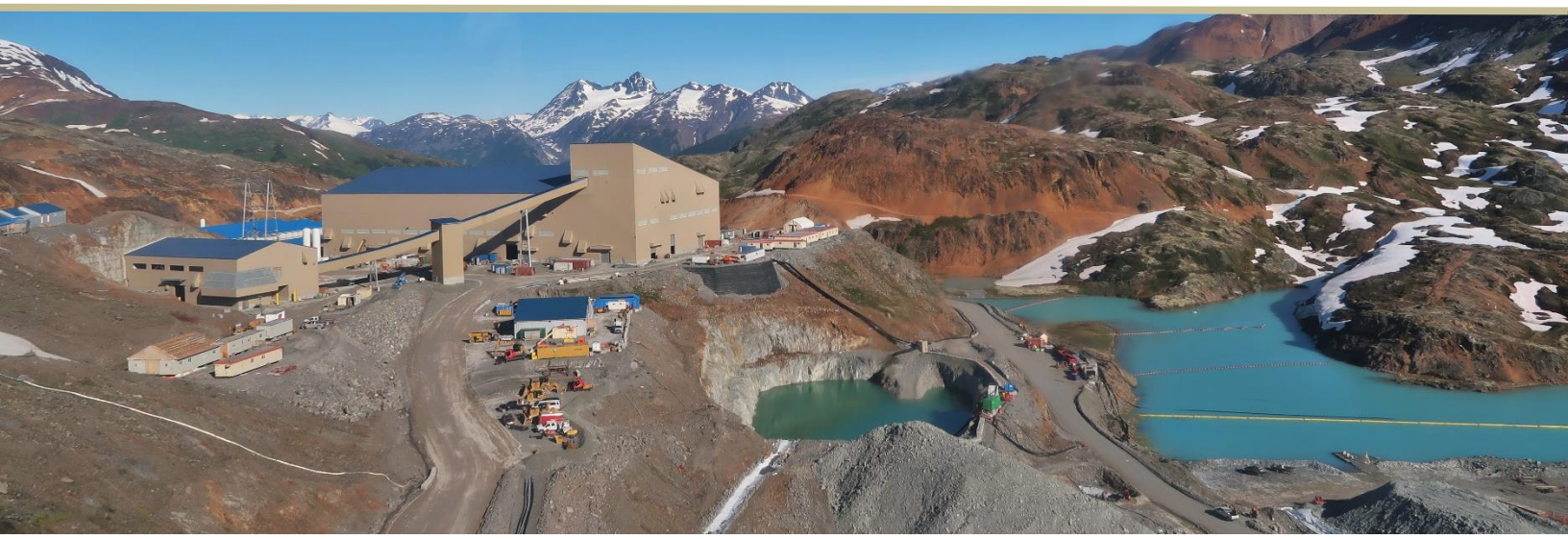
Technical Report on the Brucejack Gold Mine, Northwest British Columbia



PRESENTED TO

Pretium Resources Inc.

EFFECTIVE DATE: MARCH 9, 2020
220008-00-RPT-001

QUALIFIED PERSONS:

ALISON SHAW, PH.D., P.GEO.
CALVIN BOESE, P.ENG., M.SC.
COLIN FRASER, P.GEO. M.SC.
HASSAN GHAFFARI, P.ENG., M.A.SC.
IVOR W.O. JONES, M.SC., P.GEO., FAUSIMM
JIANHUI (JOHN) HUANG, PH.D., P.ENG.
LAURA-LEE FINDLATER, B.SC., P.GEO.
MAUREEN PHIFER, P.ENG., B.SC.
MAURICIO HERRERA, PH.D., P.ENG.
ROLF SCHMITT, M.SC., P.GEO.
TIMOTHY COLEMAN, P.ENG., BENG(HONS), ACSM, M.SC.

Tetra Tech Canada Inc.
Suite 1000 – 10th Floor, 885 Dunsmuir Street
Vancouver, BC V6C 1N5 CANADA
Tel 604.685.0275 Fax 604.684.6241

This page left intentionally blank.

TABLE OF CONTENTS

1.0 SUMMARY 1-1
1.1 Introduction 1-1
1.2 Property Description and Location 1-2
1.3 Geology and Mineralization 1-2
1.4 Mineral Resource Estimates 1-3
1.4.1 Drilling, Sampling, Assaying, and Data Verification 1-3
1.4.2 Mineral Resource Estimation 1-4
1.5 Mineral Reserve Estimates 1-6
1.5.1 Mineral Reserve Comparison 1-7
1.6 Mining Methods 1-7
1.7 Mineral Processing and Metallurgical Testing 1-8
1.7.1 Early Metallurgical Test Work and Pilot Plant Operation 1-9
1.7.2 Recent Metallurgical Test Work 1-9
1.7.3 Current Operation 1-10
1.8 Recovery Methods 1-10
1.9 Project Infrastructure 1-13
1.10 Environmental Studies, Permitting and Social and Community Impact 1-18
1.11 Capital and Operating Cost Estimates 1-18
1.11.1 Capital Cost Estimate 1-18
1.11.2 Operating Cost Estimate 1-19
1.12 Economic Analysis 1-20
1.13 Project and Operation Risks 1-21
1.14 Conclusions and Recommendations 1-21

2.0 INTRODUCTION 2-1
2.1 Terms of Reference 2-1
2.2 Site Visits 2-2
2.3 Qualified Persons 2-2
2.4 Information and Data Sources 2-4

3.0 RELIANCE ON OTHER EXPERTS 3-1
3.1 Introduction 3-1
3.2 Status of Mining Leases and Mineral Claims 3-1
3.3 Environment, Social and Sustainability 3-1
3.4 Marketing Studies 3-1
3.5 Economic Analysis 3-1

4.0 PROPERTY DESCRIPTION AND LOCATION 4-1
4.1 Location 4-1
4.2 Tenure 4-2
4.3 Status of Mining Titles 4-2
4.4 Confirmation of Tenure 4-5
4.5 Royalties, Fees, and Taxes 4-5

5.0 ACCESSIBILITY, CLIMATE, LOCAL RESOURCES, INFRASTRUCTURE AND PHYSIOGRAPHY 5-1
5.1 Climate and Physiography 5-1
5.2 Vegetation 5-1
5.3 Accessibility 5-1
5.4 Infrastructure 5-4

6.0 HISTORY 6-1
6.1 Early Exploration 6-1
6.2 Exploration by Silver Standard Resources Inc. (2001 to 2010) 6-2
6.3 Previous Feasibility Studies on the Property (1990) 6-4
6.4 Prior Mineral Production 6-4
6.5 Preliminary Economic Assessment (2010) 6-4

7.0 GEOLOGICAL SETTING AND MINERALIZATION 7-1
7.1 Regional Geological Setting 7-1
7.2 Local Geology 7-3
7.3 Brucejack Project Area Geology 7-6
7.3.1 Lithology 7-10
7.3.2 Geochronology 7-12
7.3.3 Structure 7-12
7.3.4 Alteration 7-14
7.3.5 Mineralization 7-14

8.0 DEPOSIT TYPES 8-1

9.0 EXPLORATION 9-1
9.1 Exploration – 2011 to 2014 9-1
9.2 Exploration – 2015 to 2018 9-3
9.3 Exploration – 2019 9-8

10.0 DRILLING 10-1
10.1 Pretivm Drilling (2019) 10-4
10.1.1 Drilling Activities 10-4
10.1.2 Drilling Contractors and Equipment 10-4
10.1.3 Drill Coordinates and Downhole Surveys 10-4
10.1.4 Diamond Drill Core Logging Procedures 10-5
10.1.5 Summary of Results 10-5
10.2 Opinion of Qualified Person 10-7

11.0 SAMPLE PREPARATION, ANALYSES, AND SECURITY 11-1
11.1 Sample Preparation, Analysis, and Security 11-1
11.1.1 Drillhole Sampling 11-1
11.1.2 Sample Preparation and Analysis by Analytical Laboratory 11-2
11.1.3 Specific Gravity and Bulk Density 11-2
11.2 Quality Assurance and Quality Control 11-4
11.3 Qualified Person's Opinion on Sample Preparation, Security, and Analytical Procedures 11-5

12.0 DATA VERIFICATION 12-1
12.1 Data Verification by Qualified Person 12-1
12.2 Qualified Person's Opinion of the Verification 12-1

13.0 MINERAL PROCESSING AND METALLURGICAL TESTING 13-1
13.1 Previous Bench-Scale Test Work 13-1
13.1.1 Sample Description and Characteristics 13-1
13.1.2 Gold and Silver Recovery Tests – Gravity Concentration 13-3
13.1.3 Gold and Silver Recovery Tests – Flotation Concentration 13-5
13.1.4 Gold and Silver Recovery Tests – Cyanidation 13-5
13.1.5 Variability Tests 13-6
13.1.6 Locked Cycle Tests _ Gravity Separation + Flotation Concentration 13-7
13.1.7 Other Processing Related Tests 13-9
13.2 2013 Pilot Plant Testing 13-9
13.3 Mill Operation Optimization/Expansion Test Work 13-11
13.3.1 Sample Description 13-11
13.3.2 Mineralogical Analysis on Flotation Tailings and Tailings Thickener Underflow 13-13
13.3.3 Mineralogical Analysis on Flotation Concentrates 13-13
13.3.4 Comminution Test Work 13-15
13.3.5 Gold and Silver Recovery Test Work 13-16
13.3.6 Solid and Liquid Separation Test Work 13-26
13.4 Mill Operations Optimization / Expansion Process Simulations 13-28
13.4.1 Grinding Circuit 13-28
13.4.2 Gravity Simulations 13-32
13.4.3 Flotation Simulations 13-32
13.5 Production Data 2017 to 2019 13-32
13.6 Metallurgical Performance Projection 13-33

14.0 MINERAL RESOURCE ESTIMATES 14-1
14.1 Disclosure 14-1
14.2 Known Issues that Materially Affect Mineral Resources 14-1
14.3 Modelling Approach 14-3
14.4 Data Provided for Estimation 14-4
14.4.1 Assay Dataset for Grade Estimation 14-4
14.4.2 Assay Data Import Procedure 14-5
14.4.3 Triangulations 14-5
14.5 Geological Interpretation and Modelling 14-7
14.6 Data Selection and Preparation 14-9
14.6.1 Update Area 14-9
14.6.2 Compositing 14-10
14.6.3 Grade Populations 14-11
14.6.4 Summary Statistics 14-13
14.7 Estimation 14-14
14.7.1 Methodology 14-14
14.7.2 Parameter Optimization 14-16
14.7.3 Variography 14-16

14.7.4 Search Parameters 14-21
14.7.5 Upper Tail Modelling of High Grade Population in MIK Estimation 14-22
14.7.6 Specific Gravity and Bulk Density 14-23
14.7.7 Other Variables 14-24
14.8 Model Validation 14-24
14.8.1 Statistical Checks – Final Gold and Silver Grade Estimates 14-25
14.8.2 Grade Trend Plots 14-26
14.8.3 Visual Validation 14-29
14.8.4 Reconciliation of the Resource Model with 2019 Production 14-31
14.8.5 Concluding Remarks: Model Validation 14-33
14.9 Mineral Resource Classification 14-34
14.10 Mineral Resource Reporting 14-35
14.10.1 Depletion 14-35
14.10.2 January 2020 Mineral Resource for the Brucejack Deposit 14-35
14.10.3 Resource Sensitivity 14-36
14.11 Comparison with the January 2019 Resource Estimate 14-37

15.0 MINERAL RESERVE ESTIMATES 15-1
15.1 General 15-1
15.2 Cut-off Grade 15-1
15.3 NSR Model 15-1
15.4 Mining Shapes 15-3
15.5 Orebody Description 15-3
15.5.1 Valley of the Kings Zone 15-3
15.5.2 West Zone 15-4
15.6 Mine Call Factor 15-4
15.7 Mineral Reserve Depletion Due to Grade Control Program 15-7
15.8 Dilution and Recovery Estimates 15-7
15.9 2019 Mineral Reserve Reconciliation 15-10
15.10 2020 Mineral Reserves 15-11
15.11 Mineral Reserve Comparison 15-15

16.0 MINING METHODS 16-1
16.1 General 16-1
16.2 Mine Design 16-1
16.2.1 Access and Ramp Infrastructure 16-1
16.2.2 Level Development 16-3
16.2.3 Stope Design 16-7
16.3 Mining Method and Sequence 16-9
16.3.1 Block Definition 16-9
16.3.2 Stope Cycle 16-10
16.3.3 Stope Sequence 16-11
16.3.4 Backfilling 16-13
16.3.5 Paste Backfill Test Work 16-13

16.4 Development and Production Schedule 16-15
16.4.1 Production Rate 16-15
16.4.2 Sustaining Development 16-16
16.4.3 LOM Production Schedule 16-17
16.5 Geotechnical 16-18
16.5.1 Rock Mass Properties 16-19
16.5.2 Mine-scale Fault Zones 16-20
16.5.3 Underground Rock Mechanics 16-21
16.6 Mobile Equipment Requirements 16-26
16.6.1 Production Phase 16-26
16.6.2 Support Equipment 16-28
16.7 Ventilation 16-30
16.7.1 Design Criteria 16-31
16.7.2 Total Airflow Requirements 16-31
16.7.3 Auxiliary Ventilation 16-31
16.7.4 Permanent Primary Fans 16-32
16.7.5 Mine Air Heating 16-33
16.7.6 Conveyor Decline 16-33
16.7.7 Emergency Preparedness 16-34
16.8 Underground Infrastructure 16-36
16.8.1 Mine Dewatering 16-36
16.8.2 Solids and Slimes Handling 16-38
16.8.3 Materials Handling 16-38
16.8.4 Power Requirements and Electrical Distribution 16-40
16.8.5 Compressed Air 16-45
16.8.6 Service Water Supply 16-45
16.8.7 Fueling and Lubrication 16-46
16.8.8 Workshop and Stores 16-46
16.8.9 Explosives Magazine 16-46
16.8.10 Refuge Stations 16-48
16.8.11 Communications 16-48
16.8.12 Portal Structure 16-49
16.8.13 Heating System and Propane Storage 16-49
16.8.14 Propane Supply 16-50
16.9 Paste Fill Distribution 16-51
16.9.1 Distribution System Design 16-51
16.9.2 Distribution Approach 16-52
16.9.3 Distribution System Layout 16-53
16.9.4 Manpower Requirements 16-53

17.0 RECOVERY METHODS 17-1
17.1 Mineral Processing 17-1
17.1.1 Introduction 17-1
17.1.2 Mill Operation Data 17-1
17.1.3 Flowsheet Development 17-2

17.1.4 Plant Design 17-4
17.1.5 Process Plant Description 17-5
17.2 Annual Production Estimate 17-13

18.0 PROJECT INFRASTRUCTURE 18-1
18.1 Overview 18-1
18.2 Mine Site Surface Infrastructure 18-5
18.2.1 Mill Facility Description 18-5
18.2.2 Mine Waste Management 18-8
18.2.3 Mine Site Ancillary Facilities 18-10
18.2.4 Km 72 NPAG Quarry 18-13
18.3 Off-site Infrastructure 18-13
18.3.1 Transmission Line 18-14
18.3.2 Access Road 18-14
18.3.3 Knipple Transfer Station Facilities 18-15
18.3.4 Bowser Aerodrome 18-16
18.3.5 Wildfire Security and Camp 18-17
18.4 Site Geotechnical Assessment 18-18
18.5 Avalanche Hazard Assessment 18-19

19.0 MARKET STUDIES AND CONTRACTS 19-1
19.1 Markets 19-1
19.2 Smelter Terms 19-1
19.3 Concentrate Transportation 19-1
19.4 Mining Development Contracts 19-2

20.0 ENVIRONMENTAL STUDIES, PERMITTING AND SOCIAL OR COMMUNITY IMPACT 20-1
20.1 Environment, Social and Sustainability 20-1
20.1.1 Corporate Policies, Guiding Principles and Criteria 20-1
20.1.2 Social Setting 20-4
20.1.3 Consultation 20-7
20.2 Environmental Assessment Certifications and Permitting 20-8
20.2.1 Environmental Assessment Certifications 20-8
20.2.2 Permits and Other Authorizations 20-9
20.2.3 Financial Assurance 20-13
20.3 Environment 20-13
20.3.1 Environmental Setting 20-13
20.3.2 Geochemistry 20-16
20.3.3 Hydrogeology 20-20
20.3.4 Water Management 20-23
20.3.5 Water Balance 20-25
20.3.6 Water Quality 20-29
20.3.7 Waste Management 20-30
20.3.8 Air Emission Control 20-31
20.3.9 Closure Plan and Costs 20-31

21.0 CAPITAL AND OPERATING COSTS 21-1
21.1 Capital Cost Estimate 21-1
21.1.1 Summary 21-1
21.1.2 LOM Sustaining Capital Cost Estimate 21-1
21.2 Operating Cost Estimate 21-5
21.2.1 Summary 21-5
21.2.2 Mining Operating Cost Estimate 21-6
21.2.3 Process Operating Cost Estimate 21-7
21.2.4 Mine Site G&A and Site Services Operating Cost Estimate 21-8

22.0 ECONOMIC ANALYSIS 22-1
22.1 Introduction 22-1
22.2 Pre-tax Model 22-2
22.2.1 Metal Price Scenarios 22-5
22.3 Smelter Terms 22-5
22.4 Markets and Contracts 22-5
22.5 Taxation and Royalty Considerations 22-5
22.5.1 Canadian Income Tax System 22-6
22.5.2 Provincial (BC) Mining Tax System 22-7
22.6 Royalties 22-7
22.7 Sensitivity Analysis 22-7

23.0 ADJACENT PROPERTIES 23-1
23.1 Snowfield Property 23-1
23.2 Bowser Property 23-1
23.3 Kerr-Sulphurets-Mitchell Property 23-5
23.4 Treaty Creek Property 23-6
23.5 Catear 23-6

24.0 OTHER RELEVANT DATA AND INFORMATION 24-1
24.1 Health, Safety, Environmental and Security 24-1

25.0 INTERPRETATION AND CONCLUSIONS 25-1
25.1 Geology 25-1
25.2 Mineral Resource 25-1
25.3 Mineral Reserves 25-3
25.4 Mining 25-3
25.4.1 Underground Mine Geotechnical 25-3
25.4.2 Mining Methods 25-3
25.4.3 Waste Rock 25-4
25.5 Mineral Processing and Metallurgical Testing 25-4
25.5.1 Metallurgical Testing 25-4
25.5.2 Mineral Processing 25-4
25.6 Environmental 25-5
25.6.1 Geochemistry 25-5
25.6.2 Hydrogeology 25-6

25.6.3 Water Management 25-7
25.6.4 Water Balance 25-8
25.6.5 Water Quality 25-8
25.7 Capital Cost and Operating Cost Estimates 25-9
25.8 Economic Analysis 25-9
25.9 Project and Operation Risks 25-10

26.0 RECOMMENDATIONS 26-1
26.1 Introduction 26-1
26.2 Geology 26-1
26.3 Mineral Resource 26-2
26.4 Mining 26-3
26.4.1 Underground Mine Geotechnical 26-3
26.4.2 Mining Methods 26-4
26.4.3 Waste Rock 26-4
26.5 Mineral Processing and Metallurgical Testing 26-5
26.6 Environmental 26-5
26.6.1 Geochemistry 26-5
26.6.2 Hydrogeology 26-6
26.6.3 Water Management 26-6
26.6.4 Water Balance 26-6
26.6.5 Water Quality 26-7

27.0 REFERENCES 27-1
27.1 General 27-1
27.2 Geology 27-1
27.3 Metallurgy and Recovery Methods 27-6
27.4 Mining 27-7
27.5 Mining Geotechnical 27-8
27.6 Waste Rock Disposal 27-9
27.7 Avalanche Hazard Assessment 27-9
27.8 Environmental 27-9
27.9 Water Management 27-10
27.10 Water Balance 27-10
27.11 Water Quality 27-10
27.12 Geochemistry 27-11
27.13 Hydrogeology 27-11
27.14 Adjacent Properties 27-12

LIST OF TABLES

Table 1-1: January 2020 Valley of the Kings Zone and West Zone Mineral Resource[1,2,3,4,5,6] 1-5
Table 1-2: January 2020 Valley of the Kings Zone Mineral Resource[1] 1-5
Table 1-3: West Zone Mineral Resource, April 2012[1,2] 1-5
Table 1-4: Brucejack Gold Mine Mineral Reserves[1,2] by Mining Zone and Reserve Category, Effective January 1, 2020 1-6
Table 1-5: Comparison of 2020 Mineral Reserves with Mined Actuals to 2019 Reserves 1-7
Table 1-6: Brucejack Mill 2019 Production Data 1-10
Table 1-7: LOM Sustaining Capital Cost Estimates 1-18
Table 1-8: LOM Average Operating Cost Summary 1-19
Table 1-9: Brucejack Gold Mine Economic Performance Forecast 1-20
Table 2-1: Summary of QPs 2-3
Table 4-1: Mineral Claims for the Brucejack Property 4-2
Table 6-1: Exploration History of the Sulphurets Property between 1960 and 2008 6-1
Table 7-1: Vein Generations in the Valley of the Kings Zone 7-16
Table 8-1: Principal Field-oriented Characteristics of Intermediate- and Low-sulphidation Epithermal Systems 8-1
Table 9-1: Exploration of the Brucejack Property Between 2011 and 2014 9-1
Table 10-1: Drilling Summary for the Brucejack Property 10-1
Table 11-1: Sample Preparation and Analytical Methods Conducted on Pretivm Drill Samples Between 2014 and 2018 11-3
Table 13-1: Conventional Grindability and Crushability Test Results 13-2
Table 13-2: SMC Test Results (2012) 13-3
Table 13-3: Gravity Recoverable Gold Test Results (2012) 13-4
Table 13-4: Precious Metal Material Balance (2014) 13-4
Table 13-5: Cyanidation Flowsheet Development Test Results 13-6
Table 13-6: Locked Cycle Tests Results 13-8
Table 13-7: Bulk Sample Processing Metallurgical Performances 13-11
Table 13-8: Major Metallurgical Testing and Simulations Programs 2017–2019 13-11
Table 13-9: Head Assay Results (Gekko 2017) 13-12
Table 13-10: Head Assay Results (ALS 2018) 13-12
Table 13-11: Head Assays of Processing Samples 13-13
Table 13-12: Gold Deportment and Associations of Two Flotation Con – BV 2017 13-14
Table 13-13: Bond Test Results (ALS 2018) 13-15
Table 13-14: JK Drop Weight Test Results (ALS 2018) 13-16
Table 13-15: SMC Test Results and Parameters Derived from SMC Tests (ALS 2018) 13-16
Table 13-16: Diagnostic Leach Test Results – Gravity Concentration Tailings (2019) 13-19
Table 13-17: Locked Cycle Testing Conditions 13-23
Table 13-18: Locked Cycle Test Results 13-24
Table 13-19: Third Cleaner Flotation Results on the Second Locked Cycle Test 13-24
Table 13-20: Head Assays of Processing Samples 13-25
Table 13-21: Conventional and Column Flotation Results 13-26
Table 13-22: JKSimMet 3,800 t/d Results at 92% Availability 13-30
Table 13-23: Bruckejack Mill Production Data 2017–2019[1] 13-33

Table 14-1: Valley of the Kings Zone Mineralized Domains 14-7
Table 14-2: Summary Statistics of Gold and Silver Composited Data by Grouped Domain in January 2020 Model Updated Area 14-14
Table 14-3: Thresholds Discretizing High-grade Distribution by Bigdom 14-17
Table 14-4: Indicator Variogram Parameters for High-grade Gold in Bigdom 600 14-17
Table 14-5: Variogram Model for the Probability of High-grade Gold Indicator Variable at 3.5 g/t Au 14-19
Table 14-6: Variogram Model for the Probability of High-grade Silver Indicator Variable at 20 g/t Ag 14-20
Table 14-7: Variogram Model for Low-grade Gold Mineralization 14-21
Table 14-8: Variogram Model for Low-grade Silver Mineralization 14-21
Table 14-9: Search Parameters for High-grade and Probability of High-grade Variables for Gold and Silver by Bigdom Inside the Update Area 14-21
Table 14-10: Search Parameters for Low grade Gold and Silver Inside the Update Area 14-22
Table 14-11: Mathematical Model Parameters for the Top MIK Threshold for Each Bigdom 14-23
Table 14-12: Specific Gravity Values and Bulk Density Conversion Factors for Resource Modelling in the Update Area 14-24
Table 14-13: Global Comparison of Mean Estimated and Input Composite Grade Data for Gold and Silver by BIGDOM 14-25
Table 14-14: January 2020 Model to 2019 Mill Gold Production Reconciliation 14-32
Table 14-15: January 2020 Valley of the Kings Zone Mineral Resource [1,2,3,4,5,6] 14-36
Table 14-16 West Zone Mineral Resource, April 2012 (Jones, 2012a)[1] 14-36
Table 14-17: Comparison Between January 2020 and January 2019 Estimates for the Valley of the Kings Zone Inside the Update Area Only 14-38
Table 15-1: Cut-off Grade Costs 15-1
Table 15-2: NSR Parameters 15-2
Table 15-3: Main Valley of the Kings Zone Mining Thickness by Mining Block 15-3
Table 15-4: Insitu Au Grade Cap for the Mine Call Factor 15-6
Table 15-5: Average Insitu Gold Grade of Stopes Before and After Mine Call Factor Application 15-6
Table 15-6: 2019 Reserve Reconciliation vs. 2019 Mined Actuals 15-10
Table 15-7: 2019 Reduction of Reserve Grade After Application of MCF 15-10
Table 15-8: Brucejack Gold Mine Mineral Reserves[1,2,3,4] by Mining Zone 15-11
Table 15-9: Brucejack Gold Mine Mineral Reserves[1,2,3,4] by Mining Block 15-12
Table 15-10: Comparison of 2020 Mineral Reserves with Mined Actuals to Previous Reserve[1,2] 15-15
Table 16-1: Development Design Parameters 16-5
Table 16-2: Stope Design Parameters 16-7
Table 16-3: LOM Paste Fill Requirements 16-13
Table 16-4: Summary of Stage 2 UCS Results 16-14
Table 16-5: LOM Backfilling – Waste Rock and Mill Tailings 16-15
Table 16-6: LOM Development Requirements 16-16
Table 16-7: LOM Tonnes and Grades 16-18
Table 16-8: Rock Mass Parameters Summarized by Geotechnical Domain 16-19
Table 16-9: Lateral Development Minimum Ground Support Recommendations 16-23
Table 16-10: Minimum In Ore Supplemental Ground Support 16-24
Table 16-11: Stope Dimension and Dilution Guidelines 16-25
Table 16-12: Major Underground Development and Production Equipment List 16-26
Table 16-13: Support Equipment List 16-28

Table 16-14: Primary Fan Specifications 16-32
Table 16-15: 2018 Propane Consumption 16-50
Table 16-16: Manpower by Operational Group 16-54
Table 17-1: Brucejack Mill Production Data 2019 17-2
Table 17-2: Major Design Criteria 17-4
Table 17-3: Projected Gold and Silver Production 17-14
Table 19-1: Gold and Silver Prices 19-1
Table 20-1: List of Amendments to EAC #M-15-01 20-9
Table 20-2: List of BC Major Authorizations, Licenses, and Permits Obtained to Develop and Operate the Brucejack Project 20-11
Table 20-3: List of Federal Approvals and Licenses Obtained to Develop and Operate the Brucejack Project 20-12
Table 20-4: Average Monthly Climate Data for the Brucejack Gold Mine Site 20-15
Table 20-5: Summary of Water Withdrawal Data – Brucejack Creek, 2019 20-27
Table 21-1: Summary of LOM Expansion and Sustaining Capital Costs 21-1
Table 21-2: Foreign Exchange Rates 21-1
Table 21-3: LOM Mining Sustaining Capital Cost Summary 21-2
Table 21-4: Mining Sustaining Capital Costs by Year 21-3
Table 21-5: Site Infrastructure Sustaining Capital Costs by Year 21-4
Table 21-6: LOM Average Operating Cost Summary 21-5
Table 22-1: Cash Flow Results Summary (including Discounted Post-tax NPV) 22-1
Table 22-2: Metal Production Quantities 22-3
Table 22-3: Economic Results Summary for Different Metal Price Scenarios 22-5
Table 22-4: LOM Taxes Summary 22-6
Table 23-1: February 2011 Snowfield Mineral Resource 23-1
Table 23-2: March 2019 KSM Property Mineral Reserve 23-5
Table 23-3: March 2019 KSM Property Measured and Indicated Mineral Resources 23-6
Table 25-1: LOM Average Operating Cost Summary 25-9
Table 25-2: Brucejack Gold Mine Economic Performance Forecast 25-10

LIST OF FIGURES

Figure 1-1: Simplified Process Flowsheet 1-12
Figure 1-2: Brucejack Gold Mine On-site Infrastructure Layout 1-15
Figure 1-3: Brucejack Gold Mine Off-site Infrastructure Layout 1-16
Figure 1-4: Overall Operating Cost Distribution by Area 1-19
Figure 4-1: Brucejack Property Location Map 4-1
Figure 4-2: Brucejack Property Mineral Claims 4-3
Figure 4-3: Pretivm Mineral Claims 4-4
Figure 5-1: Project Access 5-3
Figure 6-1: Visible Electrum in Valley of the Kings Zone Discovery Drillhole SU-012 6-3
Figure 7-1: Regional Geological Setting of the Brucejack Deposit 7-2
Figure 7-2: Select Mineral Showings and Deposits in the Stewart-Iskut Culmination, Highlighting the Metal-rich Nature of this Structure 7-4

Figure 7-3: District-scale Geological Setting of the Brucejack Deposit on the East Side of the McTagg Anticlinorium 7-5
Figure 7-4: Geological Map of the Brucejack Project Area Showing Location of Mineralized Zones and their Association with the Band of Quartz-Sericite-Pyrite Alteration (shown in yellow) 7-7
Figure 7-5: Brucejack Property Geology Legend for Figure 7-4 7-8
Figure 7-6: Three-dimensional Block Geological Interpretation Through the Brucejack Deposit, Showing Key Geological, Structural, and Mineralization Relationships Developed in the Valley of the Kings Zone and West Zone 7-11
Figure 7-7: Oblique View Down and Towards the West-Northwest of the Brucejack Deposit Showing Drillhole Intersections Greater than 5 g/t Gold Relative to Underground Workings in both the Valley of the Kings Zone and the West Zone 7-15
Figure 7-8: Mineralized Veins in the Valley of the Kings Zone of the Brucejack Deposit 7-18
Figure 8-1: Schematic Section of Calc-alkaline Volcanic Arc Showing High and Intermediate Sulphidation Epithermal Deposits and Porphyry Deposits 8-3
Figure 8-2: Conceptual Model of Different Arc-related Porphyry and Epithermal Copper-Gold-Silver Mineralization Deposits 8-4
Figure 9-1: Plan View of the Brucejack Deposit Showing Significant Electrum Intersections from the 2015 Surface Exploration Drilling of the Flow Dome Zone 9-4
Figure 9-2: Plan View of 1TEM Conductivity Data on the Western Edge of Pretivm's Claim Block, Illustrating the Potential Scale of the Hydrothermal System Footprint (Warmer Colours) of which the Brucejack Deposit is a Part (also shown are Peripheral Known Mineralized Zones on the Brucejack and Snowfield Properties and Drill Trances From the 2015 Surface Exploration Drill Program) 9-5
Figure 9-3: Cross Section of the Brucejack Deposit (Looking North) Showing Gold Assay Intersections from the 2015 Surface Exploration Drilling and 2018 Underground Deep Exploration Drilling of the Flow Dome Zone, as well as the Zone of Anomalous Copper and Molybdenite Assays 9-6
Figure 9-4: Plan View Part of the Brucejack Project Showing Location of the 2018 Frontier Geosciences Inc. Surface Reflection Seismic and IP Survey Lines 9-7
Figure 9-5: Cross Section of the Brucejack Deposit (Looking North) Showing Gold Assay Intersections from the 2015 Surface Exploration Drilling and 2018–2019 Underground Deep Exploration Drilling 9-8
Figure 9-6: Cross Section (Looking West) of Quantec Geoscience Ltd. 2D CSMT Line BJ19-03 Showing 'Pipe-like' Resistivity Low and Copper Assay Intersections from 2015 Surface Exploration Drilling and 2018–2019 Underground Deep Exploration Drilling 9-10
Figure 9-7: Plan View Showing Location of the 2019 Frontier Geosciences Inc. Surface IP Survey Lines and Electrode Locations 9-11
Figure 9-8: Plan View Showing the 17 and 50 ms Chargeability Isosurfaces from the 2019 Frontier Geoscience Inc. IP Survey 9-12
Figure 9-9: Plan View Showing the 500 OHM-M Resistivity Isosurface from the 2019 Frontier Geoscience Inc. IP Survey 9-13
Figure 10-1: Plan View of Brucejack Property Drilling In and Around the Brucejack Deposit 10-3
Figure 10-2: Plan View on the 1,140 m Level in the Brucejack Gold Mine Showing 2019 Drilling and Valley of the Kings Zone Mineralized Domain Interpretations (Viewing Window ±20 m) 10-6

Figure 10-3: Example SW-NE Cross Section Along Mining Crosscut 17 (Central Parts of the Mine) Showing Workings, Drilling, and Mineralized Domain Interpretations in the Valley of the Kings Zone of the Brucejack Deposit (Viewing Window ±20 m) 10-7
Figure 13-1: Cumulative Stage GRG versus Grind Size for Gold and Silver 13-4
Figure 13-2: Bulk Sample Process Flowsheet 13-10
Figure 13-3: Gold Grains Distributions with Size Range 13-14
Figure 13-4: Gravity Results Summary – Composite Samples – ALS 2018 13-17
Figure 13-5: E-GRG Test Results 13-18
Figure 13-6: Rougher Flotation Tests on Composite H and L 13-20
Figure 13-7: Rougher Flotation Tests on Composite M 13-20
Figure 13-8: Cleaner Flotation Tests on Composite L, A, H, GH, WZ, and M 13-21
Figure 13-9: Locked Cycle Test Flowsheet No. 1 13-22
Figure 13-10: Locked Cycle Test Flowsheet No. 2 13-23
Figure 13-11: Gravity and Flotation Optimization Tests 13-25
Figure 13-12: Concentrate Thickener Capacity 13-27
Figure 13-13: Tailing Thickener Underflow Concentration with Time 13-28
Figure 14-1: Plan View of the Brucejack Deposit Showing the Location of the West Zone and Valley of the Kings Zone (VOK) Resource Block Models, and the Defined Update Areas (and Dates) 14-2
Figure 14-2: Topography and Lithological Wireframes used in the Generation of the January 2020 Resource Estimate (shown in Maptek's Vulcan Mining Software): a) Plan View of Topography Draped with Aerial Photography; b) Plan View Showing Lithological Model Triangulations and Approximate Location of Cross Section; c) S-N Cross-Section Along 426525 mE (A-A'). 14-6
Figure 14-3: Plan View of Mineralized Domain Triangulations Used in the Generation of the January 2020 Mineral Resource 14-8
Figure 14-4: N-S Cross Section Along 426635 mE of Mineralized Domain Triangulations Used in the Generation of the January 2020 Mineral Resource 14-8
Figure 14-5: Plan View Showing the Main Grouped Valley of the Kings Zone Mineralized Domains (Bigdom) Used in the Generation of the January 2020 Mineral Resource 14-9
Figure 14-6: Plan View Showing Model Update Area Solid (Purple) and Drillholes (White) from the 2019 Infill Drill Campaign 14-10
Figure 14-7: Log Probability Plots of a) Gold and b) Silver Composited Data Inside the Valley of the Kings Zone Mineralization Domains - January 2020 Update Area. 14-12
Figure 14-8: Log-Normal Histogram Plot of a) Gold and b) Silver Composited Data Inside the 2019 Updated Area Mineralization Domains. 14-13
Figure 14-9: Example of Modelling the Upper Tail of the a) High-Grade Gold and b) High-Grade Silver Populations Using a Hyperbolic Model. Data Shown for Bigdom 600. 14-23
Figure 14-10: Example Gold Grade Trend Plots by Easting for Bigdom 600 14-26
Figure 14-11: Example Gold Grade Trend Plots by Northing for Bigdom 600 14-27
Figure 14-12: Example Gold Grade Trend Plots by Elevation for Bigdom 600 14-27
Figure 14-13: Example Silver Grade Trend Plots by Easting for Bigdom 600 14-28
Figure 14-14: Example Silver Grade Trend Plots by Northing for Bigdom 600 14-28
Figure 14-15: Example Silver Grade Trend Plots by Elevation for Bigdom 600 14-29

Figure 14-16: Plan View of the 1180 m Level Showing Block Grade Estimates and Input Drillhole Composite Data Colour Coded by Gold Grade 14-30
Figure 14-17: N-S Cross Section Along 426300 E Showing Block Grade Estimates and Input Drillhole Composite Data Coloured by Gold Grade 14-31
Figure 14-18: Ounces Normalized to Mill Production with Corresponding Drillhole Spacing Plot for the January 2020 Model 14-33
Figure 14-19: January 2020 Valley of the Kings Zone Measured + Indicated Mineral Resource Sensitivity 14-37
Figure 15-1: Population Variance of Au Grade within the 2020 Reserves Based on Diamond Drillhole Spacing 15-5
Figure 15-2: Distribution of Average Insitu Au Grade of Reserves Before Mine Call Factor Application 15-6
Figure 15-3: Distribution of Average Insitu Au Grade of Reserves After Mine Call Factor Application 15-7
Figure 15-4: Sources of Stope Dilution 15-9
Figure 15-5: Reserve Shapes and Mining Blocks in the Main Valley of the Kings Zone 15-13
Figure 15-6: Reserve Shapes and Mining Blocks in the West Zone 15-14
Figure 15-7: Combined Reserves, Looking West 15-14
Figure 16-1: Mine Access and Development Infrastructure 16-2
Figure 16-2: Brucejack Ramp System – Perspective View 16-3
Figure 16-3: Valley of the Kings Zone Sublevel Arrangement – Long Section 16-4
Figure 16-4: Typical Level Development – Valley of the Kings Zone 16-5
Figure 16-5: Standard Designs – General Layout for All 16-6
Figure 16-6: MSO Stope Shapes – VOK Zone 16-8
Figure 16-7: MSO Stope Shapes – West Zone 16-9
Figure 16-8: Typical LHOS Design 16-11
Figure 16-9: Example of Primary/Secondary LHOS at Brucejack Gold Mine 16-12
Figure 16-10: LOM Production Schedule by Mining Horizon 16-17
Figure 16-11: LOM Production Schedule by Activity 16-17
Figure 16-12: Oblique View of the Interpreted Mine-scale Faults at the Brucejack Area Looking Approximately South 16-20
Figure 16-13: Brucejack Gold Mine Ventilation System (Looking West) 16-30
Figure 16-14: Typical Production Level 16-32
Figure 16-15: Conveyor Fire Isolation 16-34
Figure 16-16: Dewatering Plan 16-37
Figure 16-17: Tipple and Ore Bin Sectional Projection 16-38
Figure 16-18: Crusher Feed and Crusher 16-39
Figure 16-19: Underground Power Requirement Profile 16-40
Figure 16-20: West Zone Portal Underground Single-line Diagram 16-42
Figure 16-21: Borehole Underground Single-line Diagram 16-43
Figure 16-22: ESS Feed to 1080 Single-line Diagram 16-44
Figure 16-23 Mine Service Water Distribution Schematic 16-45
Figure 16-24: Bulk Emulsion/Powder Magazine Storage Plan 16-47
Figure 16-25: Permanent Refuge Station 16-48
Figure 16-26: Paste Fill Distribution System Schematic Showing Paste Pumping Zones 16-52
Figure 16-27: Paste Fill Distribution System Schematic 16-53
Figure 17-1: Simplified Process Flowsheet 17-3

Figure 18-1: Brucejack Gold Mine General Arrangement 18-2
Figure 18-2: Brucejack Gold Mine On-site Infrastructure Layout 18-3
Figure 18-3: Brucejack Gold Mine Off-site Infrastructure Layout 18-4
Figure 18-4: Knipple Transfer Station 18-15
Figure 18-5: Bowser Aerodrome 18-16
Figure 18-6: Wildfire Camp 18-18
Figure 20-1: Observed and Simulated Inflow to Underground Workings for Selected Model Scenarios 20-23
Figure 20-2: Brucejack Gold Mine Water Balance Flow Schematic – Operations 20-28
Figure 21-1: Overall Operating Cost Distribution by Area 21-5
Figure 21-2: Mining Operating Cost Distribution by Area 21-6
Figure 21-3: Process Operating Cost Distribution by Area 21-7
Figure 22-1: Pre-tax Cash Flow 22-4
Figure 22-2: Post-tax NPV Sensitivity to Metal Prices 22-8
Figure 22-3: Post-tax NPV Sensitivity to Operating Costs 22-9
Figure 23-1: Detailed Geological Map of KSM-Brucejack Area and McTagg Anticlinorium and Section Locations 23-3
Figure 23-2: Legend for Detailed Geological Map of KSM-Brucejack Area and McTagg Anticlinorium and Section Locations 23-4
Figure 25-1: Simulated vs. Observed Inflow Rates 25-6

ACRONYMS & ABBREVIATIONS

Acronyms/Abbreviations	Definition
.csv	Comma Separated Values
.pdf	Portable Document Format
AA	Atomic Absorption
AAS	Atomic Absorption Spectroscopy
ABA	Acid Base Accounting
AES	Atomic Emission Spectroscopy
Ag	Silver
AI	Bond Abrasion Index
ALS Global	ALS
AMC	AMC Mining Consultants (Canada) Ltd.
AMT	Audio Magnetotelluric
APS	Aluminum Phosphate Sulphate Minerals
Apy	Arsenopyrite
Ar-Ar	Argon-argon
ARD	Acid Rock Drainage
As	Arsenic

Acronyms/Abbreviations	Definition
ASP	Avalanche Safety Plan
Au	Gold
AuEq	Gold Equivalent
BC	British Columbia
BCEAA	BC Environmental Assessment Act
BCMWRP	British Columbia Mine Waste Rock Pile Research Committee
BD	Bulk Density
BGC	BGC Engineering Inc.
Bi	Bismuth
Black Hawk	Black Hawk Mining Inc.
Brucejack Deposit	The Brucejack Gold-Silver Deposit
BV	Bureau Veritas Commodities Canada Ltd.
BWi	Bond Ball Mill Work Index
BZ	Bridge Zone
Cal	Calcite
CCTV	Closed-circuit Television
CDE	Canadian Development Expense
CEA	Cumulative Expenditures Account
CEAA	Canadian Environmental Assessment Act
CEE	Canadian Exploration Expense
Chl	Chlorite
CIM	Canadian Institute of Mining, Metallurgy and Petroleum
CMS	Cavity Monitoring System
CNCF	Cumulative Net Cash Flow
Corona	Corona Corporation
Cpy	Chalcopyrite
CSS	Contact Support Service Inc.
CTCA	Cumulate Tax Credit Account
Cu	Copper
CV	Coefficient of Variation
CWi	Bond Crushing Work Index
CWP	Contact Water Pond
DCS	Distributed Control System

Acronyms/Abbreviations	Definition
DDH SPC	Drillhole Spacing
DO	Dissolved Oxygen
Dol	Dolomite
DPS	Diesel Power Station
DTM	Digital Terrain Model
DWi	Drop Weight Index
EAC	Environmental Assessment Certificate
EAO	Environmental Assessment Office
EDS	Energy Dispersive Spectrometer
EGL	Effective Grinding Length
E-GRG	Extended Gravity Recoverable Gold
EIS	Environmental Impact Statement
El	Electrum
EMS	Environmental Management System
EOR	Engineer of Record
ERM	Environmental Resources Management
ESEMP	Economic and Social Effects Mitigation Plan
ESS	Electrical Substation Service
Esso	Esso Minerals Canada Ltd.
FA	Fly-ash
FLS-DM	FLSmidth Dawson Metallurgical
FOS	Factor of Safety
FS	Feasibility Study
FW	Freshwater
G&A	General and Administrative
Gekko	Gekko Systems Pty Ltd.
GeoSpark	GeoSpark Consulting Inc.
GeoSpark Core	GeoSpark Core Microsoft® Access front-end interface
GH	Galena Hill
GIS	Geographical Information System
Gn	Galena
GP	General Purpose
GPS	Global Positioning System

Acronyms/Abbreviations	Definition
Granduc	Granduc Mines Ltd.
GRG	Gravity Recoverable Gold
GSI	Geological Strength Index
Hazen	Hazen Research Inc.
HDPE	High-density Polyethylene
Hg	Mercury
HGT	High-grade Threshold
HPGR	High-pressure Grinding Roll
HSE	Health, Safety and Environmental
HSRCM	Healthy, Safety and Reclamation Code for Mines in British Columbia
HVAC	Heating, Ventilation and Air Conditioning
HW	Hanging Wall
Hy-Tech	Hy-Tech Drilling Limited
ICP	Inductively Coupled Plasma
IK	Indicator Kriging
IMC	Information Management Center
Inspectorate	Inspectorate Exploration and Mining Services Ltd.
IP	Induced Polarization
ISO	International Organization for Standardization
IT	Information Technology
JonesPL	Ivor Jones Pty Ltd
JV	Joint Venture
K-Ar	Potassium-argon
Knelson	FLSmidth Knelson
Krebs	Krebs-FLSmidth
KSM	Kerr-Sulphurets-Mitchell
Lancana	Lancana Mining Corp.
LBMA	London Bullion Market Association
LHD	Load-Haul-Dump
LHOS	Long-hole Open Stoping
LIDAR	Light Detection and Ranging
LNG	Liquefied Natural Gas
LOM	Life-of-Mine

Acronyms/Abbreviations	Definition
Lorax	Lorax Environmental Services Ltd.
LRMP	Land and Resource Management Plan
MC	MineCem
MCC	Motor Control Center
MCF	Mine Call Factor
MDMER	Metal and Diamond Mining Effluent Regulation
MEMPR	Ministry of Energy, Mines & Petroleum Resources
Metso	Metso Corporation
Met-Solve	Met-Solve Laboratories Inc.
MFLNRORD	Ministry of Forests, Lands and Natural Resource Operations and Rural Development
MIK	Multiple Indicator Kriging
ML/ARD	Metal Leaching / Acid Rock Drainage
Mo	Molybdenum
MSALabs	MS Analytical
MSO	Mineable Shape Optimizer
MT	Magnetotelluric
MTO	Mineral Titles Online
NaCN	Sodium Cyanide
NAD	North American Datum
NCF	Net Cash Flow
Newhawk	Newhawk Gold Mines Ltd.
NI 43-101	National Instrument 43-101
NPAG	Non-PAG
NPR	Neutralization Potential Ratio
NPV	Net Present Value
NSR	Net Smelter Return
OK	Ordinary Kriging
OMS	Operations, Maintenance and Surveillance
PAG	Potentially Acid Generating
PAX	Potassium Amyl Xanthate
Pb	Lead
PD	Positive Displacement
PEA	Preliminary Economic Assessment

Acronyms/Abbreviations	Definition
Placer Dome	Placer Dome Inc.
PLC	Programmable Logic Controller
PMA	Particle Mineral Analysis
PMCL	Process Mineralogical Consulting Ltd.
Pocock	Pocock Industrial Inc.
Pretivm	Pretium Resources Inc.
Procon	Procon Mines and Tunneling
PRV	Pressure Reducing Valves
Py	Pyrite
QA	Quality Assurance
QC	Quality Control
QEMSCAN	Quantitative Evaluation of Materials by Scanning Electron Microscopy
QP	Qualified Person
QPO	Quantifiable Performance Objectives
Qz	Quartz
RC	Reverse Circulation
REF-ET	Reference Evapotransiration
Re-Os	Rhenium-osmium
RMS	RMS Corp.
ROM	Run-of-Mine
RQD	Rock Quality Designation
Rt	Rutile
RWi	Bond Rod Mill Work Index
S	Sulphur
SABC	SAG Mill / Ball Mill / Pebble Crushing
SAG	Semi-autogenous Grinding
Sb	Antimony
SBT	Stewart Bulk Terminal
SCADA	Supervisory Control and Data Acquisition
SCSE	SAG Circuit Specific Energy
Seabridge Gold	Seabridge Gold Inc.
SEM	Scanning Electron Microscope
Ser	Sericite

Acronyms/Abbreviations	Definition
SFA	Screen Fire Analysis
SG	Specific Gravity
SGS	SGS Canada Inc.
Silver Standard	Silver Standard Resources Inc.
SIPX	Sodium Isopropyl Xanthate
SLS	Solid Liquid Separation
SMC	SAG Mill Comminution
Sn	Tin
SNF	SNF Canada
SOP	Standard Operating Procedure
Sp	Sphalerite
SPI	SAG Power Index
SQL	Structured Query Language
SRK	SRK Consulting (Canada) Inc.
SRMP	Sustainable Resource Management Plan
SS	Sunset Slag Blend
Strategic Minerals	Strategic Minerals LLC
Tetra Tech	Tetra Tech Canada Inc.
TIMA	Tescan Integrated Mineral Analyzer
TK/TU	Traditional Knowledge / Traditional Use
TMS	Trace Mineral Search
TSS	Total Suspended Solids
UCS	Universal Compressive Strength
UDS	Underground Distribution System
UKAS	United Kingdom Accreditation Service
UPS	Uninterruptible Power Supply
UTM	Universal Transverse Mercator
UV	Ultraviolet
VFD	Variable Frequency Drive
VG	Visible Gold
VHF	Very-high Frequency
VMS	Volcanogenic Massive Sulphide
VoIP	Voice Over Internet Protocol

Acronyms/Abbreviations	Definition
VOK	Valley of the Kings
VSF	Volcanosedimentary
VSI	Vertical Shaft Impactor
W	Tungsten
WAC	Wildlife Advisory Committee
WAP	Wireless Access Point
Wardrop	Wardrop Engineering Inc.
WBS	Work Breakdown Structure
WQG	Water Quality Guidelines
WRTSF	Waste Rock Tailings Storage Facility
WTP	Water Treatment Plant
WZ	West Zone
XRD	X-ray Diffraction
Zn	Zinc

1.0 SUMMARY

1.1 Introduction

The Brucejack Gold Mine, located in northwest British Columbia (BC), is a high-grade underground mining operation that commenced commercial production in July 2017. The Brucejack Gold Mine uses conventional gravity concentration and sulphide flotation to produce gold (Au)-silver (Ag) doré and gold-silver flotation concentrate.

Pretium Resources Inc. (Pretivm), a low-cost intermediate gold producer, owns 100% of the Brucejack Property.

In 2014, prior to mine construction and the start of operations, Pretivm commissioned a team of consultants to complete a Feasibility Study (FS) update for the Brucejack Project in accordance with National Instrument 43-101 (NI 43-101) Standards of Disclosure for Mineral Projects, the NI 43-101 Companion Policy, and Form 43-101F1 (Ireland et al. 2014).

In 2019 Pretivm released an updated NI 43-101 Technical Report which updated the operating parameters considered in the 2014 FS to assess the potential of increasing the mine and process plant throughput from 2,700 to 3,800 t/d. That assessment incorporated six quarters of mining operation information from the Brucejack Gold Mine.

In January 2020, Pretivm commissioned Tetra Tech Canada Inc. (Tetra Tech) and other consultants to complete an update to the 2019 NI 43-101 Technical Report. This NI 43-101 Technical Report, effective on March 9, 2020, updates the Mineral Resource and Mineral Reserve, the Life of Mine (LOM) plan, and operating parameters. The effective date of the 2020 Mineral Reserve and 2020 Mineral Resource is January 1, 2020.

The following consultants were commissioned to complete work and reviews for the purpose of the Technical Report:

- Tetra Tech – mineral processing and metallurgical testing, mineral reserve estimates, mining methods, recovery methods, project surface and underground infrastructure, market studies and contracts, capital and operating cost estimates, and economic analysis.
- Ivor Jones Pty Ltd – property description and location; accessibility, climate, and physiology; history; geological setting and mineralization; deposit types; exploration; drilling; sample preparation and analysis; data verification; adjacent properties; and mineral resource estimates.
- Environmental Resources Management (ERM) – aspects of environmental studies, permits, and social or community impacts; waste management; and closure plans.
- Lorax Environmental Services Ltd. (Lorax) – hydrogeology, geochemistry, water balance, and water quality.
- SRK Consulting (Canada) Inc. (SRK) – waste rock and tailings storage facility, underground and surface geotechnical design, and water management.

The effective date of the Mineral Resource and Mineral Reserve estimates is January 1, 2020 and the effective date of this Technical Report is March 9, 2020.

1.2 Property Description and Location

The Brucejack Property is centered approximately at 56°28′20″N Latitude by 130°11′31″W Longitude, a position approximately 950 km northwest of Vancouver, 65 km north-northwest of Stewart, and 21 km south-southeast of the Eskay Creek Mine in the Province of BC. The Brucejack Property consists of four mining leases and six mineral claims that cover the target Mineral Resource, totaling 3,305.85 ha in area. All mining leases are in good standing until September 17, 2020; all mineral claims are in good standing until January 31, 2031.

The Brucejack Property and the surrounding region have a history rich in exploration for precious and base metals dating back to the late 1800s. More recently in 2010, Silver Standard Resources Inc. (Silver Standard), pursuant to a purchase and sale agreement between Silver Standard (as the seller) and Pretivm (as the buyer), sold to Pretivm all of the issued shares of 0890693 BC Ltd., the owner of the Brucejack Project and the adjacent Snowfield Project. Subsequently, the name of 0890693 BC Ltd. was changed to Pretium Exploration Inc.

1.3 Geology and Mineralization

The Brucejack Deposit is currently defined as incorporating the Valley of the Kings Zone and the West Zone. Similar epithermal vein-hosted precious metal mineralization is present throughout the 5 km by 1.5 km wide arcuate band of phyllic alteration on the Brucejack Property (e.g., Gossan Hill Zone, Shore Zone, SG Zone, Golden Marmot Zone, and Hanging Glacier Zone). This alteration and mineralization band has yet to be explored in sufficient detail for resource estimation, and represents upside potential on the property. The Brucejack Deposit is located on the western side of the Stikine Terrane in the Intermontane morphogeologic belt of the Canadian Cordillera. The Brucejack Deposit occurs in an exceptionally metals-rich tectonic assemblage hosted in volcanic island arc-related rocks of the Lower Jurassic Hazelton Group in BCs Golden Triangle.

At the district level, the Brucejack Deposit forms part of a well mineralized, north-south gossanous trend (the Sulphurets Mineral District) associated with a regional unconformity and proximal mineralized Early Jurassic porphyry intrusions on the eastern limb of the McTagg Anticlinorium. Rocks of the Sulphurets Mineral District record a long history of volcanism, telescoping magmatic-hydrothermal alteration, mineralization, and deformation.

The Brucejack Deposit is interpreted to be a deformed, porphyry-related transitional to intermediate sulphidation epithermal high-grade gold-silver deposit that was formed between 184 to 183 Ma in an active island arc setting similar to the modern-day Philippines. Intermediate sulphidation epithermal deposits are considered to be a sulphide-rich sub-type of carbonate-base metal gold deposits, of which there are numerous examples in the southwest Pacific Rim region.

High-grade gold-silver mineralization was formed in association with a telescoped, multi-pulsed magmatic-hydrothermal system beneath an active local volcanic center. The high-grade precious metal mineralization appears to have been predominantly transported as colloidal suspensions, the destabilization of which during fluid mixing resulted in the ubiquitous yet highly locally variable distribution of gold and silver mineralization in the Brucejack Deposit. Precious metal precipitation from the colloidal suspension appears to have been concentrated along structural corridors within broader stockwork zones, including along faults, fractures, pre-existing foliation planes, and lithological contacts. Within the structural corridors the high-grade precious metal mineralization occurs as coarse dendritic aggregates of electrum and silver sulfosalts, largely hosted in steeply dipping, east-trending quartz-carbonate to carbonate veins and vein breccia. The occurrence of structural corridors of higher-grade east-west mineralization within the broader stockwork zones represents an opportunity for longitudinal mining. The high-grade epithermal veins co-spatially overprint low-grade intrusion-related phyllic alteration. Epithermal vein development is interpreted to have occurred during the waning stages of Early Jurassic sinistral transpression in a compressive arc environment, followed by a limited Cretaceous deformation overprint.

There is a distinct precious metal zonation between the Valley of the Kings Zone, which contains higher gold grades, and the West Zone, which is significantly more silver rich. The Valley of the Kings Zone is currently defined over 1,200 m in east-west extent, 700 m in north-south extent, and 650 m in depth, and remains open to the east, west, and at depth. The West Zone is currently defined over 590 m along its northwest strike, 560 m across strike, and down to 650 m in depth, and remains open to the northwest, southeast, and at depth to the northeast.

Brownfields exploration drilling conducted from within the Brucejack Gold Mine targeting the Flow Dome Zone and beneath the West Zone demonstrated the continuation of Valley of the Kings Zone style mineralization to the northeast, southeast, and 550 m in depth below the current resource. CSMT geophysical surveys reprocessed by Quantec Geoscience Ltd. in 2019 prompted deep exploration drilling focused on targeting a conductivity anomaly beneath the West Zone deposit to test for the source porphyry responsible for driving the epithermal mineralization in the Brucejack Deposit. Anomalous copper and porphyry-style alteration were identified at depth. Follow-up drilling is currently being conducted.

More than 40 mineralization showings, at least eight of which are currently considered as mineralized zones (e.g., Bridge Zone, Waterloo Zone, Flow Dome Zone, Gossan Hill Zone, Shore Zone, SG Zone, Golden Marmot Zone, and Hanging Glacier Zone), are recognized in this band. The alteration and mineralization band has yet to be explored in sufficient detail for mineral resource estimation and represents upside potential on the Brucejack Property.

1.4 Mineral Resource Estimates

1.4.1 Drilling, Sampling, Assaying, and Data Verification

The updated drillhole database provided to the resource team to support this update built upon the database provided for Jones et al. (2019) and included an additional 555 HQ diamond drillholes for a total of 89,121 additional drilled metres, and at the time of cut-off represented 86,719 m of new assay data.

Whole core samples were sent to the ALS Global (ALS) facility in Terrace, BC for sample preparation. Analysis was completed by the ALS Vancouver laboratory in North Vancouver, BC. Secondary lab checks were completed at MS Analytical in Langley, BC.

Pretivm's quality assurance (QA) / quality control (QC) protocols for the Brucejack Deposit included tests for data accuracy, precision, and sample cross-contamination using duplicates (coarse and pulp duplicates), coarse blanks, and certified standards. Additional coarse blank samples were inserted immediately following samples with logged visible gold to quantify and avoid any potential cross-contamination between samples during laboratory sample preparation. QA/QC assay data checks were completed on a regular basis by the Database Manager. Pulp checks were requested where certified standard samples had 3SD accuracy fails in Au mineralized areas. Re-assay results from QA/QC checks were imported and assigned precedence in the database. QA/QC reporting was completed in-house by the database manager and reviewed by the Qualified Person (QP). The QA/QC analysis indicated acceptable levels of accuracy and precision, similar to previous years.

The QP, Mr. I.W.O. Jones, P.Geo., FAusIMM has conducted sufficient data and underground verification checks to satisfy himself that the drilling, core logging, sample handling, assaying, and data QA/QC procedures were conducted using industry best practices and that the data generated were of suitable quality for use in resource modelling and estimation of the Brucejack Deposit. Furthermore, Mr. Jones considers the geological interpretation to be appropriate and representative of the mineralization in the Brucejack Deposit.

1.4.2 Mineral Resource Estimation

An updated Mineral Resource, with an effective date of January 1, 2020, has been prepared for the Brucejack Deposit, incorporating information from additional tightly-spaced infill drilling, mapping of underground geological exposures, and mine production. The updated resource estimate is presented for the combined Valley of the Kings Zone and the West Zone in Table 1-1 and separately for the Valley of the Kings Zone in Table 1-2 and the West Zone in Table 1-3.

The new resource estimate comprises that part of the Valley of the Kings Zone where new information was available; the January 2019 resource estimates for the Valley of the Kings Zone (Jones et al., 2019) and the December 2013 resource estimates for the Valley of the Kings Zone (Jones 2014) are retained outside the update area and the April 2012 resource estimate is retained for the West Zone (Jones 2012). The January 2020 Mineral Resource inside the update area is reported inclusive of Mineral Reserves and exclusive of material mined to December 31, 2019.

At the time of this report, the QP for the Mineral Resource Mr. I.W.O. Jones, P.Geo., FAusIMM was not aware of any environmental, permitting, legal, title, taxation, socio-economic, marketing, political, or other relevant factors that could materially affect the Mineral Resource presented in this Technical Report or its potential development.

The January 2020 Mineral Resource was estimated using the same methodology as for previous resource estimates for the Brucejack Deposit. The non-linear split population-based approach used is a similar one to that used in earlier estimates and is currently considered the most appropriate method for estimating the mixed and positively-skewed precious metal mineralization for the Brucejack Deposit.

The model was validated against input drillhole data and mine production for the year 2019 and found to provide a reasonable to good representation of the input data and production information: the tonnes and grade reported by production in 2019 were within 10% of those reported from the January 2020 resource model from within the mined outlines.

The resource model was classified as Measured, Indicated, and Inferred in accordance with the Canadian Institute of Mining, Metallurgy and Petroleum (CIM) (2014) Definition Standards. Measured Resources are expected to be within 15% of mine production on a quarterly production basis and Indicated Resources are expected to be within 15% of mine production on an annual production basis. Shorter-term reconciliation is not considered appropriate given the highly variable and nuggety nature of the precious metal mineralization at Brucejack.

The January 2020 resource estimate effectively overwrites the January 2019 resource estimate inside the update area. Comparisons between these models show that the new estimate (only that part inside the update area and not accounting for depletion by mining) is lower by approximately 0.7 Mt, 2.2 Moz Au, and 1.1 Moz Ag in the Measured + Indicated Resource at similar estimated gold and silver grades, using the same cut-off grade of 5 g/t AuEq (AuEq = Au + Ag / 53). The differences between the two models are largely data-driven. Additional tightly-spaced infill drilling, increased exposure of the mineralized system during mining, and over 1.5 Mt of actual production since mine commissioning have resulted in improved domain and local estimation parameter definition.

Table 1-1: January 2020 Valley of the Kings Zone and West Zone Mineral Resource[1,2,3,4,5,6]

Category	Tonnes (Mt)	Au (g/t)	Ag (g/t)	Contained Au (Moz)	Contained Ag (Moz)
Measured	4.7	8.4	183.3	1.3	27.7
Indicated	18.6	10.7	35.8	6.4	21.4
Measured + Indicated	23.2	10.1	65.5	7.6	49.1
Inferred	9.4	10.3	44.3	3.1	13.4

Notes: [1]Mineral Resources that are not Mineral Reserves do not have demonstrated economic viability. The estimate of Mineral Resources may be materially affected by environmental, permitting, legal, title, taxation, socio-economic, marketing, political, or other relevant issues. The Mineral Resources in this Technical Report were estimated and reported using the CIM Definition Standards – Prepared by the CIM Standing Committee on Reserve Definitions, Adopted by CIM Council May 10, 2014. (CIM, 2014).
[2]The quantity and grade of reported Inferred Resources in this estimation are uncertain in nature and there has been insufficient exploration to define these Inferred Resources as an Indicated or Measured Mineral Resource and it is uncertain if further exploration will result in upgrading them to an Indicated or Measured Mineral Resource category.
[3]Contained metal and tonnes figures in totals may differ due to rounding.
[4]Resources depleted for production to December 31, 2019.
[5]The January 2020 Valley of the Kings Zone Mineral Resource is reported above a gold cut-off grade of 3.5 g/t gold. The West Zone Mineral Resource is reported above a cut-off grade of 5 g/t gold equivalent (AuEq) (where AuEq=Au+Ag/53 as per previous models).
[6]Mineral Resource is reported inclusive of Mineral Reserve.

Table 1-2: January 2020 Valley of the Kings Zone Mineral Resource[1]

Category	Tonnes (Mt)	Au (g/t)	Ag (g/t)	Contained Au (Moz)	Contained Ag (Moz)
Measured	2.3	10.5	12.6	0.8	0.9
Indicated	16.1	11.4	12.2	5.9	6.3
Measured + Indicated	18.4	11.3	12.2	6.7	7.2
Inferred	5.4	13.3	15.9	2.3	2.8

Note: [1]Notes from Table 1-1 apply.

Table 1-3: West Zone Mineral Resource, April 2012[1,2]

Category	Tonnes (Mt)	Au (g/t)	Ag (g/t)	Contained Au (Moz)	Contained Ag (Moz)
Measured	2.4	5.9	347	0.5	26.8
Indicated	2.5	5.9	190	0.5	15.1
Measured + Indicated	4.9	5.9	267	0.9	41.9
Inferred	4.0	6.4	82	0.8	10.6

Note: [1]Notes from Table 1-1 apply (see Jones (2012a) for more details)
[2]Contained metal and tonnes figures in totals may differ due to rounding.
Source: Jones (2012a)

1.5 Mineral Reserve Estimates

A net smelter return (NSR) cut-off value of US$180/t or Cdn$230/t ore was used to define the Mineral Reserves. This cut-off value decreased from the previous value of US$185/t ore used in the 2019 Technical Report.

The NSR for each block in the Mineral Reserve model was calculated as the payable revenue for gold and silver, less the costs of refining, concentrate treatment, transportation, assays, consultants, penalties, and insurance. The metal price assumptions associated with the NSR value are US$1,250/oz Au and US$15.6/oz Ag. A foreign exchange rate of Cdn$1.00:US$0.78 was used.

The dilution factors used in the Mineral Reserve were calculated from standard overbreak assumptions, based on Pretivm's experience and benchmarking of other long-hole open-stoping (LHOS) operations. The overall LOM recovery is estimated to be 94%, with a dilution of 12%.

The Mineral Reserves were developed from the Mineral Resource model "res1912_MRM_NSC_2019_depl_101010_MO_OW_Reserve", which was created by Pretivm and provided to Tetra Tech in January 2020. The orebody consists of numerous lenses in the Valley of the Kings Zone and two distinct lenses in the West Zone (Table 1-4). These mineral reserves are exclusive of material mined prior to January 1, 2020.

Mineral Reserves stated herein are calculated inclusive of a Mine Call Factor (MCF). The MCF is a grade reconciliation calculation applied to individual stopes and is based on the average drillhole spacing in each stope. Each stope has been re-evaluated using both the reserve stope grade and the drillhole spacing to account for potential overestimation in grade in areas with lower average drillhole spacing. Grades are capped relative to the concentration of drilling in the stope, with areas of closer drillhole spacing, and therefore higher confidence, allocated a higher-grade cap than those areas with fewer drillholes. The 2020 Mineral Reserve reflects a reduction in gold grade from the 2019 Mineral Reserve grade due to updates to the Mineral Resource and the application of a MCF.

Table 1-4: Brucejack Gold Mine Mineral Reserves[1,2] by Mining Zone and Reserve Category, Effective January 1, 2020

Zone		Ore Tonnes (Mt)	Grade		Contained Metal	
			Au (g/t)	Ag (g/t)	Au (Moz)	Ag (Moz)
Valley of the Kings Zone	Proven	1.4	8.9	11.1	0.4	0.5
	Probable	11.3	8.7	9.8	3.2	3.6
	Total	12.8	8.8	10.0	3.6	4.1
West Zone	Proven	1.4	7.2	383.0	0.3	17.4
	Probable	1.5	6.5	181.0	0.3	8.6
	Total	2.9	6.8	278.5	0.6	26.0
Total Mine	**Proven**	**2.8**	**8.1**	**195.1**	**0.7**	**17.9**
	Probable	**12.8**	**8.5**	**29.8**	**3.5**	**12.2**
	Total	**15.7**	**8.4**	**59.6**	**4.2**	**30.1**

Notes: [1]Rounding of some figures may lead to minor discrepancies in totals.
[2]Based on US$180/t cut-off grade, US$1,250/oz Au price, US$15.6/oz Ag price, and a Cdn$1.00:US$0.78 foreign exchange rate.

1.5.1 Mineral Reserve Comparison

As significant material has been mined between the 2020 Mineral Reserves and the 2019 Mineral Reserves Update, a direct comparison of reserves will not provide an accurate assessment of the changes made. To provide a valid comparison, the inclusion of the mined-out material between these two time periods needs to be added. As the 2020 Mineral Reserves are exclusive of all material mined prior to January 1, 2020 and the 2019 Mineral Reserves were exclusive of all material mined prior to January 1, 2019, the addition of the reconciled 2019 milled actuals should provide a valid comparison. Table 1-5 shows the comparison.

Table 1-5: Comparison of 2020 Mineral Reserves with Mined Actuals to 2019 Reserves

		Reserves		
Reserves		Ore Tonnes (Mt)	Grade Au (g/t)	Contained Metal Au (Moz)
2020 Mineral Reserves + Milled Actuals	Proven + Probable	15.7	8.4	4.2
	2019 Milled Actuals	1.3	8.7	0.4
	Total	17.0	8.4	4.6
2019 Mineral Reserves	Total	16.0	12.6	6.4
2020 - 2019	Difference	1.0	-4.1	-1.8

The combined 2020 Mineral Reserves and 2019 Milled Actuals total ore tonnes exceed the 2019 Mineral Reserves due to two main factors: the mining of out-of-reserve material that was identified as being economic by the grade control program, and the increase in profitability of the NSR model. With these additions, the combined 2020 Mineral Reserves with 2019 Milled Actuals contain more tonnes at a lower grade than the 2019 Mineral Reserves. This results in a decrease in overall ounces primarily due to a decrease in overall grade of the updated portion of the resource.

1.6 Mining Methods

The updated underground mine design supports the extraction of 3,800 t/d of ore through a combination of transverse and longitudinal LHOS. Closely matching the previously stated plan disclosed in the 2014 FS (Ireland et al. 2014) and the 2019 FS Update (Tetra Tech), paste backfill and trackless mobile equipment will be employed in the majority of mining activities.

Access to the mine is via the Valley of the Kings decline, situated near the concentrator. The Valley of the Kings decline is also utilized as a conveyor way, with two conveyors installed at a combined length of 800 m. The existing West Zone portal provides the main access for large underground equipment and waste haulage.

Development initiated during the two pre-production years of the LOM continues, with the mine operating at a rate of 2,700 t/d since commercial production began in July 2017. The ramp-up period to a maximum output of 3,800 t/d is complete, with production averaging 1.3 Mt annually.

Geotechnical designs and recommendations are based on the results of site investigations and geotechnical assessments, which include rock mass characterization, structural geology interpretations, excavation and pillar stability analyses, and ground support design. No new rock mechanics site investigations or analysis work was completed for this Technical Report update.

The groundwater flow system was conceptualized to provide inflow estimates to mine workings. Total inflows were estimated to be approximately 100 L/s, including service water. This estimate referenced results of site investigations and hydrogeologic testing that was used to determine the capacity of dewatering equipment, which allows for maximum inflows of 139 L/s to account for uncertainty in the water inflow model.

The mining contractor supplies the majority of the heavy equipment with the exception of supplemental long-hole drills for production and sampling, and some auxiliary vehicles. Key equipment required includes a fleet of load-haul-dump (LHD) vehicles and trucks for material loading and transport to surface. In addition, bolters, shotcrete sprayers, long-hole drills, and cable bolters are all required.

Mining is largely conducted through a mine contractor, with Pretivm providing planning and technical services. The underground mining department consists of technical staff, mining crews, mechanics, electricians, and logistical or other support personnel. Total underground manpower, including technical support is approximately 398, with approximately 200 on site at any time.

Ventilation has been designed to comply with BC regulations. Permanent fans at surface are located at each of the main portals and exhaust to surface is via dedicated raises. An electric air heating system operates to ensure all air entering the mine is above freezing point with a propane backup.

Paste fill is distributed using a two-stage pumping system. A positive displacement pump in the paste fill plant located in the mill provides paste to all of the West Zone and the lower portion of the Valley of the Kings Zone (below 1,350 m). The paste fill plant feeds a booster pump located near the main Valley of the Kings decline. This booster pump supplies paste to the Upper Valley of the Kings Zone (above 1,350 m).

Ore is trucked from working areas to the centrally located underground crusher and subsequently transferred to surface via the two conveyors. Waste rock is utilized for backfill wherever possible or trucked to surface for disposal in Brucejack Lake.

The location and method of the mine dewatering system have been changed since the 2014 FS (Ireland et al. 2014). Mine dewatering locations are included in the long-term mine plans, with adjustments to locations based on underground observations. No settling of sediments or slimes is conducted underground with sediments and slimes pumped directly to the mill clarifier by a system of submersible and horizontal centrifugal pumps located throughout the Valley of the Kings Zone and West Zone working levels.

For underground worker safety, both permanent and portable refuge stations have been installed at Brucejack Gold Mine. A permanent, 40-person station has been established at the 1,335 m elevation, another 60-person permanent refuge station will be established at the 1,200 m elevation, with an additional six, 16-person portable rescue chambers located elsewhere throughout the mine. Emergency warning systems include phones, cap lamp warning systems, and stench gas warning systems.

1.7 Mineral Processing and Metallurgical Testing

Extensive metallurgical testing programs have been conducted on the Brucejack Property since 1988, with major metallurgical test work performed between 2009 and 2014 to support the design and construction of the 2,700 t/d process plant at the Brucejack Gold Mine. Tetra Tech completed a test work review and process design descriptions for the 2014 FS (Ireland et al. 2014). Since commercial operations began in Q4 2017, additional test work and process simulations have been completed to support the current operation, including supports for the process plant throughput increase to a target capacity of 3,800 t/d.

1.7.1 Early Metallurgical Test Work and Pilot Plant Operation

The previous test work was conducted to investigate mineralization amenability to gravity concentration, gold-silver bulk flotation, and cyanidation processes. Sample characteristics, including chemical composition, mineralogy, and hardness, as well as other processing tests, including melting and solid liquid separation (SLS) tests, were also carried out. The tested samples were obtained from the Valley of the Kings Zone, the West Zone, and adjacent gold deposits such as the Galena Hill Zone, the Gossan Hill (R-8) Zone, and others. The test results indicate that most of the individual samples responded well to gravity separation, which consisted of a centrifugal separation and panning concentration. The test results also showed that the tested samples responded well to bulk flotation and cleaner flotation. With further verification tests on variability samples and locked-cycle tests on composite samples from the Valley of the Kings Zone and the West Zone, a conventional process using combined gravity concertation and flotation on gravity tailings was recommended for the Brucejack Gold Mine. To confirm the recommended process design, between September 2013 and February 2014, Strategic Minerals LLC (Strategic Minerals) processed two batches of bulk mineral samples generated from the Valley of the Kings Zone at the Contact Mill facility located in Philipsburg, Montana. Samples totalling 11,500 t were processed. A combined process of gravity separation and rougher/scavenger flotation with rougher concentrate cleaner flotation was employed to treat the bulk material. The gravity circuit included a Knelson concentrator and a Gemini table, while a jigging and tabling circuit to recover coarse free gold was also added when high-grade material was fed to the mill. No regrind circuit was applied to the rougher/scavenger concentrates. The test results confirmed that the combined gravity and flotation method can effectively recover gold and silver from the materials with widely varied head grades.

1.7.2 Recent Metallurgical Test Work

Beginning in 2017, a series of test work was conducted to support the Brucejack Gold Mine process plant optimization and throughput increase. The test work covered mineralogy analysis, grindability, gravity separation, intensive leaching, and flotation concentration. SLS tests and tailings paste backfill related tests were also performed. The results were used to optimize the current process plant operation and to assess the performance of the relevant circuits in the proposed 3,800 t/d throughput scenario.

The metallurgical tests confirmed that significant amounts of gold and silver are gravity recoverable, which varies with the mineralization and gold head grades. Several simulations were conducted to evaluate primary grinding, gravity, flotation, and concentrate and tailings thickening processes for the 3,800 t/d plant capacity expansion. Results indicate that the primary grinding circuit is capable of reaching the target throughput capacity of 3,800 t/d. With further optimization of the grinding operation parameters, the grinding efficiency is anticipated to be improved. The existing cyclones and slurry handling systems could readily accommodate the increased throughput through minor modifications. The primary gravity circuit may reach its recommended capacity at the increased throughput, which may slightly affect the recovery of the gravity recoverable gold and silver. For the current flotation circuit, the rougher and scavenger existing cells should be able to provide sufficient flotation retention time to handle the 3,800 t/d throughput. However, the capacity of the second and third cleaner flotation cells will require some upgrades to accommodate the increased throughput.

1.7.3 Current Operation

The process flowsheet used for the current mine operation is a combination of conventional gravity concentration and bulk sulphide flotation to recover gold and silver into gold doré and gold-silver bearing flotation concentrates. Ore was first introduced to the mill in May 2017 with a focus on ramping up to the designed production throughput using ore from low-grade ore stockpiles. On July 1, 2017, Pretivm declared commercial production at the Brucejack Gold Mine. Table 1-6 summarizes the 2019 production data based on Pretivm's annual reports and news releases.

Table 1-6: Brucejack Mill 2019 Production Data

Time	Mill Feed Tonnage		Mill Feed Grade		Total Recovery		Flotation Concentrate Grade	
	Tonne	t/d	(g/t Au)	(g/t Ag)	(% Au)	(%Ag)	(g/t Au)	(g/t Ag)
Q1 2019	295,122	3,279	8.7	13.3	96.8	85.6	48.6	131
Q2 2019	324,171	3,562	8.9	15.6	96.9	83.8	51.6	153
Q3 2019	309,754	3,367	9.1	14.7	97.0	85.5	47.2	144
Q4 2019	373,954	4,065	8.3	14.1	96.8	85.6	43.2	142
Total 2019	**1,303,001**	**3,570**	**8.7**	**14.5**	**96.9**	**85.1**	**47.5**	**143**

Note: Yearly average primary grind size is 80% passing approximately 115 µm; monthly averages range from 80% passing approximately 98 µm to 126 µm.

1.8 Recovery Methods

The Brucejack Property mineralization typically consists of quartz-carbonate-adularia, gold-silver bearing veins, stockwork and breccia zones, along with broad zones of disseminated mineralization. There is a significant portion of gold and silver present in the form of nugget or metallic gold and silver.

The concentrator was designed to process gold and silver ore at a nominal rate of 2,700 t/d to produce gold doré and gold flotation concentrate. The mill was commissioned between March and May of 2017 and reached full operation in Q4 2017. In 2018, various review and assessment work was conducted to evaluate the potential of increasing mill throughput to 3,800 t/d and identify potential bottlenecks that may limit a further increase in the mill feed rate. The review work indicated that with minor modifications, such as increasing some of the slurry pump sizing and increasing the second and third cleaner flotation capacities, the process plant can handle the increased throughput of 3,800 t/d. Currently, most of the mill upgrading has been completed, while the installation of the third cleaner flotation cell and the new flocculant system are in progress. As reported, the mill was operated at 4,065 t/d average in Q4 2019.

Figure 1-1 shows the processing flowsheet, including the following components:

- One-stage primary crushing located underground
- A 2,500 t semi-autogenous grinding (SAG) mill feed surge bin on surface
- A SAG mill/ball mill/pebble crushing (SABC) primary grinding circuit equipped with a gravity concentration circuit
- Rougher flotation and scavenger flotation of hydrocyclone overflow
- Three stages of cleaner flotation on combined rougher and scavenger concentrates

- Flotation concentrate dewatering
- Flotation tailings dewatering circuits.

The mill feed ore is crushed and ground to the particle size of 80% passing approximately 100 µm. Two gravity centrifugal concentrators, together with two upgrading tables and one associated gravity centrifugal concentrator, recover the free nugget gold grains from the ball mill discharge. The resulting gravity concentrate is further refined in the gold room on site to produce gold-silver doré.

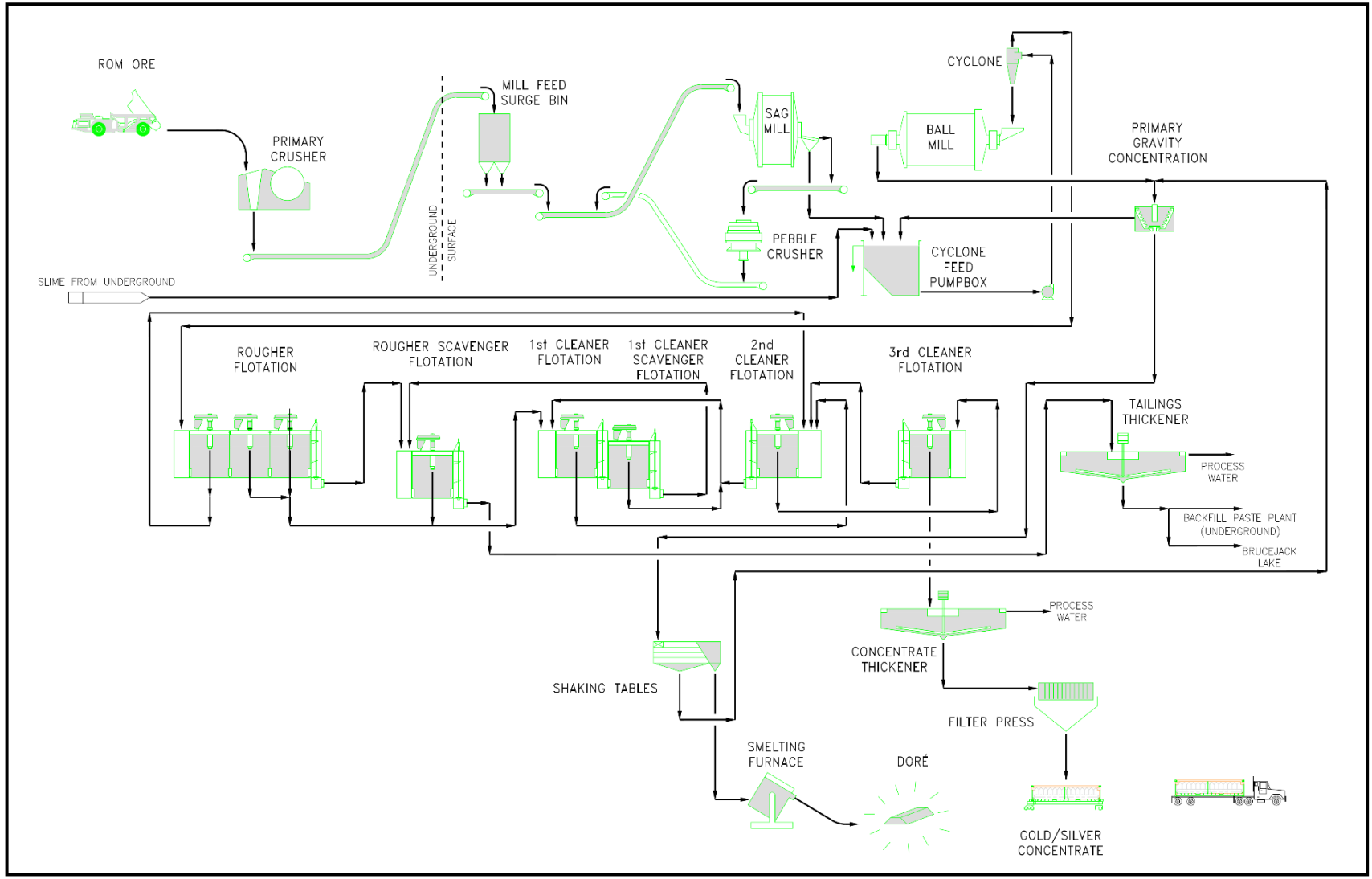
The gold and gold bearing minerals of the hydrocyclone overflow from the primary grinding circuit are floated using rougher and scavenger flotation. The resulting rougher flotation and scavenger flotation concentrates are upgraded through three stages of cleaner flotation. The first cleaner scavenger flotation tailings report to the rougher scavenger flotation to further recover the residual gold, silver, and their bearing minerals. The third cleaner concentrate that is the final flotation concentrate, is dewatered using a high-rate thickener and a tower filter press prior to being loaded in customized bulk containers for shipping.

The final rougher scavenger flotation tailings are dewatered in a deep cone thickener. Approximately 40 to 50% of the flotation tailings are used to make paste to backfill excavated stopes in the underground mine, and the balance is pumped to Brucejack Lake where the tailings are stored under water. The concentrate and tailings thickener overflows are recycled as process make-up water. The underground and collected water from the mine site are treated in the water treatment plant in the mill. The treated water is used for mill cooling, gland seal service, reagent preparation, and make-up water.

The upgraded process plant will continue to operate as two 12-hour shifts per day and 365 days per year. The overall availability for the underground primary crusher circuit is 60%. The grinding, flotation, and gravity concentration availability is 92%. The gold room operates during the day shift only.

Based on the LOM annual average, approximately 6,261 kg of gold and 4,618 kg of silver contained in doré and 3,420 kg of gold and 60,211 kg of silver contained in 67,900 t of gold-silver bearing flotation concentrate will be produced each year. On average, the flotation concentrate is expected to contain approximately 50 g/t Au and 877 g/t Ag. The arsenic content of the flotation concentrate is expected to be marginally higher than the penalty thresholds set up by most smelters.

Figure 1-1: Simplified Process Flowsheet



Source: Tetra Tech (2019)

1.9 Project Infrastructure

During mine construction between 2015 and 2017, a number of on-site and off-site infrastructure components were built to support the operation. The locations of facilities and infrastructure items were selected to take advantage of local topography, accommodate environmental considerations, avoid avalanche hazards, and ensure efficient and convenient underground crew shift changes. Figure 1-2 shows the on-site infrastructure layout and Figure 1-3 illustrates the off-site infrastructure layout.

Facilities and infrastructure at or near the Brucejack Gold Mine site are currently in operation and include the following:

- 73.5 km access road at Highway 37, travelling westward to Brucejack Lake with the 12 km section of road, from km 59 to km 71 traversing the main arm of the Knipple Glacier
- Site roads and pads
- 138 kV power supply line from the Long Lake Hydro Substation to the substation at the Knipple Transfer Station, where the voltage reduces from 138 to 69 kV; the transmission line carries on to the Brucejack Gold Mine site
- Site power distribution systems from the main substations to all the facilities
- Mill building containing process equipment, process control, and instrumentation; a gravity concentration laboratory is under planning for mine and mill feed grade control, a paste backfill plant, and a metallurgical laboratory
- Water management infrastructure, including diversion ditches for both contact and non-contact water, interceptor ditches, and a contact water drainage collection pond and pump(s) to direct contact water to the water treatment plant
- Water treatment infrastructure to treat underground infill water and surface contact water via a treatment plant that discharges the treated water to process and fresh/fire water tanks
- Potable water treatment facility
- Sewage treatment infrastructure
- Solid waste management systems, including domestic waste disposal and incinerator
- Communication systems
- Ancillary facilities including:
  - on-site fuel storage
  - on-site explosive storage
  - detonator magazine storage
  - camp accommodation with recreation area, commissary, laundry facilities, mine dry, and medical clinic and first aid/emergency response
  - truck shop

- helipad
- laydown areas
- covered storage building.

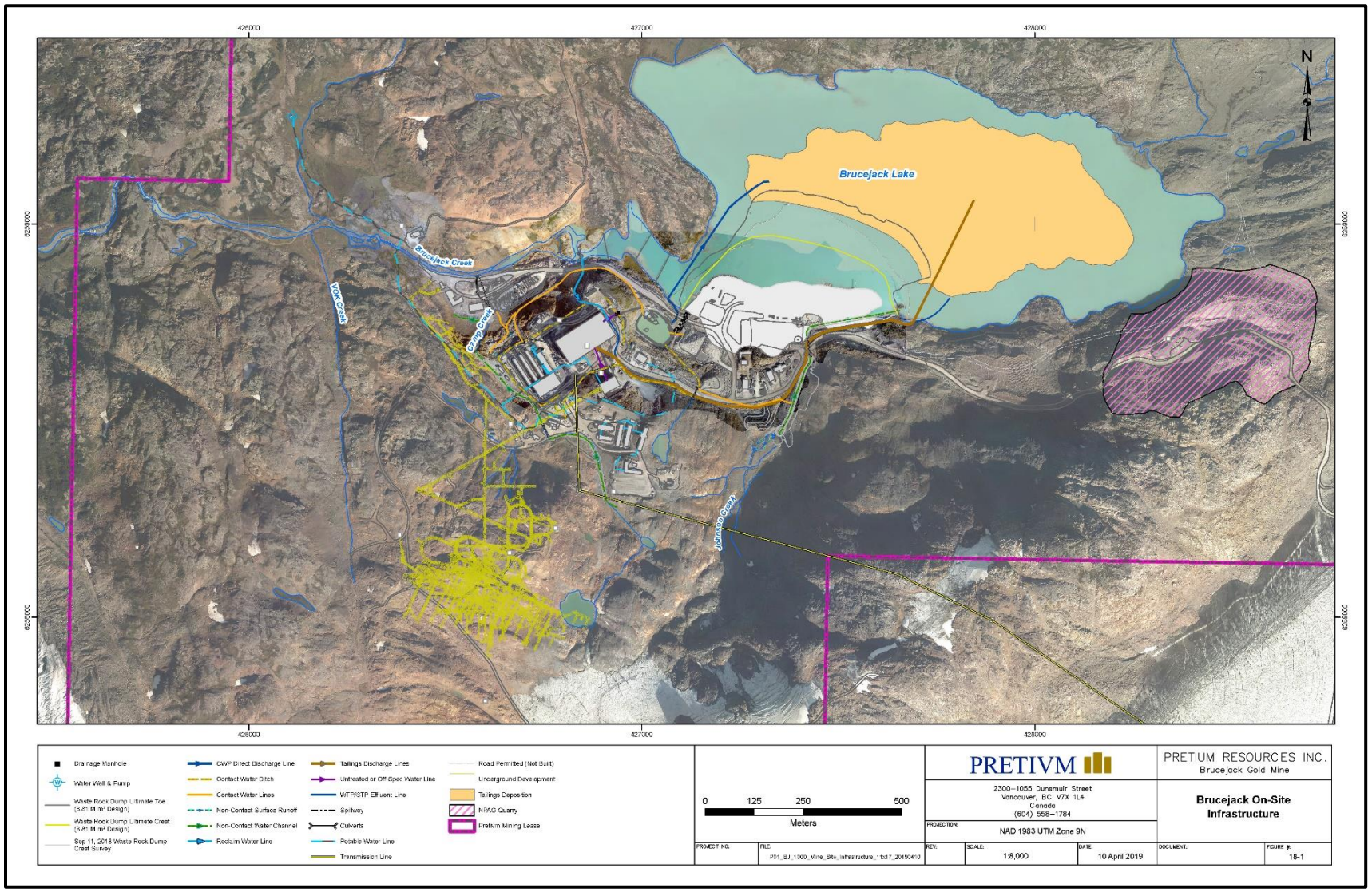
The Brucejack Access Road is an all-season, two-way access road that commences at Highway 37 at km 215 and travels generally westward to Brucejack Lake, a distance of 73.5 km. The access road is maintained throughout the year by road grooming equipment and snow plows. Regular patrols are conducted, particularly, in potential avalanche areas with avalanche control measures in place. The 12 km section of the access road (km 59 to km 71) traverses the main arm of the Knipple Glacier. During winter months the route is a groomed snow surface, but is an ice surface during the summer months.

The Knipple Transfer Station is located approximately 12 km southeast of Brucejack Gold Mine site. The Knipple Transfer Station facilities include a camp, maintenance and emergency vehicle building, cold storage, fuel dispensing system, helipad, incinerator, assay laboratory, truck scale, and laydown areas. All deliveries to and from the mill site report to this facility for intermediate storage or transfer to a different vehicle before delivery to the mine or off-site. Similarly, loads from the mill site are managed in reverse order.

An aerodrome with a 5,000 ft. long by 75 ft. wide gravel airstrip and an apron for aircraft parking at 1,424 ft. elevation is located at the Bowser site, approximately 2 km east of Knipple Lake. The aerodrome is available to provide air service by chartered flights to and from the mine. Expansion of the runway to 100 ft. width and 5,500 ft. length with lighting and apron up-grades is under study to allow AGN IIIA class aircraft, such as the DE Havilland Dash 8 turboprops, to use the aerodrome. Currently, personnel transportation between Brucejack Gold Mine and Smithers/Terrace, BC is facilitated by chartered bus service. However, routine crew changes by chartered air service is under study.

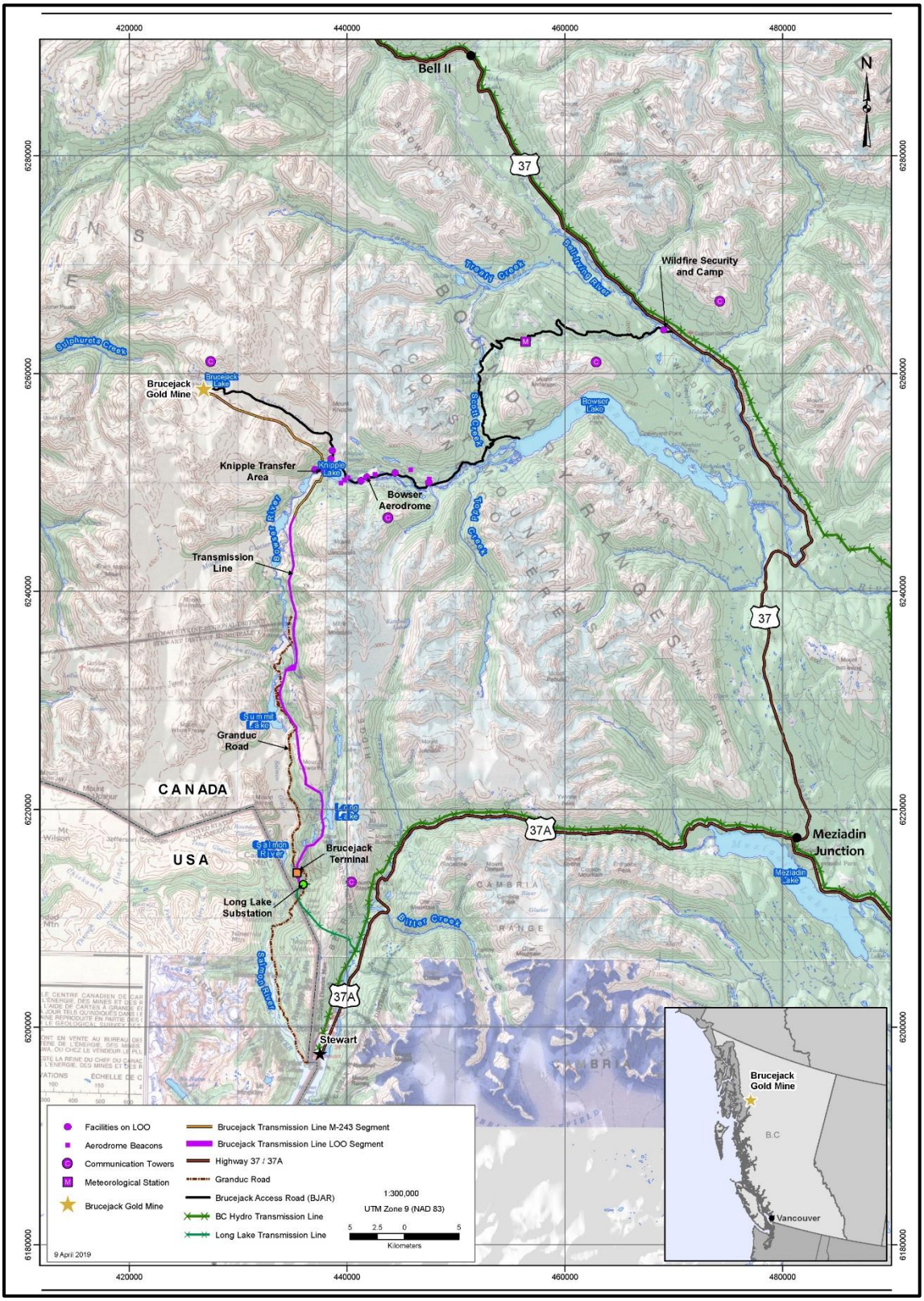
There is a security gatehouse and camp at the Wildfire Camp site, located on the Brucejack Access Road near the intersection of Highway 37. The security gatehouse provides access control to the inbound and outgoing traffic along the Brucejack Access Road.

Figure 1-2: Brucejack Gold Mine On-site Infrastructure Layout



Source: Pretivm (2019)

Figure 1-3: Brucejack Gold Mine Off-site Infrastructure Layout



Source: Pretivm (2019)

The tailings delivery system discharges thickened tailings slurry to the bottom of Brucejack Lake (approximately 80 m deep) when not used for paste backfill (approximately 40 to 50% of the time). For discharge to the lake, the tailings slurry is pumped to an agitated slurry mixing tank and then diluted at the nominal solids throughput rate of approximately 180 t/h. The diluted slurry is pumped overland and then underwater along the suspended discharge lines to the discharge point.

Both the pipes are suspended on cables to allow for vertical and horizontal repositioning over the LOM to ensure the pipe is not covered by tailings and to meet permit conditions for vertical positioning above the lake bottom.

A 138 kV overhead power supply line from the substation at Long Lake Hydro Substation was constructed in 2016/2017 and connects to the Knipple Substation.

The main site power steps down from 138 to 69 kV via two 20/26 MVA oil-filled transformers, complete with neutral grounding resistors, located in the main substation yard at the Knipple Substation. Each transformer is capable of carrying the entire site load. The 69 kV transmission line is transported to Brucejack Gold Mine where it enters into the mill.

The voltage is further stepped down from 69 kV to 4.16 kV via 2 x 15/20/25 MVA oil-filled transformers and distributed to the site via 4.16 kV rated switchgear. The rating for site on a distribution end is 4.16 kV and further transformed to 0.6 kV for smaller loads.

The main mill and underground loads are fed via power cables in cable tray. The main substation is located inside the mill. Power feeds to the mill building, camps, truck shop, and underground are all underground buried services.

Within the mill, large loads are powered at 4.16 kV. Smaller loads are powered at 600 V via switchgear and motor control centers (MCCs). Variable frequency drives (VFDs) and soft starters are employed strategically to optimize process and energy performance.

An avalanche hazard assessment of the mine site, access road, and transmission line route was presented in the 2014 FS (Ireland et al. 2014). Generally, the avalanche hazard assessment of the mine site, access road, and transmission line route remains unchanged from the 2014 FS (Ireland et al. 2014). The avalanche season for infrastructure below the 1,000 m elevation level is generally from November to May, while for elevations above 1,200 m the season is from October to June, or if cool and wet conditions persist, avalanches can occur in summer months. Snow avalanches generally occur in areas where there are steep open slopes or gullies, and deep (more than 50 cm) mountain snow packs. Risks associated with avalanches are normally due to exposure to the high impact forces that occur, as well as the effects of extended burial for any person caught in an avalanche. An avalanche path generally consists of a starting zone, a track, and a runout zone.

Pretivm has full time mountain safety technicians who monitor avalanche risk, develop hazard ratings for the Brucejack Access Road for specific sections, and release hazard bulletins with avalanche ratings for those road sections and glacier hazard ratings for travel on the glacier. Mountain safety technicians regularly survey the ice road and work with road maintenance to ensure safe travel on the ice.

1.10 Environmental Studies, Permitting and Social and Community Impact

Pretivm is committed to continuing to operate the Brucejack Gold Mine in a sustainable manner and according to the guiding principles in its corporate Social, Environmental, and Health and Safety policies. Pretivm regularly consults with public, Indigenous groups, and stakeholders on the Brucejack Mine and commitments for engagement, communication, and local recruitment. Every reasonable effort has and will continue to be made to minimize or prevent potential long-term adverse environmental effects and to ensure that the mine provides lasting benefits to local Indigenous and other communities while generating substantial economic and social value for shareholders, employees, and the broader community. Pretivm developed an Economic and Social Effects Mitigation Plan (ESEMP) as a requirement of its provincial Environmental Assessment Certificate and reports annually on the outcomes and achievements related to the ESEMP. Pretivm respects the traditional knowledge of the Indigenous peoples who have historically occupied or used the Project area and is committed to an engagement process that continues to invite and consider input from people with traditional knowledge in the area. Pretivm's objectives include continuing to retain the integrity of ecosystems within which mine infrastructure is located to the extent feasible during the remainder of mine operations. Upon mine closure, the intent will be to reclaim mine infrastructure disturbance areas to the approved end land uses in accordance with the approved reclamation plan, thereby returning the disturbed areas to levels of land productivity equal to or better than existed prior to mine development. Pretivm maintains a reclamation security of $31.7 million with the BC government for the full build-out of the mine.

1.11 Capital and Operating Cost Estimates

1.11.1 Capital Cost Estimate

The total LOM sustaining capital cost from 2020 to 2032 is estimated at US$176.7 million. Table 1-7 shows a summary breakdown of the LOM sustaining capital costs by area, including required sustaining costs for the mine and mill throughput expansion to 3,800 t/d. The estimated cost includes design, construction, installation, and commissioning.

The key inputs to this cost estimate were based on the LOM planned costs estimated by Pretivm and reviewed by Tetra Tech, including recent equipment purchased costs, equipment quotations from vendors, and recent construction cost data. All costs are inclusive of direct cost, indirect cost, and contingency. The expected accuracy range of the operating cost estimate is +20%/-15%.

Table 1-7: LOM Sustaining Capital Cost Estimates

Area Description	LOM Sustaining Capital Cost (US$ million)
Mining	66.6
Processing	3.5
Site Infrastructure and Services	91.8
Mine Throughput Expansion	14.8
Total	**176.7**

1.11.2 Operating Cost Estimate

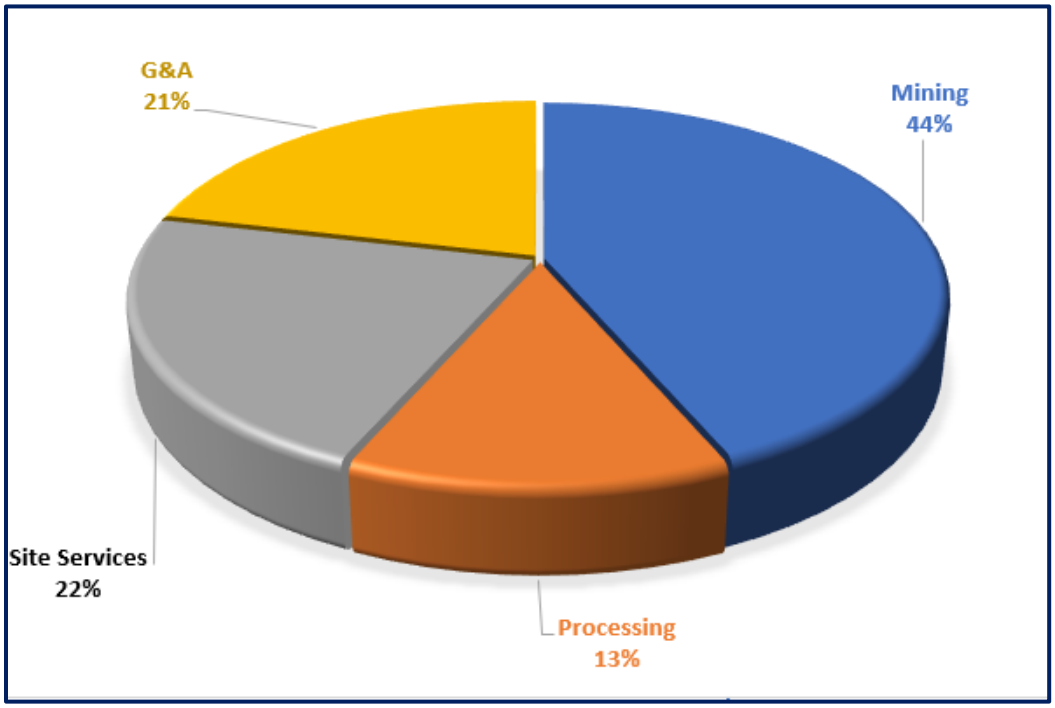
The estimated LOM average operating cost for the Brucejack Gold Mine is US$162.82/t milled. Table 1-8 shows the cost breakdown for each area and Figure 1-4 shows the cost distribution by area.

Table 1-8: LOM Average Operating Cost Summary

Area	Unit Operating Cost (US$/t milled)
Mining	70.83
Processing	21.34
Overall Site Services, including Office[(1)]	35.89
G&A	34.76
Total Operating Cost	**162.82**

Notes: [(1)]Including the costs for off-site and satellite offices.
G&A – general and administrative.

Figure 1-4: Overall Operating Cost Distribution by Area



The operating cost estimate is based on the Brucejack Gold Mine operating experience, including consumable supplies, power supply, contractor services, camp services, personnel transportation, and labour salaries/wages with a base date of Q4 2019 and do not include any escalation beyond this quarter. The expected accuracy range of the operating cost estimates is -15%/+15%. All the costs have been estimated in US dollars, unless otherwise specified.

The operating costs exclude shipping charges and sale costs for the gold-silver doré and gold-silver concentrate and royalties, which are included in the financial analysis.

All operating cost estimates exclude taxes unless otherwise specified.

1.12 Economic Analysis

Tetra Tech prepared an economic evaluation of the Brucejack Gold Mine based on a discounted cash flow model for the remaining 13-year LOM and 15.64 Mt of ore included in the mine plan. For this mine plan, a post-tax net present value (NPV) of US$1.50 billion was calculated at a discount rate of 5%.

The Brucejack Gold Mine economic model is based on the following assumptions:

- Gold price of US$1,300/oz
- Silver price of US$16.90/oz
- Foreign exchange rate of Cdn$1.00:US$0.76.

The production schedule was incorporated into the pre-tax financial model to develop annual recovered metal production. Capital expenditures include 3,800 t/d mine expansion capital cost of US$14.8 million and ongoing sustaining capital costs for mining and milling additions and equipment replacement totaling US$161.9 million. The total LOM capital cost is US$176.7 million.

The NPV was estimated at the beginning of the mining schedule and therefore has an effective date of January 1, 2020.

Table 1-9 summarizes the forecast for the economic performance of the Brucejack Gold Mine operation for the remaining LOM.

Table 1-9: Brucejack Gold Mine Economic Performance Forecast

	Unit	Amount
Tonnes Mined and Processed	kt	15,637
Gold Head Grade	g/t	8.4
Silver Head Grade	g/t	59.6
Total Project Revenue	US$ million	5,266
Operating Costs	US$ million	(2,546)
Royalties	US$ million	(63)
Sustaining Capital Costs, including Mine Expansion	US$ million	(177)
Other Expenses	US$ million	(21)
Taxes Payable	US$ million	(492)
Post-tax NPV (5% Discount Rate)	US$ million	1,496
Post-tax NPV (8% Discount Rate)	US$ million	1,293

1.13 Project and Operation Risks

There are no known environmental liabilities or other significant risks or factors that may affect access, title, or the ability or right to operate the mine or perform work on the Brucejack Property, beyond the geopolitical, economic, permitting, and legal climate that Pretivm operates in and Pretivm's ability to secure any required approvals, consents, and permits under applicable legislation.

1.14 Conclusions and Recommendations

The Brucejack Gold Mine is considered to be economically viable based on the results of the work presented in this Technical Report. The mine has a demonstrated capability of processing 3,800 t/d of ore or higher. Section 26.0 outlines detailed recommendations for the Brucejack Gold Mine.

2.0 INTRODUCTION

The Brucejack Gold Mine, located in northwest BC, is a high-grade underground mining operation that commenced commercial production in July 2017. Brucejack uses conventional gravity concentration and sulphide flotation to produce gold-silver doré and gold-silver flotation concentrate.

Pretivm, a low-cost intermediate gold producer, owns 100% of the Brucejack Property.

In January 2020, Pretivm commissioned Tetra Tech to complete an update to the 2019 NI 43-101 Technical Report. This NI 43-101 Technical Report, effective on March 9, 2020, updates Mineral Resource and Mineral Reserve, the LOM plan and operating parameters. The effective date of the 2020 Mineral Reserve and 2020 Mineral Resource is January 1, 2020.

The following consultants were commissioned to complete work and reviews for the purpose of the Technical Report:

- Tetra Tech – mineral processing and metallurgical testing, mineral reserve estimates, mining methods, recovery methods, project surface and underground infrastructure, market studies and contracts, capital and operating cost estimates, and economic analysis.
- Ivor Jones Pty Ltd – property description and location; accessibility, climate, and physiology; history; geological setting and mineralization; deposit types; exploration; drilling; sample preparation and analysis; data verification; adjacent properties; and mineral resource estimates.
- ERM – aspects of environmental studies, permits, and social or community impacts; waste management; and closure plans.
- Lorax – hydrogeology, geochemistry, water balance, and water quality.
- SRK – waste rock and tailings storage facility, underground and surface geotechnical design, and water management.

2.1 Terms of Reference

The following terms of reference are included throughout this report:

- The Brucejack Property refers to the mineral claims that were acquired as the property, as listed in Table 4-1.
- The Brucejack Gold Mine refers to the property only on the mining leases, as listed in Table 4-1.
- The Brucejack Project refers to all geological or engineering work completed on and around the Brucejack Gold Mine that leads to the short-term advancement of the existing mining operation. It includes near-mine exploration and all of the off-mining leases infrastructure.
- The April 2012 Mineral Resource for the West Zone is detailed in Jones (2012a). There has been no change to the April 2012 West Zone Mineral Resource since that time. All references to the Mineral Resource for the Brucejack Deposit from November 2012 to present incorporate the April 2012 West Zone Mineral Resource.
- The November 2012 Mineral Resource for the Valley of the Kings Zone is detailed in Jones (2012c).
- The December 2013 Mineral Resource for the Valley of the Kings Zone is detailed in Jones (2014).

- The December 2016 Mineral Resource for the Valley of the Kings Zone is detailed in Pretivm (2016) and Board et al. (2017).
- The January 2019 Mineral Resource is detailed in the 2019 Technical Report on the Brucejack Gold Mine, Northwest British Columbia, by Jones, et al (2019).
- The January 2020 Mineral Resource is detailed in the current Technical Report.

2.2 Site Visits

In accordance with NI 43-101 guidelines, the following QPs completed a visit to the Brucejack Property:

1. Hassan Ghaffari, P.Eng., M.A.Sc. of Tetra Tech visited the Brucejack Property on March 13, 2019.
2. Maureen Phifer, P.Eng., B.Sc. of Tetra Tech visited the Brucejack Property from January 20 to 22, 2020.
3. Jianhui (John) Huang, Ph.D., P.Eng. of Tetra Tech visited the Brucejack Property on March 6 and 7, 2018 and on June 5 and 6, 2018.
4. Ivor W.O. Jones, M.Sc., P.Geo., FAusIMM, CP(Geo) of Ivor Jones Pty Ltd has visited the Brucejack Property several times since 2012, with the most recent visits from August 20 to 24, 2018 and April 18, 2020.
5. Rolf Schmitt, M.Sc., P.Geo. of ERM visited the Brucejack Property from April 1 to 3, 2019.
6. Alison Shaw, Ph.D., P.Geo. of Lorax visited the Brucejack Property from June 3 to 6, 2019.
7. Timothy Coleman, P.Eng. of SRK visited the Brucejack Property on September 24, 2019.
8. Mauricio Herrera, P.Eng., Ph.D. of SRK visited the Brucejack Property from August 19 to 21, 2019.
9. Calvin Boese, P.Eng., M.Sc. of SRK visited the Brucejack Property from August 19 to 21, 2019.
10. Laura-Lee Findlater, B.Sc. P.Geo., of Lorax visited the Brucejack Property on October 7 and 9, 2019.
11. Colin Fraser, P.Geo., M.Sc. of Lorax visited the Brucejack Property from August 19 to 22, 2019.

2.3 Qualified Persons

The QPs responsible for this technical report are listed in Table 2-1.

Table 2-1: Summary of QPs

Report Section		Company	QP
1.0	Summary	All	Sign-off by Subsection
2.0	Introduction	Tetra Tech	Jianhui (John) Huang, Ph.D., P.Eng.
3.0	Reliance on Other Experts	Tetra Tech	Sign-off by Subsection
4.0	Property Description and Location	Ivor Jones Pty Ltd	Ivor W.O. Jones, M.Sc., P.Geo., FAusIMM
5.0	Accessibility, Climate, Local Resources, Infrastructure, and Physiography	Ivor Jones Pty Ltd	Ivor W.O. Jones, M.Sc., P.Geo., FAusIMM
6.0	History	Ivor Jones Pty Ltd	Ivor W.O. Jones, M.Sc., P.Geo., FAusIMM
7.0	Geological Setting and Mineralization	Ivor Jones Pty Ltd	Ivor W.O. Jones, M.Sc., P.Geo., FAusIMM
8.0	Deposit Types	Ivor Jones Pty Ltd	Ivor W.O. Jones, M.Sc., P.Geo., FAusIMM
9.0	Exploration	Ivor Jones Pty Ltd	Ivor W.O. Jones, M.Sc., P.Geo., FAusIMM
10.0	Drilling	Ivor Jones Pty Ltd	Ivor W.O. Jones, M.Sc., P.Geo., FAusIMM
11.0	Sample Preparation, Analyses and Security	Ivor Jones Pty Ltd	Ivor W.O. Jones, M.Sc., P.Geo., FAusIMM
12.0	Data Verification	Ivor Jones Pty Ltd	Ivor W.O. Jones, M.Sc., P.Geo., FAusIMM
13.0	Mineral Processing and Metallurgical Testing	Tetra Tech	Jianhui (John) Huang, Ph.D., P.Eng.
14.0	Mineral Resource Estimates	Ivor Jones Pty Ltd	Ivor W.O. Jones, M.Sc., P.Geo., FAusIMM
15.0	Mineral Reserve Estimates	Tetra Tech	Maureen Phifer, P.Eng., B.Sc.
16.0	Mining Methods	Tetra Tech/ SRK	Maureen Phifer, P.Eng., B.Sc./ Timothy Coleman, P.Eng,
17.0	Recovery Methods	Tetra Tech	Jianhui (John) Huang, Ph.D., P.Eng.
18.0	Project Infrastructure	Tetra Tech/ SRK	Hassan Ghaffari, P.Eng., M.A.Sc./ Mauricio Herrera, P.Eng., Ph.D./ Calvin Boese, P.Eng., M.Sc.
19.0	Market Studies and Contracts	Tetra Tech	Jianhui (John) Huang, Ph.D., P.Eng.
20.0	Environmental Studies, Permitting, and Social or Community Impact	ERM/ SRK/ Lorax	Rolf Schmitt, M.Sc., P.Geo./ Mauricio Herrera, P.Eng., Ph.D./ Colin Fraser, P.Geo., M.Sc./ Alison Shaw, Ph.D., P.Geo./ Laura-Lee Findlater, B.Sc., P.Geo.
21.0	Capital and Operating Costs	Tetra Tech	Jianhui (John) Huang, Ph.D., P.Eng./ Maureen Phifer, P.Eng., B.Sc./ Hassan Ghaffari, P.Eng., M.A.Sc./

table continues…

Report Section		Company	QP
22.0	Economic Analysis	Tetra Tech	Maureen Phifer, P.Eng., B.Sc.
23.0	Adjacent Properties	Ivor Jones Pty Ltd	Ivor W.O. Jones, M.Sc., P.Geo., FAusIMM
24.0	Other Relevant Data and Information	Tetra Tech	Jianhui (John) Huang, Ph.D., P.Eng.
25.0	Interpretation and Conclusions	All	Sign-off by Subsection
26.0	Recommendations	All	Sign-off by Subsection
27.0	References	All	Sign-off by Subsection

2.4 Information and Data Sources

A complete list of references is provided in Section 27.0.

3.0 RELIANCE ON OTHER EXPERTS

3.1 Introduction

The QPs who prepared this Technical Report relied on information provided by experts who are not QPs. The relevant QPs believe that it is reasonable to rely on these experts, based on the assumption that the experts have the necessary education, professional designations, and relevant experience on matters relevant to the Technical Report.

3.2 Status of Mining Leases and Mineral Claims

Ivor Jones, P.Geo., FAusIMM relied upon public information, as well as information from Max Holtby, P.Geo., Director of Permitting for Pretivm, regarding the status and circumstances of the Brucejack Property mining leases and mineral claims as reported in Section 4.0.

3.3 Environment, Social and Sustainability

Rolf Schmitt, P.Geo. relied upon public information posted on the websites of government regulators as well as information from Greg Norton, V.P. of Environment and Regulatory Affairs for Pretivm regarding components of the Brucejack Mine Environmental Management System described in Section 20.1.1.2, and mine wastes generated to date and forecast to be generated over the LOM as described in Section 20.3.6.1.

3.4 Marketing Studies

John Huang, P.Eng. relied on Janice Song, CPA, CGA, MBA, Director, Treasury from Pretivm, for guidance on marketing studies, including gold-silver doré and gold-silver concentrate smelting terms and products transportation as described in Section 19.0.

3.5 Economic Analysis

Maurie Phifer, P.Eng. relied on Velibor Petric, Site Mine Controller from Pretivm, for guidance on applicable taxes and royalties relevant to revenue or income from the Brucejack Gold Mine as detailed in Section 22.0.

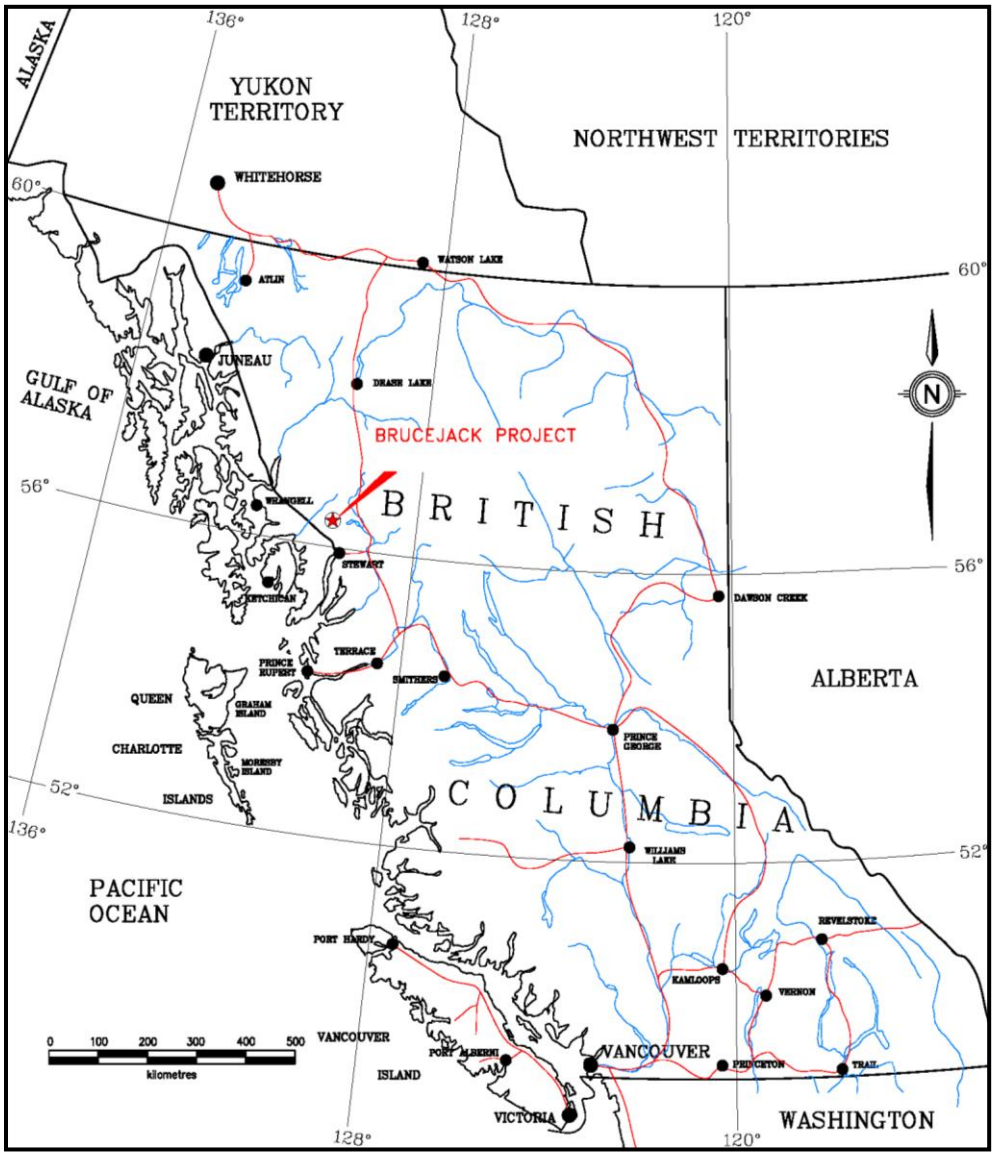
4.0 PROPERTY DESCRIPTION AND LOCATION

Information in this section has been excerpted from Jones (2014) and updated.

