# System Modernization and Reliability: A Transition to Underground

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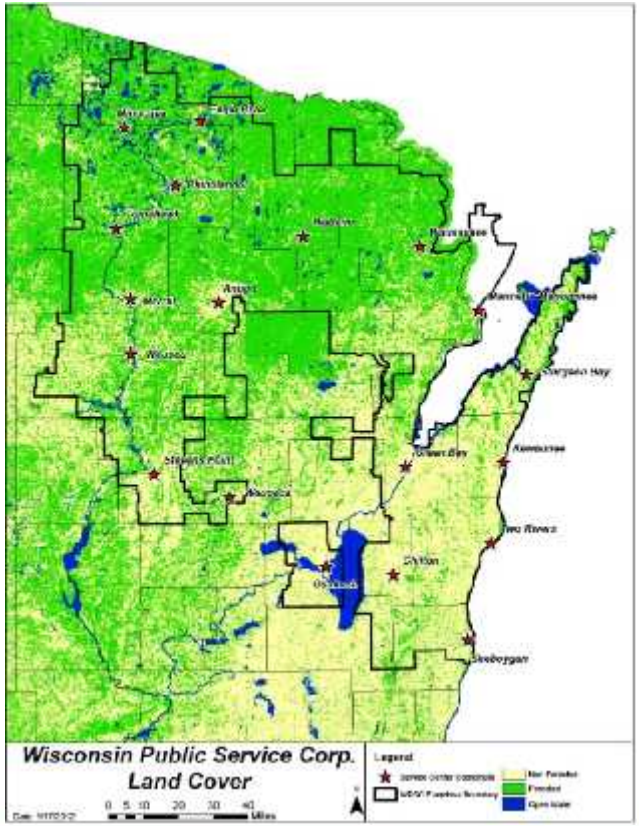
# Wisconsin Public Service Territory Review

- 453,000 electric customers
- 11,000 square miles

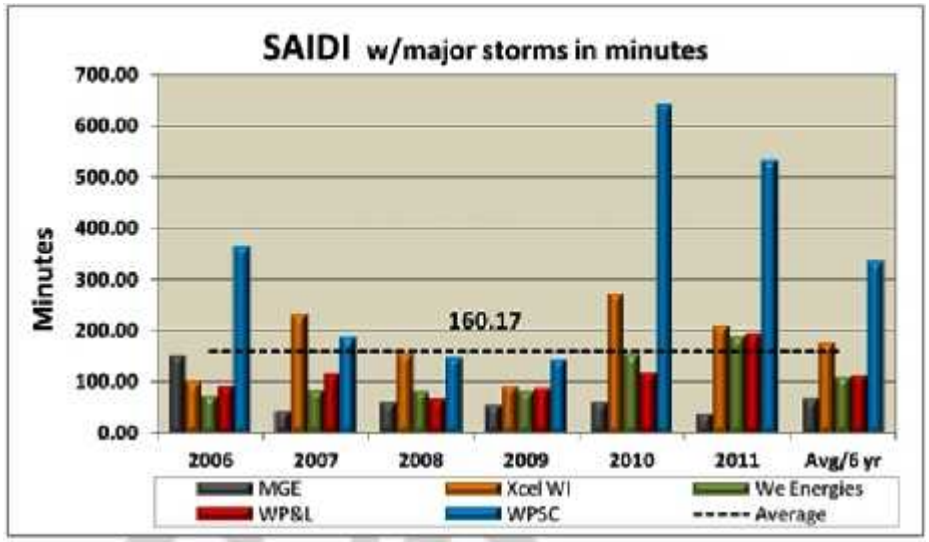
# Wisconsin Public Service Territory Coverage




- 77% of existing distribution infrastructure is Overhead
- 7800 miles (71%) considered Medium to Heavy Density Forest

# SAIDI Comparisons:

WPSC 6 year SAIDI average (336.39) was higher than the averages of other state utilities over the same period (160.17 minutes)

