

Incident Summary #II-1066582-2020 (#19230) (FINAL)

SUPPORTING INFORMATION	Incident Date	September 14, 2020	
	Location	Squamish	
	Regulated industry sector	Passenger ropeways - Above surface ropeway	
	Injury	Qty injuries	0
		Injury description	NA
		Injury rating	None
	Impact Damage	Damage description	The haul rope of a gondola was damaged and separated resulting in multiple cabins, which were suspended from the rope, to fall to the ground from various heights. Many of the cabins were damaged beyond repair. As the separated ends of the haul rope retracted it caused damage to towers, guard rails, security system and surrounding trees
		Damage rating	Major
		Incident rating	Major
Incident overview	In the early morning, security personnel stationed at the Sea to Sky Gondola witnessed movement of the gondola cabins attached to the haul rope. A short time later the main haul rope separated allowing a majority of the cabins which were suspended on the rope to fall to the ground.		
INVESTIGATION CONCLUSIONS	Site, system and components	<p>The Sea to Sky gondola is a cable transport style of aerial lift. The lift incorporated 39 cabins in which up to eight passengers per cabin could be transported from a lower terminal at the base of the mountain to a terminal at the top of the mountain. The cabins were suspended by a haul rope. The haul rope is a continuous loop of steel wire rope that travels along intermittent supporting towers between the two terminals. The haul rope loop is driven by a bull wheel and motor from the lower terminal. The rotating loop allows the passenger cabins to travel up the mountain on one side of the loop while the cabins on the other side of the loop simultaneously travel down the mountain.</p> <p>The haul rope is a 4335 metre long 52 mm nominal diameter galvanized steel wire rope made up of six individual strands wrapped around a solid plastic core. Each of the six strands is made up of 36 individual steel wires combining to a total of 216 wires in the rope.</p> <p>The support towers are constructed of steel and are secured to concrete bases. The towers support a sheave assembly, which is an in-line group of metal wheels lined with rubber or synthetic material, that the haul rope rides on to keep it suspended. The towers incorporate a ladder to access platforms that facilitate maintenance and inspection work.</p> <p>Ladder covers had been installed on some of the tower ladders. The covers are eight foot tall steel plates which fasten to the bottom of the ladders and block the lower ladder rungs from being used. The purpose of the ladder covers is to deter unauthorised individuals from climbing the ladders and accessing the top of the towers.</p>	

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	<p>The gondola travels through the Stawamus Chief Provincial Park. The park contains marked hiking trails, some of which pass directly underneath the gondola lines and are in close proximity to the bases of some of the support towers. Unmarked maintenance trails facilitate access to the tower bases for construction, maintenance or emergency services.</p>
Failure scenario(s)	<p>In the early morning of September 14, 2020, while the gondola was not in operation, the haul rope was cut while under tension. The cut was made on the downhill side of the loop from the top of one of the support towers. Once a sufficient number of the wire strands making the rope were cut, the rope separated under the tension of the gondola and attached cabins.</p>
Facts and evidence	<p>August 10, 2019, the haul rope of the Sea to Sky Gondola had been deliberately cut resulting in damage to numerous cabins, the haul rope and associated components. The incident was investigated by Technical Safety BC which produced the following report: Sea-to-Sky-Gondola-Collapse. The haul rope and damaged cabins were replaced and the gondola was put back into operation on February 14, 2020.</p> <p>Following the first incident, additional monitoring, deterrent and security measures were added to the existing security system. [REDACTED]</p> <p>[REDACTED]</p> <p>[REDACTED]</p> <p>[REDACTED]</p> <p>[REDACTED]</p> <p>[REDACTED]</p> <p>[REDACTED]</p> <p>Failure analysis (Appendix A) concluded that the wire haul rope failed as a result of being [REDACTED] cut [REDACTED]. The cutting resulted in the majority of the strands being severed while the full tension of the line transferred to the remaining strands. The remaining partially intact strands eventually suffered a catastrophic overload and separated under the tension.</p>

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	<p>Analysis of the Materials and construction (Appendix A) of the haul rope concluded that the wire haul rope met the manufacturer's requirements in terms of size, wire strength and construction.</p> <p>The haul rope minimum design factor was identified as 4.61. The design factor is the ratio between the working load limit and the minimum breaking strength. The final number of individual wires that remained prior to the haul rope separating under tension is commensurate with the design margin.</p>
<p>Causes and contributing factors</p>	<p>The gondola haul rope failed as a direct result of being deliberately cut. No design or manufacturing flaws were identified as contributing to the failure of the haul rope.</p> <p>Note: Technical Safety BC limited its investigation scope to the cause of technical failure of the gondola haul rope. Given the deliberate nature of the cut and concurrent investigation by the RCMP, Technical Safety BC did not pursue further evaluation of the installation, maintenance or operation of the gondola or persons responsible for the cutting the haul rope.</p>

