

Reliability-Centered Device Placement at PacifiCorp

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Background

- PacifiCorp serves about 1.8 million customers across 6 states within about 136,000 sq. miles (about 14 customers/sq. mile)
- PacifiCorp developed geospatial tools in early 2003 timeframe and has used the functionality successfully
- In 2013, PacifiCorp began rewriting the geospatial tools
- PacifiCorp serves customers via an extremely diverse population of circuits ranging from 10' long to 320 miles of exposure

Motivation

- Historic practices for installation of protective devices were widely varied and not always explicable
- Correlating reliability to “zones of protection” would enable the company to improve reliability at an optimal cost
- Without some structured method for analysis ability to develop repeatable and cost-quantifiable results would not be likely

Result

- Ergo, Isolation Point Analysis (IPA) was born
- Assume historic reliability can be used to estimate risk of future fault events
- Consider both momentary and sustained interrupting zones
- Calculate segment momentary and sustained fault rates to predict future fault probability
- Estimate customer interruptions & momentary customer interruption counts
- Model device to create new zone; recalc metrics

Calculated Values at Segment Level

(Both Sustained and Momentary)

- The protective device
- Number of outages (either associated or distributed)
- Upstream and downstream segment orientation
- Protective zone length
- Total connected downstream customer count (DCC)
- DCC from protective device of the zone
- DCC within the protective zone (from the segment)
- CI → Customer Interruptions
- CIR → CI Rate (per year)
- FR → Fault Rate (per year)
- FM → Faults per Mile of exposure in the protective zone (per year)
- Clred → Expected CI Reduction if a device were installed on the segment (per year)

IPA's start up screen with selections and progress

Isolation Point Analysis (IPA)

Please click here before running the IPA tool

The IPA tool was partially redesigned for use in GREATER. The reason for this is to focus on what the IPA tool is designed to do: tell you what a segments fault rate is and what reduction in CI you should expect if you installed an interrupting device on the segment. So, the need for a bunch of filtering criteria is not necessary. For example, the CI experienced from losing a transmission line or a substation cannot be avoided by installing a recloser. Thus, the only criteria selections you have are the ones below. Selections are not saved.

With all of the changes, the capabilities were expanded. It's faster, more efficient, and limits have been removed. So although it's technically possible to run the IPA on every feeder in Pacific Power, I would recommend only selecting at most a district.

☐ Show all history

Beginning (including) 7/23/2011 15

Up To (not including) 7/23/2015 15

Major Events Exclude

Districts: Feeder:

JUNCTION CITY	5G45
KLAMATH FALLS	5G56
LAKEVIEW	5G57
LEBANON	5G69
LINCOLN CITY	5G77
MEDFORD	5G79
MT SHASTA	5G83
PENDLETON	5G93
PORTLAND	5G97
ROSEBURG	5G99
STAYTON	6G101

Waiting...

Generate

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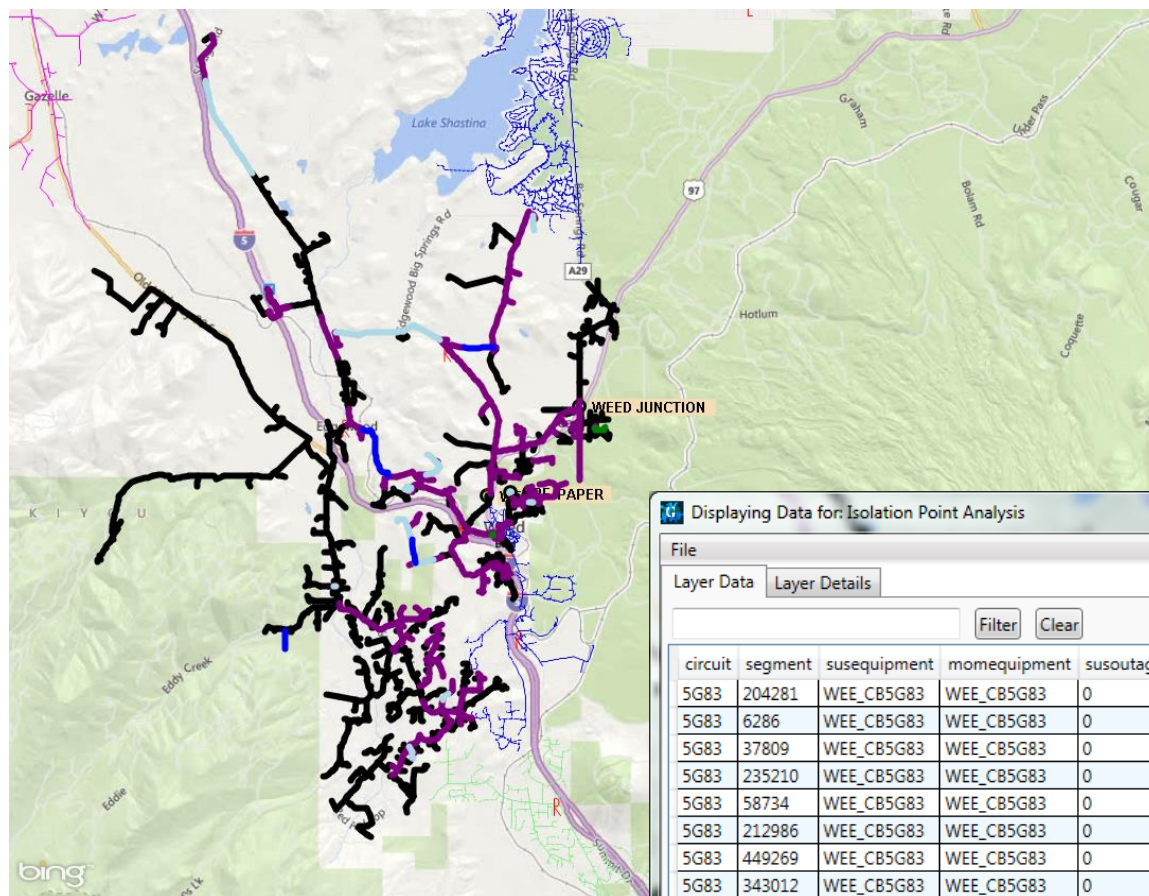
Major Events Exclude