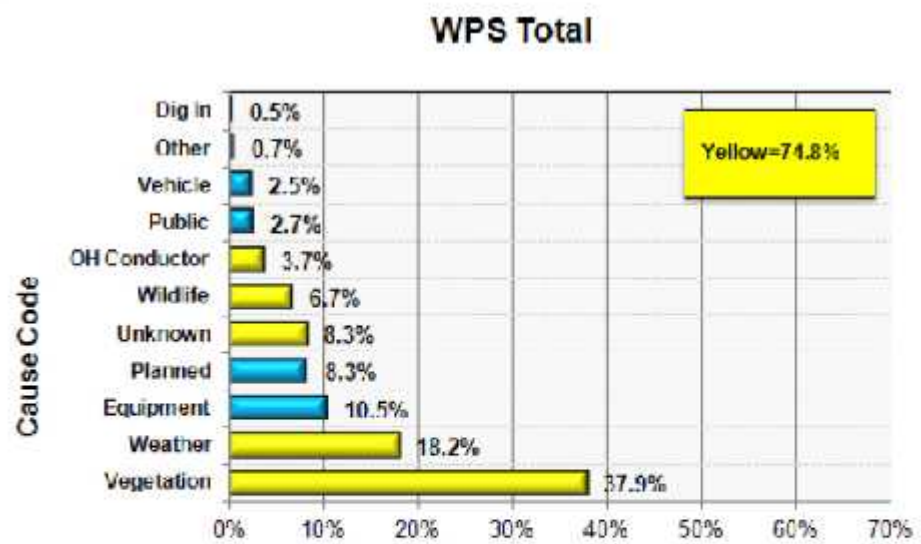



SAIDI w/major storms in minutes

(System Average Interruption Duration Index) Yrs2006-2011

| Utility | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | Avg/6 yr |
|---|---|---|---|---|---|---|---|
| MGE | 149.78 | 41.57 | 60.61 | 54.10 | 60.00 | 38.00 | 67.34 |
| Xcel WI | 100.46 | 230.63 | 155.09 | 90.01 | 270.51 | 209.00 | 175.95 |
| We Energies | 72.00 | 83.00 | 80.00 | 80.00 | 153.00 | 189.00 | 109.50 |
| WP&L | 90.60 | 115.20 | 66.00 | 87.00 | 118.20 | 193.00 | 111.67 |
| WPSC | 364.00 | 187.99 | 148.58 | 144.52 | 640.32 | 532.90 | 336.39 |
| | | | | | | | |
| Avg/yr | 155.37 | 131.68 | 102.06 | 91.13 | 248.41 | 232.38 | 160.17 |

# Outage Comparisons by Event



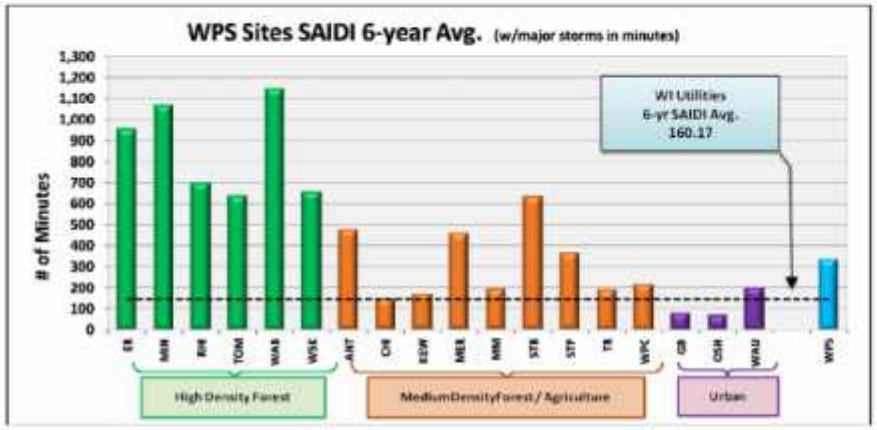

YELLOW = CAUSES ASSOCIATED WITH OVERHEAD
BLUE = CAUSES THAT ARE INDIFFERENT OR ASSOCIATED WITH UNDERGROUND

Note: experience has shown that a large percentage of the outage events in the "unknown" category are recloser lockouts for which no cause could be determined, likely trees coming in contact with the overhead lines but then releasing before the line electricians inspected the lines and determined the cause.

Approximately 75% of all WPS outage events were associated with overhead facilities and fall into categories that normally would not affect an underground system (i.e. wildlife, weather, vegetation, etc.)

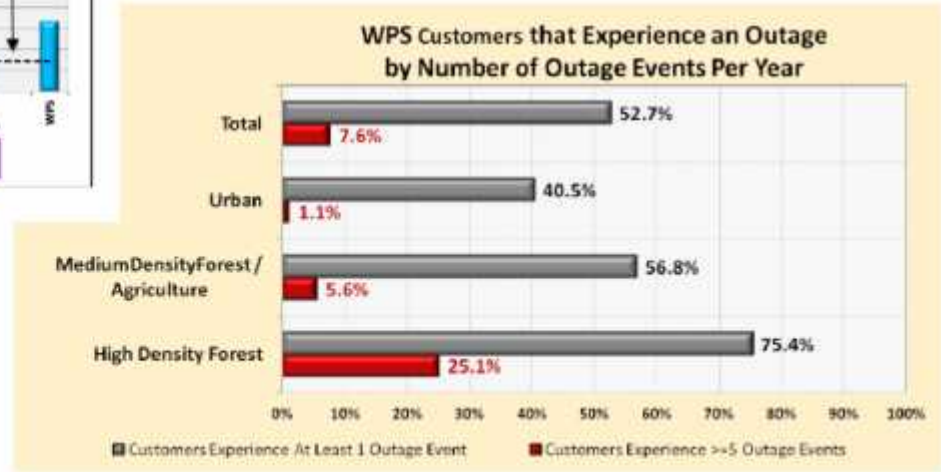
# Outage Comparisons by Territory

Outage Minute Comparison by Land Cover Type




- 33,167 customers (7.6%) experienced an average of 5+ outages per year
- 72% of those outages were located in high density forest areas

