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ASSET CONDITION ASSESSMENT REPORT 2022

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Executive Summary

This report relays the findings of an Asset Condition Assessment ("ACA") of the major electrical and select civil assets of Westario Power Inc. ("Westario"). As Westario moves towards a risk-based asset management strategy to determine the optimal timing and scope of investments into asset renewal, an ACA is prepared to determine the condition of the in-service assets. The first step towards the implementation of a risk-based asset management approach is to develop a baseline assessment tool, namely the asset Health Index ("HI"), that could be employed to measure and benchmark the health and condition of assets going forward. A comprehensive methodology has been developed and documented within this report for assets comprising the scope of this analysis. The report concludes with a series of recommendations related to the incremental enhancement of Westario's data collection practices and guidelines to include additional assets in future versions of the ACA.

Context of the Study

METSCO Energy Solutions Inc. ("METSCO") previously developed an asset HI framework for Westario's fixed electrical distribution and substation assets in December 2018. Westario engaged METSCO to update the ACA of Westario's fixed electrical distribution and substation assets to improve the accuracy of system health demographics based on the latest 2021/2022 maintenance data. Westario has taken steps to consolidate the collection of inspection data for many of its distribution and substation assets. Continuous improvement of data availability following the recommendations provided in this report will enable Westario to undertake consistent and more robust asset health analysis in future ACA iterations.

Quantitative ACA studies such as this report continue encountering material data availability gaps, in terms of availability of data across the entire asset base, including specific types of information commonly expected in asset HIF. In the instances where data gaps within a given asset class did not enable METSCO to calculate asset HIs for the entire population, METSCO identified these assets as having "No HI" in the respective sections presenting the results of the assessment. In most cases, this classification signals the fact that a given asset does not currently have the requisite number of recorded asset HI parameters to meet the data availability threshold of 70% commonly employed in the industry.

Scope of the Study

This study covers thirteen asset classes, which collectively represent the bulk of material assets owned by Westario.

- Distribution assets:
    - Wood Poles;
    - Steel Poles;
    - Concrete Poles;
    - Overhead Conductors;
    - Underground Cables;

  - Distribution Transformers;
  - Distribution Switches; and
  - Switching Cubicles.
- Station assets:
  - Station Buildings;
  - Station Power Transformers;
  - Station Circuit Breakers;
  - Station Reclosers; and
  - Station Fused Switchgear.

Methodology and Findings

For all asset classes that underwent assessment, METSCO used a consistent scale of asset health, containing five categories – from Very Good to Very Poor. The numerical HI corresponding to each condition category serves as an indicator of an asset's remaining life, given as a score from 0 to 100. The HI formulations for individual asset classes represent weighted averages of numerical scores for individual HI subcomponents, known as condition parameters, scored on a scale from 0 to 100. The numerical score ranges, condition categories, and typical characteristics of an asset are described in Table E - 1.

Table E - 1: Definition of HI Scores

Score (%)	Condition Category	Description
[85-100]	Very Good	Some evidence of aging or minor deterioration of a limited number of components
[70-85)	Good	Significant deterioration of select components to be managed through normal maintenance
[50-70)	Fair	Widespread significant deterioration or serious deterioration of specific components
[30-50)	Poor	Widespread serious deterioration across multiple components
[0-30)	Very Poor	Extensive serious deterioration – an asset has reached its end-of-life

The relative contribution of various condition parameter scores on the aggregate HI results is a function of weighting – assigned by an engineer to each HI subcomponent prior to commencing calculations. Using this methodology, METSCO calculated HI results for every asset class in the scope of our assessment. Section 3 of this report provides an extensive discussion of the HI calculations for each asset class, outlines the assumptions underlying our interpretation of the data provided by Westario, and provides recommendations for future enhancements.

METSCO's findings for each asset class developed using this methodology are provided in Table E - 2 and Figure E - 1.

Table E - 2: Numerical Summary of HI Results

Asset Category	Population – Note 1	HI Distribution (%) – Note2						DAI
		Very Good	Good	Fair	Poor	Very Poor	No HI	
Wood Poles	6638	1862	2557	1332	655	228	4	72%
Steel Poles	1499	45	1426	21	6	1	0	61%
Concrete Poles	34	0	1	6	7	20	0	100%
Distribution Transformers	3196	1466	692	879	77	25	57	94%
Distribution Switches	290	274	14	0	0	2	0	100%
Switching Cubicles	80	0	60	5	0	1	14	83%
Station Buildings	27	0	14	13	0	0	0	100%
Station Power Transformers	29	4	16	9	0	0	0	94%
Station Circuit Breakers	52	3	41	2	0	0	6	84%
Station Reclosers	33	3	21	3	0	0	6	85%
Station Fused Switchgear	15	0	0	12	3	0	0	98%

Note 1: Minor differences to be expected between ACA population count and other data sources due to data scrubbing and assumptions process.

Note 2: Totals may not add up to 100% due to rounding.

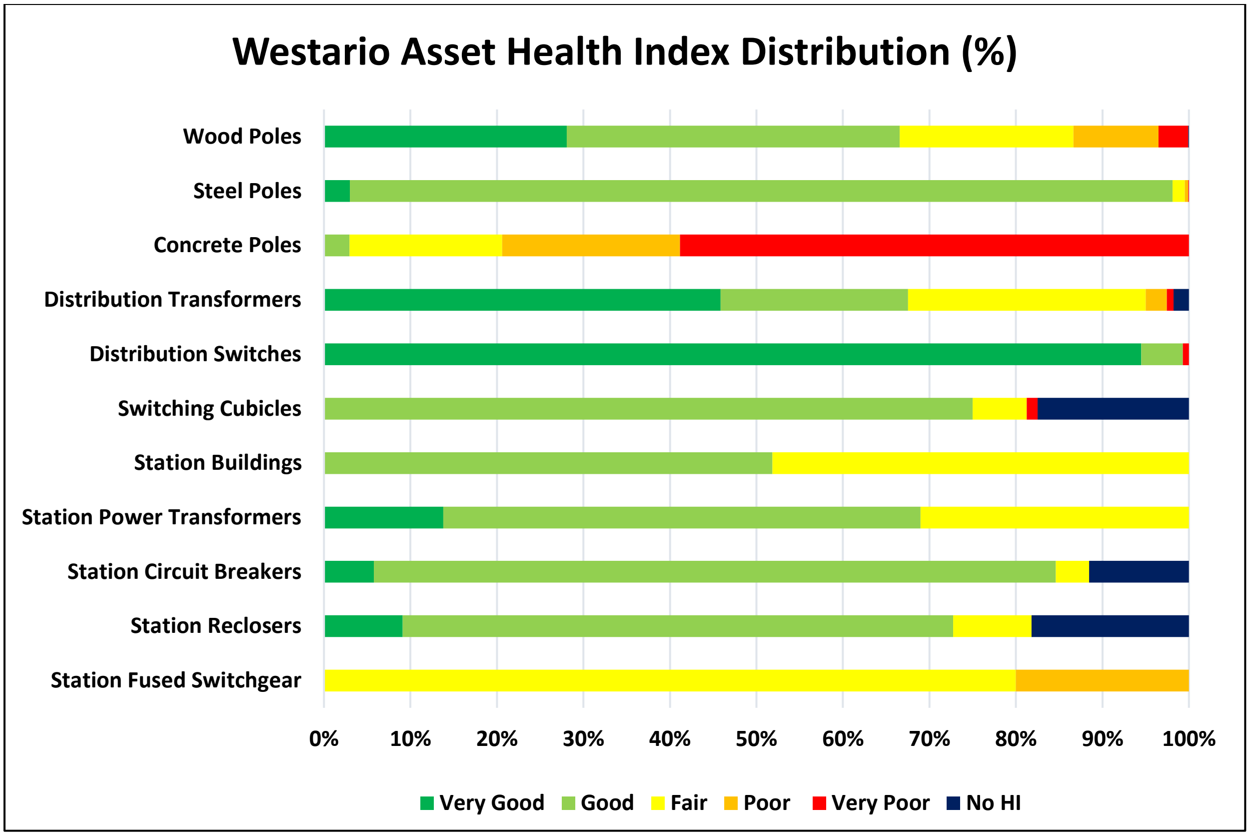

Figure E - 1: Overall Asset Condition Assessment Results

As the above figure indicates, the majority of Westario's assets are in Good condition or better, with contributions of Poor or Very Poor components being relatively minor and not indicative of extensive deterioration across the system or any concerns with the manner in which assets have been managed in the past. Two notable exceptions to this are Westario's concrete poles and station fused switchgear. In both cases, the assets are aging and should be assessed further for needed repair or replacement. Both of these asset classes represent relatively few units in comparison to other asset classes included in this study.

The presence of assets classified as having No HI corresponds to the individual units where the number of available data inputs was below the required threshold – below which the HI cannot be reliably calculated. There are portions of assets with No HI approaching 20% for some asset classes. This is due to inconsistent availability of condition data across asset classes. Recommendations have been provided in the recommendations section of this report to guide Westario to improve the quality and availability of condition data to support future iterations of the ACA.

In the cases of wood and steel poles, visual inspection information is not available for 40% and 68% of the assets, respectively. In these cases, further analysis revealed that more than 78% of the assets without visual inspection results have been in service for less than 30 years. For this reason, it was determined that the service age and/or remaining strength of these assets was sufficient to calculate a valid HI. It should be noted that although an HI was calculated across these asset classes, there is a large portion of wood and steel poles without visual inspection information, which is recommended to calculate a robust HIF for the asset class.

Westario's Current Health Index Maturity and Continuous Improvement

In several cases, Westario's current asset data records contain less than three condition parameters for each asset class – a numerical threshold that qualifies an asset health score to be formally viewed as an asset HI. In these cases, the results of the analysis were specified as two-parameter assessments while the results were presented in a consistent format across all asset classes. Overall, it was found that Westario had a material amount of data that enabled METSCO to conduct an analysis that should yield meaningful managerial insights to the utility's planners.

With respect to the core distribution utility assets like wood poles and station power transformers, relatively advanced multi-factor health indices were developed. Comparatively less information is available for some other asset classes with lower replacement values, or less criticality to system reliability. As with other operating dimensions, utility decisions regarding the scope of data collection represent strategic trade-offs in the environment of multiple priorities and constrained operating costs.

As noted at the outset of this study, Westario is a relatively small entity, with the long-term approach to Asset Management ("AM") data collection and use in decision-making remaining under development. METSCO recommends that Westario consolidate its asset condition collection and analysis activities to determine which additional parameters it will collect to support future iterations of the ACA. We expect that Westario will continue to make these determinations based on the recommendations contained in this report, balancing the continuous improvement considerations with the opportunity cost of other activities it will be required to undertake in the course of its operational and strategic consolidation.

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List of Acronyms

The following acronyms are used within the Asset Condition Assessment report:

Acronym	Definition
ACA	Asset Condition Assessment
AM	Asset Management
AMP	Asset Management Plan
CR	Contact Resistance
DAI	Data Availability Index
DFR	Dielectric Frequency Response
DGA	Dissolved Gas Analysis
EOL	End of Life
GIS	Geographic Information System
HI	Health Index
HIF	Health Index Formulation
HVAC	Heating, Ventilation and Air Conditioning
IR	Insulation Resistance
ISO	International Organization for Standardization
LDC	Local Distribution Company
METSCO	METSCO Energy Solutions Inc.
MS	Municipal Station
OH	Overhead
OQ	Oil Quality
PD	Partial Discharge
PF	Power Factor
UG	Underground
Westario	Westario Power Inc.

1 Introduction

This report summarizes the results of an Asset Condition Assessment ("ACA") study carried out by METSCO Energy Solutions Inc. ("METSCO") on behalf of Westario Power Inc. ("Westario"). METSCO previously developed an asset Health Index ("HI") framework for Westario's fixed electrical distribution and substation assets in December 2018. Westario engaged METSCO to update the ACA of Westario's fixed electrical distribution and substation assets to improve the accuracy of system health demographics based on the latest 2021/2022 maintenance data. To assist Westario with further asset condition data integration efforts, Section 4 of this report contains a set of recommendations for the utility's management to consider going forward.

In preparation of this report, METSCO relied on the following data sources:

- Asset inspection and testing data collected by Westario staff or external contractors;
- Past deliverables pertaining to specific undertakings prepared by staff or consultancies.

The ACA methodology comprising this study assessed multiple categories of assets comprising Westario's distribution and substation systems. Adoption of the ACA methodology would require periodic asset inspections and recording of their condition to identify those most at risk. Additionally, computing the HI for distribution and substation assets requires identifying End of Life ("EOL") criteria for various components associated with each asset type. Each criterion represents a factor that is influential in determining the component's current condition relative to conditions reflective of potential failure. These components and tests shown in the tables are weighted based on their importance in determining a given asset's EOL.

The assets classes covered in the report include the following:

- Distribution Poles (Wood, Steel and Concrete);
- Overhead Primary Conductors;
- Distribution Transformers (Pad- and Pole-mounted);
- Switches;
- Switching Cubicles;
- Station Buildings;
- Station Power Transformers;
- Station Circuit Breakers;
- Station Reclosers; and
- Station Fused Switchgear.

2 Asset Health Index Calculation Methodology

ACA is the process of determining an HI, which is a quantitative expression of an asset's current condition. A brand-new asset should have an HI of 100% and an asset in very poor health should have an HI below 30%. Generating an HI provides a succinct measure of the long-term health of an asset. Table 2-1 presents the HI ranges and the corresponding asset condition.

Table 2-1: HI Ranges and Corresponding Asset Condition

HI Score (%)	Condition	Description	Implications
[85-100]	Very Good	Some evidence of ageing or minor deterioration of a limited number of components	Normal Maintenance
[70-85)	Good	Significant Deterioration of some components	Normal Maintenance
[50-70)	Fair	Widespread significant deterioration or serious deterioration of specific components	Increase diagnostic testing; possible remedial work or replacement needed depending on the unit's criticality
[30-50)	Poor	Widespread serious deterioration	Start planning process to replace or rehabilitate, considering risk and consequences of failure
[0-30)	Very Poor	Extensive serious deterioration	The asset has reached its end-of-life; immediately assess risk and replace or refurbish based on the assessment

2.1 Condition Parameters

Condition parameters of the asset are characteristic properties that are used to derive the overall HI. Condition parameters are specific to each asset class. A condition parameter can be comprised of many sub-condition parameters. For example, the oil quality ("OQ") condition parameter of an asset belonging to the station power transformer asset class includes multiple sub-condition parameters such as acid number, interfacial tension, dielectric strength, and water content.

To determine the overall HI for an asset, formulations are developed based on condition parameters that can be expected to contribute to the degradation and eventual failure of that particular asset type. A weight is assigned to each condition parameter to indicate the amount of influence the condition has on the overall health of the asset. Figure 2-1 provides an example of an HI formulation ("HIF") table.

Degradation Factor:
The asset aging mechanisms, tests, or failure modes.

Condition Indicator Numerical Score:
The converted numerical score associated with the degradation factor, which corresponds directly with the indicator letter score.

Condition Max Score:
The highest obtainable Score for each degradation factor. (4 x Weight)

#	Degradation Factor	Weight	Condition Indicator Letter Score	Condition Indicator Numerical Score	Condition Max Score
1	Degradation Factor 1	4	A-E	4-0	16
2	Degradation Factor 2	6	A,C,E	4,2,0	24
3	Degradation Factor 3	6	A-E	4-0	24
				Asset Max Score	64

Condition Weight:
The impact of the condition with respect to asset failure and/or the safe operation of the asset. Higher impact results in higher weight

Condition Indicator Letter Score:
The letter grade associated with the degradation factor – this is typically captured from the raw inspection data.

Asset Max Score:
The highest numerical grade that can be assigned to the asset / asset class, given the associated degradation factors and weights.

Figure 2-1: HI Formulation Components

The scale used to determine an asset's score for a condition parameter is called the Condition Indicator. Each condition parameter is ranked from A to E and each rank corresponds to a numerical grade. In the above example, a Condition Indicator of 4 represents the best grade, whereas a Condition Indicator of 0 represents the worst grade. In some cases where there are multiple sub-condition parameters contributing to a single condition parameter, the lowest sub-Condition Indicator is taken as the overall Condition Indicator for that parameter. This prevents deficiencies in an asset's health from being covered up by an averaging process during the HI calculation.

The conversion from alphabetic ranking to numerical grade and a brief character description of the grade is provided in Table 2-2.

Table 2-2: Sample Letter-Numerical Conversion Chart

Letter/Number Grade	Grade Description
A – 4	Best Condition
B – 3	Normal Wear
C – 2	Requires Remediation
D – 1	Rapidly Deteriorating
E – 0	Beyond Repair

2.2 Final Asset Health Index Formulation

The final HI, which is a function of the Condition Indicators and weights, is calculated based on the following formula:

$$HI = \left(\frac{\sum_{i=1} W_i * CI_i}{CI_{max.}} \right) x\ 100\%$$

where:

- *i* corresponds to the condition parameter number within the HI formulation;
- CI_i represents the Condition Indicator as determined from the testing or field-inspection procedure that is associated with condition parameter *i*;
- W_i represents the relative importance of condition parameter *i* within the HI based on the impact of the parameter on the asset's overall failure probability;
- CI_{max} represents the highest numerical grade that can be assigned to the asset and is being used to normalize the final HI score between 0% and 100%; and
- *HI* represents the asset health index as a percentage.

2.3 Asset Health Index Results

An asset's HI is given as a percentage; the HI is calculated only if sufficient condition parameter data for a given asset is available. The subset of the total population with sufficient data parameters is called the sample size. HI results can be analyzed on a per-asset, per-asset-class, or per-system basis depending on the granularity required in the analysis.

2.4 Data Availability Index

The Data Availability Index ("DAI") DAI is a measure of the availability of condition parameter data for a specific asset, as they pertain to the construction of the HI score. The DAI is determined by comparing the sum of the weights of the condition parameters available to the total weight of the condition parameters used to construct the HI for an asset class. The formula is given by:

$$DAI = \left(\frac{\sum_{i=1} W_i * \alpha_i}{\sum_{i=1} W_i} \right) x\ 100\%$$

where:

- *i* iterates through the condition parameters within the HI formulation;
- W_i is the weight assigned to condition parameter *i*;
- α_i represents the data availability coefficient, which is equal to 1 if data is available, and equal to 0 when data is unavailable; and
- *DAI* represents the Data Availability Index as a percentage.

An asset with all condition parameter data available will have a DAI value of 100% independent of the asset's HI score. Assets with a higher DAI will correlate to HI scores with a higher degree of confidence.

2.5 Data Gaps

The HIFs calculated in this study are based only on available data provided by Westario. In almost all instances, additional condition parameters or tests exist that can be performed on an asset to further ascertain its state of degradation. In certain cases, condition parameters may be available for one or several assets in a class, but unavailable for others in the same class. This scenario represents a data gap, wherein the planner must determine whether the number of assets for which a particular parameter is available is sufficient to include it in the calculation of the overall HI.

An asset with all condition parameter data available will have a DAI value of 100%, independent of that asset's HI score. Assets with a high DAI will correlate to HI scores that describe the asset condition with a high degree of confidence. Unless otherwise stated, the DAI threshold is taken to be 70% throughout this study. Where missing data are assumed to be infrequent and random, the HI may be extrapolated across the asset category when the sample size is sufficient, and in other cases, the data may be flagged for collection.

2.6 Use of Age as a Condition Parameter

There is a degree of debate within the electrical utility industry regarding the appropriateness of including age as a condition parameter for calculating asset Health Indices. At the core of the argument against the use of age in assessing asset condition is the notion that age implies a linear degradation path for an asset that does not always match the experience in the field.

While some assets lose their structural integrity faster than would be expected with time, others, such as those with limited exposure to natural environmental factors, or those that benefitted from regular predictive and corrective maintenance, may retain their original condition for a longer time than age-based degradation would imply.

In recognition of the argument as to the limitations of age-based condition scoring, METSCO attempts to limit the instances where it relies on age as a parameter explicitly incorporated into the calculation of asset HI. In some cases, however, the limited number of condition parameters available for the calculation of asset health makes age a useful proxy for the important factors that the analysis would not otherwise capture. In other cases, such as when assessing the condition of complex equipment (e.g., power transformers) – which contain a number of internal mechanical components that degrade with continuous operation and the state of which cannot be assessed without destructive testing – age represents an important component of asset health calculation irrespective of the number of other factors that may be available for analysis.

In the context of the current study, the availability of data on condition parameters varied significantly across asset classes. Where METSCO deemed the number of available condition parameters as insufficient to calculate a reliable HI for a particular asset class, and especially where the available information amounted to factors that do not represent the most significant degradation factors for a particular type of equipment, we included age as one of the condition parameters where nameplate data was available.

3 Asset Condition Assessment Results

This section presents the current HIF for each asset class, the calculated HI scores, and the data available to perform the study.

For most of the asset classes, an HIF was previously developed in the 2018 ACA. Where applicable, these HIFs were modified based on the most recent industry best practices and Westario-specific data availability. In the case of Overhead ("OH") conductors and Underground ("UG") cables, asset information was limited given the lack of available condition data for these asset classes. In other cases, demographic data from the asset registry was used along with the results of visual field inspections to calculate the asset's HI. While two data points are not sufficient for a rigorous HI (which requires a minimum of three input parameters to qualify as a full HI), the availability of some condition data is significantly better than none.

In these cases, the comment is made that a two-parameter assessment was conducted. For the sake of consistency in reviewing the study's results, however, all of our findings are presented in the same visual distribution format – separating assets into five condition bands between Very Poor and Very Good with the sixth category of No HI to identify the number of assets where data availability was insufficient to meet the threshold.

Table 3-1 and Figure 3-1 present the results of the ACA study in numerical and graphical format, respectively.

