



REPORT

Geotechnical Assessment of Shotcrete on Access Road Rock Cuts

QEW Widening from West of Mississauga Road to West of Hurontario Street, Mississauga, Ministry of Transportation, Ontario, GWP 2002-13-00

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PART A

FOUNDATION INVESTIGATION REPORT
GEOTECHNICAL ASSESSMENT OF SHOTCRETE ON ACCESS ROAD ROCK
CUTS
QEW WIDENING FROM WEST OF MISSISSAUGA ROAD TO WEST OF
HURONTARIO STREET, CITY OF MISSISSAUGA
MINISTRY OF TRANSPORTATION, ONTARIO
GWP 2002-13-00

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by Morrison Hershfield Limited (MH) on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the proposed twinning of the existing bridge carrying the Queen Elizabeth Way (QEW) over the Credit River in the City of Mississauga, in the Regional Municipality of Peel, Ontario. The new bridge would carry the Hamilton bound traffic of the QEW over the Credit River and is being constructed in support of the widening of the QEW from west of Mississauga Road to west of Hurontario Street.

It is our understanding that MTO intend to repurpose the existing temporary access road that was constructed to access the underside of the existing bridge structure, to create a new multi-purpose recreational pathway. The purpose of this assignment is to visually assess the existing shotcrete on the temporary access road rock cuts to determine if remedial work is required to ensure the rock faces are stable over the design life of the new pathway.

The scope of work for the shotcrete investigation is outlined in the approved Change Request letter dated January 29, 2018, which forms part of the Consultant's Assignment Number (2015-E-0033) for this project. The work has been carried out in accordance with Golder's Supplementary Specialty Plan for foundation engineering services for this project, dated February 3, 2017.

2.0 SITE DESCRIPTION

The existing QEW Credit River Bridge is located approximately 400 m east of the QEW-Mississauga Road Interchange and approximately 1.4 km west of the QEW-Hurontario Street Interchange and crosses the Credit River Valley over the floodplain and river channel (refer to Figure 1).

The existing bridge is an approximately 256 m long and 29 m wide, seven-span structure with concrete arches at the piers supporting six lanes of traffic. The Credit River Valley is about 19 m below the surrounding plateau. The existing bridge is supported on two abutments and six piers. The piers and abutments are supported on shallow foundations.

At the west side of the valley, on the north side of the existing bridge, a construction access road was built in 2011 and this access road was cut through the shale bedrock and shotcrete was applied to the exposed rock faces. The access road splits into an upper access road (which leads to the under-bridge maintenance deck) and a lower access road (which extends down to the base of the valley). The upper access road runs parallel to the west abutment and the surface of the road is at about Elevation 89 m. Above the upper access road, shotcrete was applied to the rock face. The downslope side of the upper access road is supported by a concrete block retaining wall which protects the lower access road beneath the existing Credit River bridge. The access road(s) were cut through the west valley slope and constructed to provide access to the underside of the existing bridge and the valley floor. The west valley slopes (between the abutment and access roads) descend near vertically to meet the flood plain of the Credit River Valley. The west plateau is relatively flat, but less densely vegetated than the east plateau, consisting mainly of tall grass and some shrubs.

The proposed bridge will be located immediately to the north of the existing bridge. The land use at the east and west plateau of the valley, north of the proposed bridge is residential. A Hydro One Right-of-Way, containing high voltage transmission lines and local utility owned transmission lines, is located within the footprint of the proposed bridge and crosses the Credit River Valley just north of the existing bridge. Additionally, two buried oil pipelines, owned by Trans Northern Pipeline Inc. are located immediately to the north of the existing bridge and within the footprint of the proposed bridge.

3.0 ASSESSMENT PROCEDURES

The field work for this assignment consisted of visual mapping of the shotcrete condition including information on any cracks, spalling, hollow or 'drummy' areas, as well as notes on any groundwater seepage. The mapping of the shotcrete wall was carried out by a two-person team from Golder's office in Mississauga. The observations during the mapping have been annotated on to photo-mosaics (see Figures 2 to 31) which summarize location, length and width of the cracks in the shotcrete or other types of deterioration, the location and extent of any seepage of groundwater from the shotcrete face, and observations of the ditch area at the toe of the faces for evidence of ponding of water which would indicate that the drainage may not be operating as intended.

Numerical analysis using the finite element program RS2 (developed by RocScience) was carried out to examine the impact of traffic loading from the new traffic lanes on the existing shotcrete wall.

4.0 GEOLOGY

4.1 Regional Geology

The project area is located within the Iroquois Plain physiographic region, as delineated in *The Physiography of Southern Ontario* (Chapman and Putman, 1984)¹.

The glacial Iroquois Plain stretches along the northern shoreline of Lake Ontario, extending from the Niagara Escarpment in the west to the Scarborough Bluffs in the east. The Iroquois Plain soils consist of glaciolacustrine sediments deposited in Lake Iroquois, primarily sands, silts and gravels, with a shallow cover of till remaining over the bedrock.

The bedrock of the Georgian Bay Formation that underlies the study area consists mainly of blue-grey shale, containing siltstone, sandstone and limestone interbeds. Outcrops of this formation are commonly found along water courses on the west side of Toronto and in Mississauga, notably in the Humber River, Mimico Creek, Etobicoke Creek and Credit River valleys.

4.2 Site Geology and Bedrock Conditions

In general, the bedrock surface in the area of the proposed bridge replacement slopes relatively steeply downwards towards the river, on either side of the valley. At the locations of the boreholes drilled at the west and east sides of the river in the valley, and on the upper east valley plateau, the bedrock surface appears to be relatively flat. At the upper west valley plateau, the shallow bedrock surface is more undulating than elsewhere on the site, which may be due to previous development including installation of the buried or overhead infrastructure present on the site or the construction of the shotcrete wall or existing Credit River Bridge.

Based on a review of the bedrock core samples from the current investigation and descriptions of the bedrock from the previous investigation, the bedrock consists of shale of the Georgian Bay Formation. In general, the bedrock samples are described as an upper completely to moderately weathered shale above a slightly weathered to fresh, thinly laminated to medium bedded, fine grained, non-porous to faintly porous, very weak to weak, grey, shale with strong limestone interbeds at varying intervals of depth.

¹ Chapman, L.J. and Putman, D.F., 1984, *The Physiography of Southern Ontario*, Ontario Geological Society, Special Volume 2, Third Edition. Accompanied by Map p. 2715, Scale 1:600,000.)

5.0 ROCK CUT STABILIZATION MEASURES DURING CONSTRUCTION

The rock reinforcement installed on the rock cuts in 2011, during the original construction of the access road, consisted of 25 mm diameter rock bolts on a 1.8 m spacing pattern with 15 mm diameter reinforcing bars running horizontally and vertically between bolts and a 100 mm thick layer of shotcrete reinforced with welded wire mesh. Vertical drainage board strips, 300 mm wide, were installed approximately every 3.6 m behind the shotcrete. There is an existing ditch at the base of the shotcrete wall on the north side of the access; however, the base of shotcrete wall on south side meets the access road.

6.0 RESULTS OF SHOTCRETE INSPECTION

The results of the mapping of the shotcrete facing are shown on Figures 2 to 31. In general, the shotcrete extends from the road level up to the crest of the rock cuts and is in good condition with no evidence of honeycombing, pop-outs, or significant spalling. There were numerous cracks ranging in size from hairline cracks to 4 mm wide cracks, with a few cracks greater than 4 mm (up to 10 mm wide), however, the majority of the cracks are less than 2 mm in width. Seepage was also noted from many of the cracks and efflorescence deposits were noted along the cracks at some locations. Based on the sounding of the shotcrete facing in accessible areas (i.e. reachable on foot) the majority of the shotcrete appears to be well bonded to the rock face; however, some hollow or 'drummy' areas were noted and these are shown on Figures 2 to 31.

7.0 CLOSURE

This report was prepared by Mr. Mark Telesnicki, P.Eng., a Principal with Golder. Ms. Sandra McGaghran, P.Eng. a senior geotechnical engineer and Associate, conducted a technical review of the report and Mr. Paul Dittrich, P.Eng., a MTO Foundations Designated Contact and Principal of Golder conducted a quality control review of the report.

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PART B

FOUNDATION DESIGN REPORT
GEOTECHNICAL ASSESSMENT OF SHOTCRETE ON ACCESS ROAD ROCK
CUTS
QEW WIDENING FROM WEST OF MISSISSAUGA ROAD TO WEST OF
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8.0 GEOTECHNICAL ENGINEERING ASSESSMENT AND ANALYSIS

Based on the 'Issued For Review' design drawings provided by Morrison Hershfield dated May 23, 2018, the proposed West Abutment for the new bridge structure will be founded slightly below the upper access road level. Considering that the abutment footing will be below the upper road level, there will not be any adverse loading on the shotcrete wall from the new bridge abutment.

Analysis using the RS2 finite element code was carried out to examine the impact of traffic loading on the existing shotcrete along the south side of the access road (i.e. the side closest to the QEW). The new traffic lanes were assumed to be approximately 5 m from the south side of the access road and the analysis was carried out for the highest rock cut location which is approximately 9 m. Based on the results of the analysis, there would not be any adverse traffic loading on the shotcrete layer that would affect the shotcrete performance.

The results of the analyses indicate that the shotcrete is not required to act as a structural element to resist loading from the bridge or highway traffic. As such, the primary purpose of the shotcrete would be to mitigate weathering and erosion of the shale rock cuts and prevent rockfalls from reaching the pathway and thereby creating a rockfall hazard for the public.

9.0 REMEDIAL OPTIONS

Based on the field assessment (mapping and sounding of the shotcrete) there are no areas along the access road rock cuts that require major repairs or replacement of the existing shotcrete. Consequently, the following remedial options can be considered:

Option 1 - Do Nothing: this option would involve leaving the shotcrete covered rock cut faces as is and inspecting them every 5 years to monitor the development and/or progression of any cracking and any other new deterioration of the shotcrete facings. This option carries very little risk of a significant rockfall endangering the public considering that the mesh is fairly heavily reinforced with welded wire mesh and 15 mm rebar such that any large pieces of shotcrete that might become detached from the rock face should be retained on the face until they can be safely removed, provided the area is visually inspected and routine maintenance carried out at least every 5 years.

Option 2 – Additional Shotcrete Layer: this option would involve applying a second layer of 50 mm thick (minimum) shotcrete to the existing shotcrete wall to cover any existing cracks and increase the overall thickness to 150 mm. In order to secure the new shotcrete to the existing face it is recommended that a layer of welded wire mesh be secured to the existing shotcrete surface with 300 mm long anchor pins on a 1.8 m spacing pattern (equally spaced between the existing bolts). The existing drainholes would need to be extended out past the new shotcrete layer so that they continue to drain any groundwater seepage.

10.0 RECOMMENDATIONS

Considering that the existing shotcrete is still in fair to good condition and that it has been in place for approximately 7 years, it is recommended that 'Option 1 - Do Nothing' be adopted and that the shotcrete walls be regularly inspected (i.e. at least every 5 years) by a qualified rock mechanics/geological engineer. If at some point in the future, the shotcrete does show signs of significant deterioration, it is likely that selective repairs (application of additional shotcrete) can be easily carried out and only for the areas that require it.

11.0 CLOSURE

This report was prepared by Mr. Mark Telesnicki, P.Eng., a Principal with Golder. Ms. Sandra McGaghran, P.Eng. a senior geotechnical engineer and Associate, conducted a technical review of the report and Mr. Paul Dittrich, Ph.D., P.Eng., a MTO Foundations Designated Contact and Principal of Golder conducted a quality control review of the report.

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[https://golderassociates.sharepoint.com/sites/11176g/shared documents/07-reporting/foundations/4 - shotcrete assessment/3 - final/1662333 rpt qew credit river bridge shotcrete assessment 23july2018_fidr.docx](https://golderassociates.sharepoint.com/sites/11176g/shared%20documents/07-reporting/foundations/4%20-%20shotcrete%20assessment/3%20-%20final/1662333%20rpt%20qew%20credit%20river%20bridge%20shotcrete%20assessment%2023july2018_fidr.docx)

FIGURES



LEGEND



REFERENCE(S)

1. IMAGERY: SOURCES: ESRI, HERE, DELORME, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), SWISSTOPO, MAPMYINDIA, © OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY

CLIENT

MORRISON HERSHFIELD LIMITED

PROJECT

QEW WIDENING FROM WEST OF MISSISSAUGA ROAD TO WEST OF HURONTARIO STREET, GWP 2002-13-00

TITLE

SITE PLAN

CONSULTANT



GOLDER

YYYY-MM-DD 2018-07-20

DESIGNED SO

PREPARED SO

REVIEWED MT

APPROVED

PROJECT NO.
1662333

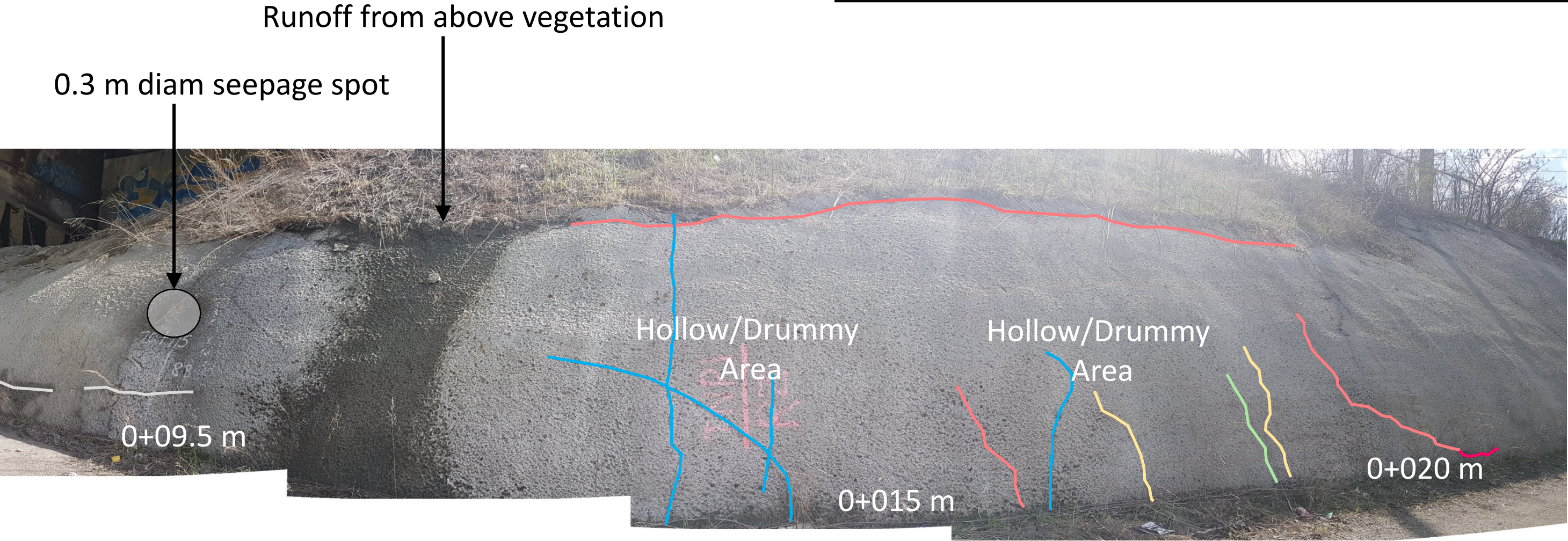
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FIGURE
1

