




Intra-Departmental Correspondence

TO: Manuelito Maestas, P.E., NMDOT North Region Design
CC: Michelle Mann, P.E., State Geotechnical Engineer
FROM: Armando M. Armendariz, P.E., State Materials Bureau Chief 
DATE: September 27, 2019
SUBJECT: STIC Incentive Program Proposal for Rockfall Monitoring System

Problem Statement

NMDOT has for many years attempted to assess the risk of rockfall through various hazard ranking schemes. Though highway corridors prone to rockfall are easily identified by such methods, rockfall occurrences and the factors that trigger them remain poorly understood. Sites where rockfall appears imminent may remain stable for years, while other sites fail catastrophically and without warning.

Proposed Work and Anticipated Result

The NMDOT Geotechnical Section began in 2017 to monitor a select few rockfall-prone corridors using a relatively simple wireless telemetry system. But the amount and quality of data is currently limited to easily monitored sites that rely on a single type of metering device, with sensor deployments that detect only representative movement across a much larger rock slope. New work proposed under the STIC Incentive Program will not only increase sensor coverage but will improve the type and quality of data received by combining existing equipment with more sophisticated devices capable of measuring a greater number of parameters. The anticipated result is that the work will improve the department's ability to anticipate rockfall events, allowing it to mobilize personnel and equipment before traffic safety becomes compromised.

The current system confirms not only that wireless telemetry is a viable means of observing incremental changes in the position of rock, but that trends in rock movement may be identified by a process of continuous measurement. What remains to be determined, however, are the thresholds or "tipping points" beyond which frictional resistance and cohesion no longer operate and freefall occurs. Transient conditions of temperature, moisture and traffic volume all appear to have some affect on the stability of rock, and both seasonal and diurnal patterns in movement can often be discerned. A further objective of the proposed work is therefore to understand the mechanisms contributing to rock slope instability, and ultimately to identify highway corridors at the greatest actual risk for rockfall so that mitigation efforts and department resources may be directed economically and effectively.

Funding Amount Requested

Project expenses for one-time hardware and equipment purchases and for recurring sensor licenses and cell carrier fees are estimated at \$98, 497 (itemized below). Recurring costs may be pre-paid for a multi-year period, but will require commitment of other, non-STIC funds to sustain the project beyond pre-paid amounts.

Commitment of Other Funding

No other funding is currently committed. Non-STIC funding for recurring, non-prepaid sensor license and cell carrier fees will be sought at a future date.

Budget Justification

The immediate benefit of project implementation is protection of the travelling public from direct impacts and in-road hazards. The longer-term benefit to the department is the efficient targeting of limited rockfall mitigation dollars to areas of objectively determined risk. If rockfall can be anticipated with some degree of reliability, then rockfall mitigation projects such as slope scaling, barrier fence construction, drapery installation or etc., can be targeted to high-priority sites instead of to sites of perceived but unsubstantiated threat.

District Maintenance personnel are typically the first responders to any sudden roadway impairment, so sensor data indicating imminent rockfall will be communicated first to the local Maintenance Patrol, then to the NM State Police and/or to local law enforcement if the situation warrants. Analysis of the data in the long-term will remain the responsibility of the NMDOT Geotechnical Section, the results of which may be used to inform mitigation design.

Project Schedule

Equipment installation will be the responsibility of the NMDOT Geotechnical Section, though assistance from the NMDOT Signal Lab may be sought for sites requiring bucket truck access. Work can begin immediately, and is anticipated to take from two to three months to complete the installation of equipment. Project duration will depend on the availability of non-STIC funds to cover non-prepaid recurring sensor licenses and cell carrier fees. Potential new monitoring locations are listed below.

