Attachment 1

SRP Video 2014

Also available online at:

https://vimeo.com/120204994

password: ccSRPr2

Attachment 2

UES – Capital

Reliability Analysis and Recommendations 2014

Unitil Energy Systems - Capital

Reliability Study

2014

Prepared By:
Cyrus Esmaeili
Unitil Service Corp.
Sept 15, 2014

UES - Capital Reliability Analysis and Recommendations 2014

Sept 15, 2014

UES - Capital Reliability Analysis and Recommendations 2014

Sept 15, 2014

1. Executive Summary

The purpose of this document is to report on the overall reliability performance of the UES-Capital system January 1, 2013 through December 31, 2013. The scope of this report will also evaluate individual circuit reliability performance over the same time period.

The following projects are proposed from the results of this study and are focused on improving the worst performing circuits as well as the overall UES-Capital system reliability. These recommendations are provided for consideration and will be further developed with the intention to be incorporated into the 2015 budget development process.

Circuit / Line / Substation	Proposed Project	Cost ($)
IRONWORKS SUB	33 LINE REMOTE FAULT INDICATION AND MOTOR OPERATORS AT IRON WORKS ROAD	$66,000
375 Line	TERRIL PARK 375J3 AUTOMATIC SECTIONALIZING	$86,000
38 Line	AUTO TRANSFER SCHEME	$76,000
8X3	RECLOSING DEVICE INSTALLATION ON HORSE CORNER ROAD	$5,000
8X3	RECLOSING DEVICE INSTALLATION ON SMITH SANBORN ROAD	$5,000
3H3	RECLOSER REPLACEMENT AT GULF STREET SUBSTATION	$25,000

Note: estimates do not include general construction overheads

2. Reliability Goals

The annual corporate system reliability goals for 2014 have been set at 191-156-121 SAIDI minutes. These were developed through benchmarking Unitil system performance with surrounding utilities.

Individual circuits will be analyzed based upon circuit SAIDI, SAIFI, and CAIDI. Analysis of individual circuits along with analysis of the entire Capital system is used to identify future capital improvement projects and/or operational enhancements which may be required in order to achieve and maintain these goals.

3. Outages by Cause

This section provides a breakdown of all outages by cause code experienced during 2013. Chart 1 lists the number of interruptions, and the percent of total interruptions, due to each cause. For clarity, only those causes occurring more than 5 times are labeled. Chart 2 details the percent of total customer-minutes of interruption due to each cause, only those causes contributing greater than 2% of the total are labeled.

UES - Capital Reliability Analysis and Recommendations 2014

Sept 15, 2014

Chart 1
Number of Interruptions by Cause

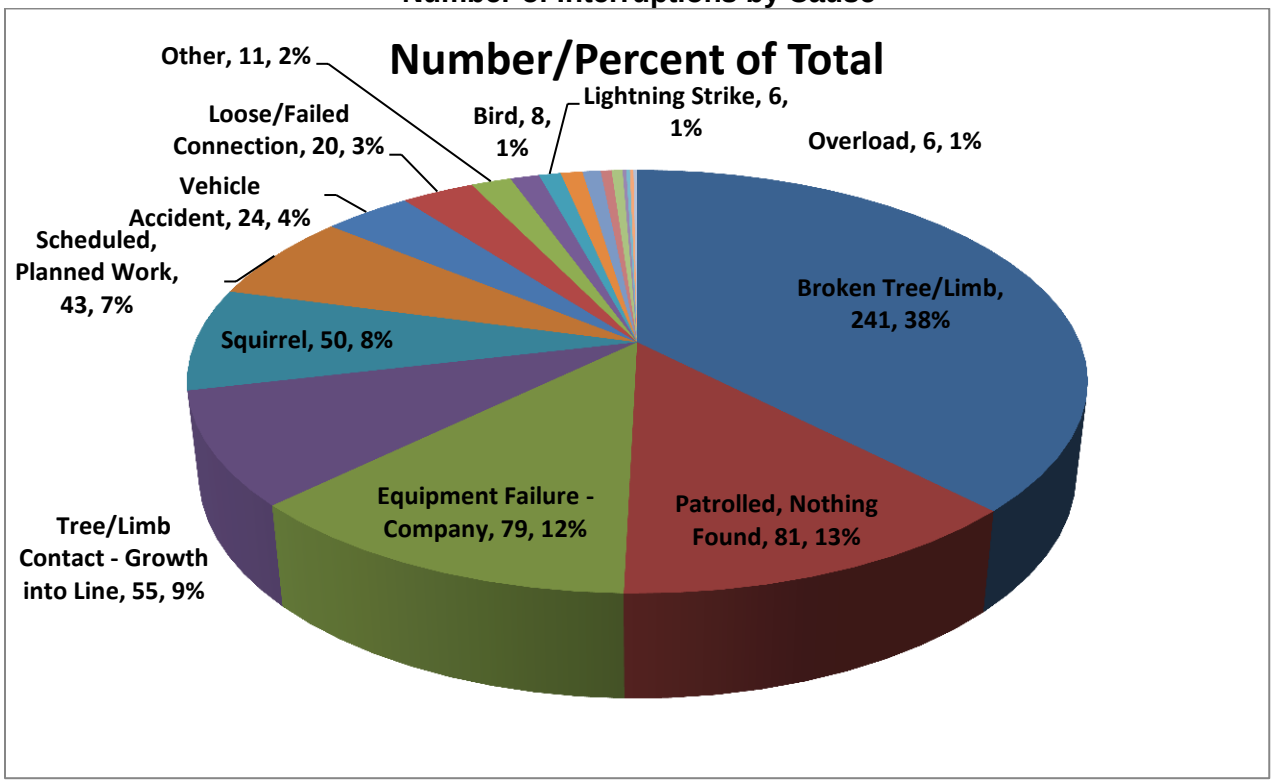
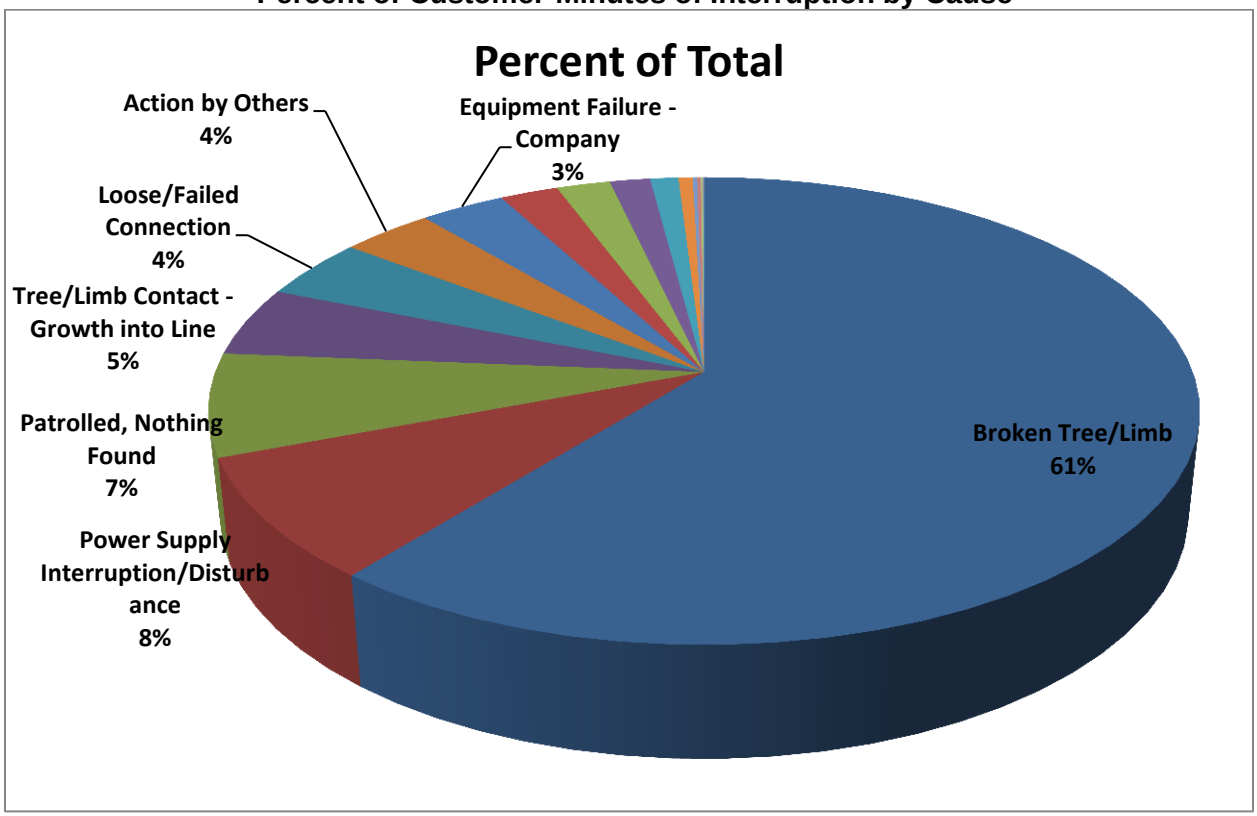


Chart 2
Percent of Customer-Minutes of Interruption by Cause



4. 10 Worst Distribution Outages

The ten worst distribution outages ranked by customer-minutes of interruption during the time period from January 1, 2013 through December 31, 2013 are summarized in Table 1 below.

Table 1
Worst Ten Distribution Outages

Circuit	Date/Cause	Customer Interruptions	Cust-Min of Interruption	SAIDI	SAIFI
8X3	11/24/2013 Broken Tree/Limb	2,294	685,906	23.06	0.077
16H1	11/24/2013 Broken Tree/Limb	297	326,997	10.99	0.010
4W3	2/23/2013 Broken Tree/Limb	889	211,582	7.11	0.030
7W3	4/2/2013 Broken Tree/Limb	909	154,085	5.18	0.031
4X1	6/14/2013 Squirrel	2,383	143,009	5.18	0.031
8X3	7/20/2013 Broken Tree/Limb	312	134,784	5.18	0.031
22W3	9/22/2013 Broken Tree/Limb	904	131,984	4.81	0.080
16H3	7/20/2013 Broken Tree/Limb	1,228	129,472	4.81	0.080
13W3	12/29/2013 Broken Tree/Limb	203	92,974	4.53	0.010
18W2	11/27/2013 Equipment Failure - Company	893	91,979	4.44	0.030

Note: This table does not include substation, sub-transmission or scheduled planned work outages.

5. Sub-transmission Line and Substation Outages

This section describes the contribution of sub-transmission line and substation outages on the UES-Capital system from January 1, 2013 through December 31, 2013.

All substation and sub-transmission outages ranked by customer-minutes of interruption during the time period from January 1, 2013 through December 31, 2013 are summarized in Table 2 below.

Table 3 shows the circuits that have been affected by sub-transmission line outages. The table illustrates the contribution of customer minutes of interruption for each circuit affected by a sub-transmission outage.

Table 2
Sub-transmission and Substation Outages

Line/Substation	Date/Cause	Customer Interruptions	Cust-Min of Interruption	SAIDI	SAIFI
Line 318	11-Sep-13 Power Supply Interruption/Disturbance	5,104	787,707	26.48	0.1716
Line 375	20-Jul-13 Broken Tree/Limb	1,504	389,108	13.08	0.0506
Line 37*	29-Dec-13 Loose/Failed Connection	2,697	353,307	11.87	0.0907
Line 374	17-Feb-13 Broken Tree/Limb	3,050	352,008	11.83	0.1026
Line 37*	19-Jul-13 Broken Tree/Limb	2,428	349,632	11.75	0.0816
Line 37*	25-Nov-13 Action by Others	2,693	325,853	10.95	0.0905
38W	01-Sep-13 Patrolled, Nothing Found	876	304,848	10.25	0.0295
38W	05-Jul-13 Bird	2,227	133,620	4.49	0.0749
Line 375	31-Jan-13 Broken Tree/Limb	1,575	47,943	1.61	0.053
Iron Works Substation	17-Aug-13 Scheduled, Planned Work	2,084	32,581	1.09	0.070

*These outages were not protected by the transfer scheme due to their location. The first 40% of the 37 line is protected by this scheme.

