AVALANCHE MITIGATION AT LIZARD HEAD PASS

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ABSTRACT: Lizard Head Pass, a section of State Highway 145 (SH 145) between the towns of Ophir and Rico, located in Southern Colorado, averages 2300 vehicles daily[×]. Though this is not a large number as compared to more trafficked highways of Colorado, it is an important thoroughfare for the local population. SH 145 is one of the few routes connecting Interstate 40 and Interstate 70. SH 145 is also the main north/south route for Southwest CO when US 550 over Red Mountain Pass is closed. Many residents of the area work in Telluride and commute over Lizard Head Pass. Throughout the years, there have been various forms of avalanche mitigation techniques including temporary passive avalanche mitigation, helicopter charge deployment, avalauncher, howitzer, hand charges, case charges, and, in 2020, remote avalanche control systems (RACS). This account details the different avalanche mitigation techniques employed and how they have evolved through the decades as well as key avalanche paths on Lizard Head Pass. Historical records of avalanche activity on Lizard Head Pass are taken into account to get a picture of the operation on Lizard Head Pass.

KEYWORDS: Remote Avalanche Control Systems (RACS), Avalanche Hazard Index (AHI), Mitigated AHI, Annual Frequency, Return Period

1. INTRODUCTION

There are 46 known avalanche paths on Lizard Head Pass with the ability to impact SH 145. Over the years, many different techniques have been employed to mitigate avalanche hazard to the public on the highway. Historically, passive measures have been used which have progressed to active measures in more recent years. These active measures include helicopter charge deployment, avalauncher, case charge, hand charge, and remote avalanche control systems (RACS).

Two miles north of the town of Rico, population 288, there are three avalanche paths called Yellow Springs Wall, Yellow Springs Gully, and Peterson that can affect the road. Yellow Springs Wall and Yellow Springs Gully are in close proximity to the highway and typically put debris on the highway multiple times in a season. The Peterson path, as with the Yellow Springs paths, has the potential to bury the road and harm drivers. The Peterson seldom hits the road, but this event does occur a couple of times within a ten-year time period. For decades, little has been known about the nature of the multiple starting zones of the Peterson avalanche path as the area cannot easily be viewed from the road or surrounding area. Other notable avalanche paths on Lizard Head Pass include Scotch Creek, Ball Park, Fry Grade North, Coal Creek, Snow Spur Northwest, and White Lizard.

In 2020, with a proposed plan for the installation of RACS, the Colorado Department of Transportation (CDOT), the Colorado Avalanche Information Center (CAIC), and Wyssen USA, Inc. (WUS) investigated the Yellow Springs and Peterson terrain to gain a better understanding of the starting zone and where to install RACS. In 2020, after analysis was finished and placements were determined, five Wyssen Avalanche Towers were installed. These towers replaced previous mitigation techniques of avalauncher and helicopter charge deployment. The winter seasons of 2020/21 and 2021/22 did not produce significant avalanche cycles at Lizard Head Pass. However, the season of 2022/23 saw more avalanche activity than previous years. During this season, the Peterson put avalanche debris on the highway twice. Yellow Springs Wall, Yellow Springs Gully, and Peterson are the only paths on Lizard Head Pass mitigated today with RACS. Other Lizard Head avalanche paths are mitigated with the use of avalauncher, case charges, helicopter charge deployment, and hand charges.

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2. HISTORY OF MITIGATION TECHNIQUES

Though there are not extensive records documenting specific avalanches throughout the years, much of the history of avalanche mitigation on Lizard Head Path is kept alive through word of mouth, written avalanche documentation, and photographs.

Avalanche mitigation at Lizard Head Pass was originally entirely passive measures which consisted of road closures and clean up when avalanches had hit the road naturally.

In the late 1980s or early 1990s CDOT started to employ the first use of helicopter avalanche control missions in the area. Soon after that the CDOT avalanche mitigation program received a Tray Loaded Avalauncher and then upgraded to a McCracken Avalauncher around 1994 or 1996.

