



## 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*

Submitted to:

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## 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)<sup>1</sup>.

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.

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<sup>1</sup> 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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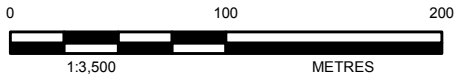
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[https://golderassociates.sharepoint.com/sites/11176g/shared documents/07-reporting/foundations/4 - shotcrete assessment/3 - final/1662333 rpt qew credit river bridge shotcrete assessment 23july2018\\_fir.docx](https://golderassociates.sharepoint.com/sites/11176g/shared%20documents/07-reporting/foundations/4%20-%20shotcrete%20assessment/3%20-%20final/1662333%20rpt%20qew%20credit%20river%20bridge%20shotcrete%20assessment%2023july2018_fir.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

CONTROL  
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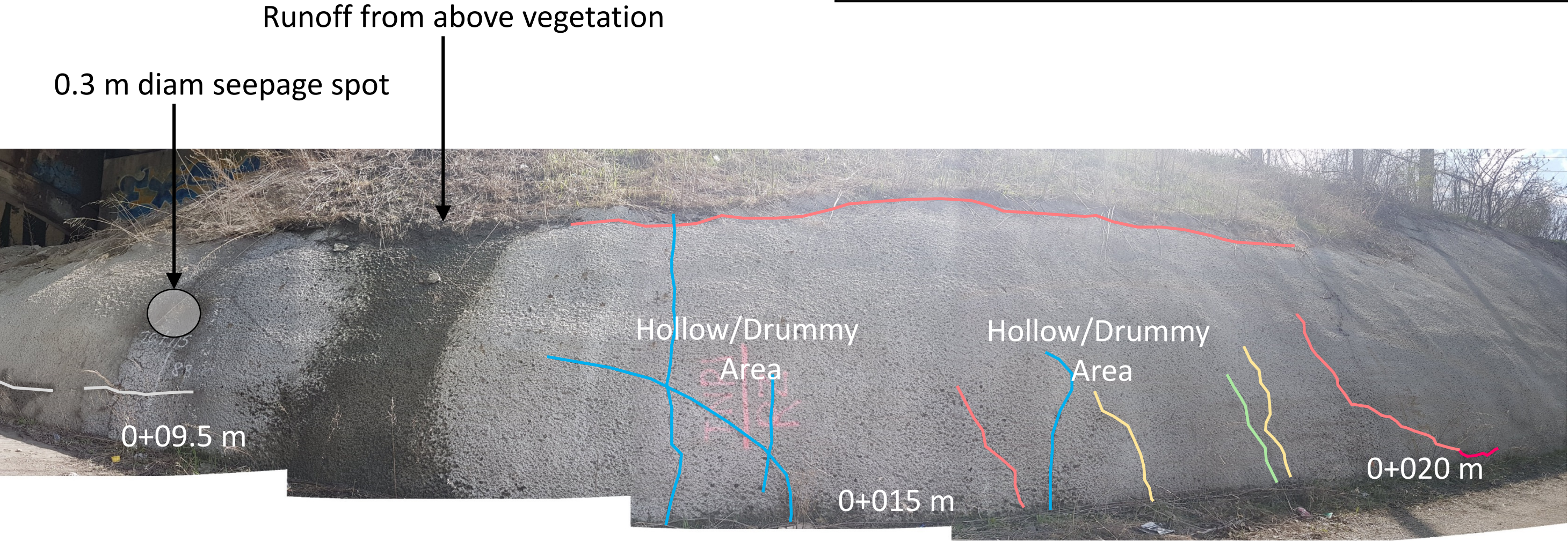
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FIGURE  
1



**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**



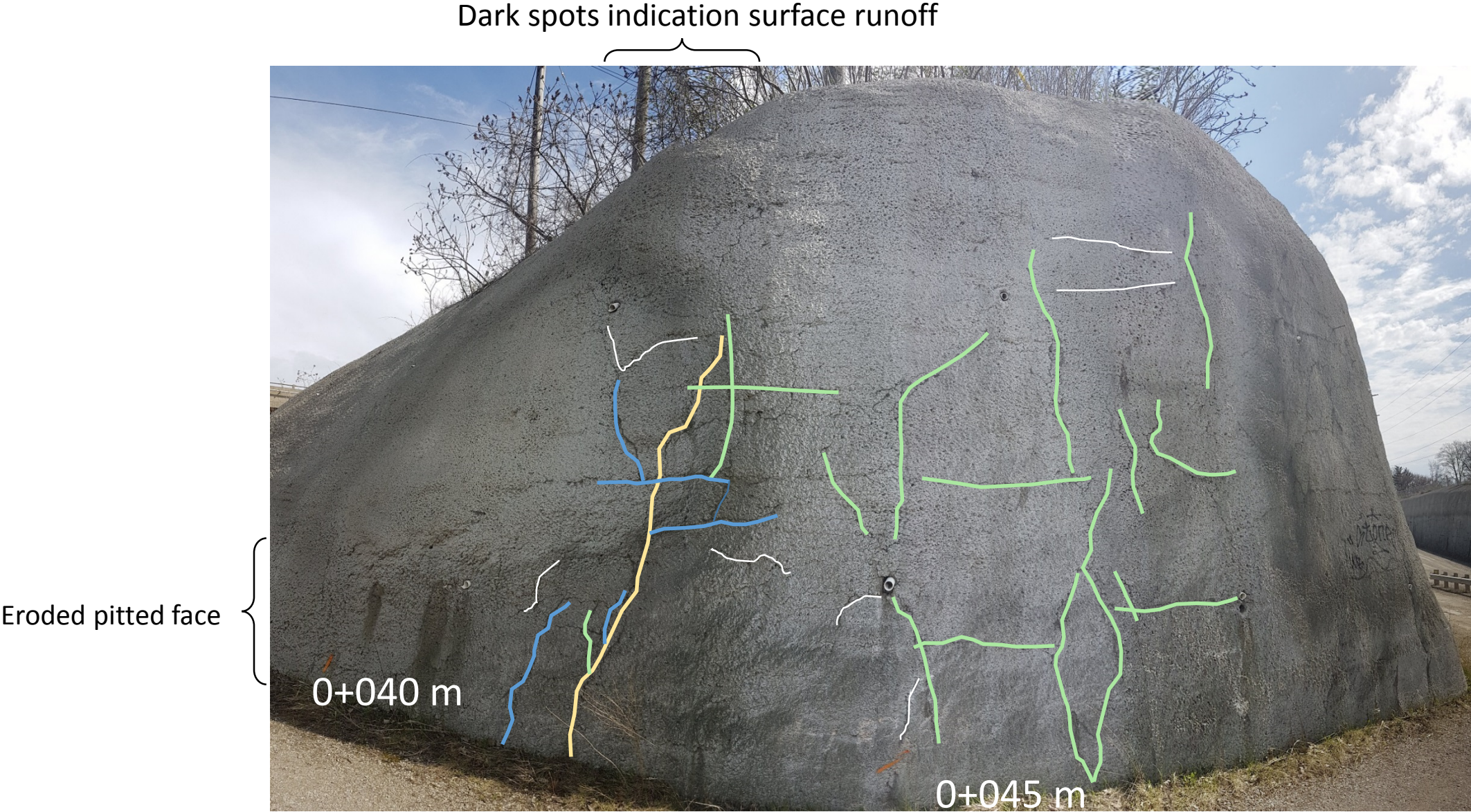
Mapping Colour		Description
		Seeping partial crack, no aperture observed
Dry	Seeping	Healed/Infilled Discontinuity, seeping, <1-2 mm
Dry	Seeping	Aperture <1 mm, Dry or Seeping
Dry	Seeping	Aperture 1-2 mm, Dry or Seeping
Dry	Seeping	Aperture 2-3 mm, Dry or Seeping
Dry	Seeping	Aperture 3-4 mm, Dry or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



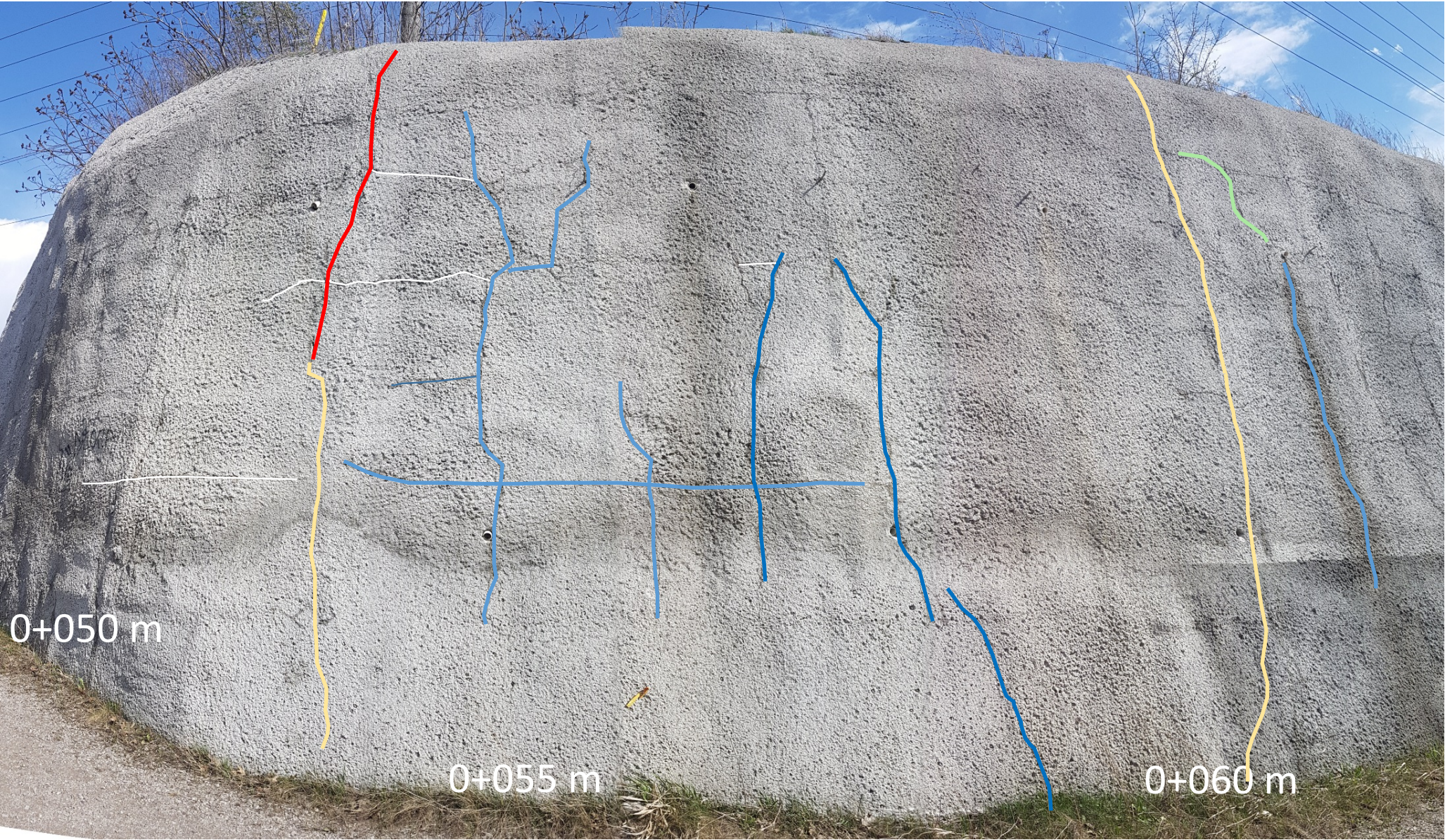
Mapping Colour		Description
		Seeping partial crack, no aperture observed
Dry	Seeping	Healed/Infilled Discontinuity, seeping, <1-2 mm
Dry	Seeping	Aperture <1 mm, Dry or Seeping
Dry	Seeping	Aperture 1-2 mm, Dry or Seeping
Dry	Seeping	Aperture 2-3 mm, Dry or Seeping
Dry	Seeping	Aperture 3-4 mm, Dry or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