Table 3
Contribution of Sub-transmission and Substation Outages

Circuit	Substation / Transmission Line Outage	Cust-Min of Interruption	% of Total Circuit CMI	Circuit SAIDI Contribution	Number of Events
13W1	Line 37	153,563	43.24%	319.87	3
13W2	Line 37	184,657	52.99%	394.78	3
13W3	Line 37	620,359	65.01%	396.37	3
13X4	Line 37	396	100.00%	396.00	3
14H1	Line 374	10,944	92.56%	115.71	1
14H2	Line 374	76,266	72.73%	113.65	1
14X3	Line 374	798	39.35%	114.00	1
15H3	38W	960	65.84%	59.08	1
15W1	38W	58,140	26.58%	59.89	1
15W2	38W	21,120	31.73%	59.60	1
16H1	Line 375	78,771	17.17%	261.70	2

Circuit	Substation / Transmission Line Outage	Cust-Min of Interruption	% of Total Circuit CMI	Circuit SAIDI Contribution	Number of Events
16H3	Line 375	159,906	55.18%	257.29	2
16X4	Line 375	185,428	92.84%	326.55	2
16X5	Line 375	5,764	100.00%	720.50	2
16X6	Line 375	1,074	100.00%	71.60	2
17X1	Line 374	236	100.00%	118.00	1
18W2	Line 374	126,732	22.52%	117.39	1
24H1	38W	129,216	77.52%	406.23	2
24H2	38W	152,184	99.92%	408.27	2
35X1	38W	600	76.92%	60.00	1
35X2	38W	240	100.00%	60.00	1
35X4	38W	360	100.00%	60.00	1
374X1	Line 374	2,394	100.00%	126.56	1
375X1	Line 375	6,108	100.00%	1018.00	2
37X1	Line 37	69,817	46.09%	396.88	3
38E	Line 318	84,672	83.23%	97.05	1
3H1	Line 374	68,628	49.57%	116.75	1
3H2	Line 374	53,466	96.74%	111.70	1
3H3	Line 374	12,426	100.00%	111.28	1
8H1	Line 318	102,135	96.74%	164.07	1
8H2	Line 318	48,015	45.29%	162.99	1
8X3	Line 318	407,217	20.52%	145.43	1
8X5	Line 318	145,668	99.50%	244.68	1
22W1	Iron Works Substation	11,976	44.92%	24.05	1
22W2	Iron Works Substation	546	1.52%	13.00	1
22W3	Iron Works Substation	20,059	2.84%	12.99	1

6. Worst Performing Circuits

This section compares the reliability of the worst performing circuits using various performance measures. All circuit reliability data presented in this section includes subtransmission or substation supply outages unless noted otherwise.

6.1. Worst Performing Circuits in Past Year

A summary of the worst performing circuits during the year of 2013 is included in the tables below. Table 4 shows the ten worst circuits ranked by the total number of Customer-Minutes of interruption. The SAIFI and CAIDI for each circuit are also listed in this table. Table 5 provides detail on the major causes of the outages affecting these circuits. Customer-minutes of interruption are given for the seven most prevalent causes during 2013.

Circuits having one outage contributing more than 75% of the Customer-Minutes of interruption were excluded from this analysis.

Table 4
Worst Performing Circuits by Customer-Minutes

Circuit	No. of Customers Interruptions	Worst Event (% of CI)	Cust-Min of Interruption	Worst Event (% of CMI)	SAIDI	SAIFI	CAIDI
8X3[1]	9,489	28.80%	1,984,534	34.56%	708.72	3.39	209.14
13W3	7,117	22.07%	954,179	23.59%	609.67	4.55	134.07
22W3	7,486	20.61%	723,040	18.25%	468.34	4.85	96.59
18W2	4,682	23.13%	562,789	22.52%	521.30	4.34	120.20
4W3	6,155	21.98%	523,562	40.41%	389.10	4.57	85.06
16H1	1,240	26.61%	458,801	71.27%	1,524.26	4.12	370.00
13W1	2,595	18.61%	355,136	20.00%	739.74	5.41	136.85
13W2	3,306	14.13%	348,449	19.26%	744.95	7.07	105.40
7W3	4,140	22.05%	335,793	45.89%	368.77	4.55	81.11
4X1	4,123	57.80%	330,066	43.33%	138.48	1.73	80.05

Note: all percentages and indices are calculated on a circuit basis

Table 5
Circuit Interruption Analysis by Cause

	Customer – Minutes of Interruption / # of Outages						
Circuit	Animal Combined	Broken Tree/Limb	Equipment Failure - Company	Loose/Failed Connection	Tree/Limb Contact - Growth into Line	Action by Others	Patrolled, Nothing Found
8X3	16,798	1,379,724 / 54	50,205 / 13	0 / 0	17,828 / 8	258 / 1	84,873 / 23
13W3	5,308 / 8	415,158 / 28	1,282 / 6	223,093 / 3	83,269 / 5	189,486 / 1	18,800 / 8
22W3	9,441 / 6	475,285 / 27	2,657 / 4	30 / 1	190,611 / 11	60 / 1	17,253 / 9
18W2	2,390 / 2	341,916 / 12	95,926 / 5	60 / 1	19,756 / 4	0 / 0	19,676 / 5
4W3	3,447 / 1	506,746 / 8	8,949 / 3	0 / 0	50 / 1	0 / 0	4,370 / 1
16H1	0 / 0	458,801 / 6	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0
13W1	1,425 / 2	220,928 / 22	1,287 / 3	63,311 / 2	7,918 / 3	58,322 / 1	1,550 / 2
13W2	5,113 / 4	217,566 / 12	606 / 2	62,744 / 3	3,861 / 1	56,507 / 1	1,890 / 2
7W3	39 / 1	298,363 / 13	10,203 / 1	12,550 / 3	70 / 1	0 / 0	10,981 / 4
4X1	144,861 / 4	70,493 / 10	492 / 6	195 / 2	84,893 / 8	180 / 1	3,600 / 3

[1] 85% of the customer minutes of interruption where during exclusionary events, two exclusionary outages account for 50% of the minutes.

6.2. Worst Performing Circuits of the Past Five Years (2009 – 2013)

The annual performance of the ten worst circuits in terms of SAIDI and SAIFI for the past five years is shown in the tables below. Table 6 lists the ten worst circuits ranked by SAIDI performance. Table 7 lists the ten worst performing circuits ranked by SAIFI.

The data used in this analysis includes all system outages except those outages that occurred during the 2012 Hurricane Sandy, 2011 October Nor'easter, Hurricane Irene and 2010 Windstorm.

Table 6
Circuit SAIDI

Circuit Ranking	2013		2012		2011		2010		2009	
	Circuit	SAIDI	Circuit	SAIDI	Circuit	SAIDI	Circuit	SAIDI	Circuit	SAIDI
1	16H1	1524.26	13W2	817.42	13W1	887.09	8X3	1,037.0	13W1	797.86
2	375X1[1]	1018.00	13W1	425.04	13W2	835.67	211A	650.29	13X4	444.00
3	37X1	861.07	211P	381.91	37X1	797.25	13W1	648.23	13W2	443.03
4	13W2	744.95	211A	270.00	13W3	660.07	13W2	487.15	18W2	369.36
5	13W1	739.74	8X3	244.17	18W2	593.77	13W3	417.67	13W3	349.28
6	16X5	720.50	18W2	223.12	22W3	421.91	2H4	414.01	211A	330.29
7	8X3	708.72	7W3	193.84	17X1	388.00	2H2	353.25	37A	269.61
8	13W3	609.67	34X2	165.00	13X4	369.00	37X1	304.57	22W3	246.30
9	24H1	524.03	15W1	152.67	21W1A	361.90	3H2	298.00	4W3	245.64
10	18W2	521.30	15W2	135.36	38W	359.61	18W2	293.13	15W1	210.10

Table 7
Circuit SAIFI

Circuit Ranking	2013		2012		2011		2010		2009	
	Circuit	SAIFI	Circuit	SAIFI	Circuit	SAIFI	Circuit	SAIFI	Circuit	SAIFI
1	13W2	7.068	13W2	9.520	13W3	10.379	13W1	5.956	211A	8.614
2	16X5	5.500	13W1	4.858	13W2	8.942	8X3	5.847	13W1	6.091
3	37X1	5.412	21W1P	3.037	37X1	7.660	13W3	5.561	13W2	3.881
4	13W1	5.405	7W3	2.458	13W1	7.500	13W2	4.638	22W1	3.240
5	22W3	4.849	18W2	2.386	22W3	6.440	37X1	4.391	4W3	3.051
6	4W3	4.574	6X3	2.283	38W	5.428	211A	4.365	13W3	2.748
7	13W3	4.547	8X3	2.250	13X4	5.000	1H5	4.235	22W2	2.720
8	7W3	4.547	15W1	2.053	22W2	4.881	1H3	4.135	15W1	2.277
9	18W2	4.337	22W1	2.000	3H1	3.245	1H4	4.127	18W2	2.004
10	16H1	4.120	13W3	1.834	4X1	3.100	3H2	4.000	37A	1.702

[1] Only two outages, one of which happened during a major event accounting for 97% of the Circuit SAIDI minutes

6.3. Improvements to Worst Performing Circuit (2012-2014)

Projects completed from 2012 to 2014 that are expected to improve the reliability of the worst performing circuits are included in table 8 below.

Table 8
Improvements to Worst Performing circuits

Circuits	Year of Completion	Project Description
37 Line[1]	2012	Implemented Source Transfer Scheme with 4X1
	2014	Cycle Pruning/New Construction on Failed Connection Pole
Boscawen S/S[1]	2012	Circuit Exit Rebuilt and Extensive Tree Removal around Substation
13W1	2013	Forestry Review / Mid Cycle Review / Storm Resiliency Pilot (SRP)
	2014	Cycle Pruning
13W2	2012	Fuse and Recloser Setting Changes
		Hazard Tree Mitigation / Mid Cycle Review
	2013	Grey Spacer Cable Replacement[2]
		Cycle Pruning
13W3	2013	Grey Spacer Cable Replacement[3]
		Hazard Tree Mitigation
	2014	Hazard Tree Mitigation / Mid Cycle Review
18W2	2013	Hazard Tree Mitigation / SRP
22W3	2012	Installed squirrel guards on all transformers in trouble areas
	2013	Mid Cycle Review
	2014	Forestry Review
4W3	2012	Cycle Pruning / Hazard Tree Mitigation
	2014	Forestry Review
4X1	2013	Hazard Tree Mitigation / SRP
	2014	Cycle Pruning
7W3	2012	Hazard Tree Mitigation / Mid Cycle Review

[1] The 37 line radially supplies Boscawen Substation (13W1, 13W2, 13W3)
[2] For more detail refer to section 10.1

Circuits	Year of Completion	Project Description
	2013	SRP
8X3	2012	Cycle Pruning / Hazard Tree Mitigation
16H1	2013	Cycle Pruning
37X1	2014	Mid Cycle Review
16X5	2013	Cycle Pruning
24H1	2013	Cycle Pruning
38W[1]	2013	Reconfigured 38W Source Recloser
	2014	Cycle Pruning / Hazard Tree Mitigation
15W1	2014	Forestry Review
2H2	2013	Cycle Pruning

7. Tree Related Outages in the Past Year (1/1/13-12/31/13)

This section summarizes the worst ten performing circuits by tree related outages during 2013.