Districts: Feeder:

JUNCTION CITY	5G45
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PORTLAND	5G97
ROSEBURG	5G99
STAYTON	6G101

Running the tracing for downstream FR counts...

Generate



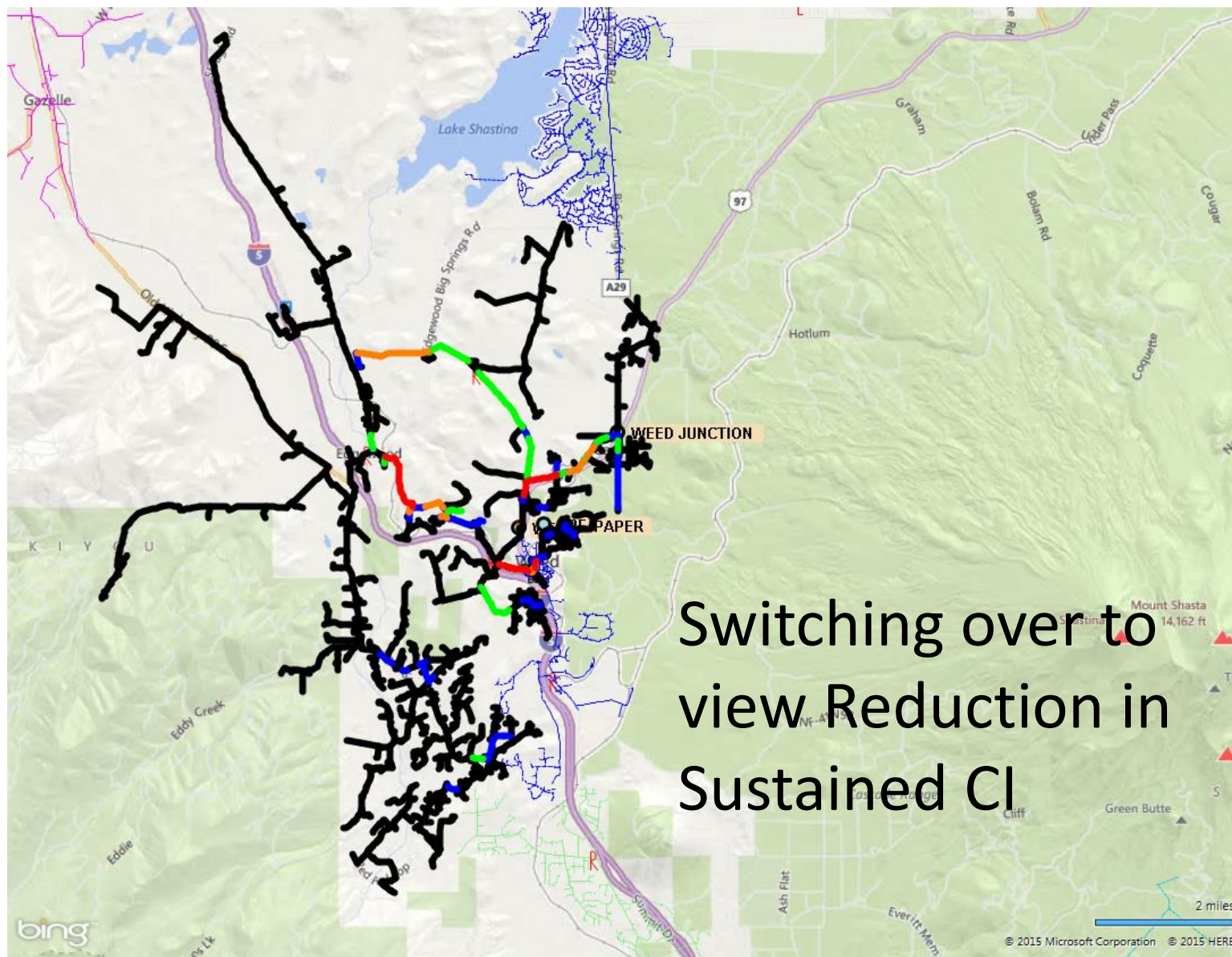
Initial segment fault rate plot, and supporting data

