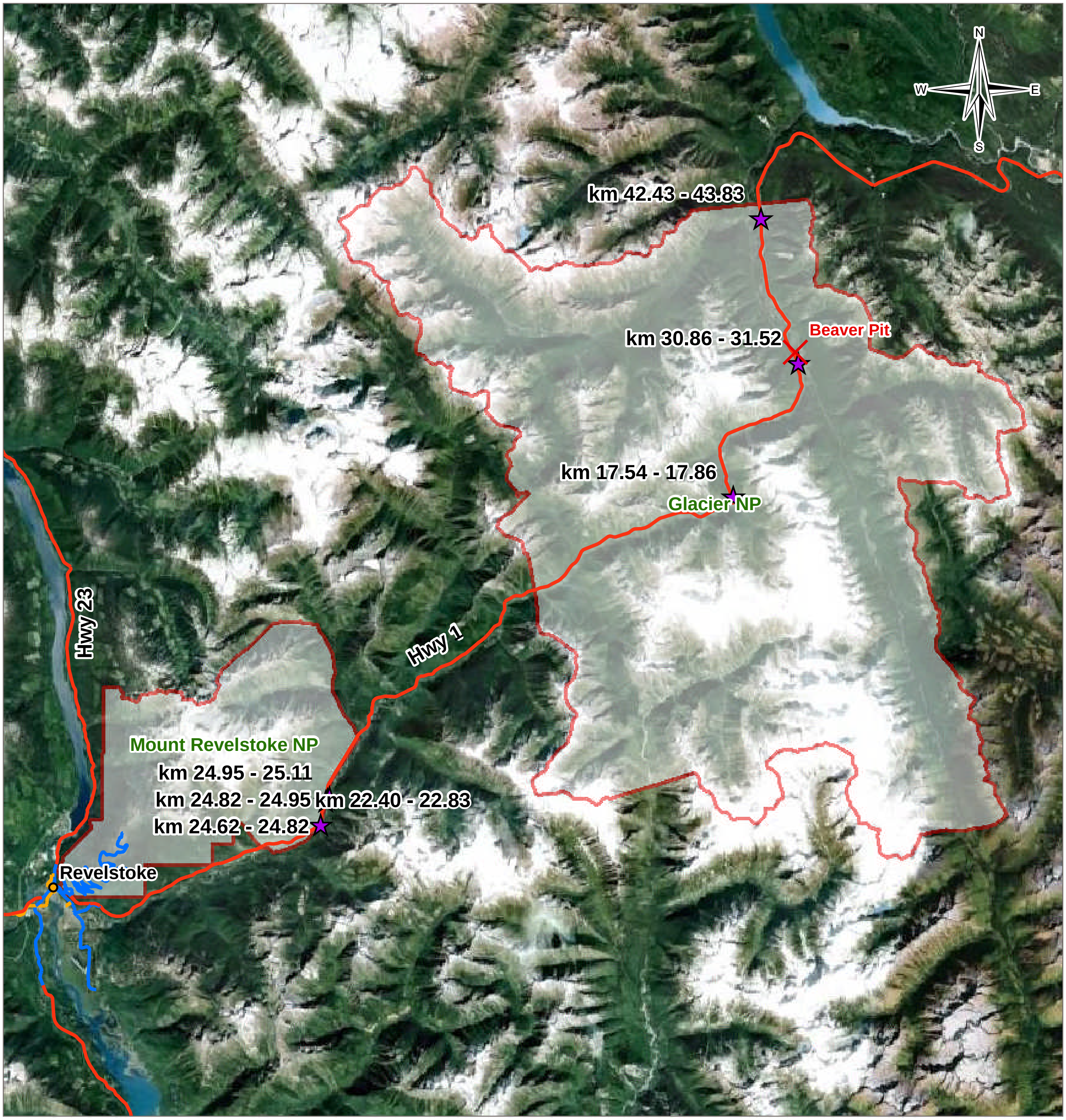

LEGEND

- Disposal_Sites
- Priority Locations
- National Parks
- freeway
- highway
- arterial
- collector

NOTES
Base data source: Imagery provided by Google Earth Pro

STATUS
Issued for Review

PRIORITIZED ROCK SLOPE STABILIZATION WORK

Mt. Revelstoke National Park & Glacier National Park

PROJECTION	DATUM	CLIENT
UTM Zone 11	NAD83	Parks Canada / Parcs Canada; Canada

Scale: 1:425,000
8 4 0 8
Kilometres

FILE NO.
RNP_and_GNP.mxd

PROJECT NO.	DWN	CKD	APVD	REV
V13403021-01	AMF	AN	CH	0

OFFICE	DATE
EBA-VANC	May 9, 2013

eba A TETRA TECH COMPANY

Figure 1

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Detailed Work Breakdown by Rock Slope Location

Park	Slope Reference	Type of Work	Estimated Quantity
Mt. Revelstoke NP		Mobilization/Demobilization	
Mt. Revelstoke - TCH	km 22.40 – 22.827	Scaling (hr)	25
		Trim Blasting (cu m)	140
		Common Excavation (cu m)	500
		Rock bolts (m)	50
Mt. Revelstoke - TCH	km 24.619 - 24.824	Scaling (hr)	75
		Trim Blasting (cu m)	30
		Common Excavation (cu m)	150
Mt. Revelstoke - TCH	km 24.824 - 24.949	Scaling (hr)	25
		Concrete guardrail (m)	240
		Common Excavation (cu m)	320
Mt. Revelstoke - TCH	km 24.949 – 25.109	Scaling (hr)	63
		Trim Blasting (cu m)	130
		Common Excavation (cu m)	240
		Rock bolts (m)	24
Glacier National Park		Mobilization/Demobilization	
Glacier National Park	km 17.543 - 17.858	Scaling (hr)	75
		Trim Blasting (cu m)	50
		Common Excavation (cu m)	400
Glacier National Park	km 30.861 - 31.521 (Beaver Hill)	Scaling (hr)	350
		Trim Blasting (cu m)	820
		Rock bolts (m)	46
		Common Excavation (cu m)	1520
Glacier National Park	km 42.432 - 43.828 (Heather Hill)	Scaling (hr)	100
		Trim Blasting (cu m)	250
		Common Excavation (cu m)	400

Appendix A Photographs of Work Areas

Note: Within Glacier and Mount Revelstoke National Parks all kilometre stations are measured in an easterly direction from the Glacier and Mount Revelstoke West Gates.

Glacier National Park – Prime Work Locations:

Glacier National Park Km 17.543 to 17.858
Relevant Photos: 17.543a; 17.543b; 17.543c; 17.543d; 17.543e; 17.542f; 17.543g; 17.543h; 17.543i; 17.543j; 17.543k; 17.543l; 17.543m.

Glacier National Park Km 30.861 to 31.169 (Beaver Hill)
Relevant Photos: 30.861a; 30.861b; 30.861c & d; 30.861e; 30.561f; 30.861g; 30.861h; 30.861i; 30.861j; 30.861k; 30.861l; 30.861l (No.2); 30.861m; 30.861n; 30.861o; 30.861p; 30.861q; 30.861r; 30.861s; 30.861t; 30.861u; 30.861v; 30.861w; 30.861x

Glacier National Park Km 42.432 to 43.828 (Heather Hill)
Relevant Photos: 42.432a; 42.432b; 42.432c; 42.432d; 42.432e; 42.432f; 42.432g; 42.432h; 42.432i &j

Mt.Revelstoke National Park – Prime Work Locations:

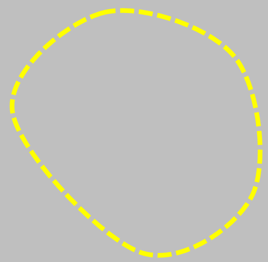
Mt.Revelstoke National Park Km 22.40 to 22.827
Relevant Photos: 22.40a; 22.40b; 22.40c; 22.40d; 22.40e; 22.40f; 22.40g

Mt.Revelstoke National Park Km 24.619 to 24.824
Relevant Photos:24.619a & b; 24.619c

Mt.Revelstoke National Park Km 24.824 to 24.949
Relevant Photos:24.824a; 24.824b; 24.824c

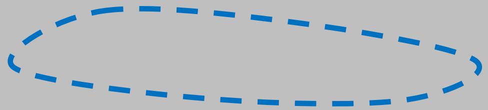
Mt.Revelstoke National Park Km 24.949 to 25.109
Relevant Photos:24.949a; 24.949b; 24.949c; 24.949d; 24.949e; 24.949f

Legend



Approximate area of scaling with total number of man hours for the section

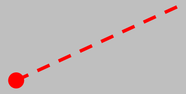
Approximate area of trim blasting



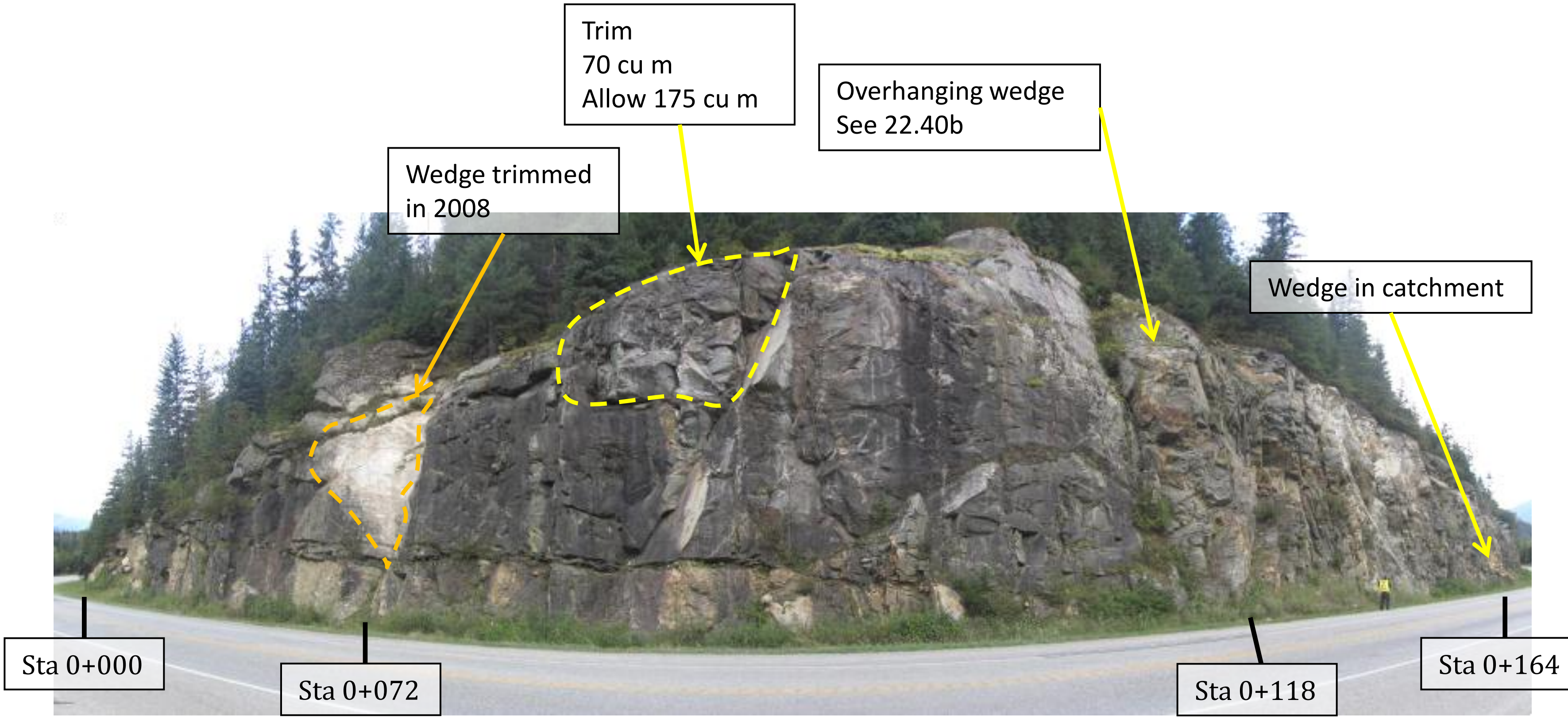
Approximate area of common excavation

Sta 0+065

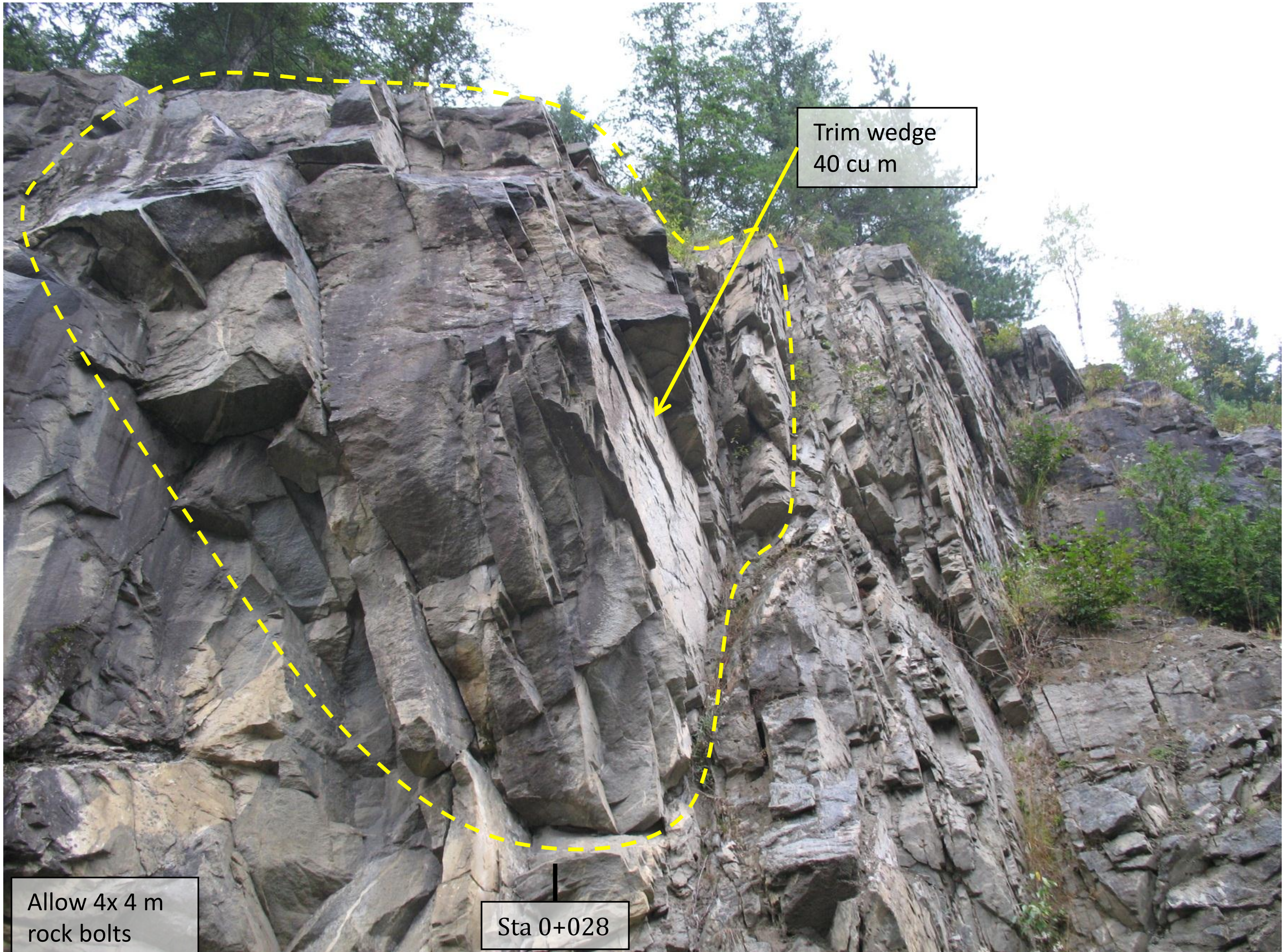
Approximate chainage from start of slope



Approximate location and orientation of rock bolts / dowels



Allow 16 m rock bolting
over entire face



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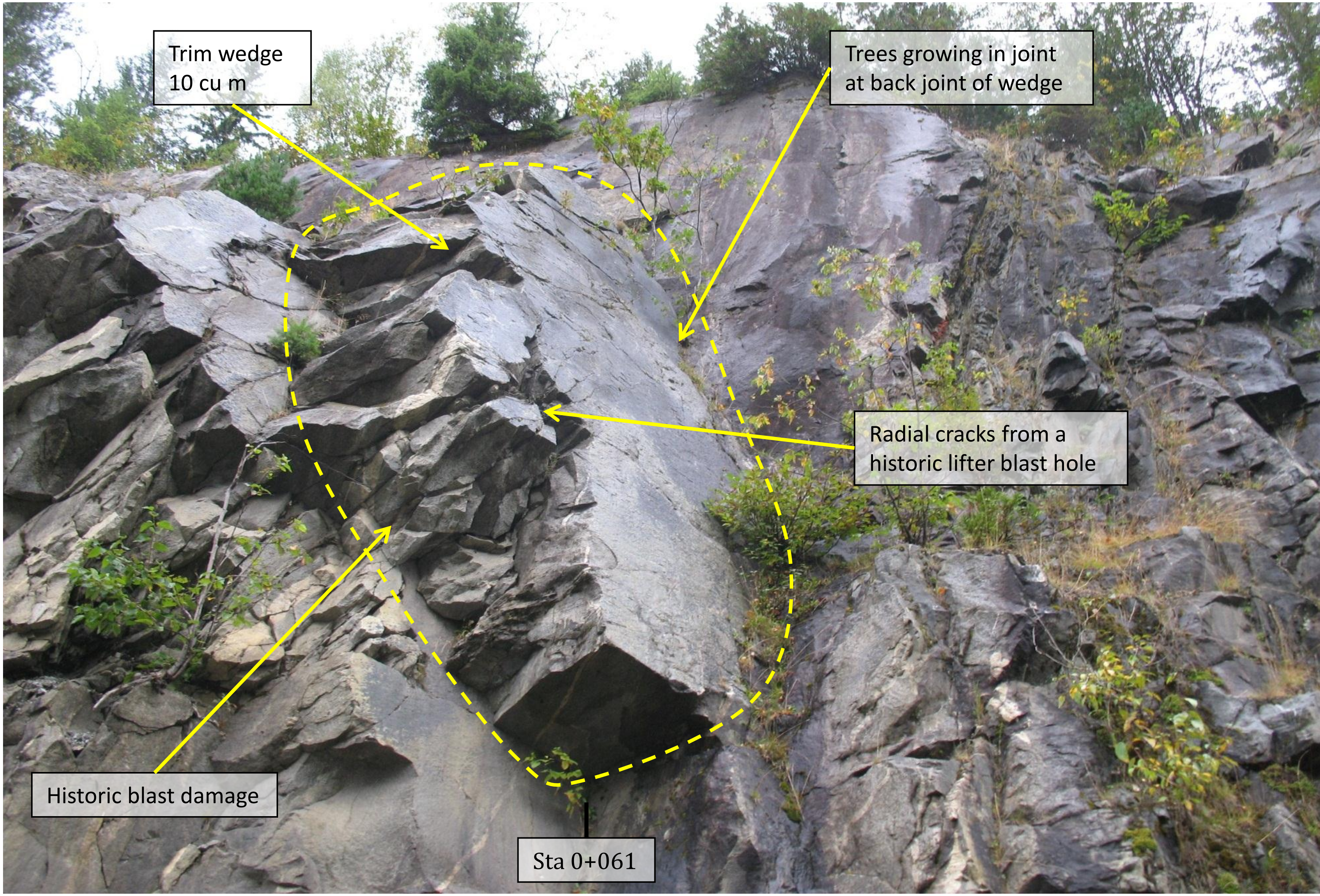