Table 9 shows the ten worst circuits ranked by the total number of Customer-Minutes of interruption caused by tree related faults on the circuit. The number of customer-interruptions and number of outages are also listed in this table. Circuits having less than three outages were excluded from this table.

All streets on the Capital System with three or more tree related outages are shown in Table 10 below. The table is sorted by number of outages and customer-minutes of interruption.

Table 9
Worst Performing Circuits – Tree Related Outages

Circuit	Cust-Min of Interruption	Customer Interruptions	No. of interruptions
8X3[2]	1,397,552	5,380	62
22W3[2,3]	665,896	5,405	38
4W3[2]	506,796	4,747	9
16H1[2]	380,030	613	4
13W3 [2,3]	310,322	1,831	33
7W3[2]	298,433	3,704	11
18W2[2]	234,940	1,185	15
13W1[2,3]	196,878	1,376	24
4X1[2]	155,386	1,218	18
15W1[2]	117,875	1,555	18

[1] The 38W line radially supplies Hazen Substation
[2] Tree trimming efforts have been or will be completed, refer to table 8 for details
[3] Reliability projects have been completed or are proposed, refer to table 8 for details

Table 10
Multiple Tree Related Outages by Street

Circuit	Street	# of Outages	Customer Interruptions	Customer Min. of Interruptions
8X3[1,2]	Dover Rd, Espom/Chichester	7	2,305	690,116
13W1[1]	Old Tilton Rd, Canterbury	5	139	20,970
7W3[1]	Route 3A, Bow	5	3,593	281,057
22W3[1,2]	Logging Hill Rd, Bow	4	1,246	151,189
13W3[1,2]	Daniel Webster Hwy, Boscawen	4	421	97,419
15W1[1]	Appleton St, Concord	4	100	11,350
22W3[1]	Stickney Hill Rd, Hopkinton	4	190	99,976
13W1[1]	West Rd, Canterbury	4	162	48,726
13W3[1,2]	Old Turnpike Rd, Salisbury	3	403	107,651
13W1[1]	Borough Rd, Canterbury	3	60	6,260
13W3[1,2]	Battle St, Salisbury/Webster	3	75	9,385
18W2[1]	Bow Bog Rd, Bow	3	584	83,891
8X3[1]	Horse Corner Rd, Chichester	3	186	26,205
8X3[1]	Bear Hill Rd, Chichester/Loudon	3	150	12,488
22W3[1,2]	Rocky Point Dr, Bow	3	92	6,905
8X3[1]	Wing Rd, Allenstown	3	42	5,418
15W1[1]	Shaker Rd, Concord	3	179	11,877
8X3[1]	Canterbury Rd, Chichester	3	168	13,496
8X3[1]	Suncook Valley Hwy. – South, Epsom	3	490	37,094
8X3[1]	New Orchard Rd, Epsom	3	185	67,441
15W1[1]	Country Club Ln, Concord	3	6	996
8X3[1]	Elkins Rd, Epsom	3	657	146,270
13W3[1,2]	White Plains Rd, Webster	3	177	20,798
6X3	Hopkinton Rd, Concord	3	118	8,230

[1] Tree trimming efforts have been or will be completed, refer to table 8 for details
[2] Reliability projects have been completed or are proposed, refer to table 8 for details

8. Failed Equipment in the Past Year

This section is intended to clearly show all equipment failures throughout the year of 2013. Chart 3 shows all equipment failures throughout the study period. Chart 4 shows each equipment failure as a percentage of the total failures within this same study period. Chart 5 shows the top four types of failed equipment within the study period with five years of historical data.

Chart 3
Equipment Failure Analysis by Cause

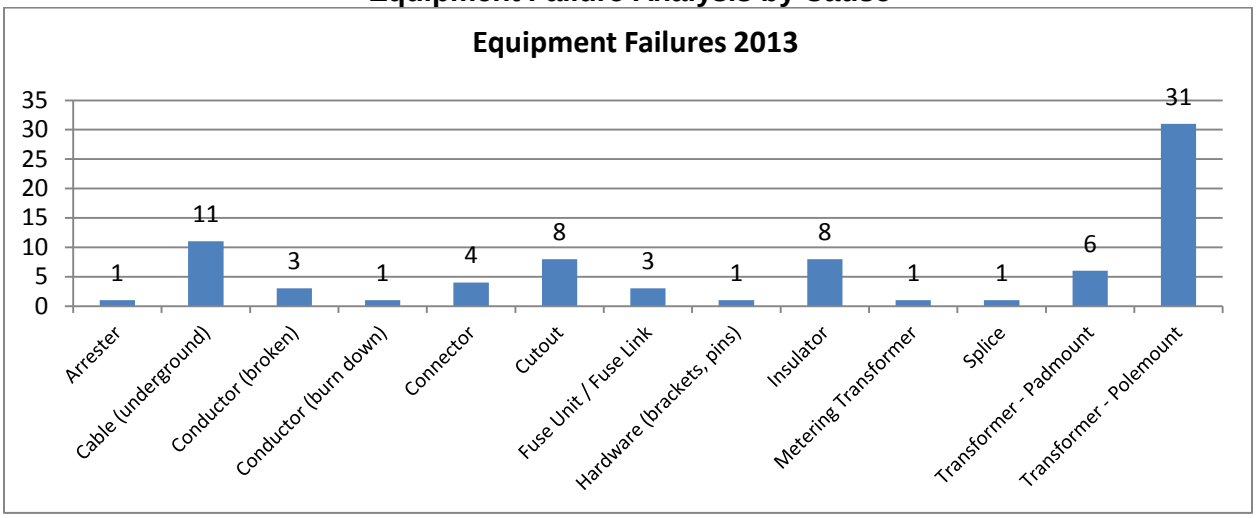


Chart 4
Equipment Failure Analysis by Percentage of Total Failures

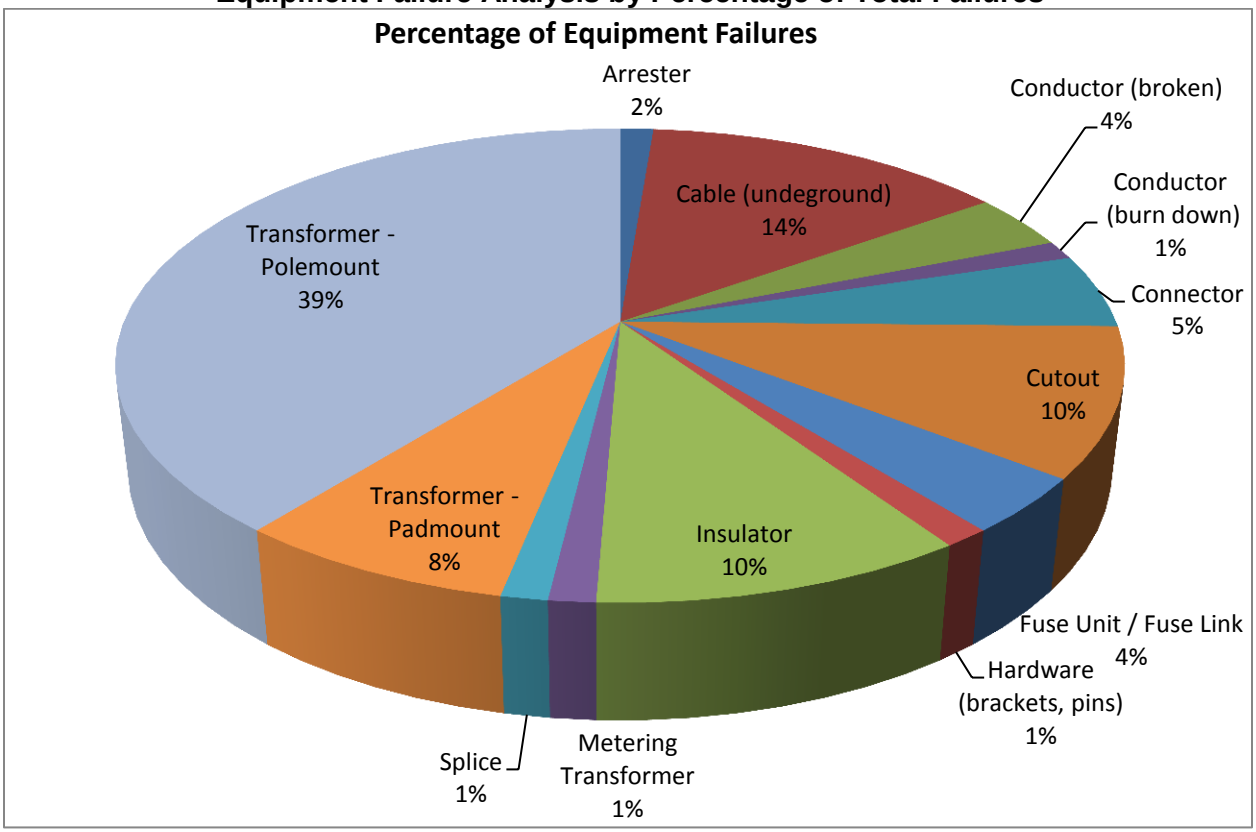
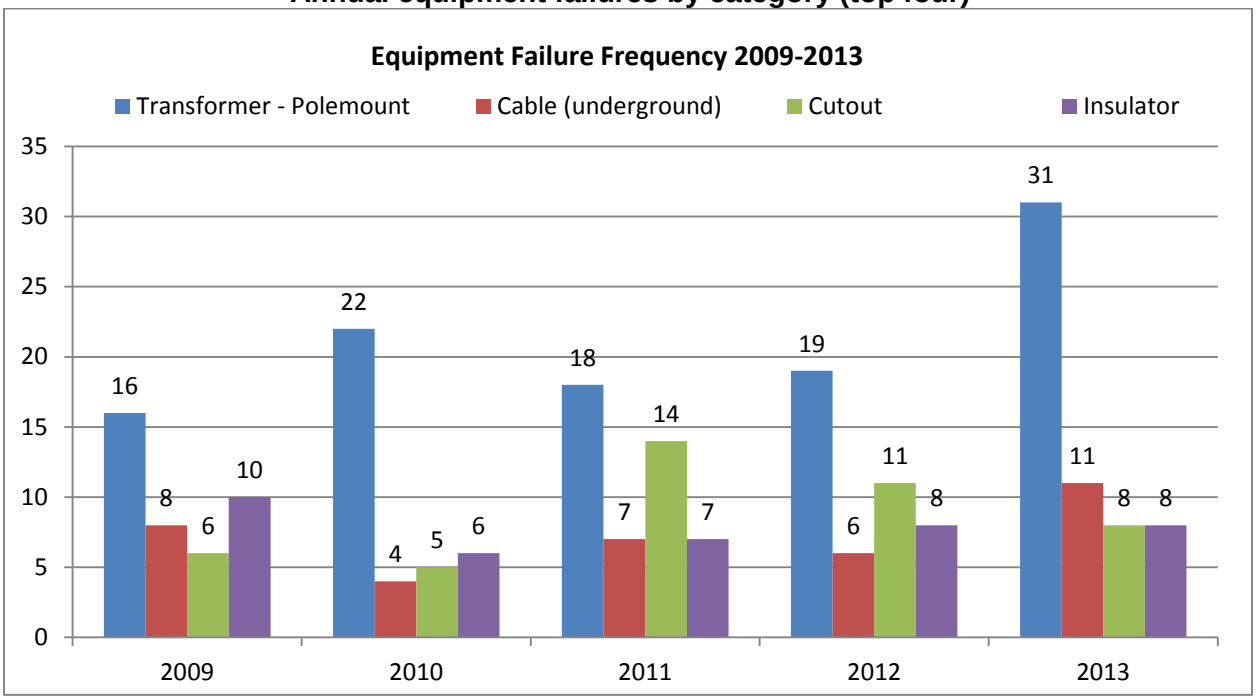


Chart 5
Annual equipment failures by category (top four)



Note: The cable failures listed have been re-associated to underground failures only as a way to better track that trend.

