

**Face Rock – Five Forks Inspection of Structures**

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## Face Rock – Five Forks Inspection of Structures

### NEETRAC Project Number 16-107

#### 1 SUMMARY

Meagan Kuchan from PPL requested NEETRAC inspect a subset of structures on their Face Rock - Five Forks 115 kV transmission line. Thirty three (33) structures were inspected from the air on June 14<sup>th</sup>, 2016, and twenty four (24) structures were inspected from the ground on June 15<sup>th</sup>, 2016. The inspections focused on obvious structural issues, paint adhesion and corrosion (rust) above the ground line. (PPL has contracted with Osmose to evaluate the footings.) The line was built in 1912 with another interconnected line built adjacent in the 1930's. In the 1950's the voltage and frequency of the line were changed and the towers were modified to provide clearance for higher voltage.

Five (5) structures had significant defects and require immediate action. Structure 39615S18127 and 39621S18116 exhibited poor paint adhesion, pervasive and deep rust, as well as pack rust. Pack rust can cause sudden catastrophic failure of gusset plates and connections as it can create up to 10,000 psi in these connections. 39615S18127 also had several bent structural members. Structures 38663S16189, 38567S15943 and 38129S14788 exhibited severe buckling and/or twisting of one of their four legs (main support column). Structure 38663S16189 is located on the side of a steep hill and there is no way it could have been damaged by heavy machinery. The damage could have been caused by heavy ice or wind loading, inadequate foundation support, seismic activity or some combination thereof. Regardless of the cause, the structural integrity of the tower is significantly compromised.

The remaining structures inspected are in various states of decay. If PPL wants to reuse these structures during upcoming reconductoring of this line, all structures inspected need to be stripped and repainted. This will likely be difficult, as the paint is likely lead based and stripping could cause environmental concerns that will need to be abated. Moving forward, PPL will need to reinstate its inspection and painting program to prevent the level of decay seen during this inspection. Most structures also exhibited at least some corrosion, and may have corrosion that impacts the structure's strength. Fourteen (14) of the thirty six (36) structures (39%) evaluated had buckled or damaged structural members.

Given the pervasive and deep rust on many of the structures, need for repainting and remediation of lead based paint, structural repairs and the need to reinstate a painting maintenance program; NEETRAC recommends that PPL replace each pair of lattice towers with a single galvanized steel pole. Since the towers were previously modified to accommodate an increase in the line voltage and some towers have unusual suspension systems to ensure NESC clearances are met, this strategy has the advantage of standardizing the line design, as well as reducing maintenance costs and the possibility of structural damage from farm equipment. It is highly likely that PPL will find this option to be the least costly and easiest to execute with the lowest cost of ownership going forward.

If PPL decides to reuse the structures, all structures in this line should receive a detailed climbing inspection with the aim of detailing and costing the repairs needed. Also, PPL needs to institute a painting and inspection maintenance program to maintain these structures.

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### 2 DISCUSSION

The line was constructed in 1912 and operated at a lower voltage and 50 Hz. At some point in the 1930's an interconnected sister line was added. During the 1950's the line voltage was increased to 115 kV and 60Hz. At this time, the original structures did not provide adequate voltage clearance and the towers were modified to provide clearance. There are approximately 80 structures in two parallel interconnected lines with approximately 600 ft. spans. In order to maintain the NESC clearance requirements using the modified towers, some double deadend configurations are suspended from suspension insulators rather than attached to the tower.

All towers inspected in this project were lattice towers. PPL has contracted with Osmose to perform ground-line inspections that involve an inspection of the foundation and the tower's attachment to it. PPL has also contracted with a consulting company to perform structural analysis of the structures and determine if the structure's design meets the loading schedules.

Inspection occurred from the air in PPL's helicopter and from the ground on June 14<sup>th</sup> and 15<sup>th</sup>, 2016 respectively. During the ground inspection, Mr. Goldenburg of NEETRAC was accompanied by PPL's Jonathan Fuge in the morning and Tom Astleford from Michels Power in the afternoon. Not all structures were inspected from both the ground and the air. The following general inspection criteria were used to evaluate the structures and results are summarized in Table 1.

- Extent and depth of corrosion (rust)
  - None – no rust observed anywhere on the structure.
  - Light – some rust spotting / surface rust, typically on less than 10% of the surface. This rust could be remediated by wire abrasion or media blasting.
  - Pervasive – light rust on more than 10% of the surface
  - Structural – rust that affects the mechanical strength of the structure. This may include pack rust, discussed in more detail later in this report.
- Buckled, bent, broken and missing structural components.
- Loose or missing hardware.
- Paint adhesion was evaluated by manually scraping structural members with a hand scraper. The amount of paint removed and exposed metal was evaluated. All structures require repainting. Section 3 of this report includes photographs taken during the inspection that show many of the problems indicated in Table 1.

The structures inspected were generally in a significant state of decay. PPL discontinued its painting maintenance program over 20 years ago, which accounts for the amount of significant and pervasive rust, as well as poor paint adhesion found on most of the structures inspected. Prior to construction, steel components were galvanized and then assembled on site. Shortly after assembly the tower was painted and the paint was maintained until PPL discontinued its painting program over 20 years ago. Paint serves as the primary defense against corrosion, but is degraded by the sun (UV), bird feces, freeze-thaw cycles and other pollutants. The zinc galvanizing serves as a secondary defense against corrosion of the base metal and also helps with paint adhesion. Once the zinc is depleted (by chemical and anodic action), the base metal is exposed and corrodes. Once a significant amount of corrosion (rust) sets in, the structural integrity of the component becomes compromised and must be replaced. First, corrosion removes material, which reduces the cross sectional area, which increases the stress, which decreases the strength. Second, the corrosion leads to pitting that acts as local stress risers, which decreases the strength. In severe cases corrosion forms between components, known as pack rust, which is a form of crevice corrosion.

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Pack rust can lead to a pressure build up between the members that can break connective hardware, such as rivets and bolts. This type of corrosion is common in bridges and towers and has caused sudden catastrophic failures of these structures. In joints with pack rust, the fastener typically must be replaced and the joint reworked.

The condition of the paint is deceptive. While a structure may look like it's painted, as the paint ages and peels and the zinc layer between it and the steel depletes, rust sets in and runs under the paint. Paint covers rusted metal and traps moisture that accelerates the corrosion process. The zinc also corrodes and this corrosion runs under the paint in a similar manner, causing the paint to lift and peel. Paint that is blistered, lifted and wavy indicates significant sub-surface corrosion. However, the zinc layer is designed to corrode sacrificially to protect the steel, and corrosion of the zinc layer does not affect the structural integrity of the member. Therefore, in this report the terms corrosion and rust will typically be used to refer to corrosion of the steel structural member, which is reddish brown.

If the structures had been maintained, a non-ablative process could have been used to prepare the towers for repainting. However, given the extremely poor paint adhesion observed on almost all structures inspected, the paint must be stripped and replaced. The most likely methods are power scrapers, wire abrasion or media blasting. (Media blasting is most likely, as that will most likely be used to remediate the light surface rust as well.) It is highly likely given the age of the structures and number of coats of paint observed, that the structures are coated with a lead based paint. Given environmental concerns surrounding lead based paint, this process could be very expensive.

Significant structural repairs are also needed. Fourteen out of thirty six structures inspected (39%), had buckled or otherwise deformed structural components. In addition components with severe rust and joints with pack rust must be replaced. Most of the deformed structural components are most likely due to farm equipment. Lattice towers are light, relative to the farm equipment that damages them and farmers are not always cautious when working around lattice towers.

Five structures had significant defects and require immediate action.

- Structure 39615S18127 exhibited extensive pack rust, multiple buckled structural members, and significant corrosion that has run under the paint. The structure is not salvageable and should be replaced soon.
- Structure 39621S18116 exhibited poor paint adhesion and pervasive and deep rust, as well as pack rust. Though expensive, this structure may be salvageable. It requires immediate action.
- Structure 38663S16189 exhibited severe deformation of one of its four legs (main support column). This structure is located on the side of a steep hill and there is no way it could have been damaged by heavy machinery. Damage could have been caused by heavy ice or wind loading, inadequate foundation support, seismic activity or some combination thereof. Regardless of the cause, the structural integrity of the tower is significantly compromised. Depending on the cause of the damage, this structure may not be salvageable. This structure requires immediate action.
- Structure 38567S15943 exhibited buckling of one of the four main legs that supports the tower. Damage from farm equipment is a likely cause. This structure requires immediate action.
- Structure 38129S14788 exhibited buckling of one of the four main legs that supports the tower. Damage from farm equipment is a likely cause. This structure requires immediate action.

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NEETRAC recommends that PPL replace each pair of lattice towers with a single galvanized steel pole. This strategy has the following benefits:

- It likely prevents further damage to structures. Lattice structures are easily damaged by farm equipment because a farmer is not likely to damage their tractor or equipment if they hit the structure. There is little risk to them for getting too close and damaging a lattice tower. However, a galvanized steel pole would likely damage their tractor or equipment, while doing little damage to the pole. This increases the reliability of the system, as well as reduces maintenance cost.
- Less potential for environmental damage to farmlands and wetlands from lead based paint chips and debris due to the stripping and repainting process.
- It is likely less expensive than option 1 because it will most likely cost more to save the current structures, given the advanced state of decay of many of them.
- Ongoing maintenance costs will likely be lower because:
  - It does not require PPL to reinstate its painting program.
  - Damage from farm equipment is less likely.
- It provides a standard design and maintenance strategy for the line. (Some structures use an interesting strategy of suspending double deadens from suspension insulators to ensure the NESC clearances are met.) New structures would obviate the need for this atypical strategy and increase the system's reliability.
- It will likely cost less than putting the existing structures in a safe and reliable condition.

Note: This was NOT a detailed inspection. Many obvious problems were observed. Less obvious problems may have been missed. In the event PPL decides to reuse the structures during its upcoming reconductoring project, NEETRAC recommends a detailed climbing inspection be performed on every structure to determine a remediation plan and cost for that structure.

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Table 1: Inspection Results							
Structure ID	Line 1 or 2	Aerial or Ground Inspect	Rust	Paint Needs Removal and Repainting	Deformed Structural Member(s)	Remediation Possible	Comments
39615S18127	2	A,G	Structural	Yes	Yes	Unlikely	Immediate action! Several bent structural members, deep rust pitting and significant loss of material to rusting, significant pack rust in joints, poor paint adhesion. Structure should be removed from service as soon as practical.
39621S18116	1	A, G	Structural	Yes	No	Unlikely	Immediate action! Severe rusting at footing, pack rust, very poor paint adhesion.
39513S18076	1	A,G	Pervasive or Structural	Yes	No	Possible	A more detailed inspection is needed to determine depth of corrosion.
39436S17961	1	A	Pervasive	Yes	No	Possible	
39404S17922	2	A	N/A	N/A	Yes	N/A	Not on inspection list, but noticed structural problem on fly-by.
39430S17964	2	A	Structural	Yes	No	Possible	
39387S17885	1	A	Light	Yes	No	Possible	

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Table 1: Inspection Results							
Structure ID	Line 1 or 2	Aerial or Ground Inspect	Rust	Paint Needs Removal and Repainting	Deformed Structural Member(s)	Remediation Possible	Comments
39382S17888	2	A	Pervasive	Yes	Yes	Unlikely	Extensive rust on lower section, slight bow in some brace members on north face.
39320S17792	2	A,G	Pervasive or Structural	Yes	No	Unlikely	
39325S17789	1	A,G	Structural	Yes	Yes	Possible	One leg is bent. This requires immediate action!
39277S17723	2	A,G	Pervasive or Structural	Yes	No	Unlikely	Corrosion is extensive.
39282S17720	1	A	Light	Yes	No	Possible	
39254S17688	2	A	Pervasive	Yes	No	Possible	
39160S17524	2	A,G	Pervasive	Yes	Yes	Unlikely	Buckled support from farm equipment, pervasive rust.
39134S17433	1	A	Pervasive	Yes	Yes	Possible	Buckled brace.
39129S17435	2	A	Pervasive	Yes	No	Possible	
38921S16877	1	A,G	Light or Pervasive	Yes	Yes	Possible	Two bent/buckled members, some rust and poor paint adhesion.
38916S16879	2	A,G	Light or Pervasive	Yes	Yes/No	Possible	Damage at footing from previous structural repair; likely won't affect structure.
38738S16387	1	A,G	Very Light	Yes	No	Possible	

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Table 1: Inspection Results							
Structure ID	Line 1 or 2	Aerial or Ground Inspect	Rust	Paint Needs Removal and Repainting	Deformed Structural Member(s)	Remediation Possible	Comments
38733S16386	2	A,G	Light	Yes	No	Possible	Mislabeled as 3877S16389
38703S16287	1	A,G	None or Light	Yes	No	Possible	Bird feces made determination of rust at the top of the structure impossible.
38698S16295	2	A,G	Light	Yes	No	Possible	
38663S16189	1	A,G	Light	Yes	No	Possible	
38658S16197	2	A,G	Light or Pervasive	Yes	No	Possible	
38591S15995	1	A	Structural	Poor	No	Possible	
38586S16005	2	A	Pervasive or Structural	Yes	No	Unlikely	
38567S15943	1	A,G	Structural	Yes	Yes	Unlikely	Immediate action! Buckled support leg.
38562S15945	2	A,G	Structural	Yes	No	Possible	
38349S15373	1	G	Light	Yes	Yes	Possible	Bent cross brace.
38378S15471	2	A	Structural	Yes	No	Possible	
38344S15375	2	G	Light	Yes	Yes	Possible	2 bent cross braces.
38124S14790	2	A,G	Structural	Yes	No	Possible	
38129S14788	1	A,G	Pervasive or Structural	Yes	Yes	Unlikely	Immediate action! Buckled leg.
38109S14748	2	G	N/A	N/A	Yes	N/A	Not on inspection list, but noticed multiple damaged members on drive-by.

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<b>Table 1: Inspection Results</b>							
<b>Structure ID</b>	<b>Line 1 or 2</b>	<b>Aerial or Ground Inspect</b>	<b>Rust</b>	<b>Paint Needs Removal and Repainting</b>	<b>Deformed Structural Member(s)</b>	<b>Remediation Possible</b>	<b>Comments</b>
38005S14453	2	A,G	Light on bottom Pervasive on top	Yes	Yes	Possible	Buckled brace.
38070S14451	1	A,G	Light	Yes	No	Possible	

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### 3 PHOTOGRAPHS OF THE STRUCTURES

Photographs with comments are included for all of the structures inspected.

#### 3.1 39615S18127

This structure requires immediate action. Several structural members were bent. The corrosion (rust) was pervasive and deep, with significant loss of base material and pack rust. Due to the amount of corrosion and the truss-like construction of the individual members, it is highly unlikely this structure can be saved.



**Figure 1:** 39615S18127 - Significant rust and bent structural members



Significant rust seen over most of the structure. The rust pitting is so significant, many components will need replacement. Also, the truss construction of each member increases the remediation cost.

This structural member is bent and needs replacement.

Figure 2: 39615S18127 - Pervasive rust and bent structural members

Pervasive and deep rust seen over most of the structure. The corrosion is actually more severe than it appears here because the rust actually runs under the paint, causing it to lift off the surface. Rust between the connection plates, girders and bolts, known as pack rust, increases the stress between these components reducing the original design safety factor of the structure.

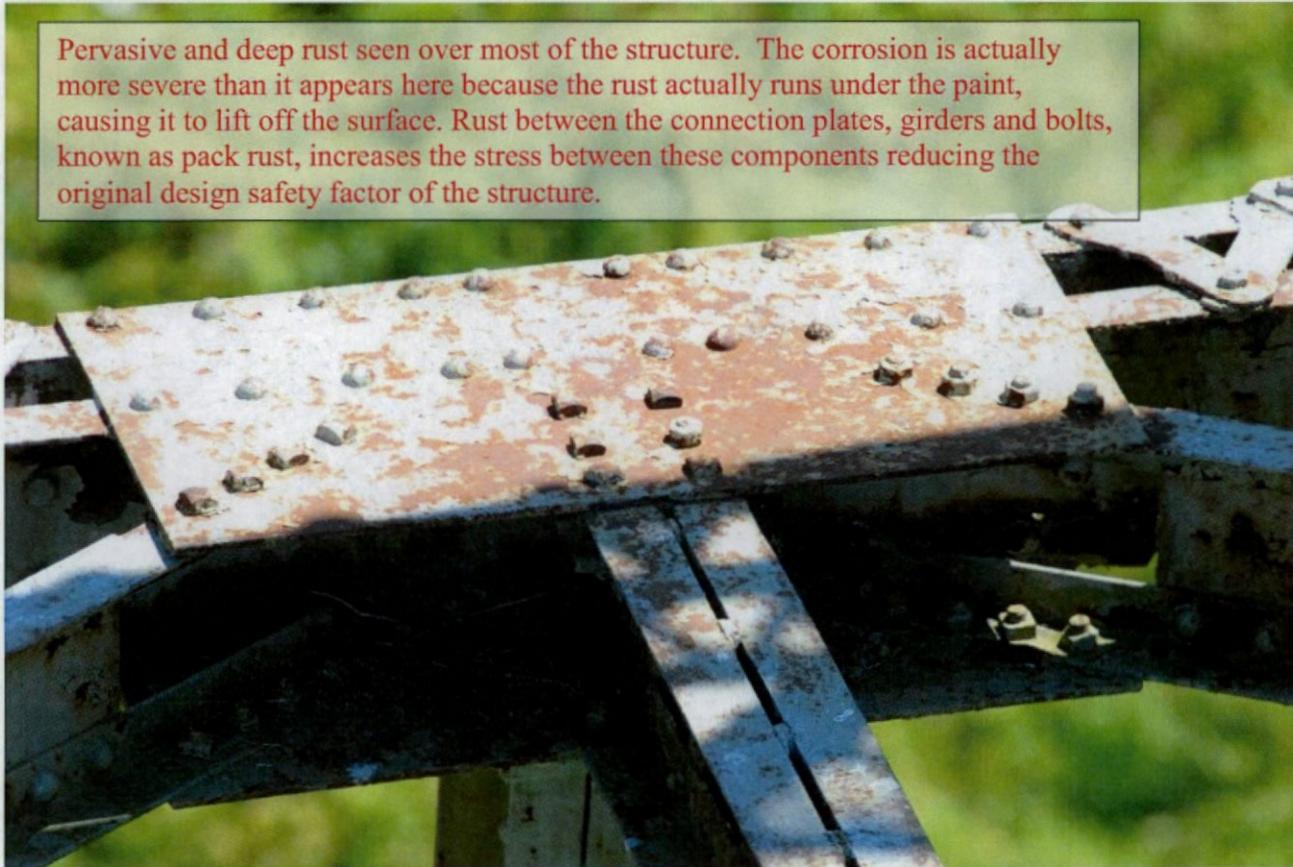


Figure 3: 39615S18127 - Pervasive rust covers most of the structure



Pervasive and deep rust seen over most of the structure. The corrosion is actually more severe than it appears here because the rust actually runs under the paint, causing it to lift off the surface. Rust between the connection plates, girders and bolts, known as pack rust, increases the stress between these components reducing the original design safety factor of the structure.

Figure 4: 39615S18127 - Pervasive rust on the structure

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Pervasive and deep rust seen over most of the structure. The corrosion is actually more severe than it appears here because the rust actually runs under the paint, causing it to lift off the surface. Rust between the connection plates, girders and bolts, known as pack rust, increases the stress between these components reducing the original design safety factor of the structure.