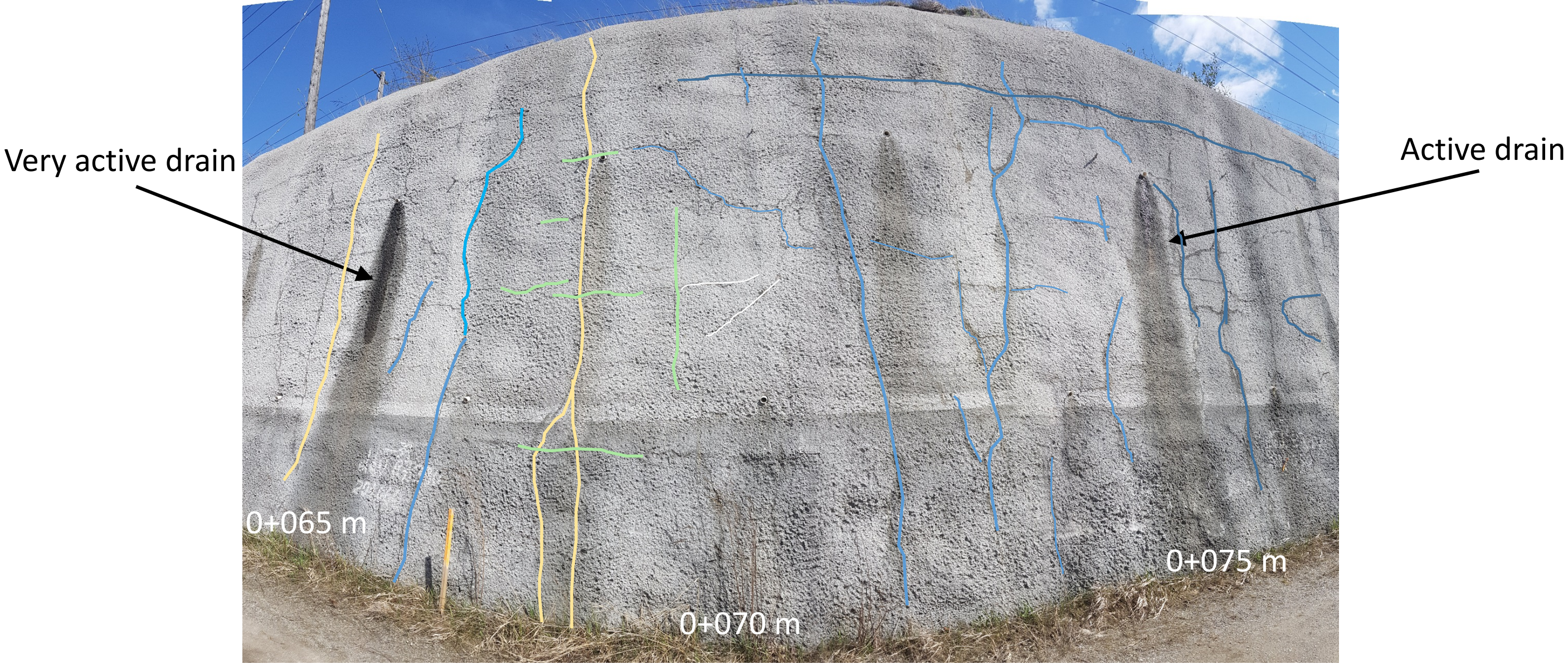
Mapping Colour		Description
		Seeping partial crack, no aperture observed
Dry	Seeping	Healed/Infilled Discontinuity, seeping, <1-2 mm
Dry	Seeping	Aperture <1 mm, Dry or Seeping
Dry	Seeping	Aperture 1-2 mm, Dry or Seeping
Dry	Seeping	Aperture 2-3 mm, Dry or Seeping
Dry	Seeping	Aperture 3-4 mm, Dry or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



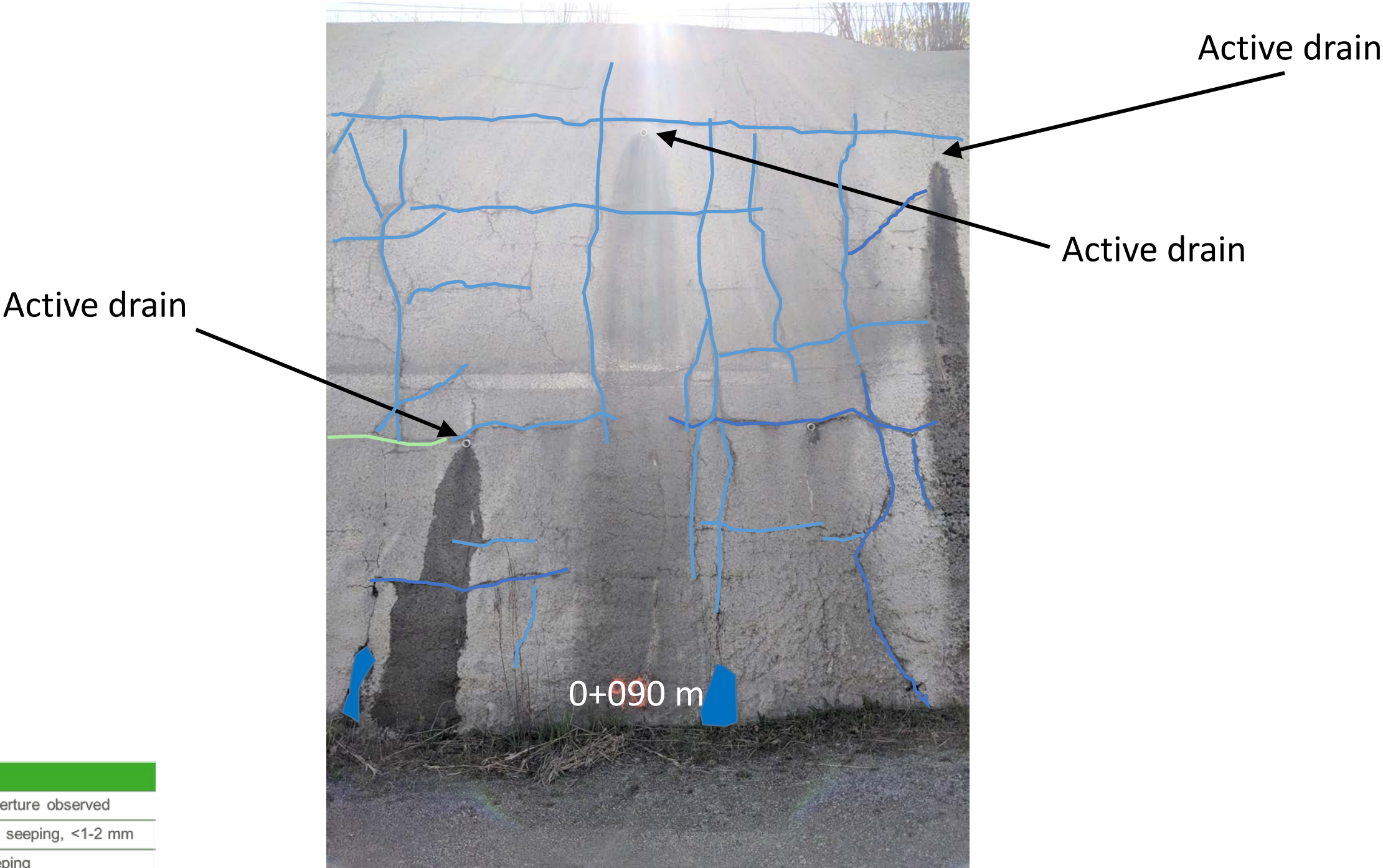
Mapping Colour		Description
		Seeping partial crack, no aperture observed
Dry	Seeping	Healed/Infilled Discontinuity, seeping, <1-2 mm
Dry	Seeping	Aperture <1 mm, Dry or Seeping
Dry	Seeping	Aperture 1-2 mm, Dry or Seeping
Dry	Seeping	Aperture 2-3 mm, Dry or Seeping
Dry	Seeping	Aperture 3-4 mm, Dry or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



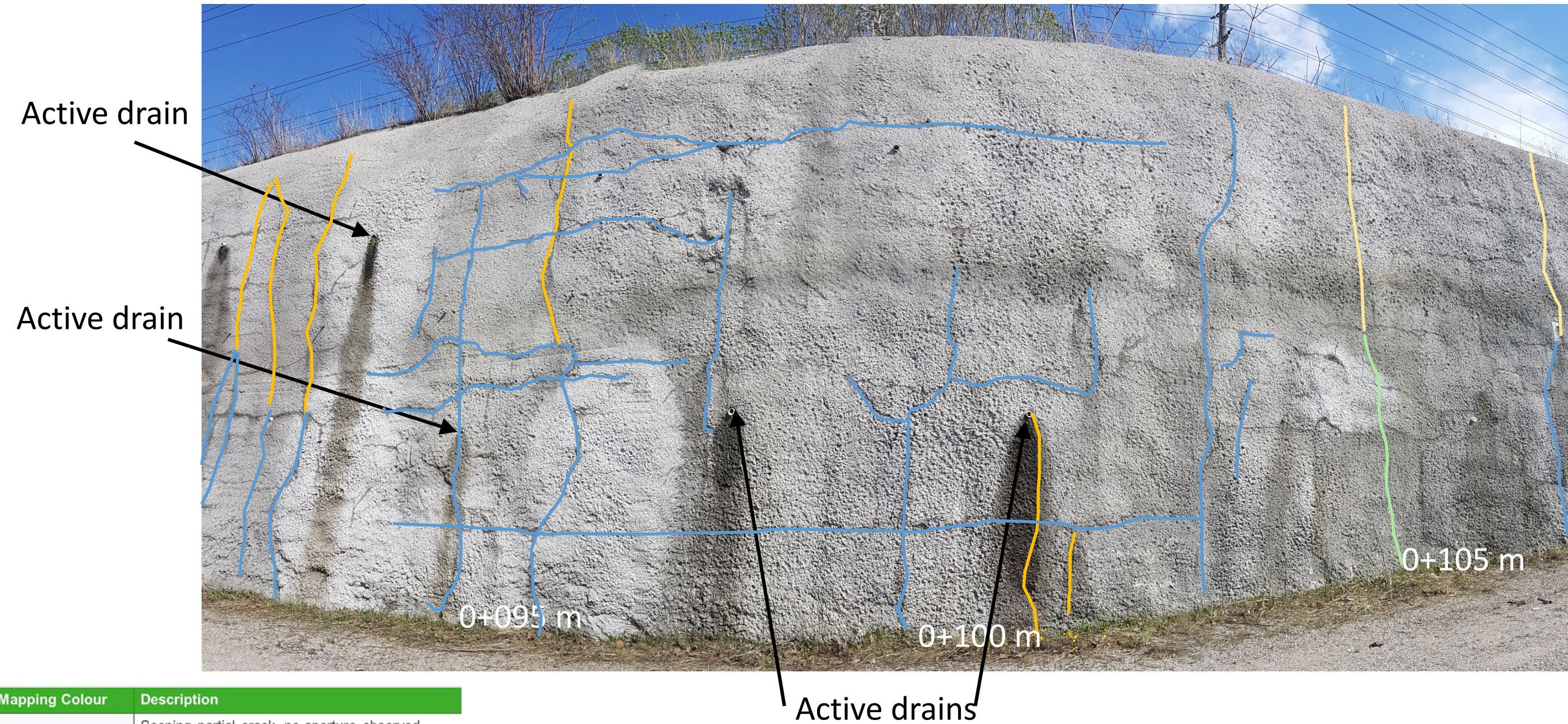
Mapping Colour		Description
		Seeping partial crack, no aperture observed
Dry	Seeping	Healed/Infilled Discontinuity, seeping, <1-2 mm
Dry	Seeping	Aperture <1 mm, Dry or Seeping
Dry	Seeping	Aperture 1-2 mm, Dry or Seeping
Dry	Seeping	Aperture 2-3 mm, Dry or Seeping
Dry	Seeping	Aperture 3-4 mm, Dry or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