9. Multiple Device Operations in the Past Year (1/1/13-12/31/13)

Table 11 below is a summary of the devices that have operated three or more times in 2013.

Table 11
Multiple Device Operations

Circuit	Number of Operations	Device	Customer-Minutes	Customer-Interruptions
22W3[1,2]	5	Fuse, Pole 1, Rocky Point Dr	9,664	154
15W1[1]	4	Fuse, Pole 51, Mountain Rd	1,232	8
15W1[1]	4	Fuse, Pole 1, Snow Pond Rd	9,781	116
8X3[1]	3	Fuse, Pole 3, Canterbury Rd	13,496	168
8X3[1]	3	Fuse, Pole 2, Center Rd	274	5
13W1[1]	3	Fuse, Pole 50, Borough Rd	6,260	60
8X3[1]	3	Fuse, Pole 76, New Rye Rd	5,418	42
22W3[1,2]	3	Line Recloser, Pole 49, Silk Farm Rd	217,140	2,007

[1] Tree trimming efforts have been or will be completed, refer to table 8 for details
[2] Reliability projects have been completed or are proposed, refer to table 8 for details

Circuit	Number of Operations	Device	Customer-Minutes	Customer-Interruptions
15W1[1]	3	Fuse, Pole 89, Mountain Rd	16,037	265
37X1	3	Fuse, Pole 203, Boyce Rd	48,900	225
8X3[1]	3	Fuse, Pole 1, Smith Sanborn Rd	65,892	228
8X3[1]	3	Fuse, Pole 1, Staniels Rd	6,700	60
15W1[1]	3	Fuse, Pole 1, Appleton St	7,225	75
15W1[1]	3	Fuse, Pole 87, East Side Dr	22,684	152
13W3[1,2]	3	Fuse, Pole 61, White Plains Rd	23,424	120
2H2[1]	3	Fuse, Pole 18, Penacook St	99,900	300

10. Other Concerns

This section is intended to identify other reliability concerns that would not necessarily be identified from the analysis above.

10.1. Grey Spacer Cable Insulation

Grey spacer cable and spacers on the Unitil System manufactured prior to1975 have been identified by the manufacturer to have reached the end of its useful life. Samples of failed sections of this cable show significant “ringing” due to the dielectric breakdown of the insulation. This is an industry known problem recognized by the manufacturer due to the UV inhibitor compound in this vintage cable. This problem raises concerns with the insulations’ effectiveness, increased probability of conductor burn down, and mechanical strength of the spacers. Locations where this type of cable is installed have been identified and a replacement plan has been developed.

10.2. Recloser Replacement

Unitil has experienced two failures of type/vintage of recloser in 2011(one at UES-Seacoast and at FG&E) and removed a third from service due to the appearance of tracking. All of these failures were of the same type and vintage of recloser. The manufacturer has acknowledged that the solid dielectric material used on these reclosers could prematurely degrade resulting in a dielectric failure.

Based on this information, a multi-year replacement program began in 2013 to replace all reclosers of this vintage. There is one of these reclosers still in service on the UES-Capital Electric System, at the 3H3 circuit position in the Gulf Street Substation.

[1] Tree trimming efforts have been or will be completed, refer to table 8 for details
[2] Reliability projects have been completed or are proposed, refer to table 8 for details

10.3. Narrow subtransmission ROW expansion

The UES-Concord subtransmission system has some areas where the Right Of Way (ROW) is narrow, thus, even after pruning trees to the edge of the ROW we leave our system vulnerable to damage by falling trees. Historically, Unitil has experienced noticeably more outages, due to falling trees, on lines that are in narrow ROW in comparison to lines in larger ROW. Thus, the engineering department recommends working with land owners to allow pruning outside of narrow ROW. This effort is expected to allow effective tree mitigation in the problem areas. ROW expansion may be considered in the future.

10.4. 13.8kV Underground Electric System Degradation

The 13.8kV underground electric system has been experiencing connector and conductor failures at an average rate of 1 per year for the last 4 years, but no failures in 2013. (This does not include scheduled replacement of hot terminations identified by inspection). This could be due to the age of the underground system, the amount of non-continuous conductor, and/or the number of tee connectors strung together in some locations. A study will be done this year to identify the best strategy for dealing with these concerns.

10.5. Alternate Mainline for Large 34.5kV Circuits

Circuit 8X3 has the largest customer exposure on the capital system at 2,764 customers with an 11.9MVA peak, in 2013. This circuit has no alternative feeds to restore customers during mainline outages.

Building an alternate mainline that can be used to divert some customer exposure permanently and allow an alternate circuit feed during contingency scenarios is the ultimate goal for this area. Three alternatives where looked at one involved crossing over PSNH territory, one involved double circuiting, and the final involved rebuilding Horse Corner Rd. The Horse Corner Rd route was selected because it will create an alternate pole line that in no way will be affected by existing mainline events and does not involve PSNH.

11. Recommended Reliability Improvement Projects

This following section describes recommendations on circuits, sub-transmission lines and substations to improve overall system reliability. The recommendations listed below will be compared to the other proposed reliability projects on a system-wide basis. A cost benefit analysis will determine the priority ranking of projects for the 2014 capital budget. All project costs are shown without general construction overheads

11.1. 33 Line Remote Fault indication and Motor Operators at Iron Works Road

11.1.1. Identified Concerns

Iron Works Substation has 2.8 miles of exposure on a radial subtransmission line. When faults occur on the 33 Line, a crew must arrive and confirm the outage is not near the Substation before restoring these customers via normal switching.

11.1.2. Recommendations

Install SCADA monitored fault sensing devices on the Bow Junction side of the 33J6 switch and the Pleasant Street side of the 33J7 switch. Also, install motor operators on the same two switches with SCADA control. This will require communication to the RTU which is included in the price of this project. This will allow CED to isolate faulted sections and restore customers.

Estimated Project Cost: $66,000
*Estimated Annual Savings – Customer Minutes: 31,000, Customer Interruptions: 0
Customer Exposure: 498(22W1), 42(22W2), 1544(22W3)

*This assumes our Electric System Dispatchers will be able to transfer Iron Works Substation in 10 minutes

11.2. Terrill Park 375J3 Automatic Sectionalizing

11.2.1. Identified Concerns

The 375 line experienced two outages, between Garvin's and Terrill Park, in 2013. This is due to the width of the ROW and the type of terrain. This scheme will eliminate 2.79 miles of line exposure, preventing sustained outages from affecting customers on the 375 Line.

11.2.2. Recommendations

Install automatic sectionalizing capability on the 375J3 switch (which already has remote operation capability). This would operate as an automatic restore of Terrill Park Substation and 375X1for a fault on the 375line between Garvin's and Terrill Park, leaving no customers without power. This project is in addition to the effort to expand tree removal zone, see section 10.3 for more details.

Estimated Project Cost: $86,000
Estimated Annual Savings – Customer Minutes: 21,000, Customer Interruptions: 1,059
Customer Exposure: 303(16H1), 620(16H3), 567(16X4), 8(16X5), 15(16X6), 1(375X1)

11.3. 38 Line: Auto Transfer Scheme

11.3.1. Identified Concerns

The 38 line (west) experienced two outages in 2013. These outages resulted in over 400,000 customer minutes of interruption and over 3,000 customer interruptions. This scheme will eliminate 1.39 miles of exposure for Hazen Drive Substation and the State tap and would have prevented two sustained outages in 2013.

11.3.2. Recommendations

Implement an auto transfer scheme between the 38R1 recloser and 38J2 switch. For outages on the Horseshoe Pond side of the 38J2 switch, the 38J2 switch should open and the 38R1 recloser should close.

Estimated Project Cost: $ 76,000
*Estimated Annual Savings – Customer Minutes: 6,900, Customer Interruptions: 138
Customer Exposure: 318(24H1), 373(24H2), 1(State Tap)
*Outage involving bird on 38 Line recloser was excluded because of new recloser configuration implemented. Outage on State Tap removed because of coordination efforts underway.

11.4. Circuit 8X3: Reclosing Device Installation on Horse Corner Rd

11.4.1. Identified Concern

This road has experienced two outages, in 2013, which may have been prevented with reclosing capability.

11.4.2. Recommendation

Replace the pole 17, Bailey Rd, low side 95N fuses with a cutout mounted reclosing device.

Estimated Project Cost: $5,000
Estimated Annual Savings – Customer Minutes of Interruption: 45,000, Customer Interruptions: 140
Customer Exposure: 199

11.5. Circuit 8X3: Reclosing Device Installation on Smith Sanborn Rd

11.5.1. Identified Concern

This road has experienced two outages, in 2013, which may have been prevented with reclosing capability.

11.5.2. Recommendation

Replace the pole 1, Smith Sanborn Rd, low side 85N fuses with a cutout mounted reclosing device.

Estimated Project Cost: $5,000
Estimated Annual Savings – Customer Minutes of Interruption: 8,000, Customer Interruptions: 152
Customer Exposure: 76

11.6. Circuit 3H3: Recloser replacement at Gulf St Substation

11.6.1. Identified Concerns

Unitil has experienced premature failures of a specific type/vintage of reclosers due to insulation breakdown of the poles.

11.6.2. Recommendations

Replace this recloser.

Estimated Project Cost: $25,000
Estimated Annual Savings - Customer Minutes: 5,905, Customer Interruptions: 84
Customer Exposure: 111

12. Conclusion

During 2013, the Capital System has been greatly affected by interruptions involving tree contact. Enhanced tree trimming efforts are still being implemented, which is expected to improve reliability for most of the worst performing circuits identified in this study.

Recommendations developed from this study are mainly focused on improving reliability of the sub transmission system because one third of the customer minutes in 2013 where due to sub transmission outages. In addition, new ideas and solutions to reliability problems are always being explored in an attempt to provide the most reliable service possible.

Attachment 3

UES - Seacoast

Reliability Analysis and Recommendations 2014

Unitil Energy Systems – Seacoast

Reliability Study

2014

Prepared By:

Jake Dusling
Unitil Service Corp.

September 22, 2014

1 Executive Summary

The purpose of this document is to report on the overall reliability performance of the UES-Seacoast system from January 1, 2013 through December 31, 2013. The scope of this report will also evaluate individual circuit reliability performance over the same time period.

The following projects are proposed from the results of this study and are focused on improving the worst performing circuits as well as the overall UES-Seacoast system reliability. These recommendations are provided for consideration and will be further developed with the intention to be incorporated into the 2015 budget development process.

Circuit / Line / Substation	Proposed Project	Cost ($)
19X2	Distribution Automation Scheme with Portsmouth Ave	$160,000
47X1	Install Devices and Implement a "Pulsefinding" Scheme	$300,000
2X2	Install Recloser on Lafayette Road	$50,000
18X1	Install Recloser on Mary Batchelder Road	$55,000
54X1	Install Reclosers and Establish Circuits 54X1 and 54X2	$165,000
13W2	Replace V4L Reclosers and Relocate Downline	$170,000
43X1	Install Recloser and Relocate Fuses	$55,000
3347 Line Tap	Recloser Replacements	$125,000
22X1	Relocate Main Line to Route 111	$825,000
3359 Line	Wireless Fault Indicators	$105,000
3348 / 3350	Rebuild Line off the Salt Marsh	$3,000,000

Note: estimates do not include general construction overheads

2 Reliability Goals

The annual corporate system reliability goals for 2014 have been set at 191-156-121 SAIDI minutes. These were developed through benchmarking Unitil system performance with surrounding utilities.