Table 3-1: Numerical Summary of HI Results

Asset Category	Population – Note 1	HI Distribution (%) – Note2						DAI
		Very Good	Good	Fair	Poor	Very Poor	No HI	
Wood Poles	6638	1862	2557	1332	655	228	4	72%
Steel Poles	1499	45	1426	21	6	1	0	61%
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Distribution Transformers	3196	1466	692	879	77	25	57	94%
Distribution Switches	290	274	14	0	0	2	0	100%
Switching Cubicles	80	0	60	5	0	1	14	83%
Station Buildings	27	0	14	13	0	0	0	100%
Station Power Transformers	29	4	16	9	0	0	0	94%
Station Circuit Breakers	52	3	41	2	0	0	6	84%
Station Reclosers	33	3	21	3	0	0	6	85%
Station Fused Switchgear	15	0	0	12	3	0	0	98%

Note 1: Minor differences to be expected between ACA population count and other data sources due to data scrubbing and assumptions process.

Note 2: Totals may not add up to 100% due to rounding.

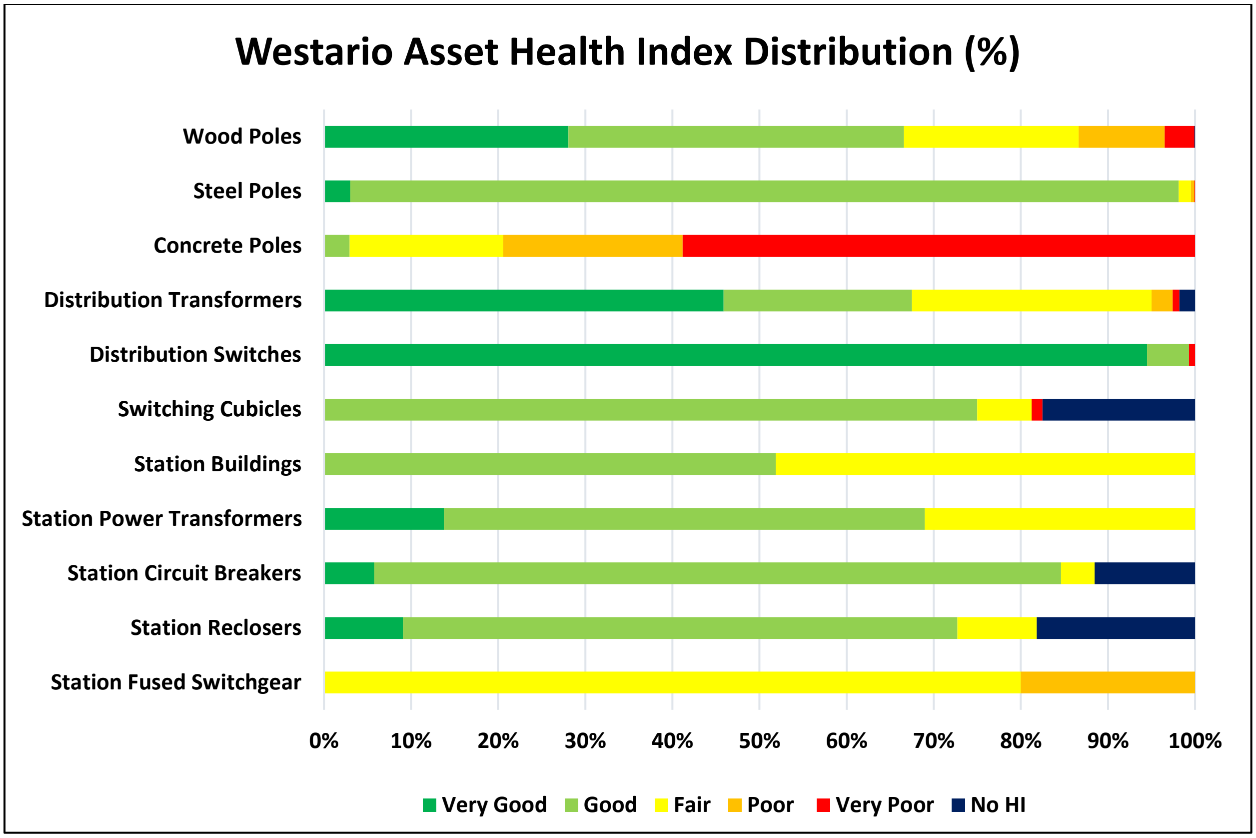

Figure 3-1: Overall Asset Condition Assessment Results

As the above figure indicates, the majority of Westario's assets are in Good condition or better, with contributions of Poor or Very Poor components being relatively minor and not indicative of extensive deterioration across the system or any concerns with the manner in which assets have been managed in the past. Two notable exceptions to this are Westario's concrete poles and station fused switchgear. In both cases, the assets are aging and should be assessed further for needed repair or replacement. Both of these asset classes represent relatively few units in comparison to other asset classes included in this study.

The presence of assets classified as having No HI corresponds to the individual units where the number of available data inputs was below the required threshold – below which the HI cannot be reliably calculated. There are portions of assets with No HI approaching 20% for some asset classes. This is due to inconsistent availability of condition data across asset classes. Recommendations have been provided in the recommendations section of this report to guide Westario to improve the quality and availability of condition data to support future iterations of the ACA.

In the cases of wood and steel poles, visual inspection information is not available for 40% and 68% of the assets, respectively. In these cases, further analysis revealed that more than 78% of the assets without visual inspection results have been in service for less than 30 years. For this reason, it was determined that the service age and/or remaining strength of these assets was sufficient to calculate a valid HI. It should be noted that although an HI was calculated across these asset classes, there is a large portion of wood and steel poles without visual inspection information, which is recommended to calculate a robust HIF for the asset class.

3.1 Distribution Assets

3.1.1 Wood Poles

Westario owns approximately 6600 wood poles distributed throughout all the towns in its service territory.

Condition Assessment Methodology

Wood poles are an integral part of the distribution system. Poles are the support structure for OH distribution lines as well as assets such as OH transformers, switches, and reclosers.

Wood, being a natural material, has degradation processes that are different from other assets in distribution systems. The most critical degradation processes for wood poles involve biological and environmental mechanisms such as fungal decay, wildlife damage, and effects of weather which can impact the mechanical strength of the pole. Loss in the strength of the pole can present additional safety and environmental risks to the public and the utility.

In the short term (one to three years), the most informative end-of-life criterion is the calculation of remaining strength through pole testing. However, since pole strength tends to fall off quickly as a pole starts to degrade, the preferred predictor over the medium to long term (three to ten years) is age. A pole that is not yet showing effects of age but exhibits other defects such as large cracks or rot may also be targeted for replacement.

The HI for wood poles is calculated based on end-of-life criteria summarized in Table 3-2. Appendix B1 provides grading tables for each condition parameter.

Table 3-2: Wood Poles HI Algorithm

Condition Parameter	Weight	Ranking	Numerical Grade	Max Score
Remaining Strength	8	A,B,C,D,E	4,3,2,1,0	32
Overall Condition	6	A,B,C,D,E	4,3,2,1,0	24
Service Age	3	A,B,C,D,E	4,3,2,1,0	12
Surface Decay	2	A,B,C,D,E	4,3,2,1,0	8
Mechanical Damage	2	A,B,C,D,E	4,3,2,1,0	8
			Total Score	**84**

Data Collection and Assumptions

Westario's annual pole inspection records and asset registry within the Geographic Information System ("GIS") were the primary sources of information used to complete the wood poles condition assessment. Pole inspection records from 2018-2021 were used to determine the remaining strength, overall condition, surface decay, and mechanical damage for each pole. The most recent record of inspection for each asset was used to determine the score for each condition parameter.

After consulting the four most recent annual pole inspection records, overall visual condition was determined for 60% of Westario's wood poles. In general, the most comprehensive visual inspection was performed in 2019, with less information being available for the assets in the 2018, 2020, and 2021 inspection records. The overall condition parameter was determined based on any cracks identified, woodpecker damage, insect infestations, and wetness on the ground surrounding the pole. These visual inspection items were available in all the inspection records. The additional visual inspection items recorded in the 2019 record (e.g., lightning damage, pole top rot, and pole lean) could not be included in the analysis because inspections were only performed on poles in 3 towns during the year: Kincardine, Port Elgin, and Southampton.

Pole age was recorded in the GIS as well as in each annual inspection record. If pole age was not recorded in the GIS for a certain asset, each annual inspection record was scanned to see if pole age was recorded for the asset. After compiling the age information from all data sources, service age was determined for 75% of Westario's wood poles. The remaining wood poles with known locations were assumed to be as old as the average age of the poles within the respective town.

METSCO was not able to align the pole inspection records to the asset registry in terms of Facility ID. The global address of each pole was provided in each file as coordinates and was used to link the inspection results to the poles in the asset registry. One additional assumption was made regarding the remaining strength of Westario's newest wood poles. The remaining strength of a wood pole represents the comparison of the pole's current strength compared to the standardized strength of a brand-new pole. All of Westario's wood poles with a service age of 10 years or less which had not been tested for remaining strength were assumed to have a remaining strength of 100%.

The overall DAI for Westario's wood poles is 72%. Initially, the calculations for wood poles were done with a DAI threshold of 66% to account for the weighting system of the asset class. Using this DAI threshold yielded a valid condition score for 60% of Westario's wood poles. Upon further analysis, it was noted that the remaining 40% of the wood pole assets were missing visual inspection results, preventing the asset from meeting the DAI threshold. It was noted that 78% of the assets without visual inspection results were in service for 30 years or less. For this reason, it was determined that the service age and/or remaining strength of these assets was sufficient to calculate a valid health index. A DAI threshold was not used for the final condition assessment of Westario's wood poles.

Demographics

Age information is directly available for 75% of Westario's wood pole population. It was estimated that wood poles with an unknown age are the average age of the poles within the same town. Table 3-3 presents the average age for wood poles within each town.

Table 3-3: Average Age of Wood Poles by Town

Town	Average Wood Pole Age
Clifford	31
Elmwood	30
Hanover	33
Harriston	25
Kincardine	27
Lucknow	15
Mildmay	24
Neustadt	23
Palmerston	7
Port Elgin	31
Ripley	15
Southampton	25
Teeswater	31
Walkerton	33
Wingham	24

Figure 3-2 presents the age distribution for wood poles within Westario's service territory. It is observed that there is a relatively consistent distribution of wood poles across the age categories, and it is estimated that 60% of Westario's wood poles were installed within the last 30 years. Four of Westario's wood poles did not have location or age information available and are shown as "Unknown" in Figure 3-2.

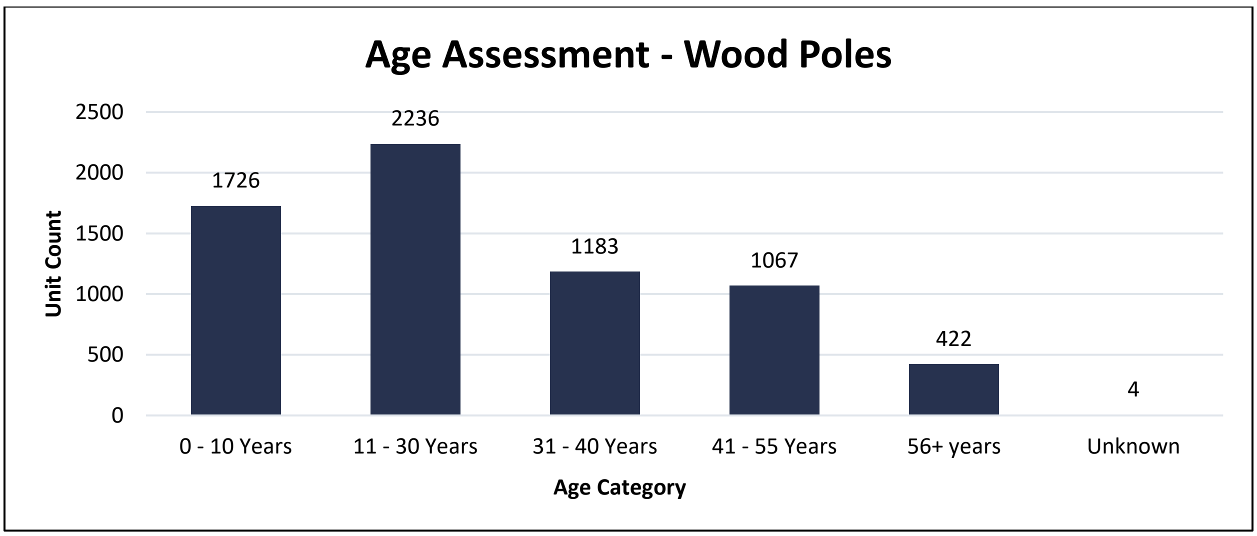

Figure 3-2: Wood Pole Age Demographic

HI Results

Westario owns approximately 6600 wood poles and valid HI results were calculated for all but 4 assets. Most of Westario's wood poles that have valid HI results are in Fair or better condition; however, 655 of the poles are in Poor condition and 228 of the poles are in Very Poor condition. The assets in Poor and Very Poor condition should be assessed for replacement. The HI results for wood poles are presented in Figure 3-3, and the HI distribution for wood poles by town is given in Figure 3-4.

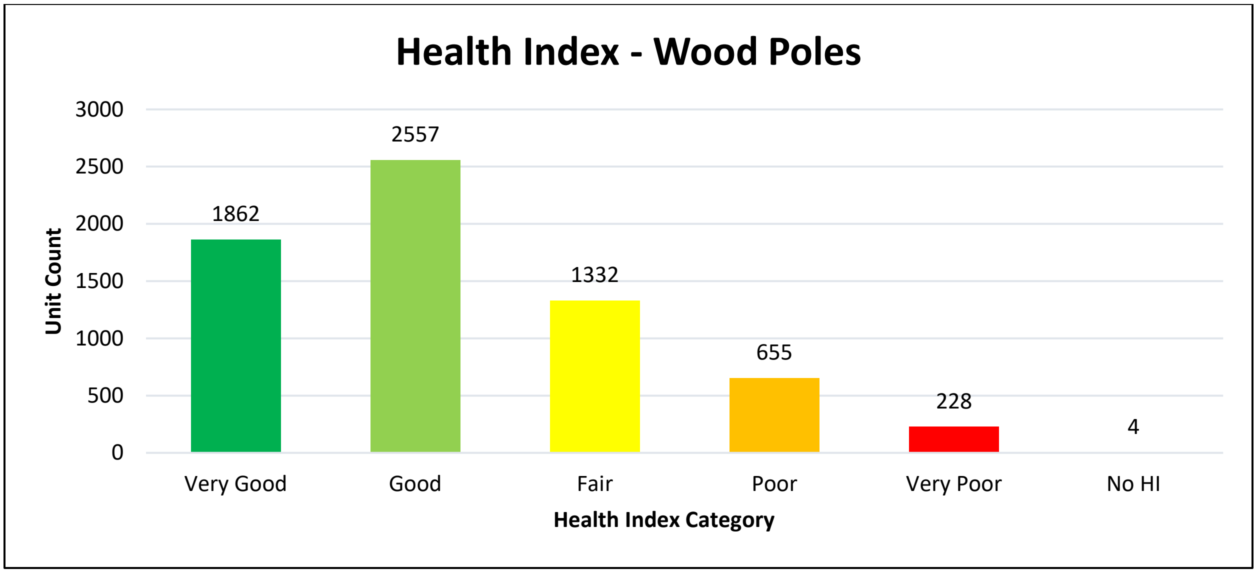

Figure 3-3: Wood Pole HI Results

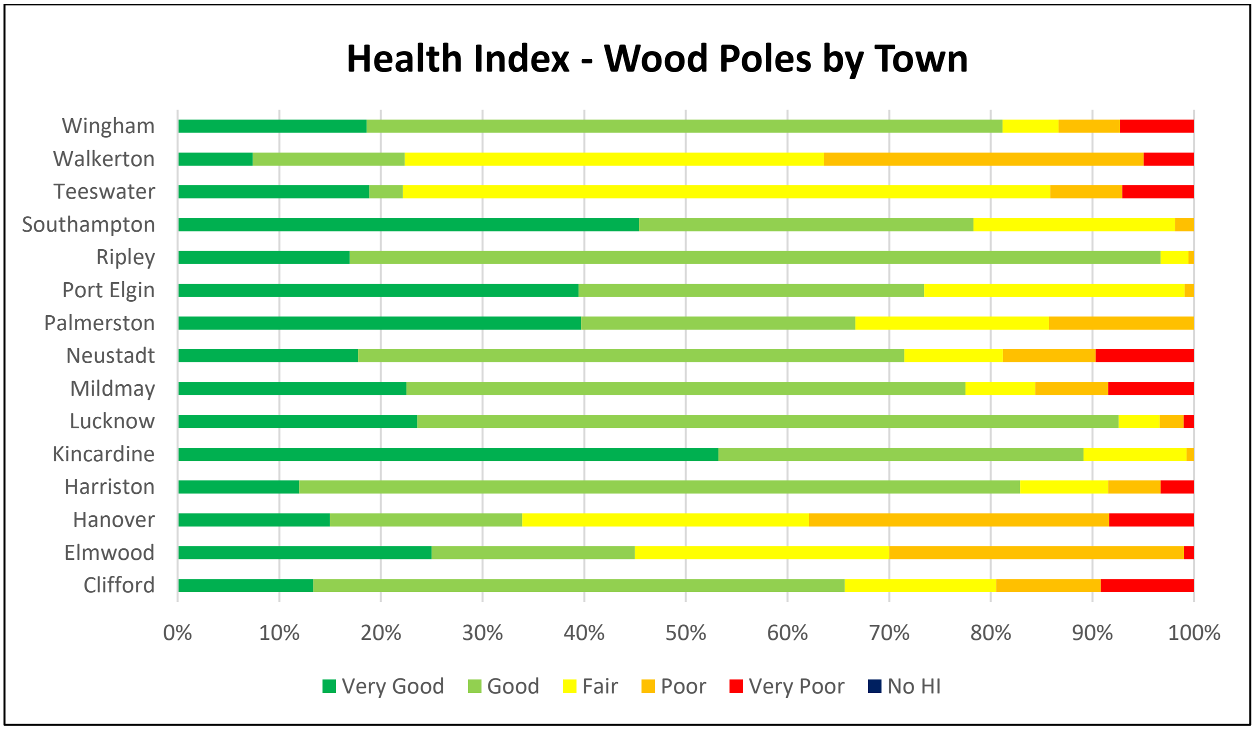

Figure 3-4: Wood Pole HI Distribution by Town

Recommendations for Future Improvements

The condition data currently being collected for wood poles is detailed and should be comprehensively recorded for all assets. Westario's inspection records generally provided useful condition information for wood poles. Having record of this condition information for all assets would be valuable for the condition assessment of wood poles. Westario should ensure that overall condition, surface decay and mechanical damage are all recorded when pole inspections are completed. Assets for which visual inspection results are not available are primarily located in the towns of Wingham, Teeswater, Ripley, Neustadt, Mildmay, Lucknow, Harriston, and Clifford. Westario should prioritize completing visual inspections of its wood poles in these towns, so that the condition of assets can include all of the parameters of the recommended health index formulation.

Westario should consider consolidating its inspection records and asset registry. One option would be to align the inspection records in terms of Facility ID so that the inspections can be linked without using the geographic coordinates. Another option would be to store the most recent visual inspection results for wood poles (e.g., presence of cracks, woodpecker, or insect damage) in the asset registry file. This would streamline the correlation of asset information and inspection records for future condition assessments.

Westario should also consider collecting additional items during the pole visual inspection which would provide insight to the overall condition of the assets. These inspection items have already been collected for wood poles in the town of Kincardine, Port Elgin, and Southampton. Westario should consider including these items on the general pole visual inspection and work towards collecting this information for the entire asset class:

- Pole top decay;
- Ground line rot;
- Pole lean;
- Lightening damage;
- Internal decay; and
- Pole accessory condition (including insulators, cross arms, guy wires, ground wires, and attachment hardware).

3.1.2 Steel Poles

Westario owns approximately 1500 steel poles distributed throughout all the towns in its service territory.

Condition Assessment Methodology

Steel poles have a similar use as wood poles in the distribution system. Replacing aging wood poles with steel distribution poles benefits the utility through higher durability and lower asset lifecycle costs. Steel poles have different degradation mechanisms than wood poles. There is no practical "pole test" for steel poles, but since poles are hollow, there are also limited opportunities for invisible degradation and interior rot. Similar to wood rot, the presence of rust on steel poles compromises the pole's strength and should be identified through visual inspections.

Table 3-4 below provides the steel pole two-parameter HI algorithm. The HI for steel poles is calculated considering both the service age and visually determined overall condition of the asset. Additional details about these condition parameters and how they are graded can be found in Appendix B2.

Table 3-4: Steel Poles HI Algorithm

Condition Parameter	Weight	Ranking	Numerical Grade	Max Score
Overall Condition	4	A,B,C,D,E	4,3,2,1,0	16
Service Age	3	A,B,C,D,E	4,3,2,1,0	12
			Total Score	**28**

Data Collection and Assumptions

The asset registry stored within Westario's GIS was the main source of information used to complete the condition assessment of steel poles. The 2019 pole inspection record also included condition information for steel poles that were tested within that year. The inspection records provided for 2018, 2020, and 2021 did not include inspection results for any steel poles. Age information was available for 96% Westario's steel poles. It was estimated that the remaining 4% of steel poles with an unknown age are the average age of the poles within the same town.

Condition information was only available for 32% of the steel poles. Upon further analysis it was noted that all the assets without visual inspection results were in service for 30 years or less. For this reason, it was determined that the service age alone was sufficient to calculate a health index that reasonably represents the condition of the assets. A DAI threshold was not used for the final condition assessment of Westario's steel poles. The overall DAI for Westario's steel poles is 61%.

Demographics

Age information is directly available for 96% of Westario's steel pole population. It was estimated that the remaining 4% of steel poles with an unknown age are the average age of the poles within the same town. Table 3-5 presents the average age for steel poles within each town.