4.1 Location

The Brucejack Property is centered approximately at 56°28'20"N Latitude by 130°11'31"W Longitude (Universal Transverse Mercator (UTM) 426,967E 6,258,719N North American Datum (NAD) 83 Zone 9), a position approximately 950 km northwest of Vancouver, 65 km north-northwest of Stewart, and 21 km south-southeast of the Eskay Creek Mine (Figure 4-1). The Brucejack Property coordinates used in this Technical Report are located relative to the NAD83 UTM coordinate system.

Figure 4-1: Brucejack Property Location Map



Source: Pretivm

4.2 Tenure

In 2010, pursuant to a purchase and sale agreement between Silver Standard (as the seller) and Pretivm (as the buyer), Silver Standard sold to Pretivm all of the issued shares of 0890693 BC Ltd., the owner of the Brucejack Gold Mine and the Snowfield Project. Subsequently, the name of 0890693 BC Ltd. changed to Pretivm Exploration Inc.

4.3 Status of Mining Titles

The Brucejack Property is located on provincial Crown land and consists of four mining leases and six mineral claims that cover the target Mineral Resource, totaling 3,305.85 ha in area. According to the BC Mineral Titles Office official information, all mining leases are in good standing until September 17, 2020; all mineral claims are in good standing until January 31, 2031 (Table 4-1).

Brucejack Property mineral claims and mining leases are contiguous with the Snowfield and Bowser properties, a large block of mineral claims held by Pretivm (Figure 4-2). The Snowfield and Bowser Properties form a block of mineral claims that total 338 mineral claims and measure approximately 122078 ha (Figure 4-3). Pretivm mineral claims extend from the Brucejack Gold Mine site area east to Highway 37, including parts of the Bowser River, Scott Creek, and Wildfire Creek watersheds, and along parts of the transmission line right-of-way. The Brucejack Gold Mine is situated within the Sulphurets District, Skeena Mining District.

Table 4-1: Mineral Claims for the Brucejack Property

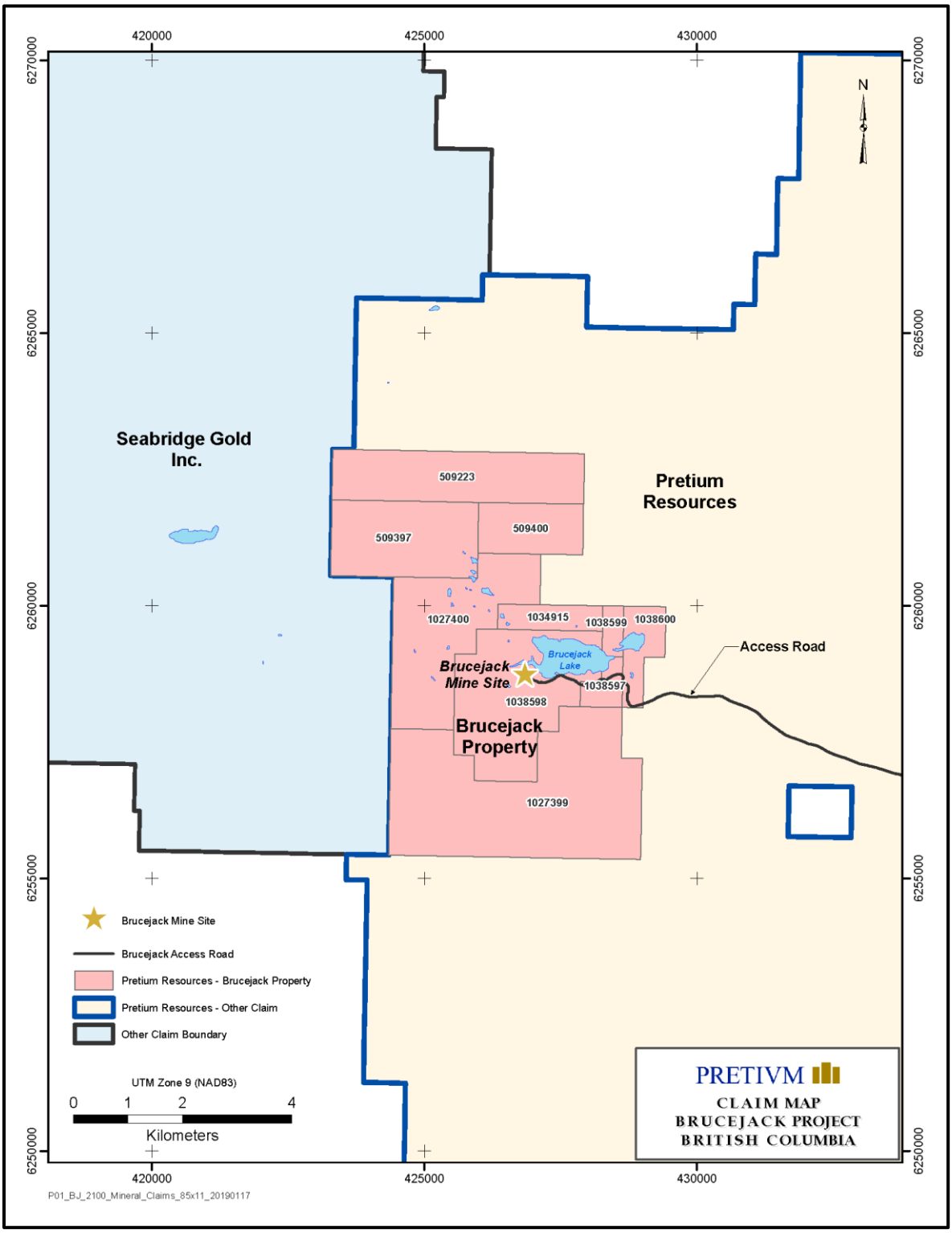
Tenure No.	Tenure Type	Map No.	Owner	Pretivm Interest (%)	Status	In Good Standing To (dd-mm-yy)	Area (ha)
509223	Mineral Claim	104B	Pretivm Exploration Inc.	100	Good	31-Jan-31	428.62
509397	Mineral Claim	104B	Pretivm Exploration Inc.	100	Good	31-Jan-31	375.15
509400	Mineral Claim	104B	Pretivm Exploration Inc.	100	Good	31-Jan-31	178.63
1027399	Mineral Claim	104B	Pretivm Exploration Inc.	100	Good	31-Jan-31	983.61
1027400	Mineral Claim	104B	Pretivm Exploration Inc.	100	Good	31-Jan-31	500.39
1034915	Mineral Claim	104B	Pretivm Exploration Inc.	100	Good	31-Jan-31	89.35
1038597	Mining Lease	104B	Pretivm Exploration Inc.	100	Good	17-Sep-20	53.60
1038598	Mining Lease	104B	Pretivm Exploration Inc.	100	Good	17-Sep-20	533.61
1038599	Mining Lease	104B	Pretivm Exploration Inc.	100	Good	17-Sep-20	35.70
1038600	Mining Lease	104B	Pretivm Exploration Inc.	100	Good	17-Sep-20	107.20
Total (ha)							**3,305.85**

The QP relied upon public information, as well as information from Pretivm, regarding the Brucejack Property claims and has not undertaken an independent verification of title and ownership. However, the QP verified information relating to tenure, to the extent possible, using public information available through the Mineral Titles Branch of the BC Ministry of Energy, Mines & Petroleum Resources (MEMPR) Mineral Titles Online (MTO) land tenure database.

A legal land survey of the mining leases was undertaken in June 2015 and approved by the BC Surveyor General on September 3, 2015. A legal survey of the mineral claims has not been undertaken.

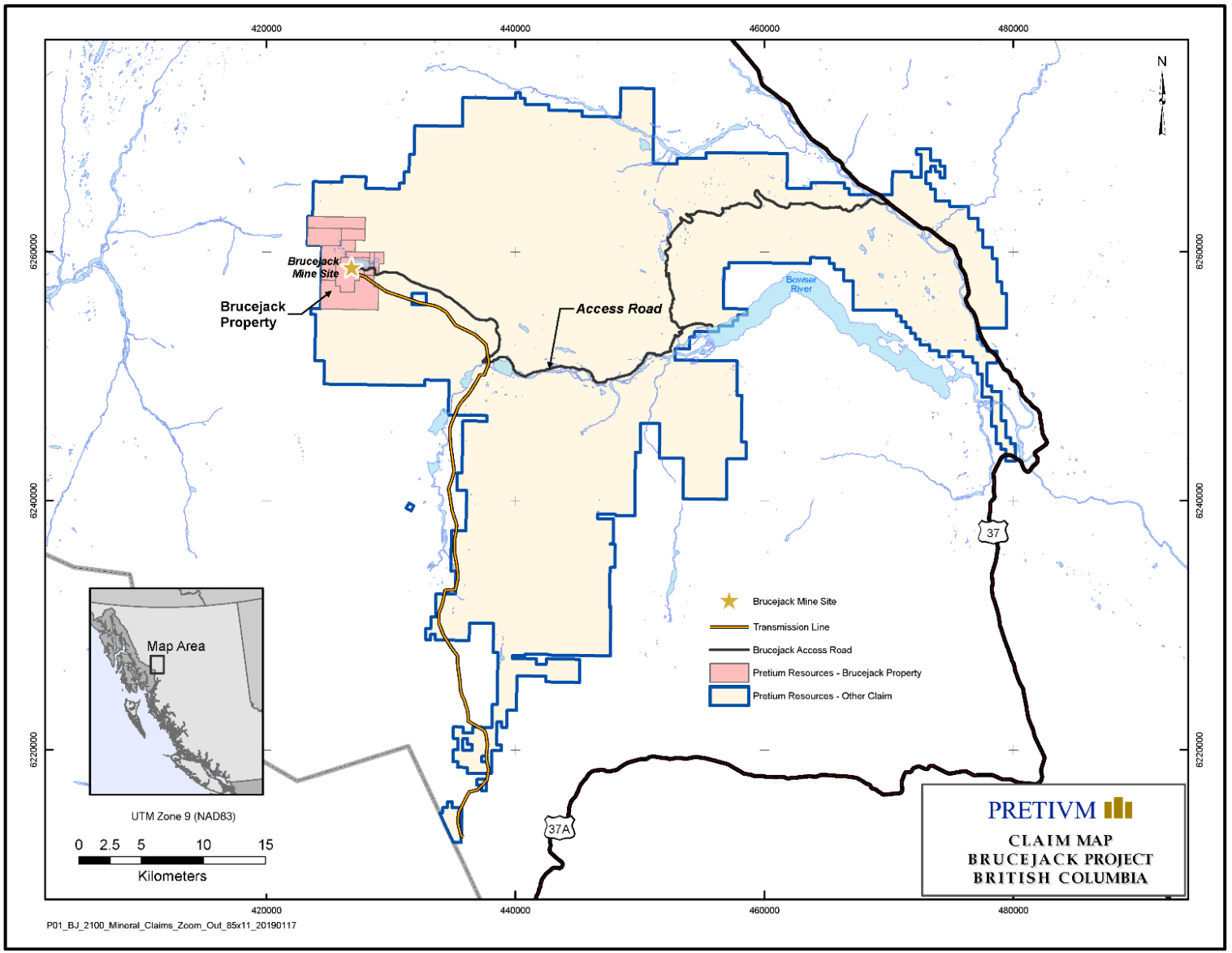
The QP understands that there are no annual holding costs for any of the six mineral claims at this time, as the claims are paid up until January 31, 2031. Annual rental holding fees for the four mining leases total Cdn$15,002.

Figure 4-2: Brucejack Property Mineral Claims



Source: Pretivm (2019)

Figure 4-3: Pretivm Mineral Claims



Source: Pretivm (2019)

The majority of the Brucejack Property lies within the boundaries of the Cassiar-Iskut-Stikine Land and Resource Management Plan (LRMP) area, with only a minor south-eastern segment of Mineral Claim No. 1027399 and Mining Lease No. 1038600 occurring outside this area. All claims and leases located within the boundaries of the LRMP are considered areas of General Management Direction, with none of the leases or claims occurring inside any Protected or Special Management Areas.

As of the effective date of this report, the land claims in the area are in review and subject to ongoing discussions between various First Nations and the Government of BC.

The mining operation is fully permitted. A *Mines Act* permit and two *Environmental Management Act* permits along with a BC *Environmental Assessment Act* certificate and the Decision Statement of July 27, 2015, under Section 54 of the *Canadian Environmental Assessment Act, 2012* provide the basis for approvals of the mine and use of the site for mining purposes. Mine infrastructure and infrastructure along the road are permitted under a variety of permits for water use and camps with land use held under various Licenses of Occupation and the access road held under a provincial Special Use permit. Tailings storage and waste rock are permitted under an *Environmental Management Act* discharge permit while surface and underground operations are regulated by the *Mines Act* permit.

There are no known environmental liabilities or other significant risks or factors that may affect access, title, or the ability or right to operate the mine or perform work on the Brucejack Property, beyond the geopolitical, economic, permitting, and legal climate that Pretivm operates in and Pretivm's ability to secure any required approvals, consents, and permits under applicable legislation.

4.4 Confirmation of Tenure

The QP is not qualified to provide legal comment on the mineral title to the reported properties and has relied on the provided information. No warranty or guarantee, be it expressed or implied, is made by the QP with respect to the completeness or accuracy of the tenement description referred to in this document.

4.5 Royalties, Fees, and Taxes

The royalties applicable to the original Brucejack area, not including Mining Lease No. 1038600, are as follows:

- "Royalty" means the amount payable by the Owner, calculated as 1.2% of the NSR, with the following exemptions:
  - Gold: The first 503,386 oz produced from the Brucejack Gold Mine.
  - Silver: The first 17,907,080 oz produced from the Brucejack Gold Mine.

The QP understands that the 1.2% NSR royalty is, at the time of this report, in favour of the Franco-Nevada Corporation.

Mining Lease No. 1038600 is subject to a 2% NSR royalty, minimum annual payments of Cdn$50,000 with a buy out provision of Cdn$4 million per 1%, i.e., a total of Cdn$8 million. Mining Lease No. 1038600 does not cover any of the area within the current mine plan.

5.0 ACCESSIBILITY, CLIMATE, LOCAL RESOURCES, INFRASTRUCTURE AND PHYSIOGRAPHY

Information in this section has been excerpted and updated from Jones (2014). It does not cover the majority of the mine infrastructure, which is covered under Section 18.0.

5.1 Climate and Physiography

The climate at the Brucejack Property is typical of northwestern BC with cool, wet summers and relatively moderate but wet winters. Annual temperatures range from +20 to -20°C. Precipitation is high with heavy snowfall accumulations ranging from 10 to 15 m at higher elevations and 2 to 3 m along the lower river valleys. Snowpacks cover the higher elevations from October to June. The optimum field season for surface works is from late June to mid-October.

Mine infrastructure is located at 1,360 to 1,415 masl along Brucejack Creek and immediately southwest of Brucejack Lake. Topographic relief is moderate to low in the immediate mine site; however, across the Brucejack Property, the terrain is generally steep with local reliefs of 1,000 m from valleys occupied by receding glaciers, to ridges at elevations of 1,900 masl. Elevations within the mine area range from 1,360 masl along Brucejack Lake to 1,500 masl at the Valley of the Kings meteorological station.

5.2 Vegetation

The Brucejack Gold Mine site is devoid of trees with only sparse mosses along drainages; the tree line is at an elevation of approximately 1,200 m. On the Brucejack Property, sparse fir, spruce, and alder grow along the valley bottoms with only scrub alpine spruce, juniper, alpine grass, moss, and heather covering the steep valley walls. Rocky glacial moraine and polished glacial-striated outcrops dominate the terrain above the tree line.

5.3 Accessibility

The Brucejack Property is located in the Boundary Range of the Coast Mountain Physiographic Belt.

Pretivm constructed a 73 km access road that links the Brucejack Camp to Highway 37 at km 215, approximately 60 km north of Meziadin Junction. From Highway 37, the road crosses the Bell Irving River to Wildfire Camp and then traverses Wildfire Creek valley to the headwaters of Scott Creek, traverses along Scott Creek valley to Bowser River valley and then proceeds along Bowser River valley to Knipple Glacier, a distance of 58 km. A 12 km road is established along Knipple Glacier to the headwaters of the Brucejack Creek watershed, at which point the road extends 3 km to the mine site.

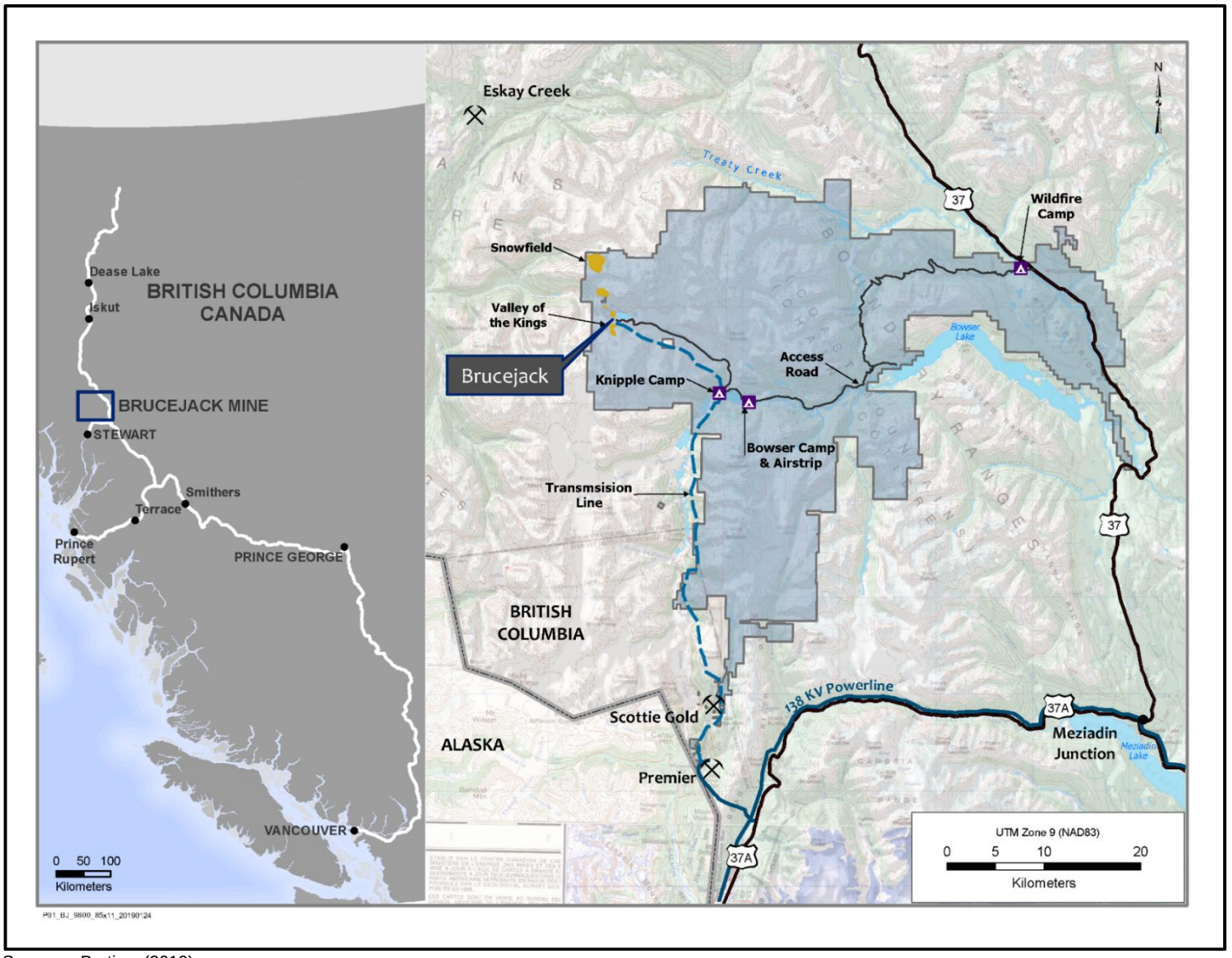
Provincial permits and federal authorization of the mine prohibit public use of the access road. A gate is located at the Highway 37 junction, and security screening is undertaken at Wildfire Camp. Along the access road, a 5,400 ft. aerodrome has been established at Bowser Aerodrome 5 km east of Knipple Camp (Lake) (Figure 5-1). Personnel, equipment, fuel, and camp provisions are driven to a staging area at Knipple Camp, before being taken over the glacier to the Brucejack Camp.

The Brucejack Property area is also easily accessible with the use of a chartered helicopter from the town of Stewart, or seasonally from the settlement of Bell II. The flight time from Stewart is approximately 30 minutes and slightly less from Bell II; however, Stewart has the advantage of having an established year-round helicopter base.

The larger communities of Smithers and Terrace, located 326 km and 300 km, respectively by road, provide hubs for mine personnel to live and airports for out-of-the-region staff to commute to site. Charter busses provide transport from these communities and other communities along Highway 16 to the Brucejack Gold Mine.

Rail traffic can load and unload in Terrace, and port facilities at Stewart and Prince Rupert are available for off-shore transport.

Figure 5-1: Project Access



Source: Pretivm (2019)

5.4 Infrastructure

The access road from Highway 37 is complete and in use (Figure 5-1).

All resources are brought into the mine and remote camps via the mine site access road connecting to highway 37. Infrastructure along the access road includes camps at Wildfire and Knipple and Bowser Aerodrome, 5 km east of Knipple Lake. At the mine, the camp comprises accommodation for 542 with recreational, office, and multiple support facilities. The nearest off-site infrastructure is located in the town of Stewart, approximately 65 km to the south, which has a minimum of supplies and personnel. The towns of Terrace and Smithers are also located in the same general region as the Brucejack Property, and both are directly accessible by daily air service from Vancouver.

The nearest railway is the Canadian National Railway Yellowhead route, which is located approximately 220 km to the southeast. This line runs east-west and terminates at the deepwater port of Prince Rupert on the west coast of BC.

Stewart, BC, the most northerly ice-free shipping port in North America, is accessible to store and ship concentrates. At the effective date of this report, Brucejack Mine ships concentrate via this terminal.

A BC Hydro high-voltage, 138 kV transmission line services Stewart, BC. The Long Lake transmission line extends north from Stewart and connects their generating facilities with a BC Hydro high-voltage transmission line. The 57 km Brucejack transmission line extends from the Long Lake generation station to the mine via the Knipple Substation. Electric power is stepped down at the Knipple Substation from 138 to 69 kV and is then delivered to Brucejack mine site. Emergency power is available from diesel generators located at Brucejack.

Mine infrastructure and infrastructure along the road are permitted under a variety of permits for water use and camps with land use held under various Licenses of Occupation. Tailings storage and waste rock are permitted under discharge permits with adequate storage capacity in Brucejack Lake. The access road is permitted under a provincial Special Use Permit.

6.0 HISTORY

Information in this section has been updated from Ireland et al. (2014).

6.1 Early Exploration

The earliest known prospecting in the Brucejack Lake area occurred in the 1880s (McPherson 1994). In 1935, copper-molybdenum mineralization was discovered on the Sulphurets Property by prospectors in the vicinity of the Main Copper Zone, approximately 6 km northwest of Brucejack Lake; however, these claims were not staked until 1960. From 1935 to 1959, the area was relatively inactive with respect to prospecting; however, it was intermittently evaluated by a number of different parties and resulted in the discovery of several small copper and gold-silver occurrences in the Sulphurets-Mitchell Creek area. In 1959, Granduc Mines Ltd. (Granduc) and Alaskan prospectors staked the main claim group, covering the known copper and gold-silver occurrences, which collectively became known as the Sulphurets Property. This was the start of what could be termed the era of modern exploration (Table 6-1).

Table 6-1: Exploration History of the Sulphurets Property between 1960 and 2008

Date	Exploration
1960 to 1979	Granduc continued exploration, conducting further geological mapping, lithogeochemical sampling, trenching, and diamond drilling on known base and precious metal targets north and northwest of Brucejack Lake. This resulted in the discovery of gold-silver mineralization in the Hanging Glacier area and molybdenum on the south side of the Mitchell Zone.
1980	Esso Minerals Canada Ltd. (Esso) optioned the Sulphurets Property from Granduc and subsequently completed an extensive program consisting of mapping, trenching, and geochemical sampling that resulted in the discovery of several showings including the Snowfield Zone, Shore Zone, West Zone, Galena Hill Zone, and Electrum Zone targets. Gold was discovered on the peninsula at Brucejack Lake near the Shore Zone.
1982 and 1983	Exploration was confined to gold- and silver-bearing vein systems in the Brucejack Lake area at the southern end of the Sulphurets Property from 1982 to 1983. Drilling was concentrated in 12 silver and gold-bearing structures, including the Near Shore Zone and West Zone, located 800 m apart near Brucejack Lake. Drilling commenced on the Shore Zone.
1983 and 1984	Esso continued work on the Sulphurets Property and (in 1984) outlined a deposit on the West Zone at Brucejack.
1985	Esso dropped the option on the Sulphurets Property.
1985	The Sulphurets Property was optioned by Newhawk Gold Mines Ltd. (Newhawk) and Lancana Mining Corp. (Lancana) from Granduc under a three-way joint venture (JV) (the Newcana JV). The Newcana JV completed work on the Snowfield Zone, Mitchell Zone, Golden Marmot Zone, Sulphurets Gold Zone, and Main Copper Zone targets, along with lesser known targets.
1986 to 1991	Between 1986 and 1991, the Newcana JV spent approximately Cdn$21 million developing the West Zone and other smaller precious metal veins, on what would later become the Bruceside Property. Newhawk completed 35,241.6 m in 511 surface diamond drillholes, 5,276 m of exploratory underground drifting, and 35,981 m of drilling in 442 underground drillholes on the West Zone between 1987 and 1990. This work resulted in the discovery of more than 40 additional showings and the outlining of a historical and no longer current mineral reserve for the West zone of 750,000 t grading 15.4 g/t Au and 678 g/t Ag (Schroeter 1994). Newhawk acquired a 60% interest in the Bruceside Property after buying out Lancana's interest in 1987.

table continues…

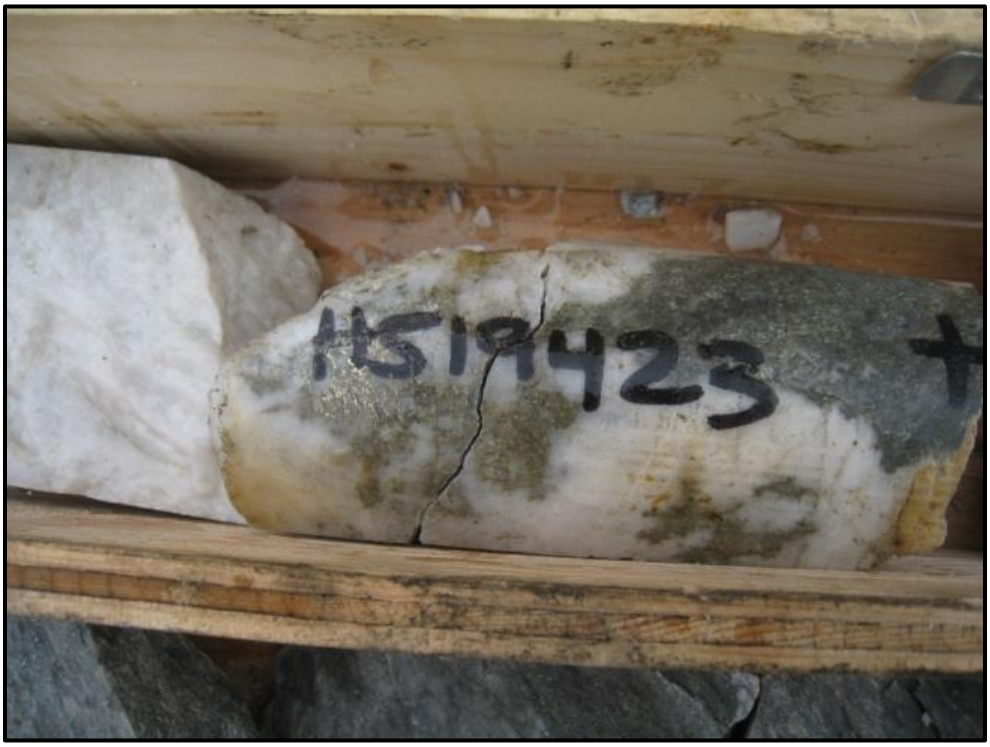
Date	Exploration
1991 and 1992	Newhawk officially subdivided the Sulphurets claim group into the Sulphside, Snowfield, and Bruceside Properties in 1991, and sold the Sulphside Property (including the Sulphurets Zone and Mitchell Zone) to Placer Dome Inc. (Placer Dome) in 1992. Newhawk continued exploration of the Bruceside Property between 1991-1994, including property-wide trenching; mapping; airborne surveys; and surface drilling, evaluating various surface targets including the Shore Zone; Gossan Hill Zone; Galena Hill Zone; Maddux Zone; and SG Zone targets. Six holes were drilled at the Shore Zone, totalling 1,200 m, to test its continuity and to determine its relationship to the West Zone and R-8 Zone. Results varied from 37 g/t Au over 1.5 m, to 13 g/t Au over 4.9 m (Payie 2017). Newhawk purchased Granduc's interest in the Snowfield Property in early 1992.
1993	A LOM Development Certificate was issued to Newhawk for the West Zone by the provincial government (under the BC Environmental Assessment Office (EAO); certificate 92-06).
1994	Exploration on the Bruceside Property consisted of detailed mapping and sampling in the vicinity of the Gossan Hill Zone, and 7,352 m of diamond drilling (in 20 drillholes) primarily on the West Zone, R-8 Zone, Shore Zone, and Gossan Hill Zone targets. Mapping, trenching, and drilling were completed on the ten best and highest priority targets (including the West Zone).
1996	Granduc merged with Black Hawk to form Black Hawk Mining Inc. (Black Hawk). The Mine Development Certificate, renewed until 1998, was replaced by a Project Approval Certificate (M98-03).
1997 and 1998	No exploration or development work was carried out on the Snowfield and Bruceside properties (Budinski et al. 2001).
1999	Silver Standard acquired Newhawk and with it, Newhawk's 100% interest in the Snowfield Property and 60% interest in the Bruceside Property, and created separate projects for the Snowfield and Brucejack deposits (Payie 2017).
1999 to 2001	No exploration or development work was carried out on the Snowfield and Brucejack properties.
2001	Silver Standard entered into an agreement with Black Hawk whereby Silver Standard acquired Black Hawk's 40% direct interest in the Bruceside Property, giving Silver Standard a 100% interest in the Bruceside Property, which it subsequently renamed the Brucejack Property. Black Hawk retained a 1.2% NSR royalty on the Bruceside Property.
2001 to 2008	No exploration or development work was carried out on the Snowfield and Brucejack properties during the period from 1999 to 2008. The Project Approval Certificate was amended in January 2004 and expired in September 2006.

6.2 Exploration by Silver Standard Resources Inc. (2001 to 2010)

Silver Standard initiated exploration on the Brucejack Property in 2009 as a result of its successful bulk tonnage drilling on the Snowfield Property (Narciso et al. 2010). Silver Standard designed the 2009 Brucejack drill program test for additional bulk tonnage resources on the Brucejack Property. The program included drilling, rock-chip and channel sampling, and re-assaying of historical drill core pulps. Silver Standard retained GeoSpark to assess the integrity of the historical (pre-2009) drilling on the Brucejack Property (Vallat 2009). Results of this work confirmed that assay data from the majority of the historical drillholes on the Brucejack Property (849 out of 901 holes targeting the West Zone, Galena Hill Zone, SG Zone, Shore Zone, and vicinity) were suitable for use in geological modeling and resource estimation. Field work included the collection of 2,739 rock-chip and channel samples from the Galena Hill Zone, Bridge Zone, SG Zone, and Mammoth Zone, as well as at the Hanging Glacier Zone, where historical surface sampling had identified rocks enriched in gold and silver. A total of 17,964 m in 37 diamond drillholes were completed during the 2009 field season. Twelve drillholes were targeted at what would become the Valley of the Kings Zone. Drillhole SU-012 (Figure 6-1) is credited as being the discovery drillhole for the Valley of the Kings Zone intersecting 16,948.5 g/t Au over 1.5 m. Other notable drillhole intersections that suggested the presence of

a gold deposit in the Valley of the Kings Zone included: 5,344 g/t Au over 0.5 m (SU-029), 184.5 g/t Au over 1.5 m (SU-006), 51.1 g/t Au over 1.5 m (SU-035), 47.5 g/t Au over 1.5 m (SU-033), and 46.1 g/t Au over 1.5 m (SU-017).

Figure 6-1: Visible Electrum in Valley of the Kings Zone Discovery Drillhole SU-012



Source: Pretivm
Note: Dendritic latticework electrum in quartz-carbonate vein in HQ diameter core (drillhole SU-012).

The 2010 drill program, which totalled 33,480 m in 73 drillholes, was designed to continue definition of bulk tonnage mineralization on the Brucejack Property and to determine the nature and continuity of the high-grade mineralization intersected in the Valley of the Kings Zone. Approximately one third of the 2010 drilling targeted the Valley of the Kings Zone and included gold intersections of up to 5,850 g/t Au over 1.5 m (SU-040). The bulk tonnage drilling achieved its intended goal when a sizeable Mineral Resource was estimated for the Brucejack Property (Ghaffari et al. 2011). The Mineral Resource estimate included the West Zone, West Zone Footwall Zone, Shore Zone, Gossan Hill Zone, Galena Hill Zone, SG Zone, Valley of the Kings Zone, Bridge Zone, and the Bridge Zone Halo, and was reported at a cut-off of 0.30 g/t AuEq inside an optimized open pit shell (Ghaffari et al. 2010b; 2011). This estimate is no longer current. The relatively dense drilling from the bulk tonnage drilling program, with drill spacings of 100 m by 100 m to 50 m by 50 m, formed the basis upon which the bulk tonnage resource model was built. Numerous high-grade intervals were intersected as part of this drilling, which allowed for the initial delineation of high-grade mineralization trends and preliminary domain definition in the Valley of the Kings Zone. These included:

- 5,850 g/t Au over 1.63 m (SU-040)
- 5,480 g/t Au over 0.43 m (SU-084)
- 2,490 g/t Au over 1.59 m (SU-054)
- 1,025 g/t Au over 1.50 m (SU-053)
- 536 g/t Au over 0.57 m (SU-040)
- 430 g/t Au over 0.50 m (SU-040)
- 231 g/t Au over 1.50 m (SU-046)
- 182.5 g/t Au over 0.50 m (SU-077)

- 171 g/t Au over 0.68 m (SU-106)
- 170.5 g/t Au over 0.50 m (SU-058)
- 164.5 g/t Au over 0.50 m (SU-058)
- 131 g/t Au over 1.00 m (SU-093)
- 92.5 g/t Au over 1.50 m (SU-106)
- 83.4 g/t Au over 1.50 m (SU-086)
- 53.7 g/t Au over 1.50m (SU-056)
- 50.0 g/t Au over 1.50 m (SU-055).

Subsequent drilling programs conducted by Pretivm have focussed on further delineating the corridors of high-grade mineralization in the Valley of the Kings Zone.

Additional details relating to Silver Standard's 2009-2010 Brucejack Property exploration and drilling programs are summarised in Ghaffari et al. (2010a; 2011) and Board and McNaughton (2013).

In 2010, Silver Standard sold the Snowfield and Brucejack properties to Pretivm, a start-up company formed by the former president specifically to acquire the properties.

6.3 Previous Feasibility Studies on the Property (1990)

Corona Corporation (Corona) completed a FS on a proposed underground mine with decline access for the Sulphurets Project (West Zone and R-8 Zone only) in 1990 (Corona 1990). Total operating costs of $145/t were estimated based on a 350 t/d mill facility for processing and resulted in a capital cost estimate of $42.7 million with a 6.7% pre-tax return at a price of US$400/oz Au and $5/oz Ag. The study concluded that higher metal prices were needed before a production decision could be taken.

The reader is cautioned that the Corona Sulphurets Project Feasibility Study (Corona 1990) is no longer relevant, is not NI 43-101 compliant, and should not be relied upon.

6.4 Prior Mineral Production

In the 1980s, more than 5 km of underground ramps, level development, and raises were completed on the West Zone down to the 1100 Level. In 1993, a Project Approval (LOM Development) Certificate was issued for the Brucejack Property by the Minister of Sustainable Resource Management and Minister of Energy and Mines for the Province of BC. The mine was not developed further, and the certificate expired in 2006. Prior to Pretivm's Bulk Sampling Program conducted in 2013, no ore had been processed from the Brucejack Property, including from the West Zone.

6.5 Preliminary Economic Assessment (2010)

Silver Standard commissioned Wardrop Engineering Inc. (Wardrop; now Tetra Tech) to complete a preliminary economic assessment (PEA) on the combined bulk-tonnage resources of the Brucejack and Snowfield properties in 2010 (Ghaffari et al. 2010a).

Based on the results of the PEA, it was recommended that Silver Standard continue with the next phase, a prefeasibility study, in order to identify opportunities and further assess bulk-tonnage viability of the two projects. The PEA was revised and re-issued to Pretivm as two separate documents: one for the combined Snowfield-Brucejack Property in October 2010 (Ghaffari et al. 2010b), and the other for the Brucejack Property as a standalone project in June 2011 (Ghaffari et al. 2011). However, these reports are no longer current.

7.0 GEOLOGICAL SETTING AND MINERALIZATION

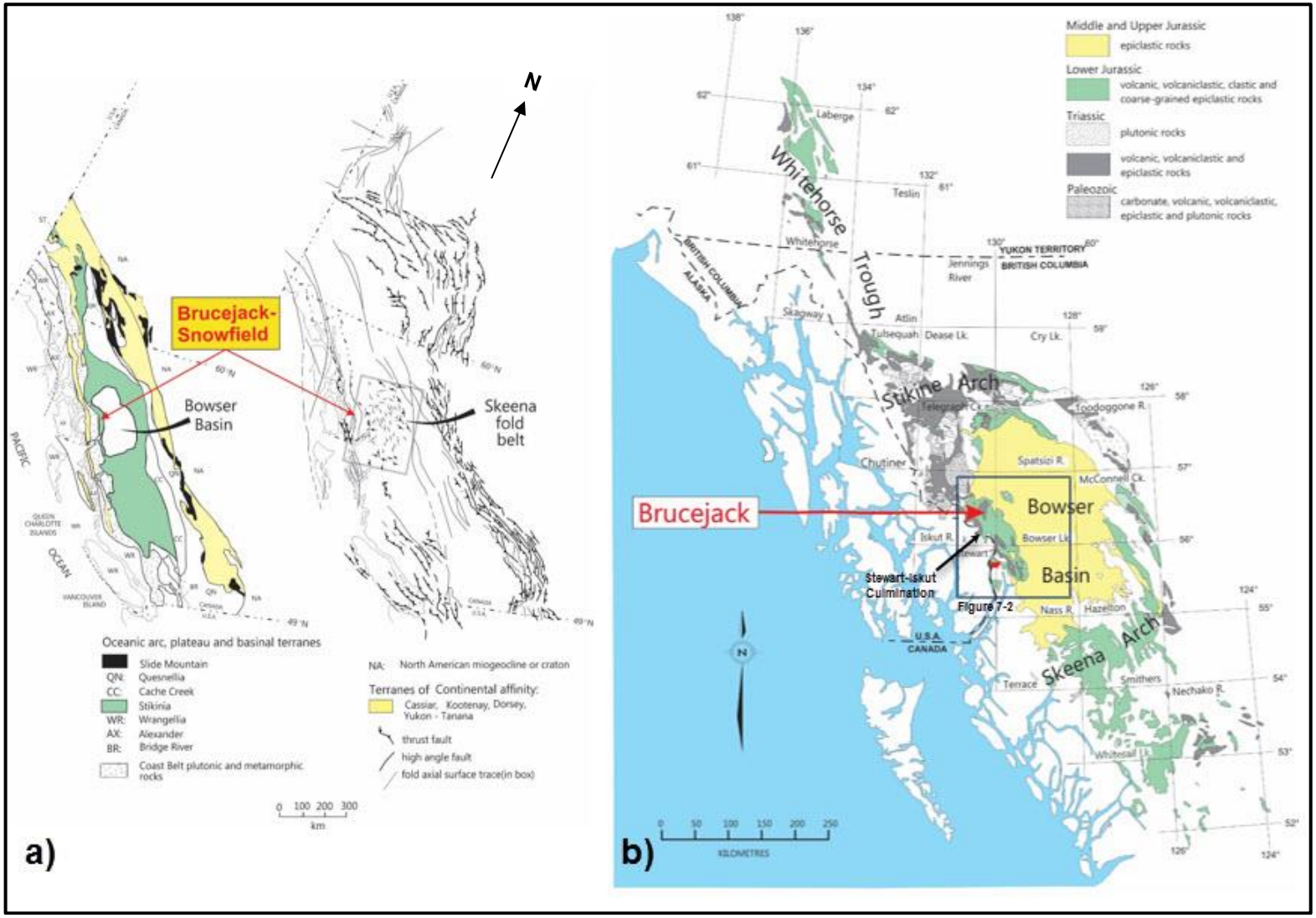
The Brucejack Gold-Silver Deposit (the Brucejack Deposit) is currently defined as incorporating the West Zone and the Valley of the Kings Zone. A brief overview of the geological setting and mineralization of the Brucejack Deposit is presented in this section to provide context for Pretivm's approaches to geological modelling, resource estimation, and mining. The information presented in this section has been excerpted from Roach and Macdonald (1992), Board and McNaughton (2013), Jones (2014), Board et al. (2017), Tombe et al. (2018), McLeish et al. (2019), and Board et al. (submitted). Readers interested in additional detail on the geology of the Brucejack Deposit should refer to these documents.

7.1 Regional Geological Setting

The Brucejack Deposit is situated on the western side of the Stikine Terrane (Stikinia; Figure 7-1) of the Canadian Cordillera. Stikinia is the largest and westernmost of several exotic terranes in the Intermontane morphogeologic belt of the Canadian Cordillera (Monger and Price 2002). Stikinia is interpreted as a Philippine-style intra-oceanic island arc terrane, formed between mid-Palaeozoic to Middle Jurassic time, when it was accreted to the North American continental margin (at about 173 Ma; Nelson and Colpron 2007; Evenchick et al. 2007; Gagnon et al. 2012). Western Stikinia was subsequently affected by thin-skinned deformation during Cretaceous accretion of the outboard Insular Belt terranes (at about 110 Ma; Evenchick 1991; Kirkham and Margolis 1995).

The deposit is located in the northern part of the northwest-trending Stewart-Iskut Culmination, a major structural feature in western Stikinia that lies between the Stikine and Skeena Arches to the west of the Bowser Basin (Figure 7-1). The Stewart-Iskut Culmination has variably been interpreted as a structural culmination that formed in response to Cretaceous deformation and, more recently, as having been an Early Jurassic structural highland upon which rocks of the Hazelton Group were deposited prior to Stikinia being accreted to the western North American continent (Nelson and Kyba 2014). The culmination contains an exceptionally metal-rich tectonic assemblage hosted in volcano-sedimentary and related comagmatic plutonic rocks of the Triassic Stuhini and latest Triassic to Middle Jurassic Hazelton Groups (Figure 7-2; Nelson et al. 2013). This area includes structurally-controlled high-potassic calc-alkaline porphyry copper-gold deposits (e.g., Kerr, Sulphurets, Mitchell, Iron Cap, Snowfield), transitional epithermal intrusion-related precious metal deposits (e.g., Brucejack, Silbak-Premier, Big Missouri, Red Mountain, and Homestake Ridge), and volcanogenic massive sulphide deposits (e.g., Granduc, Dolly Varden-Torbrit, Anyox, and Eskay Creek). These deposits are considered to have been formed while Stikinia was in a state of compression or sinistral transpression (Nelson and Colpron 2007).

Figure 7-1: Regional Geological Setting of the Brucejack Deposit



Note: The Brucejack Deposit is located on the western side of the Stikinia Terrane (Stikinia).
The deposit is hosted in Lower Jurassic volcanic arc rocks on the northern side of the Stewart-Iskut Culmination, to the west of the Bowser Basin. Detail inside rectangular outline provided in Figure 7-2.

Sources: Ghaffari et al. (2012) and Jones (2014)

7.2 Local Geology

The Brucejack Deposit, part of the Sulphurets Mineral District, is located on the eastern limb of the north-plunging McTagg Anticlinorium, the northern closure of the Stewart-Iskut Culmination (Figure 7-2). Volcanic arc-related rocks of the Triassic Stuhini Group form the core of the anticlinorium, and are successively replaced outwards by volcanic arc-related rocks of the Jurassic Hazelton Group and clastic basin-fill sedimentary rocks of the Middle Jurassic to Lower Cretaceous Bowser Lake Group (Figure 7-3). A major unconformity separates the Stuhini and Hazelton Group rocks. As a consequence of its location relative to the axis of the culmination, Brucejack Deposit rocks are tilted and generally display a progressive younging towards the east.

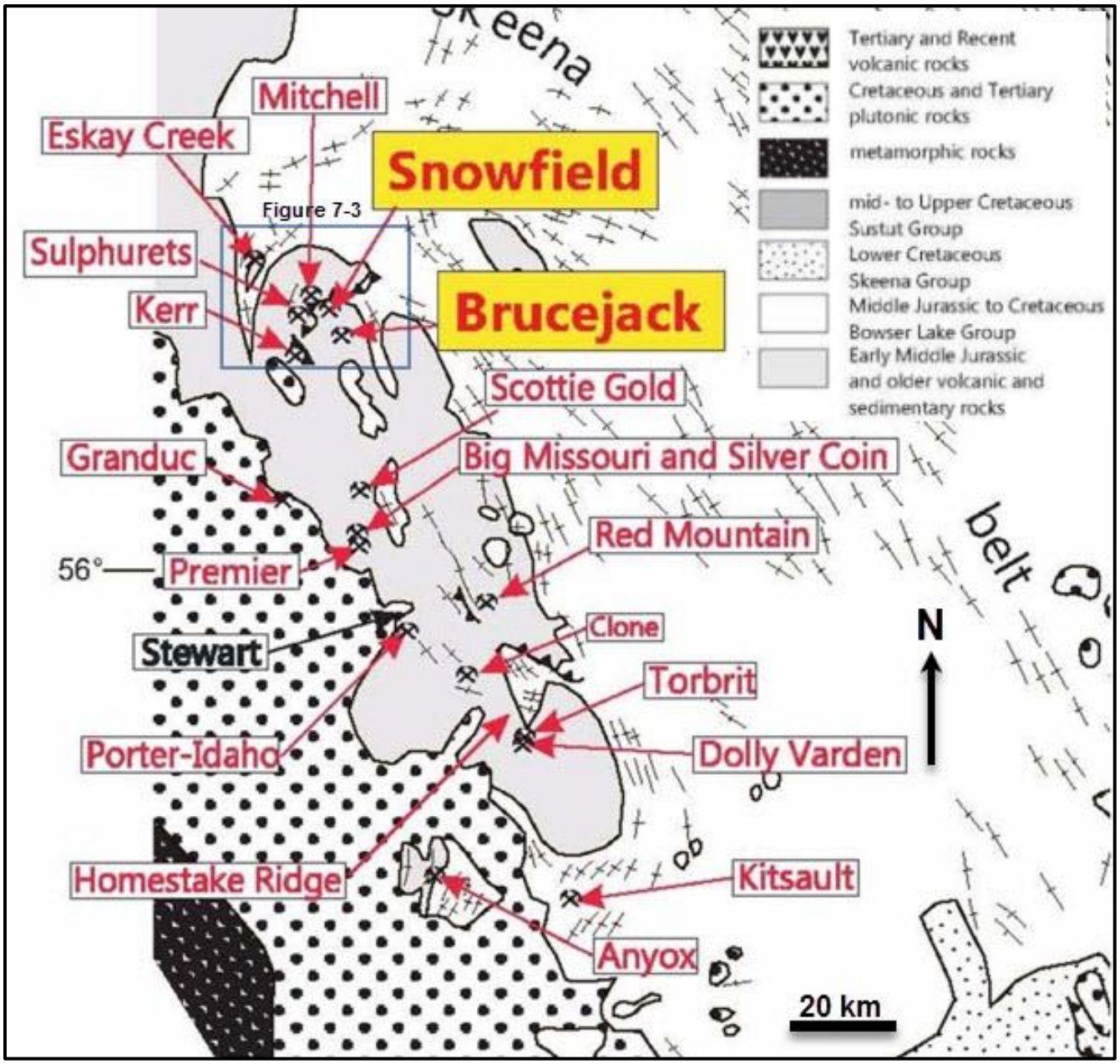
The Brucejack and neighbouring Kerr-Sulphurets-Mitchell (KSM) deposits display a strong spatial association to the unconformity between the Stuhini and Hazelton Group rocks and north-south structures to the east of this contact (Figure 7-3), suggesting that these features were important for deposit genesis (Nelson and Kyba 2014). The unconformity between the Stuhini and Hazelton Groups is associated with numerous Triassic-Jurassic mineral showings and porphyry copper-gold deposits throughout northwestern BC and is considered a key feature for mineral exploration in the area (Kyba 2014; Nelson and Kyba 2014). The KSM copper-gold-molybdenum porphyry deposits are associated with Mitchell Suite intrusive rocks of the Texas Creek Intrusive Suite (Kirkham and Margolis 1995). Campbell and Dilles (2017) noted that the deposits are broadly contemporaneous and have similar mineralogy, alteration, and textures. They noted that large areas of hydrothermal alteration affected rocks in and around the Mitchell Suite intrusions, with overprinting alteration relationships indicating that the magmatic-hydrothermal systems underwent telescoping as they evolved between about 196 and 190 Ma. Early syn-mineral potassic alteration was locally overprinted by propylitic, albitic, and chlorite-sericite alteration, before being pervasively overprinted by quartz-sericite-pyrite (phyllic) alteration. Final stage system telescoping included local advanced argillic alteration and massive pyrite vein emplacement (Mitchell) overprinting earlier assemblages before being overprinted by high-level gold-rich veins (Campbell and Dilles 2017).

West-directed thrusts and west-vergent overturned folds affect rocks on the western limb of the anticlinorium, whereas rocks on the eastern limb display east- to southeast-directed thrusts and east-vergent overturned folds (Kirkham and Margolis 1995). These structures have been kinematically linked to the mid-Cretaceous Skeena Fold and Thrust Belt. In addition to the thrust faults, the McTagg Anticlinorium is cut by late-stage brittle faults that are likely of Tertiary age and which represent reactivated older structures (e.g., the north-trending Brucejack Fault; Nelson and Kyba 2014; Board et al. submitted).

A penetrative foliation of variable orientation is preferentially developed in altered Hazelton Group rocks in the Sulphurets mineral district, with fabric intensity proportional to mica and/or clay mineral content (Kirkham and Margolis 1995). Timing of penetrative fabric development is difficult to ascertain due to the absence of unambiguous cross-cutting relationships and appropriate non-reset geochronologic data. Although it is most commonly considered to have developed in response to the mid-Cretaceous Skeena Fold and Thrust Belt deformation (Kirkham and Margolis 1995; Nelson and Kyba 2014), the possibility that it is a reactivated composite fabric recording older deformation events cannot be ruled out (Margolis 1993; Roach and Macdonald 1992; Tombe et al. 2018; Board et al. submitted).

Rocks in the Sulphurets Mineral District are affected by regional sub-greenschist facies metamorphism, which is associated with development of the mid-Cretaceous Skeena Fold and Thrust Belt (Alldrick 1993). Maximum temperatures and pressures reached approximately 290ºC and 4.5 kbar, respectively, corresponding to thermally reset potassium-argon (K-Ar) and argon-argon (Ar-Ar) ages for foliation-parallel sericite in older porphyry-related phyllic alteration zones at approximately 110 Ma (Alldrick 1993; Kirkham and Margolis 1995).

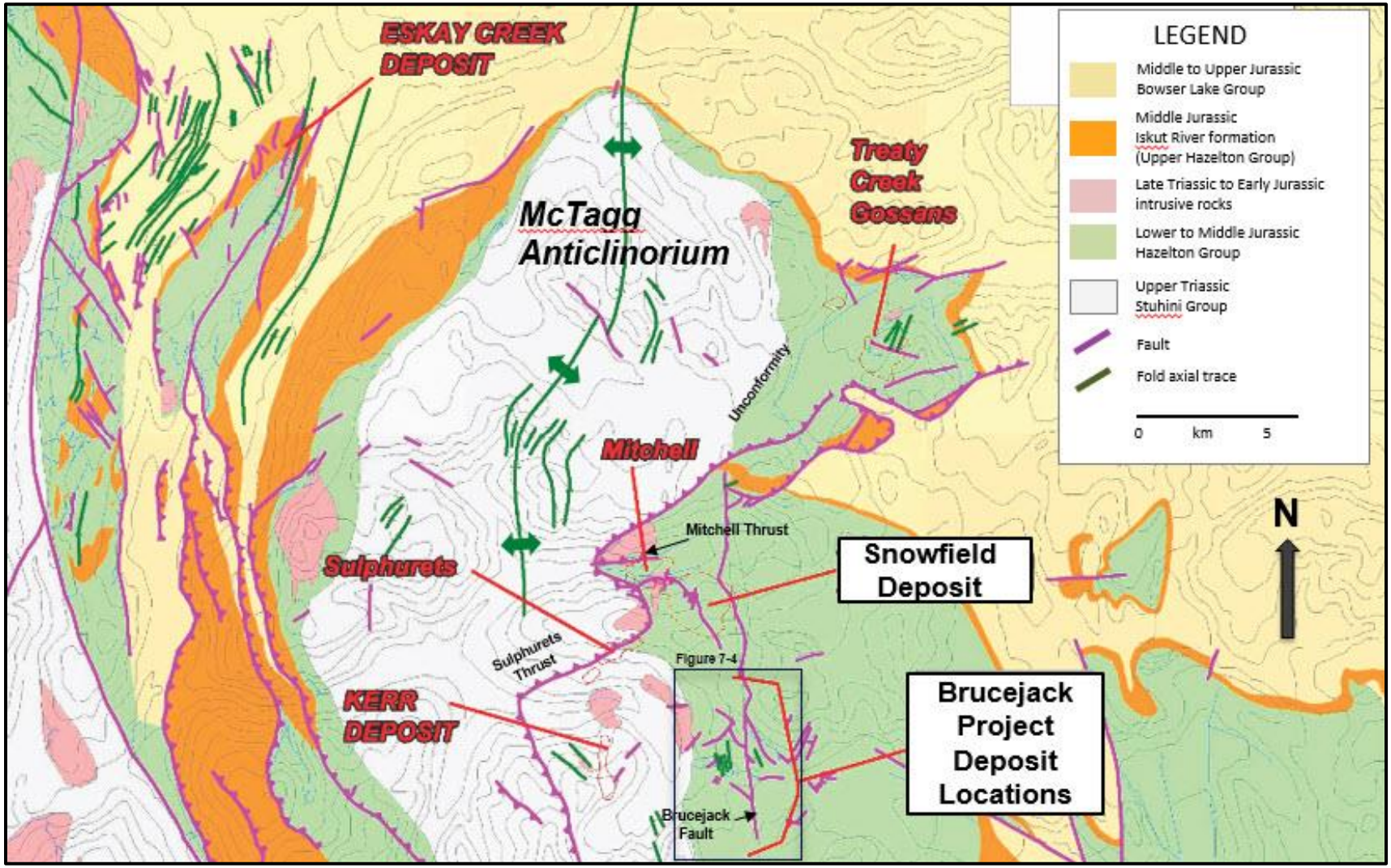
Figure 7-2: Select Mineral Showings and Deposits in the Stewart-Iskut Culmination, Highlighting the Metal-rich Nature of this Structure



Note: Pretivm's Brucejack and Snowfield Deposits are located towards the north of the culmination. Detail inside rectangular outline presented in Figure 7-3.

Source: Ghaffari et al. (2012)

Figure 7-3: District-scale Geological Setting of the Brucejack Deposit on the East Side of the McTagg Anticlinorium



Note: Detail inside rectangular outline presented in Figure 7-4.
Source: Jones (2014)

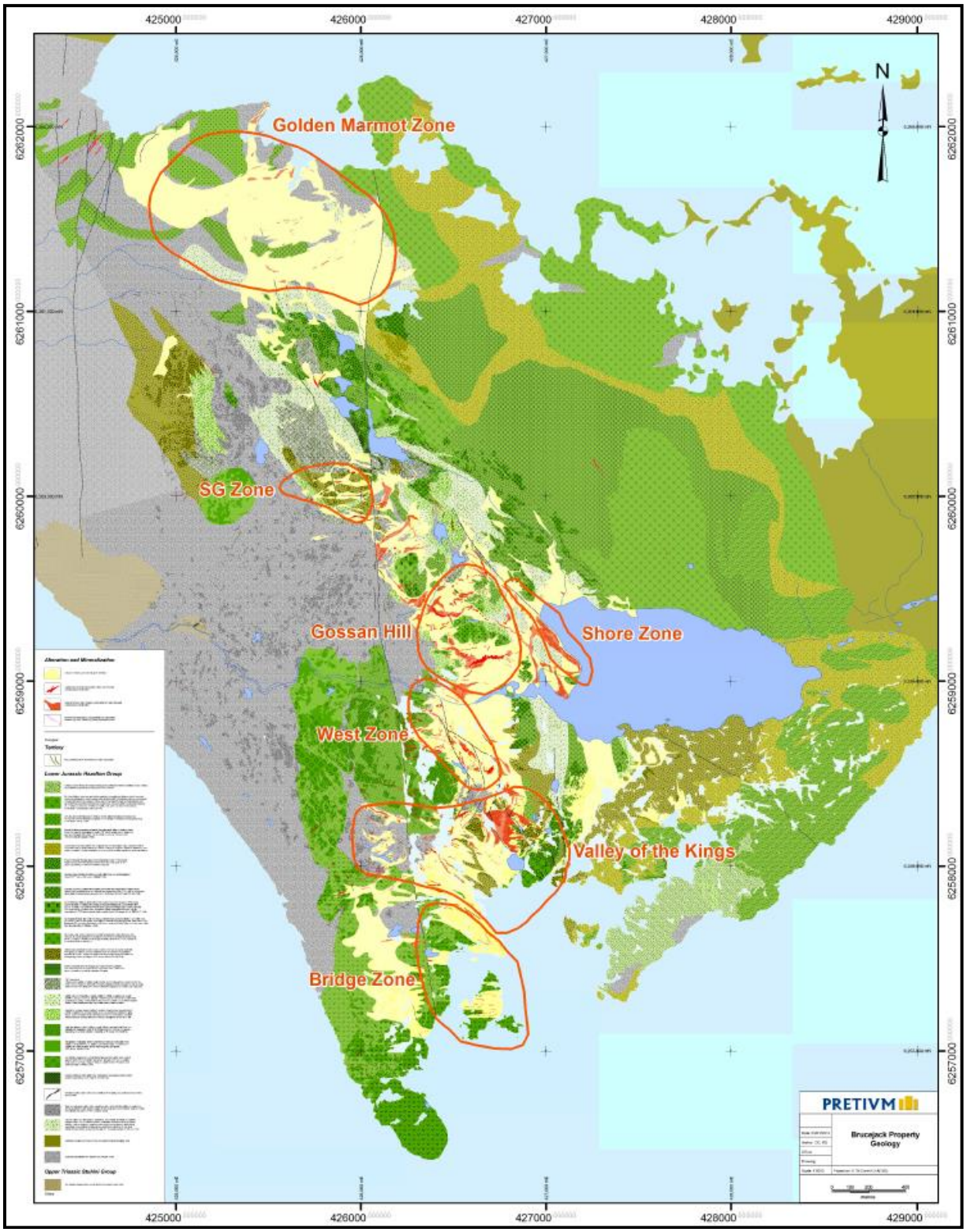
7.3 Brucejack Project Area Geology

The Brucejack Project area is largely underlain by volcano-sedimentary rocks of the Lower Jurassic Hazelton Group (Figure 7-4). These rocks unconformably overlie volcanic arc sedimentary rocks of the Upper Triassic Stuhini Group along the western-most part of the Brucejack Project area. The rocks are variably altered and deformed, with zones of intense quartz-sericite-pyrite (phyllic) alteration being associated with increased deformation due to preferential strain partitioning in sericite-rich zones.

A north-south trending, broadly arcuate, concave-westward 0.5 to 1.5 km wide band of variably phyllic-altered rocks and associated quartz stockwork extends over 5 km across the Brucejack Property area (Figure 7-4). The band straddles the Brucejack Fault across the Brucejack project area, shifting from the west side of the fault in the north of the Brucejack Project area to the fault's east side further south. The phyllic alteration typically contains between two and 20% pyrite, affects rocks from the bottom to the top of the lithological sequence (see Section 7.3.1), and, depending on the alteration intensity, can preclude protolith recognition. More than 40 mineralization showings, associated with the alteration band, have been identified on the Brucejack Project area, highlighting the exceptional exploration potential of the area (McPherson 1994; Board et al. submitted).

Ten mineralized zones are currently recognized on the Brucejack Project area, extending from the Hanging Glacier Zone in the north to the Bridge Zone in the south (Figure 7-5). Although five of these zones have been explored in some detail (West Zone, Valley of the Kings Zone, Bridge Zone, Gossan Hill Zone, and Shore Zone), mining is focused on just the two zones for which there are current Mineral Resources and Reserves: the Valley of the Kings Zone and the West Zone. This Technical Report focuses on the Valley of the Kings Zone and West Zone, with additional details on the Bridge Zone, Gossan Hill Zone, and Shore Zone provided in Jones (2012c).

Figure 7-4: Geological Map of the Brucejack Project Area Showing Location of Mineralized Zones and their Association with the Band of Quartz-Sericite-Pyrite Alteration (shown in yellow)



Note: Enlarged legend provided in Figure 7-5
Source: Jones (2014)

Figure 7-5: Brucejack Property Geology Legend for Figure 7-4

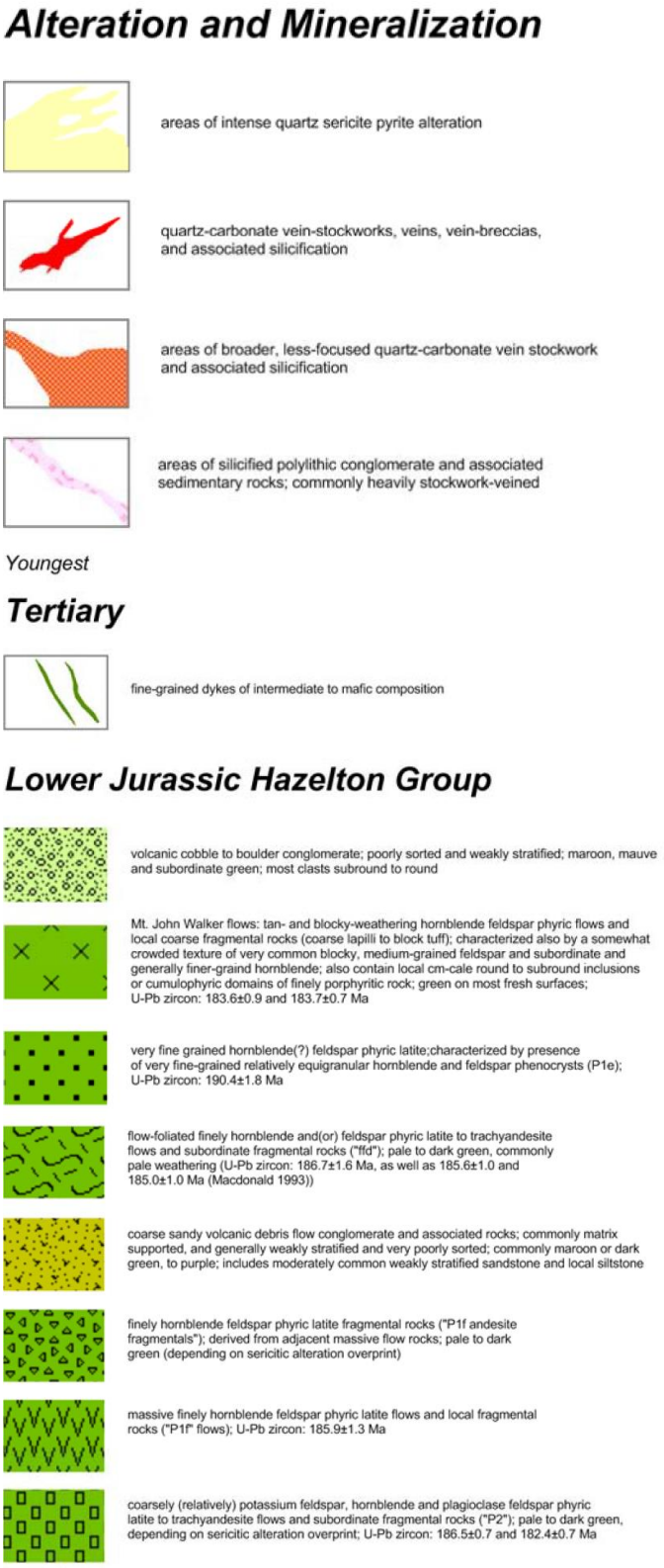


figure continues…

Figure 7-5 (cont'd) Brucejack Property Geology Legend for Figure 7-4

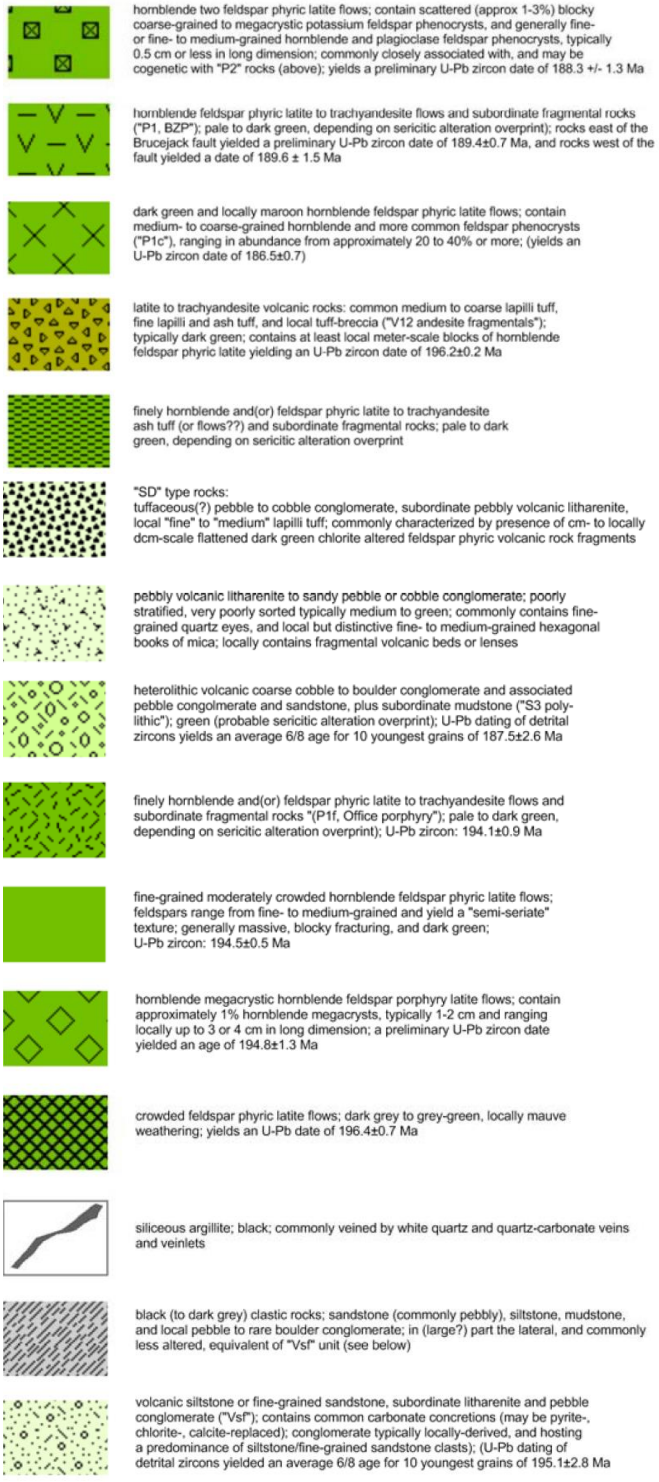


figure continues…

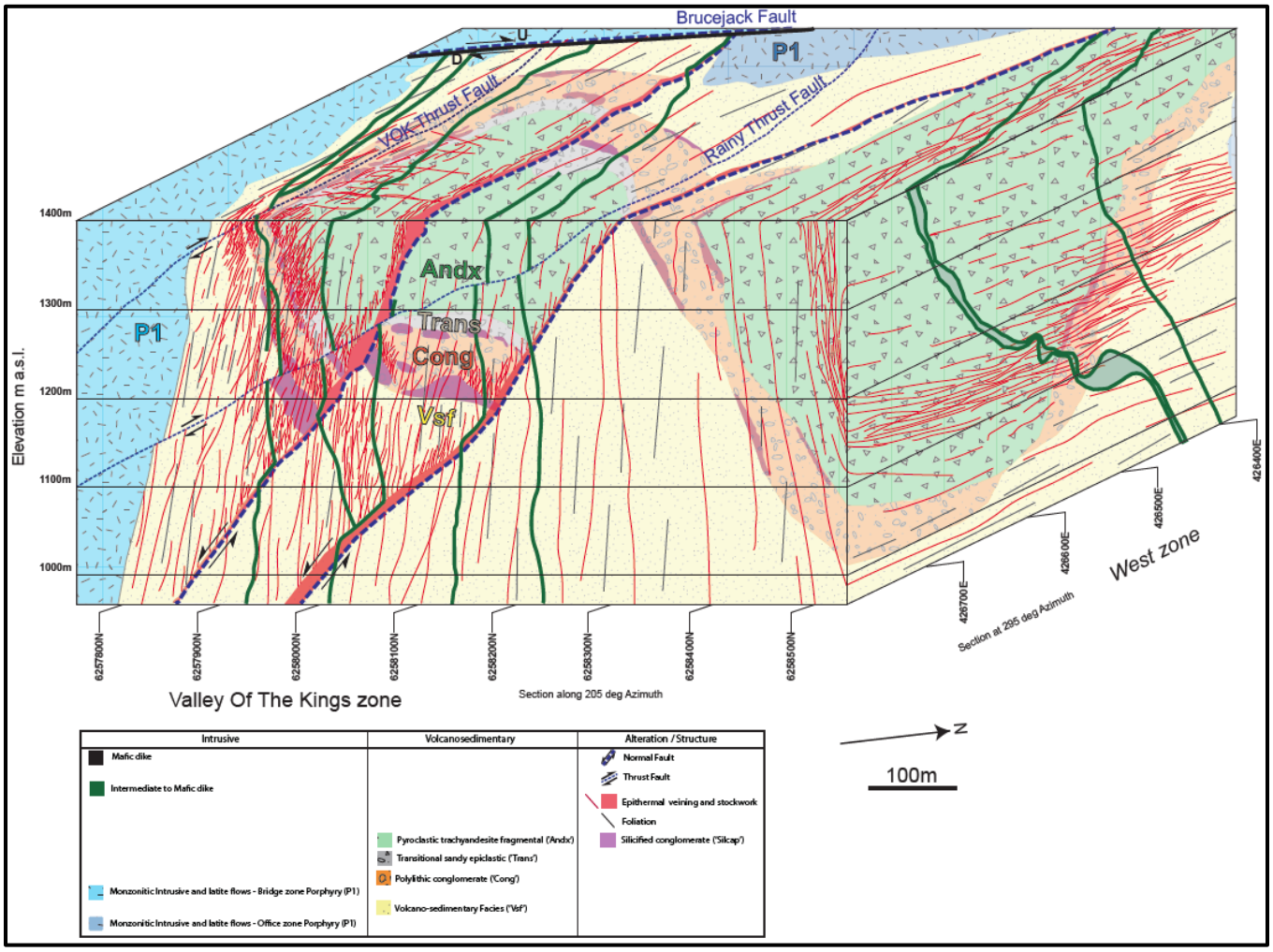
Figure 7-5 (cont'd) Brucejack Property Geology Legend for Figure 7-4

7.3.1 Lithology

The key lithologic sequence hosting the Brucejack Deposit is characterized by a basal marine volcanosedimentary (VSF) package unconformably overlain by an immature polylithic volcanic conglomerate (Cong) that grades upward through a sandy epiclastic unit (Trans) into a predominantly pyroclastic trachyandesite (latite) fragmental unit (Andx) (Figure 7-6; Board et al. submitted). This simplified lithologic sequence represents a relatively complex volcanic stratigraphy characterized by rapid lateral facies changes, which defines a general younging direction upward and to the east, and which is interpreted as having been deposited in a series of small fault-bounded half-grabens on the eastern side of the Brucejack Fault (Figure 7-6).

The Brucejack Deposit lithologic sequence is bounded to the south and northwest by massive and relatively fine-grained plagioclase feldspar±potassium feldspar±hornblende-phyric rocks (P1 porphyry) of the Bridge Zone and Office porphyries (Figure 7-6). The Office P1 and Bridge Zone P1 porphyry bodies display sharp contacts with the volcaniclastic rocks and have been variably interpreted as comagmatic subvolcanic/hypabyssal monzonitic intrusions or latite flows (Kirkham and Margolis 1995; Jones 2014). Coarser-grained feldspar-hornblende-phyric porphyry rocks (P2 porphyry) are locally present within the sequence, especially to the north and east of West Zone. East of the Brucejack Deposit, in the Flow Dome Zone, the lithologic sequence is overlain by a felsic unit that includes potassium feldspar±plagioclase feldspar±hornblende-phyric flows, breccia, bedded nonwelded and welded felsic tuffs, and a comagmatic intrusion which is flow-banded and plagioclase-hornblende phyric (Figure 7-4; Macdonald 1993). This unit is interpreted as a flow-dome complex, representing high-level intrusive and extrusive parts of a local magmatic center.

Figure 7-6: Three-dimensional Block Geological Interpretation Through the Brucejack Deposit, Showing Key Geological, Structural, and Mineralization Relationships Developed in the Valley of the Kings Zone and West Zone



Source: After Board et al. (submitted). Dated February 2019.

Hydrothermal breccia bodies are present throughout the lower Hazelton Group rocks on the Brucejack Project area and follow faults and fractures. The breccia bodies are generally 2 to 15 cm wide and consist of angular to subrounded wall-rock fragments set in a fine-grained matrix of rock flour and pyrite. Wall-rock fragments are heterolithic and commonly derived from the immediate host rock. Hydrothermal breccia bodies cut all host-rock units and are discordant to the penetrative foliation. Mineralized veins cut and are cut by breccia bodies and hydrothermal breccia grades into mineralized manganese-carbonate veins (see Section 7.3.5), suggesting that the breccia bodies are syn-mineralization in timing.

Relatively uncommon post-mineralization altered amygdaloidal intermediate to mafic dikes cut all lithological units, mineralized veins, and vein stockwork of the Brucejack Deposit (Figure 7-6; Tombe et al. 2018; Board et al. submitted). The dikes are subvertical, up to 1.5 m wide, and commonly east- to southeast-trending. Dikes in the Valley of the Kings Zone strike east to east-southeast, have a strike length of at least 900 m, and extend for more than 1,000 m down dip. Dikes in the West Zone trend northwest-southeast, have strike lengths of at least 500 m, and extend for more than 450 m down dip. The dikes follow faults and fractures in staggered zig-zag patterns, having been emplaced along variably oriented structures during local extension. Dike emplacement partially utilized

the same structures as the mineralized veins. The dikes are undeformed to weakly deformed and generally discordant to the dominant foliation. The dikes are interpreted to have been emplaced during a period of rifting post-epithermal mineralization and are not related to gold mineralization.

Late-stage, undeformed, and unaltered mafic dikes (up to several meters wide) are present to the west of and along the Brucejack Fault, but are rare on the Brucejack Project area. The north-trending dikes are subvertical and cut all host rock units, alteration, mineralization, foliation, post-mineralization intermediate to mafic dikes, and thrust faults. They are geochemically distinct from the post-mineralization intermediate to mafic dikes (Tombe 2015).

7.3.2 Geochronology

Detailed geochronological work conducted on the Brucejack Project area, which has included uranium-lead (U-Pb) on zircon, rhenium-osmium (Re-Os) on molybdenite, and Ar-Ar on sericite/muscovite (Kirkham and Margolis 1995; Tombe et al. 2018; Board et al. submitted), indicates that the Brucejack Deposit lithological sequence is between about 195 and 184 Ma in age: the VSF unit is dated at 195 to 188 Ma, the Cong and Trans units were formed between about 188 and 185 Ma, the Andx unit formed at about 185 to 184 Ma. The Office P1 porphyry is dated at about 194 Ma, and the Bridge Zone P1 porphyry is dated at about 189 Ma. Both intrude rocks of the VSF.

Molybdenite mineralization associated with the Bridge Zone P1 porphyry was formed between about 190 and 189 Ma. The Office and Bridge Zone porphyry rocks are similar in age and geochemistry to the KSM intrusive rocks (196 to 190 Ma) and are likely related to the Mitchell Intrusive Suite (Board et al. submitted).

Mineralized veins in the Brucejack Deposit (Section 7.3.5) cut the 188 to 184 Ma lithological sequence that hosts the Brucejack Deposit, and are cut by the intermediate to mafic dikes, which are dated at about 183 Ma. The mineralized veins cut rocks as young as about 184 Ma thereby indicating an age of about 184 to 183 Ma for the precious metal mineralization in the Brucejack Deposit. The Brucejack mineralization is clearly significantly younger than the KSM magmatic-hydrothermal system, and this has triggered near-mine exploration in search of the causative system (see Section 9.2).

Ar-Ar ages of sericite at about 110 Ma indicate isotopic resetting during low grade regional metamorphism associated with the mid-Cretaceous deformation event. The undeformed and barren late mafic dikes are considered to be Tertiary in age (Tombe et al. 2018).

7.3.3 Structure

Reactivation of older basement structures is considered to have played an important role in controlling magmatic and hydrothermal system development in the Sulphurets mineral district (Nelson and Kyba 2014). The Brucejack Fault, the largest of numerous north-south lineaments that occur on the Brucejack Project area, is interpreted as the latest expression of a reactivated growth fault that was active during Early Jurassic volcanism and mineralization. Evidence for this includes:

- There is a significant change in thickness of the lowermost units of the lower Hazelton Group over short distances across the fault (Jones 2014; Tombe et al. 2018)
- The development of small secondary half-graben structures along the eastern side of the fault that are filled with locally derived, immature clastic detritus
- The presence of abundant short-scale facies variations in the half-graben basins, indicating rapid infilling.
- Alteration and mineralization are broadly cospatial with the fault along its entire 11 km strike length, from Bridge Zone in the south through to Iron Cap in the north (Nelson and Kyba 2014)
- Multistage vein stockwork and vein breccia occur along half-graben normal faults, indicating reactivation of lower order structures.

Latest movement on the Brucejack Fault on the Brucejack Property is dextral and east block down, with displacement on the order of tens of meters.

A post-alteration, composite penetrative foliation is variably developed in rocks in the Brucejack Project area, with foliation intensity being closely associated with phyllic alteration intensity. The foliation is characterized by two predominantly east- to east-southeast-striking, slightly oblique steeply dipping foliations (S1 and S2), which are cut by a later north-striking, steeply dipping S3 foliation (Davis 2017). Progressive deformation has commonly resulted in S1 being rotated into parallelism with S2 in higher strain zones, forming a composite S1-S2 cleavage (Davis 2017). S3 cuts the S1-S2 foliation at high angles, with crosscutting relationships suggesting its formation during sinistral transpression (Davis 2017).

Mineralized veins (see Section 7.3.5) in the Brucejack Deposit predominantly strike southeast to east-southeast (more than 90% of all mineralized veins), with east-west and north-south striking veins being uncommon to rare (Figure 7-6). The mineralized veins occur as multistage thin sheeted veins, vein breccia, and vein stockwork, which anastomose and grade vertically and laterally into one another along fractures, faults, foliation planes, lithological contacts, and shears defining internally complex vein system structural corridors of between approximately 5 and 30 m wide. The veins range from being relatively undeformed to locally moderately deformed, and display both foliation-parallel and low- to moderate-angle foliation-discordant relationships, irrespective of rock competency and strain intensity (Tombe et al. 2018; Roach and Macdonald 1992; Board et al. submitted). Both extensional and shear vein features are developed in areas of differential strain partitioning throughout the deposit, with later mineralized veins being less deformed than earlier mineralized veins (Harrichhausen et al. 2016; Davis 2017; Tombe et al. 2018). A late- to post-deformation structural origin is envisaged for the mineralized veins, with fluid influx and hydrothermal alteration coeval with, and outlasting, ductile deformation and associated periodic brittle failure evolving in response to progressive sinistral transpression (Roach and Macdonald 1992; Davis 2017; Board et al. submitted).

The post-mineralization intermediate to mafic dikes are generally undeformed, unfoliated, and cut all lithological units, mineralized vein generations, and the S1, S2, and S3 fabrics, placing a minimum age of about 183 Ma on foliation development (Tombe et al. 2018; Board et al. submitted). Localized fabric development is present in weakly altered dikes, suggesting that the dikes formed during the waning stages of the alteration and deformation events. The dikes display apparent gentle warping about north-trending axes at the deposit scale, small sharp m-scale offsets along late-stage reverse faults, and retain their planar shape vertically over at least 900 m in the Valley of the Kings Zone (Figure 7-6). These features suggest that the intermediate to mafic dikes were subjected to limited post-emplacement deformation.

Post-mineralization reverse and thrust faulting is developed throughout the Brucejack Deposit. The brittle structures cut all host-rock lithological units, alteration assemblages, mineralized veins, and intermediate to mafic dikes, but are cut by the late mafic dikes, indicating that the causative deformation occurred after about 183 Ma. High- and low-angle reverse faults are generally southwest dipping, with a top-to-the-northeast sense of movement in the Brucejack Deposit. Barren, low angle, chlorite-bearing shear veins, tension gash veins, and undeformed, en echelon, sub-horizontal quartz veins are associated with the faults, as are local top-to-the-southwest back thrusts. Fault displacement is relatively minor (m-scale), indicating limited shortening during the thrust-related deformation. The post-mineralization faulting is considered to be mid-Cretaceous in age (about 110 Ma) based on kinematic similarities to structures in the Skeena Fold and Thrust Belt (Evenchick 1991) and Ar/Ar geochronology (Tombe et al. 2018).

7.3.4 Alteration

Phyllic (sericite) alteration is the dominant alteration style on the Brucejack Project area and is typically a fine-grained admixture of white mica (muscovite), pyrite, quartz, and calcite that replaces the matrix of the volcanosedimentary rocks, varying in intensity from trace to complete replacement. Relicts of earlier-formed alteration (e.g., potassic, albitic, propylitic) are locally preserved in the intensely phyllically altered rocks, indicating that the phyllic alteration overprinted earlier alteration assemblages and that the hydrothermal system (or systems) that drove this alteration was (were) likely telescoping.

Weak silicification has affected most of the host lithological units in the Brucejack Deposit, with moderate to intense texture destruction occurring locally. Pod-like zones (meters- to tens-of-meters in size) of intense silicification are commonly developed in the polylithic conglomerate (especially at its upper and lower contacts) and locally in rocks of the underlying VSF unit (Figure 7-6). Zones of intense silicification consist of microcrystalline quartz, pyrite, and sericite, and are associated with horizons of massive pyrite and almost monomineralic green muscovite. Irregular stockworks of unmineralized cloudy to translucent quartz veinlets of varying intensity are limited to the more intensely silicified zones, and are thought to be related to their formation. Hairline, clear, crack-seal quartz veinlets are locally present in the hardest and most intensely silicified zones, possibly reflecting local fluid overpressures developed beneath these impermeable features.

Cross-cutting relationships between mineralized veins and altered wall rock indicate that the phyllic and silica alteration predated all stages of electrum mineralization (Tombe et al. 2018). Spatial and textural associations between pyrite, sericite, and the silicified zones suggest coeval formation. Mineralized veins and the 183 Ma intermediate to mafic dikes are generally spatially associated with the phyllic assemblage, suggesting that these structures preferentially utilized pre-altered zones.

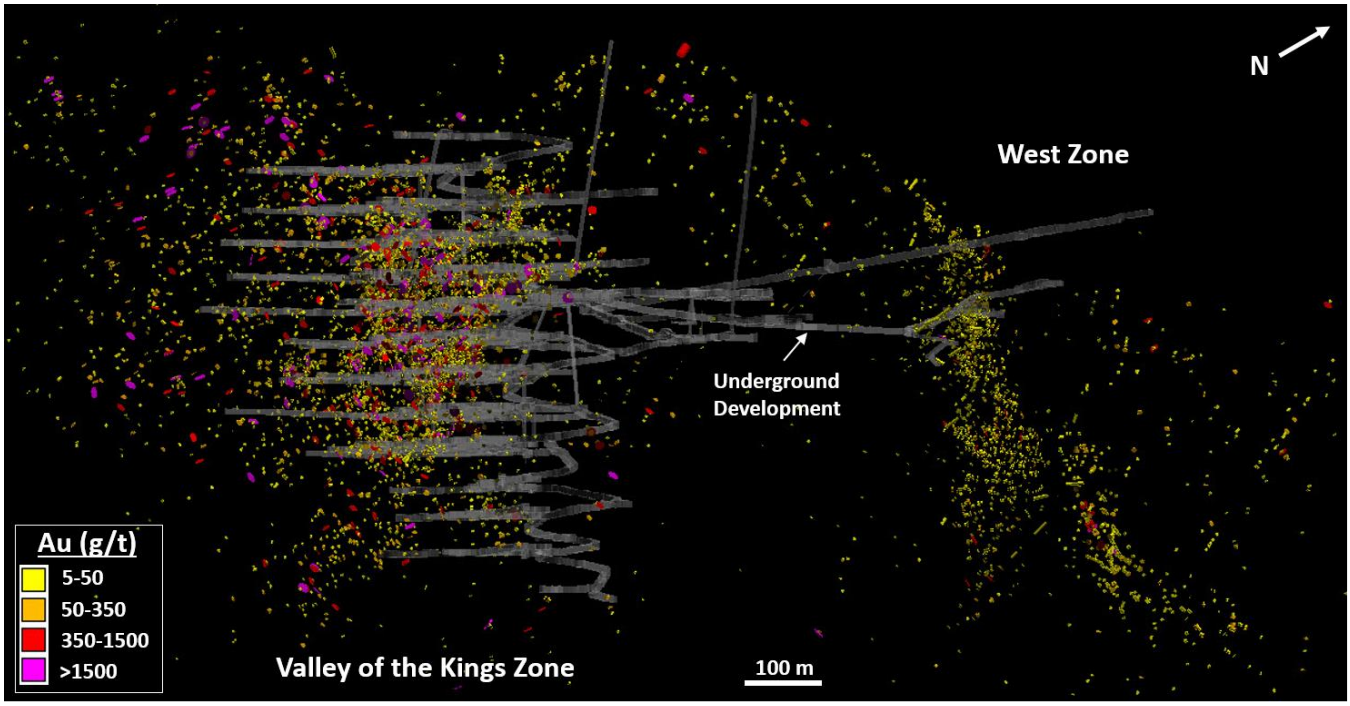
7.3.5 Mineralization

Visible gold and silver mineralization in the Brucejack Deposit occurs as electrum and is predominately hosted in quartz-carbonate to carbonate vein and vein breccia structural corridors within broader stockwork zones (Section 7.3.3; McPherson 1994; Kirkham and Margolis 1995; Tombe et al. 2018; Board et al. submitted). Additionally, low-grade (less than 5 g/t) gold mineralization occurs sub-microscopically in vein- and wall rock-hosted arsenian pyrite (invisible gold) throughout the Valley of the Kings Zone and possibly within the West Zone as well. Electrum-bearing quartz-carbonate veins and stockwork overprint and are co-spatial with earlier porphyry-related phyllic alteration in the Brucejack Deposit.

The Valley of the Kings Zone is currently defined over 1,200 m in east-west extent, 700 m in north-south extent, and 650 m in depth. Deep drilling has indicated that the alteration, mineralization, and veining in this zone extend to a depth of at least 1,100 m. Mineralization in the Valley of the Kings Zone is open to the east, west, and at depth. Deep exploration drilling conducted under the Flow Dome Zone in 2018 (Section 9.2) was successful in confirming the presence of Valley of the Kings Zone-style mineralization from the eastern edge of the Valley of the Kings Zone to beneath the Flow Dome Zone, which lies approximately 1,000 m further east. The West Zone is currently defined over 590 m along its northwest strike, 560 m across strike, and down to 650 m in depth, is open to the northwest, southeast, and at depth to the northeast. The Valley of the Kings Zone contains higher gold and lower silver grades than the West Zone.

Precious metal mineralization is ubiquitous throughout the vein systems (Figure 7-7); however, its continuity is not correlated to any specific geologic continuity; although mineralized structural corridors can be continuous on the meters- to tens-of-meters scale, the within-vein gold and silver distribution is highly erratic. Nevertheless, the distribution and grade of precious metal mineralization within the mineralized structural corridors within the broader stockwork system is of significant economic interest (Figure 7-7).

Figure 7-7: Oblique View Down and Towards the West-Northwest of the Brucejack Deposit Showing Drillhole Intersections Greater than 5 g/t Gold Relative to Underground Workings in both the Valley of the Kings Zone and the West Zone



Source: Pretivm (2019)

7.3.5.1 Valley of the Kings Zone

Six stages of veining have been recognized in the Valley of the Kings Zone (Table 7-1). Discontinuous, deformed, and variably oriented pyrite-quartz-calcite stringer veinlets represent the earliest stage of veining (Stage I). These veinlets are widespread in zones of phyllic alteration, and may represent D-type veinlets associated with early porphyry-style alteration (Tombe et al. 2018). Stage II veins are translucent to white, discontinuous, microcrystalline quartz veinlets found exclusively within pervasively silicified rocks. Stage I and II veins are pre-mineral with respect to precious metal mineralization as they are always cut by electrum-bearing epithermal veins. Electrum mineralization occurs in quartz-carbonate (Stage III), base metal sulphide-quartz-carbonate (Stage IV), and manganoan calcite (Stage V) sheeted veinlets, veins, vein breccia, and vein stockwork (Figure 7-8). Stages III-V veins are considered to have formed coevally as they display complex multiple overprinting relationships. Barren, thrust-related quartz-chlorite veins and tension gashes (Stage VI) cut all earlier vein generations and are likely mid-Cretaceous in age (Tombe et al. 2018). Stage III veins increase in abundance at depth, to the west, and to the east in the Valley of the Kings Zone.

Stages III to V veins are locally undeformed to weakly deformed, but display pinch-and-swell textures in high strain zones. Classic epithermal vein textures, including crustiform banding, sparse cockade textures, and vugs are locally present in Stage III and IV veins (Tombe et al. 2018). Electrum in all mineralized vein stages occurs in a variety of textures, including: common fine- to coarse-grained dendrites, lesser amounts of coarse subhedral clots and aggregates, and uncommon fine- to medium-grained, subhedral to euhedral sheet- to plate-like crystals. The gold/silver ratio of electrum varies significantly, with each of the three main mineralized vein stages displaying unique gold/silver signatures, ranging from 30 to 70% Au. Stage V veins typically contain electrum with the highest proportion of gold, whereas Stage IV veins contain predominantly silver-rich electrum that is locally chemically

zoned (gold-rich cores surrounded by silver-rich rims; McLeish et al. 2018). There does not appear to be any significant compositional zonation of electrum as a function of spatial location.

Table 7-1: Vein Generations in the Valley of the Kings Zone

Vein Stage	Description	Timing	Typical Size	Mineralogy	
				Metals	Gangue
I	Discontinuous stringer veinlets	Pre-mineral	Thickness: mm Continuity: cm	Invisible Au in Py tr. Cpy	Py-Qz-Cal-Ser±Chl
II	Discontinuous translucent veinlets	Pre-mineral	Thickness: mm Continuity: mm	-	Qz-Py
III	IIIa: sheeted veinlets	Syn-mineral	Thickness: cm Continuity: dam	El, tr. Sp±Gn±Cpy	Py-Qz-Cal-Dol±Ser±Rt
	IIIb: breccia/flooded zones	Syn-mineral	Thickness: cm to dm Continuity: m	El, tr. Sp±Gn±Cpy	Py-Qz-Cal-Dol±Ser±Rt
	IIIc: stockwork veins/blow-outs	Syn-mineral	Thickness: dm to m Continuity: dam to hm	El, tr. Sp±Gn±Cpy, tr. Ag sulphosalts	Py-Qz-Cal-Dol±Ser±Apy±Rt
IV	Ag-rich base metal sulphide veins	Syn-mineral	Thickness: cm to dm Continuity: m to dam	Sp-Gn-Cpy-El-Ag-sulphide+ sulphosalts: acanthite, pearcite, pyrargyrite, freibergite, proustite, polybasite, argentotennantite.	Py-Qz-Cal-Dol±Ser±Apy±Rt
V	Mn-carbonate veins	Syn-mineral	Thickness: cm to dm Continuity: m to dam	El, tr. Cpy	Cal±Qz±Py±Rt
VI	Tectonic shear/tension gash veins	Post-mineral	Thickness: cm Continuity: cm to m	-	Qz-Cal-Chl

Notes: tr. – trace; Apy – arsenopyrite; Cal – calcite; Chl – chlorite; Cpy – chalcopyrite; Dol – dolomite; El – electrum, Gn – galena; Py – pyrite; Qz – quartz; Rt – Rutile, Ser – sericite, Sp – sphalerite.
Stage I, III, IV, V, and VI correspond to Vn0, Vn1, Vn2, Vn3, and Vn4 according to the mine vein nomenclature.
Source: Modified after Tombe et al. (2018) and Board et al. (submitted)

7.3.5.2 West Zone

Mineralization and veining in the West Zone were investigated in the late 1980s and early 1990s by Newhawk and research geologists (Roach and Macdonald 1992; Macdonald 1993; Davies et al. 1994; Kirkham and Margolis 1995). These studies documented mineralization and vein parageneses broadly similar to that described above for the Valley of the Kings Zone, with two notable exceptions: ore stage veins have a lower modal abundance of electrum and higher modal abundance of base metal sulphide and silver sulphosalt minerals and, therefore, a lower gold/silver ratio than those in the Valley of the Kings Zone, and the mineralogy of pre-mineralization-stage veining in the West Zone is different to that of the Valley of the Kings Zone: Stage I veinlets in the West Zone are represented by potassium feldspar-quartz veinlets.

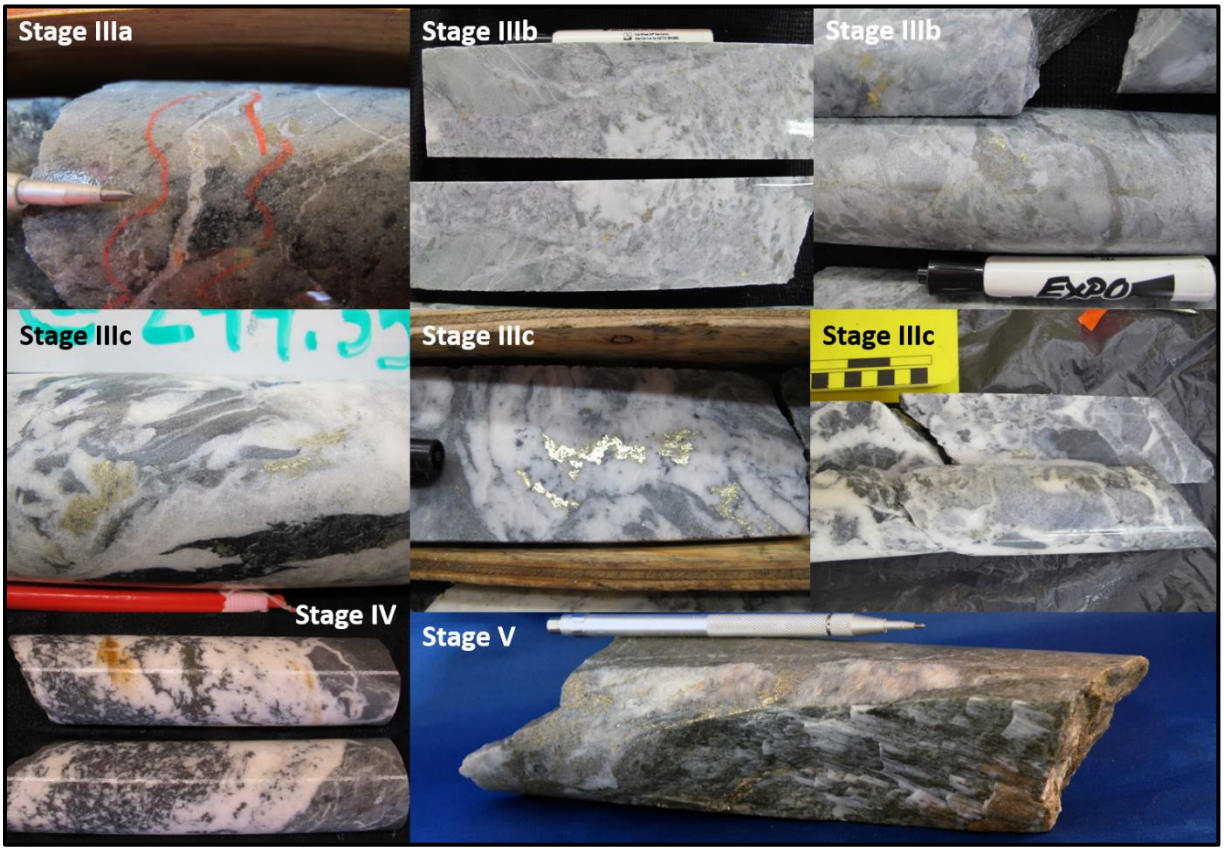
7.3.5.3 Genetic Considerations

Previously gold transportation was considered to have occurred as bi-sulphide complexes in solution (e.g., Board 2015a; McLeish et al. 2018; 2019), with the porphyry-associated pre-sulphidization and pre-sericitization of the host rock facilitating extended residency time of gold-bearing fluids due to minimal rock buffering of sulphur by host-rock iron (all taken up in the form of pre-mineral pyrite) and maintenance of near neutral fluid pH (muscovite-buffering; Heinrich et al. 2004). Recent work conducted by McLeish et al. (2018; 2019) has demonstrated that gold (and silver) was being transported as electrum nanoparticles in suspension (colloids) in association with carbonate (i.e., likely in the gas phase) rather than silica (quartz). This allows for increased capacity of mineralizing fluids to carry gold by physical transport over and above that dissolved in solution.

Controls on gold precipitation from colloidal suspensions include mixing with meteoric (including heated seawater) waters, decreasing temperature, boiling (to a lesser extent), and local destabilization near pyrite zones. McLeish et al. (2019) documented a multiphase history of porphyry to epithermal mineralization (alluded to in Board (2015a)) in pyrite grains in the Valley of the Kings Zone and the Flow Dome Zone. Early porphyry-related pyrite is resorbed and overgrown by gold-bearing arsenian-banded epithermal pyrite. Similar pyrite growth zonation patterns have been observed in the porphyry to epithermal transition at the Lihir porphyry-epithermal deposit in Papua New Guinea (Sykora et al. 2018). Overprinting of earlier porphyry alteration and mineralization by later co-spatial epithermal events (arsenian pyrite and subsequent electrum mineralization) complicates domain definition for geological modelling (see Section 14.3).

Mixing with meteoric waters (likely heated seawater) triggered explosive phreatomagmatic events that resulted in destabilization of the electrum colloids and their precipitation. This likely occurred again and again, in different faults, fractures, foliation planes, and along lithological contacts that were experiencing variable dilation and closure due to local variations in compressional and extensional stress, and resulted in the globally ubiquitous, yet locally variable and difficult to predict distribution of electrum throughout the Brucejack Deposit (Figure 7-8). As a result of the nature of gold transportation (above) and complex multistage geological history, mineralization continuity appears to better on the larger (structural corridor) scale than on the local (individual discontinuous structures) scale. It is difficult to interpret individual mineralized structures with the information available, whereas it is relatively easy to model the mineralized structural corridors with a high degree of confidence.

Figure 7-8: Mineralized Veins in the Valley of the Kings Zone of the Brucejack Deposit



Source: Pretivm (2019)

8.0 DEPOSIT TYPES

The Brucejack Deposit is interpreted to be a deformed porphyry-related transitional to intermediate sulphidation epithermal high-grade gold-silver vein, vein stockwork, and vein breccia deposit that formed between 184 to 183 Ma (Board and McNaughton 2013; Tombe et al. 2018; Board et al. submitted). High-grade gold-silver mineralization was formed in association with a telescoped, multi-pulsed magmatic-hydrothermal system beneath an active local volcanic center (Board et al. submitted).

The Brucejack Deposit has many characteristics in common with intermediate sulphidation epithermal systems (Sillitoe and Hedenquist 2003). These are highlighted (in yellow) in Table 8-1. Intermediate sulphidation epithermal systems occur in calc-alkaline andesite-dacite arcs and can be spatially associated with porphyry systems and individual volcanic centers (Sillitoe and Hedenquist 2003). Brownfields exploration drilling from 2018–2019 tested the porphyry potential below the Valley of the Kings Zone and in the Flow Dome Zone (Section 9.2–9.3).

Mineralization in these systems is overwhelmingly hosted in veins, sheeted veins, vein stockwork, and vein breccia, with gold-silver occurring as electrum (Sillitoe and Hedenquist 2003). Whilst the majority of these types of epithermal systems form in arcs with neutral to extensional tectonic environments, Victoria (the gold-rich type example) and the giant Baguio Au district (both in the Philippines) were formed in a compressive island arc (Sillitoe and Hedenquist 2003). The Brucejack Deposit appears to have formed in compressive island arc setting (Tombe et al. 2018; Board et al. submitted). Intermediate sulphidation epithermal deposits contain significant quantities of precious metals (Sillitoe and Hedenquist 2003). Examples of intermediate sulphidation deposits with significant contained gold include: Rosie (Montana; approximately 414 t Au), Baguio (Philippines; approximately 400 t Au), Comstock Lode (Nevada; approximately 260 t Au), Kelian (Indonesia; approximately 240 t Au), Tayoltita (Mexico; approximately 150 t Au), Sacarimb (Romania; approximately 84 t Au), and Victoria (Philippines; approximately 80 t Au). The Brucejack Deposit has similarities in terms of vein style, mineralization paragenesis, and alteration to the Fruta del Norte high-grade gold deposit in Ecuador (e.g., Leary et al. 2016; greater than 155 t Au) and the Porgera gold deposit in Papua New Guinea (e.g., Richards and Kerrich 1993; Ronacher et al. 2004; greater than 660 t Au).

Table 8-1: Principal Field-oriented Characteristics of Intermediate- and Low-sulphidation Epithermal Systems

	High Sulphidation			Low Sulphidation	
	Oxidized Magma	Reduced Magma	Intermediate Sulphidation	Subalkaline Magma	Alkaline Magma
Type Example	El Indio, Chile (vein); Yanacocha, Peru (disseminated)	Potosí, Bolivia	Baguio, Philippines (Au-rich); Fresnillo, Mexico (Ag-rich)	Midas, Nevada	Emperor, Fiji
Genetically Related Volcanic Rocks	Mainly andesite to rhyodacite	Rhyodacite	Principally andesite to rhyodacite but locally rhyolite	Basalt to rhyolite	Alkali basalt to trachyte
Key Proximal Alteration Minerals	Quartz-alunite/APS; quartz-pyrophyllite/dickite at depth	Quartz-alunite/APS; quartz-dickite at depth	Sericite; adularia generally uncommon	Illite/smectite-adularia	Roscoelite-illite-adularia

table continues…

	High Sulphidation		Intermediate Sulphidation	Low Sulphidation	
	Oxidized Magma	Reduced Magma		Subalkaline Magma	Alkaline Magma
Silica Gangue	Massive fine-grained silification and vuggy residual quartz		Vein-filling crustiform and comb quartz	Vein-filling crustiform and colloform chalcedony and quartz; carbonate-replacement texture	Vein-filling crustiform and colloform chalcedony and quartz; quartz deficiency common in early stages
Carbonate Gangue	Absent		Common, typically including manganiferous varieties	Present by typically minor and late	Abundant but not manganiferous
Other Gangue	Barite common, typically late		Barite and manganiferous silicates present locally	Barite uncommon; fluorite present locally	Barite, celestite, and/or fluorite common locally
Sulphide Abundance	10 to 90 vol %		5 to >20 vol %	Typically, <1 to 2 vol % (but up to 20 vol % where hosted by basalt)	2 to 10 vol %
Key Sulphide Species	Enargite, luzonite, famatinite, covellite	Acanthite, stibnite	Sphalerite, galena, tetrahedrite-tennantite, chalcopyrite	Minor to very minor arsenopyrite ± pyrrhotite; minor sphalerite, galena, tetrahedrite-tennantite, chalcopyrite	
Main Metals	Au-Ag, Cu, As-Sb	Ag, Sb, Sn	Ag-Au, Zn, Pb, Cu	Au ± Ag	
Minor Metals	Zn, Pb, Bi, W, Mo, Sn, Hg	Bi, W	Mo, As, Sb	Zn, Pb, Cu, Mo, As, Sb, Hg	
Te and Se Species	Tellurides common; selenides present locally	None known but few data	Tellurides common locally; selenides uncommon	Selenides common; tellurides present locally	Tellurides abundant; selenides uncommon

Note: Key features noted in the Brucejack Deposit are highlighted in yellow. The presence of adularia in the West Zone is still in accordance with an intermediate sulphidation classification.
APS – Aluminum-phosphate-sulphate minerals; Sb – Antimony; Hg – Mercury; Zn – Zinc; Pb – Lead; Bi – Bismuth; W – Tungsten; Sn - Tin

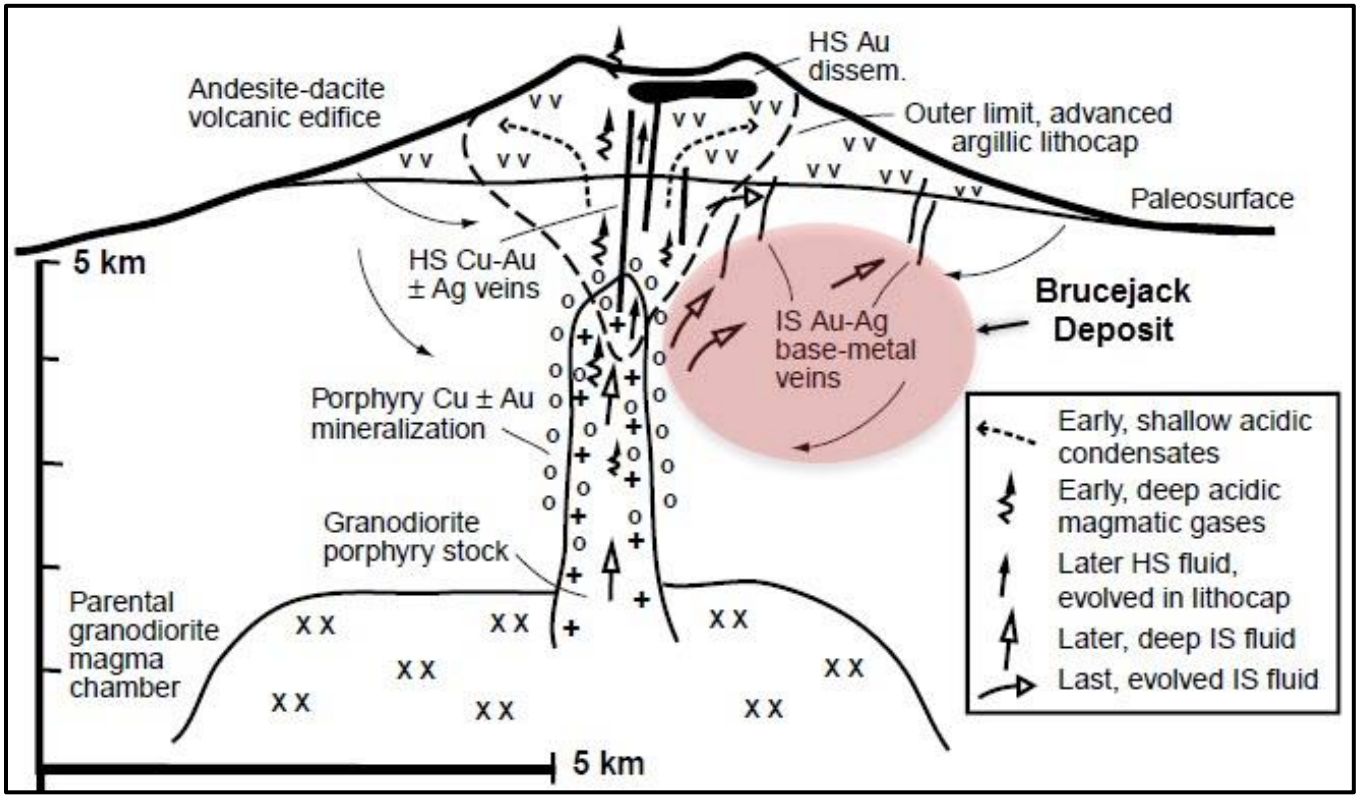
Source: Modified after Table 3 in Sillitoe and Hedenquist (2003).

Corbett (2013) generally considers intermediate sulphidation epithermal deposits as a sulphide-rich sub-type of low sulphidation epithermal deposits known as carbonate-base metal gold deposits (Corbett and Leach 1998; Figure 8-1). These types of deposits are formed from magmatic fluids that evolve to low sulphidation as they migrate from the intrusive to shallower crustal levels and mix with substantial meteoric waters (Corbett 2013). Corbett (2013) prefers the use of (sulphide-rich low sulphidation) carbonate-base metal gold for these types of deposits to intermediate sulphidation as the former more correctly accounts for the wide temperature range and paragenetic sequence related to the transition from intrusion-related quartz-sulphide gold-copper deposits through carbonate-base metal gold to epithermal gold-silver deposits. Veins in this transition show a continuum from sulphide-rich (“D-type” veinlets: proximal to porphyry; Vein Stage I at Brucejack; see Section 7.3.5.1) through

carbonate (manganese-rich; Vein Stage V at Brucejack), carbonate-quartz (Vein Stage V at Brucejack), to quartz-carbonate (distal to porphyry and shallower levels; Vein Stages III and IV at Brucejack; Corbett and Leach 1998). Considering Corbett's (2013) classification, the ubiquitous Vein Stage I veins in the phyllic alteration throughout the Brucejack Deposit being overprinted by carbonate and quartz-carbonate veins provides evidence for temperature fluctuations in the volcanic sequence: a telescoping porphyry system. The presence of increased carbonate veins at depth (Section 7.3.5.1 of this report) is encouraging as gold mineralization in the Brucejack Deposit appears to be associated with the carbon dioxide gas phase (McLeish et al. 2019).

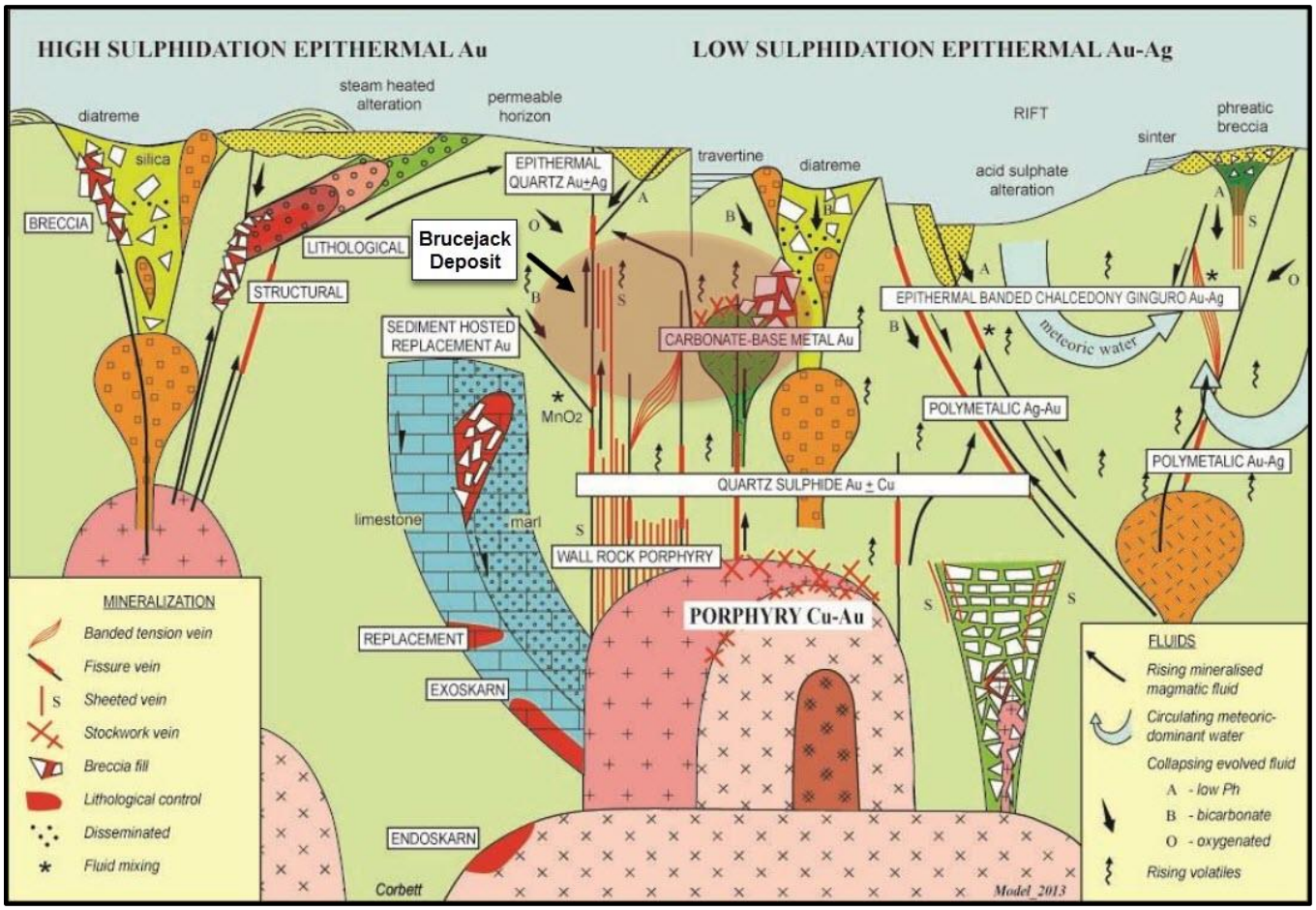
Examples of carbonate-base metal deposits from the southwest Pacific Rim include: Porgera Waruwari, Hidden Valley, Woodlark, and the Wafi Link Zone in Papua New Guinea; Cowal, Kidston, Mt Leyshon, and Mt. Rawdon in Australia, Gold Ridge in the Soloman Islands; Acupan, Antamok, Victoria, and Bulawan in the Philippines; and Kelian and Mt. Muro in Indonesia (Corbett 2013). Corbett (2013) considers Fruta del Norte (Ecuador), Golden Sunlight, Montana Tunnels, and Cripple Creek (USA), Rio Medio and San Cristobal (Chile) to be examples of carbonate-base metal gold deposits. Examples of quartz-sulphide gold-copper deposits include Kerimenge and Lihir in Papua New Guinea (Corbett 2013). Interestingly, mixing with substantial meteoric water (seawater due to caldera collapse) and overprinting of earlier porphyry mineralization by later epithermal mineralization is recorded at Lihir (Sykora et al. 2018). Similar features (to those at Lihir) have recently been documented in the Brucejack Deposit (McLeish et al. 2018; 2019; Board et al. submitted).

Figure 8-1: Schematic Section of Calc-alkaline Volcanic Arc Showing High and Intermediate Sulphidation Epithermal Deposits and Porphyry Deposits



Note: Location of Brucejack Deposit is highlighted in red.
Source: Modified after Figure 3 in Sillitoe and Hedenquist (2003).

Figure 8-2 Conceptual Model of Different Arc-related Porphyry and Epithermal Copper-Gold-Silver Mineralization Deposits



Note: Interpreted position of the Brucejack Deposit is highlighted in transparent red ellipse.
Source: Modified after Figure 1 in Corbett (2013).

9.0 EXPLORATION

9.1 Exploration – 2011 to 2014

Following acquisition of the Brucejack Property in late 2010, Pretivm management changed the exploration focus from an open-pit bulk-tonnage approach to targeting high-grade resources amenable to more selective underground mining. Surface and underground drilling was the main tool used in the exploration of the Brucejack Deposit and Property between 2011 and 2014. Geophysical surveys were conducted in 2014 to assess the exploration potential on the Brucejack Property and broader claim block scales. Table 9-1 provides a summary of the exploration carried out on the Brucejack Property between 2011 and 2013 by Pretivm. Additional detailed information on Pretivm's 2011–2014 exploration of the Brucejack Property is provided in Jones (2014) and Ireland et al. (2014).

Table 9-1: Exploration of the Brucejack Property Between 2011 and 2014

Date	Exploration
2011	A bulk-tonnage resource update was released in February 2011 (Ghaffari et al. 2011), with an initial high-grade resource for the Valley of the Kings Zone. An additional high-grade resource estimate, with sensitivity testing, was released in November 2011 (Armstrong et al. 2011).
	Brownfields exploration included detailed surface geological mapping, limited surface sampling, and limited geophysics (an initial Spartan magnetotelluric survey conducted by Quantec Geoscience Ltd.; Turkoglu et al. 2011; Ireland et al. 2013).
	A total of 178 diamond drillholes were completed, totaling 72,805 m. The program targeted previously defined high-grade intersections primarily in the Valley of the Kings Zone (60% of the total), but also in the Gossan Hill Zone, Shore Zone, West Zone, and Bridge Zone targets.
	Dewatering of the historical West Zone underground development was carried out to assess the condition of the workings and determine if the workings could be used as a launching point for a development drive to the Valley of the Kings Zone.
2012	Detailed brownfields surface geological mapping and associated supplementary surface geochemical sampling was continued.
	A total of 301 drillholes were completed, totaling 105,500 m of drilling during the 2012 drilling program. Zones within 150 m of surface were drilled at 12.5 m centers, with the deeper parts (down to about 350 m below surface) being drilled at approximately 25 m centers. Drilling at greater depths was generally only able to reliably achieve 50 m centers.
	The results of the 2012 drilling were incorporated into a revised Mineral Resource (Jones 2012c). This resource estimate formed the basis for a feasibility study on the Brucejack Property, which was completed in June 2013 (Ireland et al. 2013).
2013	A total of 24 surface diamond drillholes (5,200 m) were completed (drillholes SU-590 to SU-613) on the main and eastern parts of the Valley of the Kings Zone. An additional 575 m of shallow geotechnical drilling was conducted in 13 drillholes (drillholes SU-614 to SU-626).
	Pretivm extracted a 10,000 t bulk sample to further evaluate the geological interpretation and Mineral Resource estimate for the Valley of the Kings Zone (Jones 2014). Geological mapping (face, back, and ribs), channel, and chip sampling were conducted on a round-by-round basis for all the underground workings developed as part of the bulk sample. Bulk sample material from each round (approximately 100 t) was sampled through a sampling tower and sent as defined rounds to the Contact Mill in Philipsburg, Montana, for processing. A total of 5,923 oz Au were produced from 10,302 t of bulk sample material processed through the mill at an average grade of 17.88 g/t Au (Ireland et al. 2014). The results provided confidence in the November 2012 Mineral Resource and were used for parameter calibration and confidence classification in the December 2013 Mineral Resource (Jones 2012c; Jones 2014).

table continues…

Date	Exploration
2013	A total of 16,500 m of underground drilling was conducted to augment the bulk sample results by drilling off a larger area around the bulk sample workings on the 1,345 m level. Drilling was conducted on approximately 7.5 m centers over an area of 120 m east-west by 60 to 90 m north-south by 120 m vertically. Additional underground exploration drilling was conducted to test targets outside of the bulk sample area. Underground drilling totaled 38,840 m in 409 drillholes.
	Surface geological mapping and supplementary surface geochemical sampling was continued, albeit with a more greenfields exploration goal than in previous years. The majority of this exploration was conducted on Pretivm's claims outside of the Brucejack Property area.
2014	Approximately 11,200 m of surface drilling in 12 drillholes (SU-627 to SU-632, SU-640, SU-644, and SU-650 to SU-653) testing the mineralization potential at depth beneath the Valley of the Kings Zone was conducted in 2014. Geotechnical drilling totaled 725 m in 15 drillholes (SU-633 to SU-639, SU-641 to SU-643, SU-645 to SU-649).
	An airborne magnetic and radiometric survey was conducted over the Brucejack Property and the wider Pretivm claim area by Precision GeoSurveys Inc. (Pezzot 2015). Approximately 750-line km (of a total 1,185-line km) were flown at a 200 m line spacing over the Brucejack Property (Block 1 of the survey). Line spacings of between 400 and 500 m were flown on the broader Pretivm claim area (Blocks 2 and 3). A Scintrex Cs vapour CS-3 magnetometer and an IRIS were used to collect the data. Ancillary equipment included base station magnetometers, a laser altimeter, a Pilot Guidance Unit, GPS navigation, and an AGIS data acquisition system. Additional Spartan MT data were acquired from both the Snowfield and Brucejack Properties in August and September 2014 by Quantec Geoscience Ltd (Tuncer 2014a; b). This work, which expanded on the 2011 Spartan MT data (Turkoglu et al. 2011), was aimed at targeting porphyry and epithermal mineralization and improving geological knowledge on the two property areas. Spartan MT data were collected over a frequency range of 10 KHz to 0.001 Hz, with AMT data collected over a frequency range of 10 KHz to 3 Hz, from a total of 78 MT stations. Following 1D and 3D inversion modelling of the data, a total of ten conductive feature anomalies were identified, the most significant of these on the Brucejack Property being beneath the large flow foliated latite dome to the east of the Valley of the Kings Zone (now known as the Flow Dome Zone). These features were interpreted as reflecting increased alteration with abundant sericite content. Results of the geophysical surveys were used for enhanced structural interpretations as well as porphyry and epithermal deposit vectoring, targeting, and exploration program planning.
	A total of 605 surface rock outcrop grab, chip, and channel samples were collected on the Brucejack Property.