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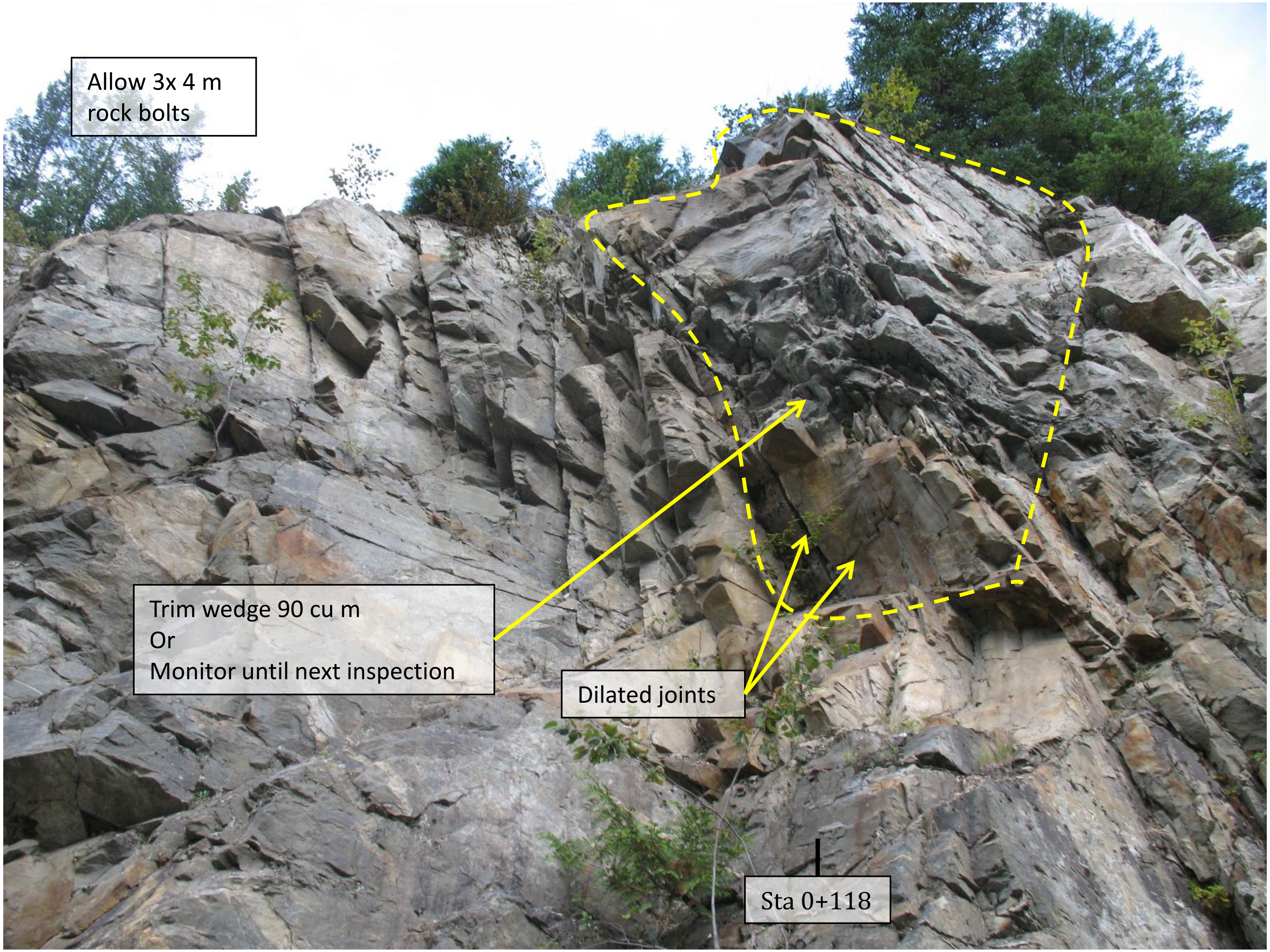

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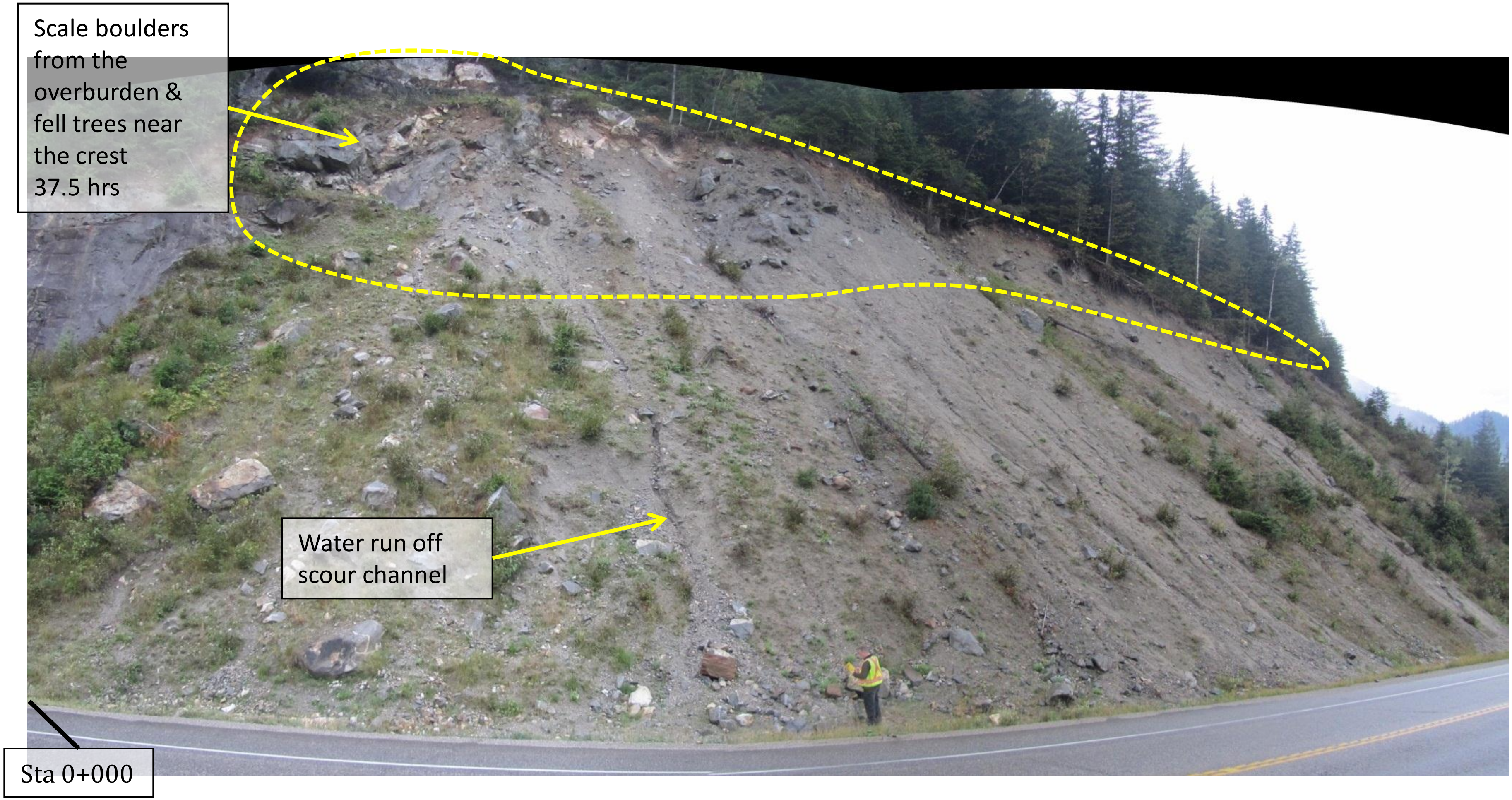

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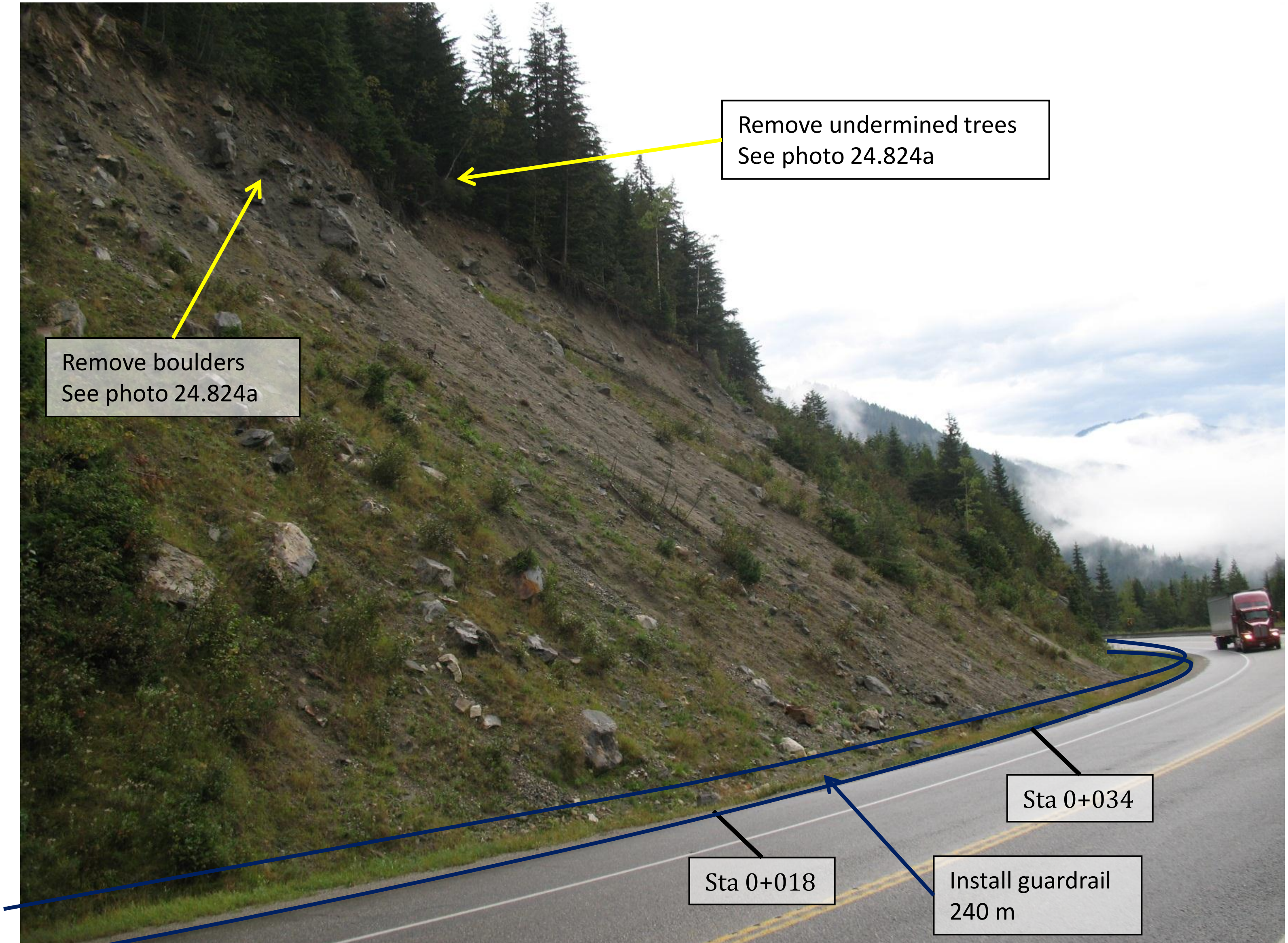

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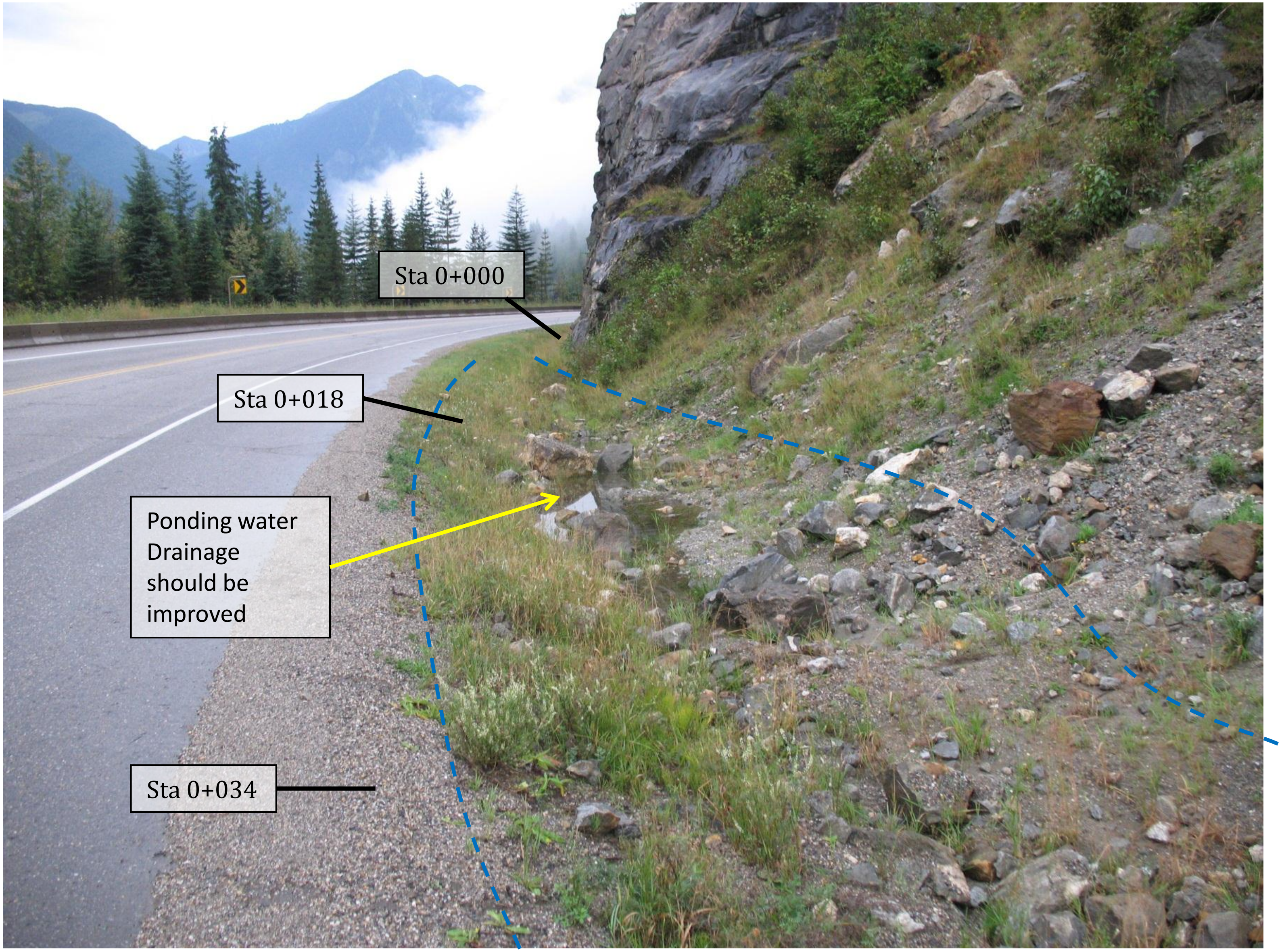

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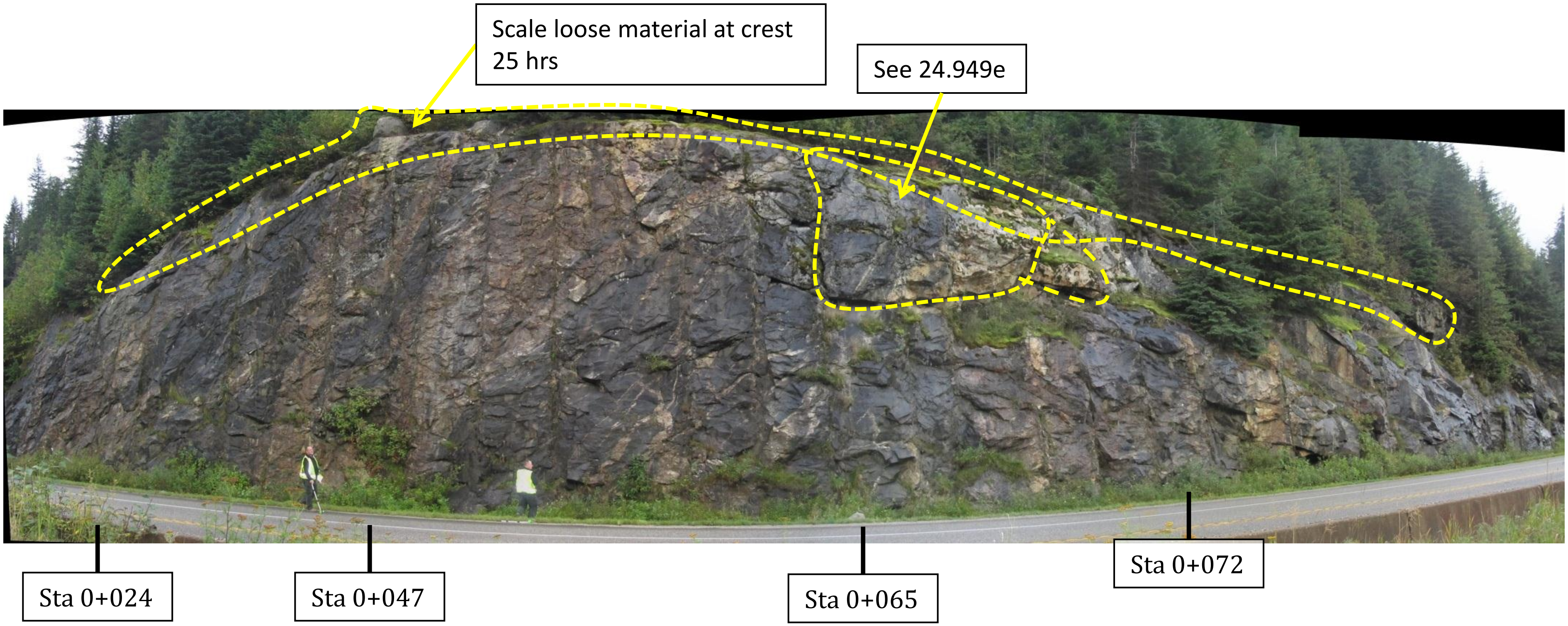

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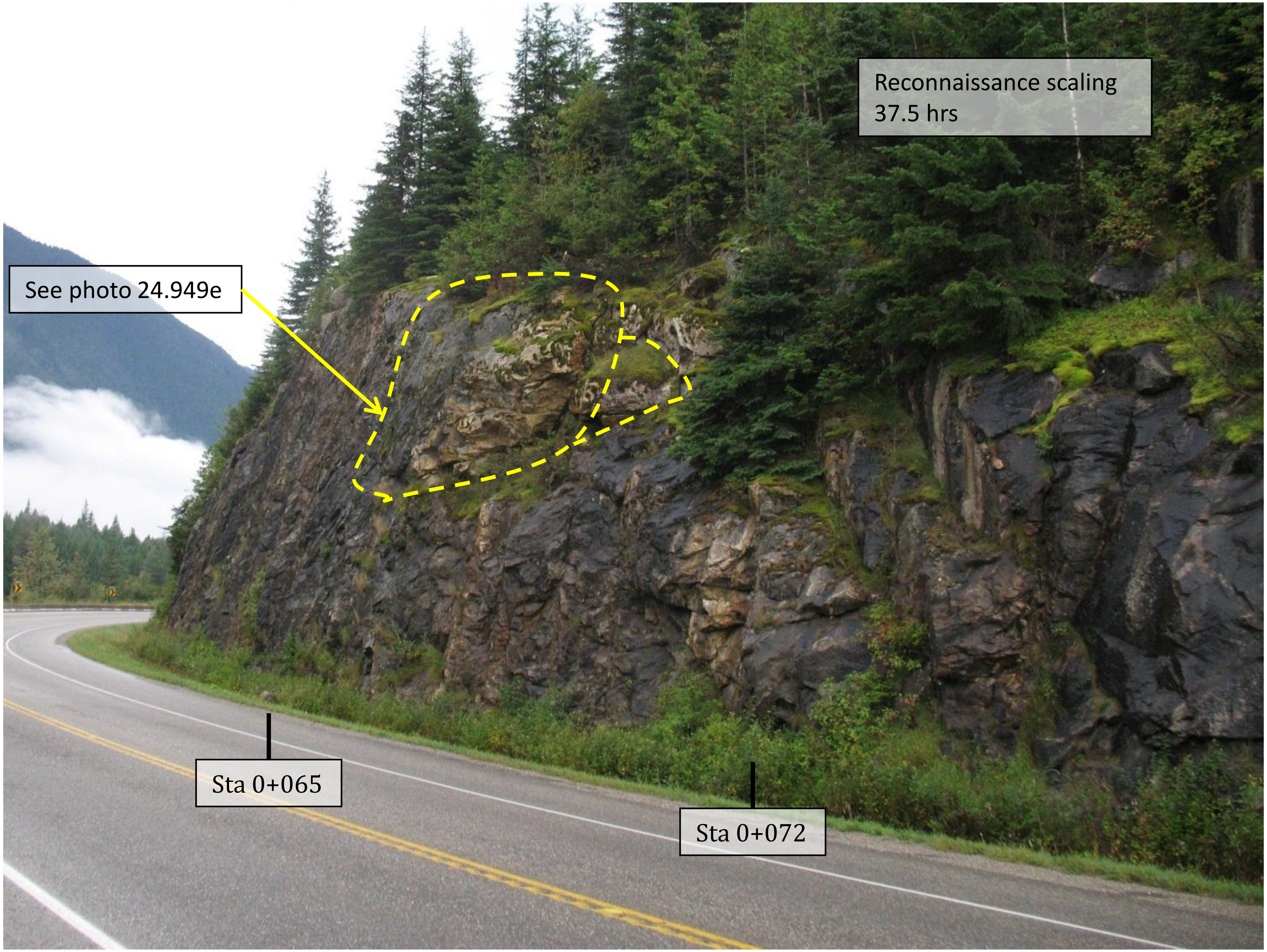