Table 3-5: Average Age of Steel Poles by Town

Town	Average Steel Pole Age
Clifford	16
Elmwood	18
Hanover	20
Harriston	15
Kincardine	17
Lucknow	16
Mildmay	18
Neustadt	15
Palmerston	3
Port Elgin	15
Ripley	16
Southampton	15
Teeswater	15
Walkerton	17
Wingham	17

Figure 3-5 presents the age distribution for steel poles within Westario's service territory. It is observed that 82% of Westario's steel poles were installed within the last 20 years.

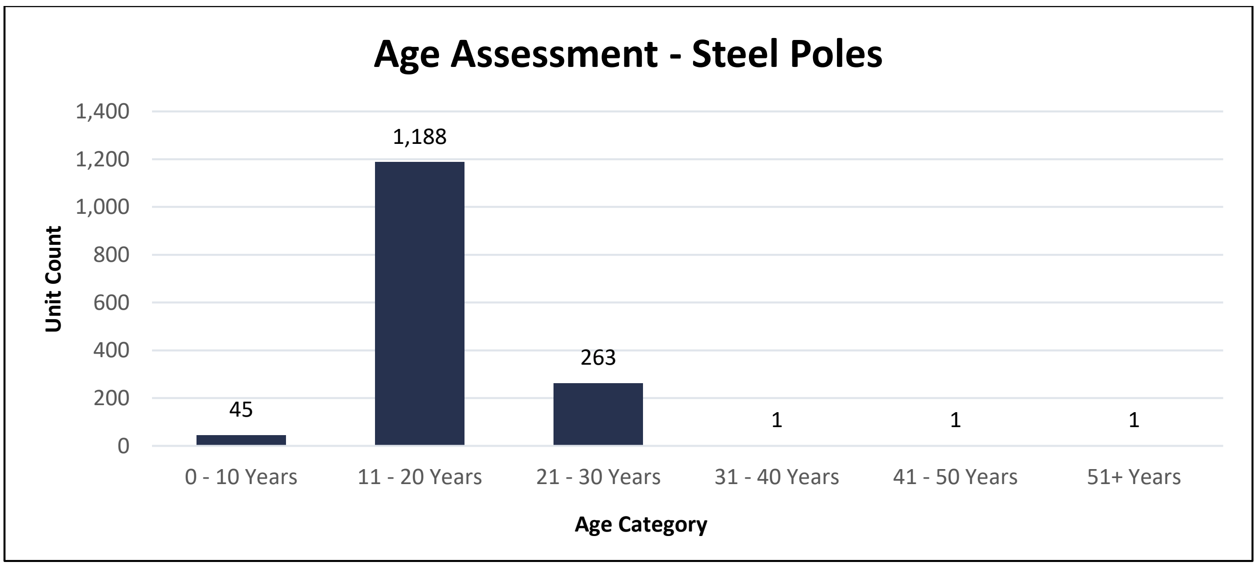

Figure 3-5: Steel Pole Age Demographic

HI Results

Westario owns approximately 1500 steel poles and valid HI results were calculated for all of them. Most of Westario's steel poles that have valid HI results are in Good condition; however 21 of the units are in Fair condition and seven of the units are in Poor or Very Poor condition. The assets in Poor and Very Poor condition should be assessed for replacement. The HI results for steel poles are presented in Figure 3-6, and the HI distribution for steel poles by town is given in Figure 3-7.

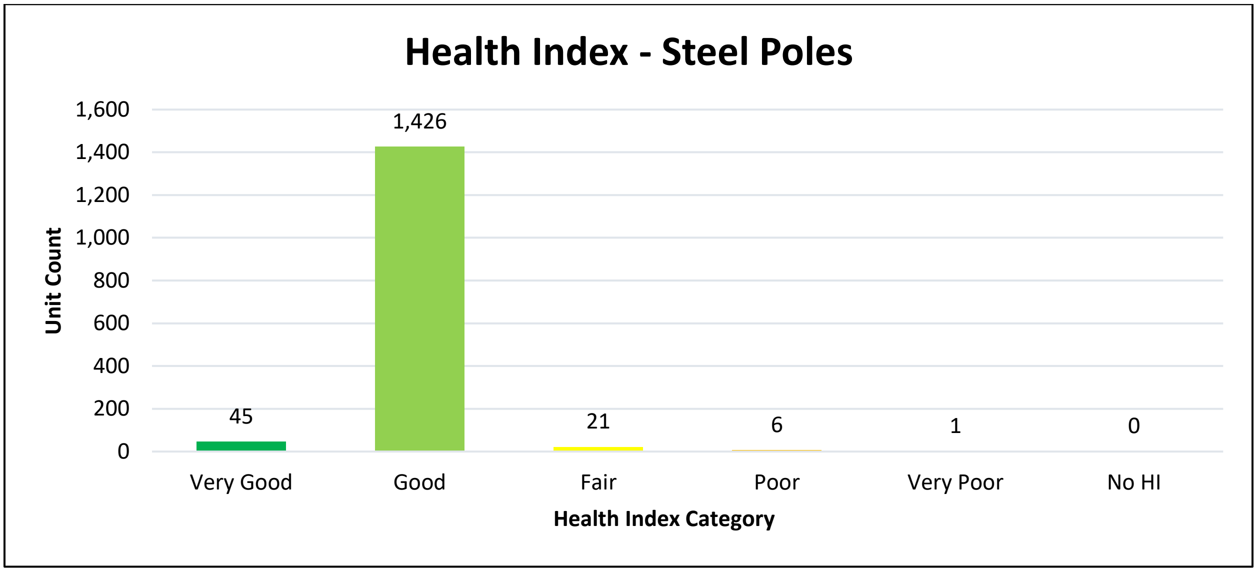

Figure 3-6: Steel Pole HI Results

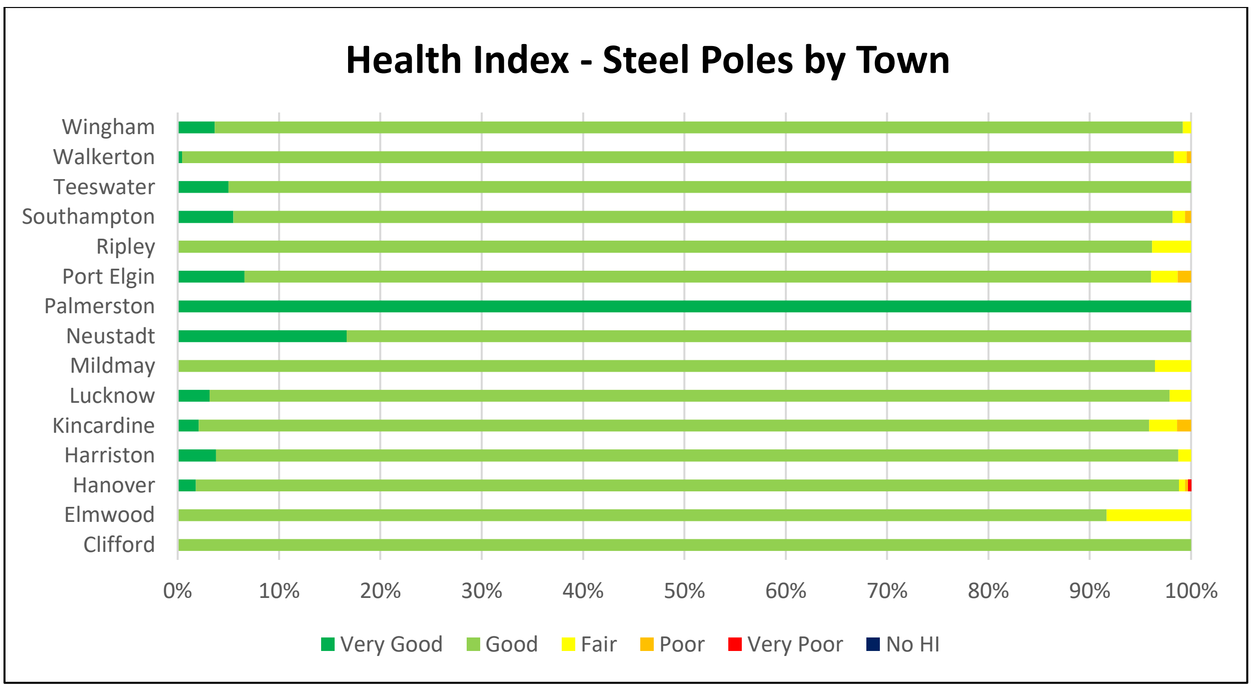

Figure 3-7: Steel Poles HI Distribution by Town

Recommendations for Future Improvements

The availability of condition data is very low for steel poles. Westario should work towards collecting consistent visual inspection data for the remaining 1018 steel poles so that HI results can be calculated across the asset population and include all the condition parameters in the HIF.

It is recommended that a more sophisticated visual inspection be established for the asset class. Recognized HI guides recommend more than a two-parameter formulation to develop a robust index. A best-practice formulation would consider additional condition parameters to be recorded during a visual inspection, including:

- Evidence of rust/corrosion; and
- Evidence of other mechanical damage or defects.

3.1.3 Concrete Poles

Westario owns a total of 34 concrete poles, located within the following towns: Port Elgin. Southampton, and Teeswater.

Condition Assessment Methodology

Concrete poles develop corrosion on the internal reinforcing bars, which expands the iron and displaces the concrete in a process known as spalling. Once spalling begins, poles become weaker and tend to fail over a short number of years. There are limited methods for the long-term repair of a spalled pole. Spalling is accelerated in the presence of road salt. In the short term (one to three years) the most informative indicator is a visual observation of spalling; there is no way to predict that corrosion is occurring inside concrete poles. The best predictor of a need for medium-term replacement (three to ten years) is the age and condition of similar poles.

Table 3-6 below provides the concrete pole two-parameter HI algorithm. The HI for concrete poles is calculated considering both the service age and visually determined condition of the asset. Additional details about these condition parameters and how they are graded can be found in Appendix B3.

Table 3-6: Concrete Poles HI Algorithm

Condition Parameter	Weight	Ranking	Numerical Grade	Max Score
Overall Condition	4	A,B,C,D,E	4,3,2,1,0	16
Service Age	3	A,B,C,D,E	4,3,2,1,0	12
			Total Score	**28**

Data Collection and Assumptions

The asset registry stored within Westario's GIS was the primary source used to complete the condition assessment of concrete poles. The 2019 pole inspection record also included condition information for concrete poles that were tested within that year. The inspection records provided for 2018, 2020, and 2021 did not include inspection results for any concrete poles. Between both sources, age information and condition information were attained for all of Westario's concrete poles. It is recommended that Westario consistently perform and document results of concrete pole visual inspections to improve the accuracy of condition data. The overall DAI for Westario's concrete poles is 100%.

Demographics

Figure 3-8 presents the age distribution for concrete poles within Westario's service territory. Age information is available for all the concrete poles. It is observed that 97% of Westario's concrete poles are between 40 and 70 years old, with 76% of the assets installed more than 50 years ago.

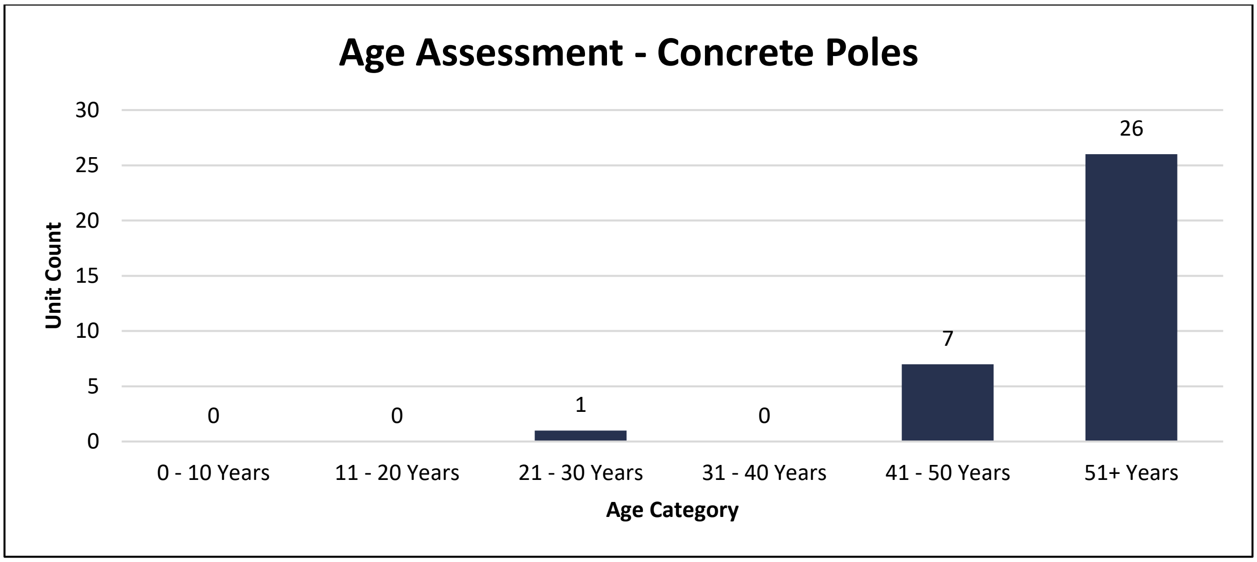

Figure 3-8: Concrete Pole Age Demographic

HI Results

Westario owns 34 concrete poles and valid HI results were calculated for all of them. 59% of Westario's concrete poles are in Very Poor condition. The demographic assessment for the asset class shows that most of Westario's concrete poles were installed more than 40 years ago, indicating that they are approaching their physical End of Life ("EOL"). Additionally, comments in the GIS indicated that 59% of the assets are cracked and visually degraded. The HI results for concrete poles are presented in Figure 3-9, and the HI distribution for concrete poles is given by town in Figure 3-10.

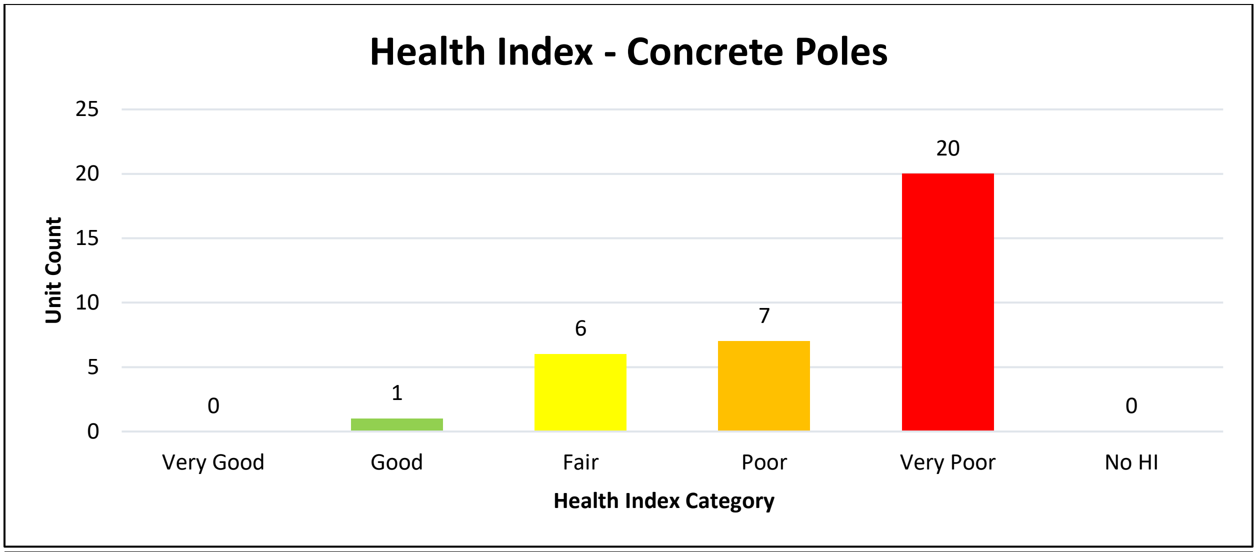

Figure 3-9: Concrete Pole HI Results

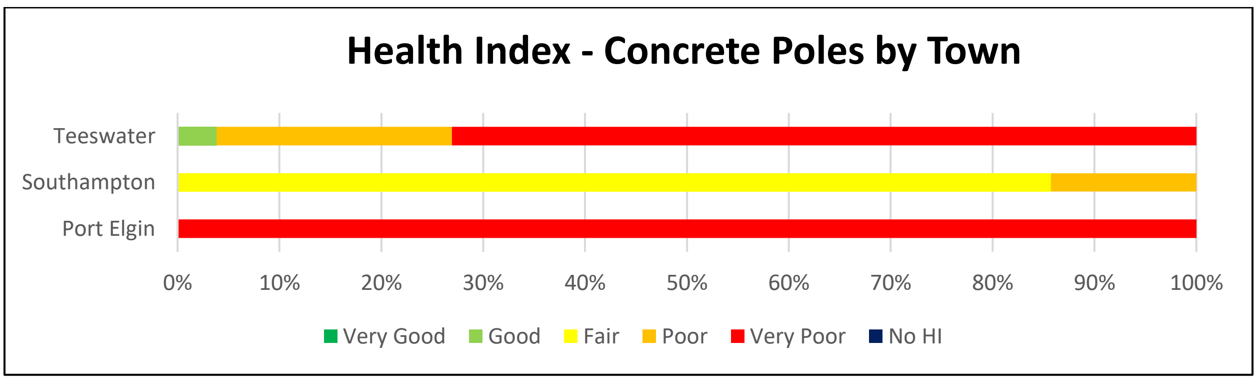

Figure 3-10: Concrete Pole HI Distribution by Town

Recommendations for Future Improvements

Based on the condition information available, 59% of Westario's concrete poles were classified as being in Very Poor condition. Given the age distribution of the assets it is recommended that Westario perform a more sophisticated visual inspection of these assets to determine the need for replacement. Recognized HI guides recommend more than a two-parameter formulation to develop a robust index. A best-practice formulation would consider various condition parameters recorded during a visual inspection such as:

- Evidence of rust/corrosion;
- Evidence of concrete spalling; and
- Evidence of other mechanical damage or defects.

3.1.4 Overhead Conductors

Westario owns 290 km of OH lines throughout its distribution system, of which, 198 km is three-phase, and the remaining 92 km is single-phase.

Condition Assessment Methodology

OH Conductor assets tend to be renewed when poles are replaced, when voltages are upgraded, or when lines are restrung for technical reasons. It is very rare that the conductor condition would drive a distinct replacement investment program. There is one recognized conductor risk, namely the tendency for small copper conductors to age at an accelerated rate and become brittle.

Although laboratory tests exist to determine the tensile strength and assess the remaining useful life of conductors, distribution line conductors rarely require testing. An appropriate proxy for estimating the tensile strength of conductors and estimating the remaining life of an asset is the use of service age.

METSCO's recommended HIF for OH conductors is shown in Table 3-7.

Table 3-7: OH Conductor HI Algorithm

Condition Parameter	Weight	Ranking	Numerical Grade	Max Score
Service Age	2	A,B,C,D,E	4,3,2,1,0	8
Small Conductor Risk	1	A,E	4,0	4
			Total Score	**12**

Data Collection and Assumptions

The asset registry stored within Westario's GIS was used to complete the assessment of OH conductors. A valid HI could not be completed for this asset class due to the poor availability of conductor age information. Age information is only recorded for 2% of the conductor line segments within the GIS. One appropriate assumption would be to estimate the conductor age using the age of the nearest pole. There was no way to link the GIS files provided for Westario's distribution poles and OH conductors. Westario should connect these files to permit the HI calculation for this asset class. Line segment length is also not available in the GIS so the age analysis was done in terms of the number of line segments.

Demographics

Figure 3-11 presents the age distribution available for Westario's OH conductors. Age information is only available for 2% of the line segments in the GIS.

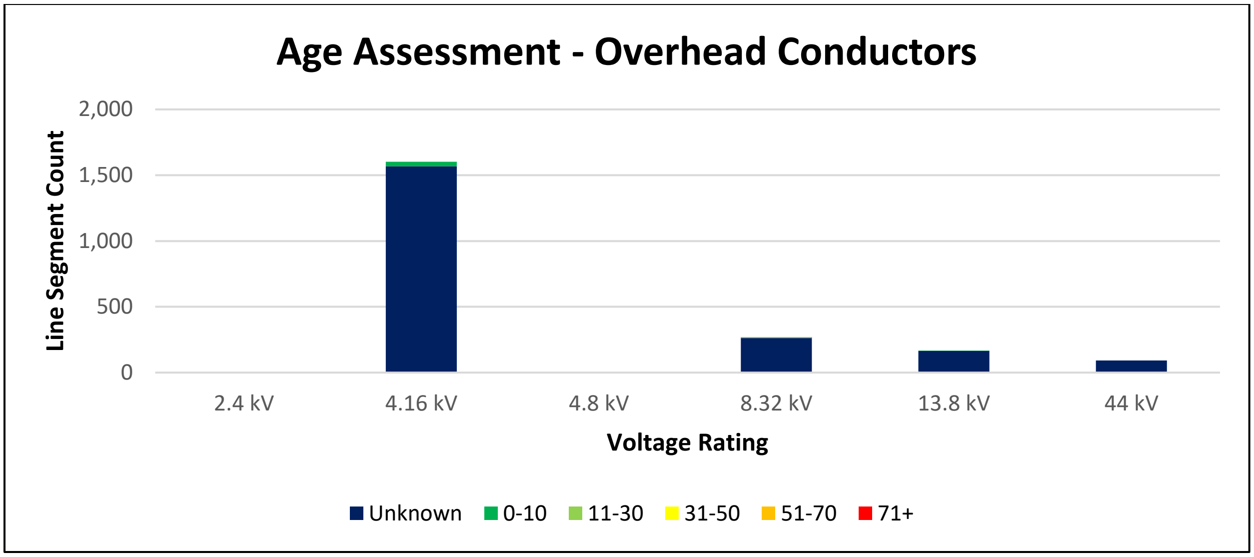

Figure 3-11: OH Conductor Age Demographic

Recommendations for Future Improvements

Westario will need to improve the availability of OH conductor age information in the GIS system to complete the ACA for this asset class. It is recommended that Westario record the Facility ID of the closest pole to each conductor line segment. Once this is done, the age of each line segment can be estimated based on the age of the closest distribution pole. Additionally, Westario should consider determining or estimating the length of each line segment within the GIS.