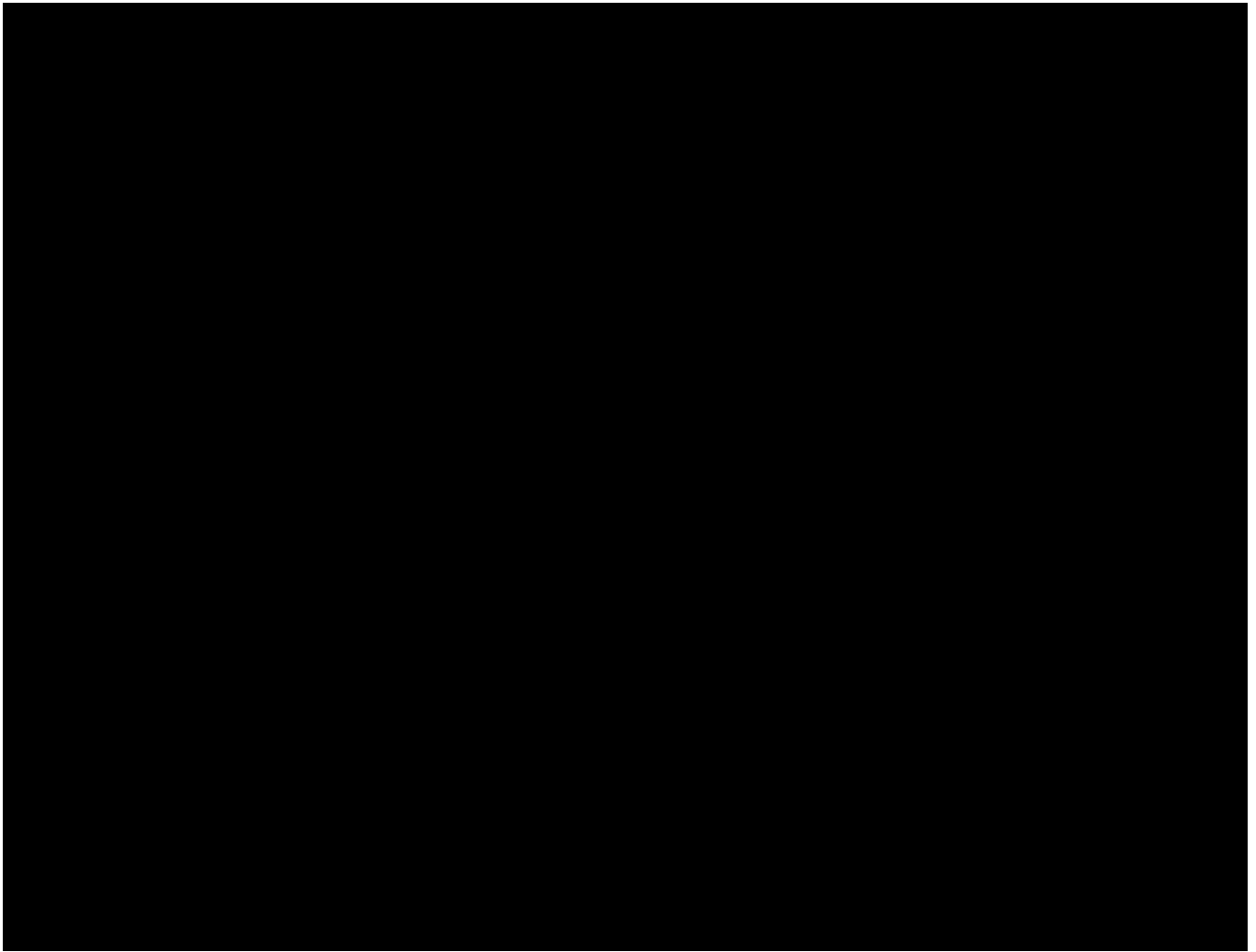


Image 1 - Damaged gondola cabins at base of tower. 