District	Route	Mile Posts	General Location
4	US 64	299 to 301	Cimarron Canyon
4	NM 104	32 to 35	Corazon Hill
5	US 64	80 to 82	Manzanares Canyon
5	NM 68	16 to 33	Rio Grande Gorge
6	US 180	2 to 18	Luna to Reserve
6	NM 118	4 to 5	Manuelito

PROJECT EXPENSES for ROCKFALL MONITORING SYSTEM

Route	General Location	Component	Unit Price	US 64 Cimarron Canyon Units	Site Cost	NM 104 Corazon Hill Units	Site Cost	US 64 Manzanares Canyon Units	Site Cost	NM 68 Rio Grande Gorge Units	Site Cost	US 180 Luna to Reserve Units	Site Cost	NM 118 Manuelito Units	Site Cost	
Sensometrics		Thread X2C, 4G/LTE (gateway)	\$ 1,995.00	1	\$ 1,995.00	1	\$ 1,995.00	1	\$ 1,995.00	1	\$ 1,995.00	4	\$ 7,980.00	1	\$ 1,995.00	
		Thread X2C, 4G/LTE (endpoint)	\$ 1,995.00		\$ -		\$ -		\$ -	1	\$ 1,995.00		\$ -	1	\$ 1,995.00	
		30 W Solar Panel w/6 ft cable	\$ 350.00		\$ -		\$ -		\$ -	1	\$ 350.00	3	\$ 1,050.00	1	\$ 350.00	
		50 W Solar Panel w/6ft cable	\$ 615.00	1	\$ 615.00	1	\$ 615.00	1	\$ 615.00	1	\$ 615.00	1	\$ 615.00	1	\$ 615.00	
		LC 2 connect cable, 10 ft	\$ 195.00	1	\$ 195.00		\$ -	1	\$ 195.00		\$ -	4	\$ 780.00	2	\$ 390.00	
		EZ-Up Pole Mount	\$ 169.00	1	\$ 169.00	1	\$ 169.00	1	\$ 169.00	2	\$ 338.00	4	\$ 676.00	2	\$ 338.00	
		Discrete Sensor License - 2 years	\$ 192.00	3	\$ 576.00	3	\$ 576.00	3	\$ 576.00	6	\$ 1,152.00	12	\$ 2,304.00	6	\$ 1,152.00	
		Compound Sensor License - 2 years	\$ 432.00	1	\$ 432.00	1	\$ 432.00	1	\$ 432.00	1	\$ 432.00	1	\$ 432.00	1	\$ 432.00	
		Cell Carrier Fees per Thread - 2 years	\$ 600.00	1	\$ 600.00	1	\$ 600.00	1	\$ 600.00	2	\$ 1,200.00	2	\$ 1,200.00	2	\$ 1,200.00	
		Vaisala Weather Transmitter WXT530 Series	\$ 2,830.00	1	\$ 2,830.00	1	\$ 2,830.00	1	\$ 2,830.00	1	\$ 2,830.00	1	\$ 2,830.00	1	\$ 2,830.00	
		Vaisala Connect Cable 10 ft	\$ 175.00	1	\$ 175.00	1	\$ 175.00	1	\$ 175.00	1	\$ 175.00	1	\$ 175.00	1	\$ 175.00	
	Geokon		Geonet RS-485 Biaxial Tilt Sensor	\$ 1,500.00		\$ -	2	\$ 3,000.00		\$ -	6	\$ 9,000.00		\$ -		\$ -
			4420-1-100mm VW Crackmeter	\$ 485.00	3	\$ 1,455.00	1	\$ 485.00	3	\$ 1,455.00		\$ -	12	\$ 5,820.00	6	\$ 2,910.00
			0.250" blue PVC cable - 100 ft	\$ 79.00	3	\$ 237.00	1	\$ 79.00	3	\$ 237.00		\$ -	12	\$ 948.00	6	\$ 474.00
		LC-2 X 4 Data Logger	\$ 1,140.00	1	\$ 1,140.00		\$ -	1	\$ 1,140.00		\$ -	4	\$ 4,560.00	2	\$ 2,280.00	
Shared		120/240V AC 3 amp backup power supply	\$ 165.00		\$ -		\$ -		\$ -		\$ -		\$ -		\$ -	
		Thread connector for 3 amp power supply	\$ 50.00		\$ -		\$ -		\$ -		\$ -		\$ -		\$ -	
	Shipping - all hardware	\$ 500.00		\$ -		\$ -		\$ -		\$ -		\$ -			\$ -	
Total Costs per Site (2-year period)					\$ 10,419.00		\$ 10,956.00		\$ 10,419.00		\$ 20,082.00		\$ 28,770.00		\$ 17,136.00	