Individual circuits will be analyzed based upon circuit SAIDI, SAIFI, and CAIDI. Analysis of individual circuits along with analysis of the entire Seacoast system is used to identify future capital improvement projects and/or operational enhancements which may be required in order to achieve and maintain these goals.

3 Outages by Cause

This section provides a breakdown of all outages by cause code experienced during 2013, excluding the 3342/3353 Line Outage. Chart 1 lists the number of interruptions due to each cause. For clarity, only those causes occurring more than 10 times are labeled. Chart 2 details the percent of total customer-minutes of interruption due to each cause. Only those causes contributing greater than 2% of the total are labeled.

Chart 1
Number of Interruptions by Cause

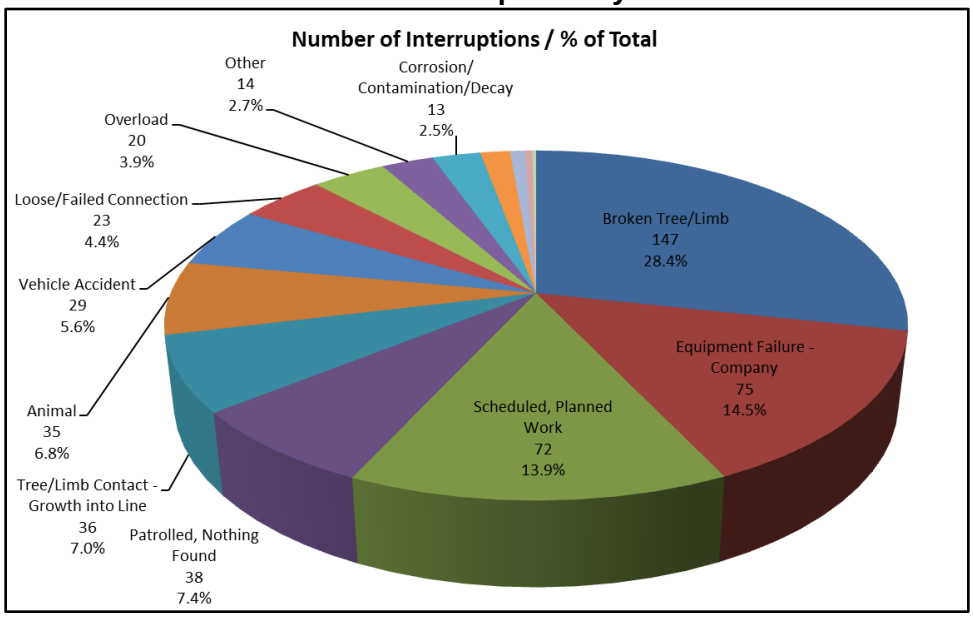
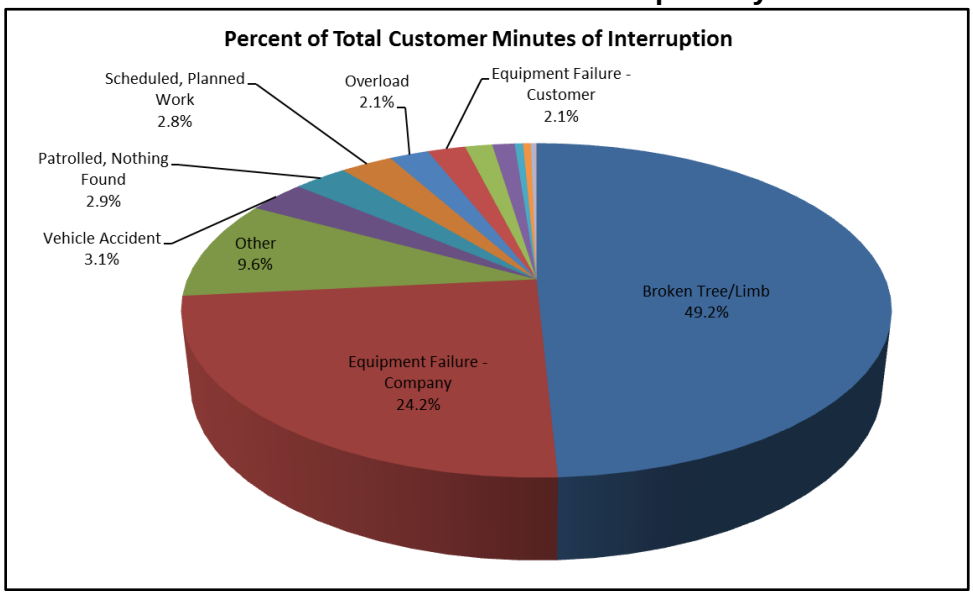


Chart 2
Percent of Customer-Minutes of Interruption by Cause



4 10 Worst Distribution Outages

The ten worst distribution outages ranked by customer-minutes of interruption during the time period from January 1, 2013 through December 31, 2013 are summarized in Table 1 below. This table does not include substation or sub-transmission outages.

Table 1
Worst Ten Distribution Outages

Circuit	Description (Date/Cause)	No. of Customers Affected	No. of Customer Minutes	UES Seacoast SAIDI (min.)	UES Seacoast SAIFI
59X1[1]	4/1/13 Equipment Failure – Company (Insulator)	3,060	304,879	6.66	0.067
47X1	1/31/13 Broken Tree/Limb	1,230	258,300	5.65	0.027
2X2	1/31/13 Other	806	236,964	5.18	0.018
18X1	1/31/13 Broken Tree/Limb	1,720	221,425	4.84	0.038
3W4	6/15/13 Other	1,567	138,267	3.02	0.034
18X1	2/14/13 Broken Tree/Limb	1,720	125,560	2.74	0.038
27X1	11/1/13 Broken Tree/Limb	227	110,095	2.41	0.005
6W1	6/20/13 Broken Tree/Limb	353	106,024	2.32	0.008
13W2	6/20/13 Broken Tree/Limb	1,503	96,192	2.10	0.033
7X2	1/31/13 Broken Tree/Limb	1,197	92,169	2.01	0.026

5 Sub-transmission and Substation Outages

This section describes the contribution of sub-transmission line and substation outages on the UES-Seacoast system from January 1, 2013 through December 31, 2013.

All substation and subtransmission outages ranked by customer-minutes of interruption during the time period from January 1, 2013 through December 31, 2013 are summarized in Table 2 below.

[1] Failed insulator on the mainline of circuit 59X1 resulted in the 59X1 recloser at Stard Road and the 3359 breaker at Guinea to lockout.

Table 3 shows the circuits that have been affected by sub-transmission line and substation outages. The table illustrates the contribution of customer-minutes of interruption for each circuit affected.

In aggregate, sub-transmission line and substation outages accounted for 51% of the total customer-minutes of interruption for UES-Seacoast.

Table 2
Sub-transmission and Substation Outages

Trouble Location	Description (Date/Cause)	No. of Customers Affected	No. of Customer Minutes	UES Seacoast SAIDI (min.)	UES Seacoast SAIFI
3342 Line	3/19/13 Equipment Failure – Company (Shield Wire)	9,546	2,377,101	51.96	0.209
3353 Line	3/19/13 Equipment Failure – Company (Shield Wire)	5,303	1,260,551	27.55	0.116
3343 Line	1/31/13 Broken Tree/Limb	3,135	106,056	1.21	0.069
3347 Line	6/5/13 Equipment Failure - Customer	3,052	97,664	2.13	0.067
3362 Line	7/23/13 Broken Tree/Limb	4,336	117,106	2.25	0.083
Westville S/S	11/21/13 Equipment Failure – Company (Recloser)	5,602	366,044	8.00	0.122

Table 3
Contribution of Sub-transmission and Substation Outages

Number of events	Trouble Location	Circuit	Customer-Minutes of Interruption	% of Total Circuit Minutes	Circuit SAIDI Contribution
1	3342 Line	2X2	262,080	49.3%	104.06
		17W1	392,904	89.9%	217.51
		17W2	196,773	87.3%	321.09
		46X1	362,730	83.3%	321.21
		3346[1]	642	100%	321.00
		3W4	1,161,972	86.5%	739.83
1	3353 Line	7W1	74,664	56.3%	61.01
		7X2	108,702	44.2%	60.82
		2H1	8,784	100.0%	60.44
		2X3	48,129	76.9%	60.93
		3H1	474,980	99.7%	635.50
		3H2	204,204	98.1%	752.46
		3H3	341,088	97.8%	745.68
1	3343 Line	27X1	3,216	1.5%	4.65
		27X2	1,494	89.3%	12.00
		43X1	31,552	13.9%	17.00
		28X1	19,266	95.6%	38.95
1	3347 Line	11X2	50,528	94.5%	33.02
		47X1	47,136	11.6%	32.01
1	3362 Line	1H3	14,256	100.0%	26.96
		1H4	12,933	92.0%	26.95
		PEA	61	100.0%	61.00
		19H1	4,374	100.0%	26.94
		19X3	85,482	78.0%	27.00
1	Westville S/S	56X2	4,092	98.3%	62.00
		56X1	46,004	54.1%	64.01
		58X1	134,168	84.4%	62.17
		21W1	96,096	31.3%	75.90
		21W2	85,684	67.0%	61.84

[1] Two customers are supplied directly off the 3346 line, Hampton Waste Water Plant and Brazonics.

6 Worst Performing Circuits

This section compares the reliability of the worst performing circuits using various performance measures. All circuit reliability data presented in this section includes subtransmission or substation supply outages unless noted otherwise.

6.1 Worst Performing Circuits in Past Year (1/1/13 – 12/31/13)

A summary of the worst performing circuits during the time period between January 1, 2013 and December 31, 2013 is included in the tables below.

Table 4 shows the ten worst performing circuits ranked by the total number of customer-minutes of interruption. The SAIFI and CAIDI for each circuit are also listed in this table.

Table 5 provides detail on the major causes of the outages on each of these circuits. Customer-minutes of interruption are given for the six most prevalent causes.

Circuits having one outage contributing more than 75% of the customer-minutes of interruptions were excluded from this analysis.

Table 4
Worst Performing Circuits Ranked by Customer-Minutes

Circuit	Customer Interruptions	Worst Event (% of CI)	Cust-Min of Interruption	Worst Event (% of CMI)	SAIDI	SAIFI	CAIDI
2X2	6,208	49.3%	531,493	49.3%	211.02	2.46	85.61
18X1	5,971	49.5%	447,681	49.5%	255.15	3.40	74.98
47X1	3,757	63.7%	405,224	63.7%	275.19	2.55	107.86
6W1	2,557	31.8%	333,268	31.8%	384.28	2.95	130.34
13W2	3,791	29.5%	326,110	29.5%	212.92	2.48	86.02
21W1	4,120	31.3%	307,423	31.3%	242.80	3.25	74.62
22X1	3,745	31.5%	281,124	31.5%	136.57	1.82	75.07
7X2	5,323	44.2%	246,100	44.2%	137.70	2.98	46.23
43X1	4,493	19.6%	227,115	19.6%	122.34	2.42	50.55
27X1	2,060	52.9%	208,243	52.9%	300.82	2.98	101.09

Note: all percentages and indices are calculated on a circuit basis

Table 5
Circuit Interruption Analysis by Cause

Circuit	Customer – Minutes of Interruption					
	Broken Tree Limb	Patrolled, Nothing Found	Scheduled, Planned Work	Vehicle Accident	Company Equipment Failure	Other
2X2	238	16,626	145	6,875	269,755[1]	237,054[2]
18X1	385,960	5,703	1,418	0	54,344	0
47X1	317,643	1,125	8	0	2,056	0
6W1	269,238	860	540	52,361	172	0
13W2	211,746	46,142	65	0	65,275	0
21W1	91,346	2,217	561	8,762	179,546	4,840
22X1	230,893	5,213	105	37,815	7,038	0
7X2	94,104	10	2,310	0	127,083	21,384
43X1	130,832	13,247	12,029	1,672	3,116	41,097
27X1	130,389	9,350	18,901	0	48,883	0
Total	**1,862,389**	**100,493**	**36,082**	**107,485**	**757,268**	**304,375**

[1] One event accounted for 176,400 Customer-Minutes of Interruption.
[2] One event accounted for 236,964 Customer-Minutes of Interruption.