Notes: GPS – Global Positioning System; MT – Magnetotelluric; AMT – Audio Magnetotelluric;
IRIS – Integrated Radiometric Information System

9.2 Exploration – 2015 to 2018

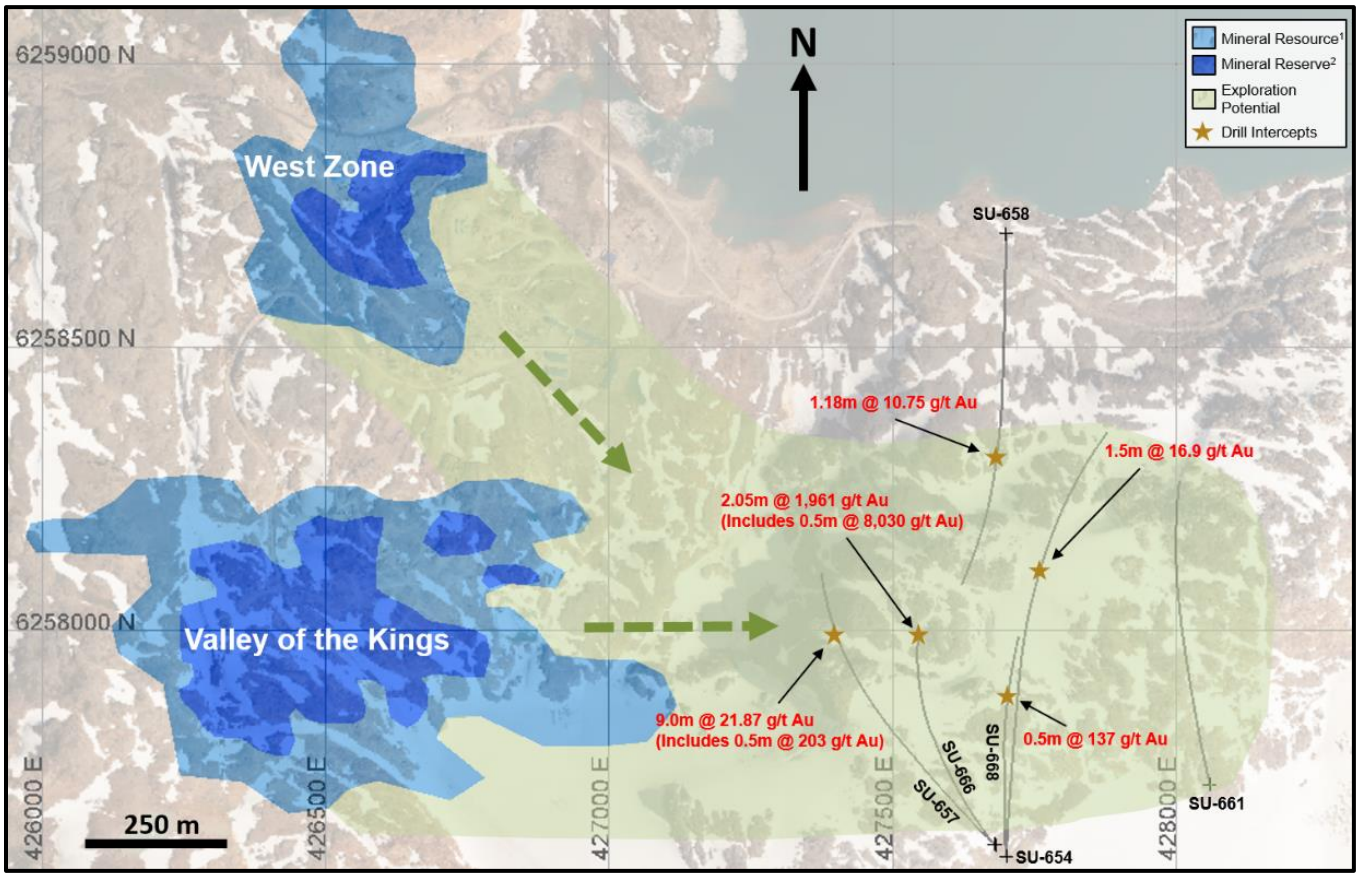
Pretivm's main focus between 2015 and 2017 was on the permitting, financing, construction, and commissioning of the Brucejack Gold Mine. Brucejack Property exploration between 2015 and 2018, consequently, largely targeted resource and reserve expansion of the Valley of the Kings Zone through underground drilling (see Section 10.0). Limited brownfields (near deposit/mine) exploration conducted on the Brucejack Property included drilling, geophysics, surface mapping, and very limited surface sampling for petrography, mineral chemistry, and geochronological analyses. Greenfields exploration of the broader Pretivm claims also occurred from 2015 through 2018, as part of the Bowser Regional Property (see Flasha 2017a; b; c; Wafforn 2018a; b).

All exploration conducted on the Brucejack Property (termed brownfields or near-mine exploration) initially followed a model that suggested the epithermal vein system was genetically linked to the long-lived KSM porphyry deposits (approximately 196 to 190 Ma; Febbo et al. 2015). The gold-bearing veins were considered to have been formed in the waning stages of the telescoping porphyry system, which was interpreted as having lasted from approximately 191 to 183 Ma (Board and McNaughton 2013). Additional geochronological data, coupled with detailed geological and geophysical reviews, resulted in the discovery that rocks as young as approximately 184 Ma were affected by phyllic alteration and cut by auriferous epithermal veins (Board et al. submitted). As none of the porphyry intrusions recognized to date in the region were as young as this, an alternative exploration model was proposed in which a younger porphyry center, as yet undiscovered, was the driver of the hydrothermal system that was responsible for the formation of the Brucejack Deposit. Detailed reviews of surface samples, drilling data, geological mapping, structural data, geophysical data, geochemical data, alteration intensity, post-mineral dyke orientations, hydrothermal breccia distribution, and geochronological data appeared to vector to the Flow Dome Zone in the east.

Limited surface exploration drilling (8,380 m in 10 drillholes and two wedges) was conducted on the Brucejack Property in 2015, with 6,199 m in 8 drillholes (including two wedges) targeting the Flow Dome Zone. Other zones targeted included the Hanging Glacier Zone (987.33 m in three drillholes) and one drillhole in the South Zone (southwards from Bridge Zone; see Flasha 2016). Surface mapping and limited surface sampling of the Flow Dome Zone augmented the drilling. Results of this drilling highlighted the continuation of Valley of the Kings Zone style phyllic alteration and electrum mineralization beneath the main part of the Flow Dome Zone (Figure 9-1), as well as isolated occurrences of relic potassic and propylitic alteration, bornite, and chalcopyrite. The drilling did not intersect the interpreted causative porphyry.

Additional airborne geophysical surveys (1TEM electromagnetic, magnetic, and radiometric) were conducted as part of Pretivm's claim block-wide airborne survey by Precision GeoSurveys Inc. between July and October 2015, as a follow-up to the 2014 airborne survey (see Section 9.1; Boyd and Poon 2015; Poon 2015; Flasha 2016b; c). Although no new magnetic or radiometric lines were flown over the Brucejack Property in 2015, 1TEM electromagnetic data were obtained as part of Block 2 of this survey (Boyd and Poon 2015). The Block 2 survey was flown at a 200 m spacing between lines, with most of the lines flown in an east-west direction. Two of six north-south tie lines (spaced at 4,500 m) were flown over the Brucejack Property. Precision GeoSurveys Inc. used a towed 1TEM structure, 1TEM transmitter (TX), 1TEM receiver (RX), laser altimeter, data loggers, a Pico data acquisition system, a Pico pilot navigation unit, and a Honda V-twin gas engine and alternator system (340 A, 80 V), all installed on its Eurocopter AS350BA helicopter. The 1TEM structure was towed 40 m below the helicopter at a nominal height of 50 m above the ground, ranging up to 74.3 m above the ground in areas of challenging relief. Results of the 1TEM electromagnetic survey over the Brucejack Property indicated the presence of an extensive hydrothermal footprint in this area, characterized by elevated conductivity (Figure 9-2). Known mineralized zones on the Brucejack Property are located within the elevated conductivity footprint. All of the 2015 surface diamond drillholes drilled into this footprint intersected extensively altered (generally phyllic alteration) and anomalously mineralized rocks. The electromagnetic data are being used in conjunction with other geological and geophysical data for brownfields exploration targeting.

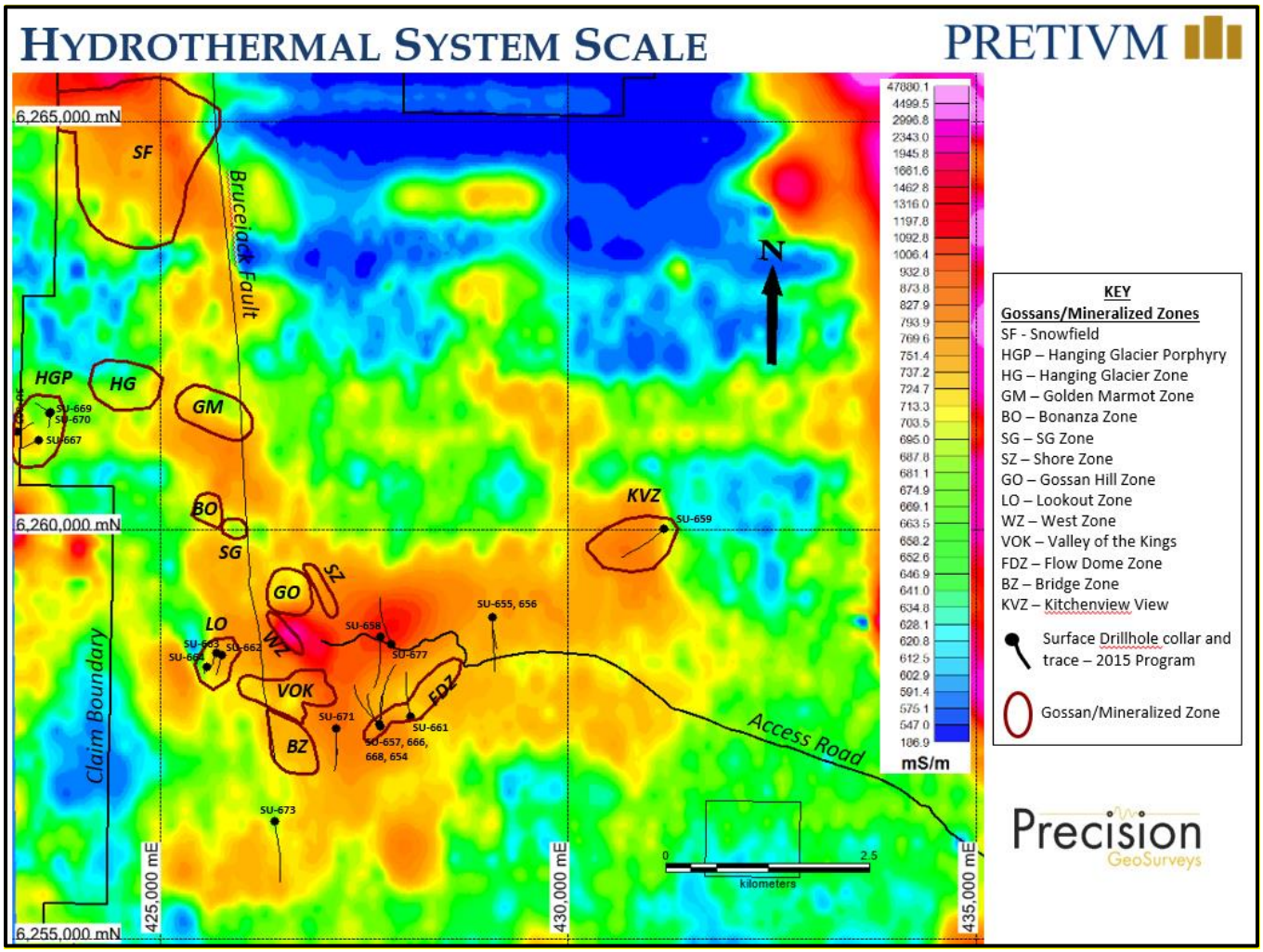
Figure 9-1: Plan View of the Brucejack Deposit Showing Significant Electrum Intersections from the 2015 Surface Exploration Drilling of the Flow Dome Zone



Notes: [1]Outline of Measured, Indicated, and Inferred Mineral Resource as at July 21, 2016.
[2]Outline of Proven and Probable Mineral Reserve, based on the 2014 FS (Ireland et al. 2014).

Source: Pretivm (2019)

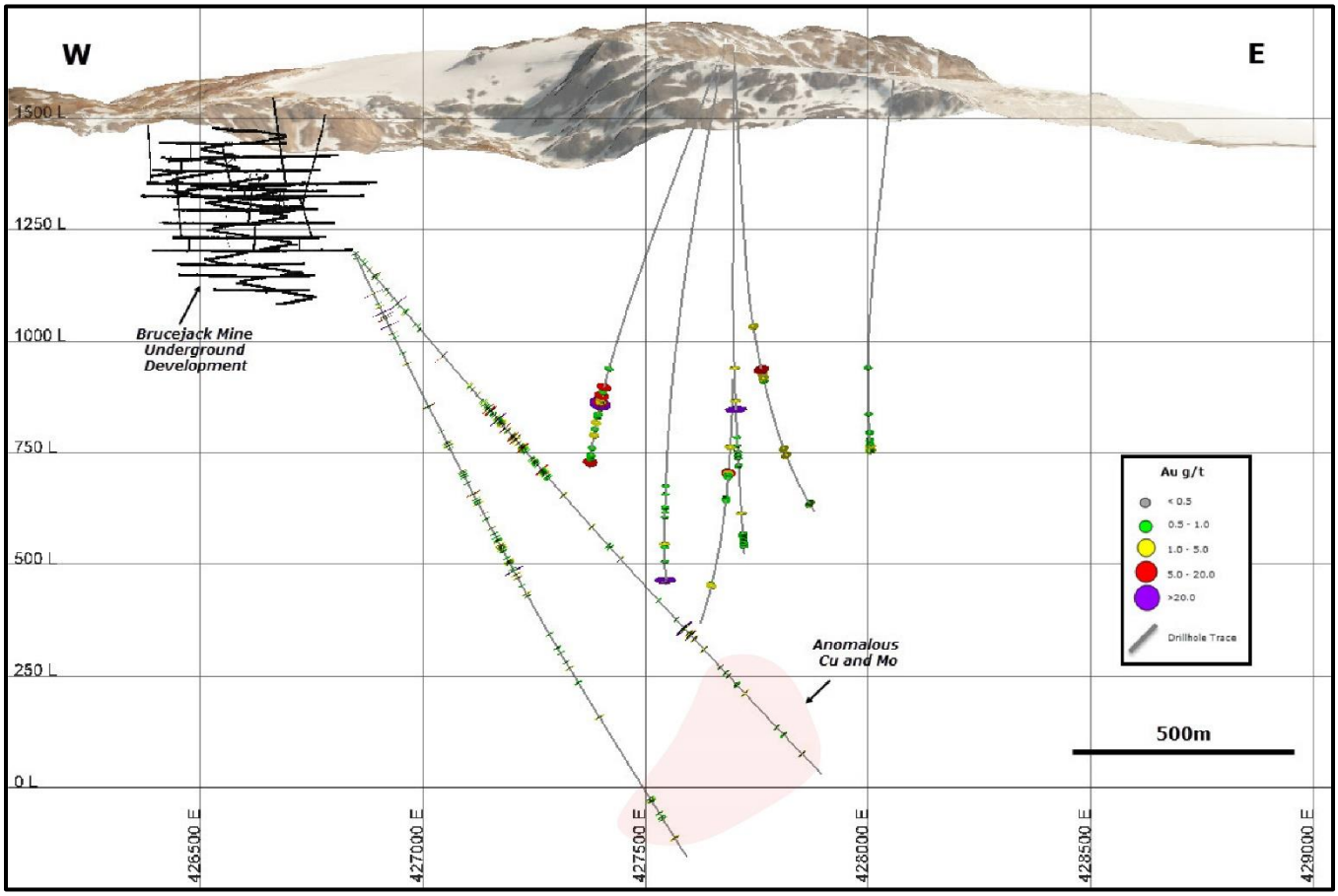
Figure 9-2: Plan View of 1TEM Conductivity Data on the Western Edge of Pretivm's Claim Block, Illustrating the Potential Scale of the Hydrothermal System Footprint (Warmer Colours) of which the Brucejack Deposit is a Part (also shown are Peripheral Known Mineralized Zones on the Brucejack and Snowfield Properties and Drill Trances From the 2015 Surface Exploration Drill Program)



Source: Pretivm (2016)

Underground exploration drilling aimed at connecting the Valley of the Kings Zone to the Flow Dome Zone and testing the porphyry potential at depth beneath the Flow Dome Zone was conducted from the 1,200 m level in the Brucejack Gold Mine in 2018. A total of 3,138 m was drilled in two underground exploration drillholes (VU-820 and VU-911). Results of this drilling showed that Valley of the Kings style mineralization and alteration was continuous from the Brucejack Gold Mine to the Flow Dome Zone (Figure 9-3). Anomalous copper and molybdenite mineralization coincided with a zone of relic potassic alteration between 1,400 and 1,485 m downhole depth in drillhole VU-911 and occurs more diffusely over a broader area in drillhole VU-820 (between downhole depths 1,260 and 1,585 m). A coarse-grained porphyry intrusive was intersected and has been dated (U-Pb zircon) at approximately 186 Ma (Board et al. submitted), in keeping with the interpretation of a younger porphyry system driving the Brucejack Deposit. McLeish et al. (2019) showed how zoned pyrites changed with depth along these two drillholes: closer to the Valley of the Kings Zone, zoned pyrites show resorbed porphyry cores overgrown with epithermal arsenian pyrite that is then cut by electrum; epithermal zonation diminishes with depth in the drillholes being replaced with porphyry pyrite (with inclusions of chalcopyrite) in the vicinity of the anomalous copper and molybdenum mineralization. Additional drilling is required to provide a three-point problem for source porphyry vectoring. The key to intersecting the source porphyry is to highlight the extent of the porphyry to epithermal transition zone and its potential for additional Valley of the Kings Zone style electrum mineralization, in addition to assessing the gold potential of the source porphyry.

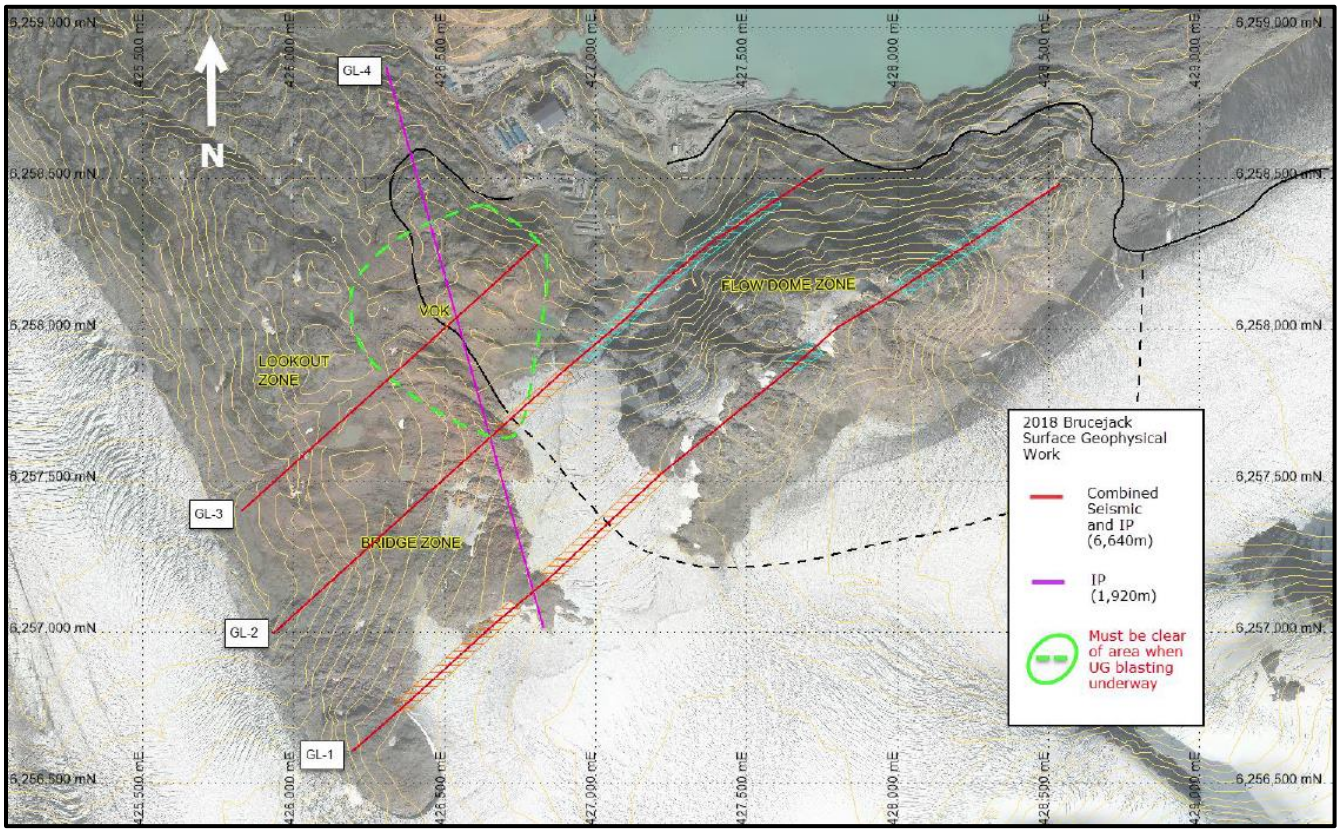
Figure 9-3: Cross Section of the Brucejack Deposit (Looking North) Showing Gold Assay Intersections from the 2015 Surface Exploration Drilling and 2018 Underground Deep Exploration Drilling of the Flow Dome Zone, as well as the Zone of Anomalous Copper and Molybdenite Assays



Source: Pretivm (2018)

Additional ground-based geophysical surveys were conducted as part of the 2018 Flow Dome Zone exploration program by Frontier Geosciences Inc. A total of 8,560 m of surface induced polarization (IP) and 6,640 m of reflection seismic ground surveys were conducted on four lines across the Brucejack Property in 2018 (Figure 9-4). Both IP and seismic surveys were conducted on each of the three northeast-southwest trending lines, with only IP being conducted on the north-northwest trending linking line. A Frontier Geosciences Inc. 24-bit full waveform time domain IP system with a GDD 3.6 kW transmitter was used for apparent resistivity and chargeability measurements as part of the IP survey. Electrodes were emplaced every 100 m. The reflection seismic survey employed a Geometric Geode 24 channel signal enhancement seismograph with Oyo Geo Space 10 Hz geophones connected at 5 m intervals in 96 phone arrays (480 m spreads) by network cables along the three survey lines (Figure 9-4). Downhole magnetic total field, self-potential, single point resistance, resistivity, chargeability, and gamma geophysical measurements were collected from VU-911, the deeper drillhole drilled into the Flow Dome Zone, using a combination of a Mount Sopris MGX II borehole logging system, a three-component fluxgate magnetometer, and a Geonics Ltd. PROTEM transmitter and receiver system. Downhole current injection electrodes were placed in both drillholes to provide additional depth resolution to the 2018 IP surface survey. Survey results were used in conjunction with other geological and geophysical data for brownfields exploration targeting in 2019.

Figure 9-4: Plan View Part of the Brucejack Project Showing Location of the 2018 Frontier Geosciences Inc. Surface Reflection Seismic and IP Survey Lines

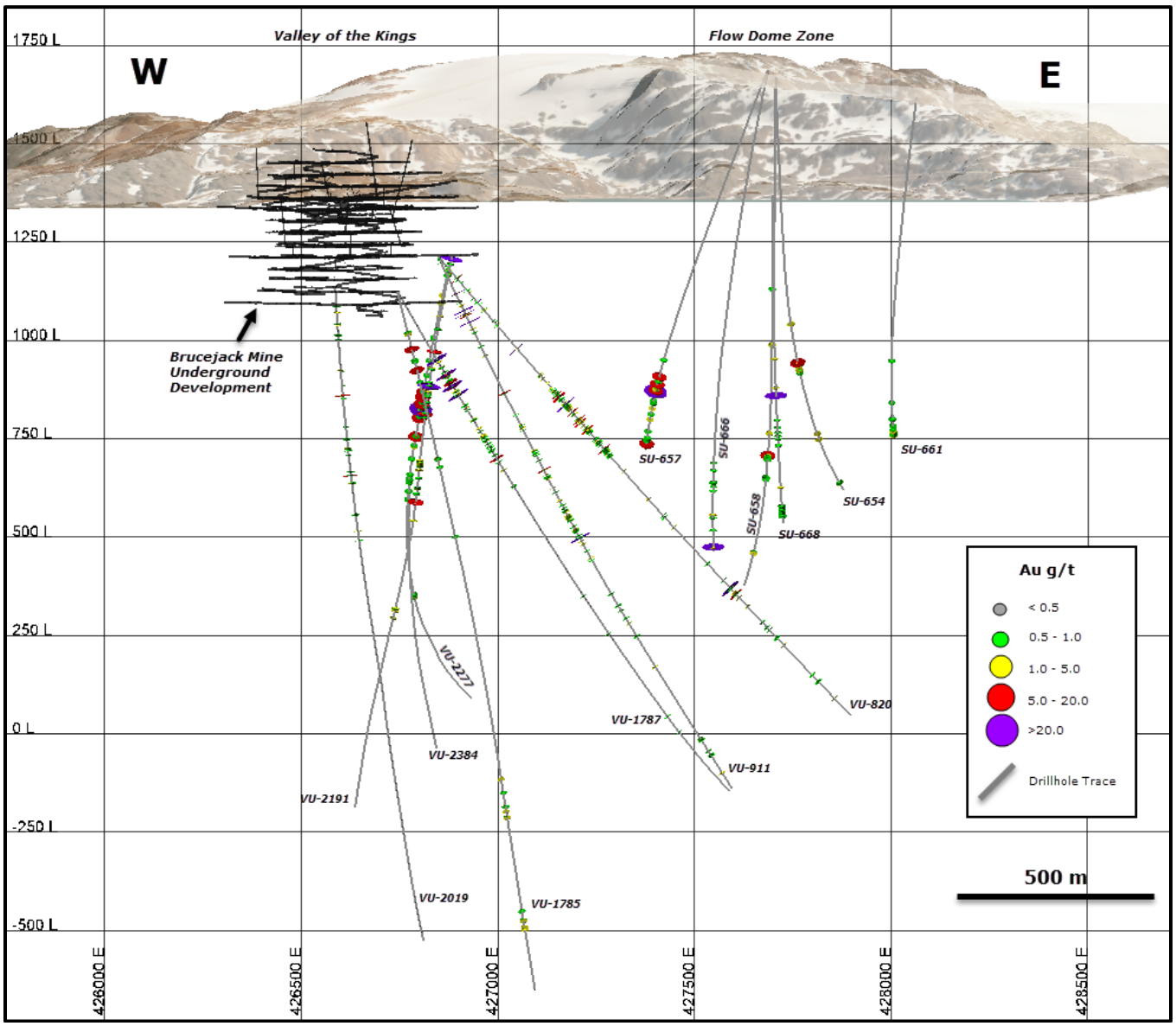


Source: Pretivm (2019)

9.3 Exploration – 2019

Underground exploration drilling to further investigate the extent of the epithermal system and potential porphyry source continued in 2019. A total of 8,810 m of drilling was completed in six underground exploration drillholes from the 1,200 m; 1,130 m; and 1,110 m levels in the underground mine. The results of this drilling demonstrated the continuity of gold mineralization below the Valley of the Kings, with visible gold mineralization observed more than 500 m below the current VOK resource (Figure 9-5).

Figure 9-5: Cross Section of the Brucejack Deposit (Looking North) Showing Gold Assay Intersections from the 2015 Surface Exploration Drilling and 2018–2019 Underground Deep Exploration Drilling



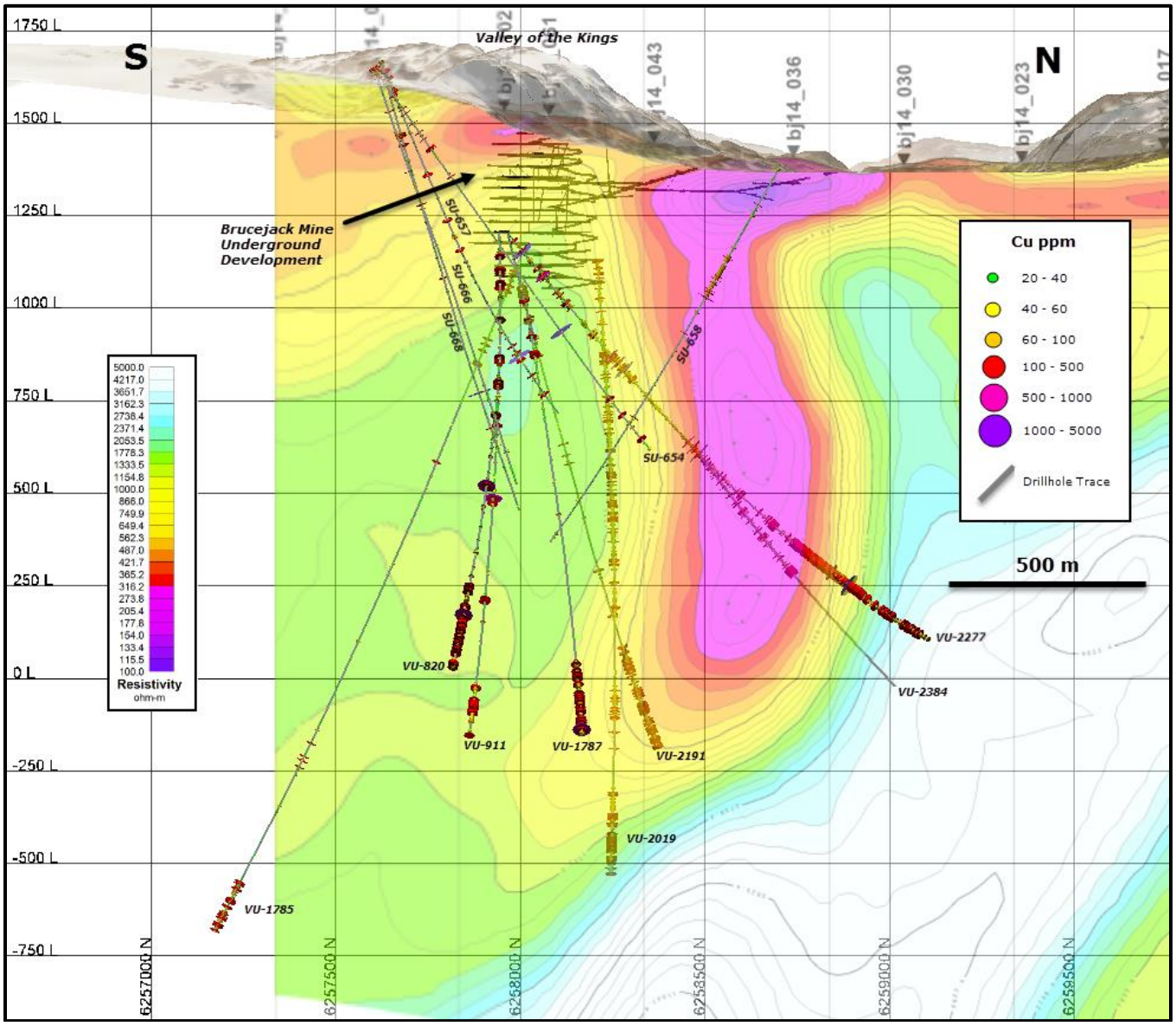
Source: Pretivm (2020)

During the initial stages of the 2019 exploration drilling program, the focus remained on testing exploration targets beneath the Flow Dome Zone, with drillholes VU-1785 and VU-1787 drilled as broad step-outs (to the south and north, respectively) from drillholes VU-820 and VU-911 from the 2018 exploration drilling campaign. Anomalous copper mineralization was encountered in VU-1787 between 1,270 and 1,536 m, coincident with propylitic-altered volcainclastic and/or epiclastic rocks. A zone of elevated copper mineralization was encountered at the bottom of drillhole VU-1785 (1,850 to 2,004 m). This mineralization was hosted in unaltered, finely laminated mudstones and siltstones of the upper-Stuhini Formation. Pretivm considers this mineralization to be primary in origin and not the product of porphyry-hydrothermal enrichment and is therefore not a priority for follow-up drilling at this time.

Drill core samples at various depth intervals in the exploration drillholes (including 2018 exploration drillholes) were collected and analyzed for chlorine content in apatite, which was observed to increase with depth down-hole (McLeish, 2019; after Williams & Cesbron, 1977 and Roegge et al., 1974). At the same time, analysis of a suite of rock chip samples collected from stations at various elevations within the underground mine showed that gold content in electrum and iron content in sphalerite both increased with depth in the underground mine (McLeish, 2019). Collectively, these geochemical trends were interpreted as being consistent with higher temperatures approaching a porphyry source (McLeish, 2019); furthermore, the porphyry source may be more centrally located than previously thought, located deep beneath the Valley of the Kings epithermal gold deposit. Drillhole VU-2019 was collared with a steep (-84°) dip angle to test beneath and slightly north of the VOK deposit, targeting an area where Mesozoic dykes modelled in the VOK, West Zone, and Shore Zone appeared to coalesce at depth. Weak, anomalous copper mineralization was observed throughout VU-2019, increasing towards the end of the drillhole from 1,450 to 1,677 m. Patches of acicular tourmaline grains and tourmaline veinlets, and occurrences of chalcopyrite and molybdenite, were coincident with an interval of phyllic alteration between 1,090 to 1,320 m. A step-out drillhole (VU-2191), drilled to the west of VU-2019, intersected similar, weak copper mineralization over an interval from 1,175 to 1,473 m.

To further aid exploration efforts, a review of previously collected magnetotelluric (CSMT) resistivity data was completed by Quantec Geoscience Ltd., producing a series of 2D inversions displaying subsurface resistivity trends along north-south and east-west oriented section lines. Section line BJ19-03 (Figure 9-6) identified a large, ‘pipe-like’, low-resistivity anomaly located approximately 200 m north of the Valley of the Kings that extended from surface to a depth of 1,360 m (from 1,400 to 40 m elevation). Drillhole VU-2277, targeting the lower portion of the resistivity anomaly, intersected an interval of strong propylitic alteration and relic potassic alteration coincident with the northern boundary of the anomaly, from 1,200 to 1,251 m. Drilling results showed an interval of highly anomalous copper mineralization between 1,200 to 1,122 m, occurring within a broader interval of weak copper mineralization from 1,150 to 1,415 m depth. To investigate the alteration and mineralization seen in VU-2277, a new drillhole (VU-2384) was wedged from VU-2277 at 728 m depth to test 100 m vertically below the zone of highly anomalous copper mineralization. Drillhole VU-2384 continued into 2020 with visual observations indicating the hole had intersected a broad interval of strong propylitic alteration similar to that seen in VU-2277; however, final assays had not yet been received at the time of writing.

Figure 9-6: Cross Section (Looking West) of Quantec Geoscience Ltd. 2D CSMT Line BJ19-03 Showing 'Pipe-like' Resistivity Low and Copper Assay Intersections from 2015 Surface Exploration Drilling and 2018–2019 Underground Deep Exploration Drilling

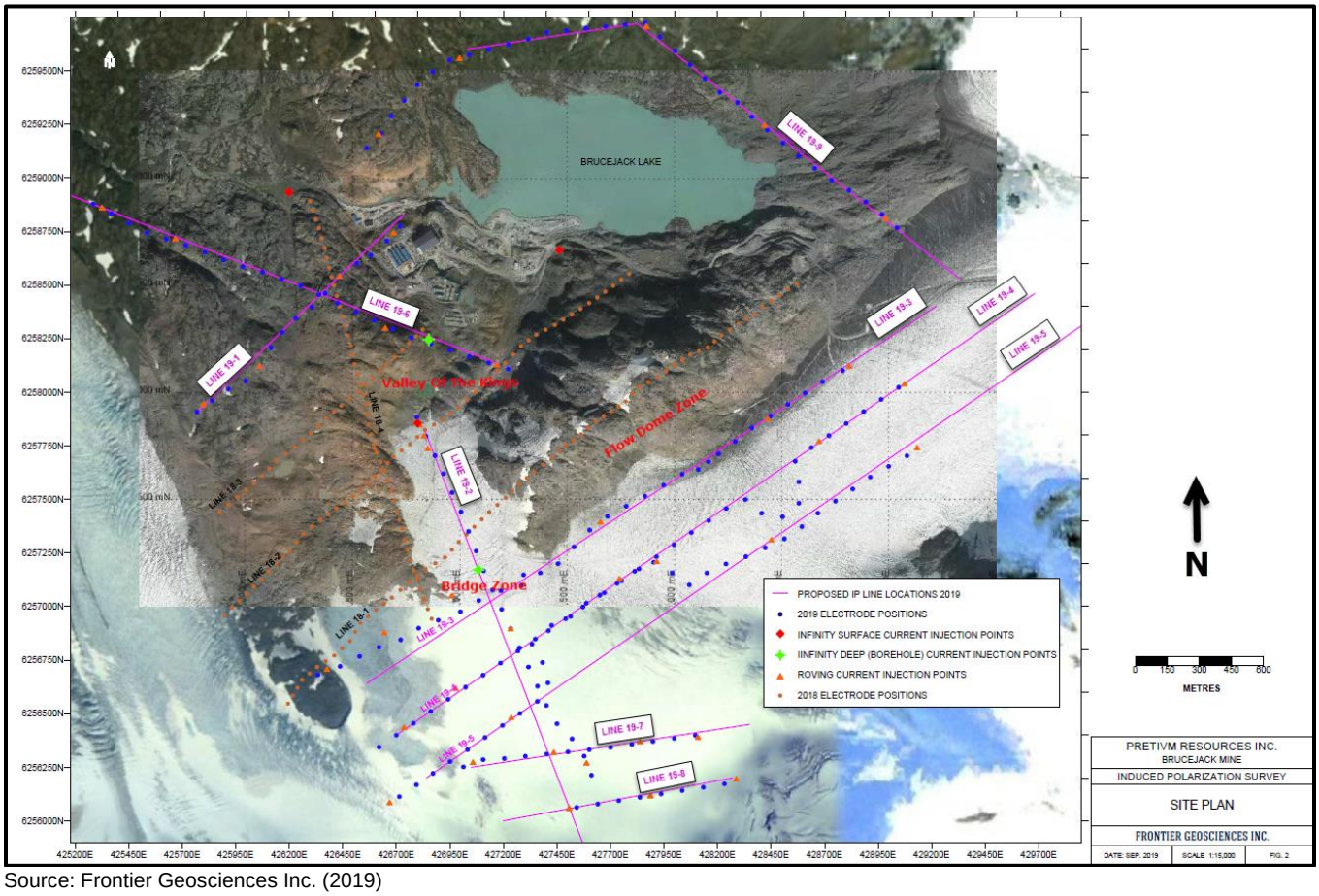


Source: Quantec Geoscience Ltd. and Pretivm (2020)

Additional ground-based IP geophysical surveying was conducted by Frontier Geosciences Inc. in 2019, as a follow-up to the surface geophysical survey completed in 2018. The survey consisted of a large-scale, 3D IP survey that covered approximately 19.8 km, over 9 separate lines. The survey was carried out using a 24-bit, full waveform, time domain IP system powered by a pair of synchronized 5 kW GDD Model Tx-4 5000 transmitters. Working together, this transmitter pair can produce up to 10 kW of power. Electrode spacing was 100 m. Downhole current injection electrodes were placed in drillholes VU-1785 and VU-2019 to provide additional depth resolution for the 2019 IP survey.

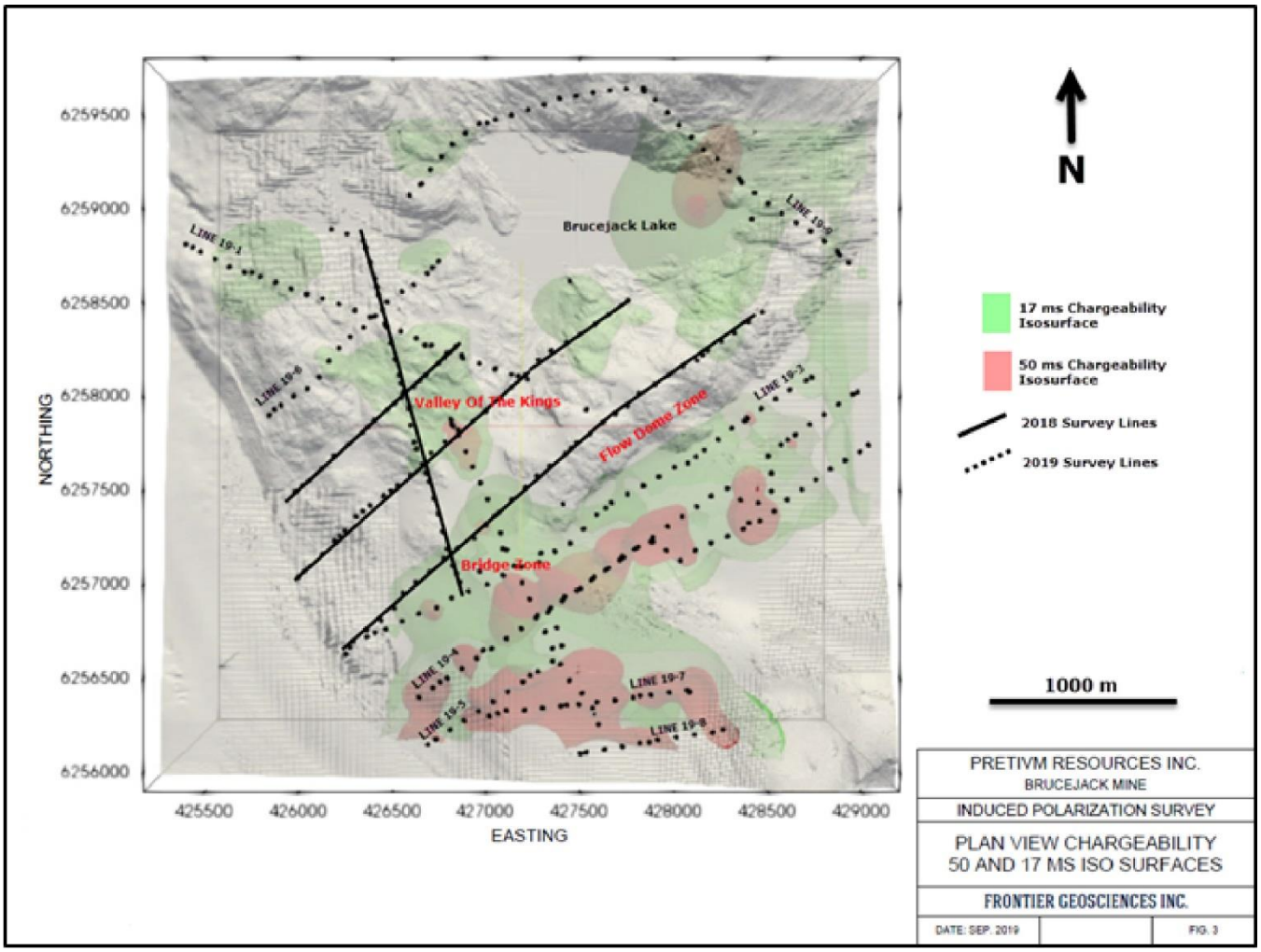
The final results and report from Frontier Geosciences Inc. had not been received at the time of writing; however, preliminary results for the survey are currently being used in conjunction with other geological and geophysical data for additional brownfields targeting of potential porphyry sources at depth near the Brucejack Deposit. The areas of highest chargeability identified in the IP survey are concentrated under the glacier to the south and east of the Bridge Zone, and on the northeast side of Brucejack Lake (Figure 9-7). High chargeability may indicate the presence of disseminated sulphides hosted within the bedrock in these areas (Figure 9-8). Low resistivity was recorded over much of the survey area (Figure 9-9), likely due to the presence of hydrothermally altered rocks and clay minerals that are widespread in the Brucejack Deposit and surrounding regions (*see also* Figure 9-2).

Figure 9-7: Plan View Showing Location of the 2019 Frontier Geosciences Inc. Surface IP Survey Lines and Electrode Locations



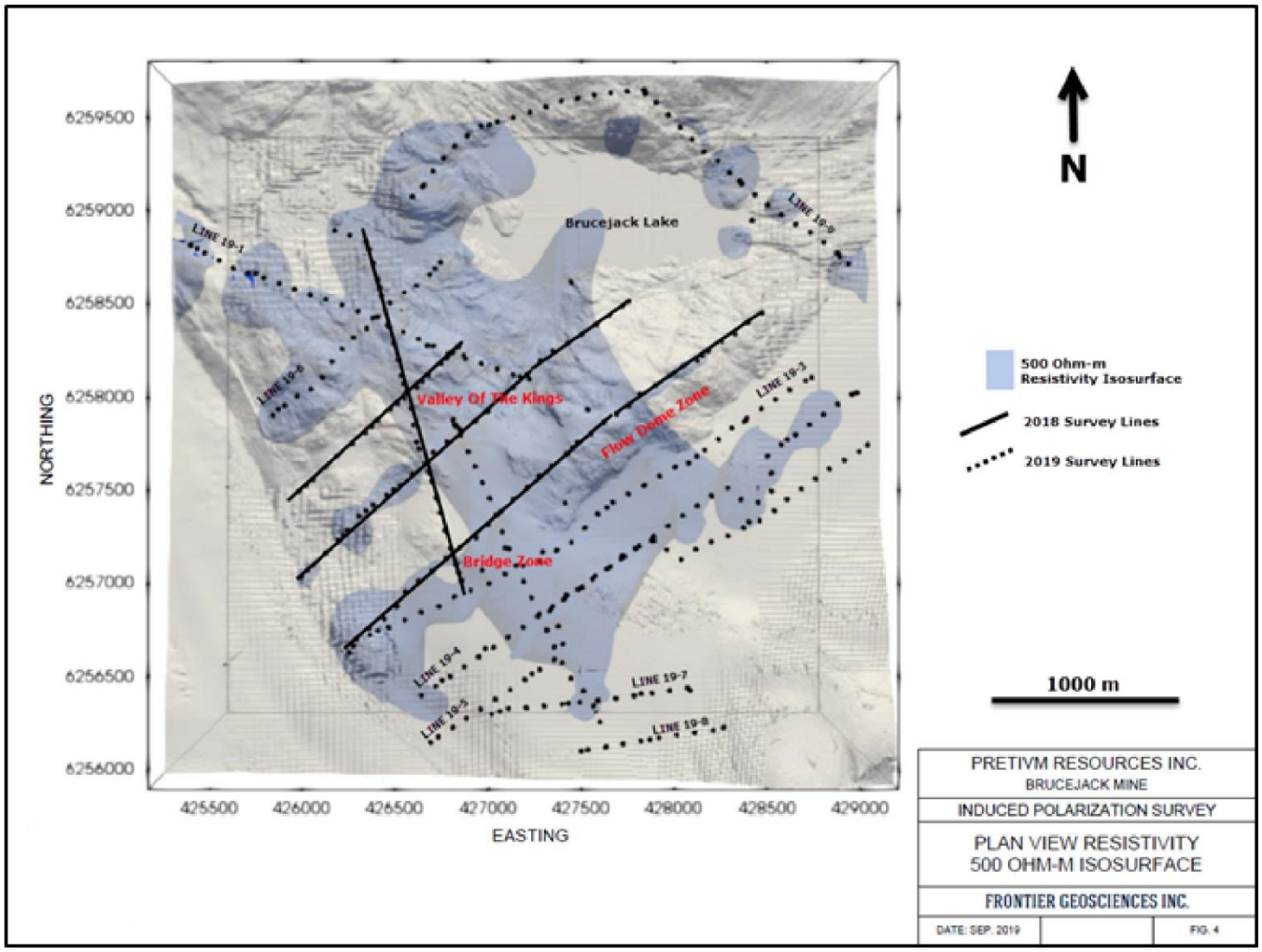
Source: Frontier Geosciences Inc. (2019)

Figure 9-8: Plan View Showing the 17 and 50 ms Chargeability Isosurfaces from the 2019 Frontier Geoscience Inc. IP Survey



Source: Frontier Geosciences Inc. (2019)

Figure 9-9: Plan View Showing the 500 OHM-M Resistivity Isosurface from the 2019 Frontier Geoscience Inc. IP Survey



Source: Frontier Geosciences Inc. (2019)

10.0 DRILLING

Drilling has been the primary tool used in the exploration of the Brucejack Property (Table 10-1; Figure 10-1). Details of drilling conducted by Pretivm up to and including 2018 is provided in Jones (2012c; 2014), Board et al. (2017) and in the April 2019 NI43-101. This section provides a summary of resource definition and exploration drilling conducted by Pretivm in 2019; drill numbers available at the time of resource cutoff (September 30, 2019), and therefore included in the updated resource estimate, are provided in italics.

Table 10-1: Drilling Summary for the Brucejack Property

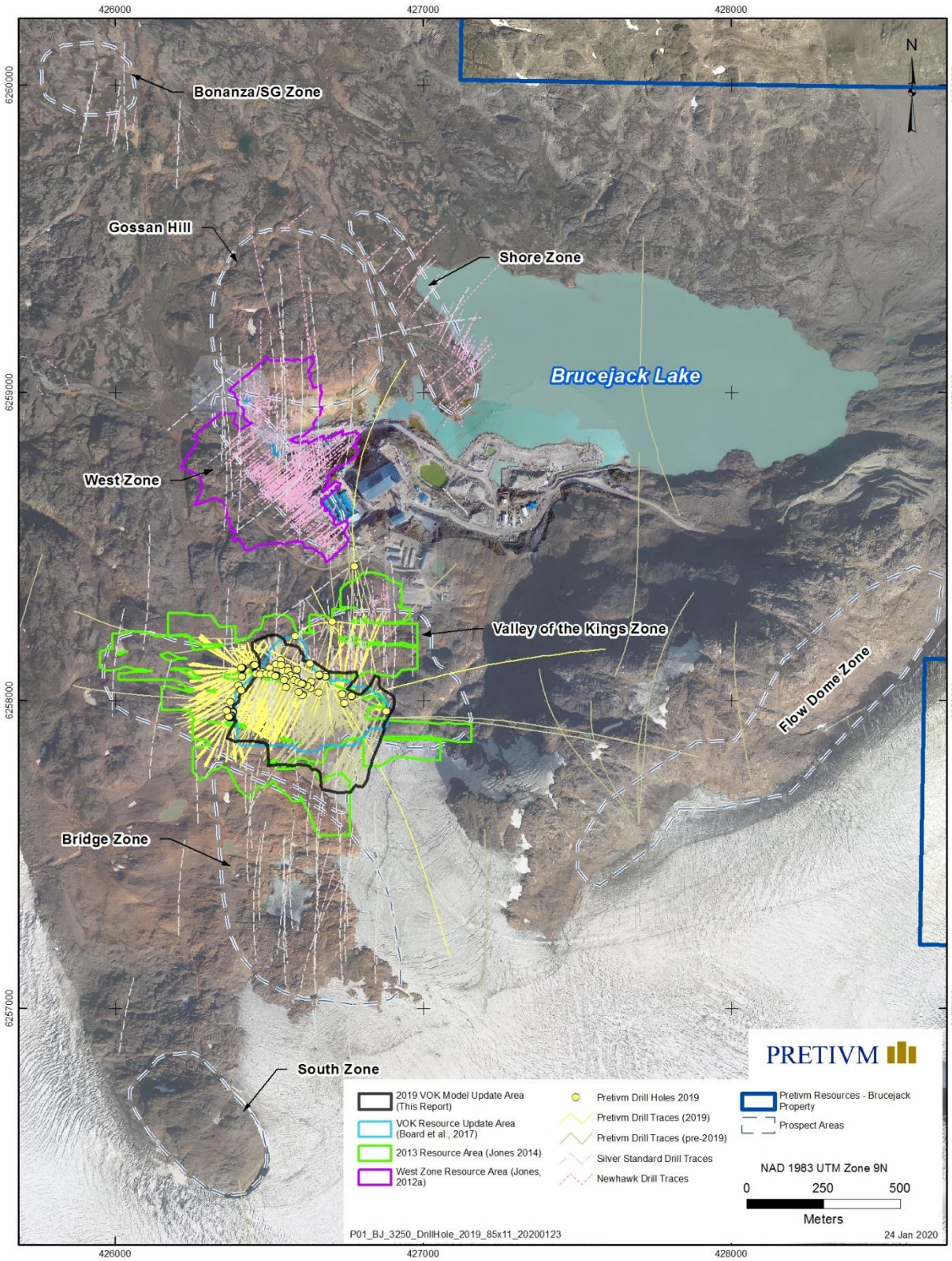
Year/ Program	Collar Location	Hole Type & Sample Size	No. of Holes	Total Meters	Goal and Targets
Historical 1960–1994	Surface	Core (BQ, NQ, HQ)	405	52,142	West Zone, Shore Zone, Galena Hill Zone, and Gossan Hill Zone.
	Underground*		442	33,750	West Zone definition, drilled proximal to the West Zone exploration ramp, drill density of approximately 5 m centres between 5 m and 10 m spaced sections.
Silver Standard 2009–2010	Surface	Core (HQ)	110	51,382	Exploration and discovery of areas with bulk tonnage mineralization locally associated with discreet high-grade intersections; Valley of the Kings Zone targeting confirmed the high-grade exploration potential of the zone.
Pretivm 2011–2013	Surface	Core (NQ, HQ, PQ)	529	184,788	Definition of high-grade resources in Valley of the Kings Zone, West Zone, and surrounding areas (HQ, some NQ at depth). Zones within 150 m of surface were drilled at 12.5 m centers. Drilling at 350 m below surface generally achieved 25 m centers, and drilling at greater depths generally achieved 50 m centers. Water well and geotechnical PQ drilling included 674 m in 13 drillholes.
	Underground	Core (HQ)	409	38,840	Definition of the bulk sample area and related proximal targets.
Pretivm 2014–2016	Surface	Core (HQ)	41	11,919	Tested deep high-grade Inferred blocks in the December 2013 Mineral Resource, tested depth potential of the Valley of the Kings Zone mineralization system, and included geotechnical (condemnation and water well) drilling.
	Underground	Core (HQ)	368	64,022	Infill drilling to achieve a nominal 7.5 to 10 m spacing with a goal of increasing confidence in grade estimates for the stopes to be mined in the first three years of operation. A service drillhole linking the mine and surface was drilled in 2016.

table continues…

Year/ Program	Collar Location	Hole Type & Sample Size	No. of Holes	Total Meters	Goal and Targets
Pretivm 2017–2018	Surface[1] & Underground	Core (NQ, HQ, PQ)	996	74,737	Predominantly stope infill (7.5 to 10 m center), stope definition (4 to 7.5 m center), and resource expansion (15 to 20 m center) HQ drilling; west-directed drilling testing north-south structures around Brucejack Fault (18 drillholes, 5,288 m, HQ); two deep exploration holes for porphyry targeting (3,138 m, HQ→NQ), 14 surface water wells (2,043 m, PQ).
		RC (4”)	97 (Infill) 74 (Defn) 178 (Prod)	5,049 1,736 2,461	Testing of reverse circulation method and definition and infill of stopes; nominal 7.5 to 10 m spacing (infill); 4 to 7.5 m spacing (definition), and 2 m spacing (production).
Pretivm 2019	Surface[1] & Underground	Core (NQ, HQ)	752 *(555 assayed)*	124,609 *(89,121 m assayed)*	Predominantly underground resource expansion (15 to 30 m centers) HQ drilling; five deep exploration holes plus one wedge hole for porphyry targeting (8,810 m, HQ→NQ)[2], and 18 surface resource expansion holes (2,298 m, HQ). *555 holes (89,121 m) had assays available at resource cutoff date.*
		RC (4”)	1423	23,552	“Production holes” intended for use as grade control and blast holes to build data set for future grade control methodologies. All RC production holes and samples were excluded from the resource data export and were not included in the updated resource.

Notes: [1]Limited surface drilling.
[2]One hole ongoing at end of 2019 and continued in 2020.
Defn – Definition; Prod – Production

Figure 10-1: Plan View of Brucejack Property Drilling In and Around the Brucejack Deposit



Source: Pretivm (2020)

10.1 Pretivm Drilling (2019)

10.1.1 Drilling Activities

Underground diamond drilling conducted on the Brucejack Property in 2019 included exploration (deep drilling) and resource expansion (15 to 30 m centers) fan drilling in the Valley of the Kings Zone (Figure 10-1). The majority of 2019 drilling was underground HQ diamond core aimed at increasing confidence and resolution to the mineral resource (Table 10-1). Underground resource drilling included 113,507 m in 727 underground diamond drillholes; 555 of these holes had results available at the time of resource cutoff for a total of 81,060 m. Surface HQ diamond core resource expansion drilling totaled 2,298 m in 18 drillholes; two holes had assay data for a total of 239 m of assayed core at the time of resource cutoff. Underground deep exploration drilling totaled 8,810 m in six drillholes, one of which was a wedge hole. Assay data for four of these holes were available at the time of resource cutoff, corresponding to a total of 6,025 m. These deep exploration drillholes were drilled towards the east, southeast, and north to test the depth extension potential of the Valley of the Kings Zone mineralization, porphyry mineralization at depth, and the potential source of the Valley of the Kings mineralization (see Section 9.0).

10.1.2 Drilling Contractors and Equipment

Hy-Tech Drilling Limited (Hy-Tech), based out of Smithers, BC, has been the primary drilling contractor on the Brucejack Project since 2013. Hy-Tech's TECH B5000 diamond core drill rigs have been used for all surface and underground exploration and resource expansion drilling on the Brucejack Property. In 2019, Hy-Tech tested a modified TECH B5000 underground diamond core rig on a smaller feed frame to improve mobility between drill sites as part of the underground resource definition drilling program. Testing showed that there was minimal improvement in mobility and reduced drill production with the modified drill, so it was removed from site.

10.1.3 Drill Coordinates and Downhole Surveys

Drillhole survey procedures in 2019 were similar to previous years (e.g., Jones 2014).

Diamond drillhole collar locations were surveyed and marked up by Pretivm's mine survey team prior to drilling, and re-surveyed post-drilling. All collar surveys were obtained using a total station theodolite in conjunction with a regular array of permanent ground control stations. Collar azimuth and dip information was recorded for each diamond core drillhole using a Reflex TN-14 Gyro instrument operated by the drill contractor. Downhole dip and azimuth data were measured for diamond core drillholes by the drill contractor using primarily a Reflex EZ single shot instrument at nominal 25 to 50 m intervals. A Reflex EZ Gyro was used to complete downhole surveys for most of the deep exploration holes.

Drillhole survey data were collected, entered into the GeoSpark logging interface, and processed by Pretivm's mine geologists. The data were verified and imported in the GeoSpark back-end geological database by Pretivm's database manager. Additional 3D checks were conducted in the Maptek Vulcan mining software: collar locations were checked in relation to surveyed topography and underground mine development solids, and downhole survey traces were checked for wayward deviations.

10.1.4 Diamond Drill Core Logging Procedures

Core logging procedures previously established for the Brucejack Property (Jones 2014) were followed during the 2019 drilling. Details on core handling and sampling are presented in Section 11.0.

Core logging is conducted in well-lit core shacks on appropriately labelled core boxes. Exploration and resource expansion drill core was geotechnically (recovery, rock quality designation (RQD), faults, fractures, joints, etc.) and geologically (lithology, structure, veining, alteration, and mineralization) logged prior to being marked up for sampling and photographed.

Core logging information was recorded in the GeoSpark core logging software, which includes data validation, picklists, and minimum required fields to ensure data capture is consistent and valid. Additional data validation is conducted by Pretivm's database manager prior to importing core logging data into the Structured Query Language (SQL) GeoSpark database. These include collar, survey, and interval (missing/overlapping geological and sampling intervals) checks and actual to planned cross-referencing.

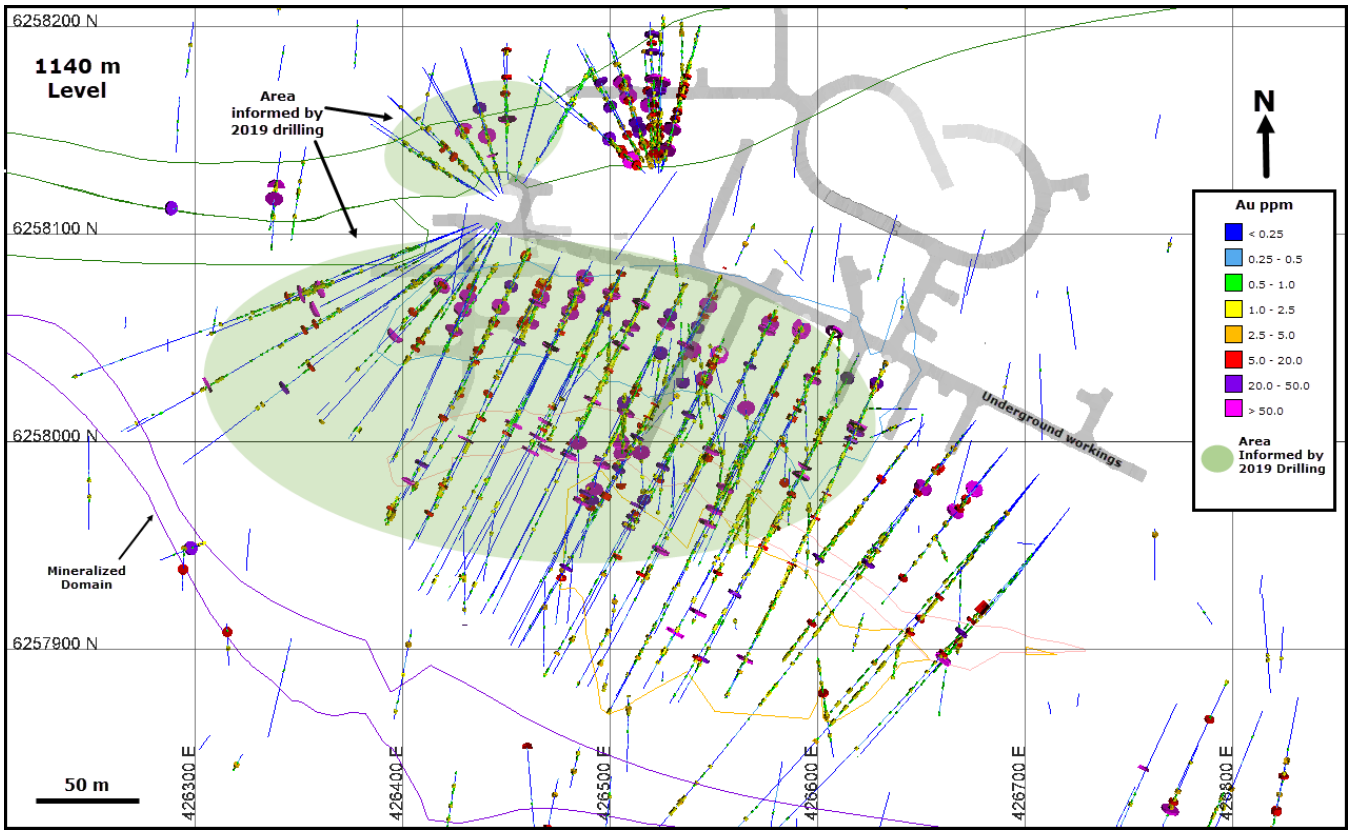
10.1.5 Summary of Results

The resource expansion drilling (15 to 30 m spacing) conducted during 2019 was designed to expand and upgrade the Valley of the Kings resource in the southern, western, and northwestern portions of the deposit. Drilling was completed in two phases with phase one being drilled from the 1,170 m; 1,140 m; and 1,110 m levels, and phase two was drilled from the western end of the 1,320 m level. Phase two was still ongoing at the writing of this report. Phase one drilling was primarily completed towards the southwest, targeting an area between the 1050 and 1200 levels across the Valley of the Kings Zone. Phase two drilling targeted a large area between the western extents of the Valley of the Kings development and the Brucejack Fault between the 1200 and 1380 m levels. A surface resource drilling program commenced in the fall of 2019 to increase confidence in mineralized domains in the upper levels of the Valley of the Kings Zone.

The resource fan drilling conducted during 2019 was designed to increase the drill density within the Brucejack resource and to test mineralized domains to depth in the south, the west, and northwest of the Valley of the Kings Zone. The drilling confirmed the geological interpretation of continuous, dominantly east-southeast-west-northwest trending structural vein and vein stockwork corridors containing ubiquitous, yet highly variable and erratically distributed gold and silver mineralization in the Valley of the Kings Zone (Figure 10-2 and Figure 10-3).

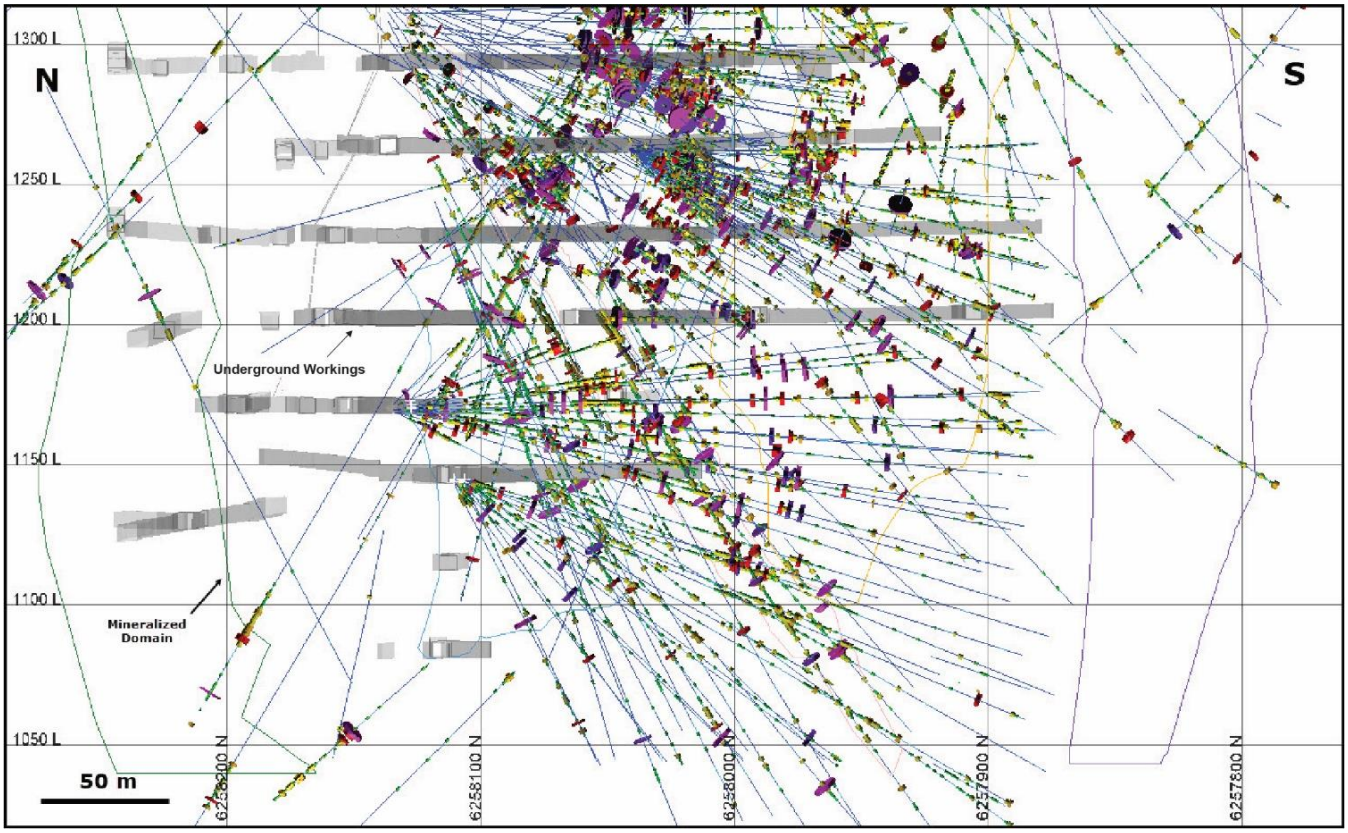
The deep exploration drillholes drilled in 2019 were successful in demonstrating the presence of Valley-of-the-Kings-Zone-style mineralization at depth. They were also successful in intersecting porphyry-style alteration and mineralization at depth (see Section 9.2).

Figure 10-2: Plan View on the 1,140 m Level in the Brucejack Gold Mine Showing 2019 Drilling and Valley of the Kings Zone Mineralized Domain Interpretations (Viewing Window ±20 m)



Note: Disks are expanded to form intervals of gold intersections greater than 2.5 g/t.
Source: Pretivm (2020)

Figure 10-3: Example SW-NE Cross Section Along Mining Crosscut 17 (Central Parts of the Mine) Showing Workings, Drilling, and Mineralized Domain Interpretations in the Valley of the Kings Zone of the Brucejack Deposit (Viewing Window ±20 m)



Note: Disks are expanded to form intervals of gold intersections greater than 2.5 g/t.
Source: Pretivm (2020)

10.2 Opinion of Qualified Person

The QP is of the opinion that the drilling, core logging, and sample handling procedures have been conducted using industry best practices. The appropriate level and quality of information has been obtained to provide sufficient confidence in drillhole spatial location for three-dimensional geological, geotechnical, and grade modelling of the Brucejack Deposit. There are no apparent drilling or recovery factors that would materially impact the accuracy and reliability of the drilling results.

11.0 SAMPLE PREPARATION, ANALYSES, AND SECURITY

Sample preparation, analysis, and security for the years 2014 to 2018 inclusive are summarized in this section. For detailed sample preparation and analysis information prior to 2014, the reader is referred to Jones (2014) and Ireland et al. (2014).

11.1 Sample Preparation, Analysis, and Security

11.1.1 Drillhole Sampling

The majority of the samples collected between 2014 and 2019 were from HQ diameter diamond drillcore. Drillcore was placed in core boxes at the drill rig (both on surface and underground), with drill footage markers recorded on wooden spacers and drillhole numbers and box numbers recorded on each box. Batches of core boxes were sealed and transported to Pretivm's core logging and processing facilities on site under the control of geological staff. Core was then geologically and geotechnically logged and photographed prior to being sampled.

Sample intervals were delineated by the core logging geologist, taking geology into account. Samples were generally broken at key lithological and stockwork zone contacts. Samples were collected at intervals of 1 to 1.5 m in length for surface and underground exploration drillholes, as well as for underground resource definition and infill drillholes. Up to the end of 2017, significant intervals of visible gold were sampled down to a minimum length of 0.5 m. All exploration drillholes testing poorly drilled or undrilled areas were marked for half core sampling with a centerline drawn down the core axis by the core logging geologist. All resource definition and/or infill drillholes were whole core sampled. Each of the diamond drillholes from the programs between 2017 and 2019 was sampled in its entirety. Whole core sampling was conducted in an effort to eliminate any sampling bias potentially associated with preferential half core selection as a function of visible electrum occurrences, as well as to ensure that any electrum in a given length of core would have a chance of being sampled.

Sampled drillcore was placed in numbered plastic bags with appropriate sample tags. Sealed sample bags were then grouped and sealed in appropriately labelled rice sacks and sent by ground transportation to the ALS sample preparation facility in Terrace, BC. Hard copies of sample manifests were enclosed with each shipment and also e-mailed directly to the sample preparation facility ahead of shipping. Ground sample preparation was either by an independent operator (Bandstra Transportation Systems or Tsetsaut Ventures Ltd.) or by a Pretivm operated vehicle depending on quantity of samples being shipped.

RC samples were collected as part of the underground RC drillhole trial conducted in early 2018. Two, 2 kg dry RC sample splits were collected from a cyclone splitter directly into pre-labelled plastic sample bags every 1.52 m. Bags of single sample splits were grouped into four samples per rice bag. Rice bags were then collected in apple crates, sealed with a lid, and then shipped to the ALS sample preparation facility in Terrace, BC in the same way as for the drillcore (see above).

Sampling and shipment creation procedures were conducted by Pretivm personnel prior to dispatch off site to the ALS sample preparation facility in Terrace, BC. ALS checked all samples against the electronic and hard copy sample manifest and assumed custody of the sealed samples upon receipt.

11.1.2 Sample Preparation and Analysis by Analytical Laboratory

ALS Vancouver has been the primary analytical laboratory for the analysis of samples from the Brucejack Property since 2009. Umpire check analytical laboratories used include MSALabs and Met-Solve. The ALS laboratory is used to provide umpire checks on the quality of production sample assays conducted at the on-site laboratory. The ALS analytical laboratory in Vancouver is an International Organization for Standardization (ISO) 9001-2015 certified and ISO 17025:2005 United Kingdom Accreditation Service (UKAS) ref. 4028 accredited laboratory. MSALabs has both ISO 17025 and ISO 9001 accreditation. These laboratories are all independent of Pretivm.

Primary sample preparation methods and analytical packages used for Pretivm drill samples from 2014–2019 are summarized in Table 11-1. After sample shipments reach the sample preparation facility, they are in ALSs custody for sample preparation, inter-laboratory shipping, and analyses. It is ALSs standard operating procedure to check all samples received from Pretivm against the electronic and hard copy sample manifests, as well as for any potentially missing sample material, compromised plastic sample bags, broken zip closures, or torn/broken rice bags upon receipt. Pretivm has not been alerted to any potential sample tampering by ALS. Laboratory sample reduction and analytical procedures have been conducted by independent accredited companies using industry standard methods. Pretivm ensured quality control was monitored through the frequent insertion of blanks, certified reference materials, and duplicates.

11.1.3 Specific Gravity and Bulk Density

Density determinations to support the resource model were carried out prior to 2014 as described in Jones (2014). In 2019, Pretivm obtained 816 new pulp specific gravity (SG) measurements and 139 corresponding core SG and bulk density (BD) measurements from key lithologies and drill locations to update the SG interpretation. 717 SG and 133 BD measurements were available at the resource cutoff date. The new data were reported by ALS minerals using the same laboratory methodology used prior to 2014.

Comparison between the pulp SG and core density measurements indicated that the core density is on average the same as the pulp SG within the siliceous zone. Bulk density estimates have been reasonable predictors of tonnage for production. Additional SG and bulk density measurements will be needed as the resource model is expanded in areas away from the current workings to reflect the change in lithology at depth, across, and along strike from the known mineralized zones.

Table 11-1: Sample Preparation and Analytical Methods Conducted on Pretivm Drill Samples Between 2014 and 2018

Year	Sample Preparation	Gold Analytical Methods	Multi-element Methods (incl. Ag and Overlimits)
2014-2018 (Q1)	Diamond Drill Core Samples 1.Crush entire sample to 70% <2 mm 2.Riffle split 3.Pulverize 500 g to 85% <75 µm	30 g charge weight fire assay by AA finish to upper limit at 10 ppm (Au-AA23) Au overlimit trigger at 10 ppm to complete 30 g fire assay with gravimetric finish (Au-GRA21) Au overlimit trigger at 10,000 ppm to complete high precision analysis by fire assay with gravimetric finish (Au-CON01) Visible Gold (VG) Samples: Au by screen fire assay for VG-bearing samples (Au-SCR21, using 30 g charge weights)	33 element package (including Ag) using a four-acid near-total digestion and an ICP-AES analysis (ME-ICP61). Ag overlimit trigger at 100 ppm Ag for three-acid digestion with HCL leach and ICP-AES or AAS finish (AG-OG62) Ag overlimit trigger at 1,500 ppm Ag by 30 g fire assay with gravimetric finish (Ag-GRA21) Overlimit triggers also for Zn, Pb, Cu by their respective OG62 methods (Zn-OG62, Pb-OG62, Cu-OG62)
2018 (Q2)	1.Crush entire sample to 70% <2 mm Diamond Drill Core Samples 2.Riffle split to 1x1 kg pulp for SFA 3.Pulverize to 85% passing 75 µm Resource RC Drill Samples 2.Riffle split into two, 2 kg splits 3.Pulverize 2 kg to 85% <75 µm 4.Riffle split pulp in half for analysis	Whole Core and Resource RC Drill Samples Au total parts per million by screen fire assay for all samples (Au-SCR24, 50 g charge weights) RC Samples Only Au parts per million by Leachwell head/tails (Au-AA15)	Diamond Drill Core Samples: unchanged from 2014 Multielement data not collected for RC drill samples
2018 (Q3) onwards	Diamond Drill Core Samples 1.Crush entire sample to 70% <2 mm 2.Riffle split 3.Pulverize 2 kg to 85% <75 µm Production RC Samples 1.Crush entire sample to 70% <2 mm 2.Riffle split 500 g 3.Pulverize to 85% <75 µm	Diamond Drill Core Samples Au parts per million by 50 g fire assay with AA finish to 18 ppm (Au-AA26; upper limit 100 ppm) Requested trigger for Au overlimit at 18 ppm for completion of 50 g fire assay by gravimetric finish (Au-GRA22) Au overlimit trigger at 10,000 ppm to complete high precision analysis by fire assay with gravimetric finish (Au-CON01) Production RC Samples Au by fire assay with AA finish (20 to 30 g charge) with upper limit of 10 ppm Au overlimit trigger for >10 ppm by fire assay with gravimetric finish	Diamond Drill Core Samples: unchanged from 2014 Multielement data not collected for production samples

Notes: ALS method codes shown in parentheses.
SFA – Screen Fire Analysis; AA – Atomic Absorption; VG – Visible Gold; ICP – Inductively Coupled Plasma; AES – Atomic Emission Spectroscopy; AAS – Atomic Absorption Spectroscopy

11.2 Quality Assurance and Quality Control

Pretivm's QA/QC protocols for the Brucejack Property included tests for data accuracy, precision, and sample cross-contamination. Field control samples were submitted together with drillhole samples to control and assess these key indicators of database quality.

Accuracy, a measure of the closeness to the true value, was tested using matrix-matched round-robin certified standard samples (certified by Smee and Associates Consulting Ltd.). Analytical precision (repeatability of results) was checked using duplicate samples. Potential cross-contamination between samples as a result of smearing of high-grade samples was checked through the use of coarse blank samples.

Field control samples were inserted into the sample stream at a frequency of 1 standard, and 1 blank sample and a minimum of 1 coarse reject or pulp duplicate sample per 20 regular samples. Additional field control blank samples were inserted immediately following samples with logged visible gold to quantify and avoid any potential cross-contamination between samples as a result of smearing from high-grade samples. Quarter core samples served as field duplicate control samples for exploration drillholes prior to 2014. Coarse reject duplicate samples have been used as field control duplicate samples to assess precision for whole core resource definition and infill drillholes from 2014 through to the present (2019). Coarse rejects were also used as field control duplicates for resource RC drilling. Secondary laboratory duplicate assays were conducted on approximately 5% of the mineralized ALS pulps at the Met-Solve (2014–2015) and MS Analytical laboratories (2016–2019) using comparable analytical methods.

From 2011–2016, GeoSpark Consulting, a Nanaimo, BC based geological database software and services company that is independent of Pretivm, managed the Brucejack assay imports and completed assay QA/QC for the database. From 2017 to present, assay data has been imported into the same database and managed by Pretivm; however, GeoSpark was retained in 2017 and 2018 to independently conduct routine QA/QC checks on Pretivm's database and compile QA/QC reporting through its GeoSpark Assure Quality Service program. QA/QC reporting for the 2019 program was completed in-house using the Geospark QAQC module. Real-time QA/QC review of Pretivm's drillhole sample data includes sample reruns where field control standard results warrant further investigation. Pretivm's drilling and sampling database has been collected, imported, stored, and managed using GeoSpark's GeoSpark Core Database System software since 2011.

Numerous QA/QC reports have been written verifying the quality of Pretivm's assay data and its applicability for use in resource estimation. QA/QC results from the 2011 through 2013 program are summarized in Jones (2014), Graindorge and Carlson (2014), and Vallat (2011; 2012; 2013; 2014). QA/QC results from the 2014 through 2016 programs are summarized in Board et al. (2017), Mooney (2015), and Vallat (2015; 2016a; b). QA/QC results from the 2017 and 2018 drilling programs are summarized in Vallat (2018; 2019). QA/QC for the 2019 drill program is provided in Madsen (2019).

Results of the QA/QC analyses indicate acceptable levels of accuracy and precision across all of Pretivm's drill programs on the Brucejack Property considering the nuggety nature of the precious metal mineralization. The main conclusions are:

- Errant values on field standard control charts are minimal and usually reflective of mislabeled standards or blanks, or are considered as acceptable in unmineralized intervals.
- Duplicate assay analysis of field control samples indicates an improved degree of precision between field duplicate quarter core and coarse reject duplicate samples, for both gold and silver. Half absolute relative difference (HARD) statistics show that:
  - 90% of all quarter core field duplicates collected between 2009 and 2015 reported at a precision of better than 30% for gold and 25% for silver, whereas

  - 90% of all coarse reject samples collected from whole core sampling between 2013 and 2018 reported at a precision of better than 14% for gold and 11% for silver (16.2% for gold and 14.8% for silver for the 2019 coarse reject subset).
  - Coarse reject duplicate samples are at the same sample support (mass) as the original field sample and are therefore better than quarter core duplicate samples for representatively assessing precision at the field duplicate level, especially given the nuggety nature of Brucejack Deposit mineralization.
- The HARD statistic demonstrated that 90% of all pulp duplicate analyses conducted by ALS during 2019 and reported at a precision of better than 9.7% for gold and 12.5% for silver comparable to previous years. This level of precision in pulp duplicate samples is expected, given the nature of precious metal mineralization in the Brucejack Deposit.
- Overall, sample cross-contamination during sample preparation and assaying is considered to be within acceptable tolerance intervals.
- Umpire pulp check assays for gold show a good comparison between analytical laboratories with an acceptable level of precision being achieved.
- Gold and silver assay data used as input for resource modelling of the Brucejack Deposit should be considered as having a variance of ±15%, 9 times out of 10.

11.3 Qualified Person's Opinion on Sample Preparation, Security, and Analytical Procedures

It is the QP's opinion that the sample preparation, sample security, and analytical procedures are satisfactory and appropriate for generating data of suitable quality for use in resource modelling and estimation of the Brucejack Deposit.

12.0 DATA VERIFICATION

Details on data verification conducted prior to 2014 is presented in previous technical reports on the Brucejack Property (Ghaffari et al. 2010a; 2010b; 2011; Jones 2012a; b; c; 2014; Ireland et al. 2013; 2014).

12.1 Data Verification by Qualified Person

Continued verification of geological information and data used for mineral exploration and resource estimation on the Brucejack Property has been conducted by Mr. I.W.O. Jones, P.Geo., FAusIMM, Pretivm's independent QP for resource estimation.

Mr. Jones has been involved with the evaluation of the Brucejack Deposit since 2011 and has conducted numerous site visits (refer to Section 2.0) to the Brucejack Property through the various exploration drilling, resource definition drilling, bulk sample extraction, mine development, and production stages between 2011 and 2019. During his mine visits, Mr. Jones reviewed sufficient surface, drill core, and underground exposures to confirm the presence and nature of the mineralization and appropriateness of the interpreted geological framework.

Mr. Jones has verified Pretivm's drilling, sample preparation, handling, security, and chain of custody procedures on site, as well as surface and underground drillhole locations, core handling, and core logging. He has also reviewed Pretivm's database integrity and data quality for use in resource estimation (see Section 11.0). Mr. Jones has reviewed and been involved in all stages of the geological modelling and domain definition for the Brucejack Deposit between 2011 and present and has assessed the applicability and robustness of these interpretations in the underground mine workings at the Brucejack Gold Mine.

Mr. Jones visited the Contact Mill in Philipsburg, Montana, during the 2013 Bulk Sample Program and has visited the Brucejack Gold Mine mill on multiple occasions, both to understand the nature of coarse- versus fine-gold mineralization as part of resource estimation process improvement, and to improve approaches to reconciliation. Mr. Jones has observed abundant visible electrum intersections in drill core as well as in underground workings, verifying the presence, nature, and deportment of gold mineralization in the Brucejack Deposit. Mr. Jones developed and has continually assessed the appropriateness of the technique used for estimation of the Mineral Resource for the Brucejack Deposit through his ongoing working relationship with Pretivm.

Mr. Jones did not deem it necessary to collect and analyze additional independent drill core samples between 2014 and 2019 for the following reasons:

- A total of 5,923 oz of gold was produced from the 10,302 t bulk sample in 2013 (Ireland et al. 2014).
- Mr. Jones has inspected abundant visible gold showings in underground workings.
- The Brucejack Gold Mine is in production: 882,091 oz of gold was produced by the end of 2019.

12.2 Qualified Person's Opinion of the Verification

Sufficient checks have been completed to satisfy Mr. Jones that the Brucejack Gold Mine drilling and sampling data and geological interpretations are of suitable quality and robustness for resource modelling and estimation.

13.0 MINERAL PROCESSING AND METALLURGICAL TESTING

Metallurgical testing programs have been conducted on the Brucejack Property since 1988, with major work performed between 2009 and 2014, to investigate the amenability of mineralization of the Valley of the Kings Zone and West Zone to conventional separation processes for gold and silver recovery. A 2,700 t/d process plant was designed based on these test results. The test work review and process design descriptions were filed in 2014 FS (Ireland et al. 2014).

Between March and May of 2017, the Brucejack Gold Mine was successfully commissioned with the first gold pour on June 20, 2017. The plant reached full operation in Q3 2017. The average production rate reached 2,950 t/d during Q4 2017, which is higher than the design capacity. Plant throughput has been tested for 3,800 t/d.

To optimize process conditions and increase the process plant throughput to reach the target capacity of 3,800 t/d, Pretivm conducted a comprehensive process and metallurgical review, including new flotation and gravity tests and grinding circuit simulations and operation test trials. This section provides a summary of previous test work, including bench scale tests and bulk sample tests, plant production data since the beginning of full operation, and new test work to support plant expansion and improve metallurgical performance.

13.1 Previous Bench-Scale Test Work

The main testing programs on the Brucejack Property were conducted between 1988 to 2014 and were noted in Ireland et al. (2014).

Test work conducted between 1988 and 1990 investigated the mineralization's amenability to gravity concentration, flotation concentrate cyanidation, as well as gravity concentration plus whole ore cyanidation. Samples collected from the West Zone and the R-8 Zone were used for this test work and the results indicated that gravity separation would recover a significant portion of the contained gold. Cyanide leaching on the gravity tailings produced good overall gold recoveries, but poor silver recoveries. The samples appeared to respond well to flotation concentration; however, results showed that the R-8 mineralization might require finer primary grinding.

Test work conducted between 2009 and 2014 established the design basis for the 2014 FS (Ireland et al. 2014), which investigated head sample characteristics; varied processing methods, including gravity concentration, gold/silver bulk flotation, and cyanidation; and melting and SLS tests. The tested samples were obtained from the Valley of the Kings Zone, the West Zone, and from adjacent gold deposits such as the Galena Hill (GH) Zone and the Gossan Hill (R-8) Zone. Ireland et al. (2014) design work focused on the Valley of the Kings Zone and the West Zone.

13.1.1 Sample Description and Characteristics

The 2009-2014 test programs utilized core samples and their composites, along with assay reject material. The head assays showed a large variation of gold content from less than 1 g/t to over 70 g/t. The occurrence of nugget gold was identified using parallelized gold assay tests, by comparing the conventional fire assay and screen metallic assay methods.

13.1.1.1 Mineralogy Analysis

Process Mineralogical Consulting Ltd. (PMCL), in 2012, and Inspectorate Exploration and Mining Services Ltd. (Inspectorate), in 2014, conducted mineralogical analysis work on head samples. The PMCL work indicated that electrum was the primary gold bearing mineral in the tested samples. Fine gold grains, from 2 to 32 µm in size,

were reported and occurred as fracture fillings in pyrite and as disseminated grains and inclusions to gangue minerals and pyrite. Carbonate mineral content was approximately 2 to 3%. Major silver-bearing minerals included electrum, polybasite, acanthite, and selenopolybasite. Most silver-bearing minerals presented as liberated grains with a lesser amount associated with pyrite and gangue minerals. The work completed by Inspectorate showed that the observed gold grains were all finer than 5 µm in circular diameter and mostly liberated. The unliberated gold was associated with pyrite. At a primary grind size of 80% passing 87 µm, 90% of the pyrite was liberated.

13.1.1.2 Comminution Studies

Gekko Systems Pty Ltd. (Gekko) conducted vertical shaft impactor (VSI) crushing test, which resulted in a positive conclusion that the samples are amenable to VSI crushing. The specific gravity measured from the samples were in the range of 2.71 to 2.87. Inspectorate and Hazen Research Inc. (Hazen) performed grindability tests during various test programs and, in general, the mineralization appears to be moderately hard. Table 13-1 shows the Bond ball mill work index (BWi) results, which were observed between 13.8 and 17.2 kWh/t, and Table 13-2 show the SAG mill comminution (SMC) test results.

Table 13-1: Conventional Grindability and Crushability Test Results

Sample ID	BWi (kWh/t)	Cut Particle Size (µm)	RWi (kWh/t)	CWi (kWh/t)	UCS (psi)	Ai (g)
Inspectorate (2013)						
MU (Upper Zone Master Composite)	15.6	106	-	-	-	-
ML (Lower Zone Master Composite)	15.0	106	-	-	-	-
Hazen (2012)						
VOK HW 1	14.2	149	14.4	12.3	20,910	0.2254
VOK Ore 1	14.4	149	15.6	11.4	15,680	0.2125
VOK Ore 2	14.4	149	14.6	11.1	8,510	0.1384
VOK Ore 3	15.4	149	17.9	10.4	9,000	0.0903
VOK Ore 4	14.2	149	15.2	9.3	11,800	0.3820
VOK Ore 5	13.8	149	14.3	7.9	5,770	0.2474
VOK Ore 6	14.4	149	13.5	8.9	11,500	0.2385
WZ HW 1	12.2	149	13.2	6.9	2,520	0.0388
WZ Ore 1	16.7	149	16.7	11.8	22,390	0.3069
WZ Ore 2	15.3	149	15.1	10.7	15,530	0.3535
WZ Ore 3	15.8	149	15.5	10.3	20,310	0.6599
WZ Ore 4	15.5	149	17.0	9.5	26,460	0.2479
Inspectorate (2012)						
VOK-1 Master Composite	15.8	74	-	-	-	-
VOK-2 Master Composite	15.3	74	-	-	-	-
VOK-3 Master Composite	15.8	74	-	-	-	-

table continues…

Sample ID	BWi (kWh/t)	Cut Particle Size (µm)	RWi (kWh/t)	CWi (kWh/t)	UCS (psi)	Ai (g)
VOK-4 Master Composite	15.7	74	-	-	-	-
WZ-1 Master Composite	17.2	74	-	-	-	-
WZ-2 Master Composite	15.7	74	-	-	-	-
Inspectorate (2009 to 2010)						
BZ Composite	16.4	105	-	-	-	-
GH Composite	15.6	105	-	-	-	-
R-8 Composite	16.2	105	-	-	-	-

Note: RWi – Bond rod mill work index; CWi – Bond crushing work index; UCS – universal compressive strength; Ai – Bond abrasion index; BZ – Bridge Zone; Cut Particle Size – screen aperture

Table 13-2: SMC Test Results (2012)

Sample ID	DWi (kWh/m^3)	A	b	Axb	Mia (kWh/t)	Mih (kWh/t)	Mic (kWh/t)	ta	Specific Gravity
VOK HW 1	5.76	52.8	0.92	48.6	16.7	12.0	6.2	0.45	2.79
VOK Ore 1	6.37	56.6	0.77	43.6	18.1	13.2	6.8	0.41	2.79
VOK Ore 3	7.12	62.9	0.62	39.0	20.2	15.0	7.8	0.40	2.75
VOK Ore 5	4.61	52.3	1.16	60.7	13.9	9.5	4.9	0.56	2.81
WZ HW 1	4.89	55.2	1.08	59.6	14.1	9.8	5.1	0.53	2.90
WZ Ore 2	7.08	66.7	0.59	39.4	19.9	14.8	7.7	0.37	2.76
WZ Ore 4	6.32	69.9	0.62	43.3	18.3	13.3	6.9	0.41	2.75
Average	6.02	59.5	0.82	47.7	17.3	12.5	6.5	0.44	2.79
Average – VOK	5.97	56.2	0.87	48.0	17.2	12.4	6.4	0.45	2.79
Average – WZ	6.10	63.9	0.76	47.4	17.4	12.6	6.6	0.44	2.80

Note: DWi – Drop weight index; Mia = coarse ore work index provided directly by SMC Test®; Mih – high-pressure grinding roll (HPGR) ore work index provided directly by SMC Test®; Mic – crushing work index provided directly by SMC Test®; ta – low-energy abrasion component of breakage; HW – hanging wall

13.1.2 Gold and Silver Recovery Tests – Gravity Concentration

Two-stage gravity separation programs (2009/2010, 2012/2013), including centrifugal and panning concentration, were carried out on head composite samples, head variability samples, and flotation concentrate samples. The results indicated that most of samples responded well to the tested gravity separation methods. Reground concentrate samples presented better performance compared with their head samples. The reported gold gravity recovery ranged between 2.7 to 56.0%, and silver recovery varied between 1.0 to 44.0% for composite head samples. The average metal recovery of variability head samples was 45.8% for gold and 21.4% for silver; the average metal recovery of the flotation concentrates produced from 11 variable samples was 24.5% for gold and 11.6% for silver.

In 2012, FLSmidth Knelson (Knelson) and Met-Solve conducted gravity recoverable gold (GRG) tests and related simulations. Table 13-3 shows the test results and Figure 13-1 shows the GRG versus grind size.

Figure 13-1: Cumulative Stage GRG versus Grind Size for Gold and Silver

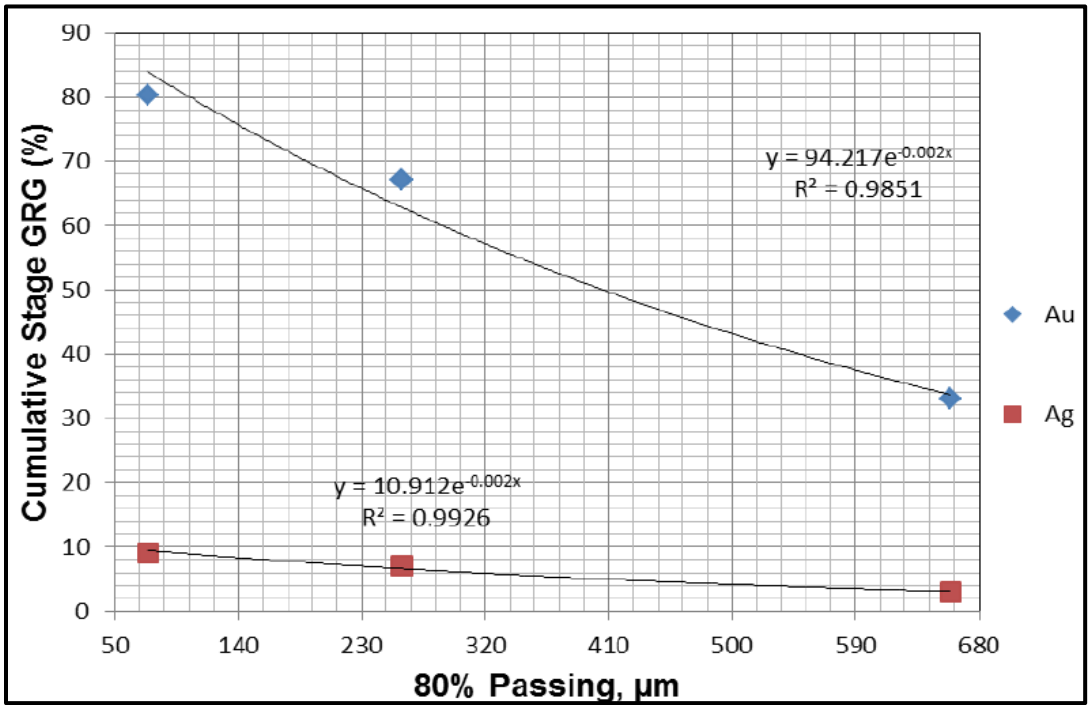


Table 13-3: Gravity Recoverable Gold Test Results (2012)

Lab	Tests	Primary Grind/ Regrind Size	Sample Head Grade (g/t)		GRG Recovery (%)		Cyanide Leaching Recovery (%)		Gravity Upgrading Tabling Recovery (%)	
			Au	Ag	Au	Ag	Au	Ag	Au	Ag
Knelson	E-GRG	P_{80} 74 µm	17.0	58.6	80.3	9.1	99.5	86.9	n/a	n/a
Met-Solve	GRG	TBD	18.7	63.0	80.7	33.7	99.2	92.2	61.1	42.5

Note: E-GRG – extended gravity recoverable gold

In 2014, FLSmidth Dawson Metallurgical (FLS-DM) conducted tabling tests on gravity concentrates samples (Table 13-4). Further, Gekko tested the amenability of the samples to in line pressure jigging technology. The results indicated that when the mass pull was reduced to 5%, the gold recovery ranged from 43 to 67%.

Table 13-4: Precious Metal Material Balance (2014)

Product	Weight (g)	Assay (g/t)		Distribution (%)	
		Au	Ag	Au	Ag
Table Concentrate	60.4	199,935	107,297	23.0	21.1
Table Middlings 1	250.7	40,571	24,715	19.3	20.2
Table Middlings 2	2,655.2	9,058	5,290	45.7	45.8
Table Tailings	6,308.6	1,000	629	12.0	12.9
Calculated Head	9,274.9	5,672	3,309	100.0	100.0

13.1.3 Gold and Silver Recovery Tests – Flotation Concentration

Inspectorate conducted a preliminary test program between 2009 and 2011 and further optimization tests from 2011 to 2013, which included bulk flotation tests and cleaner flotation tests on samples from the Valley of the Kings Zone, the West Zone, and adjacent gold deposits. Met-Solve tested slime material response to flotation in 2014.

13.1.3.1 Bulk Flotation

The bulk flotation tests were conducted to investigate the effects of primary grind size, reagent types, and pH levels. The primary grind size of 80% passing a range of 38 to 143 µm was tested on different mineralization samples. The overall gold recovery from gravity concentration and bulk flotation was found to increase with a finer primary grind size; however, for most samples, the gold recovery increase become insignificant when the primary grind size was finer than 74 µm. The reagent schedule and pH level were found to have an insignificant effect on gold flotation recovery.

13.1.3.2 Cleaner Flotation

The cleaner flotation tests were carried out on rougher and scavenger concentrates. The results indicated that the upgrading efficiencies were good for both gold and silver. The gold upgrading efficiency, which was better than silver, still varied significantly in the tests. Attempts to solve this problem were tested by introducing a regrinding circuit prior to the cleaner flotation stage, adjusting flotation pH level, applying different collectors, and/or adding sulphide depressants but were met with little success.

13.1.3.3 Other Flotation

Met-Solve conducted a preliminary flotation test to recover gold from the fine fraction generated in a de-sliming classifier. Significant gold was able to be recovered, but a low flotation pulp density, as well as a high dosage of sodium silicate (dispersant reagent) were required to control the viscosity of the slurry.

13.1.4 Gold and Silver Recovery Tests – Cyanidation

Between 2009 and 2013, Inspectorate conducted cyanidation tests on head samples of composite and individual mineralization, flotation concentrates, and gravity concentrates. A significantly varied gold recovery range was reported in direct cyanide leaching tests. Improved gold recoveries were generated when using a combined method of gravity + leaching flotation concentrates or gravity + leaching gravity tailings.

Inspectorate conducted flowsheet development tests to incorporate these observations. The following three flowsheets were examined:

- Flowsheet A: Primary grind, gravity concentration, rougher/scavenger flotation, and cyanidation on the reground flotation concentrates.
- Flowsheet B: Primary grind, rougher/scavenger flotation, and a gravity separation on the reground concentrates prior to cyanidation on the gravity tailings.
- Flowsheet C: Primary grind, primary gravity concentration, rougher/scavenger flotation, a secondary gravity separation on the reground concentrates prior to cyanidation on the gravity tailings, and intensive leaching on the panning tailings.

Table 13-5 summarized the overall gold recoveries of the three flowsheets.

Table 13-5: Cyanidation Flowsheet Development Test Results

Samples	Gravity Recovery (%)		Leaching Recovery (%)		Overall Recovery (%)	
	Au	Ag	Au	Ag	Au	Ag
Flowsheet A						
Composite BZ (Test GF35)	17.0	4.4	72.2	66.6	89.2	71.0
Composite R-8 (Test GF37)	2.7	1.8	86.4	85.3	89.1	87.1
Composite GH (Test GF36)	11.0	1.8	72.6	82.9	83.6	84.7
Composite GH (Test GF41)	25.7	1.4	59.6	83.4	85.3	84.8
Flowsheet B						
Composite R-8 (Test GF38)	33.5	2.3	50.5	63.7	84.0	66.0
Composite GH (Test GF39)	43.5	4.4	43.8	63.9	87.3	68.3
Composite BZ (Test GF40)	24.9	5.7	38.3	61.1	63.3	66.8
Composite SU-32B (Test GF42)	21.0	1.3	51.7	63.7	72.7	65.0
Composite SU-33 (Test GF43)	43.2	4.6	47.1	64.5	90.4	69.1
Composite SU-36A (Test GF44)	41.0	3.8	32.6	56.6	73.7	60.4
Composite SU-36B (Test GF45)	9.7	2.3	42.1	55.7	51.8	58.0
Flowsheet C						
Composite GH2 (Test GF26)	68.3	8.31	21.9	62.7	90.4	71.2
Composite SU98 (Test GF27)	85.6	27.7	13.5	51.0	99.1	78.9
Composite SU98 (Test GF25)	62.0	9.23	26.4	62.9	88.7	72.5

13.1.5 Variability Tests

In 2012, variability tests based on primary gravity concentration and bulk flotation were conducted with varied core samples. In general, the overall metal recoveries were consistent with the results from the composite samples. Gold recovery varied from 82.8 to 99.8%, averaging 97.2%, while the head gold grade fluctuated from 0.5 to 200 g/t, averaging 21.5 g/t. At a silver head grade range of 3.9 to 1,897 g/t, the silver recovery varied from 51.2 to 99.1%, averaging 88.5%.

In 2011, variability tests based on Flowsheet C were performed, which indicated there was no significant variation in metallurgical performance between the West Zone and the Galena Hill Zone mineralization. The overall average gold recovery was 94.5%, which was approximately 19% higher than the average silver recovery. The regrind size was finer than 80% passing 10 µm. The variability tests based on Flowsheet B showed a significant variation of the overall gold recoveries, while the overall silver recovery fluctuation was moderate.

13.1.6 Locked Cycle Tests _ Gravity Separation + Flotation Concentration

In 2012/2013, six locked cycle tests were conducted on four composite samples from the Valley of the Kings Zone and the West Zone based on the test conditions developed from comprehensive batch test work, including primary grind size, gravity separation, rougher/scavenger flotation, and rougher concentrate cleaner flotation. Four locked cycle tests were completed in 2012 on two master composites, which consisted of one blend from the Valley of the Kings Zone (VOK 1, 2, 3, and 4) and one from the West Zone (WZ 1 and 2). The procedure included:

- Primary grinding targeting a moderate size of 80% passing 80 to 85 µm
- Gravity concentration
- Rougher and scavenger flotation with the scavenger concentrate recycled
- Rougher concentrate cleaner flotation.

For tests FLC1 and FLC3, the rougher concentrates were reground prior to cleaner flotation. In an effort to activate gold- and silver-bearing minerals, copper sulphate was added during the rougher and cleaner flotation stages.

In 2013, two separate locked cycle tests were conducted on two composites generated from the upper and lower zones of the Valley of the Kings Zone. The test procedure used was similar to that used for the locked cycle tests in 2012. Table 13-6 shows the results of the six locked cycle tests, which are summarized as follows:

- The average metal recoveries from the Valley of the Kings Zone composites were approximately 97.8% for gold and 94.3% for silver. Approximately 53.9% of the gold and 28.6% of the silver reported to the gravity separation concentrate. The flotation concentrate contained approximately 130 g/t Au, 252 g/t Ag, and 0.68% As.
- Average recoveries from the master composite of the West Zone were approximately 94.0% for gold and 90.8% for silver. Approximately one-third of the gold reported to the gravity separation concentrate. The flotation concentrate contained 48.6 g/t Au, 2,800 g/t Ag, and 0.24% As.
- The addition of copper sulphate, together with regrinding the rougher flotation concentrates, did not appear to improve the recoveries of the target metals.

Table 13-6: Locked Cycle Tests Results

Composite	Test No.	Head Grade Calculated			Gravity Concentration				Flotation					
					Recovery		Concentrate Grade		Concentrate Grade				Recovery	
		Au (g/t)	Ag (g/t)	S (%)	Au (%)	Ag (%)	Au (kg/t)	Ag (kg/t)	Au (g/t)	Ag (g/t)	S (%)	As (ppm)	Au (%)	Ag (%)
VOK-1 to -4	FLC1	24.2	33.6	2.92	54.2	30.5	11.7	9.1	181.3	354	48.1	8,249	43.9	61.7
VOK-1 to -4	FLC2	24.2	31.8	2.96	48.6	27.1	9.9	7.9	175.6	341	46.9	6,930	49.3	67.0
WZ-1 and -2	FLC3	6.0	225	3.03	32.0	1.3	1.7	2.7	52.6	3,096	43.5	2,622	59.2	88.5
WZ-1 and -2	FLC4	6.3	240	3.10	36.5	1.1	2.5	2.8	44.6	2,490	34.7	2,228	60.2	90.7
VOK ML	FLC2	10.3	12.5	3.41	48.0	21.6	4.3	2.4	83.8	152	52.2	5,801	48.5	71.7
VOK MU	FLC1	12.1	13.4	2.70	64.9	35.1	6.0	3.6	78.1	160	49.5	6,059	33.9	62.4

13.1.7 Other Processing Related Tests

13.1.7.1 Melting Test Work

In 2014, FLS-DM conducted a preliminary melting test on the tabling concentrate generated from the pilot testing program (Section 13.2). The table concentrate contained approximately 20% of gold and 11% of silver. Smelted doré metal grades were 64% gold, 34% silver, and 2% lead.

13.1.7.2 Solids Liquid Separation Tests Work

In 2012, Pocock Industrial Inc. (Pocock) conducted SLS tests on the flotation concentrate and flotation tailings samples. The test program included sample particle size analysis, flocculants screening and evaluation, and static and dynamic thickening tests.

13.2 2013 Pilot Plant Testing

Between September 2013 and February 2014, Pretivm contracted Strategic Minerals to process two batches of bulk mineral samples generated from the Valley of the Kings Zone using the Contact Mill facility located in Philipsburg, Montana. Approximately 10,300 t was processed for the first campaign and approximately 1,200 t was processed for the second run. A combined process of gravity separation and rougher/scavenger flotation with rougher concentrate cleaner flotation was employed to treat the bulk materials. The gravity circuit included a Kneslon concentrator and a Gemini table while a jigging and tabling circuit to recover coarse free gold was also added towards the end of the pilot plant test. No regrind circuit was applied to the rougher/scavenger concentrates. Figure 13-2 shows the pilot plant flowsheet.

The daily feed grades to the mill ranged widely from less than 1 g/t to more than 130 g/t Au for the samples processed by the 2013 processing campaign and from approximately 40 to 300 g/t Au for the Cleo sample processed in 2014. Table 13-7 shows the test results summary as reported in the 2014 FS (Ireland et al. 2014). The results demonstrated that the flowsheet used for the program can effectively recover gold and silver and adapt well for a wide range of feed grades experienced during the pilot testing.

Figure 13-2: Bulk Sample Process Flowsheet

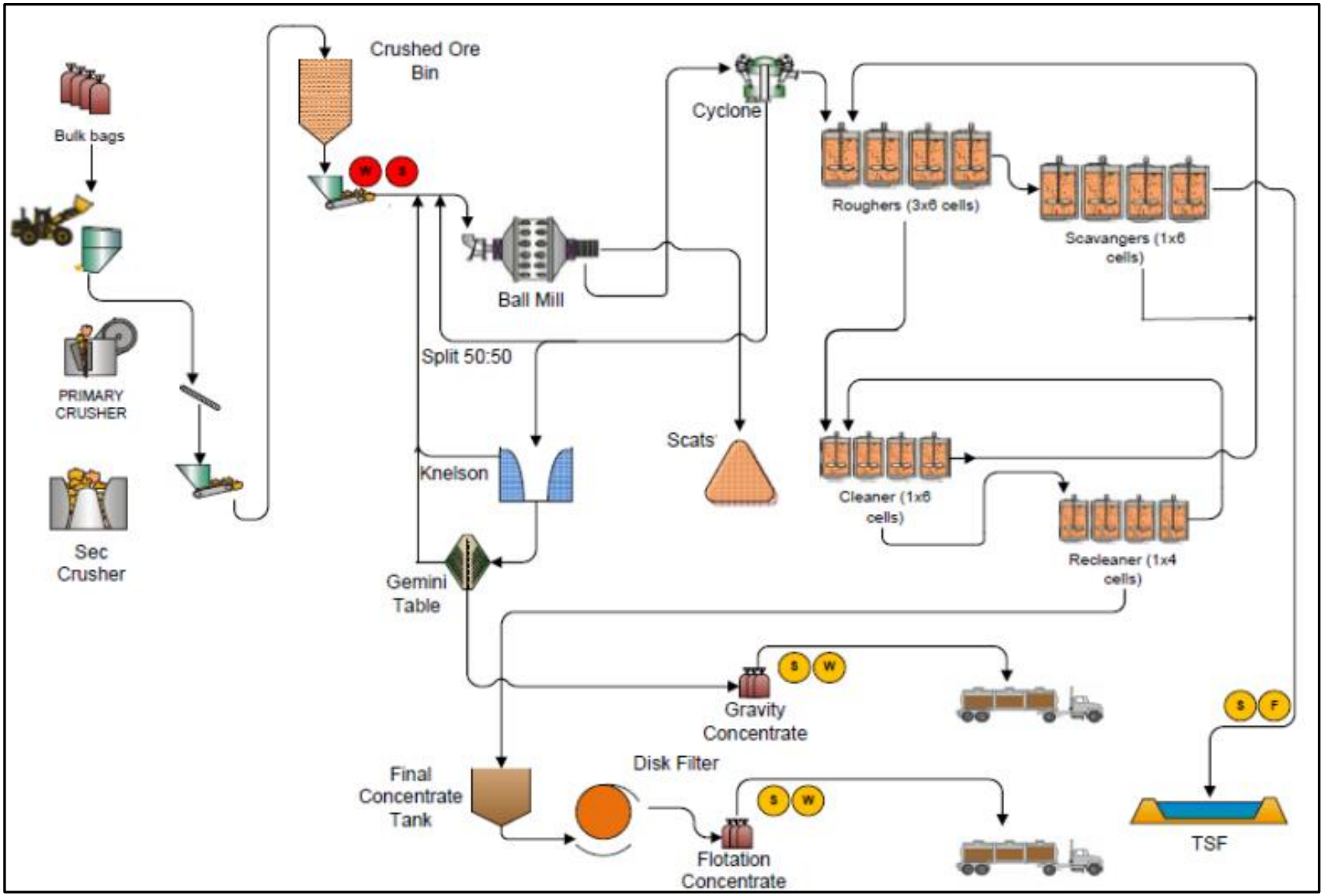


Table 13-7: Bulk Sample Processing Metallurgical Performances

Year	Feed			Metal Recovery (%)						Product Grade (g/t)			
	Tonnage (t)	Calculated Grade (g/t)		Table Con		Table Con + Table Middlings		Gravity+ Flotation Con		Table Con		Flotation Con	
		Au[2]	Ag[2]	Au[1]	Ag[1]	Au[1]	Ag[1]	Au	Ag	Au[1]	Ag[1]	Au[3]	Ag[3]
2013	10,302	17.5	17.1	41.8	18.2	47.6	21.0	97.5	86.9	259,487	110,146	79	129
2014	1,203	82.6	59.7	47.9	36.6	56.2	44.0	98.0	96.3	247,999	136,877	398	402

Notes: [1]Based on assay data from Contact Mill laboratory.
[2]Including cleanout.
[3]Flotation concentrate only.

13.3 Mill Operation Optimization/Expansion Test Work

To support the process plant optimization and throughput increase at the Brucejack Gold Mine, Pretivm began a series of test work on the samples collected from operation since 2017. The test work involved mineralogy analysis, grindability, gravity separation, intensive leaching, and flotation concentration aspects. The results were used to optimize the current plant operation and to project the performance of the relevant circuits for the 3,800 t/d scenario. In addition, SLS tests and tailings tests relating to mine backfill were also performed for similar purposes. Table 13-8 lists the current test work programs, including simulations.

Table 13-8: Major Metallurgical Testing and Simulations Programs 2017–2019

Lab Year	Mineralogy	Grindability	Gravity	Leaching	Flotation	Thickening	Tailings
SNF 2016/2017						√	
Gekko 2017				√			
ALS 2018		√	√		√		
BV 2017	√						
PMCL 2018	√						
FLSmidth 2018			√			√	
Pocock 2019						√	
RMS 2018							√

Note: SNF Canada (SNF); BV – Bureau Veritas Commodities Canada Ltd.; RMS – RMS Corp.; FLSmidth Inc. (FLSmidth)

13.3.1 Sample Description

Samples collected from the Brucejack Gold Mine operation and drill core composites at the site were used in different testing programs by different laboratories, as described in the following subsamples.

13.3.1.1 Mineralogy Analysis Samples – BV 2017 and PMC2018

In 2017 and 2019, BV and PMCL, respectively, conducted separate gold deportment studies on final flotation concentrates to support the plant operation. BVs work was based on two flotation concentrate samples labelled as 17-07-03 NS Concentrate and 17-07-04 NS Concentrate. PMCL used one flotation concentrate sample labelled as “LoCon”.

13.3.1.2 Comminution Test Work Samples – ALS 2018

ALS, located in Kamloops, BC, performed comminution, gravity, and flotation tests. For the comminution tests, nine samples were received and tested, which included eight drill core samples and one plant SAG mill feed sample. Chemical analyses were conducted on all nine samples and mineralogical analyses were completed on six of samples through x-ray diffraction (XRD).

13.3.1.3 Metallurgical Processing Test Work Samples – Gekko 2017 and ALS 2018

An intensive cyanide leaching test program was conducted at SGS Canada Inc. (SGS) laboratory facility in Burnaby, BC by using the Gekko's intensive leach procedure. Two sealed pails of Kneslon concentrate pulp samples labelled as Table Feed Sample 21-22/July/2017 (TF2) and Table Feed Sample 23-24/July/2017 (TF1) were used for the testing at the SGS Burnaby laboratory. The pulp samples were decanted to remove the supernatant water and then prepared for subsequent head characterization and intensive leaching tests. Table 13-9 shows the sample head assay results.

Table 13-9: Head Assay Results (Gekko 2017)

Assay Method	Au (g/t)		Ag (g/t)	
	TF1	TF2	TF1	TF2
Screen Metallic – Fire Assay	8,105	5,992	3,836	3,521
Fire Assay	8,875	6,510	4,925	3,740

ALS performed metallurgical test work, including comminution, gravity, and flotation testing. Four composites (H, M, L, and A) with varying feed grades were prepared from 42 subsamples. The metallurgical composite samples were used in flotation tests to optimize test conditions. Two selected variability composite samples (West Zone (WZ) and Galena Hill (GH) Zone) were tested using the developed test conditions. Table 13-10 lists the sample head assaying results. The gold and silver assays were completed using a metallic gold assay (by screening) method except for Sample A, WZ, GH and GRG Comp 2. Gold and silver concentrations varied from 3.1 to 16.2 g/t Au and 36 to 398 g/t Ag.

Table 13-10: Head Assay Results (ALS 2018)

Sample ID	Au (g/t)	Ag (g/t)	S (%)	As (%)	$S^{(-2)}$ (%)	C (%)	TOC (%)
Composite L	3.13	49	4.00	0.063	3.95	0.73	0.03
Composite M	5.73	60	3.60	0.087	3.56	0.82	0.04
Composite H	16.20	76	3.12	0.043	3.08	0.56	0.08
Composite A	4.10	53	4.02	0.062	3.98	-	-
Composite WZ	14.70	398	2.68	0.016	-	-	-
Composite GH	5.42	73	2.61	0.044	-	-	-
GRG Comp 2	9.50	36	3.64	0.048	-	-	-

Note: $S^{(-2)}$ – sulphide sulphur; C – carbon; TOC – total organic carbon

For the operation optimization tests, two flotation samples were used—one was a rougher concentrate sample and the other was a third cleaner concentrate—from the Brucejack Gold Mine process streams. The purpose of the test

was to investigate the potential gravity concentration of rougher concentrate following regrinding and for further upgrading of the third cleaner concentrate using conventional flotation and flotation column methods. Table 13-11 shows the head assay results of the two processing samples.

Table 13-11: Head Assays of Processing Samples

Sample	Grade (g/t or %)			
	Au	S	S(s)	As
Rougher Concentrate	85	37.5	37.5	0.21
Third Cleaner Concentrate	111	44.2	44.2	-

13.3.1.4 Solid/Liquid Separation Test Work Samples – SNF 2016/2017, FLSmidth 2018, and Pocock 2019

In 2016 and 2017, SNF provided a preliminary flocculant and coagulant screening tests using static settling methods. Tailings samples were used in both tests; the 2016 samples contained 27.9% solids at an initial pH of 6.8 to 7.0; however, the 2017 samples were not specified in the report.

FLSmidth conducted the SLS test work in Midvale, Utah on both the flotation concentrate and tailings samples collected from the Brucejack Gold Mine. The objectives were to optimize settling characteristics and to evaluate the performances of the two tailings and concentrate thickeners to accommodate the 3,800 t/d throughput.

Pocock tested two tailings samples collected from the Brucejack mill during the operation upset conditions in 2019. Elevated fine clay materials were found suspended in the thickener overflow which were not flocculating properly with the plant flocculant reagent. The two samples came from tailings material produced on January 5 and January 8, 2019. The purpose of this testing was to assist plant operations to clarify the tailings thickener overflow.