**Figure 5:** 39615S18127 - Pervasive rust on the structure

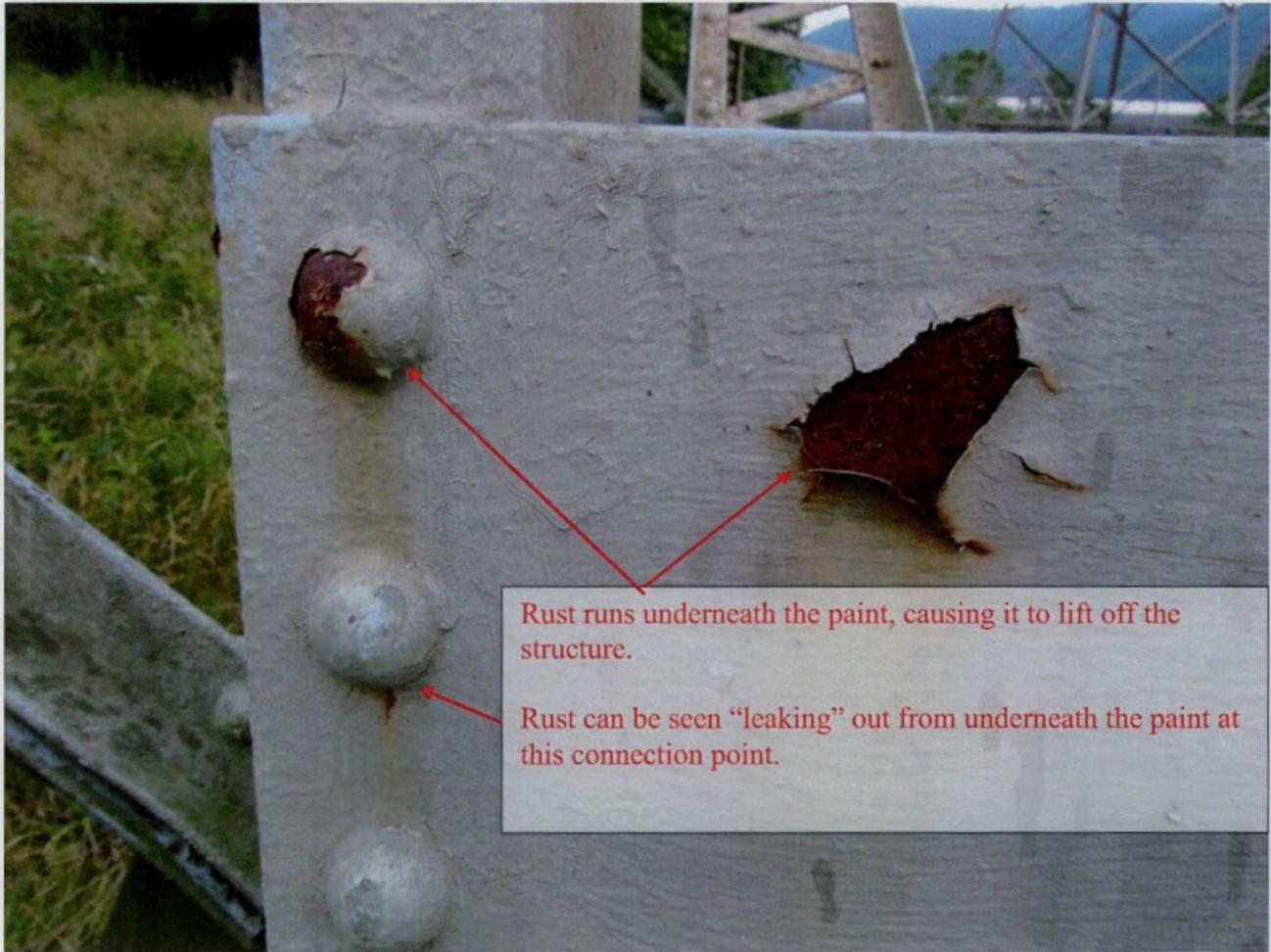


Figure 6: 39615S18127 - Peeling paint and sub-paint corrosion

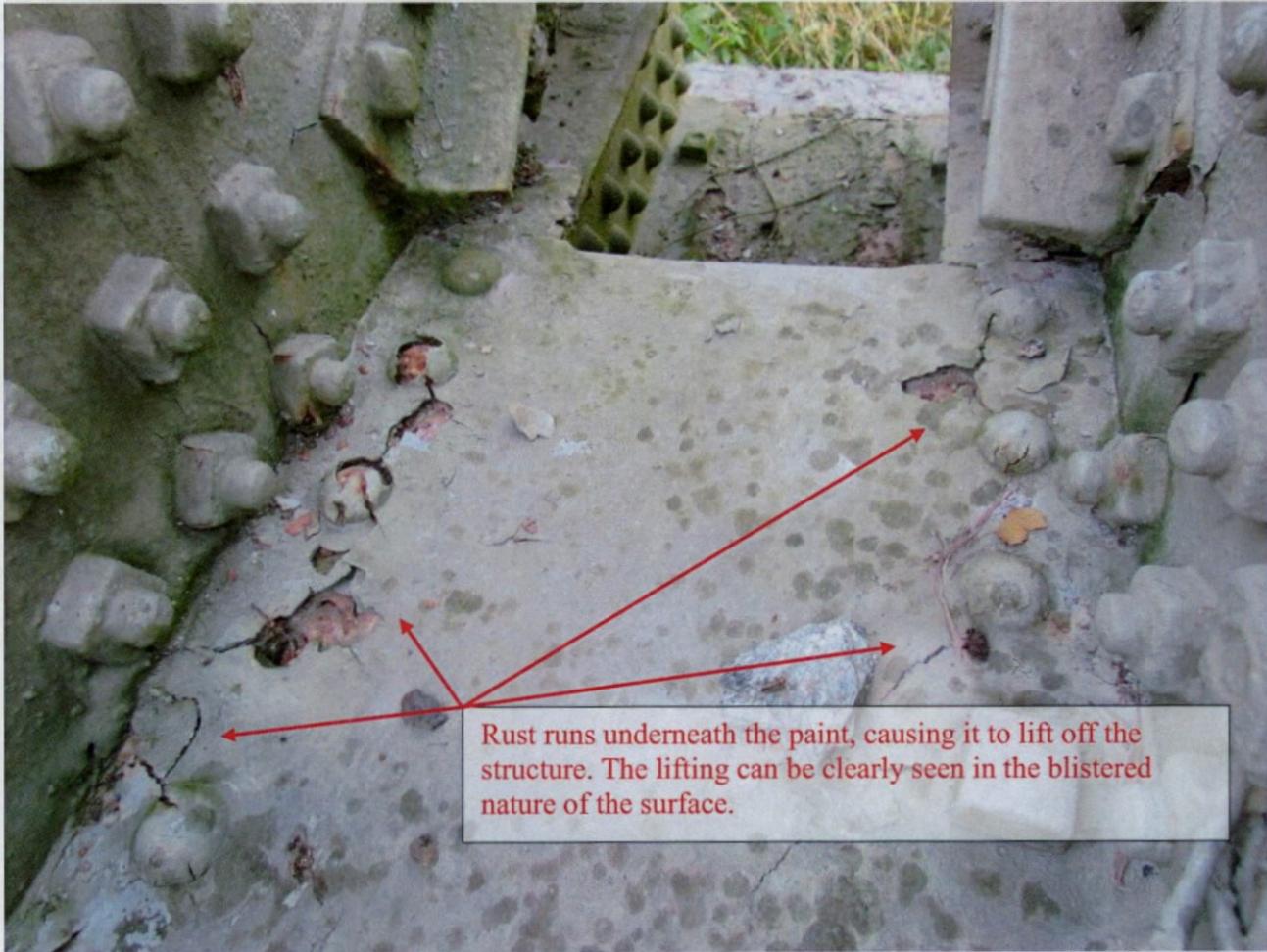


Figure 7: 39615S18127 - Sub-paint rust

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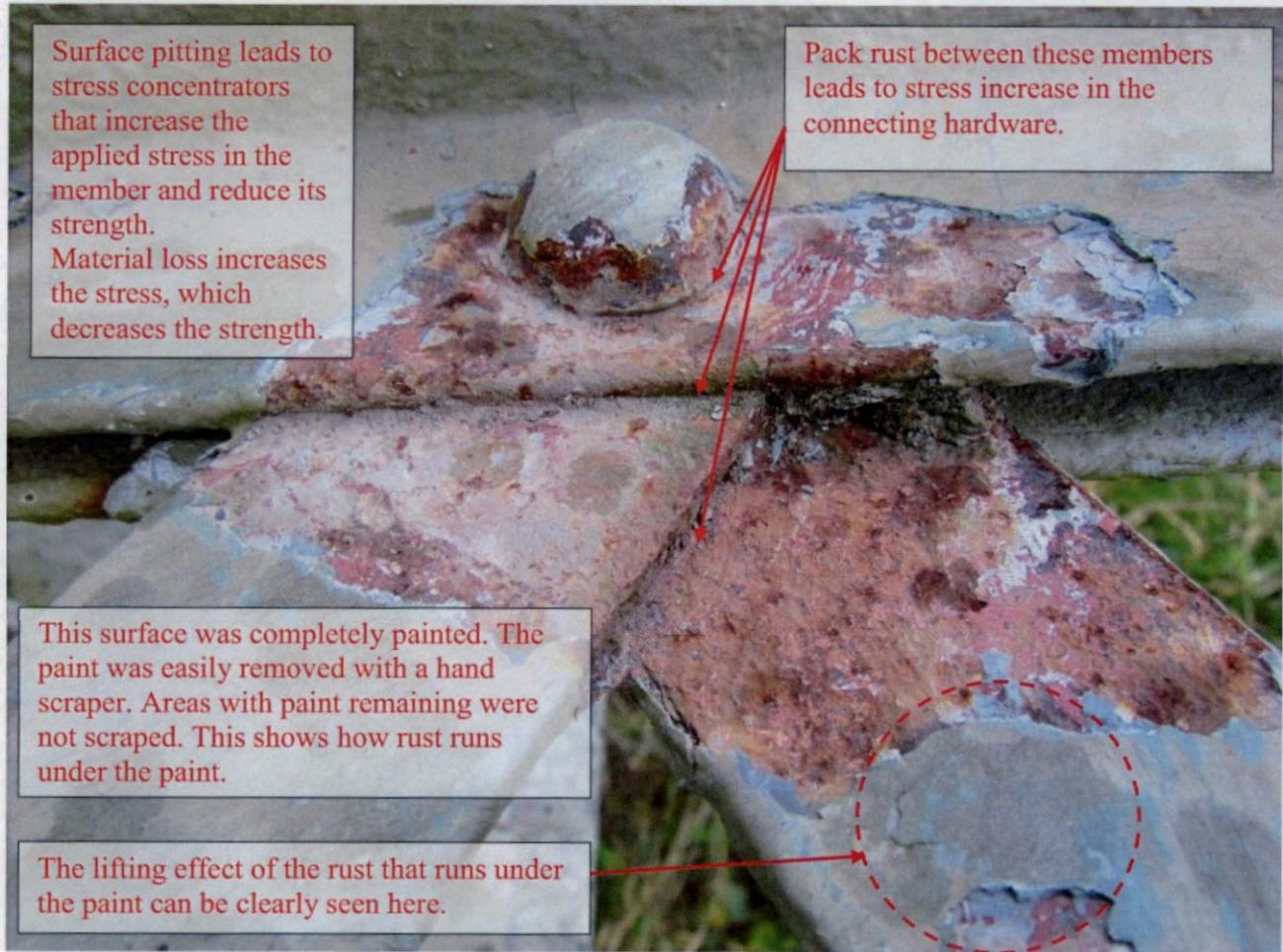


Figure 8: 39615S18127 - Sub-surface rust, rust pitting, pack rust



Figure 9: 39615S18127 - Pack rust in a joint

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### 3.2 3962S1518116

This structure requires immediate attention. There is significant corrosion with pack rust at the footing. Above the footing, some of the structural members have begun corroding. Also, there is poor paint adhesion over most of the structure. However, for much of the structure, the zinc layer is intact. The structure would require a thorough detailed climbing inspection to determine an appropriate remediation plan.



**Figure 10:** 3962S1518116 - Rust at the footing and connection plates



Figure 11: 3962S1518116 - Significant corrosion at the footing

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Figure 12: 3962S1518116 - Paint peeling and poor adhesion

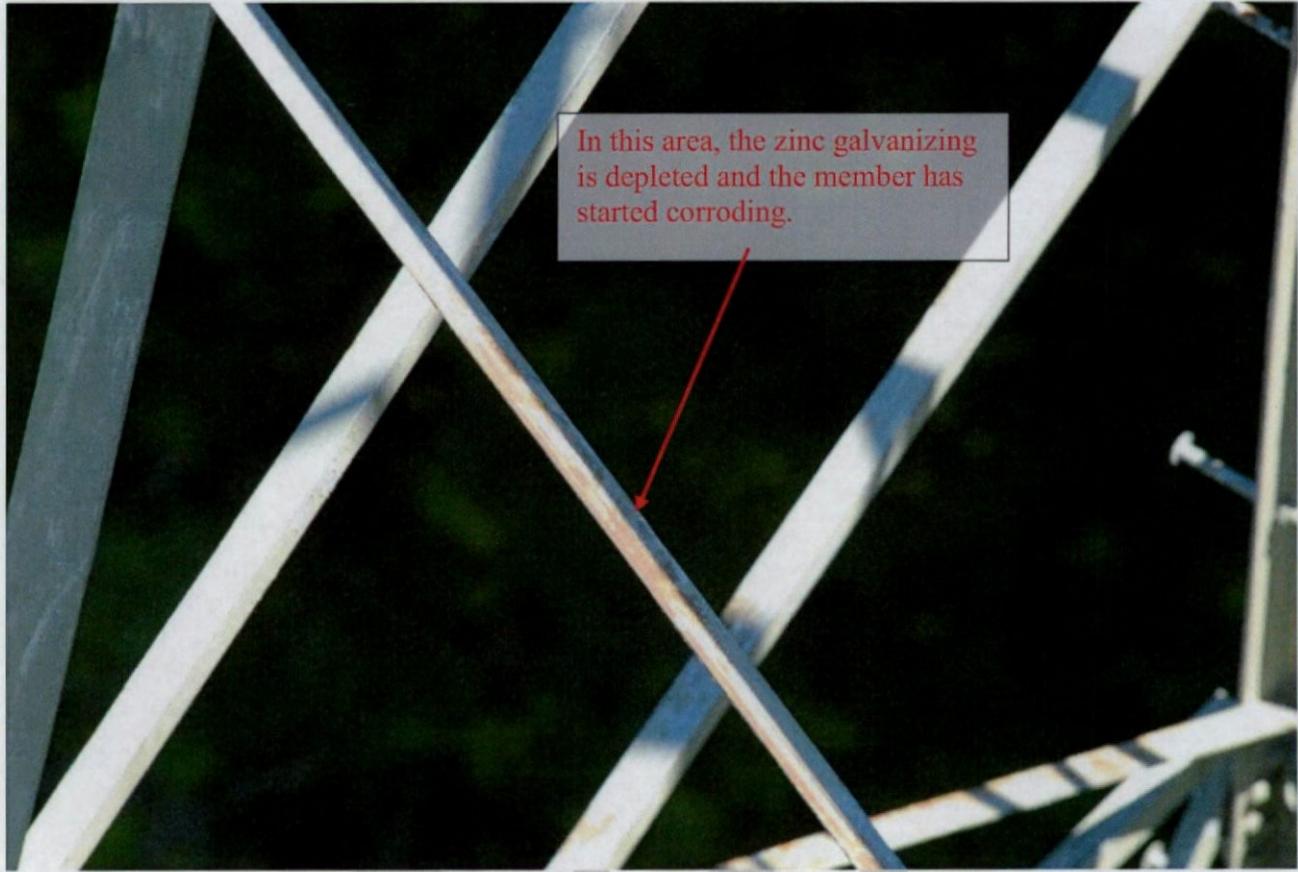


Figure 13: 3962S1518116 - Corrosion on cross bracing

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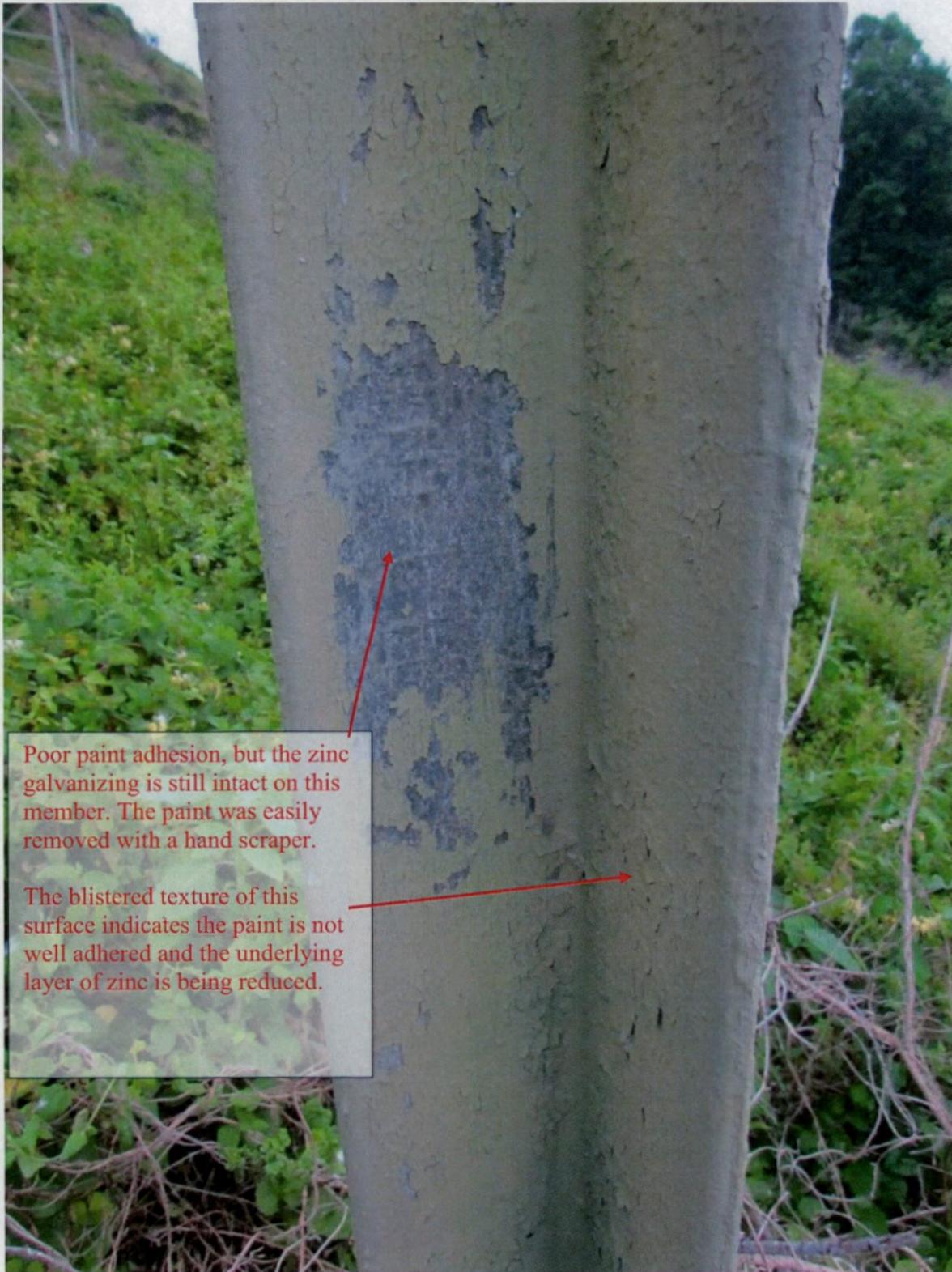


Figure 14: 3962S1518116 - Poor paint adhesion with underlying zinc galvanizing



Figure 15: 3962S1518116 - Paint removed from a cross brace

3.3 39513S18076

This structure exhibited significant paint peeling and corrosion (rust) along most of the components. A detailed climbing inspection would be needed to determine an appropriate remediation plan. In many areas, the corrosion may be too deep to be removed and the structural member will need to be replaced.



Figure 16: 39513S18076 - Pervasive rust on this structure



Figure 17: 39513S18076 - Pervasive rust on this structure

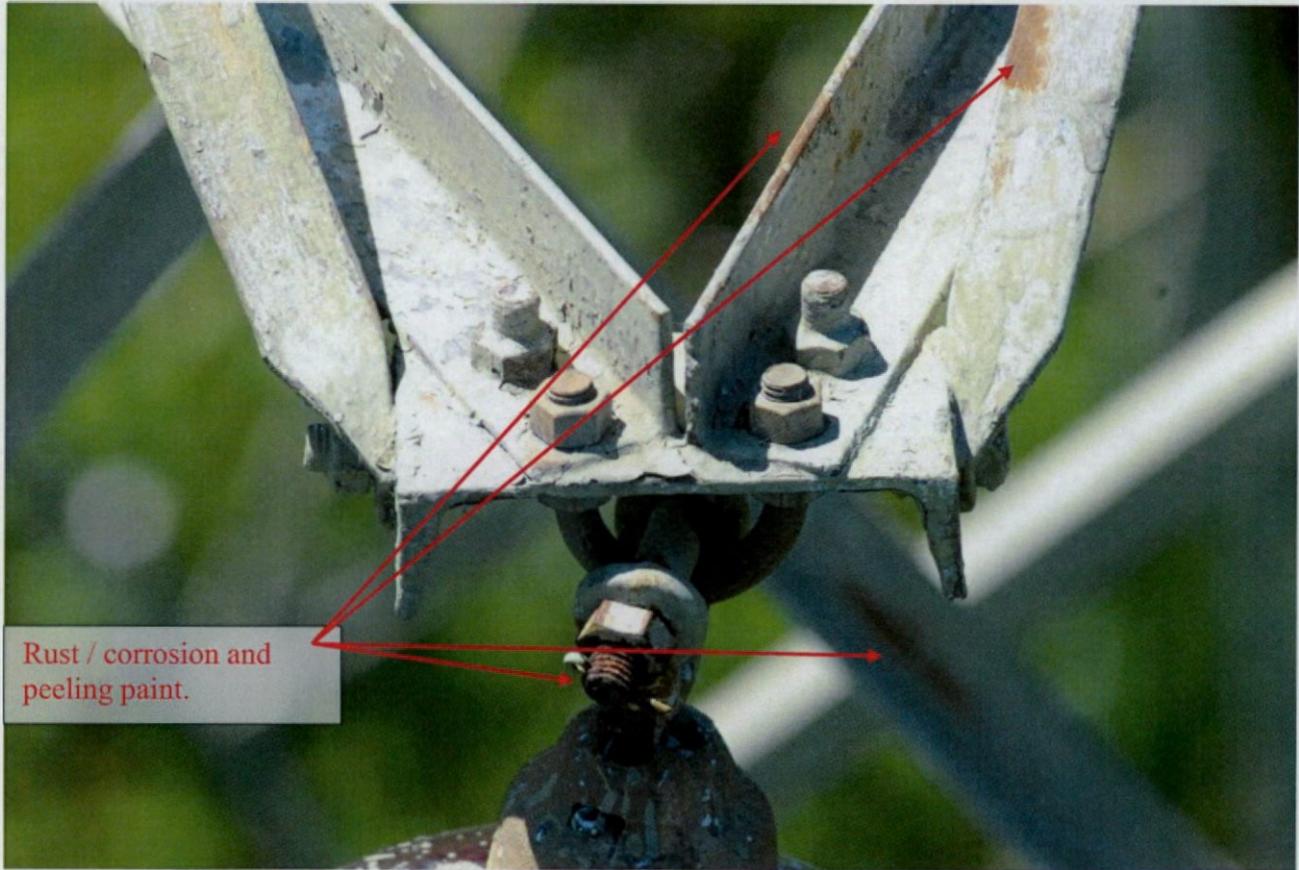
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**3.4 39436S17961**

This structure exhibited poor paint adhesion and pervasive rusting along most of the structure. A detailed climbing inspection is needed to determine a remediation plan for this structure.



**Figure 18: 39436S17961 - Corrosion and peeling paint**

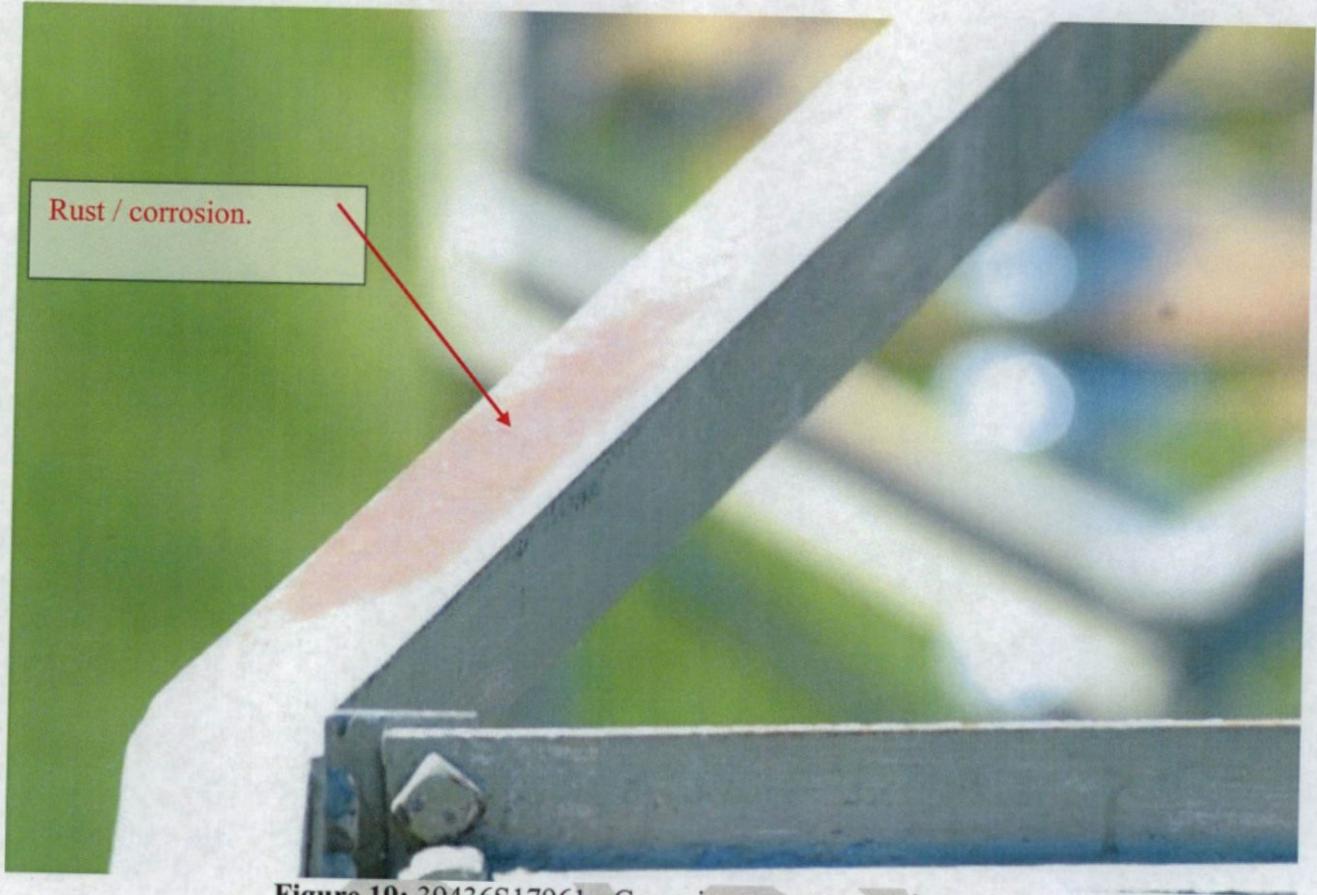


Figure 19: 39436S17961 - Corrosion on a structural member

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3.5 39404S17922

This structure was not on the list, but a bent structural member was noted on flyby.