6.2 Worst Performing Circuits of the Past Five Years (2009 – 2013)

The annual performance of the ten worst circuits in terms of SAIDI and SAIFI for each of the past five years is shown in the tables below. Table 6 lists the ten worst performing circuits ranked by SAIDI and Table 7 lists the ten worst performing circuits ranked by SAIFI.

The data used in this analysis includes all system outages except those outages that occurred during the 3342/3353 Line Outage in 2013, Hurricane Sandy in 2012, the 2011 October Nor'easter, Hurricane Irene in 2011 and the 2010 Wind Storm.

Table 6
Circuit SAIDI

Circuit Ranking (1 = worst)	2013		2012		2011		2010		2009	
	Circuit	SAIDI	Circuit	SAIDI	Circuit	SAIDI	Circuit	SAIDI	Circuit	SAIDI
1	6W1	384.28	56X2	590.69	13W2	698.61	51X1	582.06	15X1	526.90
2	27X1	300.82	13W2	556.17	54X1	557.90	3H2	575.51	22X1	526.47
3	47X1	275.19	13W1	383.59	17W2	429.40	22X1	518.07	5H2	444.34
4	18X1	255.15	2X2	376.99	22X1	407.92	59X1	509.53	56X2	430.31
5	21W1	242.80	58X1	339.87	17W1	381.20	15X1	387.88	13W2	414.30
6	13W2	212.92	7X2	317.63	46X1	372.37	23X1	378.56	13W1	365.14
7	59X1	197.65	47X1	297.13	13W1	275.45	17W2	361.53	23X1	339.98
8	22X1	136.57	43X1	296.43	21W2	239.71	58X1	308.72	18X1	323.54
9	15X1	128.33	23X1	292.58	11W1	226.92	46X1	306.30	3H1	260.91
10	43X1	122.34	15X1	263.38	7X2	213.44	21W1	291.33	21W2	260.71

Table 7
Circuit SAIFI

Circuit Ranking (1 = worst)	2013		2012		2011		2010		2009	
	Circuit	SAIFI	Circuit	SAIFI	Circuit	SAIFI	Circuit	SAIFI	Circuit	SAIFI
1	18X1	3.40	56X2	7.39	54X1	5.25	51X1	6.65	22X1	6.10
2	21W1	3.25	13W2	5.77	22X1	4.93	3H2	6.01	18X1	5.23
3	27X1	2.98	23X1	5.69	13W2	4.53	22X1	5.21	5H2	5.06
4	6W1	2.95	43X1	4.22	13W1	2.81	15X1	4.38	15X1	4.96
5	47X1	2.55	6W1	4.06	7X2	2.48	23X1	3.77	13W2	4.70
6	13W2	2.48	13W1	3.92	11W1	2.42	59X1	3.43	56X2	4.52
7	43X1	2.42	15X1	3.89	47X1	1.99	11W1	3.29	3H1	4.06
8	7X2	1.98	59X1	3.64	18X1	1.94	13W2	3.21	13W1	3.91
9	56X1	1.96	21W1	3.20	21W2	1.93	28X1	3.07	21W2	3.91
10	54X1	1.91	58X1	3.13	6W1	1.77	20H1	3.01	21W1	3.89

Circuits 13W2, 22X1 and 15X1 have been on the worst performing SAIDI circuits list four of the past five years. Circuits 13W1 and 23X1 have been on the list for three of the last five years, but were not on the list in 2013.

Circuit 13W2 has been on the worst performing SAIFI circuits list every year over the past five years and circuits 6W1, 13W1, 15X1, 18X1, 21W1 and 22X1 have been on the list for three of the past five years. However, circuits 13W1, 15X1 and 22X1 are not on the list in 2013.

6.3 Improvements to Worst Performing Circuit (2013 and 2014)

Projects completed 2013 and 2014 that are expected to improve the reliability of the worst performing circuits are included in table 8 below.

The worst performing circuits included in table 8 are all circuits on table 4, all circuits listed in 2013 on tables 6 and 7 and any circuit that was on table 6 or 7 at least three times in the last five years.

Table 8
Improvements to Worst Performing Circuits

Circuit(s)	Year of Completion	Project Description
3342, 3343 and 3348[1]	2014	Installation of reclosers at Hampton S/S on the 3342, 3353 and 3348 lines
2X2	2013	Hazard tree mitigation
18X1	2014	Planned Cycle Pruning
	2013	Hazard tree mitigation
47X1	2014	Planned Cycle Pruning
		Hazard tree mitigation
	2013	Hazard tree mitigation
6W1	2014	Hazard tree mitigation
		Planned Mid-Cycle pruning
	2013	Planned Mid-Cycle pruning
13W2	2013	Planned Cycle Pruning
21W1	2014	Planned Cycle Pruning
		Hazard tree mitigation
	2013	Forestery Reliability work
22X1	2014	Storm Resilency pruning
	2013	Forestery Reliability work
7X2	2014	Planned Cycle Pruning
		Hazard tree mitigation
43X1	2014	Storm Resilency pruning
27X1	2014	Recloser additions to split circuit 27X1 into two circuits, 27X1 and 27X2
	2013	Planned Cycle Pruning
		Hazard tree mitigation
15X1	2014	Addition of new mainline recloser
	2013	Planned Cycle Pruning
		Hazard tree mitigation

[1] Includes circuits 2H1, 2X2, 2X3, 17W1, 17W2, 46X1, 3H1, 3H2, 3H3, 3W4, 7W1 and 7X2.

Circuit(s)	Year of Completion	Project Description
15X1	2013	Planned Cycle Pruning
56X1	2013	Hazard tree mitigation
54X1	2013	Hazard tree mitigation
59X1	2014	Replace 59X1 recloser
13W1	2014	Install recloser and sectionalizer
		Planned Cycle Pruning
		Hazard tree mitigation
23X1	2014	Planned Mid-Cycle pruning
		Hazard tree mitigation
	2013	Installation of new mainline recloser
		Transfer of load to circuit 27X1
		Hazard tree mitigation

6.4 Distribution Protection Review of Worst Performing Circuits

A detailed protection review was performed on each of the ten worst performing circuits. This analysis involved reviewing circuit topology to determine if distribution protection modifications (additional devices or device relocations) will provide additional reliability benefit. The results of this review are included in table 9 below.

These results will be reviewed in additional detail and EWR's will be issued to make the necessary modifications if needed.

A detailed review of protection coordination, loading capability and sensitivity was not conducted as part of this review, unless this was required for specific areas to determine if additional devices could be installed. The loading capability of protective devices is reviewed annually and coordination and sensitivity is reviewed once every three years as part of the distribution system planning process.

Table 9
Protection Review of Worst Performing Circuits

Circuit	Proposed Modifications
2X2	Install new recloser at the intersection of High Street and Lafayette Road[1,2]
18X1	Install a new recloser on Mary Batchelder Road and relocate 175 QA fuses to Towle Farm Road[2,3]
	Install new in-line fuses along Exeter Road
47X1	Install new fuses along High Street at the intersection of Guinea Road
	Modify Bunker Hill Ave stepdown fusing to allow for the installation of fuses on Frying Pan Lane
6W1	Add fusing to the two unfused laterals along South Road
13W2	Replace V4L Reclosers and Relocate Downline[4]
21W1	Modify fusing in the Coventry Road area to allow the installation of three additional fuse locations
22X1	Modify fusing in the Sweet Street area to allow the installation of three additional fuse locations.
7X2	Modify fusing in the Marsh View Circle area to allow the installation of two additional fuse locations.
	Install new cutout feeding the single phase portion of South Main Street
	Replace the set of solid blades at pole 35 Walton Road with fuse links
43X1	Install new recloser on Exeter Road and relocate 150 QA fuses to pole 64 Exeter Road[2,5]
27X1	None

7 Tree Related Outages in Past Year (1/1/13 – 12/31/13)

This section summarizes the worst performing circuits by tree related outages during the time period between January 1, 2013 and December 31, 2013.

Table 10 shows these circuits ranked by the total number of customer-minutes of interruption. The number of customer-interruptions and number of outages are also listed in this table. Circuits having two or less tree related outages were excluded from this table.

All streets on the Seacoast system with three or more tree related outage are shown in table 11 below. The table is sorted by number of outages and customer-minutes of interruption.

[1] Additional details of this project are included in section 11.4.
[2] In the event these recloser projects do not move forward a possible alternative is to install cutout mounted sectionalizers.
[3] Additional details of this project are included in section 11.5.
[4] Additional details of this project are included in section 11.7.
[5] Additional details of this project are included in section 11.8.

Table 10
Worst Performing Circuits – Tree Related Outages

Circuit	Customer-Minutes of Interruption	Number of Customers Interrupted	No. of Interruptions
18X1[1,2]	385,960	3,995	4
47X1[1,2]	322,965	1,871	9
6W1[2,3,4]	278,666	2,199	15
22X1[5,6]	230,953	2,016	18
13W2[7]	212,484	2,069	14
27X1[1,7]	127,173	394	4
43X1[4]	99,332	1,583	17
7X2[2,4]	95,130	1,268	5
21W1[2,6,4]	93,097	1,105	8
51X1[7]	74,232	1,283	8

Table 11
Tree Related Outages by Street

Circuit	Street	# Outages	Customer-Minutes of Interruption	No. of Customer Interruptions
43X1[8]	Willow Rd, East Kingston	4	18,973	83
43X1[5]	Exeter Rd, Kingston	3	67,537	1,306
6W1[2,3,4]	South Rd, East Kingston	3	167,135	1,065
6W1[2,3,4]	Depot Rd, East Kingston	3	83,329	744
13W2[7]	Thornell Rd, Newton	3	12,710	110
58X1[7]	Forest St, Plaistow	3	7,430	67
43X1[8]	Little River Rd, Kingston	3	8,449	63
2X3[8]	Brimmer Ln, Hampton Falls	3	1,092	12

[1] Planned Hazard Tree Mitigation was performed on this circuit in 2013.
[2] Planned Cycle pruning is being performed on this circuit in 2014.
[3] Planned Mid-Cycle pruning was performed on this circuit in 2013.
[4] Hazard Tree Mitigation is being performed on this circuit in 2014.
[5] Storm Resiliency pruning (ground to sky and hazard tree removal) is being performed on this circuit in 2014.
[6] Forestry Reliability work was performed on this circuit in 2013.
[7] Planned Cycle pruning was performed on this circuit in 2013.
[8] Refer to section 11.1 for recommendations in this area.

8 Failed Equipment

This section is intended to clearly show all equipment failures throughout the study period from January 1, 2013 through December 31, 2013. Chart 2 shows all equipment failures throughout the study period. Chart 3 shows each equipment failure as a percentage of the total failures within this same study period. The number of equipment failures in each of the top three categories of failed equipment for the past five years are shown below in Chart 4.

