Incident Summary #II-743660-2018 (#8546) (FINAL)

SUPPORTING INFORMATION	Incident Date		August 30, 2018
	Location		North Vancouver
	Regulated industry sector		Passenger ropeways - Above surface ropeway
	Impact – Injury	Qty injuries	0
		Injury description	NA
		Injury rating	None
	Impact – Damage	Damage description	The center axel of a bullwheel utilized in the haul rope tension system (counter weight) had become dislodged and wedged between the channel mounts which locates and supports the bullwheel axel. Multiple counterweight guide rollers assemblies utilized in keeping the haul rope counterweight level and allow for vertical movement were broken off of damaged.
		Damage rating	Major
	Incident rating		Major
	Incident overview		A mechanical reaction due to a sudden stop resulted in a significant torqueing force being applied to the haul rope tension system counterweight. The torqueing force caused multiple counterweight guides to fail and in turn cause the counterweight to tilt from its vertical position. The side loading to a bullwheel (due to the tilt) caused its axel to dislodge and become wedged between its channel mounts.
INVESTIGATION CONCLUSIONS	Site, system and components		• This reversible passenger ropeway was installed in 1968. A cable (called “track rope”) provides support for the carriers. The two carriers (car 1 and car 2) reciprocate between the lower and upper station. Propulsion to the carriers are provided through another cable (called “haul rope”). • The bottom drive and bottom tensioning system is machinery which drives the haul rope is contained within the bottom station. Tension to the track rope and the haul rope are also provided at the bottom station. • Haul rope tension system consists of a configuration of bullwheels which guide the haul rope into the bottom station through the counterweight tension system (concrete counterweight) and the driving bullwheel (see figure 1). • The haul rope counterweight bullwheel and axel are linked to a counterweight. The bullwheel/ bullwheel axel are held between two vertical pieces of channel steel. • A series of guide rollers are utilized in keeping counterweight level while allowing for vertical movement (see figure 2). • A multiple speed zone system is utilized in ensuring the human operator is progressively reducing haul rope speeds to acceptable thresholds (rope speed is controlled by a human operator) as the carriers approach and enter the stations.

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	A rope speed which exceeds the speed zone threshold will initiate an emergency stop (a high deceleration rate stop).
Failure scenario(s)	A sudden stop, due to carrier moving through a speed zone at an excessive speed, caused an emergency stop (high deceleration rate stop). The sudden stop caused a reaction in which a torqueing force was applied to the haul rope counterweight. Counterweight guide rollers failed and this allowed the counterweight to tilt. This, in turn, caused a side load to the counterweight bullwheels resulting in a bullwheel axel to partially extract itself and become wedged between the bullwheel support channels.
Facts and evidence	Narrative of events and finding based on statements provided by operations and maintenance personnel: • Operator on duty at the time of the incident indicated that, during the deceleration process one of the speed buttons utilized in slowing the ropeway did not function and that they needed to slow the lift by switching to a rheostat as an alternative speed control method. The operator indicates that by the time a slow was initiated by use of the rheostat an emergency stop occurred due to excessive speed in a speed zone. • Staff reported that the incident started when car 2 exceeding the threshold speed of a speed zone which resulted in an emergency stop. It was then noticed that something was wrong with the haul rope west counterweight bullwheel (bullwheel attached directly to counterweight). Initially it was thought to have been a damaged bearing and the cabin was brought down to the base to allow replacement of the bearing. • After further investigation by maintenance personnel it was determined that the shaft had dislodged from the bullwheel channel mount and had wedged in between the two mounts. • When maintenance personnel removed the tension of the haul rope to the west counterweight the bullwheel axel popped back into its mount in the steel support channels, however the channel had been bent in the process. At the time of Technical Safety BC conducting onsite incident inspection, the haul rope tension had already been removed and counterweight bullwheel axel had been reinserted back into its mounting bore. Onsite incident inspection by Technical Safety BC identified that: • A gouge mark near the outer diameter of the bullwheel. This provides evidence that indicated the bullwheel was rotating after it tilted. (see photo, figure 3) • A multiple number of the counterweight roller guides were found to be damaged (broken off from mounts). Further review of this incident determined that the channels had been previously bent, which points towards a similar incident having occurred before (time of previous incident unknown). Also, in discussions with maintenance staff it was determined that historically it was common for the counterweight guides to become damaged and require repair or replacement.