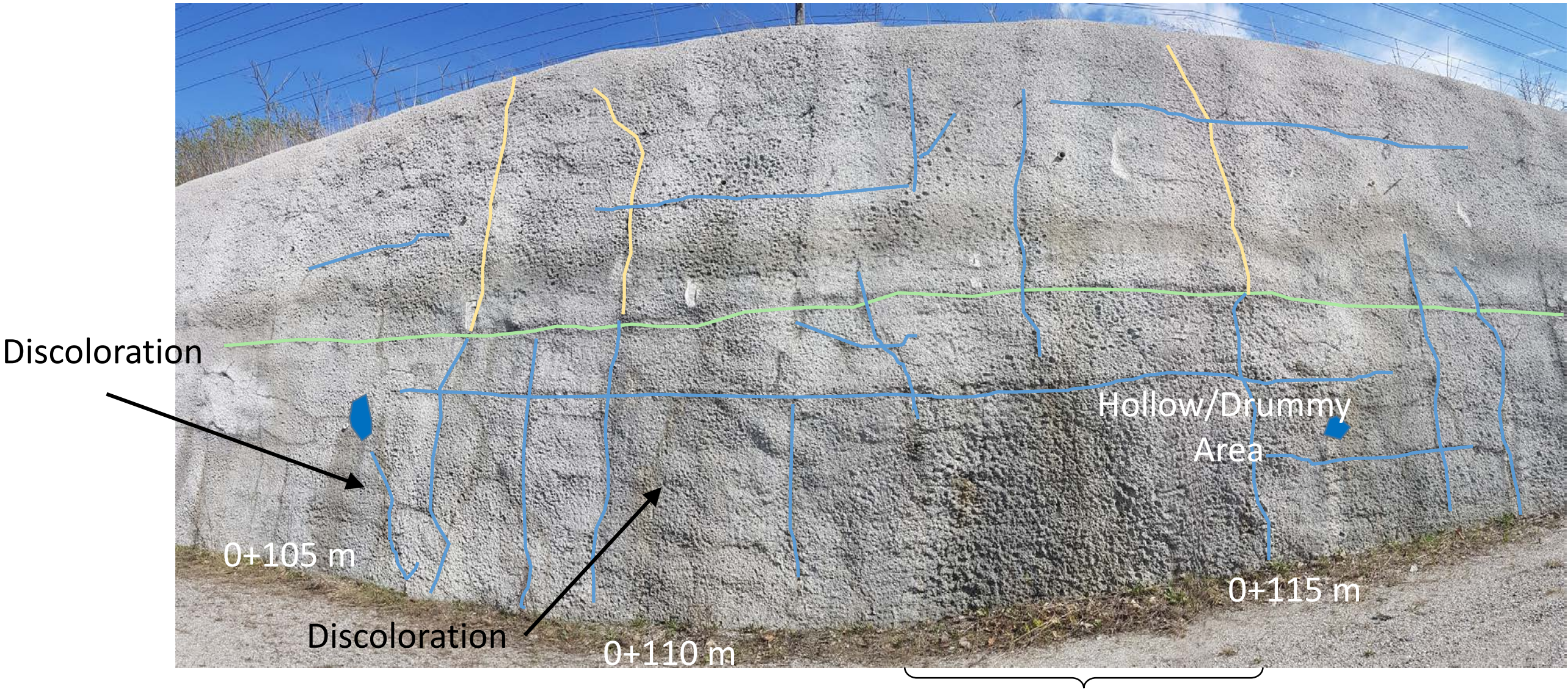
Note: Chainage 0 m at Existing Bridge



**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

Note: Chainage 0 m at Existing Bridge



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

**FIGURE 11**



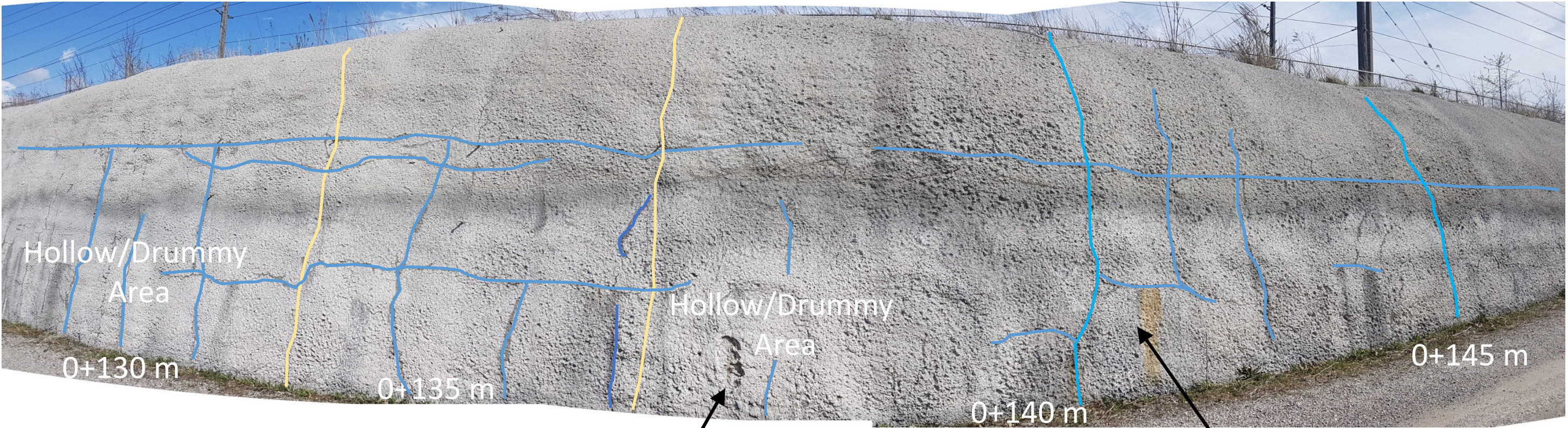
Mapping Colour		Description
		Seeping partial crack, no aperture observed
Dry	Seeping	Healed/Infilled Discontinuity, seeping, <1-2 mm
Dry	Seeping	Aperture <1 mm, Dry or Seeping
Dry	Seeping	Aperture 1-2 mm, Dry or Seeping
Dry	Seeping	Aperture 2-3 mm, Dry or Seeping
Dry	Seeping	Aperture 3-4 mm, Dry or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