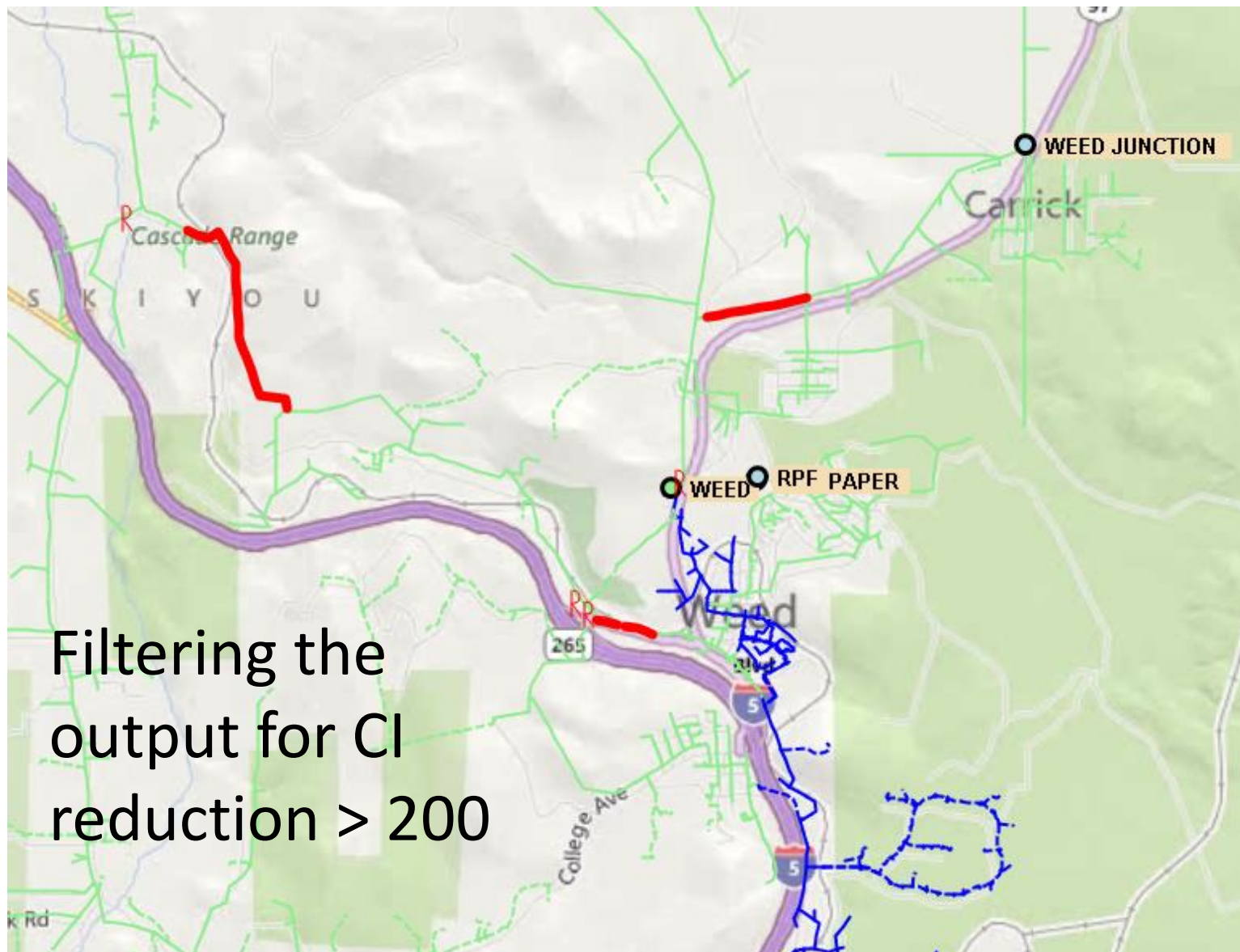
Displaying Data for Isolation Point Analysis

