**CARR** (*Human Related*)	July 2018	Shasta County, Trinity	229,651	1,614	**7**
16	**LNU Lightning Complex** (*Lightning/Arson*)	August 2020	Napa/Sonoma/Yolo/Stanislaus/ Lake	363,220	1,491	**6**
17	ATLAS (*Powerline*)	October 2017	Napa & Solano	51,624	781	6
18	**OLD** (*Human Related*)	October 2003	San Bernardino	91,281	1,003	**6**
19	**DECKER** (*Vehicle*)	August 1959	Riverside	1,425	1	**6**
20	**HACIENDA** (*Unknown*)	September 1955	Los Angeles	1,150	0	**6**

** Fires with the same death count are listed by most recent. Several fires have had 4 fatalties, but only the most recent are listed.
***This list does not include fire jurisdiction. These are the Top 20 regardless of whether they were state, federal, or local responsibility.
* Numbers not final
10/24/2022

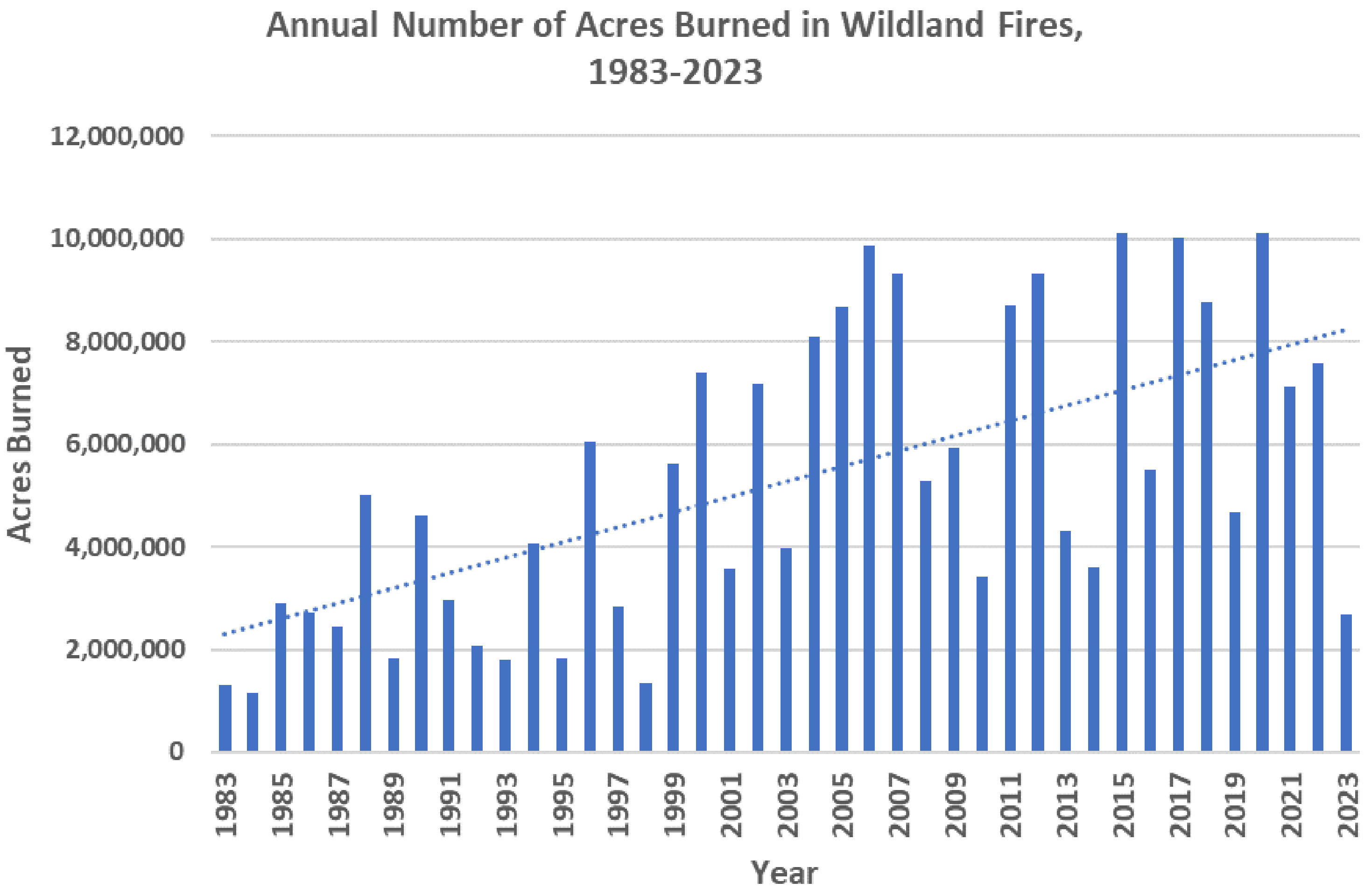
...so goes the nation



Wildfire Trends – Increasing Size & Severity

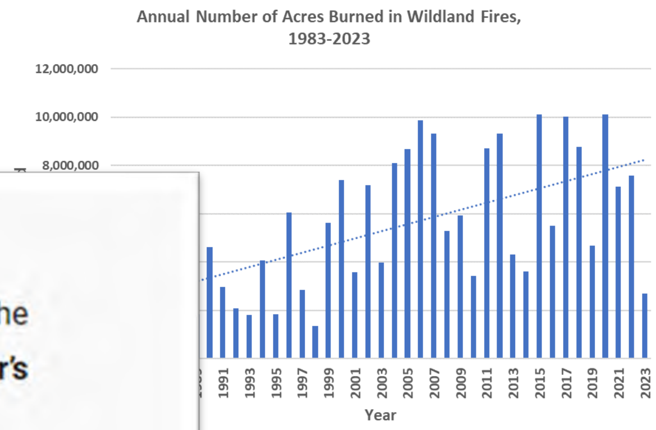
How old will your assets be in 50 years...?

...so goes the nation



Source: National Interagency Fire Center (2024)

...so goes the nation



Copilot

In **2024**, wildfires in the United States have already been a significant concern. During the first three months of the year, more than **2,669 square miles (6,912 square kilometers)** were charred, which is more than **half of last year's total**. Forecasters predict an elevated risk of fires in the following regions:

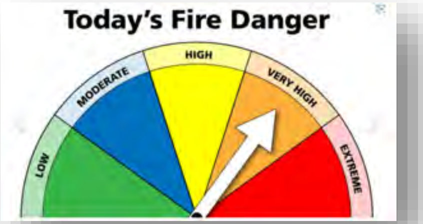
1. **Great Lakes region**
2. **Parts of the Midwest**
3. **Southwest**
4. **Hawaii**