Outage Frequency Comparison by Land Cover Type

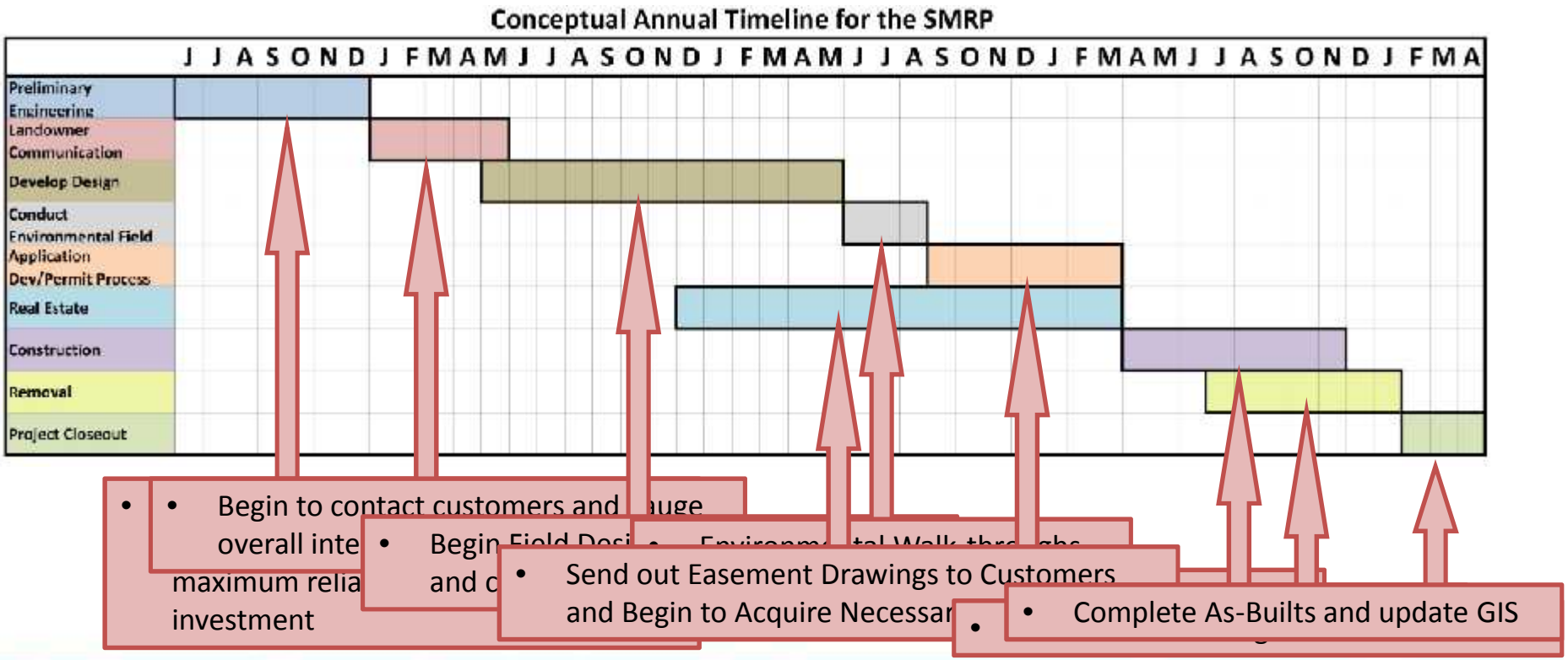



- 5,413 customers (1.2%) experienced an average of 10+ outages per year
- 90% of those outages were located in high density forest areas

# System Modernization and Reliability Overview (SMRP)

- Pilot Program in 2012 (15 miles and 238 customers)
- Project officially began in Fall of 2012
- First Construction Season in 2014 (Spring)
- Initial project duration was for 5 years (2014 - 2018)
- Approximately 200 - 300 miles per year
- Expected to decrease outage minutes of project areas by 75%
  - 20-25% reduction in WPSC overall SAIDI numbers by the end of 2018
  - Assuming similar weather severity, this reduction would move WPSC from the 3rd quartile into the 2nd quartile based on national SAIDI benchmarks
- SMRP Phase 2 approved by Public Commission of Wisconsin for 3 additional years in 2017 for construction through 2021

# System Modernization and Reliability Overview




- Begin to contact customers and
- overall inte
- maximum relia
- investment
- Begin
- and c
- Send out Easement Drawings to Customers and Begin to Acquire Necessar
- Complete As-Builts and update GIS