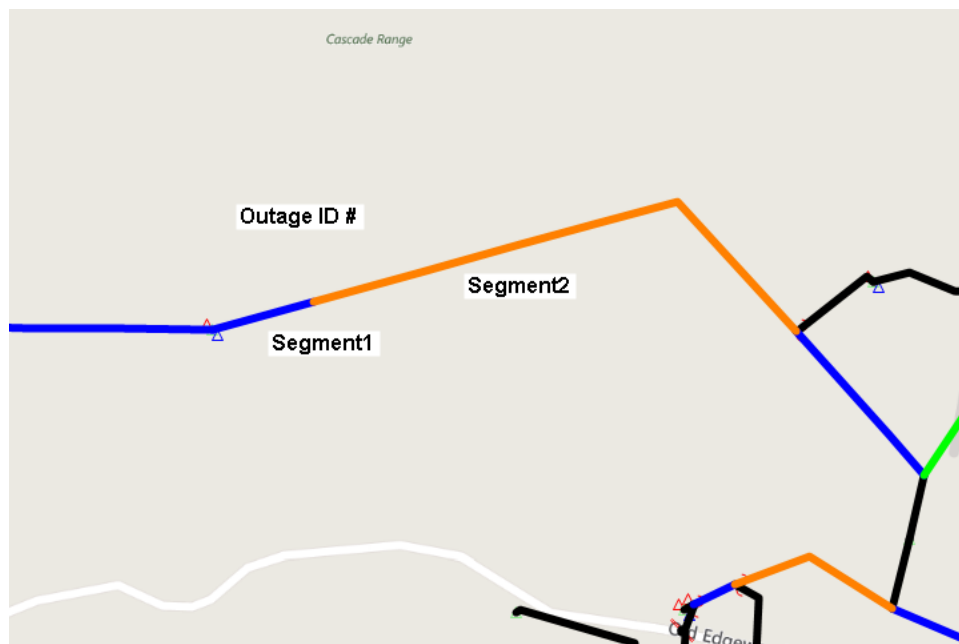
File Layer Data Layer Details

Filter Clear

circuit	segment	susequipment	momequipment	susoutages	momoutages	CI	CIR	FR	FM	CIred	MCI	MCIR	MI
5G83	204281	WEE_CB5G83	WEE_CB5G83	0	1.6275257	0	0	0	0	0	3240.4036687	810.100917175	0.4
5G83	6286	WEE_CB5G83	WEE_CB5G83	0	1.5493674	0	0	0	0	0	3084.7904934	771.19762335	0.3
5G83	37809	WEE_CB5G83	WEE_CB5G83	0	0.792287	0	0	0	0	0	1577.443417	394.36085425	0.1
5G83	235210	WEE_CB5G83	WEE_CB5G83	0	1.1231033	0	0	0	0	0	2236.0986703	559.024667575	0.2
5G83	58734	WEE_CB5G83	WEE_CB5G83	0	0.7701629	0	0	0	0	0	1533.3943339	383.348583475	0.1
5G83	212986	WEE_CB5G83	WEE_CB5G83	0	0.407044	0	0	0	0	0	810.424604	202.606151	0.1
5G83	449269	WEE_CB5G83	WEE_CB5G83	0	0.8596141	0	0	0	0	0	1711.4916731	427.872918275	0.2
5G83	343012	WEE_CB5G83	WEE_CB5G83	0	0.3476487	0	0	0	0	0	692.1685617	173.042140425	0.0
5G83	436822	WEE_CB5G83	WEE_CB5G83	0	0.1596776	0	0	0	0	0	317.9181016	79.4795254	0.0
5G83	117966	WEE_CB5G83	WEE_CB5G83	0	0.1322824	0	0	0	0	0	263.3742584	65.8435646	0.0
5G83	169829	WEE_CB5G83	WEE_CB5G83	0	0.3449131	0	0	0	0	0	686.7219821	171.680495525	0.0
5G83	448920	WEE_CB5G83	WEE_CB5G83	0	0.2186864	0	0	0	0	0	435.4046224	108.8511556	0.0
5G83	384934	WEE_CB5G83	WEE_CB5G83	0	0.2641851	0	0	0	0	0	525.9925341	131.498133525	0.0
5G83	262665	WEE_CB5G83	WEE_CB5G83	0	0.3232348	0	0	0	0	0	643.5604868	160.8901217	0.0
5G83	101648	WEE_CB5G83	WEE_CB5G83	0	0.1609602	0	0	0	0	0	320.4717582	80.11793955	0.0







Manually associating outages for more precise analysis. By default, all outages are evenly distributed throughout the device's protection zone.

Create, Edit, and Remove Outage Associations

This window allows you to create, edit, and remove outage associations. Every field should be entered as accurately as you can; the more information you provide, the better. Your P# is logged whenever you create, edit, or remove an association. Note: an "Outage ID" is not the outages "Job_No"; it's a separate field.