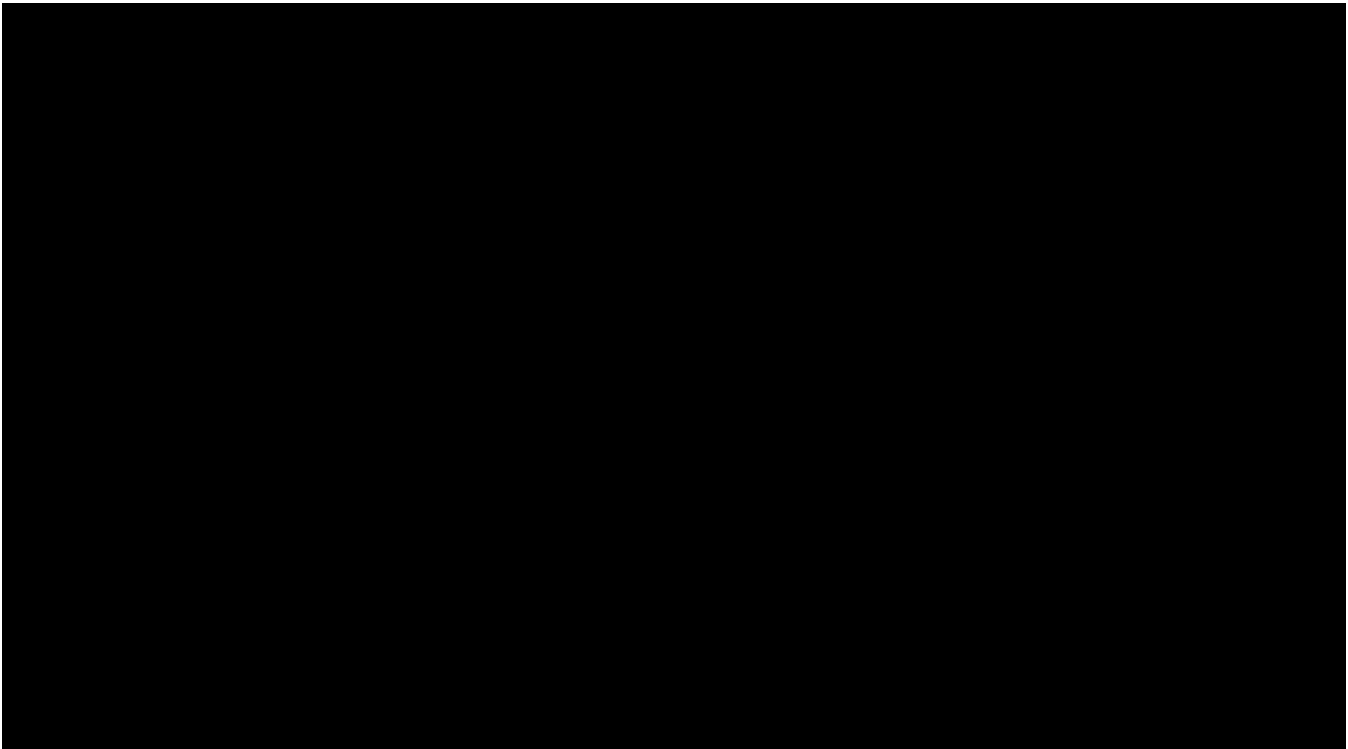


Image 2 – Diagram of gondola line. Red X's illustrate the locations where the separated ends of the downhill side of the haul rope were found.