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	Professional engineer conducting incident review indicated that: • The rope tension from the drive sheave is always unequal during operation based on the different types of loading cases. The largest difference in tensions based on the original line calculations is 4448 kg which occurs during an E-Stop. This difference in tension creates a torque on the counter weight and the guide rollers are meant to resist the movement and keep the counterweight level. (see figure 2) It is expected that this force from the movement is what broke the guide rollers allowing the counterweight to tip. This resulted in a side load being transferred to the bullwheel mount channels. The channels were not designed to take any side load. They therefore deflected and caused one side of the shaft to extract itself from its mounting bore.
Causes and contributing factors	It is very likely that the torqueing forces to the counterweight and the failure of the roller guides to maintain the level position of the counterweight caused the side loading to the bullwheel. That in turn caused the flexing of the bullwheel channel mounts and caused the bullwheel axel to partially extract itself from the bore of the mounting channel and the bullwheel in turn tilting from it vertical position. A contributing factor very likely is that the counterweight guiding equipment and the bullwheel mounting channels were not providing adequate structural support in resisting the torque forces encountered during the emergency stop situation. The failure of one of the speed buttons used to slow the ropeway may have also contributed to the incident, given that delays using the rheostat allowed an emergency stop to occur, which caused excessive forces resulting in bullwheel damage. Another possible contributing factor is that the bullwheel channels were not designed to take excessive side loading which may occur during an emergency stop.

Figure 1, Haul Rope Tension Configuration, Emergency Stop Load Scenario.