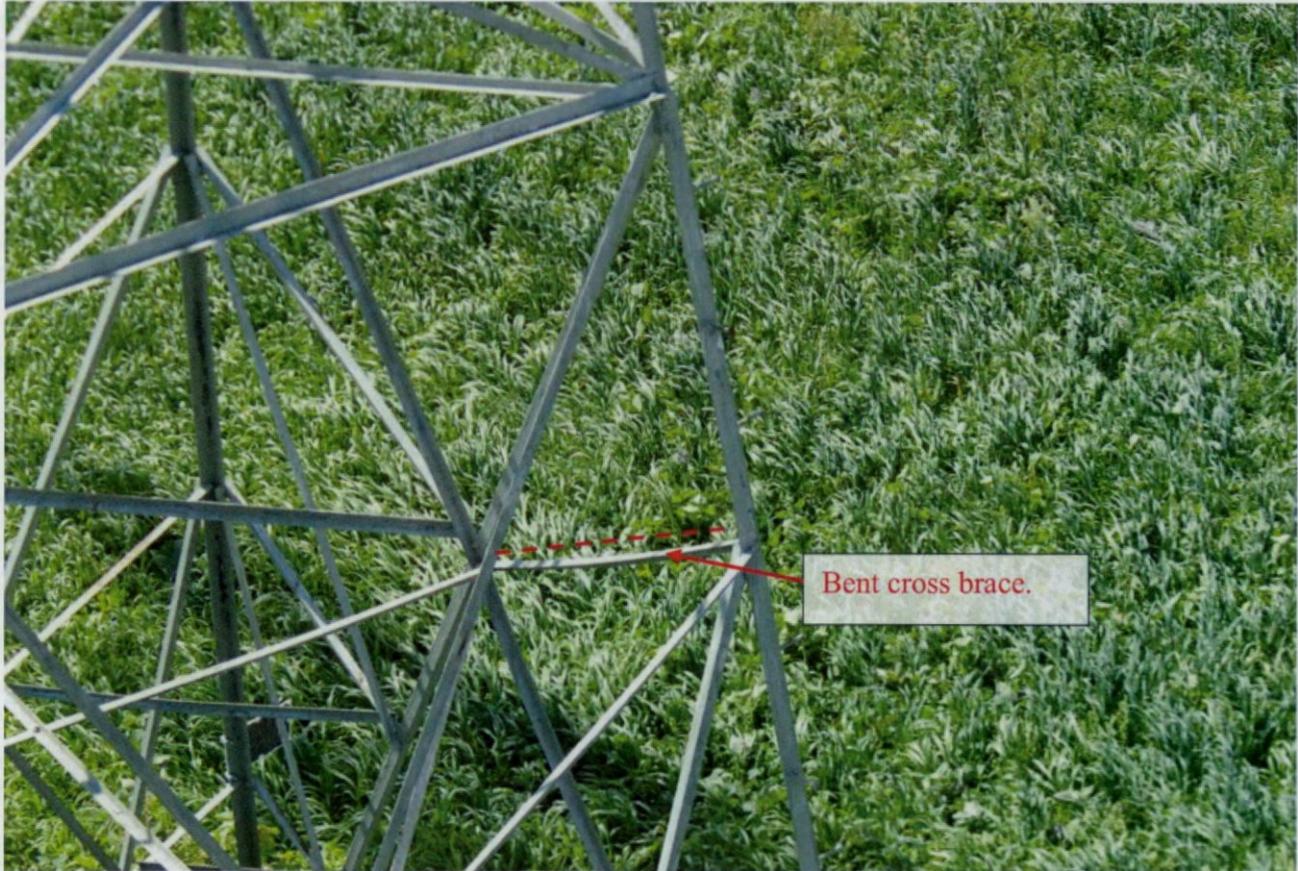


Figure 20: 39404S17922 - Bent cross brace

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### 3.6 39430S17964

This structure exhibited pervasive paint peeling and significant corrosion that may have reduced structural strength. A detailed climbing inspection would be needed to better evaluate this structure.



**Figure 21:** 39430S17964 - Pervasive corrosion and paint peeling on this structure



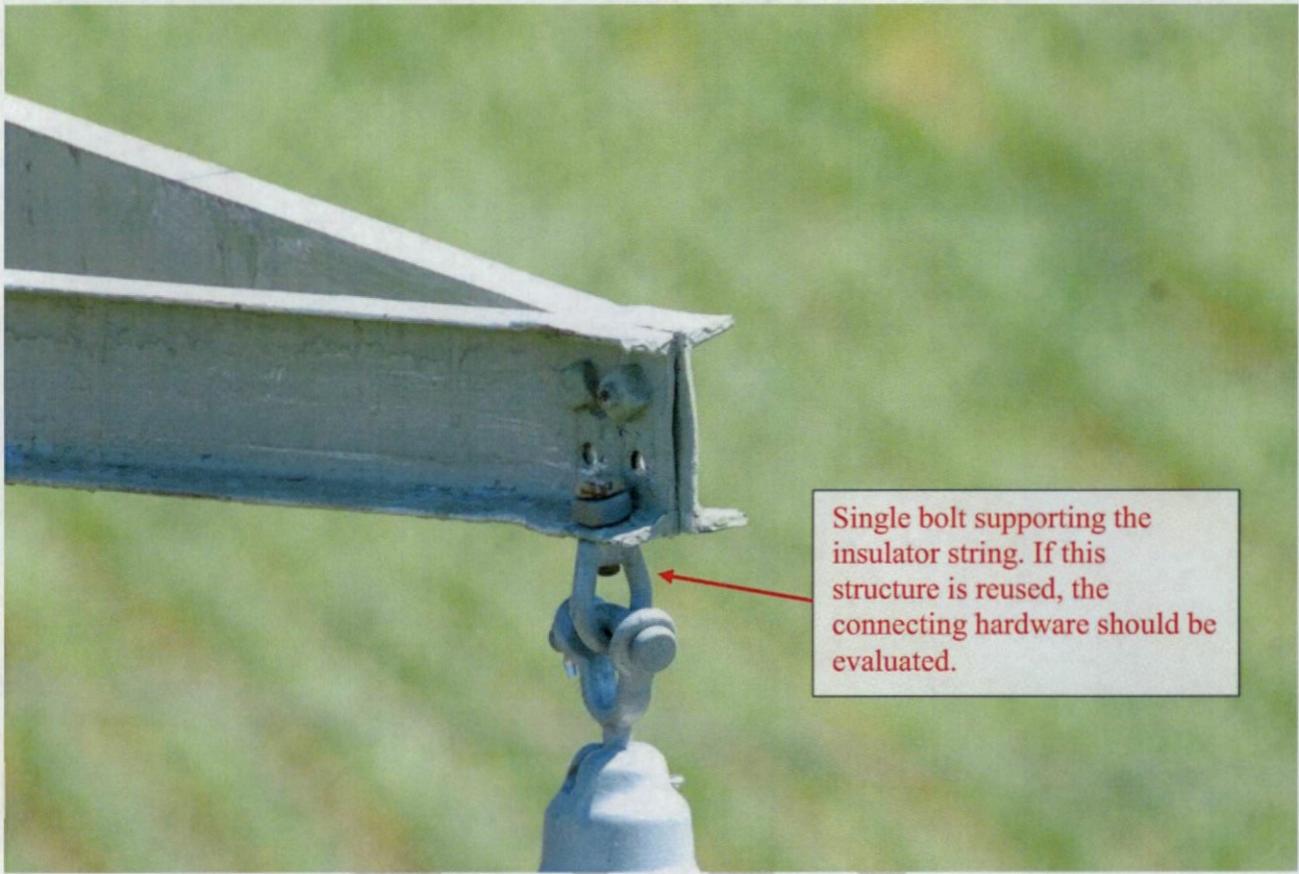
**Figure 22:** 39430S17964 - Pervasive corrosion and paint peeling on this structure

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**Figure 23:** 39430S17964 - Significant paint peeling, but mild corrosion in this area of the structure

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**Figure 24:** 39430S17964 - Insulator string is supported by a single bolt

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3.7 3387S17885

This structure exhibited spotty paint peeling and corrosion.

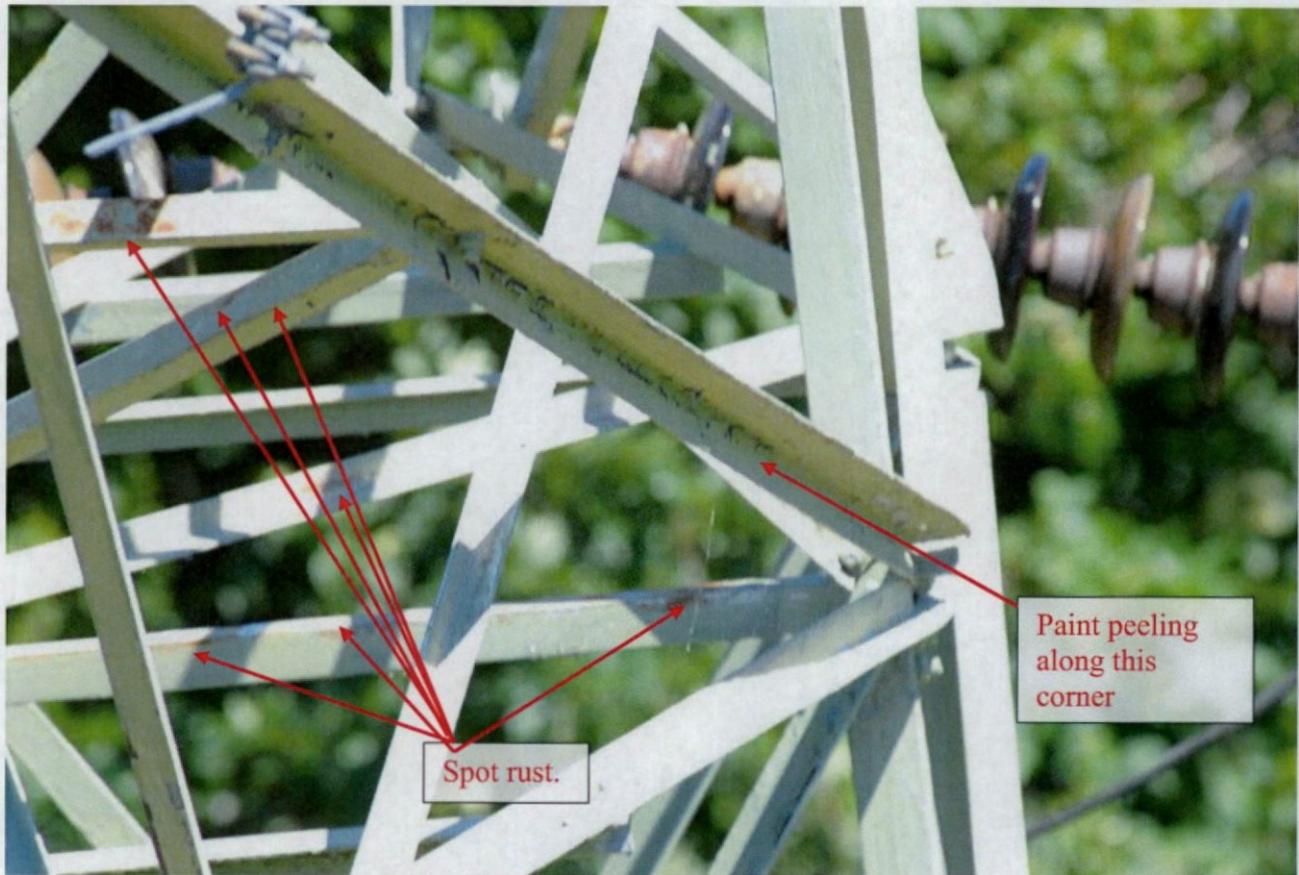


Figure 25: 3387S17885 - Peeling paint and spotty rust

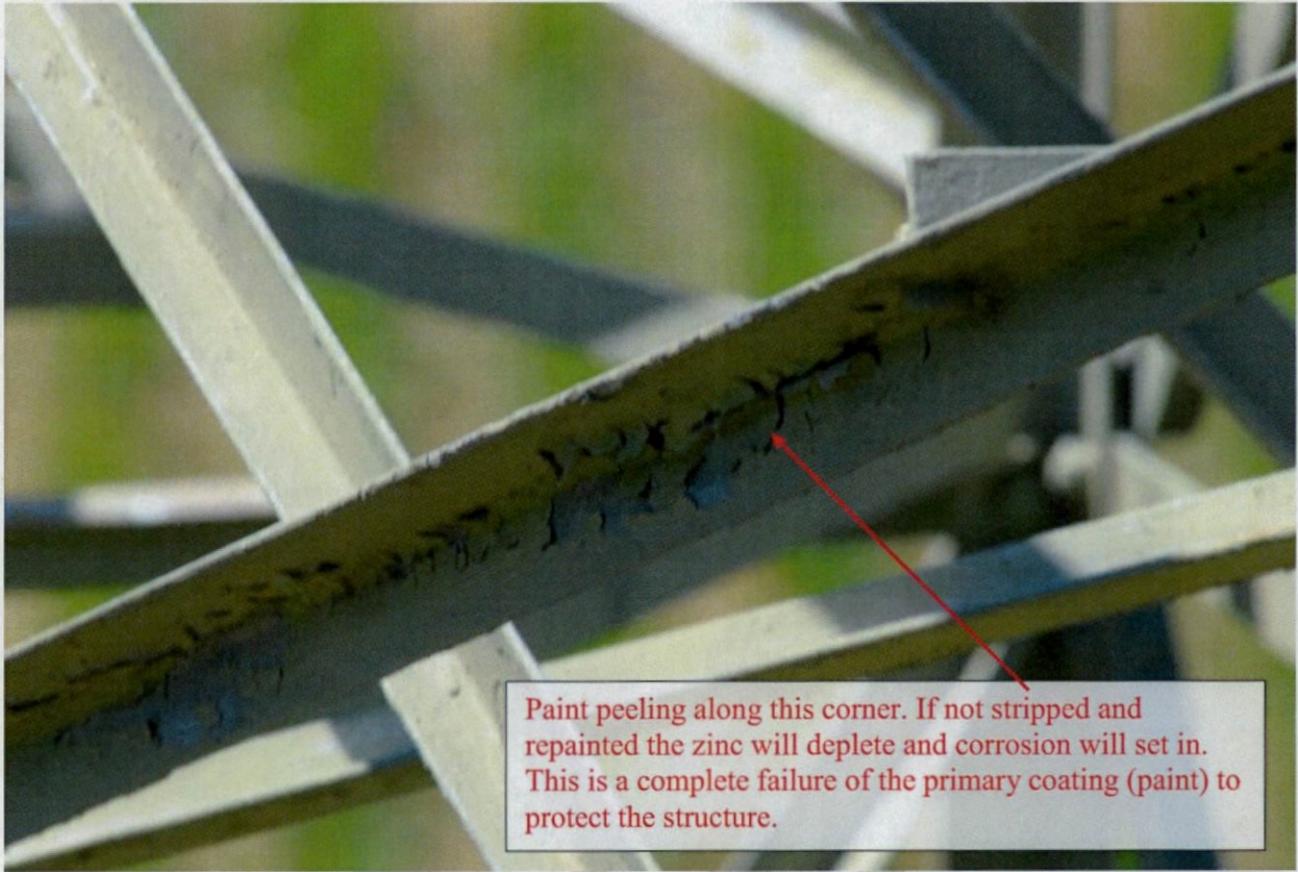


Figure 26: 3387S17885 - Paint peeling

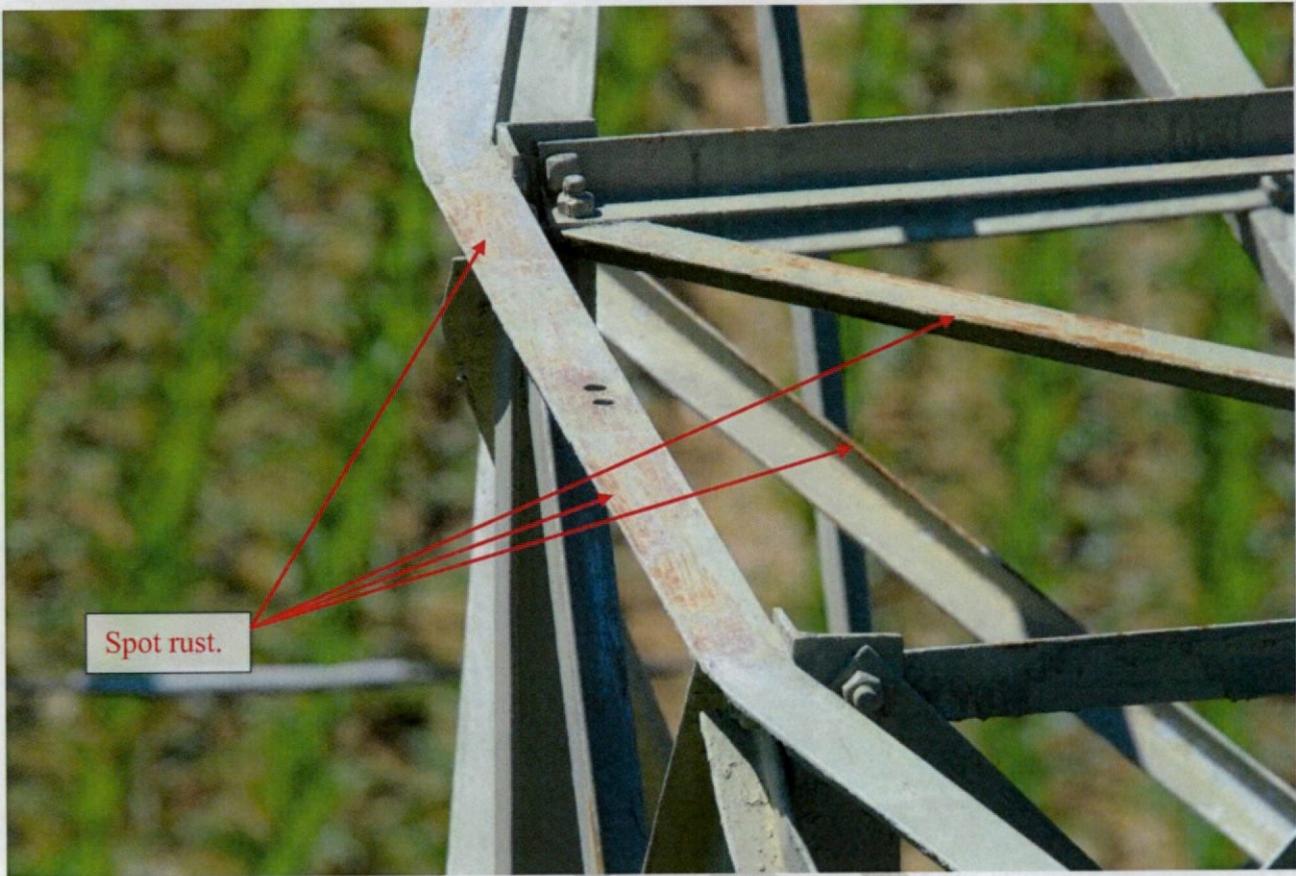


Figure 27: 3387S17885 - Surface rust

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### 3.8 39282S17888

This structure exhibited pervasive corrosion and paint peeling. There was a slight bow in several of the cross braces that couldn't be captured in a photo.

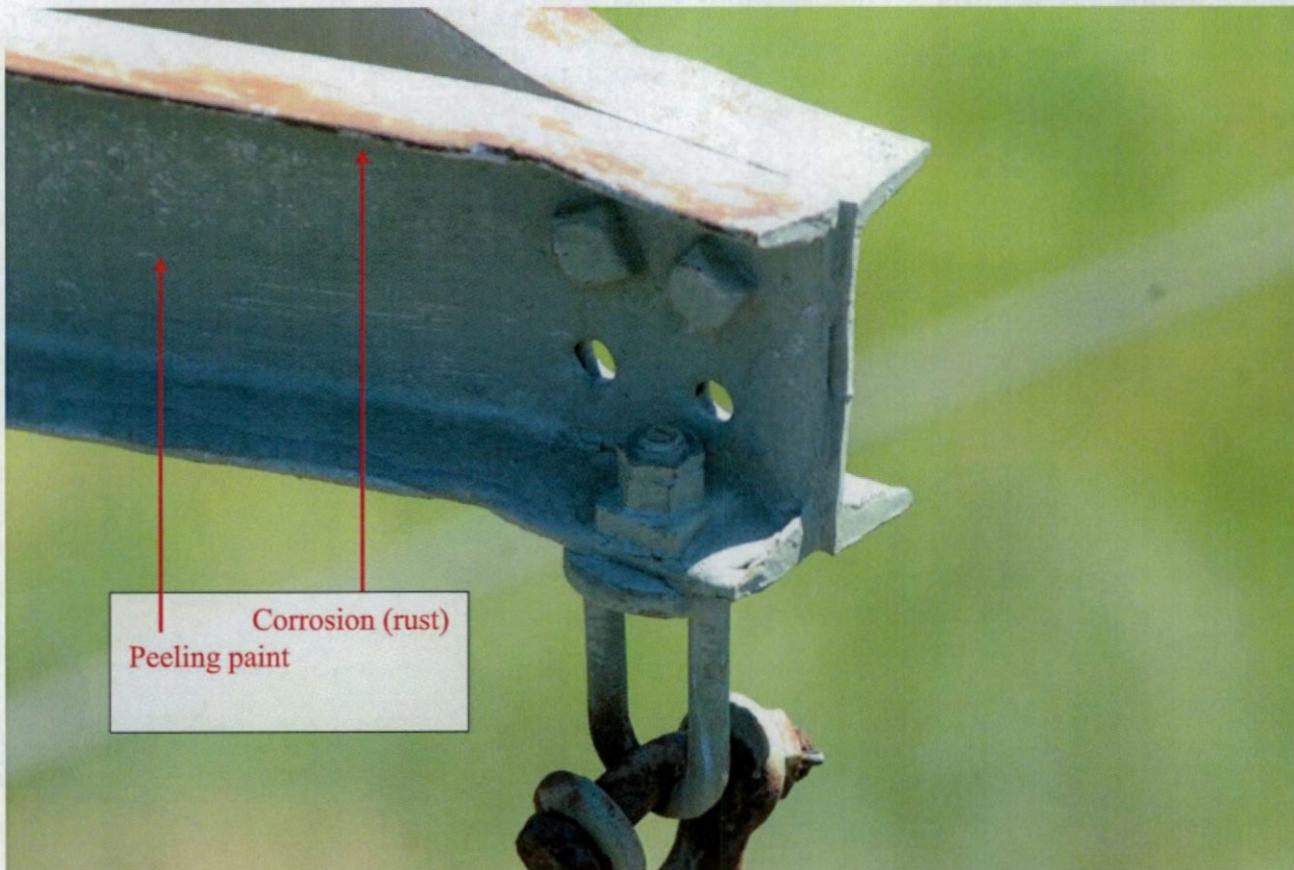


Figure 28: 39282S17888 - Corrosion and peeling paint on a structure

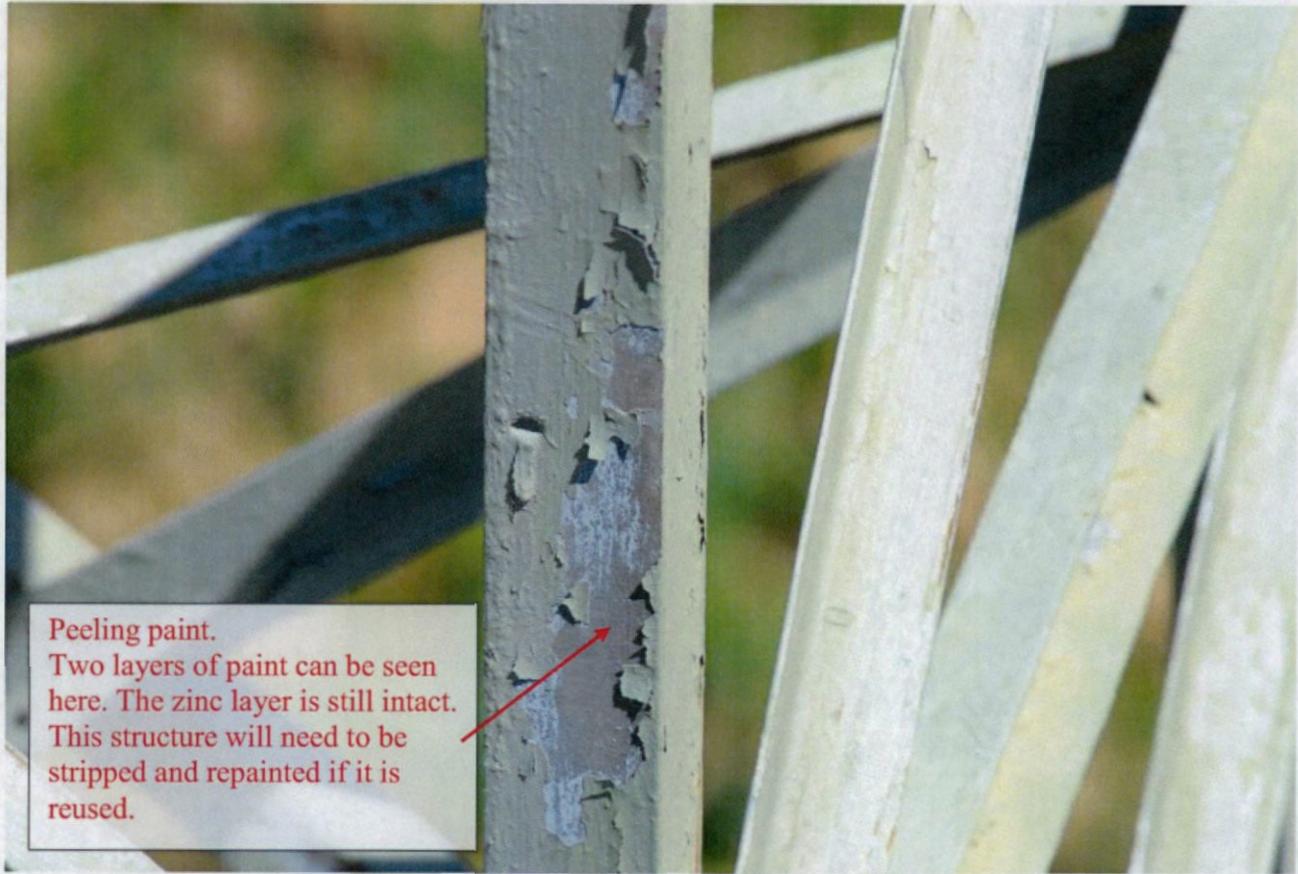


Figure 29: 39282S17888 - Two layers of paint on this structure

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3.9 39320S17792

This structure exhibited pervasive corrosion on most of the structural members, as well as poor paint adhesion in several places. A detailed climbing inspection would need to be conducted to determine which corroded structural members need to be replaced.