13.3.2 Mineralogical Analysis on Flotation Tailings and Tailings Thickener Underflow

In 2019, a mineralogical determination work was conducted on flotation tailings thickener feed and underflow by PMCL for X-ray diffraction (XRD) analysis and clay speciation analysis. The mineralogical study was to investigate possible causes for settling issues in the tailings thickener. The investigation shows that samples contain predominantly quartz (44 to 53% wt.) and muscovite/illite (37.8 to 49.5% wt.), and minor calcite (3.5 to 7% wt.), chlorite (0.8 to 2.8% wt.), albite (<2.2% wt.), and pyrite (0.6 to 1.9% wt.).

The suspicion that swelling clays might cause the settling issue in the thickener tank could not be substantiated by the completed clay speciation study as the clay mineral fraction in all examined samples contains predominantly non-swelling muscovite (polymorph 2M1) with minor illite and chlorite. Elevated levels of fine-grained sericite in the thickener feed (up to 49.5% wt.) are not matched with the thickener underflow, suggesting that the fine 2M1-muscovite/illite may cause poor thickening behavior/settling issues.

13.3.3 Mineralogical Analysis on Flotation Concentrates

BV and PMCL investigated the gold deportment in the final flotation concentrates produced from 2017 and in 2018, respectively, to support plant operation optimization.

In 2017, BV conducted its investigation on two concentrate samples by using Quantitative Evaluation of Materials by Scanning Electron Microscopy (QEMSCAN) Particle Mineral Analysis (PMA) and QEMSCAN Trace Mineral

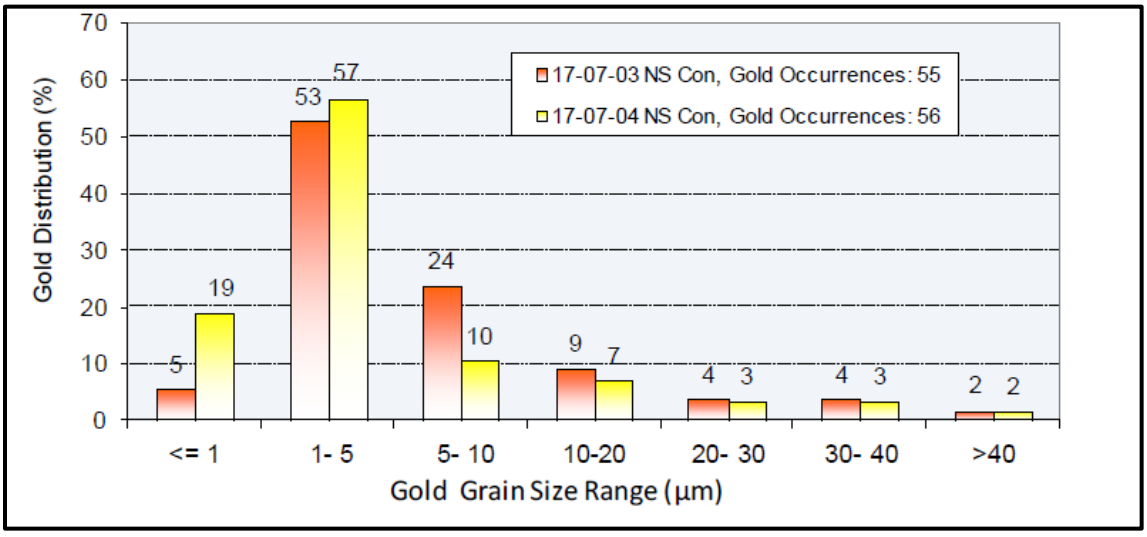
Search (TMS) protocols. The gold concentration was determined by using an energy dispersive spectrometer (EDS) and Brucker software. BVs study outlines the following major observations and conclusions:

- The gold grades of the two concentrates are 154 g/t Au and 57 g/t Au. The majority of the gold occurred as native gold and gold electrum. Table 13-12 lists gold grade and deportment percentage with minerals by mass of the two samples.
- The average gold grain size was 11 to 13 µm for both the samples; however, the majority of gold grains were in a range of 1 to 5 µm, as shown in Figure 13-3.
- Approximately 75% of the gold by weight in the two concentrates was liberated as determined by two dimensions. The unliberated gold presented as exposed surfaces and mostly attached to sulphide minerals. The liberated and attached gold accounted for over 99.5% the gold in the concentrates. The unliberated gold was found locked with pyrite and non-sulphide gangue minerals and accounted for less than 0.5% of the total gold.
- The investigation into the mineral composition of the two samples indicated that sulphide minerals were approximately 89% by weight, which were dominated by pyrite. The non-sulphide minerals were approximately 11%, which were mainly included quartz and clay minerals.
- High liberation of sulphide minerals was reported as 90% for both samples; approximately 56% non-sulphide gangue minerals were also presented as liberated.

Table 13-12: Gold Deportment and Associations of Two Flotation Con – BV 2017

Sample	Grade Au (g/t)	Au Mass Deportment % by Minerals			
		Native Au (Au)	Electrum (Au, Ag)	Acanthine (Ag_2S)	Uytenbogaardtite (Ag_3AuS_2)
17-07-03 NS Concentrate	153.6	9.2	86.3	3.6	0.9
17-07-04 NS Concentrate	57.2	86.0	4.5	0.7	8.8

Figure 13-3: Gold Grains Distributions with Size Range



In 2018, PMCL conducted a separate gold deportment study and mineralogy determination on one sample labelled as “LoCon”. Tescan Integrated Mineral Analyser (TIMA) was used to determine the sample mineral composition, mineral abundance, liberation, and grain size information. Gold deportment was investigated using a Tescan Vega 3 scanning electron microscope (SEM) equipped with an EDS on polished sections of the gravity products obtained from a Mozley table and CNT Hydroseparator.

The gold grade of the tested sample was assayed as 34.4 g/t Au. Similar to BVs observations, gold was found largely present in the form of electrum grains which were mainly finer than 8 µm. The overall gold grain size was between 16 to 32 µm. Approximately 71% of the gold grains were free and 21% of the gold was attached to silicates but with exposed surfaces. Only a trace amount of the gold was locked in grains within pyrite in a size typically less than 2 µm. The minerals are mainly composed of 76% pyrite, 12% quartz, 6% sercite/muscovite, 2% feldspar with some clay minerals.

13.3.4 Comminution Test Work

The key comminution test work generated such parameters as crushing work index, grinding work index (JK Drop Weight, SMC, and Bond ball mill work index), rock hardness, and abrasion. SGS conducted an additional comminution test using the SAG Power Index (SPI) test procedure.

Table 13-13 shows the Bond working index test results. The Bond ball work index ranged from 13.5 to 19.8 kWh/t of the twelve comminution samples, including three tests on three composite samples producing relatively average values between 15.1 and 16.0 kWh/t. The Bond crushing index was observed to be 6.5 to 17.6 kWh/t. All the samples showed relatively mild abrasive values except for SIL H8 sample.

Table 13-13: Bond Test Results (ALS 2018)

Sample ID	BWi (kWh/t)	CWi (kWh/t)	Ai (g)	Specific Gravity
SAG Feed	14.4	15.4	0.078	2.73
AND	16.6	17.6	0.025	2.78
SIL H8	16.8	11.6	0.445	2.66
CGL	16.5	6.5	0.043	2.84
VSF	14.9	10.0	0.135	2.77
ARG	19.8	7.5	0.174	2.70
V6	17.2	13.4	-	2.85
P1	15.4	14.8	-	2.83
P2	13.5	-	-	-
Composite H	16.0	-	-	-
Composite M	15.1	-	-	-
Composite L	15.5	-	-	-

Table 13-14 lists the results of JK Drop Weight testing for the SAG Feed, AND, CGL, SIL H8, and VSF samples. The remaining four samples were subjected to SMC testing and results are shown in Table 13-15. The test results show that the SAG parameters (A x b) vary significantly from 29.1 to 78.7. SAG Circuit Specific Energy (SCSE) values ranged from 7.49 to 11.97 kWh/t for all the tested samples.

Table 13-14: JK Drop Weight Test Results (ALS 2018)

Sample ID	A	b	A*b	ta	SCSE (kWh/t)	Specific Gravity
SAG Feed	60.2	0.76	45.8	0.48	9.43	2.78
AND	65.9	0.50	33.0	0.49	11.14	2.82
CGL	51.1	1.32	67.5	1.05	7.96	2.76
SIL H8	67.9	0.90	61.1	0.54	8.21	2.70
VSF	58.0	0.82	47.6	0.84	9.21	2.75

Table 13-15: SMC Test Results and Parameters Derived from SMC Tests (ALS 2018)

Sample ID	DWi (kWh/m^3)	Mia (kWh/t)	Mih (kWh/t)	Mic (kWh/t)	Specific Gravity	A	b	A*b	ta	SCSE (kWh/t)
ARG	3.5	11.3	7.3	3.8	2.75	64.5	1.22	78.7	0.74	7.49
P1	6.4	17.9	13.1	6.8	2.82	63.6	0.69	43.9	0.40	9.7
P2	5.3	15.1	10.6	5.5	2.88	57.6	0.95	54.7	0.49	8.88
V6	9.9	25.1	20.1	10.4	2.85	67.6	0.43	29.1	0.26	11.97

13.3.4.1 Comminution Circuit Simulations

Contact Support Service Inc. (CSS) performed a primary grinding circuit modelling using JKSimMet. An additional comparison was performed by Weir Minerals using their proprietary modeling simulations. The input data was generated using comminution testing results obtained by ALS and SGS and site operating information. The underground mine samples used for the testing consisted of eight rock types representing various lithologies of the mill feed. On November 23, 2017, a grinding circuit survey was conducted to collect operation data on the samples from belt cuts and process slurry streams. The simulations indicated that the grinding circuit has a sufficient capacity for the increased mill feed rate of 3,800 t/d.

13.3.5 Gold and Silver Recovery Test Work

In 2017, under the Gekko's guide SGS conducted an intensive cyanide leaching test program at SGSs laboratory facility in Burnaby, BC. The test program was to determine the amenability of the Kneslon concentrate samples from the Brucejack Gold Mine to intensive cyanide leaching.

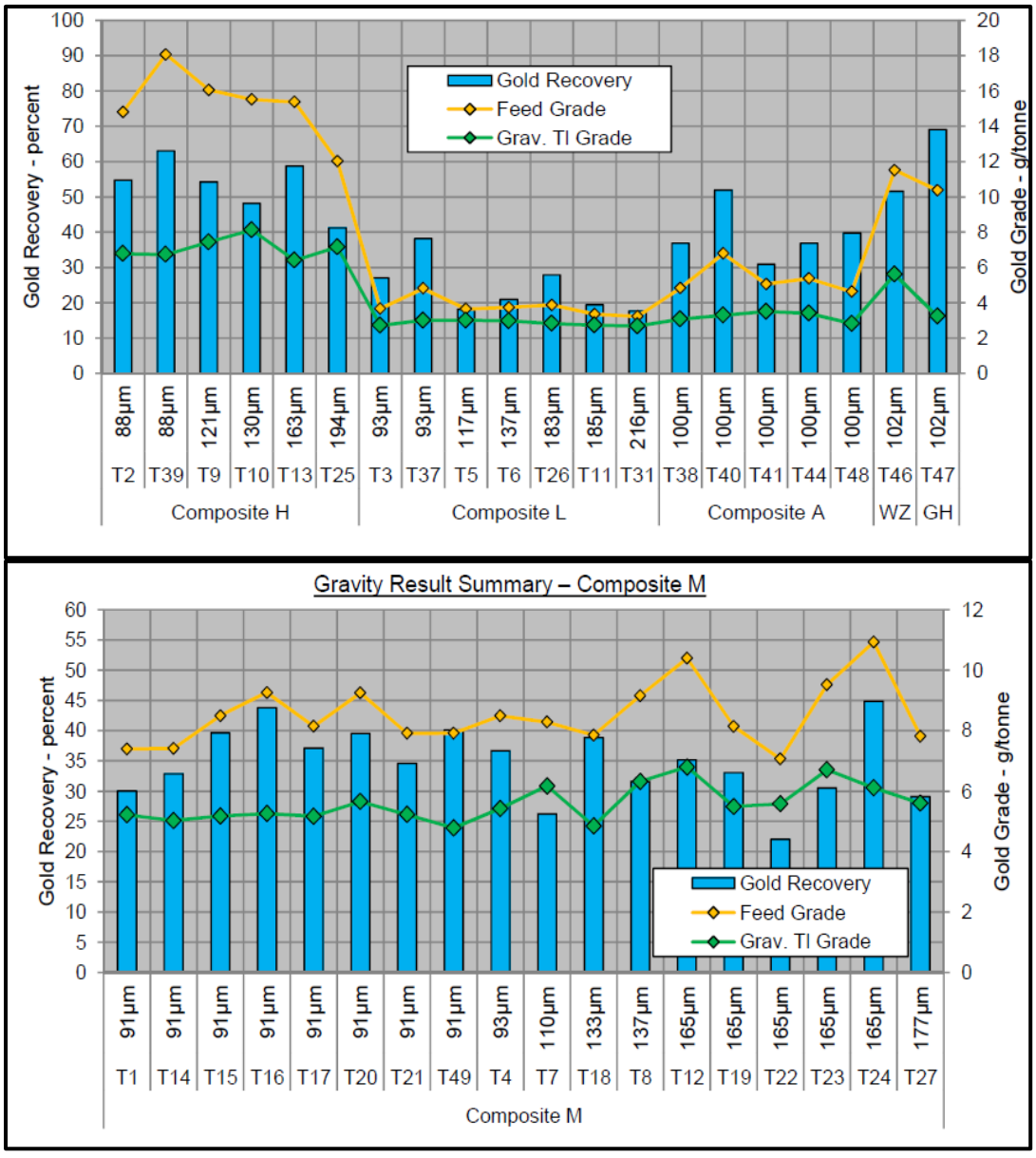
ALS also conducted a comprehensive metallurgical test program to investigate the gravity and flotation response of new samples to various test conditions, mainly primary grind size, reagent scheme, and circuit arrangement of the flotation circuit. Both the open and locked cycle tests were conducted using a flowsheet similar to the Brucejack Gold Mine operation.

The major conclusions and recommendations of the metallurgical test work by Gekko/SGS and ALS are summarized in the following subsections.

13.3.5.1 Gravity Testing Results – ALS 2018

Figure 13-4 shows the gravity testing results. Similar to previous gravity testing findings and the current operation, a significant amount of the gold is gravity recoverable gold. The gravity gold recoveries vary with the mineralization and gold head grades of the feed samples.

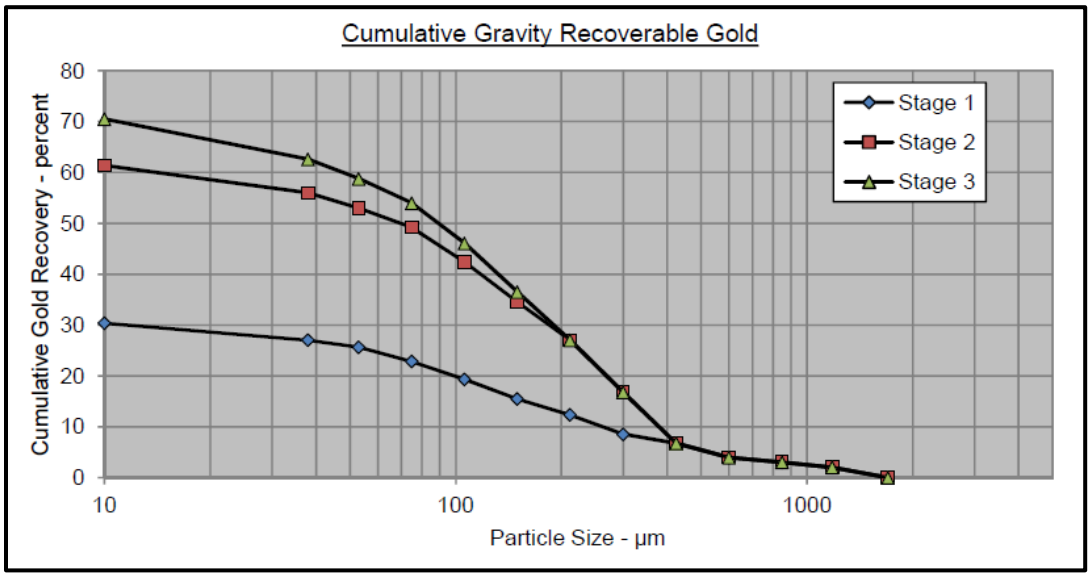
Figure 13-4: Gravity Results Summary – Composite Samples – ALS 2018



13.3.5.2 E-GRG Testing Results – ALS 2018

ALS performed an extended gravity recoverable gold test using GRG determination procedure on the Composite 2 sample. The results confirmed that most of the gold within the sample was gravity recoverable. The gold recovered at each of the three grind sizes is plotted in Figure 13-5. The overall gold recovery was 70.5% after the three recovery passes, which is lower than the previous tests by Knelson in 2012 that showed 80.3% GRG (Section 13.1.2), but still showed a high amenability to gravity recovery.

Figure 13-5: E-GRG Test Results



13.3.5.3 Intensive Leaching – Gekko 2017

Five intensive cyanide leaching tests were performed on the two Knelson concentrates samples with varied cyanide concentrations and pulp densities. The leaching pH level was maintained between 10.5 to 11.0 with the dissolved oxygen (DO) concentration of over 20 ppm for all the tests. SGS used the Gekko's test procedure. The following observations were made from the leaching tests:

- Sample TF1 produced an over 99% extraction rate of gold and silver based on assays of the residual solids; Sample TF2 reached a similar extraction rate of over 99% extraction of gold and silver.
- In addition, a further increase in cyanide concentration to 3% sodium cyanide (NaCN) or using hydrogen peroxide as an alternative oxidant did not improve the overall metal leaching recoveries.

13.3.5.4 Diagnostic Leach of Gravity Concentration Tailings – BV 2019

In 2019, BV conducted a diagnostic leach test on gravity tailings produced from the Brucejack Gold Mine. The tailings sample was from the secondary gravity concentration by a centrifugal concentrator. Duplicate tests were conducted. The test results show that the tailings sample responds well to the direct cyanide leaching. The test results are summarized in Table 13-16, showing gold occurrence in free gold form and associated forms with different mineral phases. More than 99% of the gold in the tailings product was recovered by gravity concentration (gravity recoverable, 15.2%) and cyanidation (cyanide soluble, 84.1%).

Table 13-16: Diagnostic Leach Test Results – Gravity Concentration Tailings (2019)

Recovery Stage	Distribution, % Au	
	Test 1	Test 2
Stage 1 - Gravity recoverable	13.3	15.2
Stage 2 - Cyanide soluble	86.4	84.1
Stage 3 - Primarily associated with carbonaceous minerals	0.12	0.23
Stage 4 - Primarily associated with calcite/dolomite/pyrrhotite minerals	0.01	0.03
Stage 5 & 6 - Primarily associated with sulphides	0.12	0.21
Residue - Insoluble or associated with preg-robbing and other refractory minerals	0.02	0.20
Total	**100.0**	**100.0**

13.3.5.5 Gravity Concentrate Smelting Tests – XPS 2019

In 2019, Expert Process Solution (XPS) conducted smelting test work on a low-grade gravity separation table concentrate. The test work was to determine the optimal conditions to recover gold by a combination of calcination and smelting. Characterization of the table concentrate showed that the sample contains approximately 13,100 g/t gold and 7,700 g/t silver, along with significant amounts of pyrite (FeS) and minor amounts of quartz (SiO2), arsenopyrite (FeAsS), uytenbogaardite (Ag3AuS2), and galena (PbS).

The testing shows that using the roasting and smelting combined treatment, with the same flux addition as the baseline, led to losses of 0.46% of the gold and 0.21% of the silver to slag, compared to using direct smelting, which resulted in much higher gold and silver losses to slag (56.6% of the gold and 73.7% of the silver).

13.3.5.6 Batch Flotation Test Results – ALS 2018

Both rougher and cleaner flotation tests were conducted to explore the impact of various testing conditions on gold and silver metallurgical performances. The flotation tests were conducted on the gravity tailings obtained from various composite samples.

The major observations/conclusions of the rougher flotation tests are noted in the following bullet points and shown in Figure 13-6 and Figure 13-7:

- At the tested primary grind sizes of 80% passing between 88 and 216 µm, the primary grid sizes had a modest effect on the flotation performance of the tested composite samples.
- There was no obvious effect between using mild steel rod grinding media and using stainless steel rod media in a rubber liner mill.
- Little success was obtained at the rougher and scavenger stages by modifying test conditions for concentrate grade improvement, including potassium amyl xanthate (PAX) vs. A208/sodium isopropyl xanthate (SIPX) or D233/MX-900; higher pH cleaner flotation; pH adjustment reagents (lime vs. soda ash); collector dosage; and incorporation of copper sulphate.

Figure 13-6: Rougher Flotation Tests on Composite H and L

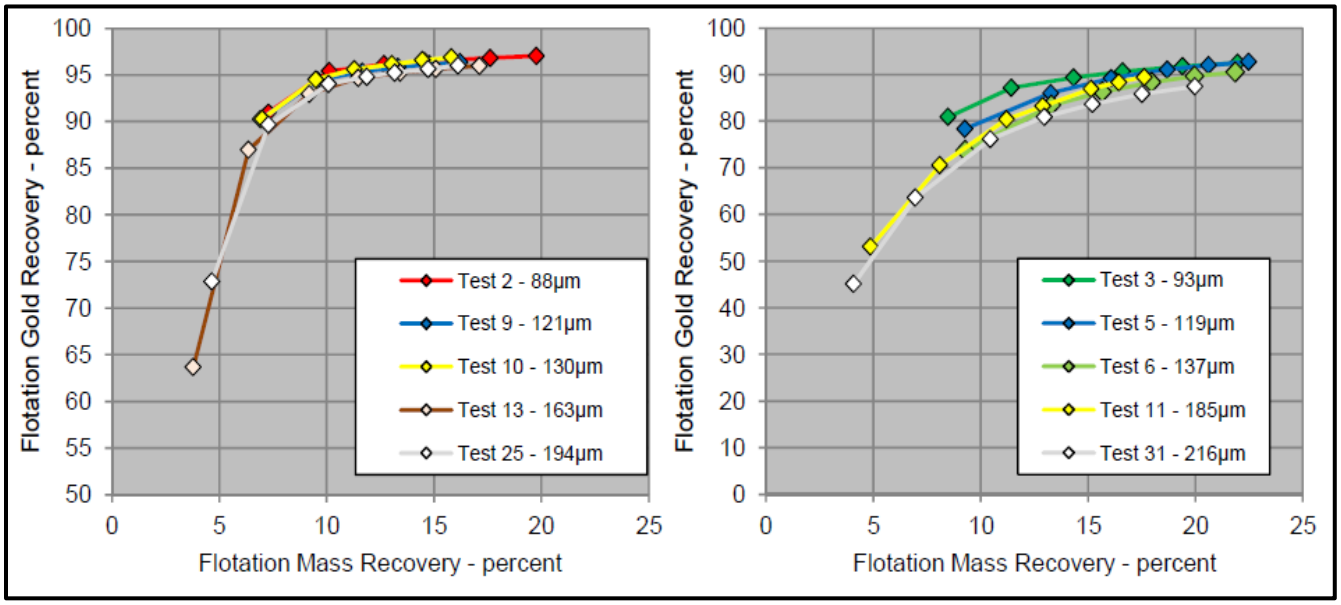
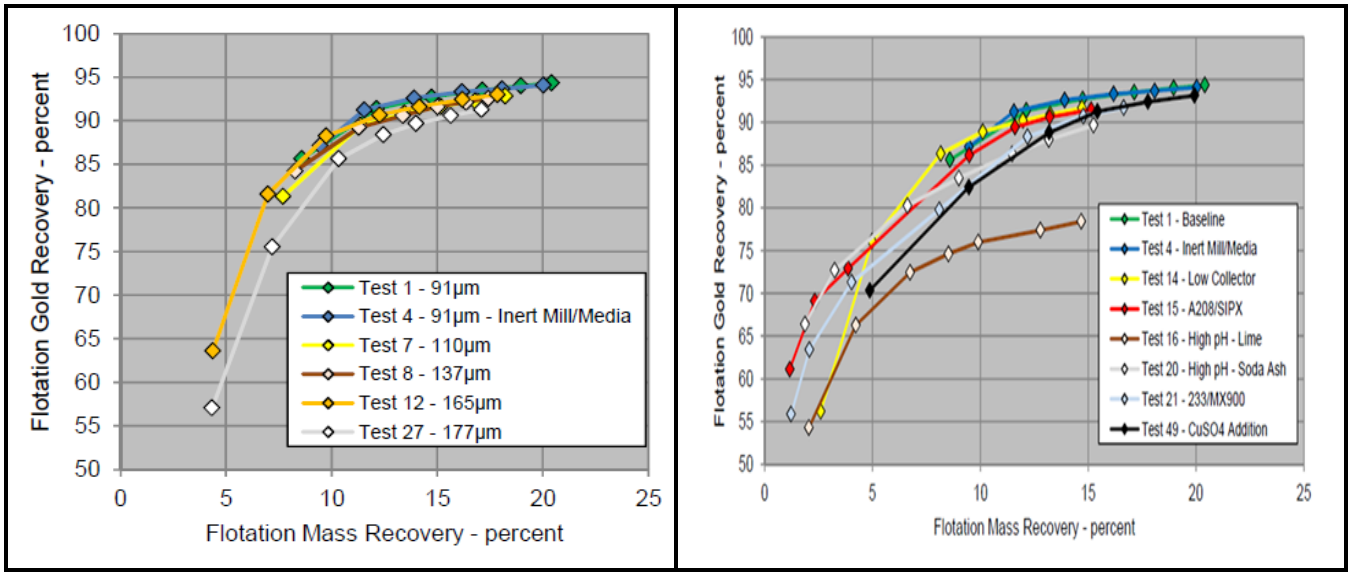


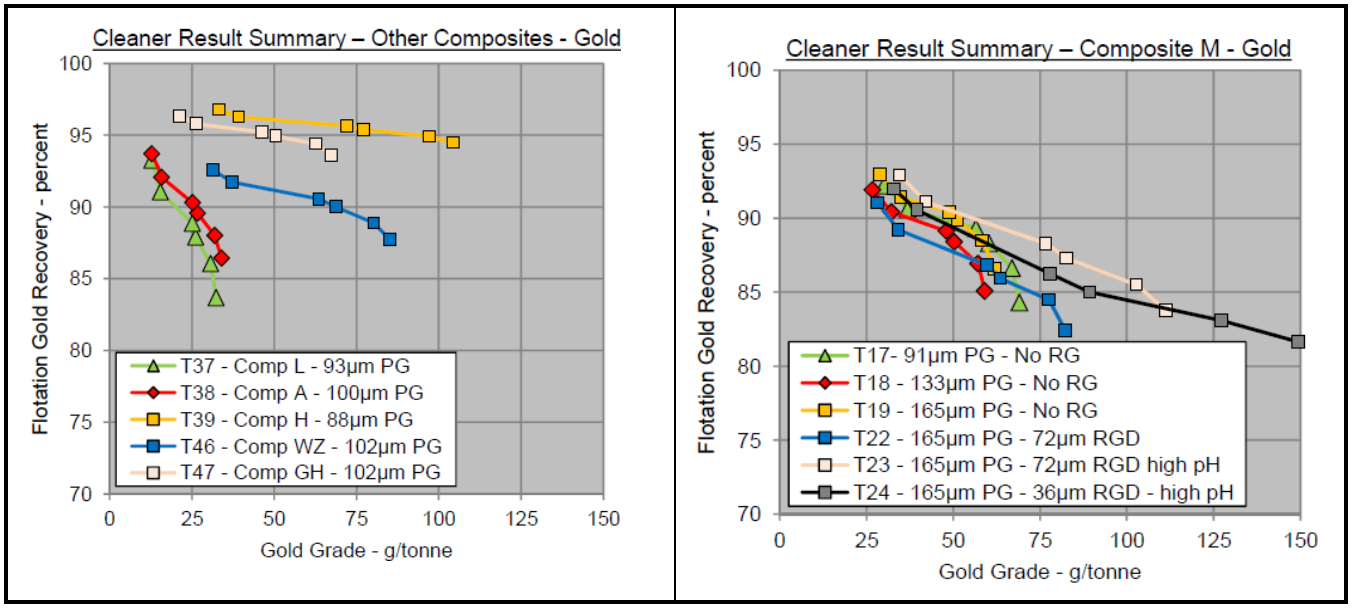
Figure 13-7: Rougher Flotation Tests on Composite M



The major observations/conclusions of the cleaner flotation tests are noted in the following bullet points and shown in Figure 13-8:

- Varied cleaner flotation responses were observed among the tested samples. At a primary grind size of 80% passing between 88 and 102 µm, Composites L and A produced low-grade cleaner concentrates of 32 g/t Au and 34 g/t Au at a gold recovery of 84% and 86%, respectively. Composites H, GH, and WZ produced higher-grade cleaner concentrates of 67 g/t Au, 85 g/t Au, and 104 g/t Au with higher gold recoveries of 95%, 94%, and 88%, respectively.
- Finer primary grind size appeared to slightly improve the gold grade of the cleaner flotation concentrate. At a primary grind size of 80% passing 165 µm, the cleaner gold recovery was 87% grading at 62 g/t Au. At a finer primary grind size of 80% passing 91 µm, the gold grade increased to 69 g/t and the gold recovery decreased to 84%.
- Regrinding the rougher concentrates to an 80% passing range of 36 to 72 µm, as well as increasing pH level to 10 and 10.5 noticeably improved the cleaner concentrate gold grade. The highest gold grade was 149 g/t at a recovery of 82% when regrinding the rougher concentrates to an 80% passing of 36 µm.
- Rougher scavenger tailings were found mainly composed of quartz and muscovite, as well as small amounts of sulphide minerals and other non-sulphide gangue minerals.
- The current flotation reagent scheme should remain. The reagent optimization tests confirmed that some alternatives can improve the concentrate grades; however, this may also result in a high sulphur content in the tailings.
- Reducing rougher and rougher scavenger retention time did not significantly reduce gold recovery, although a reduced cleaning retention time may slightly impact final concentrate grade.
- A coarse floatation feed grind size resulted in only a modest decrease in gold recovery.

Figure 13-8: Cleaner Flotation Tests on Composite L, A, H, GH, WZ, and M



13.3.5.7 Locked Cycle Gravity-Flotation Testing Results – ALS 2018

Two locked cycle flotation tests were conducted using a combination of gravity and flotation concentrations for gold and silver recovery. The gravity circuit for both tests was completed as a separate stage, following which the gravity tailings were tested in the locked cycle flotation tests. Figure 13-9 and Figure 13-10 show locked cycle test flowsheet No. 1 and No. 2, respectively, which differ from each other at the flotation stage. Flowsheet No. 1 uses a three-stage cleaner flotation circuit which is fed by rougher concentrates. Flowsheet No. 2 is based on a two-stage cleaner flotation fed by rougher concentrates 2 to 4, while rougher concentrate 1 directly reports to the second cleaner flotation stage.

Figure 13-9: Locked Cycle Test Flowsheet No. 1

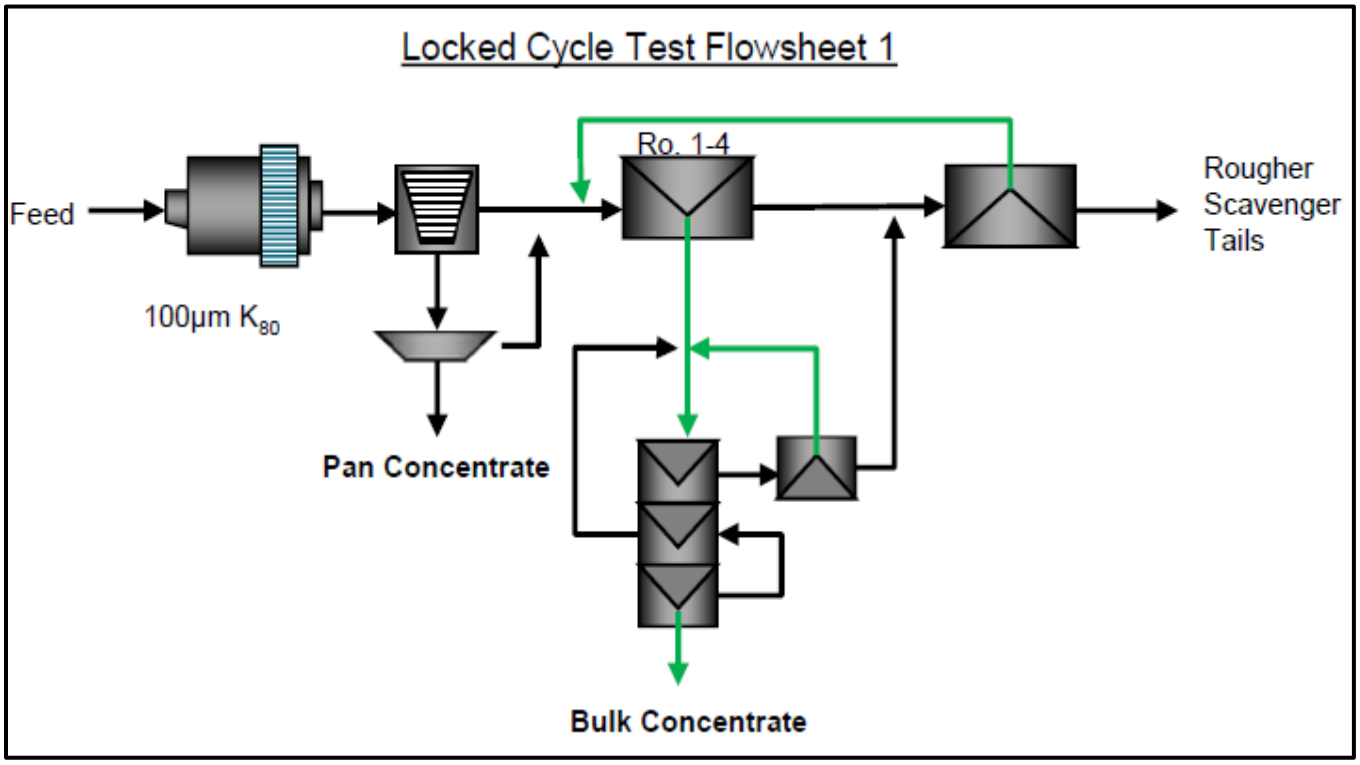


Figure 13-10: Locked Cycle Test Flowsheet No. 2

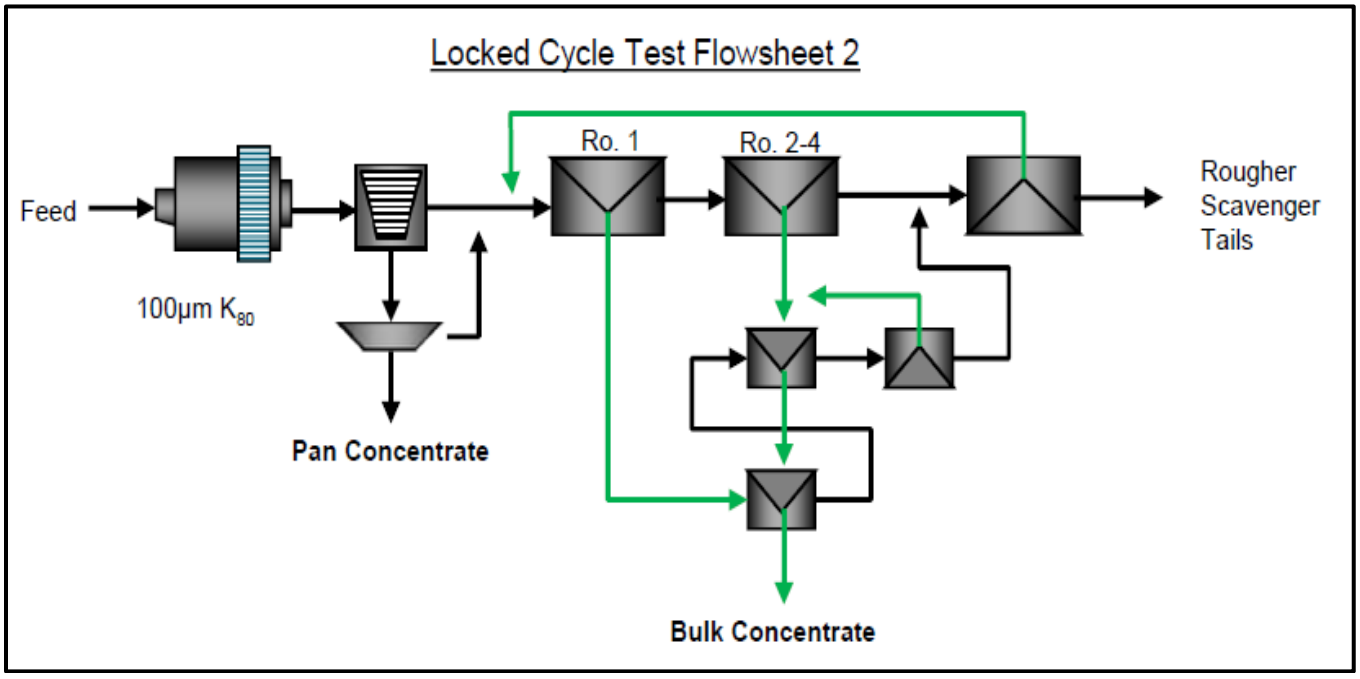


Table 13-17 summarizes the test conditions for the two locked cycle flotation tests. Both locked cycle tests were completed at a primary grind size of 80% passing 100 µm and at a natural pH with PAX as sulphide collector.

Table 13-17: Locked Cycle Testing Conditions

Testing Conditions	Unit	Flowsheet No. 1	Flowsheet No. 2
Primary Grinding Size P_{80}	µm	100	100
Rougher/Scavenger Flotation			
pH	-	Natural	Natural
Collector PAX	g/t	20/10	5/15/10
Retention Time	min	8/4	2/6/4
Cleaner/Scavenger Flotation			
pH	-	Natural	Natural
Collector PAX	g/t	0/0/0/5	0/0/5
Retention Time	min	4/3/2/2	4/6/2

Table 13-18 summarizes and compares the test results for the two flowsheets. In the first locked cycle test recovered approximately 31% gold and 4% silver to a gravity concentrate, grading at 897 g/t Au and 1,400 g/t Ag. The second locked cycle test recovered more gold and a similar amount of silver to a gravity concentrate of 37% gold and 4.5% silver grading at 1,596 g/t Au and 2,053 g/t Ag. The flotation concentrates produced in the first locked cycle test contained 34 g/t Au and 559 g/t Ag, which translated to recoveries of 63% gold and 91% silver. The second locked cycle flotation test produced a lower grade concentrate of 28 g/t Au and 450 g/t Ag which represented recoveries of 59% gold and 90% silver. The lower grade could be attributed to the flowsheet configurations.

Table 13-18: Locked Cycle Test Results

Products	Wt (%)	Grade (g/t or %)			Recovery (%)		
		Au	Ag	S	Au	Ag	S
Flowsheet No. 1							
Gravity Concentrate	0.2	897	1,400	54.8	31.4	4.3	2.4
Flotation Concentrate	9.1	34.2	559	40.5	63.0	90.8	92.3
Tailings	90.7	0.30	3	0.24	5.6	4.8	5.4
Head	100	4.97	56	4.01	100	100	100
Flowsheet No. 2							
Gravity Concentrate	0.1	1,596	2,053	53.5	36.7	4.5	1.7
Flotation Concentrate	11.3	28.0	450	33.0	58.7	90.0	94.5
Tailings	88.6	0.28	4	0.17	4.6	5.5	3.8
Head	100	5.39	56	3.94	100	100	100

A further cleaner flotation stage was added to the second locked cycle testing to treat the second cleaner flotation concentrates. As shown in Table 13-19, a high-grade concentrate was produced grading at 32.2 g/t Au and 536 g/t Ag.

Table 13-19: Third Cleaner Flotation Results on the Second Locked Cycle Test

Products	Flowsheet No.2						
	Wt (%)	Grade (g/t or %)			Recovery (%)		
		Au	Ag	S	Au	Ag	S
Feed (Second Cleaner Concentrate)	11.3	28.0	450	33.0	58.7	90.0	94.5
Third Cleaner Concentrate	9.6	32.2	536	38.9	57.7	89.0	92.4
Third Cleaner Tailings	1.7	3.03	32	4.87	1.0	0.9	2.1

ICP analysis, whole rock analyses, and sizing were conducted on concentrates and tailings samples generated from the two locked cycle tests. The following observations are made:

- Most of the sulphur was in sulphide form.
- Organic carbon was concentrating into concentrates rather than tailings.
- Arsenic assayed as 0.6% and 0.5 % for the first and second final concentrates, respectively.
- Particle size of the concentrates was approximately 80% passing 100 µm, while cleaner scavenger tailings presented a much smaller size between 15 and 20 µm.

13.3.5.8 Optimization Tests – ALS 2018

Two samples—a rougher concentrate sample and a third cleaner concentrate—were collected from the Brucejack Gold Mine process streams and tested to investigate the potential gold recovery by gravity concentration from the rougher concentrate following regrinding and further upgrading the third cleaner concentrate using conventional flotation and flotation column methods. Table 13-20 shows the head assay results of the two samples.

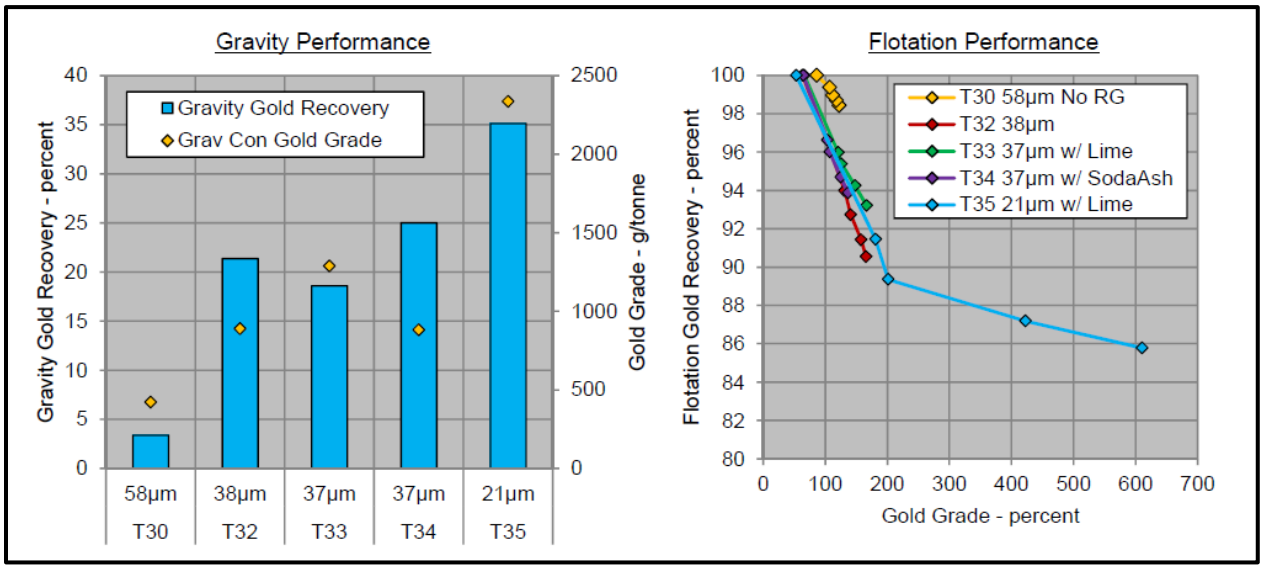
Table 13-20: Head Assays of Processing Samples

Sample	Grade (g/t or %)			
	Au	S	$S^{(-2)}$	As
Rougher Concentrate	85	37.5	37.5	0.21
Third Cleaner Concentrate	111	44.2	44.2	-

The rougher concentrate samples were subject to a combined treatment of a gravity separation and a three-stage cleaner flotation along with a cleaner scavenger flotation stage. Regrinding was incorporated prior to the gravity separation in four of five tests. Regrind time and pH level were varied to investigate the impacts. The following conclusions were made regarding the test work (also see Figure 13-11):

- Without regrinding (T31), gold recovered to gravity concentrate was low. The flotation circuit generated a gold recovery of 98% at a grade of 122 g/t Au.
- At a regrind size 80% passing approximately 37 µm (Tests 32/33/34), the gravity gold recovery was between 19 and 25%, and the gold grade of the flotation concentrates was found to be 166 g/t Au at a gold recovery of 91%. Increasing the pH level seemed to have no impact on the gold grade.
- At a regrind size 80% passing approximately 21 µm (T35), gold gravity recovery increased to 35%, while the flotation concentrates contained 611 g/t Au at a high pH level of 10 to 10.5.

Figure 13-11: Gravity and Flotation Optimization Tests



The third cleaner concentrate samples grading at 111 g/t Au were subject to a column flotation test and compared with a one-stage conventional flotation process. As shown in Table 13-21, the test results seem to show:

- The conventional flotation test (T28) upgraded the gold grade to 121 g/t Au at a gold recovery of 99%
- The column flotation test (T29), as a comparison, improved the gold grade to 147 g/t at a gold recovery of 95%.

Table 13-21: Conventional and Column Flotation Results

Products	Wt (%)	Grade (g/t or %)			Recovery (%)		
		Au	S	$S^{(-2)}$	Au	S	$S^{(-2)}$
Conventional Flotation							
Feed	100	110	44.6	44.5	100	100	100
Concentrate	90.2	121	49.0	48.9	98.6	99.1	99.1
Tailings	9.8	15.2	4.17	4.14	1.4	0.9	0.9
Column Flotation Tests							
Feed	100	116	46.6	46.5	100	100	100
Concentrate	75	147	51.0	50.9	95.3	82.1	82.1
Tailings	25	22.0	33.4	33.3	4.7	17.9	17.9

13.3.6 Solid and Liquid Separation Test Work

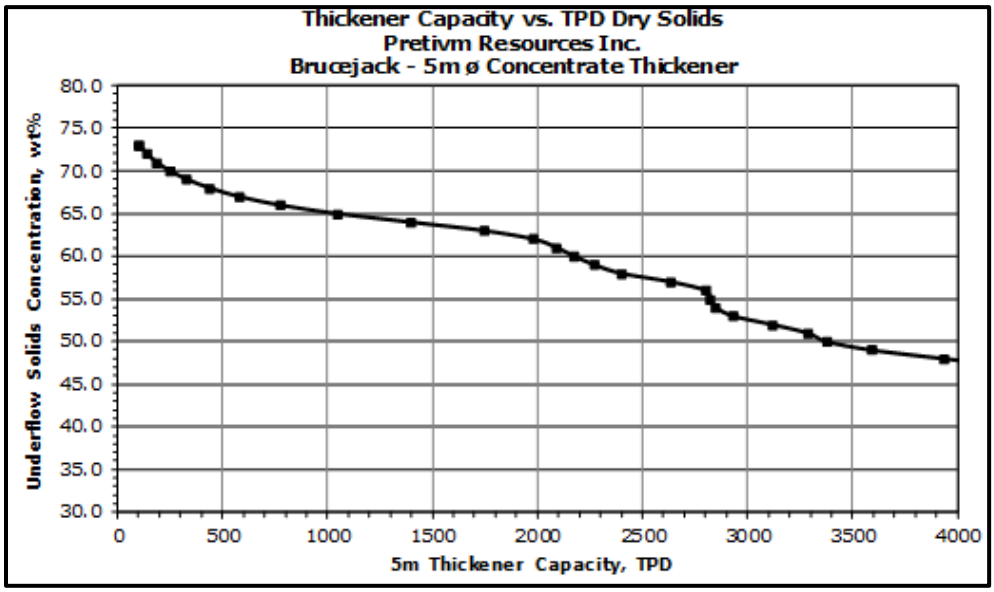
In 2016, SNF provided preliminary flocculant and coagulant screening tests using static settling methods. The test results showed that using 910 VHM alone can reach the target supernatant clarity, settling rate, and compaction. In 2017, SNF performed another screen test to control the tailings thickener overflow clarity. The results indicated that using flocculant 910 VHM alone can not prevent carryover of fines; coagulant DB45 VHM should be also added after adding flocculant.

In 2018, FLSmidth performed a comprehensive SLS test program in its laboratory located in Midvale, Utah on both the flotation concentrate and tailings samples collected from the Brucejack Gold Mine operation. The objectives of this test program were to optimize settling characteristics and to evaluate the performance of the two thickeners to accommodate the 3,800 t/d throughput. The test results and conclusions are summarized as follows:

- The flocculant that produced the best overflow clarity and settling velocities was a non-ionic polyacrylamide flocculant with a medium molecular weight. The recommended flocculant is AN 920 SH, which can be applied for both the tailings and the concentrate thickening. The suggested flocculant dosage is between 50 to 80 g/t for the tailing thickener and approximately 15 g/t for the concentrate thickener. In addition, better overflow clarity results using AN 920 SH were noticed during thickening testing, compared to the treatment of thickening followed by coagulant clarification. The use of fresh water rather than process water for flocculant dilution and makeup is also critical in optimizing performance of thickeners.
- The optimum solids concentration for flocculation was suggested to be 4 to 10% by weight for the tailings thickener feed materials and approximately 16% by weight for the concentrate thickener feed.
- The solids density of the tailings thickening underflow was estimated between 51 to 63.5% by weight using the existing thickener. The corresponding solids density of the concentrate thickener underflow was estimated as 76% by weight.

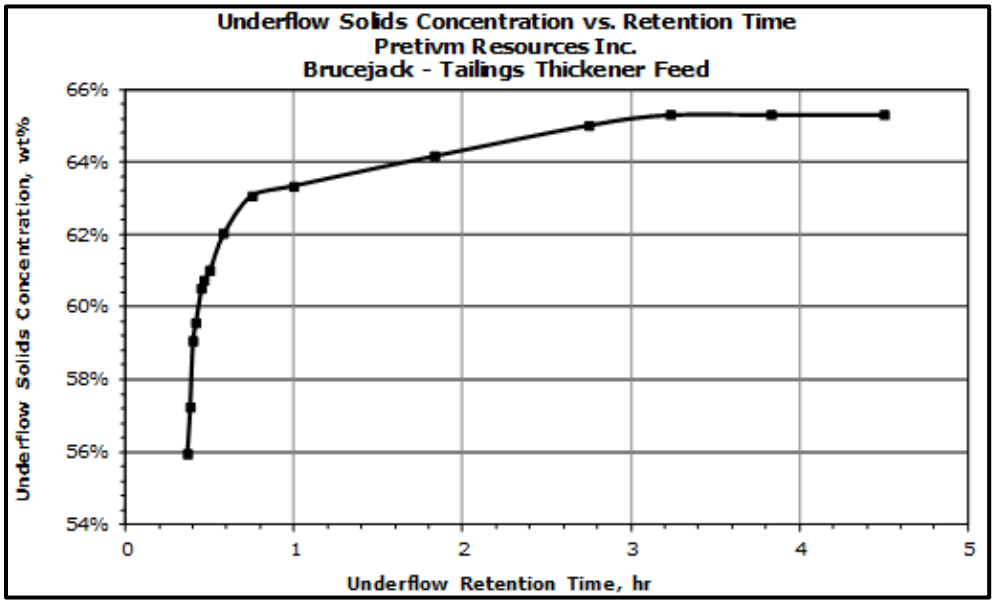
- With proper thickener feed conditioning including 15% by weight feed dilution and use of the AN-920 SH flocculant at the recommended dosages, the existing concentrate thickener would have sufficient capacity for the 3,800 t/d throughput. Careful consideration must also be given to froth suppression. Figure 13-12 shows the solids capacity as a function of underflow solids concentration for the concentrate thickener.

Figure 13-12: Concentrate Thickener Capacity



- With proper feed conditioning, including 10% solids by weight diluted feed and use of the approximately 80 g/t AN-920SH, the existing tailing thickener can handle the increased capacity of 3,800 t/d and achieve an underflow density of 64% solids. Going significantly beyond this throughput would require a new tailings thickener. FLSmidth recommended the 64% underflow solids concentration for the tailings thickener based on two considerations: the yield stress will be greater than 300 Pa at 65% by weight solids (a critical point for downstream slurry handling equipment) and the operation may encounter difficulty. Figure 13-13 shows the tailings thickener underflow solids density variations with retention time.

Figure 13-13: Tailing Thickener Underflow Concentration with Time



In 2019, two tailings samples were collected from the mill during the upset operation conditions that elevated fine-clay materials suspended in the thickener overflow which were not flocculated properly with the flocculant reagent (SNF 910 HH). The two samples were sent to and tested at the Pocock laboratory in Salt Lake City, Utah. The purpose of this testing was to assist plant operation to clarify the tailings thickener overflow by evaluating settling rheology and filtration characteristics of the tailings.

Various flocculant and coagulant reagents were screened to achieve clear overflow (less than 150 ppm total suspended solids (TSS)), acceptable settling rates, and underflow densities in static and dynamic thickening tests. Pulp rheology tests were completed on all thickened materials to estimate the maximum underflow density. Pocock concluded that using both the low cationic (SNF 4125 SH) and the anionic plant flocculant (SNF 910) appeared to meet the requirements of overflow clarity. The test results indicate that to achieve reasonable overflow clarity, a high flocculant dosage would be required. The resulted thickener underflow solids density was estimated between 53 to 57% for a conventional thickener. The solid density can be increased to over 57% solids density if a deep cone thickener is in place. The test results indicated that the feed solids density range needs to be maintained in a range of 10 to 12.5% by weight.

13.4 Mill Operations Optimization / Expansion Process Simulations

Simulations were conducted by various vendors and consultants to evaluate the major circuit performances for the Brucejack mill expansion. The grinding circuit, gravity recovery circuit, and flotation circuit modelling are described in the following subsections.

13.4.1 Grinding Circuit

CSS performed simulations on the primary grinding circuit using JKSimMet software, which were compared with another simulation method proprietary to Weir Minerals. The input data for both simulations include comminution test results from ALS and SGS and site operating data.

13.4.1.1 JKSimMet

CSS used JKSimMet software to simulate comminution circuit performances in two phases. Phase 1 estimated the maximum mill throughput at standard operations, which was outlined in the plant survey data completed under routine operating conditions. Phase 2 estimated the increased mill throughputs supported by the Phase 1 data and a significantly coarsening grind product particle size.

Phase 1

Phase 1 results were reported in the January 18, 2017 Phase 1 report titled *Results Simulation Study and Throughput Optimization of the Existing Brucejack Circuit Based on the November 23, 2017 Plant Survey* (CSS 2017a). The report indicated that at the current 2,700 t/d mill feed rate, the grinding circuit was operated at well under the available grinding capacity, with the SAG mill operating at 51% of the installed motor capacity and the ball mill at 77% of the installed motor capacity. The pebble crusher was not being used. If the current grind size is maintained for future mill expansion, the existing grinding operation will be limited first by the ball mill capacity before reaching the maximum SAG mill capacity.

The simulations showed that the 3,800 t/d target could be readily achieved for all rock (ore) types while maintaining a targeted product size 80% passing of 90 µm for the ore hardness range tested. Table 13-22 shows the simulation results for the mill feed rate of 3,800 t/d. The current feed ore, as listed in Table 13-22, represents the November 23, 2018 baseline sample.

Table 13-22: JKSimMet 3,800 t/d Results at 92% Availability

Ore Type[1]	SAG Mill Circuit									Ball Mill Circuit								
	New Feed		Combined Feed		SAG Mill		SAG Screen O/S		SAG Screen U/S	Ball Mill[2]			Cyclone		Cyclone U/F		Cyclone O/F	
	Rate (t/h)	F_{80} (mm)	Rate (t/h)	F_{80} (%)	Critical Speed (%)	Power Draw (kW)	Rate (t/h)	P_{80} (mm)	P_{80} (µm)	Power Draw (kW)	Ball Charge v/v (%)	Circulation Load (%)	Feed Solids (%)	No.	Pa (kPa)	Solids (%)	Solids (%)	P_{80} (µm)
ARG	172	112.8	176	111.8	55.3	937	4.13	18.0	731	1,980	34.0	316	52.6	6	123.0	79.4	25.4	90
CGL	172	112.8	177	111.6	58.1	993	5.12	17.8	884	1,980	34.0	287	52.9	6	104.7	77.2	27.7	90
SIL H8	172	112.8	177	111.6	57.6	978	5.07	17.9	781	1,980	34.0	232	53.9	5	106.3	76.5	32.0	90
P2	172	112.8	178	111.4	58.3	1,008	5.63	17.9	879	1,980	34.0	206	56.2	5	80.0	73.6	37.7	90
VSF	172	112.8	179	111.1	61.9	1,066	6.97	17.6	971	1,980	34.0	224	54.6	5	97.5	75.6	33.6	90
Current Feed Ore	172	112.8	179	111.2	60.7	1,044	6.77	17.7	951	1,895	32.0	220	54.9	5	93.1	75.2	34.5	90
P1	172	112.8	179	111.1	60.6	1,048	6.91	17.7	946	1,980	34.0	218	55.3	5	90.0	74.9	35.2	90
AND	172	112.8	182	110.4	64.9	1,132	9.80	17.4	1,145	1,980	34.0	229	55.1	5	97.4	76.1	33.8	90
V6	172	112.8	183	110.2	64.8	1,134	10.72	17.4	1,203	1,980	34.0	232	55.3	5	97.9	76.3	33.7	90

Notes: [1]Ore types sorted by A x b values from softest to hardest resistance to impact breakage; hardness data can be found in Section 13.4.4.
[2]Ball mill critical speed was set as of 79.0% to all simulations.

The simulation results indicated that by adjusting the SAG mill power draw, the target 3,800 t/d capacity can be reached for all the simulated ore types using the same grind size as the present operation. CSS noted that the maximum throughput could be as high as 4,239 t/d at the same grind size by increasing the SAG mill critical speed and steel ball charge rate, depending on ore characteristics. CSS recommended including an additional operating cyclone, adjust feed pressure of the cyclone, and feed solids density per the targeted operating conditions as outlined in the report (CSS 2017a).

Phase 2

The Phase 2 simulation work provided supplemental information to the Phase 1 work. The modelling was based on an increased product grind size to determine the potential of the existing grinding circuit. The results are included in the report titled *Optimization to Maximize Throughput of the Existing Brucejack Circuit Based on the November 23, 2017 Plant Survey* (CSS 2017b).

A coarse grind size used in the Phase 2 simulation was based on the ALS flotation testing results conducted in 2017/2018, which indicated that the impacts of increased grind size on flotation performance were minor to moderate for most ore types. It was reported that at a significantly coarser float feeds of up to 80% passing 160 µm, the recovery drop was relatively modest of up to 5%. At this coarse grind size, the simulations by CSS showed that the throughput of the grinding circuit can reach up to approximately 10,000 t/d depending on ore hardness.

The Phase 2 simulation findings concluded that to achieve the high throughput, using wider grate openings, maximizing the pebble crusher capacity, as well as adjusting the mill speed and charge load would be required, along with undertaking modifications to pumping, water supply, piping, and cyclones. However, it should be noted that the upstream crushing and downstream process/tailings handling circuits would be well under capacity. Therefore, the Phase 2 scenario was not incorporated into the mill upgrading.

13.4.1.2 Weir Minerals

Weir Minerals undertook modelling of the grinding circuit using their internal proprietary simulation software. The software incorporated the ALS laboratory comminution data, as well as SPI data generated by SGS. Several simulations were conducted by Weir Minerals, which showed that there is excess capacity in the current grinding circuit, which can reach the 3,800 t/d target

13.4.1.3 Krebs – FLSmidth

Four of the six hydro-cyclones are currently in operation with the remaining two on standby mode. Krebs-FLSmidth (Krebs) performed simulations to project the performance of these hydro-cyclones at a mill throughput of 3,800 t/d and higher. Using a 300% circulating load as a baseline, Krebs' findings indicated that the existing arrangement of the cyclones could readily accommodate the 3,800 t/d scenario through a small increase in the product grind size and by selecting a larger vortex finder. Alternately, an additional cyclone can be put into operation to handle the increased feed rates.

When the mill throughput increases to 6,000 t/d, all six cyclones would be in operation at a much coarser cut-off size of 80% passing approximately 135 µm. Additional standby cyclone capacity is recommended if advancing throughput substantially above the 3,800 t/d scenario.

13.4.2 Gravity Simulations

A gravity model was prepared by FLSmidth in May 2018 based on the 2018 E-GRG test results and the previous E-GRG test results to simulate the gravity recovery under the expansion of the Brucejack mill. Three scenarios were simulated: current operation rate of 2,700 t/d; planned operation rate of 3,800 t/d; and 6,000 t/d at varied primary grind sizes of 80% passing of 90 µm, 110 µm, and 135 µm, respectively. Major conclusions from the modelling are summarized as follows:

- Currently, each of the two Kneslon KC-QS40 units installed at the Brucejack Gold Mine have a recommended feed rate of 225 t/d, which can allow the two units to treat 100% of the ball mill discharge. The simulated gravity gold recovery was 59% and 65% at a 70.5% and 80.5% GRG content, respectively.
- When the plant capacity increases, gold gravity recovery would decrease mainly considering: the efficiency of the Knelson KC-QS40 will decrease as the feed rate increases, the coarser primary particle size, and the lower residence time of GRG in the grinding circuit.
  - In the 3,800 t/d scenario, the gold gravity recovery using the two KC-QS40 units may decrease by 5 to 7%; however, this could be compensated by installing an additional unit to 3 to 4%.
  - In the 6,000 t/d scenario, the gold gravity recovery may significantly drop by 17 to 18% if using the existing two units only. Adding two more units can limit the gold recovery loss to about 9%.

13.4.3 Flotation Simulations

The existing flotation circuit consists of a series of rougher and rougher scavenger flotation stage, and a three-stage cleaner flotation circuit including the first cleaner scavenger stage. The first cleaner scavenger tailings feeds to the rougher scavenger flotation stage.

Metso Corporation (Metso) and Weir Minerals performed simulations to evaluate the performance of the existing flotation circuit at a higher plant feed throughput.

Metso concluded that the retention time of the existing cells is sufficient to handle the 3,800 t/d throughput; however, due to the high froth carry rate and lip loading predicted from the increased 3,800 t/d throughput, it would be appropriate for additional cells to be installed for either (or both) second and third cleaners. The addition of new cells would increase operational flexibility and facilitate optimization of the cleaner circuit.

Weir Minerals recommended some modifications for slurry handling to improve overall operation performance for the increased throughput.

13.5 Production Data 2017 to 2019

The process flowsheet developed for the Brucejack Property mineralization is a combination of conventional bulk sulphide flotation and gravity concentration to recover gold and silver into gold doré and gold-silver bearing flotation concentrates. In May 2017, ore was first introduced to the mill with a focus on ramping up to designed production throughput using ore from the low-grade ore stockpiles. The first gold was poured on June 20, 2017. During commissioning, 8,510 oz Au were produced in June. On July 1, 2017, Pretivm declared commercial production at the Brucejack Gold Mine. Table 13-23 lists the production data from July 2017 to the end of 2019 based on the Pretivm's reports and news releases.

Table 13-23: Bruckejack Mill Production Data 2017–2019[(1)]

Time	Mill Feed Tonnage (t)		Mill Feed Grade (g/t)		Total Recovery (%)	
	Total	Daily	Au	Ag	Au	Ag
Q3 2017	261,262	2,840	10.5	n/a	96.5	n/a
Q4 2017	271,501	2,951	8.2	13.8	95.8	80.8
Total Average 2017	**532,763**	**2,895**	**9.4**	**13.8**	**96.2**	**80.8**
Q1 2018	261,443	2,905	9.1	13.0	96.8	85.7
Q2 2018	236,990	2,604	14.9	17.1	97.7	88.3
Q3 2018	240,122	2,610	12.4	14.1	97.4	88.1
Q4 2018	267,048	2,903	11.5	15.8	97.0	85.6
Total Average 2018	**1,005,603**	**2,755**	**11.9**	**15.0**	**97.3**	**87.0**
Q1 2019	295,122	3,279	8.7	13.3	96.8	85.6
Q2 2019	324,171	3,562	8.9	15.6	96.9	83.8
Q3 2019	309,754	3,367	9.1	14.7	97.0	85.5
Q4 2019	373,954	4,065	8.3	14.1	96.8	85.6
Total Average 2019	**1,303,001**	**3,570**	**8.7**	**14.5**	**96.9**	**85.1**

Note: [(1)]Excluding gold and silver from pre-commercial production.

13.6 Metallurgical Performance Projection

Since the Brucejack Gold Mine was commissioned, Pretivm has focussed on improving gold and silver recoveries to the gravity concentrate for doré production and has been successful in its strategy.

In comparison to the 2014 FS (Ireland et al. 2014) projection for the Valley of the Kings mineralization, although similar overall gold and silver recovery was observed from the operation, the gold recovery to the gravity concentrate has significantly improved by approximately 20% or higher.

Because there is no operational data available for the West Zone, the metallurgical performance is assumed to be the same as previous projections.

14.0 MINERAL RESOURCE ESTIMATES

Pretivm updated the January 2019 resource estimate (Jones et al., 2019) to incorporate new geological and assay information on the Brucejack Deposit generated through additional underground drilling, underground mine development, and mine production at the Brucejack Gold Mine. Details of the resource estimation which form the basis of the January 2020 Mineral Resource and the January 2020 Mineral Reserve presented in Section 15.0, are described below.

The January 2020 Mineral Resource for the Brucejack Deposit incorporates estimates from the Valley of the Kings Zone and West Zone. No new information has been collected from the West Zone since 2012. As such, the West Zone portion of the January 2020 Mineral Resource remains unchanged and is based on the West Zone resource estimate generated by Snowden in April 2012 (Jones, 2012a; Jones, 2014). The Valley of the Kings Zone portion of the January 2020 resource estimate has been updated in those areas surrounding the underground workings informed by new drilling data (Figure 14-1) acquired between January 9, 2019 and September 30, 2019. The December 2013 resource estimate generated by Snowden (Jones, 2014) and the January 2019 resource estimate generated by Pretivm (Jones et al., 2019) have been retained for the Valley of the Kings Zone in those parts of the deposit for which no new data has been obtained since 2013 and January 2019, respectively. No new information has been obtained for the Bridge Zone, Gossan Hill Zone, and Shore Zone targets. These zones are currently not considered part of the high-grade mineral resource on the Brucejack Project and are therefore not included in the January 2020 Mineral Resource. The Mineral Resource for the Bridge Zone, Gossan Hill Zone, and Shore Zone targets as reported in September 2012 (Jones, 2012b) is no longer current.

The January 2020 resource estimate for the Brucejack Deposit, as documented in this report, used data and geologic interpretations provided by Pretivm. New data used to inform the updated January 2020 resource estimate included 89,121 m of underground drilling since the January 2019 Mineral Resource (see Section 10.0) and production reconciliation information.

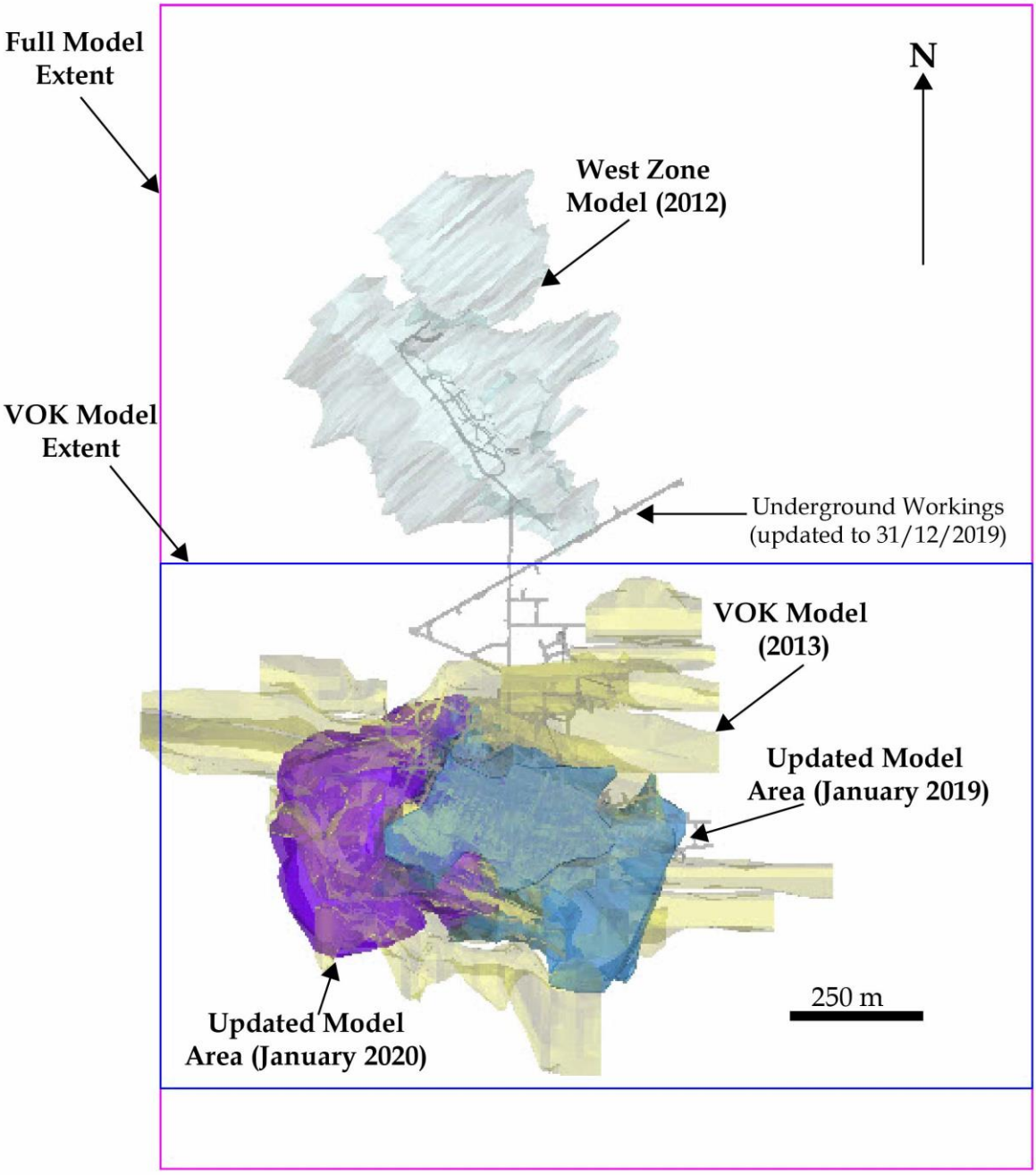
14.1 Disclosure

Mineral Resources were prepared by Ms. Kristin Chislett, P.Geo. (Resource Geologist, Pretivm) under the direct supervision of Dr. Craig Morgan, Geo.L, Pr.Sci.Nat. (Corporate Resource Geologist, Pretivm) and the QP, Mr. Ivor Jones, P.Geo., FAusIMM. Mr. Jones is an employee of Ivor Jones Pty Ltd (“JonesPL”) and is a QP as defined by NI 43-101 through his experience, membership of a recognized professional organization, and qualifications. Both Mr. Jones and Ivor Jones Pty Ltd are independent of Pretivm. Ms. Chislett and Dr. Morgan are employees of Pretivm.

14.2 Known Issues that Materially Affect Mineral Resources

At the time of this report, the QP was not aware of any permitting, legal, title, taxation, socio-economic, political, or marketing issues that could materially affect the Mineral Resource presented herein.

Figure 14-1: Plan View of the Brucejack Deposit Showing the Location of the West Zone and Valley of the Kings Zone (VOK) Resource Block Models, and the Defined Update Areas (and Dates)



Source: Pretivm 2020

14.3 Modelling Approach

The Brucejack Deposit records a complex magmatic, hydrothermal, and tectonic geological history associated with an active island arc environment that was subsequently deformed as a result of destructive plate margin tectonism (Section 7.0). Whilst geological complexity is partly the reason behind the gold tenor at Brucejack, it presents numerous challenges to effective geological and resource modelling of the deposit:

- Overprinting of an earlier, low-grade porphyry-associated mineralization system, by a later, co-spatial high-grade stockwork-hosted epithermal system precludes separation of the two different systems into separate domains.
- The variable, composite, and broad nature of the epithermal vein stockwork necessitates modelling corridors of veins, vein breccia, and vein stockwork, rather than individual veins.
- The presence of statistically significant high- to extreme-gold-grades that are an integral part of the gold grade distribution in the Valley of the Kings Zone precludes the exclusive use of traditional linear grade estimation techniques.

Multiple Indicator Kriging (MIK) has an advantage over linear estimation techniques in that it can deal with mixed and inseparable strongly-skewed grade populations characterized by high coefficients of variation (e.g., Carvalho and Deutsch, 2017). The QP considers the MIK technique appropriate for use in resource estimation of the Brucejack Deposit, as the deposit exhibits these characteristics at the deposit, domain, and local (within-domain) scales. In addition to the use of MIK, the distribution of high- and extreme-gold-grades during estimation was further controlled through the application of the split population approach to grade estimation used previously (Jones, 2014). In this technique, the low-grade gold and silver variables are estimated through Ordinary Kriging (OK), the high-grade gold and silver variables are estimated through MIK, and the probability of high-grade gold and silver occurrence are estimated through single Indicator Kriging (IK). These estimates are all done at point scale and recombined to generate final estimates. These estimates are then reblocked to an appropriate block size. This method considers the mixed, positively skewed, high coefficient of variation, highly variable, and nuggety nature of the gold mineralization at Brucejack, as well as the potential hit-and-miss nature of drilling in such a deposit (Board et al., 2017). Order relations and volume-variance considerations are an integral part of this process.

The January 2020 resource estimate for the Brucejack Deposit was prepared in the following steps:

- Digital data validation
- Data preparation
- Geological interpretation and domain modelling
- Establishment of block models
- Coding and compositing of assay intervals
- Derivation of kriging plan
- Variogram analysis and selection of kriging parameters
- Grade interpolation of gold (Au) and silver (Ag) using a mix of OK, IK, and MIK, followed by reblocking
- Validation of final Au and Ag grade estimates and models
- Reconciliation of the January 2020 resource estimate to mill production

- Confidence classification of estimates in accordance with CIM Definition Standards (CIM, 2014)
- Deduction for prior mining and additional non-resource defined material
- Mineral Resource tabulation and documentation.

14.4 Data Provided for Estimation

The January 2020 resource estimate is based upon an updated and expanded drillhole and assay data set, and updated triangulations, including topography, lithological wireframes, and mineralized domains. The source and composition of the assay data set is summarized in Section 14.4.1, and a summary of how the triangulations are created and approved for use in the resource model is provided in Section 14.4.2.

14.4.1 Assay Dataset for Grade Estimation

Drillhole and assay data available as of September 30, 2019 were used in the generation of the January 2020 resource estimate. The GeoSpark SQL drillhole database, which included the results from the 2019 drilling program, was provided by Pretivm. Collars, surveys, lithology, assay/geochemical data, and specific gravity data were exported from the database in .CSV format, and imported into the Leapfrog Geo, Snowden Supervisor, and Maptek Vulcan mining software for use in modelling and resource estimation.

Several different industry-standard gold assay techniques have been used at Brucejack (Section 11.0), including conventional fire assay with an AA or gravimetric finish (30 or 50 g charge weights), screen fire assay, and concentrate grade analyses. Where one sample had gold assay data determined using different analytical methods, an assay priority was applied. This was based on method and overlimit values in the following precedence sequence: concentrate grade analyses (for Au > 10,000 ppm) > 50 g charge fire assay with gravimetric finish (overlimit Au to 10,000 ppm) > 30 g charge fire assay with gravimetric finish (overlimit Au to 10,000 ppm) > screen fire assay (1 kg pulp, 50 g charge; for overlimit Au) > screen fire assay (1 kg pulp, 30 g charge; for overlimit Au) > 50 g charge fire assay with atomic absorption (AA) finish (100 ppm Au upper detection limit) > 30 g charge fire assay with AA finish (10 ppm Au upper detection limit) > Historical Au. Statistical evaluations of the various techniques between screen fire assays and fire assays with a gravimetric finish indicated no systematic bias, and therefore, the fire assays, which comprised a more complete dataset, were used as the primary assay.

Silver results were determined using different analytical methods (Section 11.0) and were also method-ranked based on overlimit triggers. At concentrations below 100 ppm, silver is determined by a multi-element ICP method, which uses a four acid near-total digestion (100 ppm Au upper detection limit). Above 100 ppm, an ore grade silver analysis is triggered (upper detection limit 1,500 ppm Ag), followed by a trigger to a 30 g charge fire assay and gravimetric finish (upper detection limit 10,000 ppm Ag), with a concentrate grade 30 g charge fire assay with a gravimetric finish conducted on those samples with silver above 10,000 ppm. There are 4,873 samples in the database that do not have associated silver information. This represents approximately 1.05% of the total sample database.

The Brucejack Property database as of September 30, 2019 contained 465,435 gold assay data in 3,917 drillholes, the majority of which (87.6%) were determined using conventional fire assay with an AA finish. Statistical analyses comparing conventional fire assay technique by charge sizes for paired data show no significant differences between assay data types. Similar analyses conducted on paired data comparing the different overlimit analyses showed no significant bias or difference between the four overlimit techniques. Limited historic drilling was conducted in the Valley of the Kings Zone, with the majority concentrated on the West Zone (Section 10.0; Jones, 2012a). A re-assaying campaign was conducted on select drillholes from the West Zone by Silver Standard

(Jones, 2012a), verifying the applicability of using this data for modelling and resource estimation. The Brucejack Project drilling database contains very few unsampled intervals (few historic drillholes only) and those with no sample recovery. Default values were not assigned to missing intervals in such cases. Sections 11.0 and 12.0 summarize data quality (QA/QC protocols and findings) and verification procedures for the Brucejack Project data.

14.4.2 Assay Data Import Procedure

The certified raw assay data files are received by email directly from the analytical laboratory reporting services. Data are provided in a specified digital import format (in MS Excel) as well as in a secure PDF certificate format. Each MS Excel data file is checked for inconsistencies prior to being imported into the SQL database via the GeoSpark Core MS Access front end interface (GeoSpark). Laboratory data files are not modified in any way prior to import. The SQL database is stored on a secure server and data are backed up nightly. After import, an assay ranking script is run via an SQL query or stored procedure to provide the final ranked data set. Exports from the database (to .CSV format) are conducted using a set of saved queries in the GeoSpark database interface.

14.4.3 Triangulations

14.4.3.1 Topography

Topographic constraint was provided by a digital terrain model (DTM) created from an aerial light detection and Ranging (LIDAR) survey in the summer of 2014. The survey was flown from a nominal height of 1,800 m above ground at 100 knots flying speed. The data were collected using a Riegel Q1560 laser scanner owned by Eagle Mapping, with the point data positioned with an average density of 7–9 points per square metre. Data processing was completed by Allnorth Consultants before provision to Pretivm. The survey was measured to have a root mean square error of 0.050 m, and an absolute accuracy of +/- 0.098 m. Conversion of LIDAR to the DTM was completed by Pretivm's GIS personnel and reviewed and approved by Pretivm before being imported as a triangulation into the Maptek Vulcan mining software (v.11.0.4) for use in resource modelling (Figure 14-2).

14.4.3.2 Lithology

Lithological triangulations were created in the Seequent's Leapfrog Geo (v.5.0) modelling software with a live link to Reflex Geoscience's ioGAS software (v.6.1). The triangulations were generated based on interpretations from core logs (lithology, structure), geochemical data, core photos, and surface and underground mapping by a single experienced geological modeler to ensure consistency. The triangulations were imported in the Maptek Vulcan mining software and reviewed, refined, and validated by Pretivm (Figure 14-2). The lithological triangulations were used to code lithology into the block model for specific gravity and bulk density modelling.

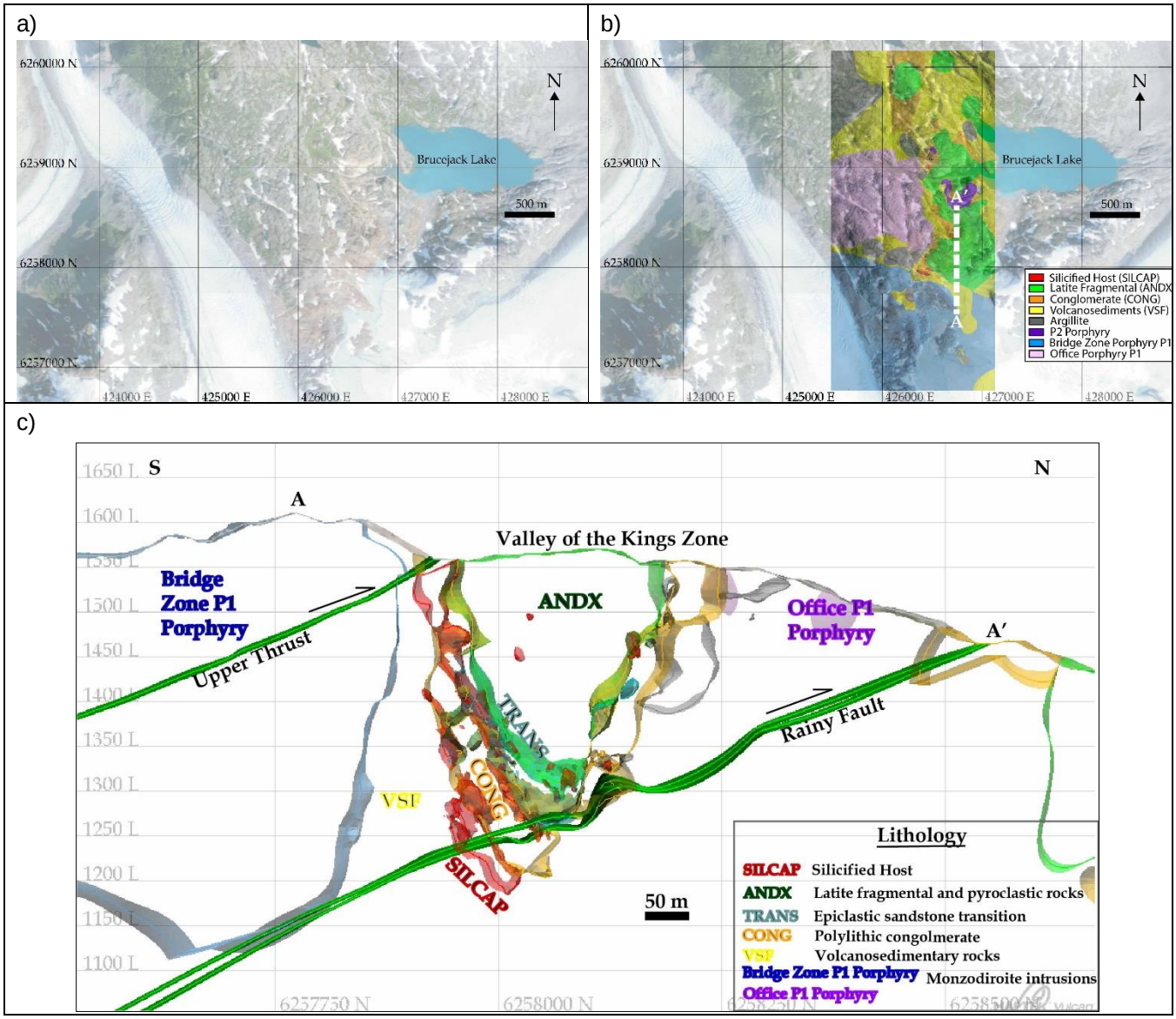
14.4.3.3 Mineralized Domains

Mineralized domains were prepared by Pretivm using the Leapfrog Geo mining software, informed by a combination of core logging data (primarily veining and structure), assay results, core photography, and underground mapping (see Section 14.5). Mineralized domain triangulations were iteratively updated as and when new information became available, imported into the Maptek Vulcan mining software, and reviewed and validated by Pretivm prior to being used for resource modelling.

14.4.3.4 Underground Development and Production Solids

As-built triangulations for underground mine development (Figure 14-1) and Cavity Monitoring System (CMS) stope void scans were generated by Pretivm's mine engineering team at the Brucejack Gold Mine. The triangulations were imported into the Maptek Vulcan mining software, reviewed, validated, and used for coding mined out areas for Mineral Resource depletion and reporting. Blasthole design triangulations were generated for each stope in the Aegis mine planning software by Pretivm's mine engineering team at the mine. A combination of CMS and Blasthole triangulations were used for reconciliation of the Mineral Resource to the mill (see Section 14.8.4). Moreover, additional wireframes were diligently prepared by Pretivm to define zones between and around mined out stopes that are now considered as either sterilized or non-mineable (see Section 14.10.1).

Figure 14-2: Topography and Lithological Wireframes used in the Generation of the January 2020 Resource Estimate (shown in Maptek's Vulcan Mining Software): a) Plan View of Topography Draped with Aerial Photography; b) Plan View Showing Lithological Model Triangulations and Approximate Location of Cross Section; c) S-N Cross-Section Along 426525 mE (A-A').



Source: Pretivm 2020

14.5 Geological Interpretation and Modelling

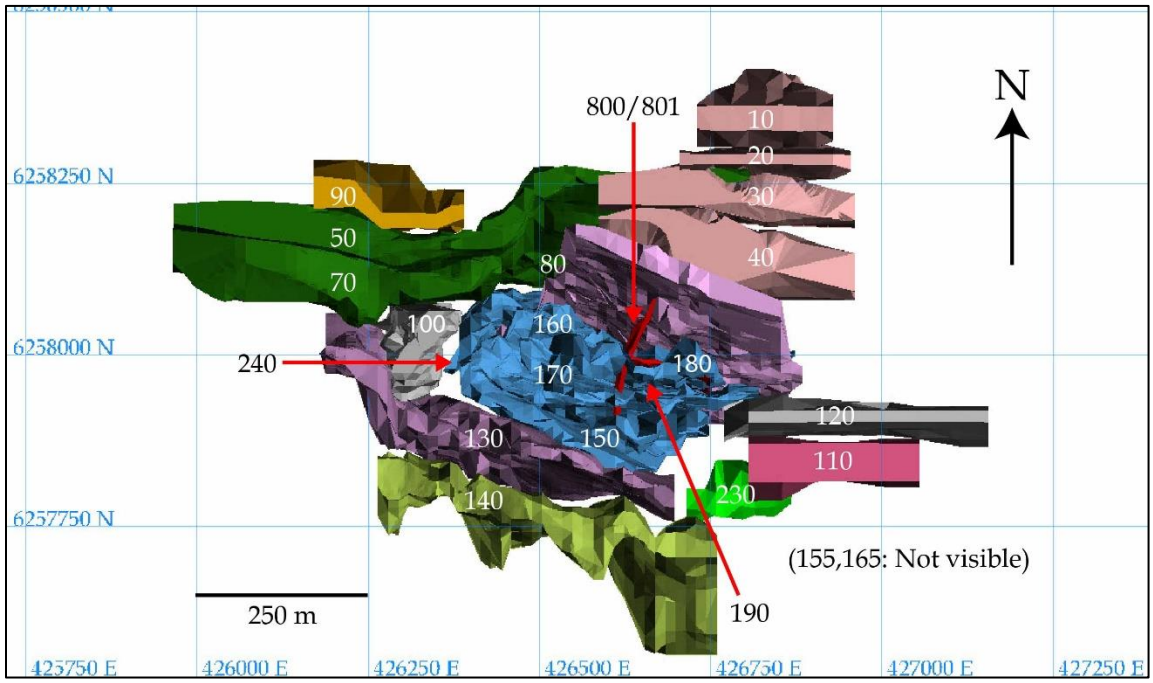
Mineralization in the Valley of the Kings Zone of the Brucejack Deposit is interpreted as occurring within a series of mineralized corridors (see Section 7.0). Triangulation solids generated as part of the November 2012 and December 2013 (Jones, 2012c; Jones, 2014) resource estimates form the basis for the mineral domain interpretations used for the January 2020 Mineral Resource update. Mineralization domain triangulation solids are continuously and iteratively reviewed and refined as additional geological information (drilling and mapping) is generated. By design these delineated mineralized domains incorporate and support most of the sampled high-grade gold occurrences. Plan and cross-sectional views of the mineralization domain triangulations used in the generation of the January 2020 resource estimate are presented in Figure 14-3, Figure 14-4, and Figure 14-5. The QP considers there to be a relatively high degree of confidence in the mineralized domain interpretations, as he has verified them in multiple underground exposures at the Brucejack Gold Mine (Section 12.0) as well as in new drilling information.

For the January 2020 resource estimate, the geological interpretations for the Valley of the Kings Zone have been updated in the areas mined and drilled during 2019 (see Section 14.6.1). Interpretation of the domains for the January 2020 resource estimate continue to refine the previous interpretations which were built on the foundation of the understanding of domains in December 2013. With the increase in infill drilling at depth, two new domains have been added to the January 2020 geologic interpretation. A total of 25 mineral domains have been interpreted for the Valley of the Kings Zone. These 25 domains have been grouped into 11 larger domains (Bigdom) for modelling purposes, based on similarities in grade statistics and geology (Table 14-1). Six of the mineralized Bigdom domains were present in the January 2020 Resource Model update area: 200, 400, 600, 800, 801, 900 (Figure 14-5; see Section 14.6.1).

Table 14-1: Valley of the Kings Zone Mineralized Domains

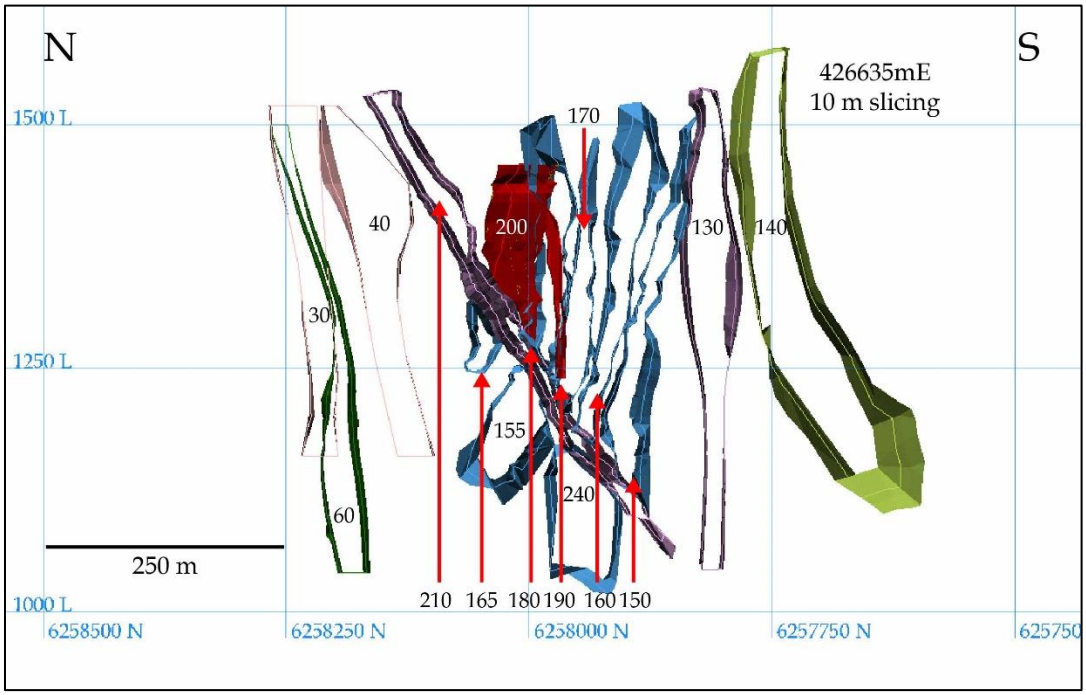
Grouped Domain (Bigdom)	Individual Mineral Domain Code	Individual Domain Detail (Domain Names, in order)
100	10, 20, 30, 40	Galena Hill (GA4, GA3, GA1, GA2)
200	50, 70, 80	Contact-related stockworks (DOM13, DOM38, DOM38B)
300	90	North VOK (NVOK)
400	130, 140	Contact-related stockwork (DOMP1), VOK/Bridge Zone P1 Contact Zone (P2)
500	110, 120	Eastern Promises VOK (EVOK1, EVOK2)
600	100, 150, 160, 170, 180, 165, 155, 240	Main VOK Domains (ARG, DOM23, DOM8, DOM11, DOM17, DOM8b, DOM23b, lowerfootwall)
700	190	VOK Lateral (EW LATERAL)
800	200	Cleopatra structure south of 6257972 mN (CLEO)
801	200	Cleopatra structure north of 6257972 mN (CLEO)
900	210, 230	Domain 20 normal fault – higher grade (DOM20), Hydrothermal (DOM20 related HBX)
-99	-99	Outside of the modelled mineralized domains

Figure 14-3: Plan View of Mineralized Domain Triangulations Used in the Generation of the January 2020 Mineral Resource



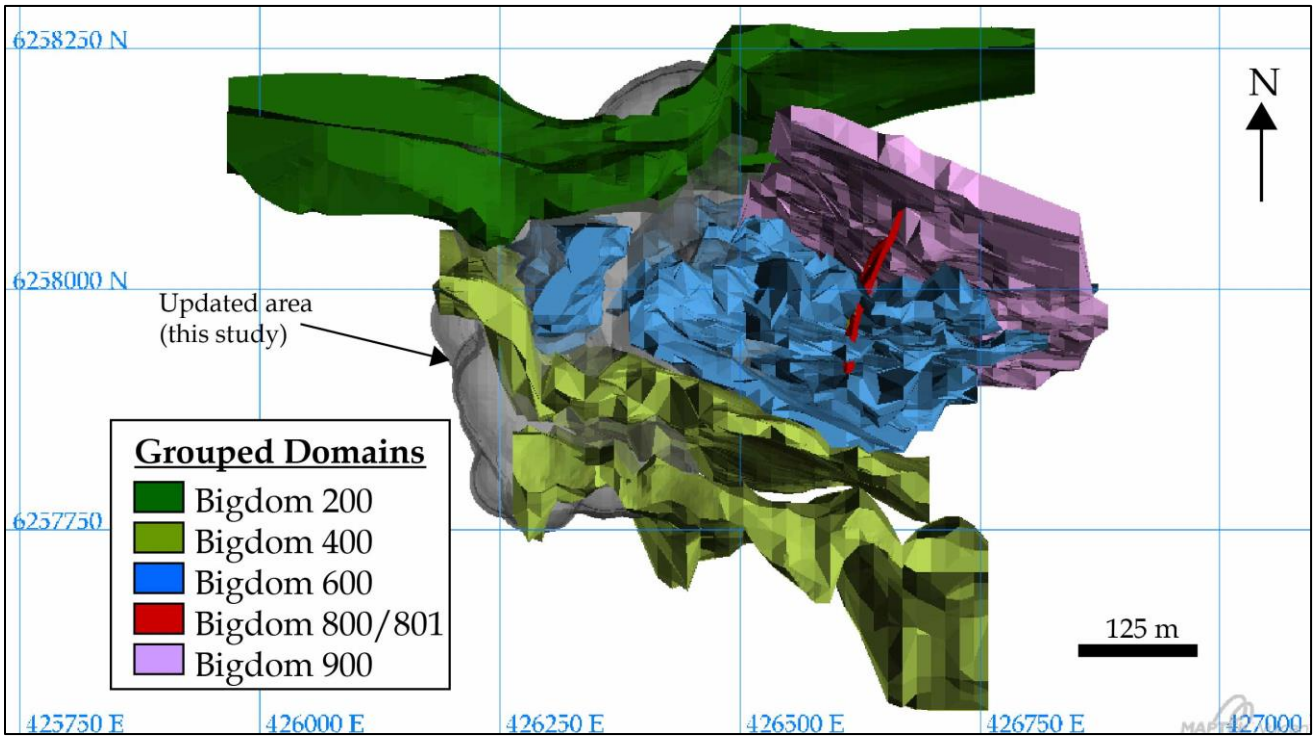
Source: Pretivm 2020

Figure 14-4: N-S Cross Section Along 426635 mE of Mineralized Domain Triangulations Used in the Generation of the January 2020 Mineral Resource



Source: Pretivm 2020

Figure 14-5: Plan View Showing the Main Grouped Valley of the Kings Zone Mineralized Domains (Bigdom) Used in the Generation of the January 2020 Mineral Resource



Source: Pretivm 2020

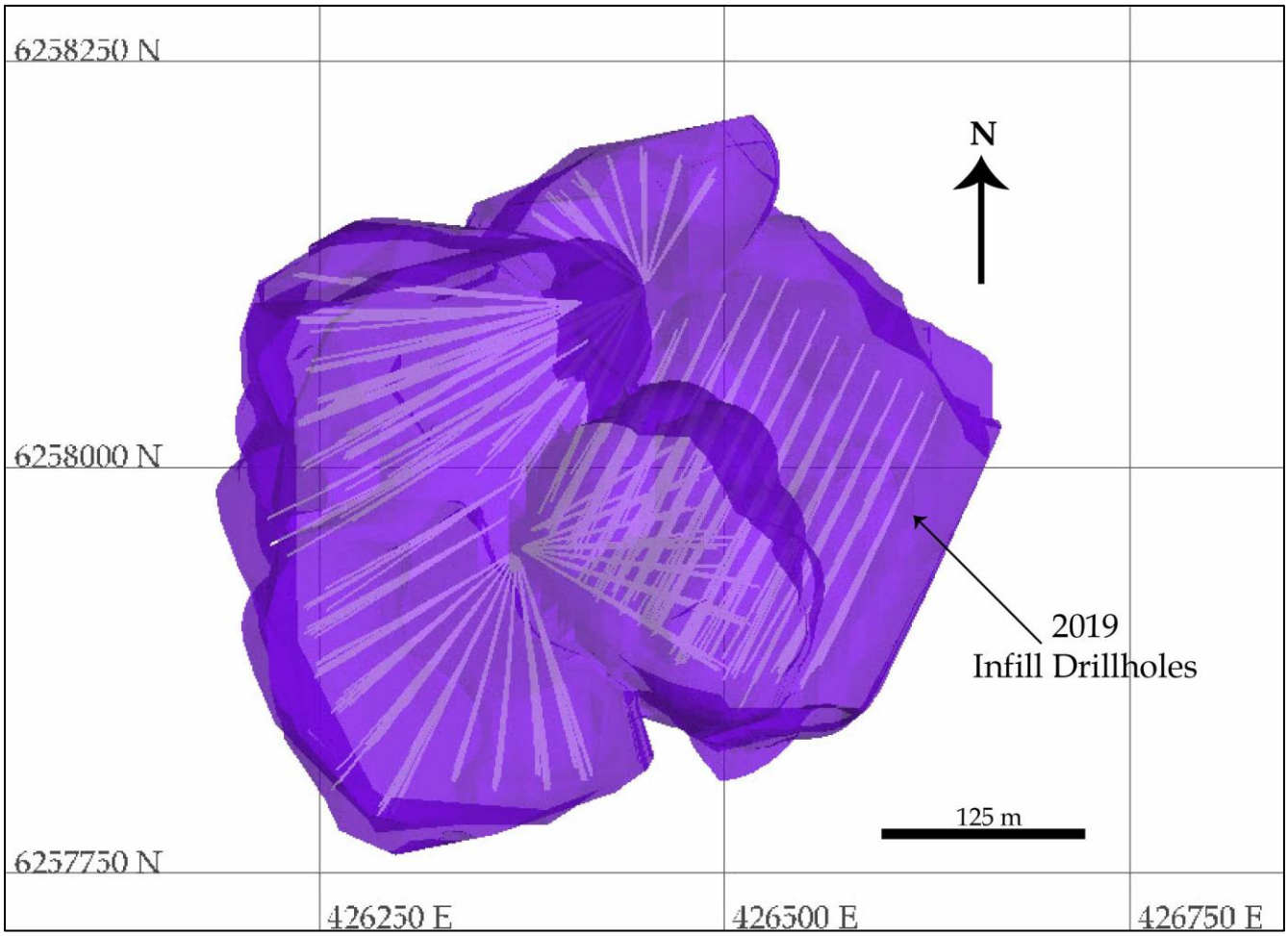
14.6 Data Selection and Preparation

14.6.1 Update Area

As noted earlier, only a portion of the Valley of the Kings Zone has been informed by new mining and drilling information post the January 2019 resource estimate (see Figure 14-1). This portion is termed the January 2020 updated model area (or update area). Pretivm has taken the view that where there is no new information; the model should not be changed unless it is shown to be clearly inaccurate. As such, the previous resource estimate (January 2019, which contains portions of the December 2013 resource) was retained outside the update area. A model update triangulation solid was generated for the area informed by new conditioning data (Figure 14-1; Figure 14-6), and the Valley of the Kings Zone resource estimate was subsequently updated inside this solid.

Drillhole data was coded as either inside the six grouped domains (Bigdoms) or as a part of the undomained regions within the update area (Figure 14-1; Figure 14-5). This resulted in a total of 116,195 gold and 115,780 silver assay data in 1,317 drillholes, 555 of which were drilled post the January 2019 resource estimate. Various exploratory data statistical analyses were conducted on the selected data using Snowden's Supervisor (v.8.11) geostatistical software.

Figure 14-6: Plan View Showing Model Update Area Solid (Purple) and Drillholes (White) from the 2019 Infill Drill Campaign



Source: Pretivm 2020

14.6.2 Compositing

All data was composited to the dominant sample length of 1.5 m prior to analysis and estimation. The composited data was then coded according to the relevant mineralized domain in preparation for modelling. Normally compositing is done with respect to geological and/or domain boundaries. As the gold mineralization at Brucejack overprints all lithological units, no geological control was used during compositing. Furthermore, as stockwork mineralization domain boundaries tend to be gradational rather than sharp, strict domain boundary control on composites was not necessary and likely represents false resolution. Consequently, normal composites of 1.5 m in length were generated from collar to end of drill string. The composites were then flagged as being in or out of the mineralization domain, depending on whether the composite centroid was inside or outside of the domain wireframe. A minimum composite length of 1.25 m was enforced for resource estimation, removing any short composite intervals from drillholes terminating in the mineralization domain wireframe.

A total of 100,535 gold and 100,132 silver domain-coded composite data (62,233 gold and 61,886 silver of the data were inside the domains) were generated inside the Valley of the Kings Zone within the update area. These composites were used in the statistical interpretation and generation of the grade estimates inside the update area.

14.6.3 Grade Populations

Infill drilling conducted during the 2019 program confirmed the nature of the gold and silver grade distributions in the mineralized zones as defined by previous drilling programs (Figure 14-7). Comparing all drillhole composites constrained inside mineralized domains in the January 2020 update area, as generated from the recent 2019 program and the previous drilling programs, highlights both the similarity in grade distributions for gold and silver between drilling programs, and the mixed nature of the precious metal distributions. Log probability plots (cumulative distribution plots) of the 2019 infill drillhole composite data for both gold and silver display a slightly higher proportion of samples in grades above the median grade to below the 90th percentile than the pre-2019 drillhole composite data, and a slightly lower proportion of grades above the 99.9th percentile (Figure 14-7). Essentially this means that whilst the histograms are very similar, the 2019 data has a slightly lower average grade in the 2019 drill area because of the lower proportion of high grade in the distribution.

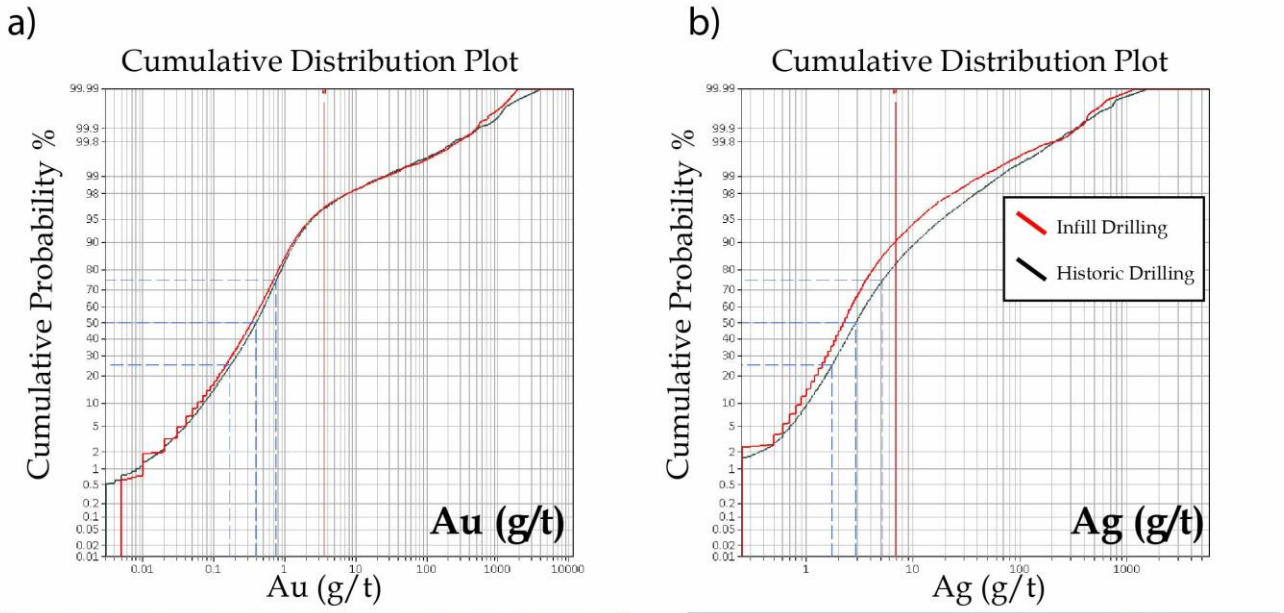
The mixed nature of the precious metal gold distributions, as a function of the co-spatial nature of the overprinting mineralization systems (Section 7.0; Section 14.3), is readily evident on the log probability plots (Figure 14-7); there is a curved inflection zone between 1 and 5 g/t Au on the gold log probability plot and between 10 and 50 g/t Ag on the silver log probability plot. Physical separation of the two principle grade distributions into individual domains is not possible due to the overlapping nature of the two mineralizing systems. The gold and silver composite datasets were therefore separated into low-grade gold (<3.5 g/t Au) and low-grade silver (<20 g/t Ag) and high-grade gold (≥3.5 g/t Au) and high-grade silver (≥20 g/t Ag) populations for grade modelling and estimation (see Section 14.7).

The high-grade distributions for gold and silver remained strongly positively-skewed (coefficients of variation at 28.72 for Au and 8.13 for Ag). The QP considers the continued use of a non-linear estimator for grade estimation appropriate based on the similarity in precious metal grade distributions between the recent (2019) infill drilling and previous drilling programs in the Valley of the Kings Zone.

The use of grade capping (top cutting) in conjunction with a linear estimator (e.g., OK, inverse distance) was considered in 2012, but was shown to produce some unrealistic results. This approach was therefore regarded as inappropriate in the modelling of the mineralization at Brucejack. There are several reasons:

- *The challenge in selecting an appropriate top cut (grade cap).* The positive tail of the grade distribution does not break down (tail decomposition method) until well into the multi-kilogram per tonne range, and even then, the more data that is collected, the higher the value before tail decomposition. Using a percentile-based approach results in an arbitrary and unjustifiable capping of extreme gold grades.
- *The appropriateness of grade capping.* Consistency of intersecting high-grade (gold and silver) throughout the Valley of the Kings Zone and the robust positive tail of the high-grade distributions, indicate that the high-grade intersections are an integral part of the grade distribution and therefore should be used for grade estimation. Selecting an arbitrary top cut value results in the artificial removal of high-grade values that are necessary to preserve the metal in the grade estimation (and value). Recent experience has shown that even with these values, the grades are under-estimated with respect to production.
- *Mixed grade populations that are impossible to separate.* Geologically the low- and high-grade populations are co-spatial (Section 7.0) and cannot be separated by creating mineral domains.
- *Block grade trends from linear estimates are poor representations of input drilling data grade at Brucejack.* This is a function of using a linear estimation technique for a highly skewed grade dataset characterized by mixed populations.

Figure 14-7: Log Probability Plots of a) Gold and b) Silver Composited Data Inside the Valley of the Kings Zone Mineralization Domains - January 2020 Update Area.



Statistic	Au (g/t)	
	Pre 2019	Infill 2019
Number of samples	31,988	30,245
Minimum grade (g/t)	-	-
Lower quartile (g/t)	0.17	0.15
Median (g/t)	0.39	0.34
80th Percentile	0.89	0.81
90th Percentile	1.41	1.31
95th Percentile	2.42	2.33
Maximum grade (g/t)	11,313	10,344
Mean grade (g/t)	3.60	3.16
Standard deviation	90.31	74.39
Coefficient of variation	25.10	23.56

Statistic	Ag (g/t)	
	Pre 2019	Infill 2019
Number of samples	31,672	30,214
Minimum grade (g/t)	0.25	0.25
Lower quartile (g/t)	1.73	1.40
Median (g/t)	2.90	2.20
80th Percentile	6.20	4.20
90th Percentile	10.66	6.70
95th Percentile	18.56	11.10
Maximum grade (g/t)	5,804	5,448
Mean grade (g/t)	6.82	4.99
Standard deviation	44.93	40.53
Coefficient of variation	6.58	8.13

Source: Pretivm 2020

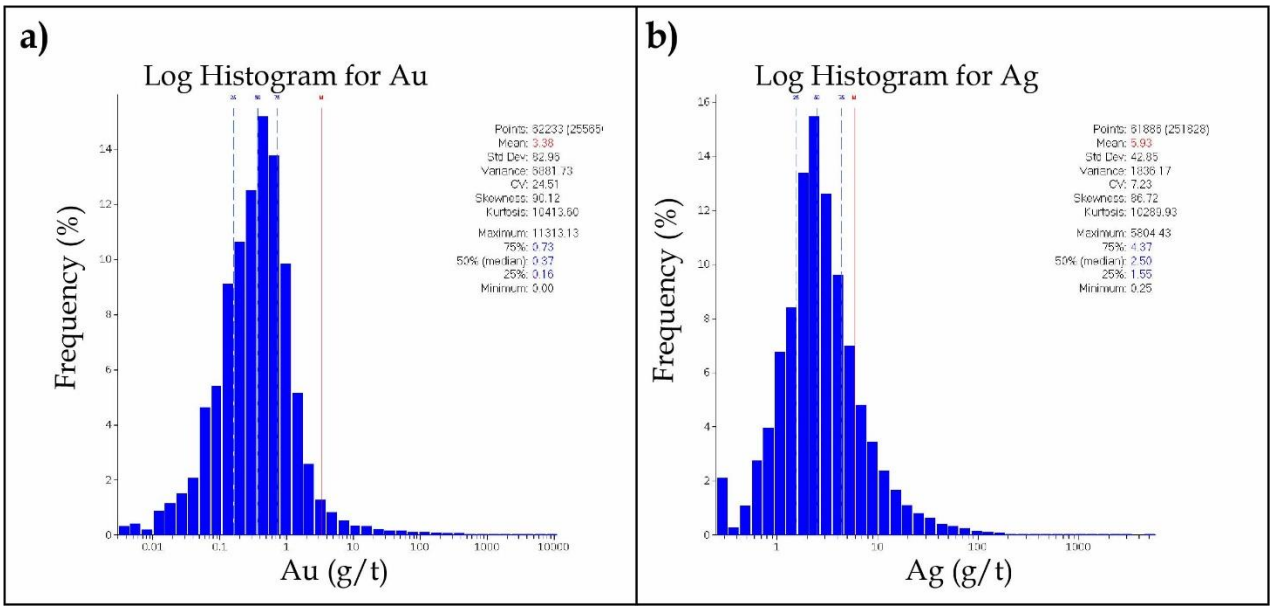
Owing to the mixed nature of the grade distribution and the extremely positively skewed nature of the gold and silver data, a non-linear estimation technique was deemed necessary to model the Valley of the Kings Zone. Non-linear techniques like MIK were developed to deal with mixed populations (e.g., Glacken and Blackney, 1998). MIK was selected because the method allows modelling of the actual grade distribution using a series of grade thresholds, as well as a mathematical model for the uppermost grade bin (or class), precluding the need for an arbitrary grade cap or top-cut. It also allows the practitioner to consider that samples with different grades have different levels of continuity, with higher grades having a lot lower continuity than the lower grades. Additional resolution on grade continuity across the distribution is provided by modelling of variograms at each grade threshold.

14.6.4 Summary Statistics

Histograms for composited data inside the Valley of the Kings Zone mineralized domains indicate that the gold and silver populations are extremely positively-skewed with a high coefficient of variation (CV) and low mean grades (see Figure 14-8). Summary statistics for the domain-coded composited drillhole data for the 2019 updated area are presented in Table 14-2.

Ranking the data by gold grade shows that 88% of the metal in the Valley of the Kings Zone mineralization domain is represented by approximately 5% of the sample data, with 80% being represented by the top 1% of the sample data. Similarly, 50% of silver metal in mineralized domains is represented by approximately 15% of the sample data, and approximately 20% represented by the top 1% of the sample data. These statistics highlight that significant value in the Valley of the Kings Zone is associated with uppermost part of the relevant grade histogram. The ubiquitous presence of elevated gold intersections throughout the Valley of the Kings Zone drilling and underground workings (visible gold) demonstrates that the grades are not anomalous, and that it is important that these high grade samples are considered in the grade estimation process. The strong positive skewness, high CV, and low mean grades of the gold and silver grade distributions indicate that the mineralized domains contain a significant level of internal low-grade. These features are in keeping with the geological interpretation (see Section 7.0) that a variable and disjunctive, high-grade, epithermal vein stockwork system was superimposed on a lower grade, porphyry-associated, phyllic alteration system in such a way that the two systems are physically inseparable for modelling purposes.

Figure 14-8: Log-Normal Histogram Plot of a) Gold and b) Silver Composited Data Inside the 2019 Updated Area Mineralization Domains.



Source: Pretivm

Table 14-2: Summary Statistics of Gold and Silver Composited Data by Grouped Domain in January 2020 Model Updated Area

Statistic	Bigdom									
	200		400		600		800/801		900	
	Au (g/t)	Ag (g/t)	Au (g/t)	Ag (g/t)	Au (g/t)	Ag (g/t)	Au (g/t)	Ag (g/t)	Au (g/t)	Ag (g/t)
Number of samples	8,025	8,025	8,863	8,856	41,957	41,662	125	125	3,263	3,218
Minimum grade (g/t)	0	0.25	0	0.25	0	0.25	0.02	0.25	0.01	0.25
Mean grade (g/t)	1.82	6.70	2.18	4.62	3.86	5.87	3.02	8.03	4.45	8.2
Maximum grade (g/t)	1,050	503	2,730	993	11,313	5,804	164	134	1197	455
Standard deviation	22.33	20.08	37.49	17.22	98.36	50.45	15.3	19.21	42.23	22.81
Variance	498	403	1,406	296	9,675	2,545	234	369	1,783	520
CV	12.26	3.00	17.22	3.72	25.51	8.59	5.06	2.39	9.49	2.78
High grade threshold (g/t) (HGT)	3.5	20.0	3.5	20.0	3.5	20.0	3.5	20.0	3.5	20.0
Percent ≥ HGT	2.9%	4.6%	3.5%	2.6%	3.4%	3.2%	8.0%	7.2%	5.7%	7.2%
Mean grade above High grade threshold (g/t)	47.1	61.8	47.7	58.5	98.9	85.3	31.2	58.7	66.5	61.2

Note: CV – coefficient of variation

14.7 Estimation

14.7.1 Methodology

Grade estimates were generated into the Bigdom domains inside the update area using the domain-coded composite data. The overall approach is similar to that used in the generation of the December 2013, July 2016, and January 2019 resource estimates in that separate high-grade, low-grade, and probability of high-grade estimates are generated for each block using the split population, non-linear estimation approach detailed in Jones (2014). Additional resolution provided by infill drilling and the evaluation of that data inside the January 2020 update area has indicated that 3.5 g/t Au and 20 g/t Ag best distinguish between low- and high-grade populations for these two grade variables. The grade estimation workflow used to generate the January 2020 resource estimate is detailed below:

- A model was prepared at the parent block size (5 mE by 5 mN by 5 mZ) and coded by lithology and mineralized domain (individual and grouped) as the parent model.
- A separate block model was set up with a 2.5 mE by 2.5 mN by 2.5 mZ block size and coded by mineralized domain (individual and grouped) for grade estimation.

- Statistical analysis was conducted on the gold and silver grade distributions using Snowden's Supervisor geostatistical software. The following was conducted:
  - Discretization of the high-grade gold (≥3.5 g/t) and silver (≥20 g/t) distributions using appropriate decluster-weighted grade thresholds
  - Lower and upper tail analysis of the high-grade gold and silver distributions and selection of appropriate mathematical models for these
  - Determination of the appropriate percentile for the threshold of the top class in the high-grade indicator thresholds using the decluster-weighted gold and silver data
  - Univariate statistical analysis of the low-grade population (<3.5 g/t Au, <20 g/t Ag).
- Three-dimensional spatial analysis (variography).
- Search, estimation, and variogram parameter sensitivity analyses.
- Grade interpolation of each grade variable (i.e., low-grade, high-grade, probability of high-grade for each of gold and silver) separately into 2.5 m by 2.5 m by 2.5 m blocks using:
  - OK for grade of the low-grade mineralization (<3.5 g/t Au, <20 g/t Ag)
  - MIK for grade of the high-grade mineralization (≥3.5 g/t Au and ≥20 g/t Ag)
  - IK of the mineralisation indicator for the proportion of high-grade (i.e., probability of Au ≥3.5 g/t and Ag ≥20 g/t).
- The 2.5 mE by 2.5 mN by 2.5 mZ estimates were post-processed to provide total gold and silver grades for each block (e-type estimates). The grade of the mineralization above 3.50 g/t Au and the grade of the mineralization below 3.50 g/t Au in the block were each multiplied by the relevant proportions to calculate the final grade estimate for each block. The same process was applied to the silver grades. Grade estimates were then re-blocked to 5 mE by 5 mN by 5 mZ blocks to provide an appropriate volume estimate.
- The individual estimates were checked/validated against the relevant input composite data (see Section 14.8).
- The validated block model inside the update area was then added to the January 2019 block model (Jones et al., 2019) to generate the full Valley of the Kings Zone resource model, as blocks in the January 2019 update area that have no recent (2019) infill drilling within approximately 40 m remained the same. The majority of blocks outside the January 2019 update area and January 2020 update area are the same as those generated as part of the December 2013 resource estimate (Jones, 2014).
- The full Valley of the Kings Zone resource model was then depleted against all mined-out solids and any additional volumes deemed to not satisfy the definition of a resource. This was then followed by a regularization up to 10 mE by 10 mN by 10 mZ block size for the entire model to account for the degree of selectivity that the QP believes is possible in the well-drilled volumes.

14.7.2 Parameter Optimization

Estimation parameter optimization through iterative model testing was conducted on several updated versions of the input drillhole database ahead of the September 30, 2019 database cut-off date (see Section 14.4.1). Iterative test work conducted ahead of final parameter selection included:

- *Tail modelling (upper tail models)*. Grade capping yielded unsatisfactory results (see Section 14.6.3 for a discussion on top cutting). All models that utilized grade capping significantly under-called actual production. The 95th percentile was selected as the uppermost percentile to model the high-grade gold and silver populations as it facilitated the most representative mathematical modelling of the upper class. Given the gold and silver populations are extremely positively-skewed, the upper 5th percentile has a large effect on the estimation. The upper tails model chosen was based on matching the majority of the curve where there was sufficient data. In domains with minor amounts of data, the parameters of Bigdom 600 were applied.

- *Number of samples.* Testing of the number of samples used in the high-grade and probability estimates indicates that the number of samples has more influence than the search ellipse. The conclusion of this work was that the use of a large number of samples resulted in extensive smearing of the highest grades. This model, which focused on areas drilled with more drill density than other parts of the model, was intended to be used for dual purposes (long and short term), and local accuracy was therefore important. The decision to limit the number of samples used in the estimation process to six was therefore made to try and maximize the local accuracy of the grade estimates, particularly now that more drill information is available in the Bigdom domains 100 to 500.

- *Number of search passes*. Adding in a second search pass in the low-grade estimation allowed the estimate to still validate well on a local scale but yields results in areas further away from data.

