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# INNOVATIVE SOLUTIONS TO GEOHAZARD CHALLENGES

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Excellence Delivered *As Promised*





# REDUCE YOUR RISK

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Gannett Fleming's dedicated team of geoprofessionals has investigated and successfully mitigated countless geohazard challenges across North America. Wherever ground movement occurs, whatever the terrain, we provide responsive, cost-effective, schedule-driven remedial solutions.

Our first task is to pinpoint the risks you face from slope instability and other geohazards. We then leverage our comprehensive experience and specialized equipment to deliver innovative mitigation solutions that reduce the risks and meet your project budget and schedule goals.

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***Emergency response:*** When severe weather reactivated a large landslide in California that blocked a key hydropower access route and put operators at risk, our slope stability experts were first on the scene. The team's evaluation of real-time conditions guided critical decisions about safety, access, and repairs.

# END-TO-END SERVICES

## Investigation

We perform a detailed review of available historical information for each project site, then customize investigation plans to collect sufficient data to ensure the generation of realistic failure and stabilization models. Our approach significantly reduces the potential for construction claims as a result of insufficient data or unforeseen conditions.

In addition to typical geotechnical borings, we use surface and borehole geophysical methods to identify adverse soil, rock, and groundwater conditions. We use unmanned aerial vehicles (UAVs) to generate imagery and mapping that accurately document existing conditions and provide a unique perspective for project plans. Photogrammetry techniques allow us to build accurate digital terrain models from UAV- or ground-based imagery that can be used to cut slope sections, develop contours, perform rockfall and slope stability analyses, and generate quantity estimates.

## Investigation Methods

- Geophysics
- Digital photogrammetry
- Unmanned aerial vehicle-derived imagery and data
- 3D laser scanning
- Cone penetrometer testing
- Handheld dynamic cone penetrometers
- State-of-the-art software

## Analysis & Design

Based on our investigation, we perform a mitigation alternatives analysis to carefully compare each remedial measure's effectiveness at reducing the risk, and to evaluate constructability, schedule limitations, and cost. This thorough analysis helps to ensure that the preferred mitigation approach meets the project goals.

Following the mitigation alternatives analysis, we provide a detailed and complete design and calculations package ready for stakeholder review.

## Analyses

- Slope stability
- Engineering geologic and structural mapping
- Rock slope kinematic analysis
- Rock mass/block limit equilibrium analysis
- Ground movement instrumentation design, installation, and monitoring
- Rockfall and landslide prediction