Figure 1: Tray Loaded Avalauncher in use at Lizard Head Pass, 1993, provided by CDOT

Figure 2: McCracken Avalauncher in use at Lizard Head Pass, 1998, provided by CDOT

Figure 3: McCracken Avalauncher in use at Lizard Head Pass, 2023

A Howitzer program was initiated in the 2010s to mitigate the Peterson avalanche path, however it was discontinued because the targets were oblique and hard to hit.

In the beginning years of the avalauncher program at Lizard Head Pass, different techniques were employed than the current practices used today. This is particularly evident at the Peterson avalanche path.

On the North side of Lizard Head Pass, the terrain consists of shorter avalanche paths with less relief than the Peterson and Yellow Springs paths. These northern paths can impact the road, but they are smaller paths with very visible avalauncher targets. Today, an avalauncher is still used on many avalanche paths on this section of Lizard Head Pass including Coal Creek and Fry Grade paths.

Until 2020 when RACS were installed, an avalauncher was used to mitigate the Yellow Springs Wall and Yellow Springs Gully avalanche paths. At these paths, the avalauncher could be positioned out of the avalanche runout and the starting zone could be properly targeted.

However, the starting zone of the Peterson avalanche path cannot be seen from the road with the exception of the runout zone. Due to the terrain, avalanches get funneled into a tight gully that directly impacts the road. This is the only place for the avalauncher to get a shot at the Peterson start zone. This involved positioning the truck with the avalauncher in this runout zone, shooting the explosive round and then driving the truck out of the way of a potential avalanche. This avalauncher avalanche mitigation technique was in use until 2014.

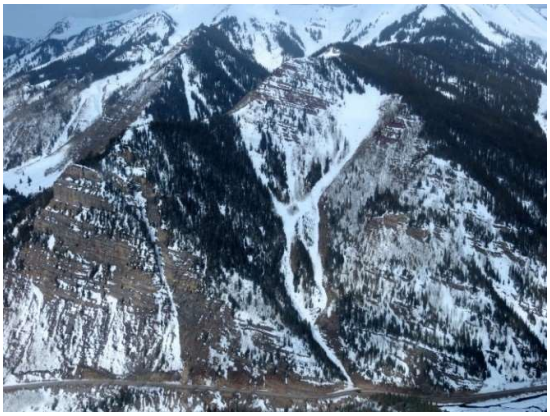

Figure 4: Yellow Springs Wall and Yellow Springs Gully, left side, and Peterson, right side, above SH 145, provided by CDOT

On 31 March 2014 there was an incident during an avalanche mitigation mission on Loveland Pass. According to a news release by CDOT "During mitigation, at approximately 7:09, the avalauncher being used this morning, prematurely detonated within the barrel injuring two state employees." Immediately after this incident CDOT entered into a statewide stand down of avalauncher use for mitigation. Eventually, the use of avalauncher for avalanche mitigation resumed, but structural barriers and distance from the avalauncher to user were required. The previous use of the avalauncher to mitigate the Peterson was no longer used.

An avalanche mitigation technique that had previously been used to mitigate Lizard Head Pass terrain was explosives deployment via helicopter. After the 2014 incident, this now became the only tool to mitigate the Peterson avalanche path. Due to the lack of helicopter ability in the area, prioritization of other avalanche paths, and winter weather conditions, this avalanche mitigation technique had limitations.

Case Charge and hand charges are also used to mitigate avalanches at Lizard Head Pass. There is a record of a hand charge used on 9 February 1993 on the Peterson producing a soft slab avalanche.

Figure 5: Avalanche Control with Case Charge on Snow Spur Northwest, 2023

3. KEY AVALANCHE PATHS

The avalanche hazard index (AHI) for the avalanche paths on Lizard Head Pass was updated on 16 May 2016 by Hamre and Associates. The total AHI is the avalanche hazard index of these paths without any avalanche mitigation.