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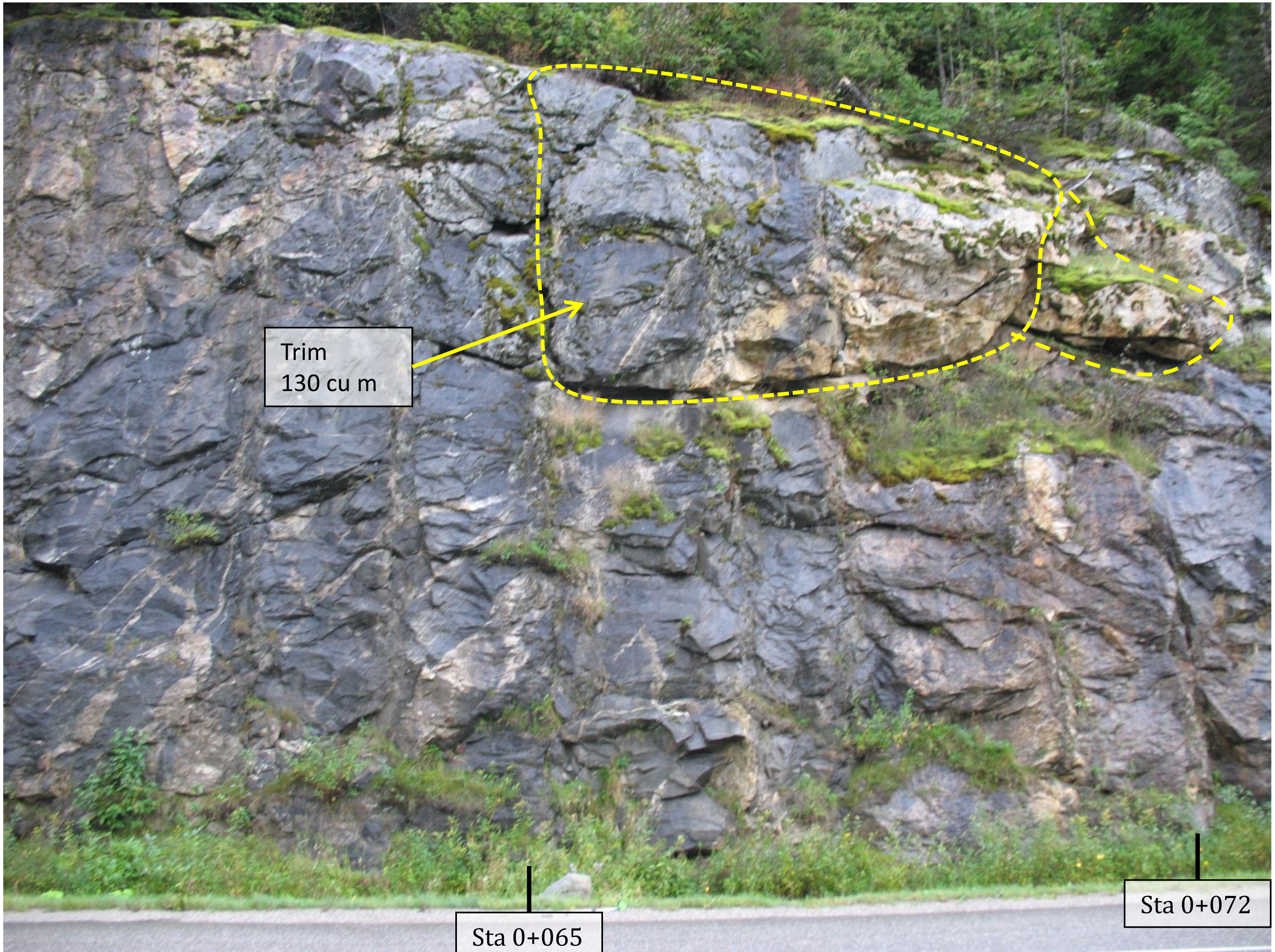

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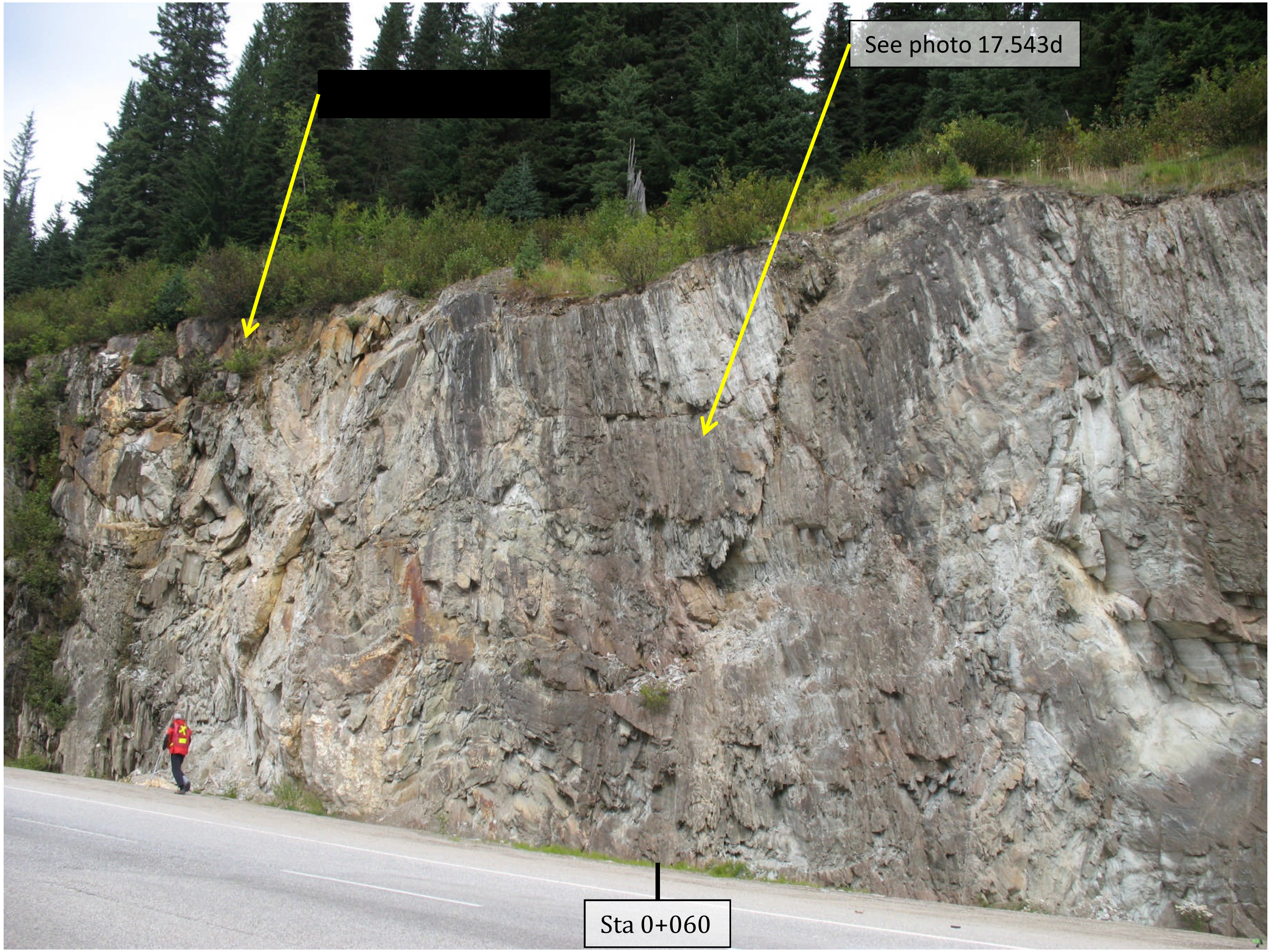

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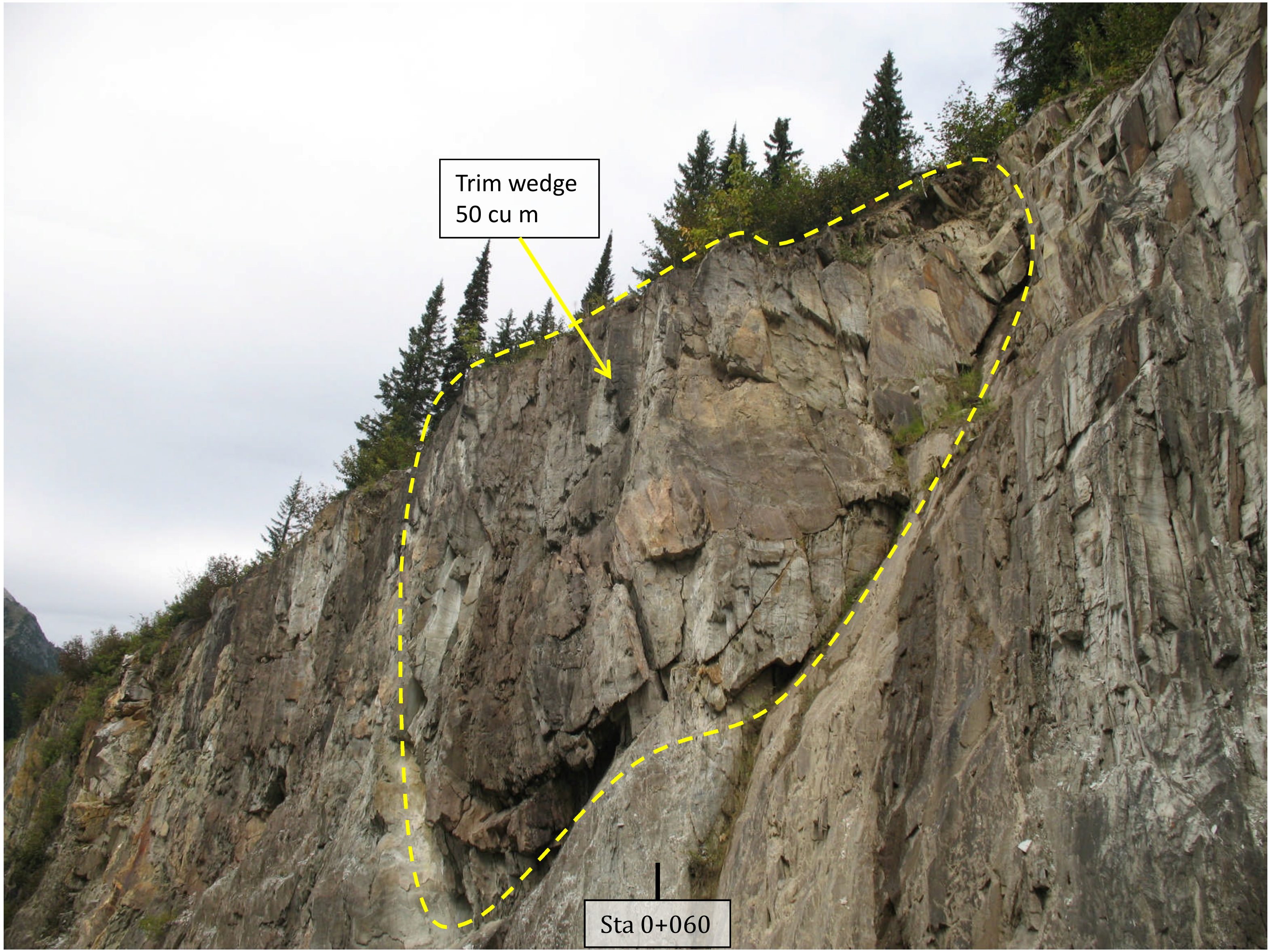

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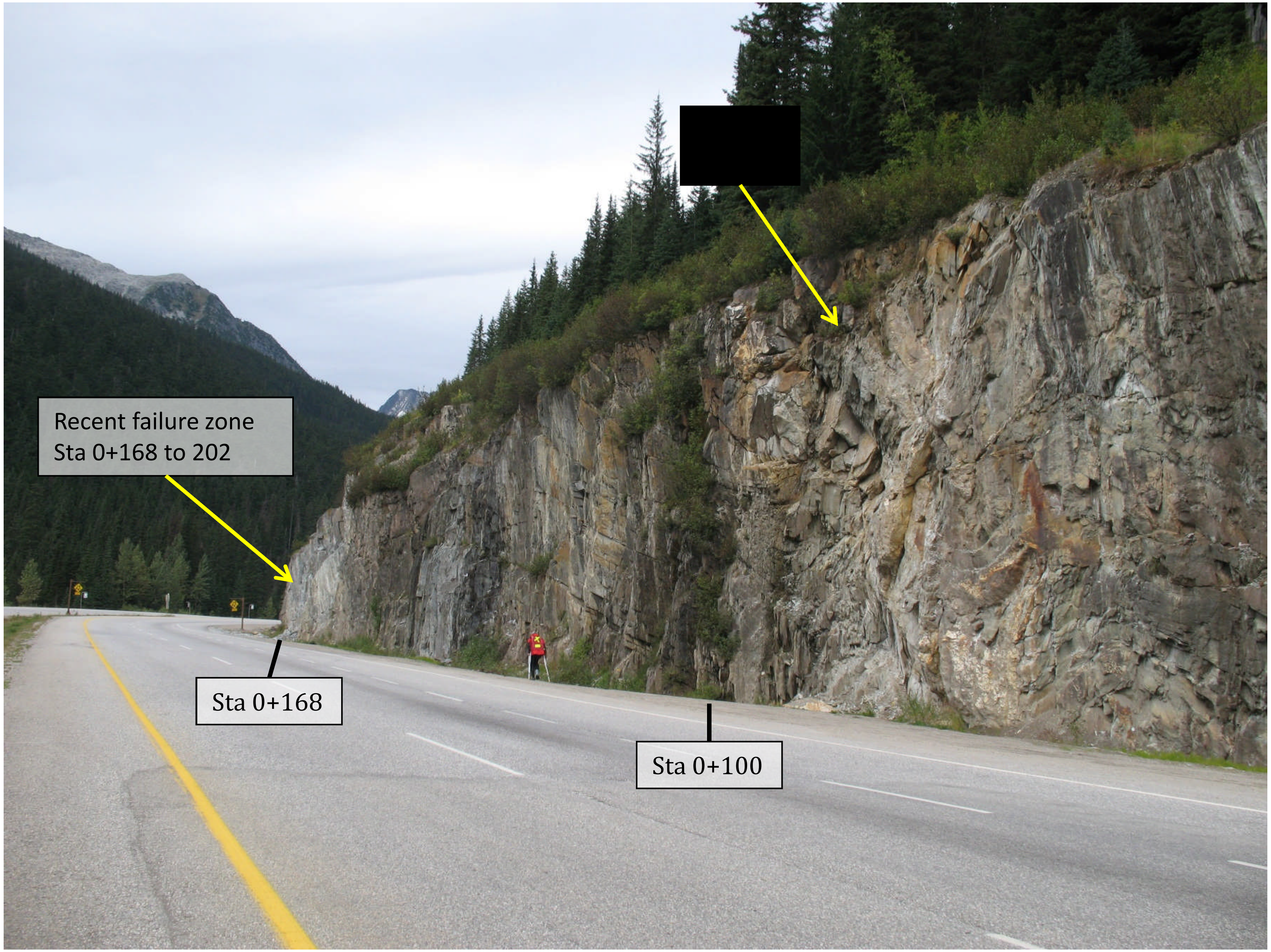

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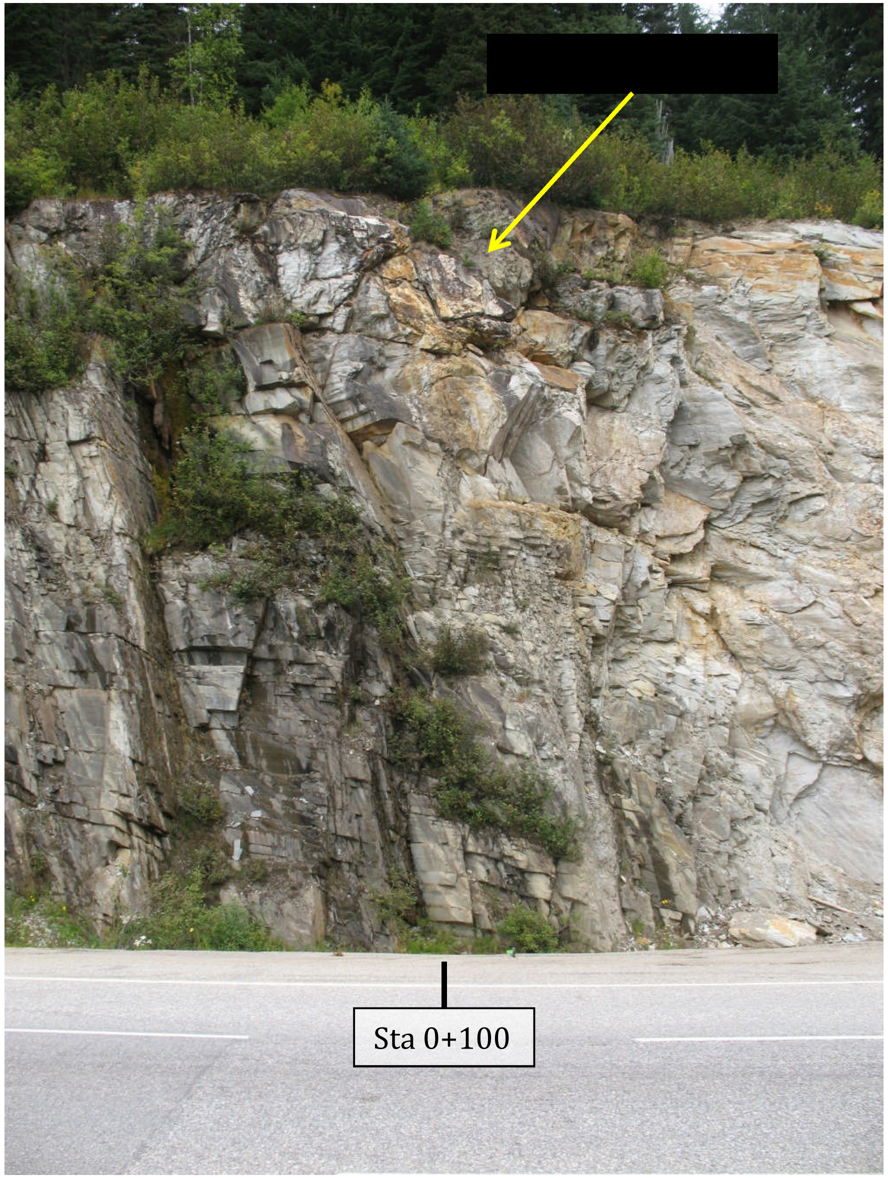

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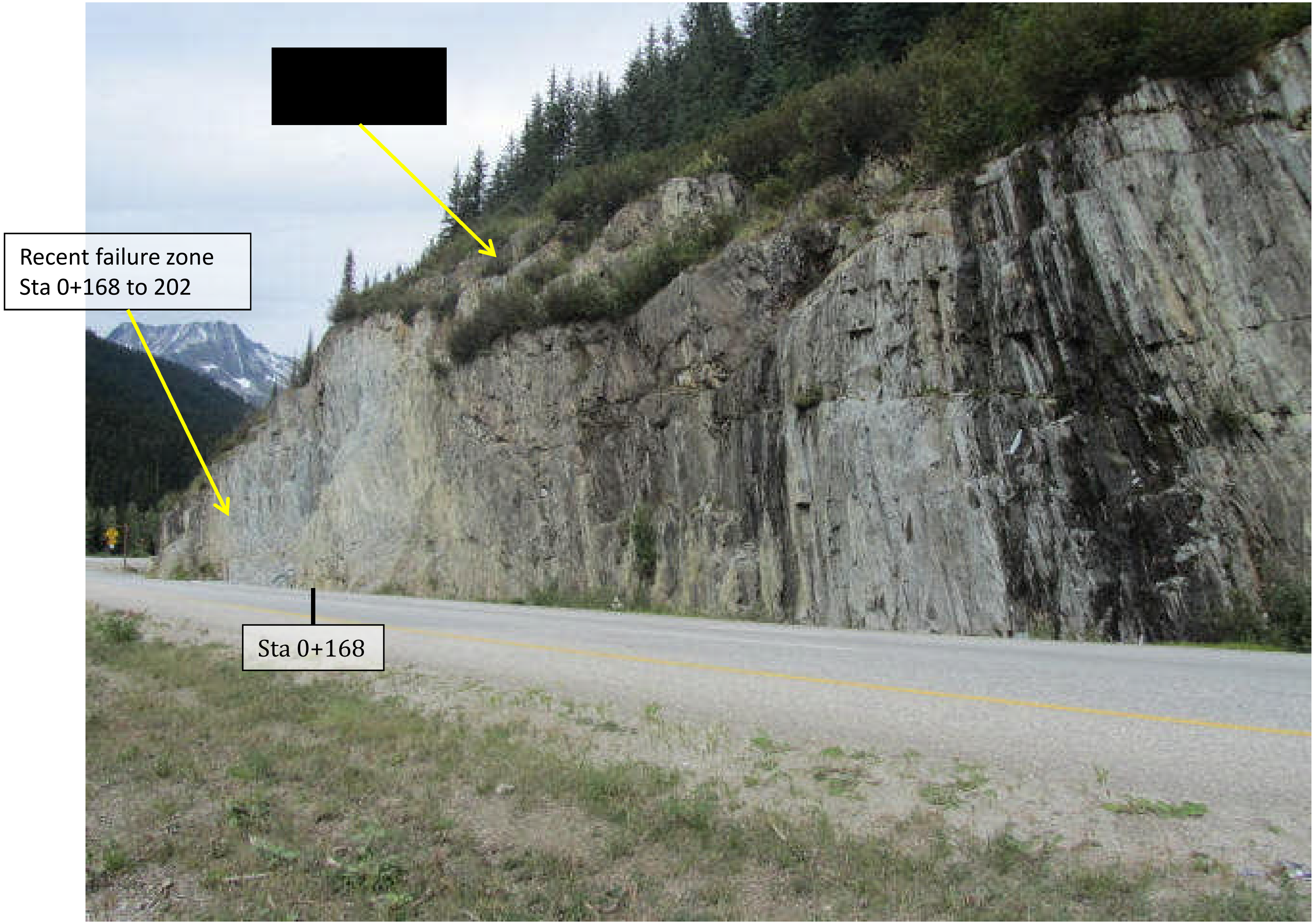