Chart 2
Equipment Failure Analysis by Cause

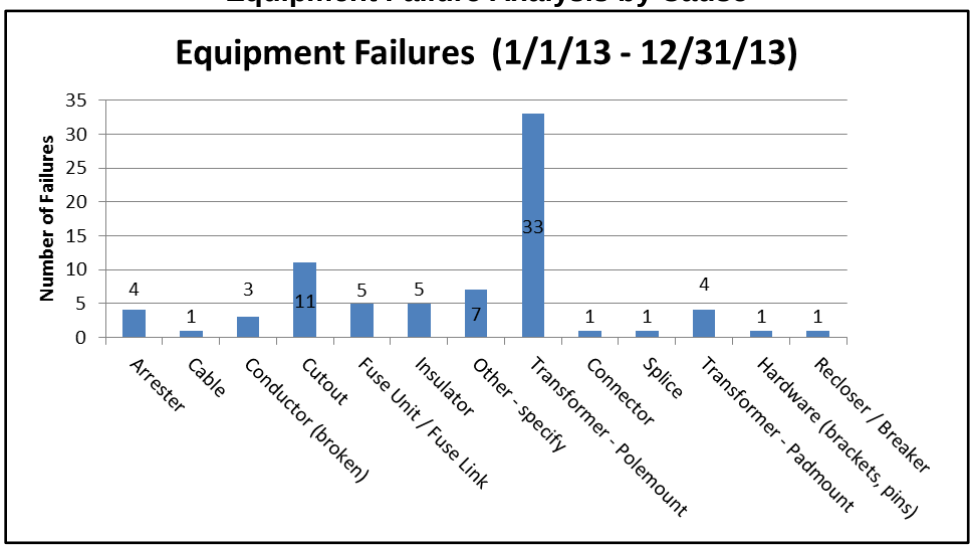


Chart 3
Equipment Failure Analysis by Percentage of Total Failures

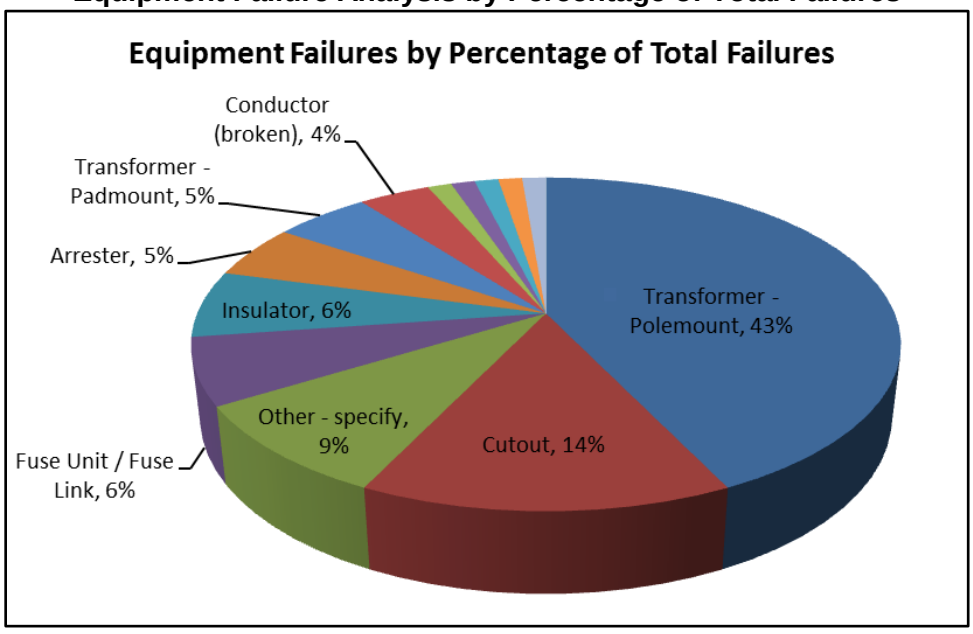
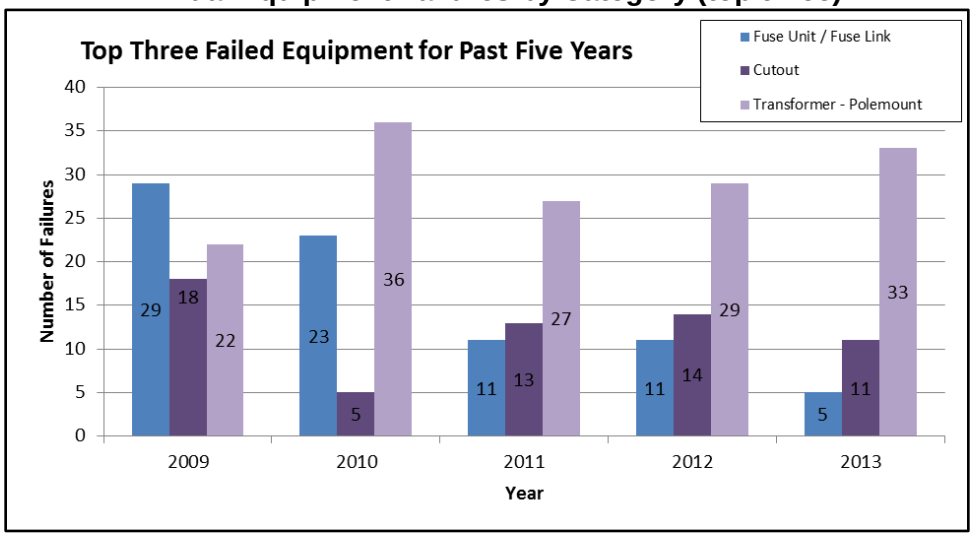


Chart 4
Annual Equipment Failures by Category (top three)



Note: Other-Specify in not included in the top three categories. None of the Other-Specify equipment had more than two outages for any specific type of equipment.

9 Multiple Device Operations in Past Year (1/1/13 – 12/31/13)

A summary of the devices that have operated three or more times from January 1, 2013 to December 31, 2013 are included in table 12 below.

Table 12
Multiple Device Operations

Circuit	Number of Operations	Device	Customer-Minutes	Customer-Interruptions
6W1[1,2,3]	3	Recloser – Pole 2 South Road, East Kingston	167,135	1,065
22X1[4]	3	Fuse – Pole 49 Long Pond Road, Danville	7,336	98
13W2[4]	3	Fuse – Pole 8 Quaker Street, Newton	6,480	72

[1] Planned Cycle pruning is being performed on this circuit in 2014.
[2] Planned Mid-Cycle pruning was performed on this circuit in 2013.
[3] Hazard Tree Mitigation is being performed on this circuit in 2014.
[4] Refer to section 11.1 for recommendations in this area.

10 Other Concerns

This section is intended to identify other reliability concerns that would not be identified from the analyses above.

10.1 Recloser Replacements

Power factor testing has identified that the solid dielectric material used for the poles on a specific type/vintage recloser degrades over time leading to premature failure. The manufacturer has confirmed this concern. Unitil has experienced two (UES-Seacoast and FG&E) failures of this type/vintage of recloser in 2011 and removed two others from service due to the appearance of tracking.

One unit at Stard Road tap and two units at Wolf Hill are scheduled to be replaced in 2014. This will two of this type/vintage reclosers in service in UES-Seacoast, at the 3347 line tap.

10.2 Subtransmission Lines Across Salt Marsh

The 3348 line experienced one outage in 2012 caused by a failed insulator and has been damaged several times during major events over the last five years, causing outages to the customers on all the distribution circuits (2H1, 2X3, 3H1, 3H2, 3H3, 7W1 and 7X2) supplied by the 3348, 3350 and 3353 lines distribution . The 3348 line is constructed through salt marsh, making it very difficult to access and repair.

In 2012, during a wind and snow event, both the 3342 and 3353 lines were damaged resulting in an outage to the Hampton Beach area that lasted nearly thirteen hours. These lines being constructed through the salt march made them difficult to patrol and inaccessible to repair with a boat. There is a multi-stage project scheduled to begin in 2014 to relocate these lines closer to the road.

The 3350 line is also constructed through salt marsh. This line has the same access concerns, but has been far more reliable than the 3348, 3342 and 3353 lines in the past. The 3350 line is a radial line that supplies Seabrook substation, if damaged load may need to be left out of service until repairs are made.

Additionally the 3348/3350 tap structure was damaged during Hurricane Sandy in 2012, requiring the 3348 and 3350 lines to remain out of service for several weeks until repairs were made. During this time of year the load normally supplied by the 3350 line was restored via distribution ties. During summer peak conditions the distribution circuits in the area do not have the capacity to restore all load for this type of event.

Reclosers are scheduled to be placed in service at Hampton substation in 2014 to reduce the impact of 3348, 3350, 3342 and 3353 line faults.

10.3 3347 Line

The 3347 line has been damaged by trees during major events over the past five years, causing outages to customers served by Guinea Road tap, Portsmouth Ave substation and Osram/Sylvania until repairs are made.

The installation of reclosers at Portsmouth Ave Substation and the replacement of the 19X2 relay at Exeter Switching were completed in 2013. These upgrades allow all customers served from Portsmouth Ave substation to be restored via distribution ties for the loss of the 3347 Line. Guinea Road tap and Osram/Sylvania load will remain out of service until repairs are made.

11 Recommendations

This following section describes recommendations on circuits, sub-transmission lines and substations to improve overall system reliability. The recommendations listed below will be compared to the other proposed reliability projects on a system-wide basis. A cost benefit analysis will determine the priority ranking of projects for the 2015 capital budget. All project costs are shown without general construction overheads.

11.1 Miscellaneous Circuit Improvements to Reduce Recurring Outages

11.1.1 Identified Concerns & Recommendations

The following concerns were identified based on a review of Tables 10 and 11 of this report; Multiple Tree Related Outages by Street and Multiple Device Operations respectively.

Mid-Cycle Forestry Review

The areas identified below experienced three or more tree related outages in 2013. It is recommended that a forestry review of these areas be performed in 2015 in order to identify and address any mid-cycle growth or hazard tree problems.

- 43X1, Willow Road, East Kingston
- 43X1, Little River Road, Kingston
- 2X3, Brimmer Lane, Hampton Falls
- 22X1, Long Pond Road, Danville[1]

13W2 Fuse at Pole 8 Quaker Street, Newton

This device operated three times in 2013 (summarized below). Quaker Street should be reviewed to ensure animal guards have been installed on all distribution transformers and to determine if localized trimming is needed.

[1] The fuse at pole 49 Long Pond Road in Danville operated three times in 2013. The cause of two of these outages was Broken Tree/Limb and the third was a patrolled, nothing found.

- 1 Animal Outage at pole 16
- 2 Patrolled, Nothing Found

Customer Exposure = 24 Customers

11.2 Circuit 19X2 – Distribution Automation Scheme with Portsmouth Ave

11.2.1 Identified Concerns

On average one subtransmission outage per year causes an outage to Portsmouth Ave substation or Exeter Switching.

Additionally, Portsmouth Ave substation is supplied from the 3347 line, which is a radial line that typically experiences damage during major events.

11.2.2 Recommendation

This project will consist of replacing the 11X2J19X2 tie switch with a recloser and the installation communication infrastructure between the new recloser, the 19X2 recloser at Exeter Switching. and Portsmouth Ave substation.

A distribution automation scheme will be implemented that will restore the 1,617 customers on circuits 11X1 and 11X2 via circuit 19X2 for the loss of the 3347 line. Additionally, for a fault on the 3352 or 3362 line the 538 customers supplied by circuit 19X2 will automatically be restored via circuit 11X2.

- Estimated annual customer-minutes savings = 71,149
- Estimated annual customer-interruption savings = 0

Estimated Project Cost: $160,000

11.3 Circuit 47X1 – Install Devices and Implement a “Pulsefinding” Scheme

11.3.1 Identified Concerns

Circuit 47X1 was one of the worst performing circuits in 2012 and 2013.

11.3.2 Recommendation

This project will consist of installing multiple S&C Intellirupters at strategic locations along circuit 47X1 and implementing a “pulsefinding” scheme.

“Pulsefinding” is a technique that allows devices with the same overcurrent protection settings to be used in series without the

installation of device-to-device communications. At this time S&C Intellirupters are the only device with this capability.