Westario should also ensure that all OH conductor segments of #4 or #6 copper are tagged in the GIS asset registry. These small copper conductors tend to age at an accelerated rate and become brittle. This condition parameter is important to include in the OH conductor HIF.

3.1.5 Underground Cables

Westario owns 156 km of UG lines throughout its distribution system, of which, 33 km is three-phase, and the remaining 123 km is single-phase.

Condition Assessment Methodology

Distribution UG primary cables are one of the more challenging assets in electricity systems from a condition assessment viewpoint. Although several test techniques, such as partial discharge testing, have become available over recent years, it is still very difficult and expensive to obtain accurate condition information for buried cables. The standard approach to managing cable systems has been monitoring cable failure rates and the impacts of in-service failures on reliability and operating costs. In recognition of these difficulties, cables are replaced when the costs associated with in-service failures, including the cost of repeated emergency repairs and customer outage costs, become higher than the annualized cost of cable replacement.

Service age provides a reasonably good measure of the remaining life of cables with the lack of visual inspection for cable defects. As a minimum, age-based parameters and the knowledge of past failure instances will allow the comparison of a given cable segment to other cables of similar vintage. An additional parameter that can be considered is that any cable sections that have previously experienced a fault are considered a higher risk for recurrence although the data on this topic requires further research.

Many test labs are offering partial discharge ("PD") measurements to assess the condition of cables in service. Partial discharge testing of cables is performed online without disrupting the plant or facilities or offline when required. The data obtained from PD tests can provide critical information regarding the quality of cable insulation and its impact on cable system health. Table 3-8 provides METSCO's recommended HIF for UG cables. Westario should consider collecting data for some or all of the HIF condition parameters to support future ACAs for UG cables.

Table 3-8: UG Cable HI Algorithm

Condition Parameter	Weight	Ranking	Numerical Grade	Max Score
Service Age	10	A,B,C,D,E	4,3,2,1,0	40
Cable Failure Analysis	10	A,B,C,D,E	4,3,2,1,0	40
Field Testing	10	A,B,C,D,E	4,3,2,1,0	40
Condition of Concentric Neutral	9	A,B,C,D,E	4,3,2,1,0	36
Outage Records in Last 5 Years	8	A,B,C,D,E	4,3,2,1,0	32
Loading History	5	A,B,C,D,E	4,3,2,1,0	20
			Total Score	**208**

Data Collection and Assumptions

The asset registry stored within Westario's GIS was used to complete the assessment of UG cables. A valid HI could not be completed for this asset class due to the poor availability of cable age information, and the absence of condition or testing records. Age information is recorded for 27% of the cable line segments within the GIS. Line segment length is also not available in the GIS requiring the age analysis to be done in terms of the number of line segments.

Demographics

Figure 3-12 presents the age distribution available for Westario's UG Cables. Age information is available for 27% of the line segments in the GIS.

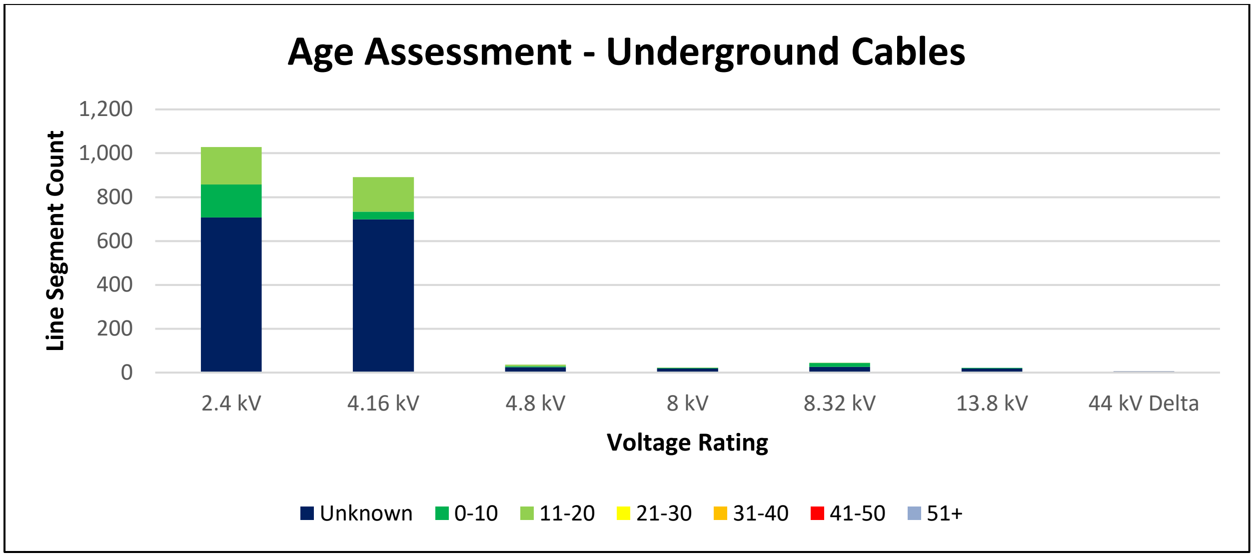

Figure 3-12: UG Cable Age Demographic

Recommendations for Future Improvements

It is recommended that Westario improve the availability of UG cable age information in the GIS system to complete the ACA for this asset class. Additionally, Westario should consider determining or estimating the length of each line segment within the GIS.

Recognized HI guides recommend a multi-parameter HIF for UG cables. The HIF is shown for UG cables in Table 3-8, and it is recommended that Westario collect the following parameters as a minimum to support future ACAs for UG cables:

- Service age;
- Cable failure analysis;
- Field testing; and
- Outage records.

3.1.6 Distribution Transformers

Westario owns approximately 3,200 distribution transformers in its service territory. 1,622 of these transformers are pole-mounted and 1,074 are pad-mounted. The remaining distribution transformers are not defined as either pole-mounted or pad-mounted.

Condition Assessment Methodology

Transformers are another large asset class within the distribution system. This asset category is made up of a large number of units, each with a modest replacement value. Distribution transformers are generally considered to be a run-to-failure asset class with little maintenance other than visual inspections. Transformers may be replaced in planned projects based on identifiable degradation, pole line rebuilds, road relocations, and upgrade projects in response to customer load growth.

Transformers typically reach their end-of-life due to physical tank deterioration such as corrosion, which in extreme cases can lead to an instance of leaking oil. Where corrosion is detected, a transformer may be cycled back to the shop and re-painted with gaskets being replaced. Other modes of failure include overheated connections due to loosened connectors, which are typically detected in infrared scanning and tightened to reduce the failure risk.

Most commonly, utilities replace distribution transformers as part of OH or UG rebuild projects. Occasionally, a transformer will become overloaded due to changes in customer usage which can be detected by summing loads monitored with automated meter infrastructure and can lead to internal failures if not rectified.

Table 3-9 shows the HI algorithm for distribution transformers. Additional details about these condition parameters and how they are graded can be found in Appendix B4.

Table 3-9: Distribution Transformer HI Algorithm

Condition Parameter	Weight	Ranking	Numerical Grade	Max Score
Overall Condition	4	A,B,C,D,E	4,3,2,1,0	16
Service Age	3	A,B,C,D,E	4,3,2,1,0	12
Oil Leaks	2	A,E	4,0	8
			Total Score	**36**

Data Collection and Assumptions

The service age was available or estimated for 84% of the transformers. Visual inspection records were used from 2020 and 2021 to determine the asset's overall condition and to identify any transformers with oil leaks. The visual inspection parameters were scored as either Satisfactory or Unsatisfactory in the inspection record. In the case where a sub-condition parameter was left blank in the inspection record, a Satisfactory condition was assumed.

The DAI threshold for distribution transformers was set at 66% to account for the weighting system defined for the asset class. A valid HI was not calculated for any assets with an individual DAI less than 66%. These assets are classified as No HI in the below plots.

A valid condition score was determined for 98% of Westario's distribution transformers. The overall DAI for this asset class is 94%.

Demographics

Figure 3-13 presents the age distribution for distribution transformers within Westario's service territory. A transformer's age is primarily calculated using the known installation year. Where this information is not available in the GIS, the unit's manufactured year is used as a proxy. If neither install year or manufacture year is known, an assumed install year is determined based on the transformer's manufacturer, shown in Table 3-10. If no transformer manufacturer is identified, Table 3-11 and Table 3-12 are used to estimate the average year of installation of the pole-mounted or pad-mounted transformer in the respective town. These ages are estimated using the town's average age of in-service transformers. 500 distribution transformers were recorded in the visual inspection record but do not appear in Westario's GIS. The ages were left as unknown for these transformers.

Following this demographic analysis, age information is available for 84% of the transformers. It is observed that 28% of Westario's distribution transformers are estimated to have been installed more than 40 years ago.

Table 3-10: Assumed Transformer Install Year by Manufacturer

Name of Manufacturer	Assumed Year of Installation
CAM TRAN	1978
Canadian Electrical Services	1978
Carte	1980
CES	1978
Federal Pioneer	1970
Ferranti Electric	1970
Ferranti Packard	1970
JIMs Electric	1975
McGraw Edison	1950
Moloney Electric	1980
Packard	1950
Porter	1970
Reliance	1975
Siemens	1990
Westinghouse	1965

Table 3-11: Average Pole-Mount Transformer Install Year by Town

Town	Assumed Year of Installation
Clifford	1989
Elmwood	1986
Hanover	1990
Harriston	1994
Kincardine	2006
Lucknow	1998
Mildmay	1997
Neustadt	1989
Palmerston	1985
Port Elgin	1999
Ripley	2008
Southampton	1995
Teeswater	1988
Walkerton	1985
Wingham	1989

Table 3-12: Average Pad-Mount Transformer Install Date by Town

Town	Assumed Year of Installation
Clifford	2013
Hanover	1997
Harriston	2003
Kincardine	1992
Lucknow	2003
Mildmay	2004
Neustadt	2017
Palmerston	2000
Port Elgin	2001
Ripley	2011
Southampton	1999
Teeswater	1992
Walkerton	2001
Wingham	1989

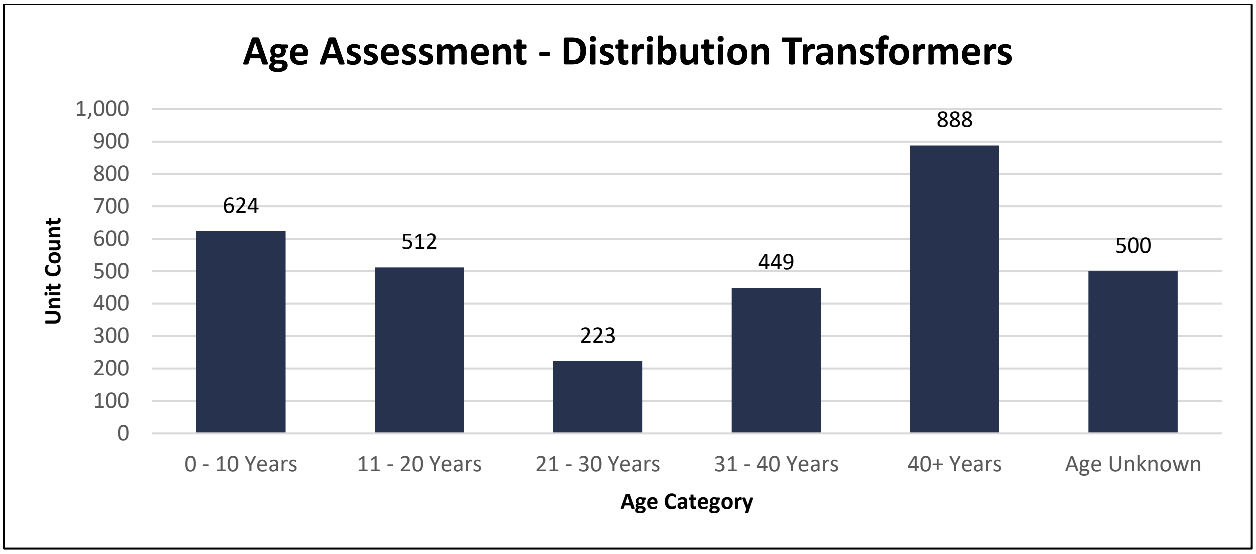

Figure 3-13: Distribution Transformer Age Demographic

HI Results

Westario owns 3,169 distribution transformers and valid HI results were calculated for 3,139 of them. Most of Westario's distribution transformers are in Fair or better condition; however, 102 transformers were ranked as Poor or Very Poor condition. These assets should be considered for possible remedial work or replacement depending on the unit's criticality. The HI results for distribution transformers are presented in Figure 3-14. The HI distribution for transformers is given by type and by town in Figure 3-15 and Figure 3-16 respectively.

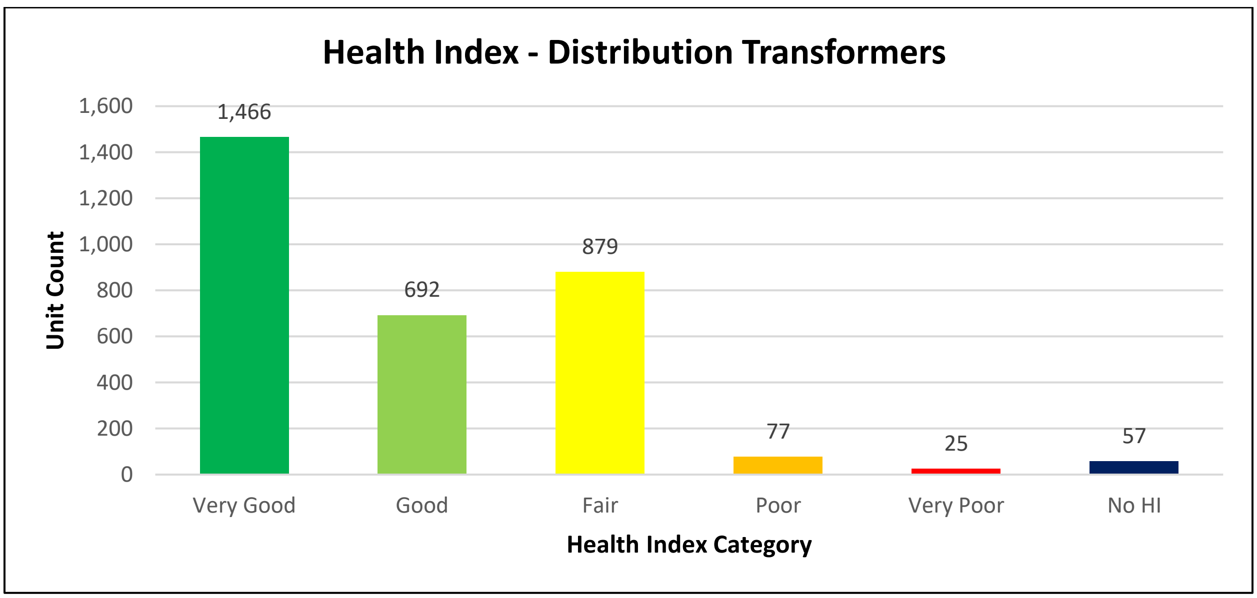

Figure 3-14: Distribution Transformer HI Results

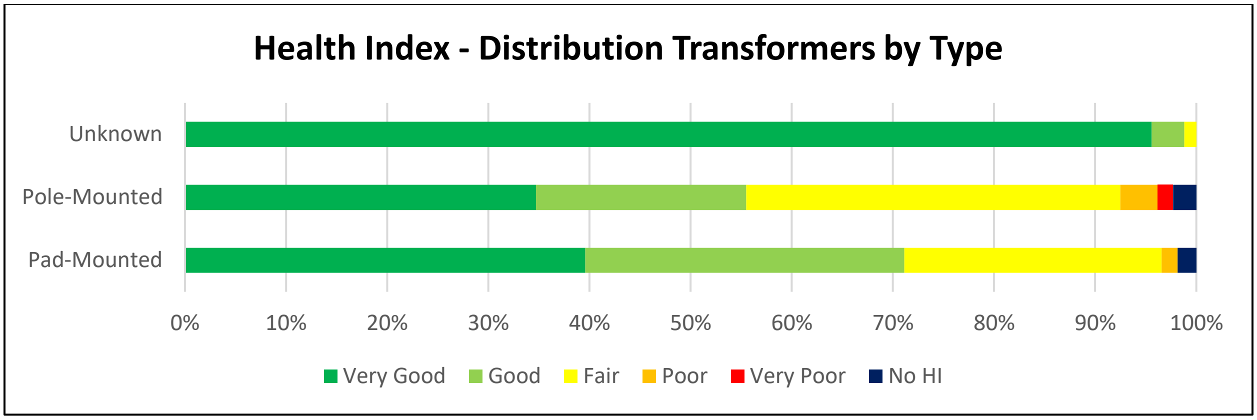

Figure 3-15: Transformer HI Distribution by Type

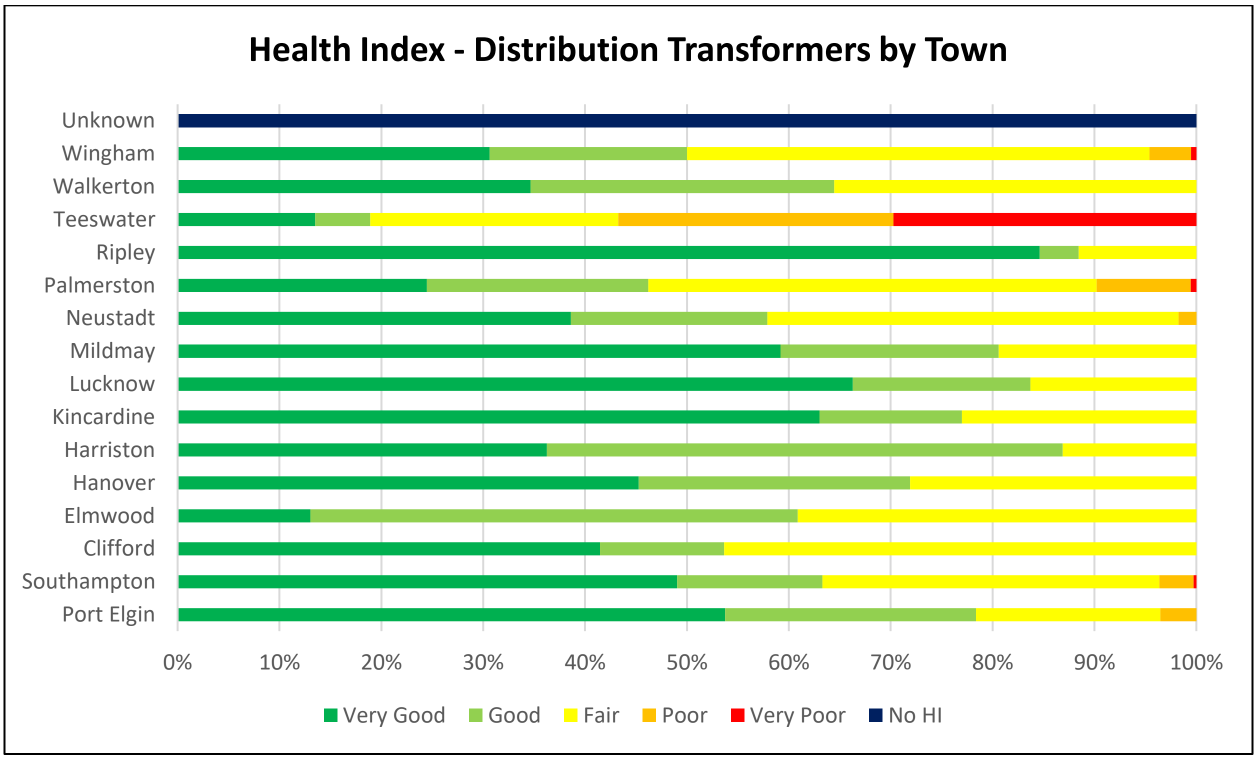

Figure 3-16: Transformer HI Distribution by Town

Recommendations for Future Improvements

Age information should be collected for distribution transformers missing age data. It is recommended that Westario establish transformer demographics for all distribution transformers as part of a regular inspection.

The condition data currently being collected for distribution transformers is detailed and should be comprehensively recorded for all assets. In addition to the data currently being collected, a best-practice formulation may consider some additional condition parameters:

- Infrared scans; and
- Peak loading history.

3.1.7 Distribution Switches

Westario owns a total of 290 distribution switches within its service territory.

Condition Assessment Methodology

Switches represent critical infrastructure for a Local Distribution Company ("LDC"). The primary means of inspecting and maintaining switches are to visually identify dirt and corrosion and to use infrared scans to find "hot" connections. Traditional air-insulated, handle-operated switches are highly maintainable and can often be extended indefinitely and nearly completely rebuilt on the pole. Newer "single-piece" devices can also be maintained but would generally be removed from the pole and maintained in a shop setting.

The HI for distribution switches is calculated by considering the overall condition of the asset. Table 3-13 provides the one-parameter HI algorithm for distribution switches. Additional details about the overall condition parameter and how it is graded can be found in Appendix B5.

Table 3-13: Switches HI Algorithm

Condition Parameter	Weight	Ranking	Numerical Grade	Max Score
Overall Condition	1	A,B,C,D,E	4,3,2,1,0	4
			Total Score	**4**

Data Collection and Assumptions

Visual inspection results are recorded annually for Westario's distribution switches. Between 2018 and 2021, visual inspection results were recorded for 290 switches. The visual inspection record could not be aligned with Westario's GIS asset registry in terms of Facility ID. It was assumed that all of Westario's in-service switches were included in the visual inspection record. In any case where there existed an inspection date for an asset, but one or more of the inspection fields were left blank, METSCO assumed that the inspection result was Satisfactory. Based on the assumptions made, the overall DAI for this asset class is 100%.