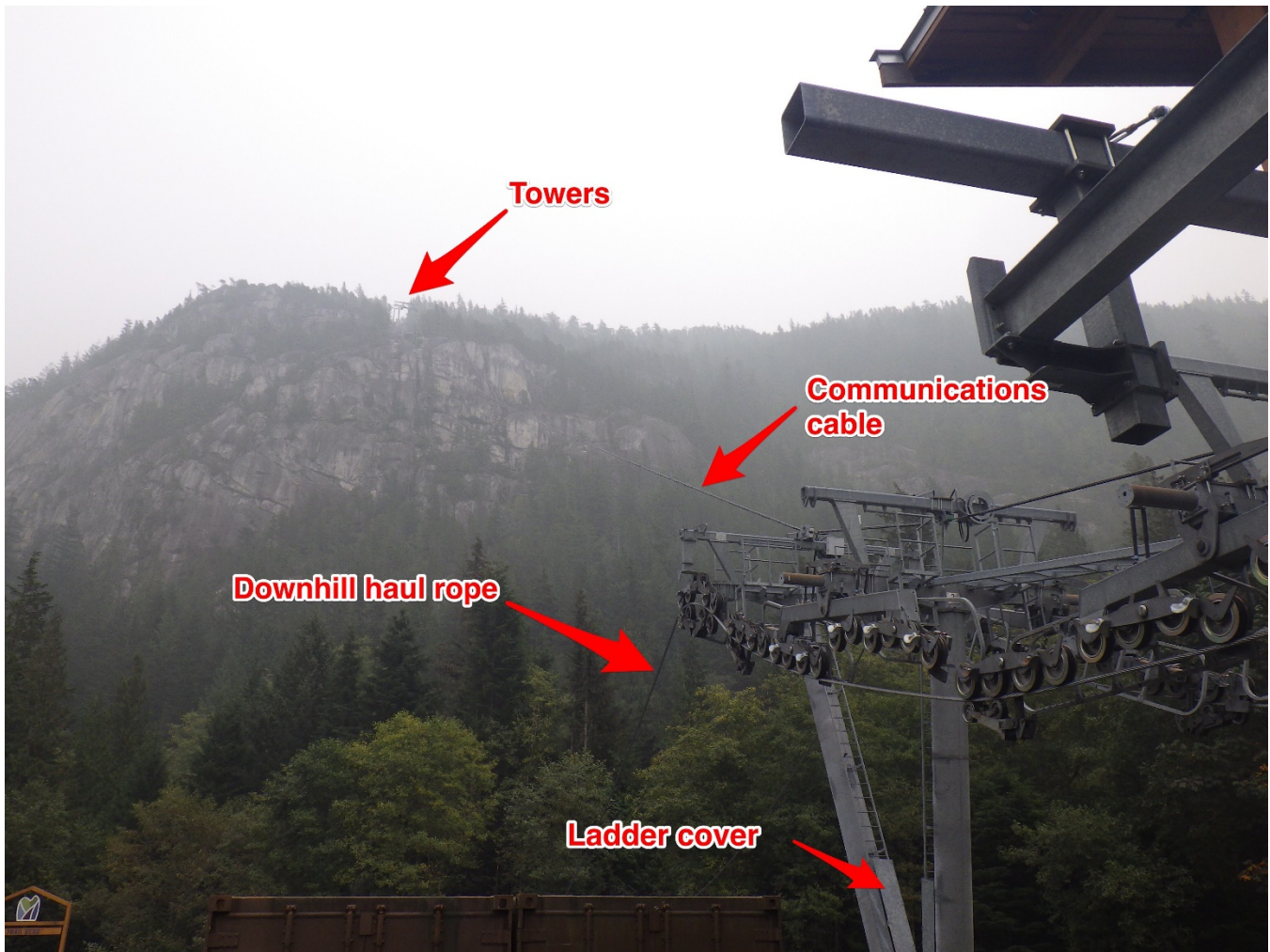


Image 3 – View from the last tower at the base terminal looking up to the towers after the first large span.