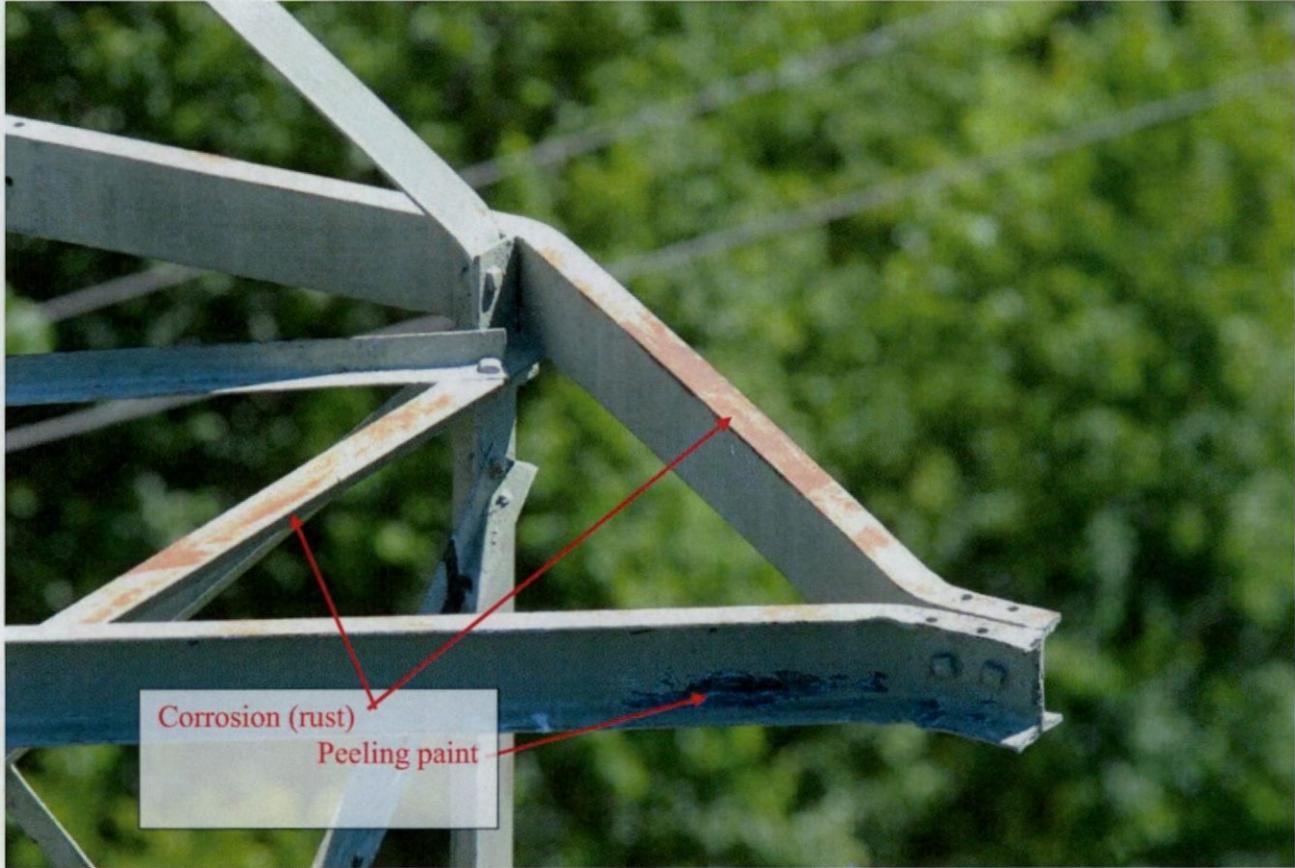


Figure 30: 39320S17792 - Rust and peeling paint

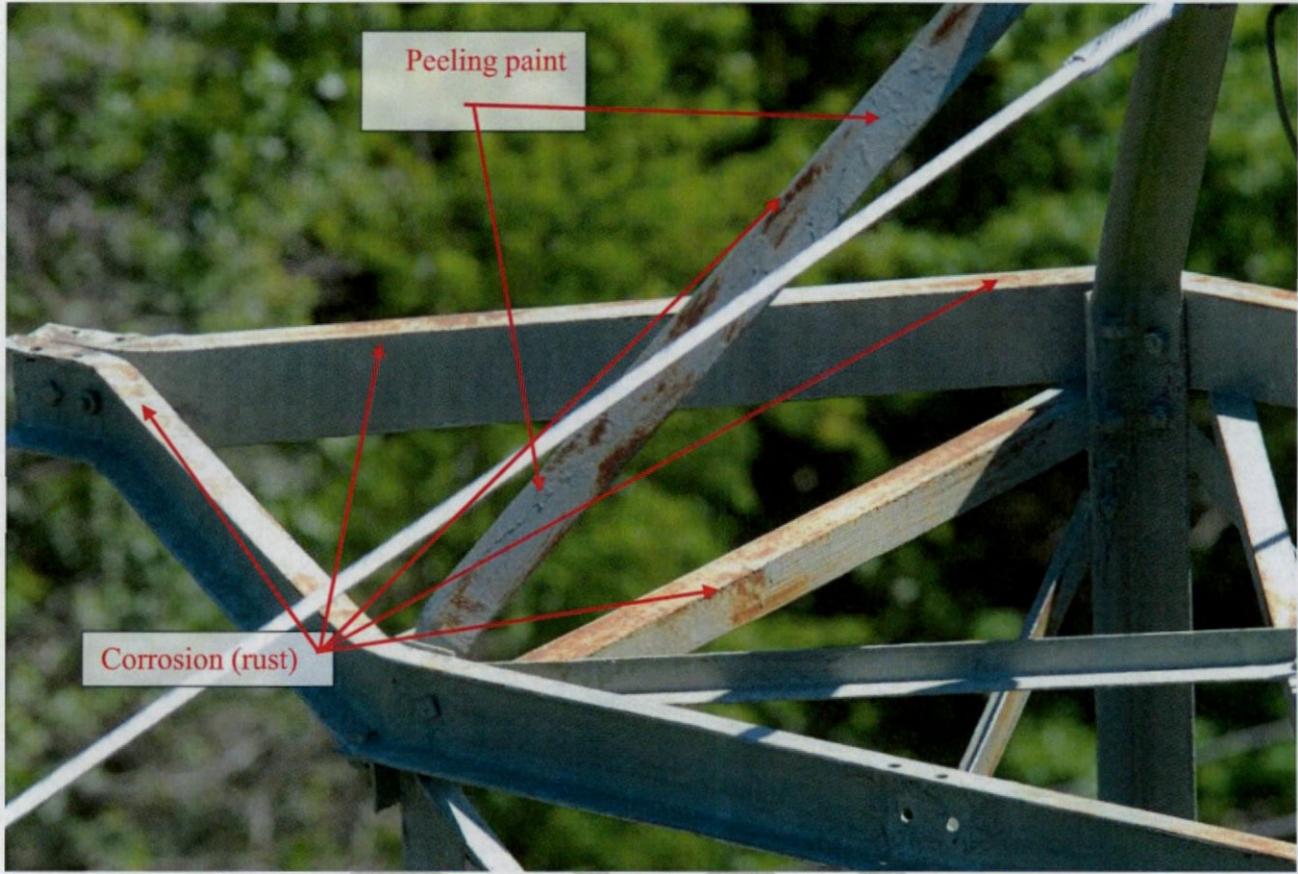


Figure 31: 39320S17792 - Corrosion and peeling paint

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Figure 32: 39320S17792 - Pervasive rust



Figure 33: 39320S17792 - Poor paint adhesion

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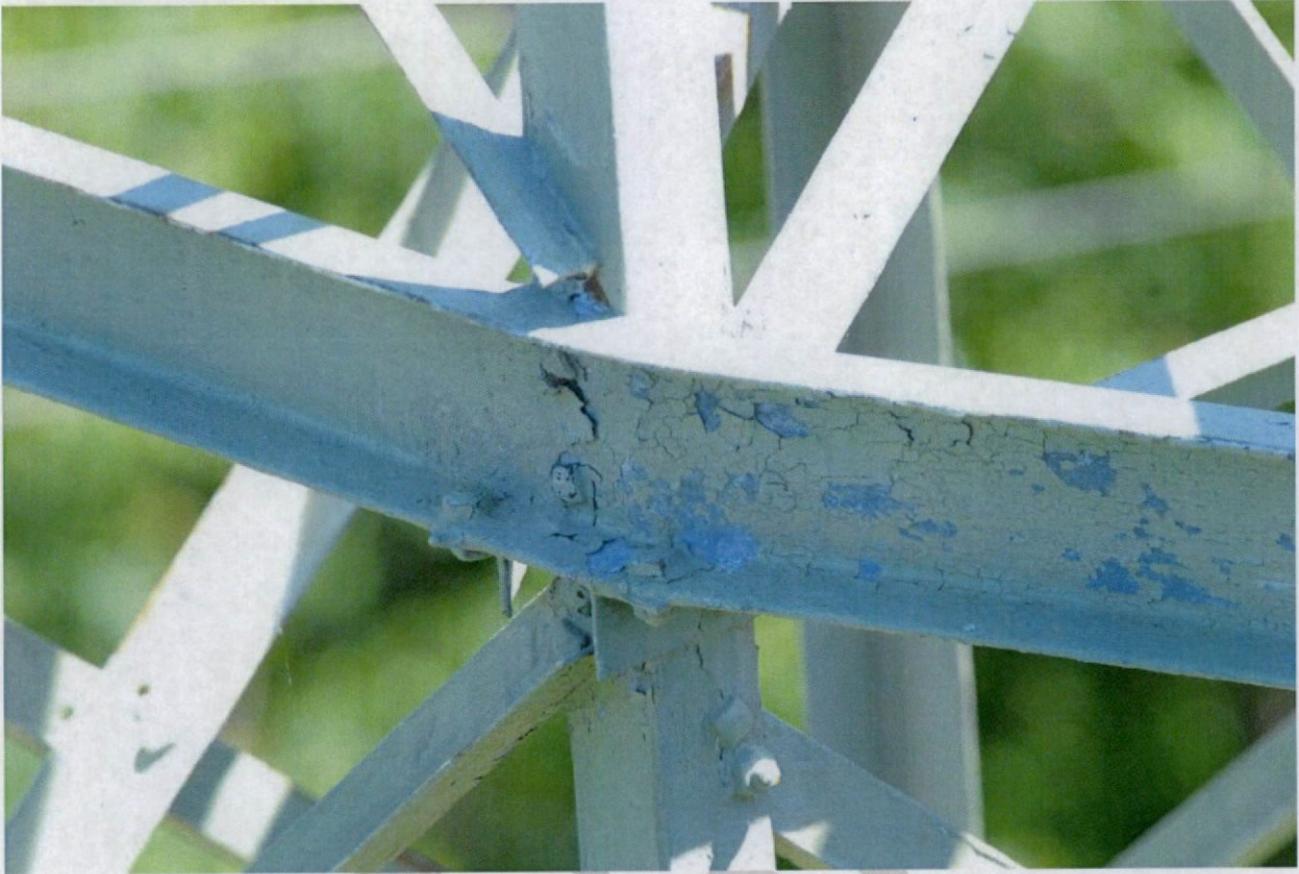


Figure 34: 39320S17792 - Poor paint adhesion

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### 3.10 39325S17789

This structure requires immediate attention because it has a buckled leg. This leg is one of the four legs that support the tower. Poor paint adhesion and corrosion were also observed.



**Figure 35:** 39325S17789 - Buckled leg on tower

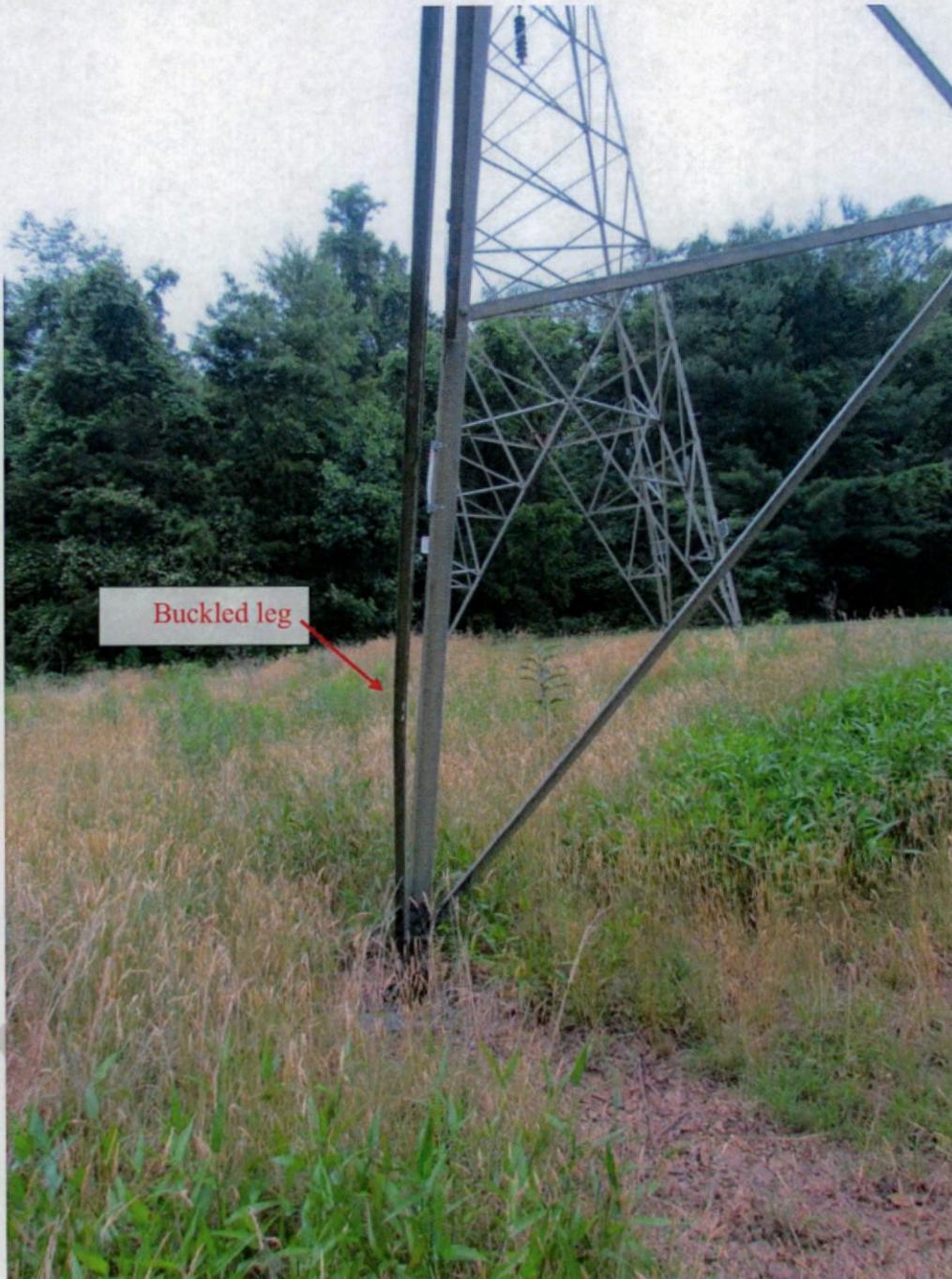


Figure 36: 39325S17789 - Buckled leg on tower

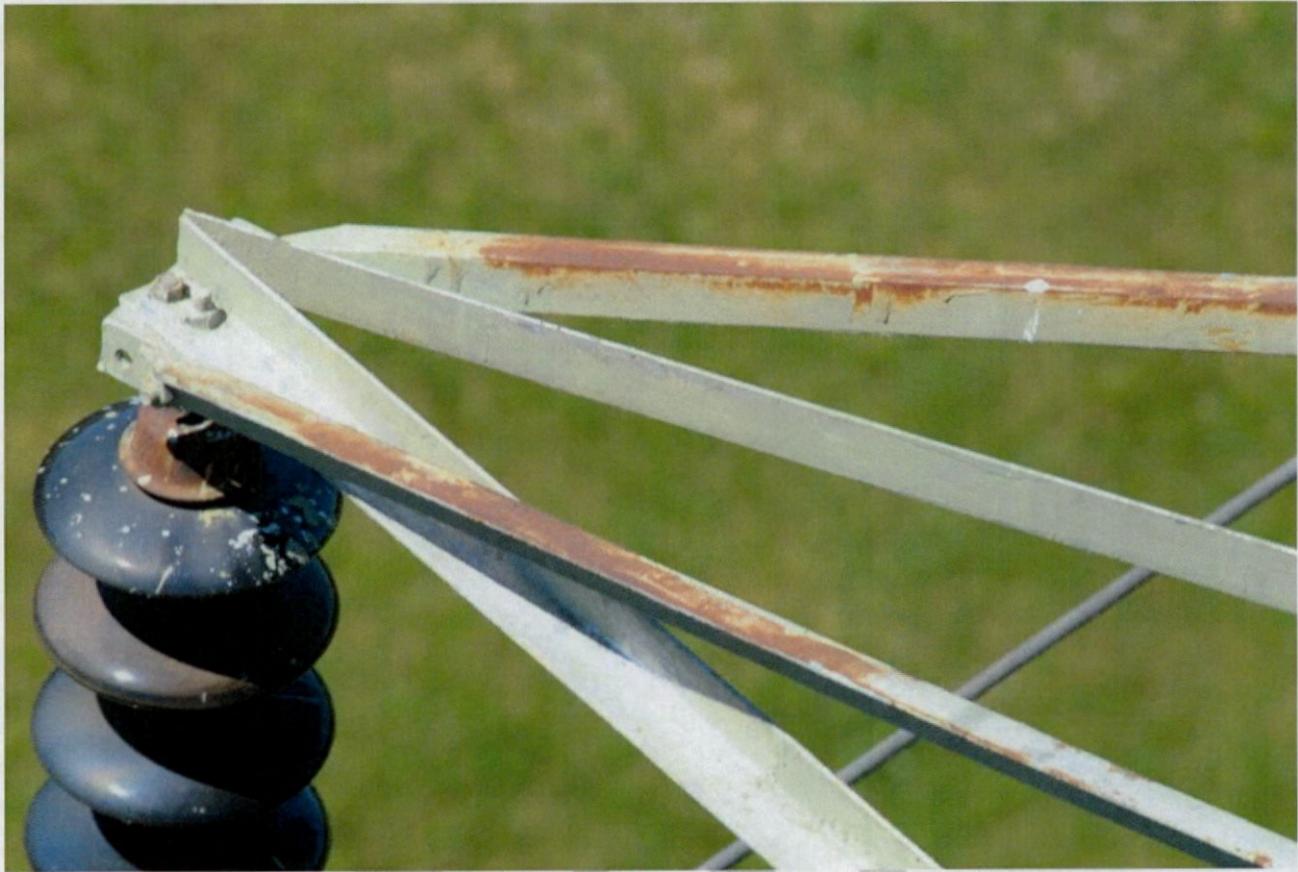


Figure 37: 39325S17789 - Corrosion on structural members

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Figure 38: 39325S17789 - Poor paint adhesion

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3.11 39277S17723

This structure exhibited pervasive corrosion on most of the structural members, with likely structural damage. A detailed climbing inspection is needed to determine a remediation plan.



Figure 39: 39277S17723 - Corrosion on structural members



**Figure 40:** 39277S17723 - Corrosion and paint peeling on structural members

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### 3.12 39282S17720

This structure exhibited poor paint adhesion and corrosion. A detailed climbing inspection is needed to determine a remediation plan and cost.



**Figure 41:** 39282S17720 - Corrosion and paint peeling on structural members



**Figure 42:** 39282S17720 - Corrosion and paint peeling on structural members

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3.13 39254S17688

This structure exhibited poor paint adhesion and pervasive corrosion.