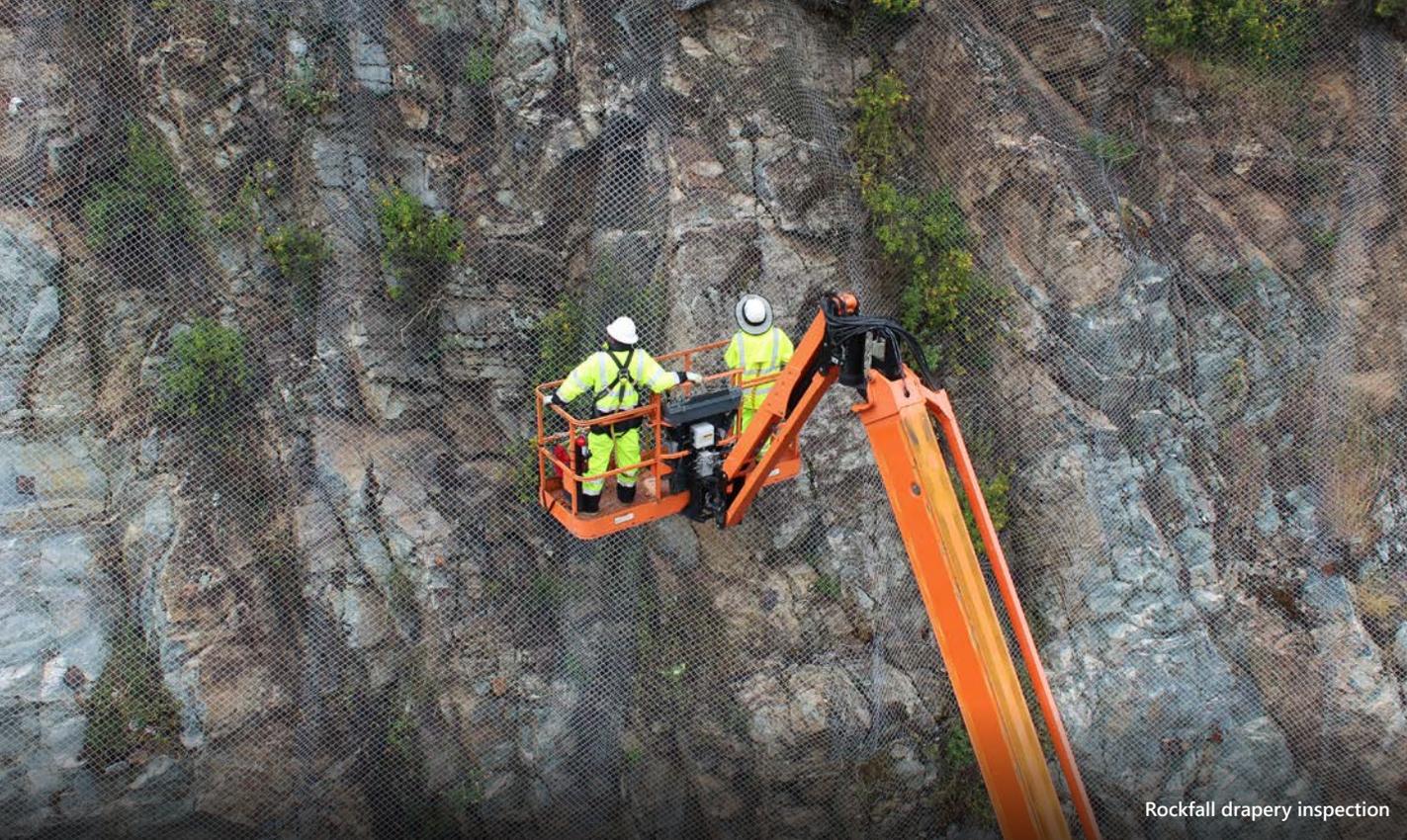




Rock slope reconnaissance of basalt dam abutment



Canal flume emergency response



Rockfall drapery inspection



## Landslide Mitigation Methods

- Soil nails
- Geofoam
- Secant caisson walls
- Auger cast-in-place piles
- Micropiles
- Ground modification
- Aggregate piers

## Rock Slope Mitigation Methods

- Rock slope scaling
- Soil nail, rock dowel, rock bolt, and tie-back anchor stabilization
- Rock block cable retention systems
- Suspended and anchored rockfall drapery
- Protective rockfall fences, berms, and hybrid attenuator systems
- Debris flow and shallow landslide barriers
- Anchored shotcrete, walers, and buttresses

## Project Execution & Construction

Accurate construction cost estimates, concise construction plans and specifications, project planning and permitting support, and assistance with bid document preparation add to the list of our end-to-end geohazard mitigation project services.

Gannett Fleming's construction management expertise provides our clients with invaluable benefits from project scoping through construction. We offer construction consultation throughout the entire life of the project to effectively address constructability issues—the biggest risks in slope stability projects.

We also provide construction reviews of third-party designs. Through our work, we have forged many strong relationships with geotechnical contactors that specialize in slope stabilization.



Strand anchor testing



Landslide remediation using drilled shafts



Soil nail walls used to stabilize slopes during excavation

# ADDED VALUE

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## Rope Access

Our certified rope access teams provide a cost-effective option for safely accessing geologic features that cannot otherwise be reached using conventional equipment or drones. Comprised of licensed engineers and geologists certified to Society of Professional Rope Access Technicians (SPRAT) standards, our teams use specialized equipment that meets or exceeds ANSI, OSHA, and Cal-OSHA safety requirements.

## Drones

In-house unmanned aerial vehicle expertise allows us to add quality and greater detail to inspection documentation. Using automated flight plans and drone data to generate 3D models enables our team and clients to clearly understand real-time conditions in areas that are inaccessible. We also use geographic information systems (GIS) to help clients visualize areas of geohazard concern.



Drone imagery of a rockfall in a quarry



Dam spillway slope reconnaissance



## ROCK SLOPE STABILITY ANALYSIS

*Top left:* Our team investigated foundation deficiencies beneath the Boulevard of the Allies, a major artery in downtown Pittsburgh. Leading-edge investigation and stability analysis techniques led to a multifaceted remediation using rock bolts, netting, and buttressing to improve the stability of the underlying rock.

## SLOPE RECONNAISSANCE

*Top right:* Rockfall geologists use a man-lift to get an elevated perspective of a slope above a powerhouse access road. Our experts have deep experience identifying adverse slope conditions and rockfall potential. Observations made during a slope reconnaissance and geologic investigation form the foundation of customized mitigation measures.

## PROTECTIVE ROCKFALL BARRIERS

*Left:* To protect a future inflatable bladder dam along a spillway's ogee weir, our team designed a flexible rockfall barrier after careful evaluation of the potential rockfall hazard from the adjacent abutment cut slope. Barrier height and energy were determined using rockfall simulation software.

## AWARD-WINNING DESIGN

*Before and after:* Emergency landslide mitigation design for Route 30 in East Pittsburgh, Pennsylvania, completed 10 days after the collapse. The highway was reopened within 80 days.

- National Recognition Award, 2019, American Council of Engineering Companies (ACEC)
- Award of Merit, 2018, American Society of Civil Engineers (ASCE) Pittsburgh Section
- Emergency Remediation Project of the Year, 2018, Engineer's Society of Western Pennsylvania





Innovative rockfall fencing along Route 28 in western Pennsylvania protects vehicles from damage, keeping travelers safe.



# **Gannett Fleming**

*Excellence Delivered **As Promised***

Gannett Fleming is a global infrastructure firm that provides planning, design, technology, and construction services for a diverse range of markets and disciplines. With 2,500 highly qualified individuals across a global network of 60 offices, we are united in our passion to deliver excellence. We have played a part in shaping infrastructure and improving communities in more than 65 countries, specializing in transportation, earth science, water, power, geospatial, and facility-related projects.

Founded in 1915, we embrace sustainability and innovation in our projects and internal activities, achieving results while being responsible stewards of our environment. Our culture of service, ingenuity, and responsiveness empowers us to fulfill our key mission: make our clients successful.

Gannett Fleming is consistently ranked in the top 10% on *Engineering News-Record's* Top 500 Design Firms list.

**Call us today for more information on our geohazard services.**

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