SUMMARY OF SHOTCRETE MAPPING
South Face
Chainage: 0+000 to 0+020

FIGURE 2



Mapping Colour		Description
		Seeping partial crack, no aperture observed
Dry	Seeping	Healed/Infilled Discontinuity, seeping, <1-2 mm
Dry	Seeping	Aperture <1 mm, Dry or Seeping
Dry	Seeping	Aperture 1-2 mm, Dry or Seeping
Dry	Seeping	Aperture 2-3 mm, Dry or Seeping
Dry	Seeping	Aperture 3-4 mm, Dry or Seeping
Dry	Seeping	Aperture >4 mm, Dry or Seeping

Note: Chainage 0 m at Existing Bridge

SUMMARY OF SHOTCRETE MAPPING
South Face
Chainage: 0+020 to 0+035

FIGURE 3

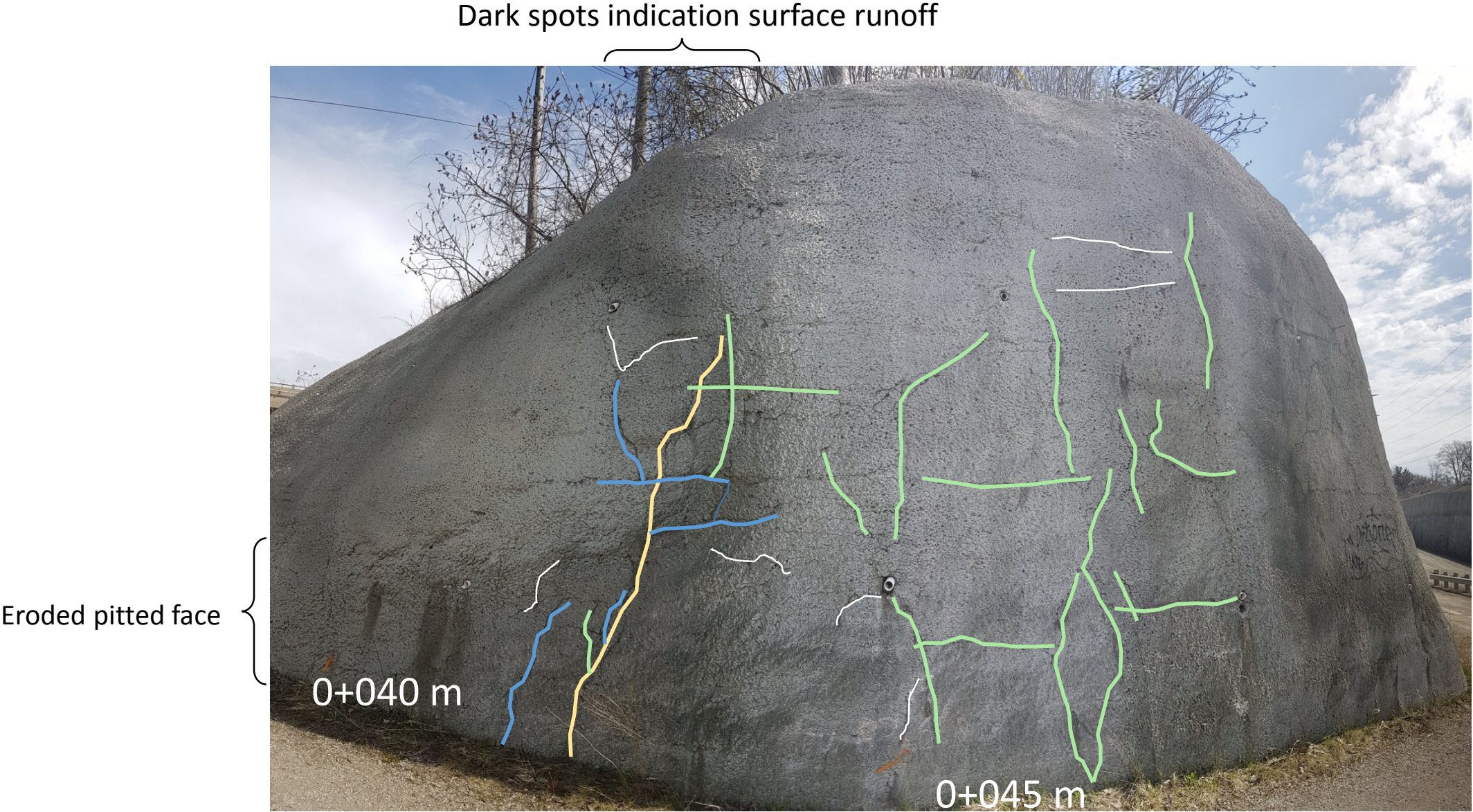


Mapping Colour		Description
		Seeping partial crack, no aperture observed
Dry	Seeping	Healed/Infilled Discontinuity, seeping, <1-2 mm
Dry	Seeping	Aperture <1 mm, Dry or Seeping
Dry	Seeping	Aperture 1-2 mm, Dry or Seeping
Dry	Seeping	Aperture 2-3 mm, Dry or Seeping
Dry	Seeping	Aperture 3-4 mm, Dry or Seeping
Dry	Seeping	Aperture >4 mm, Dry or Seeping

Note: Chainage 0 m at Existing Bridge

SUMMARY OF SHOTCRETE MAPPING
South Face
Chainage: 0+040 to 0+050

FIGURE 4

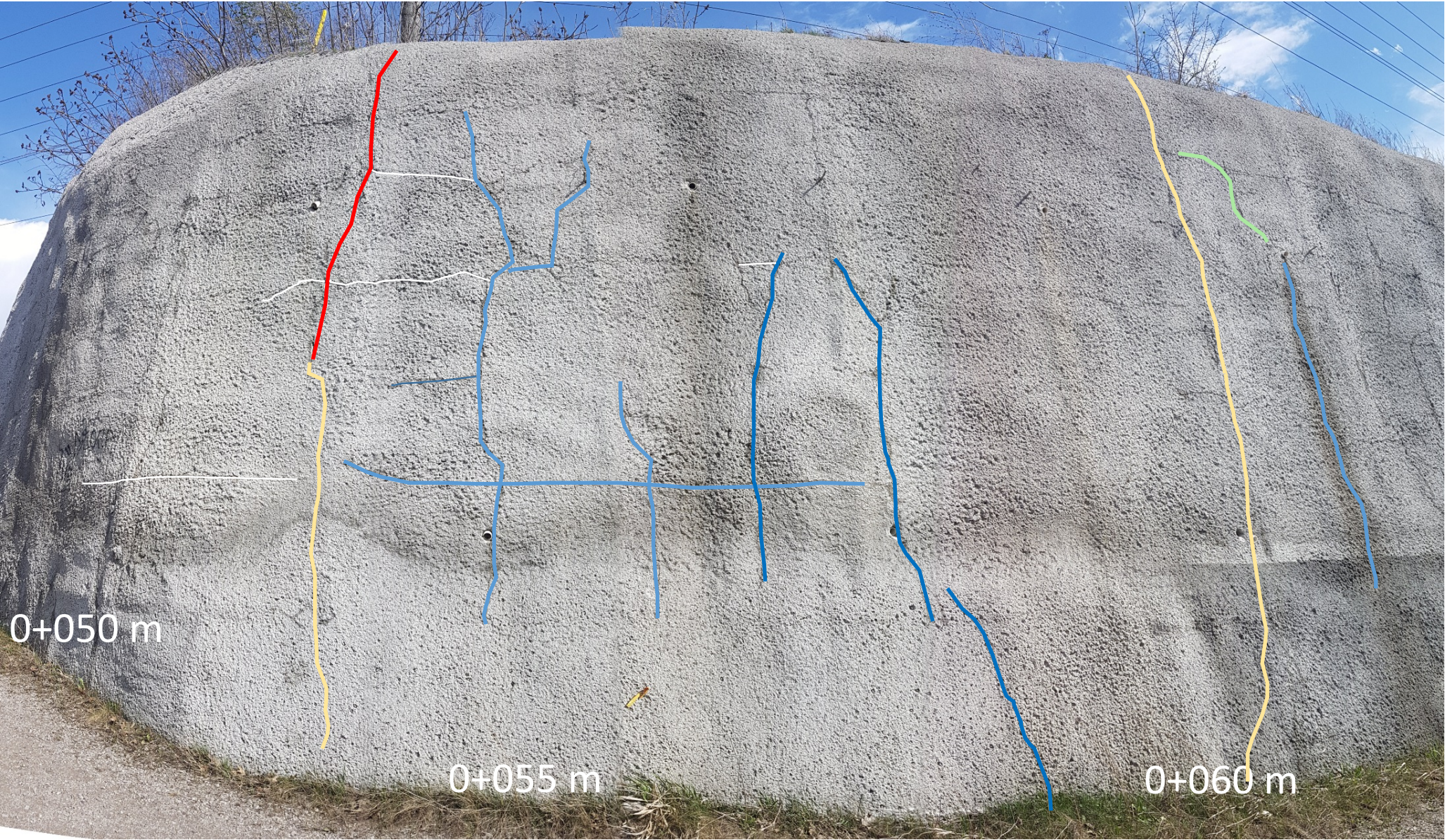


Mapping Colour		Description
		Seeping partial crack, no aperture observed
Dry	Seeping	Healed/Infilled Discontinuity, seeping, <1-2 mm
Dry	Seeping	Aperture <1 mm, Dry or Seeping
Dry	Seeping	Aperture 1-2 mm, Dry or Seeping
Dry	Seeping	Aperture 2-3 mm, Dry or Seeping
Dry	Seeping	Aperture 3-4 mm, Dry or Seeping
Dry	Seeping	Aperture >4 mm, Dry or Seeping

Note: Chainage 0 m at Existing Bridge

SUMMARY OF SHOTCRETE MAPPING
South Face
Chainage: 0+050 to 0+065

FIGURE 5



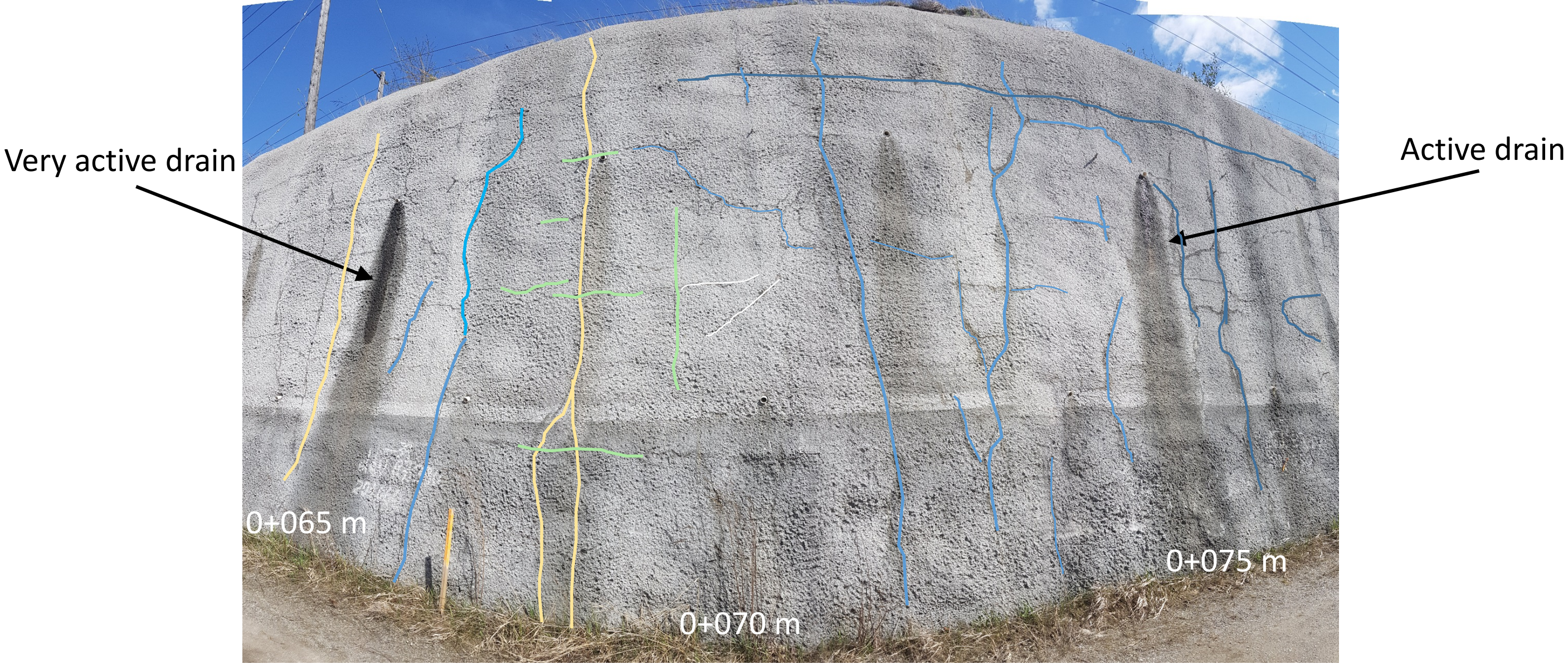
Mapping Colour		Description
		Seeping partial crack, no aperture observed
Dry	Seeping	Healed/Infilled Discontinuity, seeping, <1-2 mm
Dry	Seeping	Aperture <1 mm, Dry or Seeping
Dry	Seeping	Aperture 1-2 mm, Dry or Seeping
Dry	Seeping	Aperture 2-3 mm, Dry or Seeping
Dry	Seeping	Aperture 3-4 mm, Dry or Seeping
Dry	Seeping	Aperture >4 mm, Dry or Seeping

Note: Chainage 0 m at Existing Bridge



SUMMARY OF SHOTCRETE MAPPING
South Face
Chainage: 0+065 to 0+075

FIGURE 6



Mapping Colour		Description
		Seeping partial crack, no aperture observed
Dry	Seeping	Healed/Infilled Discontinuity, seeping, <1-2 mm
Dry	Seeping	Aperture <1 mm, Dry or Seeping
Dry	Seeping	Aperture 1-2 mm, Dry or Seeping
Dry	Seeping	Aperture 2-3 mm, Dry or Seeping
Dry	Seeping	Aperture 3-4 mm, Dry or Seeping
Dry	Seeping	Aperture >4 mm, Dry or Seeping