Figure 43: 39282S17720 - Corrosion and paint peeling on structural members



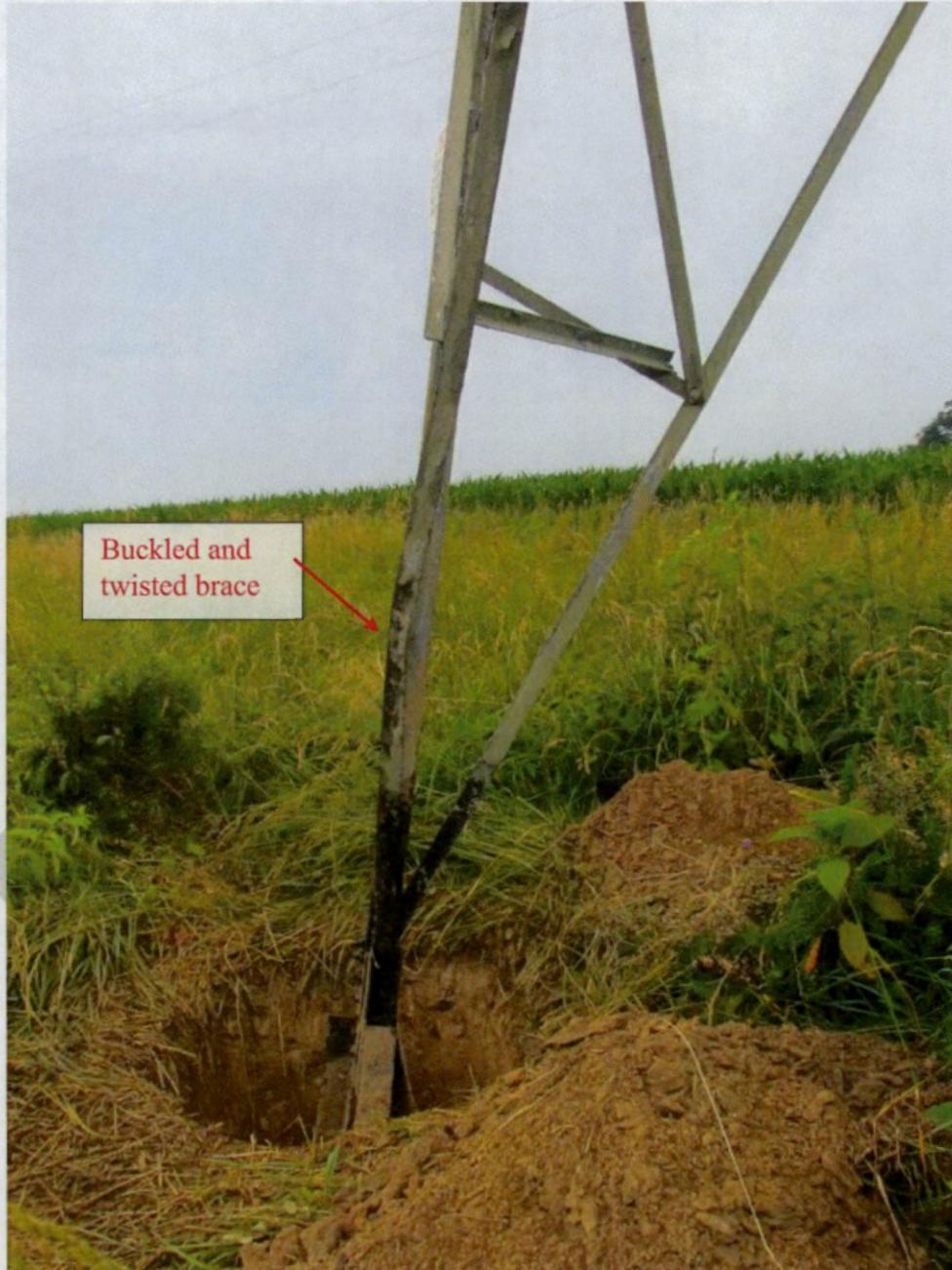
Figure 44: 39282S17720 - Corrosion and paint peeling on structural members

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### 3.14 39162S17524

This structure has a buckled and twisted cross brace as well as deformation at the end of one of the crossarms, which needs to be replaced, as well as peeling paint and corrosion. A detailed inspection is needed to determine the remediation process and cost.



**Figure 45:** 39282S17720 - Buckled and twisted brace



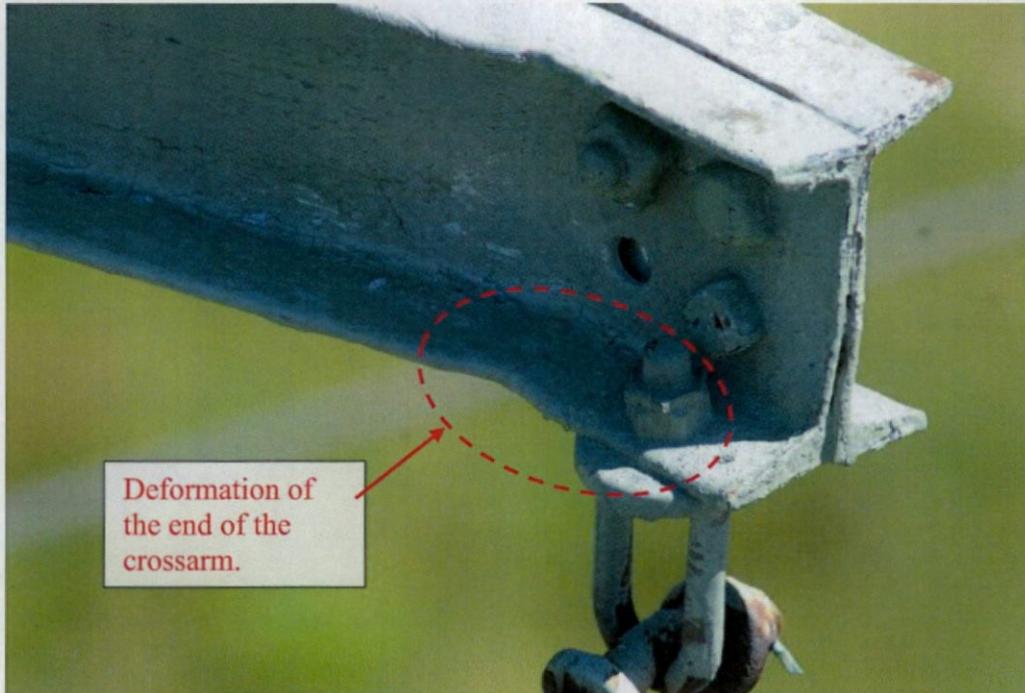
Figure 46: 39282S17720 - Close up view of the buckled and twisted brace



Figure 47: 39282S17720 - Corrosion and paint peeling on structural members

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Deformation of the end of the crossarm.

Figure 48: 39282S17720 - Deformation of the end of the crossarm



Figure 49: 39282S17720 - Peeling paint

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**3.15 39134S17433**

This structure has a buckled brace that needs to be replaced, as well as peeling paint and corrosion.



**Figure 50: 39134S17433 - Buckled support brace**



Figure 51: 39134S17433 - Peeling paint



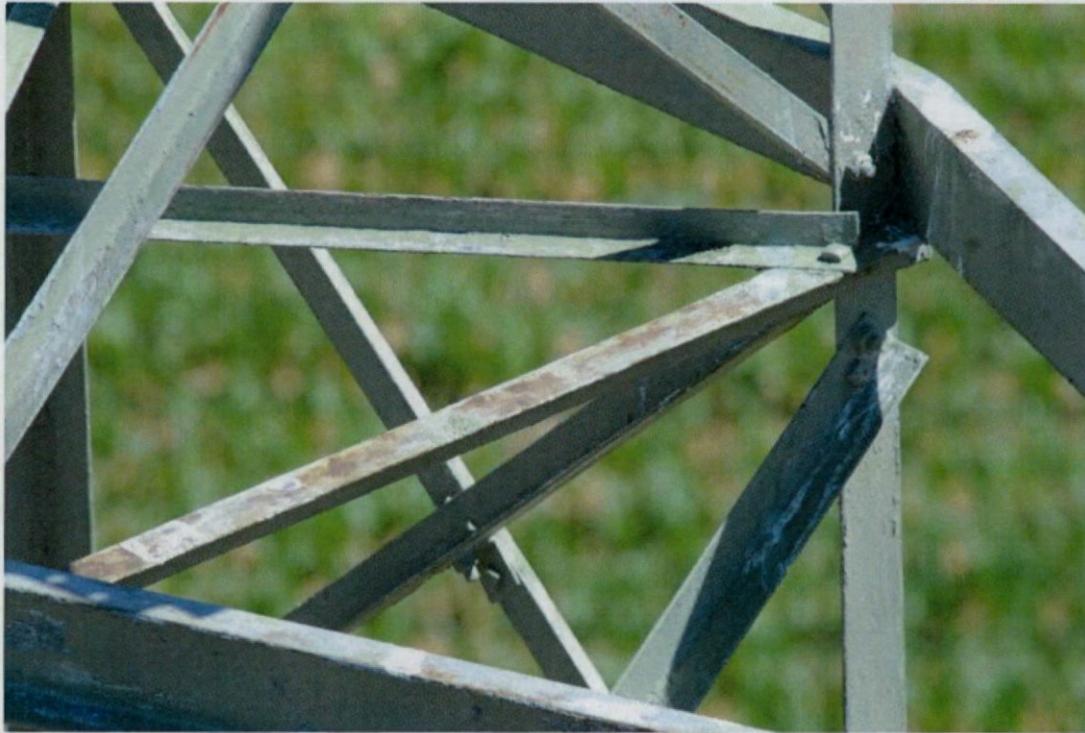
Figure 52: 39134S17433 - Peeling paint

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**3.16 39129S17435**

This structure exhibited significant corrosion of some structural members, as well as poor paint adhesion.



**Figure 53:** 39134S17433 - Corrosion and peeling paint



**Figure 54:** 39134S17433 - Peeling paint

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### 3.17 38921S16877

This structure had two (2) bent brace supports, as well as poor paint adhesion and moderate corrosion. The braces need to be replaced and a more detailed inspection needs to be conducted to determine the remediation process and cost.

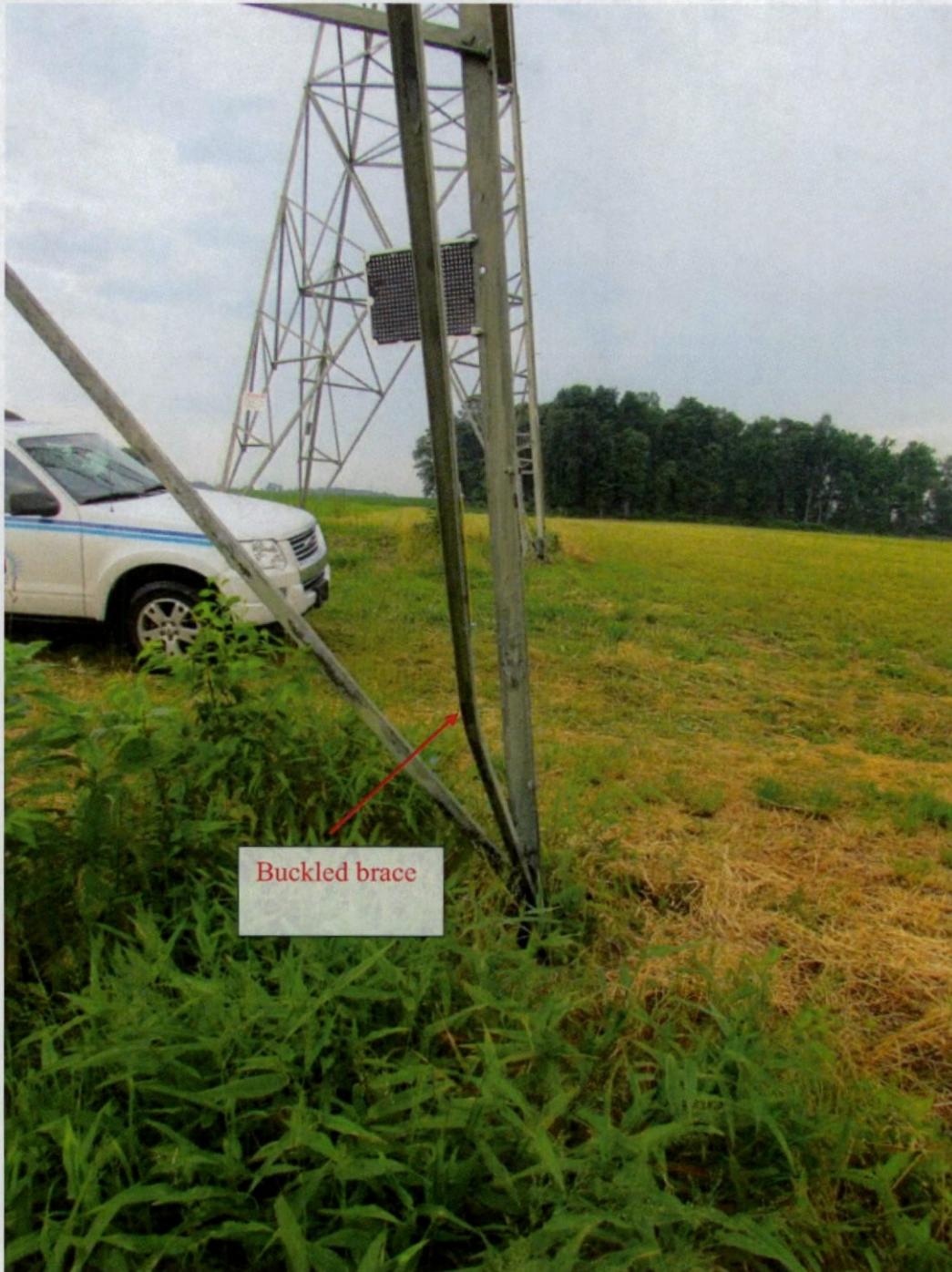


Figure 55: 38921S16877 – Buckled brace



Figure 56: 38921S16877 – Buckled brace



Figure 57: 38921S16877 – Buckled brace



Figure 58: 38921S16877 – Peeling paint



Figure 59: 38921S16877 – Corrosion on structural members



Figure 60: 38921S16877 – Corrosion and peeling paint



Figure 61: 38921S16877 – Corrosion and peeling paint

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**3.18 38916S16879**

This structure exhibited poor paint adhesion and significant corrosion. Damage to a structural member that had been repaired was also noted.



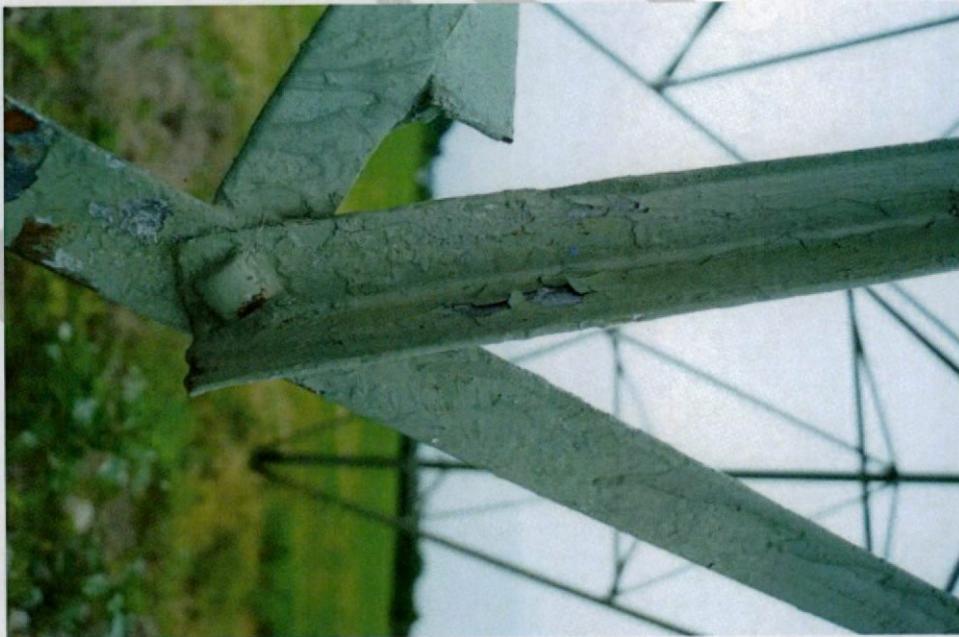
**Figure 62:** 38916S16879 - Peeling paint and corrosion



**Figure 63:** 38916S16879 - Damage to a previously repaired structural member



**Figure 64:** 38916S16879 - Corrosion and peeling paint.



**Figure 65:** 38916S16879 - Corrosion and peeling paint



Figure 66: 38916S16879 - Peeling paint.

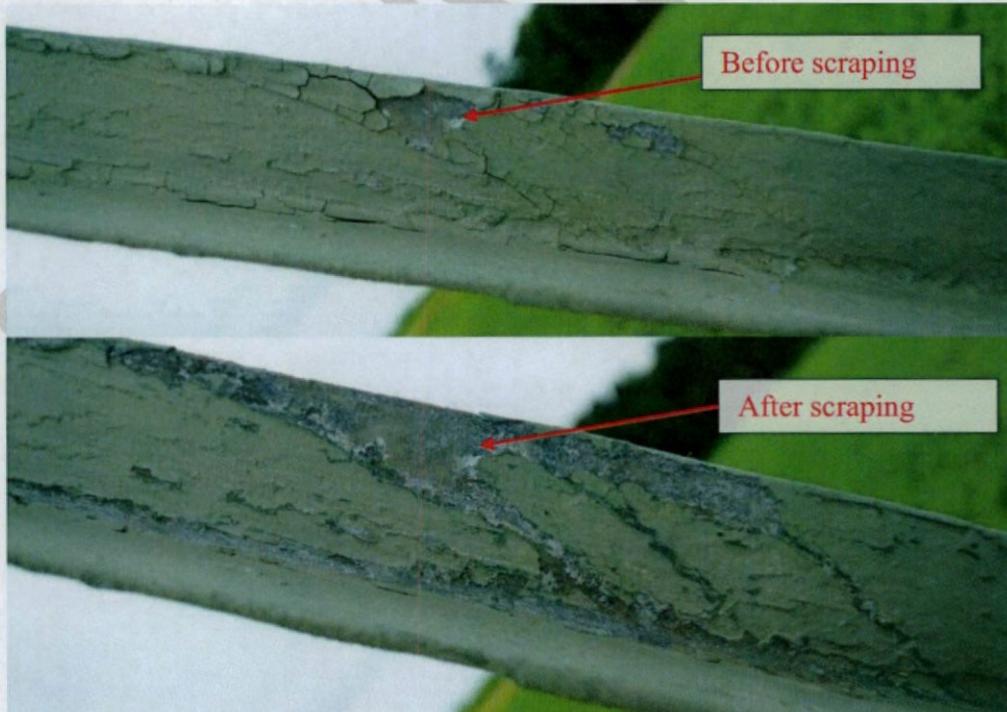


Figure 67: 38916S16879 - Paint before and after scraping with a hand scraper

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### 3.19 38738S16387

This structure exhibited some peeling paint on the lower sections, while the tops of the arms had virtually no paint on them. There was very little corrosion on this structure. The structure was in relatively good shape, but the paint needs to be removed and the structure repainted.



**Figure 68:** 38738S16387 - Paint beginning to peel on the lower portion of this structure.



**Figure 69:** 38738S16387 - Most of the paint peeled away from the top of the structure

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### 3.20 38733S16386

This structure was mislabeled as 38733S16389 in PPL's request. Spot rusting and peeling paint could be seen over much of the structure. A more detailed inspection should be conducted to determine the remediation process and cost.



Figure 70: 38733S16386 - Spot rust and peeling paint



**Figure 71:** 38733S16386 - Structure had more corrosion and paint issues near the top

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### 3.21 38703S16287

This structure exhibited a significant amount of blistered and peeling paint. Corrosion appeared minimal; however, the amount of bird feces on the top of the structure made it impossible to see paint, rust or metal on top of structure. This structure needs a more detailed climbing inspection to determine the condition of the top of the structure and to determine the remediation process and cost.



Figure 72: 38703S16287 - Paint flaking off the structure



Figure 73: 38703S16287 - Paint condition is typical of the entire structure

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Figure 74: 38703S16287 - Paint before and after scraping with a hand scraper

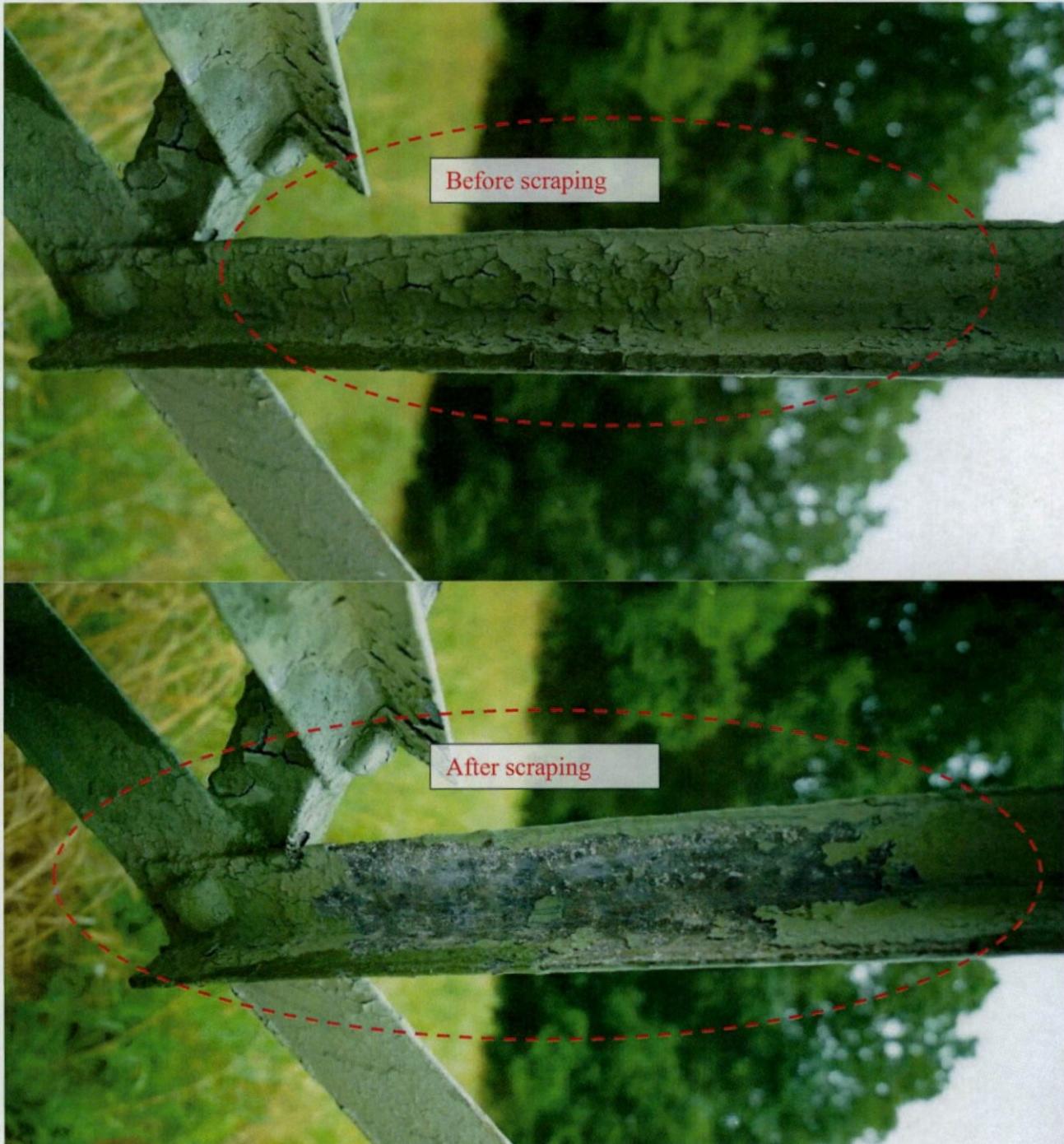


Figure 75: 38703S16287 - Paint before and after scraping with a hand scraper



Figure 76: 38703S16287 - Top of the structure with significant amount of bird feces



