Draft

Asset/Fund Management Guidebook Technical Plan: Geohazards

Colorado Department of Transportation

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1. Introduction to Geohazards Program

Mountain and canyon corridors are affected by geologic hazards, such as debris flow, embankment distress, landslides, rockfall, rockslides, and sinkholes. A goal of the Geohazard Program is to reduce the risk of these geologic hazards on Colorado’s transportation system by implementing risk-reducing treatments on strategic highway segments and corridors. Incorporating a methodical, asset management-based approach to geohazard mitigation enables CDOT to use limited resources to implement risk-reducing treatments that are most effective in keeping key corridors functioning throughout the state. This approach is facilitated by the Geohazard Management System which consists of spatial databases and approaches developed and maintained by the program staff to systematically identify statewide projects and direct funds to those that are most beneficial. This approach has proven to be more effective in reducing overall risk from geologic hazards than “worst first” project selection strategies.

The program staff also provides emergency services for geological hazards, especially highway embankment, slope, and subgrade failures. Program staff work collaboratively with the Soils/Geotechnical Program to help support soils and geotechnical engineering for the benefit of minimizing geohazard risks. The program staff also oversees and manages the contracts for CDOT’s aerial reconnaissance program used to assess and document emergency conditions and project development statewide.

The program staff designs mitigation plans, reviews consultant designs, performs site inspections during construction, and responds to rockfalls and other geological hazard-related emergencies. Other work includes responding to requests from Maintenance, Engineering, and public inquiries when slope issues are observed. When the hazard in question is considered imminent, an immediate response is made through CDOT’s Maintenance section and, if needed, by a specialty contractor.

It is important to recognize that geohazards are sporadic and unpredictable. They can occur at any time in almost any location where there is a slope. The purpose of implementing geohazard mitigation is to reduce the risk at a specific location. The current inventory of recognized geological hazards throughout the state tops 3,000 hazard sites.

2. Regulatory Considerations

2.1. Regulations/Resolutions

The following list provides an overview of relevant regulations and requirements governing planning, policy, data, performance, funding, and project selection of geohazard projects.

- CRS 43-1-106 (8) (h) and 43-10-109
- PDs 14, 704, and 1004.0

2.2. Guidelines

The following guidelines inform the management and performance of the program.
• Transportation Research Board (TRB) Special Report 247, *Landslides: Investigation and Mitigation*
• FHWA Publication HI-99-007, *Rock Slopes (Reference Manual)*
• TRB Publication, Rockfall: Characterization and Control
• CDOT Geohazard Management Plan (2017 draft)

3. **Asset Inventory and Condition**

3.1. **Asset Inventory**

CDOT developed an application called “Event Tracker” to identify and inventory highway segments, in 0.1-mile center-lane intervals, containing documented geohazard events. There are currently more than 3,400 segments affected by geohazards. These include 760 rockfall location sites, along with segments that have had landslide, erosion, flooding, and sinkhole events. The event tracker outlines the hazard event type, road closure impacts, clean-up efforts, and costs. Overall, approximately 34 centerline interstate miles have a measured geohazard exposure, or 5 percent of the total interstate system in Colorado. This is a living database and it will increase as events occur and as data collection methods improve.

Requests to access the inventory can be made through the Performance and Asset Management Branch.

3.2. **Asset Conditions**

Ultimately, geologic hazard condition is based on the likelihood of an event (e.g., slope failure) occurring, coupled with the costs created by such an event with respect to safety, maintenance, and mobility. CDOT has developed a risk-based method for evaluating geohazards along segments of CDOT roadway. Individual geohazard types are combined into a single geohazard rating for the purpose of risk-based geotechnical asset management. Each of these geohazard types present risks to CDOT performance related to safety, mobility, or maintenance expenditures. While each of the hazard types can present a different risk to various performance measures, when grouped as a single class, CDOT is able to efficiently manage an aggregated geohazard asset risk. The process is holistic and helps avoid the possibility of reducing performance benefits by focusing on a single geohazard type or location.

The risk assessment for the geohazard asset class is based on the product of an incident likelihood and its overall consequences. Asset condition and the frequency of past geohazard events are used to estimate the likelihood of an adverse event occurring in the future. Consequence is represented by potential threats in key performance areas, such as traveler injury from a geohazard event (safety), highway closure (mobility), or direct costs to CDOT (maintenance). The risks to each performance area are aggregated into a single reporting measure identified as the Level of Risk (LOR), which is intended to be similar to the Level of Service (LOS) performance indicator used in other Transportation Asset Management processes. Because geohazards generally do not provide a “service,” the LOR metric was developed to communicate relative risk exposure to CDOT stakeholders.
Data sources used in the determinations include inventory data, SAP, COGNOS, Maintenance Reporting, CDOT traffic reports, and news article clipping services.