Note: Chainage 0 m at Existing Bridge

SUMMARY OF SHOTCRETE MAPPING
South Face
Chainage: 0+075 to 0+085

FIGURE 7

Active drain,
some isolated
erosion on face
below drain

Active drain

Active drain

Active drain



Hollow/Drummy
Area

0+075 m

0+080 m

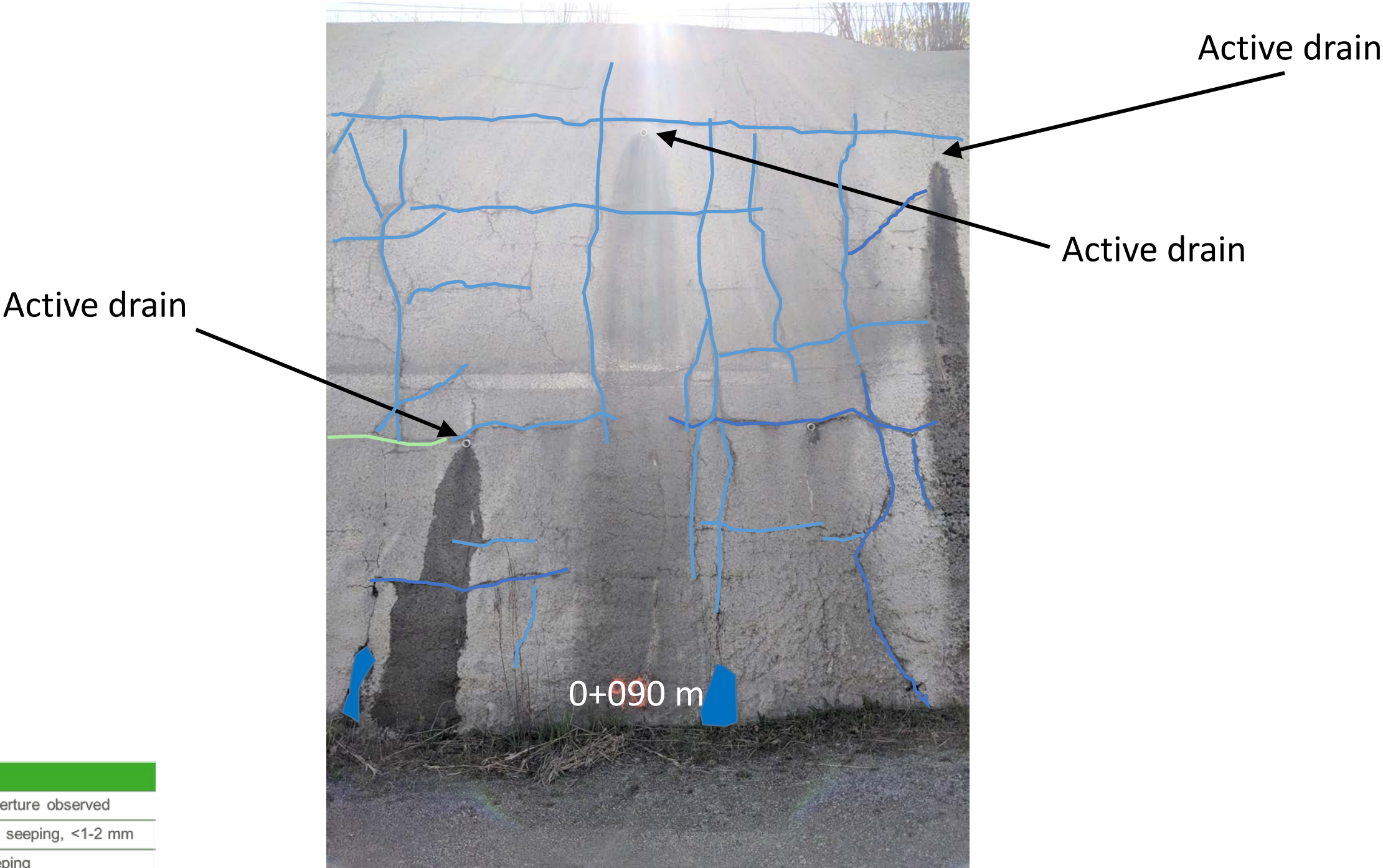
0+085 m

Mapping Colour		Description
		Seeping partial crack, no aperture observed
Dry	Seeping	Healed/Infilled Discontinuity, seeping, <1-2 mm
Dry	Seeping	Aperture <1 mm, Dry or Seeping
Dry	Seeping	Aperture 1-2 mm, Dry or Seeping
Dry	Seeping	Aperture 2-3 mm, Dry or Seeping
Dry	Seeping	Aperture 3-4 mm, Dry or Seeping
Dry	Seeping	Aperture >4 mm, Dry or Seeping

Note: Chainage 0 m at Existing Bridge

SUMMARY OF SHOTCRETE MAPPING
South Face
Chainage: 0+085 to 0+095

FIGURE 8

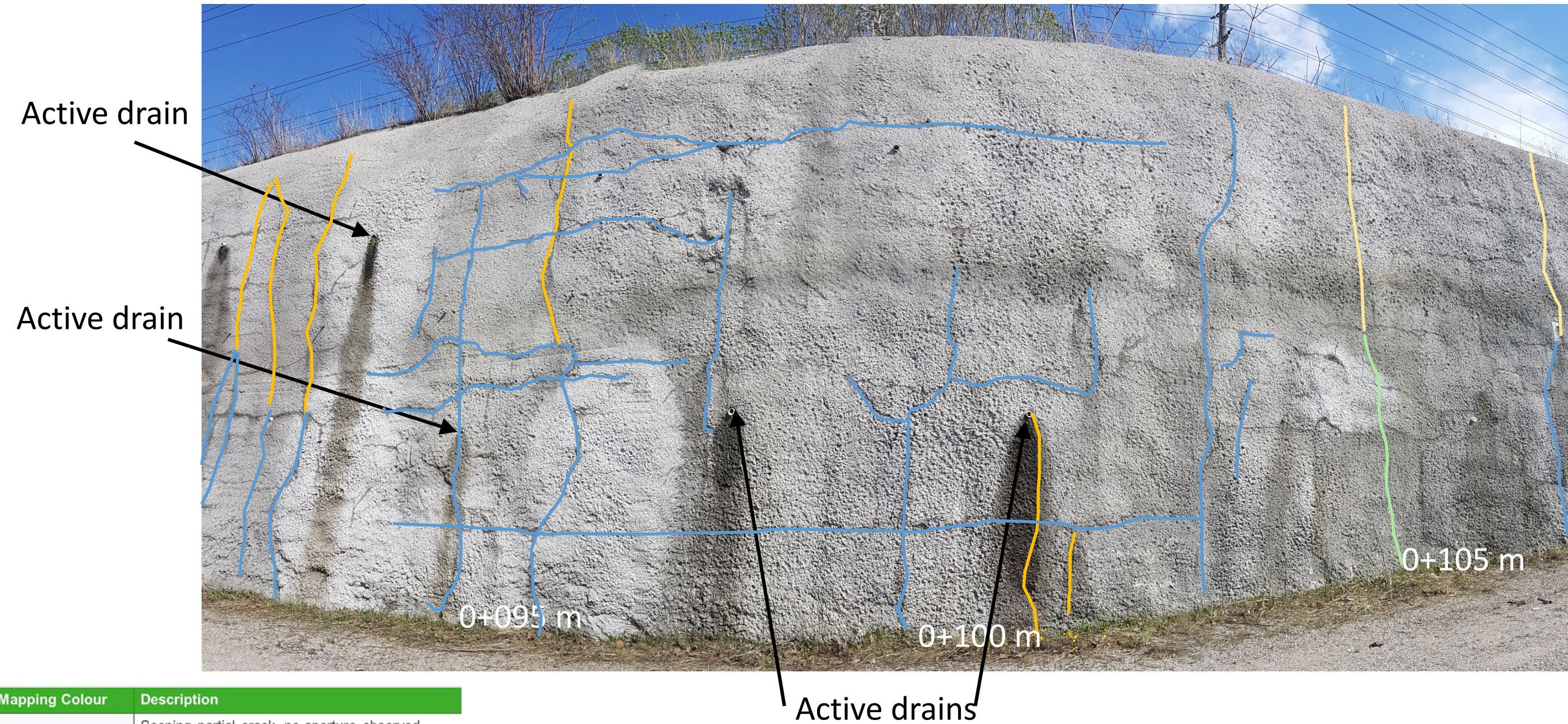


Mapping Colour		Description
		Seeping partial crack, no aperture observed
Dry	Seeping	Healed/Infilled Discontinuity, seeping, <1-2 mm
Dry	Seeping	Aperture <1 mm, Dry or Seeping
Dry	Seeping	Aperture 1-2 mm, Dry or Seeping
Dry	Seeping	Aperture 2-3 mm, Dry or Seeping
Dry	Seeping	Aperture 3-4 mm, Dry or Seeping
Dry	Seeping	Aperture >4 mm, Dry or Seeping

Note: Chainage 0 m at Existing Bridge

SUMMARY OF SHOTCRETE MAPPING
South Face
Chainage: 0+095 to 0+105

FIGURE 9



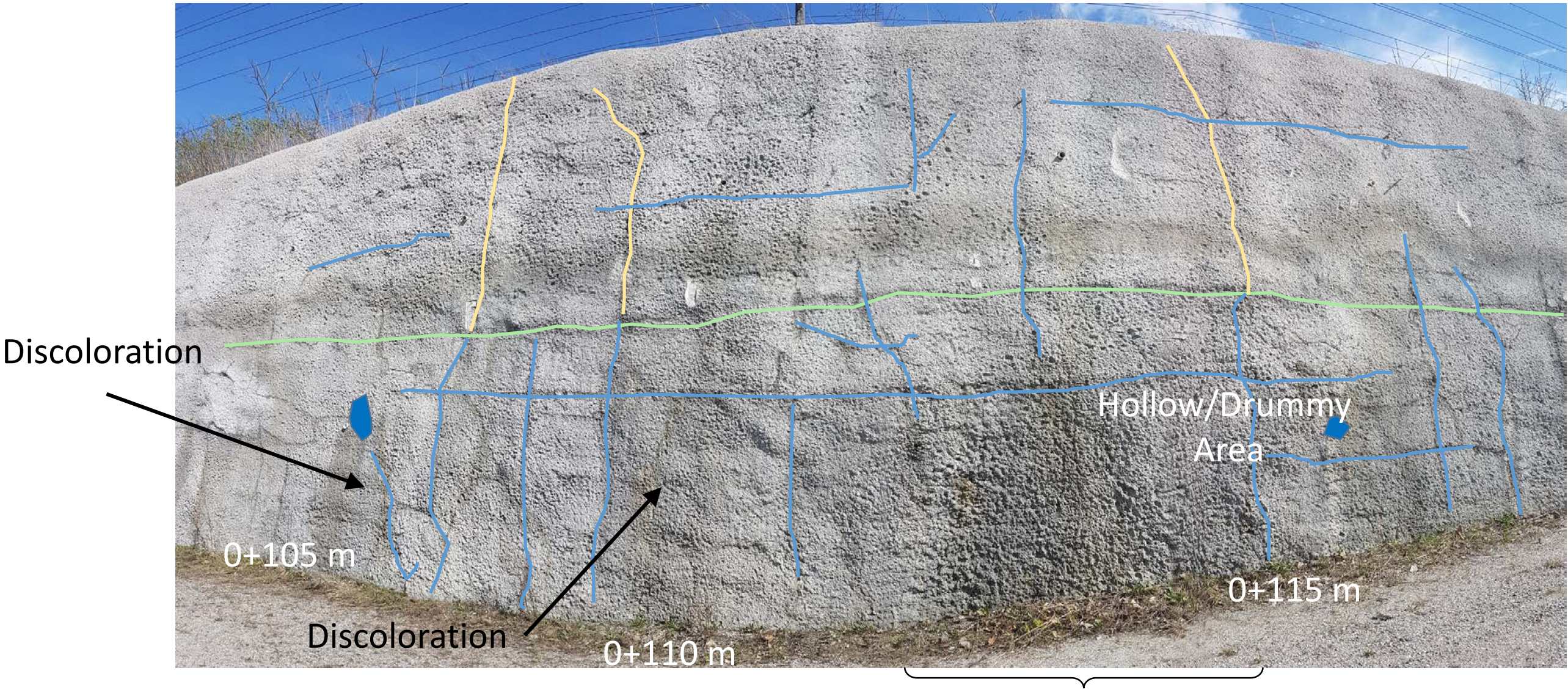
Mapping Colour		Description
		Seeping partial crack, no aperture observed
Dry	Seeping	Healed/Infilled Discontinuity, seeping, <1-2 mm
Dry	Seeping	Aperture <1 mm, Dry or Seeping
Dry	Seeping	Aperture 1-2 mm, Dry or Seeping
Dry	Seeping	Aperture 2-3 mm, Dry or Seeping
Dry	Seeping	Aperture 3-4 mm, Dry or Seeping
Dry	Seeping	Aperture >4 mm, Dry or Seeping

Note: Chainage 0 m at Existing Bridge

SUMMARY OF SHOTCRETE MAPPING
South Face
Chainage: 0+105 to 0+115

FIGURE 10

Some horizontal fractures, healed to 1 mm aperture, 1-3 m in length



Mapping Colour		Description
		Seeping partial crack, no aperture observed
Dry	Seeping	Healed/Infilled Discontinuity, seeping, <1-2 mm
Dry	Seeping	Aperture <1 mm, Dry or Seeping
Dry	Seeping	Aperture 1-2 mm, Dry or Seeping
Dry	Seeping	Aperture 2-3 mm, Dry or Seeping
Dry	Seeping	Aperture 3-4 mm, Dry or Seeping
Dry	Seeping	Aperture >4 mm, Dry or Seeping

Eroded face, possible seepage from crack above

Note: Chainage 0 m at Existing Bridge

SUMMARY OF SHOTCRETE MAPPING
South Face
Chainage: 0+115 to 0+130

FIGURE 11

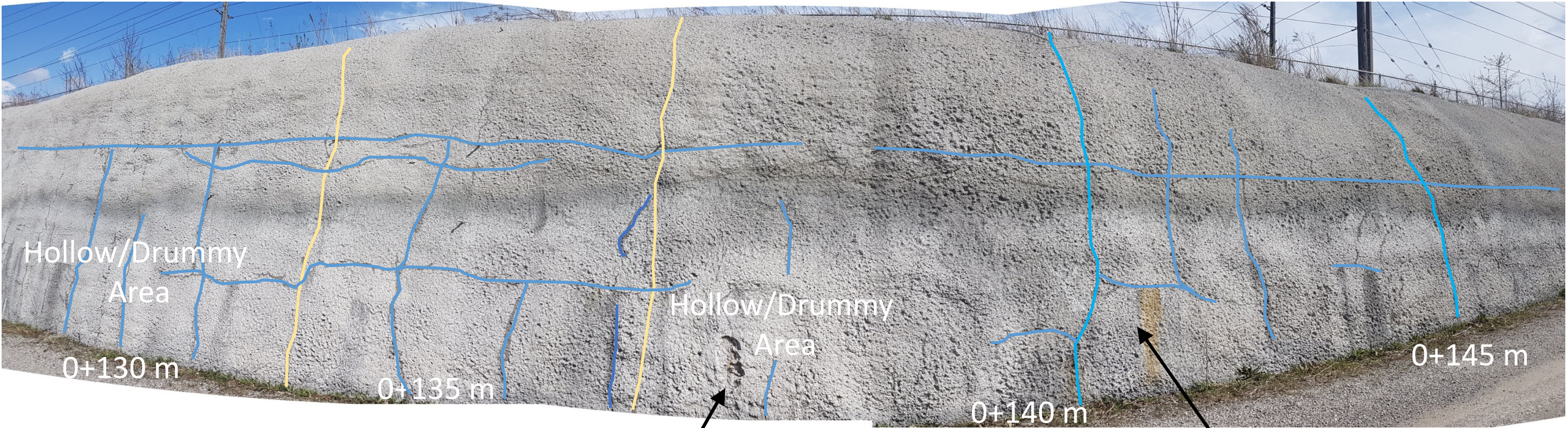


Mapping Colour		Description
		Seeping partial crack, no aperture observed
Dry	Seeping	Healed/Infilled Discontinuity, seeping, <1-2 mm
Dry	Seeping	Aperture <1 mm, Dry or Seeping
Dry	Seeping	Aperture 1-2 mm, Dry or Seeping
Dry	Seeping	Aperture 2-3 mm, Dry or Seeping
Dry	Seeping	Aperture 3-4 mm, Dry or Seeping
Dry	Seeping	Aperture >4 mm, Dry or Seeping

Note: Chainage 0 m at Existing Bridge

SUMMARY OF SHOTCRETE MAPPING
South Face
Chainage: 0+130 to 0+145

FIGURE 12



Delaminated/spalled zone,
exposing wire mesh underneath
shotcrete

Discoloration, oxidation from
seeping crack

Mapping Colour		Description
		Seeping partial crack, no aperture observed
Dry	Seeping	Healed/Infilled Discontinuity, seeping, <1-2 mm
Dry	Seeping	Aperture <1 mm, Dry or Seeping
Dry	Seeping	Aperture 1-2 mm, Dry or Seeping
Dry	Seeping	Aperture 2-3 mm, Dry or Seeping
Dry	Seeping	Aperture 3-4 mm, Dry or Seeping
Dry	Seeping	Aperture >4 mm, Dry or Seeping

Note: Chainage 0 m at Existing Bridge

SUMMARY OF SHOTCRETE MAPPING
South Face
Chainage: 0+145 to 0+160

FIGURE 13

All other features mapped beyond Chainage 0+160m were very similar.
Vertical features were <1 mm aperture, minor seepage, <1 m length.
Horizontal features were <1 mm aperture, minor seepage, 2-3 m length.