*** indicates a required field**

Outage ID *

Segment ID (fpos) *

Node #1 Facility Point *

Node #2 Facility Point *

Mouse selection latitude and longitude

Latitude: * Longitude: *

Confidence Level: *

Description and comments about the association

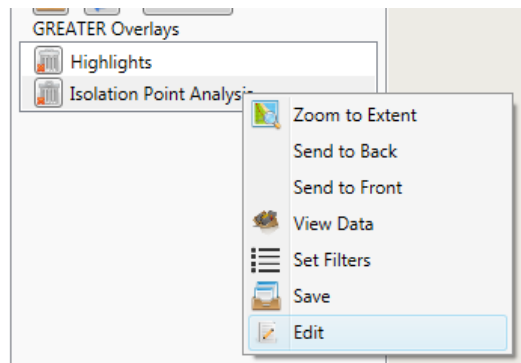
Enter a description of the location of the outage:

Enter any comments to assist others in recognizing the outage:

Change Reason: (required for changes)

Creating and Changing the View

(Momentary Reduction in CI)

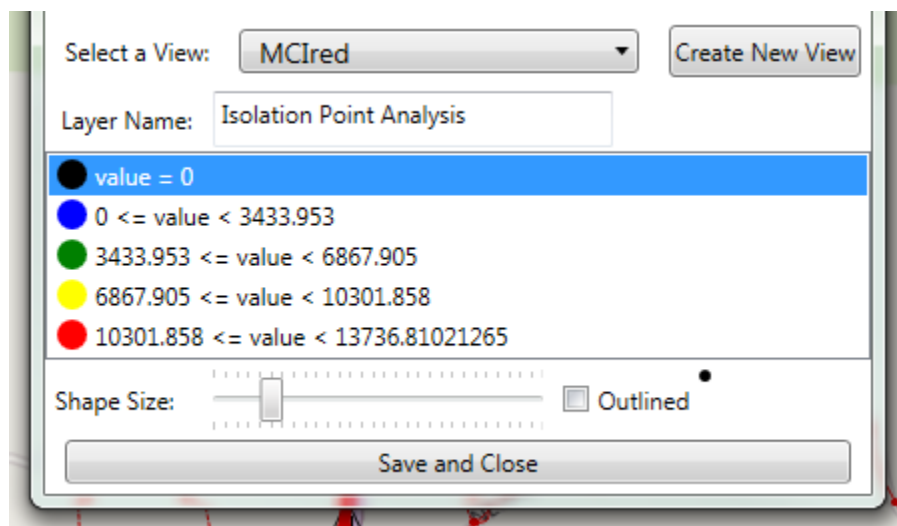


Select to edit the layer

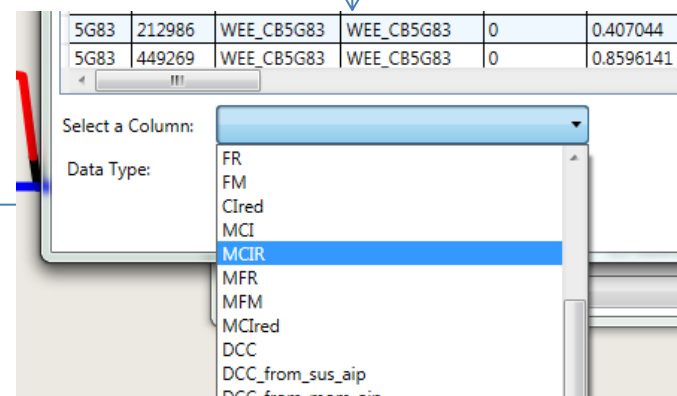
Select a View: Cired
Layer Name: Isolation Point Analysis