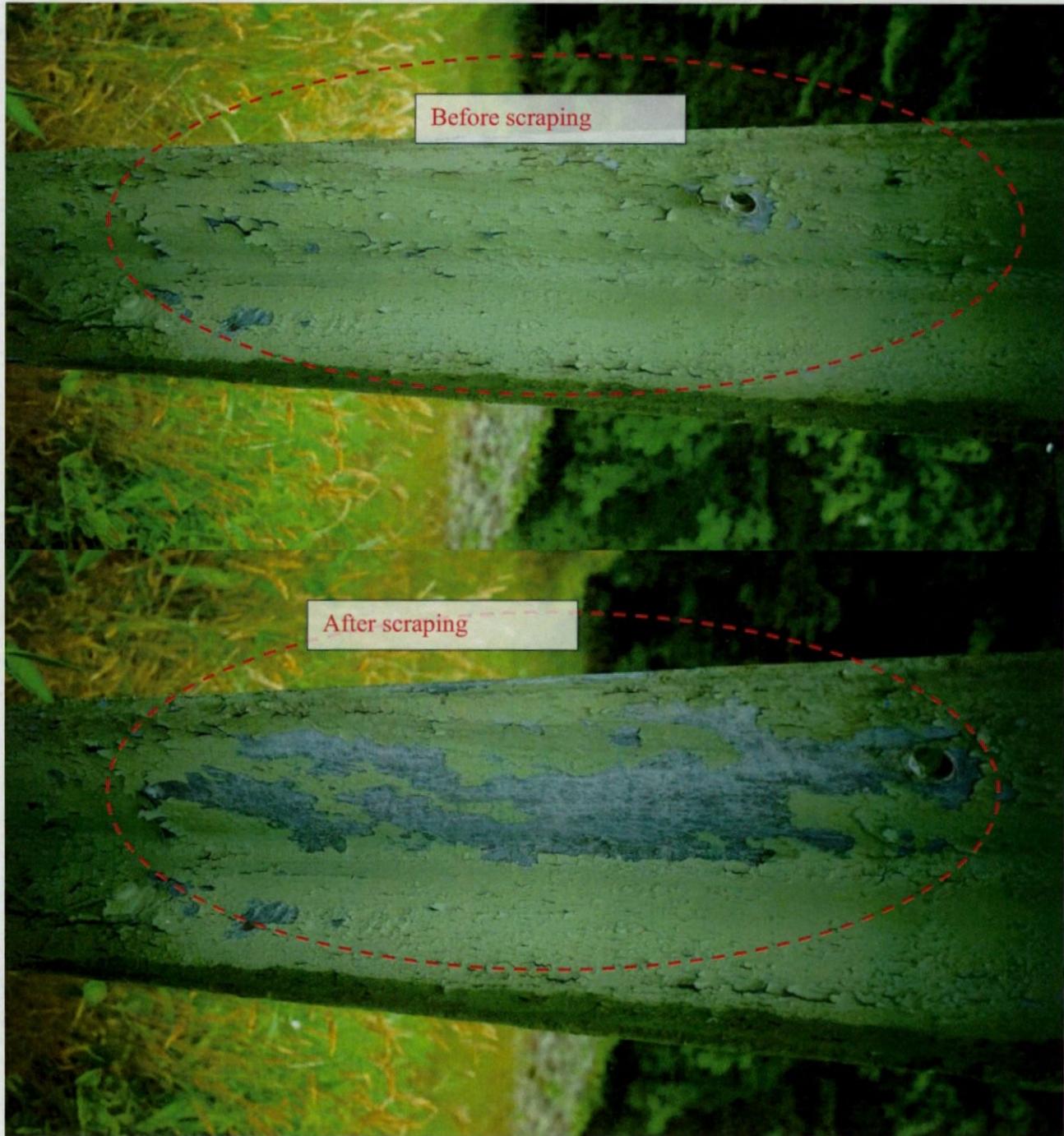
Figure 77: 38703S16287 - Top of the structure with a significant amount of bird feces

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### 3.22 38698S16295

This structure exhibited significant deterioration and peeling of the paint. Corrosion began setting in in some places; however, the overall structure is in good shape. The existing paint needs to be removed and the structure repainted. The corrosion is minimal and should be relatively easy to address.



**Figure 78:** 38698S16295 - Paint before and after scraping with a hand scraper

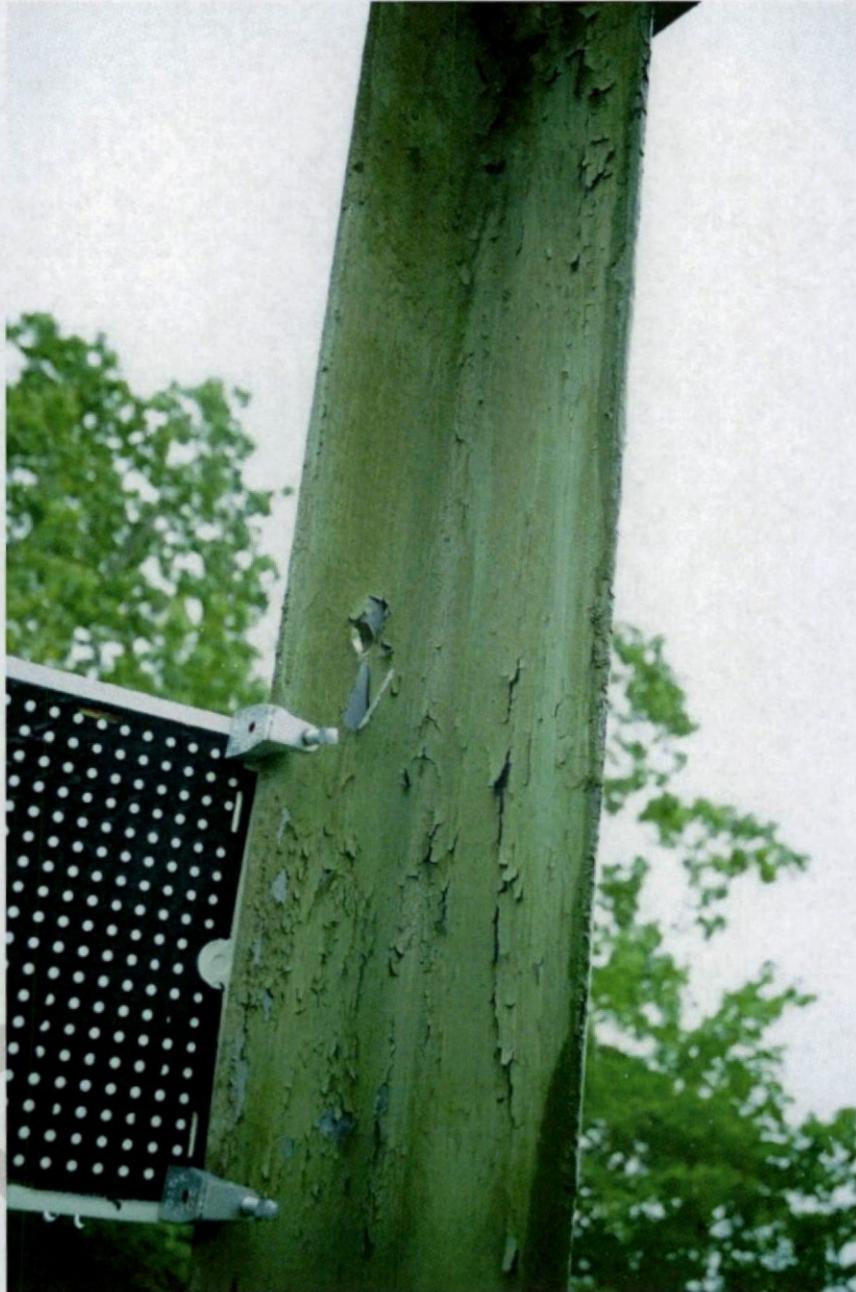
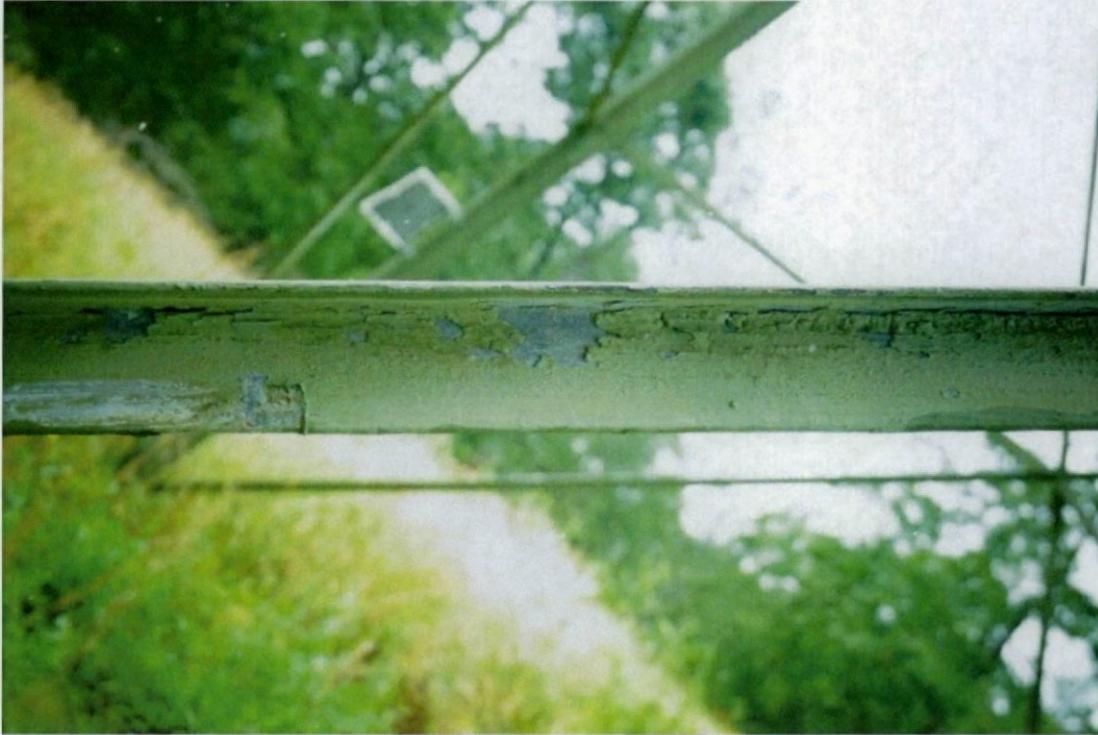
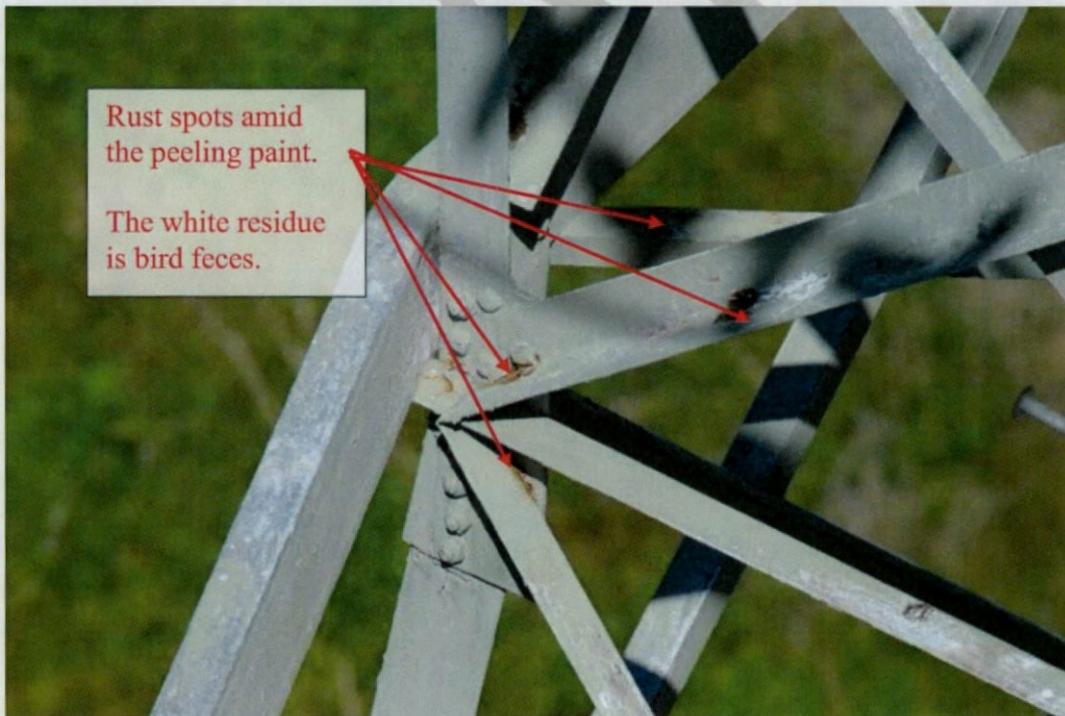


Figure 79: 38698S16295 - Paint is not well adhered to this structure



**Figure 80:** 38698S16295 - Paint is not well adhered to this structure



**Figure 81:** 38698S16295 - Spot rust and bird feces

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### 3.23 38663S16189

This structure exhibited loose and peeling paint over most of its surface. The lower sections were relatively free of corrosion, while the top of the structure exhibited a significant amount of corrosion. The paint needs to be stripped and the corrosion at the top of the structure needs to be addressed. Then the structure needs to be repainted.



**Figure 82:** 38663S16189 - Cracking and loose paint

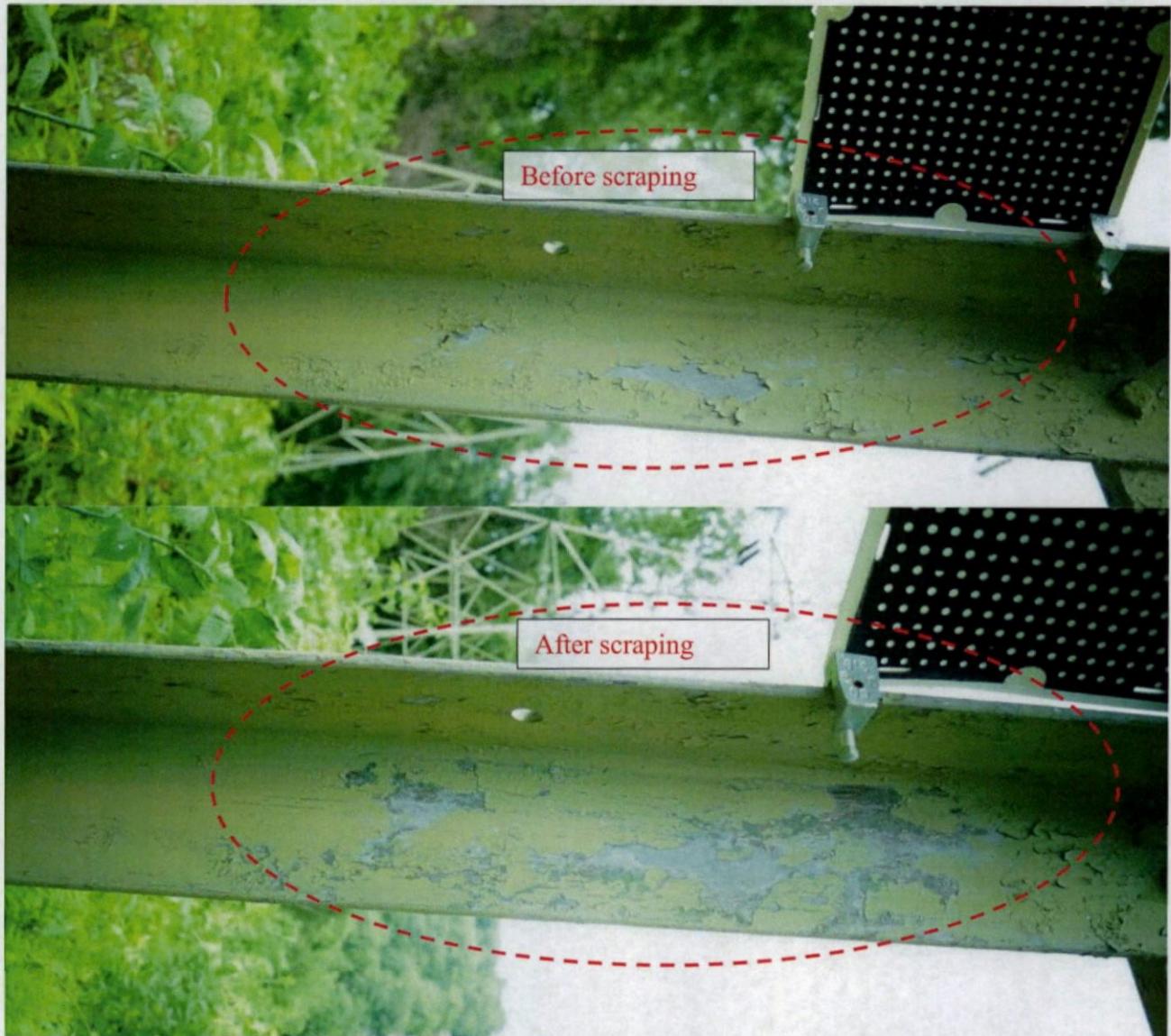


Figure 83: 38663S16189 - Paint condition, before and after scraping



**Figure 84:** 38663S16189 - Paint condition where several braces connect to a support leg



Figure 85: 38663S16189 - Paint condition before and after scraping



Figure 86: 38663S16189 - Top of the structure exhibited significantly more corrosion than the bottom

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### 3.24 38658S16197

This structure exhibited poor adhesion of the paint over its entire surface. Some components were rusty, especially at the top, but otherwise the structure appeared in good shape. A detailed climbing inspection is needed to evaluate the top of the structure and determine the remediation plan and cost to strip, repair and repaint the structure.