# Project Locations by Year

2014

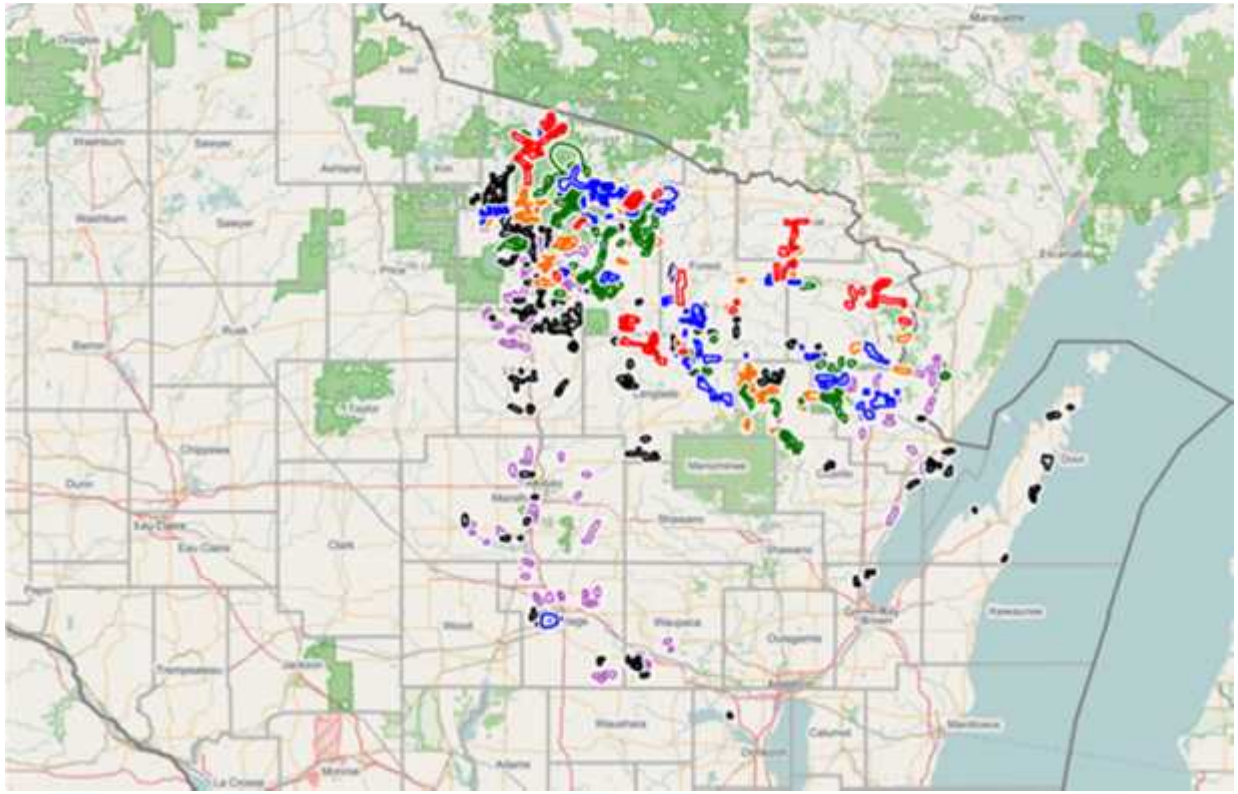
2015

2016

2017

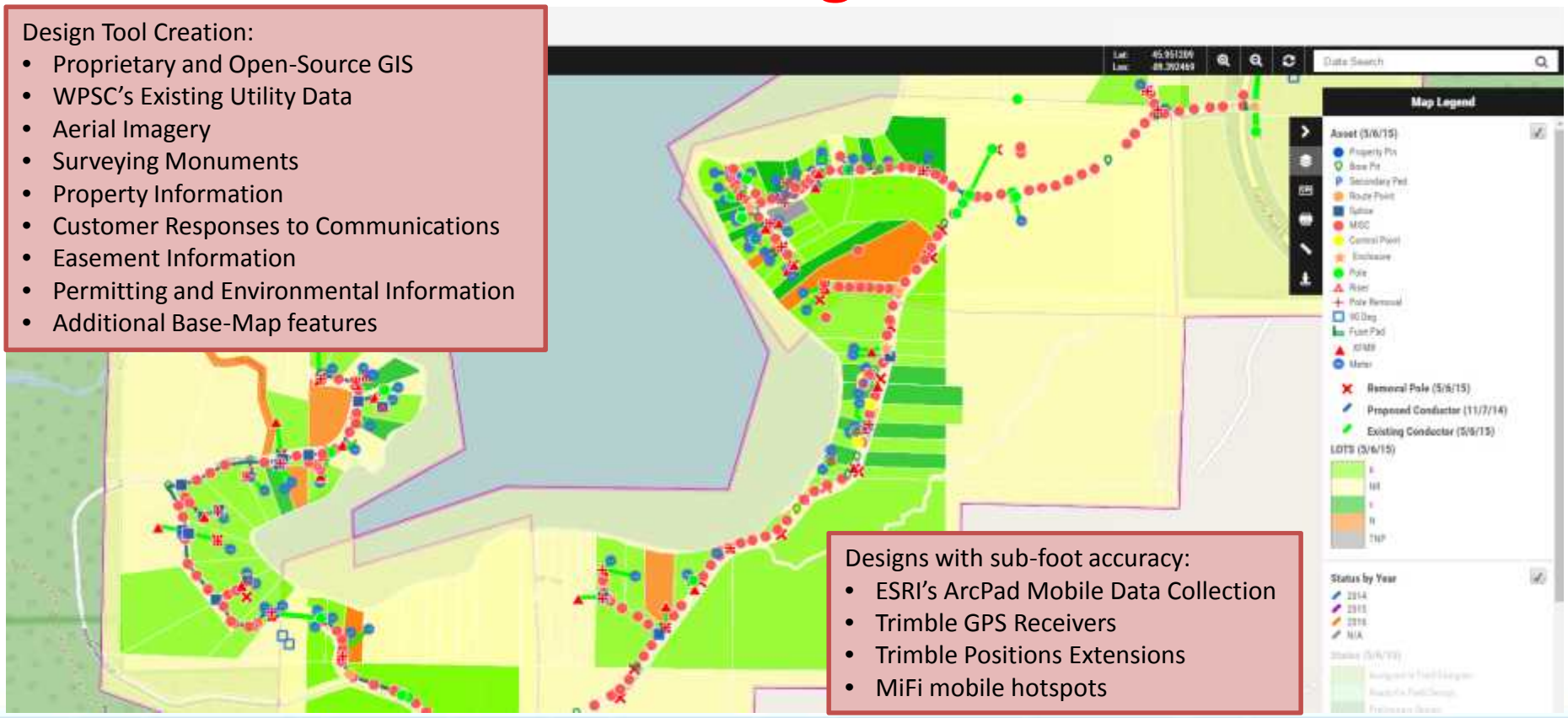
2018

2019



# Field Design Tool

Design Tool Creation:
- Proprietary and Open-Source GIS
- WPSC's Existing Utility Data
- Aerial Imagery
- Surveying Monuments
- Property Information
- Customer Responses to Communications
- Easement Information
- Permitting and Environmental Information
- Additional Base-Map features