Demographics

Ages are unknown for Westario's distribution switches, however, the HIF made use of visual inspections performed on the switches.

HI Results

Westario owns 290 distribution switches and valid HI results were calculated for all of them. Most of Westario's distribution switches are in Very Good or Good condition; however three of the units are in Very Poor condition. Assets in Very Poor condition should be immediately considered for repair or replacement. The HI results for distribution switches are presented in Figure 3-17, and the HI distribution for switches by town is given in Figure 3-18.

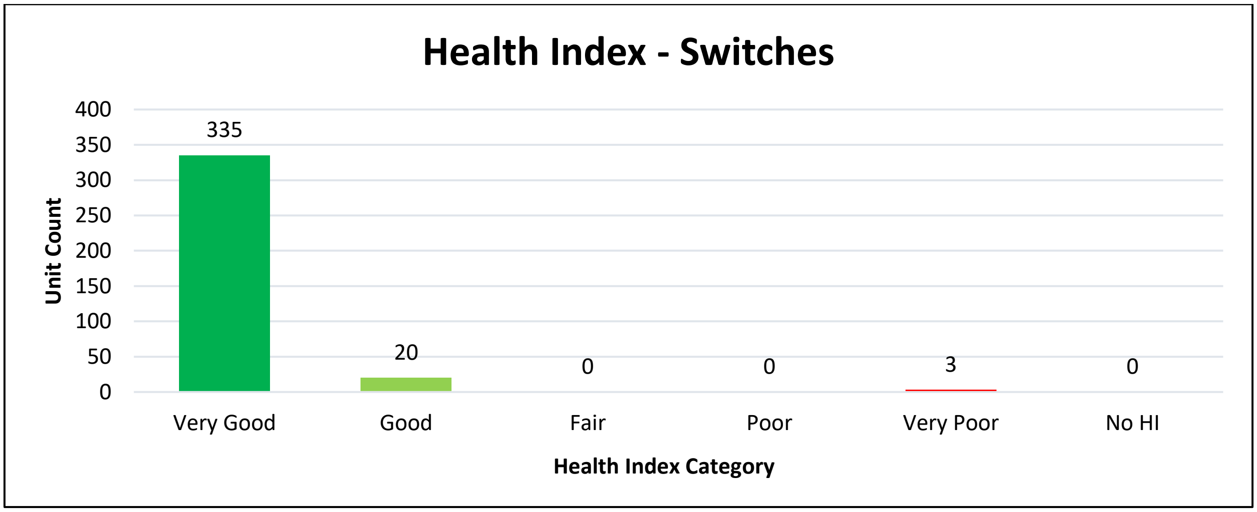

Figure 3-17: Switch HI Results

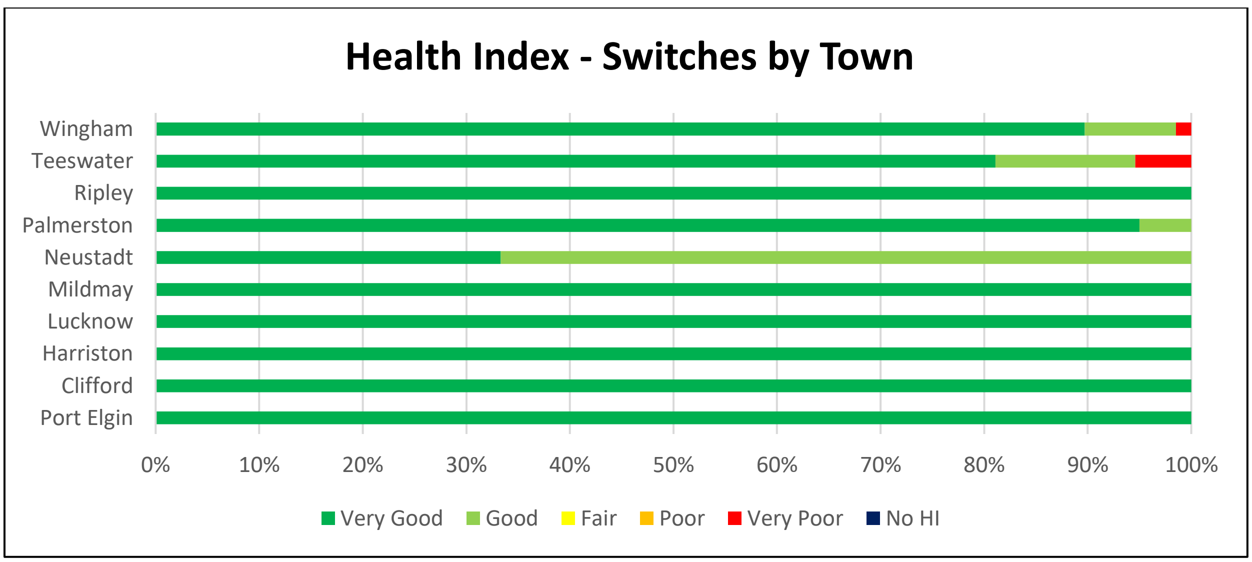

Figure 3-18: Switch HI Distribution by Town

Recommendations for Future Improvements

Westario should consider consolidating condition data from visual inspection records into a single file in the asset registry. The current visual inspection record does not align with the GIS asset registry in terms of asset Facility ID. Westario should ensure that the Facility IDs in the GIS are up to date and should ensure that the correct Facility ID is recorded during the visual inspection.

Additionally, Westario should consider standardizing the switch inspection comments to streamline the process of condition assessment. Ideally, all condition assessments should implement a five-level grading scheme, although a system of 'Satisfactory', 'Unsatisfactory', and 'Not Inspected' is also an option that Westario can consider. Condition data should be collected for any additional assets that are in service but do not exist in the inspection file.

Recognized HI guides recommend a multi-parameter formulation that can include the following condition parameters in addition to what Westario is currently collecting:

- Service age;
- Infrared scan;
- Condition of blades; and
- Condition of operating mechanism.

3.1.8 Switching Cubicles

Westario owns a total of 80 kabar switching cubicles. The switching cubicles are located within following towns: Hanover, Kincardine, Palmerston, Port Elgin, Southampton, Walkerton, and Wingham.

Condition Assessment Methodology

The HI for switching cubicles is calculated by considering the overall condition of the asset. Table 3-14 provides the one-parameter HI algorithm for Westario's kabar switching cubicles. Additional details about this overall condition parameter and how it is graded can be found in Appendix B6.

Table 3-14: Switching Cubicle HI Algorithm

Condition Parameter	Weight	Ranking	Numerical Grade	Max Score
Overall Condition	1	A,B,C,D,E	4,3,2,1,0	4
			Total Score	**4**

Data Collection and Assumptions

Visual inspection results are recorded annually for Westario's switching cubicles. Westario owns a total of 80 kabar switching cubicles and between 2019 and 2021 visual inspection results were recorded for 66 of them. In any case where there existed an inspection date for an asset, but one or more of the inspection fields were left blank, METSCO assumed that no deficiencies were found, and the inspection result was Good. The DAI for this asset class is 83%.

Demographics

Ages are unknown for Westario's switching cubicles, however, the HIF made use of visual inspections performed on the switching cubicles.

HI Results

Westario owns 80 kabar switching cubicles and valid HI results were calculated for 66 of them. Most of Westario's switching cubicles are in Good condition; however five of the units are in Fair condition and one of the units is in Very Poor condition. Assets in Fair condition should be considered for possible remedial work or replacement depending on the unit's criticality. The switching cubicle in Very Poor condition should be immediately considered for replacement. The HI results for switching cubicles are presented in Figure 3-19, and the HI distribution for switching cubicles by town is given in Figure 3-20.

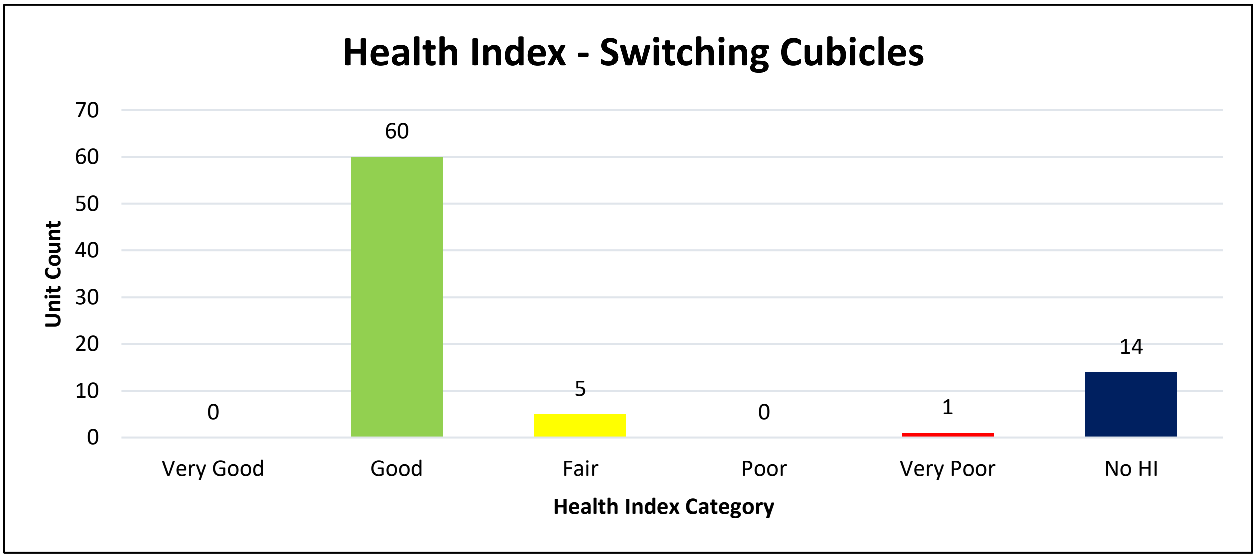

Figure 3-19: Switching Cubicle HI Results

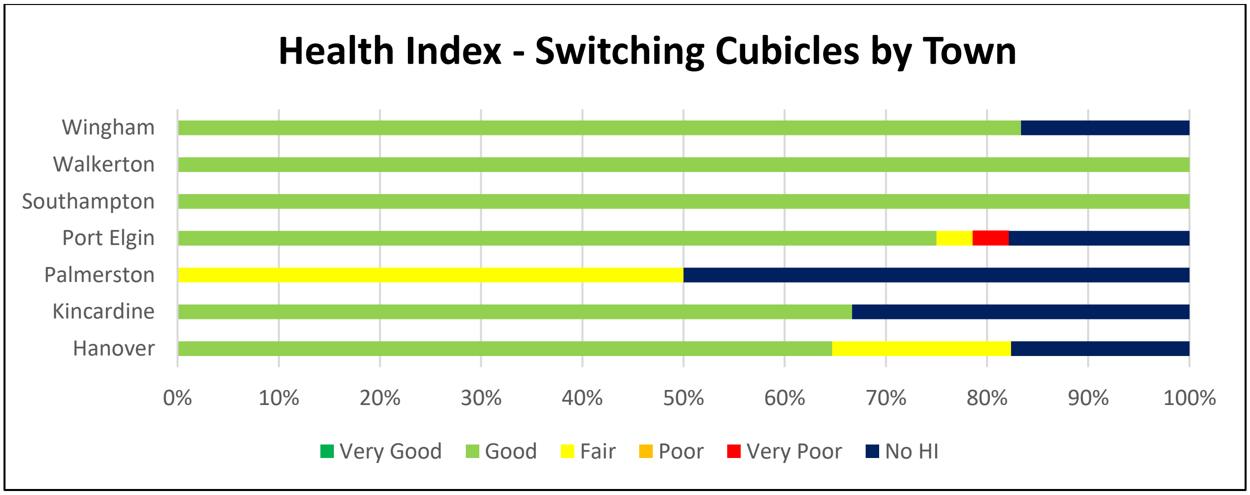

Figure 3-20: Switching Cubicle HI Distribution by Town

Recommendations for Future Improvements

Westario should consider collecting missing data for switching cubicles in the towns of Hanover, Kincardine, Palmerston, Port Elgin, and Wingham. There are 14 assets located in these towns that do not appear in the visual inspection records. In addition to the data currently being collected, Westario should consider tracking or estimating the service age of its switching cubicles so that this can be included as a condition parameter in the HIF.

3.2 Stations Assets

3.2.1 Station Buildings

Westario operates a total of 27 substations located in the following towns: Hanover, Harriston, Kincardine, Lucknow, Palmerston, Port Elgin, Southampton, Teeswater, Walkerton and Wingham.

Condition Assessment Methodology

In this ACA, station buildings refers to the walls, roof, floors, fences, yard etc. of the station. Station buildings are the major civil infrastructure components of a utility substation. Other civil infrastructure systems supporting a station may include support structures, security equipment, plumbing systems, and others.

Buildings are inspected quarterly and are maintained as issues arise. In some cases, these assets can be scheduled for replacement, especially where configurations of the station are inadequate or where projects exist to replace the entirety of the relay and switchgear lineups. Generally, however, fences are maintained, gates are repaired, and buildings are patched up as needed to remain functional.

Table 3-15 provides the HI algorithm for station buildings. Additional details about these condition parameters can be found in Appendix B7.

Table 3-15: Station Building HI Algorithm

Condition Parameter	Weight	Ranking	Numerical Grade	Max Score
Station Condition – within Station Compound	1	A,B,C,D,E	4,3,2,1,0	4
Station Condition – Outside Station Compound	1	A,B,C,D,E	4,3,2,1,0	4
Station Fence Condition	1	A,B,C,D,E	4,3,2,1,0	4
Station Indoor Room Condition	1	A,B,C,D,E	4,3,2,1,0	4
Station Civil Condition	1	A,B,C,D,E	4,3,2,1,0	4
			Total Score	**20**

Data Collection and Assumptions

For station buildings, condition data is collected in substation quarterly reports covering each of the condition parameters in Table 3-15. The most recent substation quarterly inspection report provided was completed in August 2021. This report contained complete condition information for each of Westario's substations and the DAI for this asset class is 100%. Some of the condition parameters were marked as "N/A" for certain stations in this inspection report, and it is assumed that the station does not have the component (fence, indoor room, etc…). Any of the condition parameters marked as "N/A" were omitted from the HI and DAI calculation for the particular asset.

Demographics

Demographic information for stations buildings was not part of the dataset provided and is not deemed critical in assessing the health of these assets.

HI Results

Approximately half of Westario's station buildings are in Good condition, while the other half is in Fair condition. Figure 3-21 presents the HI results of Westario's station buildings, and Figure 3-22 shows the HI distribution for station buildings by town.

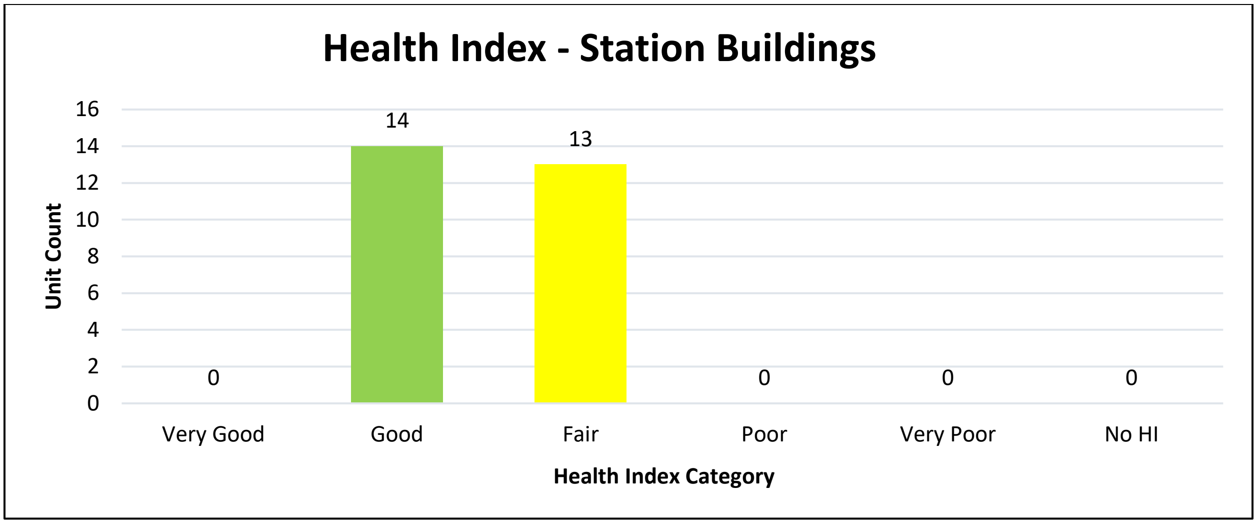

Figure 3-21: Station Buildings HI Results

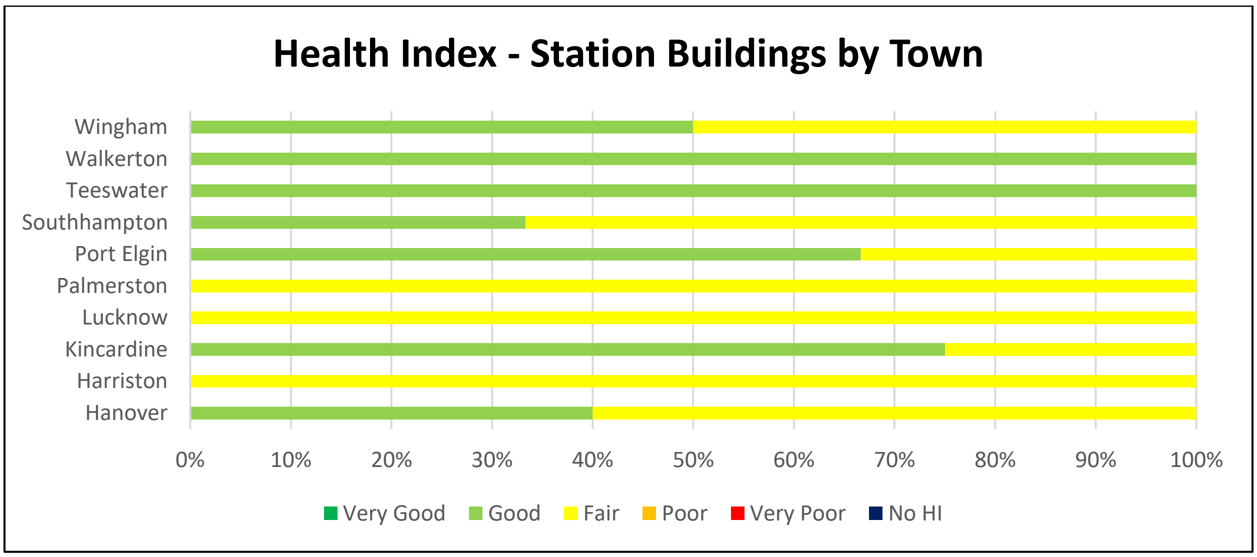

Figure 3-22: Station Buildings HI Distribution by Town

Recommendations for Future Improvements

It is recommended that Westario update its inspection records and continue to re-inspect substations to monitor facilities currently found to be in Fair condition. Specifically, substation inspection reports should be updated for Southampton Municipal Station ("MS") 2 and Walkerton MS 2.

An alternative approach to the substation building HI may involve constructing an HI framework for the entire station. If this approach is pursued, additional factors to those considered in the HI formulation of substation buildings that can inform such a formulation include:

- Condition of security systems;

- Condition of phones and LAN services;
- Condition of lanes and parking;
- Condition of plumbing and electrical;
- Condition of drainage systems; and
- Grounding/bonding of ancillaries.

3.2.2 Station Power Transformers

Westario owns a total of 29 station transformers. The station transformers are located within following towns: Hanover, Harriston, Kincardine, Lucknow, Palmerston, Port Elgin, Southampton, Teeswater, Walkerton, and Wingham.

Condition Assessment Methodology

Station power transformers are the single most critical asset class owned by an LDC. Each transformer can be valued in the range of hundreds of thousands to millions of dollars and can affect tens of thousands of customers.

Degradation mechanisms include loss of insulation or oil quality due to overload or low-level internal faults causing heating, arcing, and/or physical deterioration such as corrosion or failed cooling systems. Station power transformers are the most tested and tracked utility assets and reliable indicators of the impending need for maintenance or replacement include Dissolved Gas Analysis ("DGA"), OQ, and Power Factor ("PF") testing. Some tests can be conducted in-service and others required taking the asset out of service. Many features such as cooling fans are external to the tank and can be maintained in situ.

Table 3-16 provides the HI algorithm for station power transformers. The overall availability of data has improved significantly since the last assessment, with the inclusion of more granular visual condition parameter results and additional electrical tests being carried out on the station transformers. Electrical tests included in the HI formulation not previously recorded were the bushing hot collar test, insulation resistance test, turns test ratio and DC winding resistance test. The methodology used to assess the DGA results have also been updated to reflect the latest standard in terms of acceptable gas limits and rates of change for these gases. Despite these new condition parameters being added to the HI formulation, the overall weights were calibrated to be consistent with prior HI formulation to allow for comparison of results.

The HIF for station power transformers is the most complex of all asset classes assessed. The top five key condition parameters indicated in Table 3-16 are DGA, overall condition, service age, infrared thermography, and OQ. Additional details about these condition parameters can be found in Appendix B8.