- *Parent block size.* There is a concern that a 5 mE by 5 mN by 5 mZ parent block size for grade estimation was too small to give an accurate estimate for reporting purposes, and therefore a parent block size of 10 mE by 10 mN by 10 mZ was investigated. The smaller block size was favoured for estimation due to the better definition available for detailed mine design. Final 5 mE by 5 mN by 5 mZ block were nevertheless regularized up to 10 mE by 10 mN by 10 mZ blocks post estimation and post processing for mineral resource reporting purposes.

14.7.3 Variography

Three-dimensional spatial analysis was conducted on composite data using Snowden's Supervisor geostatistical software. Experimental variograms were generated for each of the grade estimation variables in the following way:

- Indicator semi-variograms were generated at each grade threshold discretizing the high-grade gold (≥3.5 g/t Au) and high-grade silver (≥20 g/t Ag) distributions by grouped domain (Section 14.7.3.1).

- Indicator semi-variograms were generated for thresholds set at the gold and silver delimiters (3.5 g/t Au; 20 g/t Ag) using full gold and silver grade distributions (Section 14.7.3.2).

- Traditional semi-variograms were generated for low-grade gold (<3.5 g/t Au) and low-grade silver (<20 g/t Ag) (Section 14.7.3.3).

14.7.3.1 High-grade Population Indicator Variograms

Indicator variograms for the high-grade gold and silver populations were generated and modelled using domain-coded composite data for each of the Bigdom domains. Variogram orientations were primarily defined using dominant domain orientations (which, in turn, were based on dominant mineralized vein orientations). High-grade

gold and silver grade distributions were discretized into 11 thresholds (20, 30, 40, 50, 60, 70, 75, 80, 85, 90, and 95th percentile; Table 14-3). Experimental variograms were generated and modelled at each grade threshold for both gold and silver by Bigdom. Variogram models for silver were modelled independently from gold by percentile threshold and Bigdom. Example indicator variogram parameters generated for the largest grouped domain (Bigdom 600) are presented in Table 14-4. Note for all tables presenting variogram parameters that D1, D2, and D3 are the major, semi-major, and minor axes of the continuity ellipse and that xx˚→yyy˚ means a dip of xx˚ on a bearing of yyy˚.

Table 14-3: Thresholds Discretizing High-grade Distribution by Bigdom

Threshold Percentile	Au (g/t)					Ag (g/t)				
	Bigdom 200	Bigdom 400	Bigdom 600	Bigdom 800/801	Bigdom 900	Bigdom 200	Bigdom 400	Bigdom 600	Bigdom 800/801	Bigdom 900
20	4.666	4.44	4.633	4.943	4.677	23.13	24.81	23.83	22.72	24.09
30	5.526	5.181	5.569	6.259	5.611	25.82	27.31	26.49	26.21	27.07
40	6.828	6.283	7.033	8.634	6.51	28.6	31.08	29.7	31.88	30.7
50	8.751	7.758	9.496	13.87	8.367	32.32	35.57	33.9	37.25	35.87
60	12.4	10.63	13.7	19.36	11.42	38.52	41.69	41.01	43.44	44.5
70	18.35	16.08	23.46	30.36	18.95	47.42	56.98	51.73	52.24	55.07
75	23.6	19.47	32.53	42.11	26.94	55.43	64.26	59.68	72.64	63.62
80	32.81	24.29	48.17	63.68	37.78	66.91	71.48	71.22	96.62	78.91
85	51.4	43.06	77.26	117.3	60.71	80.43	82.15	93.48	119.4	98.95
90	101.9	73.94	142.1	162.6	107.8	104.9	115.3	134.1	203.3	135.3
95	188.9	152.4	325	615.4	234.4	192.5	213.4	268	391.5	221.7

Table 14-4: Indicator Variogram Parameters for High-grade Gold in Bigdom 600

Cut-off Grade Au g/t (Percentile)	Orientation	Nugget	Structure 1		Structure 2	
			Sill	Range (m)	Sill	Range (m)
4.63 (20)	D1: -70˚→200˚	0.30	0.55	8	0.15	125
	D2: 00˚→290˚			8		125
	D3: -20˚→020˚			6		85
5.57 (30)	D1: -70˚→200˚	0.30	0.55	7	0.15	85
	D2: 00˚→290˚			7		80
	D3: -20˚→020˚			6		80

table continues…

Cut-off Grade Au g/t (Percentile)	Orientation	Nugget	Structure 1		Structure 2	
			Sill	Range (m)	Sill	Range (m)
7.03 (40)	D1: -70˚→200˚	0.30	0.55	7	0.15	80
	D2: 00˚→290˚			7		80
	D3: -20˚→020˚			5		80
9.50 (50)	D1: -70˚→200˚	0.35	0.50	7	0.15	75
	D2: 00˚→290˚			7		80
	D3: -20˚→020˚			5		25
13.7 (60)	D1: -70˚→200˚	0.35	0.50	5	0.15	45
	D2: 00˚→290˚			4		55
	D3: -20˚→020˚			4		20
23.46 (70)	D1: -70˚→200˚	0.35	0.50	5	0.15	35
	D2: 00˚→290˚			4		45
	D3: -20˚→020˚			4		10
32.53 (75)	D1: -70˚→200˚	0.35	0.50	4	0.15	30
	D2: 00˚→290˚			4		30
	D3: -20˚→020˚			4		8
48.17 (80)	D1: -70˚→200˚	0.40	0.45	3	0.15	30
	D2: 00˚→290˚			3		30
	D3: -20˚→020˚			4		8
77.26 (85)	D1: -70˚→200˚	0.40	0.45	3	0.15	30
	D2: 00˚→290˚			3		30
	D3: -20˚→020˚			3		8
142.1 (90)	D1: -70˚→200˚	0.40	0.45	2	0.15	30
	D2: 00˚→290˚			2		30
	D3: -20˚→020˚			2		8
325 (95)	D1: -70˚→200˚	0.40	0.45	2	0.15	30
	D2: 00˚→290˚			2		30
	D3: -20˚→020˚			2		8

14.7.3.2 Probability of High-grade Variograms

Variogram models generated for the probability of high-grade gold and silver were generated using all drillhole composite data inside the update area. Variogram model parameters for the probability of high-grade are presented in Table 14-5 and Table 14-6.

Table 14-5: Variogram Model for the Probability of High-grade Gold Indicator Variable at 3.5 g/t Au

Bigdom	Orientation	Axis	Nugget	Structure 1		Structure 2		Structure 3	
				Sill	Range (m)	Sill	Range (m)	Sill	Range (m)
200	D1: -90˚→000˚	Major	0.40	0.38	5	0.21	12	0.09	54
	D2: 00˚→270˚	Semi-major			1		4		60
	D3: 00˚→000˚	Minor			1		4		60
400	D1: -70˚→200˚	Major	0.40	0.38	5	0.21	12	0.09	54
	D2: 00˚→290˚	Semi-major			1		4		60
	D3: -20˚→020˚	Minor			1		4		60
600	D1: -70˚→200˚	Major	0.40	0.38	5	0.21	12	0.09	54
	D2: 00˚→290˚	Semi-major			1		4		60
	D3: -20˚→020˚	Minor			1		4		60
800	D1: -90˚→000˚	Major	0.50	0.46	24	0.18	36	-	-
	D2: 00˚→350˚	Semi-major			13		14		-
	D3: 00˚→080˚	Minor			5		22		-
801	D1: -90˚→000˚	Major	0.50	0.46	24	0.18	36	-	
	D2: 00˚→025˚	Semi-major			13		14		-
	D3: 00˚→115˚	Minor			5		22		-
900	D1: -65˚→210˚	Major	0.50	0.32	2	0.18	55	-	-
	D2: 00˚→300˚	Semi-major			2		25		-
	D3: -25˚→030˚	Minor			2		7		-

Note: Variograms modelled to experimental sill.

Table 14-6: Variogram Model for the Probability of High-grade Silver Indicator Variable at 20 g/t Ag

Bigdom	Orientation	Axis	Nugget	Structure 1		Structure 2		Structure 3	
				Sill	Range (m)	Sill	Range (m)	Sill	Range (m)
200	D1: -90˚→000˚	Major	0.40	0.45	5	0.09	44	0.15	60
	D2: 00˚→270˚	Semi-major			5		40		60
	D3: 00˚→000˚	Minor			5		17		60
400	D1: -70˚→200˚	Major	0.40	0.45	5	0.09	44	0.15	60
	D2: 00˚→290˚	Semi-major			5		40		60
	D3: -20˚→020˚	Minor			5		17		60
600	D1: -70˚→200˚	Major	0.40	0.45	5	0.09	44	0.15	60
	D2: 00˚→290˚	Semi-major			5		40		60
	D3: -20˚→020˚	Minor			5		17		60
800	D1: -90˚→000˚	Major	0.45	0.51	20	0.18	36		-
	D2: 00˚→350˚	Semi-major			13		14		-
	D3: 00˚→080˚	Minor			4		12		-
801	D1: -90˚→000˚	Major	0.45	0.51	20	0.18	36		-
	D2: 00˚→025˚	Semi-major			13		14		-
	D3: 00˚→115˚	Minor			4		12		-
900	D1: -65˚→210˚	Major	0.4	0.38	4	0.1	5	0.12	34
	D2: 00˚→300˚	Semi-major			4		14		21
	D3: -25˚→030˚	Minor			3		4		5

Note: Variograms modelled to experimental sill.

14.7.3.3 Low grade Population Variograms

Traditional semi-variograms for low grade gold and silver were generated and modelled using all composite data. There was no need to subdivide the low grade precious metal mineralization into individual or Bigdom domains as the mineralization is ubiquitous and statistically similar throughout the phyllically altered rocks in the update area. Variogram parameters generated for low grade gold and silver populations are presented in Table 14-7 and Table 14-8.

Table 14-7: Variogram Model for Low-grade Gold Mineralization

Indicator	Orientation	Nugget	Structure 1		Structure 2	
			Sill	Range (m)	Sill	Range (m)
<3.50 g/t Au	D1: -70˚→205˚	0.15	0.35	7	0.5	40
	D2: 00˚→295˚			7		30
	D3: -20˚→025˚			4		20

Table 14-8: Variogram Model for Low-grade Silver Mineralization

Indicator	Orientation	Nugget	Structure 1		Structure 2	
			Sill	Range (m)	Sill	Range (m)
<20 g/t Ag	D1: -70˚→205˚	0.15	0.20	3	0.45	170
	D2: 00˚→295˚			1		150
	D3: -20˚→025˚			4		60

14.7.4 Search Parameters

Search parameters used in the estimation of the January 2020 resource estimate were based on iterative modelling, and are presented in Table 14-9 and Table 14-10. Search parameters were optimized to reduce excessive smearing while allowing sufficient data to be used to create a representative estimate. Whilst the maximum number of samples used in estimation appears low, it was noted that using more samples created excessive grade smearing, with increasing under-calling of high-grade areas, and over-calling of seemingly low-grade areas.

Table 14-9: Search Parameters for High-grade and Probability of High-grade Variables for Gold and Silver by Bigdom Inside the Update Area

Bigdom	Orientation	Estimation Variable	First Search Pass			Second Search Pass		
			Search Ellipse (m)	No. Samples (Min,Max)	Max. No. Samples per Drillhole	Search Ellipse (m)	No. Samples (Min,Max)	Max. No. Samples per Drillhole
200	D1: -90˚→000˚ D2: 00˚→270˚ D3: 00˚→000˚	High grade	50x30x20	2,6	-	70x45x30	2,6	-
		Probability	35x35x15	12,16	8	70x70x30	2,16	8
400	D1: -70˚→200˚ D2: 00˚→290˚ D3: -20˚→020˚	High grade	50x30x20	2,6	-	70x45x30	2,6	-
		Probability	35x35x15	12,16	8	70x70x30	2,16	8

table continues…

Bigdom	Orientation	Estimation Variable	First Search Pass			Second Search Pass		
			Search Ellipse (m)	No. Samples (Min,Max)	Max. No. Samples per Drillhole	Search Ellipse (m)	No. Samples (Min,Max)	Max. No. Samples per Drillhole
600	D1: -70˚→200˚ D2: 00˚→290˚ D3: -20˚→020˚	High grade	50x30x20	2,6	-	70x45x30	2,6	-
		Probability	35x35x15	12,16	8	70x70x30	2,16	8
800	D1: -90˚→000˚ D2: 00˚→025˚ D3: 00˚→115˚	High grade	25x25x10	2,6	-	50x50x20	2,6	-
		Probability	35x35x15	12,16	8	70x70x30x	2,16	8
801	D1: -90˚→000˚ D2: 00˚→025˚ D3: 00˚→115˚	High grade	25x25x10	2,6	-	50x50x20	2,6	-
		Probability	35x35x15	12,16	8	70x70x30	2,16	8
900	D1: -65˚→210˚ D2: 00˚→300˚ D3: -25˚→030˚	High grade	40x30x15	2,6	-	80x60x30	2,6	-
		Probability	35x35x15	12,16	8	70x70x30	2,16	8

Note: Gold and silver search parameters are identical.

The search strategy attempts to maintain the variability of the local average grade and minimize grade smearing. Search ellipse orientation was defined by trends in the major mineralized structures within the domains.

Table 14-10: Search Parameters for Low grade Gold and Silver Inside the Update Area

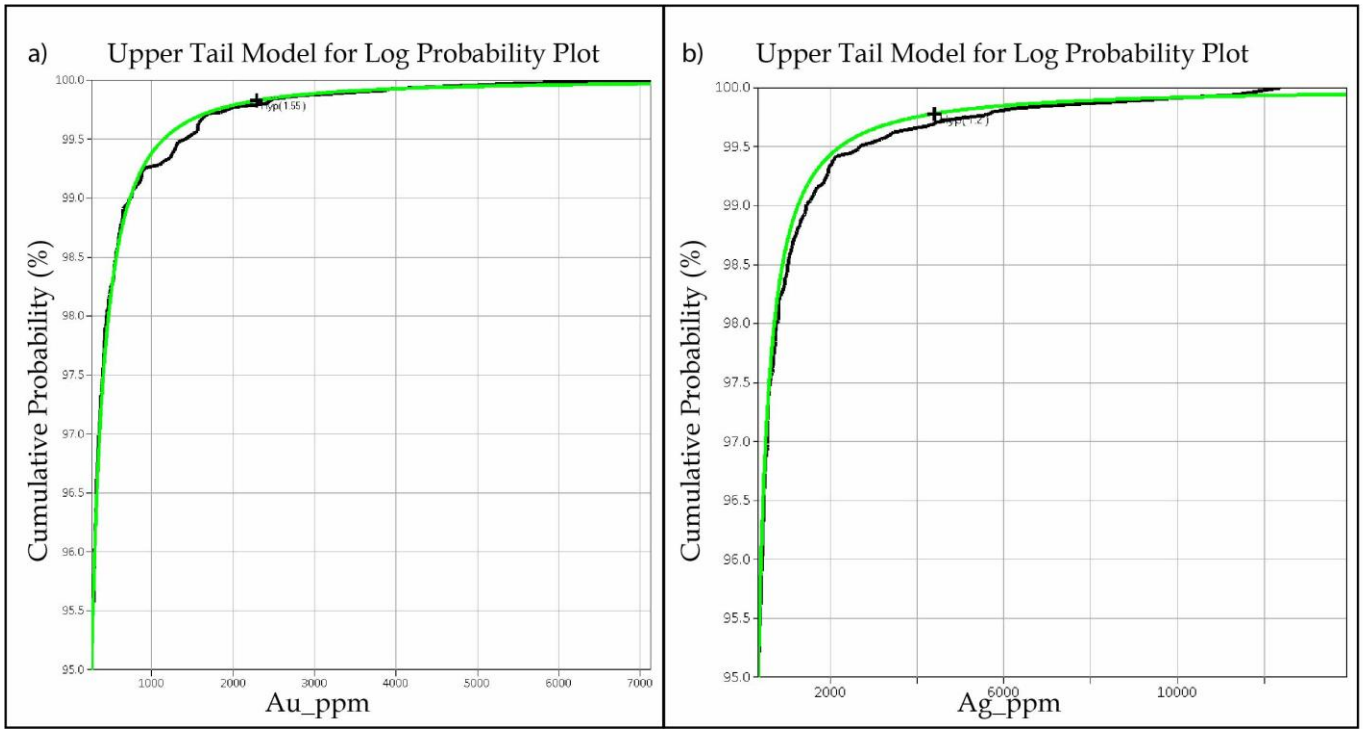
Orientation	First Search Pass			Second Search Pass		
	Search Ellipse (m)	No. Samples (Min,Max)	Max. No. Samples per Drillhole	Search Ellipse (m)	No. Samples (Min,Max)	Max. No. Samples per Drillhole
D1: -70˚→205˚ D2: 00˚→295˚ D3: -20˚→025˚	50x50x20	8,20	6	150x150x60	8,20	6

Note: Gold and silver search parameters are identical.

14.7.5 Upper Tail Modelling of High Grade Population in MIK Estimation

Estimation of the upper bin (top class) for mixed positively-skewed distributions like that of Brucejack is problematic as it represents the majority of the metal reported in the model. The use of median and mean grades to represent the grade of the top class was not considered suitable as these statistics could lead to gold and silver grade over-estimation due to the shape of the upper tails of the high-grade gold and silver distributions (see Figure 14-9). The grade of the top class was therefore modelled using either a hyperbolic or a power model, depending on which best fit the upper tail of the high-grade gold and silver distributions for each of the Bigdom domains (Table 14-11).

Figure 14-9: Example of Modelling the Upper Tail of the a) High-Grade Gold and b) High-Grade Silver Populations Using a Hyperbolic Model. Data Shown for Bigdom 600.



Source: Pretivm

Table 14-11: Mathematical Model Parameters for the Top MIK Threshold for Each Bigdom

Bigdom	Model Type		Model Parameter		Maximum Grade	
	Au	Ag	Au	Ag	Au (g/t)	Ag (g/t)
200	Hyperbolic	Hyperbolic	1.25	2.90	5,850	887
400	Hyperbolic	Hyperbolic	1.50	1.90	2,730	1,140
600	Hyperbolic	Hyperbolic	1.20	1.55	12,375	7,105
800/801	Hyperbolic	Power	1.20	1.50	14,746	9,934
900	Hyperbolic	Hyperbolic	1.35	2.05	3,568	1,885

14.7.6 Specific Gravity and Bulk Density

A total of 3,438 specific gravity and 543 bulk density measurements have been collected from the Valley of the Kings Zone of the Brucejack Deposit. A specific gravity and bulk density campaign was undertaken in the 2019 drill program to collect samples in previously sparsely drilled lithologies. A total of 717 new specific gravity and 133 new bulk density measurements were added into the Valley of the Kings Zone. Specific gravity and bulk density data were treated in a similar way to Jones (2014), with some refinements, including the use of updated lithology wireframes. A total of 1,460 specific gravity and 410 bulk density data were relevant for the January 2020 resource

estimate, including the full area of the January 2019 update box. Conversion factors between specific gravity and bulk density were determined by lithology (Table 14-12) and used in the block model.

Table 14-12: Specific Gravity Values and Bulk Density Conversion Factors for Resource Modelling in the Update Area

Rock Type	Lithology	No. of Samples	Average Specific Gravity	Bulk Density Conversion Factor
P2	Two feldspar latite porphyritic flow	-	2.82[(1)(2)]	0.9526
Silcap	Silicified conglomerate	67	2.75	0.9926
Andx	Latite fragmental	322	2.87	0.9708
Trans	Transitional unit	-	2.821[(1)(2)]	0.9616
Cong	Polylithic conglomerate	205	2.84	0.9717
VSF	Volcano-sedimentary facies rocks	756	2.79	0.9921
Arg	Argillite	15	2.77	0.9595
P1BZ	Bridge Zone latite porphyry	90	2.79	0.9941
P1OF	Office latite porphyry	5	2.79	1.1029

Notes: Bulk Density = Specific Gravity*Conversion Factor
[(1)]Factor generated using all data due to limited bulk density data for the porphyry units.
[(2)]Lithologies with no measured specific gravity have been set to the default value of 2.82. The P1 and P2 lithological units are not present in the update area and have limited representation in the full Valley of the Kings Zone model.

14.7.7 Other Variables

Block estimates were generated for As, S, and Ca as part of the January 2020 resource estimate. As and S are deleterious elements reporting to the flotation concentrate. Ca and S are used in the determination of the Neutralization Potential Ratio (NPR) of the mill feed in order to optimize tailings geochemistry (minimize acid generating potential) for disposal in the lake or as part of paste backfill, and do not constrain the Mineral Resource.

All drillhole data were composited to 1.5 m length with no breaks for lithological or mineralization boundaries; however, only those inside the January 2020 update box were flagged for use in estimation. Following exploratory data analysis, variography, and parameter selection, the As, S, and Ca variables were estimated directly into the parent 5 mE by 5 mN by 5 mZ block model using OK. Model validation was carried out by comparing global statistics between composited data and estimated grades. Additionally, local accuracy was validated by comparing sectional grades using slice plots. Both validation techniques showed good reproduction of input data.

14.8 Model Validation

Validation of the final model represents only one part of the overall validation process conducted in the generation of the January 2020 resource estimate. Detailed validation was conducted at each step of the modelling process, from data collection to resource reporting. Model validation checks included checks on the physical generation of the model (e.g., correct block coding, block model regularization, and addition processes), as well as checks on

block model grade estimate data. In the final model, grade estimates were compared against input drillhole data to assess how well the average of modelled grades match the average of the input data grades, and how well the model honours grade trends in the input data.

Grade validation checks included:

- Statistical checks of final grade, low-grade, high-grade, and probability estimates against input data by domain
- Swath plots for each of the estimated variables (final grade, low-grade, high-grade, and probability) by domain
- Visual checks comparing model grades against input drillhole data in plan, on section, and in three dimensions
- Visual checks of zones of estimated mineralization against actual underground exposures
- Production checks.

The presence of high- and extreme-gold-grades in the stockwork mineralization at Brucejack makes for challenging model validation. The high- to extreme-grades distort the local statistics on the composite grades, yet they are not anomalies in the grade distribution (see Section 14.6). High-grade mineralization is often present in the mineralization in a given volume but not represented in samples collected from that volume (evidenced both in underground workings, processing of the bulk sample, and daily mill reporting). Alternatively, if a piece of gold is intersected in a sample, there is the possibility that the sample is not representative of the surrounding rock because of the infrequent but significant nature of its occurrence. This results in challenges with respect to the accuracy of local grade estimates.

14.8.1 Statistical Checks – Final Gold and Silver Grade Estimates

Final gold and silver grade estimates in the resource model were compared against the declustered input domain-coded drillhole composite data (see Table 14-13). Overall, the global average grade estimates for gold and silver honour the grades from the input drillhole composite data, and the input drillhole data is considered globally unbiased. The variable differences between the estimated and input grades reflect variable degrees of clustering of the input data by domain: the estimated and input grades are close where the clustering effect is low.

Table 14-13: Global Comparison of Mean Estimated and Input Composite Grade Data for Gold and Silver by BIGDOM

Statistic	Bigdom									
	200		400		600		800/801		900	
	Au	Ag	Au	Ag	Au	Ag	Au	Ag	Au	Ag
Number of samples	8,025	8,025	8,863	8,856	41,957	41,662	125	125	3,263	3,218
Mean grade – Composite (g/t)	1.82	6.7	2.18	4.62	3.86	5.87	3.02	8.03	4.45	8.2
Mean grade – Estimate (g/t)	2.12	5.51	1.45	3.89	2.90	5.35	4.97	8.40	4.97	8.38

Note: Comparisons were restricted to the 2019 update area.

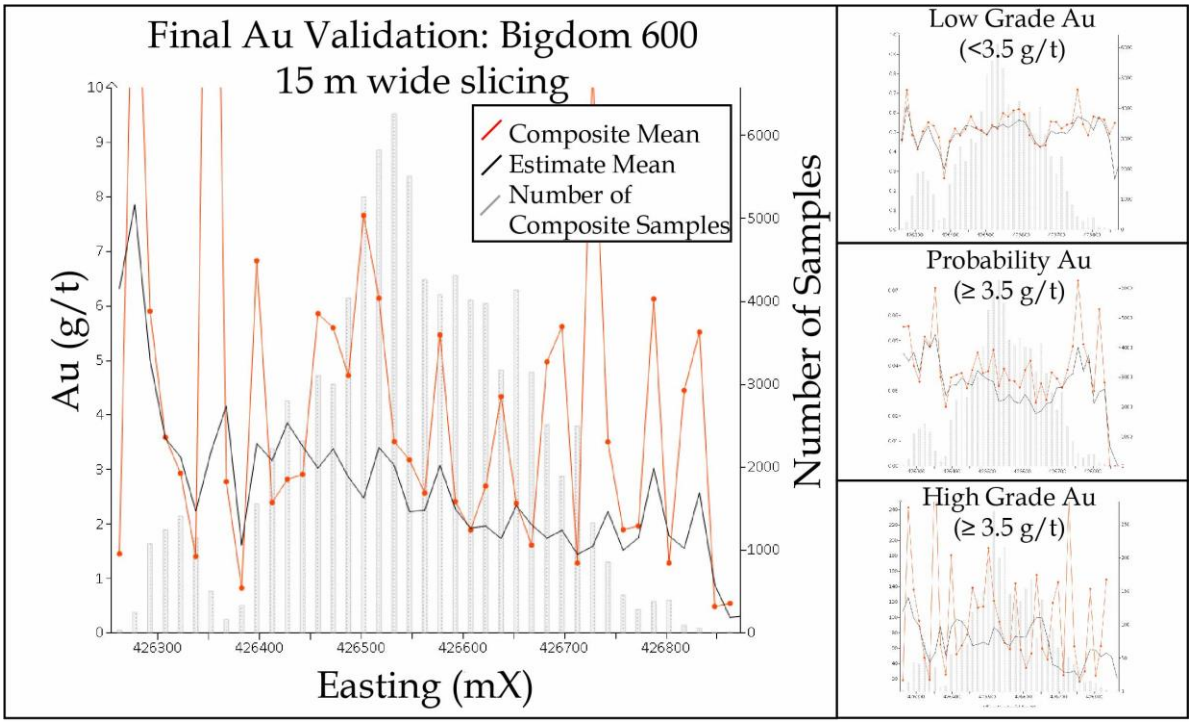
14.8.2 Grade Trend Plots

Trend plots (or swath plots) comparing model estimates and decluster-weighted input drillhole composite data by Easting, Northing, and Elevation were generated for each individual parameter (e.g., low-grade, high-grade, proportion above the grade population delimiter, and the final grade) as a primary validation tool. This was done to assess how well grade trends in the input data were being modelled in the resource estimate, a feature not apparent in univariate summary statistics. Difficulties in manually matching the declustering that occurs as part of the estimation process (see Section 14.8.1) necessitated the use of a spatially reasonable cell size to approximate declustering for comparative purposes. Example trend plots (for Bigdom 600) are presented in Figure 14-10 to Figure 14-15.

Estimates of the individual variables (low-grade, high-grade, and proportion of high-grade) showed a relatively good comparison to their respective input composite data for each domain. These estimates were therefore considered robust and suitable for being recombined to form the final gold and silver grade estimates (see Section 14.7.1).

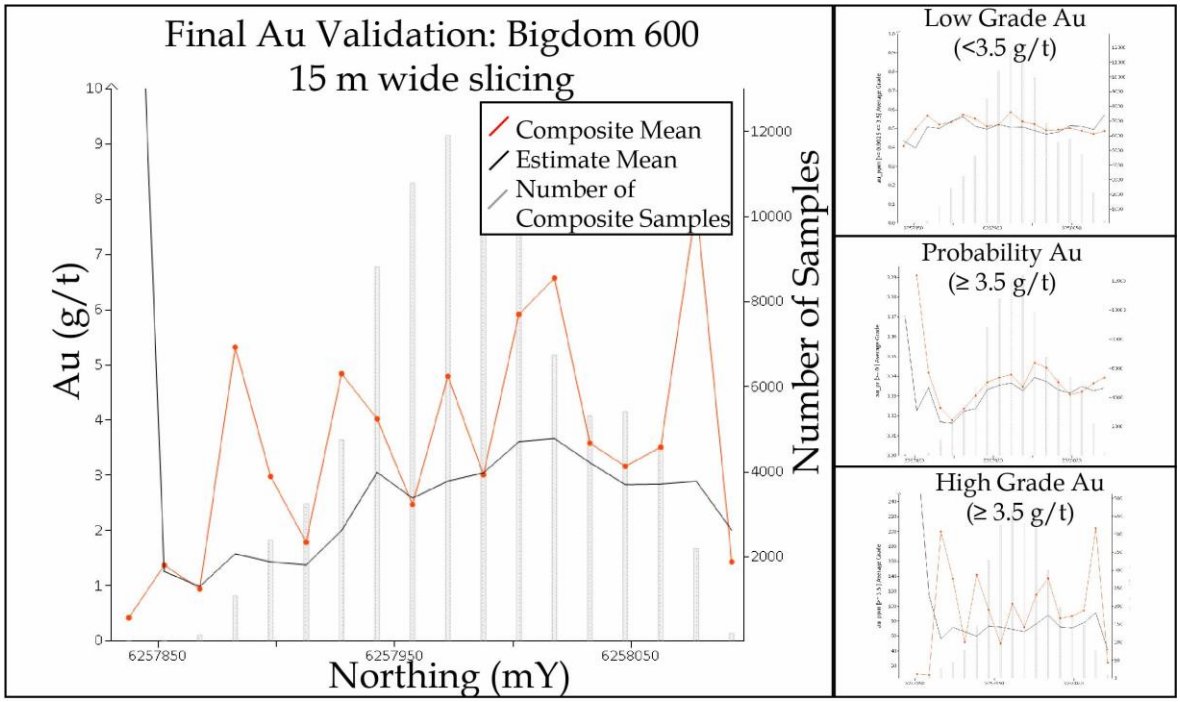
Recombined final grade estimates displayed smoother (less spikey) trend lines than those generated for the input drilling composite data, for all three directions. This is due to the volume-variance effect evident between drillhole composites (point data) and block estimates. Block grade estimate data display similar trends to the input drillhole composite data, for all three directions, with a tendency towards being slightly lower grade than the input data (i.e., the trendline is not the exact mean of the input data). This is a function of the decluster-weighting of the input drillhole composite data and difficulties associated with it, as noted above. Grade trends in the input drillhole composite data are best honoured where the conditioning data is spaced at between 10 and 15 m centres. In poorly informed areas (e.g., north of 6258080 mN and below ~1100 m elevation, the plots show relatively poor correlation between model estimates and input data. Similar observations are developed in the silver trend plots.

Figure 14-10: Example Gold Grade Trend Plots by Easting for Bigdom 600



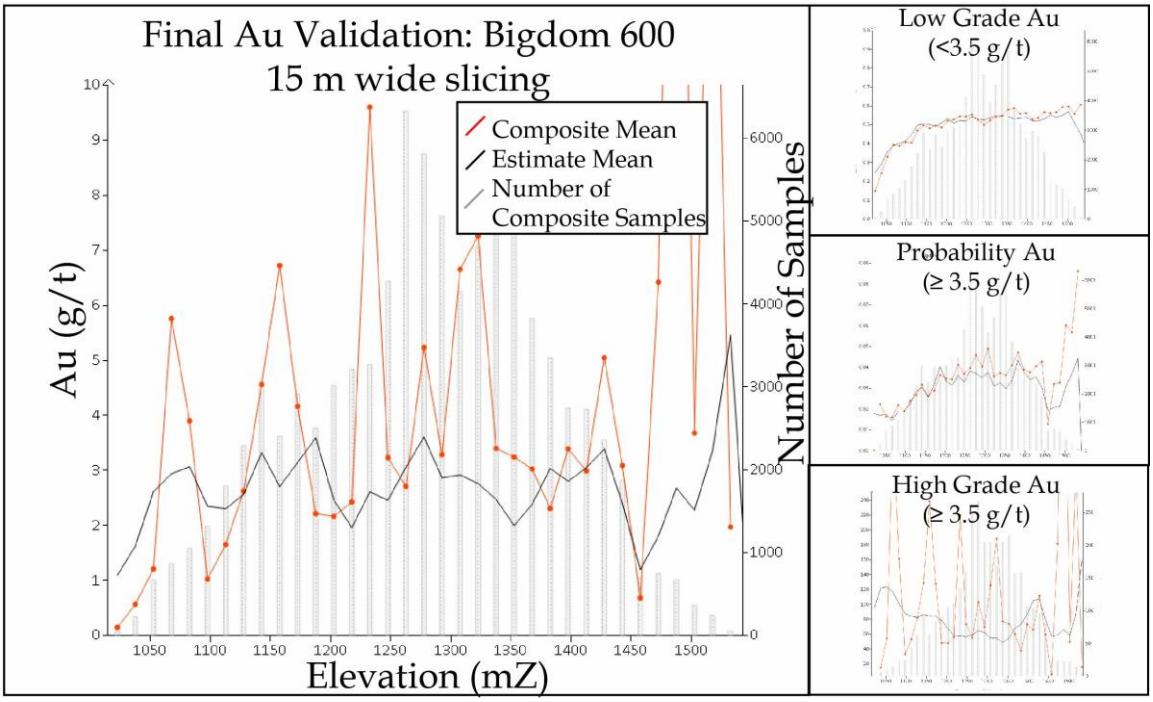
Source: Pretivm 2020

Figure 14-11: Example Gold Grade Trend Plots by Northing for Bigdom 600



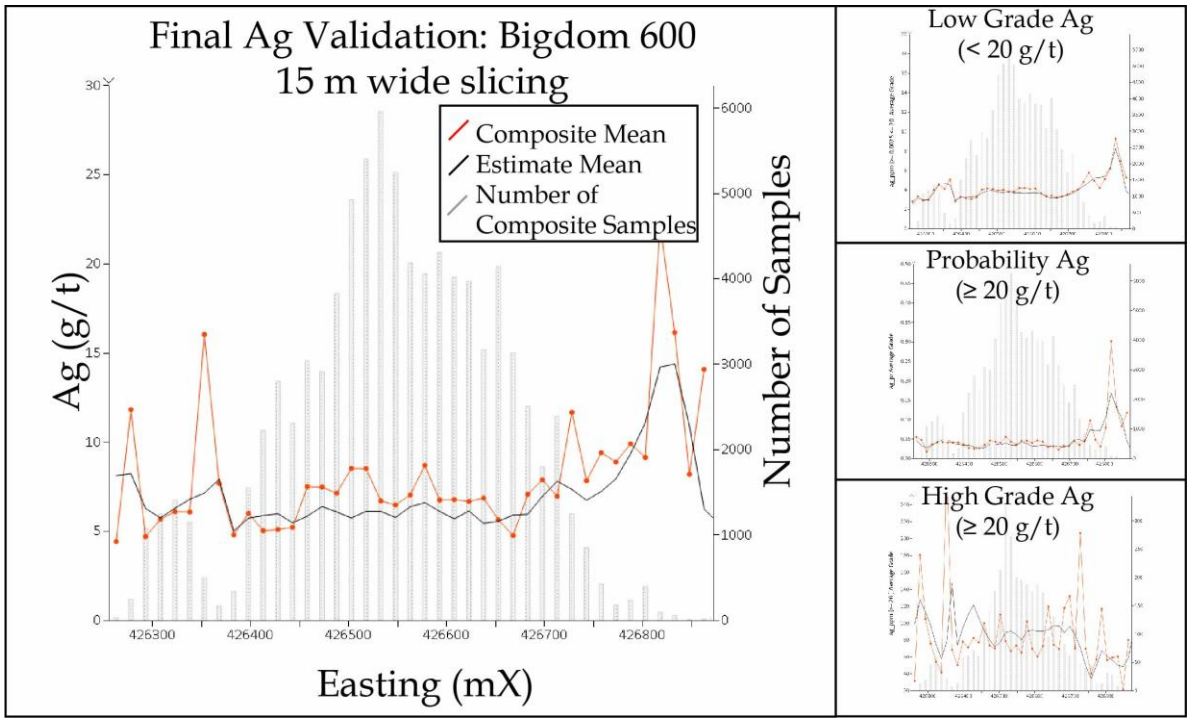
Source: Pretivm 2020

Figure 14-12: Example Gold Grade Trend Plots by Elevation for Bigdom 600



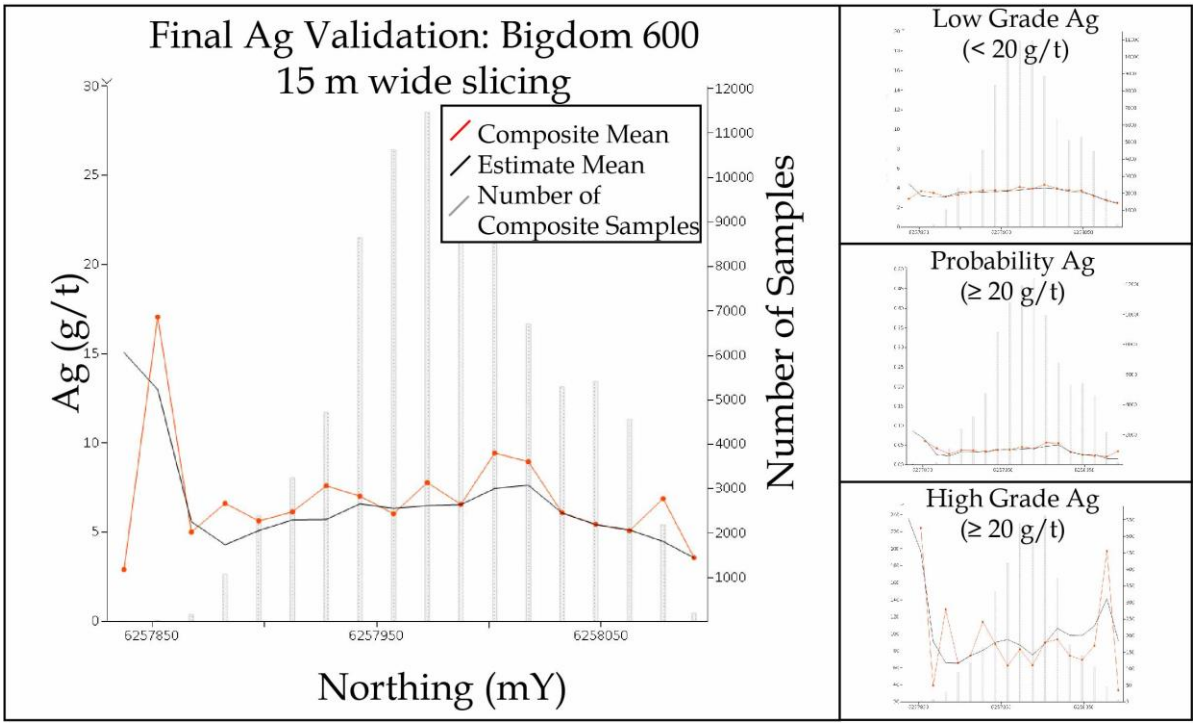
Source: Pretivm 2020

Figure 14-13: Example Silver Grade Trend Plots by Easting for Bigdom 600



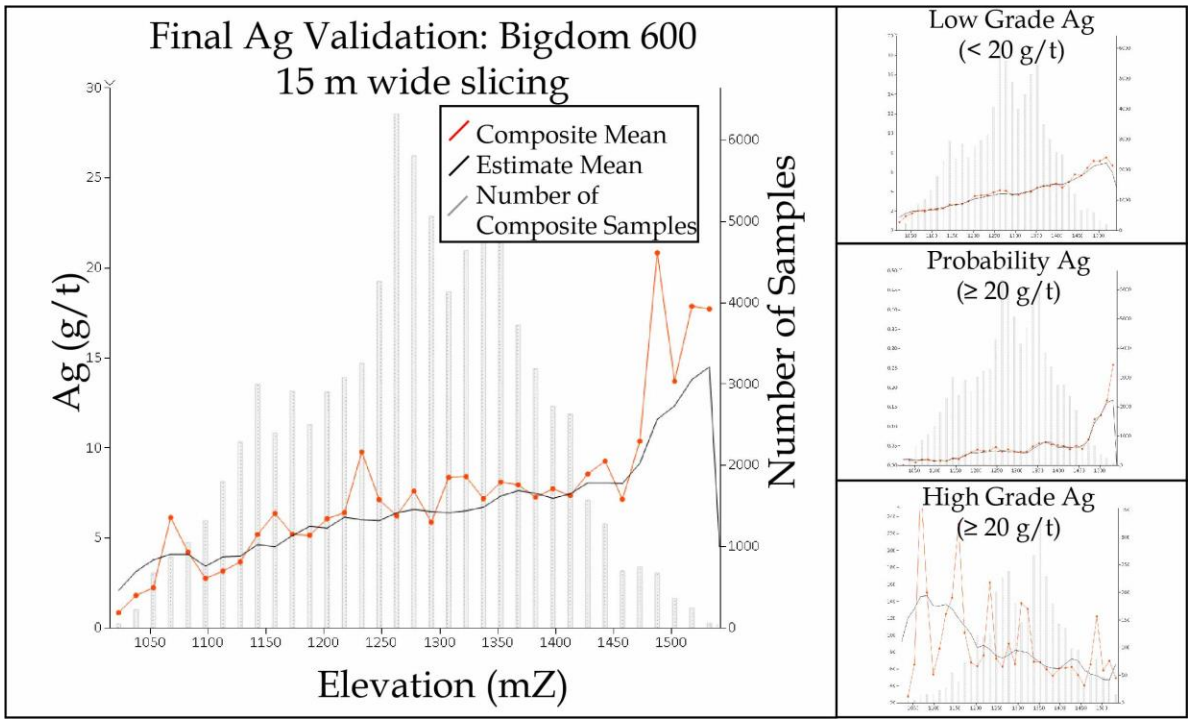
Source: Pretivm 2020

Figure 14-14: Example Silver Grade Trend Plots by Northing for Bigdom 600



Source: Pretivm

Figure 14-15: Example Silver Grade Trend Plots by Elevation for Bigdom 600



Source: Pretivm 2020

14.8.3 Visual Validation

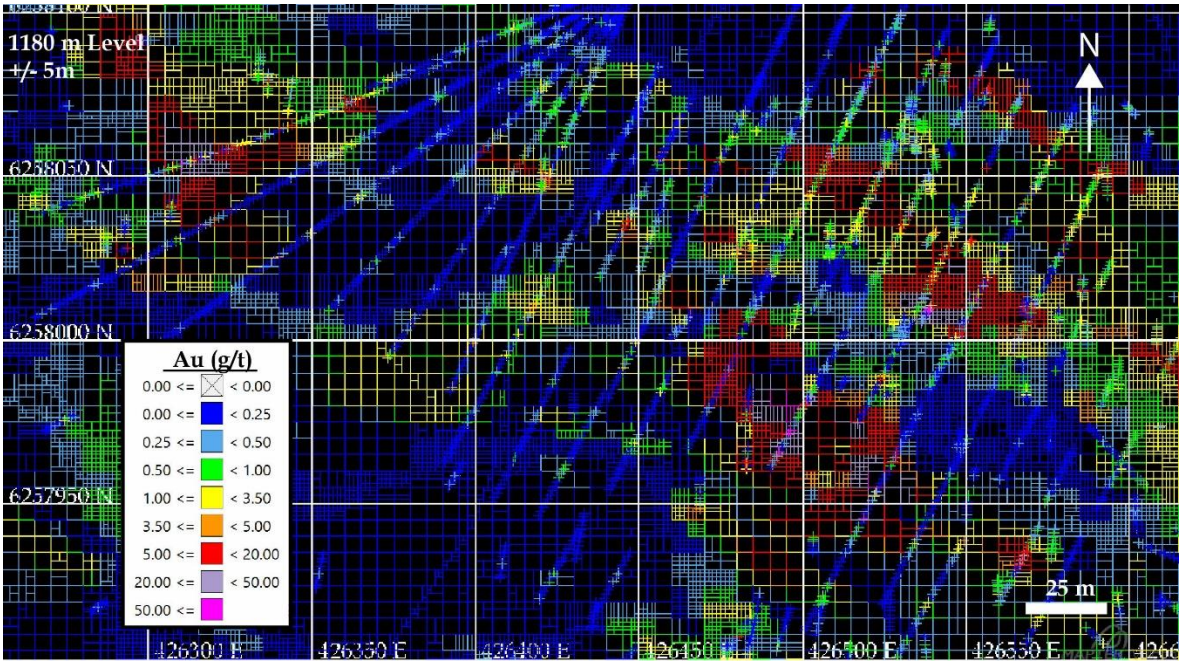
Visual validation of the block grade estimates for the January 2020 resource estimate was conducted in the update area to assess the validity of grade trends, identify potential grade blow-out zones, identify zones of high, medium, and low confidence in the block grade estimates, and to assess the edge of the modelled mineralized zone relative to actual epithermal veining. Visual model validation was conducted by comparing block grade estimates against input drillhole composites in the Maptek Vulcan software and to geology in the underground mine exposures.

Block model grade estimates were compared against input drillhole composite grades in three dimensions (model rotation and iterative zoom-in, zoom-out), as well as on a section-by-section basis (along Easting, Northing, and in plan view). Incremental slicing tools in the Vulcan mining software, with variable viewing windows, were used for this check. Example section and plan views are shown in Figure 14-16 and Figure 14-17.

Overall the visual validation check indicated that high-grade blocks were being informed by high- and extreme-grade mineralization, and that in areas of higher infill drilling density, high-grade blocks were reasonably constrained by lower grade mineralization (i.e., no blow-outs). Mineralization trends in the input composite data appear to be reasonably represented in the block grade estimates. Underground geological exposures confirmed the presence of epithermal veining where mineralized blocks were estimated, including the presence of visible electrum in places. Estimates in mineralized domains showed reasonable boundary resolution relative to the edges of the mineralized epithermal vein system exposed in the underground workings, particularly in areas informed by tightly-spaced drilling.

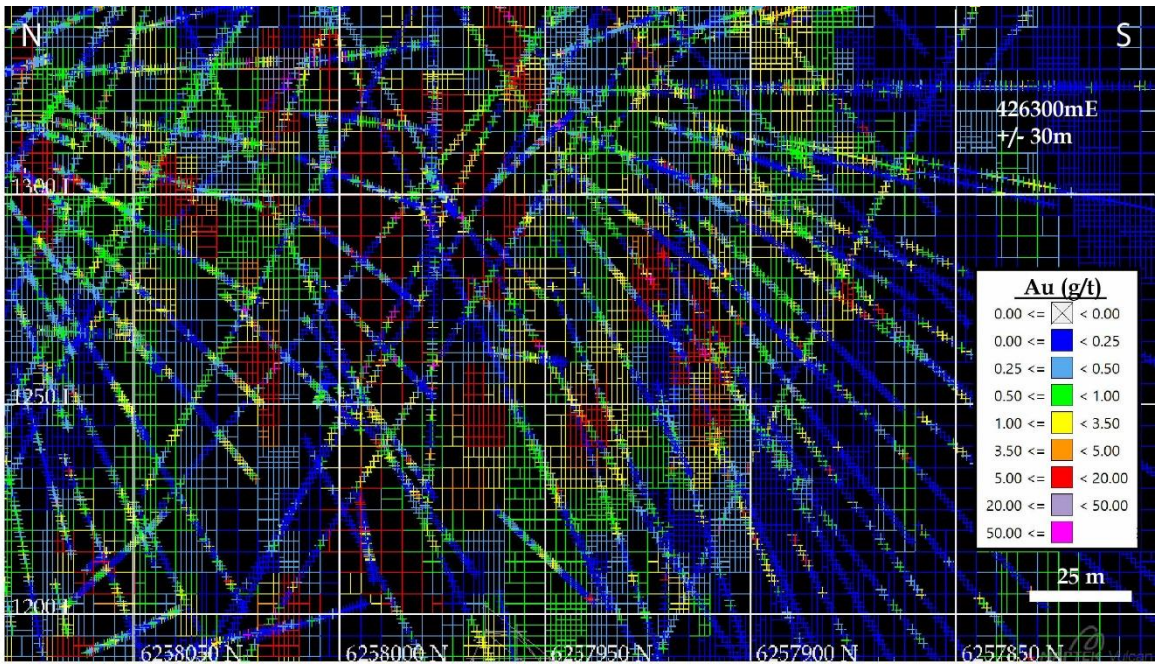
Low- and medium-grade composite data are well represented by the model, although there are numerous places where high- and extreme-grades are suppressed by lower grade composite data, with no significant expression in the block grade estimates. This is due to the low estimate of the proportion of high-grade in areas dominated by lower grade intersections. Given the hit-and-miss nature of the high-grade data in the drilling (see Section 10.0) and the heterogeneous nature of the gold mineralization in the Valley of the Kings Zone (see Section 7.0), it is likely that the block model estimate is relatively conservative in such areas.

Figure 14-16: Plan View of the 1180 m Level Showing Block Grade Estimates and Input Drillhole Composite Data Colour Coded by Gold Grade



Note: Viewing window is ±5 m; drillhole composites shown as '+' markers.
Source: Pretivm 2020

Figure 14-17: N-S Cross Section Along 426300 E Showing Block Grade Estimates and Input Drillhole Composite Data Coloured by Gold Grade



Note: Viewing window is ±30 m; drillhole composites shown as '+' markers
Source: Pretivm 2020

14.8.4 Reconciliation of the Resource Model with 2019 Production

Additional validation checks were conducted by reconciling the January 2020 resource model to the mill grade and recovered ounces for 2019 production (see Table 14-14 and Figure 14-18). The reconciliation presented in this section compares the resource model to mill production prior to application of mill recovery factors. Two reconciliation approaches were used as a test to enhance confidence in the validity of the resource model:

- Model to mill reconciliation in as-mined shapes to provide a single annual production reconciliation
- Model to mill reconciliation using material movement tracking data to provide a time-based reconciliation.

As-mined shapes are wireframe solids and included those from the Maptek Aegis mining software blast shapes for stope rings sent as ore or waste, surveyed underground development rounds sent as ore or waste, and stope CMS scans. Assayed surface stockpile material sent to the mill was included, although this represented a very small portion (<1%) of the material mined. Aegis blast shapes for a given stope were compared against final surveyed CMS of stopes and found to be reasonably representative of the mined volume.

Material movement tracking was conducted by truck counting on a per shift basis, with an applied mass factor per truck and LHD (scoop) bucket. These factors were reconciled monthly against actual crusher weightometer data. Challenges associated with material movement tracking included variable residency times of mucked ore in remuck bays on mining levels, as well as in crusher feed remuck bays, and ore from different stopes being blended together in variable quantities as a function of mining exigencies. The nature of material movement and stope blending in the Brucejack Mine therefore precluded exact reconciliation by source (i.e., on a stope-by-stope basis). Material movement tracking data did, however, facilitate approximation of model to mill reconciliation through the year for trend analysis.

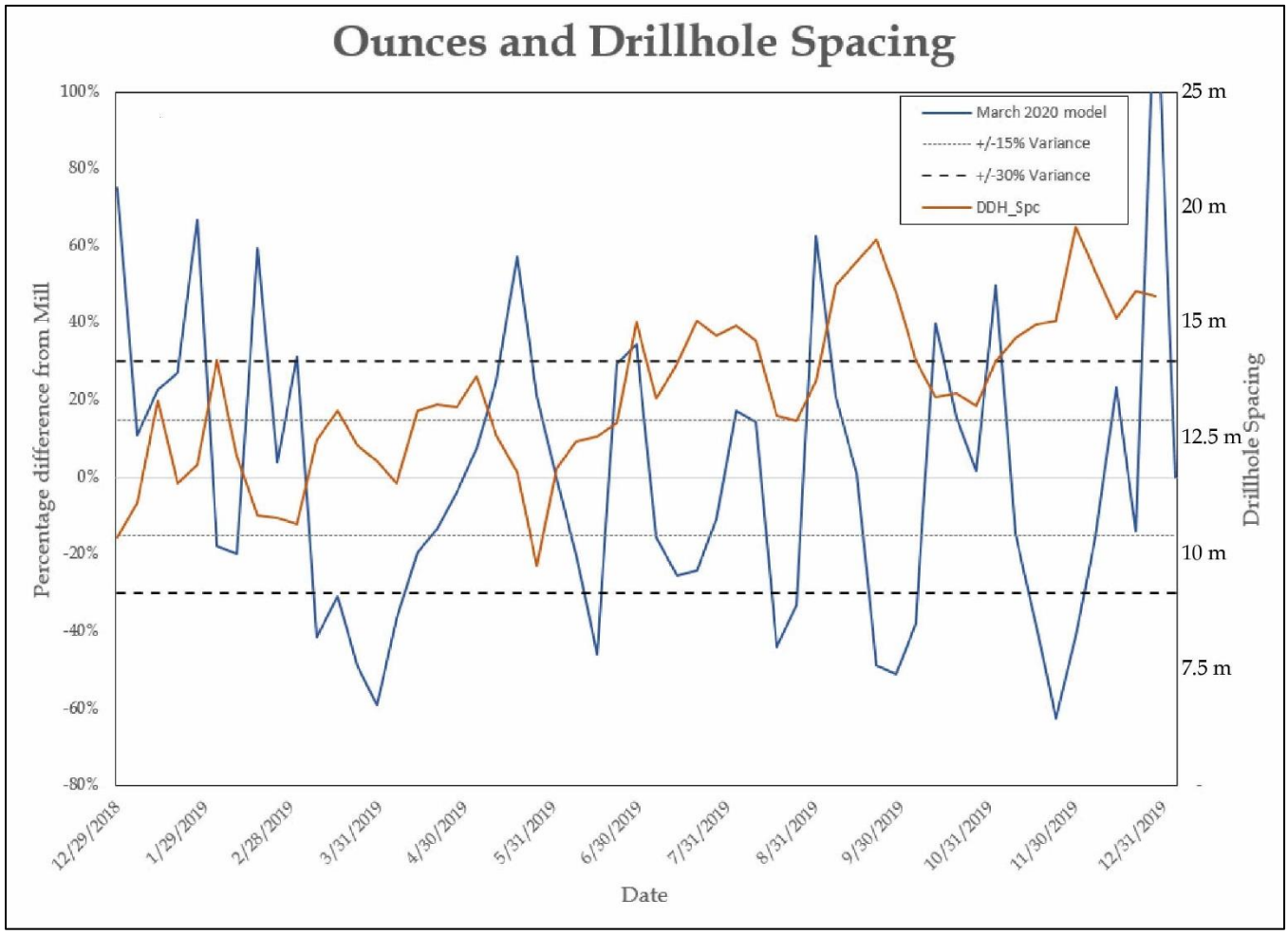
Table 14-14: January 2020 Model to 2019 Mill Gold Production Reconciliation

	Tonnage ('000s t)	Au (g/t)	Contained Au ('000s Oz)
Total Mined Wireframe Approach	1,356	8.09	353
Total Mined Materials Movement Tracking Approach	1,385	7.95	354
Mill Data	**1,303**	**8.73**	**366**
Percentage Difference Mined to Mill Wireframe Approach	+4.0%	-7.3%	-3.5%
Percentage Difference Mined to Mill Materials Movement Tracking	+6.3%	-8.9%	-3.1%

Note: Silver grades are not reported in daily figures by the mill.

Results of both reconciliation approaches show that the predicted grades and contained ounces in the January 2020 model are within 10% of the raw mill production data for 2019. This is well within acceptable limits for the mining of heterogeneous nuggety gold deposits on an annual production basis. Local over- and under-estimation of grade for short-term mining volumes as noted in the reconciliation figures (Figure 14-18) have averaged out over the annual production volume indicating an unbiased model. Large differences in ounces from the mill, as noted in Figure 14-18, usually correspond to production in areas with a wider drillhole spacing.

Figure 14-18: Ounces Normalized to Mill Production with Corresponding Drillhole Spacing Plot for the January 2020 Model



Note: 2019 production data is shown pre-mill recovery; percent difference of ounces with respect to the mill for the December 2019 resource model is based on material movement tracking data to approximate time-based reconciliation. Difficulties inherent in truck tracking preclude exact stope-by-stope reconciliation due to stope blending and variable underground muck residency times.
Source: Pretivm 2020

14.8.5 Concluding Remarks: Model Validation

Based on the various model validation checks presented above, it is the QP's opinion that the January 2020 resource model is a reasonable representation of the input drilling data at the block scale and a reasonable predictor of gold grade and contained metal, particularly in well-drilled areas.

14.9 Mineral Resource Classification

Additional data generated as part of the 2019 infill drill campaign and from extensive underground development completed since the July 2016 resource estimate were incorporated into an updated resource classification for parts of the January 2020 Mineral Resource. Changes to the resource classification were limited to that part of the resource estimate updated in this study (see introductory comments to Section 14 and Section 14.6.1).

Details of Measured, Indicated, and Inferred classification criteria pertaining to the December 2013 estimate outside of the update area are presented in Farley et al. (2014) and Jones (2014). Classification criteria pertaining to the July 2016 estimate are presented in Board et al. (2017). Classification criteria pertaining to the January 2019 estimate are presented in Jones et al. (2019). The Mineral Resource defined in Farley et al. (2014) and Jones (2014) was a global resource predicated on bulk mining, and included the classification of Indicated Resources where the drillholes were spaced up to 40 m apart.

The May 10 (2014) definition standards of the Canadian Institute of Mining (CIM, 2014) were followed in the classification of the January 2020 resource estimate, whereby:

*A **Measured Mineral Resource** is that part of a Mineral Resource for which quantity, grade or quality, densities, shape, and physical characteristics are estimated with confidence sufficient to allow the application of Modifying Factors to support detailed mine planning and final evaluation of the economic viability of the deposit. Geological evidence is derived from detailed and reliable exploration, sampling and testing and is sufficient to confirm geological and grade or quality continuity between points of observation. A Measured Mineral Resource has a higher level of confidence than that applying to either an Indicated Mineral Resource or an Inferred Mineral Resource. It may be converted to a Proven Mineral Reserve or to a Probable Mineral Reserve*

*An **Indicated Mineral Resource** is that part of a Mineral Resource for which quantity, grade or quality, densities, shape and physical characteristics are estimated with sufficient confidence to allow the application of Modifying Factors in sufficient detail to support mine planning and evaluation of the economic viability of the deposit. Geological evidence is derived from adequately detailed and reliable exploration, sampling and testing and is sufficient to assume geological and grade or quality continuity between points of observation. An Indicated Mineral Resource has a lower level of confidence than that applying to a Measured Mineral Resource and may only be converted to a Probable Mineral Reserve.*

*An **Inferred Mineral Resource** is that part of a Mineral Resource for which quantity and grade or quality are estimated on the basis of limited geological evidence and sampling. Geological evidence is sufficient to imply but not verify geological and grade or quality continuity. An Inferred Mineral Resource has a lower level of confidence than that applying to an Indicated Mineral Resource and must not be converted to a Mineral Reserve. It is reasonably expected that the majority of Inferred Mineral Resources could be upgraded to Indicated Mineral Resources with continued exploration*.

Drillhole spacing, geological maps of the extensive underground development, model validation (Section 14.8) results, and production reconciliation (Section 14.8.4) were reviewed in detail as part of the resource classification process. Existing wireframe solid interpretations for Measured and Indicated classifications were then refined and validated. Blocks in the January 2020 resource model were coded according to resource classification using the revised wireframe solids, where:

- Measured Resources are those with infill drilling characterized by up to 15 m spacing in areas informed by new underground development. Measured Resources are expected to be within 15% of production on a quarterly basis.

- Indicated Resources are those informed by appropriately spaced (up to 25 m centers) drilling and using information from a minimum of two drillholes. Indicated Mineral Resources using this classification scheme are expected to be within 15% of production on an annual basis. Portions of the Indicated Resource that fell outside of the mineralised domain wireframes were downgraded to Inferred because of the lack of confidence in the geological framework for those estimates.

Indicated Resources outside of the update box include drilling between 25-40 m centers, originally considered appropriate for bulk mining of the deposit (Farley et al., 2014; Jones, 2014). Additional infill drilling, ahead of mine scheduling, will be necessary in these areas to increase definition of high grade corridors within the broader stockwork zones should more selective mining scenarios (e.g., longitudinal mining) be envisaged.

It is the Qualified Person's opinion that the approach to resource classification is appropriate given the nature of the mineralization in the Brucejack Deposit. It is his opinion that the information used to define the Mineral Resource is of a high quality and suitable for the estimation and classification of resources with a high level of confidence.

14.10 Mineral Resource Reporting

14.10.1 Depletion

Depletion was applied to the January 2020 resource model. This includes the CMS of stopes (current to December 31 2019), full development and manual depletion of areas that have been deemed unmineable by the QP, engineers and geologists. The majority of the areas that have been deemed unmineable are mainly artefacts of the CMS (e.g., pillars) and not material volumes. However, there are instances of half-height stopes wherein only half of the stope was mined, based on the block model and/or grade control sampling. In such cases, the remainder of the stope has also been removed from the mineral resource as there is no intention of mining it in the future.

The resource estimate identifies the general area wherein the targeted grade is located in the mine. After the reserve process optimizes the stope location and the life of mine plan is embedded, a grade control drill plan is designed. The grade control drill plan is based on local geologic information (e.g., mapping and jumbo sampling), in conjunction with drilling and a mid-term mine planning model, and endeavors to optimize and identify the exact spatial location of the mineralization. This process results in leaving certain drill rings in-situ (based on grade) despite the previous or current pre-processed resource model grade. These areas have not been depleted from the January 2020 resource model but a lower grade has been assigned based on subsequent sampling information. This mineralization is not considered unmineable (depending on the assigned grade), but mining is deferred to a later date and therefore considered to remain as a part of the mineral resource.

14.10.2 January 2020 Mineral Resource for the Brucejack Deposit

The January 2020 Mineral Resource of the Valley of the Kings Zone is reported above a cut-off grade of 3.5 g/t gold; differing from the previous reporting above a gold equivalent (AuEq) of 5 g/t AuEq cut-off (calculated as AuEq = Au + Ag / 53) used in the November 2012 (Jones, 2012c), December 2013 (Jones, 2014), July 2016 (Board et al., 2017), and January 2019 (Jones et al., 2019) Mineral Resources. The decision to report the Mineral Resource at a lower cut-off grade is based on a comparison between actual mining practice and results and the resource model.

The January 2020 Mineral Resource of the West Zone continues to be reported above a cut-off grade of 5 g/t gold equivalent as there has been no further studies within the area.

The January 2020 Mineral Resource for the Brucejack Deposit (Valley of the Kings Zone and West Zone) are presented in Table 14-15 and Table 14-16.

Table 14-15: January 2020 Valley of the Kings Zone Mineral Resource [(1,2,3,4,5,6)]

Category	Tonnes (Mt)	Au (g/t)	Ag (g/t)	Contained Au (Moz)	Contained Ag (Moz)
Measured	2.3	10.5	12.6	0.8	0.9
Indicated	16.1	11.4	12.2	5.9	6.3
Measured + Indicated	**18.4**	**11.3**	**12.2**	**6.7**	**7.2**
Inferred	5.4	13.3	15.9	2.3	2.8

Notes:
[(1)]Mineral Resources which are not Mineral Reserves do not have demonstrated economic viability. The estimate of Mineral Resources may be materially affected by environmental, permitting, legal, marketing, or other relevant issues. The Mineral Resources in this Technical Report were estimated and reported using the CIM Definition Standards – Prepared by the CIM Standing Committee on Reserve Definitions, Adopted by CIM Council May 10, 2014. (CIM, 2014).
[(2)]The quantity and grade of reported Inferred resources in this estimation are uncertain in nature and there has been insufficient exploration to define these Inferred Resources as an Indicated or Measured Mineral Resource and it is uncertain if further exploration will result in upgrading them to an Indicated or Measured Mineral Resource category.
[(3)]Contained metal and tonnes figures in totals may differ due to rounding.
[(4)]Resources depleted for production to December 31, 2019.
[(5)]The January 2020 Valley of the Kings Zone Mineral Resource is reported above a gold cut-off grade of 3.5 g/t gold. The West Zone Mineral Resource is reported above a gold equivalent cut-off grade of 5 g/t gold equivalent (AuEq) (where AuEq=Au+Ag/53 as per previous models).
[(6)]Mineral Resource is reported inclusive of Mineral Reserve.

Table 14-16 West Zone Mineral Resource, April 2012 (Jones, 2012a)[(1)]

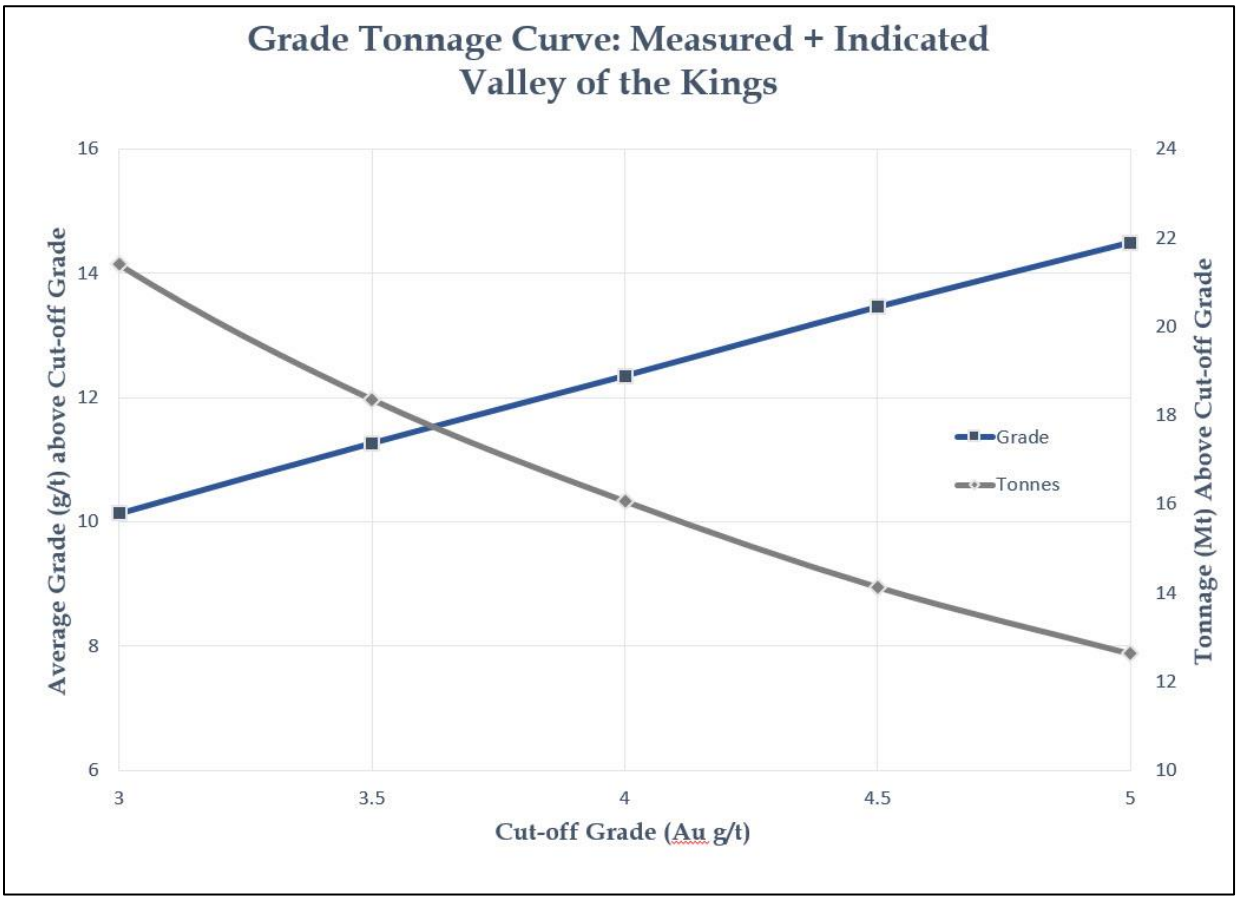
Category	Tonnes (Mt)	Au (g/t)	Ag (g/t)	Contained Au (Moz)	Contained Ag (Moz)
Measured	2.4	5.9	347	0.5	26.8
Indicated	2.5	5.9	190	0.5	15.1
Measured + Indicated	**4.9**	**5.9**	**267**	**0.9**	**41.9**
Inferred	4.0	6.4	82	0.8	10.6

Note:
[(1)]Notes from Table 14-15 apply (see Jones, 2012a for more details).

14.10.3 Resource Sensitivity

The portion of the January 2020 Resource Model categorized as Measured and Indicated for the Valley of the Kings Zone (depleted for production up to December 31, 2019) is reported at a series of gold cut-off grades to demonstrate sensitivity (see Figure 14-19). Estimated gold grade decreases and tonnage increases at progressively lower gold cut-offs (and vice versa at higher cut-offs). Gold grade remains above 10 g/t Au at a cut-off of 3.5 g/t Au.

Figure 14-19: January 2020 Valley of the Kings Zone Measured + Indicated Mineral Resource Sensitivity



14.11 Comparison with the January 2019 Resource Estimate

As there have been no changes to the West Zone Mineral Resource, nor the December 2013 and January 2019 Valley of the Kings Zone Mineral Resources outside of the update area (see introductory comments to Section 14 and Section 14.6.1), comparison between the January 2020 and January 2019 resource estimates is limited to the Valley of the Kings Zone inside the update area (see Table 14-17). The comparison focuses on resource estimates that have not been depleted for production to demonstrate the true variance between these models as informed by definition drilling.

Table 14-17: Comparison Between January 2020 and January 2019 Estimates for the Valley of the Kings Zone Inside the Update Area Only

Resource Model	Au Cut-off (g/t)	Tonnes (Mt)	Au (g/t)	Ag (g/t)	Contained Au (Moz)	Contained Ag (Moz)
Measured						
January 2020	3.5	**0.5**	**10.3**	**13.2**	**0.2**	**0.2**
January 2019	3.5	0.5	13.8	14.8	0.2	0.2
Change	-	-	*-3.5*	*-1.6*	-	-
Indicated						
January 2020	3.5	**7.2**	**10.8**	**8.4**	**2.5**	**2.0**
January 2019	3.5	6.9	14.6	9.5	3.2	2.1
Change	-	*+0.3*	*-3.8*	*-0.7*	*-0.7*	*-0.1*
Measured + Indicated						
January 2020	**3.5**	**7.7**	**10.8**	**9.1**	**2.7**	**2.3**
January 2019	3.5	7.4	14.6	9.9	3.5	2.3
Change	-	*-0.3*	*-3.8*	*-0.7*	*-0.8*	-

Note: These numbers have been reported for comparative purposes and have not been depleted to account for production. The reader should refer to Table 14-15 for the current January 2020 Valley of the Kings Zone Mineral Resource, reported depleted of production as at December 31, 2019.

The January 2020 resource estimate effectively overwrites the January 2019 resource estimate inside the update area. Comparisons between these models (inclusive of mine production) show that the new estimate is lower by approximately 0.7 Mt, 2.2 Moz Au, and 1.1 Moz Ag in the Measured + Indicated Resource at similar estimated gold and silver grades, using the same cut-off grade of 5 g/t AuEq (AuEq = Au + Ag / 53). The differences between the two models are largely data-driven. Additional tightly-spaced infill drilling, increased exposure of the mineralized system during mining, and over 1.5 Mt of actual production since mine commissioning have resulted in improved domain and local estimation parameter definition.

15.0 MINERAL RESERVE ESTIMATES

15.1 General

The Mineral Reserve estimate stated herein is consistent with the CIM Standards on Mineral Resources and Mineral Reserves and is suitable for public reporting. As such, the Mineral Reserves are based on Measured and Indicated Mineral Resources and do not include any Inferred Mineral Resources. This Mineral Reserve estimate update only pertains to the Valley of the Kings mining area; no additional work has been completed on the West Zone since the 2014 FS (Ireland et al. 2014).

The Valley of the Kings Mineral Reserves were developed from the Mineral Resource model "res1912_MRM_NSC_2019_depl_101010_MO_OW_Reserve_id", which was created by Pretivm and provided in January 2020. These Mineral Reserves do not include the mined-out material up to the year-end of 2019.

15.2 Cut-off Grade

A NSR cut-off grade of US$180/t or Cdn$230/t of ore was used to define the Mineral Reserves. This cut-off grade is based on a 3,800 t/d mining operation and has decreased from the previous cut-off grade of US$185/t from the 2019 Technical Report on the Brucejack Gold Mine (Jones, 2019). Table 15-1 shows the average site operating cost estimates over the LOM.

Table 15-1: Cut-off Grade Costs

Area	Cost
Mining	Cdn$121/t
Processing	Cdn$26/t
Maintenance	Cdn$42/t
General and Administrative	Cdn$41/t
Total (Cdn$)	**Cdn$230/t**
Foreign Exchange Rate	Cdn$1.00:US$0.78
Total (US$)	**US$180.00/t**(1)

Note: (1)Total US$ rounded to nearest tenth of a dollar

15.3 NSR Model

An NSR model was created for the Mineral Reserves and used the parameters summarized in Table 15-2. The NSR for each block in the Mineral Resource model was calculated as the payable revenue for gold and silver, less the costs of refining, treatment, transportation, assays, and penalties.

The metal price assumptions for delineation of the Mineral Reserves are US$1,250/oz Au and US$15.60/oz Ag. A foreign exchange rate of Cdn$1.00:US$0.78 was used.

The NSR contributions for both doré and floatation were calculated separately, then combined to create a total NSR for each block in the Mineral Resource model. The recovery and mass pull percentages were calculated using trends from mill data obtained throughout production.

Table 15-2: NSR Parameters

Items		Units		Parameters
Foreign Exchange Rate		Cdn$:US$	-	01:0.78
Metal Prices	Gold	US$/oz	-	1,250.00
	Silver	US$/oz	-	15.6
Doré				
Selling Cost	Transport	US$/Au oz doré	-	2.9
	Assays	US$/Au oz doré	-	0.45
	Treatment	US$/Au oz doré	-	0.5
Metal Payable	Gold	%	-	99.95
	Silver	%	-	99
Flotation Concentration				
Mass Pull		%	-	0.0055*(S/C)+0.0401
Selling Cost	Treatment	US$/dmt	-	157.81
	Refining	US$/payable Au oz	-	8.13
	Refining	US$/payable Ag oz	-	1.13
	Transport	US$/wmt	-	166.13
	Assays	US$/wmt	-	4
Metal Payable	Gold	%	-	96.75
	Silver	%	-	82.5
Arsenic Recovery		%	-	0.0367*(S/C)+0.485
Arsenic Penalty		US$/t concentrate	As <= 0.2%	0
		US$/t concentrate	As > 0.2%	(As-0.2)*7.5
Recoveries				
Gold	Doré	%	Au_Doré =	15.009*ln(Au/s)+48.244)*0.0098
	Flotation	%	Au_Float =	(-13.12*ln(au_s)+46.724)*(1.02/100)
			if (Au_Doré + Au_Float) > 98%	
	Flotation		Au_Float =	98 - Au_Dore
Silver	Doré	%	Ag_Doré =	15.009*ln(Au/s)+48.244)*0.0098
	Flotation	%	Ag_Float =	(-13.12*ln(au_s)+46.724)*(1.02/100)
			if (Ag_Doré + Ag_Float) > 89%	
	Flotation		Ag_Doré =	(Ag_Doré)-((Ag_Doré)+(Ag_Float) - 89)

Note: All costs and metal prices were based upon estimates and used solely for the generation of the NSR model and delineation of the Mineral Reserves.

15.4 Mining Shapes

Pretivm used the Mineable Shape Optimizer (MSO) module from Vulcan v. 12.0.0 software to produce design excavations that met both the cut-off grade and operational design criteria.

The design criteria constrain the geometry of all planned excavations to mineable shapes through the planned mining methods. Section 16.0 provides further detail on mining shapes and design parameters.

The preliminary shapes were individually refined where necessary to ensure stope geometry viability and to minimize the amount of sub-economic material within the shape volume that is inseparable from profitable material due to the practical constraints of mining.

The Mineral Reserve stope and development shapes were used as the basis for mid-term mine planning by the Brucejack Gold Mine site mine planning department. Based on further grade control drilling and assaying work completed prior to mining, additional stope shape changes may occur to adjust mining to the results of grade control work.

Based upon the NSR model, mineable shapes are only created where the average grade of the stope is greater than or equal to 4.5 g/t gold.

15.5 Orebody Description

Mineral Reserves delineated at the US$180/t NSR cut-off define an orebody consisting of numerous independent lenses in the Valley of the Kings Zone and two distinct lenses in the West Zone extending over a 570 m vertical distance from the 990 m elevation level to surface (approximately 1,560 m elevation level).

15.5.1 Valley of the Kings Zone

The Valley of the Kings Zone hosts multiple lenses that comprise approximately 82% of the combined Mineral Reserve tonnage. Mineral Reserves in the Galena Hill Zone are proximal to the Valley of the Kings Zone and have been considered as part of the Valley of the Kings Mineral Reserves.

Strike length varies considerably with elevation, but the core of the Valley of the Kings Zone has reserves located within a 550 m strike length over an elevation change of 570 m. The other main lens in the Valley of the Kings has reserves located within a 500 m strike length over an elevation change of 495 m. The average thickness of the stope block varies by elevation. Table 15-3 shows the average mining thickness of the main Valley of the Kings Zone by mining block.

Table 15-3: Main Valley of the Kings Zone Mining Thickness by Mining Block

Level	Mining Thickness (m)
990-1050	16
1080-1170	13
1200-1290	13
1320-1560	14

Narrow Mineral Reserves have been delineated down to a minimum 10 m mining thickness. The Valley of the Kings Zone has a slight plunge towards the east.

15.5.2 West Zone

Mineral Reserves for the West Zone remain unchanged from the 2014 FS (Ireland et al. 2014) as no new drilling has been completed and no new information has been obtained in this zone. Mineral Reserves within the West Zone are contained within four lenses, three of which host 90% of West Zone Mineral Reserves. Strike lengths vary considerably with elevation, averaging approximately 100 m in the larger lenses, while the smaller lenses are no more than 35 m along strike.

The average thickness is approximately 25 m, with the smaller lenses averaging only 15 m.

15.6 Mine Call Factor

Through 2.5 years of operations and mining reconciliation, an applicable MCF has been determined necessary to account for the local overcalling of historic resource and reserves. As this MCF is based upon historic mining data of previous resources, it is only applied to the areas of the current resource that have not been updated (models 1 and 2). The MCF applies to areas estimated by the original 2013 Snowden resource (20131219_Snowden_V3_BM), and the 2019 resource updates ("res1901_finmod_20190115_v3") (models 1 and 2). The MCF has not been applied to the West Zone (model 3) as mining has not yet occurred on this zone and lacks any reconciliation statistics.

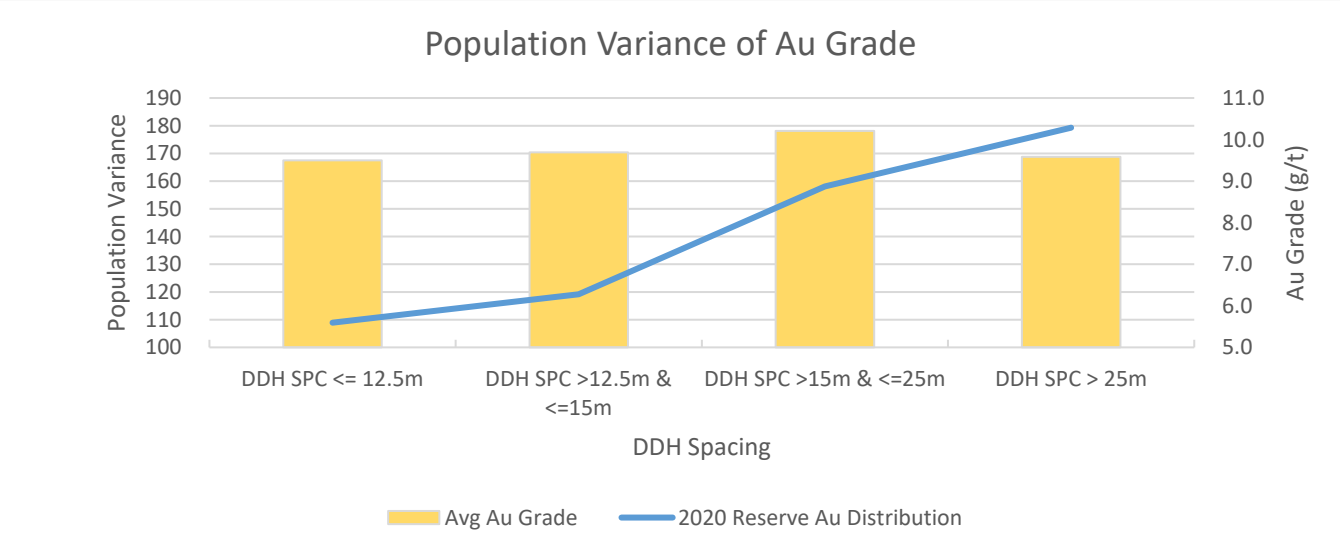
Through mining data and reconciliations, it was found that the best indicator of possible misrepresentation of grade is the average spacing of diamond drillhole data influencing that particular area of the model. It was found that as the amount of information influencing that block decreased, the likelihood of local error significantly increased. Therefore, as of 2019, Pretivm began using diamond drillhole spacing as a measure of risk and a way of systematically applying an MCF to the mine plans.

When undertaking a statistical comparison of the reserve stope shapes and the gold grades estimated in the block model, it was identified that the mean grade of all the individual reserve shapes varied very little when compared to diamond drillhole spacing. However, the same cannot be said about the relationship between drillhole spacing and the individual estimated gold grades of each block in the block model. During reconciliation, it was observed that as drillhole spacing increased, the differential between estimated gold grades and achieved mined out grades also increased.

Further reconciliation analysis shows that for regions of the model with tighter drillhole spacing, significantly lower grade variance was observed between the estimated and realized grades. Areas that were modelled with drillhole spacings greater than 15 m exhibited greater variance between estimated and observed grades, when compared to drillhole spaces of less than 12.5 m.

From a short term mine planning perspective, stopes that rely on higher drillhole spacings for reserve estimation carry a lower statistical confidence, thereby making the short term mine planning and forecasting more difficult. Figure 15-1 shows the relationship of average grade and population variance by diamond drillhole spacing.

Figure 15-1: Population Variance of Au Grade within the 2020 Reserves Based on Diamond Drillhole Spacing



To account for the increased variability in individual stope grades, an MCF is applied to the average stope grade of the reserves. Each reserve shape is evaluated based upon its average insitu gold grade along with its average drillhole spacing (DDH SPC). Based upon these two averages, the average grade of the stope is capped at varying grades depending on the average drillhole spacing. Reserve shapes that exhibit higher variability, or greater DDH SPC, are accounted for by being capped at lower gold grades. Reserve shapes that have closer average drillhole spacing are shown to have statistically less grade variability, and thus, less likely to be overcalled, are capped at a higher gold value. The MCF parameters used are shown in Table 15-4.

The MCF is only applied to the average grade of the reserve shapes as it was found that capping of individual high-grade blocks of the model would result in an unrealistic negative estimation of the grade. Therefore, applying the MCF to the average grade of the stope limits the impact of reducing these high nugget grades and provides a more appropriate estimation of the expected grade. The MCF is applied prior to dilution and only to the areas not updated in this resource update. By limiting its application to these areas, the MCF is only applied to areas where historic mining has taken place and previous reconciliations are valid.

Through the grade control program, Pretivm has found that significant material outside of the reserve has grade that exceeds the economic threshold of the NSR model. As this current MCF solely reduces the upper limit of the reserves, it is expected that the overall ounce and tonnage predicted by the reserves with MCF applied will be lower than what is actually present due to the expectation that the grade control program will continue to identify out of reserve material not captured in the current reserves. The parameters and uses for this MCF will be adjusted as Pretivm gains more experience mining the updated Mineral Resource and Mineral Reserves. A comparison of the MCF and the 2019 Reserve Reconciliation is covered in Section 15.9. Table 15-5 shows the average insitu Au grade of reserves before and after the MCF is applied.

Table 15-4: Insitu Au Grade Cap for the Mine Call Factor

Diamond Drill Hole Spacing (DDH SPC)	Average Stope Au Grade Upper Limit (g/t)
DDH SPC <= 12.5 m	17.5
DDH SPC > 12.5 m & <= 15 m	15
DDH SPC > 15 m & <= 25 m	12
DDH SPC > 25 m	12

Table 15-5: Average Insitu Gold Grade of Stopes Before and After Mine Call Factor Application

Model	Resource Category	Au Mean (g/t) – Pre MCF	Au Mean (g/t) – Post MCF
1	2	18.19	9.25
2	1	11.35	8.99
2	2	11.18	8.53
3	1	6.43	6.43
3	2	8.71	8.71

Figure 15-2: Distribution of Average Insitu Au Grade of Reserves Before Mine Call Factor Application

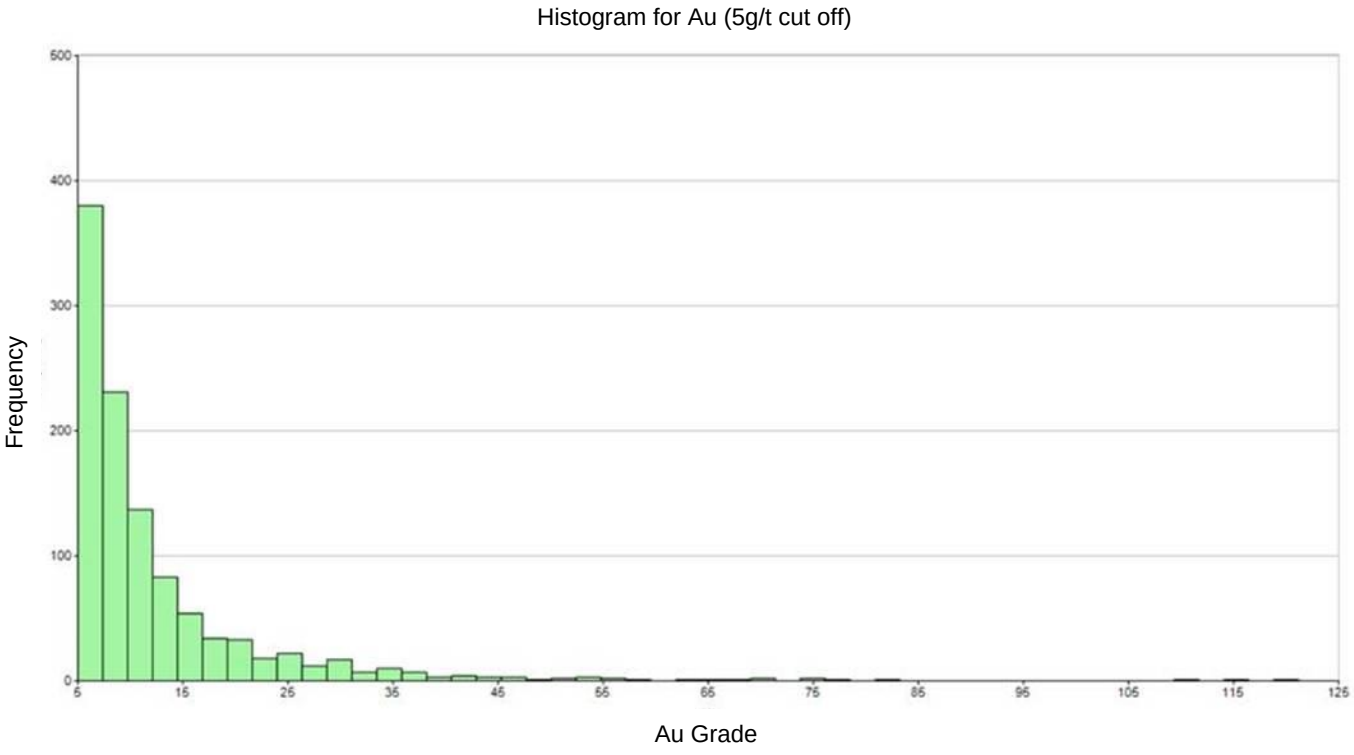
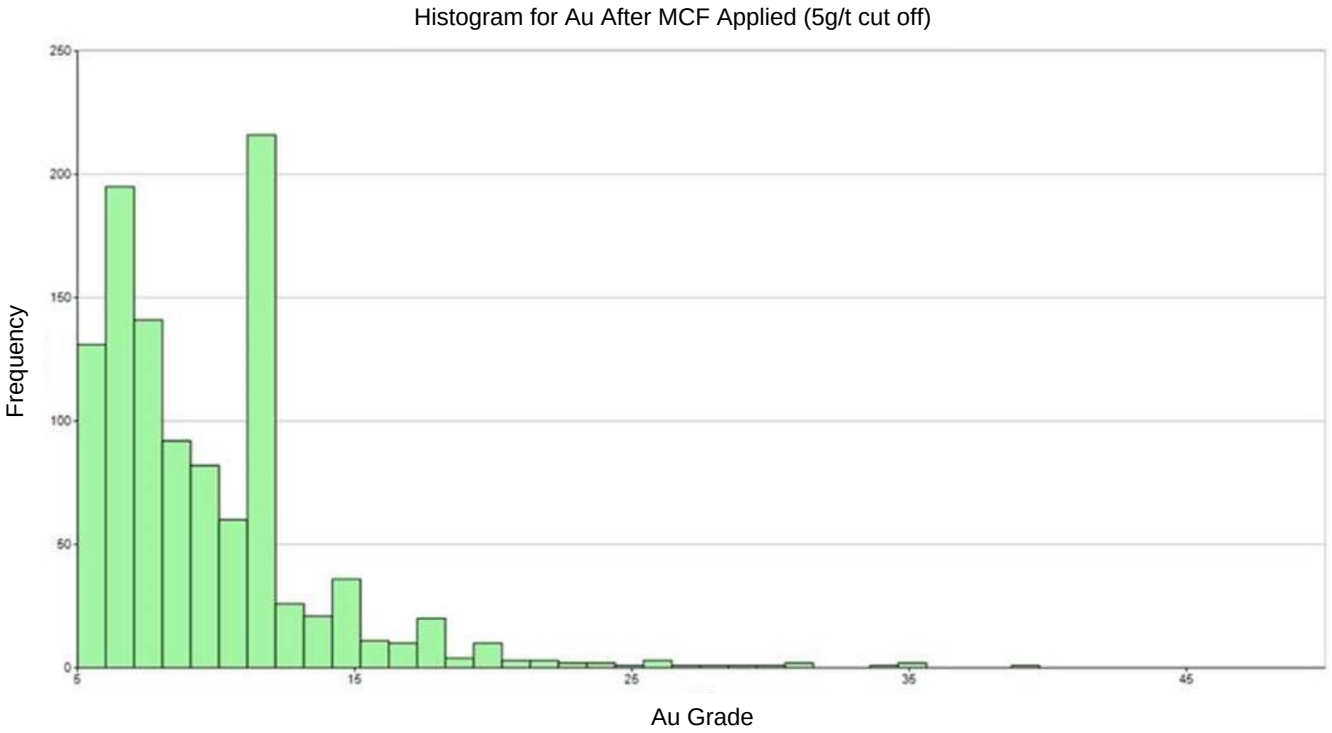


Figure 15-3: Distribution of Average Insitu Au Grade of Reserves After Mine Call Factor Application



15.7 Mineral Reserve Depletion Due to Grade Control Program

As part of the grade control program, stopes are drilled and sampled via long hole or RC drilling. These results are then analyzed, and depending on the grade and additional geological factors, an ore/waste call is made on the associated drill ring. Reserves that have been grade control sampled and determined to be uneconomic with no potential to mine above the reserve cutoff grade have been subsequently removed from the reserves. For a more complete explanation of the grade control process, please refer to Section 14.10.1.

15.8 Dilution and Recovery Estimates

In evaluating the Mineral Reserves, modifying factors were applied to the tonnage and grade of all mining shapes (both stoping and development) to account for the dilution and ore loss.

Ore dilution includes overbreak into the design hanging wall and design footwall, as well as into adjacent backfilled stopes. Diluting materials were assumed to carry no metal values in the estimation of Mineral Reserve grades.

The largest component of dilution at the Brucejack Gold Mine will be paste backfill due to its inherently weaker strength as compared to the hanging wall and footwall rock masses for any given dimensions of exposure. Ore loss (recovery factors) is related to the practicalities of extracting ore under varying conditions, including difficult mining geometry, problematic rock conditions, losses in fill, and blasting issues.

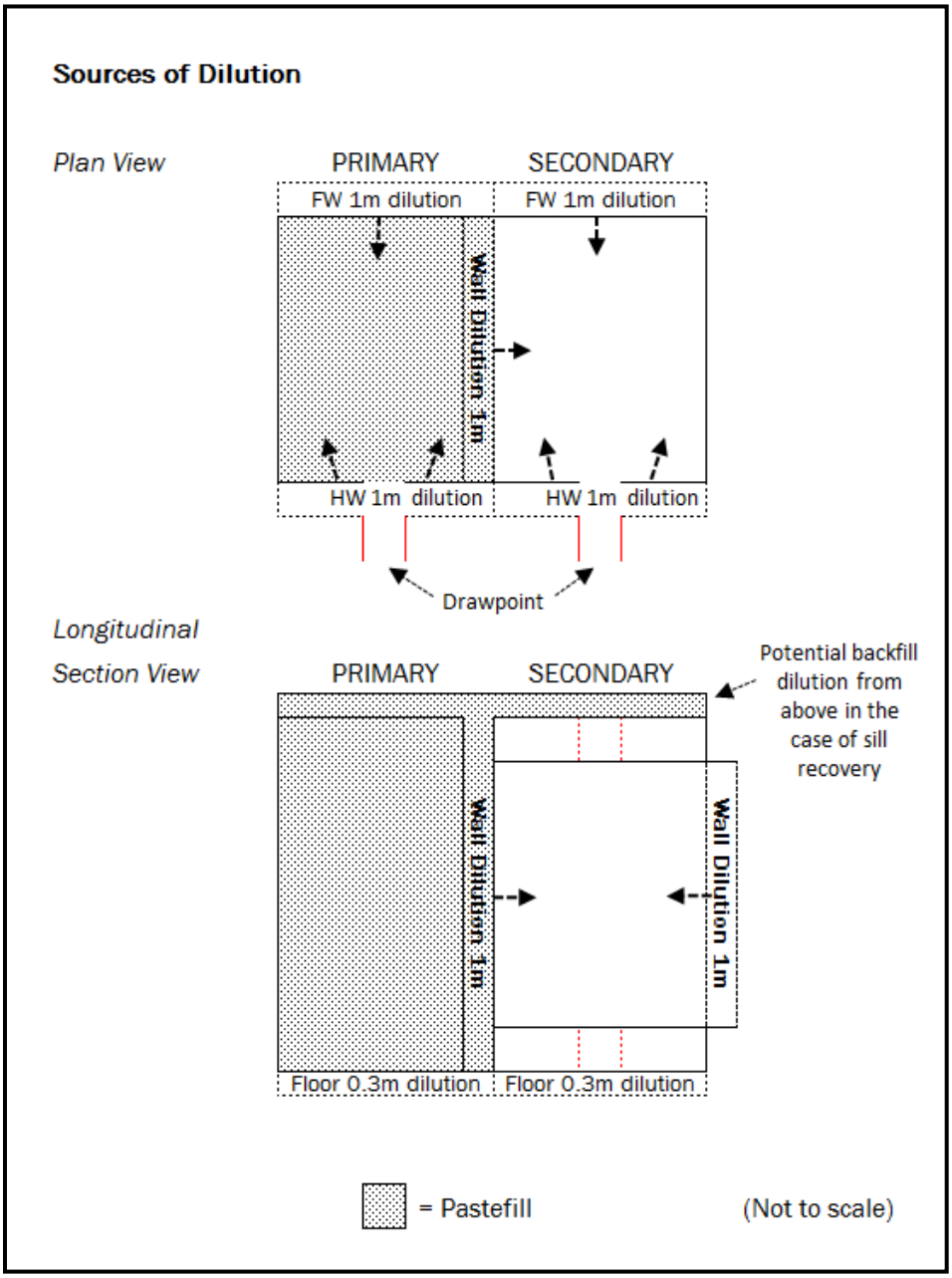
The dilution factors were estimated from standard overbreak assumptions based on Pretivm's experience and benchmarking of similar long-hole open stope operations:

- Long-hole stopes (primary, secondary, and tertiary) carry 1.0 m of dilution from paste or country rock overbreak into the design hanging wall and design footwall and 0.3 m of backfill dilution from the floor.

- Secondary or tertiary stopes carry an additional 1.0 m of backfill dilution on each wall that exposes a primary stope.
- Sill pillar stopes are treated as secondary stopes, given the additional backfill dilution that can be expected from the roof.
- Ore cross-cuts carry 0.5 m of dilution from rock overbreak into the design hanging wall and design footwall.
- Production slashing of secondary stopes carries 0.5 m of backfill dilution on each wall that exposes a primary stope.

Figure 15-4 shows the typical sources of stope dilution.

Figure 15-4: Sources of Stope Dilution



Source: AMC (2014)

The application of the above parameters yields an overall LOM ore recovery of 94% and an overall ore dilution of 12%. The use of parallel production drillholes in stoping operations at the Brucejack Gold Mine will provide improved dilution control in comparison to fan drilling (discussed further in Section 16.0). These dilution and recovery factors were taken into account when calculating the 2020 reserves.

15.9 2019 Mineral Reserve Reconciliation

The 2019 Mineral Reserve Reconciliation was completed by evaluating the 2019 Mineral Reserves against the 2019 Mined Actuals. Reserve shapes that are spatially proximal with the 2019 actual stopes and development ore positions were compared to the 2019 Milled and Mined results. Applicable reserve shapes were determined by the use of CMS scans of the mined material for all material mined in 2019. In 2019, ore was mined from 67 stopes over 10 levels from the 1,170 m level to the 1,410 m level across a distance ranging 290 m east to west and 155 m north to south. Late in 2019, material was also mined from one stope on the 1,110 m level. Table 15-6 shows the 2019 Reserve reconciliation versus the 2019 mined actuals.

Table 15-6: 2019 Reserve Reconciliation vs. 2019 Mined Actuals

Year	Tonnes (000's)	Gold Grade (g/t)	Contained Gold Ounces (000's)
Mined 2019 Reserve Material	1,023	12.1	396
Grade Control Depleted 2019 Reserves	60	12.9	25
2019 Mineral Reserve Material in Reconciliation	1,083	12.1	421
2019 Mined Actuals	1,303	8.7	366
Reconciliation	**120%**	**72%**	**87%**

The 2019 Reserve Material is inclusive of reserve material that was identified as uneconomic with no possibility of future mining via the grade control program. This material amounted to 60,000 tonnes of 2019 Mineral Reserve material. The tonnage from the 2019 Mined Actuals is 20% more than planned primarily resulting from the identification of out of reserve material that was determined to be economic via the grade control program. All material sent to the mill was determined to be economic by this program.

The 2019 grade control program identified approximately 570,000 tonnes of material located outside of reserve shapes as economic that the 2019 Mineral Resource model identified as sub-economic. This material was either mined or added to drilled inventory throughout 2019. These additional tonnes were not accounted for in the LOM plan reflected in the 2019 Report and are not accounted for in the 2020 Mineral Reserve and 2020 LOM plan.

The 2019 Reserve Reconciliation demonstrates the local overcalling of the resource when compared to the Au reserve grades. After the MCF has been applied we see a comparable reduction in grade. Table 15-7 shows the reduction of grade of the reserves when separated by areas updated in the 2020 Resource.

Table 15-7: 2019 Reduction of Reserve Grade After Application of MCF

Portion of Reserves	Tonnes (000's)	Au Grade After MCF Applied	Change in Reserve Au Grade Due to MCF
Non Updated Area of Resource	6,906	8.8	-29%
Updated Area of Resource	5,872	8.6	0%
Total	**12,778**	**8.8**	**-18%**

The 2019 Reserve Reconciliation is showing a 28% reduction in grade, which is comparable to the Au reserve grade after the MCF is applied. This results in a 29% reduction in grade in the applied areas. As additional material is mined from the 2020 Reserves, the MCF will be adjusted to account for the new findings. Currently no MCF is applied within the update area, but as future reconciliations and mining data is compiled this may change.

15.10 2020 Mineral Reserves

Table 15-8 presents the Mineral Reserves tabulated by zone and by reserve category. All Mineral Reserves are scheduled in the LOM plan, which is presented in Section 16.0. The reserve values reported are inclusive of mining factors such as dilution and mining recovery. The reserve totals are indicative of material prior to milling; therefore, milling recovery has not been included. This recovery is accounted for in the LOM plan.

The mining blocks divide the Mineral Reserves into logical parcels consistent with the mining sequence and form the basis of the LOM development and production schedule, also discussed in Section 16.0. Table 15-9 details the Mineral Reserves by mining block, inclusive of the MCF. Figures 15-5 to 15-7 show the Reserves in the Valley of the Kings and West Zone.

Table 15-8: Brucejack Gold Mine Mineral Reserves[1,2,3,4] by Mining Zone

Total Reserves	Brucejack 2020 Mineral Reserves				
	Tonnes (Mt)	Au Grade (g/t)	Ag Grade (g/t)	Au Ounces (Moz)	Ag Ounces (Moz)
Valley of Kings	**12.8**	**8.8**	**10.0**	**3.6**	**4.1**
Proven	1.4	8.9	11.1	0.4	0.5
Probable	11.3	8.7	9.8	3.2	3.6
West Zone	**2.9**	**6.8**	**278.5**	**0.6**	**26.0**
Proven	1.4	7.2	383	0.3	17.4
Probable	1.5	6.5	181	0.3	8.6
Combined	**15.7**	**8.4**	**59.6**	**4.2**	**30.1**
Proven	2.8	8.1	195.1	0.7	17.9
Probable	12.8	8.5	29.8	3.5	12.2

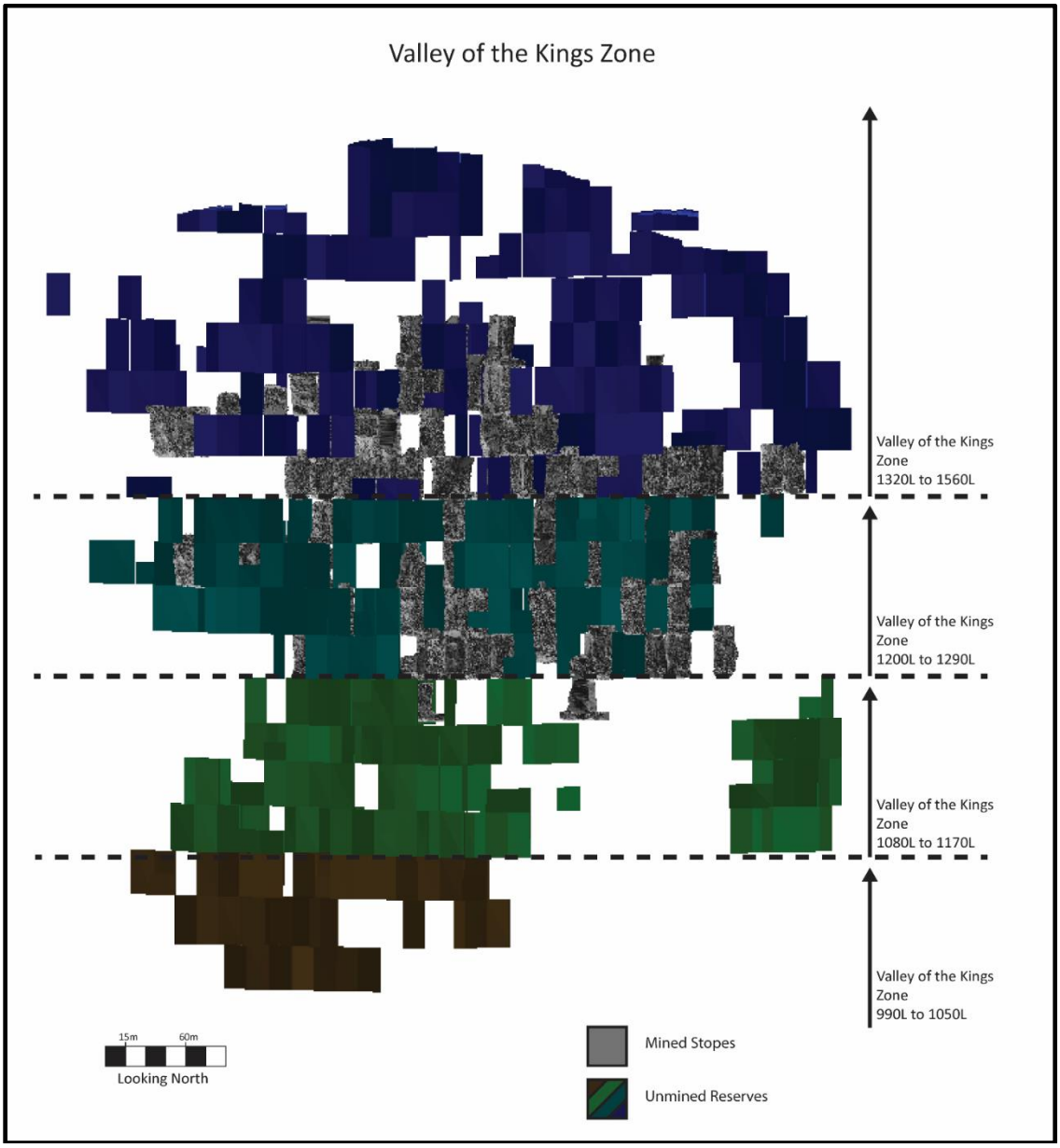
Notes: [1]Rounding of some figures may lead to minor discrepancies in totals.
[2]Based on US$180/t cut-off grade, US$1,250/oz Au price, US$15.6/oz Ag price, and a Cdn$1.00:US$0.78 foreign exchange rate.
[3]All reserve values are inclusive of mining dilution and mining recovery.
[4]Gold grades of Valley of the Kings Zone are inclusive of Mine Call Factor.

Table 15-9: Brucejack Gold Mine Mineral Reserves[1,2,3,4] by Mining Block

Zone		Ore Tonnes	Grade		Contained Metal	
		(Mt)	Au (g/t)	Ag (g/t)	Au (Moz)	Ag (Moz)
Valley of the Kings Zone	990-1050	1.3	8.8	5.4	0.4	0.2
	1080-1170	3.3	8.6	7.8	0.9	0.8
	1200-1290	3.1	8.4	9.2	0.8	0.9
	1320-1560	5.1	9.1	12.9	1.5	2.1
	Total	12.8	8.8	10.0	3.6	4.1
West Zone	Upper West Zone	0.6	4.2	407.0	0.1	8.0
	Lower West Zone	2.3	7.6	245.0	0.6	18.1
	Total	2.9	6.9	278.5	0.6	26
Mine Total	All Mining Blocks	15.7	8.4	59.6	4.2	30.1

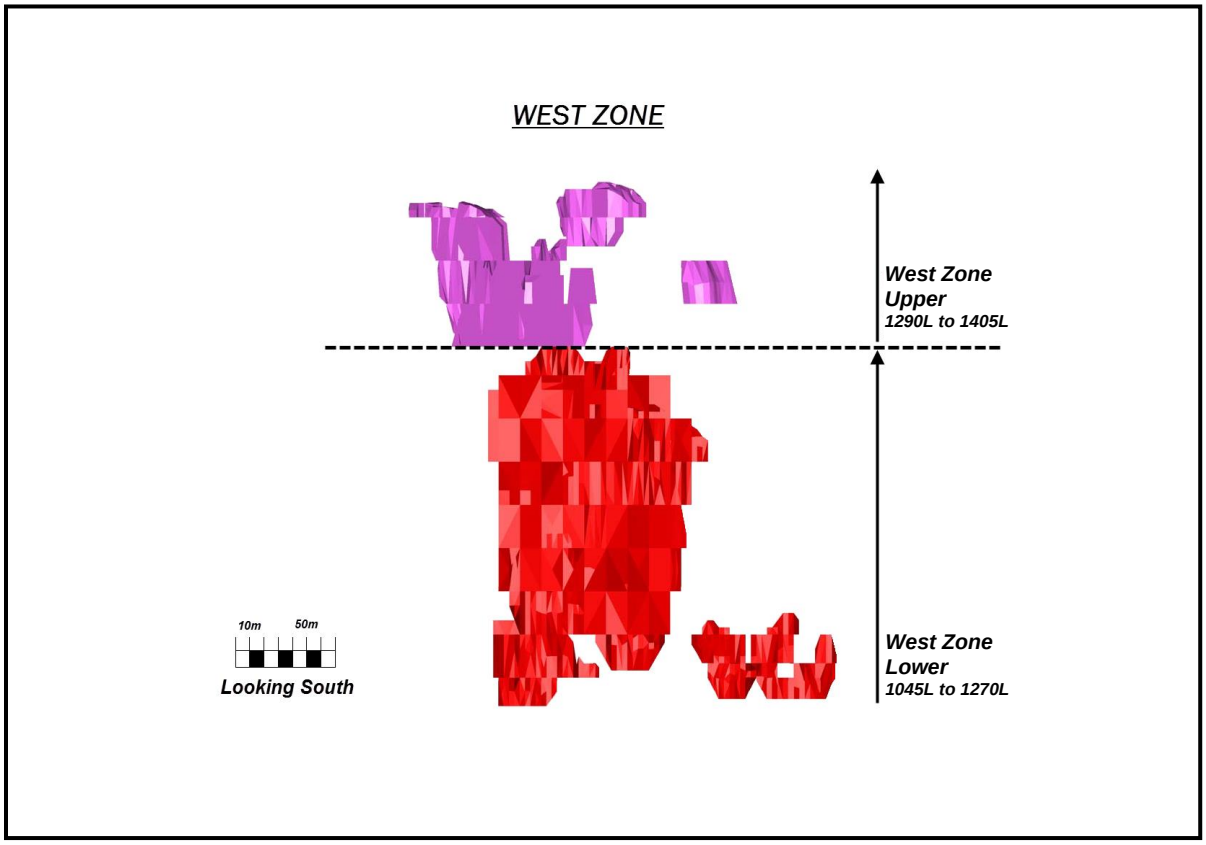
Notes: [1]Rounding of some figures may lead to minor discrepancies in totals.
[2]Based on US$180/t cut-off grade, US$1,250/oz Au price, US$15.6/oz Ag price, and a Cdn$1.00:US$0.78 foreign exchange rate.
[3]All reserve values are inclusive of mining dilution and mining recovery.
[4]Gold grades of Valley of the Kings Zone are inclusive of Mine Call Factor.

Figure 15-5: Reserve Shapes and Mining Blocks in the Main Valley of the Kings Zone



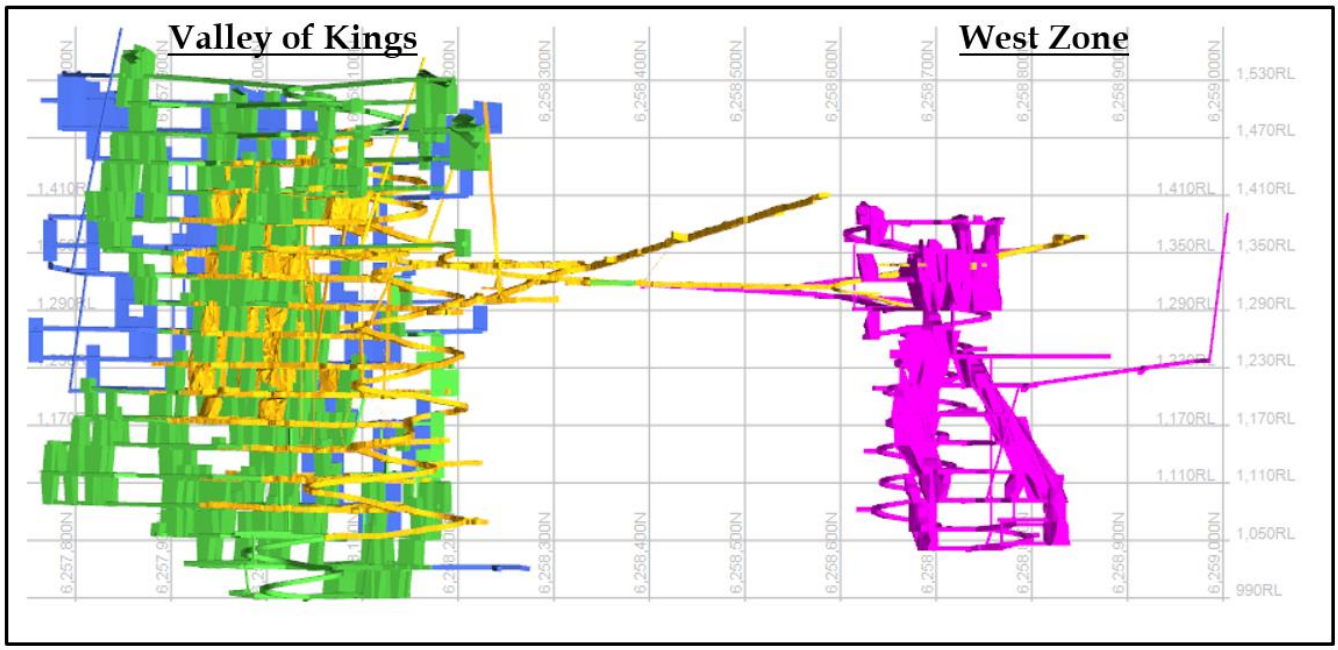
Source: Pretivm (2020)

Figure 15-6: Reserve Shapes and Mining Blocks in the West Zone



Source: AMC (2014)

Figure 15-7: Combined Reserves, Looking West



Source: Pretivm (2020)

15.11 Mineral Reserve Comparison

As significant material has been mined between the 2020 Mineral Reserves and the 2019 Mineral Reserve update, a direct comparison of reserves will not provide an accurate assessment of the changes made. To provide a valid comparison, the inclusion of the mined-out material between these two time periods needs to be added. As the 2020 Mineral Reserves are exclusive of all material mined prior to January 1, 2020 and the 2019 Mineral Reserves were exclusive of all material mined prior to January 1, 2019 the addition of the reconciled 2019 milled actuals should provide a valid comparison. Table 15-10 shows the comparison.

Table 15-10: Comparison of 2020 Mineral Reserves with Mined Actuals to Previous Reserve[1,2]

Reserves		Reserves		
		Ore Tonnes (Mt)	Grade Au (g/t)	Contained Metal Au (Moz)
2020 Mineral Reserves + Milled Actuals	Proven + Probable	15.7	8.4	4.2
	2019 Milled Actuals	1.3	8.7	0.4
	Total	17.0	8.4	4.6
2019 Mineral Reserves	Total	16.0	12.6	6.4
2020–2019	Difference	1.0	-4.1	-1.8

Notes: [1]Rounding of some figures may lead to minor discrepancies in totals.
[2]All milled actuals are based off of reconciled year end results. 2019 milled actuals include material from outside of the 2019 Reserves.

The combined 2020 Mineral Reserves and 2019 Milled Actuals total ore tonnes exceed the 2019 Mineral Reserves due to two main factors: the mining of out of reserve material that was identified as being economic by the grade control program, and the increase in profitability of the NSR model. With these additions, the combined 2020 Mineral Reserves with 2019 Milled Actuals contain more tonnes at a lower grade than the 2019 Mineral Reserves. This results in a decrease in overall ounces primarily due to a decrease in overall grade of the updated portion of the resource.

16.0 MINING METHODS

16.1 General

Brucejack Gold Mine development has been ongoing since the start of commercial production in 2017. The execution of the mine plan closely matches the mine plan as disclosed in the 2014 FS (Ireland et al. 2014). Locations for some infrastructure items have been adjusted to improve practicality as the mine has developed. These changes include the location and type of the main dewatering system and the utilization of settling sumps to pump the sediment and slimes directly to the mill clarifier. The explosives magazine was moved to isolate the location from the main works and to allow direct ventilation exhaust to surface in the event of combustion or explosion. The layout for the underground service facilities was also modified.

The updated underground mine design supports the extraction of 3,800 t/d of ore through a combination of transverse and longitudinal LHOS. Paste backfill is integral to the mine plan to maximize both orebody recovery and mining productivity. Modern trackless mobile equipment is employed in the majority of mining activities.

A main decline, designated as the Valley of the Kings access, extends from the surface portal near the concentrator and is used to access the mine and as a conveyor way. The conveyors installed have a combined length of 800 m. The existing West Zone portal will continue to provide access (and egress) to the mine and serve as the main access for large underground equipment and waste haulage.

A fleet of LHD and underground trucks are used for material loading and transport from the underground working areas and through an internal ramp system that connects all levels to the centrally located crusher.

Permanent fans provide ventilation by forcing air down the declines through the internal ramps and exhausting to surface via dedicated raises that connect the working levels to surface in each zone. The primary fans are located at each of the main surface portals. An electric mine air heating system is used to take advantage of low electricity prices, with a propane system available as a back-up.

Ongoing development to sustain 3,800 t/d of ore production will average approximately 900 m/mo during the first two years of production ramp-up and will decrease around 250 m/mo for the remainder of the LOM.

Major underground infrastructure includes crusher, conveyors, ventilation raises, fans, heating system, pumping stations, electrical substations, explosives magazines, paste fill booster pump station, refuges, mine communications, and other ancillary installations that include an underground maintenance service facility and a fuelling facility

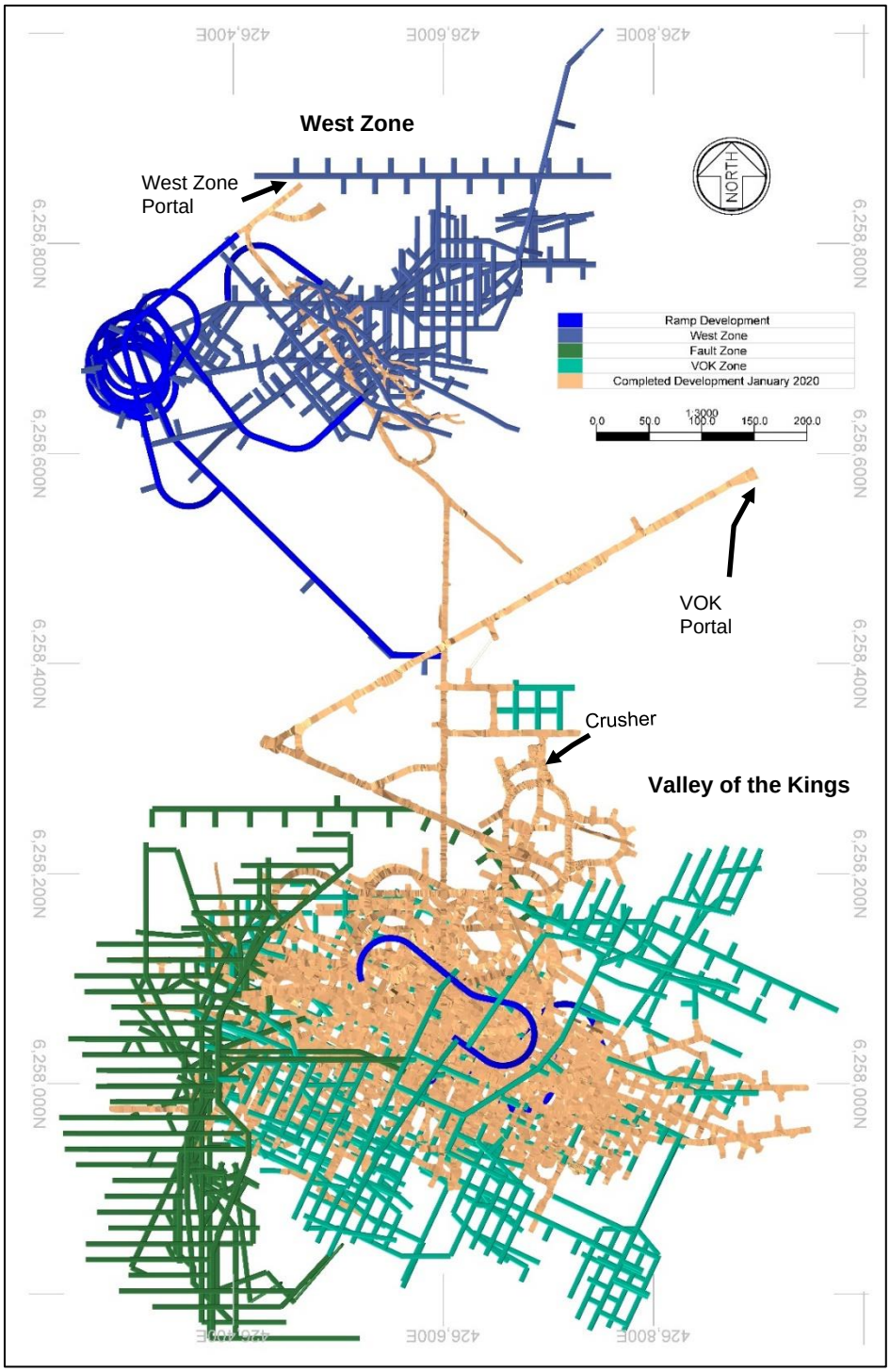
16.2 Mine Design

16.2.1 Access and Ramp Infrastructure

The Valley of the Kings Zone is currently accessible via internal ramps between the 1,050 m and 1,470 m elevation levels via both the Valley of the Kings ramp and the West Zone ramp from surface. The continued infrastructure development program will utilize this existing infrastructure.