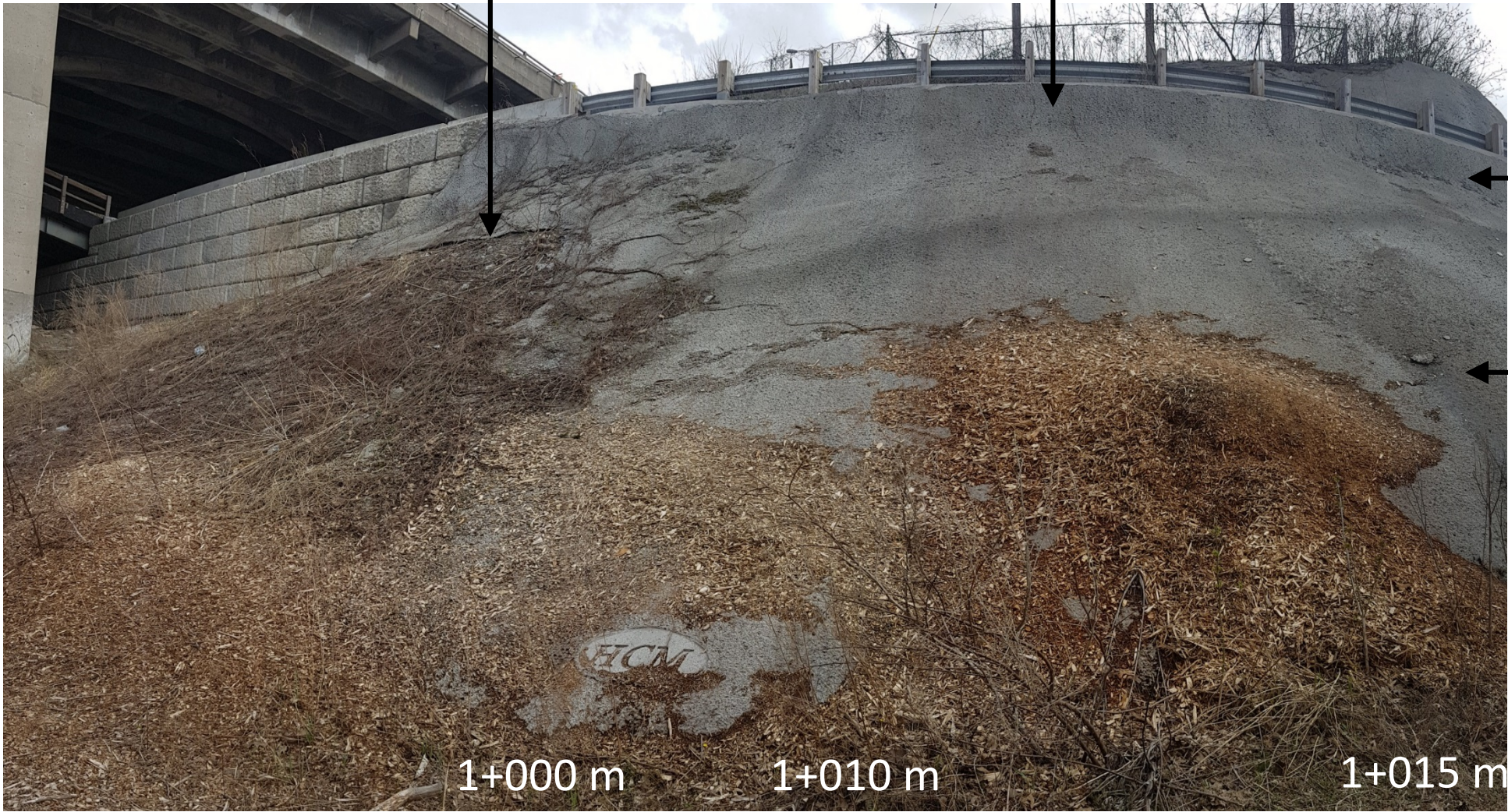


**SUMMARY OF SHOTCRETE MAPPING**  
**Lower South Face**  
**Chainage: 1+000 to 1+015**

**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



1+020 m

1+025 m

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

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

Seepage from  
intersecting  
vertical and  
horizontal  
fractures

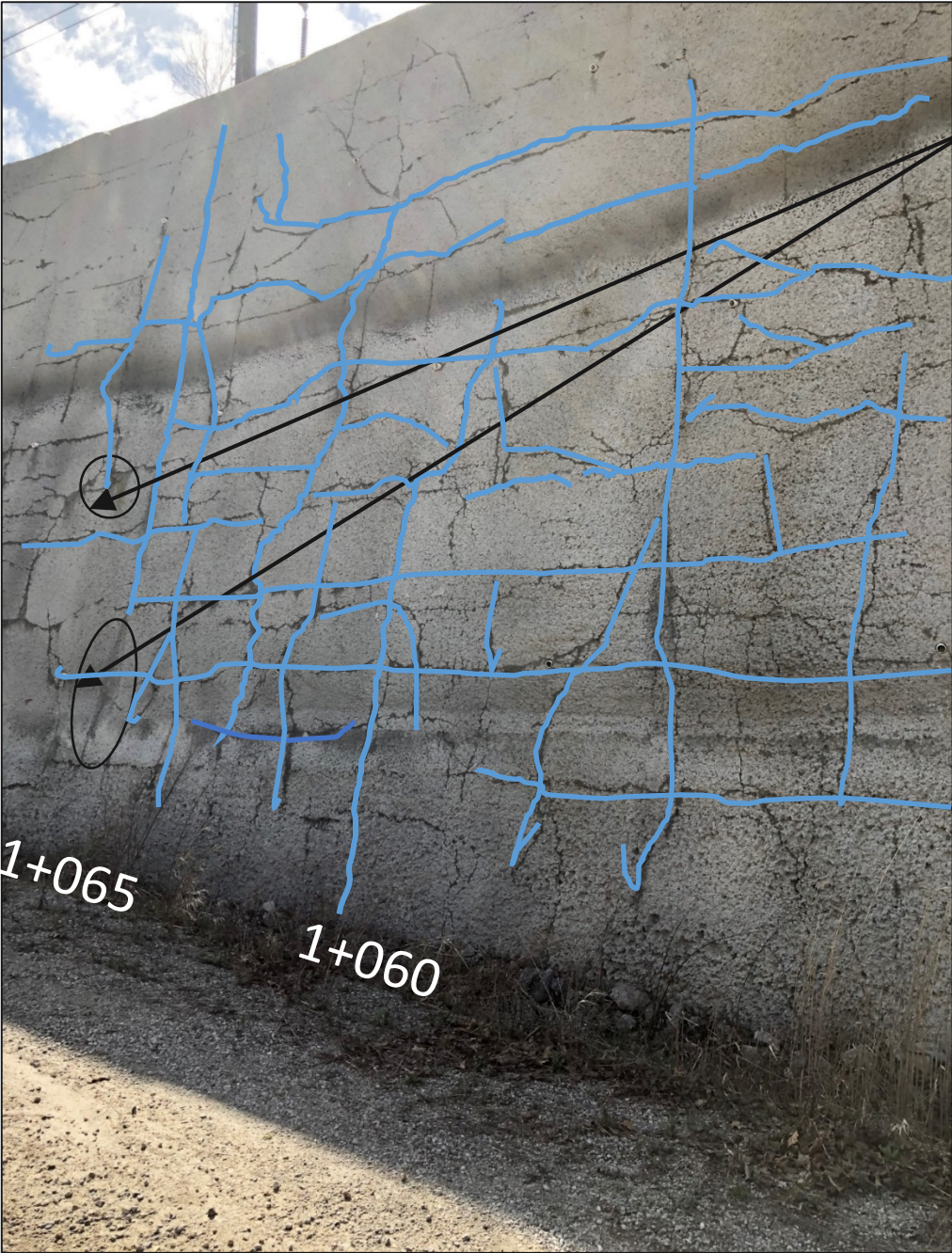


1+050



**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.

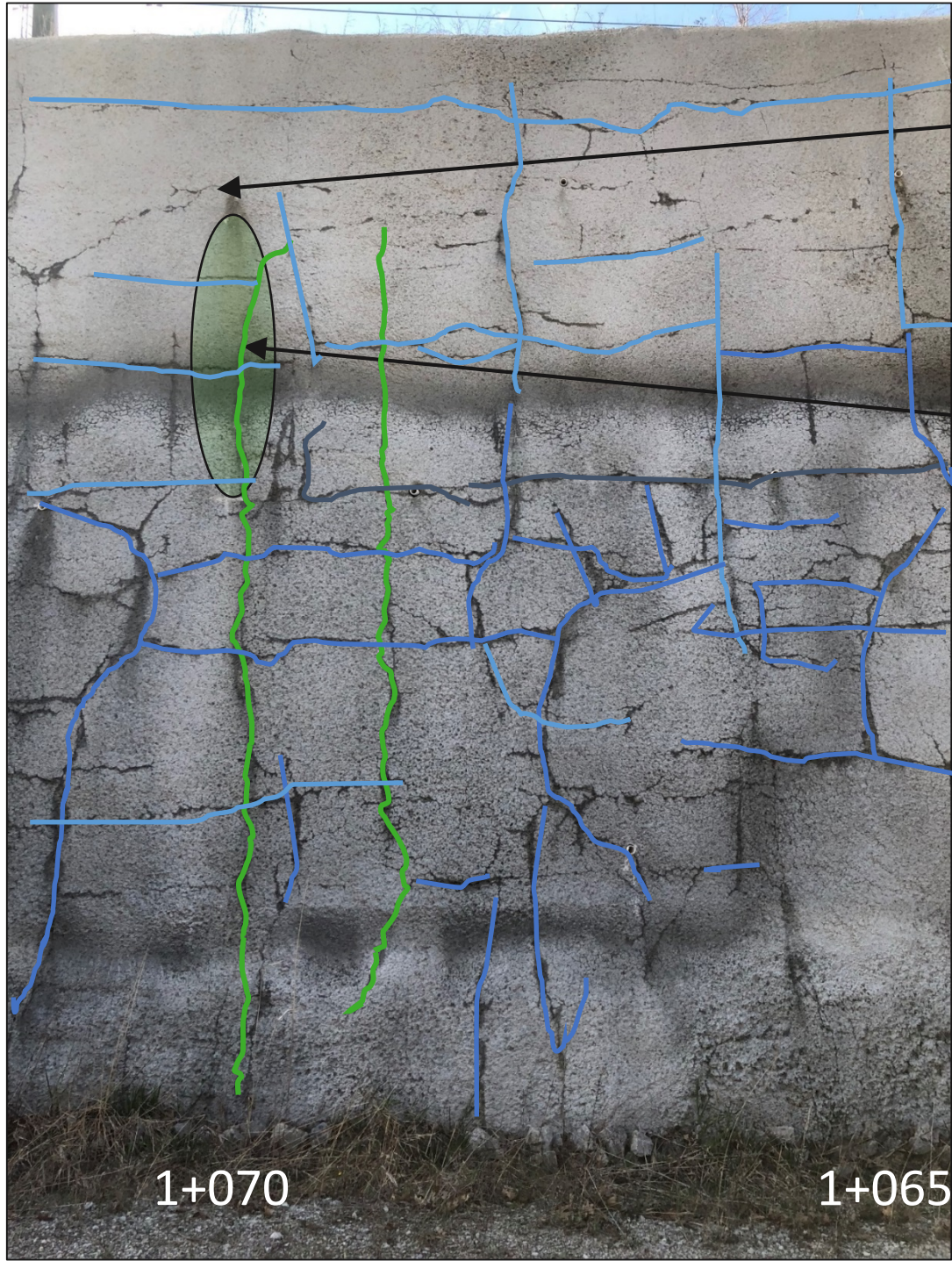
Base of the  
shotcrete  
has a  
'pitted'  
texture due  
to erosion

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**

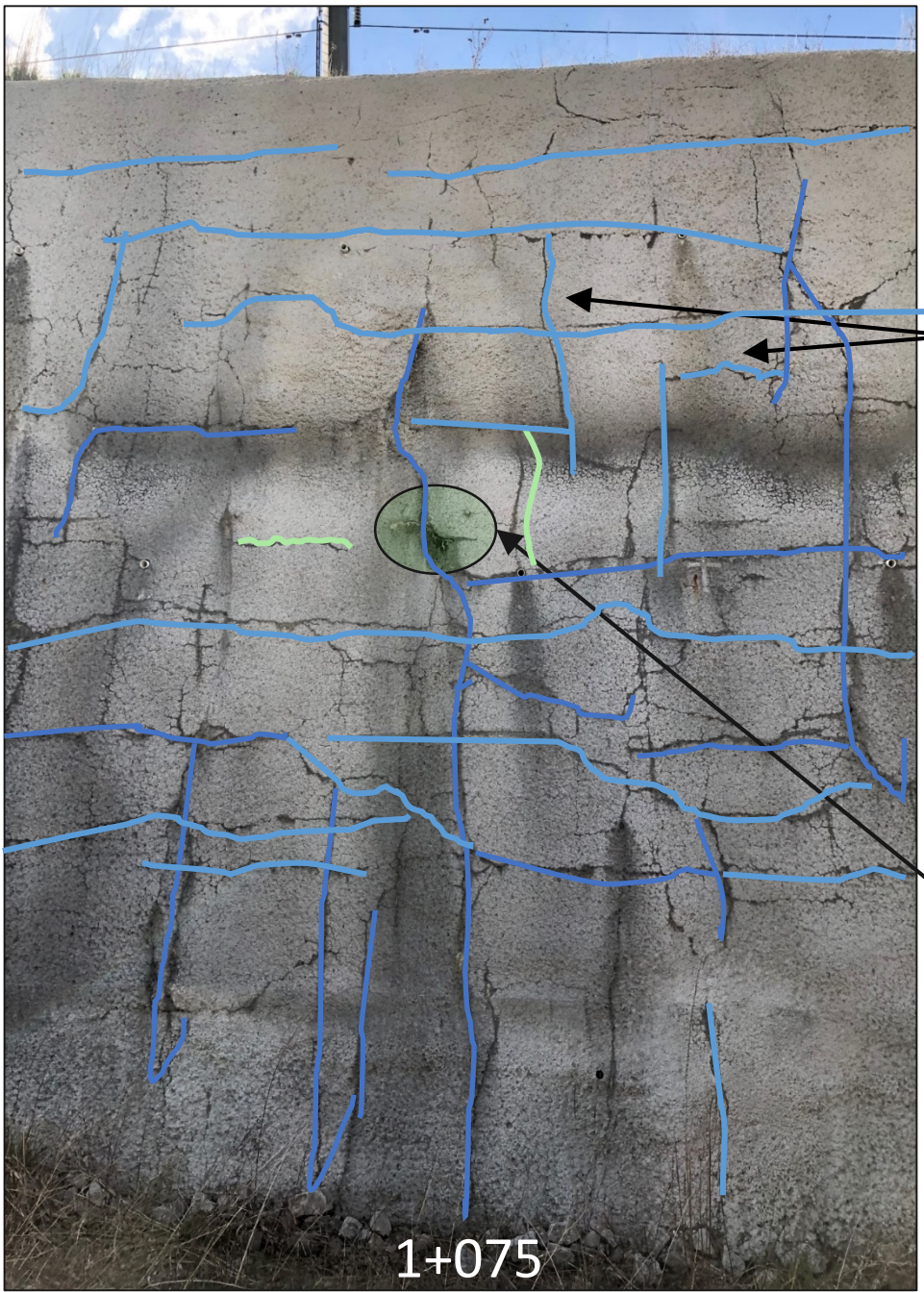


Active drainpipe

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.