Table 3-16: Station Power Transformer HI Algorithm

Condition Parameter	Weight	Ranking	Numerical Grade	Max Score
Dissolved Gas Analysis	10	A,B,C,D,E	4,3,2,1,0	40
Overall Condition	10	A,B,C,D,E	4,3,2,1,0	40
Service Age	8	A,B,C,D.E	4,3,2,1,0	32
Infrared Thermography	8	A,E	4,0	32
Oil Quality	8	A,C,E	4,2,0	32
Power Factor Test	6	A,B,C,D,E	4,3,2,1,0	24
Turns Ratio Test	5	A,B,C,D,E	4,3,2,1,0	20
Winding Resistance Test	5	A,B,C,D,E	4,3,2,1,0	20
Insulation Resistance Test	4	A,B,C,D,E	4,3,2,1,0	16
Oil Leaks	4	A,B,C,D,E	4,3,2,1,0	16
Oil Level	3	A,B,C,D,E	4,3,2,1,0	12
Foundation & Grounding	2	A,B,C,D,E	4,3,2,1,0	8
			Total Score	**292**

Data Collection and Assumptions

Data was provided for 29 station power transformers. An infrared and oil analysis report from 2021 was utilized with results for all 27 substations. In addition to this, individual substation maintenance reports from 2018 to 2021 were available for 25 of Westario's 27 substations. These reports provided mechanical and electrical inspection records for the station power transformers. The DAI for this asset class is 94%.

Demographics

Figure 3-23 presents the age distribution of Westario's station power transformers. As the figure indicates, 41% of station power transformers have been in service for more than 45 years which corresponds to the typical useful life of the asset class.

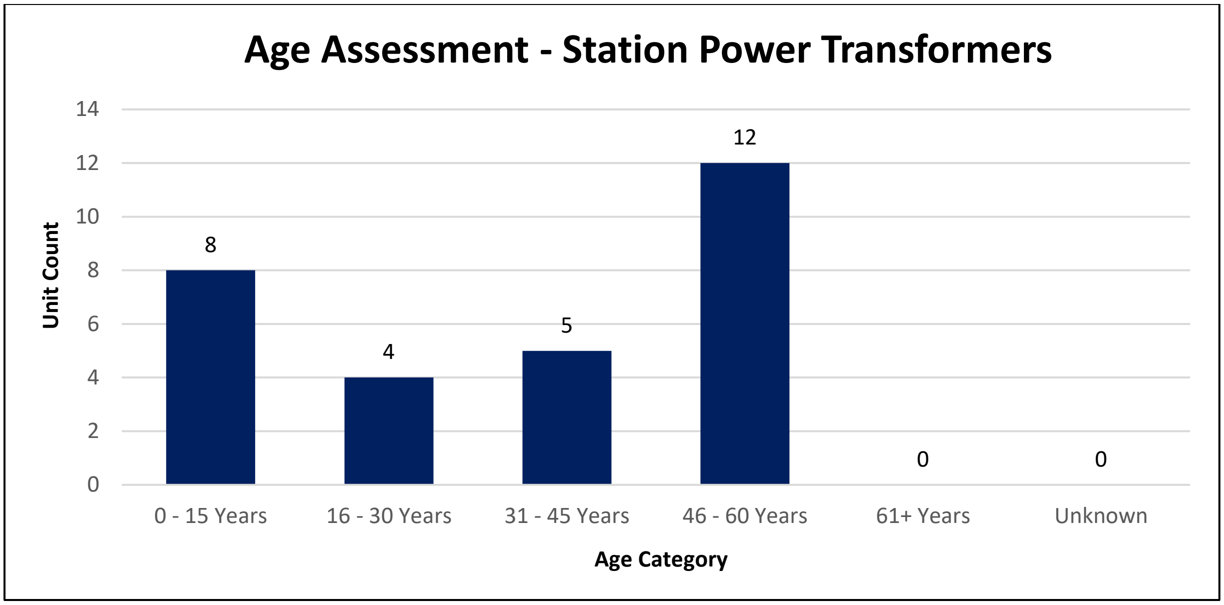

Figure 3-23: Station Power Transformer Age Demographics

HI Results

The overall HI distribution is presented in Figure 3-24. All the transformers are in Fair condition or better. Since power transformers are critical assets, the nine transformers in Fair condition should be considered for possible remedial work or replacement depending on the unit's criticality. The HI distribution for station power transformers by town is given in Figure 3-25.

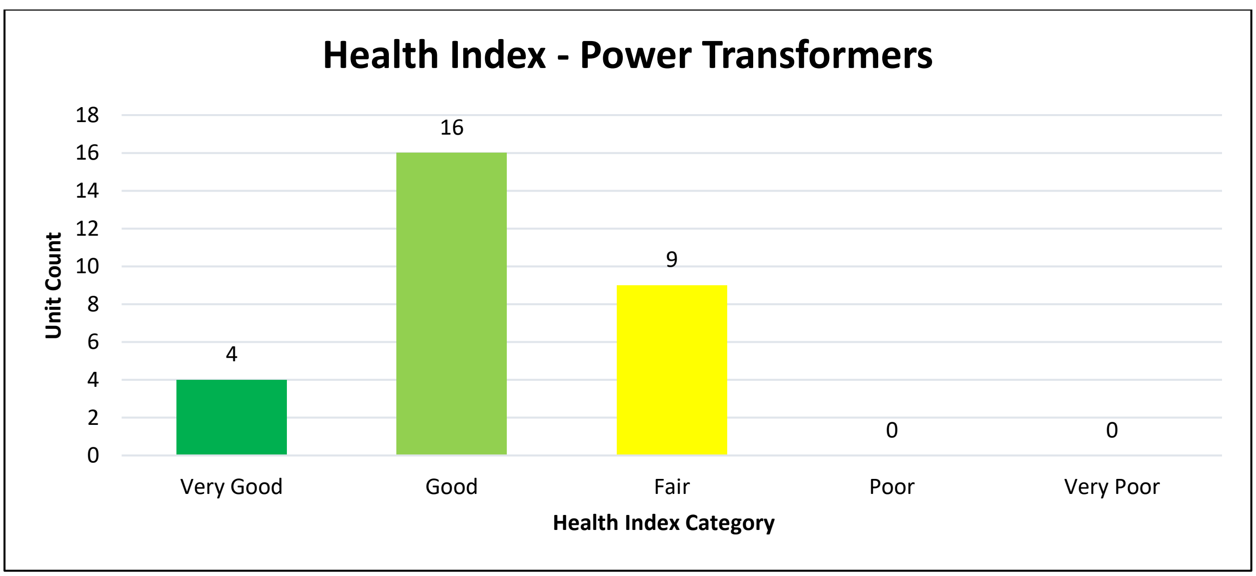

Figure 3-24: Station Power Transformer HI Results

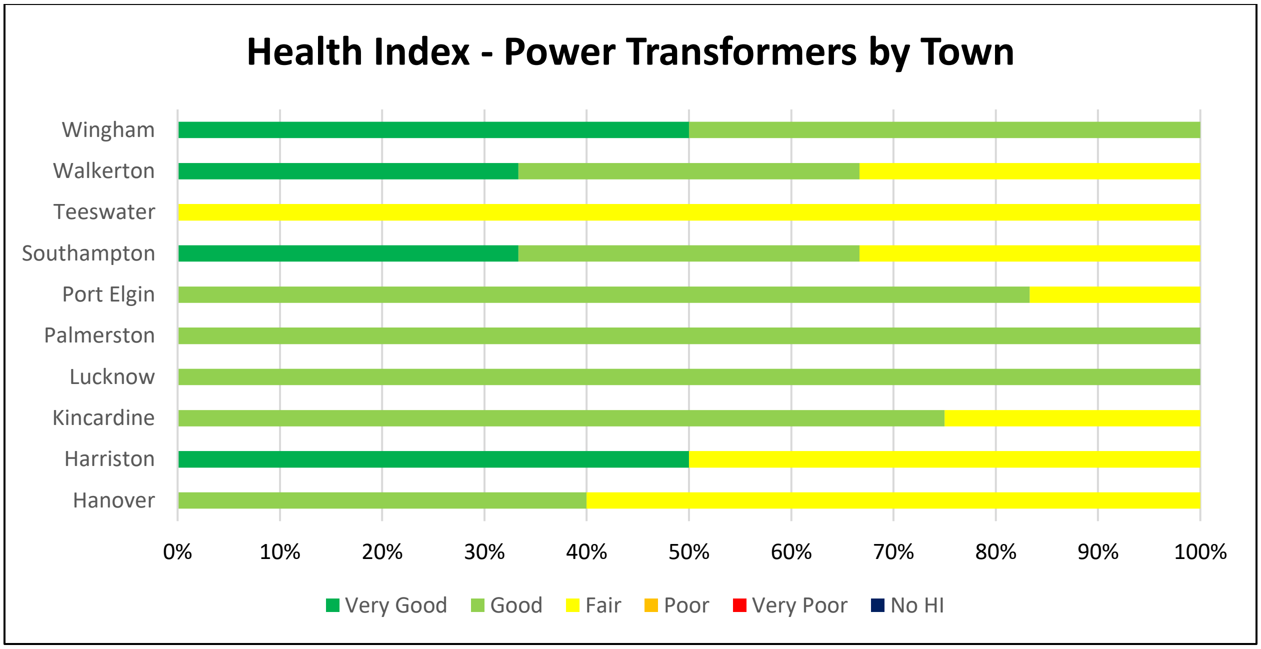

Figure 3-25: Station Power Transformers HI Distribution by Town

Table 3-17 lists the results for the ACA of station power transformers in order of increasing HI.

Table 3-17: Station Transformers HI Results

Substation	Equipment ID	Primary Voltage (kV)	Rating (kVA)	Asset Age	Health Index (%)
Southampton MS 3	Main TX	44	5000	44	64%
Teeswater MS 1	Main TX	44	3000	50	64%
Walkerton MS 2	Main TX	44	5000	51	65%
Hanover MS 4	Main TX	44	5000	54	66%
Harriston MS 1	Main TX 1	44	5000	28	66%
Hanover MS 3	Main TX	44	5000	50	67%
Port Elgin MS 3	Main TX	44	5000	47	68%
Kincardine MS 4	Main TX	44	5000	46	68%
Hanover MS 2	Main TX	44	5000	35	68%
Palmerston MS 1	Main TX 2	44	5000	8	71%
Port Elgin MS 4	Main TX	44	5000	45	72%
Wingham MS 1	Main TX	44	5000	52	72%
Southampton MS 1	Main TX	44	6000	29	73%
Lucknow MS 1	Main TX	44	5000	29	73%
Port Elgin MS 5	Main TX	44	5000	59	74%
Kincardine MS 3	Main TX	44	7500	38	74%
Walkerton MS 3	Main TX	44	5000	5	74%
Hanover MS 1	Main TX	44	5000	54	76%
Port Elgin MS 1	Main TX	44	5000	50	76%
Port Elgin MS 2	Main TX	44	5000	48	77%
Port Elgin MS 6	Main TX	44	5000	26	78%
Kincardine MS 1	Main TX	44	7500	8	79%
Palmerston MS 1	Main TX 1	44	5000	6	80%
Kincardine MS 2	Main TX	44	7500	42	80%
Hanover MS 5	Main TX	44	5000	6	84%
Wingham MS 2	Main TX	44	5000	52	86%
Walkerton MS 1	Main TX	44	5000	14	88%
Harriston MS 1	Main TX 2	44	5000	4	92%
Southampton MS 2	Main TX	44	5000	2	94%

Recommendations for Future Improvements

Station transformers should be managed under the context of a thorough Asset Management Plan ("AMP"). Westario should consider creating an asset registry file for its station power transformers to store asset nameplate information. Key information from electrical and oil testing reports can be digitized to improve the data analysis process for ACA.

The condition data currently being collected for station transformers is both comprehensive and detailed. In addition to the data currently being collected, a best-practice formulation may consider some additional condition parameters:

- Furans analysis;

- Load history; and
- Insulation moisture content (from Dielectric Frequency Response Testing "DFR").

3.2.3 Station Circuit Breakers

Westario owns a total of 52 station circuit breakers. The station circuit breaker population consists of both air- and vacuum- insulated breakers operating at 4.16 kV, 13.8 kV, and 44 kV. The station circuit breakers are located within following towns: Hanover, Harriston, Palmerston, Port Elgin, and Walkerton.

Condition Assessment Methodology

Station circuit breakers are critical substation assets and are the primary protective devices for maintaining public safety and protecting other station equipment. Breakers work with station relays to open, either in a fault situation, as directed by the operations center, or as part of the automation scheme.

Breaker degradation occurs primarily through physical processes, such as corrosion, accumulation of debris on insulators, or operations under load. In general, the more current passing through the breaker when it operates, the more wear and tear it sustains.

Table 3-18 provides the HI algorithm for Westario's station circuit breakers. Additional details about these condition parameters and how they are graded can be found in Appendix B9.

Table 3-18: Station Circuit Breaker HI Algorithm

Condition Parameter	Weight	Ranking	Numerical Grade	Max Score
Insulation Resistance Test	5	A,B,C,D,E	4,3,2,1,0	20
Contact Resistance Test	4	A,B,C,D,E	4,3,2,1,0	16
Condition of Contacts	4	A,B,C,D,E	4,3,2,1,0	16
Breaker Truck Condition	3	A,B,C,D,E	4,3,2,1,0	12
Arc Chutes	3	A,E	4,0	12
Control & Operating Condition	2	A,B,C,D,E	4,3,2,1,0	8
Operating Counter	2	A,B,C,D,E	4,3,2,1,0	8
			Total Score	**92**

Data Collection and Assumptions

Individual substation maintenance reports provided the visual and electrical inspection results for Westario's station circuit breakers. Between 2018 and 2021 these reports were available for 25 of Westario's 27 substations. The DAI for this asset class is 84%.

Demographics

Ages are unknown for Westario's station circuit breakers, however, information was provided for number of operations and results of visual and electrical inspections.

HI Results

Westario owns 52 station circuit breakers, of which valid HI results are calculated for 46 of them. Most of Westario's station circuit breakers are in Very Good to Good condition, excluding the 6 circuit breakers with No HI. The HI results for station circuit breakers are presented in Figure 3-26, and the HI distribution for circuit breakers by town is given in Figure 3-27.

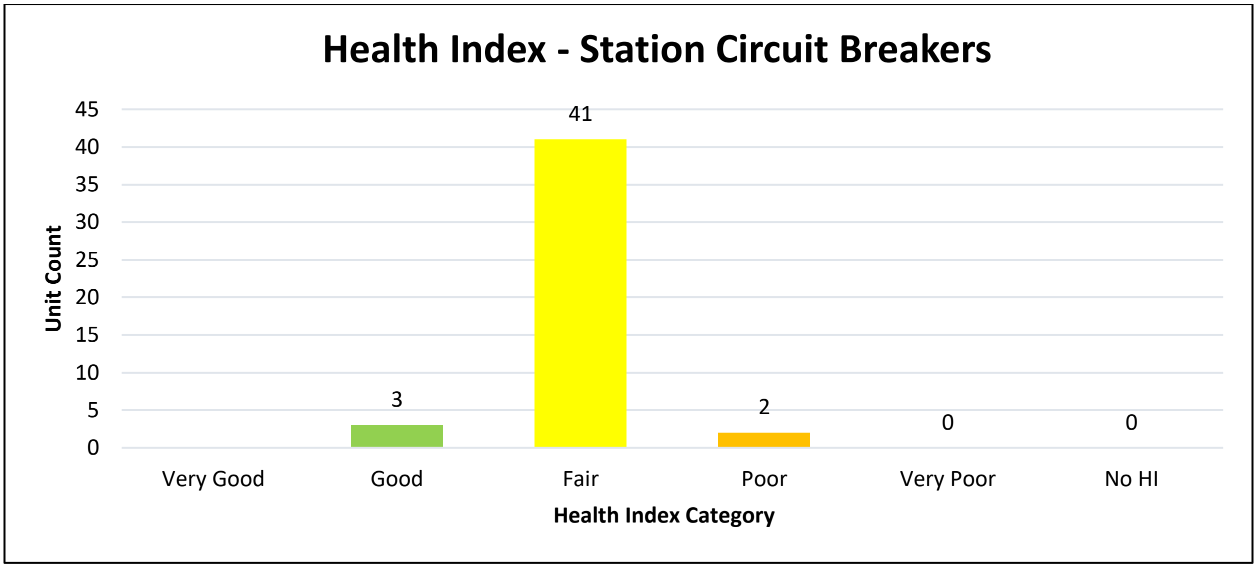

Figure 3-26: Station Circuit Breaker HI Results

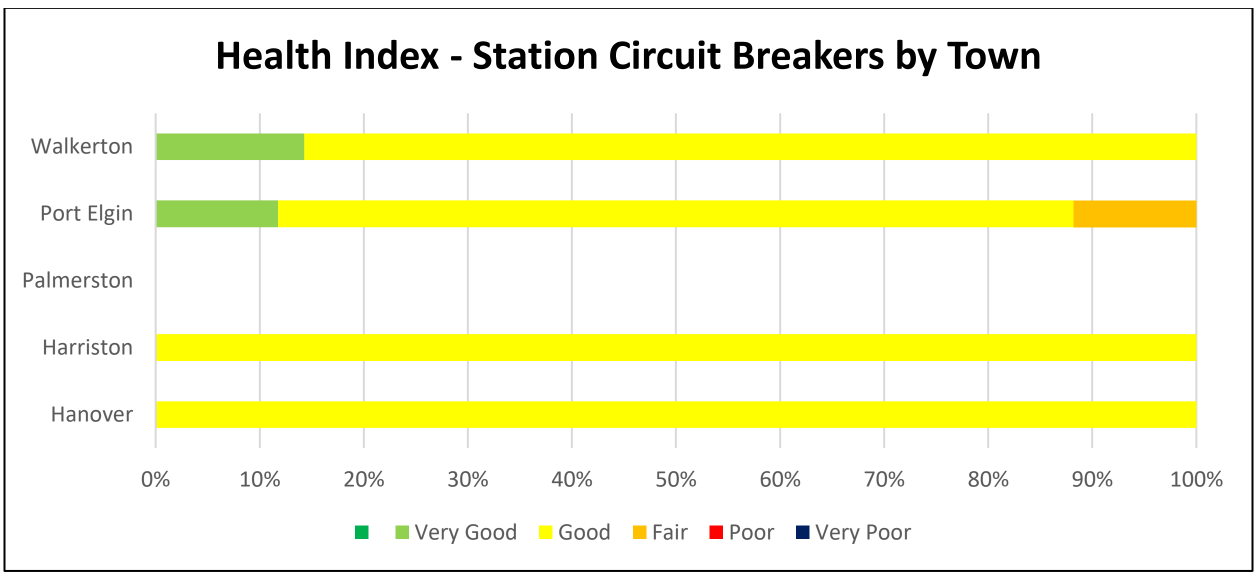

Figure 3-27: Station Circuit Breakers HI Distribution by Town

Recommendations for Future Improvements

Westario should consider collecting missing data for station circuit breakers in the towns of Palmerston and Walkerton. Condition data from visual inspection reports should be consolidated into a single file in the asset registry. As station breakers are renewed over time and new stations are built, new technology is likely to be introduced into the system, warranting the formulation of a more comprehensive HI. In addition to the data currently being collected, additional condition parameters that Westario can consider collecting are:

- Condition/operability of the communications system;
- Condition of foundations and structures;
- Time/travel tests; and
- Vacuum bottle integrity (if applicable).

3.2.4 Station Reclosers

Westario owns a total of 33 station reclosers. The station reclosers are located within following towns: Hanover, Kincardine, Lucknow, Palmerston, Port Elgin, Southampton, Teeswater, and Wingham.

Condition Assessment Methodology

Station reclosers are a critical dynamic protective asset used to maintain public safety and protect other station equipment. Reclosers will open in a fault situation and will automatically test the line to allow itself to close if the fault was resolved.

Recloser degradation occurs primarily through physical processes, such as corrosion, accumulation of debris, or operations under load. In general, the more current passing through the recloser when it operates, the more wear and tear it sustains.

Table 3-19 provides the HI algorithm for Westario's station reclosers. Additional details about these condition parameters and how they are graded can be found in Appendix B10.

Table 3-19: Station Recloser HI Algorithm

Condition Parameter	Weight	Ranking	Numerical Grade	Max Score
Recloser Overall Condition	2	A,B,C,D,E	4,3,2,1,0	8
Insulation Resistance	1	A,B,C,D,E	4,3,2,1,0	4
Contact Resistance	1	A,B,C,D,E	4,3,2,1,0	4
			Total Score	**16**

Data Collection and Assumptions

Individual substation maintenance reports provided the visual and electrical inspection results for Westario's station reclosers. Between 2018 and 2021 these reports were available for 25 of Westario's 27 substations. The DAI for this asset class is 85%.

Demographics

Ages are unknown for Westario's station reclosers, however, the HIF made use of visual and electrical inspections performed on the reclosers.

HI Results

Westario owns 33 station reclosers, of which valid HI results are calculated for 27 of them. Most of Westario's station reclosers are in Very Good to Good condition. Station reclosers in Fair condition should be considered for possible remedial work or replacement depending on the unit's criticality. The HI results for station reclosers are presented in Figure 3-28, and the HI distribution for reclosers by town is given in Figure 3-29.