Designs with sub-foot accuracy:
- ESRI's ArcPad Mobile Data Collection
- Trimble GPS Receivers
- Trimble Positions Extensions
- MiFi mobile hotspots

# Alternatives to SMRP

1. Continue to maintain the existing system with current maintenance
   - Lower cost when compared to SMRP, but only provides minimal “as-needed” improvements without the large increase in system reliability that WPS was seeking
2. Expand the existing ROW to clear additional vegetation and/or increasing the frequency of the trim cycle
   - The cost of purchasing additional easements to increase ROW and the increased input of landowners on the negative impact to aesthetics led to this option not being viable
3. Rebuild overhead distribution lines with taller and stronger poles coupled with larger and stronger conductors
   - Weather events that now may break the conductor could potentially break or down poles with a hardened system, causing extended outages. In addition, the cost of rebuilding a rural distribution system would cost an estimated $99,000 per mile. Approximately 2/3 the estimates for underground construction and would still require continued vegetation maintenance.

# Estimated Cost of SMRP

## Installation Cost

| Installation Cost | Cost Per Mile |
|---|---|
| 1Φ Primary Circuit | $105,000 |
| 3Φ Primary Circuit | $110,000 to $170,000 |
| Service Installation | $7,000 |
| Design Cost | $77,000 |
| Overhead Removal Cost | $30,000 |
| Distribution Automation | $50,000 |

- Over the initial five year plan, total SMRP costs were estimated at $218 million.
- $40 million/year for Underground Construction and the balance for Distribution Automation
- Cost to be offset by the reduced operation and maintenance, and an increase in the traditional cost of service to assign distribution cost to mostly residential and small commercial customers.

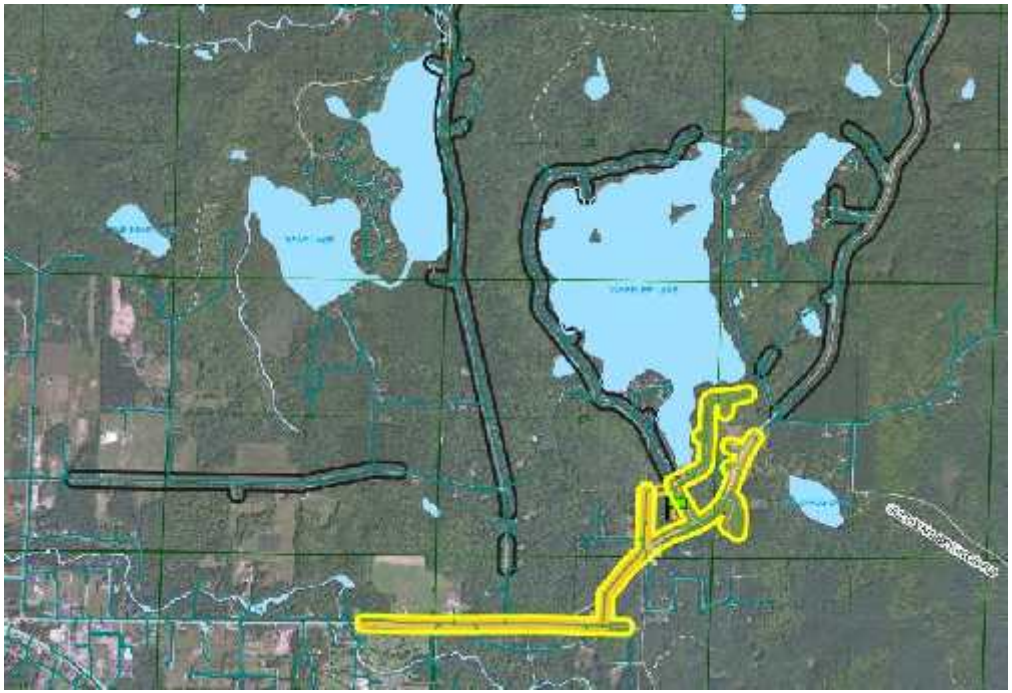
## Cost to Customers

- A typical residential customer would see an approximate increase of $0.45/month (0.5%) in the initial year of SMRP and at the end of the initial 5 year construction period; a typical residential customer would experience the highest increase at approximately $4.30/month.

# Feeder Prioritization

Created an internal weighted reliability matrix which includes:

- Total Length of Line
- Length of Line Cross Country
- Total Connected Transformer kVA
- Existing Overhead Conductor Size and Remaining Service Life
- Estimated Cost to Rebuild Line
- Annual Trimming Costs
- Customer Minutes of Interruption
- Reliability Cost



# Gauging Customer Interest

A self-addressed stamped post card was provided so that they could easily reply to essentially one of two options regarding their participation in the project.

Option 1: Choose to bury their existing overhead service from the last overhead point to the service entrance. If the service was less than a certain distance from the last WPS pole then the work would be completed at no cost to the customer if they were ready to accept the new service at the time of cut-over and all electrician work had been completed.

Option 2: Choose to leave their existing service overhead and WPS would bury the overhead system up to the last pole.

For those services within the projects that were already underground, WPS would remove the service from the overhead system and splice it into the new underground system at no additional cost to the customers.