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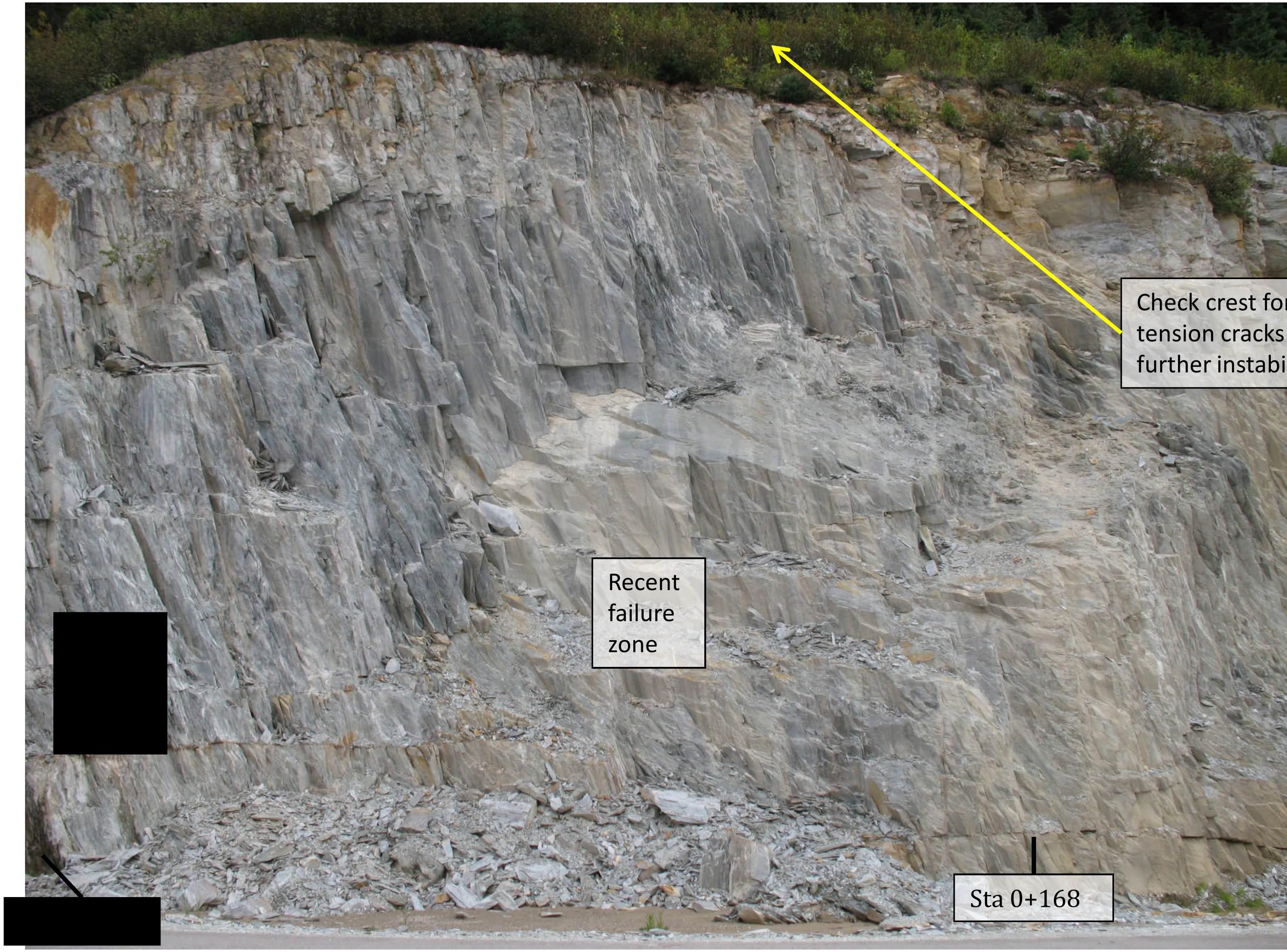

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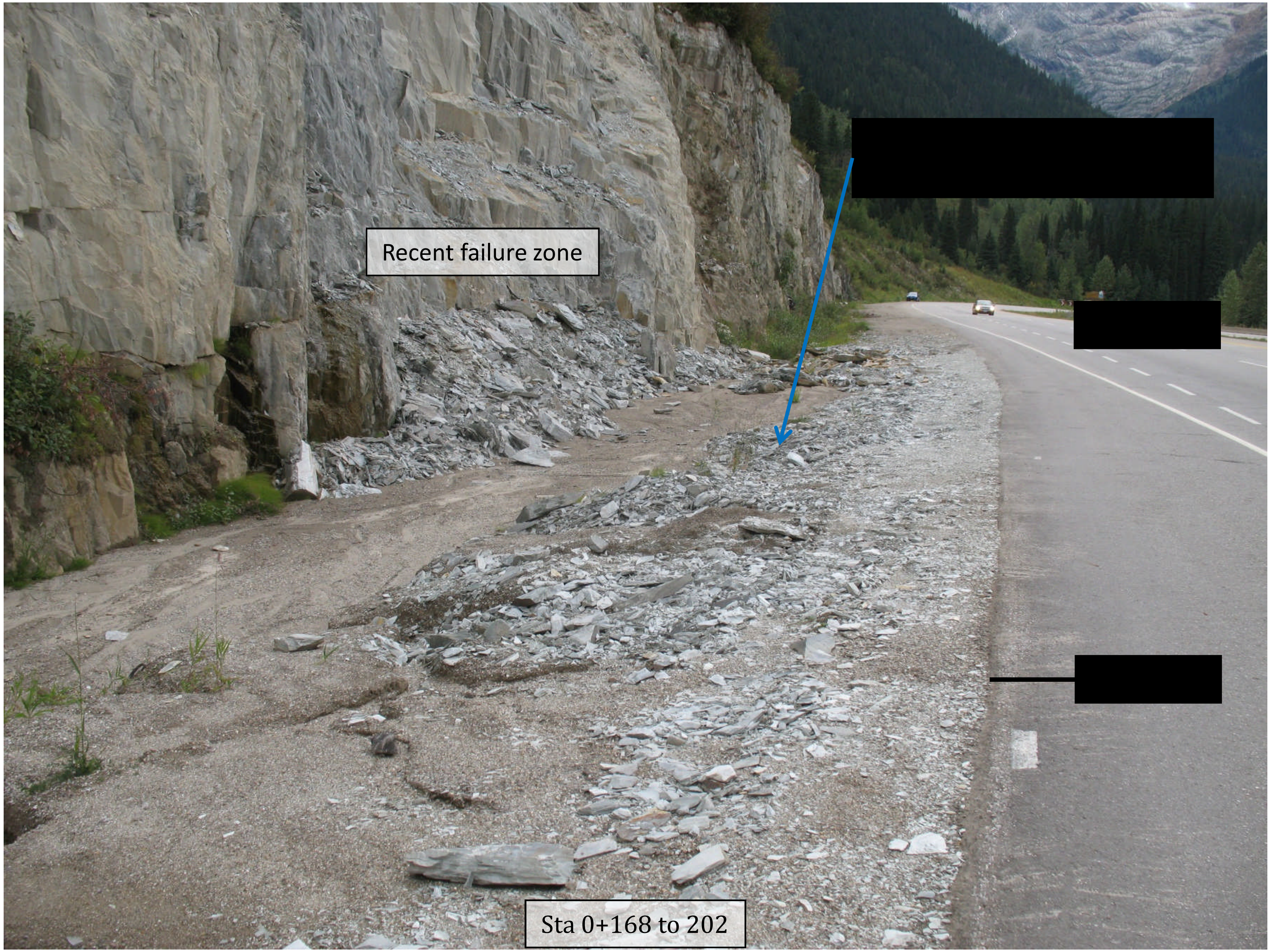

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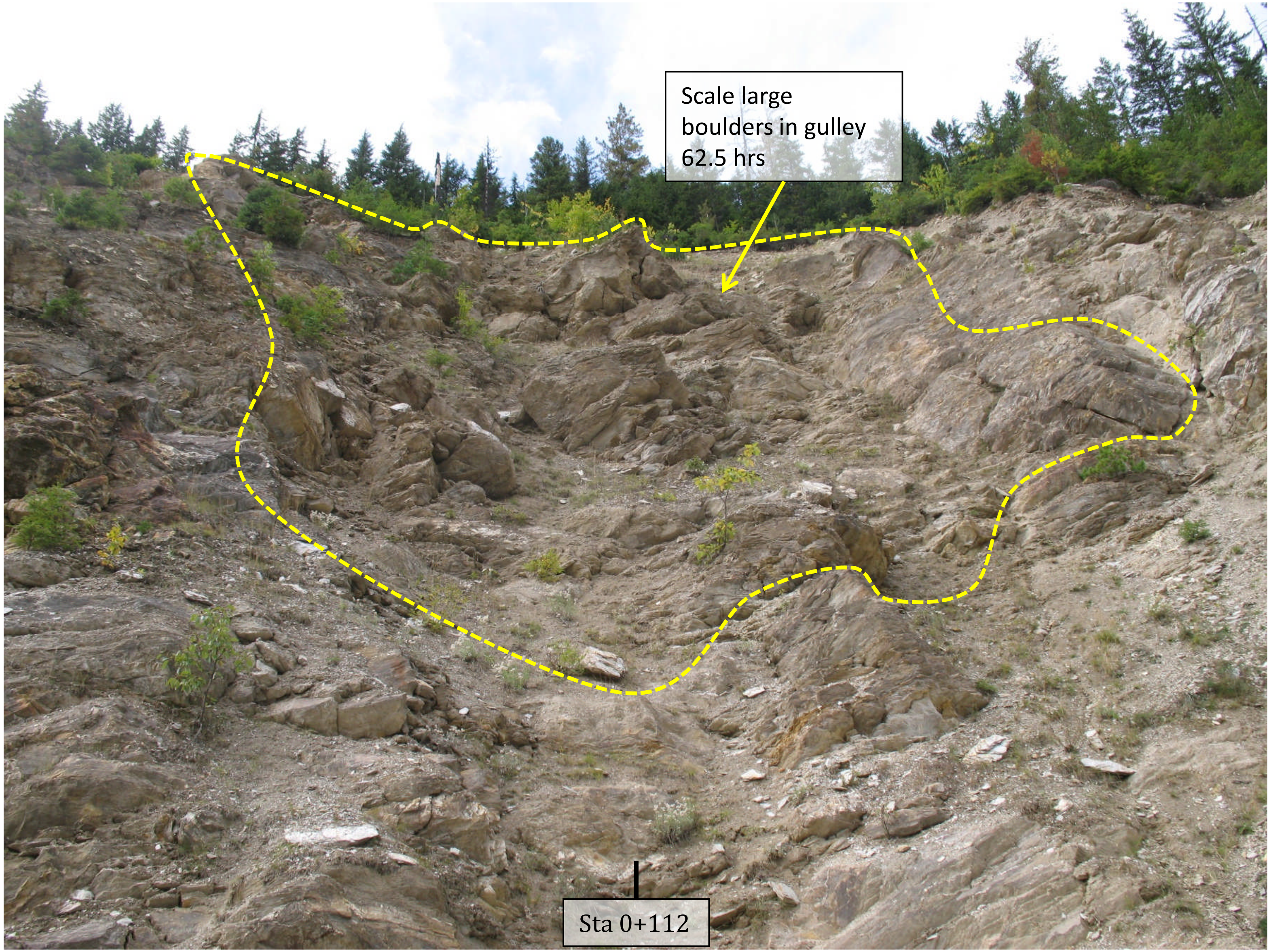

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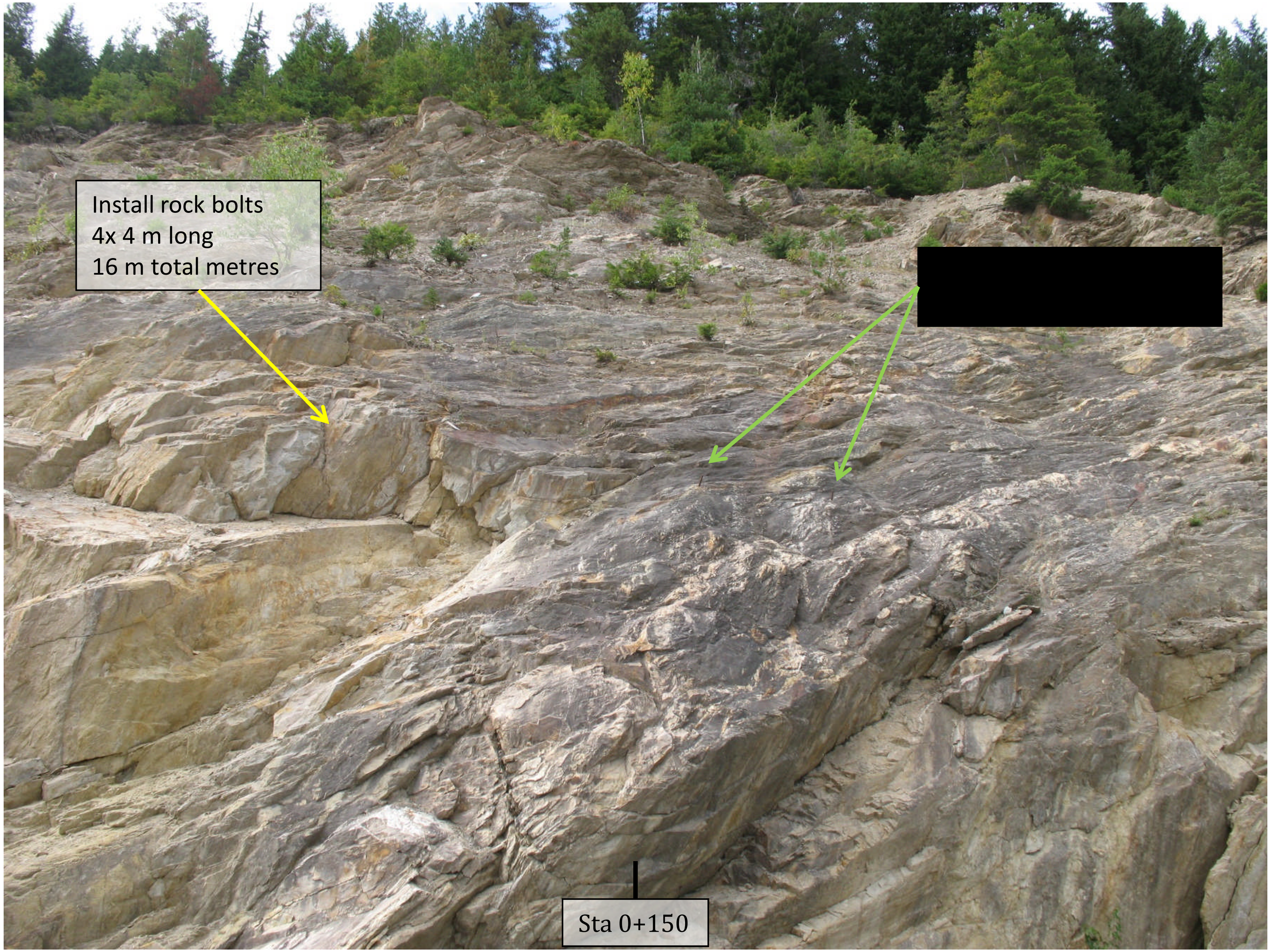

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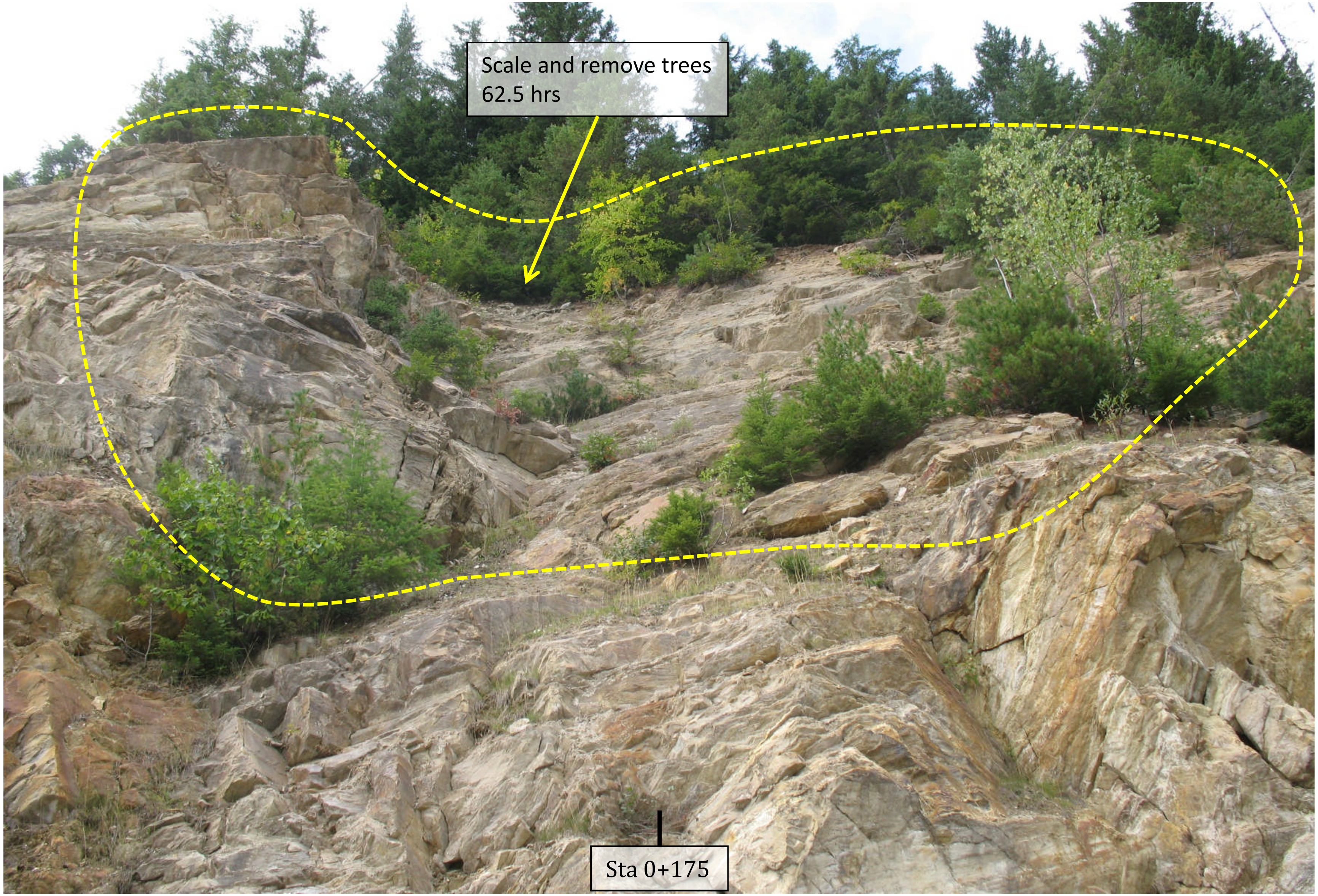