Image 4 – Damaged gondola cabin in the woods with the haul rope laying on top



Image 5 – Fallen haul rope lying across public trail

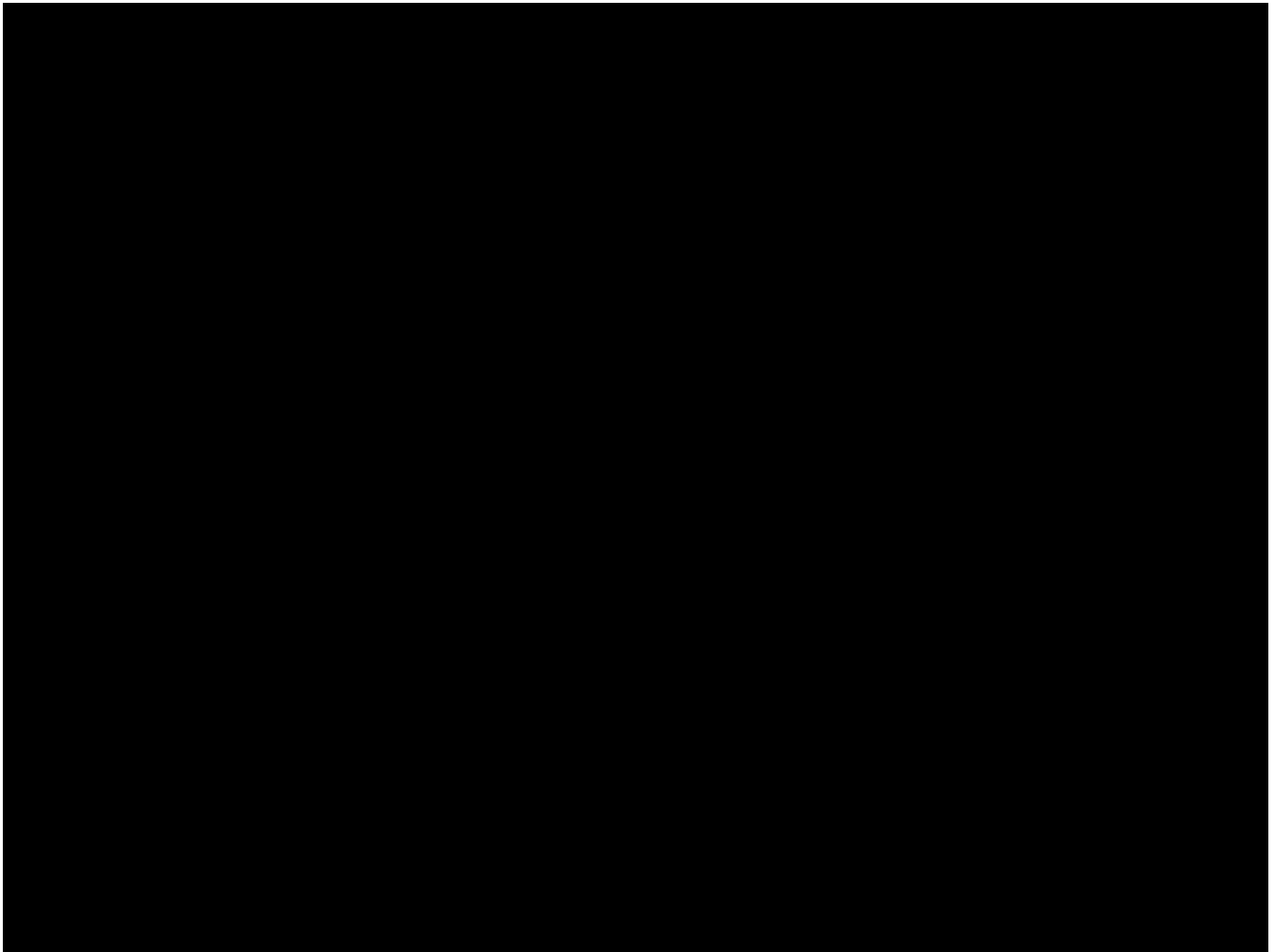


Image 6 – Detail of haul rope, strands and plastic core