The encounter probability is the likelihood of an avalanche affecting vehicles on the road. The weighting factor takes into account the consequences of a vehicle being hit by an avalanche. The total AHI takes into account the encounter probability and the weighting factor.

The mitigated AHI is the AHI of these paths considering that the avalanche paths are mitigated and therefore a more realistic scenario since the paths on Lizard Head Pass are monitored and mitigated.

The annual frequency is how often the avalanche occurs in a year. The return period is the reciprocal of the annual frequency or the average number of years in between the avalanche occurrence.

The Yellow Springs Wall, Yellow Springs Gully, and Peterson have the highest total AHI on Lizard Head Pass with 9.18, 9.71, and 17.87 respectively. The mitigated AHI for these paths is 2.75, 2.91, and 8.93 respectively.

The return periods for Yellow Springs Wall, Yellow Springs Gully, and Peterson are 0.5, 0.3, and 2.8.

Other notable paths in terms of AHI on Lizard Head Pass are Scotch Creek, Ball Park, Fry Grade North, Coal Creek, Snow Spur NW, and White Lizard. See Figure 6 for the annual frequency, return period, total AHI, and mitigated AHI of these paths.

Name	Annual Frequency	Return Period (years)	Total AHI	Mitigated AHI
Scotch Creek	0.18	5.57	0.26	0.13
Ball Park	0.38	2.67	0.40	0.20
Yellow Springs Wall	2.00	0.50	9.18	2.75
Yellow Springs Gully	3.00	0.33	9.71	2.91
Peterson	0.36	2.79	17.87	8.93
Fry Grade North	1.00	1.00	0.31	0.15
Coal Creek	0.85	1.17	0.32	0.16
Snow Spur NW	1.00	1.00	0.26	0.13
White Lizard	1.00	1.00	0.25	0.13

Figure 6: Annual Frequency, Return Interval and AHI for specific paths on Lizard Head Pass

Figure 7: Avalanche paths on Lizard Head Pass, provided by CDOT

Figure 8: Zoomed in view of avalanche paths on Lizard Head Pass, provided by CDOT

4. RECENT DEVELOPMENTS

In 2020, CDOT pursued an installation of remote avalanche control systems (RACS) at Lizard Head Pass, specifically Yellow Springs Wall, Yellow Springs Gully, and Peterson. These paths were seen as a significant hazard to drivers on SH 145 that had limited avalanche mitigation options, particularly Peterson. Also, only a relatively small number of RACS would need to be installed to mitigate the terrain in question. The installation of these systems would decrease highway closure time and promote worker safety by creating more distance between CDOT employees and detonating explosives. Additional motivation for RACS here was to maintain a more reliable north-south route when US 550 was closed.

Through a bidding process, Wyssen USA, Inc. was contracted to install Wyssen Avalanche Towers at Lizard Head Pass. Many investigative site visits were conducted with the CAIC, CDOT, and WUS. Previously, not much was known about this terrain as it was shot at from below or from a helicopter and generally people did not enter the terrain.

Before conducting field visits, the terrain was analyzed with pictures of the area and Google Earth. Through this process, rough placements of the Wyssen Avalanche Towers were determined.

Software like Google Earth and QGIS are powerful tools for analyzing terrain, however, setting foot in the starting zone is needed to determine final RACS locations and can expose terrain features unnoticed by digital mapping methods. For example, it was found that Yellow Springs Gully, which looked like an insignificant feature from photos and Google Earth was a significant gully with walls around 300 feet tall.

Figure 9: Yellow Springs Gully

After several site visits were conducted, it was determined that five Wyssen Avalanche Towers were needed to properly mitigate avalanches in this terrain. A site visit with geotechnical experts was also conducted to determine if the placements had sufficient rock quality for ground anchors.

The final step was to analyze the terrain using a viewshed analysis to estimate the effective range

of the explosives deployed by the Wyssen Avalanche Towers in the identified locations. A viewshed analysis takes a point and used a digital elevation model to create an area which is in sight of that point. This can give an idea of the effective range of an explosive at this location. See Figure 10.