Additional Information Gathered from Customers:

- If access is granted to the parcel for design
- If customer is interested in converting service to underground
- If customer would consider granting an easement
- If additional follow-up was requested by parcel owner

# Developing the Design

With parcel owners interest confirmed and Right of Entry granted, the SMRP designers would also attempt to utilize public ROW whenever possible and practical in order to minimize the number of easements required to construct each project.

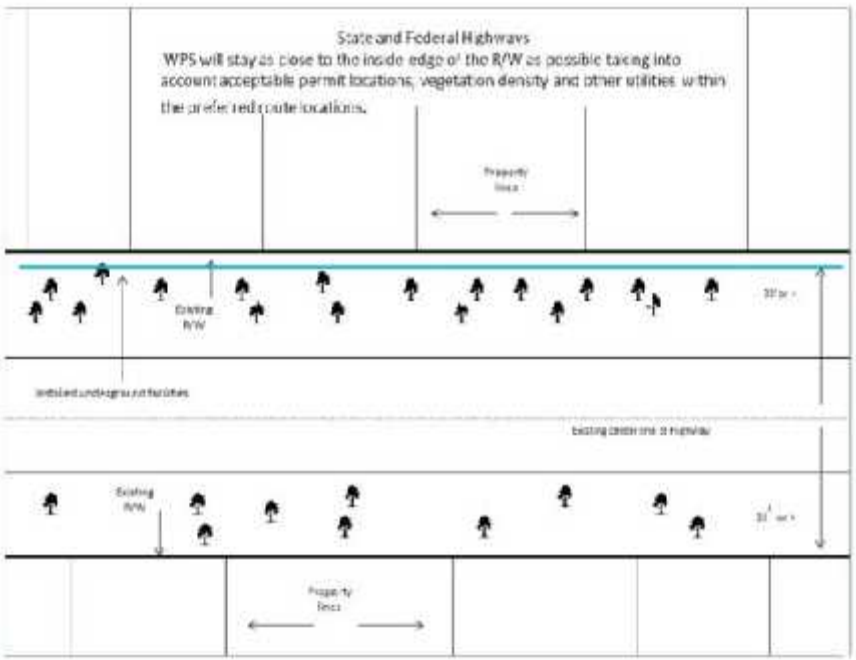
Basic Construction Methods used

- Directional Bore (Trenchless method)
- Plowing (Both vibratory and plug)
- Open Cut Trenching

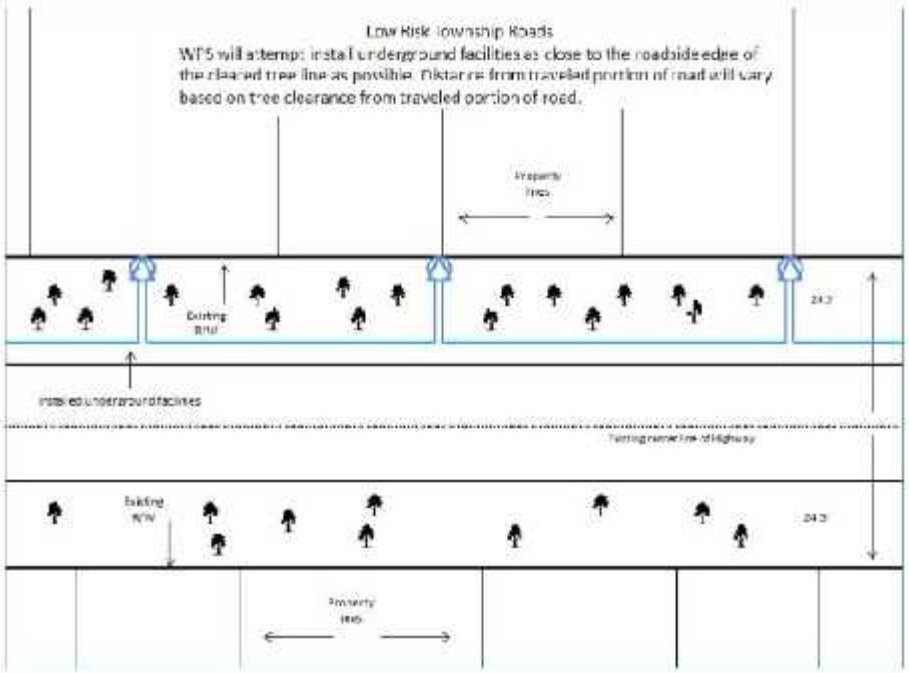
Each method offers various benefits and consequences in regards to soil impact, cost, and constructability.