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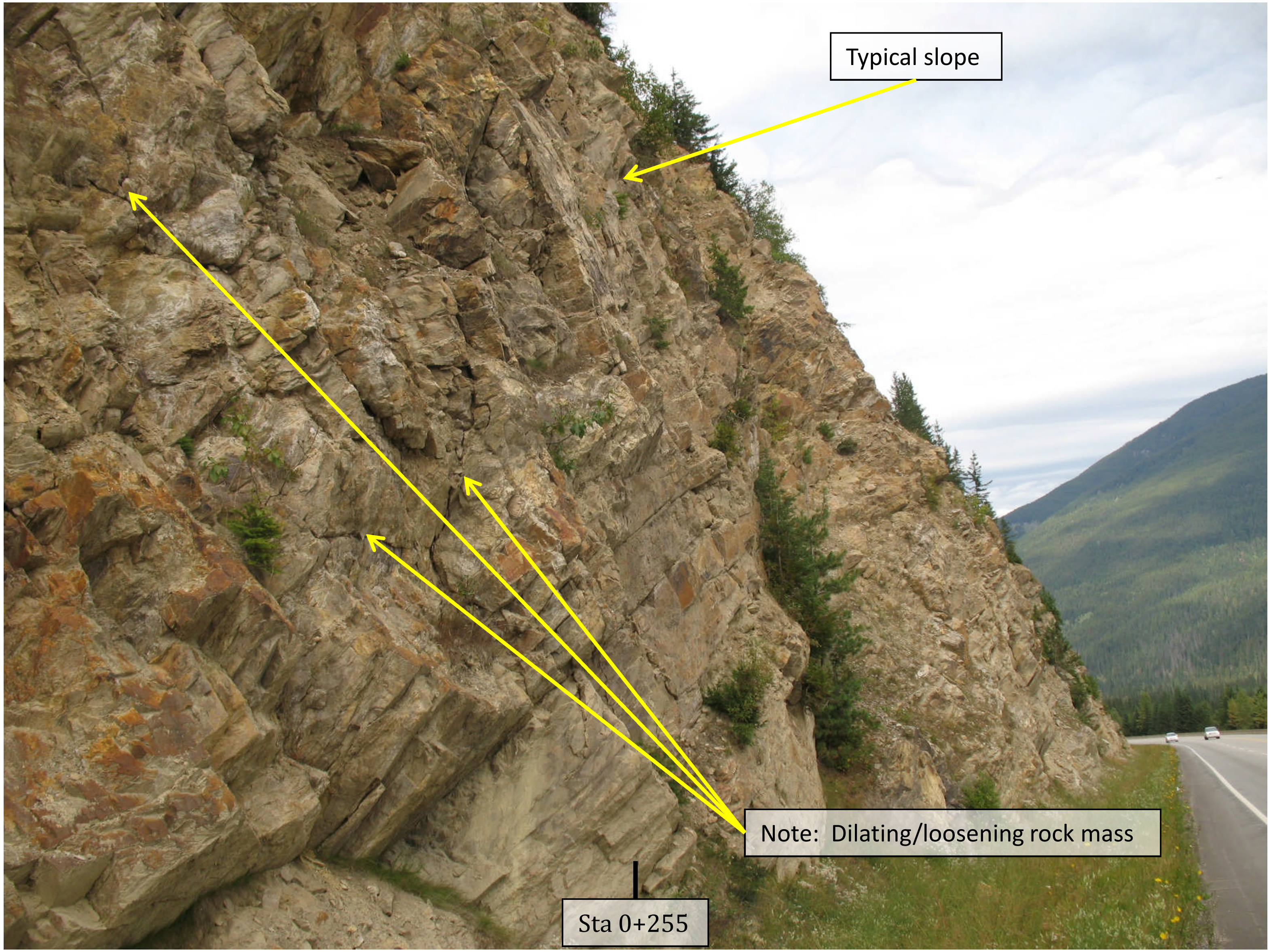

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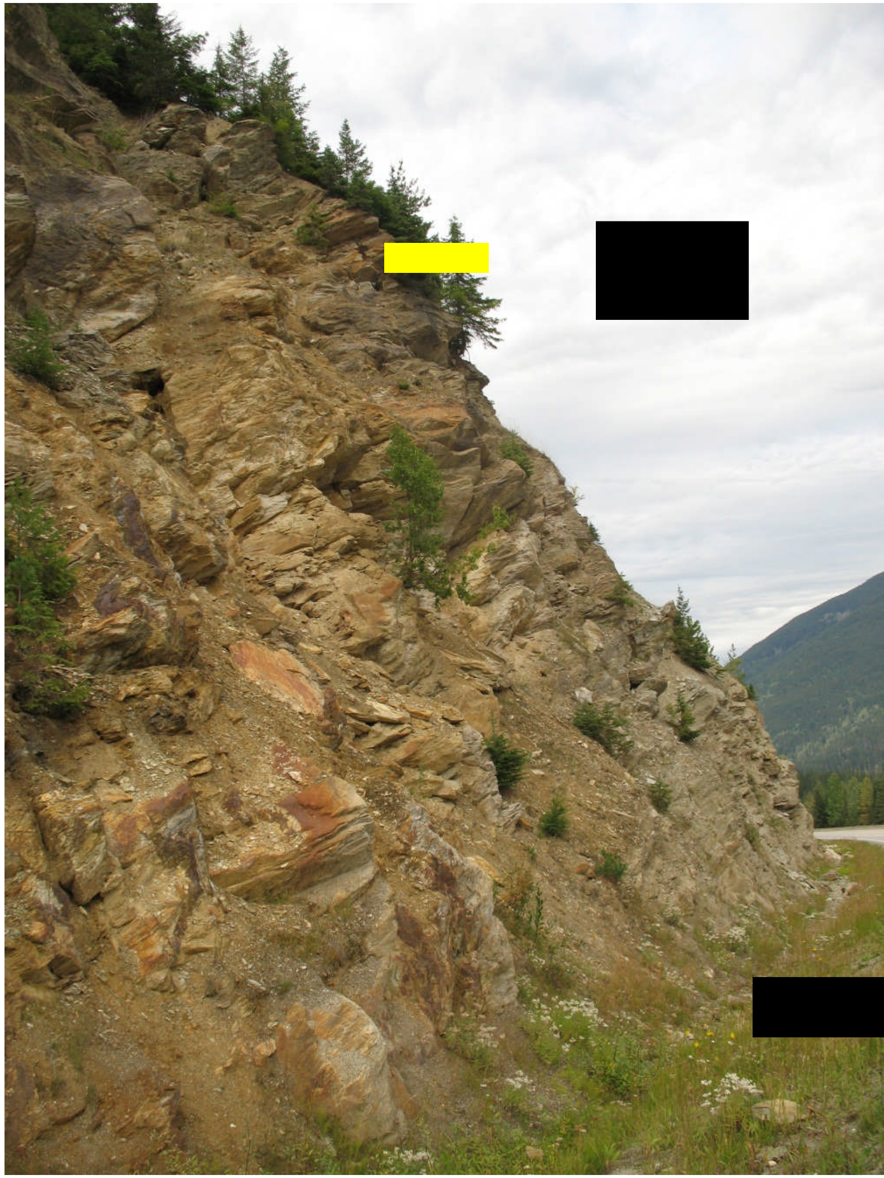

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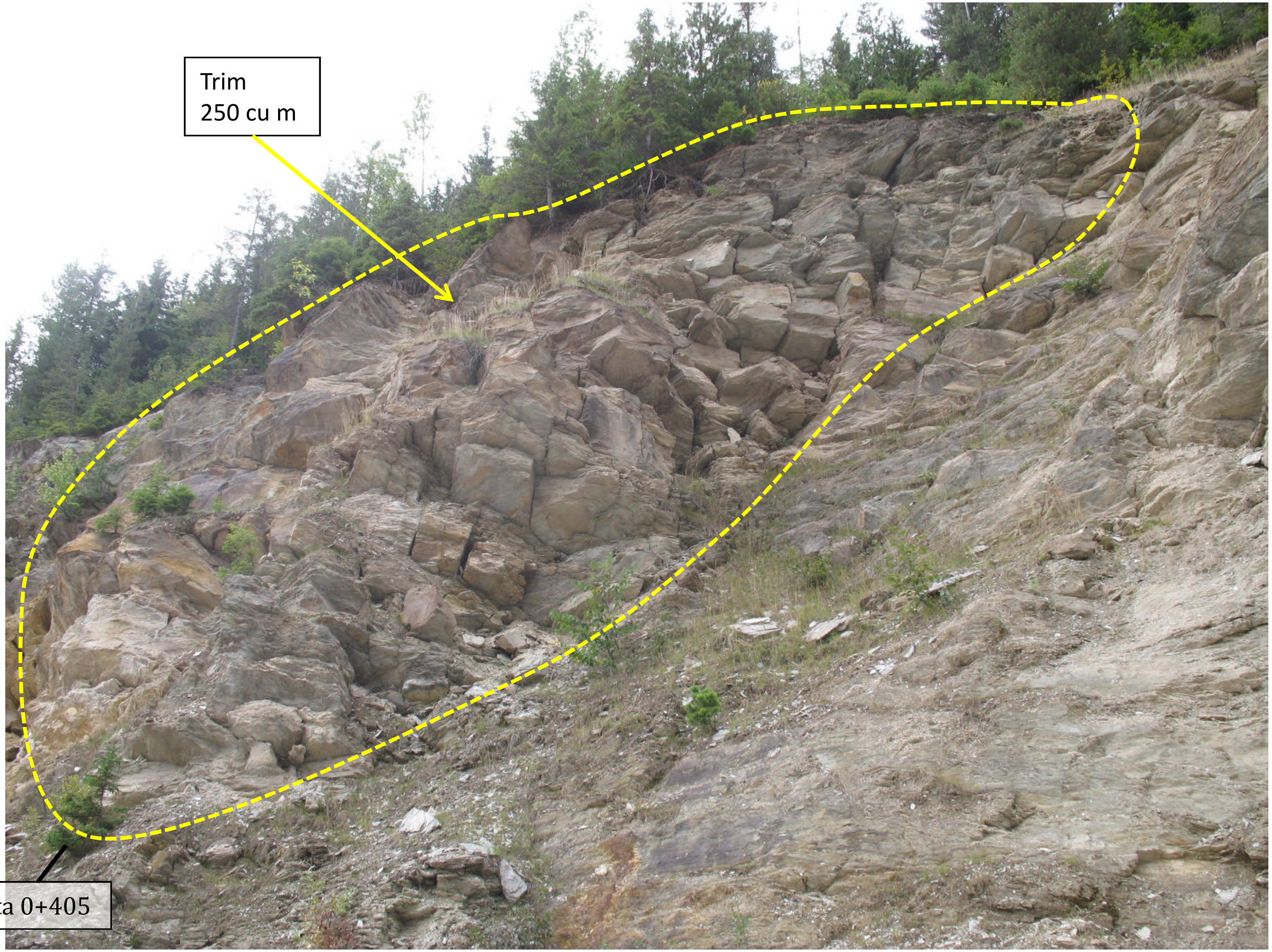

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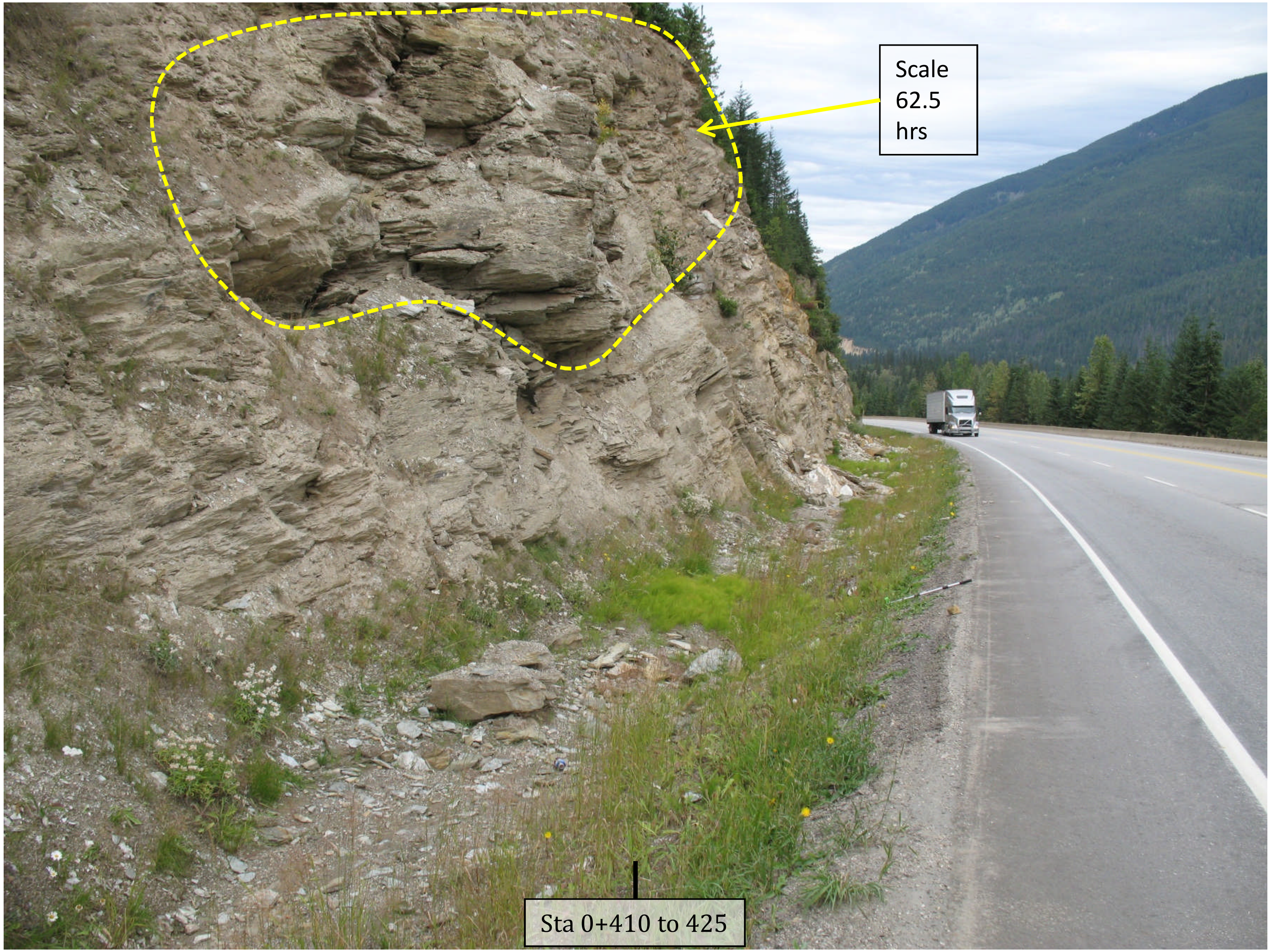

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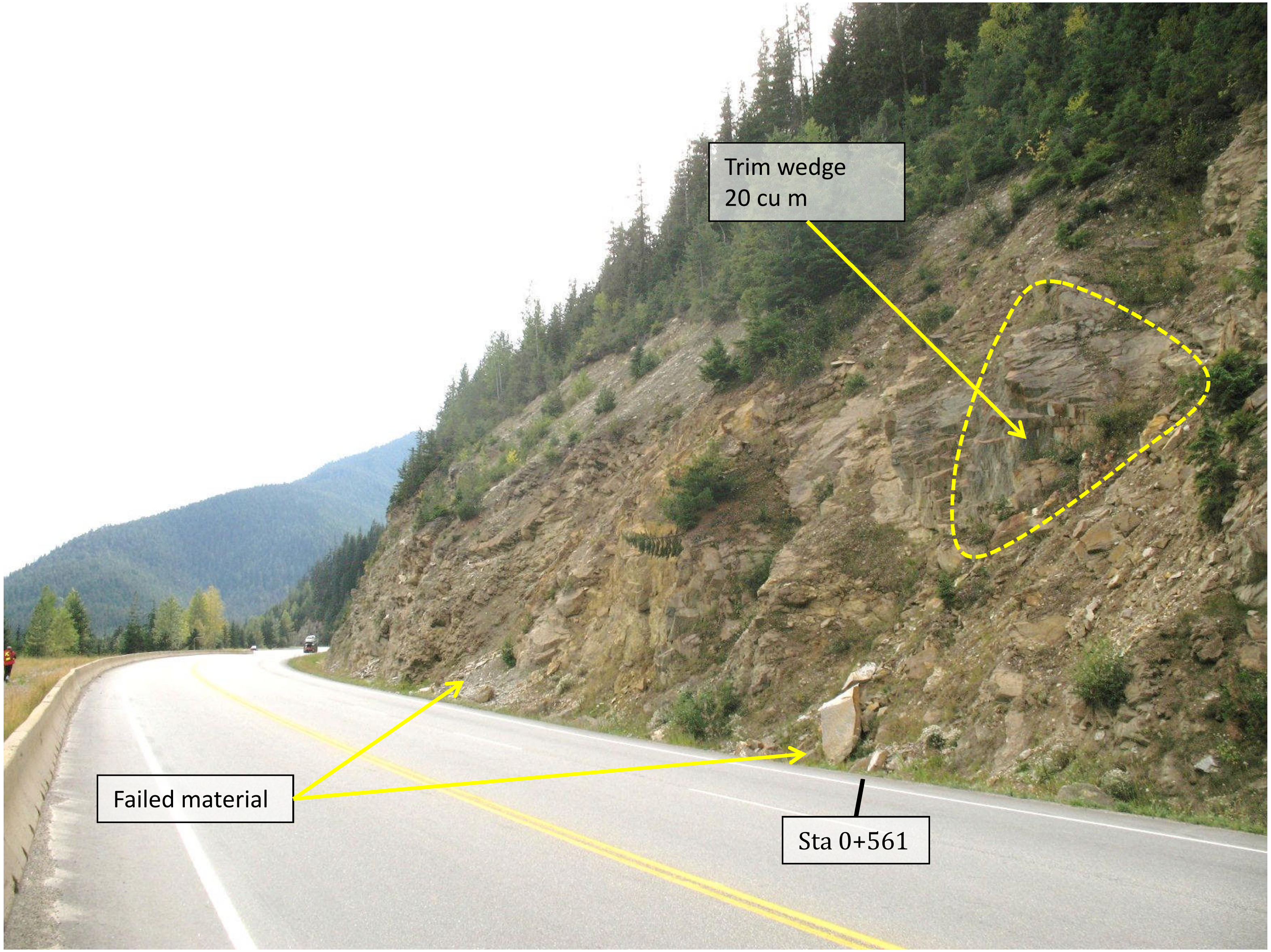

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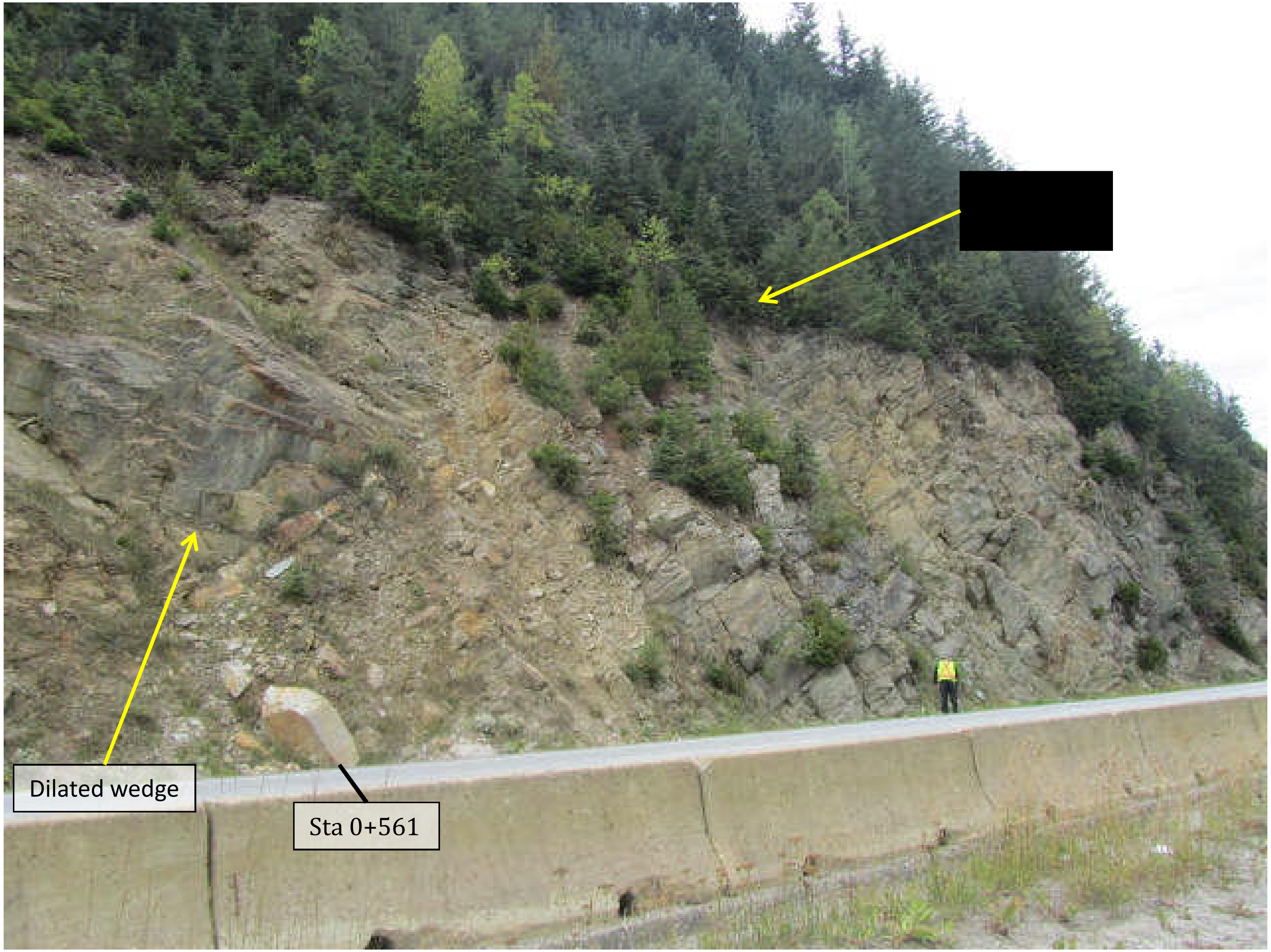