4. Performance

The Geohazards Asset Management Program evaluates targets and funding to achieve targets on a 10-year time horizon. The program is responsible for working to achieve these targets. Targets may be reviewed in response to advances in data usage or as geohazard performance becomes better understood.

4.1. Metrics

The goal is to ensure that no less than 90 percent of on-system segments are rated at a LOR grade “B” under the statewide letter grading system—or 85 percent if CDOT is operating in a fiscally constrained scenario.

4.2. Targets

The Geohazards Asset Management Program has a fiscally constrained target of 85 percent of segments at or above LOR Grade B, and an aspirational target of 90 percent. Current performance is 76.8 percent of segments at or above LOR Grade B.

5. Funding

5.1. Funding Mechanisms

The main source of funding for the Geohazards Program is the State Highway Fund—specifically, the FASTER Safety allocation of the Asset Management Program.

5.2. Region Pool Distributions

Recent Geohazards Mitigation Program budget allocations and estimates are summarized in Table 1. This is a state-wide program that does not have regional distributions.

<table>
<thead>
<tr>
<th>Table 1. Geohazards Mitigation Program Budget Allocations (millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual FY 2015-16</td>
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<tr>
<td>$5.1</td>
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(From FY 2018-19 Final Budget Allocation Plan)

6. Investment Strategies

The program’s investment strategy focuses on addressing geohazard risks that have a high likelihood of occurring and have potential high-dollar impacts when considering the consequences of safety, maintenance, and mobility. Geohazard planning focuses on the prevention of threats to the overall CDOT system through hazard mitigation. Hazardous areas are evaluated and monitored.
to understand the likelihood of an event and the damage or consequence created by that event. The program uses Event Tracker to evaluate and prioritize locations for mitigation. The likelihood of a geohazard event occurring is evaluated by the number of events that occur in a segment. The impact to traffic of a geohazard event is evaluated as a mobility consequence if the event were to occur.

7. Lifecycle Management and Project Selection

7.1. Lifecycle Management

For many of the potential geohazard mitigation options, regular maintenance labor and expenditures are required. Therefore, the selection of mitigation efforts and treatments can consider lifecycle costs. Common ongoing lifecycle costs include maintenance activities, such as removing debris behind barriers and fences, cleaning shoulder ditches, patching steel mesh on a steep slope, and repairing proprietary metal fence systems. If maintenance activities are not performed, the service life of mitigation assets is reduced, and the hazard level may increase.

7.2. Treatment Lists

Current geohazard treatments are considered either active or passive and are integrated into AIMS. Development of mitigation reduction factors for specific hazards and treatments is in-progress.

7.3. Project Selection Process

The Geohazard Management System combines geologic and climate information with traffic and slope data to rank geohazards according to the severity of the risk. CDOT prioritizes sites for mitigation based on this system. Project selection considers bundled projects within corridors. Corridors are selected based on average risk determined throughout the corridor, region input, activities underway within the corridor, and budget levels. Results of corridor feasibility studies are used to prioritize specific project locations within a corridor. Projects may be implemented in phases based on funding levels.

8. Regions and Headquarters Roles

8.1. Region Roles

The regions participate in project selection, manage, and deliver mitigation projects in their jurisdictions. Maintenance crews regularly patrol highways with rockfall hazards and report areas where additional investigation is warranted. Maintenance crews provide immediate response to geohazard events.

8.2. Headquarters Roles

Headquarters manages Geohazard Program funding and may support engineering for on-system segment risk mitigation. The Geohazards Program tracks geohazard risks and performs mitigation design. Staff from the program also responds to emergencies such as slope failures and rock falls.
9. **Reporting, Management, and Documentation**

9.1. **Reporting to Internal and External Stakeholders**

The Program’s Event Tracker captures and reports event data. This custom desktop and mobile device application can be used to quickly report geohazard events in a consistent and geographically referenced format. The tool uses this and other data to create quick and accurate reports and mapping of events to support internal and external reporting needs. Users of these reports include:

- Transportation Asset Management Oversight Committee
- Transportation Commission