# Developing the Design

## Highway Construction Preference




## Township Road Construction Preference



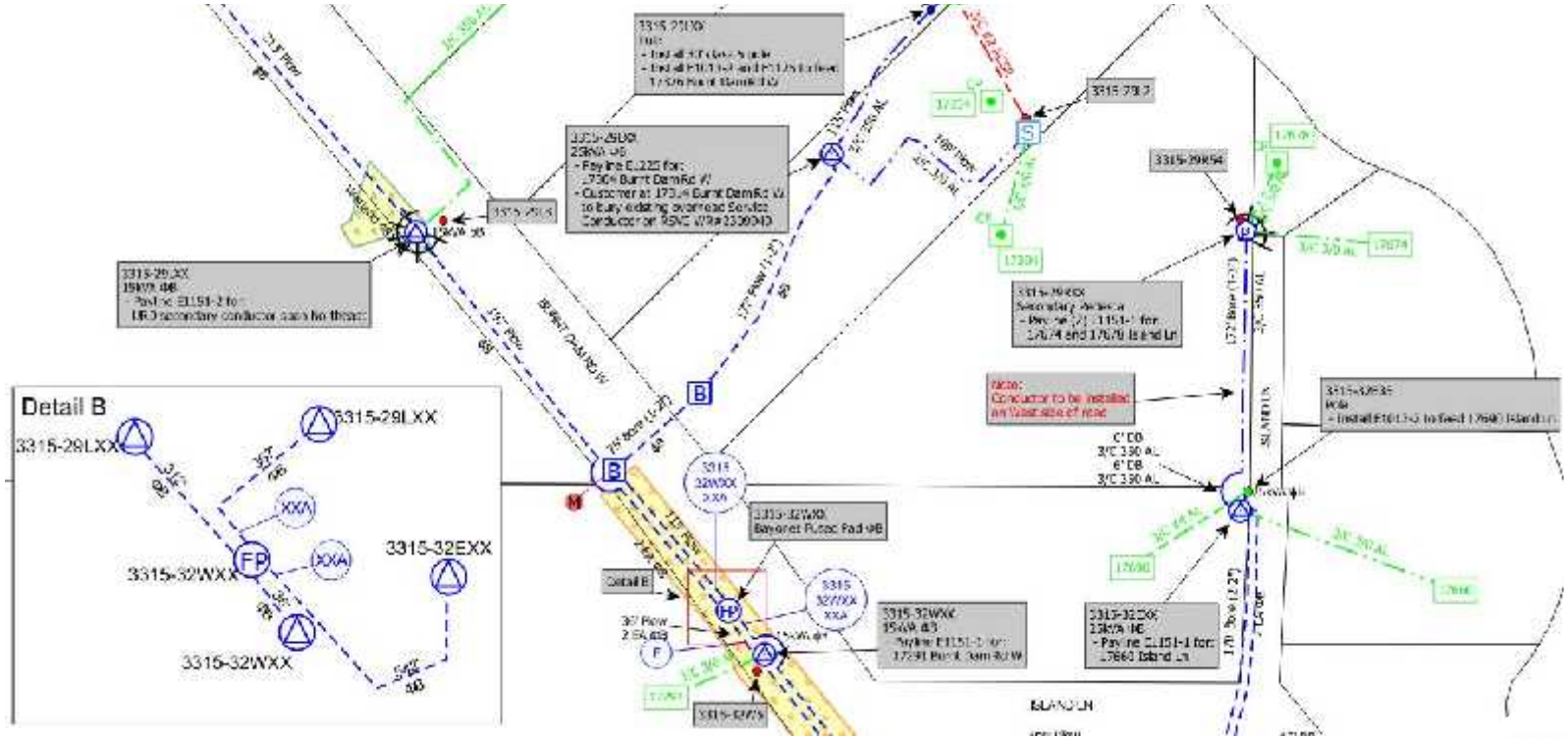
# Desk Design Tool (QGIS)

QGIS provides:

- Customizable Interface
  - Create custom symbology
- Access to Data Attributes
  - Anyone has the ability to access the attributes collected in the field at any time
- Ability to develop custom scripts and plugins
  - Run Quality Control Checks
  - To summarize project details such as asset counts, conductor lengths, billable criteria, or accounting details.
- Ease of Use
  - Data could be easily transferred between field and design states with no data conversion translator was required