Create New View

Click to create a View



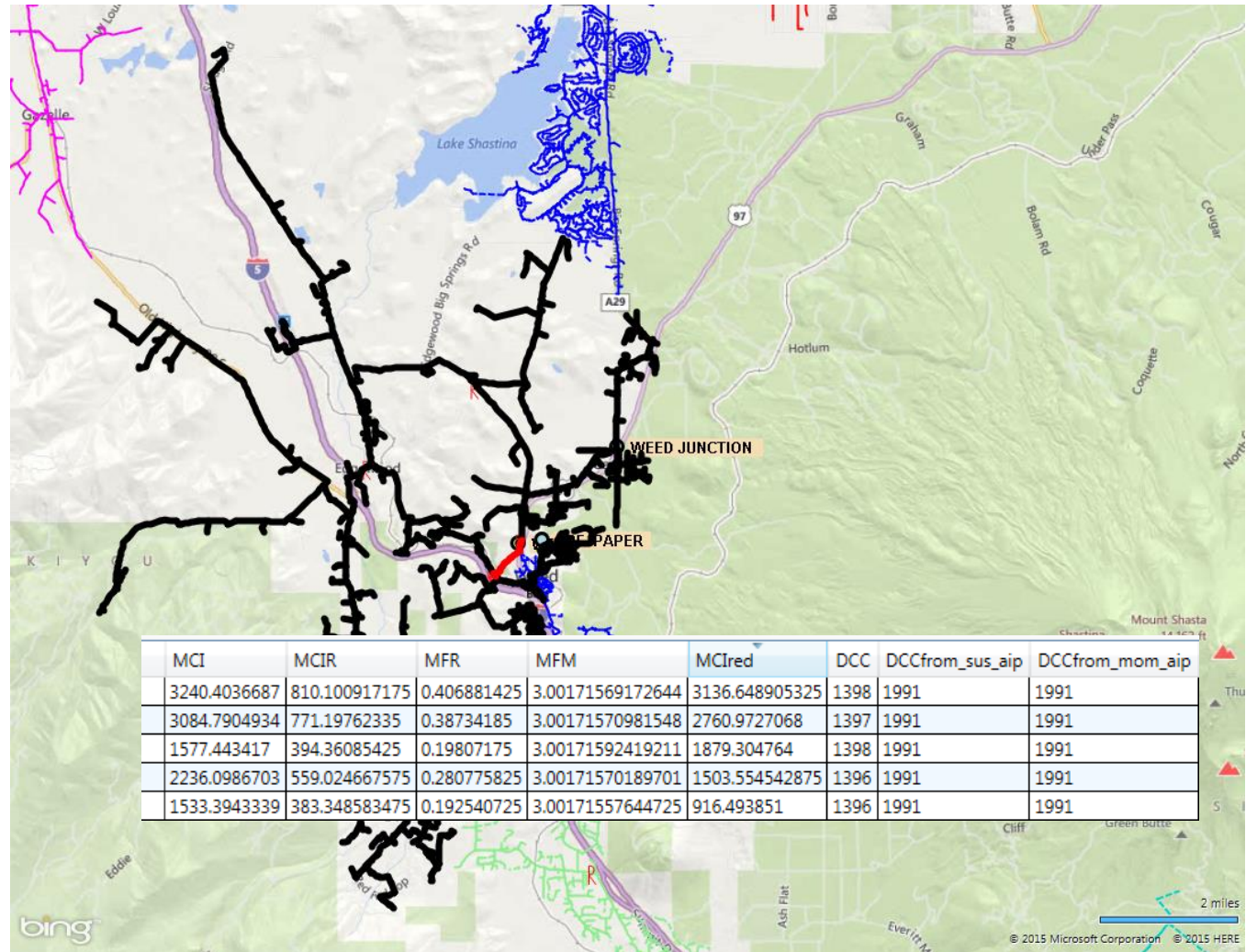
Create a custom range and Save



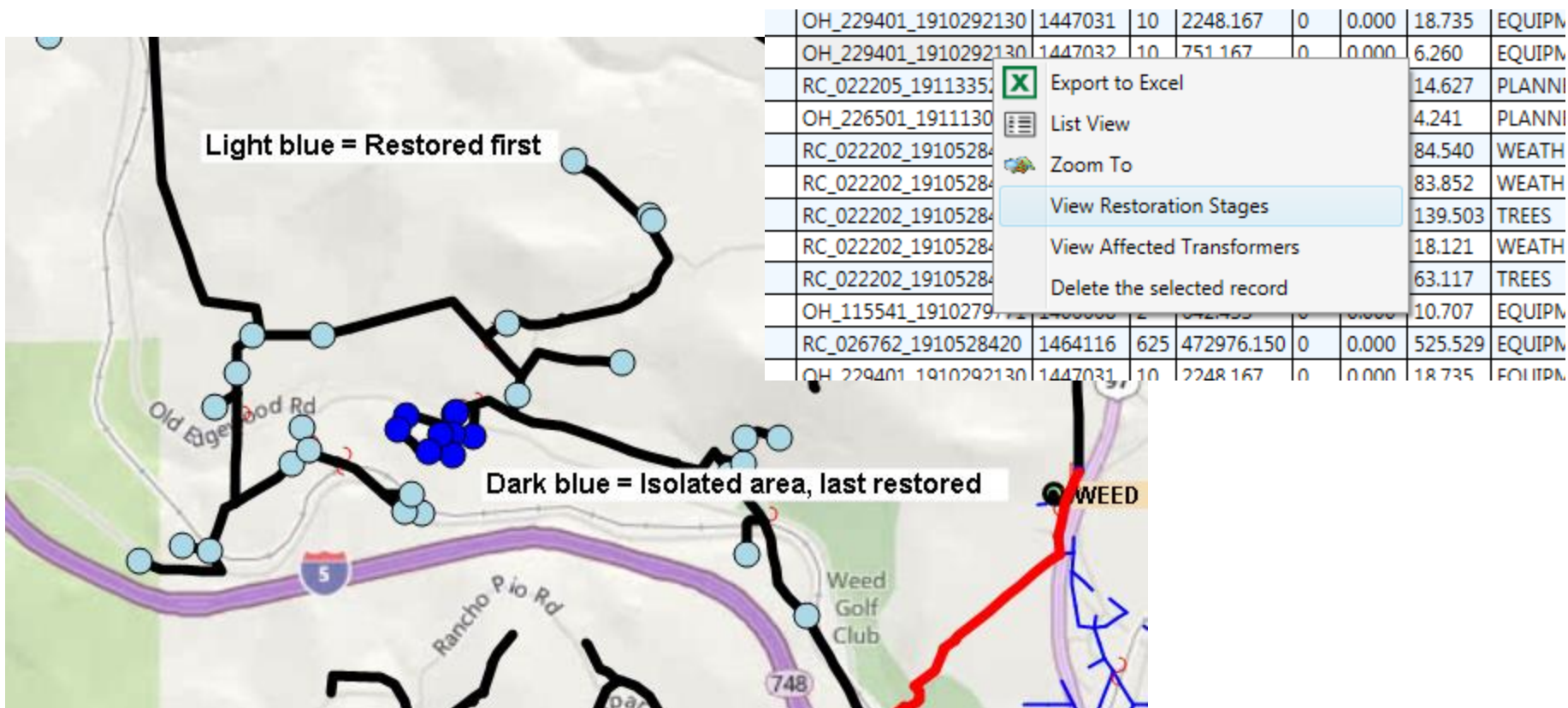
Select an available column

Momentary Reduction in CI

- Identify areas where momentary outages are affecting lots of customers
- Typically only momentary breaker operations are readily available



Digging into the Outages



Viewing the restoration stages is another way of determining where outages may have occurred to improve your analysis.

Virtual Device Placement (part 1)

The original IPA (in GREAT) was capable of placing virtual devices on the feeder to demonstrate the expected reduction. It would also perform cost to benefit analysis.

Virtual Isolation Point Creation

Device List:

156573,158410,1

Device Type:

☒ (1) Sustained capabilities only

☐ (2) Momentary with Sustained capabilities

Segment fpos:

☒ Upstream Node

☐ Downstream Node

Note: When a virtual device is installed it is installed on all phases. It is assumed that an outage affects all customers downstream from a segment/device without regards to the phase the fault occurred on.

Cost to Benefit Design Assistant