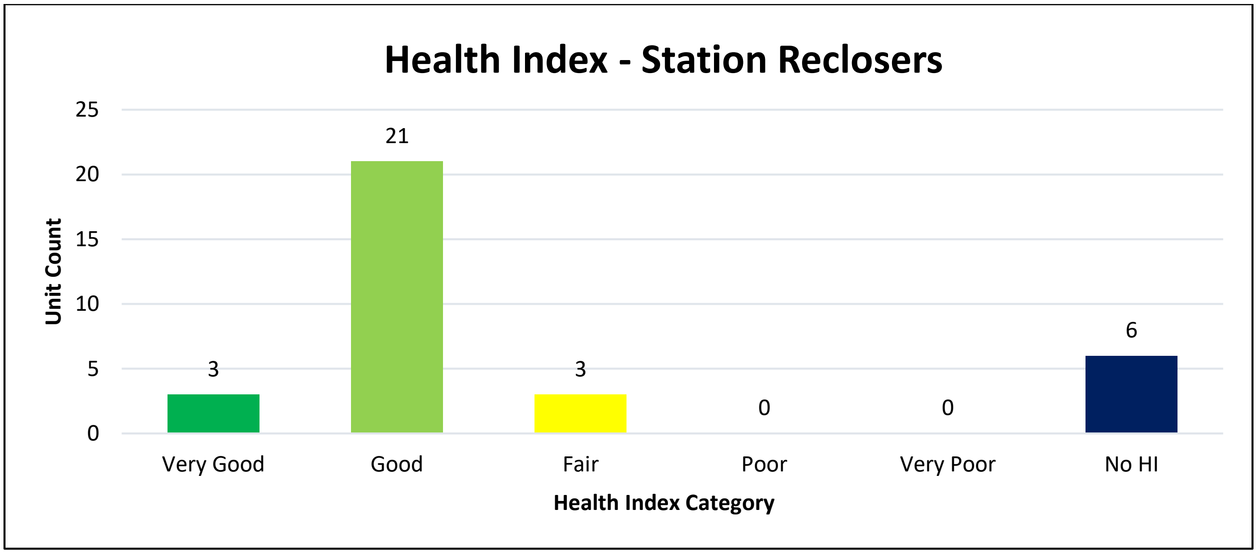

Figure 3-28: Station Recloser HI Results

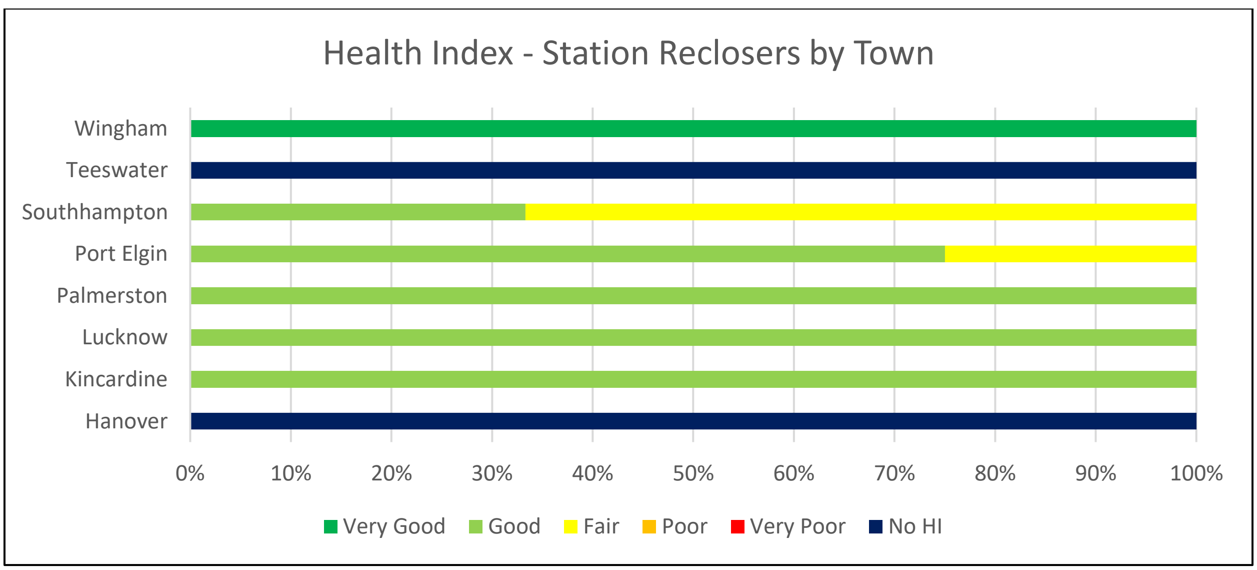

Figure 3-29: Station Reclosers HI Distribution by Town

Recommendations for Future Improvements

Westario should consider collecting missing data for station reclosers in the towns of Teeswater and Hanover. Condition data from visual inspection reports should be consolidated into a single file in the asset registry. In addition to the data currently being collected, Westario should also consider reporting the counter readings/number of operations of its reclosers during the visual inspections.

3.2.5 Station Fused Switchgear

Westario owns a total of fifteen station fused switchgear. The station fused switchgear are located within following towns: Kincardine, Southampton, and Wingham.

Condition Assessment Methodology

Station fused switchgear are a critical dynamic protective asset used to maintain public safety and protect other station equipment. These switchgear are made up of several fused switches. The switches provide a method to manually shut off the power, while the fuse will automatically disconnect the circuit if the amperage on the circuit exceeds the rating.

Fused switchgear degradation occurs primarily through physical processes, such as corrosion, accumulation of debris, or operations under load. In general, the more current passing through the fused switchgear when it operates, the more wear and tear it sustains.

Table 3-20 provides the HI algorithm for Westario's station fused switchgear. Additional details about these condition parameters and how they are graded can be found in Appendix B11.

Table 3-20: Station Fused Switchgear HI Algorithm

Condition Parameter	Weight	Ranking	Numerical Grade	Max Score
Switch Condition	2	A,B,C,D,E	4,3,2,1,0	8
Switch Insulation Resistance	1	A,B,C,D,E	4,3,2,1,0	4
Switch Contact Resistance	1	A,B,C,D,E	4,3,2,1,0	4
Fuse Condition	2	A,B,C,D,E	4,3,2,1,0	8
Fuse Insulation Resistance	1	A,B,C,D,E	4,3,2,1,0	4
Fuse Contact Resistance	1	A,B,C,D,E	4,3,2,1,0	4
			Total Score	**32**

Data Collection and Assumptions

Individual substation maintenance reports provided the visual and electrical inspection results for Westario's fused switchgear. Between 2018 and 2021 these reports were available for 25 of Westario's 27 substations. The DAI for this asset class is 98%.

Demographics

Ages are unknown for Westario's fused switchgear, however, the HIF made use of visual and electrical inspections performed on the fused switchgear.

HI Results

Westario owns fifteen station fused switchgear and valid HI results were calculated for all of them. All of Westario's fused switches are in Fair to Poor condition. Westario should assess all of their assets for possible remedial work or replacement depending on the unit's criticality. The HI results for station fused switchgear are presented in Figure 3-30, and the HI distribution for fused switchgear by town is given in Figure 3-31.

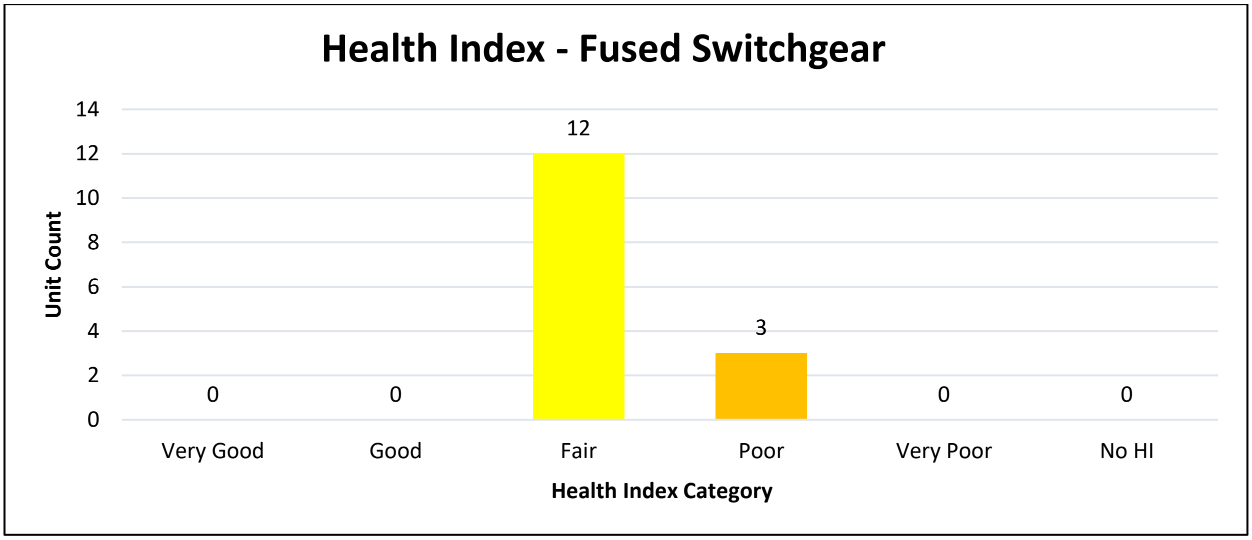

Figure 3-30: Station Fused Switchgear HI Results

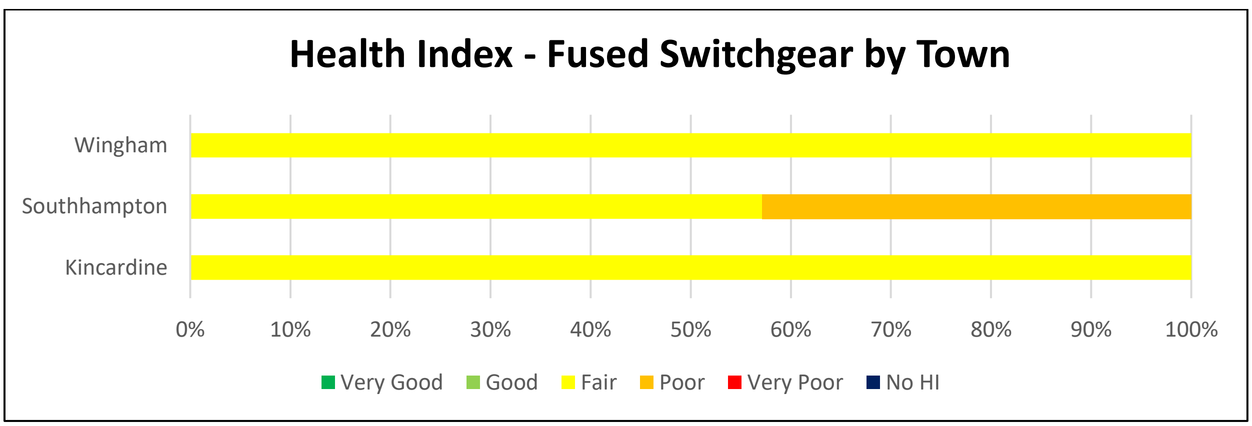

Figure 3-31: Station Fused Switchgear HI Distribution by Town

Recommendations for Future Improvements

Condition data for fused switchgear from visual inspection reports should be consolidated into a single file in the asset registry.

4 Recommendations

4.1 Advanced Asset Condition Parameters

METSCO recommends that Westario should focus their efforts on collecting missing asset data noted in this study and collecting data for new condition parameters to improve the accuracy and add incremental value from a more granular approach. The advanced parameters typically represent the measurements associated with equipment degradation processes known to be most detrimental to the normal operation of electrical assets over time.

The following set of recommendations consolidates METSCO's suggestions provided throughout Chapter 3. The recommendations target additional condition parameters or the means of collecting and storing the data already being utilized. The recommendations are based on the advanced ACA framework for assets and should not be interpreted as suggesting that immediate action is warranted.

4.1.1 Wood Poles

The condition data currently being collected for wood poles is detailed and should be comprehensively recorded for all assets. Westario's inspection records generally provided useful condition information for wood poles. Having record of this condition information for all assets would be valuable for the condition assessment of wood poles. Westario should ensure that overall condition, surface decay and mechanical damage are all recorded when pole inspections are completed. Assets for which visual inspection results are not available are primarily located in the towns of Wingham, Teeswater, Ripley, Neustadt, Mildmay, Lucknow, Harriston, and Clifford. Westario should prioritize completing visual inspections of its wood poles in these towns, so that the condition of assets can include all the parameters of the recommended health index formulation.

Westario should consider consolidating its inspection records and asset registry. One option would be to align the inspection records in terms of Facility ID so that the inspections can be linked without using the geographic coordinates. Another option would be to store the most recent visual inspection results for wood poles (e.g., presence of cracks, woodpecker, or insect damage) in the asset registry file. This would streamline the correlation of asset information and inspection records for future condition assessments.

Westario should also consider collecting additional items during the pole visual inspection which would provide insight to the overall condition of the assets. These inspection items have already been collected for wood poles in the town of Kincardine, Port Elgin, and Southampton. Westario should consider including these items on the general pole visual inspection and work towards collecting this information for the entire asset class:

- Pole top decay;
- Ground line rot;
- Pole lean;
- Lightening damage;

- Internal decay; and
- Pole accessory condition (including insulators, cross arms, guy wires, ground wires, and attachment hardware).

4.1.2 Steel Poles

The DAI for steel poles is 61% and should be improved to accurately represent the distribution of health indices for the asset class. Westario should work towards collecting consistent visual inspection data for the remaining 1018 steel poles so that HI results can be calculated across the asset population and include all the condition parameters in the HIF.

It is recommended that a more sophisticated visual inspection be established for the asset class. Recognized HI guides recommend more than a two-parameter formulation to develop a robust index. A best-practice formulation would consider additional condition parameters to be recorded during a visual inspection, including:

- Evidence of rust/corrosion; and
- Evidence of other mechanical damage or defects.

4.1.3 Concrete Poles

Based on the condition information available, 59% of Westario's concrete poles were classified as being in Very Poor condition. It should be noted that concrete poles comprise only 0.4% of the pole population. Given the age distribution of the assets it is recommended that Westario perform a more sophisticated visual inspection on these assets to determine the need for replacement. Recognized HI guides recommend more than a two-parameter formulation to develop a robust index for concrete poles. A best-practice formulation would consider various condition parameters which can be recorded during a visual inspection:

- Evidence of rust/corrosion;
- Evidence of concrete spalling; and
- Evidence of other mechanical damage or defects.

4.1.4 Distribution Transformers

Age information should be collected for distribution transformers missing age data. It is recommended that Westario establish transformer demographics for all distribution transformers as part of a regular inspection.

The condition data currently being collected for distribution transformers is detailed and should be comprehensively recorded for all assets. In addition to the data currently being collected, a best-practice formulation may consider some additional condition parameters:

- Condition of structures/pads;
- Infrared scans; and
- Peak loading history.

4.1.5 Distribution Switches

Westario should consider consolidating condition data from visual inspection records into a single file in the asset registry. The current visual inspection record does not align with the GIS asset registry in terms of asset Facility ID. Westario should ensure that the Facility IDs in the GIS are up to date and should ensure that the correct Facility ID is recorded during the visual inspection.

Additionally, Westario should consider standardizing the switch inspection comments to streamline the process of condition assessment. Ideally, all condition assessments should implement a five-level grading scheme, although a system of 'Satisfactory', 'Unsatisfactory', and 'Not Inspected' is also an option that Westario can consider. Condition data should be collected for any additional assets that are in service but do not exist in the inspection file.

Recognized HI guides recommend a multi-parameter formulation that can include the following condition parameters in addition to what Westario is currently collecting:

- Service age;
- Infrared scan;
- Condition of blades; and
- Condition of operating mechanism.

4.1.6 Switching Cubicles

Westario should consider collecting missing data for switching cubicles in the towns of Hanover, Kincardine, Palmerston, Port Elgin, and Wingham. There are 14 assets located in these towns that do not appear in the visual inspection records. In addition to the data currently being collected, Westario should consider tracking or estimating the service age of its switching cubicles so that this can be included as a condition parameter in the HIF.

4.1.7 Station Buildings

It is recommended that Westario update its inspection records and continue to re-inspect substations that have not been inspected in the last three years. Substation inspection reports should specifically be updated for Southampton MS 2 and Walkerton MS 2.

An alternative approach to the substation building HI may involve constructing an HI framework for the entire station. If this approach is pursued, additional factors to those considered in the current HIF of substation buildings that can inform such a formulation include:

- Condition of security systems;
- Condition of phones and LAN services;
- Condition of lanes and parking;
- Condition of plumbing and electrical;

- Condition of drainage systems; and
- Grounding/bonding of ancillaries.

4.1.8 Station Power Transformers

Station power transformers should be managed under the context of a thorough AMP. Westario should consider creating an asset registry file for its station power transformers to store asset nameplate information. Key information from electrical and oil testing reports can be digitized to improve the data analysis process for ACA.

The condition data currently being collected for station transformers is both comprehensive and detailed. In addition to the data currently being collected, a best-practice formulation may consider some additional condition parameters:

- Load history; and
- Insulation moisture content (from Dielectric Frequency Response Testing “DFR”).

4.1.9 Station Circuit Breakers

Westario should consider collecting missing data for station circuit breakers in the towns of Palmerston and Walkerton. Condition data from visual inspection reports should be consolidated into a single file in the asset registry. As station breakers are renewed over time and new stations are built, new technology is likely to be introduced into the system, warranting the formulation of a more comprehensive HI. In addition to the data currently being collected, additional condition parameters that Westario can consider collecting are:

- Condition/operability of the communications system;
- Condition of foundations and structures;
- Time/travel tests; and
- Vacuum bottle integrity (if applicable).

4.1.10 Station Reclosers

Westario should consider collecting missing data for station reclosers in the towns of Teeswater and Hanover. Condition data from visual inspection reports should be consolidated into a single file in the asset registry. In addition to the data currently being collected, Westario should also consider reporting the counter readings/number of operations of its reclosers during the visual inspections.

4.1.11 Station Fused Switchgear

Condition data for fused switchgear from visual inspection reports should be consolidated into a single file in the asset registry.

4.2 Additional Asset Class Considerations

In addition to including advanced condition parameters to already existing asset HI formulations, METSCO recommends the following asset classes be considered for future iterations of the ACA study:

- Overhead Conductors;
- Underground Cables; and
- Station Protective Relays; and
- Station Batteries.

4.2.1 Overhead Conductors

Westario will need to improve the availability of OH conductor age information in the GIS system to complete the ACA for this asset class. It is recommended that Westario record the Facility ID of the closest pole to each conductor line segment. Once this is done, the age of each line segment can be estimated based on the age of the closest distribution pole. Additionally, Westario should consider determining or estimating the length of each line segment within the GIS.

Westario should also ensure that all OH conductor segments of #4 or #6 copper are tagged in the GIS asset registry. These small copper conductors tend to age at an accelerated rate and become brittle. This condition parameter is important to include in the OH conductor HIF.

4.2.2 Underground Cables

Westario will need to improve the availability of UG cable age information in the GIS system to complete the ACA for this asset class. Additionally, Westario should consider determining or estimating the length of each line segment within the GIS.

Recognized HI guides recommend a multi-parameter HIF for UG cables. METSCO recommends that Westario collect the following parameters as a minimum to support future ACAs for UG cables:

- Service age;
- Cable failure analysis;
- Field testing; and
- Outage records.

4.2.3 Station Protective Relays

It is recommended that Westario consolidate an asset registry for their protective relays in the GIS. Westario is already collecting some electrical testing results which could be used to complete an ACA for station protective relays. A recommended HIF for this asset class would include the following condition parameters that Westario should consider collecting:

- Service age;
- Electrical test results;
- Overall condition;
- Mean time between failures (per relay type); and
- Discretionary or non-discretionary obsolescence.

4.2.4 Station Batteries

It is recommended that Westario consolidate an asset registry for their station batteries in the GIS. Westario is already collecting some electrical testing results which could be used to complete an ACA for station batteries. A recommended HIF for this asset class would include the following condition parameters that Westario should consider collecting:

- Service age; and
- Electrical test results.

5 Conclusion

On top of a condition assessment of Westario's major asset classes, this report provided Westario with a broad range of recommendations with respect to specific types of information that it may choose to collect and the metrics it may deploy to enhance it's AM analytics. Westario is a smaller utility that made significant efforts in capturing condition data of its in-service assets. However, improvements can be made to enhance the ACA framework and to further justify asset renewal, capital investments, operational expenditures, and maintenance activities.

Keeping records of assets' condition is good practice, as it may assist in planning and assessing the quality of assets being replaced in-service. METSCO recommends collecting and keeping condition records consistent for all assets inspected. It would also be beneficial to consolidate condition information within the GIS for all assets with a complete asset registry. Westario should consider creating an asset registry for station assets identified to not be in the GIS. Obtaining and organizing more comprehensive condition data records would establish a stronger baseline of the asset health indices rather than being dependent on age. METSCO recommends that Westario incorporate a five-level grading scheme for any asset condition inspections, where applicable to bring its practices closer to the ISO55000 recommended approaches. A five-level grading scheme will allow for more discrepancy between assets and their respective HI values that will be used for prioritizing assets.

This concludes METSCO's ACA report for Westario's assets. We thank Westario's staff and management for the opportunity to participate in this complex study and for their ongoing support throughout its development.

Appendix A: METSCO Company Profile

METSCO Energy Solutions Inc. is a Canadian corporation which started its operations on the market in 2006. METSCO is engaged in the business of providing consulting and project management services to electricity generating, transmission, and distribution companies, major industrial and commercial users of electricity, as well as municipalities and constructors on lighting services, asset management, and construction audits. Our head office is in Concord, ON and our western office is located in Calgary, AB. We have satellite offices in Whitehorse, YK, and Houston, TX. Through our network of associates, we provide consulting services to power sector clients around the world. A small subset of our major clients is shown in the figure below.

METSCO has been leading the industry in Asset Condition Assessment and Asset Management practices for over 10 years. Our founders are the pioneers of the first Health Index methodology for power equipment in North America as well as the most robust risk-based analytics on the market today for high-voltage assets. METSCO has since completed hundreds of Asset Condition Assessments, Asset Management Plans, and Asset Management Framework implementations. Our collective record of experience in these areas is the largest in the world, with ours being the only practice with widespread acceptance across regulatory jurisdictions. METSCO has worked with over 100 different utilities through its tenure, and as such, has been exposed and introduced to practices and unique challenges from a variety of entities, environments, and geographies. When a client chooses METSCO to work on improving Asset Management practices, it is choosing the industry-leading standard, rigorously tested and refined on a continued basis. Our experts have developed, supported, managed, led and sat on stand defending their own Distribution System Plans as utility staff giving METSCO the qualified expertise to provide service to Westario.

In addition to our work in the area of asset health assessments and lifecycle enhancement, our services span a broad common utility issue area, including planning and asset management, design, construction supervision, project management, commissioning, troubleshooting operating problems, investigating asset failures and providing training and technology transfer.