After the devices are installed and programmed the 47X1 recloser and all series Intellirupters will trip in response to a downstream fault. The 47X1 recloser will reclose and stay closed if the fault is no longer present. The first downstream Intellirupter, upon sensing the return of voltage, pulsecloses (pulsecloses are too short to initiate a time-overcurrent trip of the recloser) and the Intellirupter will close if the fault is no longer present. This continues with each Intellirupter until the fault is isolated or the circuit is fully restored.

This installation will allow the 51X1/47X1 circuit tie to be used throughout the year and will have the capability to be integrated into a distribution automation scheme with circuit 51X1 in the future.

This project will act as a pilot installation for this technology and if successful there are several other large circuits in Unitil's territory that could greatly benefit from this type of scheme.

- Estimated annual customer-minutes savings = 115,668
- Estimated annual customer-interruption savings = 756

Estimated Project Cost: $300,000 (4 Locations @ $75,000 per location)

11.4 Circuit 2X2 – Install Recloser on Lafayette Road

11.4.1 Identified Concerns

Circuit 2X2 has been the worst performing customer-minutes of interruption circuit for the last two years.

A detailed protection review of circuit 2X2 indicated that the installation of a new recloser along Lafayette Road is expected to improve overall circuit reliability.

11.4.2 Recommendation

This project will consist of installing a new electronically controlled recloser along Lafayette Road just north of the High Street intersection.

The new recloser will benefit approximately 950 customers and is expected save approximately 1,550 customer interruptions for faults along the northern portion of Lafayette Road.

- Estimated annual customer-minutes savings = 117,174
- Estimated annual customer-interruption savings = 1,221

Estimated Project Cost: $50,000

11.5 Circuit 18X1 – Install Recloser on Mary Batchelder Road

11.5.1 Identified Concerns

Circuit 18X1 was one of the worst performing circuits in 2013 and has been on the worst performing SAIFI circuit list three of the last five years.

A detailed protection review of circuit 18X1 indicated that the installation of a new recloser along Mary Batchelder Road is expected to improve overall circuit reliability.

11.5.2 Recommendation

This project will consist of replacing the 175 QA fuses at pole 1 Mary Batchelder Road with an electronically controlled recloser, with the intent of relocating the 175 QA fuses to the vicinity of pole 2 Towle Farm Road.

The new recloser will benefit approximately 700 customers and the new fuse location is expected save approximately 325 customer interruptions per year.

- Estimated annual customer-minutes savings = 19,655
- Estimated annual customer-interruption savings = 205

Estimated Project Cost: $55,000

11.6 Circuit 54X1 – Install Reclosers and Establish Circuits 54X1 and 54X2

11.6.1 Identified Concerns

Circuit 54X1 currently supplies approximately 1,450 customers. The circuit exits New Boston Road Tap and heads in two directions with the Newton side of Route 125 serving approximately 950 customers and the Danville side of Route 125 supplying approximately 500 customers.

11.6.2 Recommendation

This project will consist of installing two new electronically controlled reclosers along New Boston Road and splitting circuit 54X1 into two circuits, 54X1 and 54X2.

Once complete circuit 54X1 will supply the east side of Route 125 towards Newton and serve approximately 950 customers. Circuit 54X2 will serve approximately 500 customers on the west side of Route 125.

- Estimated annual customer-minutes savings = 195,114
- Estimated annual customer-interruption savings = 2,032

Estimated Project Cost: $165,000

11.7 Circuit 13W2 – Replace V4L Reclosers and Relocate Downline

11.7.1 Identified Concerns

Circuit 13W2 is typically one of the worst performing circuits on the UES-Seacoast system. It has been on the worst performing SAIFI list every year for the past five years and has been on the worst performing SAIDI list four of the past five years.

11.7.2 Recommendation

This project will consist of replacing the two existing sets of 140A V4L reclosers on circuit 13W2 with electronically controlled reclosers. This will allow the existing reclosers to be relocated to Peaslee Crossing Road and Thornell Road. Two additional sets of 100A V4L reclosers will be installed on Highland Street and Pond Street. The existing 13W2 recloser control at Timberlane substation will most likely need to be replaced to accommodate this project.

The new reclosers will benefit approximately 1,100 customers.

- Estimated annual customer-minutes savings = 31,705
- Estimated annual customer-interruption savings = 330

Estimated Project Cost: $170,000

11.8 Circuit 43X1 – Install Recloser and Relocate Fuses

11.8.1 Identified Concerns

Circuit 43X1 was one of the worst performing circuits in 2013 and has been on the worst performing SAIDI circuit list three of the last five years.

A detailed protection review of circuit 43X1 indicated that the installation of a new recloser and relocating the existing 150 QA fuses is expected to improve overall circuit reliability.

11.8.2 Recommendation

This project will consist of replacing the 150 QA fuses at pole 55 Exeter Road with an electronically controlled recloser, with the intent of relocating the 150 QA fuses to the vicinity of pole 64 Exeter Road.

The new recloser will benefit approximately 1,395 customers and the new fuse location is expected save approximately 650 customer interruptions per year.

- Estimated annual customer-minutes savings = 200,973
- Estimated annual customer-interruption savings = 2,093

Estimated Project Cost: $55,000

11.9 Recloser Replacements

11.9.1 Identified Concerns

Unitil has experienced premature failures of a specific type/vintage of recloser due to insulation breakdown of the poles.

11.9.2 Recommendation

This project will consist of replacing the remaining two reclosers on the UES-Seacoast system.

- Two (2) at 3347 Line Tap

Below is a summary of the reliability benefit for this project:

Recloser	Customers of Exposure
3347A	5,350
3347B	7,900

- Estimated annual customer-minutes savings = 110,088
- Estimated annual customer-interruption savings = 1,147

Estimated Project Cost: $125,000

11.10 Circuit 22X1 – Relocate Main Line to Route 111

11.10.1 Identified Concerns

Circuit 22X1 has been one of UES-Seacoast's worst performing circuits three of the last five years.

Additionally, the existing main line along Kingston Road and Pleasant Street typically sustain significant damage during major storms, requiring lengthy repairs to energize the mainline of 22X1.

11.10.2 Recommendation

This project will consist of building approximately 2.25 miles of new three-phase open wire construction along Route 111 from Mill Road to the Danville Tie. Route 111 is a major state road-way with very little tree exposure.

Additionally, approximately 2,500' of Route 111A will be rebuilt to three-phase construction and a new recloser will be installed along Route 111A to prevent sustained outages for potentially momentary faults.

Once complete, the new main line of 22X1 will run along Route 111 and Route 111A . Kingston/Danville Road will become protected laterals off the new mainline.

This project is expected to save approximately 1,900 customer interruptions per event for faults on Danville Road and Pleasant Street. This will also reduce damage to the mainline of 22X1 during major events.

- Estimated annual customer-minutes savings = 287,266
- Estimated annual customer-interruption savings = 2,992

Estimated Project Cost: $825,000

11.11 3359 Line – Wireless Fault Indicators

11.11.1 Identified Concerns

Due to the nature of the 3359 and 3348 lines, the 3359 line must be patrolled prior to performing restoration switching.

The 3359 has experienced four outages (not including major events) since the beginning of 2010 and the 3359 typically sustains damage during major storm events.

11.11.2 Recommendation

This project will consist of installing six sets of wireless fault indicators, two each at Cemetery Lane substation, Stard Road tap and Mill Lane tap. The indicators will be integrated into the existing RTU's at these locations to provide status via SCADA.

The addition of the fault indicators will provide immediate indication of the fault location to allow crews to be dispatched to the appropriate locations for patrolling and/or restoration switching.

This is expected to save approximately 275,000 customer-minutes of interruption per event for faults on the 3359 line.

- Estimated annual customer-minutes savings = 167,391
- Estimated annual customer-interruption savings = 0

Estimated Project Cost: $105,000

11.12 3348 and 3350 Line – Rebuild off the Salt Marsh

11.12.1 Identified Concerns

The 3348 line and 3350 line are constructed entirely through the salt marsh in Hampton, Hampton Falls and Seabrook, which makes them difficult to patrol and repair.

The 3350 line is a radial line to Seabrook substation. Load will remain out of service during peak load conditions for faults on the 3350 line until the line is repaired.

These lines are concerns during all major wind events. During the 2010 wind storm several structures on the 3348 line were damaged causing the line to be out of service for several months. The line was also damaged in March of 2012 due to a failed insulator which required the line to remain out of service for a few weeks.

During Hurricane Sandy the 3350 tap structure on the 3348 line was damaged, causing the 3350 and 3348 lines to remain out of service for several weeks. Due to the time of year all customers were able to be restored via distribution ties, however during peak load periods approximately 1,200 customers would remain out of service.

11.12.2 Recommendation

This project will consist of building a new 34.5 kV subtransmission line from Hampton substation to Seabrook substation. Once complete the 3348 and 3350 line will be removed from the marsh. There are several possible routes for the new line, including Route 1, the 3359 line right-of-way or along the railroad right-of-way from Hampton to Seabrook.

This project will most likely need to be a multi-year project to allow sufficient time for design and construction.

This project removes approximately 4.5 miles and 3,000 customers of exposure from lines on the salt marsh.

- Estimated annual customer-minutes savings = 112,996
- Estimated annual customer-interruption savings = 1,177

Estimated Project Cost: $3,000,000

12 Conclusion

The UES-Seacoast system has experienced a large number of outages caused by tree contact as well as outages affecting a large number of customers. A more aggressive tree trimming program began in 2011 and has started to reduce the number of tree related outages and should continue to reduce the number of tree related outages experienced in the future.

In 2012 three circuits on the UES-Seacoast benefited from a storm resiliency pruning pilot, which consisted of ground to sky trimming and hazard tree removal. Due to the success of this pilot, three additional UES-Seacoast circuits are scheduled to have storm resiliency pruning preformed in 2014.

The recommendations made for capital improvement projects within this report are aimed at reducing the duration and customer impact of outages, improving the reliability of the subtransmission system and mitigating damage to distribution mainlines and subtransmission lines during major events.

Attachment 4

REP Project Listing

2014 Actual Expenditures

REP Project Spending 2014

All projects closed to Plant In Service

Budget Number	Auth #	Description	Budget Amount	Installation Costs	Cost of Removal	Salvage	Retirements	Total Project Spending	Comments
DPBC01	C-140109	Distribution Pole Replacement	$ 686,373.00	$ 807,818.78	$ (35,240.13)	$ 639.03	$ (36,639.24)	$ 736,578.44	Posted to CPR 12/2014
DRBE03	E-141020	13W1 - Install Recloser and Sectionalizer Crystal Hil	50,382.00	16,304.09	-	-	(846.71)	$ 15,457.38	Posted to CPR 12/2014
DRBE01	E-141041	Replace 59X1 Recloser at Stard Road Tap	75,936.00	66,964.49	-	-	(2,425.99)	$ 64,538.50	Posted to CPR 12/2014
DRBE07	E-141051	Installing Cutouts on Various Circuits to Address Unprotected Laterals	60,000.00	33,463.30	(910.76)	11.25	(664.37)	$ 31,899.42	Posted to CPR 11/2014
DPBE01	E-141010	Distribution Pole Replacements (REP)	683,531.00	562,965.40	(152,553.15)	1,469.49	(39,200.41)	$ 372,681.33	Posted to CPR 11/2014
			$ 1,602,795.00	$ 1,487,516.06	$ (188,704.04)	$ 2,119.77	$ (79,776.72)	$ 1,221,155.07	

DRBC02	C-140148	33 Line Remote Fault Indication at Pleasant Street	22,073.00	Not complete, Carry over
DRBE08	E-141066	3341 Line and 3352 Line Remote Fault Indication at Exeter Switching	24,500.00	Not complete, Carry over