Eroded face, possible surface runoff

Eroded face, possible surface runoff

Mapping Colour		Description
		Seeping partial crack, no aperture observed
Dry	Seeping	Healed/Infilled Discontinuity, seeping, <1-2 mm
Dry	Seeping	Aperture <1 mm, Dry or Seeping
Dry	Seeping	Aperture 1-2 mm, Dry or Seeping
Dry	Seeping	Aperture 2-3 mm, Dry or Seeping
Dry	Seeping	Aperture 3-4 mm, Dry or Seeping
Dry	Seeping	Aperture >4 mm, Dry or Seeping

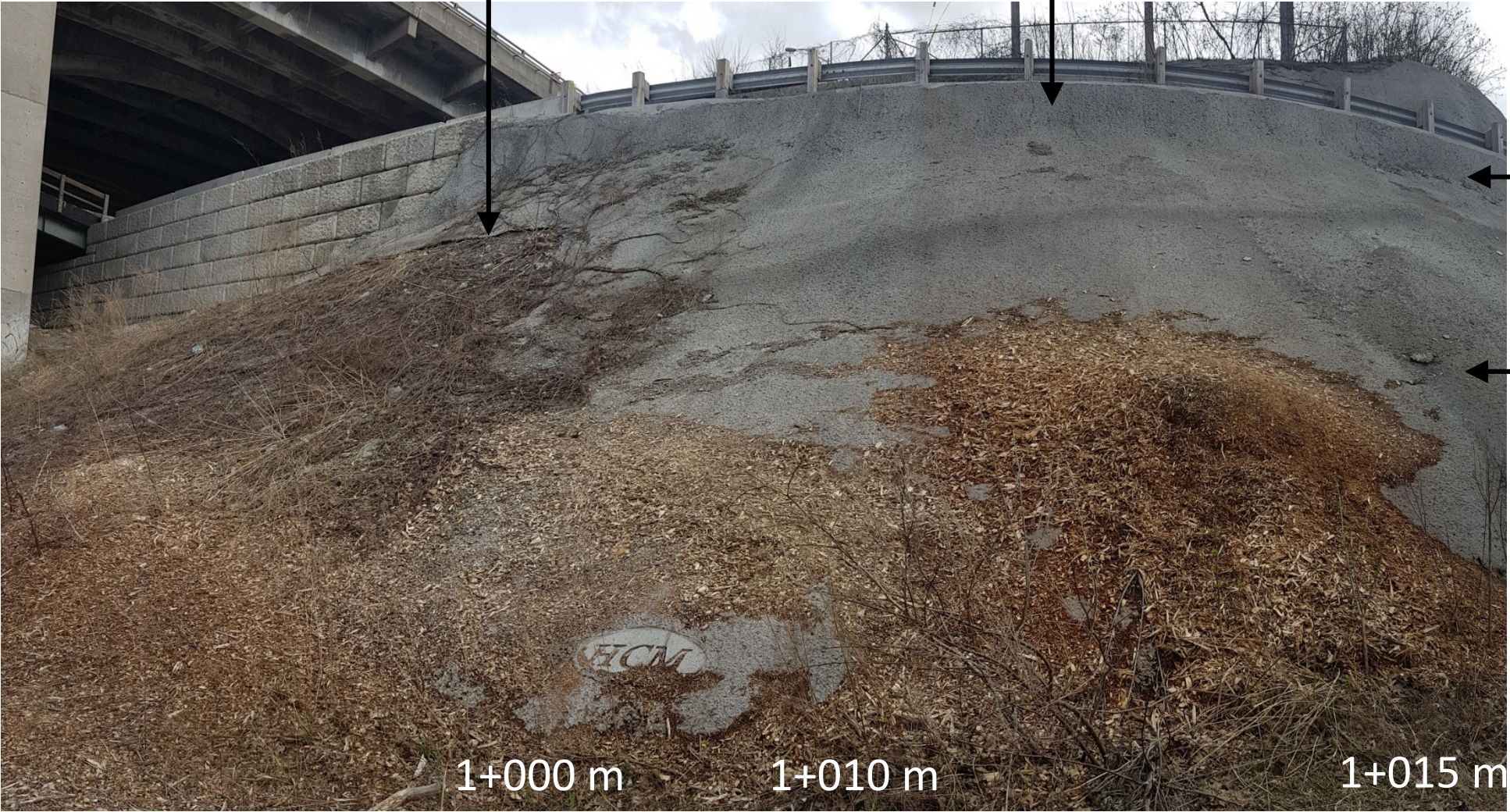
Note: Chainage 0 m at Existing Bridge

SUMMARY OF SHOTCRETE MAPPING
Lower South Face
Chainage: 1+000 to 1+015

FIGURE 14

Shotcrete lip, vegetation growing underneath

Small vertical cracks



Rock debris
from road

Eroded surface
from surface
runoff

Mapping Colour		Description
		Seeping partial crack, no aperture observed
Dry	Seeping	Healed/Infilled Discontinuity, seeping, <1-2 mm
Dry	Seeping	Aperture <1 mm, Dry or Seeping
Dry	Seeping	Aperture 1-2 mm, Dry or Seeping
Dry	Seeping	Aperture 2-3 mm, Dry or Seeping
Dry	Seeping	Aperture 3-4 mm, Dry or Seeping
Dry	Seeping	Aperture >4 mm, Dry or Seeping

Note: Chainage 1000 m at Start of Metal Guard Rail

SUMMARY OF SHOTCRETE MAPPING
Lower South Face
Chainage: 1+020 to 1+025

FIGURE 15

Small vertical cracks



Eroded/dissolved face, possible surface runoff

Mapping Colour		Description
		Seeping partial crack, no aperture observed
Dry	Seeping	Healed/Infilled Discontinuity, seeping, <1-2 mm
Dry	Seeping	Aperture <1 mm, Dry or Seeping
Dry	Seeping	Aperture 1-2 mm, Dry or Seeping
Dry	Seeping	Aperture 2-3 mm, Dry or Seeping
Dry	Seeping	Aperture 3-4 mm, Dry or Seeping
Dry	Seeping	Aperture >4 mm, Dry or Seeping

Note: Chainage 1000 m at Start of Metal Guard Rail

SUMMARY OF SHOTCRETE MAPPING
Lower South Face
Chainage: 1+025 to 1+035

FIGURE 16



Mapping Colour		Description
		Seeping partial crack, no aperture observed
Dry	Seeping	Healed/Infilled Discontinuity, seeping, <1-2 mm
Dry	Seeping	Aperture <1 mm, Dry or Seeping
Dry	Seeping	Aperture 1-2 mm, Dry or Seeping
Dry	Seeping	Aperture 2-3 mm, Dry or Seeping
Dry	Seeping	Aperture 3-4 mm, Dry or Seeping
Dry	Seeping	Aperture >4 mm, Dry or Seeping

Note: Chainage 1000 m at Start of Metal Guard Rail

SUMMARY OF SHOTCRETE MAPPING
Lower South Face
Chainage: 1+035 to 1+040

FIGURE 17



Seepage
source
not
visible

Mapping Colour		Description
		Seeping partial crack, no aperture observed
Dry	Seeping	Healed/Infilled Discontinuity, seeping, <1-2 mm
Dry	Seeping	Aperture <1 mm, Dry or Seeping
Dry	Seeping	Aperture 1-2 mm, Dry or Seeping
Dry	Seeping	Aperture 2-3 mm, Dry or Seeping
Dry	Seeping	Aperture 3-4 mm, Dry or Seeping
Dry	Seeping	Aperture >4 mm, Dry or Seeping

Note: Chainage 1000 m at Start of Metal Guard Rail

SUMMARY OF SHOTCRETE MAPPING
Lower South Face
Chainage: 1+040 to 1+050

FIGURE 18



Mapping Colour		Description
		Seeping partial crack, no aperture observed
Dry	Seeping	Healed/Infilled Discontinuity, seeping, <1-2 mm
Dry	Seeping	Aperture <1 mm, Dry or Seeping
Dry	Seeping	Aperture 1-2 mm, Dry or Seeping
Dry	Seeping	Aperture 2-3 mm, Dry or Seeping
Dry	Seeping	Aperture 3-4 mm, Dry or Seeping
Dry	Seeping	Aperture >4 mm, Dry or Seeping

Note: Chainage 1000 m at Start of Metal Guard Rail

SUMMARY OF SHOTCRETE MAPPING
Lower South Face
Chainage: 1+050 to 1+070

FIGURE 19

Major overhanging horizontal joint, top layer of shotcrete hanging over vertical wall, open, dry, 1-5 mm



Surface runoff from below gravel layer at top

Eroded/pitted large seeps, discolouration on healed joints

Seeping, healed joints, <1 mm
Only one vertical joint 1-2 mm, dry

Mapping Colour		Description
		Seeping partial crack, no aperture observed
Dry	Seeping	Healed/Infilled Discontinuity, seeping, <1-2 mm
Dry	Seeping	Aperture <1 mm, Dry or Seeping
Dry	Seeping	Aperture 1-2 mm, Dry or Seeping
Dry	Seeping	Aperture 2-3 mm, Dry or Seeping
Dry	Seeping	Aperture 3-4 mm, Dry or Seeping
Dry	Seeping	Aperture >4 mm, Dry or Seeping

Note: Chainage 1000 m at Start of Metal Guard Rail

SUMMARY OF SHOTCRETE MAPPING
North Face
Chainage: 1+030 to 1+055

FIGURE 20



1+050 1+045 1+040 1+035 1+030

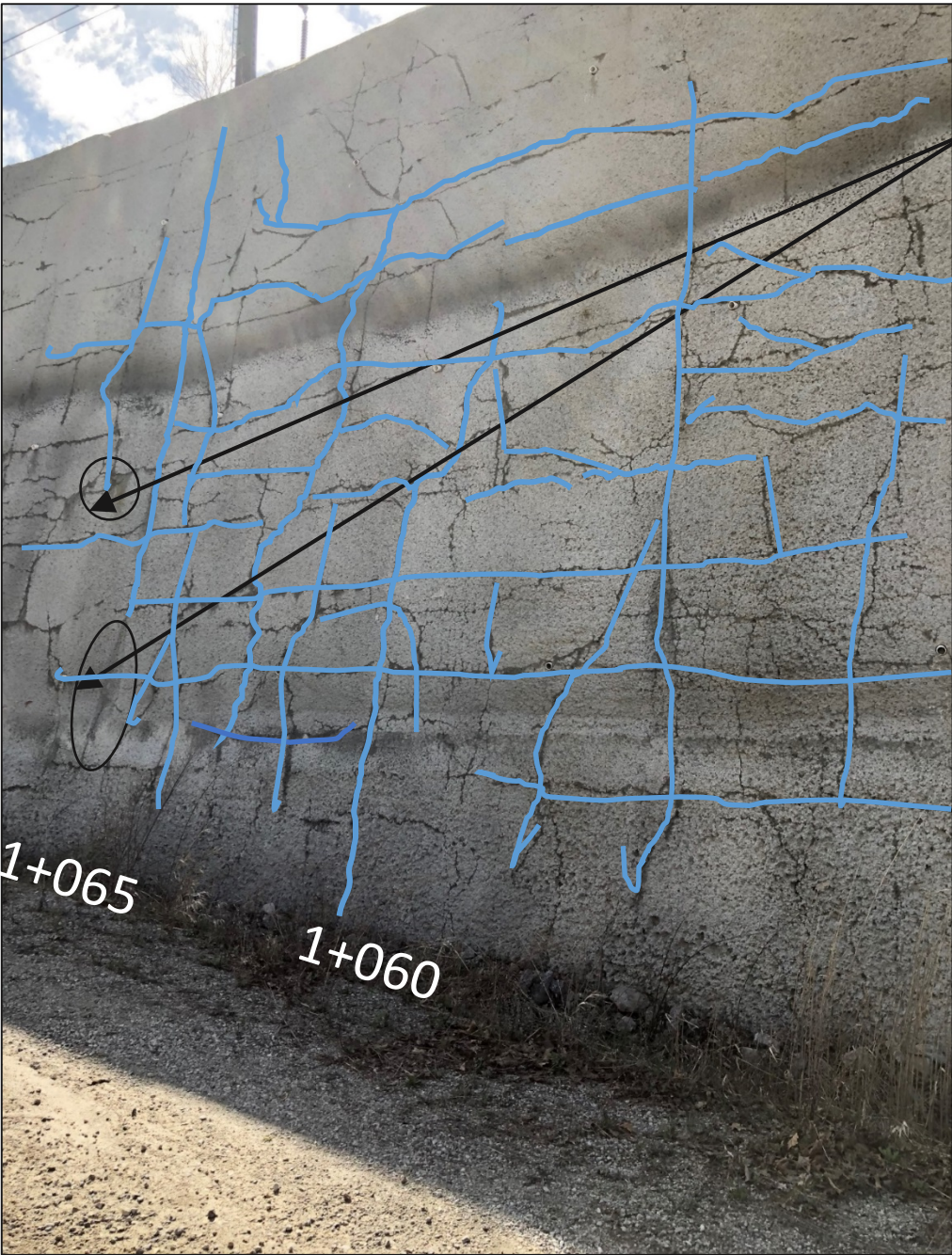
Seepage from
intersecting
vertical and
horizontal
fractures



Mapping Colour		Description
		Seeping partial crack, no aperture observed
Dry	Seeping	Healed/Infilled Discontinuity, seeping, <1-2 mm
Dry	Seeping	Aperture <1 mm, Dry or Seeping
Dry	Seeping	Aperture 1-2 mm, Dry or Seeping
Dry	Seeping	Aperture 2-3 mm, Dry or Seeping
Dry	Seeping	Aperture 3-4 mm, Dry or Seeping
Dry	Seeping	Aperture >4 mm, Dry or Seeping