The Valley of the Kings access decline joins the main surface portal to the Valley of the Kings ramp at the 1,290 m and at the 1,320 m elevation levels on the West Zone access ramp. The West Zone will likewise be accessed from the existing bulk sample access drive during the latter half of the LOM. Figure 16-1 illustrates the general development arrangement.

Figure 16-1: Mine Access and Development Infrastructure



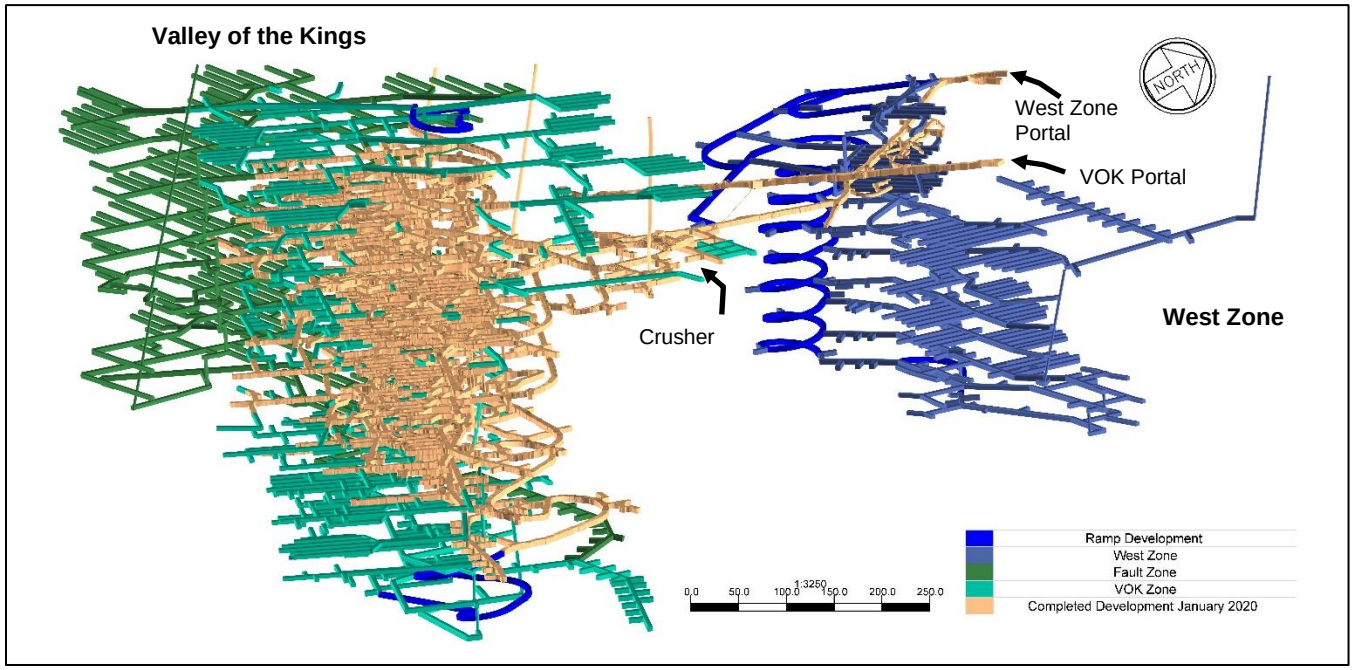
Source: Pretivm (2020)

The internal ramp starts at the 1,335 m elevation level and proceeds up and down the Valley of the Kings deposit at ±15% gradient. At the 1,290 m elevation level the internal ramp connects with the bottom of the Valley of the Kings access ramp. The decline and incline have been developed in a race-track configuration.

An independent ramp for each zone—as opposed to a single ramp servicing both the Valley of the Kings Zone and the West Zone—was selected and developed in the interest of access and capital efficiency, given that the West Zone is mined later during the LOM.

For ease of entry and exit, ramps have been developed with a 25 m turning radius and a 15% gradient, levelling out to a 0% gradient in proximity to a level access intersection. Passing bays are incorporated where required in the main Valley of the Kings Zone and West Zone access ramps. Figure 16-2 shows the ramp system for both zones in perspective view.

Figure 16-2: Brucejack Ramp System – Perspective View



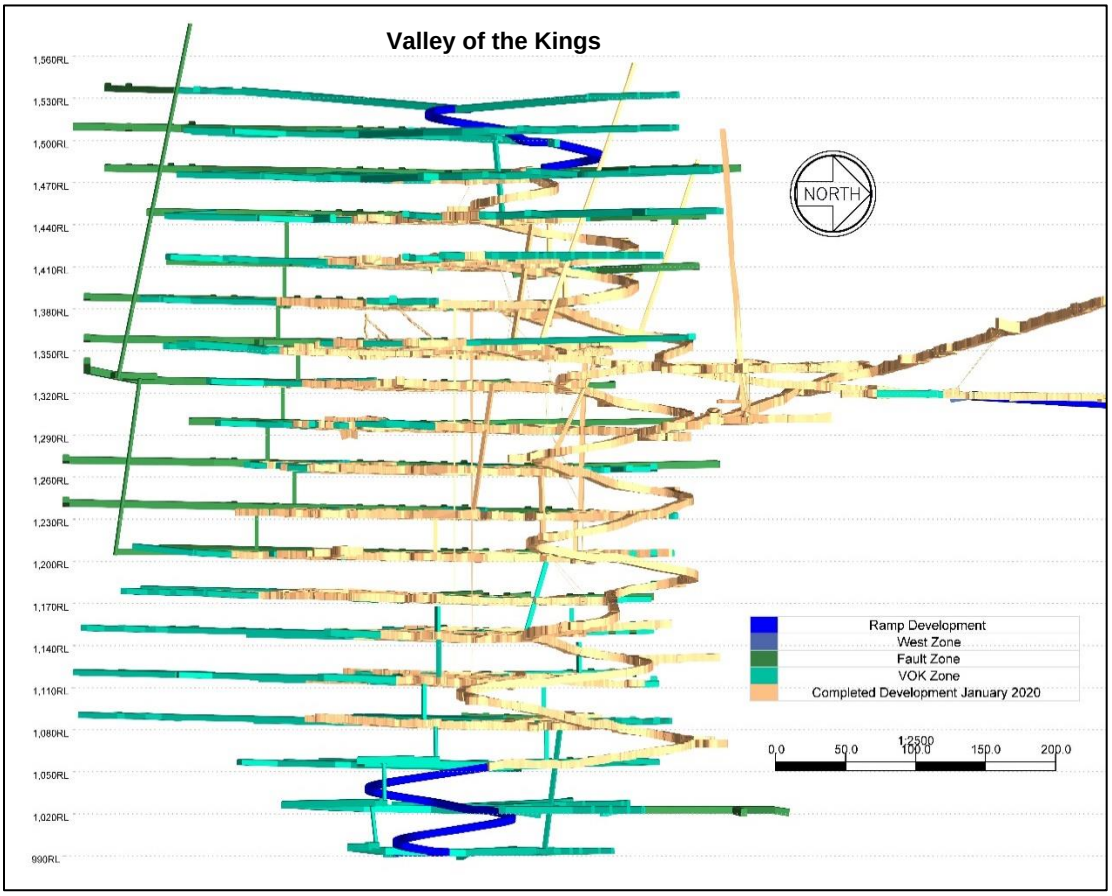
Source: Pretivm (2020)

16.2.2 Level Development

Sublevels are accessed from the ramps on 30 m vertical intervals that are defined by the planned stoping heights. Footwall and/or hanging wall drives are set back a minimum of 10 m from the ore contact, whereas ramp development is set back at a minimum of 50 m from the ore contact. This arrangement promotes long-term geotechnical stability and provides adequate space for the placement of a fresh air raise and other ancillary services between the ramp and level development.

Sublevels generally have a raise on one or both ends, permitting the exhaust of contaminated air from activity on the level. Figure 16-3 illustrates the Valley of the Kings Zone sublevel arrangement in long section.

Figure 16-3: Valley of the Kings Zone Sublevel Arrangement – Long Section



Source: Pretivm (2020)

Level development follows the general strike of the various lenses of the Brucejack Deposit, providing access to the mineralized zones in a manner that allows for either transverse or lateral mining; whichever is more suitable for that zone of the deposit. Level development is generally in the footwall and includes excavations for sumps, refuges, transformers, remucks, paste fill line, and raise accesses.

Stope-access cross-cuts located outside of the Brucejack Fault Zone are on 15 m spacings for transverse stope blocks, while the multiple access configuration of lateral mining stopes is determined based on efficiency and mining sequence. This excludes those levels where sill extraction or near-surface weathered ore is recovered in smaller stopes that are designed to geotechnical criteria. Likewise, all Brucejack Fault Zone ore is developed on 10 m spacings to accommodate poorer ground conditions. These spacings are modified as geotechnical experience is gained.

Figure 16-4 illustrates typical level development requirements from the LOM plan.

Figure 16-4: Typical Level Development – Valley of the Kings Zone

Source: Pretivm (2020)

Level development design considers equipment size, services, and required activity. Table 16-1 summarizes the design parameters and Figure 16-5 illustrates standard designs for development drives.

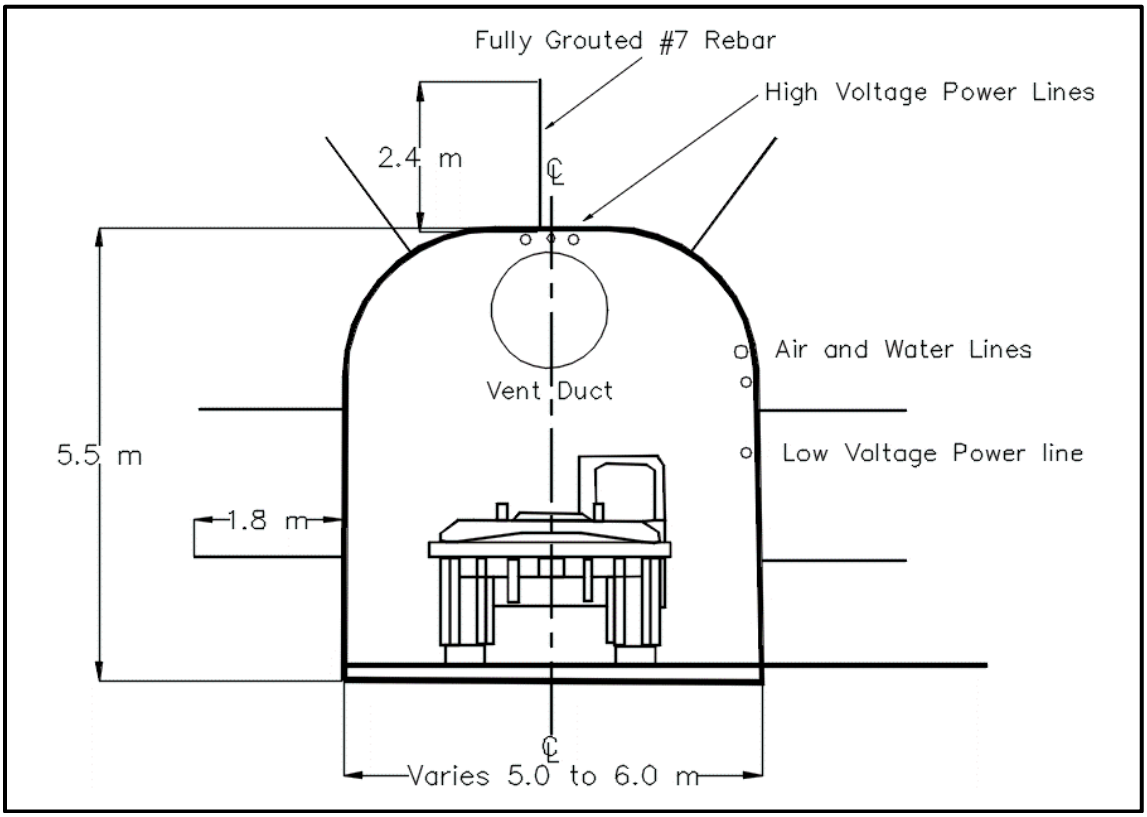
Table 16-1: Development Design Parameters

Development Type	Parameter		
	Width (m)	Height/Length (m)	Maximum Gradient (%)
Remuck	5.5	5.5	2
Footwall Drives	5.5	5.5	15
Access Drive	5.5	5.5	2
Electric LHD Cut-out	5.5	5.5	2
Conveyor Decline	6.0	6.5	15
Main Access Decline	6.0	5.5	15
Infrastructure Drive	5.5	5.5	2

table continues…

Development Type	Parameter		
	Width (m)	Height/Length (m)	Maximum Gradient (%)
Drainage Cut-out	5.5	5.5	2
Waste Cross-cut	5.0	4.5	2
Refuge Bay Cut-out	5.5	5.5	2
Ore Cross-cut	5.0	4.5	2
Fresh Air Drive	5.5	5.0	2
Return Air Drive	5.5	5.0	2
Paste Fill Line Drive	5.5	5.0	2
Vertical			
Alimak Raise	3.0	3.0	-
Return Air Drive	3.0	3.0	-
Fresh Air Raise	3.0	3.0	-

Figure 16-5: Standard Designs – General Layout for All



16.2.3 Stope Design

The Brucejack Gold Mine uses the MSO module from the Vulcan mine planning software package to produce conceptual stope shapes. Table 16-2 summarizes the key design parameters used in the MSO. The conceptual stope shapes are refined as necessary to minimize planned dilution and to meet practical mining constraints.

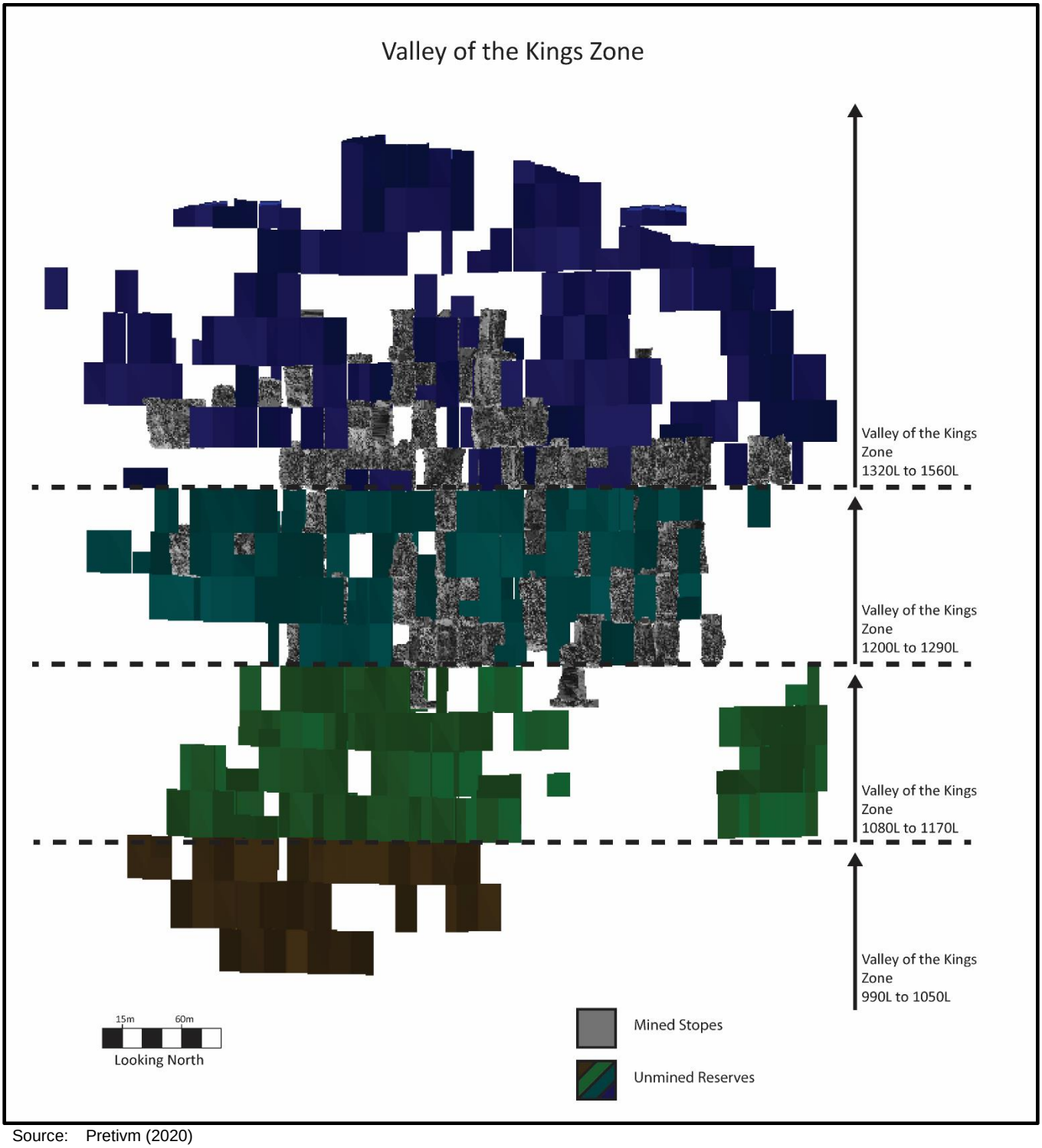
Table 16-2: Stope Design Parameters

Parameter	Units	Valley of the Kings Zone			West Zone		
		Standard	Weathered[(1)]	Sill Pillar	Standard	Weathered[(1)]	Sill Pillar
NSR Cut-off	US$/t	185	185	185	180	180	180
Level Spacing	m	30	30	30	30	30	30
Stope Span	m	15	15	15	15	10	10
Minimum Mining Width	m	10	10	10	3	3	3
Minimum Waste Pillar Width	m	5	5	5	5	5	5
Minimum Footwall Dip	degrees	85	85	85	60	60	60
Minimum Hanging Wall Dip	degrees	85	85	85	60	60	60

Note: [(1)]Refers to stoping in weathered material immediately below the surface crown pillar. Weathered material extends 10 to 50 m below surface.

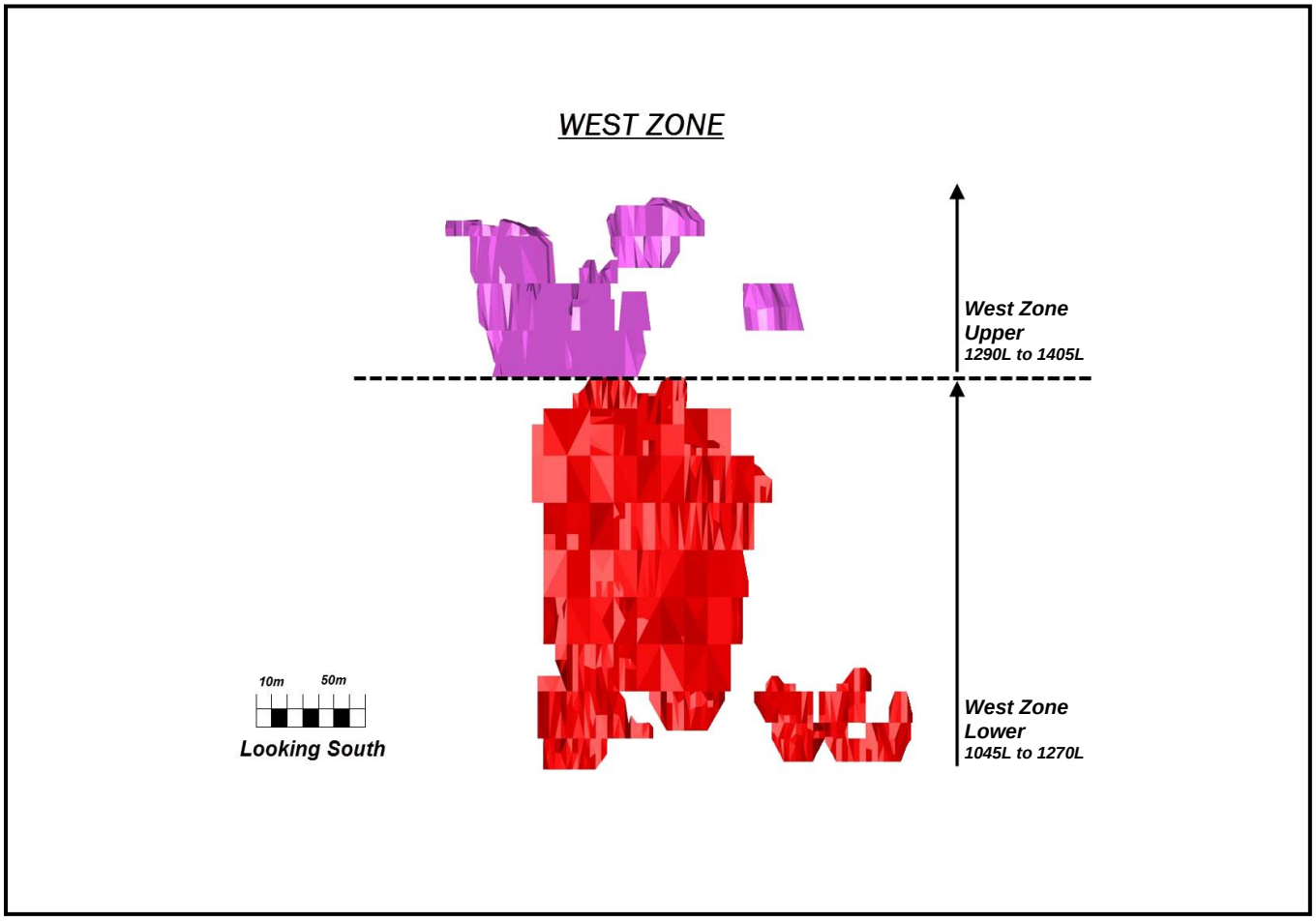
Individual areas meeting the cut-off grade are evaluated against access development costs to determine economic viability before including them in the mining plan. The LOM plan includes 671 stopes in the Valley of the Kings Zone and 135 stopes in the West Zone. The number of stopes may vary if stopes are combined or split for optimization during operations. Figure 16-6 and Figure 16-7 are long-section views showing stope shapes generated by the MSO process.

Figure 16-6: MSO Stope Shapes – VOK Zone



Source: Pretivm (2020)

Figure 16-7: MSO Stope Shapes – West Zone



Source: Pretivm (2019)

16.3 Mining Method and Sequence

16.3.1 Block Definition

The orebody is divided into six blocks, defined by elevation and zone, that facilitate a total of 3,800 t/d of production from multiple working areas. Mining progresses upward from the lowest elevation in each block.

The general levels are defined in the long-term mine plan, but the selection has been redefined for operational considerations. The current block sill levels are located at the 990 m, 1,080 m, 1,200 m, and 1,320 m elevation levels for the Valley of the Kings Zone.

16.3.2 Stope Cycle

The predominant mining method is transverse LHOS and is based on a standard primary/secondary sequence. No permanent pillars are required, and maximum ore extraction is targeted.

The footwall drives are completed, and a through ventilation circuit is established before mining begins between any two levels.

Cross-cuts are driven from the footwall drive, through the centre of the stope, to the far ore contact on the undercut and overcut levels.

Cross-cuts on both levels are supported by long support-system cables and Swellex from the central access to pre-support the roof prior to full-width slashing of the entire stope footprint. The secondary stopes are not slashed to full width for ground control considerations.

Long holes are drilled with parallel holes, or in fan configurations, depending on whether the stope can be safely slashed across the entire mineralized width.

Where ground conditions permit, full-width slashing allows parallel production hole drilling across the entire width of the stope. This in turn reduces the potential for ore in stope corners to fail due to inadequate free face or poor explosives distribution. Ore recovery with parallel hole drilling is typically higher than with fan drilling (in the absence of full-width slashing). In poor or difficult grounds and in secondary stopes, fan drilling is used due to geotechnical constraints, utilizing only the initial cross cut and a hammerhead as the drilling platform.

Once the stope footprint is slashed out, a 762 mm pilot hole is drilled in the slot raise location. Production drilling follows in the raise and slot area, followed by the production rings, as drilling progresses towards the end of the stope.

The raise and slot are generally opened in five shots or less. Production blasting and mucking proceed cyclically until the stope is depleted and all ore has been mucked out. LHOS is a non-entry method, with remote mucking of blasted ore required once the draw point brow is open to the extent where the operator may be exposed to uncontrolled sloughing from the stope cavity.

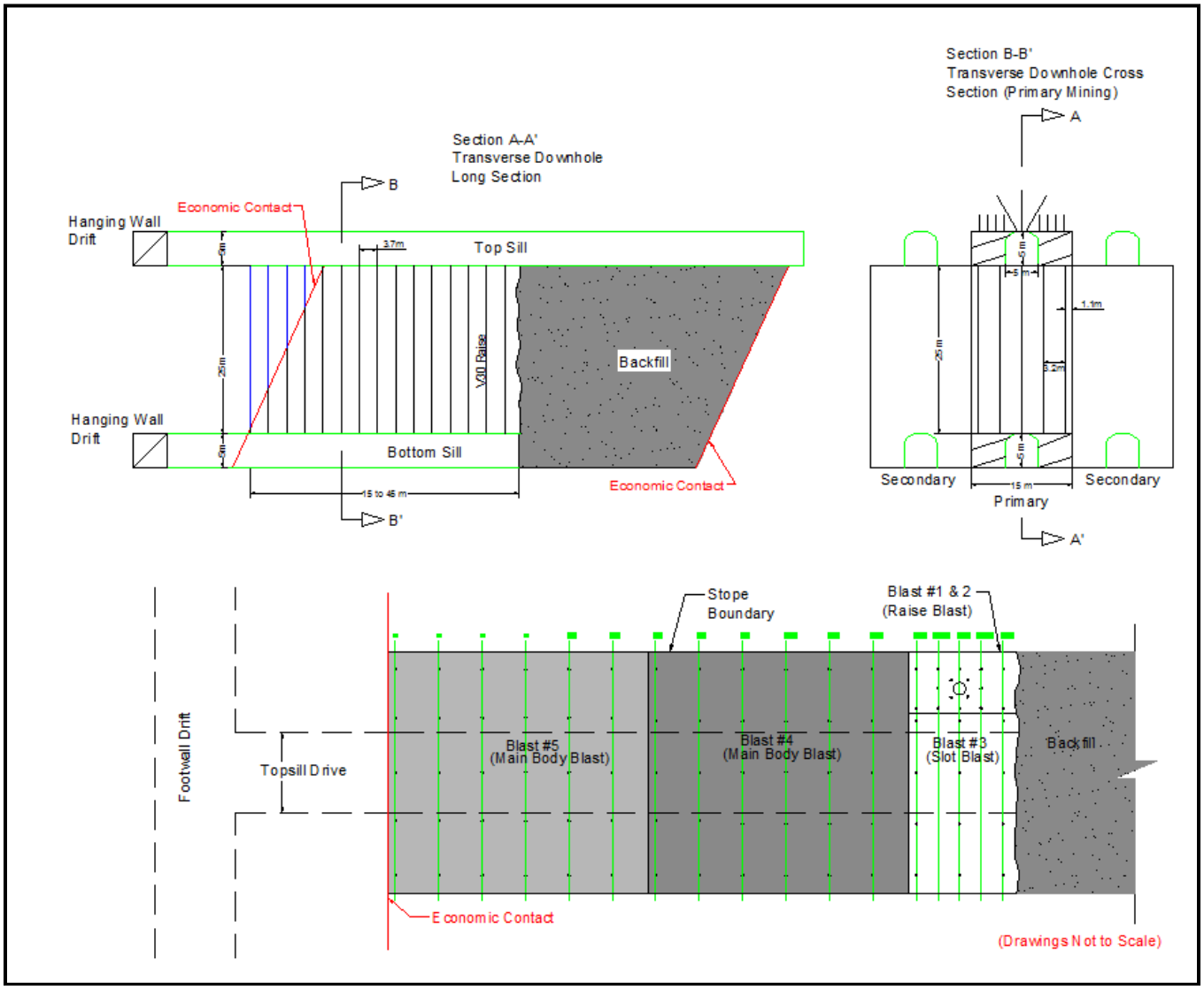
The empty stope is remotely surveyed with cavity monitoring equipment. A barricade is constructed in the draw point and the stope backfilled to just below the floor elevation of the top level. Crushed aggregate or run-of-mine (ROM) waste is spread over the fill surface to reduce backfill dilution and increase trafficability of mucking equipment for the next lift of the stope.

In sills and other areas where top access is not available, mining proceeds in a similar manner; however, raise development and production drilling is performed via drilling up holes from the bottom level. Figure 16-8 illustrates the typical LHOS design for these areas.

Longitudinal LHOS is also employed at the mine, where, in contrast to transverse LHOS, mining progresses along the strike of the orebody to a common access point.

Where applicable, the overcut and undercut are slashed to the footwall and hanging wall contacts, although in numerous longitudinal stopes no overcut is required, and ore is extracted via upwards drilling. In all other respects, the stope cycle is similar to transverse LHOS.

Figure 16-8: Typical LHOS Design



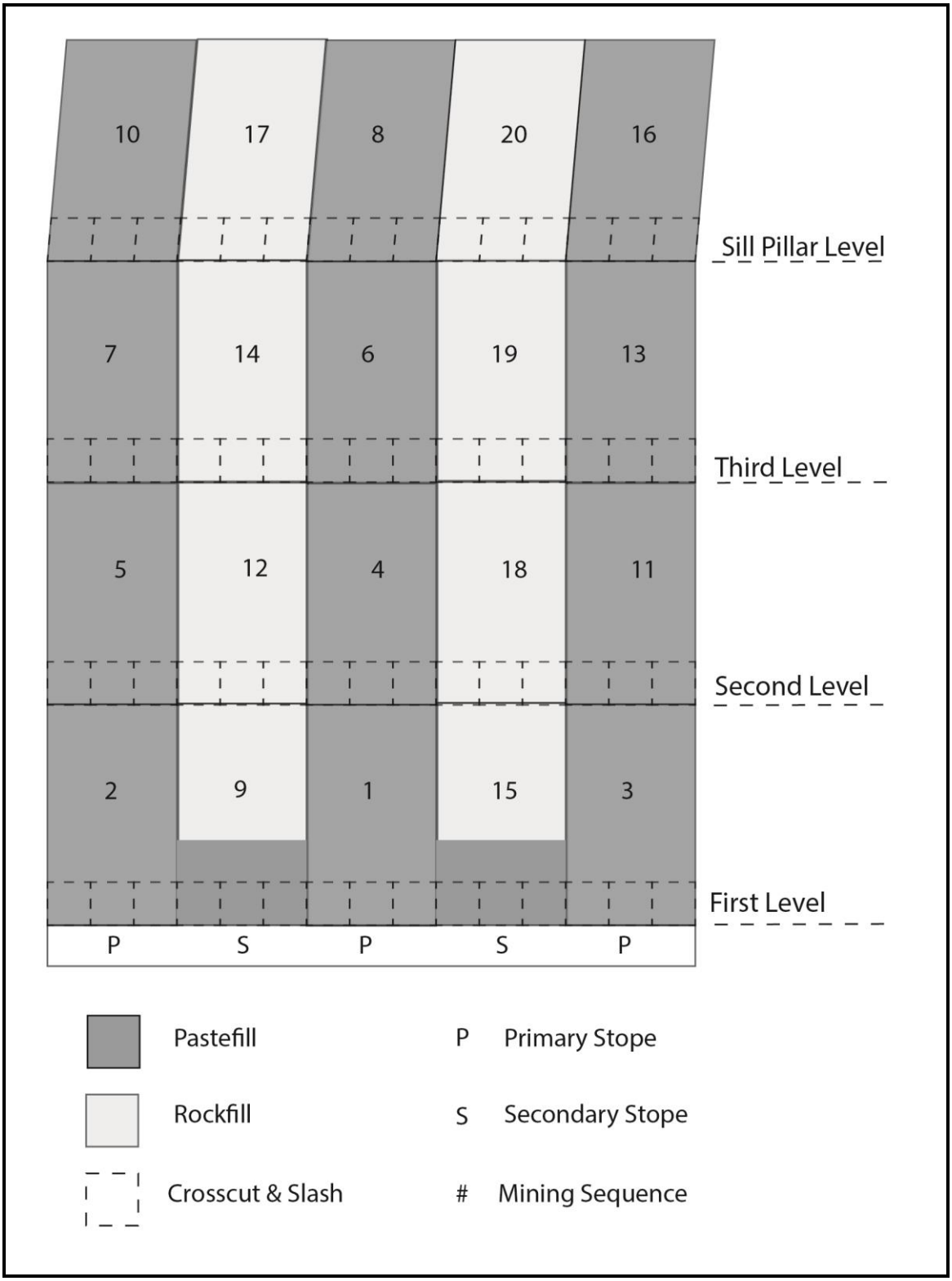
Source: AMC (2014)

16.3.3 Stope Sequence

The mining sequence in any area of a given block begins with the extraction of the primary stopes on the first (lowest) level. Wherever possible, the first primary stope is located near the middle of the lens to develop a pattern of stope extraction that moves outwards to the extremities of the lens while progressing upwards towards the top. This generally promotes a favourable redistribution of ground stress, although many smaller lenses in the Brucejack orebody are either irregular in shape or of insufficient dimensions to properly develop this sequence.

When the adjacent primary stopes from the level above have been filled and cured, secondary stoping commences. Figure 16-9 illustrates typical sequencing for the more massive lenses at the mine.

Figure 16-9: Example of Primary/Secondary LHOS at Brucejack Gold Mine



Source: Pretivm (2019)

16.3.4 Backfilling

The primary means of backfilling is paste fill, generated from unclassified mill tailings mixed with adequate cementitious binder to meet the strength requirements of re-exposure. Regular strength paste fill is commonly required where there will be re-exposure of vertical stope walls.

Stopes that are planned to not be re-exposed by adjacent mining and are below the 1,350 m elevation level may be backfilled with unconsolidated waste and/or by paste fill with sufficient binder to remove any risk of future liquefaction (low-strength paste fill). High-strength paste fill will be required in the lower portion of all primary and secondary stopes that will be undercut by sill extraction from below. Table 16-3 tabulates the total projected paste fill volumes over the LOM by strength requirement and by binder dosage.

Table 16-3: LOM Paste Fill Requirements

Paste Fill Type	LOM Quantity ('000 m^3)	28-day Strength (kPa)	Binder Dosage (%)	Density Dry Paste (t/m^3)	Mass Dry Paste (t)	Binder Required (t)
High-strength Paste Fill	393	800	11.80%	1.11	436	46
Regular Paste Fill	2,630	300	6.80%	1.11	2,920	144
Low-strength Paste Fill	1,742	100	4.60%	1.11	1,933	95
Total	**4,765**	**-**	**-**	**-**	**5,289**	**285**

16.3.5 Paste Backfill Test Work

Pretivm engaged AMC Mining Consultants (Canada) Ltd. (AMC) to undertake the first stage of a high-level study on the suitability of using mill flotation tailings for paste fill at the Brucejack Gold Mine (AMC 2015). The results showed a higher-then-expected cement requirement for the range of determined paste fill strengths. The density of the paste fill was low and resulting strengths required higher-than-expected cement content to achieve the target strengths.

Pretivm also engaged AMC to undertake second-stage laboratory testing. Stage 2 test work aimed to identify other classes of binders that would achieve target strengths at lower dosing rates (AMC 2018). In particular, the Stage 2 test work investigated the use of blended blast furnace slag and fly-ash with cement as possibly better paste mix recipes.

The Stage 2 test work program included:

- Material characterization tests in areas such as specific gravity and particle size distribution
- Determination of paste fill density at a yield stress of 250 Pa as the benchmark for the paste fill mix
- UCS tests of mixes using General Purpose (GP) cement, slag, and fly-ash blend cements to look at the effect of adding fine-ground iron blast furnace slag and fly-ash to the GP cement binder; two slag blends were tested: MineCem (MC) containing 55% slag and Sunstate Slag Blend (SS) containing 35% slag; medium-size fly-ash (FA) was also used.

As shown in Table 16-4, the Brucejack Gold Mine tailings paste fill mixes responded very favourably to the slag-based and fly-ash binders. The test program demonstrated a significant difference in the strength values for the paste fill mix with GP cement compared to the slag-based (MC and SS) and FA mixes. The following differences were noted:

- At 6% and 10% addition, consistently using MC binder (slag content 55%) produced a paste fill strength of more than double that of the GP mix.
- At 6% and 10% addition, the SS binder (slag content 35%) consistently increased paste fill strengths by over 50% compared to the GP mix.
- Using FA in the paste fill mixes reflected the expected lower strength gain in the early curing time (14 days) typical of FA mixes. However, the 28-day and final 56-day strengths steadily gained higher strength levels, showing the benefit of the FA in partly replacing the GP cement.

Table 16-4: Summary of Stage 2 UCS Results

Batch	Tailings (%)	Cement/Binder	14 days	28 days	56 days
1	94	6% GP	405	448	565
2	90	10% GP	875	1,038	1,204
3	94	6% MC	909	1,145	1,428
4	90	10% MC	2,008	2,507	2,783
5	94	6% SS	577	738	903
6	90	10% SS	1,525	1,831	1,920
7	94	3% GP + 3% FA	340	537	681
8	90	5% GP + 5% FA	1,050	1,824	2,415

Stage 3 strength and rheology test work on bulk sample material is currently being completed to update paste recipes and binder dosages for the key strength targets. For this study, AMC is adopting industry standard dosages to achieve the required 28-day strengths, as outlined in Table 16-4.

Pasting operations at the Brucejack Gold Mine commenced in August 2017. AMC developed paste fill recipes for various scenarios to be encountered during stoping, like a requirement for a sill beam or backfilling of a secondary stope. AMC recommended that Pretivm begin pasting operations with increased binder addition (20% higher than recommended recipes) as a contingency while the paste plant and pasting operations overall were being commissioned. During this time, as site-specific, consistent paste quality control data was acquired and analyzed by AMC, the recommended recipes would then be the default recipes moving forward.

16.3.5.1 Waste Management and Stope Filling

Waste rock from mine development is generated on an ongoing basis throughout the LOM.

Stopes are filled with development waste wherever possible, with waste additionally hauled to surface for disposal in Brucejack Lake. The waste-backfilled stopes are mainly secondary stopes below the 1,350 m elevation level in the mine. Waste generated before the start of secondary mining is hauled to surface since it is unsuitable for backfilling primary voids without a cementitious binder.

In addition, disused headings in mined-out areas are used for development waste disposal, and an allowance has been made in the waste disposal profile in this respect.

The disposal of waste rock in underground stopes has the effect of reducing the total void volume requiring paste backfill, and hence reduces the percentage of mill tailings that can be returned to underground. Table 16-5 tabulates the projected volumes of waste to be generated from milled ore and development headings and the destination of these volumes over time. Over the LOM, 62% of development waste and 33% of tailings generated from milled ore will be placed back underground; the balance will be disposed of in Brucejack Lake.

Table 16-5: LOM Backfilling – Waste Rock and Mill Tailings

Year	Ore Tonnes ('000 t)	Total Tailings ('000 t)	Waste Tonnes ('000 t)	Waste Fill Tonnes ('000 t)	Waste Fill Volume ('000 m^3)	Paste Fill Volume ('000 m^3)	Tailings Underground ('000 t)	Waste to Surface ('000 t)
2020	1,387	1,301	676	175	70	349	388	501
2021	1,387	1,305	702	240	96	331	367	462
2022	1,387	1,306	650	316	126	347	386	334
2023	1,387	1,307	654	164	66	399	443	490
2024	1,387	1,306	216	192	77	432	480	24
2025	1,387	1,305	245	176	71	389	432	69
2026	1,387	1,313	177	176	70	415	461	2
2027	1,387	1,316	51	48	19	474	526	3
2028	1,387	1,318	41	35	14	453	503	6
2029	1,040	987	32	30	12	403	447	2
2030	1,040	981	20	19	8	353	392	1
2031	693	653	13	11	4	253	281	2
2032	380	357	6	5	2	166	184	1
Total	**15,637**	**14,754**	**3,483**	**1,587**	**635**	**4,765**	**5,289**	**1,896**

16.4 Development and Production Schedule

16.4.1 Production Rate

From the start of commercial production in July 2017, the mine had been operating at a rate of 2,700 t/d. In December 2018, Pretivm received a permit to allow a mining rate increase to 3800 t/d. The updated Measured and Indicated Mineral Reserves supports this increase.

A detailed mine design was subsequently completed for the new Mineral Resource model and scheduled to 3,800 t/d steady state ore production. There is a ramp-up period of identified in the production schedule, which is considered reasonable and achievable with respect to current development plans.

The final production schedule was constrained to reflect realistic mining practices and availability of equipment. The model limits the number of active stopes at any one time to four blasting and mucking, one backfilling, four drilling, and up to seven curing. The average number of active stopes at any one time is 12, with variations from 10 to 16.

16.4.2 Sustaining Development

Development of the Valley of the Kings Zone Upper and Middle blocks alone is insufficient to sustain 3,800 t/d of ore production. The Lower blocks must also be developed as a critical path activity. The following development activities will run in parallel with the Upper block development and mining and will continue until the Lower block begins producing critical stope ore in the fourth year of activity:

- Advancement of the Valley of the Kings ramp downward to the 990 m elevation level
- Development of the 1,080 m, 1,140 m, and 1,170 m elevation levels
- Continuation of VR1 from the 1,140 m elevation level to the 1,050 m elevation level
- Excavation of the fresh air raise system from the 1,020 m elevation level to the 1,080 m elevation level
- Excavation of the fourth exhaust raise in two stages from 1,200 m elevation to surface.

The Valley of the Kings ramp development will advance to the bottom of the mine (990 m elevation level). Levels will continue to be developed and stoping will continue in all four blocks. Development to the West Zone will begin later in the LOM to allow production from the Lower and Upper West Zone blocks. This development will be timed such that the 3,800 t/d mining rate can continue for as long as possible without interruption. Table 16-6 shows the LOM development rates.

Table 16-6: LOM Development Requirements

	Capital		Operational		Total	
Year	Lateral (m)	Vertical (m)	Ore (m)	Waste (m)	Lateral (m)	Vertical (m)
2020	730	447	2,749	8,520	12,000	447
2021	916	186	2,050	9,033	12,000	186
2022	1,006	234	1,902	7,892	10,800	234
2023	1,131	325	1,626	8,043	10,800	325
2024	0	237	1,240	3,083	4,324	237
2025	0	105	1,186	3,462	4,648	105
2026	0	65	1,222	2,665	3,887	65
2027	0	25	284	736	1,020	25
2028	0	18	325	636	961	18
2029	0	16	291	475	766	16
2030	0	0	227	334	561	0
2031	0	0	172	223	396	0
2032	0	0	51	99	150	0
Total	**3,783**	**1,658**	**13,327**	**45,202**	**62,312**	**1,658**

16.4.3 LOM Production Schedule

Full 2,700 t/d production was effectively achieved in Year 1 (2017). In Year 3 (2019), the mine completed ramp up to 3,800 t/d.

Figure 16-10 shows the LOM production schedule and the phasing of the various blocks.

Figure 16-11 shows the LOM split of production by development and stoping.

Figure 16-10: LOM Production Schedule by Mining Horizon

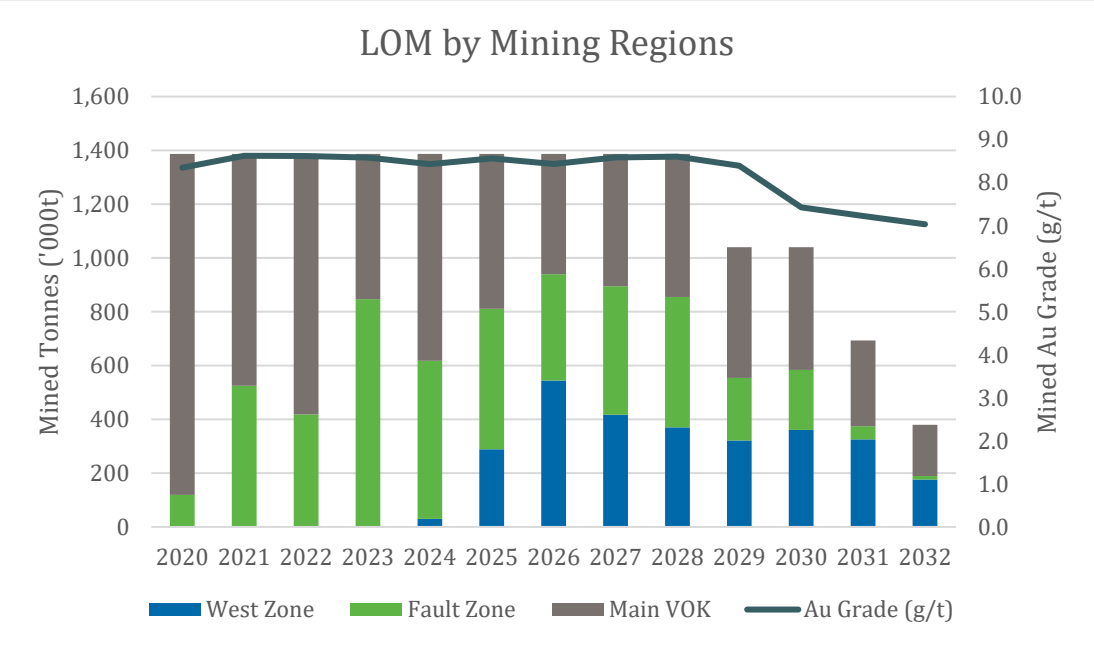


Figure 16-11: LOM Production Schedule by Activity

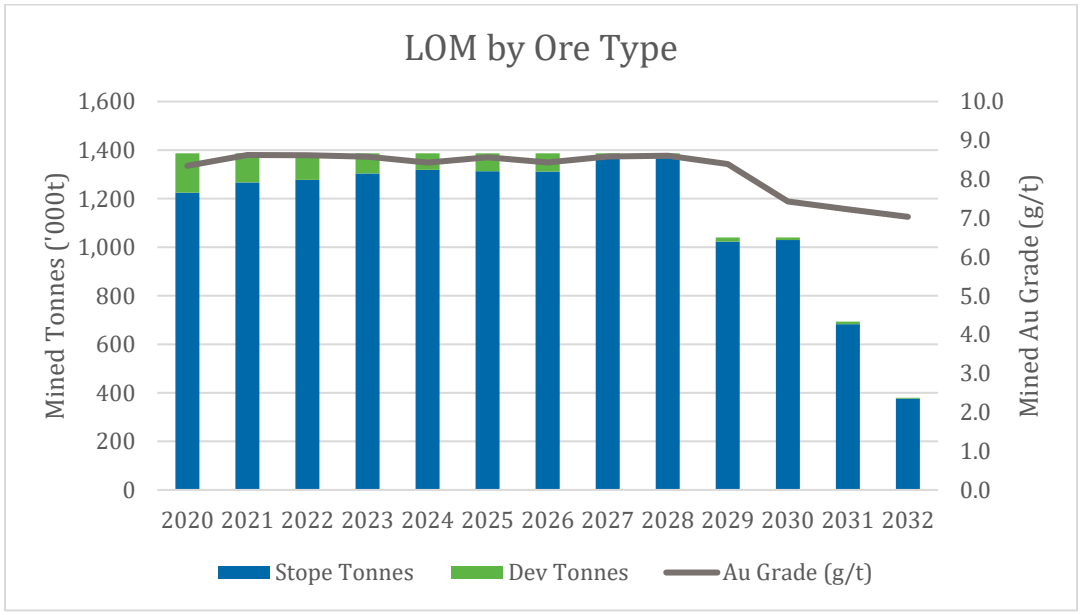


Table 16-7 is a summary of projected LOM production tonnes and grade.

Table 16-7: LOM Tonnes and Grades

Year	Ore (kt)	Au (g/t)	Ag (g/t)
2020	1,387	8.3	13.7
2021	1,387	8.6	9.3
2022	1,387	8.6	10.7
2023	1,387	8.6	11.4
2024	1,387	8.4	14.0
2025	1,387	8.6	51.8
2026	1,387	8.4	98.1
2027	1,387	8.6	88.5
2028	1,387	8.6	57.4
2029	1,040	8.4	110.1
2030	1,040	7.4	122.1
2031	693	7.2	159.3
2032	380	7.0	231.0
Total	**15,637**	**8.4**	**59.6**

16.5 Geotechnical

SRK undertook a geotechnical review and evaluation of the Brucejack Gold Mine Project that included a review of historic geotechnical data, underground excavation conditions, stope performance, and structural geology to support the confirmation of underground mine design and geotechnical design guidelines. These guidelines included excavation design parameters, estimates of dilution, as well as ground support requirements. The various elements of the geotechnical evaluation program and their findings are discussed in more detail in the following sections.

The source data for the geotechnical review and design confirmation came from previous studies conducted by BGC supplemented with data provided by Pretivm's technical personnel and collected during site inspections and reviews by SRK in 2019 and early 2020. The geotechnical data, excavation designs, and recommendations contained in the 2013 FS (Ireland et al. 2013; 2014), combined with observed mining practices and ground condition, provided the basis for the geotechnical review and evaluation.

Geotechnical site investigations completed to support the 2013 FS assessments included geotechnical drilling and logging, oriented drill core measurements, borehole televiewer surveys, laboratory testing of rock core samples, and installation of borehole instrumentation to measure groundwater pressures. Geotechnical mapping of the dewatered historic underground workings was completed to provide structural geology information. The geotechnical performance of excavations in the existing mine were also reviewed. The FS site investigations were supplemented by a review of historical reports and inclusion of data collected during previous site investigation programs.

16.5.1 Rock Mass Properties

The rock mass of the Brucejack area was divided into eight main geotechnical domains in the 2013 FS based on the characteristics of the rock mass.

The geotechnical units in the Valley of the Kings Zone are as follows:

- The Valley of the Kings Fault Zone (VOK FZ) unit includes fault-disturbed rock. The Fault Zone unit includes Brucejack Fault Zone rock and rock from all geologic units. It is strong with good RQD (Bieniawski 1976) and close discontinuity spacing.
- The Valley of the Kings Weathered Rock Zone (VOK WRZ) unit comprises near-surface weathered rock. This unit is strong with good RQD and close discontinuity spacing.
- Rock mass Valley of the Kings Domain 1 (VOK D1) comprises the Argillite (ARG) geologic unit and is very strong with good RQD and moderate discontinuity spacing.
- Rock mass Valley of the Kings Domain 2 (VOK D2) comprises the Bridge Zone Porphyry (BZP1), Office Porphyry (OFP1) and Silcap geologic units, which are strong with excellent RQD and moderate discontinuity spacing.
- Rock mass Valley of the Kings Domain 3 (VOK D3) comprises the Volcaniclastics, VSF, S3-Trans, and ANDX geologic units, which are very strong with excellent RQD and wide discontinuity spacing.

The geotechnical units in the West Zone are as follows:

- The West Zone Fault Zone (WZ FZ) unit includes fault-disturbed rock. This unit is strong (according to the methods of ISRM (1978)) with fair rock RQD and close to moderate discontinuity spacing.
- The West Zone Weathered Rock Zone (WZ WRZ) unit includes weathered, near-surface rock. It is medium strong with good RQD and moderate discontinuity spacing.
- The West Zone Fresh Rock (WZ FR) unit comprises all remaining rock, which is very strong with excellent RQD and wide discontinuity spacing.

Table 16-8 summarizes the rock mass parameters used in the design.

Table 16-8: Rock Mass Parameters Summarized by Geotechnical Domain

Geotechnical Unit	UCS[3] (MPa)	Median GSI[1]	Average Unit Weight[2] (kN/m³)	m_i	m_b	S	E_{rm}[4] (GPa)
VOK FZ	89	60	26.3	12	1.110	0.0023	5.13
VOK WRZ	50	63	28.6	17	1.879	0.0037	0.77
VOK D1	116	72	27.2	17	3.211	0.0144	9.76
VOK D2	95	70	27.1	19	3.186	0.0106	9.02
VOK D3	73	85	27.3	26	10.647	0.1030	14.37

table continues…

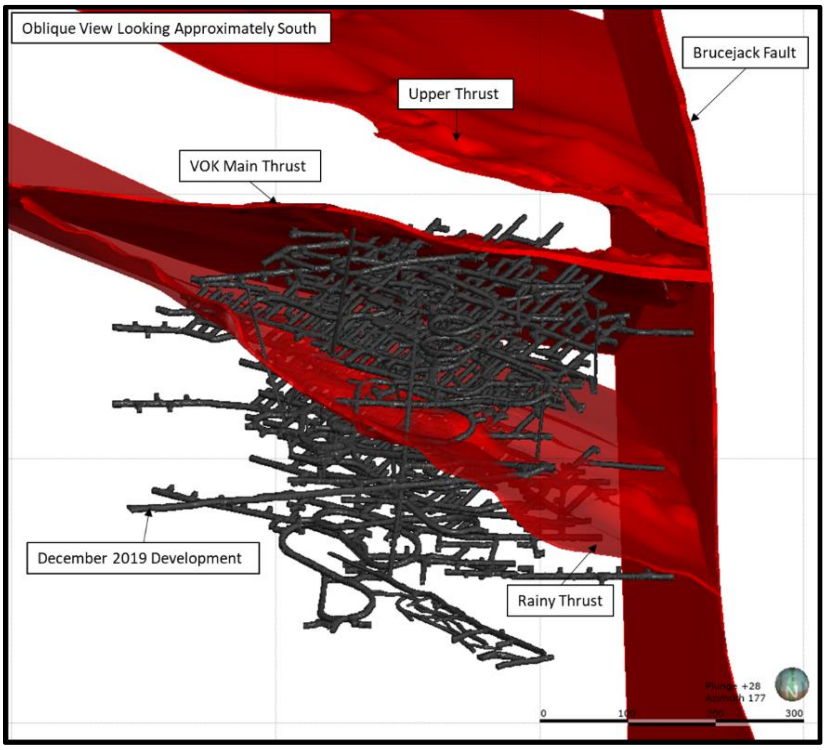
Geotechnical Unit	UCS[3] (MPa)	Median GSI[1]	Average Unit Weight[2] (kN/m³)	m_i	m_b	S	E_{rm}[4] (GPa)
WZ FZ	77	57	26.3	12	0.928	0.0015	4.27
WZ WRZ	37	62	28.6	17	1.771	0.0032	0.73
WZ FR	116	85	27.3	21	8.599	0.1030	16.77

Notes: [1] Geologic Strength Index (GSI) is calculated from median rock mass parameters for each unit, where GSI = RMR '76.
[2]Unit weights are based on average results of specific gravity testing when possible.
[3]UCS = Intact unconfined compressive strength.
[4]E_{rm} = Young's Modulus of the rock mass.
The Hoek-Brown failure criteria (mi, mb, s) were estimated assuming a disturbance factor ('D') of 0.8 for all units.
The Hoek-Brown curves were derived using a sigma3 maximum for a tunnel depth of 650 m.

16.5.2 Mine-scale Fault Zones

The three-dimensional major structures (fault) model developed by Pretivm shows that four large (i.e., mine-scale) fault zones are known to intersect the mining footprint: the Brucejack Fault Zone, the Rainy Fault, the Valley of the Kings Main Fault, and the Upper Thrust Fault, as seen in Figure 16-12.

Figure 16-12: Oblique View of the Interpreted Mine-scale Faults at the Brucejack Area Looking Approximately South



Source: Pretivm (2020)

The Brucejack Fault Zone is a northerly striking anastomosing fault zone located along the western margin of the study area and extends north to the Iskut River Fault. In places, the lineament appears to be several sub-vertical to moderately (greater than 60°) dipping fault strands braided together. The zone has normal faulting with variable displacement estimated at 500 to 800 m (ERSi 2010). It is comprised of a core of highly fractured rock with a zone of less fractured, fault-disturbed rock mass on either side. The width of the fault zone varies with depth and along strike from approximately 5 to 40 m. It is considered to be continuous along strike, dips slightly to the east above the 1,325 m elevation, and dips slightly west below the 1,325 m elevation. For design purposes, the median RQD, joint condition, and point load index derived UCS value (ISRM 1985) are 62%, 16, and 3.5 MPa, respectively, compared to the “excellent” median RQD value (91%) and median point load index derived UCS value of 6.5 MPa in the surrounding undisturbed VOK D2 rock mass.

The Rainy Fault is a gently dipping (10 to 30°) south-southwest striking (220 to 240°) fault. The fault has a thickness ranging between 0.5 and 15 m (average thickness is 2 m), with the thickness appearing to increase with depth. The rock mass within the Fault Zone is generally very blocky with very poor to poor RQD (less than 50%) and discontinuity spacing of less than 0.20 m but varies from relatively unbroken rock to compact silty/clayey gouge zones up to 1.5 m thick. Often, the fault zone is comprised of multiple gouge zones separated by more competent zones of very blocky rock mass. Seepage conditions within the zone vary significantly, from dry to dripping.

The Valley of the Kings Main Fault is gently-dipping and south-southwest striking, and was intercepted during the FS drilling program. The Fault Zone resulted in locally reduced RQD (between 40 to 80%) and fracture spacing (between 0.06 to 0.50 m) compared to the fresh (unfaulted) rock.

The Upper Thrust Fault is highest in the stratigraphic sequence of the three known faults in this package of gently-dipping, south-southwest striking structures. This structure does not appear to intersect any of the current or planned mine workings, and as such, has not been considered in the geotechnical assessment.

16.5.3 Underground Rock Mechanics

16.5.3.1 Geotechnical Design Approach

Excavation stability assessments have been completed using well-established empirical and semi-empirical relationships and engineering experience. These relationships enable estimates to be made of the expected mining conditions and support requirements based on a detailed description of the rock mass, excavation geometry, and prevailing stress conditions. The design procedure involves two steps: the quality of the rock mass is rated using a pre-defined classification system, and then the expected performance of the underground openings is predicted using an empirically derived stability correlation with the rock mass quality.

Two distinct rock mass classes were used in the geotechnical review and evaluation. A Fair to Good rock mass class with RMR_{76} values greater than 40 and a Poor to Very Poor rock mass class with RMR_{76} values less than 40.

16.5.3.2 Geotechnical Design Criteria (Man-entry Excavations)

The required man-entry design spans (3 to 5 m) have been reviewed based on the critical span design curve presented by Ouchi et al. (2004). In the static stress condition, the excavations in the fair to good domains are expected to remain stable with standard ground support (i.e., rock bolt and mesh). Additional ground support (i.e., rock bolt, mesh, and shotcrete) and modifications to standard excavations are required in the poor to very poor domains to maintain stable excavations.

Full width (15 m) undercuts for primary stopes in the fair to good rock mass class are considered acceptable utilizing the ground support described in Table 16-9. Full width undercuts are not recommended in the poor to very poor rock mass class or in secondary stopes in either rock mass class.

The structural stability of the excavations was analyzed using an empirical design chart after Grimstad and Barton (1993) and Unwedge© (Rocscience 2003) to develop minimum ground support recommendations. Ground support analyses for primary (permanent “man-entry”) and secondary (temporary “development”) headings were conducted in each structural domain. Recommendations for minimum ground support for lateral development are provided in Table 16-9 with in-ore stope development supplemental support recommendations in Table 16-10.

Table 16-9: Lateral Development Minimum Ground Support Recommendations

Rock Mass Condition	Dimension (m x m)	Ground Support Type	Length (m)	Spacing (m x m)	Additional Comment
Level Development (Access Drift, Level Drift, Remuck And Refuge Station)					
Fair to Good (RMR_{76} > 40)	5.5w x 5.5h	**#7 fully grouted rebar** plus #8 welded wire screen to cover the back and walls to maximum 2.5 m from sill.	2.4	1.8 x 1.8	
Poor to Very Poor (RMR_{76} < 40)			2.4	1.2 x 1.2	Special instruction might be required from geotechnical engineer. 2.4 m long Swellex may be required in very poor ground conditions. Screen is to be installed down to 1.5 m from sill.
Main Ramp (Decline, Incline and Other Hauling Routs)					
Fair to Good (RMR_{76} > 40)	6.0w x 5.5h	**#7 fully grouted rebar** plus #8 welded wire screen to cover the back and walls to maximum 1.5 m from sill.	2.4	1.8 x 1.8	
Poor to Very Poor (RMR_{76} < 40)			2.4	1.2 x 1.2	Special instructions might be required from geotechnical engineer.
Cross Cut (Waste Cross Cut)					
Fair to Good (RMR_{76} > 40)	5.0w x 5.0h	**#7 fully grouted rebar** plus #8 welded wire screen to cover the back and walls to maximum 3.0 m from sill.	2.4	1.8 x 1.8	
Poor to Very Poor (RMR_{76} < 40)			2.4	1.2 x 1.2	Special instruction might be required from geotechnical engineer. 2.4 m long Swellex may be required in very poor ground conditions. Screen is to be installed down to 1.5m from sill.
Cross Cut (Ore Cross Cut)					
Fair to Good (RMR_{76} > 40)	5.0w x 5.0h	**2.1m Splitset** plus #8 welded wire screen to cover the back and walls to maximum 3.0 m from sill.	2.1	1.2 x 1.2	
Poor to very poor (RMR_{76} < 40)			2.1	1.2 x 1.2	Special instruction might be required from geotechnical engineer. Screen is to be installed down to 1.5 m from sill.

Table 16-10: Minimum In Ore Supplemental Ground Support

Rock Mass Condition	Dimension (m x m)	Ground Support Type	Length (m)	Spacing (m x m)	Additional Comment
Top Cut of Ore Stope (Primary Stopes)					
Fair to Good (RMR_{76} > 40)	5 - 15 w x 5 h	Single strand cable bolts	6	2.5 x 2.5	
Poor to very poor (RMR_{76} < 40)	5 w x 5 h	Single strand cable bolts	6	2.0 x 2.0	Special instruction might be required from geotechnical engineer.
Top Cut of Ore Stope (Secondary Stope)					
Fair to Good (RMR_{76} > 40)	5 w x 5 h	Double strand cable bolts	12.5	2.5 x 2.5	
Poor to Very Poor (RMR_{76} < 40)		Double strand cable bolts	12.5	2.0 x 2.0	Special instruction might be required from geotechnical engineer.
Bottom Cut of Ore Stope (Pilot Drift and Secondary Stopes)					
Fair to Good (RMR_{76} > 40)	5 w x 5 h	Connectable Super Swellex	4.88	2.5 x 2.5	Three Superswellex per ring in the back to be installed before slash.
Poor to Very Poor (RMR_{76} < 40)		Connectable Super Swellex	4.88	2.0 x 2.0	Three Superswellex per ring to be installed before slash. Special instructions may be required from geotechnical engineer.
Bottom Cut of Ore Stope (Primary Stopes, Full Width Expansion for Drilling)					
Fair to Good (RMR_{76} > 40)	15 w x 5 h	Connectable Super Swellex	4.88	2.5 x 2.5	Three Superswellex per ring to be installed prior to slashing out to full width. Slashed area will have the rest of the Superswellex installed into the pattern as the slash is developed.
Poor to Very Poor (RMR_{76} < 40)	5 w x 5 h	Connectable Super Swellex	4.88	2.0 x 2.0	Special instruction might be required from geotechnical engineer.

Where very poor ground conditions are encountered underground, local assessment of the ground should be conducted by mine rock mechanics personnel and suitable modifications to excavation practices and ground support made. Consideration should be given to using Swellex bolts of equivalent length in place of resin grouted rebar in very poor ground condition because of potential issues with ensuring adequate mixing and bonding of the resin.

Where poor ground conditions are encountered associated with fault zones, then excavation practices may need to be modified such as shortening round length and supplementing standard ground support with shotcrete.

16.5.3.3 Geotechnical Design Criteria (Stope Design and Dilution)

For non-man entry excavation, such as longhole stopes, assessments were completed using the modified Matthews stability curve after Stewart and Forsyth (1995) and the failure iso-probability curves developed by Mawdesley and Trueman (2003). A range of stope dimensions were evaluated for stability and dilution. A fixed sub-level spacing of 30 m (floor to floor) was used for all mining zones with maximum strike length, stope span, and geotechnical dilution determined for each of the mining zones.

Empirical estimates using the estimated linear overbreak and sloughing (ELOS) approach and benchmarking have been used to come up with the dilution estimates (Clark, 1998).

Based upon the rock mass conditions, the stope dimensions and geotechnical dilution estimations presented in Table 16-11 are considered appropriate for the fair to good and poor to very poor rock mass classes.

Table 16-11: Stope Dimension and Dilution Guidelines

Rock Mass Condition	Maximum Stope Dimensions (m)	Estimated Geotechnical Dilution (ELOS) (m)
Fair to Good (RMR76 > 40)	15 w x 30 h x 15 to 40 l	< 1.0
Poor to Very Poor (RMR76 < 40)	15 w x 30 h x 15 l	1.0 to 3.0

Where stopes are planned within fault zones, there is the potential for reduced stability and increased dilution. Further shortening of stope lengths should be considered if stope performance and dilution is unacceptable.

Maximum achievable secondary stope dimensions will be predominantly controlled by backfill performance.

SRK recommends that the Brucejack Gold Mine review actual stope performance and recovered volumes against planned stope volumes to identify any potential stope performance patterns associated with specific geotechnical domains or geologic structures. Stope dimensions can then be modified to optimize safe ore recovery.

16.5.3.4 Crown Pillar

To maximize crown pillar recovery, the minimum crown pillar thickness for the West Zone and the Valley of the Kings Zone is 15 m. SRK recommends the cable bolting of the crown pillar using 5.0 m long single strand bulbed cable bolts on a 2.5 m spacing. Tight filling of both primary and secondary stopes immediately below the crown pillar is recommended.

16.6 Mobile Equipment Requirements

16.6.1 Production Phase

The mining contractor supplies the bulk of the heavy equipment, with the exception of supplemental long-hole drills for production and sampling and some auxiliary vehicles. Table 16-12 lists the required equipment for development, stoping, and support activities.

Table 16-12: Major Underground Development and Production Equipment List

Description	Total Number of Units Required
6 yd Scoop	1
8 yd Scoop	5
10 yd Scoop	3
30 t Trucks	12
Development Jumbos	3
Long-hole Drills	5
RC Drills	4
Bolters	5
Emulsion Carrier	2
Face Emulsion Loader	2
Bulk Emulsion Loader/Carrier (LH)	1
Shotcrete Machine	1
Transmixer	2

16.6.1.1 Jumbos

Development advance (in ore and waste) will average approximately 500 m/mo during the first 12 years of production. Two-boom units, capable of drilling holes 3.6 m deep, have been selected by the contractor to perform the work. Data from the first 18 months of operations show the jumbos averaged 780 m/mo, or approximately 390 m/mo per unit, exceeding the projected performance from the 2014 FS (Ireland et al. 2014). There is a single-boom jumbo on site that is used as a back up to the two-booms and for utility work where the two-boom is inefficient in smaller headings. The single boom is used sparingly.

16.6.1.2 LHDs

On site there are three, 10 yd LHDs and five, 8 yd LHDs for production and development. This fleet is sufficient for the 3,800 t/d operation of the mine. The mine is evaluating battery electric LHDs as an alternative to diesel LHDs.

16.6.1.3 Haulage Trucks

The mine contractor has twelve, 30 t trucks on site to support the development required to maintain current production. Later when the majority of ore hauled to the crusher is from the lower levels or the West Zone, one additional truck maybe required to support operations. The need for additional haulage capacity may be

counteracted by the reduction of development needs at that same time, depending on the LOM schedule. The mine is researching the use of electric haul trucks on a trial basis and initially to be used as supplemental units until the evaluation is completed. The battery trucks could replace the diesel trucks providing benefits in costs, environmental health, and safety.

16.6.1.4 Bolters

The ground control management plan for pattern bolting development headings and stope backs utilizes bolters equipped for the installation of rebar and split set bolts. Currently, three Maclean bolters and a Rowbolter are on site, with one additional Maclean bolter added to the fleet for the 3800 t/d increase. The bolters are also used to assist in the installation of cable bolts. The mine is investigating a transition from Maclean bolters to Rowbolters.

16.6.1.5 Long-hole Drills

Production drilling is performed with top and bottom hammer drills. Slot raises are drilled with a V30 bit to allow void space in the slot. On site there are currently four drills; one additional drill will be added to the fleet for production drilling and an RC drill has been added and an additional three more are being added for sampling.

16.6.1.6 Explosive Loaders

One face charger is on site and another one will be required for the 3,800 t/d production increase for development loading. For a period, there will be up to nine rounds per day that will require loading. Each unit has pumps for face charging with emulsion. In addition to the face charges, there is one long-hole loading unit available for uphole and downhole emulsion loading in the stopes.

16.6.1.7 Shotcrete Sprayers

It was anticipated that 5 to 10% of development would require shotcrete; however, to date, shotcrete has primarily been required in areas near the Rainy Fault. Shotcrete is also required for paste fill exposures in stope development and barricade construction for backfilling and ventilation bulkheads. One unit is on site and provides adequate capacity for this activity. Wet, non-fiber-reinforced shotcrete is used as the standard.

16.6.1.8 Transmixers

Shotcrete is delivered from the underground batch plant. The contractor has two transmixers at the mine to support shotcrete operations on site. These are sufficient for the needs of the mine.

16.6.2 Support Equipment

Table 16-13 presents the complete list of support equipment.

Table 16-13: Support Equipment List

Description	Total Number of Units Required
MT Truck	1
Cassette Water / Fuel Truck	1
Skid Steer	1
Telehandler	4
Shotcrete Machine	1
Transmixer	2
Boom Truck	2
Scissorlift	3
Kabota Tractor	2
Jeffery Flatdeck/Boomtruck	1
Jeffery Lube Truck	1
Kabota RTV Personnel Carrier	14
Four-man Jeffery Mancarrier Personnel Carrier	1
Ten-person Jeffery Mancarrier Personnel Carrier	3

16.6.2.1 Personnel Carriers

Personnel are transported in mancarriers. There are 4 carriers and 14 Kobotas to transport personnel through the mine. Technical services and Pretivm supervision use underground Toyota trucks of various configurations to access and work in the mine.

16.6.2.2 Scissor Lift Trucks

The contractor has three scissor lift trucks to support development and occasionally assist Pretivm maintenance crews.

16.6.2.3 Lubrication Truck

There is a lubrication truck on site to service underground equipment. The lubrication truck is required to fuel and lubricate all equipment that is not likely to return to the shop area at frequent intervals. Downtime can be reduced by keeping equipment near the working headings. This also helps improve traffic flow on the ramp. This equipment includes LHDs, jumbos, long-hole drills, and bolters. The service truck travels between these equipment pieces to perform daily servicing.

16.6.2.4 Boom Trucks

Boom trucks are required for daily transport of materials from surface to underground and to facilitate loading and unloading. Material stockpiles are set up throughout the mine for supplies such as rock bolts, screen, resin, vent duct, etc.

16.6.2.5 Explosives Vehicles

Explosives consumption is roughly 6.0 t/d of bulk emulsion per day and is delivered to the mine in three custom-made ISO-standard tanks, each with a capacity of 17,500 L.

A purpose-built truck transports the full tanks to the emulsion bays. Emulsion pumps are used to transfer emulsion from the full 17,500 L tank to 21,000 L ISO tanks in the emulsion bay. Consumption averages three ISO tanks per week. All other explosives are transported to the cap and powder magazines by the explosives handling truck. Approximately 272 to 610 caps and primers are required daily for development, depending on advance rates, with 60 caps and primers per day on average required for the long-hole production blasting.

16.6.2.6 Water Truck

The water truck is on site to facilitate mine wall washing on an ongoing basis.

16.6.2.7 Tractors, Telehandlers and Utility Vehicles

Tractors are used for nipping materials and general transport through the mine. All tractors are equipped with a cargo/man carrying compartment in the back. Telehandlers are used for nipping materials and general transportation throughout the mine and are also capable of being fitted with man baskets for installing or maintenance of the services which are out of reach from the ground.

Utility vehicles are used by personnel for quick transport between headings and will be the preferred mode of transport for supervision and technical support staff.

The following crews will be issued utility vehicles for use during their shifts:

- Development blasters
- Backfill crew
- Mechanics
- Electricians
- Production blasters
- Diamond drillers
- Warehouse
- Managers/shifters and technical support staff.

16.7 Ventilation

The ventilation system is designed to meet the requirement of the Health, Safety and Reclamation Code for Mines in British Columbia – June 2017 (HSRCM), which requires a minimum of 0.06 m^3/s of ventilating air for each kilowatt of power of diesel-powered equipment operating. Additional air is supplied for fixed facilities and a leakage and balancing factor. All diesel-powered equipment operating underground are fitted with CANMET certified engines.

The design is based on a “push” configuration, with permanent surface fans located at two portals: the West Zone ramp and the Conveyor ramp. These two intake airways provide sufficient ventilation capacity to support the underground mining operations. To ensure the temperature of the air does not enter the mine below the freezing point, mine air heaters are fitted in front of the primary fans.

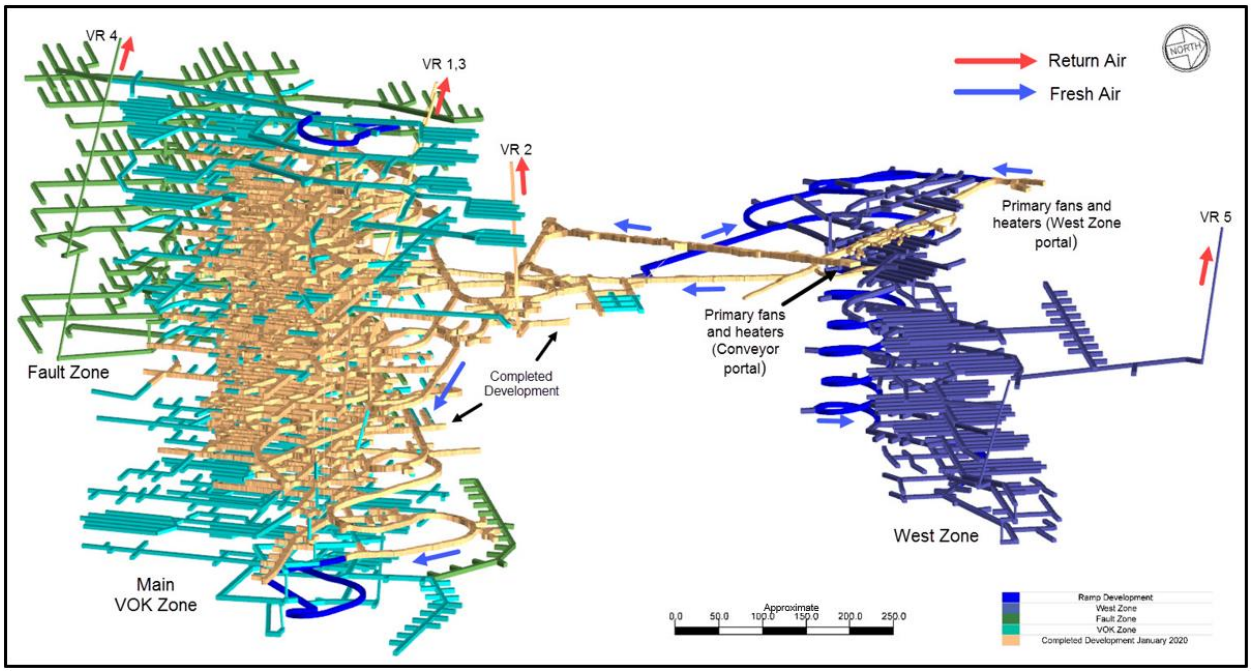
The Valley of the Kings production ramp is connected to the intake ramps to deliver fresh air to the active production levels. An escape-way ladder system is installed in fresh air raises in parallel with the production ramp.

Fresh air travels from the production ramp, along the footwall drives, and exhausted to return air raises located at the extremities of the level. At the current time there are three exhaust raises to surface; additional exhaust raises will be developed as the mine is further developed. Regulators are installed at the raise connections to distribute the required volume of air to the level. An appropriately designed and located auxiliary fan and duct system force fresh air to development headings and active stope faces.

The underground fixed facilities have a dedicated return air raise to eliminate the introduction of dust and other unwanted contaminants into the production areas. The volume of air flowing through the crusher area is controlled with a combination of fan and regulators.

Figure 16-13 shows an isometric view of the Brucejack Gold Mine ventilation system.

Figure 16-13: Brucejack Gold Mine Ventilation System (Looking West)



Source: Pretivm (2020)

16.7.1 Design Criteria

The ventilation system design has drawn information from the HSRCM. As stated in Part 4 of the HSRCM, Section 4.6.1 (3): “a minimum of 0.06 m^3/s of ventilating air for each kilowatt of power of the diesel-powered equipment operating shall be circulated by mechanical means through every workplace where diesel-powered equipment is operating”.

A diesel engine exhaust emissions dilution rate of 0.06 m^3/s/kW is used in the ventilation system design. The design criteria also includes commonly accepted industry best practices.

16.7.2 Total Airflow Requirements

Total airflow requirements were determined based on the diesel equipment fleet and fixed facilities required to support steady state production and development activities. An airflow allowance was also determined for leakage and balancing inefficiencies.

The current total airflow requirement for the Brucejack Gold Mine is as follows:

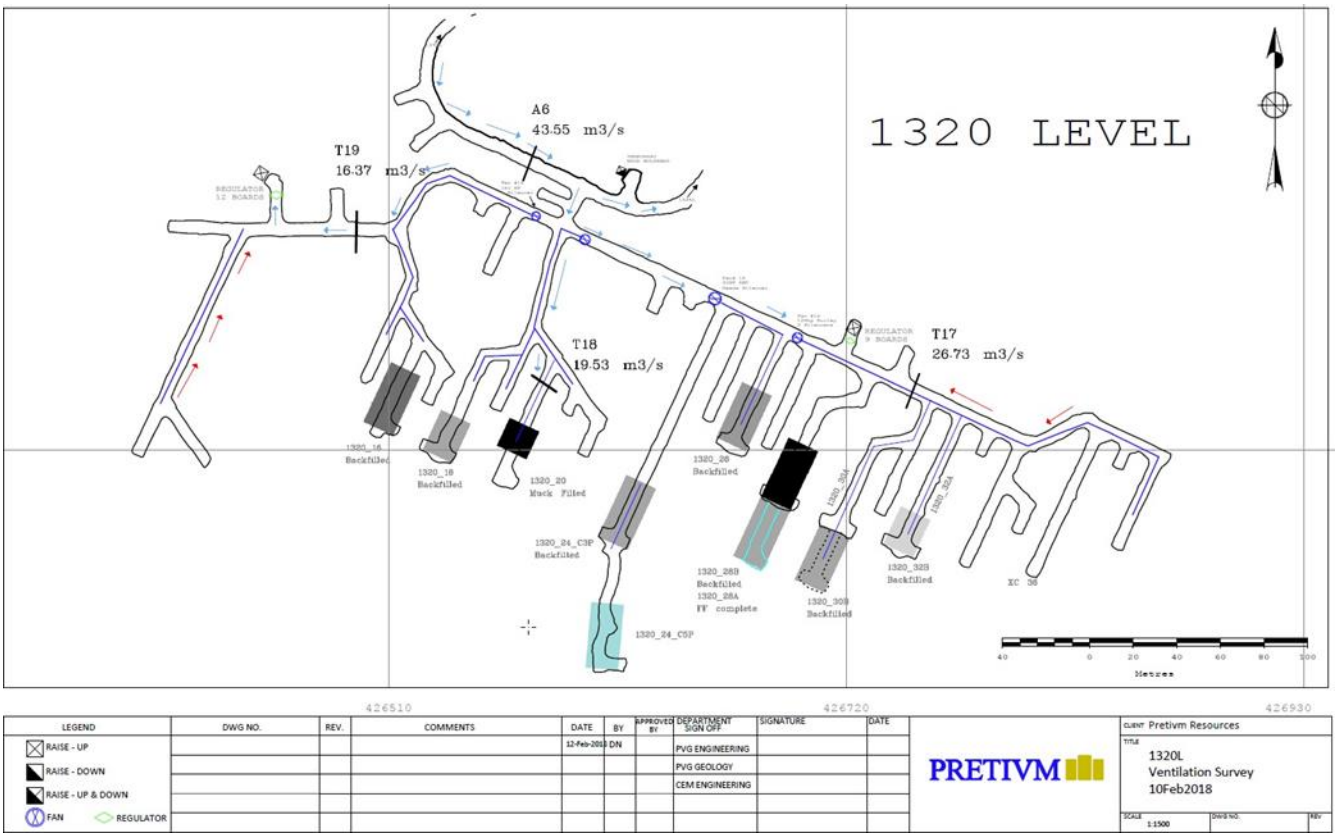
- Diesel equipment – 345 m^3/s
- Fixed facilities – 55 m^3/s
- Leakage and balancing (10%) – 40 m^3/s
- Total – 440 m^3/s.

16.7.3 Auxiliary Ventilation

All work areas, such as development headings and draw-points, not supplied with a direct split of fresh air are ventilated using auxiliary systems. The auxiliary systems consist of axial fans and flexible ducting. The fan power and duct size are specified to provide the required amount of air for the activity.

Figure 16-14 shows a ventilation configuration for a typical production level with auxiliary fans ventilating active areas.

Figure 16-14: Typical Production Level



16.7.4 Permanent Primary Fans

Over the LOM, there are a multitude of settings for the ventilation circuit, depending on the type of activities and their location throughout the mine. For operational flexibility, the primary fans include a variable frequency drive (VFD) and adjustable pitch blades. The fans and motors are capable of delivering the required duty to meet the peak demands of the production and development activities over the current LOM plan.

Table 16-14 summarizes the primary fan requirements.

Table 16-14: Primary Fan Specifications

Description	Specification
Fan Diameter	2.4 m
Type	Horizontal mount axial mine fan. Adjustable pitch blades.
Configuration	Two forcing fans, each connected with ducting to the WZ decline and Conveyor decline.
Voltage	600 V
Fan Motor	600 kW, 900 revolutions per minute, VFD capability

16.7.5 Mine Air Heating

All intake air entering the mine is heated for the following reasons:

- Protect the health and safety of personnel working or travelling in intake airways.
- Prevent the freezing of service water and discharge lines.
- Ensure reliable operation of conveying and other mechanical equipment in the decline.
- Maintain ice-free and safely trafficable roadways.
- Prevent rock surface (or shotcrete lining) expansion/contraction damage from freezing and thawing of rock joints in the upper parts of the intake airways.
- Prevent ice buildup in airways that would potentially lead to unsafe conditions.

Mine air heaters are located in front of permanent primary fans. Four MW (2 MW per fan) of electrical heaters are installed as the primary heating method. Propane heating is installed to augment the electrical heating in extreme cold conditions.

The heating system is designed and installed as per the relevant requirements of the HSRCM (BC EMPR 2017). The system has been submitted to the BC EMPR and approved.

16.7.6 Conveyor Decline

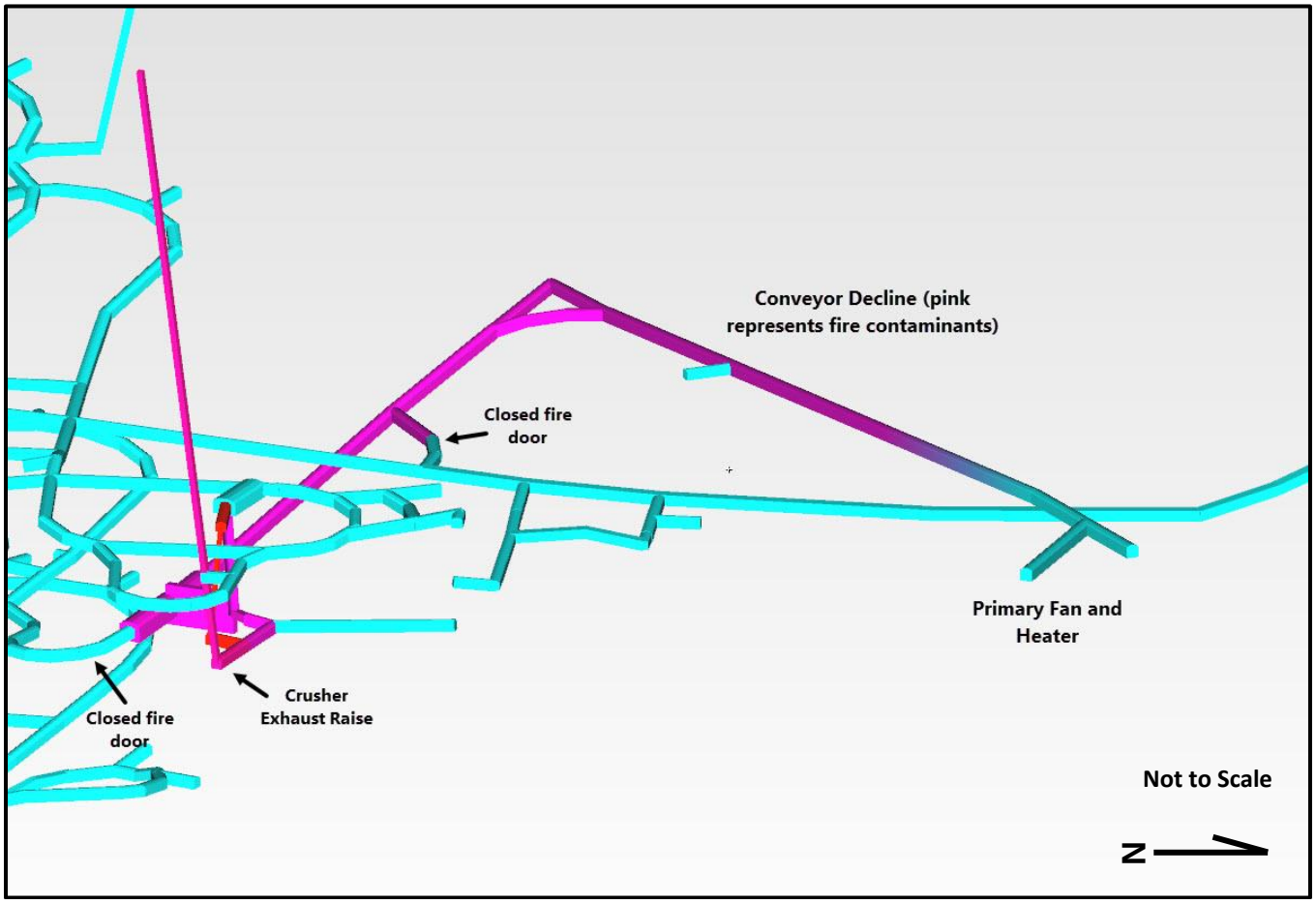
The conveyor decline is the main mine intake with dimensions of 6.0 m wide by 6.5 m high. Care is taken to ensure that the air speed in the conveyor decline is not too high to prevent the uptake of dust into the intake mine air.

Given that the conveyor is located in a primary air intake, the risk of the conveyor catching fire is also managed. The design includes the following:

- Fire retardant belt
- Fire retardant grease and lubricants
- Ventilation controls to isolate the air in the conveyor decline in the event of a fire
- Regular inspection of the conveyor declines during operation in order to detect the development of faulty rollers or belt misalignment.

In the unlikely event of a conveyor belt fire, fire doors placed in key areas would close and smoke would flow directly to the workshop/crusher exhaust raise. Figure 16-15 shows the isolation of conveyor fire contaminants from the ventilation circuit.

Figure 16-15: Conveyor Fire Isolation



Source: Pretivm (2019)

16.7.7 Emergency Preparedness

In developing the ventilation strategy for the Brucejack Gold Mine, consideration was given to the potential for mine emergencies. As such, the following criteria was established:

- In general, ramps are in fresh air once developed.
- On almost all levels, escape can be either to a ramp or to the escape ladder-way.
- The escape ladder-ways are located in the internal fresh air raises installed as part of the development of the ramps.
- In each ramp, escape may either be up the ramp or down the ramp to a safe area.
- One permanent 40-person refuge station is established and services both the WZ and the VOK Zone; another permanent 60 person refuge station is being established and will service the Lower VOK.
- Other refuge chambers are portable for flexibility of location at the most appropriate points in the mine.

- While the primary means of communication is by radio, a stench system is in place for introduction of ethyl mercaptan into both portals concurrently in the event of fire.
- Fire doors are located in accordance with legislated requirements and to isolate areas of high fire potential to ensure noxious gases are not distributed through the mine workings.

There are a variety of incidents that would trigger the emergency response plan and/or evacuation plan. Such events may be fire, rock fall, injured personnel, or major ventilation equipment breakdown. Emergency coordination occurs from the control room where all information and communications can be monitored.

The emergency response procedures incorporate trained, onsite mine rescue teams made up of a cross section of the workforce and staff. These teams will be trained in administration of first aid and fire-fighting procedures. Since the Brucejack Gold Mine site is considered remote, a first aid facility run by a trained person, sufficient medical supplies, and provisions for an air ambulance and landing pad is available.

For the two surface portals, both of which are supplied with fresh air, the West Zone portal is considered the primary escape and the conveyor portal the secondary escape.

For the production stoping blocks, a ladder-way is installed in each of the raises located next to main ramps. The raises are sized to afford easy passageway.

For the production stoping blocks, a ladder-way is installed in each of the raises located next to the main ramps. The raises are sized to afford easy passageway. Ladder-ways are designed, installed, and maintained in compliance with the HSRCM, Sections 6.28.1 through 6.28.7 (BC EMPR 2017).

The exhaust raises to surface are for ventilation only and not used as a second means of egress. Therefore, the exhaust raises do not have ladder-ways installed.

An automatic stench gas warning system is installed on the supply side of the WZ vehicle portal and conveyor portal. When fired, this system will release stench gas into the main fresh air system allowing the gas to permeate rapidly throughout the mine workings. Once stench gas is released, underground mine personnel would report immediately to the nearest mine refuge station or surface, whichever is closer.

The primary purposes of fire doors are to prevent noxious gases from reaching workers should they be trapped underground and to prevent fire from spreading as much as possible.

Fire doors are required to isolate the following areas:

- Magazine
- Conveyor decline.

Portal doors are also designed to meet the fire door criteria.

16.8 Underground Infrastructure

16.8.1 Mine Dewatering

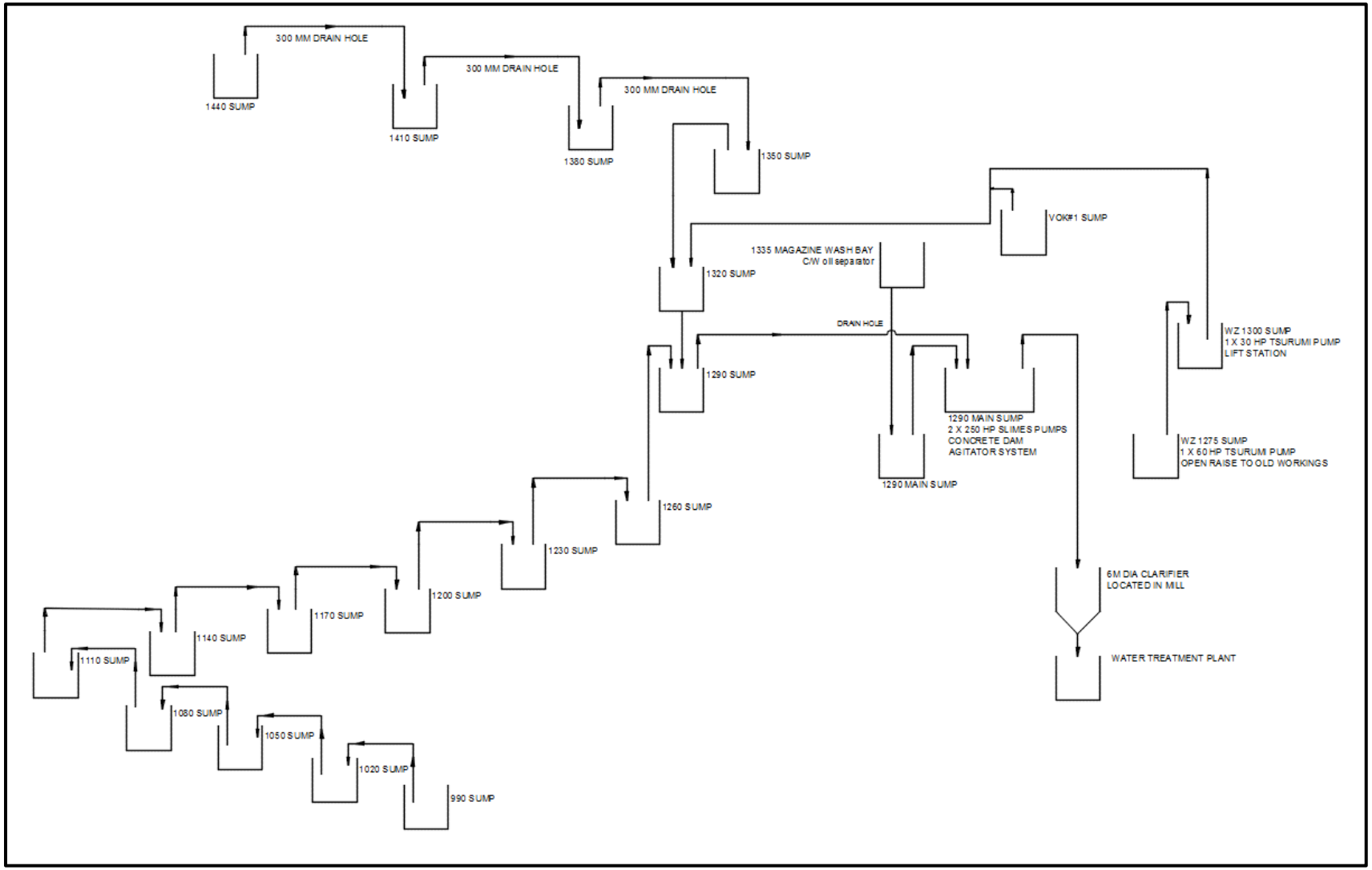
Mine dewatering is designed to accommodate groundwater inflows from the Valley of the Kings Zone workings, the West Zone workings, and inflows from drill and other operating equipment. Total inflows were estimated to be approximately 100 L/s (including service water); however, to accommodate for uncertainty in the water inflow model, the design capacity for the pumping system is based on maximum inflows of 139 L/s.

Brucejack Gold Mine dewatering is handled by a combination of submersible and horizontal centrifugal pumps located throughout the West Zone and Valley of the Kings Zone working levels. The pumps handle ground inflow and send drill water via multiple 30 m lifts throughout the mine.

The main sump consists of a single 30 m by 6 m wide sump with an outlet connected to the centrifugal pump system. The flow of underground water with slimes is pumped via four centrifugal pumps (two running, two backup) to the process plant on surface via a dedicated line up the Valley of the Kings conveyor way. Currently, there are sumps to the 1,110 m elevation level, with the remainder of sumps created as development advances.

To minimize up-front capital, pump procurement is staged such that pumps only arrive as their assigned sumps are excavated. Figure 16-16 is a line diagram of the current dewatering system.

Figure 16-16: Dewatering Plan



Source: Pretivm (2019)

16.8.2 Solids and Slimes Handling

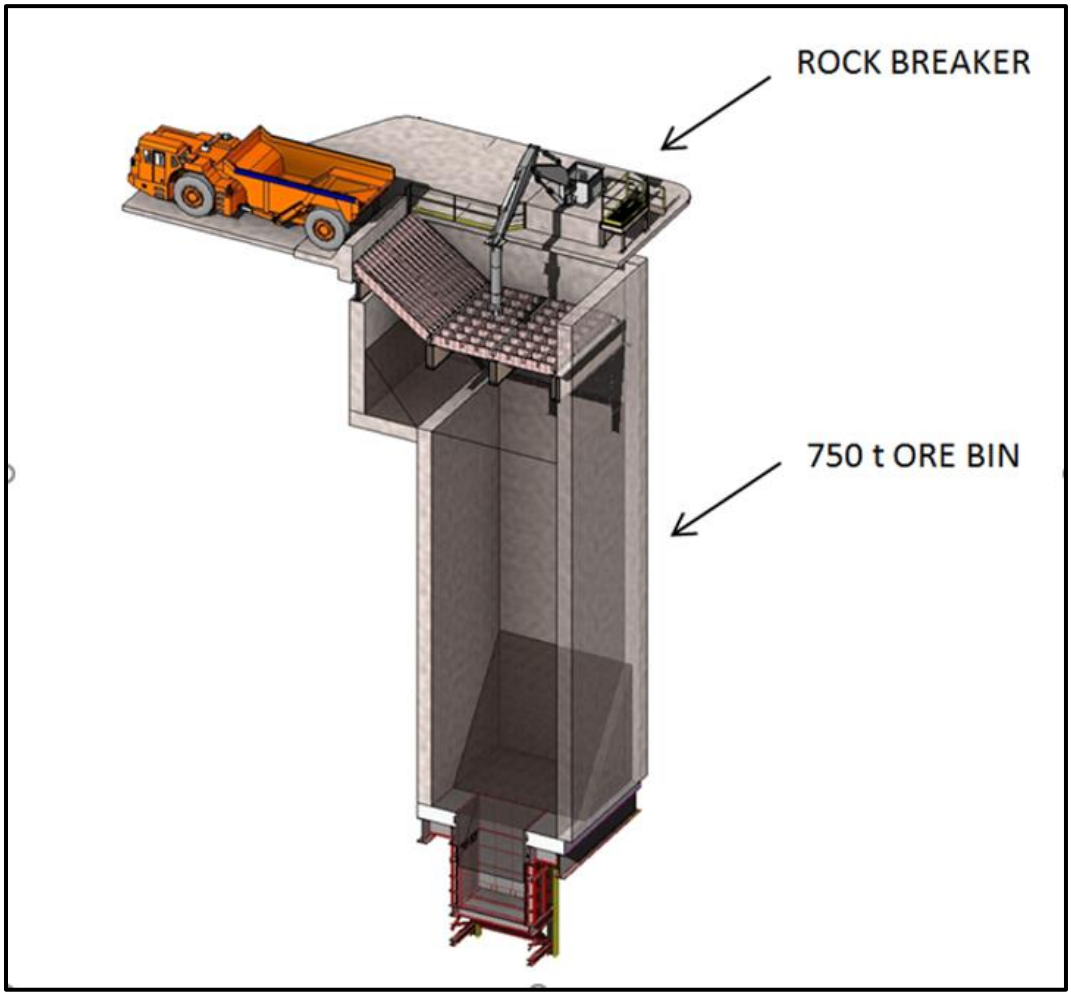
Solids and slimes entrained in water are pumped through the dewatering system to the main sump located at the 1,290 m elevation level. This main sump is described in Section 16.8.1.

16.8.3 Materials Handling

The crusher is located at the 1,300 m elevation level of the mine close to the Valley of the Kings Zone. The tipple for the ROM bin is located at the 1,335 m elevation level.

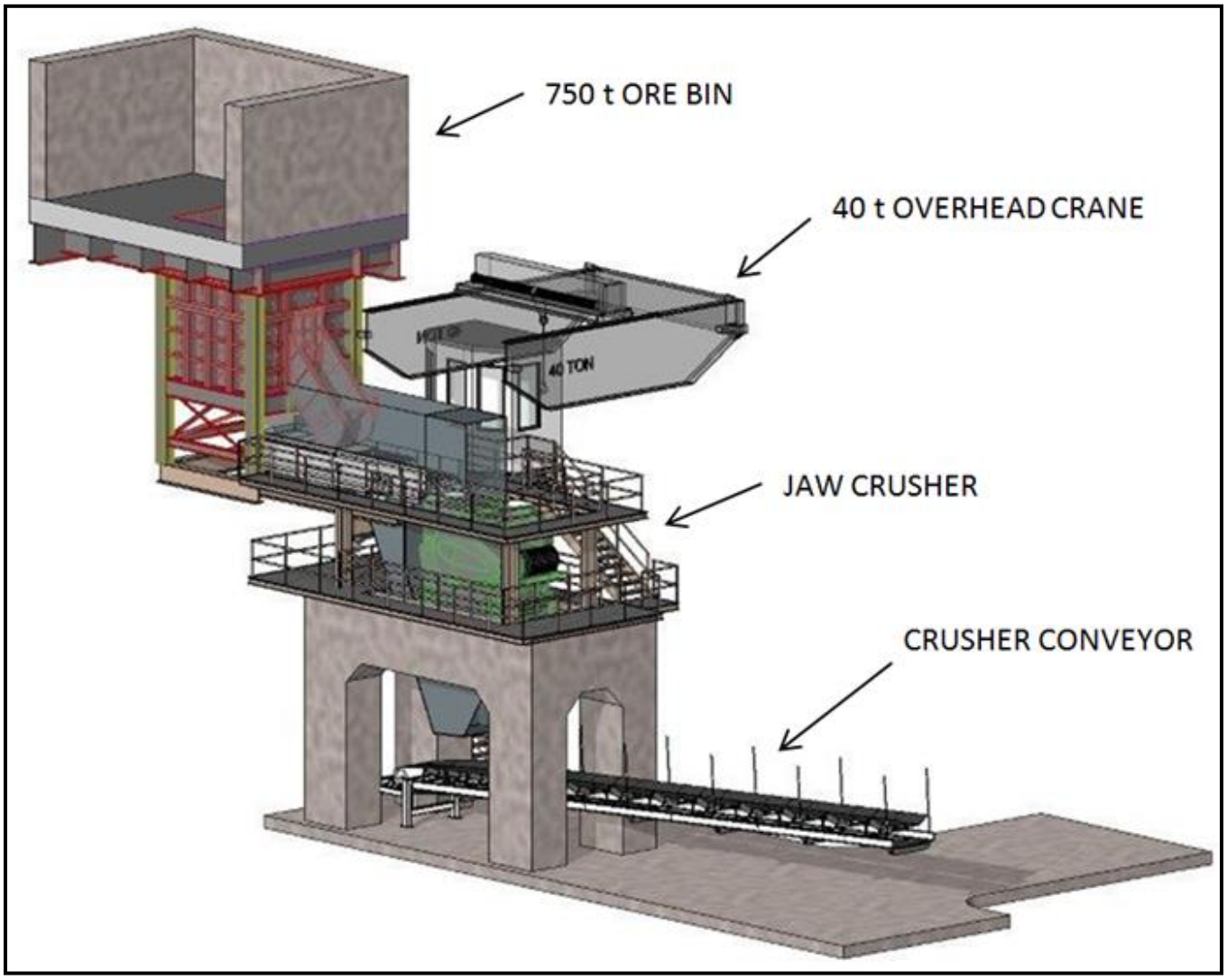
ROM material is transported underground by truck from the West Zone and the Valley of the Kings Zone and is preferentially dumped onto the ROM bin grizzly. If the ROM bin is full, or for other reasons the trucks cannot dump into the ROM bin, the trucks will dump into remucks near the ROM bin location. Material stockpiled in the remucks will be re-handled and deposited onto the grizzly by a LHD. At the grizzly, material smaller than 400 mm falls through to the ore bin and larger material is broken down by a hydraulic rock breaker stationed above the grizzly screen. Figure 16-17 shows a sectional projection through the coarse ore bin with the rock breaker and scalping grizzly.

Figure 16-17: Tipple and Ore Bin Sectional Projection



The 750 t capacity ore bin feeds material down through a hopper at the bottom of the bin to a vibratory feeder. This vibratory feeder transports the ROM material to a jaw crusher and the crusher reduces the material down to 120 mm or finer in size and drops this product down the fines chute to the crusher belt conveyor. Figure 16-18 shows an isometric view of the crusher feed and crusher.

Figure 16-18: Crusher Feed and Crusher



The 1 m wide belting on the crusher conveyor carries material at a rate of approximately 225 t/h from the crushing area to the intermediate conveyor at a speed of 1 m/s. The ore on the crusher conveyor moves past a magnet that removes any tramp iron, depositing this iron into a waiting bin.

The intermediate conveyor also moves at a rate of 1 m/s, transporting the ore up the intermediate decline tunnel to the main conveyor. The main conveyor exits the decline tunnel into the portal structure. The ore is dropped onto the mill feed conveyor, which exits the portal structure and carries the ore to the mill through an enclosed, heated, rectangular gallery.

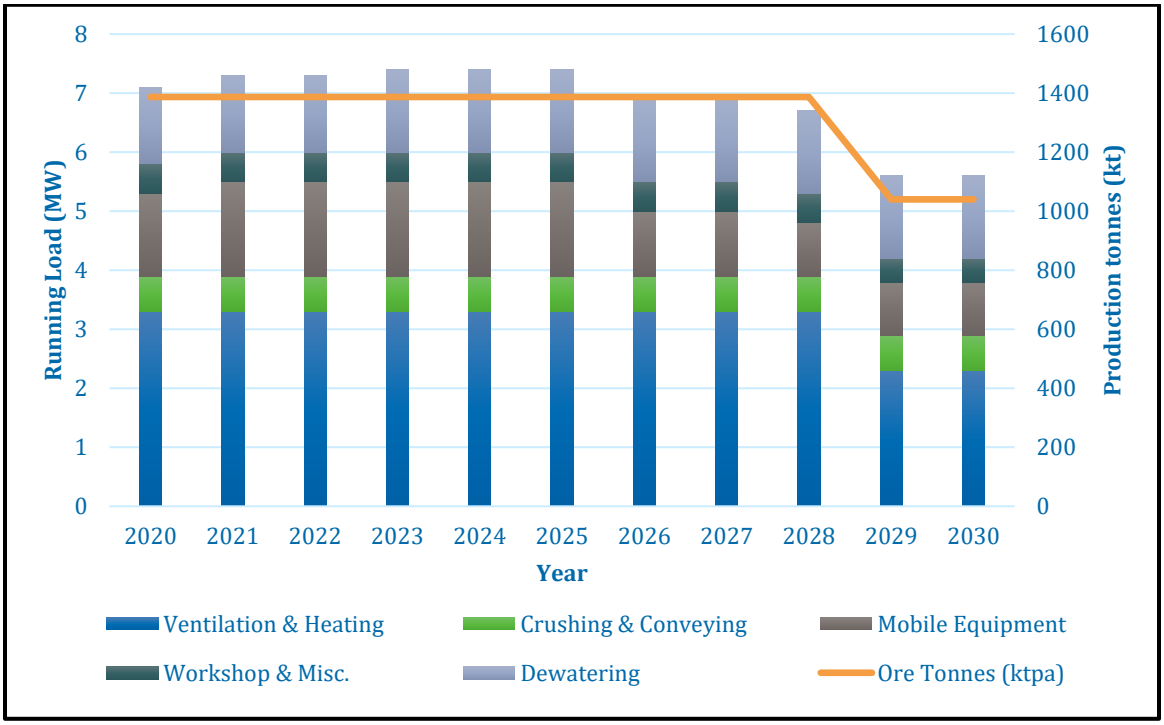
16.8.4 Power Requirements and Electrical Distribution

BC Hydro indicated that the total electric power supply available for the Brucejack Gold Mine site is limited to a connected load of 20 MW only if no electrical reinforcement is added to the main BC Hydro Line. The maximum underground connected load to support full production and development activities is approximately 8 MW, inclusive of ventilation and heating.

Considering the other key consumers of mine power, such as the mill and paste plant, the power available for mine air heating is limited to 4 MW. As the mine air heaters will at times require more than the fixed 4 MW of electric power, a propane direct-fired system makes up the remaining heating requirement.

Figure 16-19 shows the growth of the power requirements over the LOM in relation to ore production. Ventilation and heating, mobile equipment, and dewatering are the main consumers of power. The maximum running load is estimated to be 8 MW and will occur when full production levels are achieved. As the mine is developed deeper, the dewatering power demand will increase due to a higher lifting head and increased inflows. As development activity and production decrease, the power requirements will also reduce.

Figure 16-19: Underground Power Requirement Profile



Electrical power is supplied to the mine three ways:

- Through the Valley of the Kings portal into the underground electrical substation service (ESS) comprised of two 500 MCM cables serviced at 4.16 kV
- Through the West Zone portal from the E4C e-house comprised of one 500 MCM cable serviced at 4.16 kV
- Through a borehole from surface to the lower mine comprised of one 500 MCM cable serviced at 4.16 kV.

The E4C e-house, which supplies power to the underground workings, is comprised of one 3,000 A breaker that is fed from the mill to supply transmission line power to the E4C bus. The E4C bus has a 3,000 A tie-breaker to facilitate splitting the bus if necessary. There are also additional loads that feed off the E4C e-house such as:

- Underground ventilation fan house
- Camp services
- Underground workings through the West Zone portal
- Underground supply through a borehole.

The system is comprised of two zig-zag transformers that supply a neutral grounding resistor on either side of the tie-breaker. Only one is on at any given time to supply the system with a ground reference. The E4C also has the breakers that tie the two 1,450 kW generators, six 1,850 kW generators, and transformer that feeds the bus via four 600 V generators.

The underground system is distributed via 4.16/0.6 kV portable transformers. The transformers are fed through load break switches, which enable the transformers to be de-energized for maintenance purposes.

The additional feeds to the underground system run via the West Zone portal, the Valley of the Kings portal, and through a borehole fed via the E4C e-house. All the transformers are distributed as per the above configuration. These transformers feed mine development, pumps, fans, lights, and all electrical workings underground.

Figure 16-20, Figure 16-21, and Figure 16-21 show single-line electrical diagrams for the underground mine.

Figure 16-20: West Zone Portal Underground Single-line Diagram

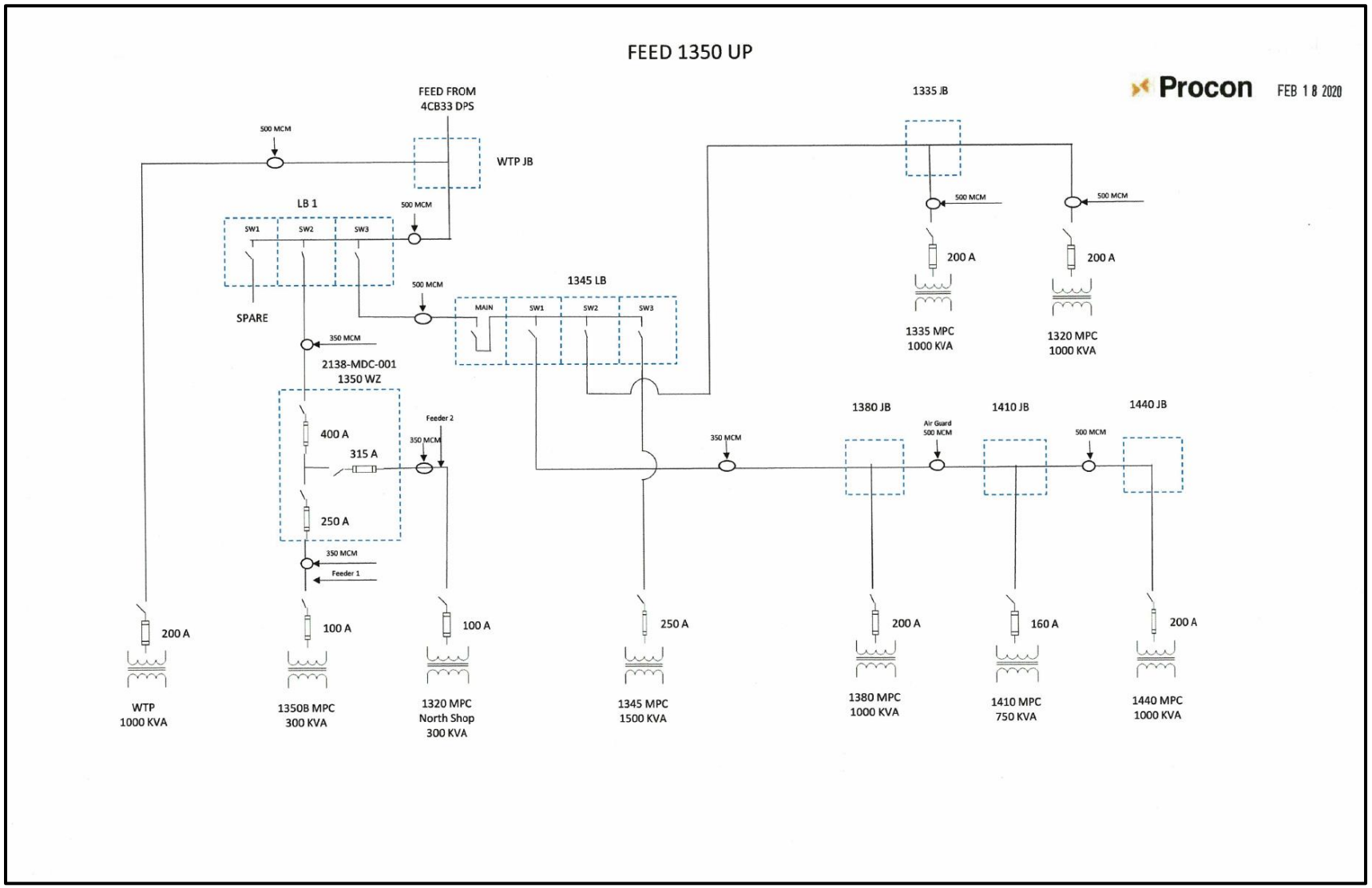


Figure 16-21: Borehole Underground Single-line Diagram

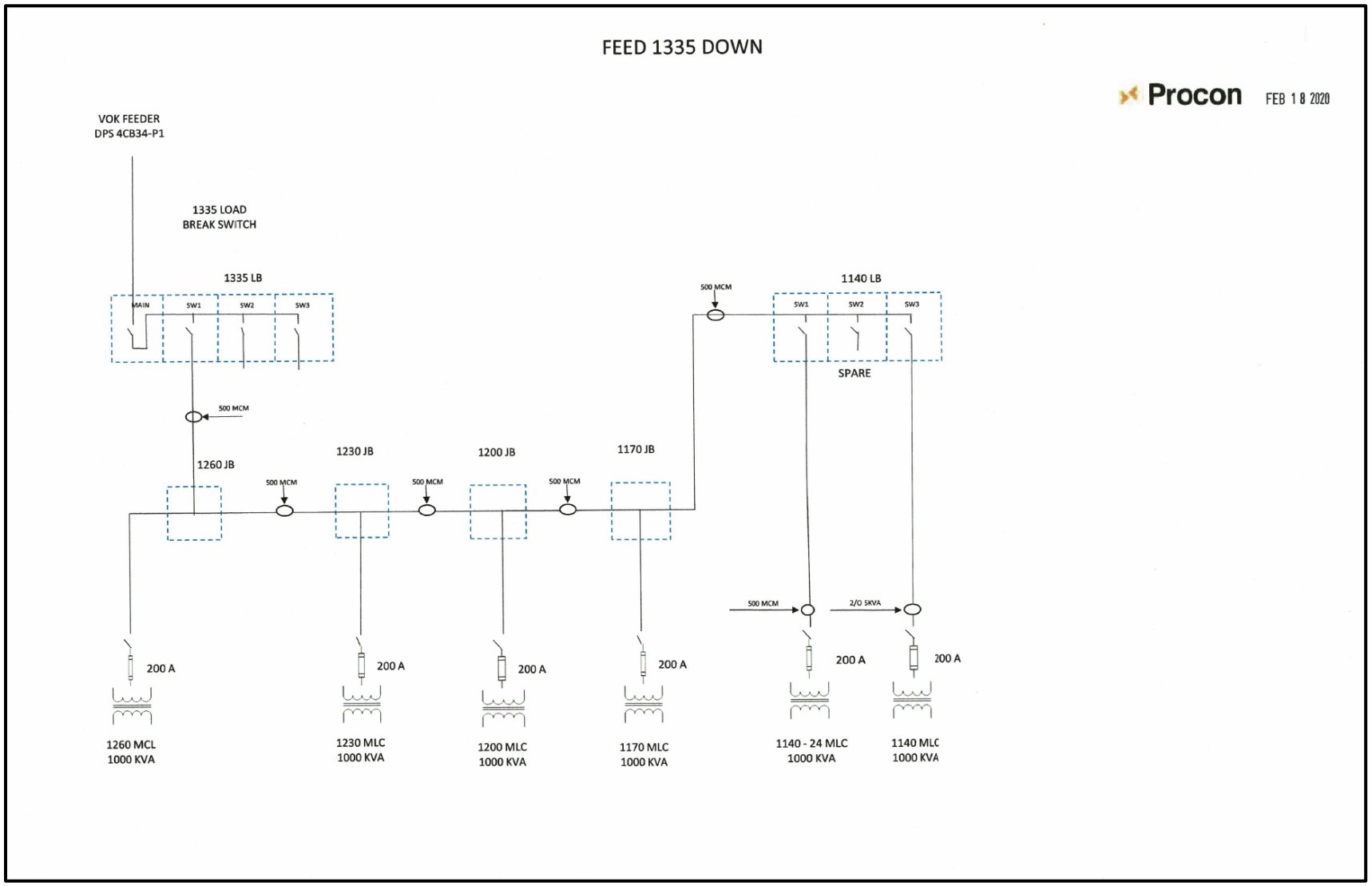
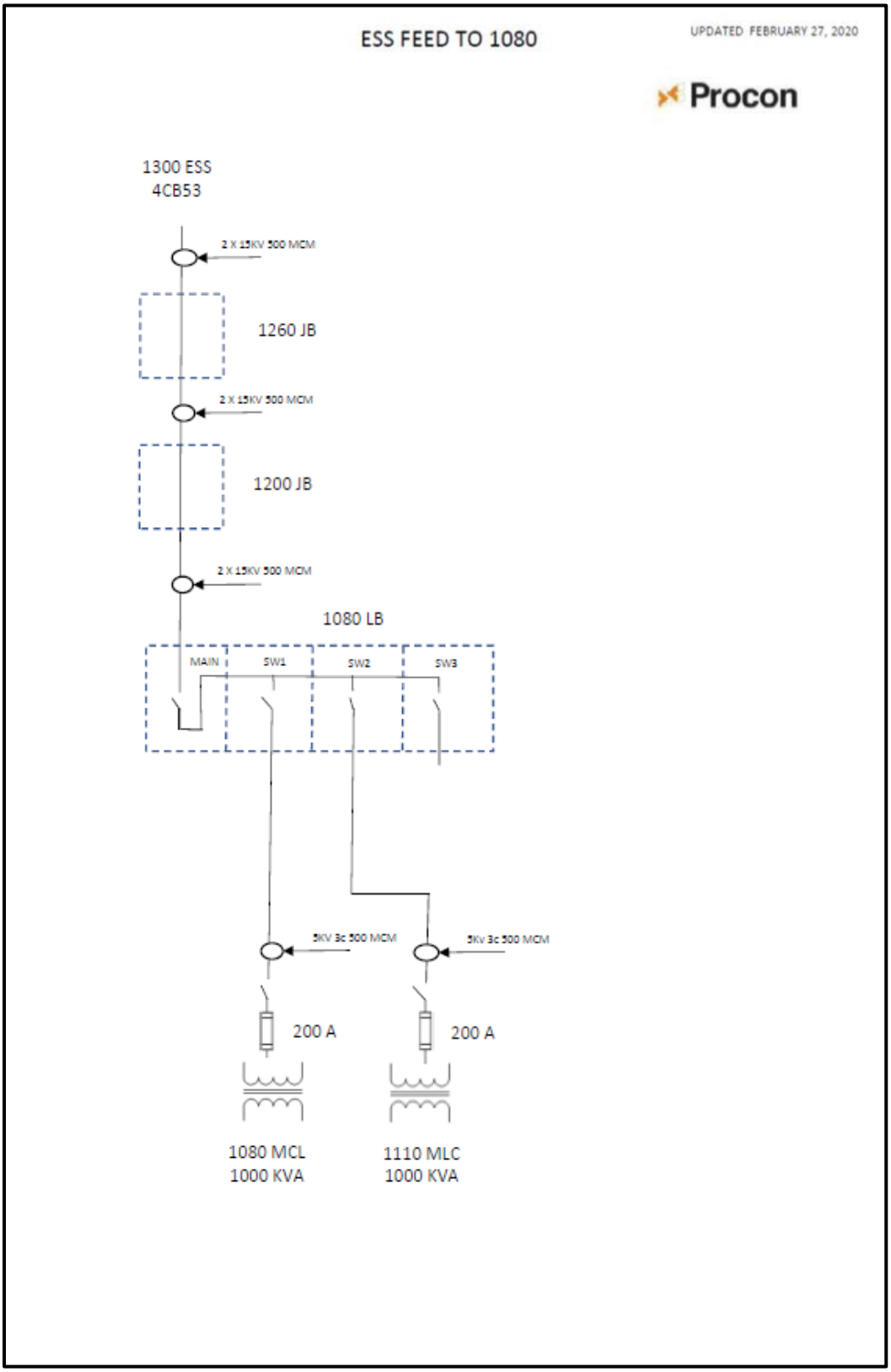


Figure 16-22: ESS Feed to 1080 Single-line Diagram



16.8.5 Compressed Air

Compressed air is supplied by two compressors located near the West Zone portal and by three compressors spread through the Brucejack Gold Mine to reduce line loss in the system.