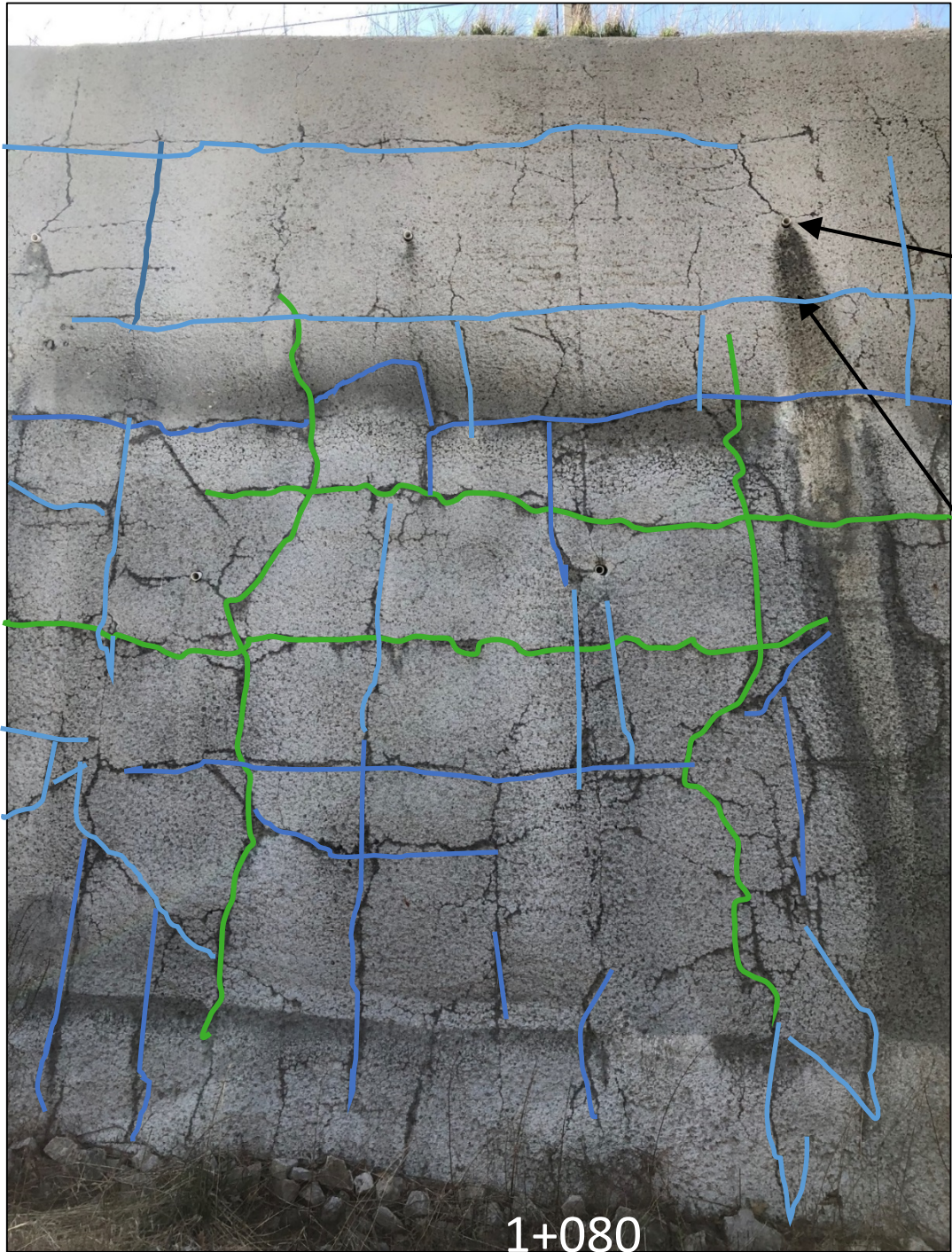


# SUMMARY OF SHOTCRETE MAPPING

## North Face

### Chainage: 1+075 to 1+090

FIGURE 23



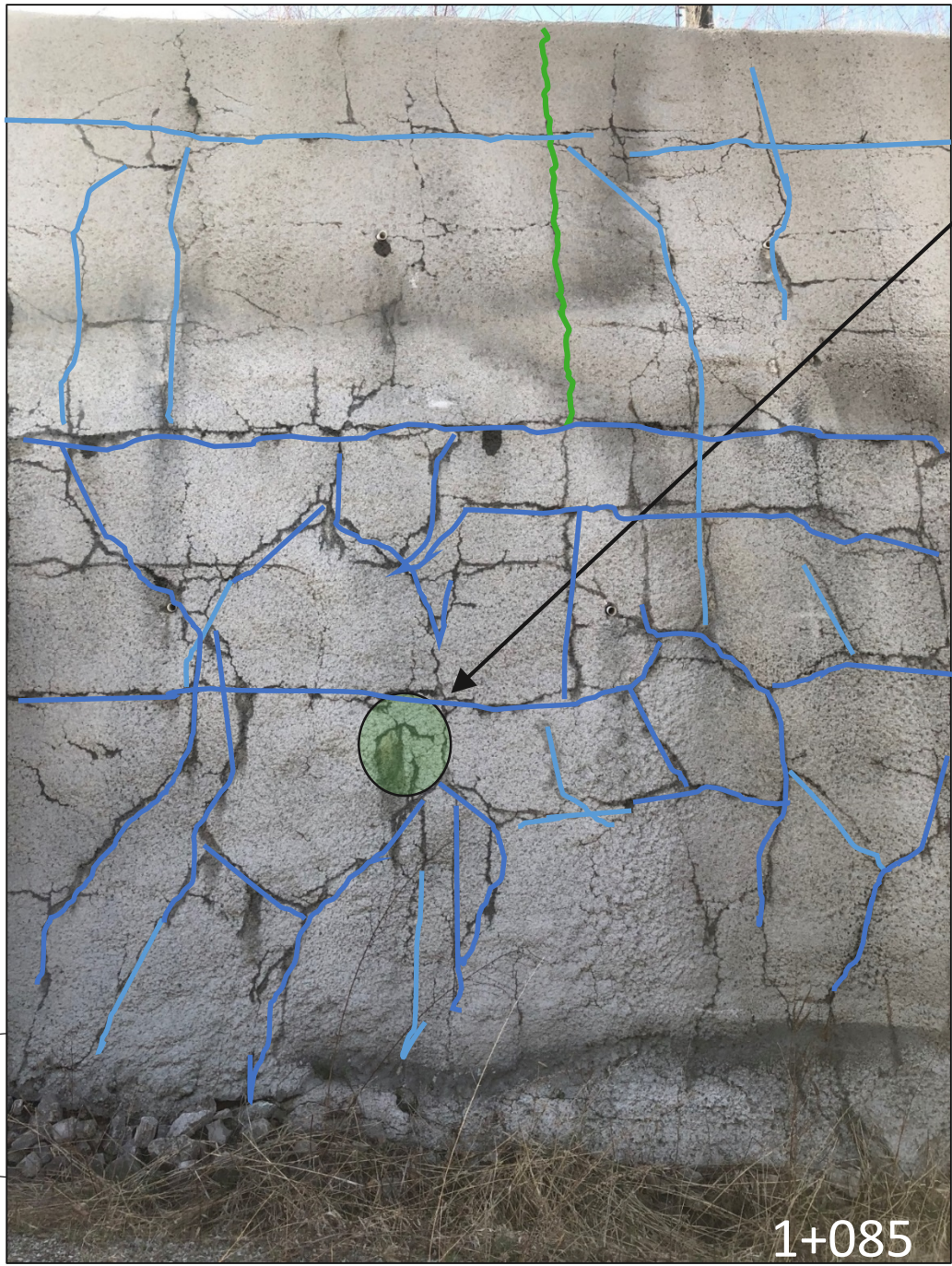
Active  
Drainpipe

Light grey/yellow  
discoloration  
along drainage  
path

Base of  
shotcrete  
begins to  
be exposed

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

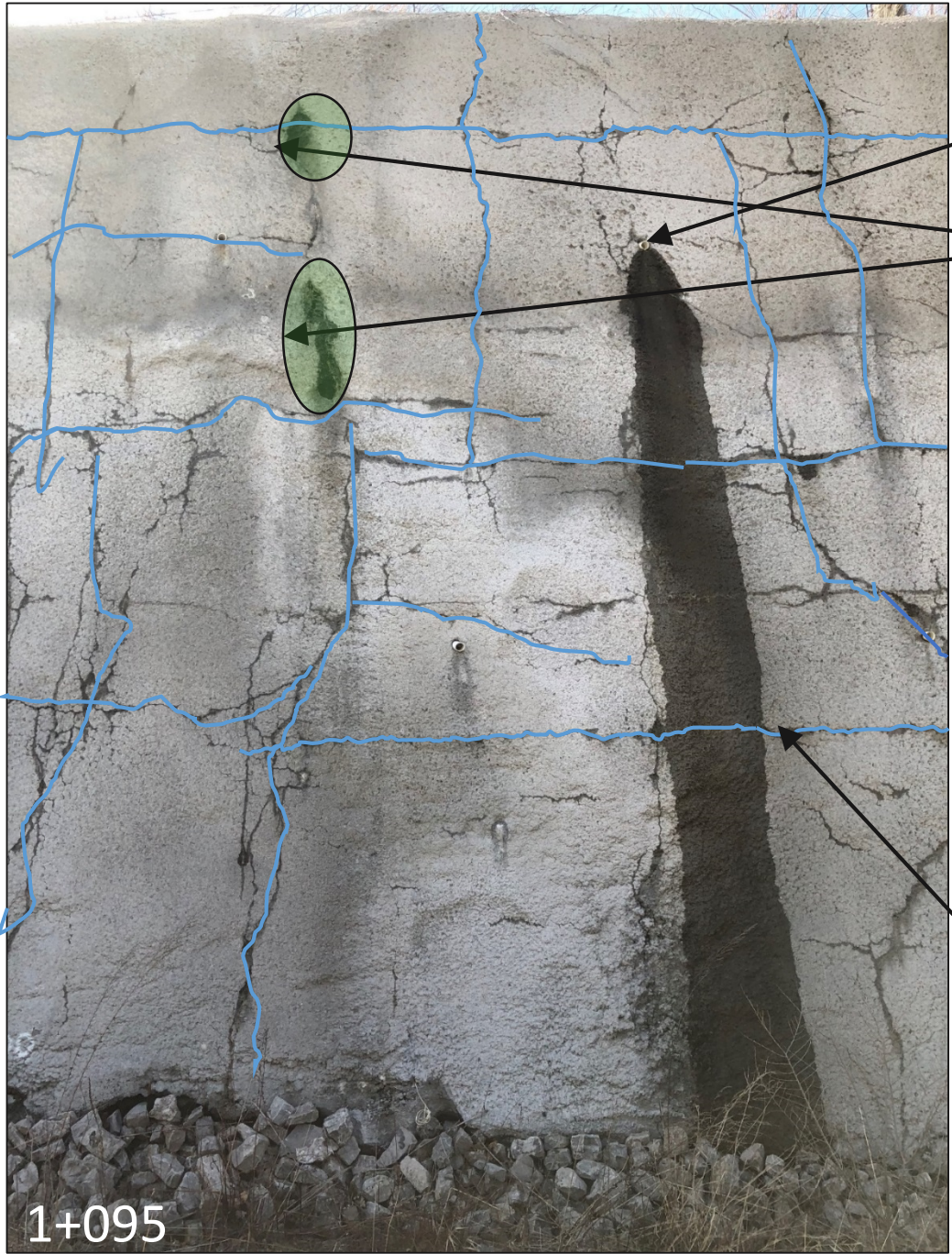


Healed  
fracture,  
Light grey  
seepage,  
discoloration



**SUMMARY OF SHOTCRETE MAPPING**  
**North Face**  
**Chainage: 1+095 to 1+100**

**FIGURE 24**



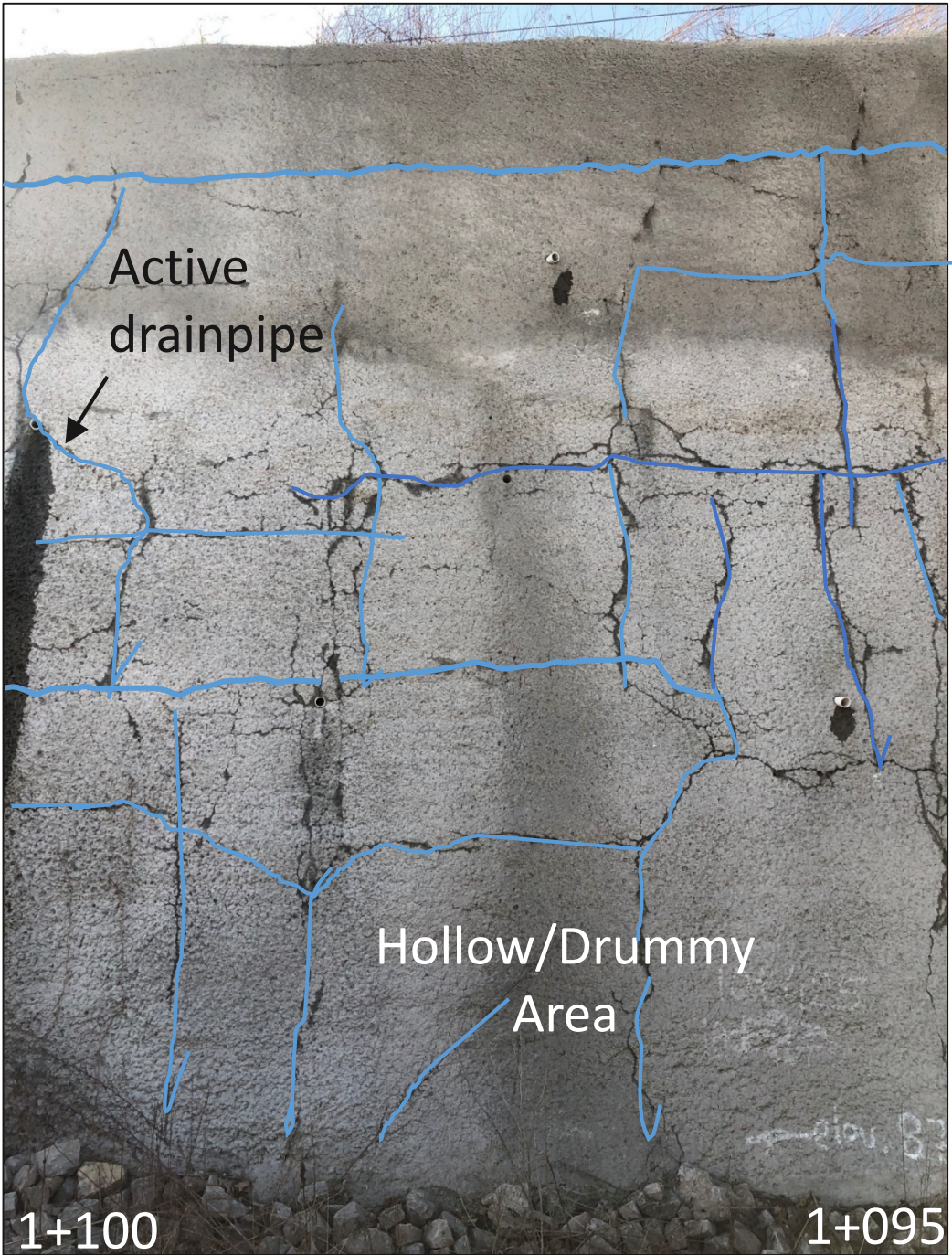
Active  
drainpipe

Dark  
brown/black  
discoloration  
from seepage  
at healed  
fracture.