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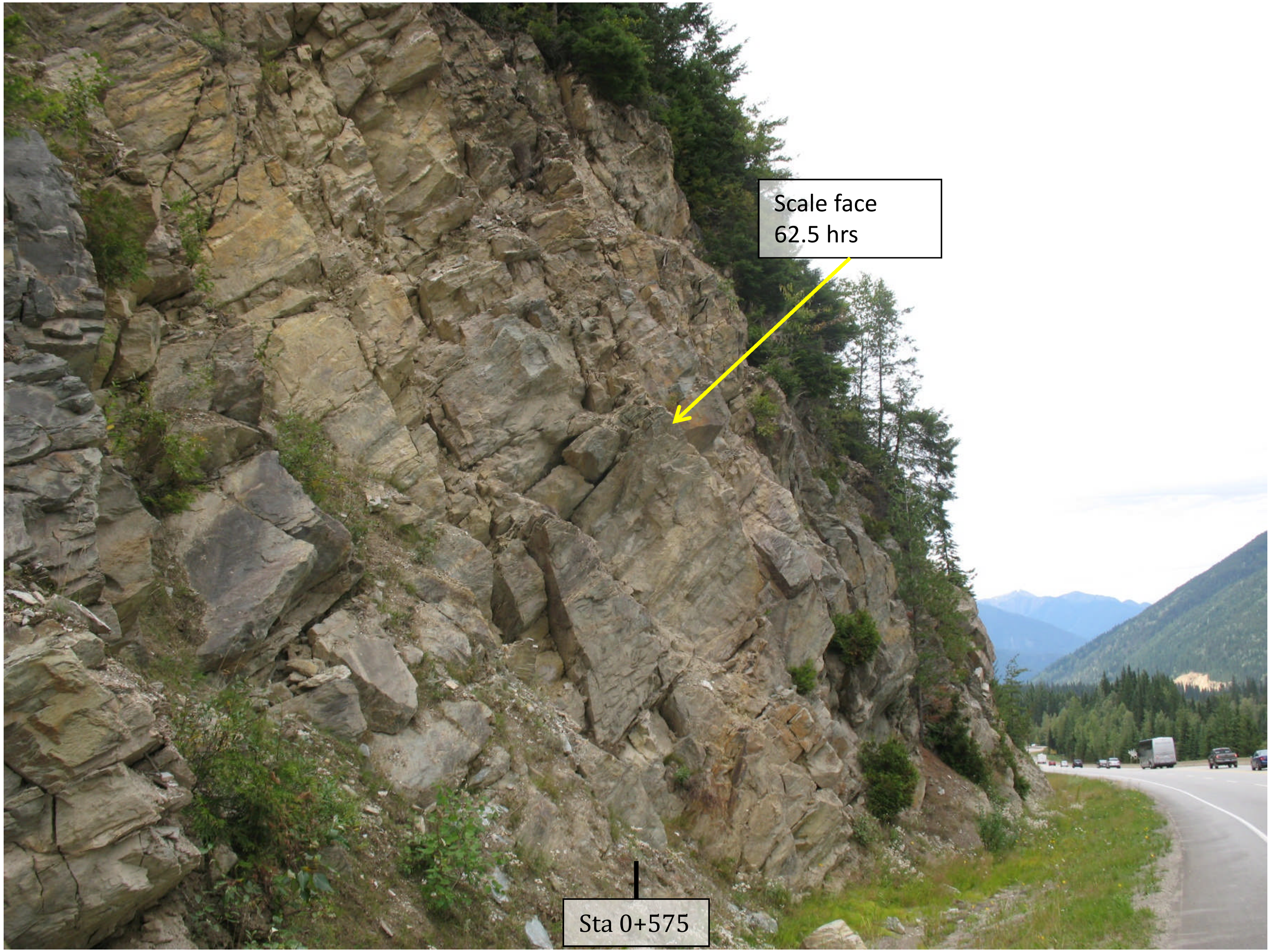

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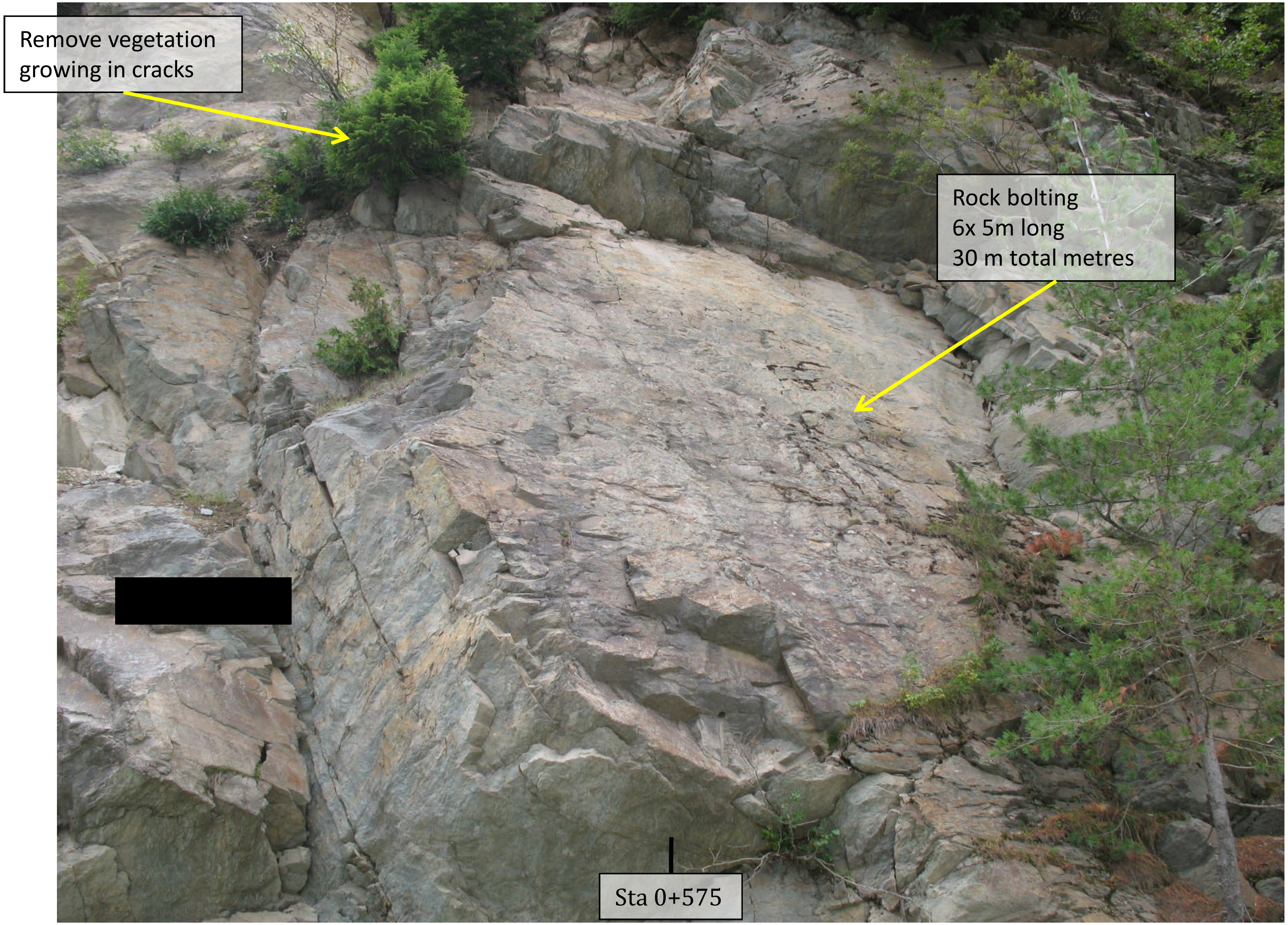

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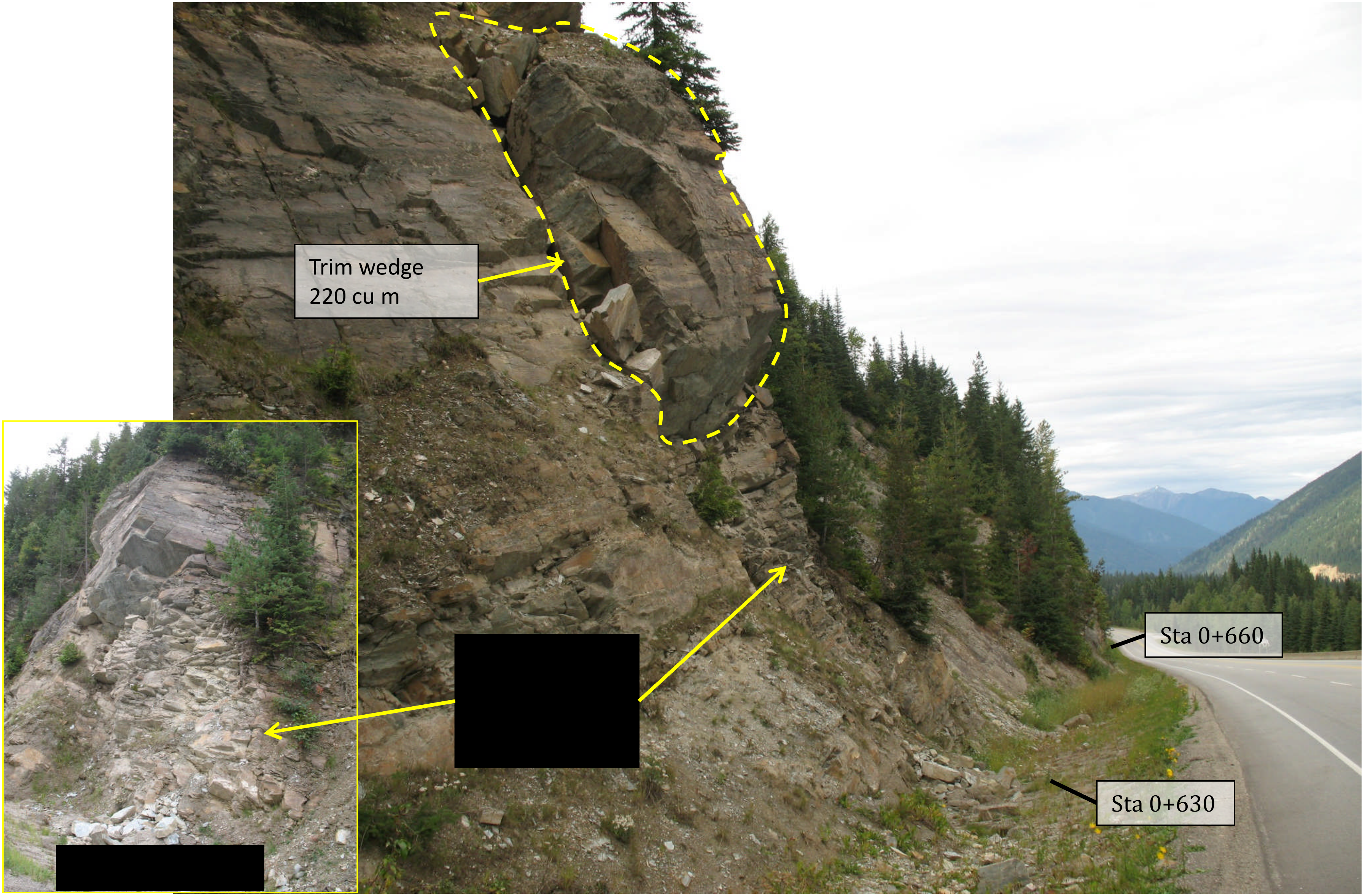

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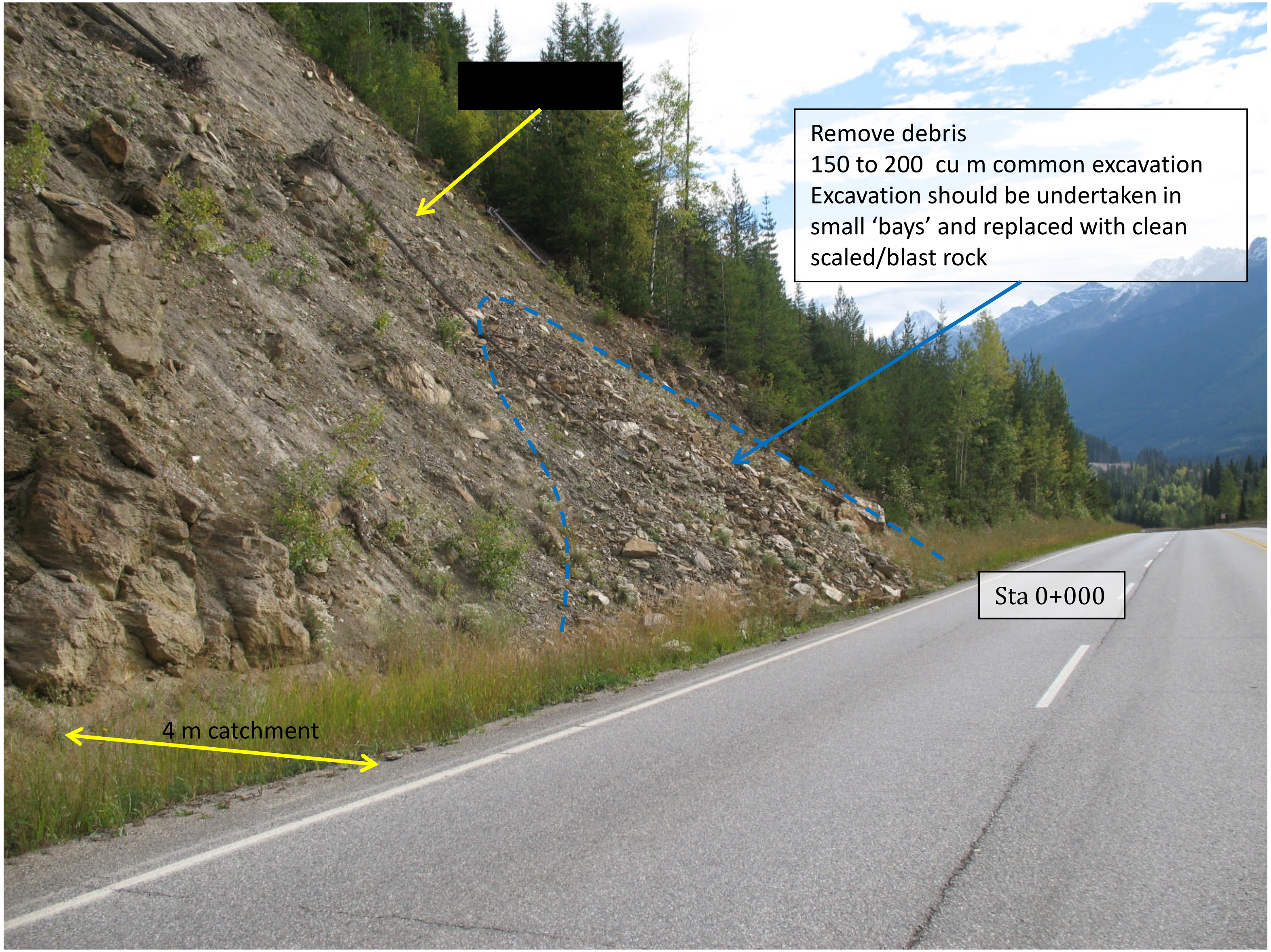

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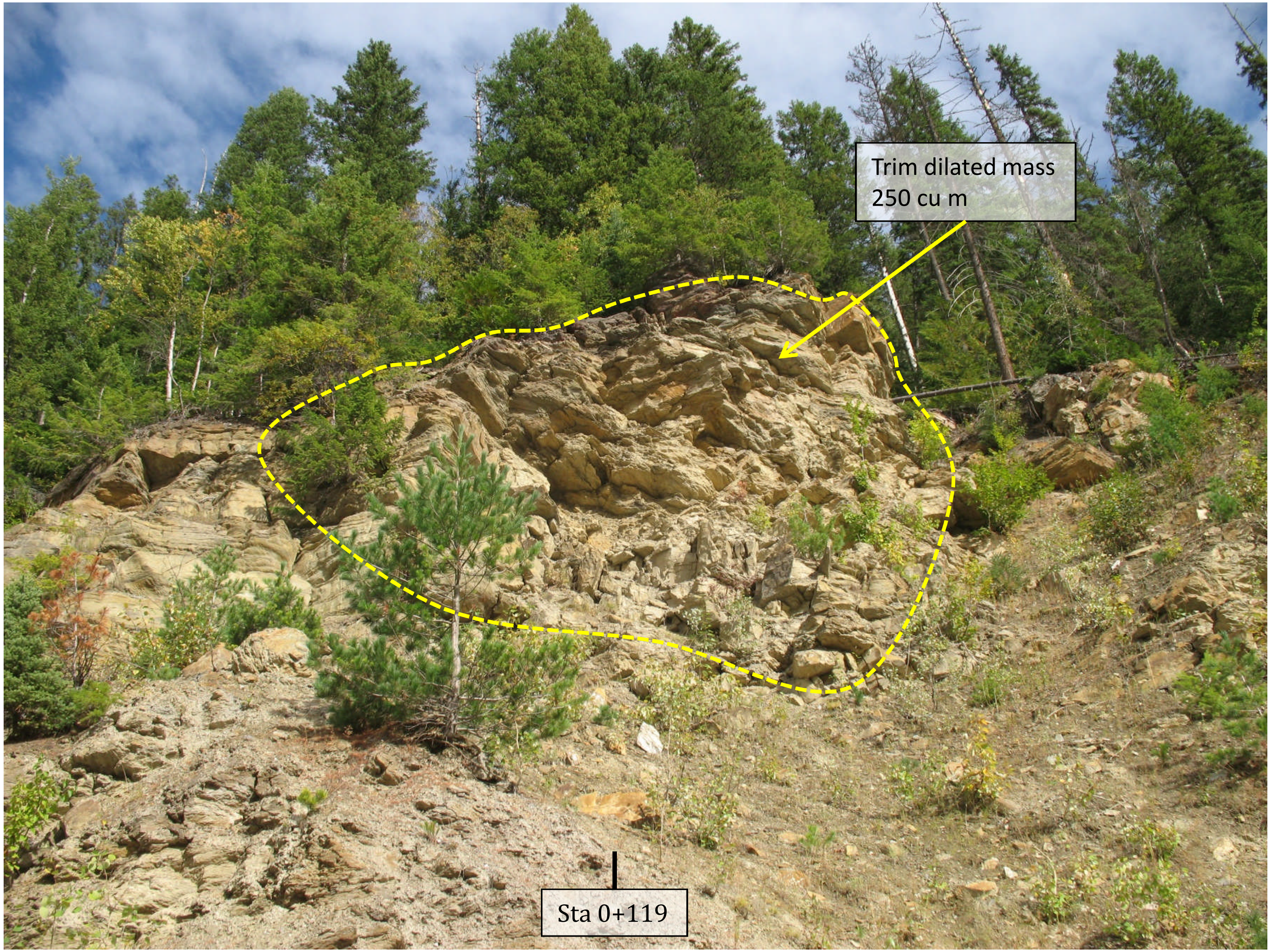