Figure 87: 38658S16197 - Paint peeling off this structure

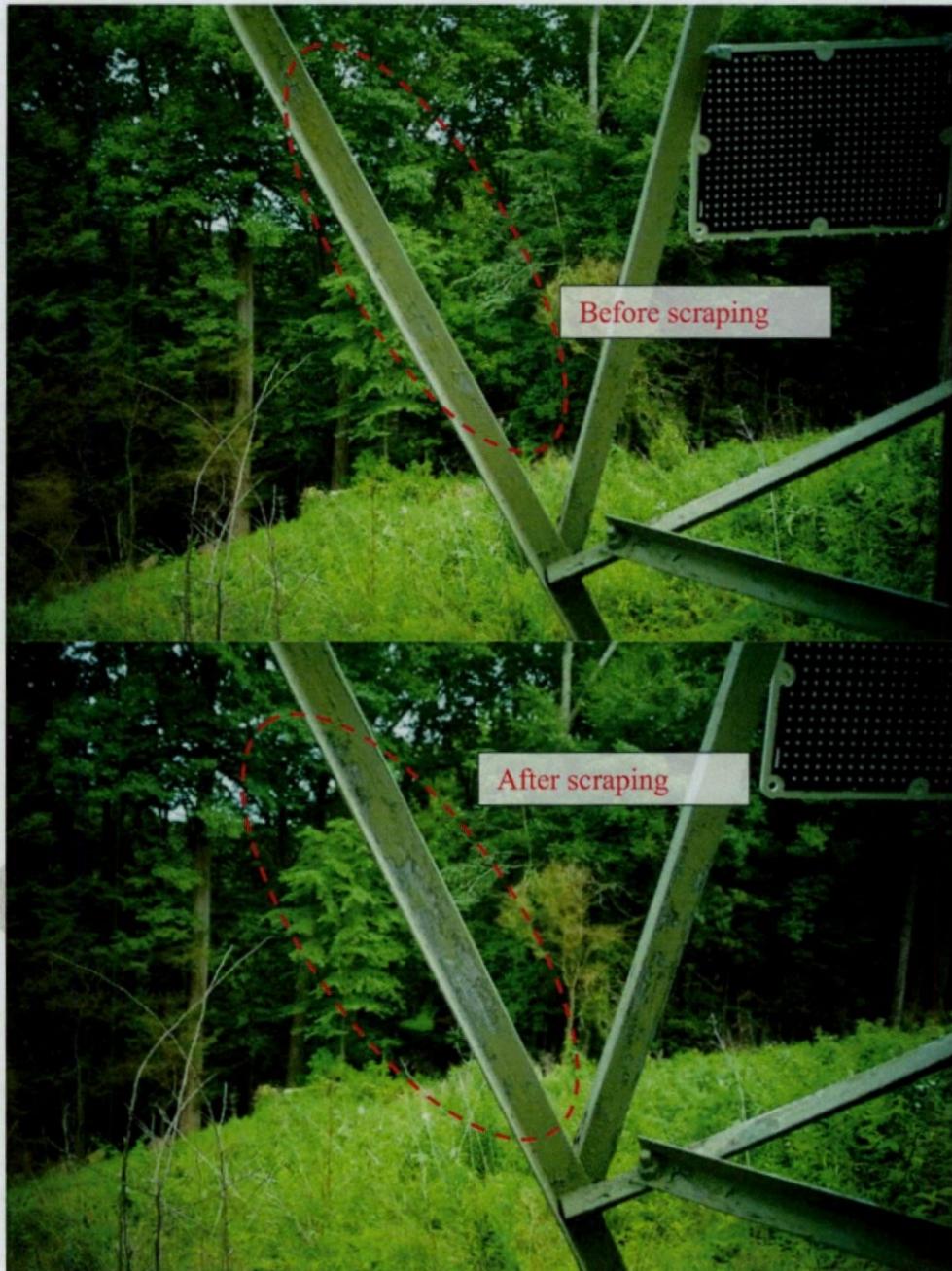


Figure 88: 38658S16197 - Paint condition before and after scraping

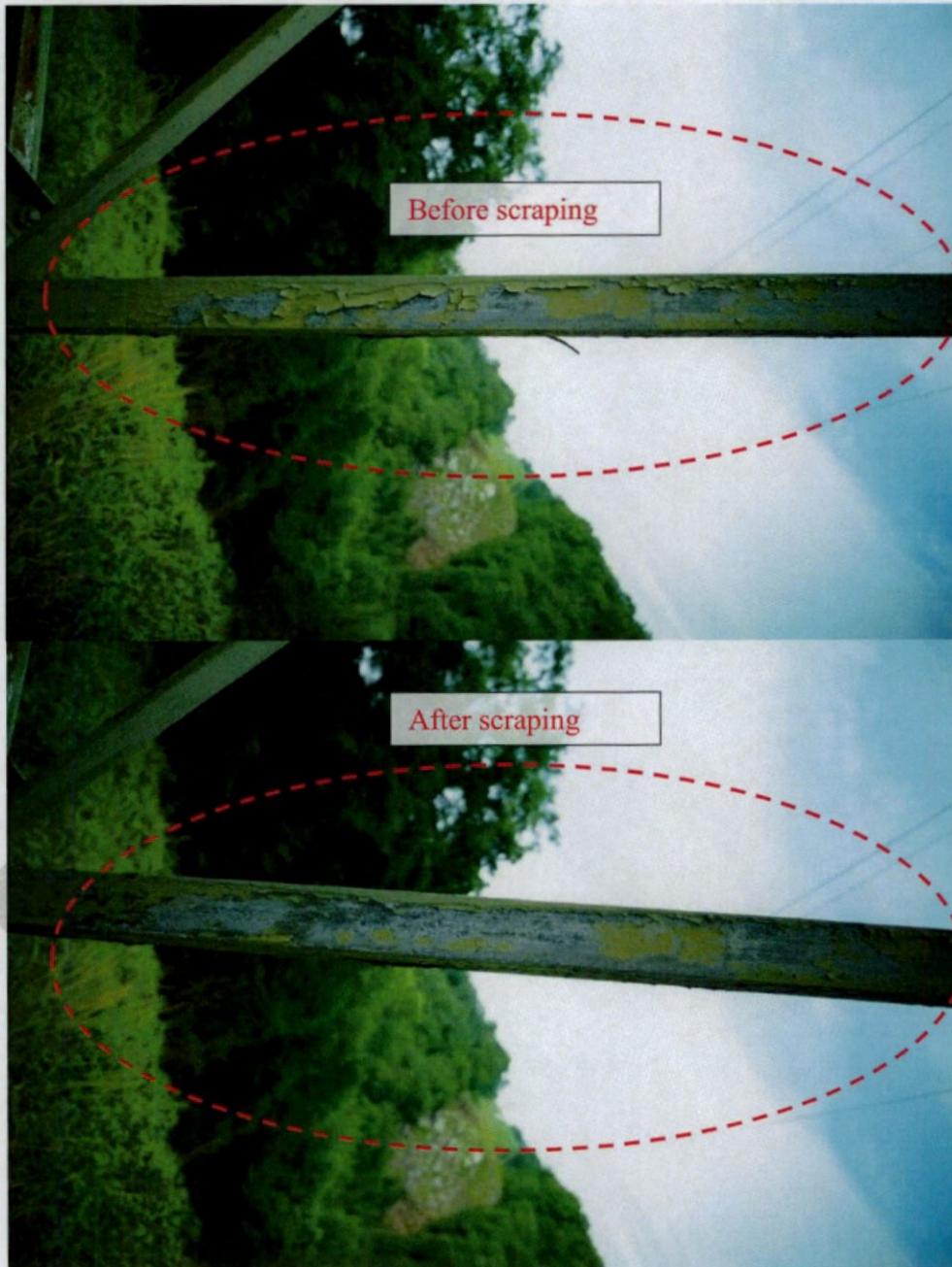


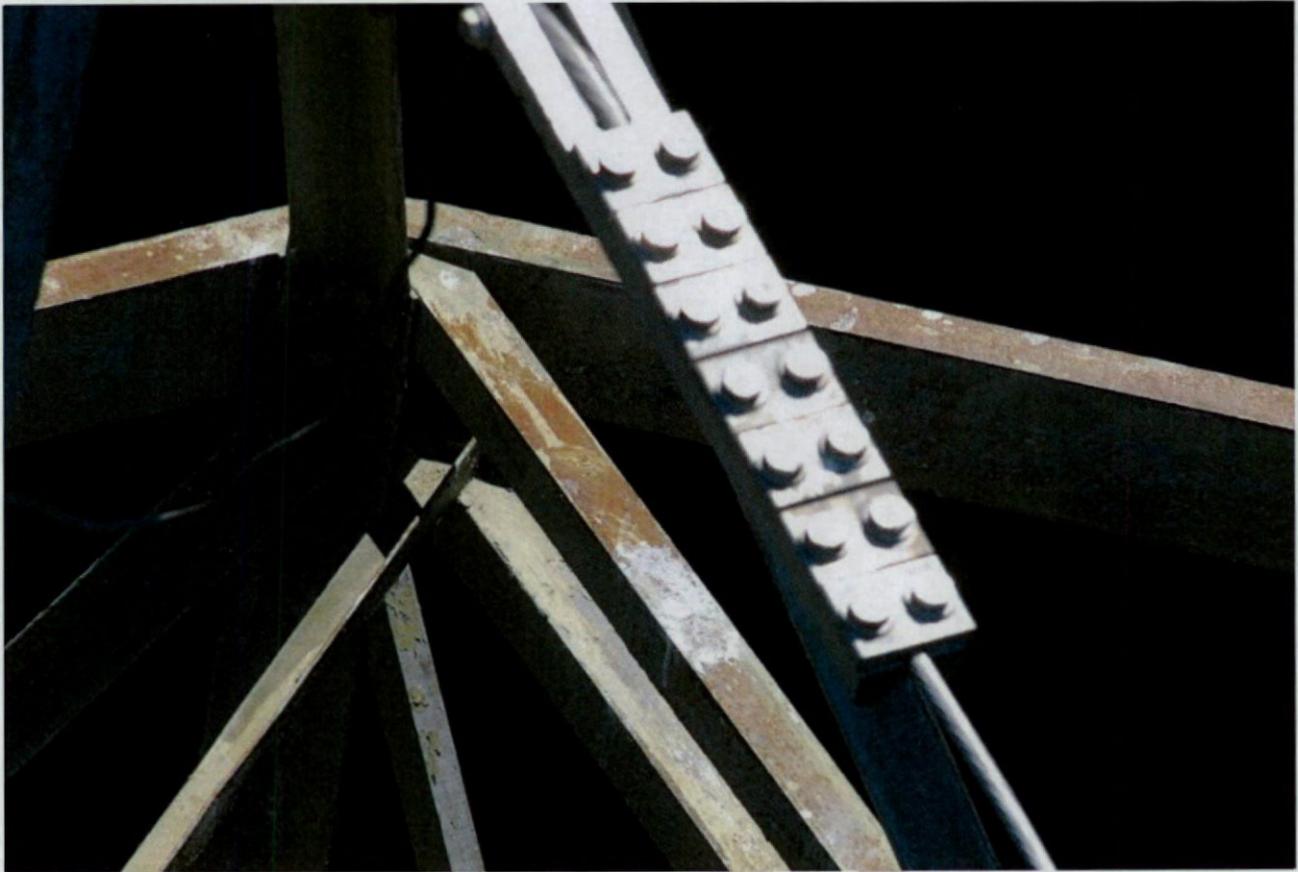
Figure 89: 38658S16197 - Paint condition before and after scraping



**Figure 90:** 38658S16197 - One of the few places near the ground that exhibited rust



**Figure 91:** 38658S16197 - Paint was not stripped on this brace. This is the as-found condition.



**Figure 92:** 38658S16197 - Top of the structure exhibited significant rusting and bird feces

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3.25 38591S15995

This structure exhibited significant rust and paint peeling at the top of the structure. A more detailed inspection is needed to determine the extent of the rusting at the top, as well as to determine the remediation plan and cost.



Figure 93: 38591S15995 - Top of the structure exhibited significant rust

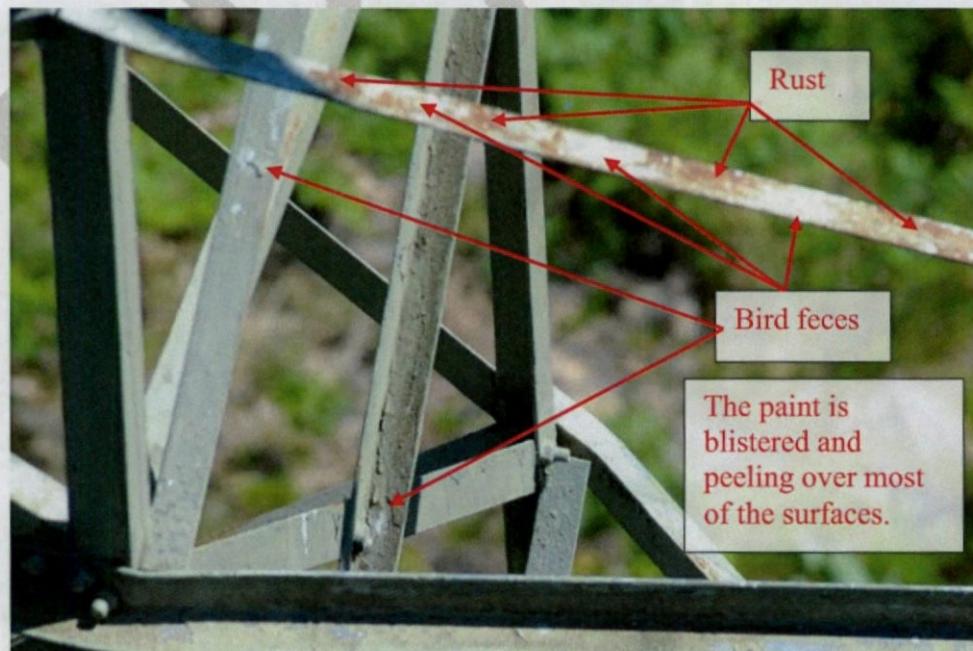


Figure 94: 38591S15995 - Top of the structure showed significant rust, bird feces and blistered paint

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3.26 38586S16005

This structure exhibited significant corrosion (rusting) of many of the components at the top of the structure. The rust may be deep enough that the components need to be replaced. A detailed climbing inspection will be needed to make that determination, as well as to determine the remediation plan and cost.



Figure 95: 38586S16005 - Top of the structure showed significant rust and blistered paint

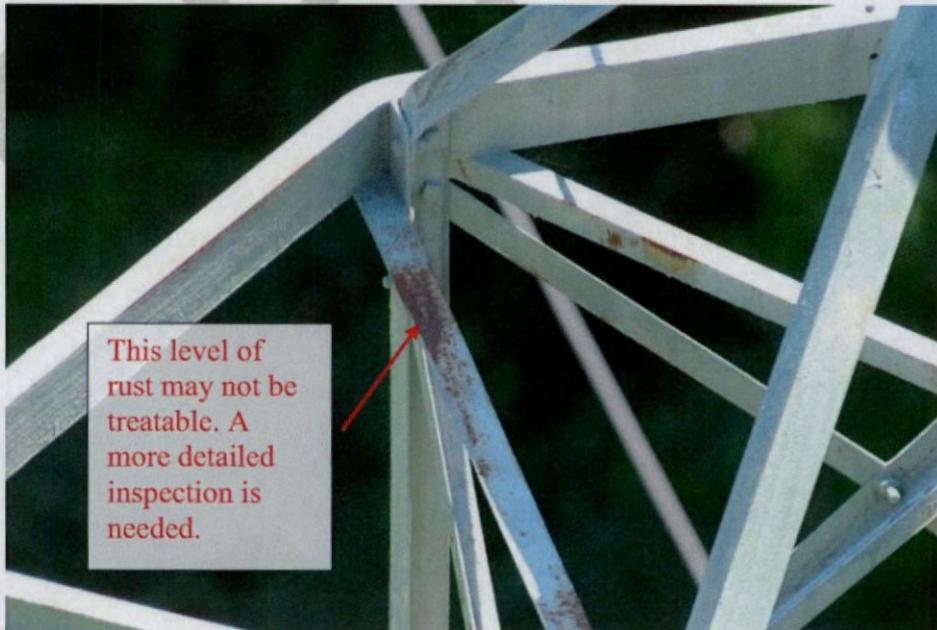


Figure 96: 38586S16005 - Top of the structure showed significant rust and blistered paint

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### 3.27 38567S15943

This structure requires immediate attention. One of the legs is buckled and twisted. Given the structure's location on the side of a steep hill, it does not seem reasonable that the damage could have been caused by farm equipment. More likely causes include overloading from wind or ice, as well as seismic activity or an inadequate footing. In addition, the lower portion of the structure exhibited poor paint adhesion and the top of the structure exhibited significant rust. A more detailed inspection is needed, especially of the footing and replacement will likely be the best option.

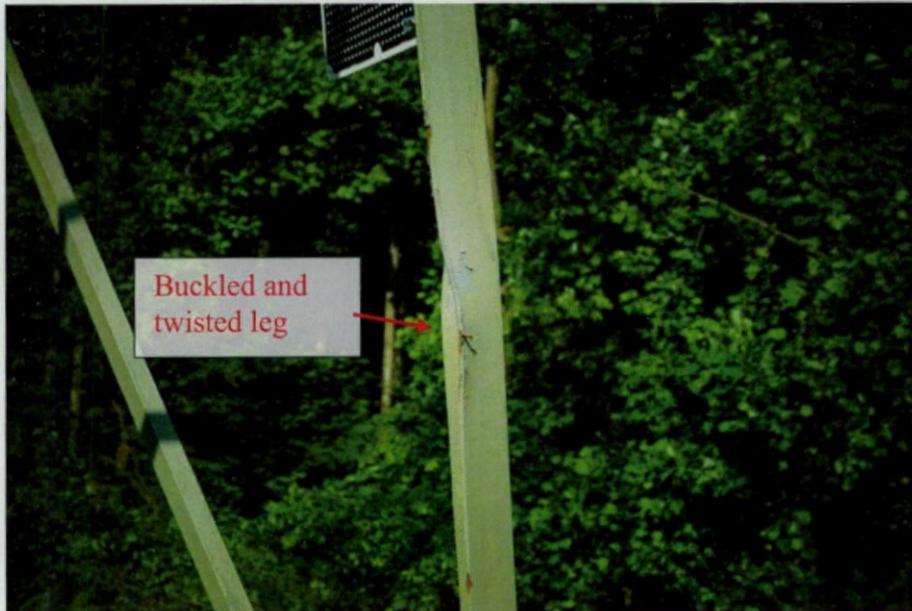


Figure 97: 38567S15943 - Buckled and twisted leg



Figure 98: 38567S15943 - Buckled and twisted leg



Buckled and twisted leg

Figure 99: 38567S15943 - Buckled and twisted leg

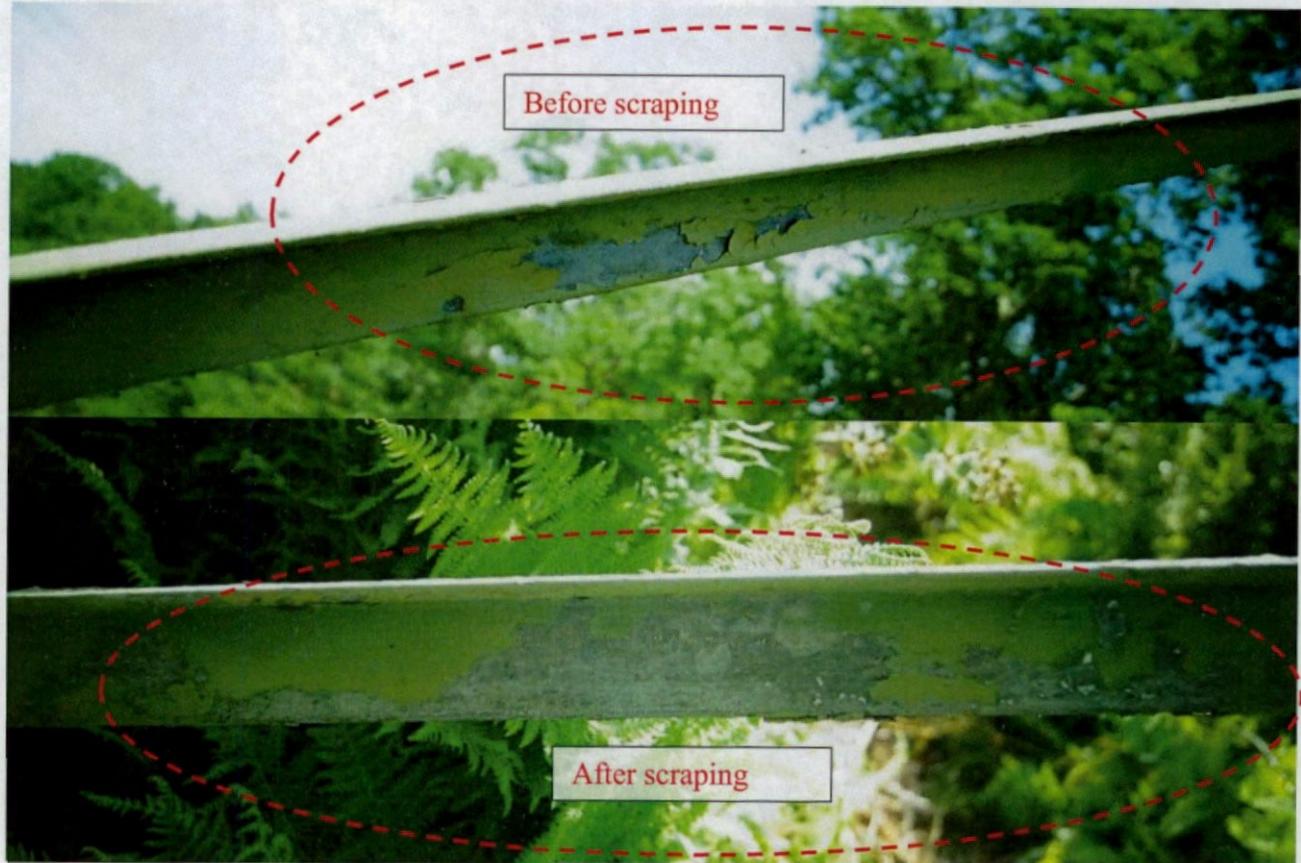


Figure 100: 38567S15943 - Paint before and after scraping

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**Figure 101:** 38567S15943 - Top of the structure exhibited significant rust

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3.28 38562S15945

This structure exhibited poor paint adhesion and significant rusting, especially at the top of the structure. A more detailed climbing inspection is needed to determine the extent of the rust at the top of the structure, as well as the remediation plan and cost. Some structural components will need replacement.



Figure 102: 38562S15945 - Paint before and after scraping



Figure 103: 38562S15945 - Paint after scraping

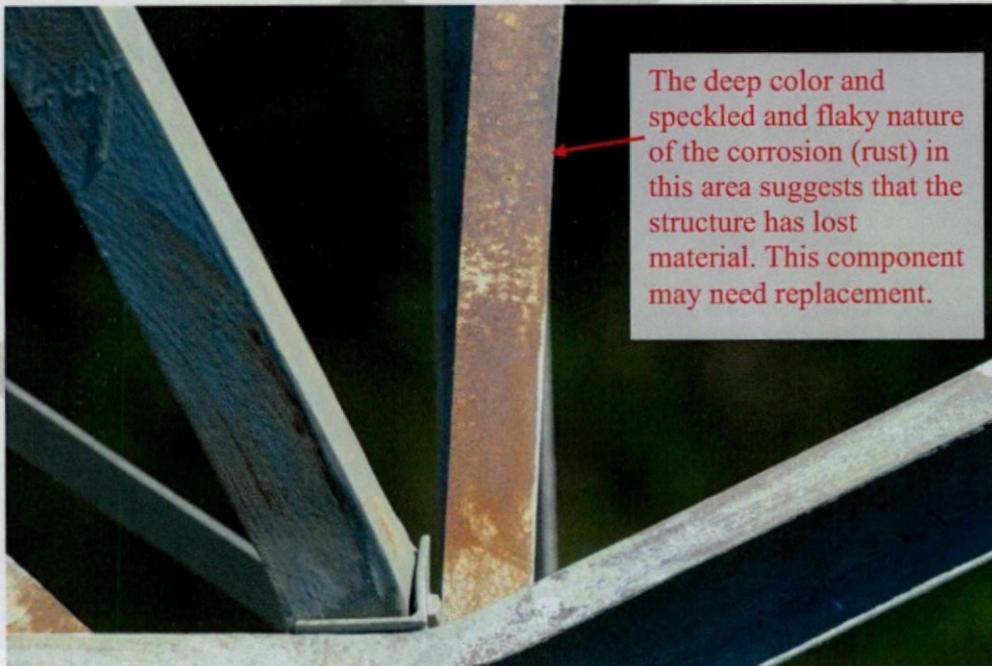


Figure 104: 38562S15945 - Significant rusting on this component

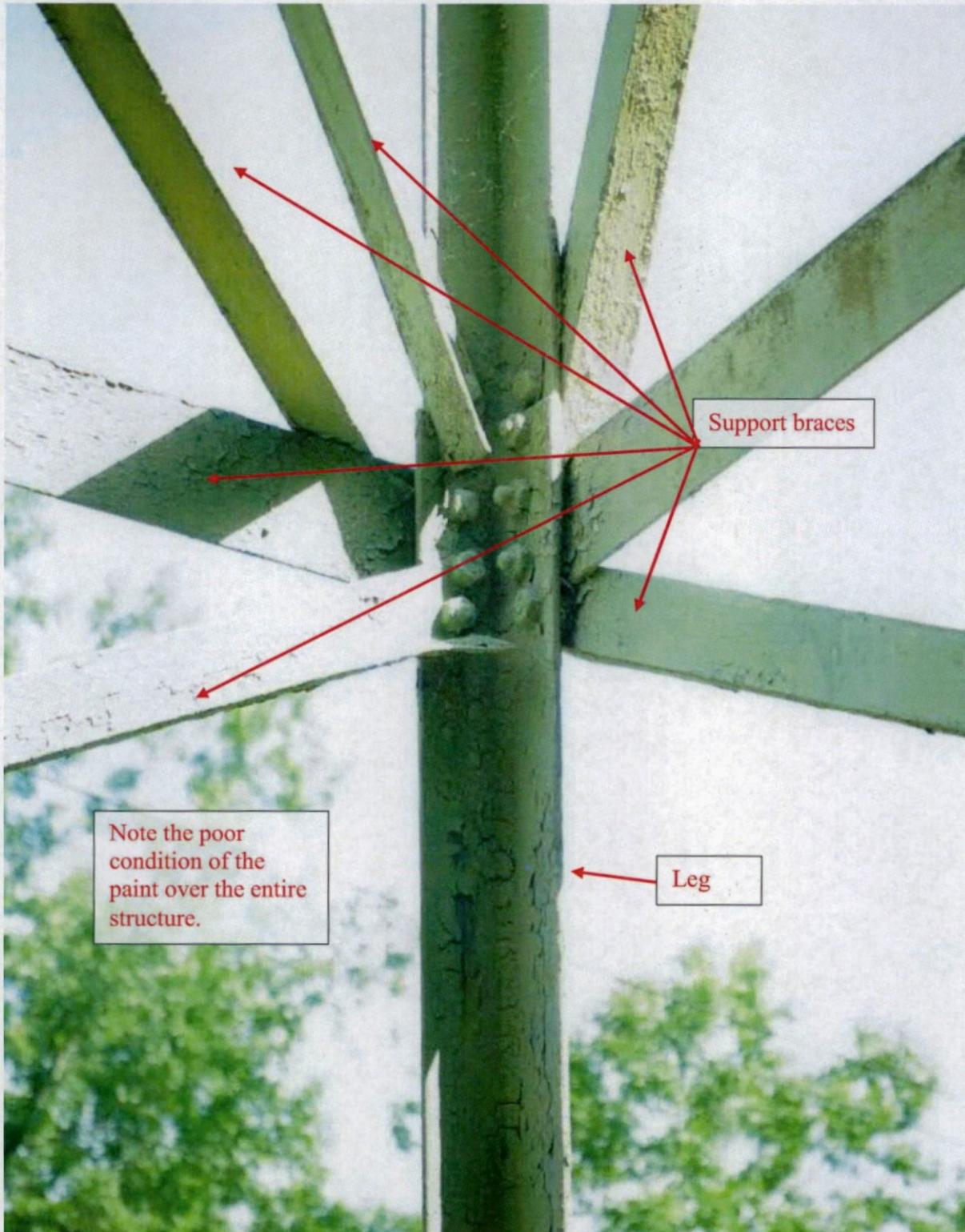


Figure 105: 38562S15945 - Detail of several cross braces connecting to a support leg

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### 3.29 38349S15373

This structure exhibited poor paint adhesion and corrosion over most of the structure. Also a twisted cross brace has been reattached to the footing during a previous foundation repair. A more detailed inspection is needed to determine the remediation plan and cost.