☐ Momentary ☒ Sustained

Cost of a Fuse/Recloser (\$):

Amount per CI to spend (\$):

Borderline area (%):

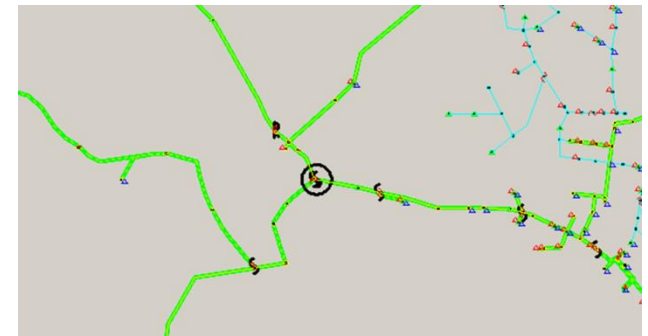
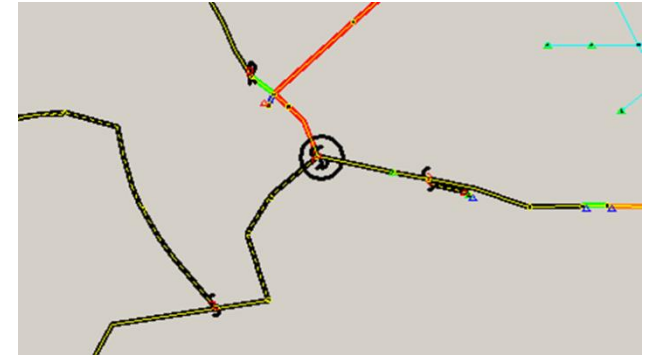
Total Reduction in CI = 1657.79318

Number of Devices = 1

Average Reduction in CI per Device = 1657.79318

Green if \geq Red if \leq Otherwise Yellow

110 90



Sum = (1,657.793) :: Mea

Virtual Device Placement (part 2)

- IPA in GREATER was altered for faster and broader analysis. This translates to removing analysis restrictions such as only viewing analysis for one feeder at a time.
- GREATER is optimized to show you where problems areas are, not design a new protection scheme.
 - Associate outages and calculate segment fault rates
 - Colorful layers
 - View the data: it'll tell you the expected reduction
 - A cost to benefit analysis can be performed from the data
- We are hoping to utilize third party applications the company is already using to perform more complex analysis such as virtual devices and new protection schemes.
 - Ability to place a fuse or recloser and perform power flow analysis, coordination, etc.
 - Use the outage data from GREATER