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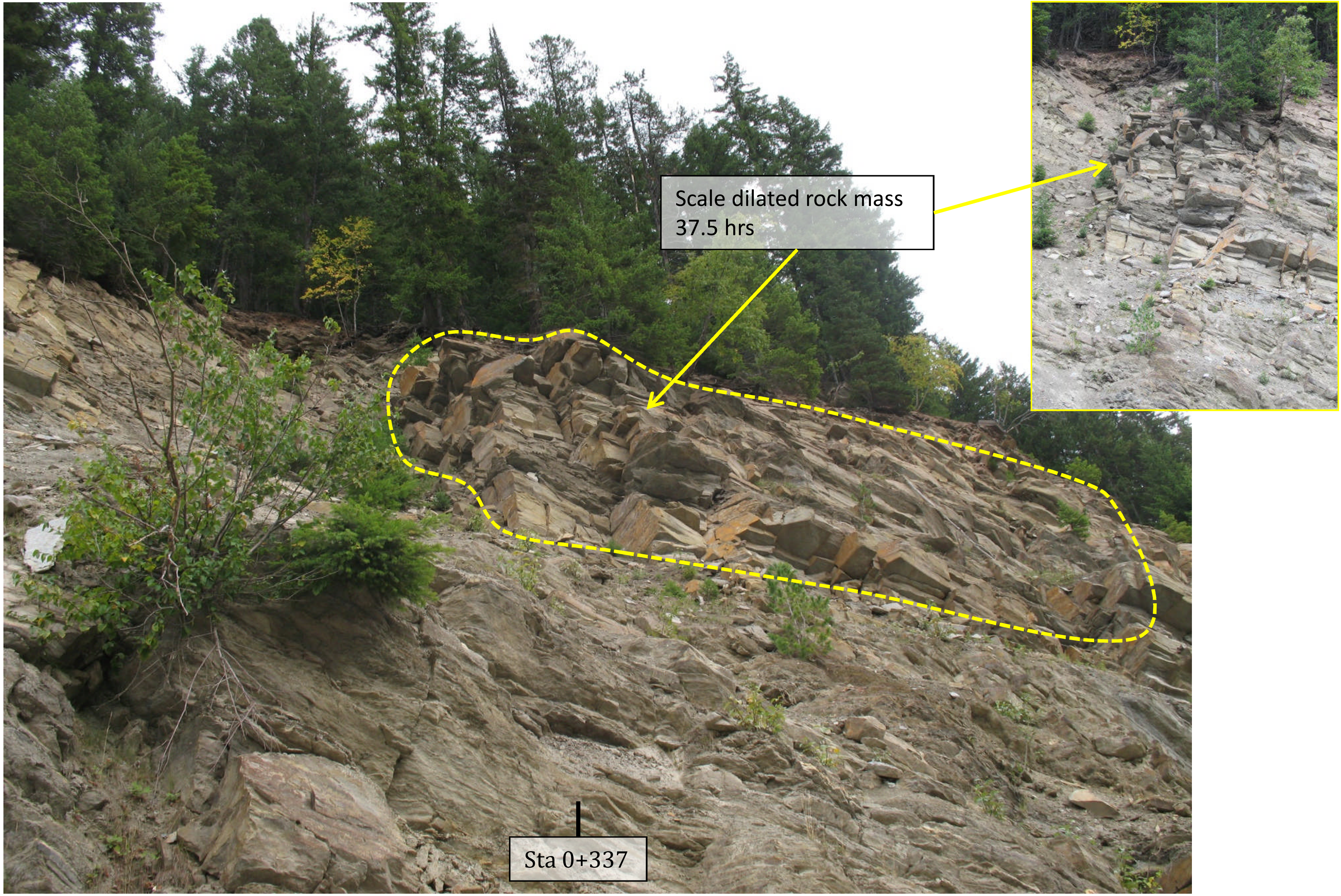

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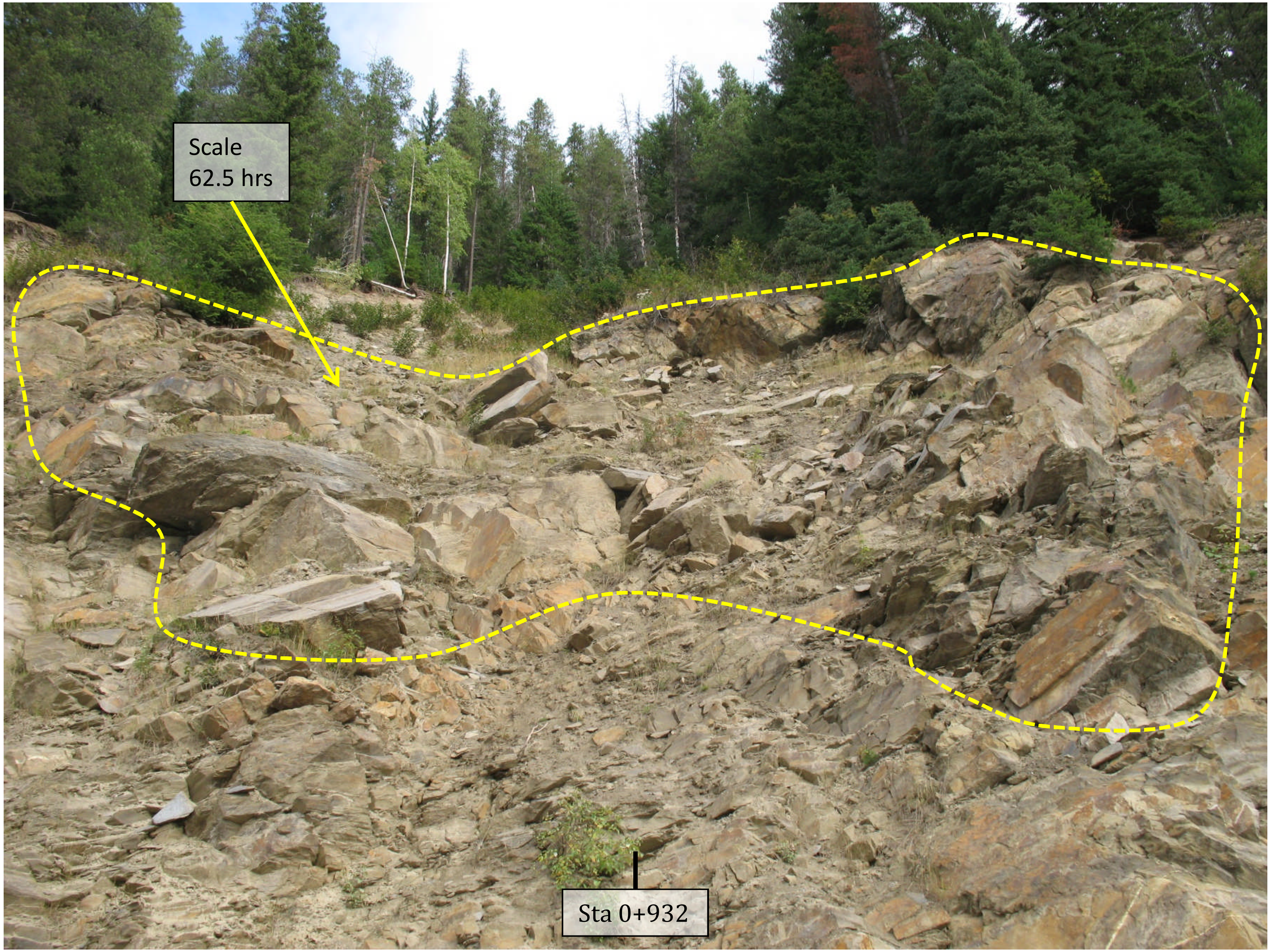

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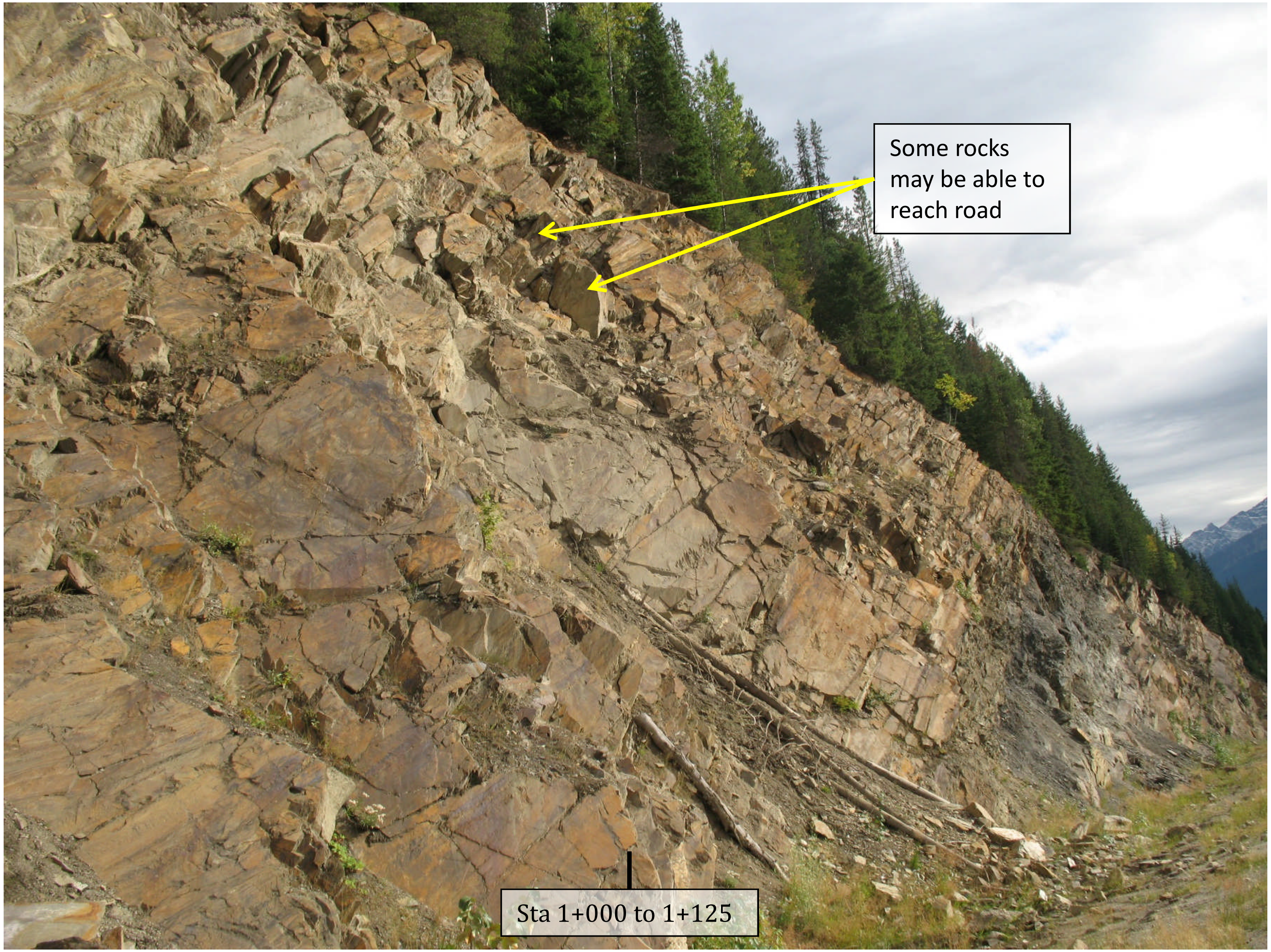

Photo Taken: September 21st, 2011

PARKS CANADA AGENCY

INSPECTION OF HIGH PRIORITY ROCK AND SOIL SLOPES
MOUNT REVELSTOKE NATIONAL PARK
TRANS CANADA HIGHWAY
MEADOWS IN THE SKY PARKWAY
NELS NELSEN ROAD

REPORT

NOVEMBER 2012
ISSUED FOR USE
EBA FILE: V33101078

creating & delivering | BETTER SOLUTIONS

A TETRA TECH COMPANY

LIMITATIONS OF REPORT

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EBA Engineering Consultants Ltd. operating as EBA, A Tetra Tech Company
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Vancouver, BC V6E 3X2 CANADA
p. 604.685.0275 f. 604.684.6241

EXECUTIVE SUMMARY

Parks Canada Agency (PCA) retained EBA Engineering Consultants Ltd. operating as EBA, A Tetra Tech Company (EBA) to undertake an inspection of high priority rock and soil slopes in Canada's National Parks in the Rocky Mountains. EBA visited Mount Revelstoke National Park on September 21, 2011.

The most recent remediation program in 2008 addressed some of the slopes along the TransCanada Highway (TCH) and Meadows in the Sky Parkway. EBA does not have any records of remedial work being undertaken on Nels Nelson Road. This report presents the findings of our inspections and prioritizes slope remediation based on this inspection.

The slope assessments in this report take into account various data when assessing the slope:

- Previous remediation programs,
- Kinematic assessment of the face,
- Other adjacent services/utilities.
- Highway geometry,
- Type of highway users, and

Based on these assessments the remediation strategies undertake simple yet effective practices of using or improving a catchment ditch, routine removal of loose material on the slopes (scaling), removal of deteriorating features (trim blasting), or installation of rock anchors or shotcrete to provide in situ support.

(Executive summary abbreviated for the purpose of the tender documents)

TABLE OF CONTENTS

APPENDICES

Appendix A Photomontages
Appendix B EBA's General Conditions

ACRONYMS & ABBREVIATIONS

MRNP	Mount Revelstoke National Park
TCH	Highway 1 – Trans Canada Highway
MITSP	Meadows in the Sky Parkway – Mount Revelstoke Road
NNR	Nels Neilson Road – Ski Jump Road
GNP	Glacier National Park
JNP	Jasper National Park
MHR	Miette Hotsprings Road
MCR	Maligne Canyon Road
IFP	Icefields Parkway – Highway 93N
BNP	Banff National Park
BVP	Bow Valley Parkway
YNP	Yoho National Park
ELR	Emerald Lake Road
YVR	Yoho Valley Road
ODoT	Oregon Department of Transportation Ditch Design Guidance
cu m	cubic metres
sq m	square metres
MoT	Ministry of Transportation – British Columbia Ministry of Transportation (BCMoT)
LHS	Left Hand Side
RHS	Right Hand Side

1.0 INTRODUCTION

At the request of Mr. Pierre Chambefort, P.Eng., of Parks Canada, EBA Engineering Consultants Ltd. operating as EBA, A Tetra Tech Company (EBA) re-inspected rock and soil cut slopes and natural slopes in Mount Revelstoke National Park (MRNP) along Highway 1 (TCH), Meadows in the Sky Parkway or Mount Revelstoke Road (MITSP) and Nels Nelsen Road or Ski Jump Road (NNR). These slopes had been rated high priority (class "A") by the BC Ministry of Transportation (MoT) in a November 2001 rock fall assessment report, or in some instances had been considered as a “B” or moderate priority during previous inspections by EBA.

The inspections are part of Parks Canada’s ongoing rock fall hazard management program. The purpose of the inspections is to provide detailed recommendations and cost estimates for necessary mitigation/stabilization work to reduce rock fall hazards. Recommendations are prioritized such that available funds can be directed where the most benefit (greatest hazard reduction) can be realized.

The most recent previous rock fall assessment along sections of Highway 1 through MRNP was performed by EBA in September 2006, report published in March 2007. The MoT inspected the slopes in November 2001, and previously by EBA in 1987 and 1979 – the original rock cut inventory published in the late 1970s.

EBA provided on site construction monitoring for a scaling program in 2008, for which a report was published in April 2009. The extent of remedial works or inspections between 1978 and 1986 is not known by EBA.

The inspection of the rock slopes was originally scheduled for May 2011, but was postponed by PCA until September 21 and 22, 2011, due elevated avalanche risks. The inspection was undertaken by Mr. Anders Frappell, B.Eng., FGS, and Mr. Charles Hunt, P.Eng., of EBA.

Slopes were visually assessed from the road level. Photographs and other documentation collected during the work are presented here in a format that may be adapted to form the basis of rock slope remediation contract documents. Appendix A contains photomontages for the proposed stabilization work can be found in Section 4.1 . Sections 3.1 to 3.3 of this report provide a description of the work. Technical specifications can be developed to meet the specific requirements of MRNP and its environmental assessment.

2.0 SLOPE LOCATION IDENTIFICATION

For rock cuts in MRNP, the TCH and MITSP used the intersection of MITSP with TCH as km 0.000; NNR used the intersection of MITSP and NNR as km 0.000.

The western park boundary is located some 16.6 km heading east along the TCH. We acknowledge that this is a break from the standard use of the western park boundary, but this keeps the chainage system the same as the most recent EBA reports for consistency.

The slope sections are either to the left or right of the highway relative to the direction of increasing distance.

The MoT used MoT segment number 975, which starts at Victoria Road in Revelstoke as km 0.000. This puts the MoT's slope reference system about 1.34 km further in terms of a chainage. Previously EBA used the eastern park boundary and measured distances west from this point in kilometres.

Minor discrepancies exist between the historical chainage systems and the ones used in this inspection program due to slight variations in the assumed starting point of each slope, accuracy of the vehicle odometers, and travelled paths.

3.0 RECOMMENDED REMEDIATION WORK OPTIONS IN MRNP

There are three roads within MRNP boundaries. The TCH follows the valley floor from the town of Revelstoke towards Albert Canyon. About 1.34 km east of Victoria Road in Revelstoke, MITSP meets with the TCH. About 600 m north of the MITSP/TCH intersection is the junction of NNR.

3.1 TransCanada Highway (TCH)

3.1.1 TCH – km 20.186 to 20.271 – (Not included)

3.1.2 TCH – km 22.40 to 22.827 – (Main Work Item and Prime Cost Item)

The eastern end of this rock face corresponds to km 22.40. The rock slope comprises quartz diorite over 25 m in height. Large wedges (> 200 cu m) have formed. There appears to be a fault running along the face at low levels. This does not appear to have overbearing properties on the structural integrity of the face. The quartz diorite deteriorates quite slowly and the 5 m wide ditch should contain most small failures.

EBA's site inspectors noted a large wedge at Sta 0+028. This wedge is starting to show signs of dilation. The wedge should be removed by trim blasting. Another wedge was noted at Sta 0+061. The base of this wedge has suffered historical blast damage. Trees are growing out of the back joint of the wedge, and eventually they will lever the block from the face. The ditch beneath this wedge is 4.75 m wide and is unlikely to contain the wedge if it was to fail as a single block.

At about Sta 0+085, a series of wedges appear detached. This area should be check/scaled.

As part of the prime cost item, at Sta 0+105, a large wedge should be trimmed. In the 2008 program, a trim was estimated to be ~100 cu m, but was increased to 175 cu m due to additional tension cracks identified during the drilling of the wedge.

At Sta 0+118, an overhanging wedge has started to detach from the back face. For a wedge to fail, two joints need to intersect, and at the time of inspection the second joint had not been identified. For this program, we suggest monitoring until the next inspection in 5 years. Alternatively, the wedge can be trimmed. We estimate that the wedge is 90 cu m.

Using the vegetation growing in the ditch as a guide, the frequency of rock fall seems to be fairly low; however, the size of the potential rock fall is large boulders. With this in mind, ditch cleaning/improvement will only create a small increase in protection of the highway. Hence, we have only allotted ~50 cu m for ditch improvement/cleaning.

Table 3.1.2 – TCH – km 22.40 to 22.827 (Main Work Item)

Type of work	Estimated quantity
Scaling (hrs)	25
Trim blasting (cu m)	140
Rock bolting (m)	50
Common excavation (cu m)	500

Table 3.1.3 – TCH – km 22.40 to 22.827 (Prime Cost Item)

Type of work	Estimated quantity
Trim blasting (cu m)	175

3.1.3 TCH – km 24.619 to 24.824 – (Main Work Item)

The eastern end of this slope corresponds to km 24.619. The rock slope is about 25 m high granodiorite with various cooling joints that have produced blocky rock and large wedges. Using the well-established vegetation in the ditch as guidance, this slope seems to have produced a fairly low amount of rock fall over the years.

The section of rock face between Sta 0+160 and Sta 0+205 should be scaled. It would be prudent to keep an allowance for blasting either on the face or boulder busting in the ditch.

The ditch can be improved by cleaning out the accumulation of winter gravel and other debris.

Table 3.1.3 – TCH – km 24.619 to 24.824

Type of work	Estimated quantity
Scaling (hrs)	75
Trim blasting (cu m)	30
Rock bolting (m)	nil
Common excavation (cu m)	150

3.1.4 TCH – km 24.824 to 24.949 – (Main Work Item)

The eastern end of this slope corresponds with the end of the previous slope and km 24.842. This slope is about 25 m in height and comprises mainly outwash material formed into talus fan. The silts and sands have been washed out from the face and have undermined larger boulders. These could roll down the slope, and the ditch at the base is unlikely to retain them. The ODoT guidance suggests that for a flat ditch the run out could be somewhere between 15 m and 24 m depending on how much material has washed into the ditch.

At the time of inspection the capacity of the ditch had significantly diminished since EBA's 2004 inspection report photographs. This ditch was almost filled to capacity with washout material and winter gravel. This should be reinstated as a priority. Between Sta 0+018 and Sta 0+034, there was a pond of water. If the pond exists at times of freeze/thaw, the formation of ice could damage the highway. A culvert or other cross highway drainage could not be located, so we recommend that drainage at this location should be improved.

At Sta 0+080, a few large trees have become undermined and when they fall could reach the road. These should be felled.

The slope will lend itself to washing finer material from the slope, which will then cause larger boulders to roll down the slope. Installing a concrete guardrail along the base of the slope would significantly reduce risk to the TCH.

Table 3.1.4 – TCH – km 24.619 to 24.824

Type of work	Estimated quantity
Scaling (hrs)	25
Trim blasting (cu m)	nil
Rock bolting (m)	nil
Common excavation (cu m)	320
Concrete guardrail (m)	240

3.1.5 TCH – km 24.949 to 25.109 – (Main Work Item)

The east end of this slope corresponds with the end of the previous slope and km 24.949. The slope comprises granodiorite in which large wedges formed as the igneous rock cooled. One of these large wedges has started to detach from the rock face and should be trimmed because the ditch is unlikely to contain rock mass failures of this size. The rock face is located on the inside of a curve.