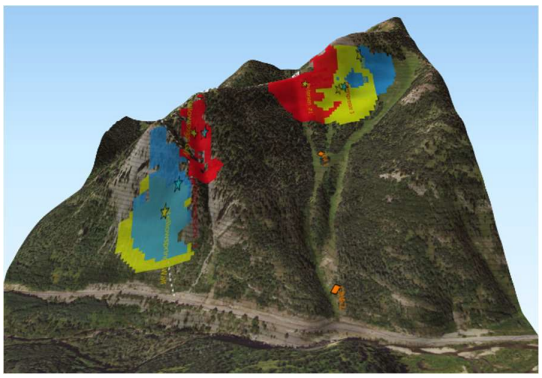

Figure 10: Viewshed Analysis of Yellow Spring Wall, Yellow Springs Gully, and Peterson, provided by Wyssen Avalanche Control

One tower placement was located on the Yellow Springs Wall and one on the Yellow Springs Gully. Three towers were needed to cover the area of the Peterson start zone. From first glance, one would assume that the snow field looker's right of the top of the Peterson would be the obvious start zone. However, this area is a low angle meadow where the snow does not move. Looker's left, in the steeper terrain, is the area where the three Wyssen tower placements were needed.

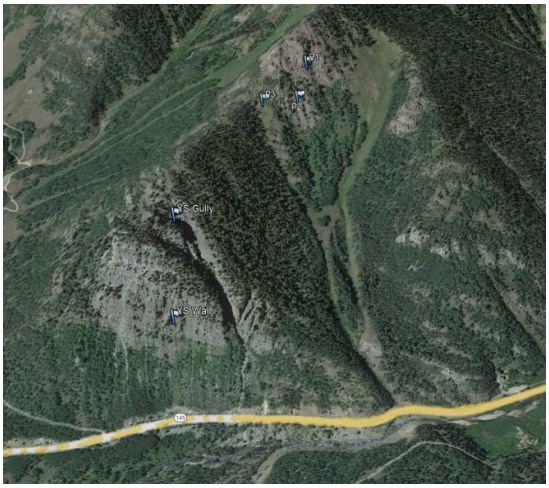

Figure 11: Final locations of Wyssen Avalanche Towers

Construction of the tower foundations began in August of 2020 and was completed in mid-September 2020. The final step was charge assembly and loading and then flying the deployment boxes to the towers. This occurred mid-November 2020 and the Wyssen Avalanche Towers were ready for the winter season. This was the first installation of Wyssen Avalanche Towers in the state of Colorado.

Figure 12: Yellow Springs Gully tower after construction was complete

Figure 13: Wyssen Avalanche Tower Deployment Boxes being loaded for the winter season

5. RECENT AVALANCHE ACTIVITY

The winter seasons of 2020-2021 and 2021-2022 had total snowfall from November to April of 213.5 inches and 221 inches, respectively. This information comes from the Colorado Avalanche Information Center (CAIC) records of snowfall on Lizard Head Pass. The winter season of 2022-

2023 saw a total snowfall of 225.3 inches and although this total snowfall is not much more than the previous two winters, Lizard Head Pass saw a significant increase in avalanche activity.

Avalanche Year	November	December	January	February	March	April	Nov - Apr
2021	22	42	31.5	48	61	9	213.5
2022	5	96	14	41	46	19	221
2023	23	46.2	53.1	29	63	11	225.3

Figure 14: Snowfall totals per month recorded on Lizard Head Pass. Each year includes the November and December snow totals from the previous year.

There were 2 days with Wyssen Avalanche Tower mitigation missions in 2020-2021 with a total of 7 detonations. There were 8 days with missions in 2021-2022 with a total of 26 detonations. The Peterson never hit the road during these two winter seasons.