SUMMARY OF SHOTCRETE MAPPING North Face Chainage: 1+055 to 1+065

FIGURE 21



Zone of
Greenish-brown
discoloration

Base of the
shotcrete
has a
'pitted'
texture due
to erosion



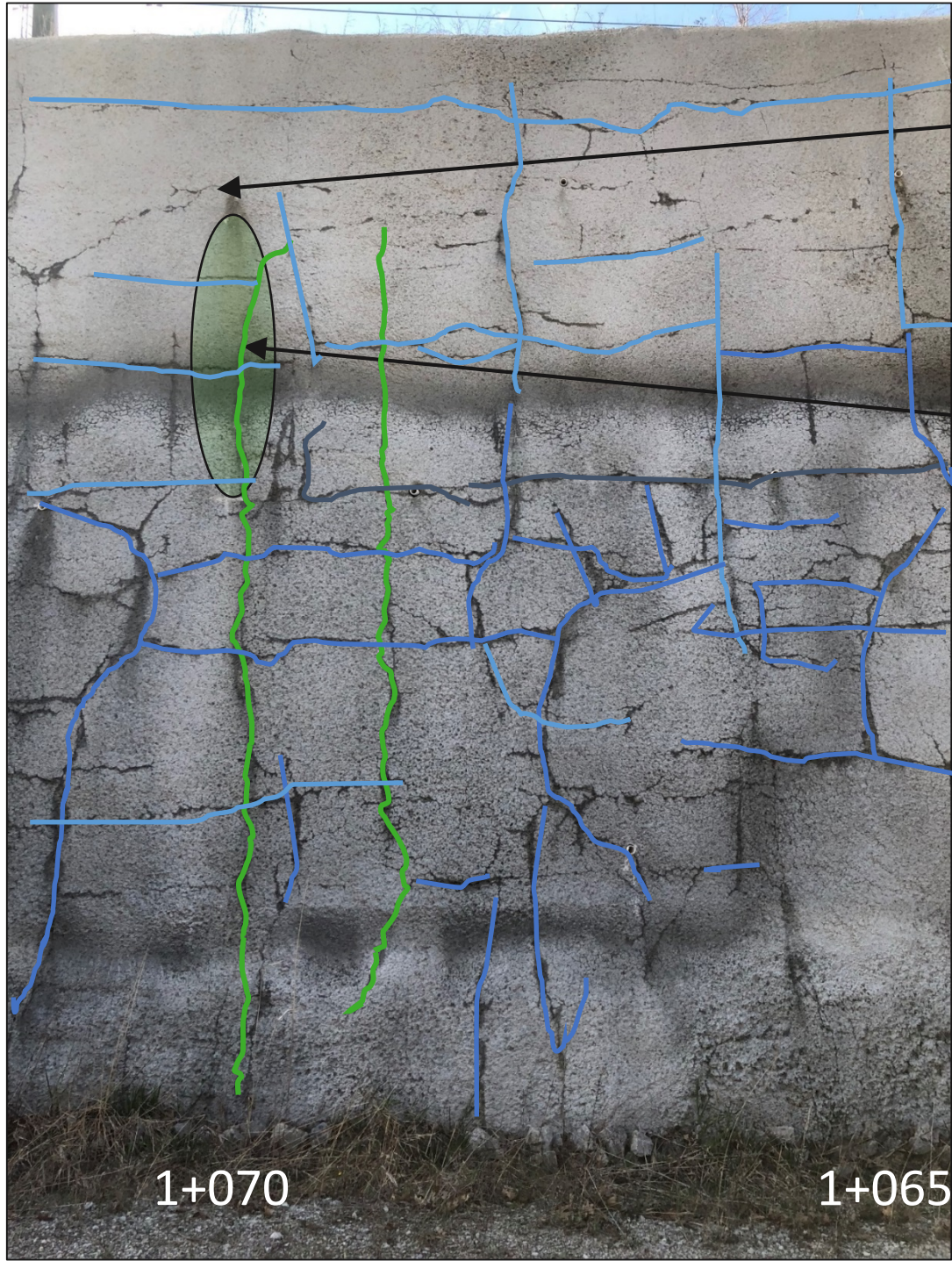
Minor seepage at
Intersection of
vertical and
horizontal
fractures, 1-2 mm
apertures.

Base of the
shotcrete
has a
'pitted'
texture due
to erosion

Mapping Colour		Description
		Seeping partial crack, no aperture observed
Dry	Seeping	Healed/Infilled Discontinuity, seeping, <1-2 mm
Dry	Seeping	Aperture <1 mm, Dry or Seeping
Dry	Seeping	Aperture 1-2 mm, Dry or Seeping
Dry	Seeping	Aperture 2-3 mm, Dry or Seeping
Dry	Seeping	Aperture 3-4 mm, Dry or Seeping
Dry	Seeping	Aperture >4 mm, Dry or Seeping

SUMMARY OF SHOTCRETE MAPPING
North Face
Chainage: 1+065 to 1+075

FIGURE 22

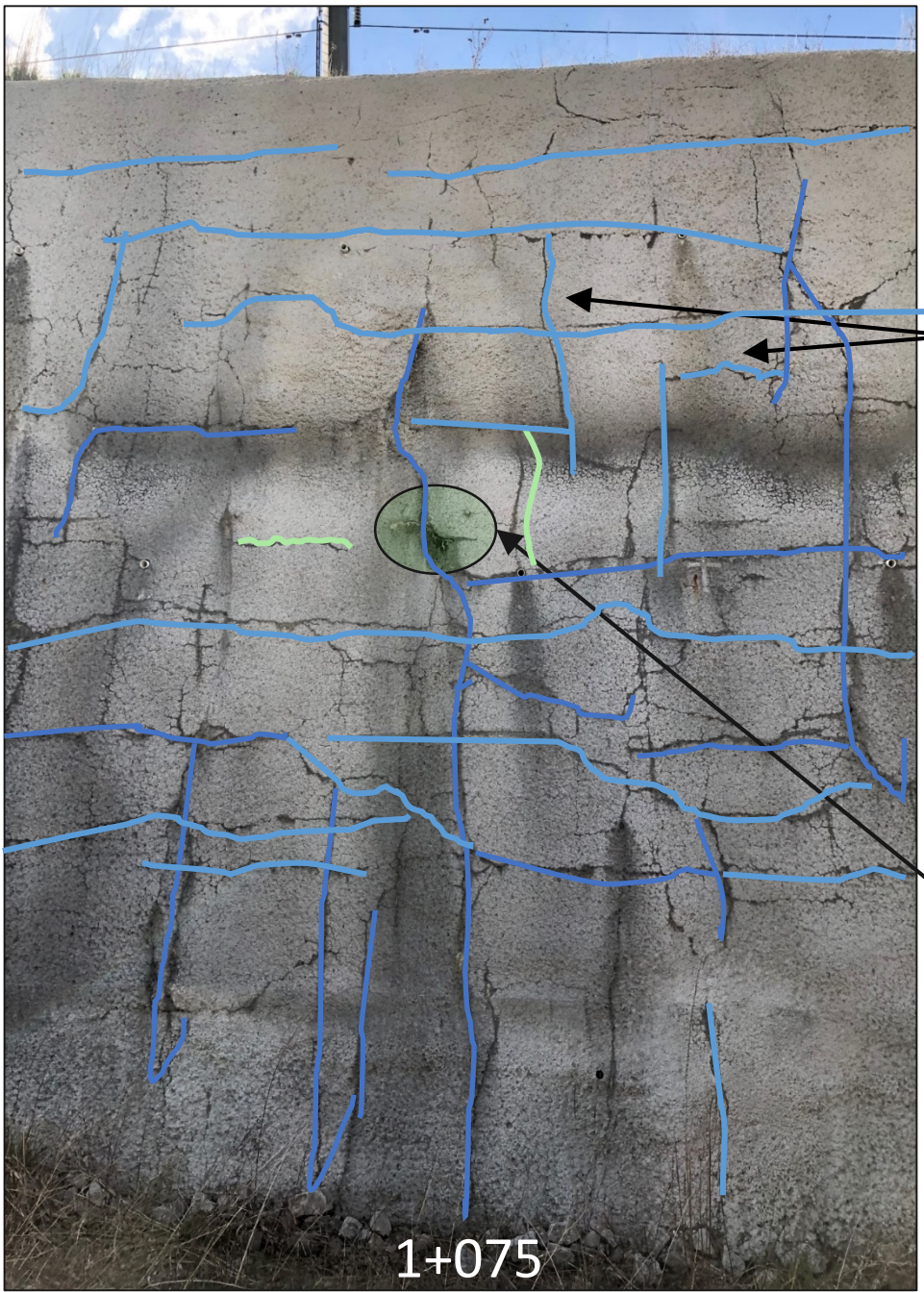


Active drainpipe

Yellow-brown discoloration along drainage path

Shotcrete has 'pitted' texture due to erosion

Mapping Colour		Description
		Seeping partial crack, no aperture observed
Dry	Seeping	Healed/Infilled Discontinuity, seeping, <1-2 mm
Dry	Seeping	Aperture <1 mm, Dry or Seeping
Dry	Seeping	Aperture 1-2 mm, Dry or Seeping
Dry	Seeping	Aperture 2-3 mm, Dry or Seeping
Dry	Seeping	Aperture 3-4 mm, Dry or Seeping
Dry	Seeping	Aperture >4 mm, Dry or Seeping

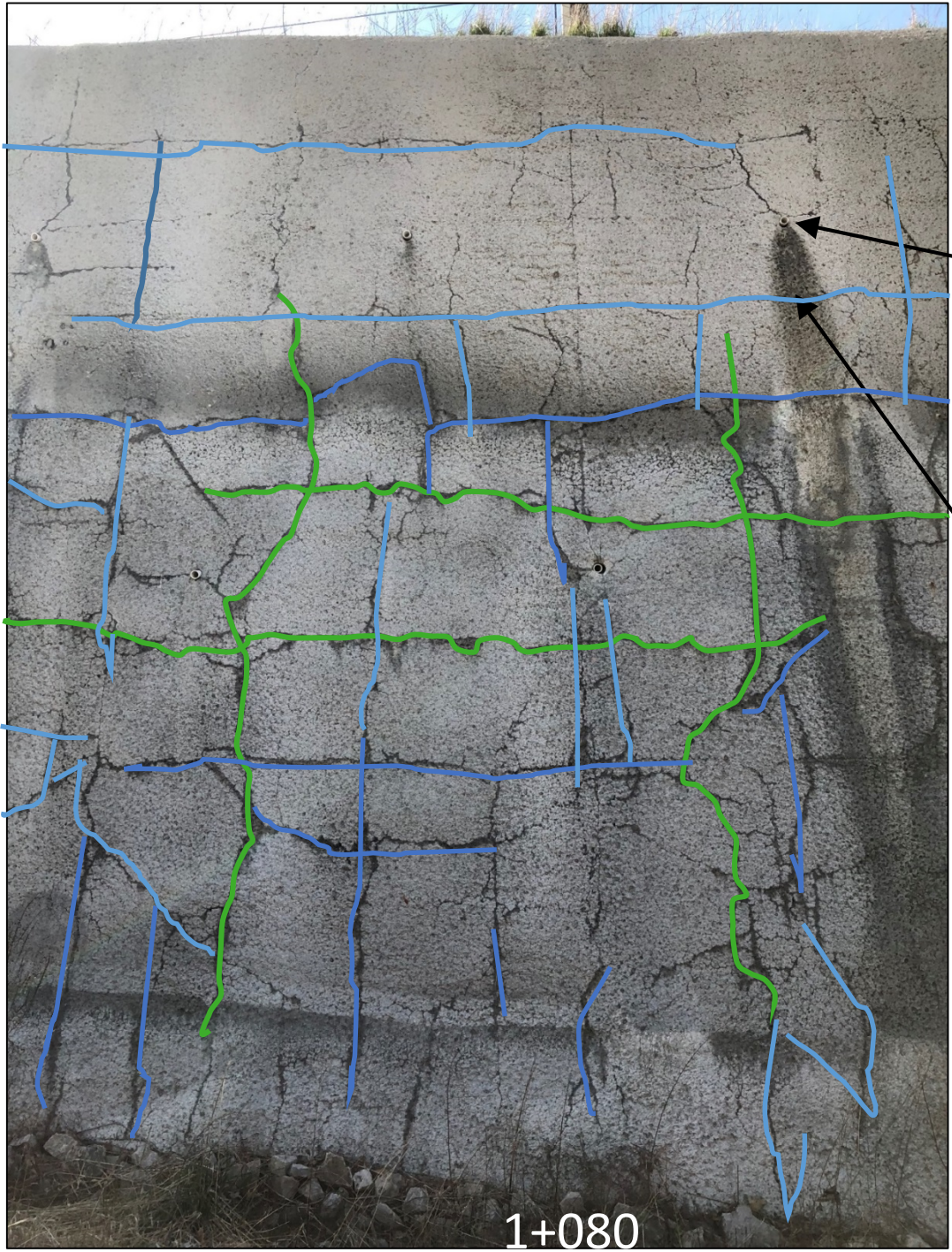


Various discontinuous horizontal/vertical healed fractures, some seepage, 0.5 m-3 m length

Active seepage from healed fracture junction.

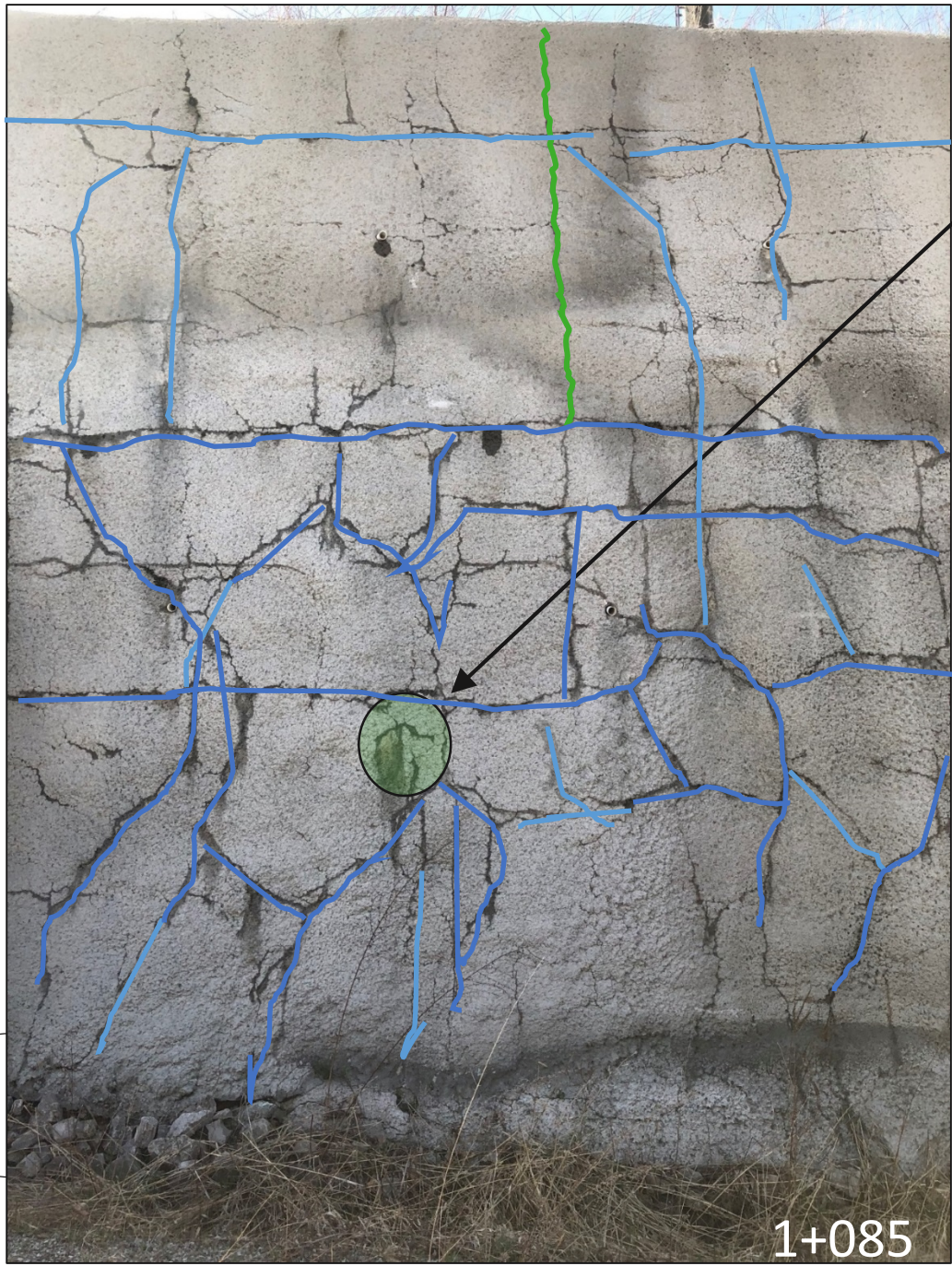
SUMMARY OF SHOTCRETE MAPPING
North Face
Chainage: 1+075 to 1+090