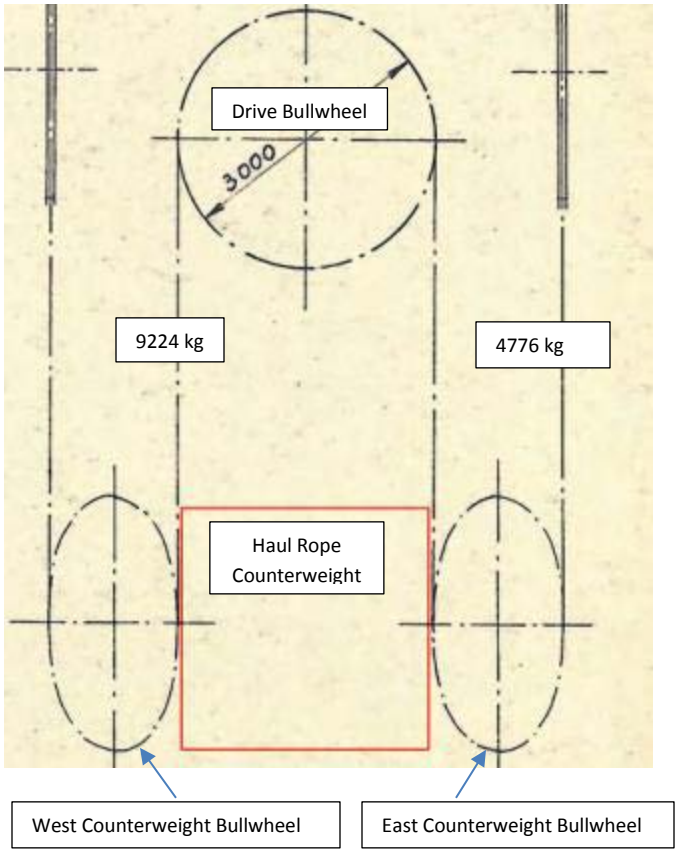

Figure 2, Haul Rope Counterweight Assembly

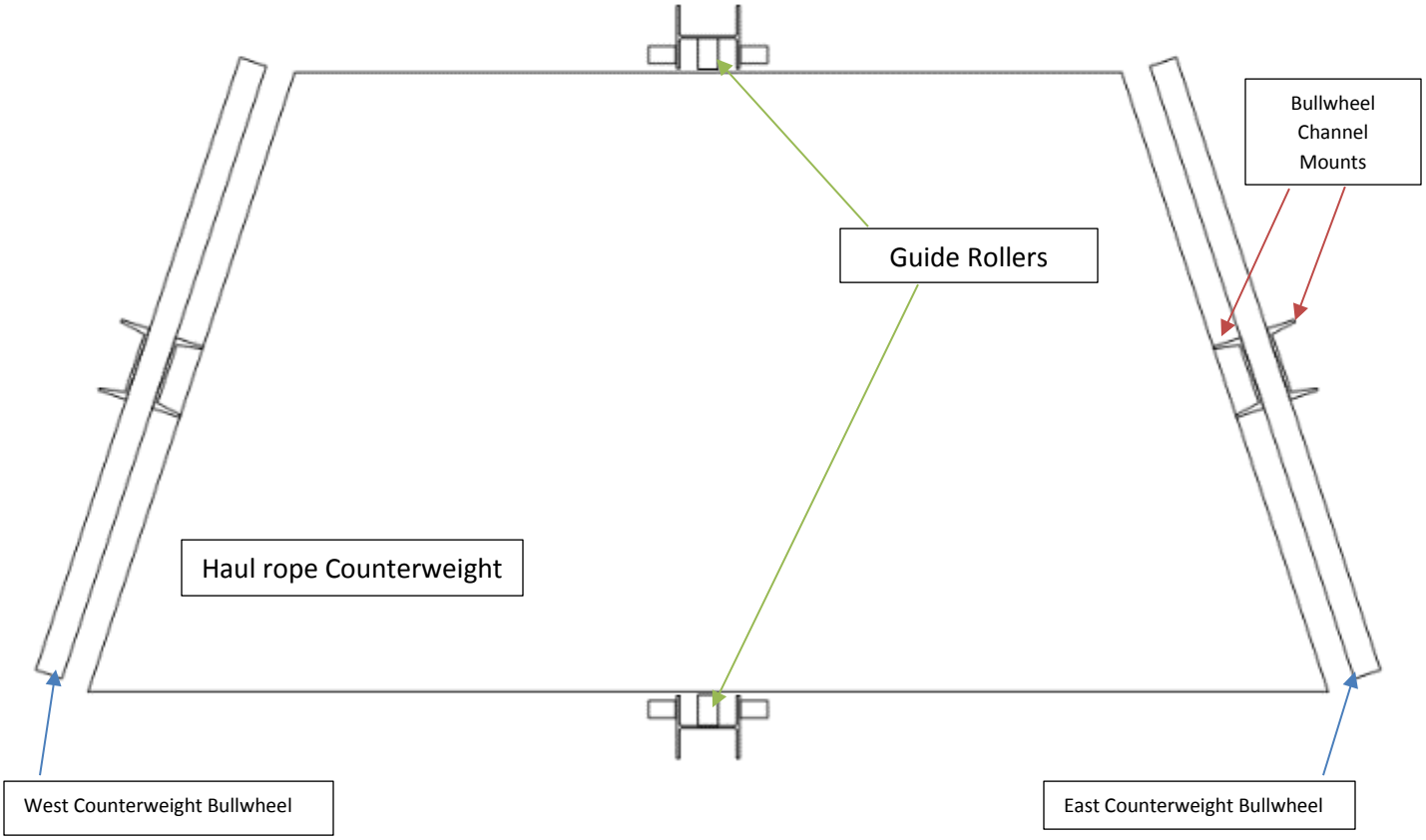

Figure 3, Photo of Gouge Mark in Outer Diameter of the Counterweight Bullwheel. (Photo taken after due to the incident extra reinforcement had been added to channel mounts)