Image 7 – Upper end of cut haul rope as found



Image 8- Upper end of cut haul rope showing strands, wires and plastic core

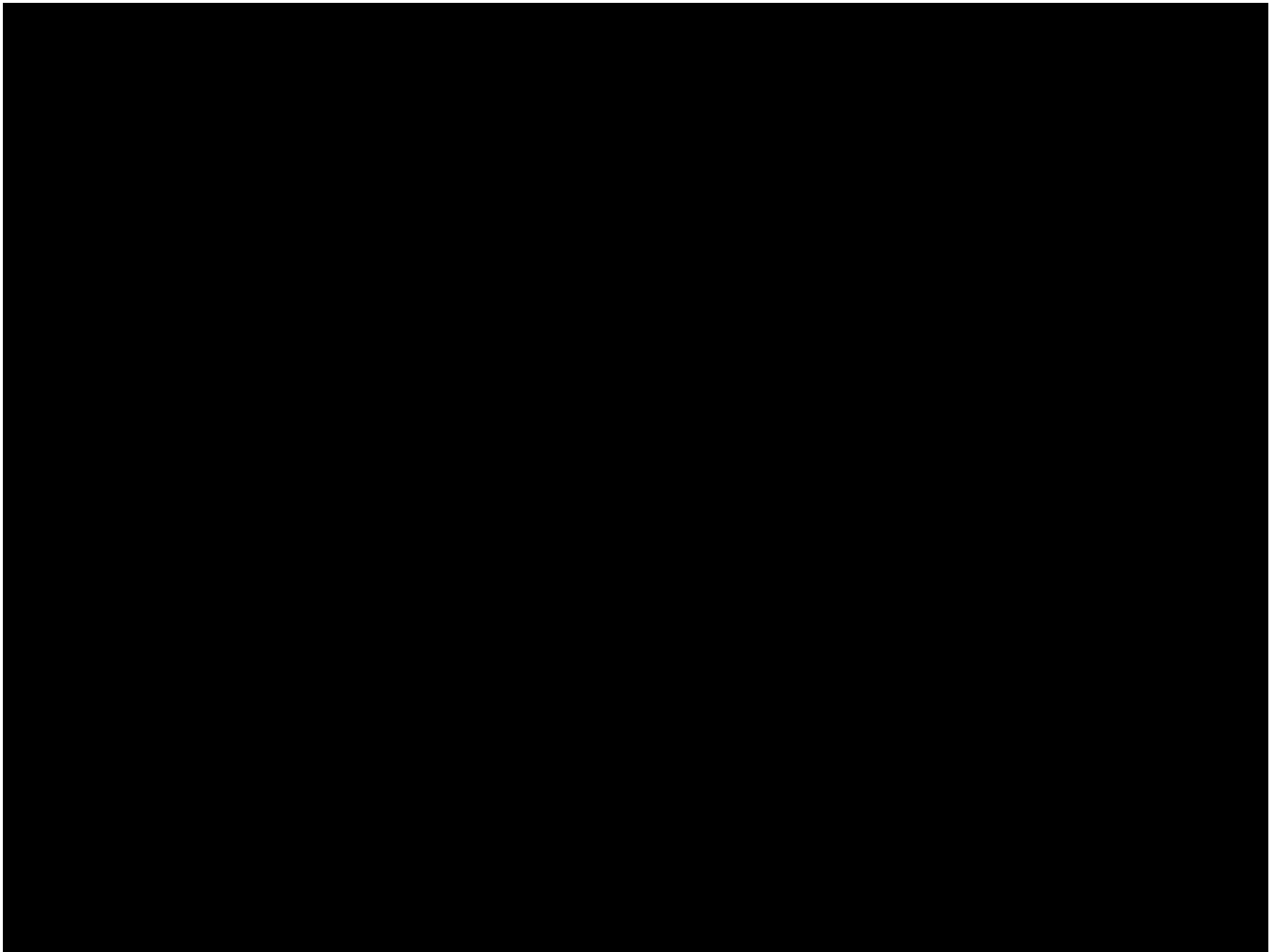


Image 9 – Base of a tower showing 

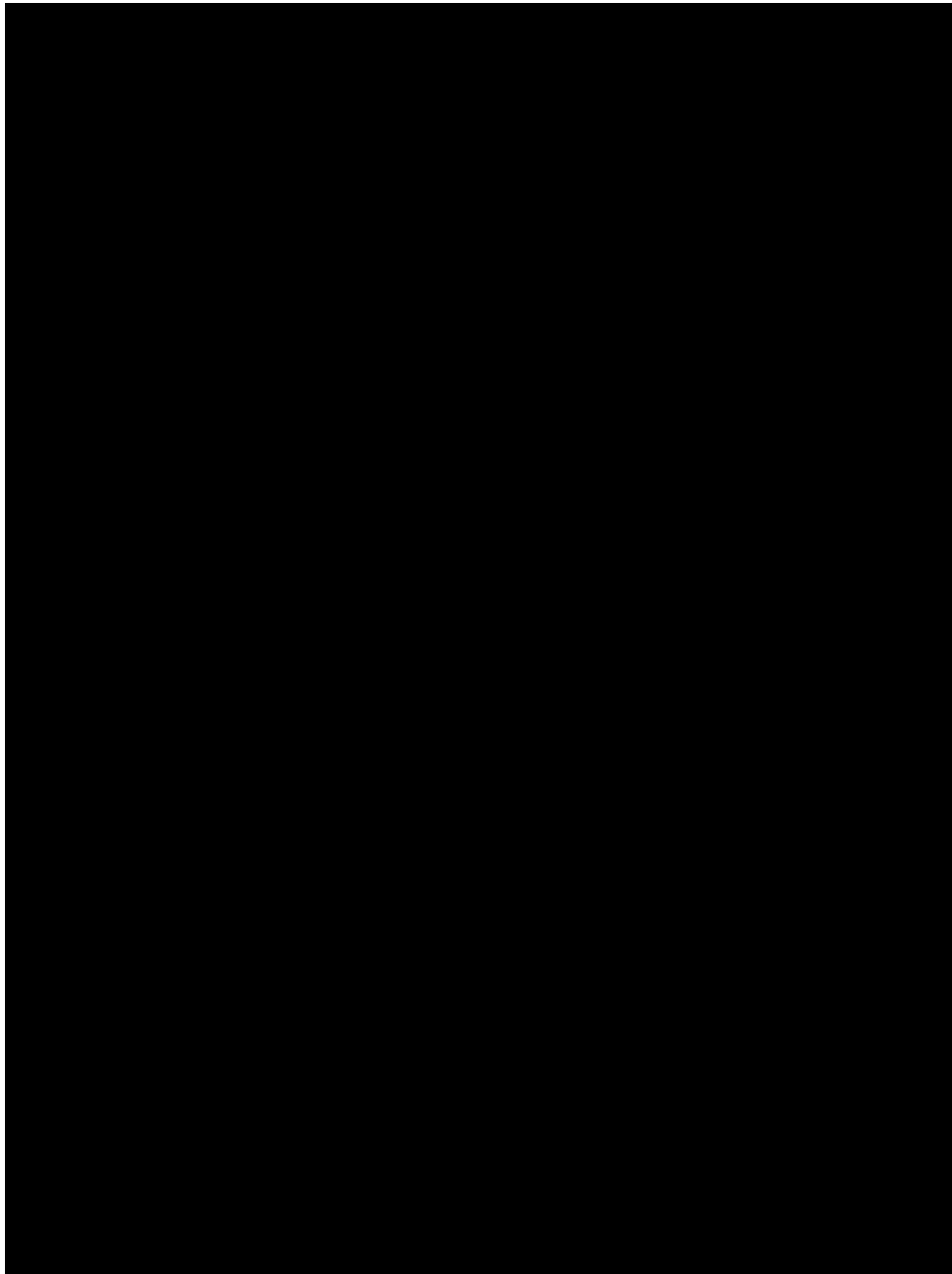