The in-the-hole drilling equipment has portable compressors close to the drill to meet their elevated pressure requirements.

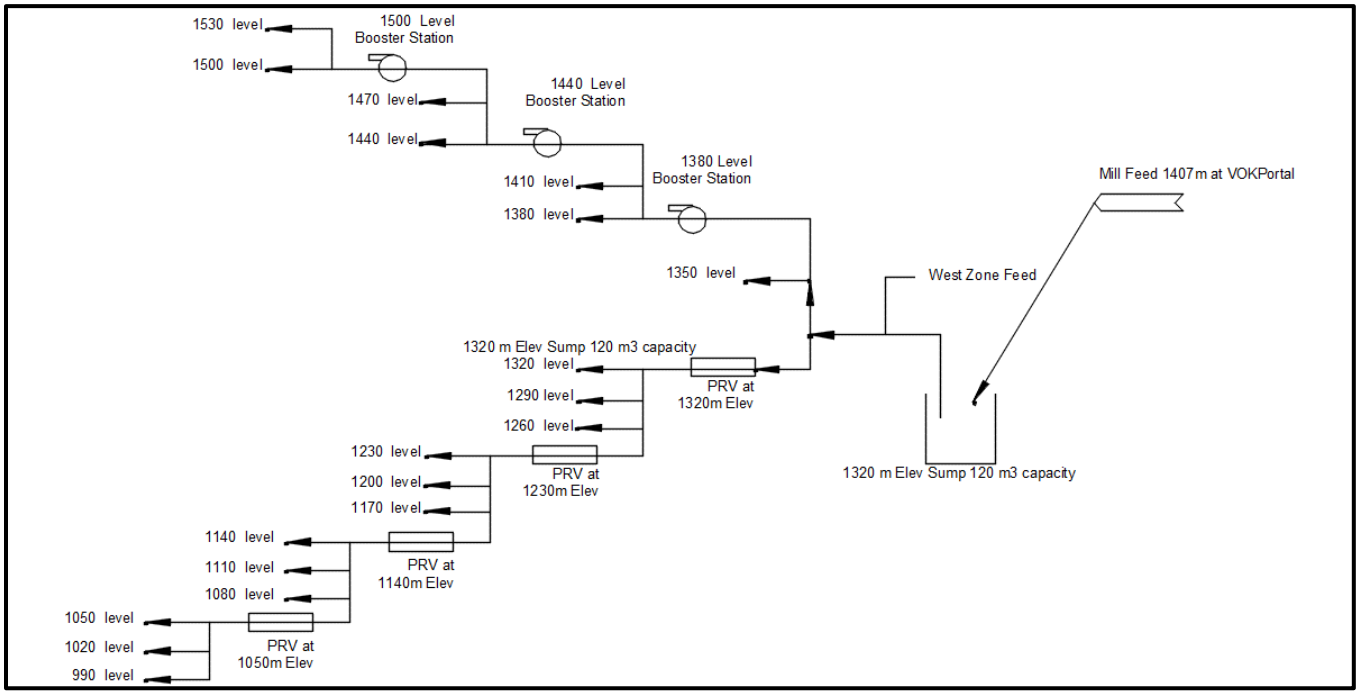
16.8.6 Service Water Supply

Service water for drilling and dust control is supplied via a 100 mm (4 inch) steel line at the Valley of the Kings portal. The line continues through the Valley of the Kings decline ramp to the supply sump. The water supply sump is located at the 1,320 m elevation level in the West Zone area along the West Zone access. From this sump, the mine is supplied service water from which the pressure reducing valves (PRV) will be supplied at the 1,320 m, 1,230 m, 1,140 m and 1,050 m levels to reduce the supply pressure below 689 kPa (100 psig). Near the 1,380 m and 1,440 m elevation levels, a booster pump station is installed to supply operating pressure for the upper portion of the Valley of the Kings Zone.

Over the last year, the process water requirements for all the mine equipment jumbos, long-hole drills, bolters, diamond drills, and other equipment was approximately 1000 m3/d for development and stoping.

Figure 16-23 is a schematic of the main water distribution system.

Figure 16-23 Mine Service Water Distribution Schematic



Source: Pretivm (2019)

16.8.7 Fueling and Lubrication

Daily fuel consumption is estimated to be approximately 5,500 L. Currently, an underground fuel bay has not been excavated and facilities have not been installed. Large mine equipment haul trucks, LHDs, and vehicles that come to surface regularly fuel up on surface. Other equipment such as bolters, jumbos, and scissor decks are fueled by a lube truck. An underground lube bay may be installed in the future.

16.8.8 Workshop and Stores

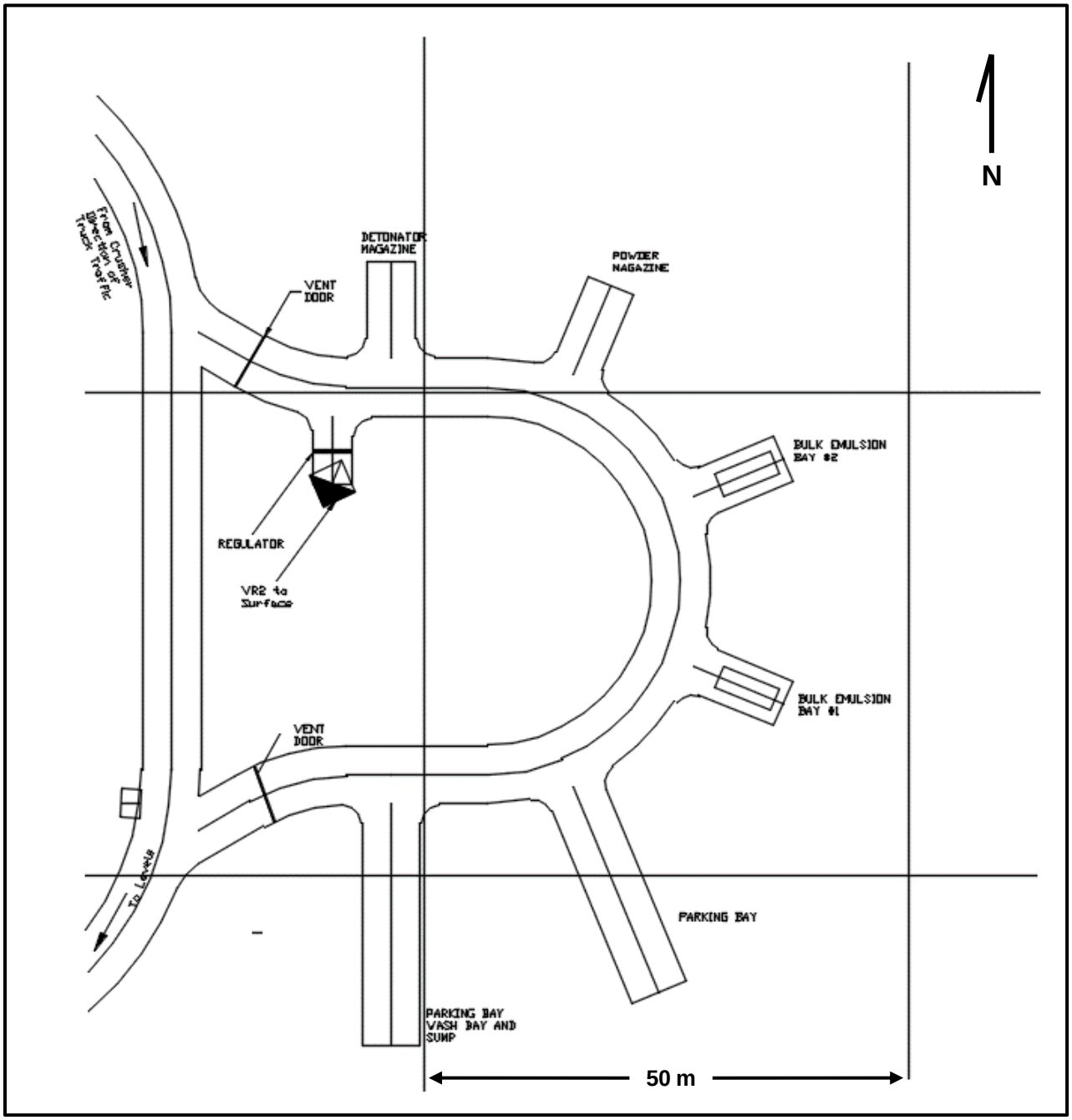
The main maintenance area is located on surface (covered in Section 18.0 of this report). All major scheduled planned maintenance and rebuilds take place in the surface shop. Various areas throughout the mine are used to store consumable supplies.

16.8.9 Explosives Magazine

The entrance to the explosives magazine has rollup doors and man doors to allow access from both ends of the facility. Two bays provide storage of bulk emulsions; one bay contains a 20,000 L storage tank and storage area, and the other bay contains a 17,000 L storage tank and storage area. A powder bay is designated for the storage of all other explosive products (other than the bulk emulsion and the detonators) on wooden shelves. A fourth bay is designated for the storage of detonators on wooden shelves. A concrete wall with a steel door separates this bay from the rest of the mine works.

Figure 16-24 shows the underground magazine layout.

Figure 16-24: Bulk Emulsion/Powder Magazine Storage Plan



Source: Pretivm (2019)

Currently bulk emulsion will be transported by the explosives supplier directly from the manufacturing plant to the KM 48 explosive magazine/transfer. Each shipment will be delivered via transport trailer with one custom made 17 t (17,500 L) ISO tank per load. The ISO tank trailer will be transferred to the Brucejack Gold Mine site immediately upon arrival. Once the full ISO tank is offloaded from the transport trailer onto the special built emulsion hauler, the hauler will take the ISO tank to the emulsion storage area, where the emulsion will be pumped out of the tank into one of the two installed tanks. Once emptied, the ISO tank will be brought to surface, reloaded onto the surface

transport trailer, and taken to the KM48 magazine area where it will wait for the next load to come in and the transport truck to take it to the manufacturer's facility for refilling.

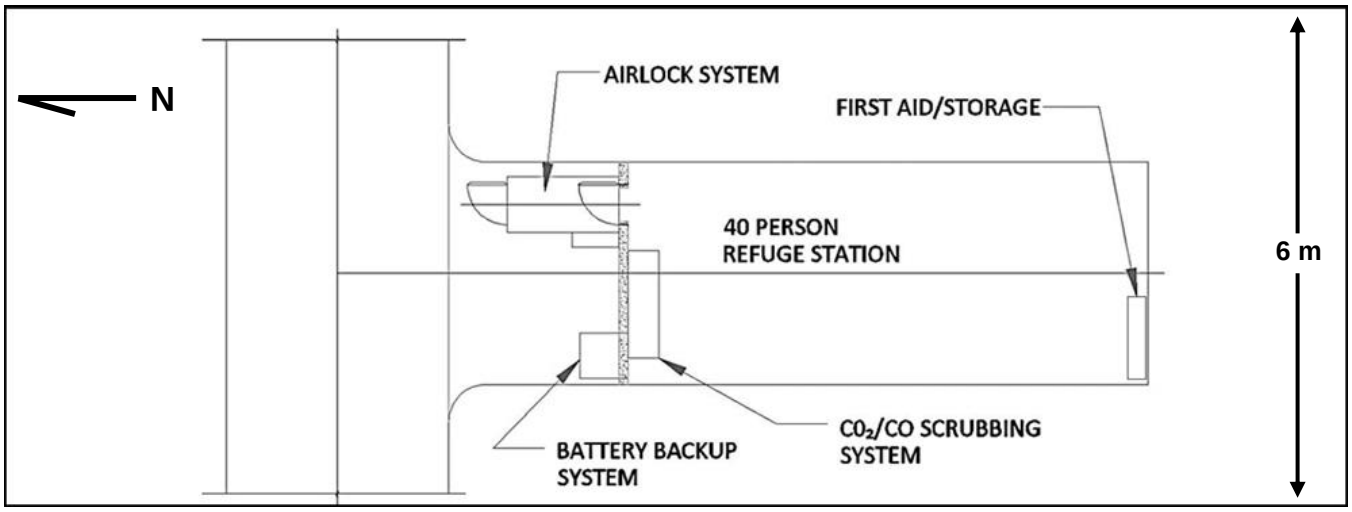
16.8.10 Refuge Stations

A refuge station (Figure 16-25) is located between the decline and incline drifts at the Valley of the Kings Zone. The station accommodates 40 people and is equipped with an airlock entrance, a battery back-up electrical system, an air conditioning unit, a carbon dioxide/carbon monoxide scrubbing unit, cache of oxygen-type cylinders, and emergency supply of first aid, food, water, and oxygen candles.

The refuge station is located in a bay off a drift and is separated from the drift by a concrete wall. Access to the station is through an airlock system.

This refuge station is also used as a lunchroom.

Figure 16-25: Permanent Refuge Station



Source: Pretivm (2019)

16.8.11 Communications

16.8.11.1 Fiber Optics and Phone and Radio Communications

The mine has a multifaceted communications system using fiber optics as a data/telephony back bone and leaky feeder for voice communications for crew.

The underground network infrastructure consists of:

- Fiber optic redundant loops
- Wireless LAN transceivers
- Leaky feeder radio communications system.

Radio communications is a leaky feeder system using Motorola digital hand and base mobile radios for voice communication throughout the mine.

16.8.11.2 Personnel and Equipment Tracking

Personnel tracking is accomplished via the wireless access point (WAP) installation throughout the mine and interrogating devices to allow location tracking of personnel and vehicles. The system will be integrated into a browser-based tracking and reporting application, allowing operators and mine controllers to monitor, track and allocate personnel and resources. Having the ability to ensure that mine staff are accounted for in an emergency increases safety and speeds up the provision of help to any potentially injured personnel. Tracking vehicles and assets also leads to increased productivity and efficiency by eliminating time wasted looking for equipment underground.

16.8.11.3 Fixed Plant Monitoring and Control

Programmable logic controllers (PLCs) will be used for fixed plant monitoring and control. Remote PLC racks are placed near equipment (as necessary) and will monitor and control the underground systems, including but not limited to:

- Rock box levels
- Crusher
- Conveying equipment
- Magnet
- Substations
- Sumps and pumps
- Ventilation equipment.

The fibre optic backbone throughout the mine provides a means for monitoring the remote PLCs from surface from both the mill control room as well as other dedicated supervisory control and data acquisition (SCADA) systems.

16.8.12 Portal Structure

The portal structure has been constructed at the access to the underground Valley of the Kings decline tunnel. The structure houses a mine air heater and ventilation fan, the top conveyor drive motor and structure, an electrical substation, and the access way for vehicles to enter the Valley of the Kings portal though the building. The main decline conveyor exits up from the portal and transfers ore to the mill feed conveyor. This transfer is located inside the portal structure. Access into the portal structure is via one of four overhead doors and man doors. The portal structure was built up against the mill site high wall and to resist roof snow loads with pressures up to 400 kg/m^3.

A monorail located in the ceiling of the portal structure allows for removal of the mine air fan motor and components.

16.8.13 Heating System and Propane Storage

The electrical energy is used to run mine air heaters, with propane supplementing the electric heater during colder ambient temperatures, when the electricals cannot maintain the temperature set point to provide above freezing air to the mine. The propane for the two heaters is stored in two vertical storage tanks in both the Valley of the Kings portal area and the West Zone area. The tanks are located in accordance with regulatory clearance requirements to the mine portals. Each of the two tank farms contains two tanks with a capacity of 68,180 L each or a total of 136,360 L per tank farm.

16.8.13.1 Climatic Data

In the 2014 FS (Ireland et al. 2014), climactic data from site was analyzed to quantify the amount of annual electric power and propane required for mine air heating. This established the operating parameters for the currently installed mine heaters. Reviewing the current year of data shows that the design parameters was within 10% of actual. The volumes will change depending on the severity of the temperature experienced at the mine site year to year.

16.8.14 Propane Supply

Mine air heating is the only consumer of propane for the underground operations. Surface infrastructure, including the camp, requires propane; however, storage of propane for this purpose is independent of mine air heating. Table 16-15 shows the first and second full-year monthly and annual propane consumption for mine heating during steady state operations.

Table 16-15: 2018 Propane Consumption

Month	Propane Consumption 2018 (L)	Propane Consumption 2019 (L)[(1)]
January	115,226	202,375
February	267,534	119,410
March	147,316	277,386
April	15,469	0
May	8,122	0
June	8,787	550
July	0	4855
August	0	0
September	961	13,082
October	0	0
November	0	5,704
December	58,670	55,381
Total	**622,084**	**678,743**

Note: [(1)]Based on delivery dates.

Propane for mine air heating is delivered to site approximately seven months of each year. The propane is delivered to site via the Brucejack Access Road.

The propane supplier remotely monitors the levels in the propane farms and initiates a tank fill as required to ensure there are adequate supplies at the mine site at all times.

A 50,000 L propane delivery truck drives from Terrace, BC to the Brucejack Gold Mine site, and the delivery truck transfers propane into the various site tank farms. The site tanks supply propane to the heaters via a buried pipeline.

The frequency of propane delivery is dependent upon the air temperature and airflow volume required for the mine. During the coldest months of the year, January and February, at the maximum airflow volume, the mine air heaters consume approximately 5,500 L of propane each day of the month.

16.9 Paste Fill Distribution

Paste from the surface plant is fed to the underground stopes through a pipeline system. The paste was characterized through laboratory rheology testing on un-cemented paste samples.

The paste fill distribution requires a two-stage pumping system. A positive displacement pump in the paste fill plant provides paste to all of the West Zone (West Zone Upper and West Zone Lower) and the lower zones of the Valley of the Kings Zone (below the 1,350 m level). The paste plant pump also feeds a booster pump located near the ramp to Valley of the Kings Zone. This booster pump pumps paste up to the Upper Valley of the Kings Zone and Galena Hill (1,350 m level and above). Due to line resistance of longer pipelines to the stopes, the booster plant will be required to pump paste below the 1,350 m level.

The paste pumps are positive displacement piston pumps of 100 m^3/h peak capacity with a pressure rating of 120 bar. The nominal flow rate for the system is 80 m^3/h, with a nominal design supply rate of 112 dmt/h.

The underground booster pump station currently has one pump installed and includes a pump feed hopper, a water tank with a high-pressure pump for pipeline flushing, and a level platform for changing the distribution routing through the mine. A second pump is on order and will be installed as backup.

If there is an upset during pasting operations, there are two points that can be used to allow an emergency drain of the system to prevent the pipe system from plugging. The first point is located at the low point in the line between the mill and the 1,345-level booster station and the second point is located at the first low point after the booster station for the lines going into the upper part of the mine.

Instrumentation installed to ensure controlled operation includes pressure sensors on each operating level, cameras to allow the control room vision of conditions at the booster pump, power activated diversion valves and manual diversion stations, and integrated process control within the paste fill plant.

This paste fill distribution system provides paste to the stopes at a nominal yield stress of 250 Pa with a range of 100 to 375 Pa. This equates to cemented paste percent solids of 66.1% solids by weight (ranging from 62 to 69% solids by weight).

The piping specified for this distribution system is 8 in API 5L X52. The schedule of the pipe varies with the pressure rating of the area: borehole casing and loops in the Upper Valley of the Kings Zone levels are Schedule 120, while the Lower Valley of the Kings Zone and all the West Zone casing and loops are Schedule 80. The main drift piping (trunk) and level piping to the stopes is Schedule 80 and Schedule 40, respectively. Victaulic couplings are used as the connection method for the level distribution lines.

16.9.1 Distribution System Design

The pipe routing for the underground distribution system (UDS) was developed taking into consideration site conditions, pipeline operation experience, and hydraulic modelling. Some of the conditions that were taken into account in the design include:

- The difficulty foreseen in accessing any trenched pipelines on surface due to site conditions, especially during winter months
- The mining schedule, which defines that the Valley of the Kings Zone will be developed in the early years while the West Zone will only be developed in the second half of the LOM

- The long distance from the paste fill plant to the underground workings (more than 800 m)
- The location of the paste fill plant below the elevation of the top third of the Valley of the Kings Zone.

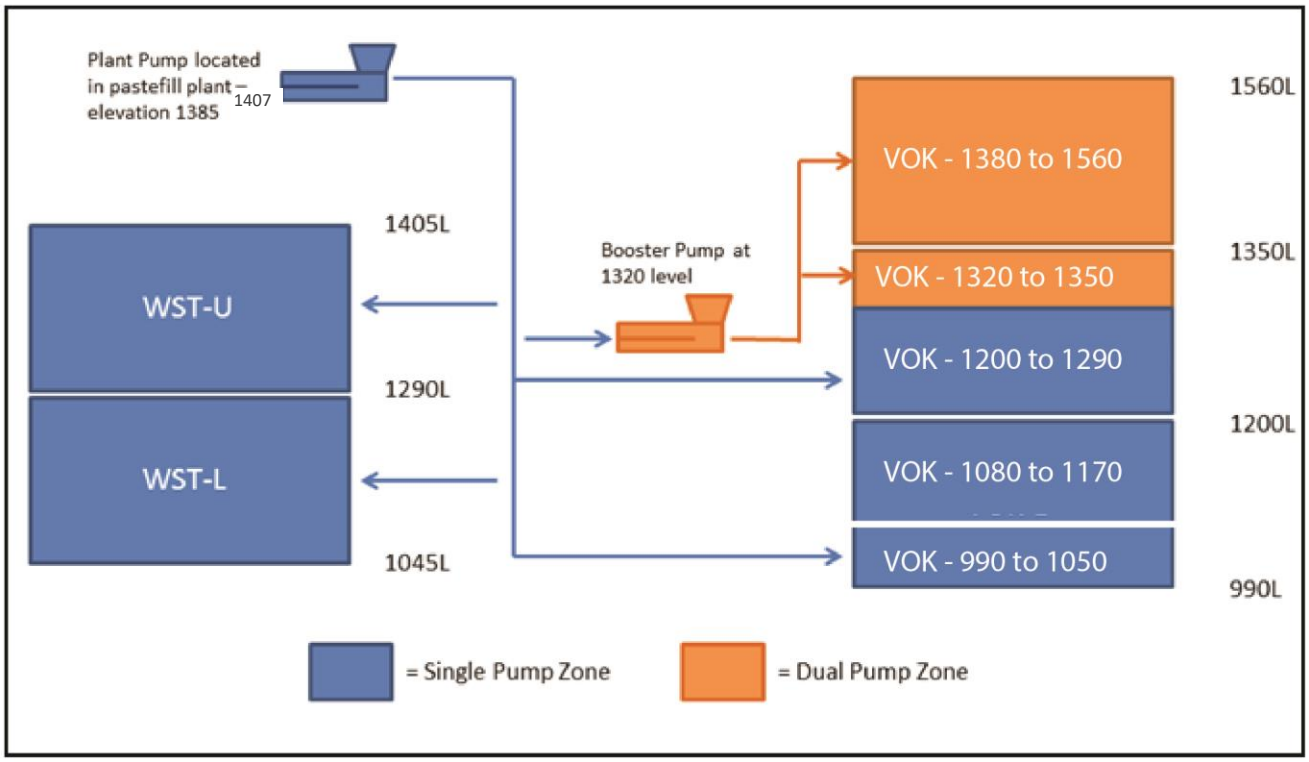
The mining schedule breaks down the Brucejack orebody into six areas: VOK-990 to 1050, VOK-1080 to 1170, VOK- 1200 to 1290, VOK-1320 to 1560, WST-U, and WST-L, as shown with their respective elevations in Figure 16-26 and Figure 16-27. The first areas to be mined will be the VOK-1200 to 1290, and VOK- 1320 to 1560, which are currently being mined. Production in VOK-1080 to 1170 will start in Year 2 (2020), while the WST Zones will only come online after Year 8 (2026). The Valley of the Kings Zones have continuous production scheduled until end of mine life. The paste fill distribution system was designed with the schedule shown in Table 16-5 in mind.

The main challenge for the Brucejack paste fill distribution system is that a portion of the orebody is located above the elevation of the paste fill plant. A balance in strategy is required to ensure that paste can be pumped to this section of the orebody without compromising the quality and proper flow distribution to the rest of the mine.

16.9.2 Distribution Approach

The philosophy developed for the paste fill distribution system is a dual pumping system. This optimizes the pumping capacity and minimizes wear on the paste pumps. A positive displacement pump in the paste fill plant will provide paste to all of the West Zone (WST-U and WST-L) and the Lower Valley of the Kings Zone (below the 1,350 m level). The paste plant pump will also feed the booster pump located near to the main entrance to the Valley of the Kings Zone on the 1,345 m elevation level. This booster pump pumps paste up to the Upper Valley of the Kings Zone (1,350 m level and above). Figure 16-26 shows the breakdown of the Brucejack Deposit ore zones by the paste pumps feeding them: single pump zone and dual pump zone.

Figure 16-26: Paste Fill Distribution System Schematic Showing Paste Pumping Zones



Modified from AMC (2014)

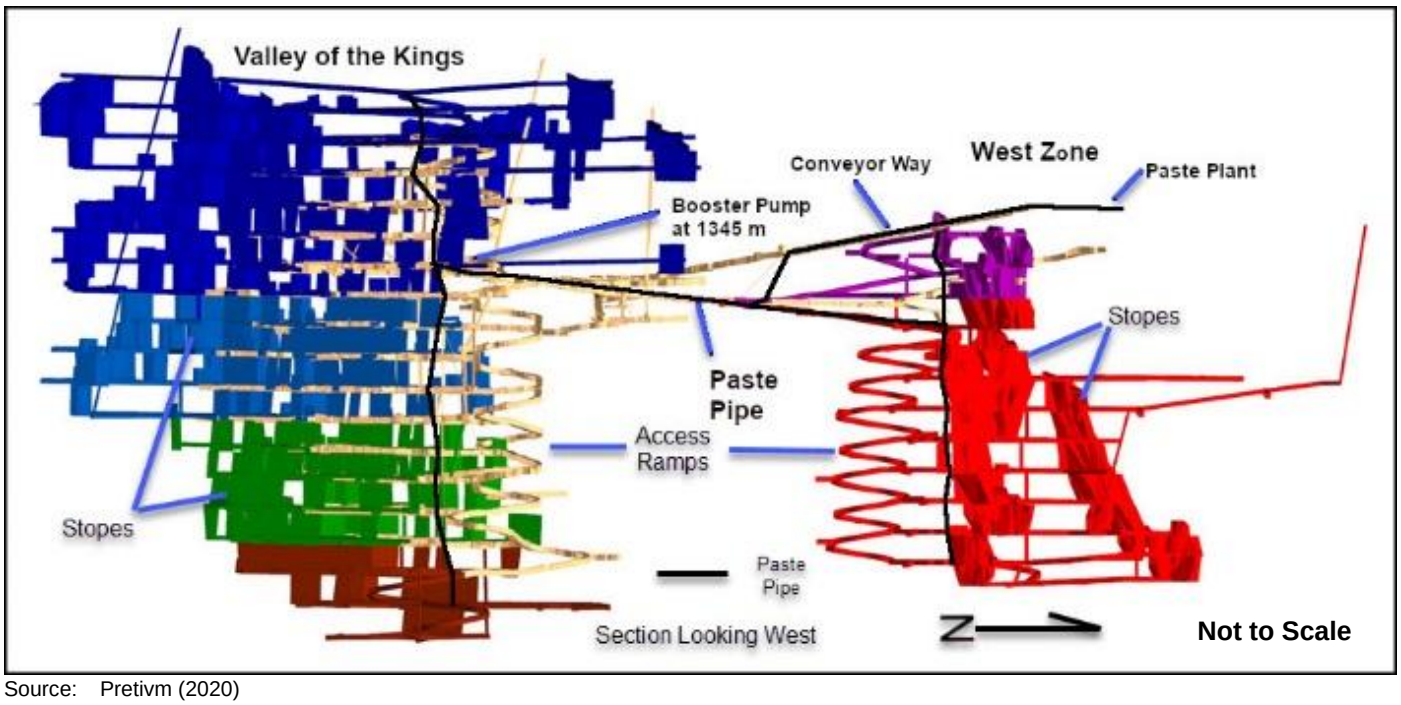
16.9.3 Distribution System Layout

The underground perspective view of the paste fill distribution system is provided in Figure 16-27.

Key points of the piping strategy are:

- One pump plus installed spare at the paste fill plant
- One booster pump plus spare to be installed near the ramp to the Valley of the Kings Zone 1,345 m elevation
- Main distribution pipeline in the Valley of the Kings decline and then a bore to the West Zone Access Drift then to the Valley of the Kings Zone
- One sump to divert paste from the pipeline during operation upsets.

Figure 16-27: Paste Fill Distribution System Schematic



Source: Pretivm (2020)

16.9.4 Manpower Requirements

16.9.4.1 Schedule

The mine is operated by a mining contractor with Pretivm supplying operational oversight and technical service support personnel.

As the Brucejack Gold Mine site is remote, a reasonable crew rotation is required to attract the skilled labour that will be necessary for operations. The Pretivm crews are on a two-week-in, two-week-out rotation, and the contractor crews operate on a three-week-in and three-week-out rotation. The working time per day is based on an 11-hour shift; allowing one hour for smoke to clear after end-of-shift blasting. However, the effective working time per day is less than 11 hours considering travel time, daily safety briefs, and pre-start safety checks. The effective working time per shift during production operations is nine hours.

To operate an 11-hour shift, a variance has been granted from the BC Government (to allow work over 8 hours per shift). The current mine contractor has obtained such a variance for the work at the mine.

16.9.4.2 Organization and Manpower

The underground mining group is organized into operational groups consisting of mining, logistics, maintenance, and technical support with mining logistics and maintenance under the contractor, and the operations contract management and technical support under Pretivm. Table 16-16 shows the total personnel underground required by the operational group currently at the mine at full steady state production of 3,800 t/d.

Initial loading will primarily be provided by the mining contractor, with technical support and operations contract supervision provided by Pretivm. Additional hires are personnel employed to compensate for shortages due to vacations, absenteeism, and turnover.

Table 16-16: Manpower by Operational Group

Role	Head Count	Role	Head Count
Mining Supervision (12) Pretivm			
Underground Superintendent	2	Mine Captain	2
Operations Engineer	2	UG Supervisor	2
Safety / Training / First Aid	4		
Contractor Supervision and Support (14)			
Superintendent	2	Engineers/Technicians	4
Administrator	2	Safety/Training	4
Expeditors	2		
Development Crew (132) Contractor			
Development Shift Boss	4	LHD Operators	12
Jumbo Operators	12	Truck Operators	32
Face Screening	7	Water/Fuel Truck Operator	1
Bolter Operators	21	Blasters	9
Pillar Strapping	8	Telehandler Operator	4
Alimak Miners	4	Service Installers	9
Grader Operator	2	Materials Support / Mine Cleanup	3
Shotcrete	4		

table continues…

Role	Head Count	Role	Head Count
Production Crew (110) Contractor			
Production Shift Boss	8	Backfill Services / Bulkhead & Construction Crew	17
Long Hole Drillers	33	Mine Maintenance (Pump/Sumps)	8
Blasters	8	Boom Truck/Services	1
Truck Operators	10	Water/Fuel Truck Operator	4
LHD Operators	17	Paste Watch	4
Maintenance (66) Contractor			
Maintenance Superintendent	1	Welders	2
Master Mechanic	2	Warehouse	4
Mechanics	32	Lead Electrician	2
Mechanic Apprentices	8	Electricians	10
Tire Technician	2	Maintenance Planner	3
Technical Services (64) Pretivm			
Technical Services Manager	1	Chief Engineer	1
Senior Engineer	3	Planning / Ventilation / Drill Blast Engineer	5
Chief Geologist	2	Mine Planning & Scheduling	3
Senior Production Geologist	2	Surveyors	8
Production Geologist	7	Geotechnical Engineer	7
Junior Production Geologist	8	Geological Samplers	17
Total Personnel	**398**		

17.0 RECOVERY METHODS

17.1 Mineral Processing

17.1.1 Introduction

The Brucejack Deposit mineralization typically consists of quartz-carbonate-adularia, gold-silver bearing veins, stockwork and breccia zones, along with broad zones of disseminated mineralization. Gold and silver are the major economical metals contained in the mineralization. There is a significant portion of gold and silver present in the form of nugget or metallic gold and silver.

The concentrator was designed to process gold and silver ore at a nominal rate of 2,700 t/d with an equipment availability of 92% (365 d/a) using a combination of gravity concentration and conventional bulk sulphide flotation. The Brucejack Gold Mine was successfully commissioned from March to May of 2017, with the first gold pour on June 20, 2017. The process plant reached full operation in Q4 2017. Since then, new test programs have been conducted to further improve the mill operation. In 2018, further throughput increase reviews and test work were conducted by mill metallurgists and engineers, equipment suppliers, and independent consultants to improve the mill operation in an effort to increase the mill throughput to 3,800 t/d. Most of the mill upgrading has been completed, excluding the installation of the third cleaner flotation cell and the new flocculant system, which are currently being installed. As reported, the mill was operated at 4,065 t/d in Q4 2019.

17.1.2 Mill Operation Data

The process flowsheet originally developed for the Brucejack Gold Mine uses a combination of conventional bulk gravity concentration and sulphide flotation. The gravity concentrate is refined in the gold room on site to produce gold-silver doré by directly smelting the upgraded gravity concentrate. The doré is shipped by air to precious metal refineries located worldwide for further processing to produce refined metals for sale. The final flotation concentrate is dewatered, loaded into customized bulk containers and trucked to the transload facility in Stewart, BC. From there, the concentrates in bulk form are shipped to international smelters or traders.

A portion of the flotation tailings is used to make a paste to backfill excavated stopes in the underground mine, and the balance is stored in Brucejack Lake. Water from the concentrate and tailings thickener overflows is recycled as process make-up water. Treated water from the water treatment plant is used for mill cooling, gland seal service, reagent preparation, and make-up water.

In May 2017, ore was first introduced to the mill from the low-grade ore stockpiles with a focus on ramping up tonnage throughout to design capacity. The first gold was poured on June 20, 2017. On July 1, 2017, Pretivm declared commercial production at the Brucejack Gold Mine. Table 17-1 lists the 2019 production data.

Table 17-1: Brucejack Mill Production Data 2019

Time	Mill Feed Tonnage		Mill Feed Grade		Total Recovery	
	Tonne	t/d	(g/t Au)	(g/t Ag)	(% Au)	(%Ag)
Q1 2019	295,122	3,279	8.7	13.3	96.8	85.6
Q2 2019	324,171	3,562	8.9	15.6	96.9	83.8
Q3 2019	309,754	3,367	9.1	14.7	97.0	85.5
Q4 2019	373,954	4,065	8.3	14.1	96.8	85.6
Total 2019	**1,303,001**	**3,570**	**8.7**	**14.5**	**96.9**	**85.1**

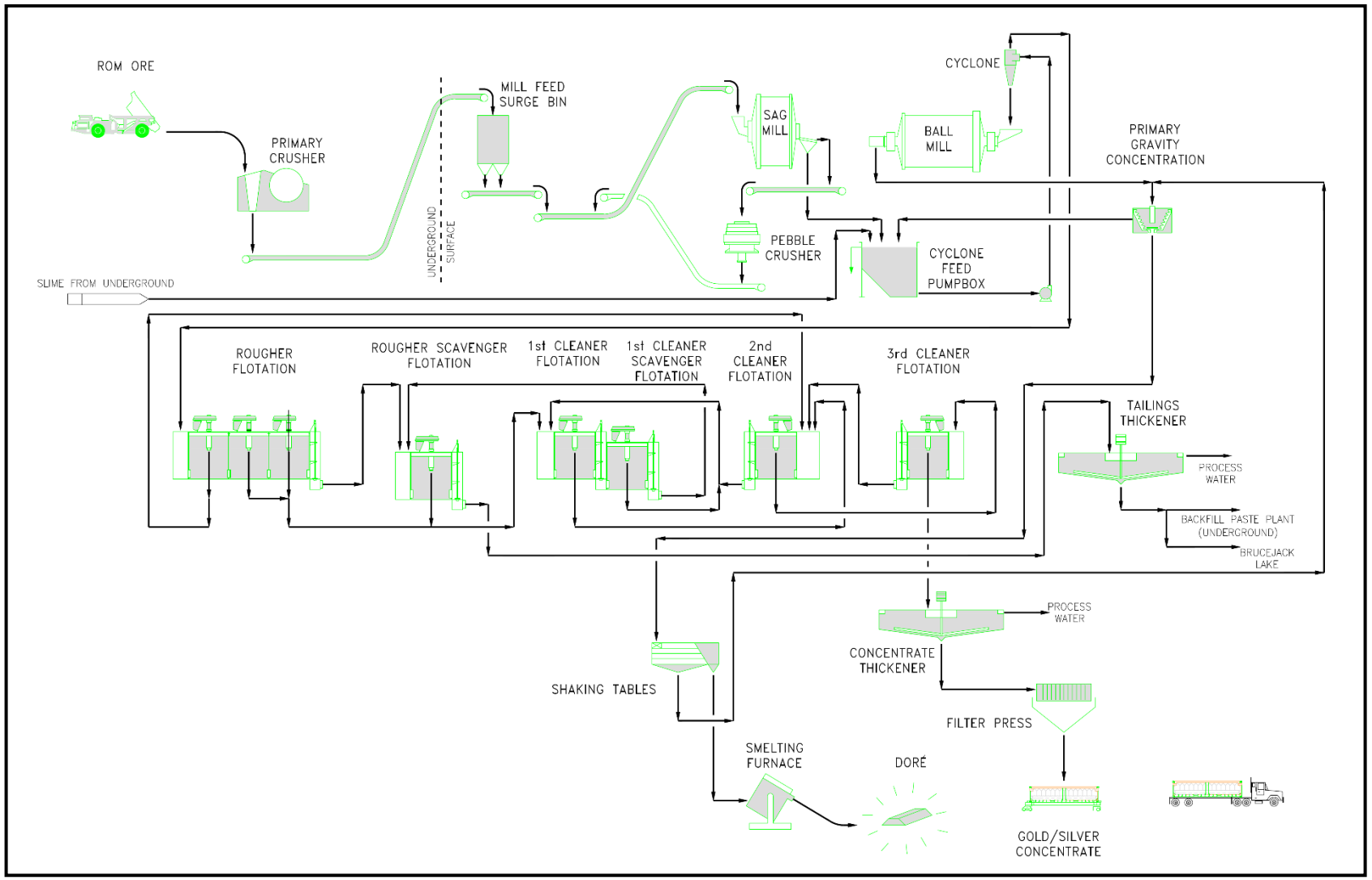
17.1.3 Flowsheet Development

The process flowsheet for the expanded mill (3,800 t/d throughput) is based on the existing operation, new test work and simulations, as well as Tetra Tech's engineering experience.

In 2018, mill throughput increase reviews were conducted by Pretivm's metallurgists and engineers, equipment suppliers, and independent consultants through various supporting test work and simulations. The process flowsheet used in the expanded mill is identical to the existing operation flowsheet, as shown in Figure 17-1. The operation units include:

- One stage of crushing located underground
- A mill feed surge bin with a live capacity of 2,500 t located on surface
- A SABC primary grinding circuit integrated with a gravity concentration circuit
- Rougher flotation and scavenger flotation of the hydrocyclone overflow (gravity separation tailings)
- Cleaner flotation on combined rougher and scavenger concentrates
- Flotation concentrate dewatering
- Flotation tailings dewatering circuits.

Figure 17-1: Simplified Process Flowsheet



Source: Tetra Tech (2019)

17.1.4 Plant Design

17.1.4.1 Major Design Criteria

The nominal throughput of the upgraded process plant is 3,800 t/d of ore at a mill availability of 92%. Table 17-2 outlines the major criteria used to upgrade the process flowsheet.

Table 17-2: Major Design Criteria

Criteria	Unit	Value
Daily Processing Rate	t/d	3,800
Operating Days per Year	d/a	365
Operating Schedule	-	Two shifts/day; 12 hours/shift
Mill Feed Grades – Average	g/t Au	5 to 20
	g/t Ag	5 to 200
	% S	2.85
Primary Crushing (Underground)		
Crushing Availability	%	60
Crushing Product Particle Size, 80% passing	mm	120 or finer
Grinding / Flotation / Gravity Concentration		
Availability	%	92
Milling and Flotation Process Rate	t/h	172
SAG Mill Feed Size, 80% passing	mm	120 or finer
SAG Mill Grind Size, 80% passing	µm	800 to 1,000
Drop Weight Breakage Parameter	A x b	41.4 (ranging 29.1 to 78.7)
Ball Mill Grind Size, 80% passing	µm	100
Ball Mill Circulating Load	%	300
Bond Ball Mill Work Index – Average	kWh/t	14.0
Bond Ball Mill Work Index – Design	kWh/t	16.6
Nugget Gold Recovery from Primary Grinding Circuit	-	Centrifugal and Tabling Gravity Concentration

17.1.4.2 Operating Schedule and Availability

The upgraded process plant is operated on two, 12-hour shifts per day, 365 d/a. The overall availability of the underground primary crusher circuit is 60%. The grinding, flotation, and gravity concentration availability is 92%. The gold room is in operation during the day shift only. These availabilities allow for a potential increase in processing rate, downtime for scheduled and unscheduled maintenance of the crushing and process plant equipment, and potential weather interruptions.

17.1.5 Process Plant Description

17.1.5.1 Primary Crushing (Underground)

The primary crushing facility has an average process rate of 264 t/h at a crushing availability of 60% to meet the increased mill throughput of 3,800 t/d at a closed-side setting of approximately four inches.

The current primary crushing unit is located underground and includes the following major units:

- Hydraulic rock breaker
- Stationary grizzly
- Jaw crusher (150 kW)
- Vibrating grizzly feeder
- Associated dump pocket and belt conveyor
- Belt scales
- A dust collection system.

The ROM ore is trucked from the underground mine to the underground primary crushing facility. The particle size of the jaw crusher feed is typically less than 700 mm. The jaw crusher reduces the ROM material to 80% passing 120 mm or finer.

The crusher product is transported by a conveyor system from the underground primary crushing facility to the SAG mill feed surge bin located on surface. The primary crushing and conveying facilities are equipped with a spray water dust suppression system to control fugitive dust generated during crushing and conveyor loading. The crushing and conveying system are monitored through closed-circuit television (CCTV) and can be controlled by the local control system or from the process central control room located in the process plant.

17.1.5.2 Mill Feed Surge Bin

The SAG mill feed surge bin has a live capacity of 2,500 t. The crushed product from the underground primary crushing facility is first conveyed to the transfer tower, which is part of the portal building on the surface. From there, it is further transported to the SAG mill feed surge bin.

The ore from the mill feed surge bin is reclaimed by two 1,067 mm wide by 15,000 mm long apron feeders onto the SAG mill feed conveyor at a nominal rate of 172 t/h.

The stocking and re-handling system for the crushed ore includes the following major components:

- One jaw crusher discharge belt conveyor
- Two belt conveyors located in the underground and one conveyor located at surface to feed the SAG mill feed surge bin
- One SAG mill feed surge bin with a live capacity of 2,500 t
- Two apron feeders, 1,067 mm wide by 15,000 mm
- Local dust collection systems.

The crushed ore conveyor transfer points at the portal and at the SAG mill surge bin are equipped with a dust collection system to control fugitive dust generated while transporting the crushed material.

17.1.5.3 Grinding, Classification and Gravity Concentration

A SABC grinding circuit has been installed at the mine site and incorporated with two centrifugal gravity concentrators to recover gold/silver nugget grains that are liberated or partially liberated from their host minerals.

The upgraded primary grinding circuit has an average feed rate of 172 t/h at a 92% availability to meet the increased mill throughput of 3,800 t/d and maintain a target product size of 80% passing approximately 100 µm. According to the new comminution tests and simulation results (Section 13.0), the capacity should be readily achieved within the current circuit by:

- Increasing the SAG mill critical speed
- Increasing the SAG mill charge loading
- Placing one of the two stand-by cyclones into operation.

According to the simulations, the grinding mills should be able to achieve approximately 4,240 t/d before the grind size needs to increase to coarser than 80% passing 90 µm.

The two gravity concentrators (Model QS40) have a design unit capacity of 250 t/h. This arrangement also allows the two units to treat 100% of the ball mill discharge at the increased operating rate.

The grinding/gravity concentration circuit includes:

- One SAG mill, 6,096 mm diameter by 3,048 mm long (20 ft. by 10 ft.) (effective grinding length (EGL)), driven by a 2,013 kW VFD
- One ball mill, 3,960 mm diameter by 7,260 mm long (13 ft. by 23.8 ft.) (EGL), powered by a 2,013 kW VFD
- One hp 100 cone crusher
- One 1.83 m wide by 3.66 m long vibrating screen
- Two 10-inch x 8-inch hydrocyclone feed slurry pumps, each with an installed power of 250 hp
- Six 381 mm hydrocyclones (gMax15-3123), with five in operation and one on standby
- Two QS40 centrifugal gravity concentrators and ancillary screens
- Two shaking tables, one secondary Knelson concentrator (CD12), one melting furnace, and related ancillary equipment in the secured gold room
- One particle size analyzer
- One online sampler.

The crushed ore from the surge bin is reclaimed onto the belt conveyor that feeds the ore to the SAG mill. The SAG mill is equipped with 40 mm pebble ports to discharge the fine fraction from the SAG mill. The SAG mill discharge is screened by a vibrating screen, which has an opening of 8.0 mm (slot wide). The oversize from the screen is transported by conveyor to the HP100 pebble crusher. The screen undersize is discharged by gravity to the hydrocyclone feed pump box in the grinding circuit.

The ball mill is operated in closed circuit with hydrocyclones and two centrifugal gravity concentrators. The product from the ball mill is discharged into the gravity concentrator feed pump box. The entire ball mill discharges report to the gravity concentration circuit. The stream is then split into two and each stream feeds to a safety screen with the undersize reporting to one of the centrifugal gravity concentrators. The gravity concentrator tailings, together with the safety screen oversize, flow by gravity to the hydrocyclone feed pump box where the gravity separation tailings join with the SAG mill trommel screen undersize slurry.

The blended slurry in the pump box is pumped to the hydrocyclones for classification. The hydrocyclone underflow returns by gravity to the ball mill. The circulating load to the ball mill is approximately 300%. The particle size of the hydrocyclone overflow, or the product of the primary grind circuit, is 80% passing approximately 100 µm. The pulp density of the hydrocyclone overflow slurry is approximately 33% w/w solids. Steel balls are manually added into the mills on a batch basis as grinding media.

Dilution water is added to the grinding circuit as required. A particle size analyzer monitors and optimizes the operating efficiency, in conjunction with an automatic sampling system and the required instrumentation such as solid density, pressure, and flow rate meters.

17.1.5.4 Rougher and Scavenger Flotation

The pulp from the primary grinding circuit is subjected to conventional flotation to recover the free gold, silver, and their bearing minerals from the hydrocyclone overflow. Flotation reagents are added to the flotation circuits as defined through testing and the existing operation. The flotation reagents include PAX as the collector and D250 as the frother. The mass recovery of the rougher concentrate is approximately 15% of the flotation feed. The concentrates produced from the rougher flotation circuit are sent to the cleaner flotation circuit. The rougher flotation tailings are further floated by scavenger flotation, along with the tailings from the first cleaner flotation circuit. The scavenger concentrate returns to the head of rougher flotation for re-processing or to the first cleaner circuit for upgrading. Rougher and scavenger flotation are carried out at the natural pH level (without slurry pH adjustment).

The upgraded feed rate of the rougher flotation circuit is 172 t/h. The rougher/scavenger flotation circuit includes:

- Four 100 m^3 rougher flotation tank cells
- Two 100 m^3 scavenger flotation tank cells.

The tailings from the rougher scavenger flotation circuit are discharged to the tailings thickener. Depending upon the mining operation requirements, the thickener underflow is pumped either to the paste backfill surge tank for excavated stope backfilling and/or to the tailings disposal surge tank prior to being pumped to Brucejack Lake for storage.

Automatic sampling systems installed for the circuits, including the flotation feed, rougher scavenger tailings, and final flotation concentrate, collect the samples required for process optimization and metallurgical accounting.

17.1.5.5 Cleaner Flotation

In the current operation, the rougher and scavenger flotation concentrates undergo three stages of cleaning by flotation in order to produce the final gold-silver bearing concentrate.

The feed rate of the cleaner flotation circuit is estimated to be approximately 44 t/h. As per the planned upgrading in 2018, to meet the increased mill feed rate, the existing second and third cleaner cells need to be converted for the second cleaner flotation and operate in series. A new 30 m^3 flotation cell is required for the third cleaner flotation. The third cleaner cell is currently being installed.

The rougher/scavenger flotation circuit includes:

- Four 15 m^3 tank cells for the first cleaner flotation
- Two 15 m^3 tank cells for the first cleaner/scavenger flotation
- Two 15 m^3 tank cells for the second cleaner flotation
- One 30 m^3 tank cell for the third cleaner flotation.

The rougher concentrate together with the scavenger concentrate are initially upgraded in the first cleaner tank cells. As an option, the current operation can also direct the rougher-scavenger concentrate to the rougher flotation head depending on the flotation feed mineralogy. Also, based on the concentrate grade of the first rougher flotation cell, the rougher concentrate can bypass the first cleaner flotation and report to the second cleaner flotation directly.

The first cleaner concentrate is pumped to the second cleaner circuit, while the first cleaner tailings reports to the first cleaner scavenger flotation cells for further concentration. The first cleaner scavenger flotation concentrate is returned to the head of the first cleaner flotation cell bank, joined with the rougher and scavenger flotation concentrates and the second cleaner tailings. The first cleaner scavenger flotation tailings are pumped back to the rougher scavenger flotation feed box.

The concentrate from the second cleaner flotation stage is further upgraded by the third cleaner flotation with a new 30 m^3 flotation cell; the second cleaner tailings is pumped back to the first cleaner flotation. The concentrate from the third cleaner flotation cell, the final concentrate product, is pumped to the concentrate thickener. The third cleaner tailings are recycled back to the head of the second cleaner flotation circuit.

The reagents used in the primary bulk flotation circuits are also added to the three stages of cleaner flotation to float the target minerals. The cleaner flotation processes are carried out at the natural slurry pH level.

17.1.5.6 Gravity Concentrate Upgrading/Refining

The primary gravity concentrate is further upgraded and refined in the gold room, which is located within a security room and has 24-hour CCTV surveillance. The access to the gold room is only for authorized personnel.

For the increased plant feed throughput of 3,800 t/d, it is anticipated that the gold room treatment capacity is able to meet the increased gravity concentrate production by extending the operating time.

Key equipment in the gold room includes:

- One 1.8 m wide by 4.9 m primary gravity concentration table
- One Knelson CD-12 centrifugal gravity concentrator

- One 1.7 m wide by 2.7 m secondary gravity concentration table
- One table concentrate dryer
- Flux reagent storage
- One flux mixer
- One 138 kW induction melting furnace
- One vault for storing doré and table concentrate
- One electrostatic dust collector
- One off-gas and dust scrubbing system
- Ancillary equipment, including slag treatment devices.

The primary gravity concentrate is pumped to the gold room for further upgrading by tabling on the 1,800 mm wide by 4,900 mm long shaking table. The tailings from the primary tabling is further processed by the CD12 centrifugal concentrator and the table middlings is recycled back to the table feed surge bin. The concentrate produced from the secondary centrifugal concentrator is upgraded using a 1,700 mm wide by 2,700 mm long shaking table while the centrifugal concentrator tailings are pumped to the hydrocyclone feed pump box. The secondary table tailings are pumped to the primary table feed surge bin. The concentrates from both the primary and secondary tables, which are the final products, are dried and melted in the induction furnace to produce gold-silver doré. The discharge from the furnace is poured into bar molds in a cascade-casting arrangement. The gold doré bars are weighed, sampled, and stored in the vault prior to being shipped to refineries.

The concentrates from both the tables are dewatered, dried in a dryer, then weighed and stored in the vault prior to smelting.

The existing wet scrubbing system is used to clean the off-gas generated during the drying, calcination, mixing, melting, and slag crushing operations. The equipment used for these processes are equipped with hoods. Sufficient ventilation is provided in the gold room to protect the operators. All clothes, gloves, and other safety equipment necessary for high-temperature protection are provided to the operators working in the secure area.

17.1.5.7 Concentrate Handling

The concentrate from the third cleaner flotation is thickened, filtered, and loaded into customized bulk containers prior to being transported to off-site smelter(s).

The current concentrate dewatering system is expected to be able to handle the increased tonnage with diluting the thickener feed to 15% w/w and using a more efficient flocculant at recommended dosages. It is expected that the existing concentrate filtration capacity is sufficient for the increased mill feed rate with upgrading the filtration system, including adding two additional filter plates.

The concentrate dewatering/handling facility includes the following equipment:

- One 5 m diameter high-rate thickener
- Three thickener underflow slurry pumps, two in operation and one on standby
- One concentrate filter feed stock tank (5,000 mm diameter by 6,000 mm high)

- One tower-type pressure filter with a total filtration area of 25 m^2
- One concentrate cake handling system.

The final flotation concentrate is pumped to the concentrate thickener. Flocculant is added to the thickener feed well to aid the settling process. The thickened concentrate is pumped to the concentrate stock tank. The underflow density of the thickener is approximately 70% solids. The concentrate stock tank is an agitated tank, which serves as the feed tank for the concentrate filter. A tower-type press filter is used for further concentrate dewatering. The filter press reduces the moisture content of the thickener underflow to approximately 8%. The filter press solids are discharged into a bulk container. The loaded containers are stacked in the concentrate loading area prior to being loaded into vehicles with chained tires and transported to the Knipple Transfer Station, then to Stewart, BC. The concentrate is then transported in bulk by sea to international smelters or traders. The process plant provides sufficient on-site storage capacity for up to 10 days of production in the event of unexpected transportation disruption. Additional secured storage is also provided at the Knipple Transfer Station.

The filtrate from the pressure filter is circulated back to the concentrate thickener feed well as dilution water. The overflow from the thickener is pumped to the process water tank or to the grinding circuit for re-use as process water.

17.1.5.8 Tailings Disposal

The final tailings is pumped to an 18 m deep cone thickener where most of water is removed as thickener overflow and re-used in operation. Part of the thickened tailings, approximately 40 to 50% of the overall tailings, is pumped to the paste backfill feed surge tank prior to feeding the paste plant for underground mine backfilling. The remaining thickened tailings is pumped to Brucejack Lake for storage.

At an increased process plant feed rate of 3,800 t/d, based on the completed test results and simulations, the existing 18 m tailings thickener is capable of handling the capacity by using proper feed conditioning, including feed dilution and the use of the optimum flocculant type at recommended dosages. The projected solids density of the tailings thickener underflow is approximately 65% by weight.

The existing tailings handling facility has the following equipment:

- One 18 m diameter deep cone thickener
- One 4 m diameter by 5 m high disposal surge tank for the tailings that is discharged to Brucejack Lake
- One 11.0 m diameter by 11.6 m high thickener underflow stock tank
- Two thickener underflow positive displacement (PD) pumps, each with an installed power of 20 hp
- Two thickener underflow recycle PD pumps, each with an installed power of 20 hp
- Two tailings disposal pumps with an installed power of 75 hp.

The flotation tailings are pumped directly from the pump box in the flotation circuit to the tailings thickener feed well where the tailings are diluted in an inner dilution launder and flocculant is added to improve settling efficiency. The thickener underflow is pumped to a 11 m diameter by 11.6 m high thickener tailings stock tank. The thickened tailings are pumped to the tailings disposal tank and then pumped to Brucejack Lake for storage. When the backfill plant is in operation, the tailings are also pumped to the paste plant fully or partially based on the paste plant requirement. The thickener overflow is sent to the process water tank for re-use as process water.

17.1.5.9 Reagent Handling and Storage

PAX and D250 are added to the flotation process slurry stream to modify the chemical and physical characteristics of mineral particle surfaces, and to enhance the floatability of the valuable mineral particles into the concentrate products.

PAX is shipped to the mine site in solid form. A 20% reagent solution is made by mixing PAX with fresh water in a mixing tank. The reagent solution is stored in a 1.50 m diameter by 1.50 m high holding tank and added to the various addition points through metering pumps. The PAX consumption is in the range of approximately 50 to 80 g/t milled.

D250 in liquid form is added directly into the flotation cells without dilution through metering pumps. The dosage applied is approximately 20 g/t milled.

Flocculant is used as a settling aid for the flotation concentrate and tailings thickening. The existing flocculant system is being replaced with a larger unit, which is currently being installed, for the higher process rate requirement. Solid flocculant is prepared in the standard manner in a wetting and mixing system to a dilute solution of less than 0.2% solution strength. The solution is stored a holding tank prior to being pumped to the thickener feed wells. The flocculant dosages added to the concentrate and tailings thickeners are approximately 15 to 20 g/t concentrate and 60 to 80 g/t milled, respectively.

Hydrated lime is used to prepare an alkaline solution for scrubbing.

Anti-scalant chemicals are delivered in liquid form and added to the process water tank as required to minimize scale build-up in the water pipelines and process equipment. This reagent is added in undiluted form.

17.1.5.10 Assay and Metallurgical Laboratory

The assay laboratory, located at the Knipple Transfer Station, is equipped with the necessary analytical instruments to provide all routine assays for the mine, process plant, and environmental department.

A metallurgical laboratory is located in the mill to undertake the necessary test work to monitor metallurgical performance and, more importantly, to improve process flowsheet unit operations and efficiencies.

17.1.5.11 Water Supply

Two separate water supply systems are provided to support the operations for the process plant: one fresh water supply system and one process water supply system.

Fresh Water Supply System

Fresh water is supplied to a fresh/fire water storage tank (10 m diameter by 11 m high) from the water treatment plant or from Brucejack Lake. Fresh water is primarily used for:

- Fire water for emergency use
- Cooling water for mill motor and mill lubrication systems
- Gland water for the slurry pumps
- Reagent make-up
- Process water make-up.

The fresh/fire water tank is equipped with a standpipe for fire water requirements.

Wells supply water to the mine site potable water supply system. The water is sanitized and stored in potable water storage tanks prior to delivery to various service points within the mill and camp.

Process Water Supply System

The overflow solution from the tailings thickener is pumped to the process tank (8,000 mm diameter by 8,000 mm high) and re-used in the process circuit. The water treatment plant, which treats water from the mine (underground water), water collected from the plant site, or from Brucejack Lake, as required, provides the balance of the process water.

17.1.5.12 Air Supply

The air system supplies air to the following service areas:

- Crushing circuit – An air supply system located underground supplies high-pressure air for dust suppression and equipment services.
- Flotation – Air blowers provide low-pressure air for flotation cells.
- Filtration circuit – Dedicated air compressors provide high-pressure air for filtration and drying.
- Plant air service – Dedicated air compressors provide high-pressure air for various services.
- Instrumentation – Plant air compressors provide service air that is dried and stored in a dedicated air receiver.

17.1.5.13 Process Control and Instrumentation

There is a central control room in the mill office complex that can monitor and control plant operations, including the underground crushing and conveying systems. CCTV cameras are installed at various locations throughout the plant.

Sampling and Inline Analysis

The process plant relies on the on-stream or in-stream particle size analyzer and various flow rate and solid density meters for process control. The analyzer and meters examine the various slurry streams in the circuit. The on-stream particle size monitor determines the particle sizes of the hydrocyclone overflows in the primary grinding circuit. Required samples are taken in order to control hydrocyclone overflow particle size and optimize the grinding circuit operations. Specific samples taken for metallurgical accounting purposes include the flotation feed to the circuit, the final tailings, the final concentrate sample, and occasionally the middling products. These samples are collected on a shift-basis and assayed in the assay laboratory.

17.2 Annual Production Estimate

The process plant generates two products: gold-silver doré and gold-silver bearing concentrate for the expected remaining LOM of 13 years. Table 17-3 shows the annual metal production, which has been projected based on the mining production plan outlined in Section 16.0 and the operation data and metallurgical results outlined in Section 13.0. Based on the annual average and excluding the last year of operation, the process plant is estimated to produce approximately 6,261 kg Au and 4,618 kg Ag contained in doré, and 67,874 t Au-Ag bearing flotation concentrate with average grades of approximately 50 g/t Au and 887 g/t Ag. The arsenic content of the flotation concentrates to be shipped to the smelter(s) is expected to be marginally higher than the penalty thresholds outlined by most smelters and will require further review.

Table 17-3: Projected Gold and Silver Production

Year	Tonnage (kt)	Mill Feed Grade		Metal Recovery to Doré and Flotation Concentrate						Flotation Concentrate		
				Doré		Concentrate		Total		Tonnage (dmt)	Grade	
		(g/t Au)	(g/t Ag)	(% Au)	(% Ag)	(% Au)	(% Ag)	(% Au)	(% Ag)		(g/t Au)	(g/t Ag)
2020	1,387	8.3	13.7	61.9	24.5	34.4	59.9	96.3	84.4	85,913	46.3	132.8
2021	1,387	8.6	9.3	64.5	35.4	32.0	53.6	96.5	89.0	81,858	46.8	84.9
2022	1,387	8.6	10.7	64.8	32.6	31.8	55.3	96.5	87.9	81,314	46.7	100.5
2023	1,387	8.6	11.4	65.5	30.6	31.1	56.3	96.6	86.9	79,974	46.3	111.3
2024	1,387	8.4	14.0	64.3	24.5	32.2	63.5	96.5	88.1	81,237	46.4	151.8
2025	1,387	8.6	51.8	62.8	7.5	33.7	82.2	96.4	89.7	81,885	48.8	721.1
2026	1,387	8.4	98.1	60.1	4.4	36.1	85.7	96.2	90.1	74,382	56.8	1566.0
2027	1,387	8.6	88.5	62.4	4.4	34.0	86.2	96.4	90.6	70,757	57.3	1496.3
2028	1,387	8.6	57.4	62.9	5.9	33.4	83.6	96.2	89.5	68,626	58.0	969.5
2029	1,040	8.4	110.1	61.4	4.0	34.9	87.2	96.3	91.2	53,554	56.9	1864.3
2030	1,040	7.4	122.1	57.5	3.6	38.5	87.6	96.0	91.2	59,296	50.2	1875.0
2031	693	7.2	159.3	55.5	3.1	40.4	88.1	95.9	91.2	40,495	50.0	2402.9
2032	380	7.0	231.0	55.3	2.6	40.5	89.7	95.9	92.4	23,065	46.9	3412.2
Total	**15,637**	**8.4**	**59.6**	**62.3**	**6.4**	**34.0**	**84.0**	**96.3**	**90.4**	**882,357**	**50.4**	**887.1**

18.0 PROJECT INFRASTRUCTURE

18.1 Overview

The Brucejack Gold Mine is situated approximately 65 km north-northwest of Stewart, BC. During construction from 2015 to 2017, a number of on-site and off-site infrastructure were built to support the mining operation (Figure 18-1, Figure 18-2, and Figure 18-3). The locations of operation and supporting facilities and infrastructure were selected to take advantage of local topography, accommodate environmental considerations, avoid avalanche hazards, and ensure efficient and convenient underground crew shift change.

The Brucejack Gold Mine is accessed via a 73.5 km access road that intersects Highway 37 at km 215, some 60 km north of Meziadin Junction. Electrical power is supplied from the BC Hydro grid via a 57 km transmission line constructed in 2016/2017, from the Long Lake Substation located 13 km north of Stewart, BC. The transmission line is a 138 kV power supply line from the Long Lake Hydro Substation to the Knipple Substation, with a 69 kV power supply line from the Knipple Substation to the mine distribution centre.

Facilities and infrastructure are split between those at the Brucejack Gold Mine site and those along the Brucejack Access Road. Infrastructure at the mine site includes mill; camp; fire hall; warehouse; transmission power line power distribution; emergency diesel power station (DPS); fuel farm; waste management facilities, including incinerator; mobile equipment maintenance shops; underground miners support facility; explosives storage; mine ventilation and heating equipment; water management facilities; potable and wastewater treatment facilities; ore storage; and waste rock/tailings storage facility (WRTSF).

Support facilities along the Brucejack Access Road are located at the Knipple Transfer Station, Bowser Aerodrome, and Wildfire Camp. The Knipple Transfer Station is the main hub for materials staging and transfer to suitable vehicles for delivery to the Brucejack Gold Mine. Facilities at the Knipple Transfer Station include the transmission line stepdown substation, camp, cold storage building, potable water supply and treatment, waste materials handling facility with incinerator, fuel storage and distribution facility, paste binder silos, assay laboratory, emergency vehicle storage, first aid facility, and sewage disposal system.

The Bowser Aerodrome is a 5,000 ft. long by 75 ft. wide gravel airstrip suitable for such aircraft as a Beechcraft 1900, or similar speed and weight category aircraft, or Twin-Otter type aircraft. Adjacent to Bowser Aerodrome were Bowser, Bowser Temporary Construction, and Bowser West Camps. Bowser Camps were used for mineral exploration crews and construction crews. The general site was used for extensive laydown of equipment for mine and transmission line construction and is currently used for mobile equipment, core, and spare parts storage.

Wildfire Camp is at km 1 on the Brucejack Access Road. Wildfire Camp comprises a gate at the highway intersection to screen access, a security building with gate for access control, camp, potable water well with water treatment, sewage disposal system, and large laydown yard for incoming and outgoing freight. Just west of Wildfire Camp (at km 1.5), there is an area designated for paste binder storage and transfer.

Figure 18-1: Brucejack Gold Mine General Arrangement

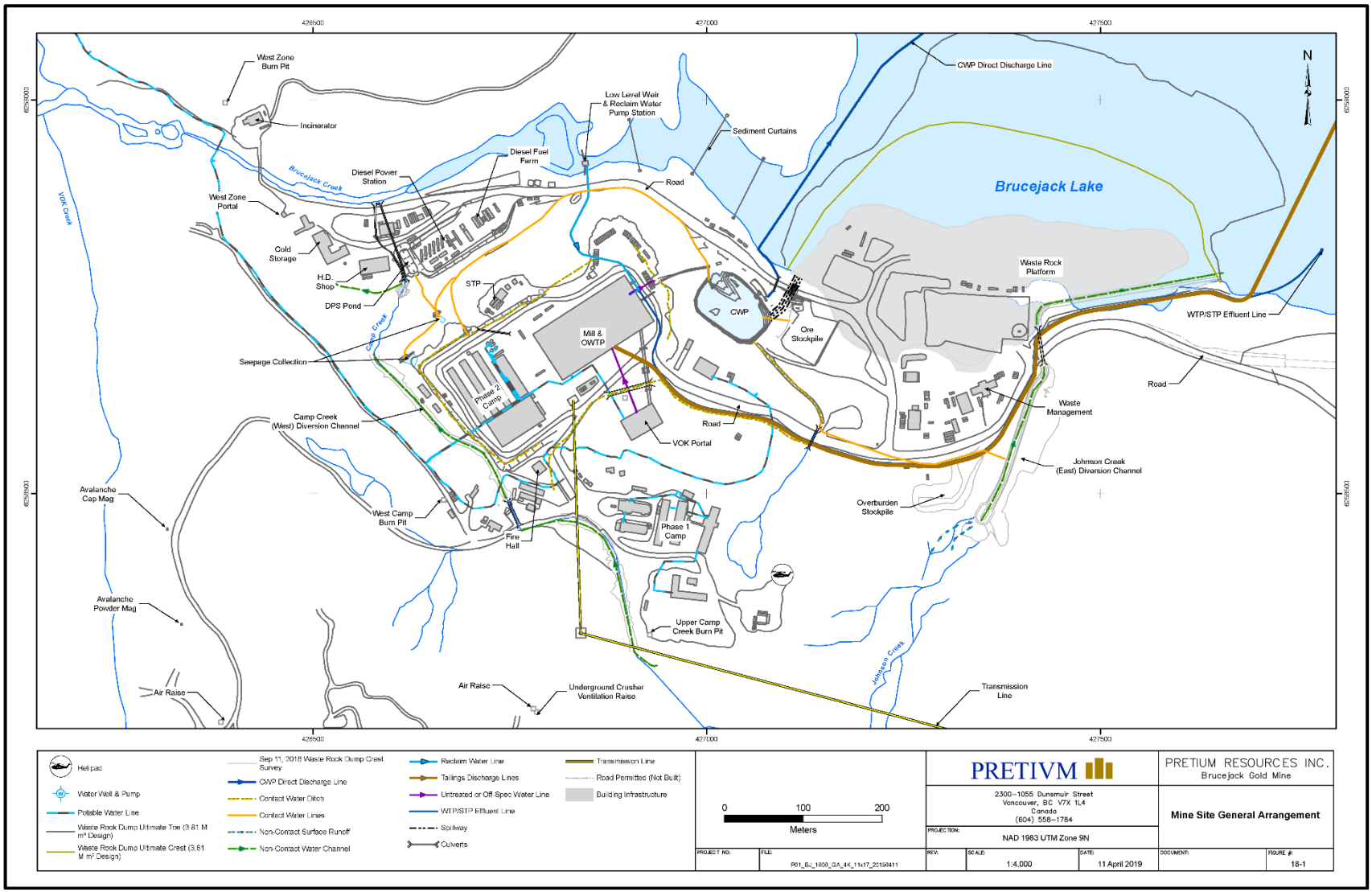
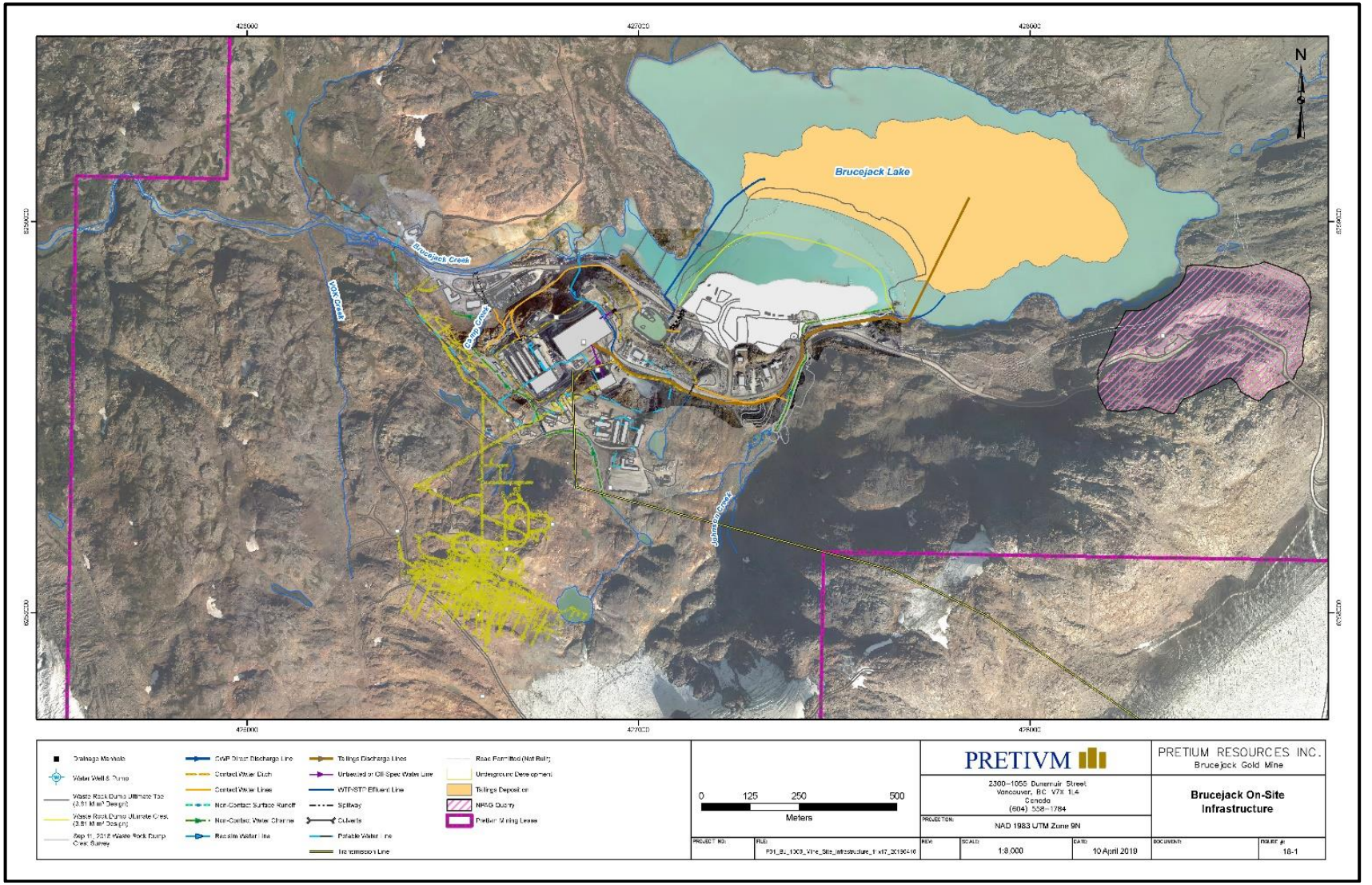
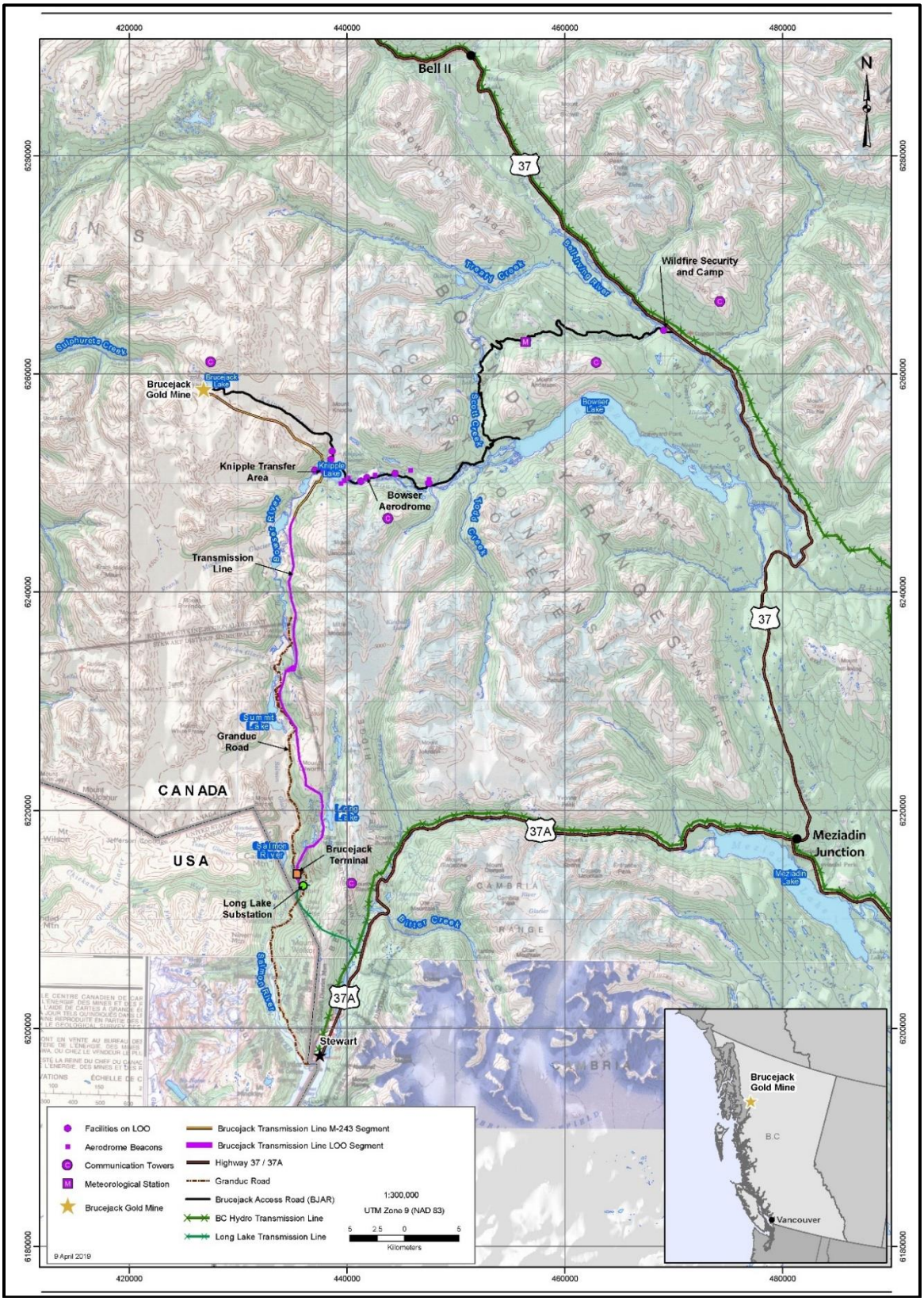


Figure 18-2: Brucejack Gold Mine On-site Infrastructure Layout



TETRA TECH

Figure 18-3: Brucejack Gold Mine Off-site Infrastructure Layout



Source: Pretivm (2019)

18.2 Mine Site Surface Infrastructure

Mine site infrastructure (Figure 18-1) covers a compact area due to the nature of the site terrain. Facilities are localized to three general locations all in close proximity. Underground mine-related facilities are located along the south side of Brucejack Creek in proximity to the West Zone portal, the main access for personnel and vehicles. Also located along the south side of Brucejack Creek are the fuel farm, emergency DPS, and associated DPS pond/sump. Centrally located on the mine site are the mill, fire hall, emergency vehicles, two phases of camp buildings, truck shop, and the Valley of the Kings portal. East of the mill area waste handling, warehouse and miscellaneous buildings, ore storage and overburden storage, and waste rock dump are all located along the southwest shore of Brucejack Lake. Outlier facilities include the potable water well and incinerator located northwest of the main site, and the Valley of the Kings weather station located south of the main site. Water collection and diversion infrastructure (e.g., collection ponds and ditches, diversion channels, high-density polyethylene (HDPE) pipelines, sumps, weirs) are present throughout the mine site to appropriately manage water.

18.2.1 Mill Facility Description

The mill building houses equipment for the entire process following delivery of ore from underground. The 3,800 t/d process flowsheet (Section 17.0, Figure 17-1) outlines the following sequence: ore delivery from the Valley of the Kings Zone via the conveyor system to the surge bin located at the surface. The main surface processing circuits include:

- Primary grinding circuit consisting of a SAG mill, a ball mill, a pebble crusher, and a related cyclone pack
- Gravity concentration and refining circuit consisting of two centrifugal concentrators, two shaking tables, and one centrifugal concentrator for recovering the gold and silver grains from the tabling tailings; and one smelting furnace for production of doré
- Rougher and scavenger flotation followed by three stages of cleaner flotation to produce gold-silver concentrate
- Concentrate dewatering system using one high rate thickener and one tower-type filter press to dewater concentrate to less than 10% w/w moisture; flotation concentrate is loaded into customized containers prior to being shipped offsite; the bulk containers replaced the previous bagging system in April 2019; concentrate in bulk containers is trucked to Stewart, BC for transshipment by ocean freight to smelter(s)
- Flotation tailings dewatering and management system consisting of one deep cone tailings thickener, one thickened tailings surge tank, and one tailings disposal surge tank; thickened tailings is sent either to the tailings surge tank and then to backfill paste preparation system prior to the underground mine or to the disposal surge tank prior to being pumped to Brucejack Lake for deposition on the lake bottom
- Process water recirculation system; both the overflows from the tailings thickener and the flotation concentrate thickener are reused as process water.

The mill building also houses a metallurgical laboratory equipped with all necessary laboratory equipment for metallurgical testing and control.

A bulk gravity concentration laboratory is under planning to prepare the assay samples for the mill feed and infill drill samples. With the assay sample preparation procedure, the grade control assay procedure is expected to significantly mitigate the nugget effect on the gold and silver assay. The laboratory will process the bulk samples through centrifugal concentrators after grinding. The gravity concentrate and tailings will be assayed separately by fire assay procedure to calculate head sample gold and silver grades.

18.2.1.1 Process Plant Control

A control system provides equipment interlocking, process monitoring and control functions, supervisory control, and an expert control system. The control system generates production reports and provides data and malfunction analyses, including a log of all process upsets. All process alarms and events are logged by the control system.

Operator interface to the distributed control system (DCS) is via PC-based operator workstations located in the underground crushing, process plant, water treatment, and paste plant area control rooms. Control rooms are staffed by trained personnel 24 h/d.

Operator workstations can monitor the entire plant site process operations, viewing alarms, and controlling equipment within the plant. Supervisory workstations are provided in the offices of the senior metallurgists, as well as in the mine operations hallway. An additional operator interface is located in the main camp boardroom and is used in emergency situations.

Field instruments used in the mill process include microprocessor-based “smart” type devices. Instruments are grouped by process area and wired to local field instrument junction boxes in each respective area. Signal trunk cables connect the field instrument junction boxes to the control system input/output cabinets.

Intelligent-type MCCs are located in electrical rooms throughout the plant. A serial interface to the control system facilitates the MCCs’ remote operation and monitoring. Control systems philosophy is primarily focused on crushing, concentrator, and remote monitoring.

For site-wide infrastructure (i.e., telephone, Internet, security, fire alarm, and control systems), a fiber optic backbone is installed throughout the plant site.

A PC workstation is installed in the main control room to monitor the underground and crushing operations and conveying operations to the surge bin. The information is provided to the mill process control system via serial or Ethernet gateway. System controls include SAG feed conveyors (zero speed switches, side travel switches, emergency pull cords, and plugged chute detection) and surge bin levels (radar level, plug chute detection).

To control and monitor all mill building concentrator processes, three PC workstations are installed in the mill building’s central control room. They control and monitor the following: grinding conveyors (zero speed switches, side travel switches, emergency pull cords, and plugged chute detection), SAG and ball grinding mills (mill speed, bearing temperatures, lubrication systems, clutches, motors, and feed rates), particle size monitors (for grinding optimization and cyclone feed), pump boxes, tanks, bin levels, variable speed pumps, cyclone feed density, thickeners (drives, slurry interface levels, underflow density, and flocculent addition), flotation cells (level controls, reagent addition, and airflow rates), samplers (for metallurgical accounting and flotation optimization), gravity concentrators, pressure filter, load out, reagent handling and distribution systems, tailings disposal to paste backfill or tailings storage, water treatment, water storage (including underground sumps and contact water pond (CWP)) and reclamation/distribution (including tank level automatic control), air compressors, paste plant (vendor control system), fuel storage, and vendors’ instrumentation packages.

An automatic sampling system collects samples from various product streams for online analysis and daily metallurgical balance. Composite samples are generated for each 12-hour shift and are sent for assay at the Knipple assay laboratory.

A particle-size-based computer control system is used to maintain the optimum grind sizes for the primary grinding circuits. The particle-size analyzer provides main inputs to the control system.

Remote monitoring is achieved through CCTV cameras installed at various locations throughout the plant, such as the crusher conveyor discharge point, the SAG surge feed conveyer, the SAG and ball mill grinding area, the flotation area, the paste plant, the gold room, the concentrate handling area, and the tailings handling facilities. The cameras are monitored from the plant control room.

18.2.1.2 Water Treatment Plants

Water treatment is undertaken in three separate facilities: operations water treatment plant (WTP), potable WTP, and wastewater (sewage) treatment plant.

18.2.1.3 Operations Water Treatment Plant

The operations WTP, located in the mill building, treats underground inflows and surface water from the contact water collection system, process water, and water from Brucejack Lake.

The operations WTP is capable of treating up to 10,000 m^3/d. The treatment process consists of the following steps: suspended solids removal (via clarification, coagulation using ferric sulphate and flocculation using silica sand and anionic flocculants), dissolved metal precipitation and total metals removal (through hydrated lime precipitation and ferric sulphate co-precipitation), fine solids filtration (via 10 µm disc filters), and pH adjustment (using sulphuric acid or hydrated lime). Sludge from this water treatment is mixed with tailings and deposited in Brucejack Lake.

Under 3,800 t/d production, it is estimated that following cessation of mining, projected to be in 13 years, the operations WTP will continue to operate for less than a year to achieve acceptable discharge water quality.

18.2.1.4 Potable Water Treatment Plant

The Brucejack Gold Mine site potable WTP is located adjacent to the Phase 2 Camp. Raw water is pumped from a groundwater well located approximately 1.5 km northwest of the camp site to two raw water storage tanks. A booster pumping system withdraws raw water from the storage tanks and pumps it through green sand filters, woven canister filters (down to 1 µ) and through ultraviolet (UV) disinfection. Distribution pumps transport the water to both the Phase 1 and 2 camps, as well as the mill building.

Potable water within the mill building is treated in a similar manner (cartridge filters and UV disinfection) and is used to supply the lunchroom, bathrooms, and safety shower/eye wash stations through the mill.

The Brucejack Gold Mine potable WTP currently supplies approximately 75 m^3/d based on an average usage rate of 200 L/d per person and a camp population of 360 persons. The facility is sized to treat water sufficient for a camp population of at least 720 persons. The potable water well has more than enough capacity to provide 150 m^3/d.

18.2.1.5 Sewage Treatment Plant

The Brucejack Gold Mine site sewage treatment plant consists of two packaged C-75 Filterboxx treatment plant units, each designed to treat up to 75 m^3/d of wastewater, for a total current treatment capacity of 150 m^3/d. The current treatment rate is an average of approximately 75 m^3/d, sufficient for 360 persons. The total treatment capacity is capable of treatment for approximately double the current camp population. Sewage is piped from the two camps and mine dry to the sewage treatment plant. Portable bathrooms at the mine site that are not plumbed into the sewage lines are regularly pumped out with a vacuum truck that offloads the raw sewage into the main lift station, which feeds the treatment plant. Raw sewage is treated via primary screens, biological aeration reactors, and biological membrane filtration. The sludge from the sewage treatment plant is dewatered using a rotary vane filter and dried prior to final disposal by incineration at the on-site incinerator.

The mine is authorized via its Effluent Permit for an additional 25 m^3/d treatment unit and can add this if required. Effluent from these treatment plants is discharged into Brucejack Lake in accordance with the mine's Effluent Permit.

18.2.1.6 Non-potable Water

Mill non-potable water requirements are supplied from the operations WTP and the reclaim pump house located at Brucejack Lake. The operations WTP treats underground mine water, surface contact water (via the CWP), and process water from within the mill. The treated effluent is then pumped into the fresh/fire water tank located in the mill. The fresh/fire water tank is also supplied by the reclaim pump house. The operations WTP supplies approximately 70% of the fresh water for the mill and the reclaim pump house supplies 30% of the mill's fresh non-potable water needs. Water is pumped from the fresh/fire water tank through a distribution manifold within the mill, which supplies water for use in gravity recovery, flotation, paste plant, reagent preparation, gland seal water, and wash down hoses.

The fresh/fire water tank is approximately 785 m^3 in volume and only the top 30% is used for fresh water within the mill. The lower 70% of the tank volume is used for fire protection water within the mill and camp buildings.

18.2.2 Mine Waste Management

18.2.2.1 Waste Rock and Tailings Storage Facility (WRTSF)

Waste rock and tailings deposition entails depositing tailings and potentially acid generating (PAG) waste rock into Brucejack Lake, or as underground mine backfill. Brucejack Lake is a deep natural glacier and snow meltwater lake allowing for LOM subaqueous waste rock and tailings deposition without the need for any engineered containment structures, including dams.

Waste rock from the underground mine is transported to surface and temporarily stockpiled at the waste rock dump (WRD) platform site. Most of this waste rock is almost immediately deposited 1 m or more below the WRTSF surface water elevation via excavator ('bailing') or tele-stacker ('stacking'). Waste rock deposited into the WRTSF via these methods builds up and eventually forms the WRD platform, where some waste rock extends to or above the normal WRTSF water level. This subaerially exposed PAG waste rock is replaced with either non-PAG (NPAG) material or freshly excavated PAG waste rock, or left with a 1 m water cover, such that surface-deposited PAG waste rock is ultimately subaqueously deposited with a minimum 1 m water cover within the allowable two-year subaerial exposure period. Tailings are NPAG and deposited in the deepest part of the lake via tailings discharge line or used for paste backfill in underground mined stopes.

The initial WRTSF design is documented in SRK (2016). This report includes the WRTSF stability and settlement analysis (SRK 2014, Appendix C), which takes into consideration site-specific physical characterization of the lake bed sediments, the lake bathymetry, and measured lake bed sediment thickness. The design includes measured tailings rheological properties (SRK 2015, Appendix A), which confirms that tailings material properties will perform the same or better than lake bed sediments.

SRK (2018) contains an updated WRTSF design triggered by the requirement for increased waste rock and tailings volumes to be deposited into Brucejack Lake. This updated design includes comprehensive stability analysis of a critical section of the WRTSF considering leanings from monitoring data collected since the start of dump construction. It therefore represents an up-to-date evaluation of all site-specific data and confirms that actual dump behavior is representative of the numerical analysis completed.

Prescribed stability requirements are not available for subaqueous waste rock deposition in BC (or globally). However, the *Mined Rock and Overburden Piles Investigation and Design Manual* (BCMWRP 1991) can be used as a starting point to inform a possible minimum acceptable factor of safety (FOS).

The WRTSF design (SRK 2018) confirmed that physical stability of the Brucejack waste rock dump results in inherently low FOS when compared to the British Columbia Mine Waste Rock Pile Research Committee (BCMWRP) (1991). Fundamentally, it was determined that the active dumping face of the Brucejack WRTSF remains in a quasi-stable state with a FOS near unity for a period of weeks to months depending on the thickness of the unconsolidated undrained and highly variable lake bed sediments (and tailings), until enough pore pressure dissipation has occurred to allow the WRTSF foundation to carry the load of the waste rock and remain stable.

Because the design analysis confirmed that a conventional FOS approach, based on numerical analysis, would not allow for construction of the WRTSF, the observational method (Terzaghi and Peck 1967; Peck 1969) was adopted as the design approach for the WRTSF. This method was developed from the need to avoid highly conservative assumptions about ground properties in geotechnical design when faced with unavoidable uncertainties of natural ground conditions. It takes advantage of observations and data gathered during construction to adapt the design to actual ground conditions in an orderly and planned way. Implementation of this approach in the context of the WRTSF requires the following:

- Conduct numerical analysis to establish behavioral bookends.
- Develop monitoring requirements to allow behavioral tracking.
- Develop and implement safe operating procedures for WRTSF construction.
- Develop Quantifiable Performance Objectives (QPOs) to inform safe operating procedures.
- Conduct ongoing monitoring and reanalysis as necessary.
- Continuously revisit and update safe operating procedures as necessary.

As a result, strict operational controls were set to ensure safe WRTSF construction. This rigorous dumping procedure allows for enough safe preloading of the foundation, subject to continuous monitoring and review by a qualified geotechnical site engineer, with ongoing oversight by the engineer of record (EOR).

This dumping procedure is independent of the lake bed sediment (and tailings) thickness or strength, because it assumes that the foundation cannot initially carry the load whether it is due to sediment (and tailings) thickness or strength (or both).

Waste rock and tailings deposition is governed by the Operations, Maintenance and Surveillance (OMS) Manual, the last version having been updated in March 2020 (SRK 2020). Specifically, waste rock dumping is done in accordance with a standard operating procedure (Brucejack Lake Waste Rock Disposal, Standard Operating procedure (SOP) 011), which is an appendix to the OMS Manual. Pretivm's engineering team manages the day-to-day waste rock deposition, and follow-up monitoring and surveillance following procedures outlined in the OMS Manual. The OMS Manual has been developed in accordance with SRK's design recommendations and undergoes updates as necessary. All employees working on the WRTSF are provided training on the OMS Manual, specifically the WRTSF SOP.

The required surveillance procedures for waste rock and tailings deposition is explicitly outlined in the OMS Manual, as are the QPOs.

A daily report is produced by the Pretivm on-site geotechnical engineers that outlines all activities pertaining the waste rock dumping. This report is circulated internally to Pretivm staff, including senior management, all off-shift geotechnical personnel to ensure continuity, as well as to the EOR. If the EOR identifies any anomalies or areas of concern based on the daily report, he reaches out to the on-site geotechnical engineers.

18.2.2.2 Tailings Delivery

The tailings delivery system discharges thickened tailings slurry to the bottom of Brucejack Lake (80 m deep) when not used for paste backfill (approximately 40 to 50% of the time). For discharge to the lake, the tailings slurry is pumped to an agitated slurry mixing tank at approximately 65% w/w solids and then diluted with water to a maximum 55% w/w at the nominal solids throughput rate of approximately 180 t/h. The diluted slurry is pumped overland from the mill building up to the air release station through one of the two 6″ HDPE DR 17, then to Brucejack Lake, a distance of approximately 900 m, through two pipes that have been upsized to 8″ HDPE DR 17, and then underwater along the suspended discharge lines for another 400 m to the discharge point. There is one duty pump and one standby pump to permit an immediate switch over when necessary. The pumps discharge the diluted slurry at a variable flow rate of varying concentration, which depend upon the throughput and concentration of tailings slurry entering the mixing tank. The mixing tank is typically maintained at a constant level through the addition of water through a control valve. There is a constant flow through the pipeline to prevent blockage of the pipe through tailings deposition within the pipe. When the thickened tailings are used in the backfill plant, flow is maintained with water.

Portions of the pipeline alignment are subject to avalanches, and those sections of the pipeline are placed in a trench and backfilled to protect the pipe. The pipeline is heat traced to prevent freezing in winter and has a continuous downward slope from the mill building to the lake shore to ensure that the line drains during shutdowns.

The pipelines discharge a maximum of 7 m above the lake bottom, a Discharge Permit condition. The pipelines are switched if the active pipe become unusable, such as if the back-pressure approaches the upper operating range of the discharge pump, or if bathymetric surveys indicate excessive accumulations at the pipe discharge site. Both pipes are suspended on cables to allow for vertical and horizontal repositioning over the LOM to ensure the pipe is not covered by tailings and to meet permit conditions for vertical positioning above the lake bottom.

There are air/vacuum valves at the lake shore to prevent the possibility of air entering the underwater section. A large volume of air entering the underwater section could potentially float sections of the pipeline. The valves function primarily during start-up and shutdown.

18.2.3 Mine Site Ancillary Facilities

18.2.3.1 Accommodations

There are two accommodation complexes at the mine site: Phase 1 and Phase 2 camp complexes. The main (Phase 2) camp complex is located approximately 100 m southwest of the mill and can accommodate up to 327 persons. The Phase 2 camp complex features common facilities such as kitchens, mess halls, recreation rooms, common rooms, and offices. The older (Phase 1) camp complex is located 200 m south of the mill and can accommodate up to 183 persons. Each dormitory module contains dormitory rooms, washrooms with showers, and laundry rooms. The older Phase 1 camp kitchen has been repurposed as a training center with safety offices.

18.2.3.2 Solid Waste Handling and Domestic Waste Incineration

Camp and facilities waste are managed following the Waste Management Plan and, with respect to incineration, the Refuse Incinerator Management Plan and the Air Discharge Permit. Wastes are initially separated and disposed into receptacles appropriate to each waste stream and further sorted at the mine's waste handling and sorting facility.

A batch-fed containerized incinerator system is designed to process up to 1,800 kg of mixed solid waste material generated at the mine site per day. Solid waste includes mixed camp waste; non-hazardous solid waste consisting of food-waste; kitchen waste, including packaging, cardboard, wood waste, and kitchen grease; and general refuse.

Clean or untreated wood waste is burned at approved burn pits at the mine site following requirements specified in the Waste Management Plan and the Air Discharge Permit. Recyclables are separated at the time of disposal, further sorted as appropriate, then transported to off-site recycling facilities. Hazardous wastes are deposited in dedicated receptacles and taken to off-site licensed facilities for disposal. Remaining materials requiring landfilling are transported to local regional landfills as needed.

18.2.3.3 Power Supply and Distribution

At the Brucejack Gold Mine, 69 kV electrical power enters the mill via the transmission line from the Knipple Substation. There, the voltage is further stepped down from 69 to 4.16 kV via two 15/20/25 MVA oil-filled transformers and distributed to the site via 4.16 kV rated switchgear. The rating for site on a distribution end is 4.16 kV and further transformed to 0.6 kV for smaller loads.

The main mill and underground loads are fed via power cables in cable tray and/or messenger cable hangers. The main substation is located inside the mill. Power feeds to the mill building, camps, truck shops, and underground are either underground buried services or surface run cables.

Within the mill, large loads are powered at 4.16 kV. Smaller loads are powered at 600 V via switchgear and MCCs. VFDs and soft starters are employed strategically to optimize process and energy performance.

Underground buried services provide power to outlying buildings.

18.2.3.4 Emergency Power Generating Facility

Emergency power is supplied from four 500 kW, 600 V generators, located at the DPS, that supply a step-up transformer and feed the E4C e-house. Additionally, there are two 1,450 kW, 4.16 kV diesel generators that are also directly interconnected to the E4C bus. As well, there are six 1,825 kW, 4.16 kV diesel generators that are interconnected into the E4C e-house. The total emergency power for the mine site is 15.85 MW, which can adequately supply the mill, underground, and camp facilities with sufficient power if the transmission line sourced power is interrupted.

A dedicated power system PLC is included in the E4C e-house. This PLC controls the breakers for system synchronization of the generators. An uninterruptable power supply (UPS) backs up the PLC and communications to ensure reliable operations under all circumstances. The power system PLC performs two important functions: load optimization / load shedding to ensure line limits are not exceeded, while maximizing electricity use and power control during emergency power operations to ensure correct sequencing and operations of critical loads.

The controls for the power house can be activated via fiber optic through the mill electrical SCADA system, as well as through a local SCADA system. If there is a loss of power, the system will automatically start the generators to achieve operating temperature and the E4C bus will be energized.

Extensive bedrock exposures and extremely thin and spotty soils result in very poor resistivity. As a result, remote grounds have been constructed in addition to substation yard grounding.

18.2.3.5 Fuel Supply and Distribution

Diesel fuel, primarily for mobile equipment, is stored in four 50,000 L double-walled tanks and one 45,000 L double-walled tank located at the mill site. The storage has approximately six to seven days capacity, including allowance for auxiliary equipment. The fueling station includes loading/unloading pumps and filters.

Aviation fuel is delivered in totes and barrels to both Brucejack and Knipple camp sites. Gasoline for mobile equipment is stored in one 5,000 L double-walled fuel tank located adjacent to the diesel fuel tanks.

One 18,000 gal propane tank is located adjacent to the permanent camp facility. Two 18,000 gal and one 10,000 gal propane tanks are located near the West Zone area. One 18,000 gal propane tank is located at the VOK area.

18.2.3.6 Water Management System

Surface water management is accomplished through a system of diversion ditches to direct non-contact water around the core of the mine site area. The Johnson Creek (East) Diversion directs water to Brucejack Lake, while the Camp Creek (West) Diversion directs water to Brucejack Creek. Contact water from within the mill and camp pads area is directed to the CWP via collection weirs, ditches, sumps, pumps, and HDPE pipelines. The CWP is primarily a water management facility that is used to store water and prevent unwanted discharges into Brucejack Lake. The CWP acts as a reservoir where water can be directed to the water treatment plant and/or to Brucejack Lake, provided water quality concentrations are acceptable. If there is insufficient process water available from dewatering the mine or the CWP pond, then process water is pumped from Brucejack Lake.

18.2.3.7 Telecommunications

A complete site-wide telecommunications system has been installed comprising four relay microwave stations and one backup microwave system, which include:

- VoIP telephone system for buildings, camps, and offices
- Emergency satellite communications for critical voice and data needs
- Ethernet cabling for site infrastructure and wireless internet access
- Very-high frequency (VHF) two-way radio system with nine public channels
- Four remotely located VHF repeaters
- Satellite TV and Internet for employees at all camps
- Wireless access tower for communications at the towers
- Satellite phones available for remote work or communications outside the normal area limitations.

A pre-manufactured trailer is used as an information management center (IMC) to house all communications equipment. The IMC includes all heating, ventilation and air conditioning (HVAC) equipment and a UPS.

The site telecommunications are linked to the site fiber optic backbone via the IMC. Two separate emergency satellite communications systems with phone and data capabilities are provided and are isolated in the main camp

building. This system handles emergency off-site contact in the unlikely event that the IMC and its vital equipment are compromised, or the main microwave system is interrupted.

The microwave network towers are powered by multiple redundant power sources of EFOY fuel cell, solar energy, and propane power generation. Power and network traffic are also continually monitored to ensure proper maintenance routines. Internal facilities / information technology (IT) and specialized vendor support are contracted for the microwave system technical support.

18.2.3.8 Miscellaneous Buildings

A metallurgical laboratory, located on two 20 ft. containers inside the mill building, houses all necessary laboratory equipment for metallurgical testing and control. The laboratory is equipped with all appropriate HVAC and chemical disposal equipment as needed.

The warehouse facility, including cold storage, located at the mine site houses consumable parts storage and conducts logistic support for inbound and outbound freight.

A medical clinic is located within the main camp and provides routine and emergency first aid services.

A fire hall houses emergency vehicles, including ambulance, fire trucks, and rescue equipment.

The mine dry is part of the camp and can accommodate up to 350 people, each with individual lockers and hanging baskets. The wicket and lamp rooms are located in the main camp adjacent to the dry where underground personnel are picked up by underground vehicles and transported to and from the underground mine.

A mill dry 3-level complex is being constructed between the mill building and main camp. The facility includes a dry that will accommodate 160 persons, a mine meeting/training room, and offices.

A light vehicle/heavy equipment maintenance shop is located along the road immediately east of the mill building. The shop includes an oil water separator located on the north side of the building.

18.2.4 Km 72 NPAG Quarry

Construction aggregate for the mine was sourced from the NPAG quarry located at km 72 on the access road near the southeast corner of Brucejack Lake. Site investigations, which began in 2013, determined that the porphyry rock mass was NPAG and subsequent sampling each year of quarrying has confirmed that determination. Quarry material is used for road capping, both on surface and in the mine, and to provide a working surface on the waste rock dump for that portion of the waste rock dump above the lake surface level. There is sufficient quarriable material for all foreseeable mine needs.

18.3 Off-site Infrastructure

Off-site infrastructure (Figure 18-3) comprises the Brucejack Access Road from Highway 37, transmission line, Bowser Aerodrome, Knipple Transfer Station Camp, and Wildfire Camp. During construction, other camp infrastructure was located at the Bowser site, but the accommodation and kitchen facilities have been decommissioned. The exploration geological core logging/sampling facilities have been relocated to the Knipple Site.

18.3.1 Transmission Line

Electricity for the Brucejack Gold Mine and Knipple Camp is provided from the BC Hydro network. An interconnection to the provincial grid is located at the Long Lake Hydro Substation, approximately 13 km north of Stewart. From the Long Lake Substation, the 138 kV line proceeds northward for 1.5 km to a control station, Brucejack Terminal, and then continues a further 42 km to the Knipple Substation. The Knipple Substation reduces the voltage from 138 to 69 kV; the transmission line then carries on to Brucejack Camp and is introduced into the mill where the main Brucejack distribution transformers are located. The 57 km line was completed on March 31, 2017.

18.3.1.1 Transmission Line Operations, Maintenance, and Emergency Response

The transmission line is controlled via the main incoming breaker located at the control station, Brucejack Terminal, 1.5 km north of Long Lake Substation. The line section from Long Lake Substation to the control station is under control of BC Hydro. The Brucejack Transmission Line, past Brucejack Terminal, is controlled either through the Brucejack Camp control station or the Knipple Substation. An operating procedure establishes the procedures and communication protocols for operation of the transmission line to protect any transmission line workers and the integrity of the BC Hydro system.

Maintenance of the Brucejack Transmission Line consists of visual inspections along the transmission line, as well as periodic infrared surveys to look for potential deterioration in splices or other energized components. This is complemented with a periodic inspection of the transmission line towers, with climbing inspections to ensure the functionality of all conductors, guy wires, cross arms, and other transmission tower components. Emergency response is also important to manage the risk to the transmission line, with spare tower sections and other parts kept at Bowser Aerodrome to facilitate rapid response and restoration in the event of extreme weather damaging the transmission line.

18.3.2 Access Road

The Brucejack Access Road is an all-season, two-way gravel surfaced road that commences at Highway 37 at km 215 and travels generally westward to Brucejack Lake, a distance of 73.5 km.

The Brucejack Access Road is maintained throughout the year by maintenance crews stationed at Knipple Transfer Station. Aggregate materials for road maintenance are sourced from quarries located at km 10 and km 58. Regular patrols are conducted in potential avalanche areas with avalanche control measures in place.

An 11.5 km section of road, from km 59.5 to km 71, traverses the main arm of Knipple Glacier. The glacier toe has receded about 1 km and melted at least 100 m vertically since the route was pioneered by Newhawk in the 1980s. In 2012, when Pretivm reactivated the route, a new ramp was developed onto the ice but continued melting has required further road development off the glacier. A new 600 m section of road was activated on the south side of the glacier in 2019 to bypass the lowermost portion of the glacier road.

Unlike other glaciers in the area, the Knipple Glacier is generally free from large crevasse fields that would present a difficult and hazardous route to vehicles and equipment. It does contain crevasses and mill holes (moulins) large enough to present hazards to all-terrain vehicles or personnel on foot. These hazardous crevasses and mill holes become increasingly visible throughout the summer as winter snows melt. Seracs, or ice cliffs, are not present along the immediate travel route.

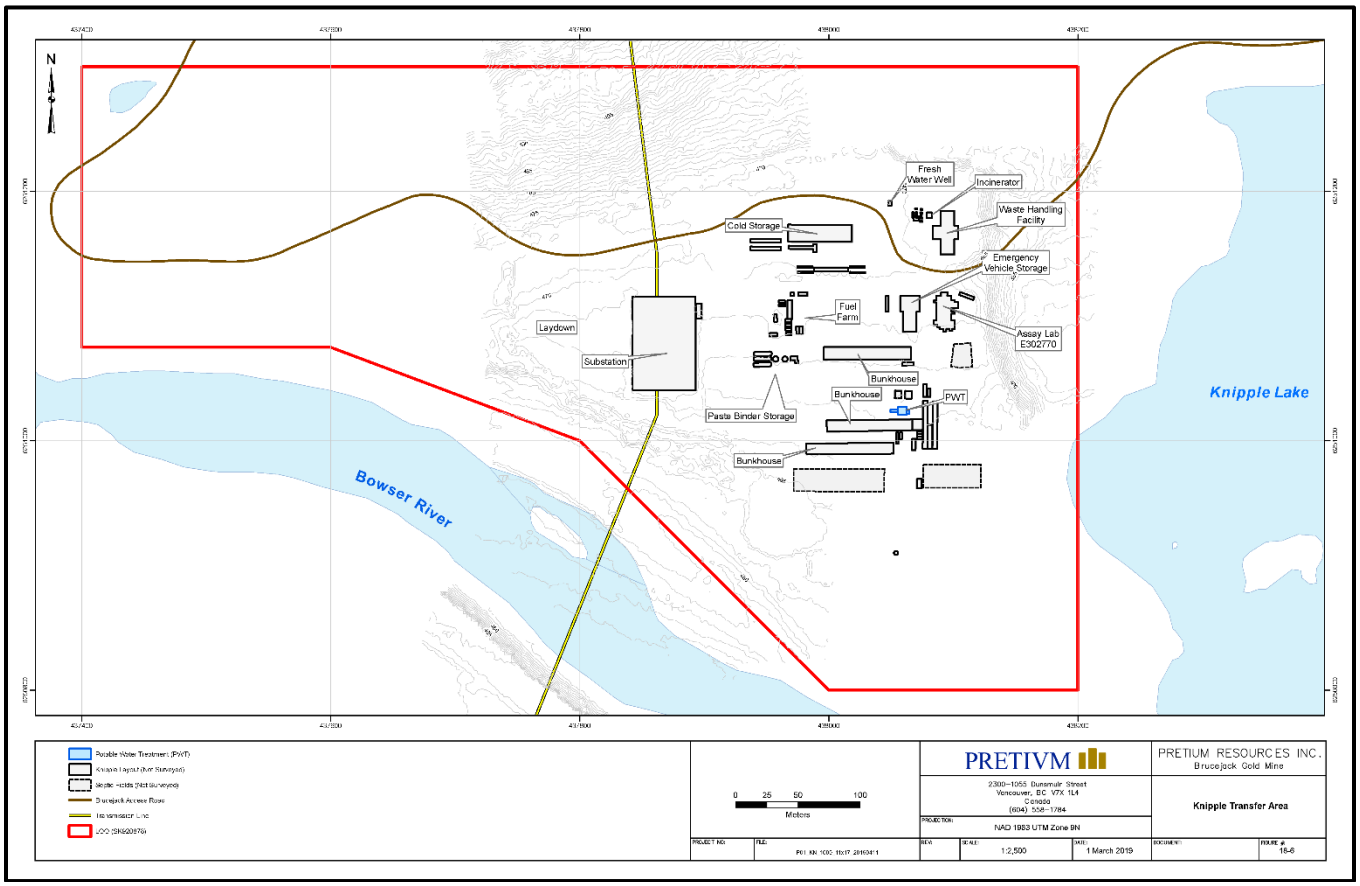
Glacier travel guidelines and glacier emergency response plans have been developed and implemented by Pretivm. Personnel on foot are not allowed to traverse the glacier unless for a specific task related to road maintenance or

monitoring. Only specially trained persons are allowed to exit vehicles on the ice. These personnel operating on the glacier receive additional safety training and are issued additional personal protective equipment such as rescue harnesses, avalanche beacons, rope rescue equipment, and avalanche rescue equipment.

18.3.3 Knipple Transfer Station Facilities

The Knipple Transfer Station facilities include a camp with offices; potable water well with treatment system; maintenance and emergency vehicle building; covered storage facility, including cold storage, fuel storage, and dispensing system; helipad; waste handling facility with an incinerator, assay laboratory, paste binder silos, sewage treatment by septic systems; transmission line substation; exploration core logging and splitting facility; and laydown area as shown in Figure 18-4. All deliveries to and from the mill site report to this facility for intermediate storage or transfer to a different vehicle before delivery to the mine or off site.

Figure 18-4: Knipple Transfer Station



18.3.3.1 Camp

The camp is sized to accommodate 177 people, complete with kitchen, recreation, dormitories, potable water treatment system, and a sewage treatment system. Offices are included in the camp to manage the shipping and receiving of goods. An emergency diesel generator provides power to the camp in case of transmission line power interruption. A wireless system provides communications.

Knipple Camp facilities include a first aid / emergency vehicle parking building, a cold storage / maintenance building, storage in sea can containers, and a waste handling facility with incinerator.

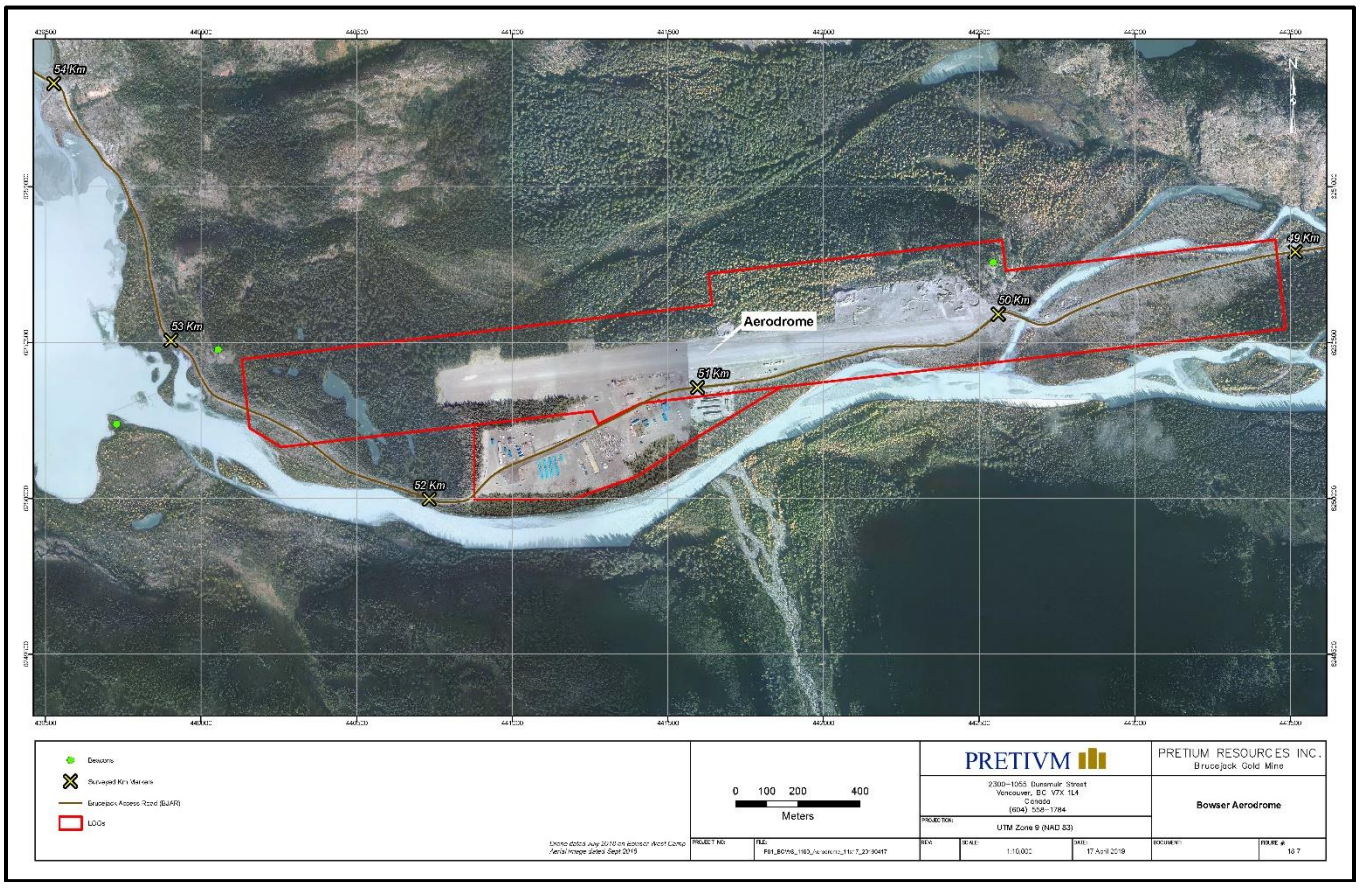
18.3.3.2 Fuel Storage

Fuel is delivered to the Knipple Transfer Station and then stored in tanks before transshipment to the Brucejack mine site, except for propane, which is delivered directly to the mine. Storage facilities comprise one 150,000 L and one 10,000 L diesel storage tanks, one 10,000 L gasoline tank, and propane in 30,000 L, two 8,000 L, and two 4,000 L tanks. Diesel fuel, primarily for mobile equipment, is stored in one 150,000 L double-walled tank located at the laydown area. Aviation fuel is stored in one 35,000 L double-wall tank. The fueling station lies on a lined pad and includes an oil water separator, a receiving pump, a strainer, and delivery pumps and filters.

18.3.4 Bowser Aerodrome

Bowser Aerodrome comprises a 5,000 ft. long by 75 ft. wide gravel airstrip with an apron for aircraft parking. The aerodrome is located 2 km east of Knipple Lake at 1,424 ft. elevation. The airstrip is shown in Figure 18-5.

Figure 18-5: Bowser Aerodrome



The airstrip was constructed at the site by expanding and improving an existing gravel airstrip to provide a safe and maintainable facility for chartered air traffic. It is available to provide air service by chartered flights to and from the mine. Currently, the personnel transportation between Brucejack Gold Mine and Smithers/Terrace, BC is facilitated by chartered bus service. However, routine crew changes by chartered air service is under study. Personnel would be transported from the aerodrome to the mine camp by bus.

The passenger aircraft used in the initial design of the aerodrome was the Beechcraft 1900; however, the design width was not completed nor were all approach/departure obstacle clearing requirements met. Expansion of the runway to 100 ft. width and 5,500 ft. length with lighting and apron up-grades is under study to allow AGN IIIA class aircraft, such as the DE Havilland Dash 8 turboprops, to use the aerodrome. Obstacle removal is planned to alleviate the requirement to displace runway 06 threshold.

Regular maintenance, provided by road maintenance personnel and equipment, permit year-round operation.

18.3.4.1 Maneuvering and Movement Surfaces (Runway and Apron)

The runway and apron surfaces are granular and suitable for turbo-prop aircraft. The runway surface is 1,643 m (5,392 ft.) long and 23 m (75 ft.) wide and oriented magnetically to correspond to the runway designations 06-24. Runway 06 (western approach direction) has a displaced threshold, elevation 1,445 ft., that is 364 m (1,195 ft.) from the west end of the airstrip. Runway 24 (eastern approach direction) threshold, elevation 1,440 ft., is located 60 m (198 ft.) from the runway's eastern end. The runway includes a 7.5 m (25 ft.) graded area along each runway edge. The aircraft parking apron is located on the south side of the runway at runway 06 displaced threshold and has been sized to allow two Beach 1900 sized aircraft to maneuver and park.

All granular surfaces are treated with water for dust reduction.

18.3.4.2 Aerodrome Equipment Requirements

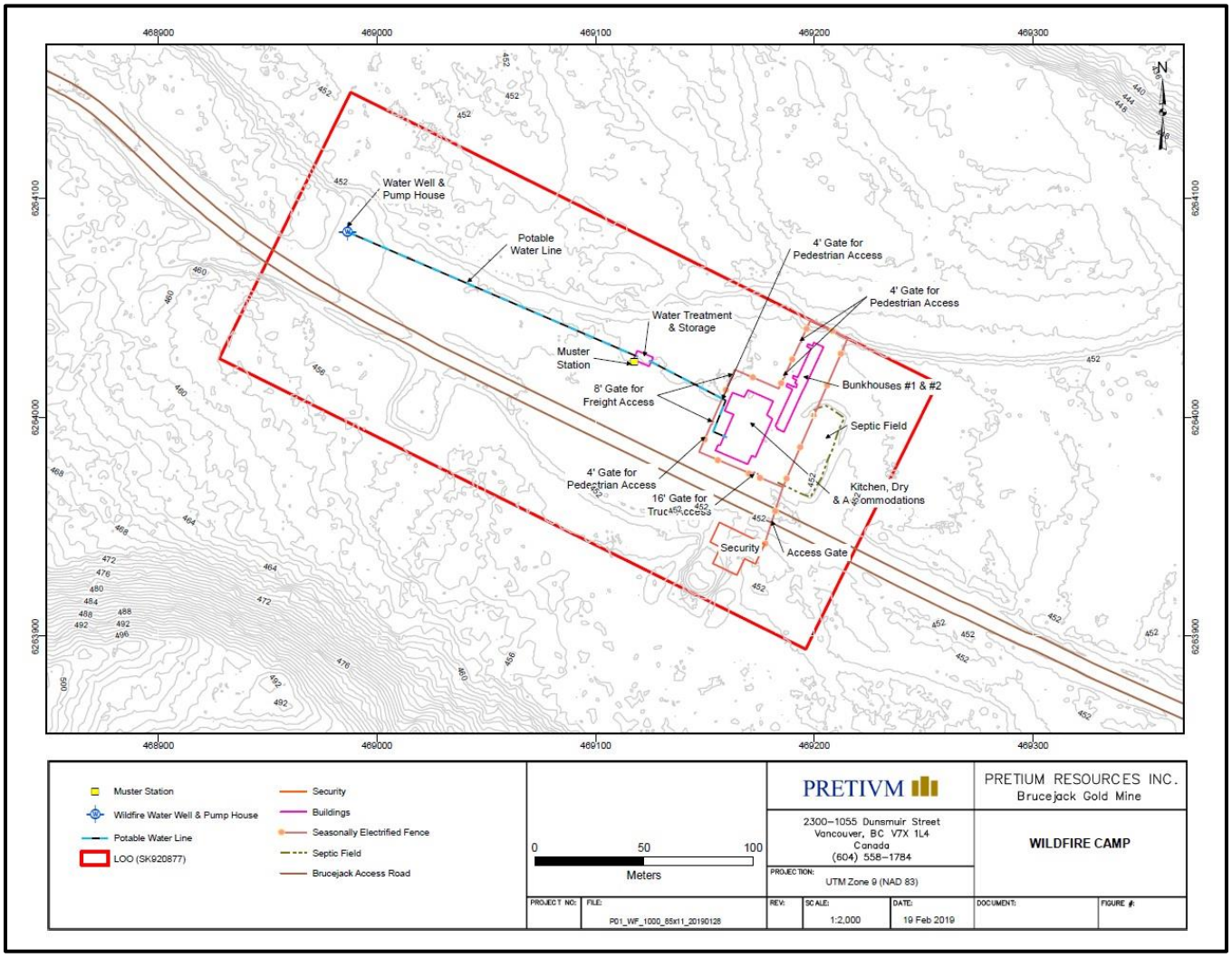
A weather station is located just east of the aerodrome and a ceilometer and altimeter are located at the aerodrome. A trained radio operator at site communicates with aircraft prior to arrival and is available after the flights have departed. This allows the operator to relay weather and altimeter information to the pilots prior to, during, and after departure (in case an emergency return is required).