Light grey  
discoloration  
along drainage  
path

~5 m  
long  
fracture

1+095



1+100

1+095

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



1+100

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

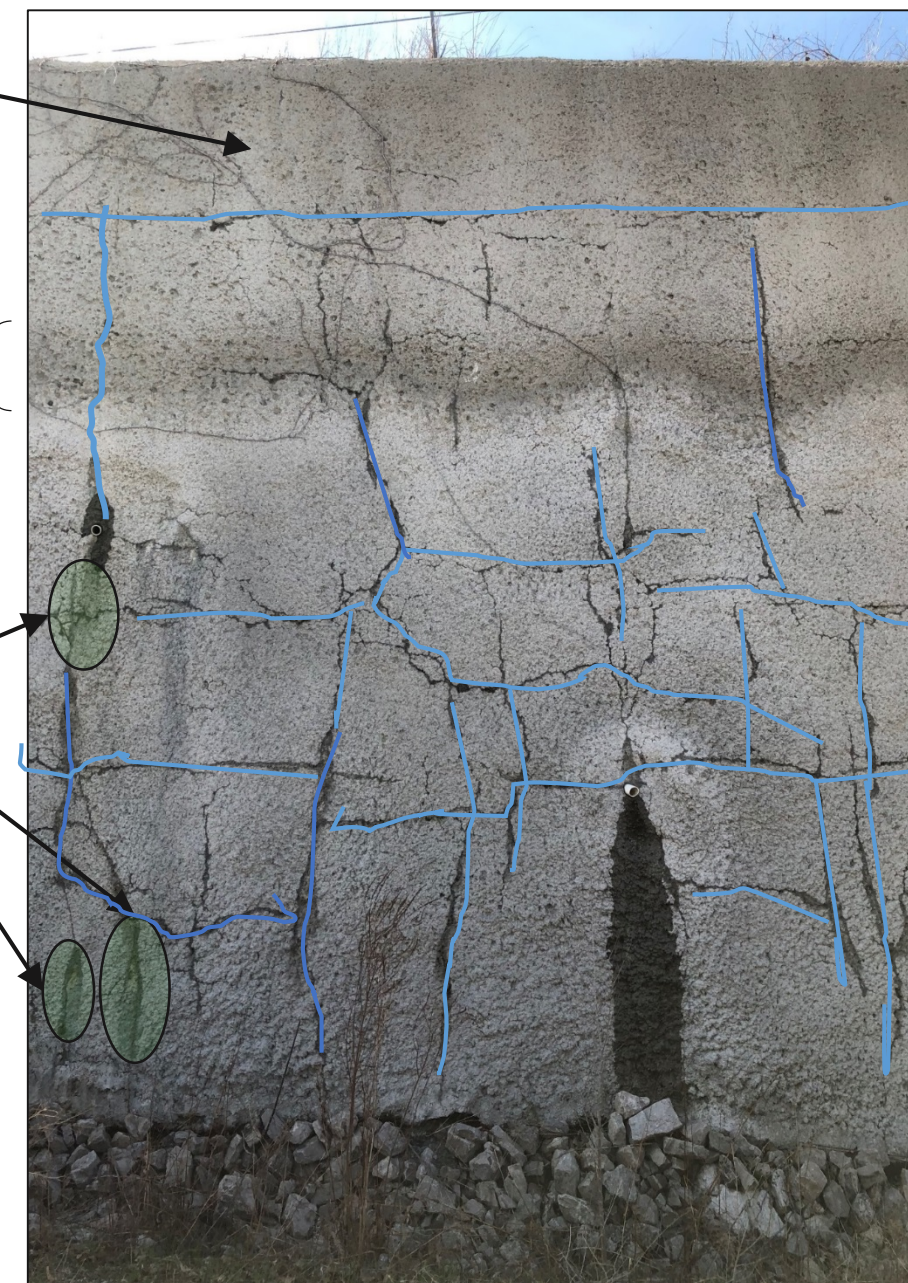
### Chainage: 1+100 to 1+105

FIGURE 25

Vine growth  
over shotcrete

Shotcrete eroded  
from water causing  
'pitted' texture.

Light grey  
discoloration  
from drainage



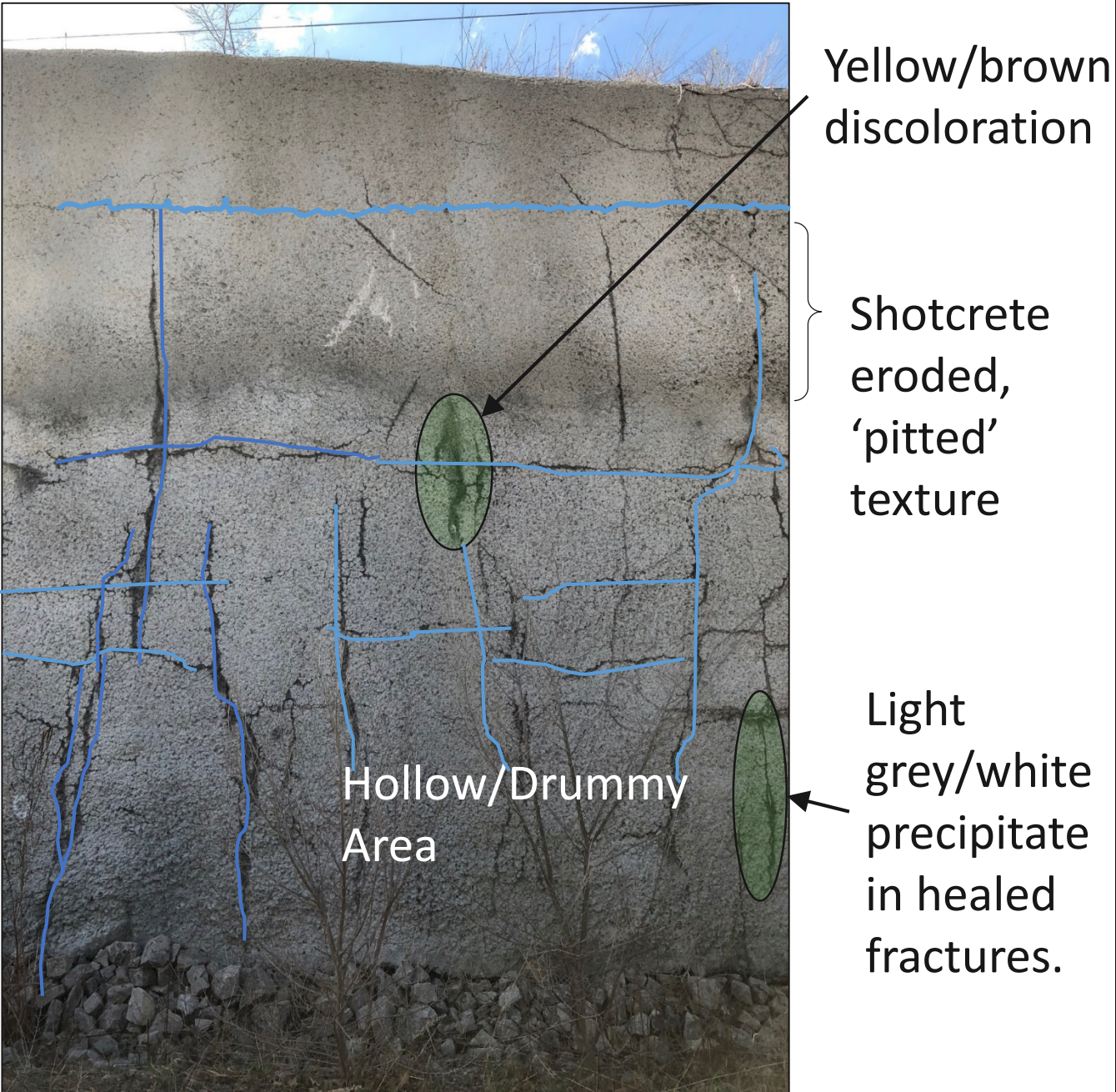
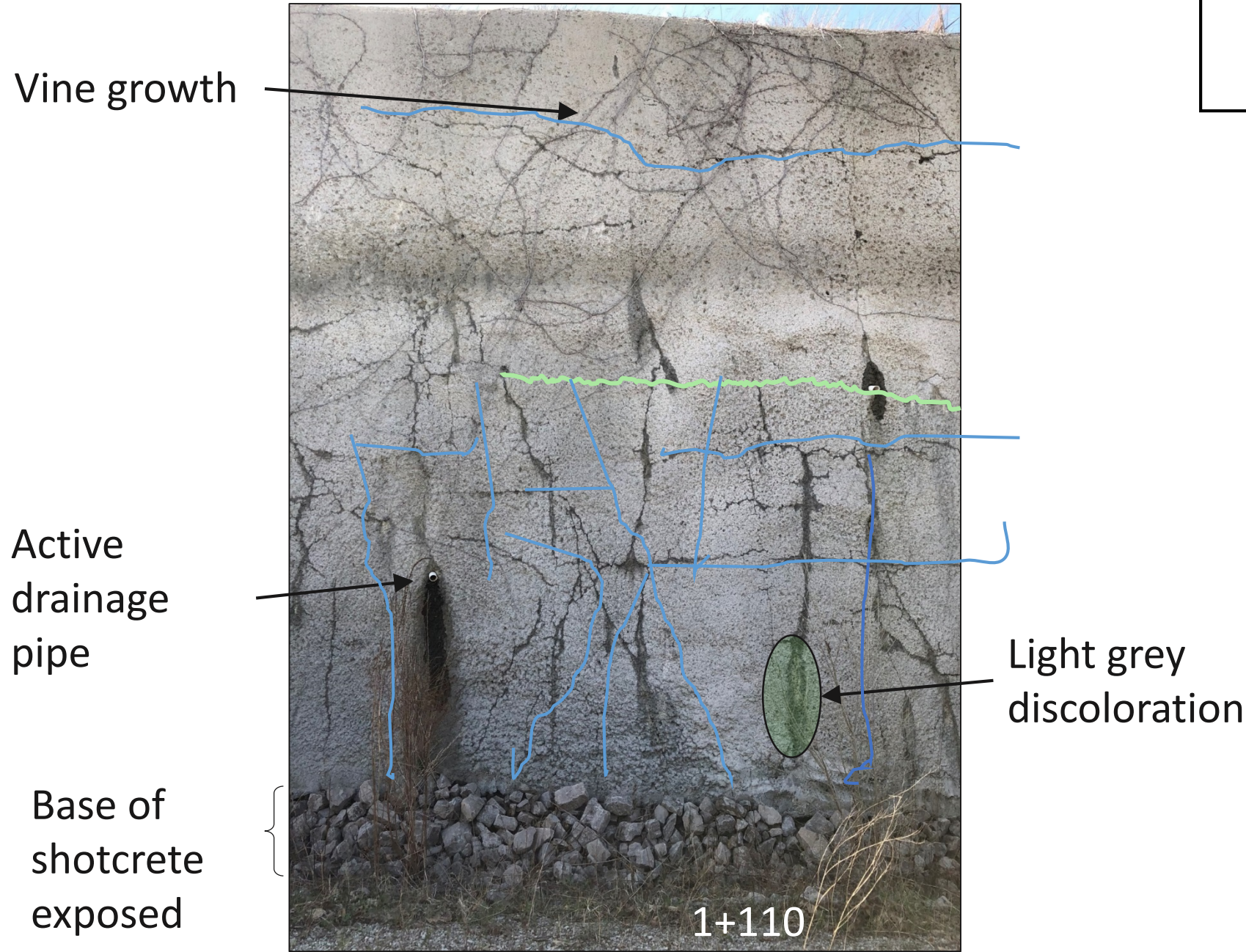