Image 10 – Tower showing access ladder, work platforms and sheave assembly

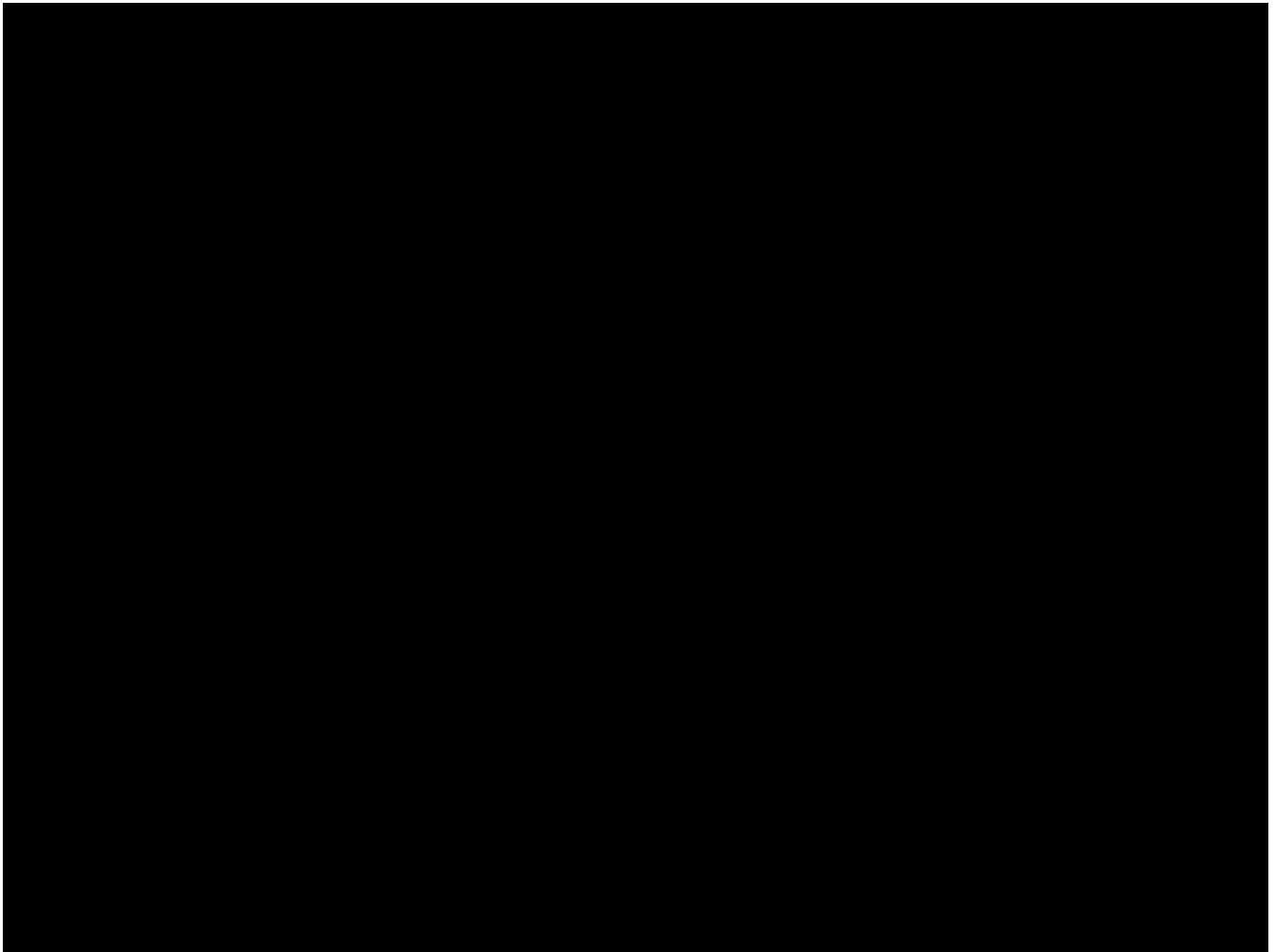


Image 11 – View of sheave assembly from an upper tower work platform. The haul rope would typically lay on top of the sheaves.