Exporting the Results

Easily export to excel (.xlsx format) for further analytic capabilities and report generation. GREATER will ask you if you want the coordinates re-projected before exporting.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	circuit	segment	sus_equipr	mom_equipr	sus_outage	mom_outage	CI	CIR	FR	FM	CIred	MCI	MCIR	MFR	MFM	MCired
2	5G83	204281	WEE_CB5G8	WEE_CB5G8	0	1.6275257	0	0	0	0	0	3240.40367	810.100917	0.40688143	3.00171569	3136.64
3	5G83	6286	WEE_CB5G8	WEE_CB5G8	0	1.5493674	0	0	0	0	0	3084.79049	771.197623	0.38734185	3.00171571	2760.97
4	5G83	37809	WEE_CB5G8	WEE_CB5G8	0	0.7922287	0	0	0	0	0	1577.44342	394.360854	0.19807175	3.00171592	1879.30
5	5G83	235210	WEE_CB5G8	WEE_CB5G8	0	1.1231033	0	0	0	0	0	2236.09867	559.024668	0.28077583	3.0017157	1503.55
6	5G83	58734	WEE_CB5G8	WEE_CB5G8	0	0.7701629	0	0	0	0	0	1533.39433	383.348583	0.19254073	3.00171558	916.493
7	5G83	212986	WEE_CB5G8	WEE_CB5G8	0	0.407044	0	0	0	0	0	810.424604	202.606151	0.101761	3.00171556	844.819
8	5G83	449269	WEE_CB5G8	WEE_CB5G8	0	0.8596141	0	0	0	0	0	1711.49167	427.872918	0.21490353	3.00171584	767.205
9	5G83	343012	WEE_CB5G8	WEE_CB5G8	0	0.3476487	0	0	0	0	0	692.168562	173.04214	0.08691218	3.00171564	568.840
10	5G83	436822	WEE_CB5G8	WEE_CB5G8	0	0.1596776	0	0	0	0	0	317.918102	79.4795254	0.0399194	3.00171512	426.099
11	5G83	117966	WEE_CB5G8	WEE_CB5G8	0	0.1322824	0	0	0	0	0	263.374258	65.8435646	0.0330706	3.00171508	333.384
12	5G83	449131	WEE_CB5G8	WEE_CB5G8	0	0.186864	0	0	0	0	0	686.721982	171.680496	0.08622828	3.00171612	253.683
13	5G83	641851	WEE_CB5G8	WEE_CB5G8	0	0.232348	0	0	0	0	0	435.404622	108.851156	0.0546716	3.00171626	229.292
14	5G83	5609602	WEE_CB5G8	WEE_CB5G8	0	0.20348	0	0	0	0	0	525.992534	131.498134	0.06604628	3.00171579	184.797
15	5G83	20348	WEE_CB5G8	WEE_CB5G8	0	0.598706	0	0	0	0	0	643.560487	160.890122	0.0808087	3.00171614	180.365
16	5G83	09394	WEE_CB5G8	WEE_CB5G8	0	0.198272	0	0	0	0	0	320.471758	80.1179396	0.04024005	3.00171603	80.0776
17	5G83	25421059	WEE_CB5G8	WEE_CB5G8	0	0.20348	0	0	0	0	0	40.512868	10.128217	0.005087	3.00171658	30.2676
18	5G83	09394	WEE_CB5G8	WEE_CB5G8	0	0.198272	0	0	0	0	0	119.202365	29.8005912	0.01496765	3.0017165	22.0174
19	5G83	25421059	WEE_CB5G8	WEE_CB5G8	0	0.20348	0	0	0	0	0	18.703454	4.6758635	0.0023485	3.00171387	20.8899
20	5G83	09394	WEE_CB5G8	WEE_CB5G8	0	0.198272	0	0	0	0	0	39.4759552	9.8689888	0.0049568	3.00170937	20.6450
21	5G83	25421059	WEE_CB5G8	WEE_CB5G8	0	0.20348	0	0	0	0	0	83.8328469	20.9582117	0.01052648	3.00171679	14.7265
22	5G83	09394	WEE_CB5G8	WEE_CB5G8	0	0.198272	0	0	0	0	0	54.9830578	13.7457645	0.00690395	3.00171739	7.70480
23	5G83	82522	WEE_CB5G8	WEE_CB5G8	0	0.0068994	0	0	0	0	0	13.7367054	3.43417635	0.00172485	3.00171655	3.43417
24	5G83	490723	OH_274800_RC_334700_0.8919168	0	0.8919168	0.2229792	0.2229792	1.9042577	0	0	0	0	0	0	0	0
25	5G83	141582	OH_359003_RC_026762_0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	5G83	302840	OH_119401_RC_022205_0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	5G83	351465	OH_093001_RC_334700_0.0555611	0	17.4461854	4.36154635	0.01389028	0.24175235	8.18137198	0	0	0	0	0	0	0
28	5G83	470689	OH_226501_RC_334700_0.0011951	0	0.1697042	0.04242605	0.00029878	0.10763728	0	0	0	0	0	0	0	0
29	5G83	193196	OH_116646_RC_022205_0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	5G83	63606	OH_193641_RC_026762_0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	5G83	449974	OH_151301_RC_334700_0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	5G83	422749	RC_022205_RC_022205_0.015078	0	13.19325	3.2983125	0.0037695	0.19841254	31.241616	0	0	0	0	0	0	0
33	5G83	69250	OH_369761_RC_026762_0	0	0	0	0	0	0	0	0	0	0	0	0	0
34	5G83	153819	OH_029207_RC_022205_0	0	0	0	0	0	0	0	0	0	0	0	0	0

Reproject?

Do you want to reproject the x/y coordinates to lat/lon before exporting?

Yes

No