Total Project Cost (2-year period) \$ 98,497.00

Route	US 64 Cimarran	NM 104 Corona	US Manzanar	NM Rio Grande	US Luna	NM 118 Manuelito
General Location	Units	Site Cost	Units	Site Cost	Units	Site Cost
Component	Unit Price	Units	Site Cost	Units	Site Cost	Units
Sensemetrics Thread X2C; 4G/LTE	\$1,995.00	1				
30 W Solar Panel	\$350.00					
50 W Solar Panel	\$615.00					
LCZ connect cable, 10 ft.	\$195.00					
EZ-Up Pole Mount	\$169.00					
Vaisala Weather Transmitter WXT530	\$2,830.00					
Vaisala Connect Cable, 10 ft.	\$175.00					
Geonet RS-485 Biaxial Tilt Sensor	\$1,500.00					
Geokon 4420-1-100 VW crackmeter	\$485.00					
Geokon LC-2 8002-4-1-SM Data Logger	\$1,140.00					
Geokon LC-2 connect cable - 10 feet	\$195.00					
Geokon 0.250" PVC meter cable - 100 ft.	\$79.00					
Discrete Sensor Licenses	\$192.00					
Compound Sensor Licenses	\$432.00					
Cellular Carrier Fees	\$600.00					
120/240V AC 3-amp backup power supply	\$165.00					
Thread connector for 3-amp power supply	\$50.00					
Shipping (all hardware)	\$500.00					
Total Cost per Site (2-year period):						
Total Project Cost (2-year period)::						

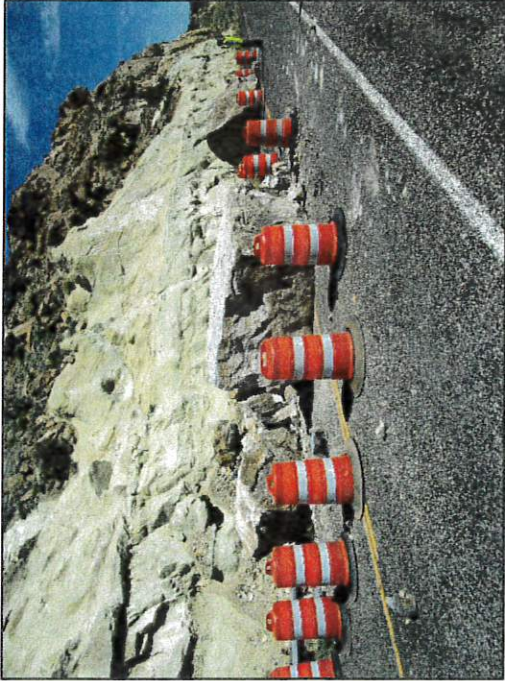


Photo 1: August 2019 rockfall on NM 118 near Manuelito (District 6), the second significant event here in three years.



Photo 3: extensometer installed on NM 104 (District 4); sensor data shows progressive crack growth over the last year.

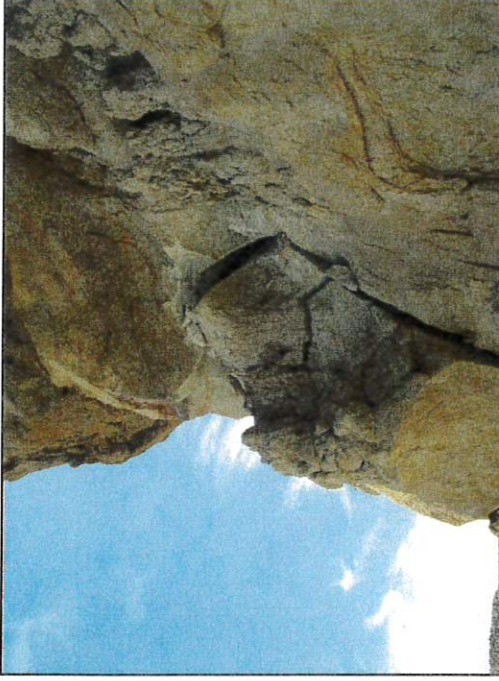


Photo 2: source area for the rockfall event seen in Photo 1 showing fractured rock face and destabilized overlying rock.



Photo 4: typical installation on I-25 at Romeroville (District 4) showing solar panel, cellular transmitter and data logger.