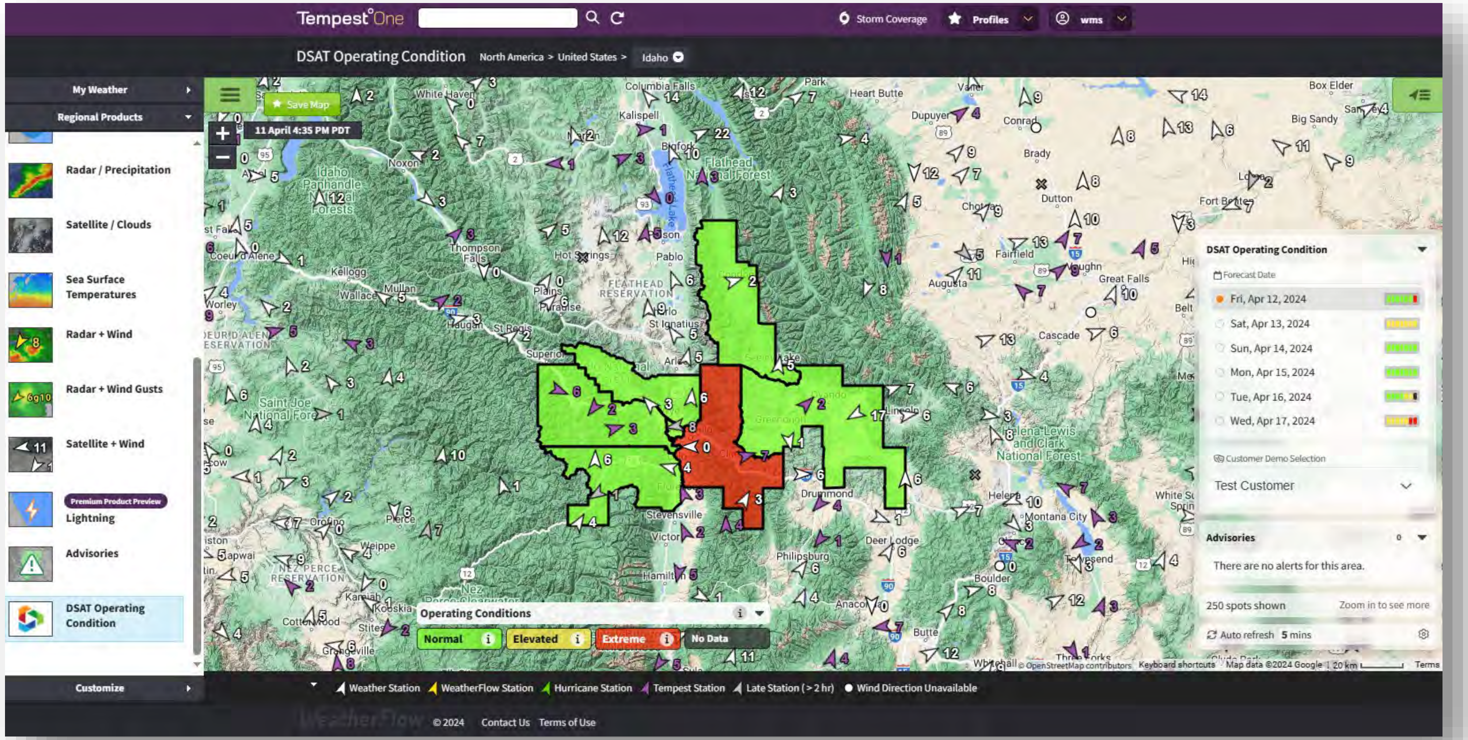
Federal officials are adapting their wildfire management strategies to address the growing size and duration of fires. They aim to ensure there are more personnel with the necessary training to handle the most complex fires. Climate change, with its heat waves and historic droughts, has made wildfires harder to fight in the American West. As a result, this shift in wildfire management represents a significant step in responding effectively to these natural disasters [1].

Let's hope for effective firefighting efforts and a safer year ahead! 🌲🔥🚒

Situational Awareness

- Fire Potential Index
- Daily Situational Awareness Tool





Hazard Mapping

- Defining areas of highest risk, threat, hazard.
- Those areas where you don't want to be the cause of an ignition on the bad days.

Fire Hardening

- Taller poles, wider cross arms, heavier conductor, attention to wildlife protections, etc.
- Undergrounding (can you afford not to?)

System Operations

- Wildfire settings
- Seasonal or more granular temporally
- PSPS

Learning Organizations

- Strong leadership
- Forward leaning
- Decisive
- Nimble

Even if you are not looking at your wildfire risk, your insurers, investors and board members are.

"No fires, no fires, no fires."

A Fire Safe Culture

Why does a utility adopt a Fire Safe Culture?

In response to regulatory pressure
In response to insurance pressure
In response to visionary leadership
In response to a catastrophic fire event

One of these things is not like the others…

A Fire Safe Culture

What does a Fire Safe Culture look like?

Fire safety becomes part of daily decision-making, organically, across the enterprise

wildfirefighters

No fires, no fires, no fires...

A Wildfirefighter Production

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EDM

T&D SERVICES

ENVIRONMENTAL SERVICES

PRODUCTS

Overcoming utility infrastructure challenges by merging excellence in engineering, science and technology with a passion for client satisfaction.