Our founders and leaders are pioneers in their respective fields. The fundamental electrical utility-grade engineering services we provide include:

- Power sector process engineering and improvement
- Fixed Asset Investment Planning – development of economic investment plans
- Regulatory Proceeding Support
- Power System Planning and Studies – identifying system constraints
- Smart Grid Development – from planning to implementation of leading technologies
- Asset Performance and Asset Management
- Distribution and Transmission System Design
- Mentoring, Training, and Technical Resource Development
- Health Index Validation and Development
- Business Case Development
- Owners Engineering Services
- Risk Modeling – Asset Lifecycle and Risk Assessment

Appendix B: Condition Parameters Grading Tables

B1. Wood Poles

Table B - 1: Criteria for Wood Pole Remaining Strength ("RS")

Condition Rating	Corresponding Condition
A	RS >90%
B	80%< RS ≤90%
C	70%< RS ≤80%
D	60%< RS ≤70%
E	RS ≤60%

Table B - 2: Criteria for Wood Pole Overall Condition

Condition Rating	Corresponding Condition
A	No signs of any defects on the wood pole due to cracks, wet ground, or woodpecker and insect damage
B	Minor signs of defects on the wood pole due to cracks, wet ground, or woodpecker and insect damage
C	Significant signs of defects on the wood pole due to cracks, wet ground, or woodpecker and insect damage
D	Major signs of defects on the wood pole due to cracks, wet ground, or woodpecker and insect damage
E	Serious signs of defects on the wood pole due to cracks, wet ground, or woodpecker and insect damage

Table B - 3: Criteria for Wood Pole Service Age

Condition Rating	Corresponding Condition
A	0 to 10 years
B	11 to 30 years
C	31 to 40 years
D	41 to 55 years
E	More than 55 years

Table B - 4: Criteria for Wood Pole Surface Decay ("SD") – Measured in Inches of Depth

Condition Rating	Corresponding Condition
A	SD < 0.1 in
B	0.1 in ≤ SD < 0.5 in
C	0.5 in ≤ SD < 1 in
D	1 in ≤ SD < 1.5 in
E	SD ≥ 1.5 in

Table B - 5: Criteria for Wood Pole Mechanical Damage ("MD") – Measured in Inches of Depth

Condition Rating	Corresponding Condition
A	MD < 0.5 in
B	0.5 in ≤ MD < 1 in
C	1 in ≤ MD < 1.5 in
D	1.5 in ≤ MD < 1.6 in
E	MD ≥ 1.6 in

B2. Steel Poles

Table B - 6: Criteria for Steel Pole Overall Condition

Condition Rating	Corresponding Condition
A	No signs of any defects on the steel pole due to vandalism, vehicular accidents, electrical burns, or soil erosion. Insulators, cross arms, ground wires, and attachment hardware are all in like-new condition. The pole is mounted without showing any signs of lean.
B	Minor signs of defects on the steel pole due to vandalism, vehicular accidents, electrical burns, or soil erosion. And/or the insulators, cross arms, ground wires, or attachment hardware are in good condition.
C	Significant signs of defects on the steel pole due to vandalism, vehicular accidents, electrical burns, or soil erosion. And/or the insulators, cross arms, ground wires, or attachment hardware are in fair condition.
D	Major signs of defects on the steel pole due to vandalism, vehicular accidents, electrical burns, or soil erosion. And/or the insulators, cross arms, ground wires, or attachment hardware are in poor condition.
E	Serious signs of defects on the steel pole due to vandalism, vehicular accidents, electrical burns, or soil erosion. And/or the insulators, cross arms, ground wires, and attachment hardware are severely degraded beyond repair. And/or the pole is out of plumb.

Table B - 7: Criteria for Steel Pole Service Age

Condition Rating	Corresponding Condition
A	0 to 10 years
B	11 to 30 years
C	31 to 40 years
D	41 to 60 years
E	More than 60 years

B3. Concrete Poles

Table B - 8: Criteria for Concrete Pole Overall Condition

Condition Rating	Corresponding Condition
A	No signs of any defects on the concrete pole due to vandalism, vehicular accidents, electrical burns, or cracking. Insulators, cross arms, ground wires, and attachment hardware are all in like-new condition. The pole is mounted without showing any signs of lean.
B	Signs of minor defects on the concrete pole due to vandalism, vehicular accidents, electrical burns, or cracking. And/or the insulators, cross arms, ground wires, or attachment hardware are in good condition.
C	Signs of significant defects on the concrete pole due to vandalism, vehicular accidents, electrical burns, or cracking. And/or the insulators, cross arms, ground wires, or attachment hardware are in fair condition.
D	Signs of serious defects on the concrete pole due to vandalism, vehicular accidents, electrical burns, or cracking. And/or the insulators, cross arms, ground wires, or attachment hardware are in poor condition.
E	Signs of very serious defects on the concrete pole due to vandalism, vehicular accidents, electrical burns, or cracking. And/or the insulators, cross arms, ground wires, and attachment hardware are severely degraded beyond repair. And/or the pole is out of plumb.

Table B - 9: Criteria for Concrete Pole Service Age

Condition Rating	Corresponding Condition
A	0 to 10 years
B	11 to 30 years
C	31 to 40 years
D	41 to 50 years
E	More than 50 years

B4. Distribution Transformers

Table B - 10: Criteria for Distribution Transformer Overall Condition

Condition Rating	Corresponding Condition
A	Transformer is easily accessed and there is no visible rust on the tank/enclosure. The grounding system, insulator, safety decals, locks, hoods, doors, and latches are all in good condition and are showing no signs of deterioration.
B	Normal signs of wear with respect to the above characteristics.
C	One of the above characteristics is unacceptable.
D	Two of the above characteristics are unacceptable.
E	The transformer is damaged/degraded beyond repair.

Table B - 11: Criteria for Distribution Transformer Service Age

Condition Rating	Corresponding Condition
A	0 to 10 years
B	11 to 20 years
C	21 to 30 years
D	31 to 40 years
E	More than 40 years

Table B - 12: Criteria for Distribution Transformer Oil Leaks

Condition Rating	Corresponding Condition
A	No oil leaks identified in transformer visual inspection.
E	One or more oil leaks detected in transformer visual inspection.

B5. Distribution Switches

Table B - 13: Criteria for Switch Overall Condition

Condition Rating	Corresponding Condition
A	No rust present, no damage to insulators, arrestors, bushings or phase indicator
B	Normal signs of wear with respect to the above characteristics.
C	One of the above characteristics is unacceptable.
D	Two of the above characteristics are unacceptable.
E	The switch is damaged/degraded beyond repair.

B6. Switching Cubicles

Table B - 14: Criteria for Switching Cubicle Overall Condition

Condition Rating	Corresponding Condition
A	Support Insulators are not broken and are free of chips, radial cracks, flashover burns, copper splash and copper wash. Cementing and fasteners are secure. Blades are clean, free from corrosion, cracks, distortion, abrasion or obstruction. All fasteners are tight. No visible evidence of looseness, loss of adjustment, or excess bearing wear. Operating mechanism is in good condition and all parts are moving with adequate speed. No evidence of rust or friction in moving parts.
B	Normal signs of wear with respect to the above characteristics.
C	One of the above characteristics is unacceptable.
D	Two of the above characteristics are unacceptable.
E	The switching cubicle is damaged/degraded beyond repair.

B7. Station Buildings

Table B - 15: Criteria for Station Condition - Within the Station Compound

Condition Rating	Corresponding Condition
A	Substation yard within the station compound is free of debris and there is no vegetation present on stone surfaces. The crushed stone depth is at an acceptable level. The station's buried ground grid connections are in good condition.
B	Normal signs of wear with respect to the above characteristics.
C	One of the above characteristics is unacceptable.
D	Two of the above characteristics are unacceptable.
E	The station yard is damaged/degraded beyond repair within the station compound.

Table B - 16: Criteria for Station Condition - Outside the Station Compound

Condition Rating	Corresponding Condition
A	Substation yard outside of the station compound is free of debris and there is no vegetation present on stone surfaces within 2m of the station fence. There are no metal objects found within 2m of the station fence. The crushed stone depth within 2m of the station fence is at an acceptable level.
B	Normal signs of wear with respect to the above characteristics.
C	One of the above characteristics is unacceptable.
D	Two of the above characteristics are unacceptable.
E	The station yard is damaged/degraded beyond repair outside of the station compound.

Table B - 17: Criteria for Station Fence Condition

Condition Rating	Corresponding Condition
A	No deficiencies are present in regards to the station fence. The fence itself, fence grounding, and fence barbed wire are all clean and free from any signs of deterioration.
B	Normal signs of wear with respect to the above characteristics.
C	One of the above characteristics is unacceptable.
D	Two of the above characteristics are unacceptable.
E	The station fence is damaged/degraded beyond repair.

Table B - 18: Criteria for Station Indoor Room Condition

Condition Rating	Corresponding Condition
A	The station indoor room is free of debris. The station batteries are free of corrosion and the battery electrolyte is at an acceptable level. The indoor room's Heating, Ventilation, and Air Conditioning ("HVAC") and Lighting systems are in good condition and are showing no signs of deterioration. All emergency, control, weather tightness and security systems are functioning as expected.
B	Normal signs of wear with respect to the above characteristics.
C	One of the above characteristics is unacceptable.
D	Two of the above characteristics are unacceptable.
E	The station indoor room is damaged/degraded beyond repair.

Table B - 19: Criteria for Station Civil Condition

Condition Rating	Corresponding Condition
A	The substation's civil components are clean and showing no signs of deterioration. The equipment concrete bases are clean and free of cracking and discolouration, and the building's civil structures are draining effectively.
B	Normal signs of wear with respect to the above characteristics.
C	One of the above characteristics is unacceptable.
D	Two of the above characteristics are unacceptable.
E	The station civil components are damaged/degraded beyond repair.

B8. Station Power Transformers

The power transformer DGA condition criteria require data on gas concentrations and dissolved gas rate of change. For both DGA and OQ, the worst condition is taken as the dominant grade.

Table B - 20: Gas Concentration (ppm) Limits for Power Transformers[1]

Gas	O2/N2 Ratio <= 0.2				O2/N2 Ratio >0.2			
	Transformer Age in Years				Transformer Age in Years			
	Unknown	1-9	10-30	>30	Unknown	1-9	10-30	>30
H_2	80	75		100	40	40		
CH_4	90	45	90	110	20	20		
C_2H_6	90	30	90	150	15	15		
C_2H_4	50	20	50	90	50	25	60	
C_2H_2	1	1			2	2		
CO	900	900			500	500		
CO_2	9000	5000	10000		5000	3500	5500	

Table B - 21: Gas Rate of Change Limits for Power Transformers (ppm)[1]

Gas	Maximum (ppm) variation between consecutive DGA samples	
	O2/N2 Ratio <= 0.2	O2/N2 Ratio >0.2
H_2	40	25
CH_4	30	10
C_2H_6	25	7
C_2H_4	20	
C_2H_2	Any Increase	
CO	250	175
CO_2	2500	1750

Table B - 22: Criteria for Power Transformer DGA Results

Condition Rating	Corresponding Condition
A	All parameters within acceptable limits
B	1 parameter does not meet acceptability limits.
C	2 parameters do not meet acceptability limits.
D	3 parameters do not meet acceptability limits.
E	4 or more parameters do not meet acceptability limits.

[1] IEEE Std. C57.104, "IEEE Guide for the Interpretation of Gases Generated in Mineral Oil-Immersed Transformers," 2019.

Table B - 23: Criteria for Power Transformer Overall Condition

Condition Rating	Corresponding Condition
A	Station transformer is externally clean and corrosion free. All monitoring, protection and control, pressure relief, gas accumulation and auxiliary systems mounted on the station transformer are in good condition. Bushings are not broken and are free of chips, radial cracks, flashover burns, copper splash, and copper wash. No rust or corrosion on body of radiators. Fans are free of rust and corrosion and securely mounted in position operating per design. No rust, corrosion, or moisture evident on main tank or conservator tank. All primary and secondary connections are in good condition. No external sign of deterioration of tank gaskets, weld seams, or gaskets on valve fittings.
B	Normal signs of wear with respect to the above characteristics.
C	One or two of the above characteristics are unacceptable.
D	More than two of the above characteristics are unacceptable – repairable.
E	More than two of the above characteristics are unacceptable - damaged beyond repair.

Table B - 24: Criteria for Power Transformer Service Age

Condition Rating	Corresponding Condition
A	0 to 15 years
B	16 to 30 years
C	31 to 45 years
D	46 to 60 years
E	More than 60 years

Table B - 25: Criteria for Power Transformer Infrared Scan

Condition Rating	Corresponding Condition
A	No hot spots detected; no deficiency identified for switch and no further action required.
E	One or more hot spots detected; maintenance may be required to correct the issue(s).

Table B - 26: Criteria for Power Transformer Oil Quality Tests[2]

Test	Station Transformer Voltage Class U ≤ 69 kV	Grade
Acid Number	≤0.05	A
	0.05-0.20	C
	≥0.20	E
IFT [mN/m]	≥30	A
	25-30	C
	≤25	E
Dielectric Strength [kV]	>40 (2 mm gap)	A
	≤40	E
Water Content [ppm]	<35	A
	≥35	E

Table B - 27: Criteria for Power Transformer Power Factor Test[2]

Condition Rating	Corresponding Condition
A	0-0.49
B	0.50-0.99
C	1.00-1.49
D	1.50-1.99
E	≥ 2.00

Table B - 28: Criteria for Power Transformer Turns Ratio Test[2]

Condition Rating	Corresponding Condition
A	Maximum Deviation: 0-0.09%
B	0.10-0.29%
C	0.03-0.39%
D	0.40-0.49%
E	≥ 0.5%

[2] IEEE Std. C57.152, "IEEE Guide for Diagnostic Field Testing of Fluid-Filled Power Transformers, Regulators, and Reactors," 2013.

Table B - 29: Criteria for Power Transformer Winding Resistance Test

Condition Rating	Corresponding Condition
A	0-0.49%
B	0.50-2.49%
C	2.5-3.99%
D	4.0-4.99%
E	≥ 5%

Table B - 30: Criteria for Power Transformer Insulation Resistance ("IR") Test[3]

Condition Rating	Corresponding Condition
A	IR ≥ 20 GΩ
B	15 ≤ IR < 20 GΩ
C	10 ≤ IR < 15 GΩ
D	5 ≤ IR < 10 GΩ
E	IR < 5 GΩ

Table B - 31: Criteria for Power Transformer Oil Leaks

Condition Rating	Corresponding Condition
A	No oil leakage or water ingress at any of the bushing-metal interfaces or at gaskets, weld seals, flanges, valve fittings, gauges, monitors.
B	Minor oil leaks evident, but no moisture ingress is likely.
C	Clear evidence of oil leaks but rate of loss is not likely to cause any operational or environmental impacts.
D	Major oil leakage and probable moisture ingress. If left uncorrected it could cause operational and/or environmental problems.
E	Oil leaks or moisture ingress have resulted in complete failure or damage/degradation beyond repair.

[3] NETA, "Standard for Maintenance Testing Specifications for Electrical Power Equipment & Systems," 2019.

Table B - 32: Criteria for Power Transformer Oil Level

Condition Rating	Corresponding Condition
A	Transformer oil level is acceptable with insignificant variation from the previous inspection.
B	Transformer oil level is acceptable with noticeable variation from the previous inspection.
C	Transformer oil level is acceptable, but considerable variation from the previous inspection.
D	Transformer oil level is unacceptable. Topped up during inspection.
E	Transformer oil level is unacceptable and could not be topped up; and/or oil level indicates unsafe transformer operation or hazardous rate of oil loss.

Table B - 33: Criteria for Power Transformer Foundation and Grounding Condition

Condition Rating	Corresponding Condition
A	Concrete foundation is level and free from cracks and spalling. Support steel and/or anchor bolts are tight and free from corrosion. No issues with settling. Ground connections are tight and free of corrosion. Connections are made directly to tanks, radiators, cabinets and supports without any intervening paint or corrosion.
B	Normal signs of wear with respect to the above characteristics.
C	One of the above characteristics is unacceptable.
D	Two of the above characteristics are unacceptable.
E	Foundation or supports are damaged/degraded beyond repair.

B9. Station Circuit Breakers

Table B - 34: Criteria for Circuit Breaker Insulation Resistance Test

Condition Rating	Corresponding Condition
A	$IR \geq 5.00$ GΩ
B	$4.25 \leq IR < 5.00$ GΩ
C	$3.50 \leq IR < 4.25$ GΩ
D	$2.50 \leq IR < 3.50$ GΩ
E	$IR < 2.50$ GΩ

Table B - 35: Criteria for Circuit Breaker Contact Resistance ("CR") Test

Condition Rating	Corresponding Condition
A	CR ≤ 25 μΩ
B	25 < CR ≤ 50 μΩ
C	50 < CR ≤ 75 μΩ
D	75 < CR ≤ 100 μΩ
E	CR > 100 μΩ

Table B - 36: Criteria for Circuit Breaker Condition of Contacts

Condition Rating	Corresponding Condition
A	Stationary, Moving, and Arcing Contact Surfaces are clean, lubricated, free from corrosion or cracks, distortion, abrasion, and obstruction.
B	Normal signs of wear with respect to the above characteristics.
C	One of the above characteristics is unacceptable.
D	Two of the above characteristics are unacceptable.
E	Breaker contacts are damaged/degraded beyond repair.

Table B - 37: Criteria for Circuit Breaker Truck Condition

Condition Rating	Corresponding Condition
A	Ground bus stab connections to the tank are secure. Stationary and moving bus stabs are in Good condition.
B	Normal signs of wear with respect to the above characteristics.
C	One of the above characteristics is unacceptable.
D	Two of the above characteristics are unacceptable.
E	Breaker truck is damaged/degraded beyond repair.

Table B - 38: Criteria for Circuit Breaker Arc Chutes

Condition Rating	Corresponding Condition
A	No arc chutes identified; no further action required.
E	One or more arc chutes detected; maintenance may be required to correct the issue.

Table B - 39: Criteria for Circuit Breaker Control and Operating Condition

Condition Rating	Corresponding Condition
A	Operating mechanism, racking mechanism, and phase barrier are all in good condition. Electrical & manual operation is as per the intended design with cells aligned and interlocks in place.
B	Normal signs of wear with respect to the above characteristics.
C	One of the above characteristics is unacceptable.
D	Two of the above characteristics are unacceptable.
E	Circuit breaker control and operating mechanism is damaged/degraded beyond repair.

Table B - 40: Criteria for Circuit Breaker Operating Counter

Condition Rating	Corresponding Condition
A	Operations ≤ 3000
B	3000 < Operations ≤ 4000
C	4000 < Operations ≤ 5000
D	5000 < Operations ≤ 6000
E	Operations > 6000

B10. Station Reclosers

Table B - 41: Criteria for Recloser Overall Condition

Condition Rating	Corresponding Condition
A	All components of the recloser are functioning as expected and are free from any signs of deterioration. The operating mechanism, contact surfaces, closing solenoid, phase barrier, bushings, connections, grounding, gaskets, and lifting strap are all in good condition. No arc chutes or oil leaks were noted in the inspection.
B	Normal signs of wear with respect to the above characteristics.
C	One of the above characteristics is unacceptable.
D	Two of the above characteristics are unacceptable.
E	The station recloser is damaged/degraded beyond repair.

Table B - 42: Criteria for Recloser Insulation Resistance Test

Condition Rating	Corresponding Condition
A	IR ≥ 5.00 GΩ
B	4.25 ≤ IR < 5.00 GΩ
C	3.50 ≤ IR < 4.25 GΩ
D	2.50 ≤ IR < 3.50 GΩ
E	IR < 2.50 GΩ

Table B - 43: Criteria for Recloser Contact Resistance Test

Condition Rating	Corresponding Condition
A	CR ≤ 50 μΩ
B	50 < CR ≤ 100 μΩ
C	100 < CR ≤ 200 μΩ
D	200 < CR ≤ 300 μΩ
E	CR > 300 μΩ

B11.Station Fused Switchgear

Table B - 44: Criteria for Fused Switchgear Overall Condition of Switch

Condition Rating	Corresponding Condition
A	All components of the switch are functioning as expected, are clean, and are free from any signs of deterioration. The operating mechanism, contact surfaces, connector(s), insulator(s), phase barrier, grounding, lightning arrestor, heaters & thermostat, potential indicators, and support structure are all in good condition.
B	Normal signs of wear with respect to the above characteristics.
C	One of the above characteristics is unacceptable.
D	Two of the above characteristics are unacceptable.
E	The switch is damaged/degraded beyond repair.

Table B - 45: Criteria for Fused Switchgear Overall Condition of Fuse

Condition Rating	Corresponding Condition
A	All components of the fuse are functioning as expected, are clean, and are free from any signs of deterioration. The operating mechanism, contacts, filters, fuse barrel, connector, insulator, phase barrier, support structure, and heaters and thermostat are all in good condition.
B	Normal signs of wear with respect to the above characteristics.
C	One of the above characteristics is unacceptable.
D	Two of the above characteristics are unacceptable.
E	The fuse is damaged/degraded beyond repair.

Table B - 46: Criteria for Fused Switchgear Insulation Resistance Test for Switch/Fuse

Condition Rating	Corresponding Condition
A	IR ≥ 5.00 GΩ
B	4.25 ≤ IR < 5.00 GΩ
C	3.50 ≤ IR < 4.25 GΩ
D	2.50 ≤ IR < 3.50 GΩ
E	IR < 2.50 GΩ

Table B - 47: Criteria for Fused Switchgear Contact Resistance Test for Switch/Fuse

Condition Rating	Corresponding Condition
A	CR ≤ 50 μΩ
B	50 < CR ≤ 100 μΩ
C	100 < CR ≤ 200 μΩ
D	200 < CR ≤ 300 μΩ
E	CR > 300 μΩ