The Peterson hit the road twice during the winter season of 2022-2023, once on 2 January 2023 and again on 11 April 2023. This is assumed to be the first time Peterson had hit the road for 6 years. Though it could not be confirmed, it is likely that the last time the Peterson hit the road was in 2017. There is a record of a D scale 2.5 avalanche occurring on 10 January 2017. There are no details in the record on if the avalanche hit the road, but there are word of mouth accounts that have indicated the Peterson hit the road around this time period. Though the overall season snowfall was not significantly more than the previous two seasons there was more snow in January 2023 than the previous two winters, and there were significantly more avalanches in the 2023 season. During this season there were 11 different days that the Wyssen Avalanche Towers at Lizard Head Pass were utilized for avalanche control with 40 total detonations.

Figure 15: Yellow Springs Gully hitting the road during a control mission using Wyssen Avalanche Towers on 15 February 2023

Comparing the snowfall totals throughout recent years as compared to avalanches per season, the snowfall totals roughly relate to the number of avalanches recorded. But there are many other factors that influence avalanche occurrence in a year besides only the total snowfall. A lack of data prevents further research for this account. See Figure 16 for a comparison of total snowfall per avalanche year and avalanches recorded.

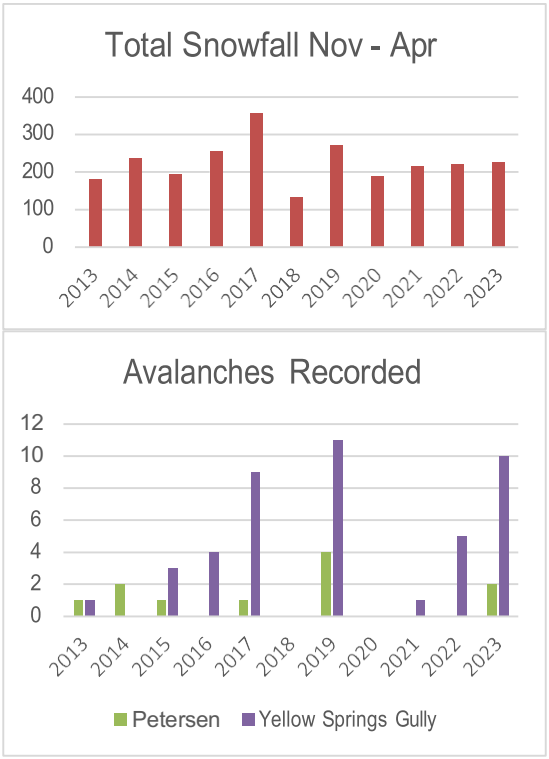

Figure 16: Total Snow Depth Recorded on Lizard Head Pass as compared to avalanches recorded for the Peterson and Yellow Springs Gully

6. CONCLUSION

There are many different forms of avalanche mitigation that are used by CDOT, and these different techniques have evolved over the years. This account details the types of mitigation used by the avalanche program at Lizard Head Pass including helicopter charge deployment, avalauncher, case charge, hand charge, and remote avalanche control systems (RACS).

At Lizard Head Pass, new technology has brought efficiency to avalanche mitigation alongside other techniques that have stayed the same for decades. In the future, new techniques will likely be used as the sector continues to develop.

Wyssen avalanche towers allow avalanche mitigation to take place in minutes instead of hours for the Yellow Springs Wall, Yellow Springs Gully, and Peterson avalanche paths. This causes

shorter closure times on SH 145. Additionally, less people are needed for operations and employees are not handling explosives when avalanche mitigation is being conducted. These advantages were significant for the 2023 avalanche season as there was an increase in avalanche activity and an increase in avalanche mitigation at Lizard Head Pass.

There are many other sections of highway that use some of the same techniques as Lizard Head Pass and as well as other forms of avalanche mitigation. Other Colorado avalanche programs will likely change and evolve as well. An example of this is Red Mountain Pass, near Lizard Head Pass, which is more complex than Lizard Head Pass. Avalanche mitigation at Red Mountain Pass will likely continue to develop as more RACS are implemented.

This account was limited by the data available for this area. Many avalanches were recorded over the years, but the details of these avalanches, such as if they hit the road or not, were not always available.

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