# SUMMARY OF SHOTCRETE MAPPING

## North Face

### Chainage: 1+105 to 1+115

FIGURE 26



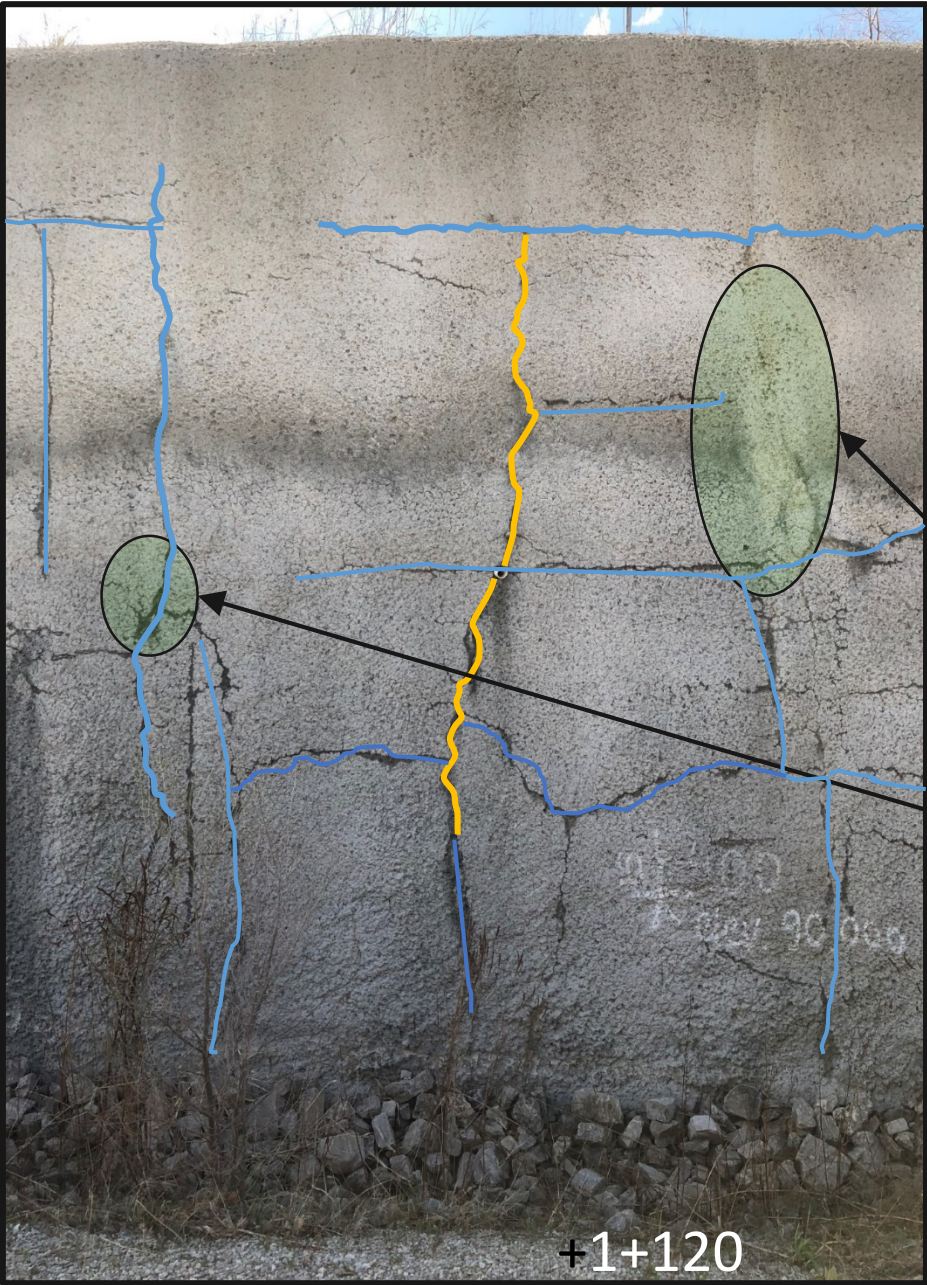
Mapping Colour		Description
		Seeping partial crack, no aperture observed
Dry	Seeping	Healed/Infilled Discontinuity, seeping, <1-2 mm
Dry	Seeping	Aperture <1 mm, Dry or Seeping
Dry	Seeping	Aperture 1-2 mm, Dry or Seeping
Dry	Seeping	Aperture 2-3 mm, Dry or Seeping
Dry	Seeping	Aperture 3-4 mm, Dry or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

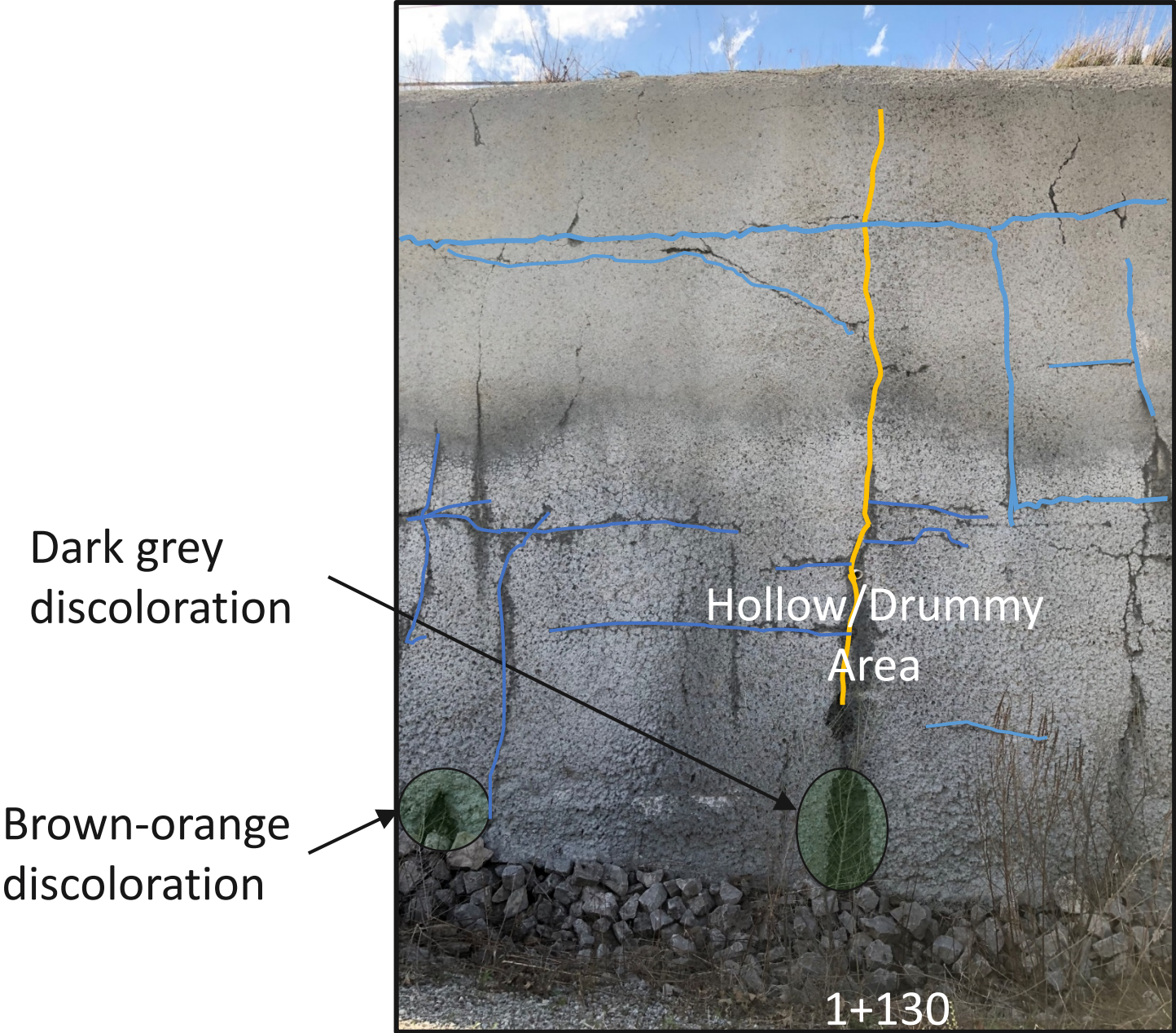
Mapping Colour		Description
		Seeping partial crack, no aperture observed
Dry	Seeping	Healed/Infilled Discontinuity, seeping, <1-2 mm
Dry	Seeping	Aperture <1 mm, Dry or Seeping
Dry	Seeping	Aperture 1-2 mm, Dry or Seeping
Dry	Seeping	Aperture 2-3 mm, Dry or Seeping
Dry	Seeping	Aperture 3-4 mm, Dry or 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 9<sup>th</sup>)