**Figure 106:** 38349S15373 - Poor paint adhesion on this structure



**Figure 107:** 38349S15373 - Twisted cross brace reattached to footing



**Figure 108:** 38349S15373 - Poor paint adhesion, typical of most of the structure



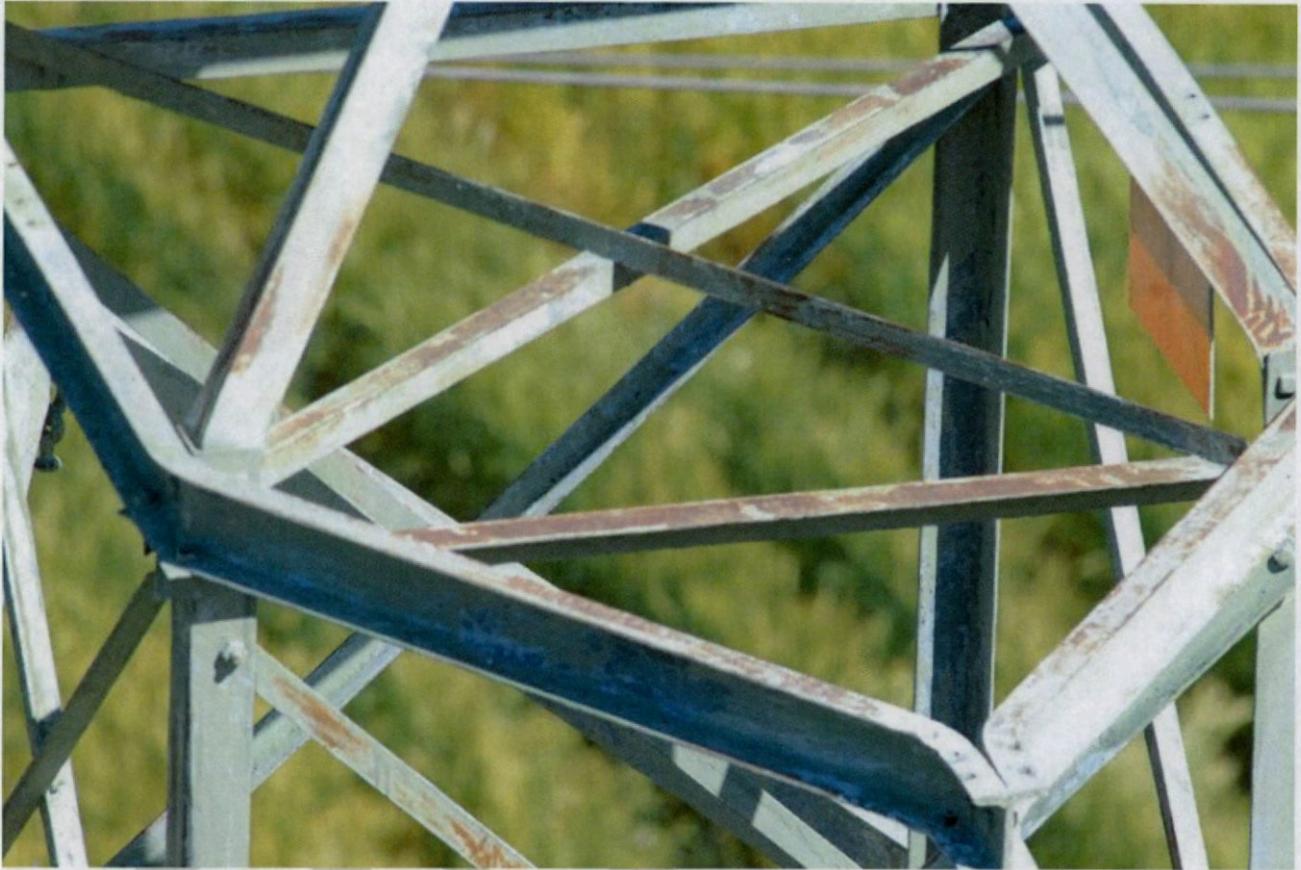
**Figure 109:** 38349S15373 - Poor paint adhesion and corrosion, typical of most of the structure

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### 3.30 38378S15471

The top of this structure is heavily corroded. A more detailed climbing inspection is needed to determine which components need replacement and to determine a remediation plan and cost.



**Figure 110:** 38378S15471 - Corrosion and bird feces on the top of this structure

3.31 38344S15375

This structure exhibited two (2) buckled cross braces. Also, the paint was in poor condition with corrosion setting in over the entire structure. A more detailed inspection is needed to determine the remediation plan and cost.

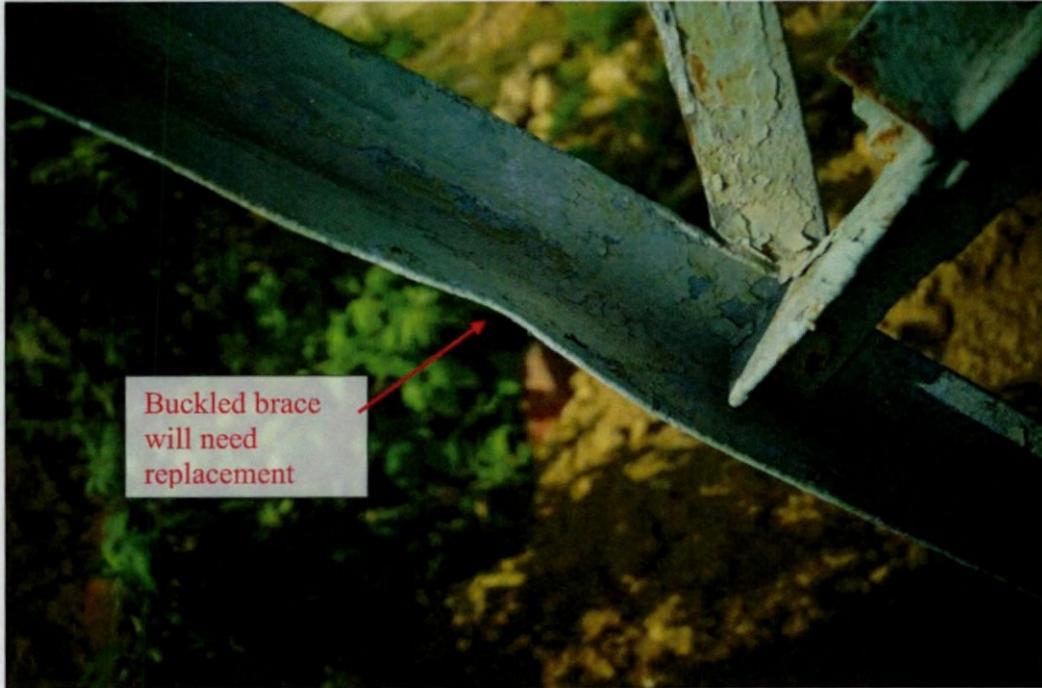


Figure 111: 38344S15375 - Buckled brace



Figure 112: 38344S15375 - Damage likely caused by the footing repair



**Figure 113:** 38344S15375 - Typical poor condition of the paint on this structure



**Figure 114:** 38344S15375 - Typical condition of the paint with spot rust



**Figure 115:** 38344S15375 - Typical condition of the paint with spot rust

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3.32 38124S14790

This structure exhibited poor paint adhesion and spot rust over its entire lower surface. The top of this structure exhibited significant rust and several components may need to be replaced. A more detailed inspection is needed to determine the remediation plan and cost.



**Figure 116:** 38124S14790 - Poor paint adhesion and spot rust typical of the lower part of this structure

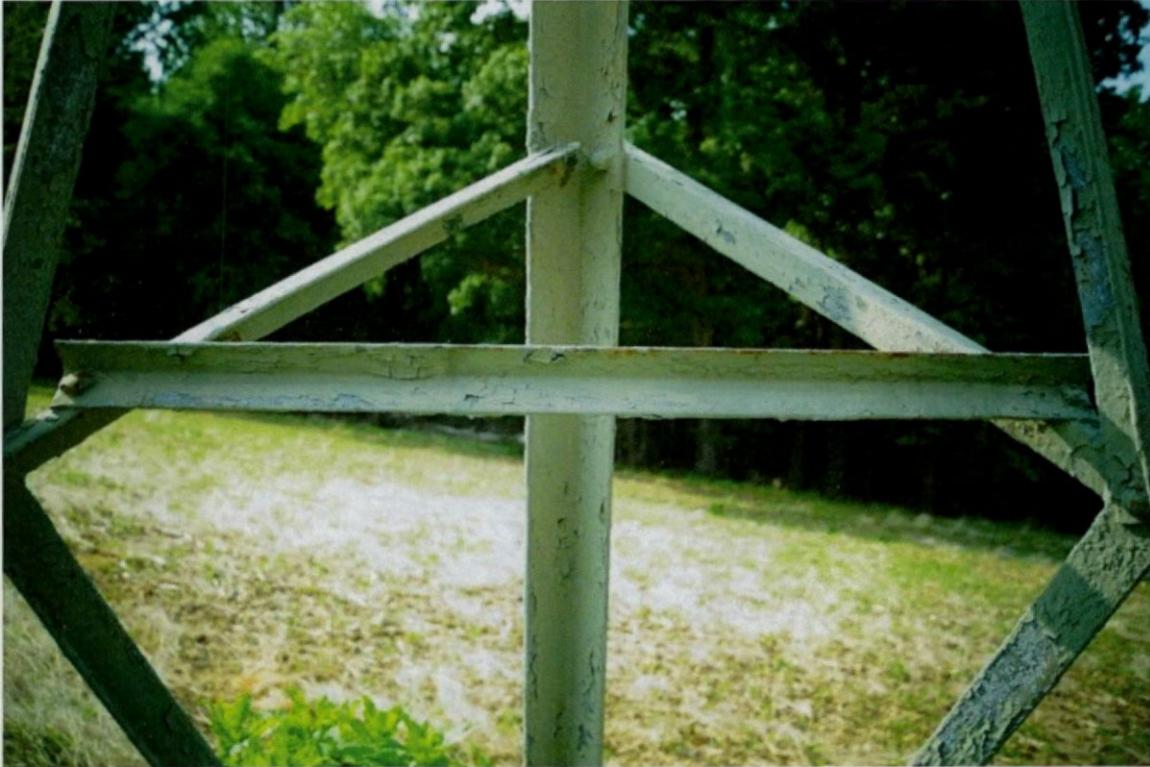


Figure 117: 38124S14790 - Poor paint adhesion and spot rust typical of the lower part of this structure



Figure 118: 38124S14790 - Poor paint adhesion and spot rust typical of the lower part of this structure



**Figure 119:** 38124S14790 - Poor paint adhesion and rust typical of the upper part of this structure



**Figure 120:** 38124S14790 - Poor paint adhesion and rust typical of the upper part of this structure

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3.33 38129S14788

This structure exhibited a buckled leg and requires immediate action.



**Figure 121:** 38129S14788 – Buckled and twisted leg



Figure 122: 38129S14788 – Buckled and twisted leg



Figure 123: 38129S14788 – Poor paint adhesion typical of the lower part of this structure

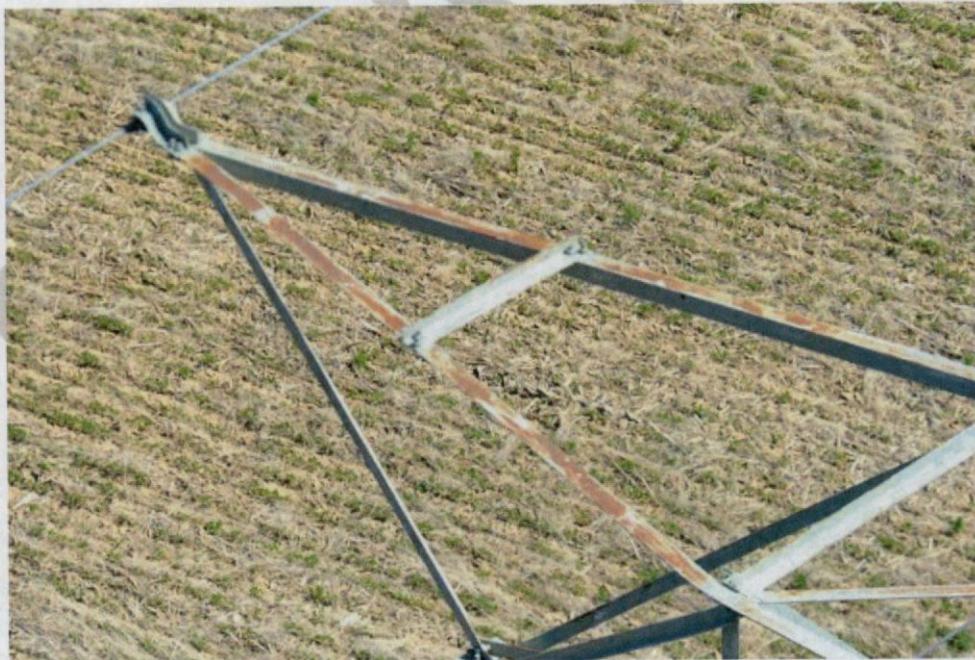


Figure 124: 38129S14788 – Poor paint adhesion and rust typical of the upper part of this structure



Figure 125: 38129S14788 – Poor paint adhesion and rust typical of the upper part of this structure

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3.34 38109S14748

This structure was not on the inspection list. However, several buckled braces were observed while passing it.



Figure 126: 38129S14788 – Buckled brace

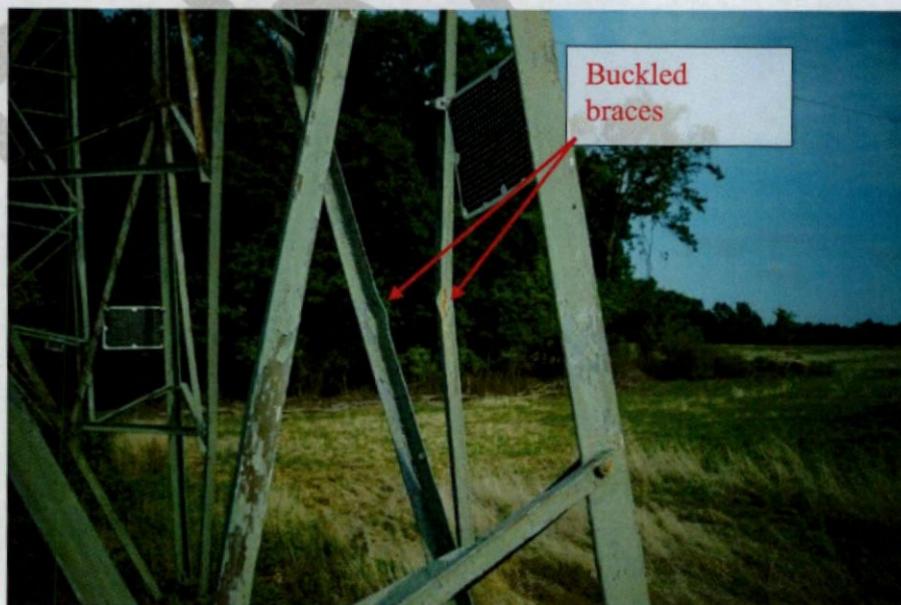


Figure 127: 38129S14788 – Buckled braces

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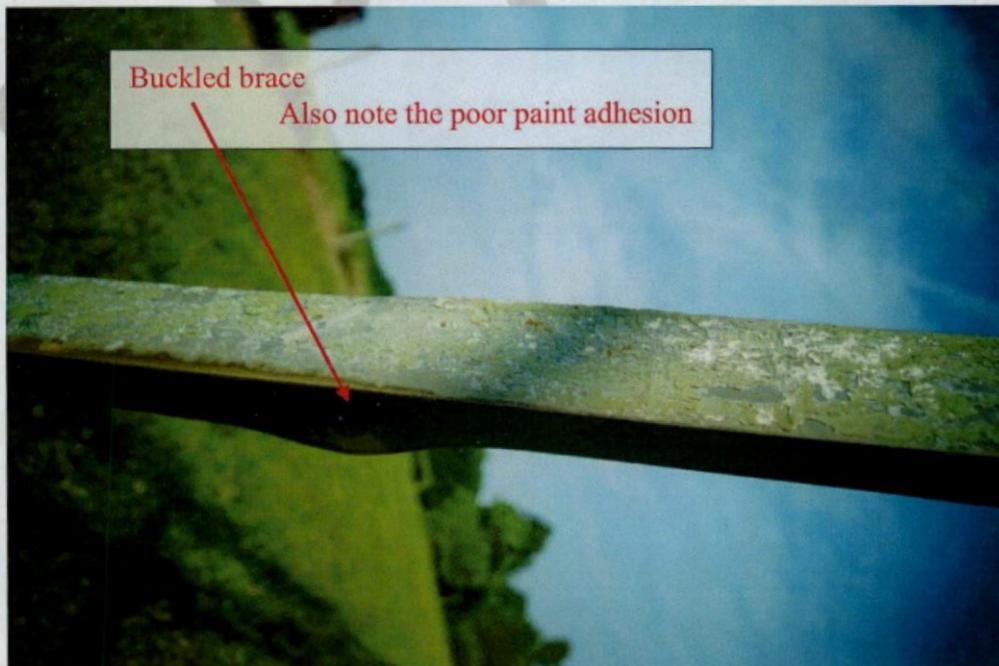
3.35 38005S14453

This structure exhibited a damaged brace. The lower portion exhibited poor paint adhesion and spot rust, while the top portion exhibited poor paint adhesion and more significant rust. A more thorough inspection is needed to determine a remediation plan and cost.



Buckled brace

Figure 128: 38005S14453 - Buckled brace



Buckled brace  
Also note the poor paint adhesion

Figure 129: 38005S14453 - Buckled brace and poor paint adhesion



**Figure 130:** 38005S14453 - Typical poor paint adhesion of the lower portion of this structure



**Figure 131:** 38005S14453 - Typical poor paint adhesion with spot rust, typical of the lower portion of this structure



**Figure 132:** 38005S14453 - Poor paint adhesion and corrosion typical of the upper portion of this structure



**Figure 133:** 38005S14453 - Poor paint adhesion and corrosion typical of the upper portion of this structure

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### 3.36 38010S14451

This structure exhibited poor paint adhesion, but minimal rusting over the entire structure. The paint needs to be stripped and the structure repainted.



**Figure 134:** 38010S14451 - Poor paint adhesion typical of the entire structure

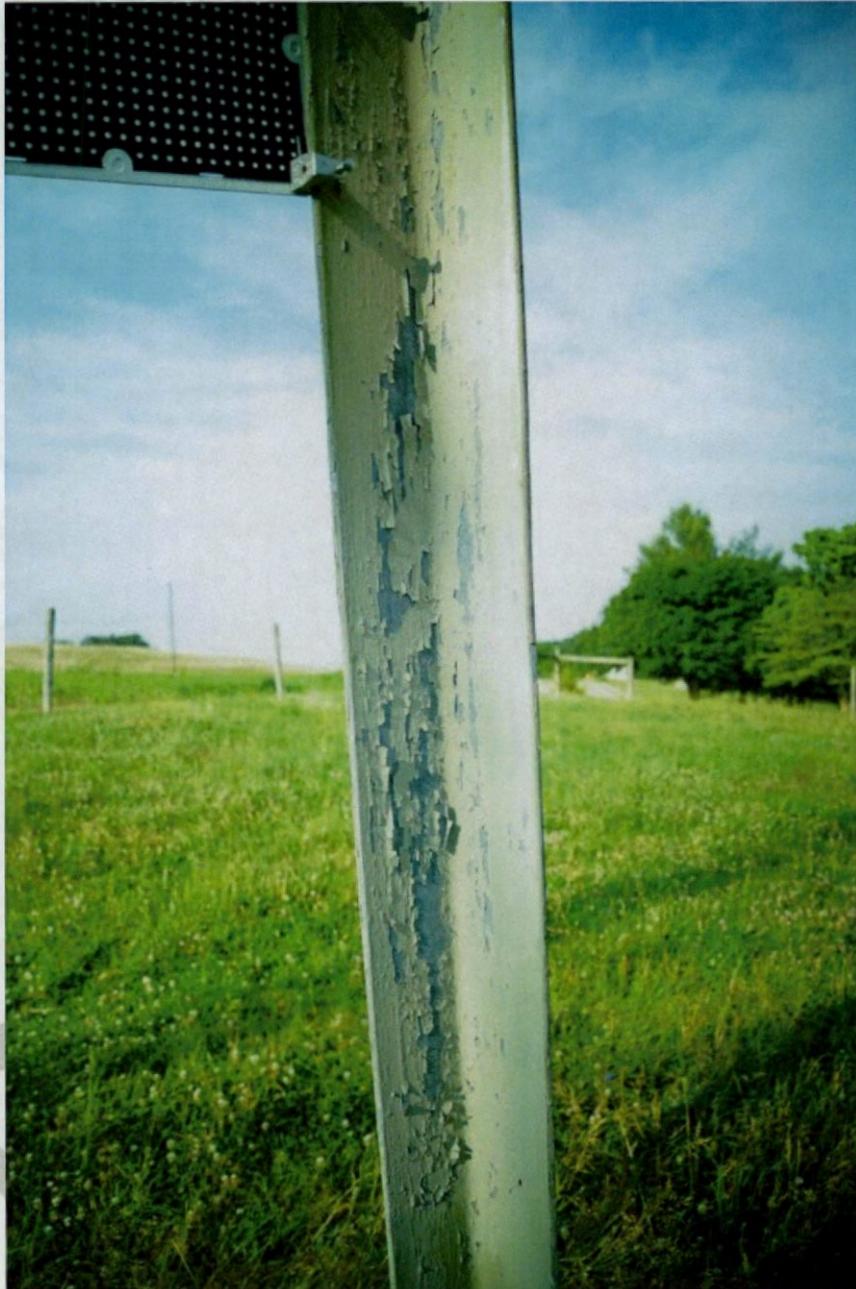


Figure 135: 38010S14451 - Poor paint adhesion typical of the entire structure



**Figure 136:** 38010S14451 - Poor paint adhesion typical of the entire structure

#### 4 CONCLUSIONS

Thirty six (36) structures from PPL's Face Rock - Five Forks 115 kV transmission line were inspected on June 14<sup>th</sup> and 15<sup>th</sup> 2016. The inspections focused on obvious structural issues, paint adhesion and corrosion (rust) above the ground line. (PPL has contracted with Osmose to evaluate the footings.)

Five (5) structures had significant defects and require immediate action. Structure 39615S18127 and 39621S18116 exhibited poor paint adhesion, pervasive and deep rust, as well as pack rust. Pack rust can cause sudden catastrophic failure of gusset plates and connections as it can create up to 10,000 psi in these connections. 39615S18127 also had several bent structural members. Structures 38663S16189, 38567S15943 and 38129S14788 exhibited severe buckling and/or twisting of one of their four legs (main support column). Structure 38663S16189 is located on the side of a steep hill and there is no way it could have been damaged by heavy machinery. The damage could have been caused by heavy ice or wind loading, inadequate foundation support, seismic activity or some combination thereof. Regardless of the cause, the structural integrity of the tower is significantly compromised.

The remaining structures inspected are in various states of decay. If PPL wants to reuse these structures during upcoming reconductoring of this line, all structures inspected need to be stripped and repainted. This will likely be difficult, as the paint is likely lead based and stripping could cause environmental concerns that will need to be abated. Moving forward, PPL will need to reinstate its inspection and painting program to prevent the level of decay seen during this inspection. Most structures also exhibited

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at least some corrosion, and may have corrosion that impacts the structure's strength. Fourteen (14) of the thirty six (36) structures (39%) evaluated had buckled or damaged structural members.

Given the pervasive and deep rust on many of the structures, need for repainting and remediation of lead based paint, structural repairs and the need to reinstitute a painting maintenance program; NEETRAC recommends that PPL replace each pair of lattice towers with a single galvanized steel pole. Since the towers were previously modified to accommodate an increase in the line voltage and some towers have unusual suspension systems to ensure NESC clearances are met, this strategy has the advantage of standardizing the line design, as well as reducing maintenance costs and the possibility of structural damage from farm equipment. It is highly likely that PPL will find this option to be the least costly and easiest to execute with the lowest cost of ownership going forward.

If PPL decides to reuse the structures, all structures in this line should receive a detailed climbing inspection with the aim of detailing and costing the repairs needed. Also, PPL needs to institute a painting and inspection maintenance program to maintain these structures.

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