FIGURE 23



Mapping Colour		Description
		Seeping partial crack, no aperture observed
Dry	Seeping	Healed/Infilled Discontinuity, seeping, <1-2 mm
Dry	Seeping	Aperture <1 mm, Dry or Seeping
Dry	Seeping	Aperture 1-2 mm, Dry or Seeping
Dry	Seeping	Aperture 2-3 mm, Dry or Seeping
Dry	Seeping	Aperture 3-4 mm, Dry or Seeping
Dry	Seeping	Aperture >4 mm, Dry or Seeping

Overall: Various vertical/horizontal fractures, some seepage, 0.5 m – 4 m length

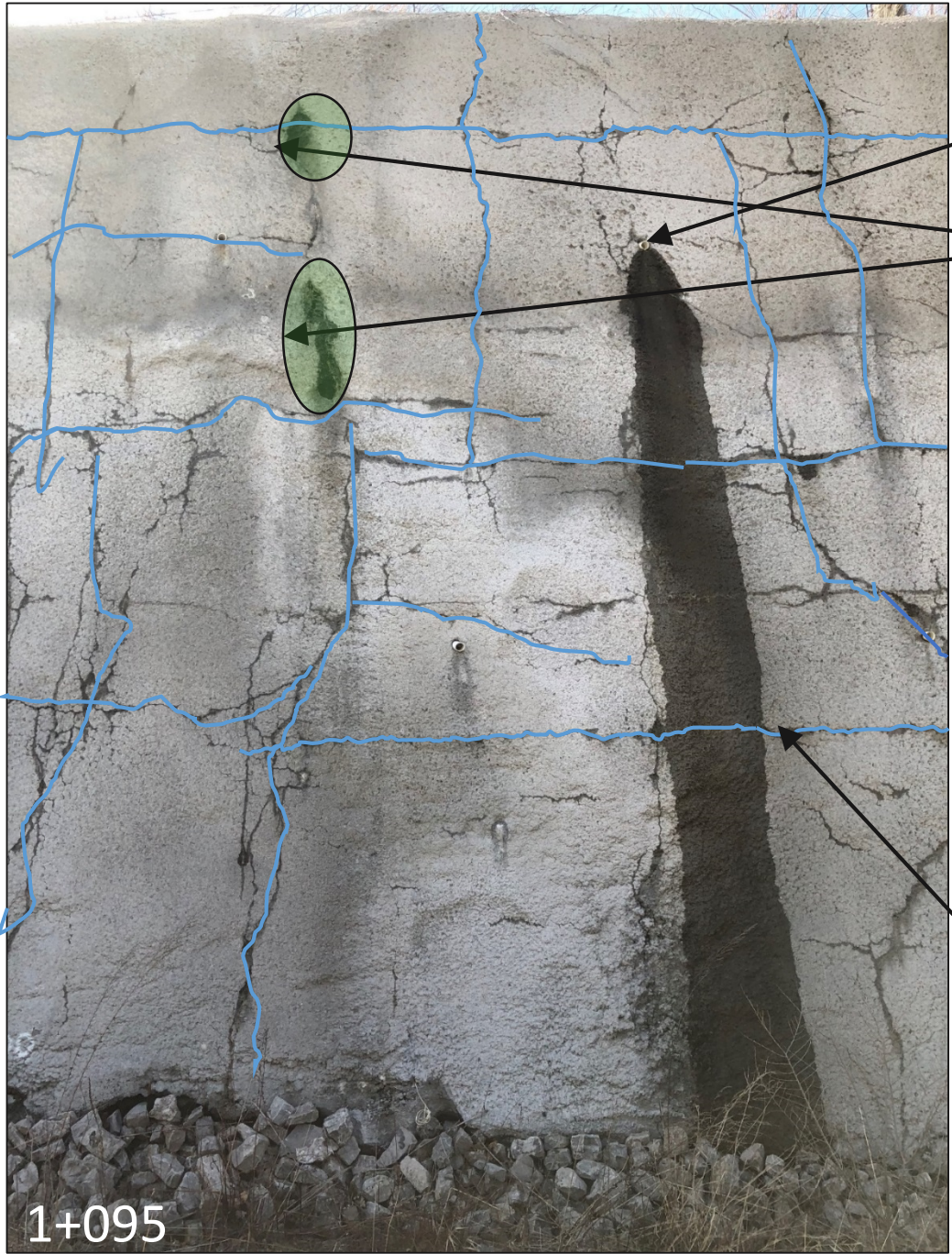


SUMMARY OF SHOTCRETE MAPPING

North Face

Chainage: 1+095 to 1+100

FIGURE 24

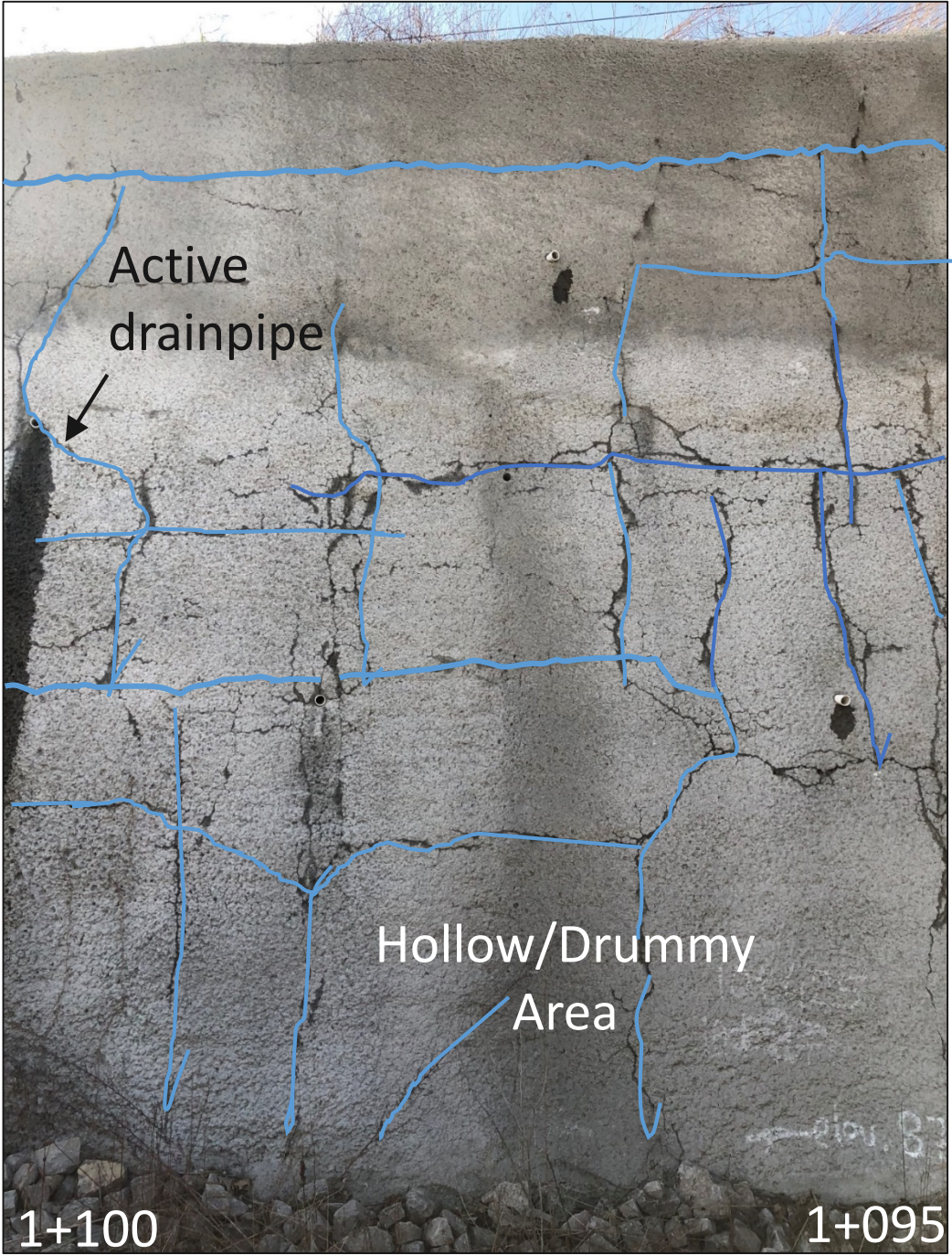


Active
drainpipe

Dark
brown/black
discoloration
from seepage
at healed
fracture.

Light grey
discoloration
along drainage
path

~5 m
long
fracture



Mapping Colour		Description
		Seeping partial crack, no aperture observed
Dry	Seeping	Healed/Infilled Discontinuity, seeping, <1-2 mm
Dry	Seeping	Aperture <1 mm, Dry or Seeping
Dry	Seeping	Aperture 1-2 mm, Dry or Seeping
Dry	Seeping	Aperture 2-3 mm, Dry or Seeping
Dry	Seeping	Aperture 3-4 mm, Dry or Seeping
Dry	Seeping	Aperture >4 mm, Dry or Seeping

Overall: various
vertical/horizontal healed
fractures, minor to some
seepage, 0.5 m – 4 m length

Active drainage pipes. Dark grey/brown discoloration.

Base of shotcrete exposed



SUMMARY OF SHOTCRETE MAPPING North Face Chainage: 1+100 to 1+105

FIGURE 25

Vine growth over shotcrete

Shotcrete eroded from water causing 'pitted' texture.

Light grey discoloration from drainage



Mapping Colour		Description
		Seeping partial crack, no aperture observed
Dry	Seeping	Healed/Infilled Discontinuity, seeping, <1-2 mm
Dry	Seeping	Aperture <1 mm, Dry or Seeping
Dry	Seeping	Aperture 1-2 mm, Dry or Seeping
Dry	Seeping	Aperture 2-3 mm, Dry or Seeping
Dry	Seeping	Aperture 3-4 mm, Dry or Seeping
Dry	Seeping	Aperture >4 mm, Dry or Seeping

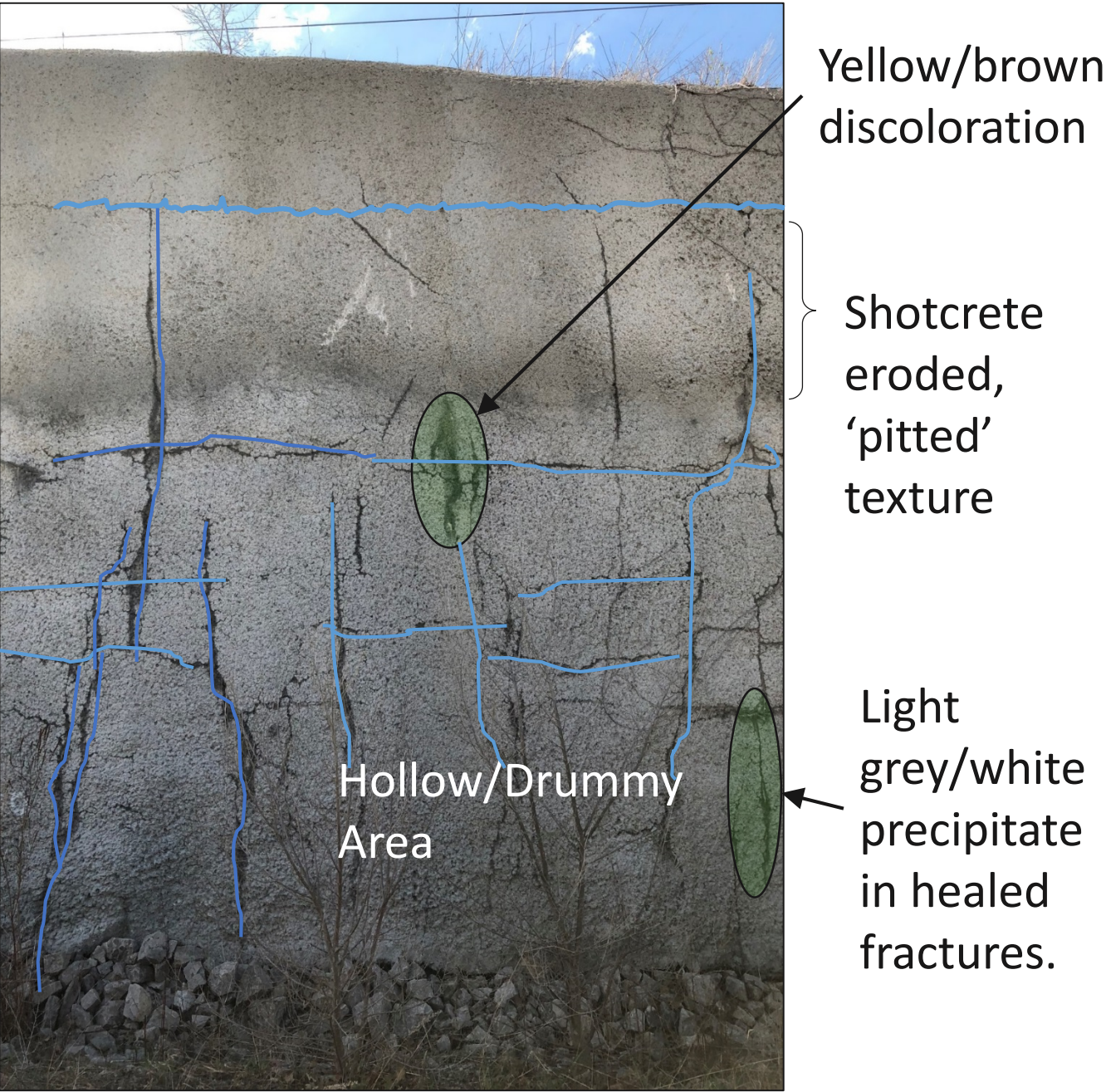
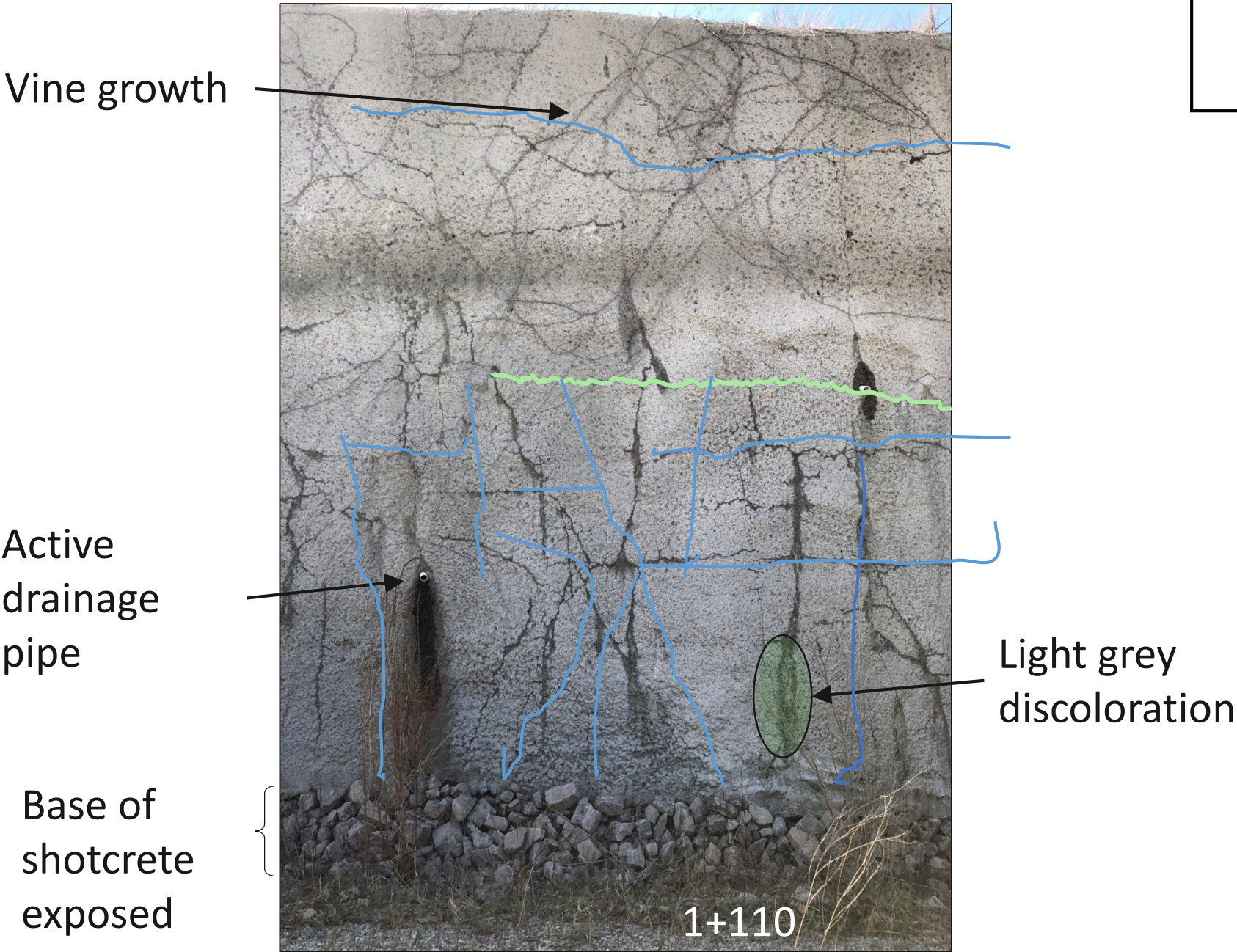
Overall: Various healed vertical/horizontal fractures. Minor seepage. 0.5 m – 4 m length fractures