# Construction Prints

Create custom asset symbology and notations

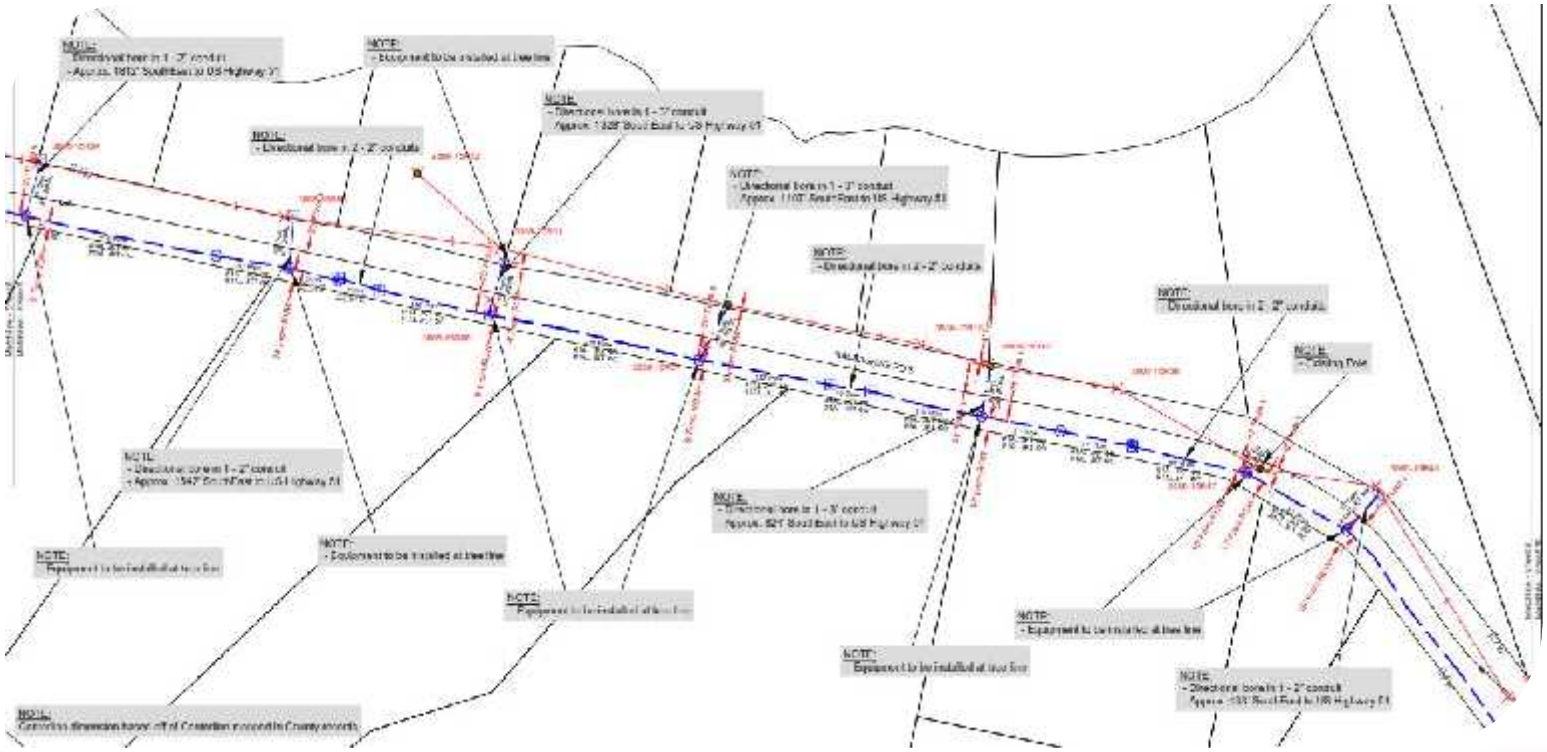


# Environmental Data

Import environmental data to be visualized with construction design

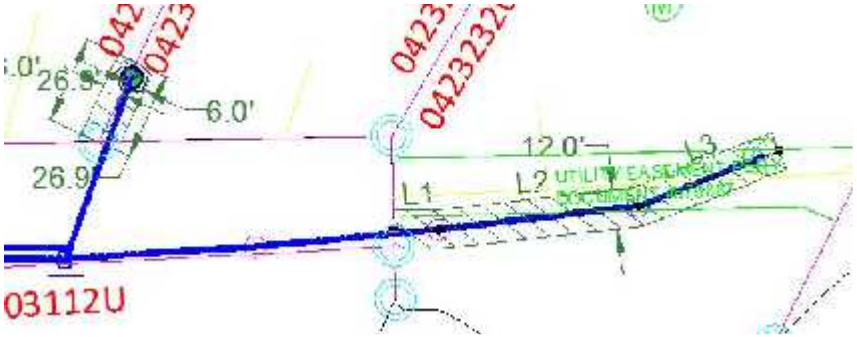
# Permitting

Export Data for General Permitting and Applications



# Easement Drawings

**Export data for Easement Exhibits**



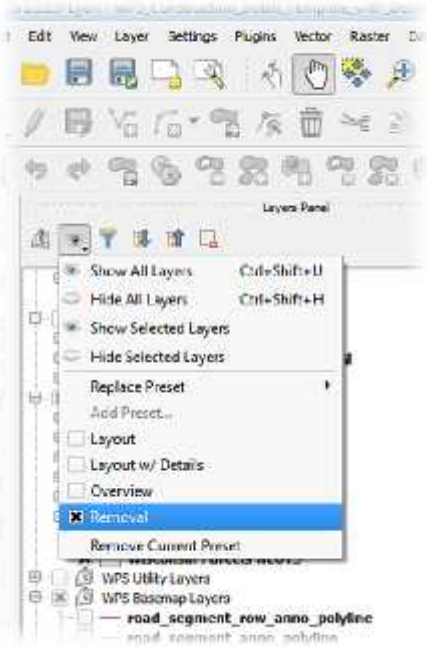

**Import Exhibits to check with design**

# Staking and Construction

Real-Time GPS tracking for equipment staking and flagging routes

# Overhead Removal

Preset Layer Control that allows for multiple prints from one data file




# As-Built Reconciliation

Collect and compare separate layers within one project

- asset_wps
- as_built_asset_wps
- Proposed_Conductor
- as_built_conductor_wps

# Post Construction Early Observations

The first two full years of the SMRP included an installation of:

- 4,997,683' of primary and secondary underground conductor
- Over 934 Junction Enclosures
- 492 Pad-mounted Switchgear devices
- 2,742 Pad-mounted Transformers
- 1,349 new underground services
- Over 280 miles of overhead conductor removed from the system
- There were 9,710 parcels involved including parcels with electric services and vacant parcels
  - Only 437 landowners (approximately 4.5%) that refused right-of-entry for design purposes

SAIDI Impact:

- From 2008 through 2011 specifically for the 2014 underground segments, the average annual SAIDI impacts was 22.84 minutes with an average of 126 outage events annually.
- During 2015 there were a total of 16 outage events in those same 2014 project areas with a total SAIDI impact of 0.76 minutes.
- Other detailed examples of immediate benefits and some important "lessons learned" are summarized in the annual post construction reports that were submitted to the Public Service Commission.

# Questions?

# Thank you!