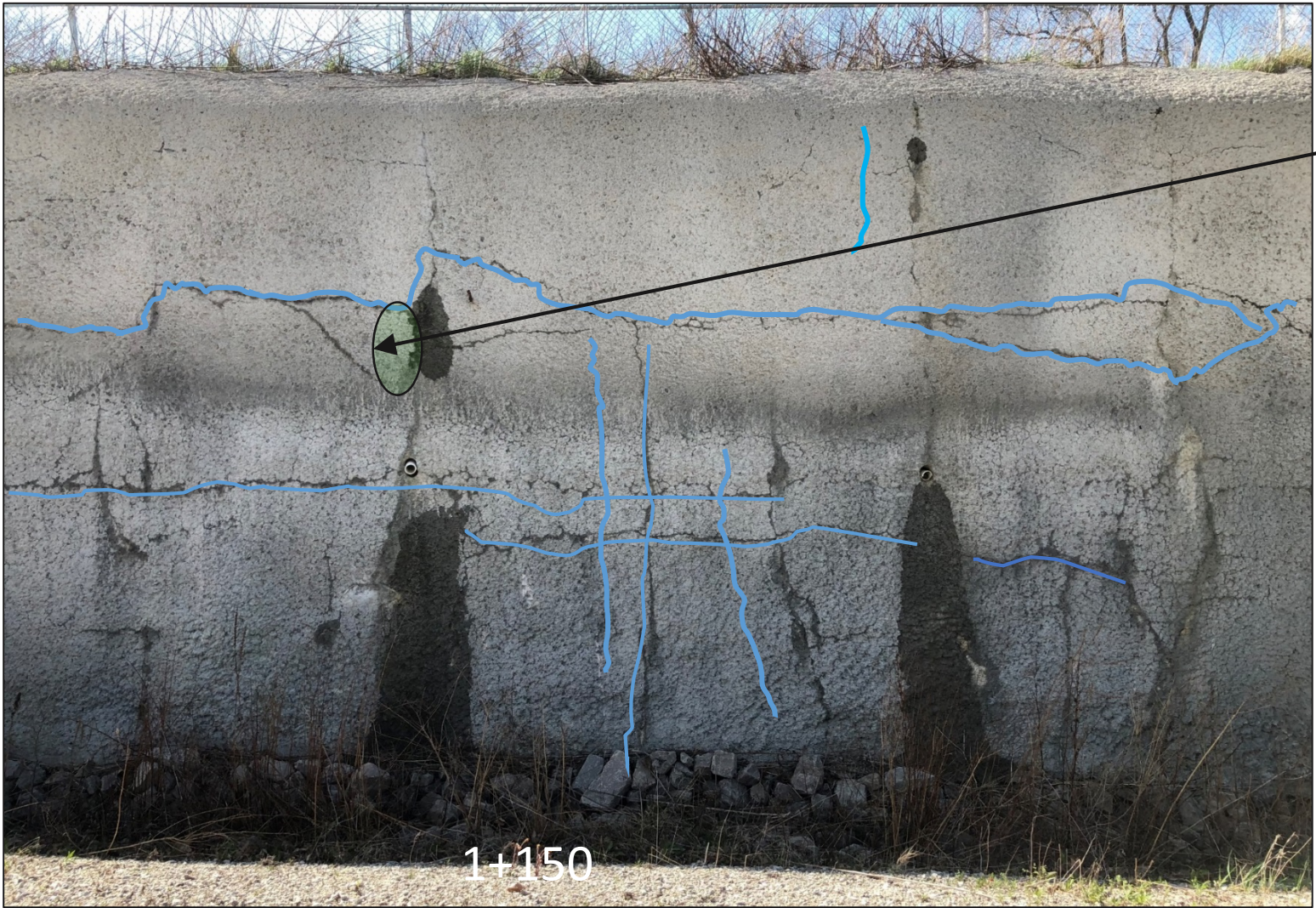
Major seepage and discoloration

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

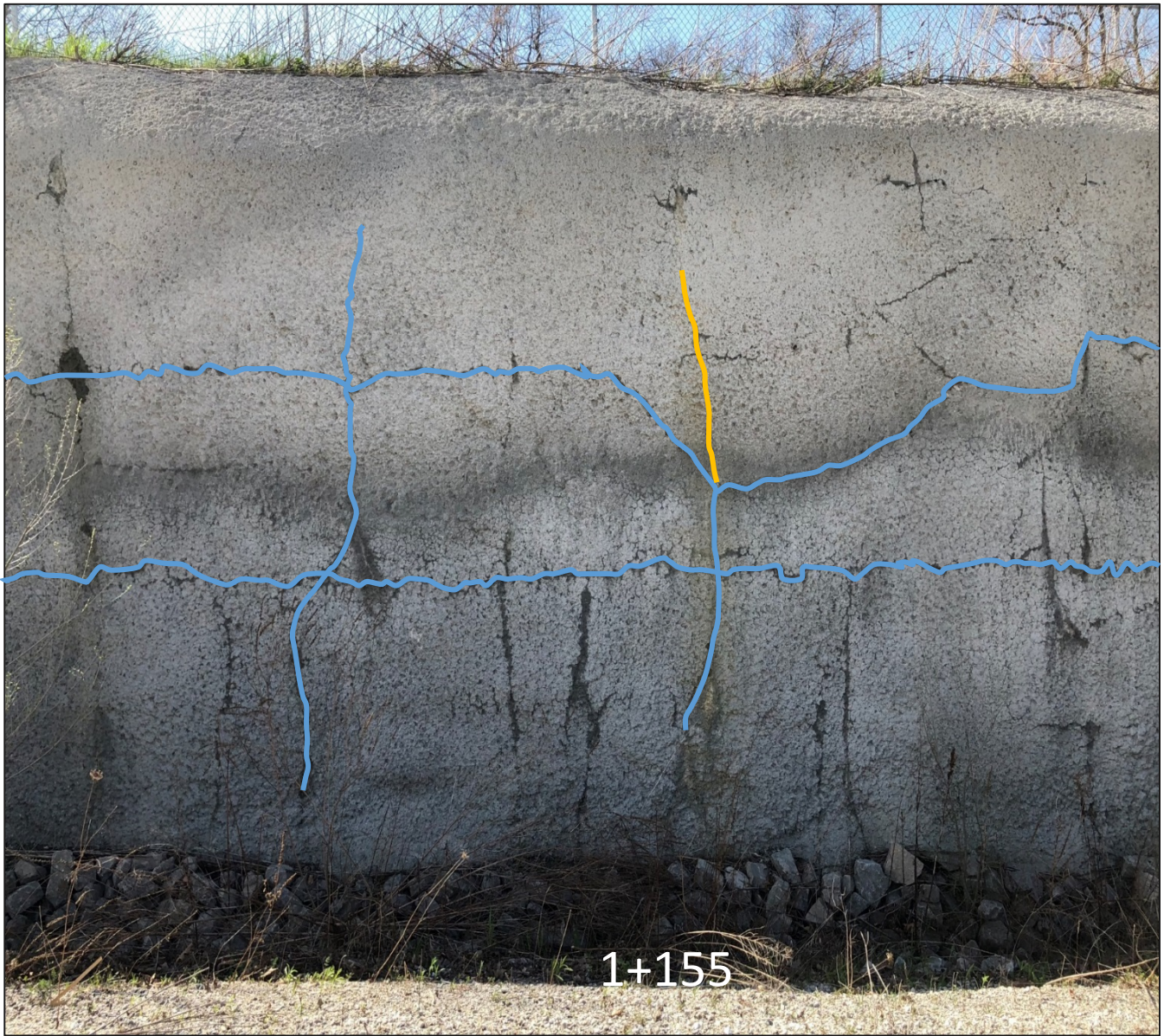


**SUMMARY OF SHOTCRETE MAPPING**  
**North Face**  
**Chainage: 1+147 to 1+157**

**FIGURE 30**



Seepage

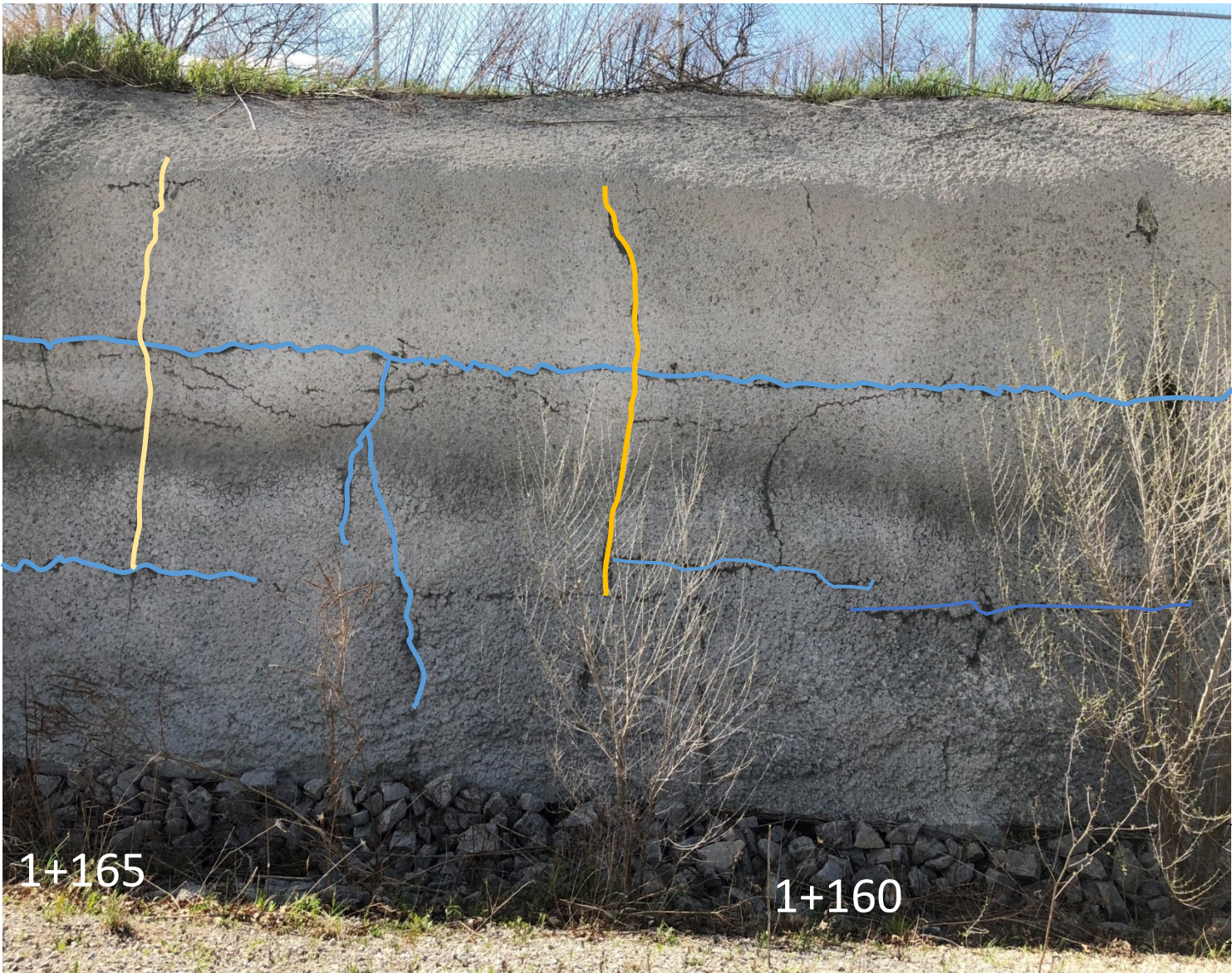


Mapping Colour		Description
		Seeping partial crack, no aperture observed
Dry	Seeping	Healed/Infilled Discontinuity, seeping, <1-2 mm
Dry	Seeping	Aperture <1 mm, Dry or Seeping
Dry	Seeping	Aperture 1-2 mm, Dry or Seeping
Dry	Seeping	Aperture 2-3 mm, Dry or Seeping
Dry	Seeping	Aperture 3-4 mm, Dry or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

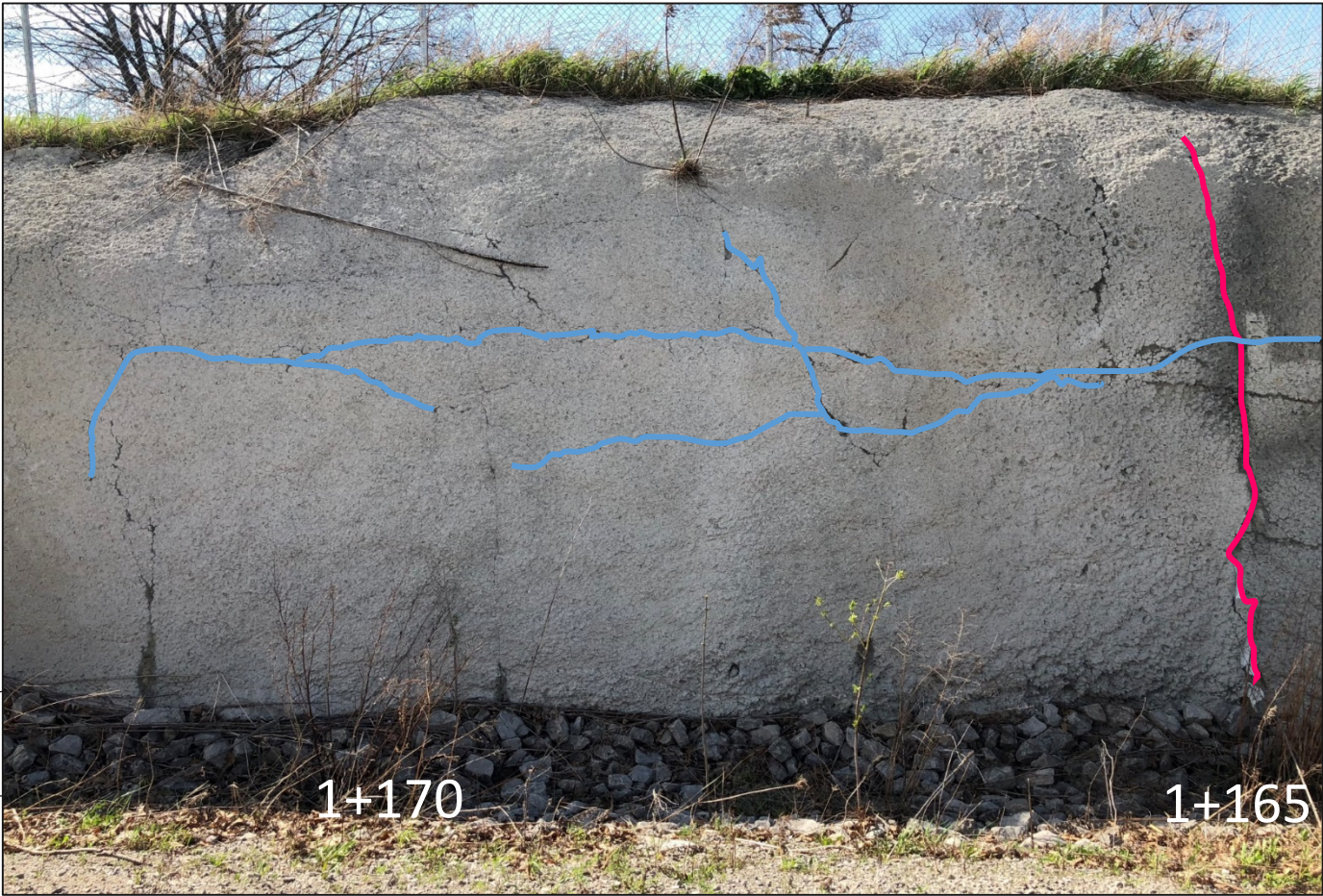


**SUMMARY OF SHOTCRETE MAPPING**  
**North Face**  
**Chainage: 1+157 to 1+170**

**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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