SUMMARY OF SHOTCRETE MAPPING

North Face

Chainage: 1+105 to 1+115

FIGURE 26



Mapping Colour		Description
		Seeping partial crack, no aperture observed
Dry	Seeping	Healed/Infilled Discontinuity, seeping, <1-2 mm
Dry	Seeping	Aperture <1 mm, Dry or Seeping
Dry	Seeping	Aperture 1-2 mm, Dry or Seeping
Dry	Seeping	Aperture 2-3 mm, Dry or Seeping
Dry	Seeping	Aperture 3-4 mm, Dry or Seeping
Dry	Seeping	Aperture >4 mm, Dry or Seeping

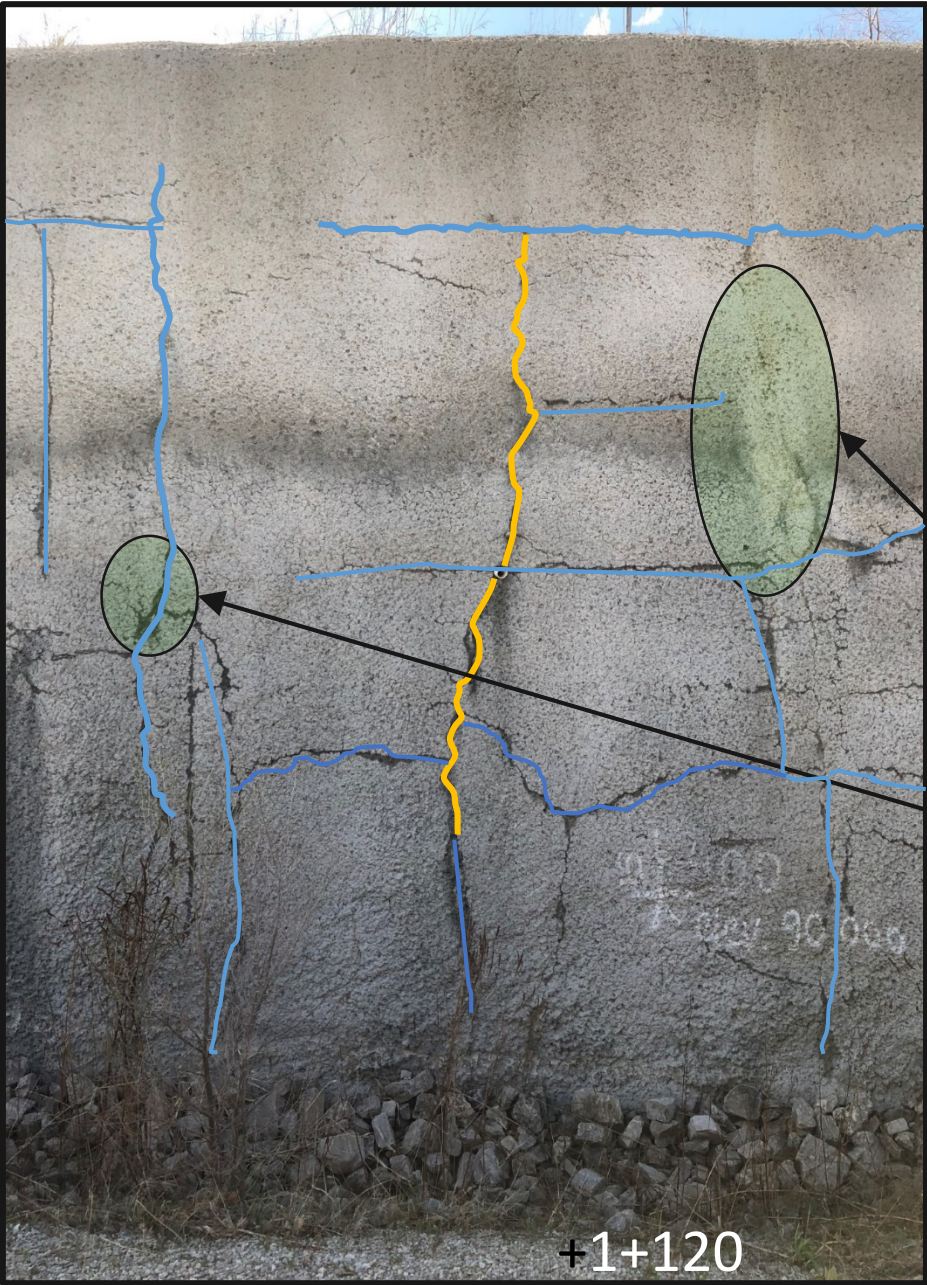
Overall: Various vertical/horizontal healed fractures. 0.5 m -3 m length. Minor seepage.

SUMMARY OF SHOTCRETE MAPPING

North Face

Chainage: 1+115 to 1+125

FIGURE 27



Continuous healed horizontal fracture (1+105 to 1+150)

Light grey discoloration

White precipitate in fracture

+1+120



Active drainage pipes

Lichen growth

Hollow/Drummy Area

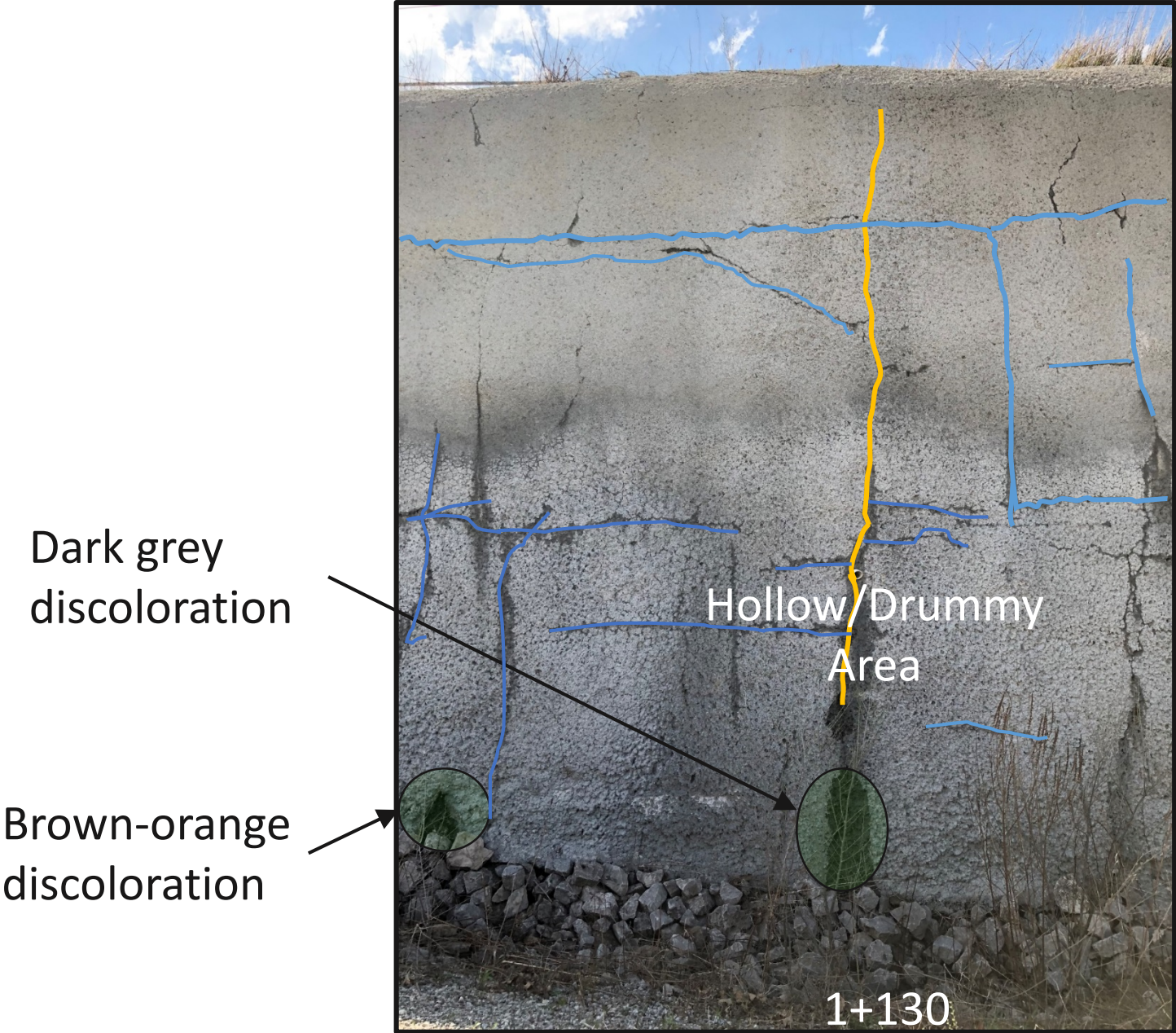
1+125

Mapping Colour	Description
	Seeping partial crack, no aperture observed
Dry Seeping	Healed/Infilled Discontinuity, seeping, <1-2 mm
Dry Seeping	Aperture <1 mm, Dry or Seeping
Dry Seeping	Aperture 1-2 mm, Dry or Seeping
Dry Seeping	Aperture 2-3 mm, Dry or Seeping
Dry Seeping	Aperture 3-4 mm, Dry or Seeping
Dry Seeping	Aperture >4 mm, Dry or Seeping

Overall: Various horizontal/vertical healed fractures. Minor seepage. 0.25 m -3 m length.

SUMMARY OF SHOTCRETE MAPPING
North Face
Chainage: 1+125 to 1+135

FIGURE 28



Mapping Colour		Description
		Seeping partial crack, no aperture observed
Dry	Seeping	Healed/Infilled Discontinuity, seeping, <1-2 mm
Dry	Seeping	Aperture <1 mm, Dry or Seeping
Dry	Seeping	Aperture 1-2 mm, Dry or Seeping
Dry	Seeping	Aperture 2-3 mm, Dry or Seeping
Dry	Seeping	Aperture 3-4 mm, Dry or Seeping
Dry	Seeping	Aperture >4 mm, Dry or Seeping

Overall: Various healed horizontal/vertical fractures. Minor seepage. 0.5 m-3 m in length. Shotcrete in good condition.

Shotcrete base exposed at some points.