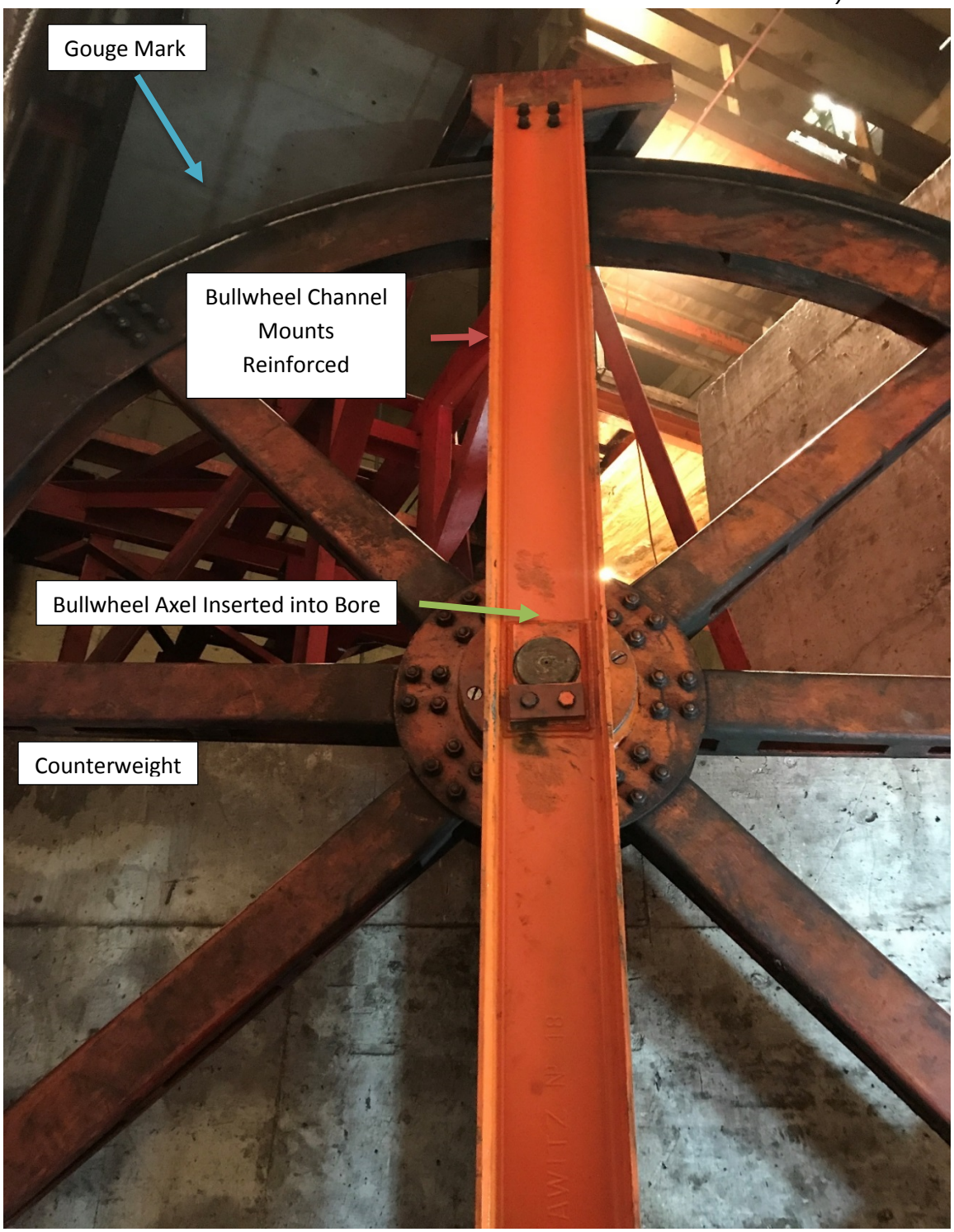

Figure 4, Photo of Bullwheel Configuration Prior to Upgrades