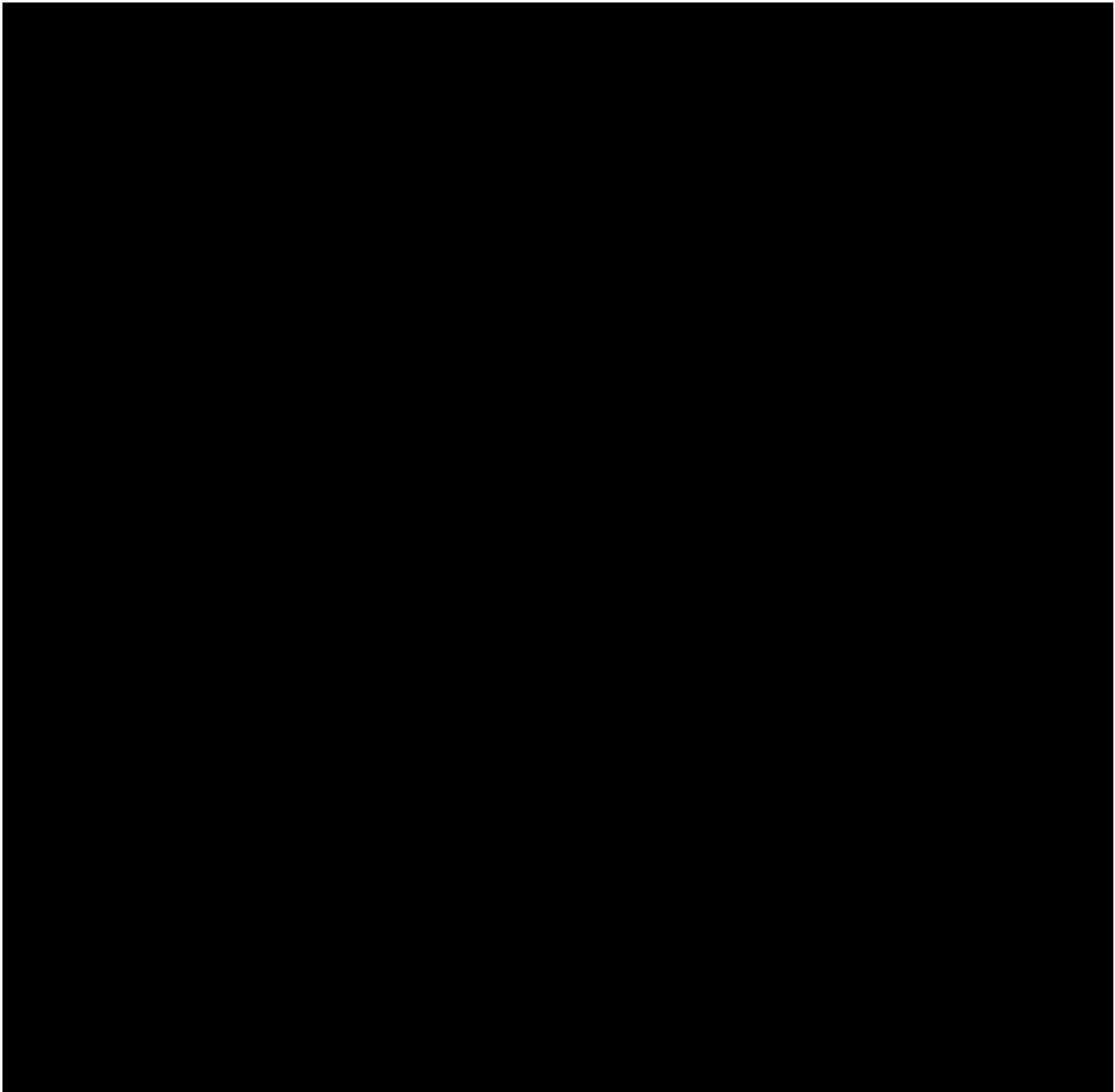


Image 12 - Diagram of haul rope cross-section showing individual wire failure mode. The diagram was produced to illustrate the failure methods determined and described in Appendix A. The location of cut-through, partially cut or not cut wires within each strand shown is an estimate only.

Cutting was likely initiated at strands with the most number of cut-through wires. As cutting progressed, more wires failed from being either partially cut or becoming overloaded without being cut as the tension was redistributed. The last strands cut were those that failed predominantly in tension overload (not cut). Given the number of wires partially cut in these last remaining strands, it is likely that these strands failed and the haul rope separated during the cutting action.

Appendix A:
Sea-to-Sky Gondola Haul Rope Failure
Acuren Group Inc.

Note: Technical Safety BC limited its investigation scope to the technical cause of the gondola haul rope failure. This appended report has portions redacted so that its publication does not interfere with an RCMP investigation into this incident.