SUMMARY OF SHOTCRETE MAPPING
North Face
Chainage: 1+135 to 1+147

FIGURE 29



'Pitted' texture



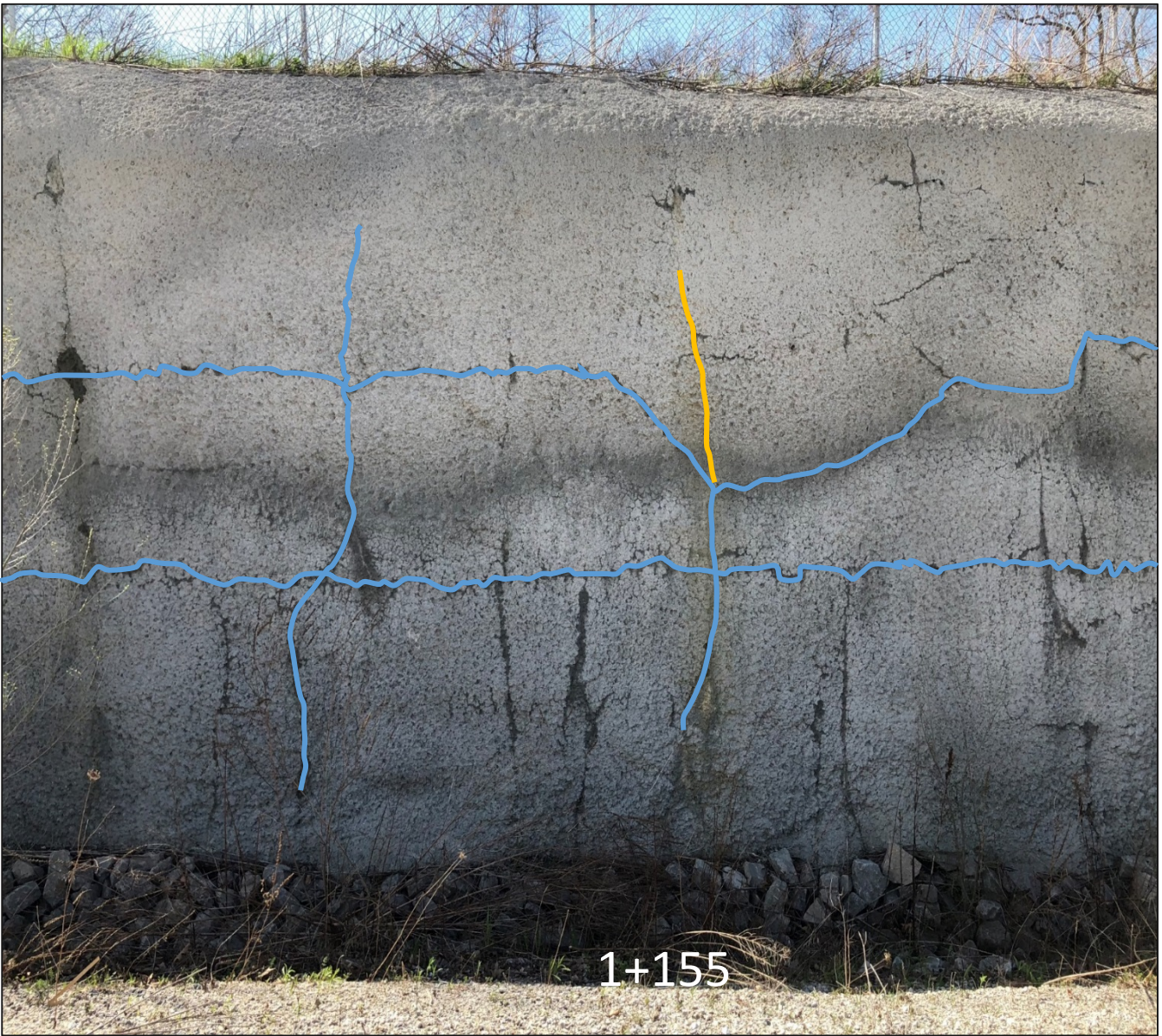
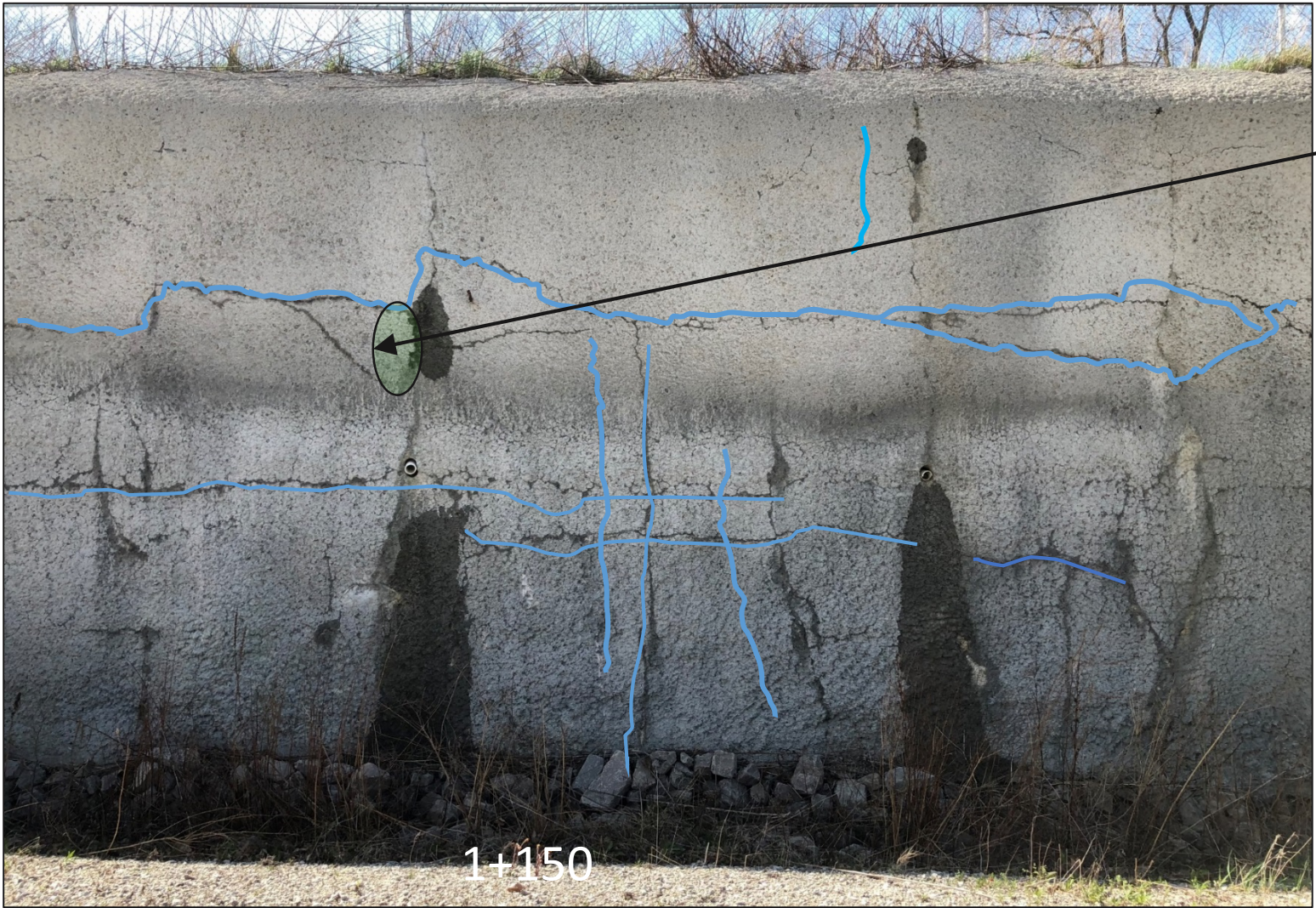
Dry during field assessment on (May 9th)

Major seepage and discoloration

Mapping Colour		Description
		Seeping partial crack, no aperture observed
Dry	Seeping	Healed/Infilled Discontinuity, seeping, <1-2 mm
Dry	Seeping	Aperture <1 mm, Dry or Seeping
Dry	Seeping	Aperture 1-2 mm, Dry or Seeping
Dry	Seeping	Aperture 2-3 mm, Dry or Seeping
Dry	Seeping	Aperture 3-4 mm, Dry or Seeping
Dry	Seeping	Aperture >4 mm, Dry or Seeping

SUMMARY OF SHOTCRETE MAPPING
North Face
Chainage: 1+147 to 1+157

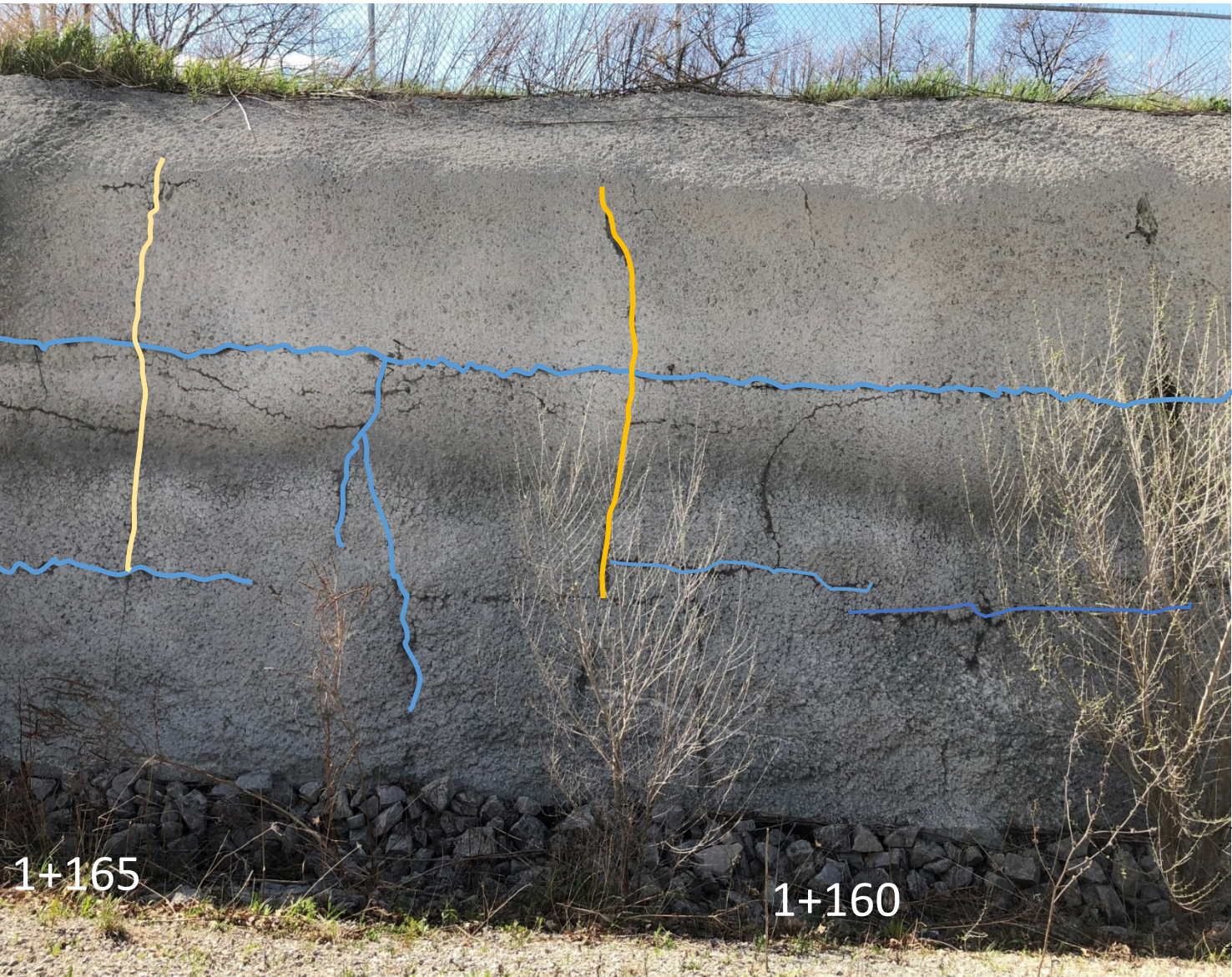
FIGURE 30



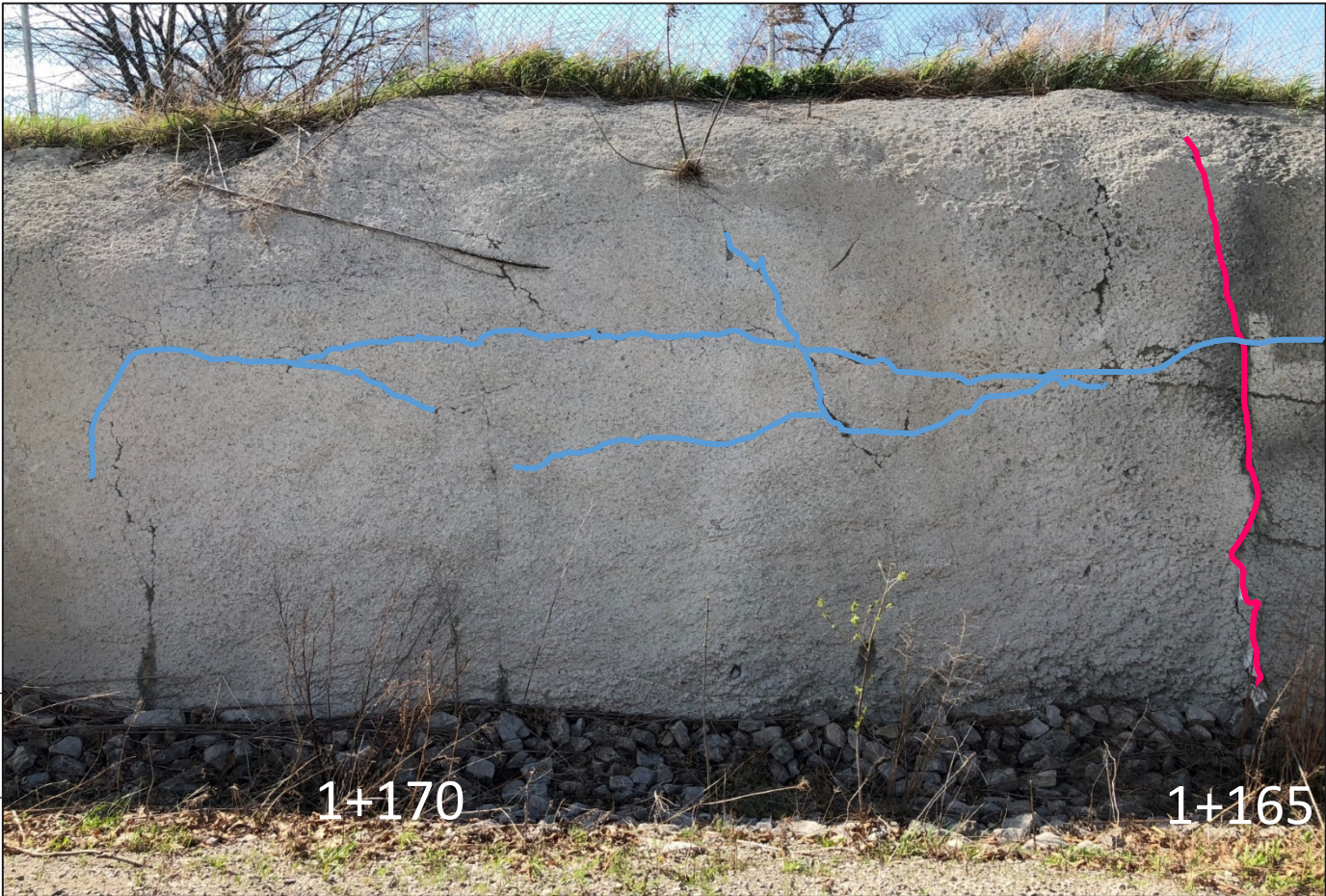
Mapping Colour		Description
		Seeping partial crack, no aperture observed
Dry	Seeping	Healed/Infilled Discontinuity, seeping, <1-2 mm
Dry	Seeping	Aperture <1 mm, Dry or Seeping
Dry	Seeping	Aperture 1-2 mm, Dry or Seeping
Dry	Seeping	Aperture 2-3 mm, Dry or Seeping
Dry	Seeping	Aperture 3-4 mm, Dry or Seeping
Dry	Seeping	Aperture >4 mm, Dry or Seeping

SUMMARY OF SHOTCRETE MAPPING
North Face
Chainage: 1+157 to 1+170

FIGURE 31



Mesh at
bottom of
shotcrete



Black mesh at
base of
shotcrete

Mapping Colour		Description
		Seeping partial crack, no aperture observed
Dry	Seeping	Healed/Infilled Discontinuity, seeping, <1-2 mm
Dry	Seeping	Aperture <1 mm, Dry or Seeping
Dry	Seeping	Aperture 1-2 mm, Dry or Seeping
Dry	Seeping	Aperture 2-3 mm, Dry or Seeping
Dry	Seeping	Aperture 3-4 mm, Dry or Seeping
Dry	Seeping	Aperture >4 mm, Dry or Seeping



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