Since the ditch is the primary protection against rock falls reaching the TCH, the catchment should be improved though removing the accumulation of organic material and winter gravel.

At the far end of this slope, rock boulders could be seen in the ditch. The source of these boulders could not be seen from TCH level. The slope where they could have originated is heavily vegetated (see photo24.949 d & f) and should undergo reconnaissance scaling.

Type of work	Estimated quantity
Scaling (hrs)	63
Trim blasting (cu m)	130
Rock bolting (m)	24
Common excavation (cu m)	240

3.2 Meadows in the Sky Parkway (MITSP) – (Not included)

3.2.1 MITSP – km 5.35 – (Not included)

3.2.2 MITSP – km 5.91 – (Not included)

3.2.3 MITSP – km 6.20 – (Not included)

3.2.4 MITSP – km 13.60 – (Not included

3.2.5 MITSP – km 14.35 – (Not included

3.2.6 MITSP – km 15.70 to 15.883 – (Not included)

3.2.7 MITSP – km 16.20 to 16.269 – (Not included)

3.2.8 MITSP – km 23.50 to 23.607 – (Not included)

3.3 Nels Nelsen Road (NNR) – (Not included)

3.3.1 NNR – km 0.000 to 0.167 – (Not included)

4.0 REMEDIATION COST ESTIMATE AND CONTRACT NOTES

4.1 Cost Estimate

The recommended stabilization work includes a mixture of necessary maintenance work and selective improvements in some areas. The recommendations were developed with due consideration that the available funds for the work may be limited. Recognizing that the recommended work may exceed the available funding, EBA has prioritized the recommendations (HI – highest priority, MED – medium priority, and LOW – lowest priority) to assist PCA in selecting work that will provide the best value within the available budget. Therefore, a stabilization program developed based on this report may not include all work described herein.

The main items of work include scaling, trimming, and common excavation. Rock bolting (dowels) is also suggested at a few locations. If there is a discrepancy between the quantities in the photomontages and the tables in this report, the tables should be considered correct as some of the slopes are quite large and it is difficult to collect accurate meaningful photos of each work item.

Table removed for tendering purposes

Although Table 4.1 has been broken down into cost estimates associated with each priority, it may not be feasible or cost effective to select only the high priority work items. Each slope should be selected on its own merits.

4.2 Specifications and Contract Notes

We would propose to use as a starting point the specifications used in the Kootenay National Park 2010 remediation program. These specifications can be tailored to the requirements of PCA's environmental assessment or other site (or Park) specific requirements.

Payment for scaling is based on hours worked, excluding mobilization time to the crest of each drop. EBA has endeavoured to carefully delineate on the photographs the key areas that require scaling to assist the contractor for pricing. However, an assessment will be made when the scaling crews are on the face. Note that excavation and disposal of material produced by scaling will be measured and paid separately as common excavation.

Payment for trimming is based on the bank volume (in place) of rock to be removed. Note that excavation and disposal of material produced by trimming will be measured and paid separately as common excavation. Blasting operations must be suitable for the individual rock cut constraint. Some of the rock cuts are far enough away from other environmental factors to allow the expertise of the blasting contractor's experience to design trim blasts. Other rock cuts may be close to sensitive concrete structures which may be adversely impacted by blasting. These rock cuts should have their blasts designed by a suitably qualified, experienced, blasting consultant.

Rock bolting (or dowels) is based on number of metres of tendon installed. As most of the cost of the rock bolt involves setting up the drilling equipment at a specific location. This means that discrete rock anchors would be more expensive than a number in an area that requires minimal movement from the drilling station. The contractor should be required to carry a stock of galvanized steel tendon in case locations are discovered post-scaling or blasting.

Common excavation will be measured to the nearest cubic metre as the bulked volume of material produced by scaling and trimming, as well as any material excavated from the ditch or lower portions of the slope within reach of an excavator. The specifications mandate the use of an excavator or gradall for common excavation since, in most areas, a front-end loader cannot properly clean and shape the ditch to maximize its catchment effectiveness.

As disposal is included in the common excavation unit price, the contract documents must identify the location of suitable disposal site(s) and the approximate capacity of these site(s). Placement and grading requirements for each disposal site should also be clearly identified. The tender documents should also identify disposal sites for brush, trees, and organic materials.

5.0 CLOSURE

This report has been prepared for the exclusive use of Parks Canada and their authorized agents. Recommendations presented herein are based on the review of available information and the field investigation and analyses carried out by EBA. The conditions indicated in this report are considered to provide a reasonable representation of the site geotechnical characteristics. However, variations in conditions at specific locations may be encountered during rock slope stabilization and may necessitate site-specific revisions to the recommendations presented. If such variations are encountered, EBA should be notified and given the opportunity to review whether our recommendations are still appropriate.

Rock fall mitigation work recommended and summarized in this report is to reduce and control the rock fall and geohazard risk to a level of "as low as reasonably practical" or ALARP, as the risk cannot be eliminated together. The main reason the risk cannot be eliminated altogether is that rock faces are surfaces exposed to long-term deterioration caused by factors such as weathering, tree roots, rain, freeze-thaw effects, and animal disturbance. They are therefore dynamic structures where a fixed or set rate of deterioration is not appropriate. Furthermore, and equally dynamic in terms of the rate of deterioration are the support measures that have been installed on rock face in MRNP over the last 40 years. These support measures vary in terms of type, quality of installation, and life expectancy. For example, rock bolt life expectancy depends on the thickness of the bolt, the aggressivity of the groundwater around the bolt, corrosion protection, and the quality of installation. Therefore, there is considerable variation with respect to the environmental, geomechanical and support life expectancy at any given location. Notwithstanding the fact that the risk from rock fall and geohazards cannot be eliminated altogether, EBA contends that by adopting the recommendations in this report, the risk will be reduced to an acceptable level, despite the continuing potential for rock fall.

Recommendations presented in this report are based on engineering judgement and have been prepared in accordance with generally accepted rock slope engineering practices. The recommendations are intended to provide practical and economic stabilization measures with a reasonable balance between cost and reduction of the rock fall hazard. Use of this report is subject to the attached General Conditions in Appendix B.

We trust that this report meets Parks Canada's present requirements. We will be pleased to provide any further assistance that may be needed during detailed design and construction of the remedial works.

Please contact our office if you require additional information.

Respectfully submitted,
EBA Engineering Consultants Ltd.

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REFERENCES

ODoT (2001) Oregon Department of Transportation "**Rockfall Catchment Area Design Guide**". L. A. Pierson., C. F. Gullixson, C. E. G., R. G. Chassie, P. E. http://www.oregon.gov/ODOT/TD/TP_RES/docs/Reports/RockfallReportEng.pdf?ga=t

APPENDIX A

APPENDIX A PHOTOMONTAGES

APPENDIX B

APPENDIX B EBA'S GENERAL CONDITIONS

PARKS CANADA AGENCY

INSPECTION OF HIGH PRIORITY ROCK AND SOIL SLOPES GLACIER NATIONAL PARK TRANSCANADA HIGHWAY

REPORT

NOVEMBER 2012
ISSUED FOR USE
EBA FILE: V33101078

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LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of Parks Canada Agency and their agents. EBA Engineering Consultants Ltd. does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than Parks Canada Agency, or for any Project other than at the subject site. Any such unauthorized use of this report is at the sole risk of the user. Use of this report is subject to the terms and conditions stated in EBA's Services Agreement. EBA's General Conditions are provided in Appendix B of this report.

EXECUTIVE SUMMARY

Parks Canada Agency (PCA) retained EBA Engineering Consultants Ltd. operating as EBA, A Tetra Tech Company (EBA) to undertake an inspection of high priority rock and soil slopes in Canada's National Parks in the Rocky Mountains. EBA visited Glacier National Park on September 21, 2011.

The most recent remediation program in Glacier National Park was in the summer of 2008, which addressed selected areas on some slopes along the TransCanada Highway. This report presents the findings of our inspections and prioritizes slope remediation based on this inspection.

The slope assessments in this report take into account various data when assessing the slope:

- Previous remediation programs,
- Kinematic assessment of the face,
- Other adjacent services/utilities.
- Highway geometry,
- Type of highway users, and

Based on these assessments the remediation strategies undertake simple yet effective practices of using or improving a catchment ditch, routine removal of loose material on the slopes (scaling), removal of deteriorating features (trim blasting), or installation of rock anchors or shotcrete to provide in situ support.

(Executive summary abbreviated for the purpose of the tender documents)

TABLE OF CONTENTS

ACRONYMS & ABBREVIATIONS

GNP	Glacier National Park
TCH	Highway 1 – Trans Canada Highway
JNP	Jasper National Park
MHR	Miette Hotsprings Road
MCR	Maligne Canyon Road
IFP	Icefields Parkway – Highway 93N
BNP	Banff National Park
BVP	Bow Valley Parkway
MRNP	Mount Revelstoke National Park
MSP	Meadows in the Sky Parkway
NNR	Nels Neilson Road
YNP	Yoho National Park
ELR	Emerald Lake Road
YVR	Yoho Valley Road
ODoT	Oregon Department of Transportation Ditch Design Guidance
cu m	cubic metres
sq m	square metres
MoT	Ministry of Transportation – British Columbia Ministry of Transportation (BCMoT)
LHS	Left Hand Side
RHS	Right Hand Side

1.0 INTRODUCTION

At the request of Mr. Pierre Chambefort, P.Eng., of Parks Canada, EBA Engineering Consultants Ltd. operating as EBA, A Tetra Tech Company (EBA) re-inspected rock and soil cut slopes and natural slopes in Glacier National Park (GNP) along Highway 1 (TCH). These slopes had been rated high priority (class "A") by the BC Ministry of Transportation (MoT) in a November 2001 rock fall assessment report, or in some instances had been considered as a "B" or moderate priority during previous inspections by EBA.

The inspections are part of Parks Canada's ongoing rock fall hazard management program. The purpose of the inspections is to provide detailed recommendations and cost estimates for necessary mitigation or stabilization work to reduce rock fall hazards. Recommendations are prioritized such that available funds can be directed where the most benefit (greatest hazard reduction) can be realized.

Before the 2011 inspection, the most recent rock fall assessment along sections of the TCH through GNP was performed by EBA in March 2006, with an addendum in February 2007. MoT inspected the slopes in October 2001; EBA conducted inspections in June 2002 and October 1996, and completed the original rock cut inventory published in 1978.

EBA provided on site construction monitoring for a scaling program in 2008, for which a report was published in April 2009. The previous remediation program possibly undertaken in 1992 comprised just over 2,000 man hours scaling.

The extent of remedial works or inspections between 1978 and 1992 is not known by EBA.

The inspection of the rock slopes was originally scheduled for May 2011, but was postponed by PCA until September 21 and 22, 2011, due elevated avalanche risks. The inspection was undertaken by Mr. Anders Frappell, B.Eng., FGS and Mr. Charles Hunt, P.Eng. of EBA.

Slopes were visually assessed from the road level. Photographs and other documentation collected during the work are presented here in a format that may be adapted to form the basis of rock slope remediation contract documents. Appendix A contains photomontages and a Unit Price Table for the proposed stabilization work can be found in Section 4.1. Sections 3.1 to 3.6 of this report provide a description of the work. Technical specifications can be developed to meet the specific requirements of GNP and its environmental assessment. Assessment of the Eastgate Landslide or the debris flow to the south of the dormant Heather Hill landslide (September 2010) were not part of the scope of this inspection.

2.0 SLOPE LOCATION IDENTIFICATION

For rock cuts in GNP along the TCH, the western park boundary was designated as km 0.000, and distances were measured to the east from this point, to the west end of each rock cut. The slope sections are either to the left or right of the highway relative to the direction of increasing distance.

Prior to 2001, locations of individual rock slopes along TCH through GNP were identified in Parks Canada's Rock Cut Inventory (RCI) as kilometres (and miles) east of the western boundary of GNP.

Minor discrepancies exist between the historical chainage systems and the ones used in this inspection program due to slight variations in the assumed starting point of each slope, accuracy of the vehicle odometers, and travelled paths.

3.0 RECOMMENDED REMEDIATION WORK OPTIONS IN GNP

The TCH follows the valley floor between various mountains in GNP. Various locations have been protected from avalanche, debris, and rock fall risks by concrete avalanche structures. The six slopes comprise a mixture of cut and natural slopes. A few of the slopes have had concrete guardrails installed near the highway to reduce the risk of rock fall rolling onto the TCH. This method has provided excellent protection. As an example, in the spring of 2010, a 10+ cu m block fell from the face and rolled towards the highway; judging by the deflection in the barriers and the impact marks, the guardrails were successful in retaining the block in the ditch.

3.1 TransCanada Highway – km 17.543 to 17.858 (Main Work Item)

The southern end of this slope corresponds to km 17.543. The slope is located after a right-angled curve in the highway. The slope is a mixture of cut and natural slope comprising phyllite/slatey rock rising to a height of about 10 to 15 m above highway level. The orientation of the discontinuities tends to produce a topping failure. There is a natural overburden slope above the main rock face. Immature plants and shrubs have established themselves, providing some interceptor cover from rain and adding to the general stability of the soil due to the root mat. The thicker brush also will resist minor rock falls.

At Sta 0+060, a large wedge has started to detach from the main face. If this failed as a mass, the ditch would be unlikely to contain the volume of material. This wedge should be removed by trim blasting. A recent failure, thought to be in 2010, requires check scaling to determine whether additional material could be released in the near future. These items are not currently high priority, but will increase in priority with time.

Surface water runoff has created a few scour channels in the accumulation of winter gravel found in the ditch. When the ditch undergoes improvement, care should be taken to avoid undermining the shoulder of the highway.

Table 3.1 – TCH – km 17.543 to 17.858

Type of work	Estimated quantity
Scaling (hrs)	75
Trim blasting (cu m)	50
Rock bolting (m)	nil
Common excavation (cu m)	400

3.2 TransCanada Highway – km 28.523 to 28.715 (Not included)

3.3 TransCanada Highway – km 30.861 to 31.521 (L) – Beaver Hill (Main Work Item)

The southern end of this rock slope corresponds with km 30.861. This slope is at the start of a decline into the valley and is over 660 m in length. This slope is a mix of phyllite and competent bands of sandstone dipping into the face, bisected by orthogonal joints. The predominant failure mechanism is relaxation of phyllite at lower elevations on the face. This has a knock-on relaxation effect further up the slope destabilizing other blocks. Based on historical photos and the size and number of blocks in the ditch, the slope appears to be deteriorating at a fairly fast rate, releasing boulders. A large pull out, which motorists frequently use as a viewing point, is located on the opposite side of the TCH. A section of concrete guardrail has been installed on the opposite side of the TCH. On the far side of this guardrail is a wide section of fairly level ground which is currently covered in winter gravel.

The ditch varies between 3 m wide and 6 m wide. Even at 6 m wide, the ODoT ditch design guidance shows that nearly all the impact locations would project further than the ditch, and the ditch may only contain about 60% of the blocks if they roll from the upper portions of the slope. With this in mind, we recommend a concrete guardrail should be installed over the full length of the rock slope.

A number of undesirable features located on this rock slope should be remediated.

At Sta ~0+050, 0+080, and 0+380, promontories of rock which becoming dilated as the rock beneath relaxes. These are not a high priority in the short term but will increase in priority with time. If either of these were to fail, even with concrete guardrail installed, the ditch would be unlikely to contain this volume of fallen material.

At Sta 0+112, using photos taken in the 2008 scaling program, we can determine large boulders have come to rest on the slope. These should be removed by scaling. At Sta 0+140, a rock fall has removed a block that was being supported as a keystone resisting planar failures above. EBA's engineers noted four additional rock bolts installed at this location (see photos 30.861 h, i & j). Since the rock bolts appear to be installed as dowels (acting in shear), a relatively small amount of movement could crack the grout, which would leave the ungalvanized steel tendon prone to preferential corrosion. With this in mind, we recommend that the rock bolts should be replaced with 25 mm diameter (about twice the diameter) galvanized rock bolts that should have a working life of 50 to 60 years.

At Sta 0+175, there is another gulley. Vegetation has become established on ledges and in cracks. This will eventually destabilize the rock face, and if the trees become large enough, they could fall and block the TCH in some years to come.

At Sta 0+405, a large pillar of rock has become particularly dilated (see photo 30.861n & o). The dilation will continue due to natural weathering processes (freeze-thaw cycles, root leverage, rain, and general dissolution of rock) until the pillar fails. The pillar is likely to fail as a mass in a catastrophic event and has sufficient material to cover all lanes of the TCH. This pillar should be removed by trim blasting.

At Sta 0+630, there is a competent pillar of sandstone resting on top of thinly bedded sandstone and phyllite. The pillar has become detached on two sides. The mass of the pillar has started to cause the rock beneath to fracture (fail) under its own mass. The smaller blocks have ravelled from below the competent block reducing the cross-sectional area, and as the mass of the competent block remains about the same, the rate of failure will increase proportional to the rate of deterioration of the mass below. This block should be removed by trim blasting. If this block fails, it would likely reach the road.

A permanent rock fall risk reduction strategy would be to realign the highway away from the toe of the slope. On the opposite side of the TCH is a fairly level portion of ground. This could be used for twinning/upgrade as well as reducing the risk of rock falls reaching the TCH (see photo 30.861x).

Type of work	Estimated quantity
Scaling (hrs)	350
Trim blasting (cu m)	200 (photo 30.861b) 80 (photo 30.861e) 50 (photo 30.861m) 250 (photo 30.861o) 20 (photo 30.861q) 220 (photo 30.861v)
Trim blasting total	820
Rock bolting (m)	46
Common excavation (cu m)	1,520 (including all trim blasts)
Concrete guardrail installation (m)	660

3.4 TransCanada Highway – km 34.741 to 35.475 (Not included)

3.5 TransCanada Highway – km 36.197 to 36.747 (Not included

3.6 TransCanada Highway – km 42.432 to 43.828 – Heather Hill – (Main Work Item)

The south end of this slope corresponds to km 42.432. This slope is over 1.4 km in length; since meaningful overview photographs would be difficult to capture while maintaining a reasonable viewpoint, we have included salient features only. The first 200 m of the slope is located in the toe of the dormant Heather Hill landslide. The remainder of the slope comprises competent sandstone beds dipping into the face bisected by orthogonal joints and occasional fault zones at acute angles. The ditch beneath the rock face undulated between 4 and 6 m in width, locally larger at some of the curves in the highway.

Between Sta 0+012 and 0+032, a debris fan has started to encroach on the highway; as much of this material should be removed without destabilizing the slope above. If this removal was undertaken in small bays, perhaps a couple of excavator bucket widths, the material could be replaced with scaled or blast rock, which would have a higher angle of repose while keeping mass at the toe of the slope. In addition, this would also keep the toe free draining (see photo 42.432a).

The slope has many large boulders in the debris comprising the toe of Heather Hill Landslide (see photo 42.432f). Some of these boulders are round enough to roll down the face and past the ditch onto the TCH. Rocks above large cobble size should be removed by scaling (see photos 43.432b & c). The larger trees should be felled to remove the hazard of falling trees. The root balls should be left in place as these will provide some stability to the slope for a few years. Eventually, the root balls will rot and fail, but this should be picked up in a future inspection.

Various areas on the rock face would greatly benefit from scaling, but if small 'pockets' of the face are scaled, this could drive up the scaling cost because mobilization time could be a significant percentage of the work hours. The access trails to the crest could be quite long. With this in mind, we have increased the time at each location, being mindful that scaling the face may be of medium priority on the whole, but will reduce the high hazard areas as well.

(Text abbreviated from original report)

On the opposite side of the road, a section of bin walls does not show any signs that raise concern about its stability. The galvanized steel has corroded in a couple of locations, and one of the horizontal supports has been punched through (see photo 42.432s). No remedial work is recommended at this time, but the bin walls should be inspected as part of future rock slope inspections.

Table 3.6 – TCH – km 42.432 to 43.828

Type of work	Estimated quantity
Scaling (hrs)	100
Trim blasting (cu m)	250
Rock bolting (m)	nil
Common excavation (cu m)	400

4.0 REMEDIATION COST ESTIMATE AND CONTRACT NOTES

4.1 Cost Estimate

The recommended stabilization work includes a mixture of necessary maintenance work and selective improvements in some areas. The recommendations were developed with due consideration that the available funds for the work may be limited. Recognizing that the recommended work may exceed the available funding, EBA has prioritized the recommendations (HI – highest priority, MED – medium priority, and LOW – lowest priority) to assist PCA in selecting work that will provide the best value within the available budget. Therefore, a stabilization program developed based on this report may not include all work described herein.

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Respectfully submitted,
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REFERENCES

ODoT (2001) Oregon Department of Transportation "**Rockfall Catchment Area Design Guide**". L. A. Pierson., C. F. Gullixson, C. E. G., R. G. Chassie, P. E. http://www.oregon.gov/ODOT/TD/TP_RES/docs/Reports/RockfallReportEng.pdf?ga=t

APPENDIX A

APPENDIX A PHOTOMONTAGES

APPENDIX B

APPENDIX B EBA'S GENERAL CONDITIONS