18.3.5 Wildfire Security and Camp

The Wildfire Camp (Figure 18-6) is located at km 1 on the Brucejack Access Road. Facilities include a gate at the Highway 37 junction to screen access and a security building with a gate at the eastern side of Wildfire Camp to control access and importation of banned substances and fishing and hunting equipment. The security screening is to prevent unauthorized departure with gold. Screening of vehicles and equipment for invasive plant species is also undertaken at Wildfire Camp. All traffic entering or exiting the Brucejack Access Road must report to this facility. Access to/from the mine is controlled by the security personnel at site. The camp area includes a large laydown area for incoming and outgoing freight vehicles.

Wildfire Camp is sized to accommodate 23 people, complete with kitchen, dormitories, potable water well and pumphouse, potable WTP, and a septic field for sewage disposal. For bear protection, the camp dormitories, dry, and kitchen buildings are enclosed with an electric fence with gates for pedestrians and service vehicles.

Figure 18-6: Wildfire Camp



18.4 Site Geotechnical Assessment

This section is reproduced from the 2019 Technical Report. The geotechnical engineering assessment for the Brucejack Gold Mine site has included several subsurface investigation programs completed over the past decade. The regional and local geologic conditions near the plant site are well understood based on surface mapping and sampling of overburden soils and bedrock. The geotechnical engineering parameters that were recommended for inclusion in the earthworks design and foundation analysis at the Brucejack, proved satisfactory in the preparation of Issued for Construction documents in 2016-17. Construction Record Reports for earthworks documented that the design intent of the drawings and specifications were met at the Brucejack Gold Mine. Further expansion will require only site-specific recommendations for any proposed expansion facilities as there is a large volume of site investigation and construction records from the main plant available.

18.5 Avalanche Hazard Assessment

An avalanche hazard assessment of the mine site, Brucejack Access Road, and transmission line route was presented in the 2014 FS (Ireland et al. 2014). Generally, this hazard assessment remains unchanged other than for the section of access road constructed in 2019 from 59 to 59.5 km.

In summary:

- The avalanche season for infrastructure below 1,000 m elevation is generally from November to May, while for elevations above 1,200 m the season is from October to June, or if cool, wet conditions persist avalanches can occur in summer months. Snow avalanches generally occur in areas where there are steep open slopes or gullies, and deep (more than 50 cm) mountain snow packs. Risks associated with avalanches are normally due to exposure to the high-impact forces that occur, as well as the effects of extended burial for any person caught in an avalanche. Avalanches may reach speeds up to 60 m/s (200 km/h). Impact pressures from dense flows are much greater than the powder component due to the density of the snow.

- An avalanche path generally consists of a starting zone, a track, and a runout zone. Avalanches start and accelerate in the starting zone, which typically has a slope incline greater than 30°. Downslope of the starting zone, most large avalanche paths have a distinct track in which the slope angle is typically in the range of 15 to 30°. Large avalanches decelerate and stop in the runout zone where the incline is usually less than 15°. Smaller avalanches may decelerate and even stop on steeper slopes (15 to 24°).

- Avalanche frequency is the reciprocal of avalanche return period and is typically referred to as an order of magnitude ranging from 1:1 (annual) up to 1:300 (1 in 300) years. Each winter the probability of an avalanche with a specified return period is constant; however, the frequency depends upon snow supply, decreases with distance downslope in the track, and runout zone and varies from year to year.

- Destructive potential of an avalanche relates to the magnitude of an avalanche. In general, large destructive avalanches occur less frequently, while smaller ones occur on a more regular basis. The spacial relationship of infrastructure to the location along an avalanche path will affect the destructive potential. A further distance from the toe of an avalanche will result in less risk and frequency of that risk.

- Prior to construction, 15 avalanche paths or hazard areas were estimated that potentially could reach infrastructure or access roads, and many of those on an annual basis. These avalanche hazards were avoided wherever possible. At the mine site, there remains a risk of avalanches along the Brucejack Access Road between the NPAG quarry and the waste management facility on the eastern side of the mine site. There are also avalanche hazard zones along the Brucejack Access Road, particularly at km 44 and between Knipple Transfer Station and the ramp onto Knipple Glacier. In the km 44 area, remote avalanche control systems are installed to trigger avalanches at controlled times in order to avoid significant likelihood of large avalanche development. Remote avalanche control systems are also installed along the new section of Brucejack Access Road from 59 km to the ramp onto Knipple Glacier where a number of potential avalanche paths were identified (Gould and Campbell, 2019).

- Pretivm has full time mountain safety technicians who monitor avalanche risk, develop hazard ratings for the Brucejack Access Road by specific sections, and release hazard bulletins with avalanche ratings for those road sections and glacier hazard ratings for travel on the glacier. The mountain safety technicians regularly survey the ice road and work with road maintenance to ensure safe travel on the ice.

19.0 MARKET STUDIES AND CONTRACTS

19.1 Markets

The Brucejack Gold Mine produces doré and flotation concentrate, which contain both gold and silver. The doré is shipped to precious metal refineries located worldwide for further processing to produce refined metals for sale. The concentrate is sold to international smelters or traders in concentrate form. The concentrates is exported out of Stewart, BC in bulk form.

Gold and silver prices have fluctuated significantly. Table 19-1 shows the spot gold and silver prices (as of March 4, 2020) together with the last two-year and the last five-year average prices.

Table 19-1: Gold and Silver Prices

Metal	Unit	Spot[(1)]	Two Years	Three Years
Gold	US$/oz	1,641	1,353	1,328
Silver	US$/oz	17.2	16.0	16.4

Note: [(1)]Gold and silver price on March 4, 2020.

19.2 Smelter Terms

The following smelter terms are reflected in the doré refinery and/or concentrate sales contracts that Pretivm currently holds at the time of this Technical Report. The related charge rates are within the industry normal rates. The terms are summarized as follows:

- Gold-silver doré:
  - Gold and silver – pay approximately 99% of gold and silver content. Gold is refined at the refineries and sold at the spot market and subject to treatment charges, and other agreed deleterious charges are deducted from the proceeds of silver sales to the refineries.
- Gold-silver concentrate:
  - Gold and silver – approximately 95 to 97% of gold depending on the gold contents and approximately 85% of silver content. Industry normal treatment and refining charges are applied for payable metals. A penalty charge for arsenic in the concentrate is charged over certain agreed upon levels.

19.3 Concentrate Transportation

Concentrate are transported to the Stewart Bulk Terminal (SBT) in customized bulk containers (maximum capacity of approximately 23 t). The containers are designed to have an openable lid on top and hinged doors on the side. Containers are loaded at the Brucejack Gold Mine site and trucked down to the Knipple Transfer Station where a third-party trucking company further transports them down to the SBT. From the SBT, the concentrate is exported to international customers in bulk vessels.

The estimated concentrate transportation cost is US$138.38/wmt of concentrate, including ocean freight to Asian destinations at current market.

19.4 Mining Development Contracts

Underground mining at the Brucejack Gold Mine is currently completed by Procon. This work includes lateral and ramp development, long hole drilling and blasting, mucking, hauling to the underground crusher, and backfilling. Mine planning is conducted by Pretivm employees who oversee the execution of the mining done by Procon.

20.0 ENVIRONMENTAL STUDIES, PERMITTING AND SOCIAL OR COMMUNITY IMPACT

20.1 Environment, Social and Sustainability

20.1.1 Corporate Policies, Guiding Principles and Criteria

20.1.1.1 Mine Operations Philosophy

Pretivm is committed to continuing to operate the Brucejack Gold Mine in a sustainable manner and according to the guiding principles in its corporate Social, Environmental, and Health and Safety policies. Every reasonable effort has and will continue to be made to minimize or prevent potential long-term adverse environmental effects and to ensure that the mine provides lasting benefits to local Indigenous and other communities while generating substantial economic and social advantages for shareholders, employees, and the broader community. Pretivm is focused on ensuring that the safe, successful operation of the Brucejack Gold Mine benefits the Province of British Columbia, and in particular, the Nisga'a Nation, Tsetsaut Skii km Lax Ha First Nation, Tahltan Nation, and the communities of Gitlaxt'aamiks, Gitwinksihlkw, Laxgalts'ap, Gingolx, Dease Lake, Telegraph Creek, Iskut, Stewart, Terrace, Smithers, Hazelton, and New Hazelton.

Pretivm is committed to sustainable resource development, which balances environmental, social, and economic interests. Pretivm will continue to comply with regulatory requirements and to apply technically proven and economically feasible methodologies to protect the environment throughout mining, processing, and closure activities.

20.1.1.2 Environmental Management System

Environmental management is a corporate priority. Pretivm developed a comprehensive Environmental Management System (EMS) as part of its environmental assessment certification and major permits applications, implemented this during construction, and will continue to do so during mine operations and closure. The Brucejack Gold Mine approved EMS, including 20 component plans required by the mine's Environmental Assessment Certificate (EAC #M15-01) and additional plans approved via other mine authorizations, is integrated into all aspects of mine operations.

Environmental management is implemented on a basis of continual improvement. All of the component plans are considered to be live documents and undergo internal review a minimum of annually in accordance with regulatory requirements. Component plans are modified as appropriate based on these reviews and as required based on approved mine plan or environmental program modifications. Revised component plans are included in the mine's annual report for its BC *Mines Act* (M-243) and *Environmental Management Act* Permits (PE-107835 and PA-107025) and distributed to applicable BC provincial regulatory agencies, the Nisga'a Nation through the Nisga'a Lisims Government, the Tsetsaut Skii km Lax Ha First Nation, the Tahltan Nation (as represented by the Tahltan Central Government), and to the State of Alaska Department of Natural Resources. Updated versions of the EMS component plans are also provided to BC EAO.

Component plans developed and implemented pursuant to the EAC are as follows:

- Aboriginal Consultation Plan
- Air Quality Management Plan
- Ancillary Infrastructure Decommissioning and Reclamation Plan
- Aquatic Effects Monitoring Plan
- Avalanche Safety Plan
- Chemicals and Materials Storage and Handling Plan
- Economic and Social Effects Mitigation Plan
- Heritage Management Plan
- Health Services Monitoring Plan
- Invasive Plants Management Plan
- Metal Leaching / Acid Rock Drainage (ML/ARD) Management Plan
- Mine Emergency Response Plan
- Operation, Maintenance, and Surveillance Manual: Brucejack Gold Mine Subaqueous Waste Rock and Tailings Deposition
- Operation, Maintenance, and Surveillance Manual: Water Management Plan
- Reclamation and Closure Plan
- Soils Management Plan
- Spill Response Plan
- Traffic and Access Management Plan
- Vegetation Management Plan
- Waste Management Plan
- Wildlife Management Plan.

Additional management plans required for other authorizations or completed internally include:

- Geohazards Management Plan
- Chromium Management Plan
- Ground Control Management Plan
- Health and Medical Services Plan
- Nitrogen Management Plan

- Refuse Incinerator Management Plan
- Surface Erosion Prevention and Sediment Control Plan
- Potable Water Management Plan
- Construction Environmental Management Plan (applied to Construction phase only).

Pretivm's Environment and Regulatory Affairs department personnel implement and/or direct, provide training as appropriate, and monitor the implementation of federal and provincial environmental requirements under the mine's authorizations (BC EAC, Environmental Impact Statement (EIS) Decision Statement, permits, licenses, tenures) and EMS. Health and safety (including medical, security, and avalanche safety) requirements of applicable component plans are implemented and/or directed by the mine's Health and Safety Department. Engineering related requirements, including geotechnical and geohazards, are led by the Technical Services Department. Standard Operating Procedures (SOP) have been developed as appropriate for the various plans and are implemented by personnel trained in their use.

20.1.1.3 Traditional Knowledge

Pretivm respects the traditional knowledge of the Indigenous peoples who have historically occupied or used the Project area. Pretivm recognizes that it has significant opportunity to learn from people who have generations of accumulated experience regarding the character of the plants and animals, and the spiritual significance of the area. Traditional knowledge informs planning for various aspects of the mine, including planning and design for future changes to the mine plan as may be applicable.

Pretivm is committed to an engagement process that continues to invite and consider input from people with traditional knowledge in the area.

20.1.1.4 Ecosystem Integrity

Prior to about 1980, the local ecosystem was relatively undisturbed by human activities, although it was not static. Glacier retreat and relatively recent volcanic activity (within the last 10,000 years), along with landslides, debris flows, and snow avalanches, have and continue to modify the landscape. In the 1980s and through the 1990s, Newhawk Gold Mines Ltd. completed mineral exploration, including advanced underground exploration, at Brucejack. In 2008, Silver Standard Resources began surface exploration of Brucejack. Pretivm began major exploration programs starting in 2011, leading to mine construction in 2015.

The Brucejack Gold Mine was designed and constructed with a minimal disturbance area (surface disturbance of approximately 50 ha for core infrastructure at the mine site). Pretivm is committed to retaining current ecosystem integrity as much as possible during mine operations and closure. This objective is being met by:

- Minimizing the mine infrastructure development footprint, and reclaiming areas that are no longer required for mine operations
- Implementing rigorous surface water management practices to reduce erosion and sediment transport of easily erodible soils
- Avoiding adverse effects, where feasible
- Minimizing and/or mitigating unavoidable adverse effects.

Following completion of operations, the mine and its supporting infrastructure will be closed and reclaimed to the approved end land uses in accordance with the Reclamation and Closure Plan. Objectives of the Reclamation and Closure Plan include returning disturbed areas to a land use meeting the average level of capability that existed prior to project development, where practical, and for the end configuration to be consistent with pre-existing ecosystems to the extent feasible.

20.1.1.5 Biodiversity and Protected Species

Pretivm remains committed to making every reasonable effort toward maintaining biodiversity in the area of the mine. Biodiversity is defined by the BC Ministry of Forests, Lands and Natural Resource Operations and Rural Development (MFLNRORD) as “the diversity of plants, animals, and other living organisms in all their forms and levels of organization, and includes the diversity of genes, species, and ecosystems, as well as the evolutionary and functional processes that link them” (MFLNRORD 1995).

Maintenance of biodiversity is not an isolated effort, but an integral part of project planning (mitigation and monitoring), environmental effects analyses, and achievement of environmental protection and mitigation goals. This approach was implemented throughout the mine’s environmental assessment and permits applications processes and subsequent development, and will continue to be implemented through operations.

20.1.2 Social Setting

20.1.2.1 Socio-economic Setting

Northwest BC is a sparsely populated and relatively undeveloped region of the province. Many of the smaller communities have predominantly Indigenous populations that are distant from one another as well as from the main regional centers of Smithers and Terrace. Nationally, the Indigenous population is one of the fastest growing populations, increasing at four times the rate of the non-Indigenous population since 2006. This suggests that the Indigenous population in this region will continue to represent a significant segment of the regional population into the future.

The Brucejack Gold Mine is located in the Regional District of Kitimat-Stikine. The mine’s area of influence is generally considered to be northwest BC, inclusive of communities from the Nass Valley and Terrace to Smithers, Stewart, and as far north as Dease Lake.

Primary resource industries, principally mining and forestry, are the mainstay of the regional economy. The forest industry declined in recent decades, which has significantly affected the economy and led to a steady decline in the regional population. As is typical of resource-dependent economies, communities in the region have experienced multiple cycles of “boom and bust” associated with mining and resource extraction, with the attendant population peaks and troughs. However, announcements of major projects (including mining and liquefied natural gas (LNG)) have drawn workers to the region, potentially leading to population growth in communities such as Smithers and Terrace.

Transportation infrastructure in northwest BC is limited. The primary transportation corridors are Highway 37 (north to south) and Highway 16 (east to west). Air transportation hubs include the Northwest Regional Airport in Terrace, which serves the communities of Terrace and Kitimat (including daily flights to Kelowna, Vancouver, Victoria, and Prince George), the Smithers Regional Airport in Smithers (with flights to Vancouver, Dease Lake, Prince George, and other communities), and the Prince Rupert Airport in Prince Rupert (with scheduled flights to Vancouver).

Community and socio-economic impacts of the Brucejack Gold Mine are favourable for the region, with many long-term opportunities created for local and regional workers. Pretivm is committed to hiring workers from northwest BC; as of December 2019, 51% of Pretivm's direct workforce of 741 employees were residents of the region and 31% self-identified as Indigenous. The total workforce amounted to 1,201, of which 460 were employed as on-site contractors. These rotational jobs allow workers to continue living in their home communities and have likely helped to reduce and possibly reverse the out-migration to larger centers. Pretivm has and continues to work actively with Indigenous groups (including the Nisga'a Nation, Tsetsaut Skii km Lax Ha First Nation, Tahltan Nation, and Gitanyow Hereditary Chiefs) and representatives of local communities to maximize benefits through employment and business opportunities, training, and skills development programs. Through multiple initiatives, including working with local training organizations and holding career fairs throughout the region, Pretivm is committed to enhancing local benefits and improving economic growth in the region. Pretivm also owns a warehouse and office in Smithers where it bases its off-site supply chain management, warehousing, travel, and some senior environmental and permitting personnel; approximately 20 employees work at this location.

Pretivm reached a Cooperation and Impacts Benefits Agreement with Nisga'a Nation in April 2015, with Gitanyow Hereditary Chiefs in June 2016, and with the Tahltan Central Government in October 2017.

The following subsections profile northwest BC focusing on the Highway 16 and Highway 37 corridors with reference to population data from Statistics Canada's 2016 *Census of Canada*.

Highway 16 Corridor

From the deepwater port at the City of Prince Rupert on the west coast, Highway 16 extends eastward to Terrace, the Hazeltons, Smithers, and Prince George; the Canadian National Railway also follows this route. Rural settlements and Indigenous reserves are interspersed throughout the region. With a strong history in forestry, mining, and rail transport, these communities have shown business growth and development of a wide array of goods and service contractors related to mineral exploration and mining. In 2016, Terrace was home to more than 11,000 residents and Smithers had a population of 5,350; further east, the northern service center of Prince George has a population of more than 86,000 people.

Highway 37 Corridor

Highway 37 connects with Highway 16 at Kitwanga and extends northward to the Yukon border. At Meziadin Junction, a secondary route (Highway 37A) branches west and connects to the deep-water port in the community of Stewart. The Brucejack Access Road intersects Highway 37 60 km north of Meziadin Junction at km 215 of Highway 37. Mining and forestry industries use the Stewart World Port and the SBT to ship products from northern BC and Yukon to international destinations, taking advantage of Canada's most northerly ice-free port. Further north, the communities along this corridor include Iskut, Dease Lake, and Good Hope Lake.

With the exception of Stewart, most communities in this area are Indigenous. Indigenous communities include the Nisga'a Nation communities of Gitlaxt'aamiks, Gitwinksihlkw, Laxgalts'ap, and Gingolx and the Tahltan Nation's communities of Iskut, Telegraph Creek, and Dease Lake. These communities rely heavily on public sector employment, with growing involvement in the mining industry. They are distant from larger service centers and Dease Lake and Telegraph Creek are not connected to the provincial electricity network. Dease Lake, with a population of approximately 400 people (on- and off-reserve) in 2016, is the main center for goods and services (including a small airstrip), and is located approximately an eight-hour drive to either Smithers or Whitehorse.

Stewart, BC was established in 1902, and following an influx of gold seekers beginning in 1906, had a population of approximately 10,000 by 1910. Its population has subsequently fluctuated in response to mining (primarily) and forestry cycles, with many of the current structures constructed for development of the Granduc Mine in the 1960s. Since the Granduc Mine's closure in the 1980s, the town's population declined dramatically from nearly 1,500 in

1981 to approximately 500 people between 2006 and 2011. This was followed by a further 19% decline to 400 residents in 2016. Possible mine developments in the Highway 37A corridor have the potential to reverse the decline in population.

As mentioned above, announcements of mining and LNG investments in recent years have created renewed optimism for opportunities in the shipping and LNG industries and the potential for increased jobs and investment to the region.

20.1.2.2 Traditional Use

The Brucejack Gold Mine is located on Crown land in an area historically used by several Indigenous groups. A desk-based ethnographic overview for the potentially affected Indigenous groups was undertaken in 2012 and 2013. In addition, a Traditional Knowledge/Traditional Use (TK/TU) study was completed for the Tsetsaut Skii km Lax Ha. These studies identify areas and seasons where Indigenous groups have engaged in traditional interests and activities, including hunting, fishing, gathering, and spiritual activities.

As described further below, the location of the mine site is covered by the Cassiar-Iskut Stikine LRMP, which was developed by the province of BC resource agencies in consultation with Indigenous partners, communities, and other stakeholders. When the LRMP was approved in 2000, the Tahltan Nation became the first Indigenous group in BC to have participated in a LRMP process.

20.1.2.3 Non-Indigenous Land Use

The mine site is located in the area covered by the Cassiar Iskut-Stikine LRMP, which was approved by the province in 2000 and encompasses 5.2 million hectares of northwestern BC. The LRMP is a sub-regional integrated resource plan that establishes the framework for land use and resource management objectives and strategies, and provides a basis for detailed management planning. The LRMP outlines the management direction, research and inventory priorities, and economic strategies for the Cassiar Iskut-Stikine area, and presents an implementation and monitoring plan to reach the established objectives.

The Brucejack Access Road and transmission line east of the head of Knipple Glacier lie within the boundaries of the South Nass Sustainable Resource Management Plan (SRMP) area, finalized in June 2012. The SRMP is a landscape-level plan that addresses the sustainable management of land, water, and resources while considering economic interests.

The area surrounding the Brucejack Gold Mine has been the focus of mineral exploration for many years. There are indications that prospectors explored the area for placer gold in the late 1800s and early 1900s. Placer gold production has been reported for Sulphurets Creek in the 1930s, and a large log cabin near the confluence of Mitchell and Sulphurets Creeks was reportedly used by placer miners until the late 1960s. The region surrounding the mine is extensively staked with mineral claims and several other mining companies have active exploration programs nearby.

The mineral deposits in and adjacent to the Brucejack Gold Mine have been extensively explored on an intermittent basis since the 1960s. Intensive underground exploration adjacent to Brucejack Lake in the 1980s by Newhawk was supported by an exploration road from Bowser Lake over Knipple Glacier.

Results of the 2012 non-traditional land use baseline research program indicate that a limited number of people access the general area between the town of Stewart and Bell II. Those known to access the broader general area include those with specific licenses and tenures for land and resource use, such as trappers, guide outfitters, hunters, and those who participate in commercial recreation activities, such as heli-skiing, guided freshwater

recreation, and guided mountaineering. Other individuals with interests in the general area include those who hold forestry licenses, mineral claims, and placer claims, all linked to resource development and industry, as well as water licenses, which may be linked to commercial recreation businesses. Overall, land use in the area is of low intensity and activities are generally seasonal in nature.

20.1.2.4 Archaeology and Heritage Resources

Archaeological assessments were conducted in accordance with approved methodologies of permits issued under the *Heritage Conservation Act* around the mine site and along the access and transmission corridors. Two small prehistoric archaeological sites were identified in proximity (within 1 km) to mine-related infrastructure and were avoided during construction. Pretivm maintains a Heritage Management Plan with a Chance Find Procedure in the event that additional archaeological resources are encountered.

20.1.2.5 Social and Community Management Systems

Pretivm developed an ESEMP as a requirement of its EAC. The ESEMP comprises specific strategies to minimize, mitigate, and/or manage potential adverse effects while enhancing positive impacts of the Brucejack Gold Mine on surrounding local and Indigenous communities. These communities comprise the Nisga'a villages of Gitlaxt'aamiks, Gitwinksihlkw, Laxgalts'ap, and Gingolx, and Telegraph Creek, Dease Lake, Iskut, Hazelton, New Hazelton, Stewart, Terrace, and Smithers. Strategies relate to local employment, procurement, training, transportation, and communications protocols, including reporting and feedback. The ESEMP was first drafted in August 2015 and provided to the Nisga'a Lisims Government, Tahltan Central Government, and Tsetsaut Skii km Lax Ha First Nation for review and comments. The ESEMP is updated on an annual basis.

Pretivm prepares an annual report on the outcomes and achievements related to the ESEMP each year and circulates it to the BC EAO, Indigenous groups, and Local Study Area communities. This report documents the following:

- Engagement with, and feedback from, local and regional residents
- Employment, hiring, and recruitment statistics, including efforts for local and Indigenous hiring
- Summary of education and training initiatives
- Procurement initiatives, including local and Indigenous contracts
- Changes or updates to the workforce transportation strategy.

20.1.3 Consultation

Pretivm recognizes the importance of carrying out consultation and will continue to meet all regulatory requirements to conduct consultation. Pretivm regularly engages with Indigenous groups, community residents, local governments, and educational institutions in northwest BC in order to provide information and seek feedback about the Brucejack Gold Mine. Pretivm is aware of and committed to implement new BC regulatory requirements arising from Bill 41, the BC *Declaration on the Rights of Indigenous Peoples Act* that came into effect in November 2019.

20.1.3.1 Consultation Policy Requirements

Provincial and federal regulations, various permit requirements, best practices, and internal company policies contain provisions for consultation with Nisga'a Nation, Tsetsaut Skii km Lax Ha, Tahltan Nation, and various communities, both Indigenous and non-Indigenous.

20.1.3.2 Consultation

Community engagement and consultation are fundamental to the success of the Brucejack Gold Mine. Since 2011, Pretivm has regularly consulted with the Nisga'a Nation, Tahltan Nation, Tsetsaut Skii km Lax Ha, as well as other Indigenous groups. As part of the environmental assessment process, Pretivm participated in all BC EAO technical working group meetings, which involved engagement with all relevant government agencies, and Indigenous representatives. Through this process, Pretivm developed a specific consultation plan for engagement with Indigenous groups, spanning from the environmental assessment pre-application through to the post-application periods. Indigenous, public, and government consultation activities, such as private and community meetings, open houses, information distribution activities and site tours, all informed the EAC application process and subsequent permitting processes. In recent years, engagement has focused on permit amendments and local hiring to fill positions at the mine (including Pretivm and contractor workers) and opportunities for education, training, procurement, and addressing barriers to employment.

Pretivm employs a full-time community relations manager, based at the company's office in Smithers. The community relations manager is responsible for engagement with Indigenous groups and other local stakeholders, and works with Pretivm's staff and contractors to ensure that the company's commitments for engagement, communication, and local recruitment are addressed. Consultation activities are tracked and recorded using an online database and are regularly reviewed to promote and strengthen continual relationship building and issues tracking.

Ongoing consultation efforts aim to engage both the leadership and community membership and attempt to resolve potential issues and concerns as they arise, with a focus on proactive inclusion and increased supplier development within the Brucejack supply chain for local and Indigenous businesses. No substantive issues have been raised to date regarding the mine.

Pretivm has and continues to engage and collaborate with the federal, provincial, regional, and municipal government agencies and representatives as required with respect to topics such as permit compliance, land and resource management, and environmental and social studies.

Pretivm consults with the public and relevant stakeholder groups, including land tenure holders, businesses, economic development organizations, businesses and contractors (e.g., suppliers and service providers), education and training providers, and special interest groups (e.g., environmental, labour, social, health, and recreation groups), as appropriate.

20.2 Environmental Assessment Certifications and Permitting

Mining projects in BC are subject to regulation under federal and provincial legislation to protect workers and the environment. This section discusses the principal licenses and permits acquired for the Brucejack Project.

20.2.1 Environmental Assessment Certifications

Major mining projects in BC are subject to environmental assessment and review prior to certification and issuance of permits to authorize construction and operations. Environmental assessment is a means of ensuring the potential for adverse environmental, social, economic, health, and heritage effects or the potential for adverse effects on Aboriginal interests or rights are addressed prior to project approval. Brucejack was subject to both the BC *Environmental Assessment Act* (BCEAA) and Canadian *Environmental Assessment Act* (CEAA) 2012 review processes. The design production rate of 2,700 t/d exceeded the BC provincial threshold criterion for requirement of an environmental assessment as specified in the BC Reviewable Project Regulations (75,000 t/a (or 205 t/d)), and the federal threshold criterion for gold mine developments of 600 t/d, as specified under the Regulations

Designating Physical Activities. On March 26, 2015, BC EAC #M15-01 was awarded and on July 27, 2015, a federal project approval was issued in a Decision Statement under Section 54 of the CEAA*, 2012*.

The Brucejack EAC #M15-01 has been amended five times. These amendments were to bring the EAC into conformance with changes to infrastructure and design that resulted both during the initial *Mines Act* and *Environmental Management Act* permits application and review process, and later, due to facility refinements during subsequent detailed design and construction. The fifth EAC amendment included increasing the total tonnage to be mined and increased the daily/annual mining rate. The federal Decision Statement is not subject to amendments and the increase in production rate was not sufficient to require a new federal environmental review.

Table 20-1: List of Amendments to EAC #M-15-01

Amendment	Date	Purpose
1	10 March 2016	Added NPAG rock quarry, set time limit for PAG rock storage, removed borrow source component, and amended layout figures and maps.
2	12 August 2016	Added electric fencing to Wildfire Camp and revised Schedule A and figures.
3	23 November 2016	Added aviation beacons and revised layout figures and maps.
4	13 March 2017	Changed time limit for PAG rock storage in amendment #1.
5	15 November 2018	Changed maximum production to 18.5 Mt of ore, added snow melter and process water pumping system, and changed wording related to waste rock and tailings storage.

On December 21, 2017, the EAO issued a determination that the project has been substantially started, which has the effect that the EAC remains in effect for the life of the project, subject to the Minister's power to cancel and suspend a certificate under Section 37 of the BCEAA.

20.2.2 Permits and Other Authorizations

A variety of applicable BC and Canadian environmental and safety standards and practices required permits and other authorizations for Brucejack Gold Mine construction and operations. Pertinent provincial and federal legislation and/or under which authorizations have been obtained include:

- *Environmental Assessment Act* (BC)
- *Environmental Management Act* (BC)
- *Forest Act* (BC)
- *Forest and Range Practices Act* (BC)
- *Forest Practices Code of British Columbia Act* (BC)
- *Health Act* (BC)
- *Health, Safety and Reclamation Code for Mines in British Columbia* (BC)
- *Industrial Roads Act* (BC)
- *Land Act* (BC)
- *Mineral Tenure Act* (BC)

- *Mines Act* (BC)
- *Mining Right of Way Act* (BC)
- *Motor Vehicle Act* (BC)
- *Nisga'a Final Agreement Act* (BC)
- *Safety Standards Act* (BC)
- *Transportation Act* (BC)
- *Water Sustainability Act* (BC)
- *Wildlife Act* (BC)
- *Canadian Environmental Protection Act* (Canada)
- *Canada Transportation Act* (Canada)
- *Transportation of Dangerous Goods Act* (Canada)
- *Canada Explosives Act* (Canada)
- *Nuclear Safety and Control Act* (Canada)
- *Navigation Protection Act (formerly Navigable Waters Protection Act)* (Canada)
- *Fisheries Act* (Canada)
- *International Rivers Improvement Act* (Canada).

Major federal and provincial licenses, permits, and approvals that were obtained to construct and operate the Brucejack Gold Mine are summarized in the following sections. This summary cannot be considered final for the LOM due to the complexity of government regulatory processes, which evolve over time, and the large number of minor permits, licenses, approvals, consents, authorizations, and potential amendments that are required from time to time. More than 100 authorizations have been issued to date for construction and operation of the Brucejack Gold Mine and its supporting infrastructure. Additional minor notifications, authorizations, and amendments to existing authorizations will be required on an on-going basis to support continual improvement of the mine plan, surface and ancillary infrastructure, as well as changes to regulatory changes applicable to the mine's operation. A compliance tracking system is used.

20.2.2.1 British Columbia Authorizations, Licenses, and Permits

Issuance of statutory permit approvals occurred following receipt of the EAC and federal EIS Decision Statement. The BC *Mines Act* Permit M-243 and *Environmental Management Act* Permits PE 107835 and PA 107025 were issued in July and August 2015, respectively. *Mines Act* Permit M-243 has been amended seven times to accommodate mine plan changes, including the increase in production rate to 1,387,000 t/a (3,800 t/d). The *Environmental Management Act* discharge permits for waste discharges to both water and air have been amended four times. The Brucejack Access Road, initially permitted under a BC *Mines Act* exploration permit, was re-permitted as Special Use Permit S25923 under the Provincial Forest Use Regulation (*Forest Practices Code of British Columbia Act*), which has been amended once. A full summary of active provincial authorizations for the Brucejack Gold Mine is presented in Table 20-2.

Table 20-2: List of BC Major Authorizations, Licenses, and Permits Obtained to Develop and Operate the Brucejack Project

BC Government Agency – Permits and Licenses	Enabling Legislation and Authorization
Environmental Assessment Office	*Environmental Assessment Act* EAC #M15-01 issued 26 March 2015; amended 10 March 2016, 12 August 2016, 23 November 2016, 31 March 2017, and 15 November 2018.
Ministry of Energy, Mines and Petroleum Resources, Approving Mine Plan and Reclamation Program, including the northern one-third of the transmission line on Pretivm mineral tenures.	*Mines Act* Permit M-243 issued 22 July 2015; amended 26 August 2015, 9 September 2015, 17 March 2016, 4 August 2016, 3 April 2017, and 14 December 2018.
Ministry of Energy, Mines and Petroleum Resources Issuance of Mining Leases	*Mineral Tenure Act* Tenures 1038597, 1038598, 1038599, and 1038600 issued 17 September 2015.
Ministry of Environment and Climate Change Strategy Discharge Mine Related Contaminants and Effluent to Water Permit	*Environmental Management Act* Permit 107835 issued 31 August 2015; amended 4 February 2016, 12 July 2016, 31 March 2017, and 14 December 2018.
Ministry of Environment and Climate Change Strategy Discharge Mine Related Contaminants to Air and Ash to Ground Permit	*Environmental Management Act* Permit 107025 issued 9 January 2014; amended 22 July 2015, 12 July 2016, 8 September 2017 (temporary item that was included in next amendment), and 27 March 2018.
Ministry of Forests, Lands, Natural Resource Operations and Rural Development Access Road	*Forest Practices Code of British Columbia Act (Provincial Forest Use Regulation)* and *Mining Right of Way Act* Special Use Permit S25923 issued 23 July 2015; amended 7 June 2016.
Ministry of Forests, Lands, Natural Resource Operations and Rural Development Occupant License to Cut	*Forest Act* Licenses to cut to clear timber along the transmission line and access road route and other infrastructure sites; OLTC L48433 and L50280 issued 1 May 2015 and 23 July 2015, respectively.
Ministry of Forests, Lands, Natural Resource Operations and Rural Development Water License – Use	*Water Sustainability Act* Process Water Withdrawal License 500684 issued 26 November 2018 (replaces prior license).
Ministry of Forests, Lands, Natural Resource Operations and Rural Development Water Licenses – Diversion and Use	*Water Sustainability Act* Diversion of surface waters around site and withdrawal from mine. Licenses C132076 and C132077.
Technical Safety BC Design Registration	*Safety Standards Act* Incinerators
Ministry of Forests, Lands, Natural Resource Operations and Rural Development Licenses of Occupation (a total of 20 sites) Transmission Line (southern two-thirds), Wildfire Camp / Laydown, Bowser Aerodrome / Camp / Laydown, Explosives Storage Areas, Knipple Transfer Station, Scott Weather Station, Communication Tower Sites, Aviation Beacon Sites	*Land Act* Most issued in 2015 with additions in 2016.

table continues…

BC Government Agency – Permits and Licenses	Enabling Legislation and Authorization
Ministry of Environment and Climate Change Strategy Hazardous Waste Generator Registration	*Hazardous Waste Regulation* Provincial Identification Number BCG 10829 issued 6 September 2013.
Northern Health Camp Operation Permits (potable water system (including wells), sewage systems, camp operations, camp food services)	*Drinking Water Protection Act/Health Act/Municipal Wastewater Act* All issued by Northern Health starting in 2013, ongoing as annual updates for changes in design and operations.

20.2.2.2 Federal Approvals and Authorizations

Applications for federal approvals can be completed concurrently with or following the provincial environmental assessment process, but permits and authorizations cannot be obtained until federal approval of the EIS. Table 20-3 lists federal approvals obtained for the Brucejack Gold Mine.

Table 20-3: List of Federal Approvals and Licenses Obtained to Develop and Operate the Brucejack Project

Federal Government Approvals and Licenses	Enabling Legislation and Authorization
Canadian Environmental Assessment Agency (as of 2019 replaced by Impact Assessment Agency of Canada) EIS	CEAA 2012 (replaced in August 2019 by Impact Assessment Act) Decision Statement issued 27 July 2015.
Environment and Climate Change Canada Alteration of Flow on an International River	*International Rivers Improvement Act* Exception received 26 November 2015.
Environment and Climate Change Canada MDMER	*Fisheries Act/Metal and Diamond Mining Effluent Regulation (MDMER)* The mine became subject to MDMER on 12 January 2016.
Transport Canada, Navigable Waters Protection Program Stream Crossing Authorizations	*Navigation Protection Act* (in 2019 replaced by *Canadian Navigable Waters Act*) Group 4 “Navigable Waters Protection Program” Issued 10 December 2012; not subject to the act as of 6 July 2016.
Natural Resources Canada Explosives Storage Facilities	*Explosives Act*
Innovation, Science and Economic Development Canada Radio Licenses	*Radio Communication Act*
Canadian Nuclear Safety Commission Radioisotope License (Nuclear Density Gauges)	*Nuclear Safety and Control Act*

20.2.3 Financial Assurance

The current reclamation security for activities within the area covered by *Mines Act* Permit M-243 (primarily the area within the Mining Leases) totals $31,700,000, which is based on a full build-out of the mine. This reclamation security is reviewed annually as part of the annual MEMPR reporting requirements and is also subject to major review at least every five years to reflect changes in mine plans and anticipated reclamation costing rate changes. The next five-year review is due in July 2020. The Brucejack Access Road reclamation security held under the Special Use Permit totals $2,000,000. This security is subject to annual changes based upon Canadian Consumer Price Indices. A number of smaller reclamation securities are established under each license agreement for facilities built on Licenses of Occupation that have an aggregate value of $70,000.

20.3 Environment

20.3.1 Environmental Setting

20.3.1.1 Introduction

The Brucejack Gold Mine is located in an alpine area along the southwest shore of Brucejack Lake at the western terminus of the Brucejack Access Road (Figure 4-2). The mine site elevation is approximately 1,400 masl and the treeline is at approximately 1,200 masl. Elevations of the Knipple Camp (km 56), Bowser Aerodrome (km 51), and Wildfire Camp and Security (km 1) areas are approximately 470, 444, and 453 masl, respectively. The 73 km Brucejack Access Road climbs to an elevation of approximately 1,000 masl at the summit of Scott Pass, near km 17 between Wildfire Camp and Bowser Aerodrome.

This topographic and spatial variation results in significant temperature, precipitation, and wind differences between these project infrastructure areas and along the Brucejack Access Road. The mine and its supporting infrastructure lie in a transition zone between the very wet coastal and drier interior regions of BC. This part of northwestern BC is dominated by weather systems generated from the Pacific Ocean, but is also strongly influenced by orographic effects caused by the local mountain topography that produces high spatial variability in snowfall and precipitation, and in temperatures and snowmelt. In addition, the large glacial areas around the mine site can impact snowmelt rates and produce high runoff volumes during the summer months. The humid climate and physical characteristics of the region result in dynamic streams and rivers with high annual runoff rates and high average stream flows.

The Brucejack Gold Mine and its supporting infrastructure are located in a rugged area with elevations ranging from approximately 500 masl at the lower elevations along parts of the Brucejack Access Road and the transmission line to 1,400 m at the mine site. Peaks surrounding the mine site and for the northernmost part of the transmission line reach elevations of up to approximately 2,200 masl. Glaciers and icefields surround the mine site to the west, south, and east.

Recent and rapid deglaciation has resulted in over-steepened and unstable slopes in many areas. Recently deglaciated areas typically have limited soil development, consisting of glacial till and colluvium. Lower elevation areas with mature vegetation may have a well-developed organic soil layer. Avalanche chutes are common throughout the area, and management of avalanche hazards is a key aspect of mine and access road operations. Avalanche and glacier access hazards are actively monitored and managed by mountain safety personnel within the mine's health and safety department, in accordance with the Avalanche Safety Plan (ASP).

The mine site area (all mine infrastructure west of the upper Knipple Glacier, km 71) is situated within the Brucejack Creek watershed, which is a small headwater sub-basin within the Sulphurets Creek watershed (drainage area 299 km^2). Sulphurets Creek is a tributary of the Unuk River that flows southwest, eventually discharging to the Pacific Ocean northeast of Ketchikan, Alaska (drainage area 2,577 km^2 at the mouth). The first 71.5 km of the Brucejack Access Road and the infrastructure areas along the road are located within the Bell-Irving River watershed, which drains to the Nass River. The Nass River discharges into the Pacific Ocean in Canada.

There are no fish present within Brucejack Lake or Creek, or in most of Sulphurets Creek downstream of the mine. The nearest recorded fish presence is more than 20 km downstream of the mine, approximately 300 m upstream of the confluence of Suphurets Creek with the Unuk River. The Bowser and Bell-Irving rivers are both fish-bearing, including anadromous salmonids and resident Dolly Varden char. Wildlife species present in the area include black and grizzly bears, moose, and mountain goats.

Pretivm undertook extensive environmental baseline studies in support of its application for an EAC and EIS Decision Statement as well as for subsequent major provincial permit applications (*Mines Act* Permit, *Environmental Management Act* permits, and other authorizations). These included atmosphere/climate, surface and subsurface hydrology, aquatics, geochemistry, hydrogeology, surface water and sediment quality, limnology, fish habitat, soils, vegetation, and wildlife studies to characterize the local and regional ecosystem prior to major disturbances. Archaeology, heritage, land use, cultural, TK, and socioeconomic baseline studies were also carried out to characterize the regional human environment. An extensive environmental monitoring program was implemented through mine construction and is being continued through mine operations in accordance with the mine's authorizations.

20.3.1.2 Climate

The climate of the region is relatively extreme and daily weather patterns are unpredictable. Prolonged clear sunny days can prevail during the summers. Precipitation in the region is approximately 1,600 to 2,100 mm annually. The majority of precipitation falls during the autumn and winter months, from October to April. Records show that Brucejack Lake receives approximately 70% of its annual precipitation on average during this period. The months of October through to January typically have the highest monthly precipitation amounts, while late spring or early summer months are typically much drier. Snowpack typically ranges from 1 to 2 m deep, but high winds can create snowdrifts up to 15 m deep. Permanent icefields are present in the upper reaches of the Brucejack Lake watershed.

A full meteorological station was established west of the Brucejack Camp in mid-October 2009 to collect site-specific weather data. The station measures wind speed and direction, air temperature and pressure, rainfall, snowfall, relative humidity, solar radiation, net radiation, and snow depth. The Brucejack Lake station operated from October 2009 to August 2014. The tower and instrumentation were relocated to a site in the Valley of the Kings valley, closer to and approximately 0.6 km from the Brucejack Camp, in September 2014. Additional meteorological stations have been installed at the Bowser aerodrome, 18.2 km from Brucejack Camp, and Scott Pass at km 18 along the Brucejack Access Road, approximately 30 km from Brucejack Camp.

Table 20-4 presents the estimated average monthly climate data for the Brucejack Project site (BGC 2017).

Average monthly temperature data for the mine site area are based on temperature data collected at site for the 2013-2016 period.

Annual evaporation and sublimation at the site was estimated using local climate data from the on-site climate station for the period 2010 to 2012, and Reference Evapotranspiration (REF-ET) calculation software (Version 3.1.14). Climate inputs required for the model include air temperature, wind speed, incoming solar radiation (or sunshine hours), relative humidity, dew point temperature, and atmospheric pressure.

Table 20-4: Average Monthly Climate Data for the Brucejack Gold Mine Site

Month	Average Temperature (°C)	Average Precipitation (mm)	Average Evaporation/ Sublimation (mm)
January	-5.0	269	2
February	-6.9	231	2
March	-5.8	196	2
April	-2.6	105	4
May	3.8	95	10
June	5.8	72	23
July	8.1	90	46
August	8.5	150	41
September	4.5	224	25
October	-0.1	267	8
November	-5.2	233	2
December	-7.7	267	2
Average/Total	**-0.2**	**2,200**	**167**

Source: BGC (2017)

20.3.1.3 Ecosystems

The mine site is situated in a gossanous area above the treeline. Prior to construction, it was dominated by unvegetated and sparsely vegetated terrain, with limited areas of alpine ecosystems within the gossan itself. Alpine ecosystems, including tundra, heather, and fellfield classes, are common in the area surrounding the mine site. The Brucejack Access Road traverses valley bottom forests, subalpine stands of subalpine fir, and Engelmann spruce in higher elevation sections, particularly through Scott Pass. Dry glaciofluvial terraces supporting early seral pioneer ecosystems are present within the lower elevation portions of the Bowser River valley. The transmission line from the mine site to its intertie at the Long Lake Hydro substation traverses both mature forest and recently deglaciated terrain, dominated by scoured rock, eroding moraine, and glaciofluvial deposits. The northernmost segment extending from Knipple Camp to the mine site traverses mountain ridges and tops and includes several large glacier spans.

There are several wetlands along or near to the Brucejack Access Road in the Scott Pass area between km 15 and 30, and along the Bowser River floodplain section of the road. Wetlands are limited in extent in the vicinity of the mine site. Wetlands are valued ecosystem components and were assessed as part of the Brucejack Gold Mine environmental assessment process. Baseline studies were conducted to map and classify wetlands and to identify the primary wetland functions. These baseline data were used to identify areas where toad tunnels were installed along the Brucejack Access Road to provide safe access to wetlands for migrating Western toads, a protected species under the federal *Species at Risk Act*.

The region surrounding the Brucejack Gold Mine and its supporting infrastructure is home to many terrestrial and aquatic wildlife species, including black and grizzly bears, mountain goats, moose, bats, furbearers, small mammals, birds of prey, migratory songbirds, waterfowl, and herptiles. These include several species at risk, as well as species of cultural and economic importance. Prior to the environmental assessment process, Pretivm

evaluated the potential for adverse effects on representative species that were identified as being at risk or of concern within the area through baseline surveys. Species at risk that were encountered during baseline studies included wolverine, fisher, grizzly bear, western toad, barn swallow, rusty blackbird, olive sided fly catcher, and little brown Myotis. While no little brown Myotis bat habitat was identified as disturbed, bat houses were installed along the Brucejack Access Road and along the transmission line. Species of concern include those that may not be of conservation concern but are of regional importance for other reasons, or are identified in the Cassiar Iskut-Stikine LRMP, and include moose, mountain goat, black bear, and American marten.

Wildlife monitoring is conducted, and additional mountain goat and moose surveys will be conducted for these species at five-year intervals throughout mine life. Wildlife observations at mine infrastructure areas are recorded and helicopter pilots are required to implement measures to minimize or prevent disturbance of mountain goats and other species. The mine implements a rigorous waste management program and other measures, including seasonal electrified fencing around Knipple and Wildfire camp located within areas of high bear activity, to prevent wildlife access to food or other potential mine-related attractants. A Wildlife Advisory Committee (WAC), which includes representatives of the Nisga'a Nation, Tahltan Central Government, Tsetsaut/Skii km Lax Ha, and BC MFLNRORD, was established at the beginning of mine construction and continues to meet during mine operations on an annual basis.

The Brucejack Gold Mine is situated in the headwaters of the Brucejack Lake watershed; Brucejack Creek drains Brucejack Lake and enters the subglacial flow of Sulphurets Creek approximately 3.1 km downstream of the Brucejack Lake outlet. Sulphurets Creek flows approximately 20 km downstream of the Brucejack / Sulphurets Creek confluence to its confluence with the Unuk River. Fish are absent within and downstream of Brucejack Lake in all waterbodies, including Sulphurets Creek, upstream of a barrier located 300 m upstream of the confluence of Sulphurets Creek and the Unuk River. The Unuk River is a large river system that provides important habitat for the five species of Pacific salmon, as well as habitat for resident trout (cutthroat, rainbow), and resident Dolly Varden.

The Brucejack Access Road traverses the watershed of the Bell-Irving River, including its tributaries Wildfire Creek, Todedada Creek (tributary to Treaty Creek, which is tributary to the Bell-Irving River), and the Bowser River. The Bell-Irving River, in turn, drains to the Nass River. The Bell-Irving River system provides habitat for sockeye, Coho, and Chinook salmon; resident and anadromous trout (rainbow and steelhead); resident char (Dolly Varden and bull trout); mountain whitefish; and coarse fish species. The fisheries resources and fish habitat of potentially affected rivers and their tributaries were assessed as part of the baseline program for the Brucejack Gold Mine.

20.3.2 Geochemistry

20.3.2.1 Introduction

The geochemistry of rock that has been or will be disturbed, excavated, or exposed at the Brucejack Gold Mine has been characterized through static and kinetic test programs. The characterization programs have also evaluated the water quality impacts of explosives used for blasting and cement products used in shotcrete and paste backfill. Static tests include acid base accounting (ABA) analyses to evaluate whether material is PAG, elemental analyses to identify parameters that are elevated and of potential concern, and shake flask extraction tests to provide an indication of soluble loads and drainage chemistry. Kinetic tests including field bins (n=14), humidity cells (n=81) and saturated columns (n=34) have been carried out to assess the long-term behaviour of materials under site-specific conditions. Baseline studies and confirmatory sampling programs have been carried out for the following:

- Waste rock
- Ore, tailings, and paste backfill

- Quarry rock
- Underground mine water
- Water treatment plant effluent and associated treatment residues (i.e., sludge)
- Excavated surface rock exposures and runoff contacting these exposures
- Explosives-related residues.

The results of these characterization studies have informed management and monitoring plans designed to prevent or minimize potential geochemistry and chemistry related adverse environmental effects associated with development, operation, and closure/reclamation of the Brucejack Gold Mine. The following sections summarize the geochemical characteristics of the above referenced rock, mine wastes, and contact waters, and describe the associated management strategies.

20.3.2.2 Waste Rock

Waste rock generated at the Brucejack Gold Mine is predominantly PAG and is managed following best practices to minimize the oxidation of sulphide minerals (i.e., pyrite). All waste rock is managed as PAG and has and will continue to be either deposited subaqueously in Brucejack Lake or placed as backfill in the underground mine below the post-closure final water table elevation. Surface waste rock excavated to support development of the mine site during construction was placed subaqueously in Brucejack Lake. Excavation of underground mine waste rock is ongoing, with this waste rock placed both in Brucejack Lake and in the underground mine as backfill. There are no permanent surface subaerial waste rock dumps at the mine site; however, the *Mines Act* Permit (M-243) authorizes temporary subaerial storage of waste rock for up to two years prior to subaqueous deposition in Brucejack Lake. Geochemical studies have been carried out to assess the behaviour of waste rock in both saturated and unsaturated conditions.

Static characterization studies (ABA and total elemental analyses) carried out on a total of 160 surface waste rock samples from five different lithologic units (Fragmental Andesite (ANDX), VSF, Porphyry 2 (P2), Conglomerate, and Porphyry 1 (P1)) indicated that 78 samples (49%) were characterized as PAG (Pretivm 2017; Pretivm 2018a). Surface waste rock characterization studies identified enrichments (greater than 10x average continental crust) in silver, arsenic, manganese, antimony, and selenium (Pretivm 2016; Pretivm 2017). Kinetic tests (field bins and saturated columns) were initiated on the four rock units comprising 95% of surface waste rock excavated, and results confirm that permanent subaqueous waste rock storage will minimize potential metal leaching. The test data also indicate that subaerial exposure of waste rock for two years prior to permanent subaqueous storage will not result in any significant changes to Brucejack Lake water quality (Lorax 2016a; Lorax 2017).

Underground waste rock samples (n=568) from six lithologic units (VSF, Fragmental, Conglomerate, P1, P2, and Silicified Cap) have been characterized through static and kinetic test work. The results indicate that rocks from all units are dominantly PAG (n=472; 83.1%) with elevated concentrations of metals (e.g., silver, cadmium, zinc) and metalloids (arsenic, antimony) compared to continental crust. The data also show that many of the PAG samples contain significant amounts of carbonate minerals (mostly calcite) that will neutralize acidity generated and prolong the onset to acid generation (Pretivm 2016). Under oxidizing unsaturated conditions, waste rock and associated wall rock exposures have the potential to leach metals into mine water. During mine operations, the underground mine and surface contact water has and will continue to be treated by the WTP, which has been designed to treat and manage metals of potential concern. The mine will be flooded at closure, at which point saturated conditions are expected to limit acid generating reactions (as supported by saturated column test results), thereby minimizing potential adverse effects on water quality of the aquatic receiving environment. Similarly, saturated column tests simulating underground mine waste rock leaching behaviour in Brucejack Lake, as well as onsite water quality

monitoring data, indicate that permanent subaqueous storage of waste rock deposited in Brucejack Lake will not result in exceedances of regulated discharge concentrations at the outlet of Brucejack Lake.

20.3.2.3 Ore, Tailings, and Paste Backfill

The Brucejack Gold Mine mill began operating in July 2017; tailings generated by milling have and will continue to be placed as thickened tailings in Brucejack Lake and as cemented paste backfill in mined out stopes. The Brucejack Gold Mine ore is characterized as PAG with elevated concentrations of silver, arsenic, cadmium, manganese, and selenium, compared to continental crust (BGC 2014). Characterization studies carried out on thickened tailings generated from the mill (n=38) show the same metal enrichments, but samples are predominantly NPAG, with a median NPR of 3.1 (Pretivm 2018a; Pretivm 2019). Paste samples (n=23) are similar in composition to thickened tailings, but with a slightly higher median NPR (4.8). Kinetic tests have been carried out to assess the behaviour of tailings deposited in Brucejack Lake, as well as the behaviour of cemented paste in unsaturated and saturated conditions within the underground mine.

Saturated column tests comprised of tailings flushed with lake water were carried out under both oxidizing and reducing conditions to estimate potential leaching rates and changes to Brucejack Lake water quality following deposition. The results of the study (Lorax 2016b) indicated that chemical loads released into the lake from tailings would not result in significant changes to Brucejack Lake water quality.

Kinetic test work to assess chemical loads released from paste backfill during mine operations indicates that chemical loads from paste backfill are minor compared to other mine-related sources. Some potential concerns with chromium were raised based on early-stage test work, with an off-shore sourced binder; however, follow-up kinetic test work, using binder sourced for use at the mine, and updated water quality modeling (Lorax 2018) do not predict any exceedances of chromium water quality guidelines in the aquatic receiving environment. No exceedances of chromium have been reported since paste backfilling commenced (Pretivm 2019).

Saturated column tests carried out on paste backfill are used to predict underground mine water quality for the post-closure flooded mine condition. The results of these tests (Pretivm 2019) do not identify backfilled tailings as the dominant source of any parameters of potential concern.

20.3.2.4 Quarry Rock

Rock excavated from the Brucejack Gold Mine NPAG Quarry located at km 72 of the Brucejack Access Road was used to construct the mill and Phase 2 camp pads, and for various building foundations, roads and other construction activities at the mine site. It continues to be used for road surfacing and other maintenance requirements. The NPAG Quarry is located near the southeast end of Brucejack Lake; quarry runoff flows into Brucejack Lake. The NPAG Quarry is comprised predominantly of volcanic (plagioclase-hornblende) porphyry, with lesser amounts of conglomerate, and has negligible sulfide mineralization. Characterization studies of 72 NPAG Quarry rock samples have confirmed that rock excavated from the NPAG Quarry is consistently NPAG, with low neutral metal leaching potential.

20.3.2.5 Mine Water

Underground mine water at the Brucejack Gold Mine is dominantly comprised of groundwater with added geochemical loads from blasted rock, wall rock, waste rock backfill, and paste backfill. Underground mine water chemistry is monitored twice a month, and results indicate that the water quality has been within the range predicted by the water quality model. Despite the prevalence of PAG waste rock, mine water has alkaline pH levels, supporting the assertion that neutralization afforded by carbonate minerals will buffer any acid generated from sulphide oxidation reactions for several decades or more (Pretivm 2015). Similarly, there is no indication of increasing concentrations of dissolved metals associated with the onset of ML/ARD as predicted by kinetic tests (e.g., cadmium, cobalt, copper, iron, zinc) since gold production commenced in June 2017. Mine water will be treated throughout mine operations and into the closure phase.

20.3.2.6 Water Treatment Plant Effluent and Sludge

The WTP receives and treats underground mine water from mine dewatering, surface contact water from with the surface contact water collection system, WTP effluent collected in the CWP, and recycled process water from the mill. The WTP is designed to chemically precipitate targeted dissolved metals and remove resultant chemical precipitates and influent TSS. The WTP effluent has consistently met design specifications. The water treatment design, metals and solids removal process, and effluent design criteria are described in the 2015 *Mines Act-Environmental Management Act* Permits Application (Pretivm 2015).

The WTP generates a solid waste product (sludge) that requires management and disposal. Sludge generated from the WTP is currently being co-deposited with thickened tailings into Brucejack Lake. Static test results indicate that the sludge is NPAG with elevated concentrations (greater than 10x average continental crust) of several metals (e.g., silver, arsenic, cadmium, manganese, molybdenum, antimony, and selenium). However, the results also show that the sludge is stable under a range of pH and redox conditions. Kinetic tests have been carried out to evaluate potential chemical loads that may leach into Brucejack Lake under both oxidizing and reducing conditions. The studies predict low metal leaching rates for the co-deposited tailings and sludge and thus no long-term effects to Brucejack Lake water quality are anticipated.

20.3.2.7 Surface Rock Exposures and Runoff

The contact water collection system collects contact water from within the main Mine Site areas of excavated bedrock exposures, particularly the mill, Phase 2 Camp, and Valley of the Kings portal pads. The contact water collection system directs water to the WTP via the CWP. Non-contact surface runoff from areas immediately surrounding the mine site are directed to Brucejack Lake via the East (Johnson Creek) Diversion Channel, and to Camp Creek via the West (Camp Creek) Diversion Channel. Camp Creek runoff is naturally acidic, with elevated metal concentrations (e.g., silver, cadmium, copper, and zinc). Mine Site contact water system runoff has been assessed based on direct CWP samples (n=7), drainage into the CWP (n=4) and shake flask experiments carried out on all surface exposed rock units (n=92). Results of ongoing monitoring are presented in the Annual Reclamation reports. During the operations phase, all surface runoff within the contact water collection system has and will continue to be treated by the WTP. At closure, the mine site will be reclaimed and surface runoff will follow natural pathways to the receiving environment. The potential effects of this drainage on the receiving environment will continue to be assessed as monitoring data are collected. Based on the SFE data and water quality predictions, no significant impacts to water quality in the receiving environment are anticipated.

20.3.2.8 Explosives-related Residues

Water quality model predictions presented in the *Mines Act/Environmental Management Act* Permits Application (Pretivm 2015) identified nitrite as a parameter of potential concern. The main source of nitrite in Brucejack Gold Mine related discharge is from explosives used to blast waste rock and ore. Explosives-related residues contain water soluble nitrogen compounds that can affect water quality in the receiving environment. Site monitoring data have been used to derive and refine water quality predictions with respect to these compounds (Lorax 2018). Pretivm implements a Nitrogen Management Plan that was developed for the Brucejack Gold Mine and includes monitoring requirements, source control measures and management triggers for mitigation. The water quality model was updated based on the latest data sets and no exceedances of the current discharge limits for nitrogen compounds are predicted, nor have any been observed since gold production commenced (Pretivm 2018a and 2019).

20.3.3 Hydrogeology

20.3.3.1 Overview

The groundwater flow system at the Brucejack Gold Mine has been conceptualized to provide estimates of groundwater inflow to the existing and future underground mine workings during operations and closure, and of groundwater flow paths at post-closure.

Numerical groundwater modeling of the mine was undertaken in 2013, 2014, and 2015 to support applications for an Environmental Assessment Certificate and *Mines Act* / *Environmental Management Act* permits (BGC 2014; 2015). These modeling studies drew upon site investigations characterizing hydrogeological conditions initiated in 2010. These investigations included drilling, hydraulic testing, and monitoring well and vibrating wire piezometer installations. Data available through late 2014 were used in conceptual and numerical groundwater model development, calibration, and benchmarking.

Routine groundwater quantity monitoring has been ongoing at the Brucejack Gold Mine site since 2011. Hydrogeological field programs comprised of drilling, hydraulic testing, and monitoring well installation were undertaken in 2016 and 2018 (BGC 2017; 2019). The 2018 field investigation established 14 new monitoring wells, fulfilling *Environmental Management Act* Permit PE-107835 and *Mines Act* Permit M-243 requirements. BGC designed and supervised all hydrogeological drilling programs while Pretivm staff have performed ongoing routine monitoring of groundwater levels, groundwater quality, and underground dewatering rates.

Site monitoring data indicates that continuous dewatering of the mine since the fall of 2012 has resulted in significant depression of water levels and development of strong, downward, vertical hydraulic gradients at most nested well locations. The 2015 groundwater model has reasonably simulated these impacts but slightly overpredicts underground dewatering rates.

The numerical groundwater model is currently being updated in support of the 5-Year Mine Plan and Reclamation Program Update pursuant to permit requirements. The model update aims to refine underground dewatering rates in light of the expanded hydrogeological data set and the increased production rate. Groundwater system conceptualization for the 2020 Update is reasonably consistent with the 2015 model. Preliminary results indicate dewatering rates that are within ranges previously provided by the 2015 model (BGC 2015).

20.3.3.2 Conceptual Hydrogeologic Model

Surface topography has a pervasive influence on the groundwater flow system at the Brucejack Gold Mine. The elevation within the immediate mine area ranges in elevation from approximately 1,350 masl at the outlet of Brucejack Lake to over 2,000 masl at the highest peaks. Measured groundwater elevations suggest that the water table is a subdued replica of topography, with depths to groundwater typically greater in the uplands relative to the valley bottoms. Groundwater enters the flow system from infiltrating precipitation and snowmelt, with lesser components supplied by surface water infiltration in lakes. Groundwater discharge zones are generally restricted to lakes, creeks, gullies, and breaks in slope.

The hydrostratigraphy of the mine site is comprised of a thin, discontinuous layer of glacial till or colluvium underlain by bedrock. Thicker unconsolidated deposits are confined to local sections of the valley bottom and are not present near the mine.

The bedrock at the mine site can be broadly divided as follows:

- Triassic marine sedimentary and volcanic rocks of the Stuhini Group
- Jurassic sediments and volcanics of the Hazelton Group
- Early Jurassic dikes, sills, and plugs of diorite, monzonite, syenite, and granite, the most common of which are grouped as the “Sulphurets Intrusions”.

There is a general site-wide trend of decreasing bedrock hydraulic conductivity, K, with depth, although K may vary by a few orders of magnitude at any given depth. Based on available data, fault structures are not universally conductive across the mine site.

20.3.3.3 Numerical Hydrogeologic Model

The conceptual model described in Section 20.3.3.2 was used as the basis for the development of a numerical hydrogeologic model. The numerical model was initially developed in 2013 (BGC 2013), and was subsequently refined in 2014 (BGC 2014) and again in 2015 (BGC 2015) for the *Mines Act* / *Environmental Management Act* permits application (Pretivm 2015). The model was built using the graphical user interface Groundwater Vistas (Environmental Simulations Inc. 2011) and MODFLOW-Surfact code (Harbaugh et al. 2000; HydroGeoLogic 2012). The numerical model was calibrated in stages to available hydrogeologic data collected within the study area, including steady-state and transient hydraulic head targets, vertical hydraulic head gradients, streamflow data, and winter low-flow estimates for the period 2008 to 2014, and volumetric discharge data available from mine dewatering activities for the period 2011 to late-2014. The results of model calibration to pre-disturbance and post-disturbance conditions, and benchmarking to transient adit dewatering data indicated that the numerical representation of the hydrogeological system was suitable for predictive analyses.

The 2015 groundwater model is currently being updated to support water balance and water quality model updates for the 5-Year Mine Plan and Reclamation Program Update pursuant to permit requirements (due July 2020). The 2020 groundwater model update will build on the assumptions underpinning the 2015 groundwater model, incorporating a longer water level and underground dewatering record. The 2020 groundwater model is being constructed in FEFLOW 7.2, a part of the MIKE software suite (DHI 2020). FEFLOW is a widely accepted program for groundwater flow models in the mining industry. FEFLOW is three-dimensional finite-element package capable of simulating groundwater flows in complex hydrogeological settings. FEFLOW was selected over the MODFLOW-Surfact code for the 2020 model update on account of its flexible mesh design, which facilitates presentation of faults and complex underground geometries. The 2020 model will provide increased horizontal and vertical discretization in the mine area.

20.3.3.4 Predictive Simulations and Inflow Estimates

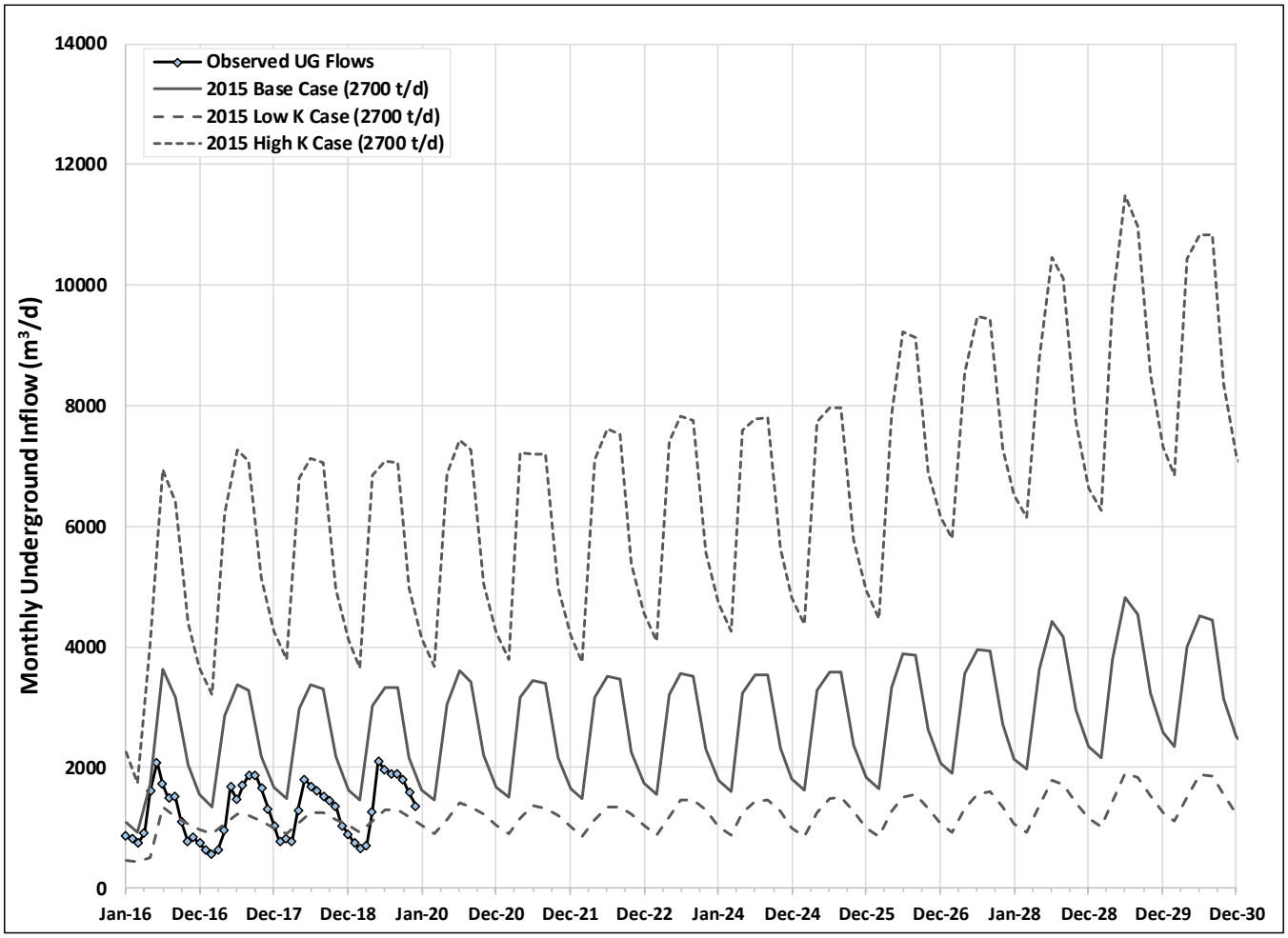
Predictive simulations from the 2015 groundwater model were based on the 18-year underground mine plan with a throughput of 2700 t/d as presented in the 2014 FS (Ireland et al. 2014). Model boundary conditions representing the development (i.e., underground workings, access and egress ramps, and declines) were activated according to the annual schedule in the mine plan, and remained active throughout mining operations, while mining stopes were deactivated after a period of one year, at which point the stopes were assumed to be backfilled with paste.

The 2020 groundwater model update will consider a 14-year underground mine plan with an annual average production rate of 3800 t/d. The 2015 groundwater model provided a range of groundwater inflows based on three model scenarios: a base case, a low K case, and a high K case. The base case reflected the best calibrated parameters set and represented the 'best estimate'. The low K and high K cases represent lower and upper ranges of key parameters sets controlling flow rates; however, these scenarios did not present optimal calibration statistics. Results from these three cases are presented in Figure 20-1 for the 18-year mine plan.

The 2015 base case average annual rate of groundwater inflow to the underground workings was predicted to remain relatively stable throughout the development of the Valley of the Kings resource, ranging between 2,500 and 2,900 m^3/d. With initiation of mining in the West Zone, predicted annual average inflows increased from 2,900 to 3,500 m^3/d, stabilizing at 3,500 m^3/d for the remainder of mine life. The overall average inflow for the simulated mining period was 2,900 m^3/d. Groundwater inflow to the underground workings for the base case was predicted to vary seasonally by about 2,000 m^3/d; estimated inflows varied from approximately 1,400 to 3,400 m^3/d (58 to 141 m^3/h) over the first half of mine life and from approximately 2,400 to 4,400 m^3/d (100 to 183 m^3/h) later in mine life.

Observed monthly underground dewatering rates from 2016 to 2019 are shown in Figure 20-1. The average annual dewatering rate for this period is 1,280 m^3/d (53 m^3/hr) with annual minima and maxima ranging from 550 m^3/d (23 m^3/hr) to 2100 m^3/d (88 m^3/hr), respectively. The observed data track between the low K case and base case model runs with annual minima overpredicted by the low K case.

Figure 20-1: Observed and Simulated Inflow to Underground Workings for Selected Model Scenarios



20.3.4 Water Management

20.3.4.1 General

Water management is a critical component at the Brucejack Gold Mine, for its operation and associated environmental protection in this high precipitation and runoff environment. As such, through its consultants and in accordance with its regulatory requirements, Pretivm developed a Water Management Plan that applies throughout the LOM. The Water Management Plan was prepared prior to mine construction as part of the EMP; was updated as appropriate during construction; and following completion of the contact water management system (infrastructure), was expanded to an OMS Manual (Surface Water Management Facilities OMS Manual) that includes both the Water Management Plan component and other details such as specifics of procedures, roles, and responsibilities. The goals of the Water Management Plan are to:

- Provide necessary guidance for the management of surface water within the core infrastructure area of the mine site, where significant PAG bedrock excavation was necessary as part of site preparation and where construction also resulted in significant changes to local flow pathways and drainage areas

- Provide guidance in terms of processes, maintenance activities, inspections and all necessary methods to ensure that all surface water discharges from the mine are in compliance with regulatory water quality requirements (i.e., to protect the water quality of the aquatic receiving environment downstream of the mine)
- Provide and retain water for mine operations
- Divert non-contact water around the mine site
- Define water management control structures.

Strategies for water management that were applied as part of mine design and construction which remain in effect through operations include:

- Separation of non-contact water (from the area surrounding the mine site) from contact water via non-contact diversion channels (Camp Creek and Johnson Creek diversion channels), and directing the undisturbed runoff away from mining related activities
- Minimizing the size of the mine site development area and minimizing surface PAG rock excavation by adjusting the elevations of the mill and Phase 2 Camp pads
- Collecting water within the surface contact water management system area and groundwater from the underground mine, and treating it to meet water quality discharge criteria prior to release
- Minimizing the use of fresh water through recycling of water to the extent feasible.

20.3.4.2 Water Management Overview

Contact Water

Contact water in the context of the Brucejack Gold Mine site is defined as water contacting PAG rock exposed through mining or mine related rock excavation (i.e., the latter occurring during site preparation for mine surface infrastructure construction).

There are three sources of contact water during operations:

- Waste rock deposited in Brucejack Lake
- Surface contact water from PAG bedrock excavations that occurred during site preparation for infrastructure construction, the largest of these being rock excavation to create the pad areas for the mill and the Phase 2 Camp
- Groundwater seepage to the underground mine.

Runoff from the latter two sources is managed by collection and treatment. All runoff within the mine site contact water management system is collected in the CWP. This pond has been sized to contain the runoff volume (50,000 m^3) associated with the 24-hour, 200-year return period rain on snow event (The 24-hour 200-year rainfall has been estimated at 226 mm, while snowmelt potential has been estimated at 43 mm). The CWP is located near the southwest shore of Brucejack Lake. Runoff is directed to the facility through a series of contact water ditches, pipes, and sump collection areas. From the CWP, contact water is pumped to the WTP, located within the mill building. Treatment of collected surface contact water began part way through mine construction and will continue throughout the LOM. The treated water is either used in process or discharged to Brucejack Lake at depth. The WTP has been designed with a nominal capacity of 9,600 m^3/d. The system is scalable such that additional units can be added if required.

Groundwater seepage into the underground workings is initially sent to the WTP for treatment before being sent to the process plant, where its use is maximized in process. Excess treated groundwater is discharged to Brucejack Lake at depth.

Diversion Channels

Two fresh water (non-contact) diversion channels divert non-contact water around the core mine site surface infrastructure area. The Johnson Creek (East) Diversion Channel drains into Brucejack Lake, while the Camp Creek (West) Diversion Channel discharges to Brucejack Creek.

Process Water Requirements

Process water is required for the tailings slurry to the lake, the underground paste backfill, the concentrate slurry, and underground mine supply. Process water is sourced from:

- Treated underground seepage water
- Treated contact water from the CWP
- Ore moisture
- Water withdrawal from Brucejack Lake at its outlet.

Water withdrawal from Brucejack Lake is required because there are periods in the winter when groundwater inflows are less than the process requirement.

Details of subaqueous tailings deposition are provided in Chapter 18.0. Tailings are either directed to the paste backfill plant or diluted and sent to Brucejack Lake, but never concurrently. A constant flow (either tailings or water) is required through the tailings pipeline at all times to prevent a buildup of tailings and blockage of the pipelines; however, the tailings line to the lake will be operational approximately 60 to 70% of the time. Therefore, when the thickened tailings are being directed to the paste plant for underground mine paste backfill, fluidizing water is discharged via the tailings pipeline.

20.3.5 Water Balance

A site-wide water balance model was constructed for the Brucejack Gold Mine in Excel using a monthly time-step (BGC 2017a,b). A flow schematic of the water balance for Operations is shown in Figure 20-2.

The site-wide water balance model provides an accounting of project activities at the spatial scale of the mine site (i.e., the tracking of flows between the Freshwater (FW) Tank, the Underground Mine, the CWP, the WTP, the Mill, and Brucejack Lake), and also tracks background and surface water flows from the headwaters of the Brucejack Lake watershed, downstream to the BJ 1.74 monitoring location, which is below Brucejack Lake. In addition, the water balance model tracks volumes of water and mine waste that report to Brucejack Lake over the period of active mining. For example, the model accounts for the displacement of lake water resulting from tailings and waste rock deposition and losses of lake water to tailings voids upon placement in Brucejack Lake.

Main sources of water for ore processing at the Brucejack Gold Mine include water that is recycled from the mill process, water conveyed by contact water ditches and surface sumps and reports to the CWP, water that reports to sumps of the Underground Mine and is pumped to surface, and permitted water withdrawals that are sourced from Brucejack Creek adjacent the BJ 3.10 weir. Water recycled from the mill process and that is withdrawn from CWP storage is first treated prior to being used in the mill. Surplus treated water may be discharged to Brucejack Lake when mill water requirements are fully met or it is necessary to manage pond volumes at a certain level.

Operational water data collected in 2018 and 2019 indicates that discharges of treated effluent to the lake are necessary between May and October because the majority of annual runoff is realized during these months and water surpluses are encountered at the CWP.

Water that reports to the Underground Mine is captured in sumps and pumped to surface. Like water sourced from the CWP, sump water is treated prior to being used in the mill or discharged to the lake when freshwater supply exceeds mill water demand. A major component of underground sump water is groundwater recharge that daylights in the mine due to dewatering activities. Groundwater inflows are seasonally variable, with values being lower in winter (e.g., February, March), and notable that recharge rates to the mine are lower than base case predictions indicate (Figure 20-1). In addition to groundwater recharge, water from the FW Tank in the mill building is also directed below ground to support mining activities, such as drilling and dust suppression. Like groundwater recharge, this circulated water reports back to underground sumps and is pumped to surface for treatment, use in the mill, or release to the lake.

Mill demands and underground mine water requirements based on the LOM Backfilling – Waste Rock and Mill Tailings schedule presented in Chapter 16 (refer to Table 16-5 and averages based on the period 2020 through 2028, which corresponds to 3,800 tpd throughput) are summarized as follows:

- Concentrate: The model assumes 177 t/d (approximately 5% of total production) reports to an off-site facility as concentrate for secondary processing in a slurry of 93% solids by weight. The concentrate demand is estimated by the model to be 13 m^3/d.
- Tailings to Brucejack Lake: For years 2020–2028, 2,372 t/d (approximately 64% of total tailings production), on average, will be deposited at depth in Brucejack Lake in a slurry of 55% solids by weight (1,976 m^3/d of slurry water).
- Paste Backfill: The model shows 1,213 t/d (including 5 to 6% bonder) will be deposited in the underground mine in a cemented backfill paste of 60% solids by weight (873 m^3/d of slurry water).
- Underground (mine supply) water: Originally estimated in the model to be 20 m^3/hr (BGC, 2017a,b), operational water monitoring data collected in 2019 indicates water demand of the underground mine is on the order of 35 m^3/hr (or 840 m^3/d) for 3,800 tpd production.

In summary, sources of water comprising the mill water supply are subject to seasonal changes, and in the case of groundwater recharge, measured inflows are lower than originally projected. Despite this, Pretivm has demonstrated an ability to operate at a 3,800 tpd production level while remaining within permitted limits for reclaim (Table 20-5) and within the constraints of the existing water management system. Beyond the opportunities provided by Brucejack Creek reclaim, there is often usable water stored within the CWP, which provides additional contingency for the mine operation in terms of water supply.

The site-wide water balance model is currently being updated as part of the 5-Year Mine Plan and Reclamation Program Update pursuant to permit requirements to consider several years of high-quality climate, streamflow, and operational water data that have been collected at the mine site since the water balance was developed. The Brucejack Gold Mine water quality model is encoded in GoldSim, and there are efficiencies to be gained by adopting a common software platform for the water balance and water quality models. Accordingly, a recommended task under the update is to the encode the site-wide water balance model within a GoldSim environmental modelling framework, rather maintain the water balance within MS-Excel software.

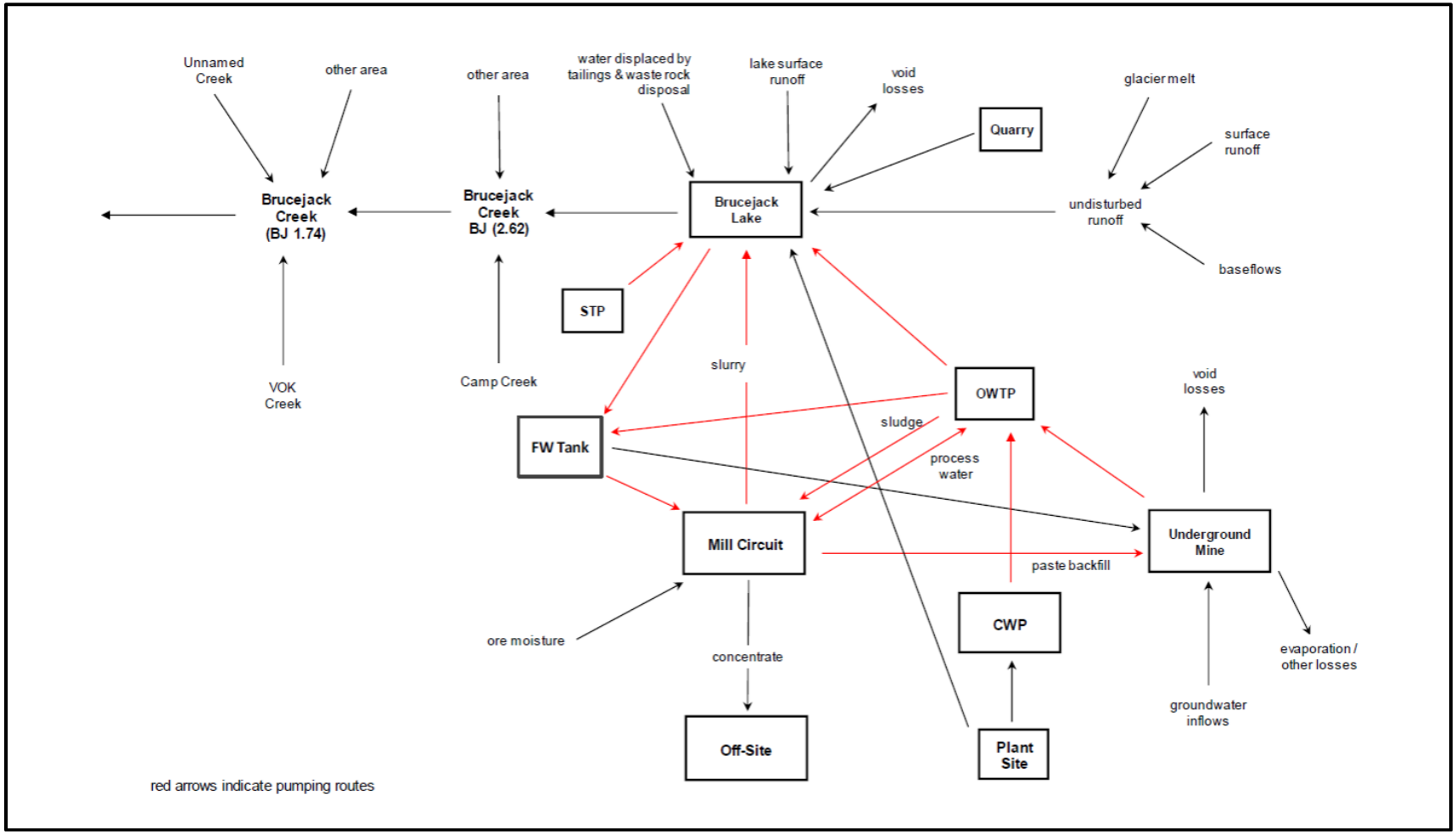
Table 20-5: Summary of Water Withdrawal Data – Brucejack Creek, 2019

Month	Total Reclaim Water (m^3)	Average Reclaim (m^3/day)
Jan	51,072	1,647
Feb	45,230	1,615
Mar	51,633	1,666
Apr	49,979	1,666
May	51,302	1,655
Jun	36,492	1,216
Jul	29,115	939
Aug	33,051	1,066
Sep	39,308	1,310
Oct	51,122	1,649
Nov	50,340	1,678
Dec	51,782	1,670
Total	**540,427**	**1,482**

Source: Pretivm (2020)

Note: Condition e) of Water License # C500684 (dated November 26, 2018) indicates the maximum quantity of water that may be diverted for mining/processing ore is 70 m^3/h.

Figure 20-2: Brucejack Gold Mine Water Balance Flow Schematic – Operations



Source: BGC (2017a)

20.3.6 Water Quality

Effluent Permit 107835 (PE-107835), most recently amended December 14, 2018, authorizes the Brucejack Gold Mine to discharge specified effluents under the conditions of the permit. PE-107835 specifies maximum concentrations for certain parameters in WTP effluent discharged to Brucejack Lake (TSS, pH, aluminum, arsenic, cadmium, cobalt, chromium, copper, iron, lead, manganese, silver, and zinc) and for the discharge from Brucejack Lake to Brucejack Creek at the lake outlet (TSS, pH, nitrite, nitrate, ammonia, antimony, arsenic, iron, and silver). The permit specifies that other parameters should meet BC Water Quality Guidelines (WQGs) for protection of aquatic life at the Brucejack Lake outlet. Effluent quality at the Brucejack Lake outlet is also required to meet federal MDMER. Water quality results from Brucejack Lake outlet samples in 2019 did not exceed any effluent permit discharge limits or Metal and Diamond Mining Effluent Regulation (MDMER) limits, and all other parameters that were monitored were below BC WQGs.

Water quality has been modelled at the Brucejack Lake outlet and at a location in Brucejack Creek downstream of the lake outlet to provide estimates of water quality during the mine operations, closure, and post-closure phases. The GoldSim water quality model derives estimates of contaminant loadings from mine sources (water from the underground mine, WTP effluent, WTP sludge, sewage treatment plant effluent, mine tailings, surface runoff from the NPAG Quarry, waste rock) and combines these with background loadings to derive water quality predictions. Background water quality was derived from pre-construction monitoring (ERM Rescan 2014), while mine-related water quality signatures were based on geochemical source terms developed from geochemical characterization studies and monitoring data sets reported in annual reports. Modelled flows were assigned based on the water balance model (Pretivm 2018b, Appendix C). The modelled monthly flows in the water balance model vary throughout the year, reflecting site hydrology and hydrogeology.

Water quality predictions were most recently generated for a Base Case and an Upper Case scenario for the 3800 t/d *Mines Act* and *Environmental Management Act* amendment application (Appendix A of Pretivm 2018b). These model results are also considered representative of the 2020 updated mine plan, since there was a negligible change in waste rock volumes as compared to the 3800 t/d model. The Base Case represents an expected condition, whereas the Upper Case applies upper case geochemical source terms to all mine-related inputs to the model. The Upper Case scenario, while not the expected case, was conservatively used for water quality management planning, such as the design of the WTP. Water quality monitoring results from the lake outlet are compared to water quality model results in the Brucejack Gold Mine annual reports. This comparison has shown that measured concentrations have been well represented by the Base Case model. The Base Case model predicts that concentrations at the lake outlet will continue to meet discharge limits or WQGs throughout the operations, closure, and post-closure phases.

At closure, the Brucejack Gold Mine will be flooded and most of the flow from the underground mine is modelled to report directly to Brucejack Creek via subsurface pathways. The Base Case model predicts that Brucejack Creek will experience periods during closure when arsenic and zinc are slightly above discharge limits or WQGs, but even if the maximum Upper Case modelled concentrations are realized, they are not expected to have a significant effect on aquatic life (Lorax 2018). Iron concentrations are also predicted to be higher than WQGs in groundwater flowing to Brucejack Creek from the underground mine. However, it is expected that ferrous iron in groundwater will oxidize to relatively insoluble ferric iron after entering Brucejack Creek and form iron-oxyhydroxide precipitates. This precipitation process will lower the iron concentration in water to concentrations that are below BC WQGs. Potential effects to aquatic life in Brucejack Creek from iron precipitates were assessed as having low significance (Pretivm 2015). All other parameters modelled for closure and post-closure are predicted to have concentrations that are below discharge limits or BC WQGs.

20.3.7 Waste Management

20.3.7.1 Mine Wastes

Mine wastes, including waste rock and tailings, are backfilled in the underground mine workings and deposited subaqueously into Brucejack Lake, which acts as the waste rock and tailings storage facility as approved under the mine's authorizations. Under current authorizations, 3,734,000 t of waste rock and 1,865,000 t of tailings have been deposited in the waste rock and tailings storage facility through December 2019. Total mine waste forecast to be produced over the remainder of the LOM is 3,483,000 t of waste rock and 14,754,000 t of tailings, both of which are aligned with existing authorizations. Additional details of the mine waste handling and associated rationale are provided in Sections 16.3, 16.5, 18.2.2, and 20.3.2. Table 16-5 tabulates LOM Backfilling – Waste Rock and Mill Tailing. As described in Section 20.3.2, all waste rock is assumed to be PAG and is deposited either below the ultimate flooding elevation of the underground mine or under water in Brucejack Lake to prevent ARD. Subaqueous deposition of waste rock into Brucejack Lake was previously conducted by Newhawk in 1999, following underground development by Newhawk. As noted in Section 20.3.1.3, Brucejack Lake and its downstream drainage are not fish-bearing for a distance of more than 20 km.

20.3.7.2 Non-hazardous Waste

Waste handling facilities located at the mine site and Knipple Transfer Area are the primary facilities used for temporarily storing and separating waste. All non-hazardous industrial and domestic solid wastes are managed in accordance with the mine's approved Waste Management Plan and Refuse Incinerator Management Plan to minimize potential adverse effects to the environment, wildlife, and mine personnel. Non-hazardous waste is separated for recycling or disposal.

On-site disposal of non-hazardous waste consists of incineration, recycling, and open pit burning. Incineration of non-hazardous products includes the operation of two authorized high temperature incinerators located at the Brucejack Gold Mine site and Knipple Transfer Area. Open pit burning of non-hazardous waste is conducted at permitted locations at the mine site and at the Knipple and Wildlife camps.

Recycling of non-hazardous material is an important component of waste management and environmental protection. Personnel at all Brucejack Gold Mine infrastructure areas participate in the mine's recycling program, which reduces the amount of refuse shipped off-site and thereby reduces the quantity of waste disposed at regional landfills. Recycling of various materials is implemented at mine facilities, including recyclable containers, tin cans, batteries, e-waste, cardboard, light bulbs, heavy plastics, metal, aerosol cans, and electrical wire. Recyclable waste generated on site is transported off site to local recycling facilities.

20.3.7.3 Hazardous Waste

Hazardous waste generated at the Brucejack Gold Mine is managed in accordance with the approved Waste Management Plan and the Refuse Incinerator Management Plan, the *Environmental Management Act* Hazardous Waste Regulations, and the Transportation of Dangerous Goods Regulations to protect mine personnel and the environment. Hazardous wastes generated at the mine site and supporting infrastructure are temporarily stored in the mine's waste handling facilities prior to transport and disposal at licensed off-site disposal facilities.

On-site disposal of hazardous waste is limited but does occur in the form of incineration of some items and waste oil heat production; both of these are conducted in accordance with the approved Waste Management Plan and other applicable requirements under the *Environmental Management Act*.

20.3.8 Air Emission Control

Since mining occurs underground and mine wastes (tailings and waste rock) are ultimately stored either subaqueously within Brucejack Lake or backfilled into the underground mine, combined with the use of electricity as the primary source of power during operations, rather than on-site generators using diesel, air emissions are not substantial. There is some fugitive dust from waste rock handling on the waste rock dump, and seasonally from road use. There are point source air emissions from the mill and assay lab.

Pretivm implements its approved Air Quality Management Plan to mitigate air emissions. Key mitigations for fugitive dust from roads include road watering and application of dust control solution. Emission controls were designed and implemented for mill and assay lab emission sources and include various enclosures, ventilation systems, dust collectors, wet scrubbers, fans, and related appurtenances. These emission controls are also regulated under the mine's Air Permit (PA-107025); Pretivm conducts monitoring and maintenance in accordance with the permit. The Air Permit also regulates operations of the mine's incinerators and has conditions specific to fugitive dust, the underground mine, and the burn pits.

20.3.9 Closure Plan and Costs

Following completion of mining, the Brucejack Gold Mine will be closed, reclaimed, and monitored in accordance with its authorizations, Reclamation and Closure Plan, Ancillary Infrastructure Decommissioning and Reclamation Plan, and other applicable EMS component plans. Closure of the mine site at the end of operations will include flooding of the underground mine, with continued water treatment during flooding; removal of all structures and equipment; closure of the mine portals; and rehabilitation of site disturbances. The mine has been planned and designed to operate and be closed and reclaimed in a manner that achieves the approved end land use objectives, returns the site to as close to its pre-disturbance condition as practical, and minimizes the potential for long-term adverse effects on the environment.

Closure of the underground facilities will include the removal of material supplies and mobile equipment, such as ventilation fans and safety equipment. These will be removed from the site for reuse or will be recycled. Hydrocarbons will be drained from all equipment and from underground storage and the distribution system, and disposed in an approved manner.

The underground mine workings will be progressively backfilled with tailings and waste rock throughout mine operations, to the level of expected water table rebound, and once mining is completed, the underground will be allowed to flood. The ventilation shafts and underground portals will be sealed with concrete plugs. The water table is not expected to reach higher than the elevation of Brucejack Lake.

Closure of the above-ground facilities will include the removal of all buildings and structures at the mine site and along the Brucejack Access Road. Buildings will be dismantled, and removable materials will be taken off-site for reuse or recycling. Concrete pads (mill, Valley of the Kings Zone and West Zone portal buildings, and West Zone shop) will remain in place, and the Phase 2 Camp supporting pedestals will be cut off at ground level. Oil, fuels, and processing fluids will be drained from equipment before the equipment is removed, and disposed of in an approved manner. Processing equipment will be removed from site and sold or recycled. Above-ground pipes and sediment curtains in Brucejack Lake and Creek will be removed and disposed in accordance with the Reclamation and Closure Plan.

Post-closure water management features will be constructed and pad and road surfaces will be recontoured, decompacted, and revegetated as applicable in accordance with the Reclamation Plans. Once active water treatment is no longer required, the transmission line will be dismantled. The steel poles and the conductors will be removed off-site and sold, recycled, or disposed in an approved manner.

The reclamation security for all infrastructure authorized under *Mines Act* Permit M-243, including the mine site, is $31.7 million. An additional reclamation security of $2 million is held for the Brucejack Access Road under Special Use Permit S25923. There are other reclamation securities, totaling $70,000, for infrastructure located on Licenses of Occupation. Due to the limited surface footprint of the mine and ancillary infrastructure, there are no substantive opportunities for progressive reclamation that would be used to reduce the *Mines Act* reclamation security prior to closure.

21.0 CAPITAL AND OPERATING COSTS

21.1 Capital Cost Estimate

21.1.1 Summary

The total LOM sustaining capital cost from 2020 to 2032 is estimated at US$176.7 million. Table 21-1 shows a summary breakdown of the LOM sustaining capital costs by area, including required sustaining costs for the mine and mill throughput expansion to 3,800 t/d. The estimated cost includes design, construction, installation, and commissioning.

The key inputs to this cost estimate were based on the LOM planned costs estimated by Pretivm and reviewed by Tetra Tech, including recent equipment purchased costs, equipment quotations from vendors, and recent construction cost data. All costs are inclusive of direct cost, indirect cost, and contingency. The expected accuracy range of the operating cost estimate is +20%/-15%.

Table 21-1: Summary of LOM Expansion and Sustaining Capital Costs

Description	Expansion and Sustaining Capital Costs (US$ million)
UG Mining	66.6
Processing	3.5
Site Infrastructure	91.8
Mine Throughput Expansion	14.8
Total LOM Expansion and Sustaining Capital Cost	**176.7**

Note: Numbers may not total due to rounding.

21.1.2 LOM Sustaining Capital Cost Estimate

21.1.2.1 Estimate Base Date

This estimate was prepared with a base date of Q4 2019 and does not include any escalation beyond this quarter.

21.1.2.2 Estimate Approach

Base Currency

The LOM sustaining capital cost estimate was estimated using US dollars as the base currency. All costs presented in this section are in US dollars unless otherwise stated. All costs in Canadian dollars were converted to US dollars using the foreign exchange rate listed in Table 21-2.

Table 21-2: Foreign Exchange Rates

Canadian Currency	US Currency
Cdn$1.00	US$0.76

Duties and Taxes

Duties and taxes are not included in this estimate.

Work Breakdown Structure

The estimate is organized according to the following hierarchical work breakdown structure (WBS):

Description
UG Development
UG Equipment
UG Infrastructure
Processing
Site Infrastructure
Mine Throughput Expansion

21.1.2.3 Scope of the LOM Sustaining Capital Cost Estimate

The all-in construction for the LOM sustaining capital cost estimate from 2020 to 2032 is US$176.7 million. The cost includes detailed engineering design activities, freight to site, supply and installation of equipment and structural facilities, and commissioning. The construction cost is based on information from the construction of the Brucejack Gold Mine and recent work on the mill dry complex upgrade escalated to Q4 2019. Major mechanical equipment costs are based on recent purchase information and quotations from equipment manufacturers. All equipment and material costs are all inclusive of spare parts, freight, and packaging.

21.1.2.4 LOM Mining Sustaining Capital Cost for Underground Development, Equipment and Infrastructure

Mining sustaining capital cost estimates are based on ongoing underground development, additional mining equipment purchases, and underground infrastructure. Underground development includes ramp and raise development, whereas lateral and stope development are considered operating costs. Underground development is conducted by Pretivm and their contractors. Underground infrastructure includes the supply and installation of high voltage cables for underground development, underground electrical substation, underground network infrastructure, underground crusher dust collection, and conveyor transfer dust collection.

Table 21-3 summarizes the mining sustaining capital cost estimates and Table 21-4 shows the year-by-year sustaining cost breakdown for underground operations.

Table 21-3: LOM Mining Sustaining Capital Cost Summary

Description	Mining Sustaining Capital Costs (US$ million)
Underground Development	35.6
Underground Equipment	13.1
Underground Infrastructure	17.9
Total LOM Mining Sustaining Capital Costs	**66.6**

Table 21-4: Mining Sustaining Capital Costs by Year

Area	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Underground Mining (US$ million)	15.39	18.39	8.56	10.13	4.08	3.49	3.81	2.60	0.11	0.10

21.1.2.5 Processing

The scope of work for processing includes the upgrading and addition of process mobile vehicles and process equipment, including concentrate container spray system, dust suppression system, and mobile crane.

The total cost for processing is US$3.5 million.

21.1.2.6 Site Infrastructure

Brucejack Surface

The Brucejack surface includes the cost of upgrading, supply and installation of a multi-use facility, artic corridor, new dorm, bulk gravity lab, kitchen loading dock modification, elevated walkway to VOK, mill roof modification, core facility, warehouse expansion, fire hall, network system and hardware upgrade, and mobile equipment addition and replacement.

Knipple Site

The Knipple site includes the cost of the upgrading, supply, and installation of a multiple-use facility, DAL lab fire assay expansion, additional soil treatment facility, engine replacement, truckshop, wash bay complete with oil water separator, and Knipple camp upgrades.

Bowser Site

The Bowser site includes the cost of the upgrading, supply, and installation of an airstrip, Bowser Lake dock, boat for spillage response, and lake cleanup.

Wildfire Site

The Wildfire site includes the cost of the upgrading, supply, and installation of a multiple-use facility, project signage at the main gate, workshop, core facility, fuel storage and containment, camp upgrade, water management and road deviation work, septic upgrade, and bear fence upgrade.

Access Road

The access road area includes the costs of construction for road upgrades, bridge decking replacement, and maintenance.

Other Pending Works/Upgrades

Other pending works/upgrades include costs for the Quonset storage slab, data management system, safety management system, and support infrastructure upgrades.

The total cost for the mine site facilities area is US$91.8 million. Table 21-5 shows the year-by-year sustaining cost breakdown for the site infrastructure upgrading and construction.

Table 21-5: Site Infrastructure Sustaining Capital Costs by Year

Area	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Site Infrastructure (US$ million)	18.70	32.35	16.40	7.32	3.55	2.32	3.46	1.73	4.61	1.39

21.1.2.7 Mine Throughput Expansion

The mine expansion includes the upgrading, installation, construction, and commissioning of the underground service bay and wash bay, flocculant system, flotation circuit, paste plant binder silo #2, tailings thickener, cyclone addition, upgrading dust collection systems, apron feeder, 13.8 kV transformer, and rock breaker. The mine expansion also includes the overhead crane, heavy duty truckshop, core logging facility, Phase 2 of the mill dry complex, and Wildfire Camp upgrades.

The total cost for the mine expansion is US$14.8 million.

21.1.2.8 LOM Expansion and Sustaining Capital Cost Exclusions

The following items are excluded from this capital cost estimate:

- Working or deferred capital
- Upgrading cost spent prior to 2020
- Financing costs
- Refundable taxes and duties
- Land acquisition
- Currency fluctuations
- Lost time due to severe weather conditions
- Lost time due to force majeure
- Additional costs for accelerated or decelerated deliveries of equipment, materials, labor, or services resultant from a change in project schedule
- Any project sunk costs (studies, exploration programs, etc.)
- Mine reclamation costs (included in financial model)
- Mine closure costs (included in financial model)
- Escalation costs
- Additional permitting costs not identified in the estimate
- Community relations (included in financial model).

21.2 Operating Cost Estimate

21.2.1 Summary

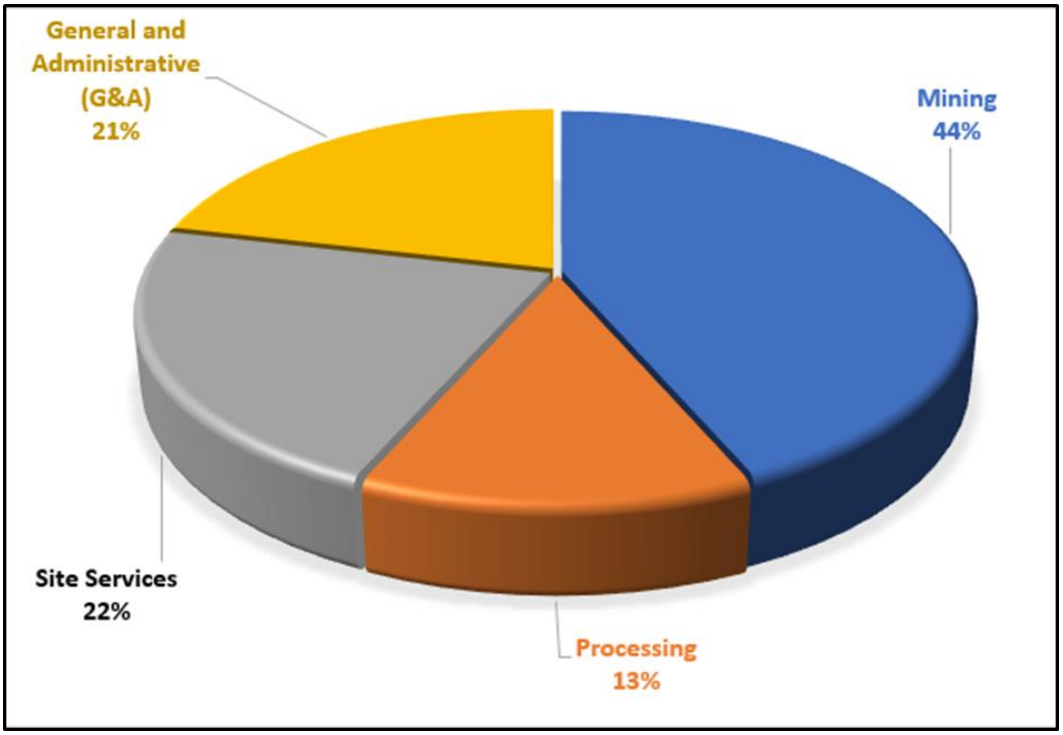
The estimated LOM average operating cost is US$162.82/t milled. Operating costs are defined as the direct operational costs, which include mining, processing, water treatment, tailings storage, site services, and general and administrative (G&A) expenses at the Brucejack mine site. The operating cost estimates exclude product freight costs, sale-related costs, and royalties, which are included in the economic analysis (Section 22.0). The estimate was based on an average annual plant feed rate of approximately 1.387 Mt of ore processed (3,800 t/d milled). Table 21-6 shows the cost breakdown for each area and Figure 21-1 shows the cost distribution.

Table 21-6: LOM Average Operating Cost Summary

Area	LOM Unit Operating Cost (US$/t milled)
Mining	70.83
Processing	21.34
Overall Site Services, including Off-site/Satellite Offices[(1)]	35.89
G&A	34.76
Total Operating Cost	**162.82**

Note: [(1)]Includes costs for off-site and satellite offices.

Figure 21-1: Overall Operating Cost Distribution by Area



The operating cost estimates were based on the Brucejack Gold Mine operating experience, and include consumable supplies, power supply, contractor services, camp services, worker transportation, and labour salaries/wages. These costs were estimated with a base date of Q4 2019 and do not include any escalation beyond this quarter. The expected accuracy range of the operating cost estimate is +15%/-15%. All costs were estimated in US dollars, unless otherwise specified.

Table 21-2 shows the foreign exchange rates used for the estimate.

The operating costs exclude shipping charges and sale costs for the gold-silver doré and gold-silver concentrate, as well as royalties, which are included in the economic analysis (Section 22.0).

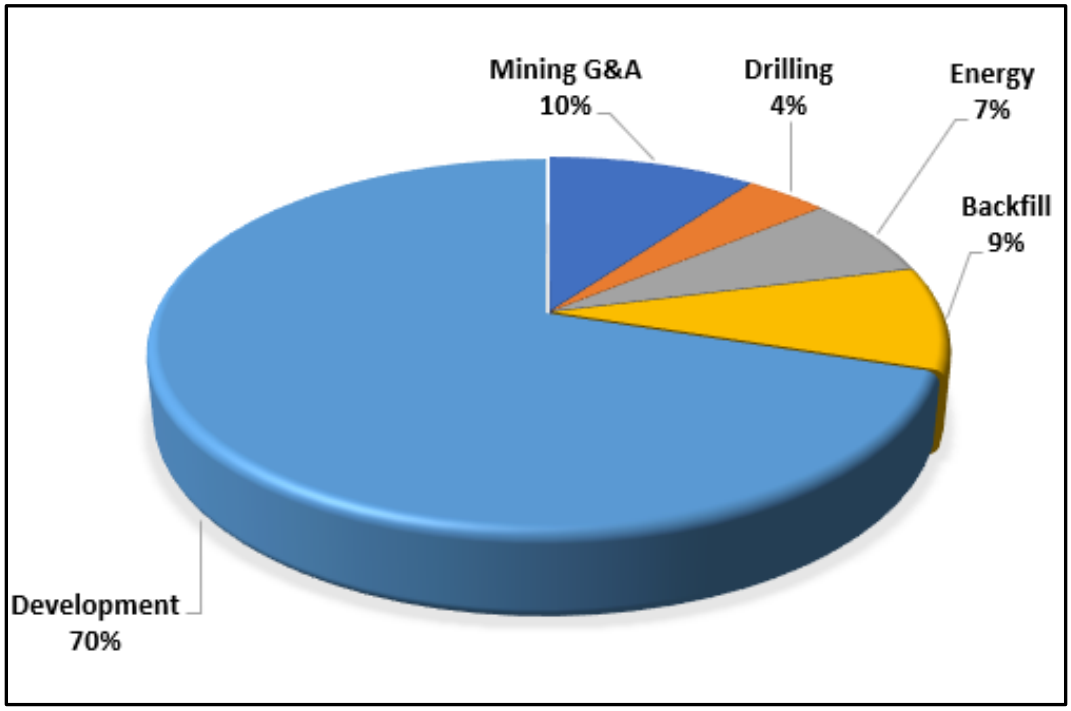
All operating cost estimates exclude taxes unless otherwise specified.

21.2.2 Mining Operating Cost Estimate

Mining operating costs include production costs such as drilling, blasting, explosives, mucking, backfill, and support costs. Non-capitalized underground development (lateral development and stope development) are considered operating costs. The estimated LOM average mining cost is US$70.83/t milled, with a high of US$100.74/t milled forecast for Q2 of 2020.

The estimated mining operating costs are based on current and forecast contractor rates. Figure 21-2 illustrates the cost distribution.

Figure 21-2: Mining Operating Cost Distribution by Area



21.2.3 Process Operating Cost Estimate

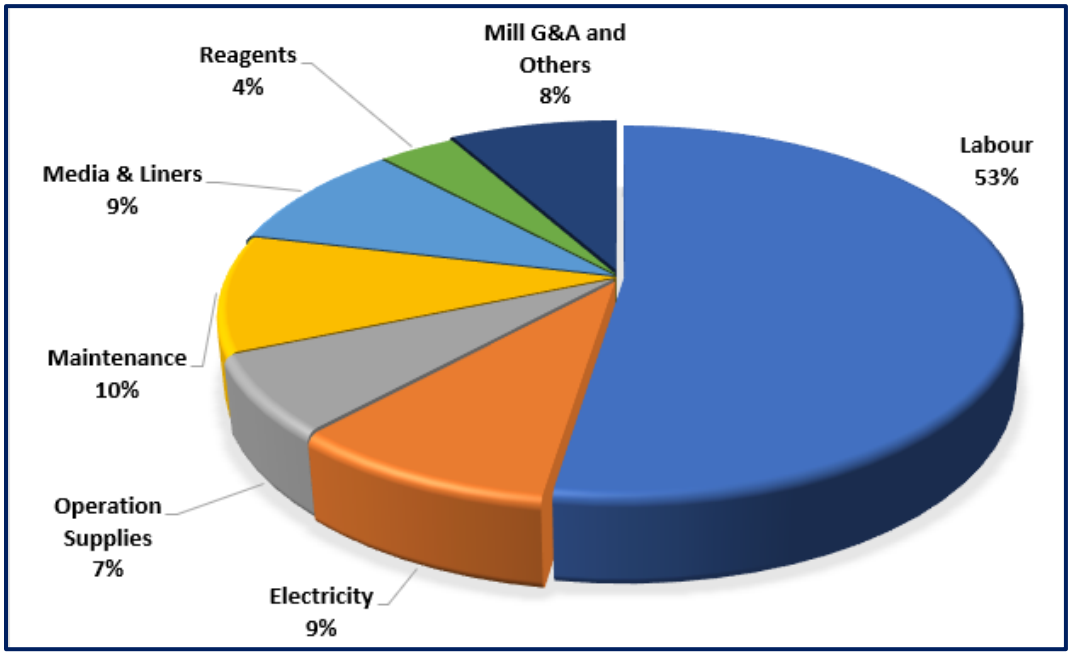
The estimated LOM average unit process operating cost is US$21.34/t milled at an average annual plant feed rate of approximately 1.387 Mt of ore processed, or a nominal plant feed rate of 3,800 t/d, including tailings delivery. The estimate is based on 12-hour shifts per day, 24 h/d and 365 d/a.

The process operating cost estimate includes:

- Personnel requirements, including supervision, operation and maintenance, and salary/wage levels, including burdens, based on Q4 2019 labour rates
- SAG mill and ball mill liner and grinding media consumption
- Maintenance supplies
- Reagent consumptions
- Other operation supplies
- Power consumption for the processing plant
- Other process related costs, such as mobile equipment, consulting, and general expenses.

Figure 21-3 shows the process operating cost distribution.

Figure 21-3: Process Operating Cost Distribution by Area



21.2.4 Mine Site G&A and Site Services Operating Cost Estimate

Mine site G&A and site services costs include expenditures that do not relate directly to mining or process operating costs. The estimated LOM average unit operating cost is US$34.76/t milled for mine site G&A and US$35.89/t milled for Site Services, based on a nominal daily ore plant feed rate of 3,800 t.

The mine site G&A and site service costs include costs related to the satellite site operations at the Knipple Transfer Station and the mine access security station. In addition, mine site G&A costs include operation-related costs for the off-site office in Smithers, BC.

Site services costs include:

- Manpower related costs, including supervision, operation and maintenance, and salary/wage levels, including burdens, based on Q4 2019 labor rates
- Energy
- Operating supplies and consumables
- Maintenance supplies
- Rental and lease
- Other related costs.

Mine site G&A costs include:

- Manpower related costs, including supervision, operation and maintenance, and salary/wage levels, including burdens, based on Q4 2019 labor rates
- Various general operating management and services related costs, mainly for the following main areas:
  - General mine site administration
  - Environmental and permitting
  - Procurement and supply chain
  - Camp services
  - Health and safety
  - Accounting and financial services
  - Human resources
  - IT-related various services
  - Worker transportation services.

22.0 ECONOMIC ANALYSIS

22.1 Introduction

Tetra Tech prepared an economic evaluation of the Brucejack Gold Mine based on a discounted cash flow model for the remaining 13-year LOM and 15.64 Mt of mine plan tonnage. The current forecast for the remaining Brucejack Gold Mine LOM shows a post-tax NPV of US$1.50 billion at a 5% discount rate, and US$1.29 billion at an 8% discount rate. Internal rate of return and payback period results as referenced by NI 43-101F1 are not relevant to this Technical Report as mine revenues provide sufficient cash flow to cover expansion capital and no negative cashflow periods are expected.

Table 22-1 shows a summary of the economic analysis results.

Table 22-1: Cash Flow Results Summary (including Discounted Post-tax NPV)

	Unit	Amount
Tonnes Mined and Processed	kt	15,637
Gold Head Grade	g/t	8.4
Silver Head Grade	g/t	59.6
Doré Production		
Gold Ounces Produced	‘000 oz	2,617
Silver Ounces Produced	‘000 oz	1,960
Concentrate Production		
Concentrate Sold	‘000 dmt	882
Gold Contained in Concentrate	‘000 oz	1,430
Silver Contained in Concentrate	‘000 oz	25,166
Total Project Revenue	US$ million	$5,266
Operating Costs	US$ million	(2,546)
Royalties	US$ million	(63)
EBITDA	US$ million	2,642
Capital Costs	US$ million	(177)
Other Expenses	US$ million	(21)
Pre-tax Cash Flow	US$ million	2,444
Allowable Tax Deductions	US$ million	(1,146)
Taxable Income	US$ million	1,307
Taxes Payable	US$ million	(492)
Post-tax Cash Flow	US$ million	1,952
Post-tax NPV (5% Discount Rate)	US$ million	1,496
Post-tax NPV (8% Discount Rate)	US$ million	1,293

The Brucejack Gold Mine economic model is based on the following assumptions:

- Gold price of US$1,300/oz
- Silver price of US$16.90/oz
- Foreign exchange rate of Cdn$1.00:US$0.76.

Note that the metal prices listed above differ from metal pricing used for Mineral Reserve delineation. Gold price for financial modelling is based on the London Bullion Market Association (LBMA) AM and PM three-year average for gold (US$1,306/oz). Silver price is based solely on the three-year average (US16.32/oz).

Pretivm provided current doré and concentrate payment terms, smelting and refining charges, transportation costs, and insurance costs. Gold and silver recoveries are based on the Brucejack Gold Mine operational data and metallurgical test results as discussed in Section 13.0 of this Technical Report.

22.2 Pre-tax Model

The production schedule has been incorporated into the pre-tax financial model to develop annual recovered metal production. The annual at-mine revenue contribution of each metal was determined by deducting the applicable treatment, refining, and transportation charges (from mine site to market) from gross revenue.

Sustaining capital costs have been incorporated on a year-by-year basis over the LOM and operating costs were deducted from gross revenue to estimate annual mine operating earnings. Capital expenditures include ongoing sustaining capital costs for mining, milling, and site services additions and equipment replacement, and remaining capital costs completing mine and mill feed throughput expansion to 3,800 t/d. The total LOM capital cost is US$176.7 million, including US$14.8 million in expansion capital remaining to complete the throughput expansion.

The mine closure and reclamation cost of US$21.2 million has been included in the financial model.

Working capital has not been included in the model, as the Brucejack Gold Mine is currently in operation and generating positive cash flow.

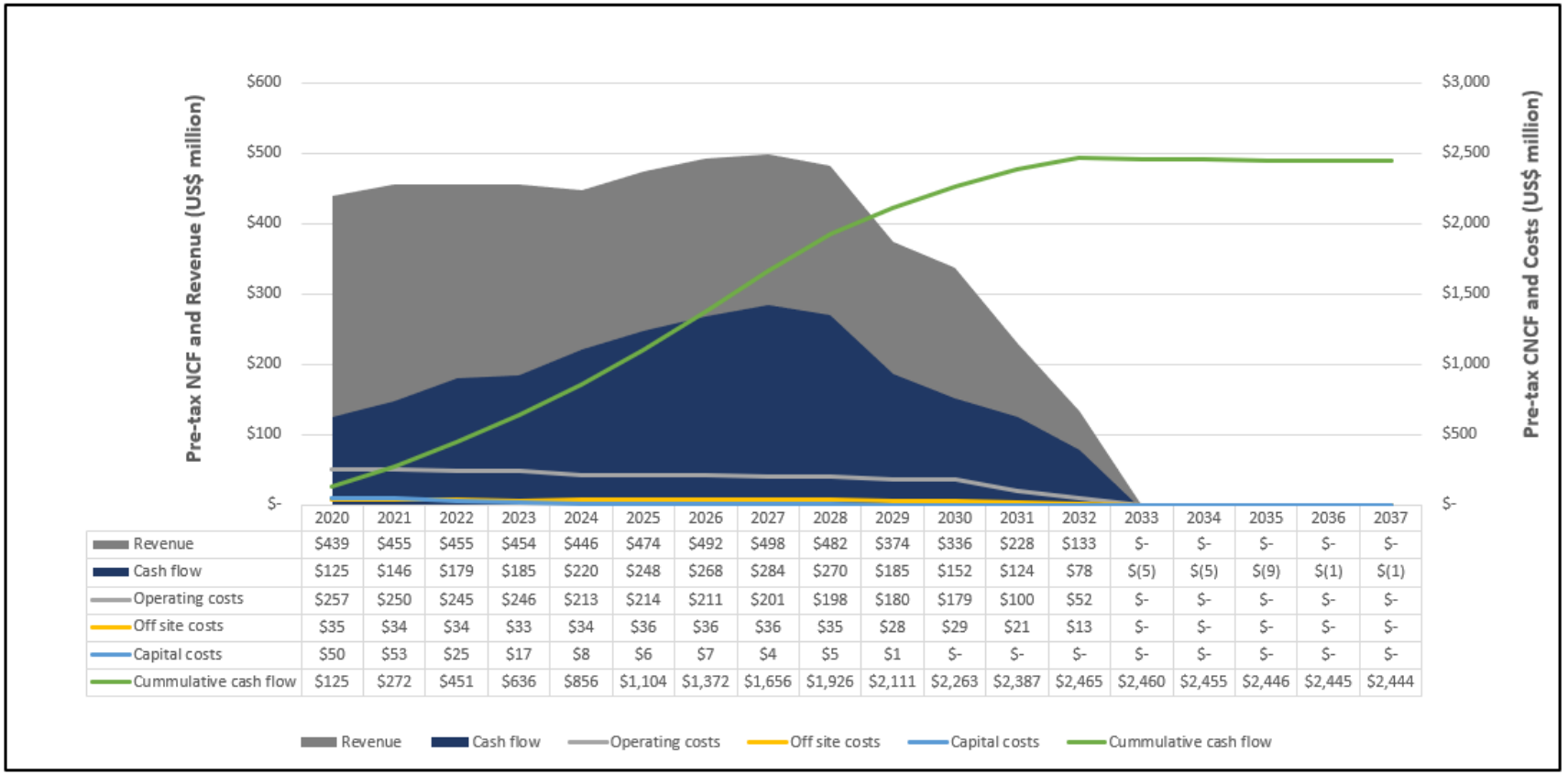
NPV has been estimated at the beginning of the mining schedule and therefore has an effective date of January 1, 2020.

Table 22-2 shows the metal production quantities and Figure 22-1 shows the annual pre-tax net cash flows (NCFs) and cumulative net cash flows (CNCFs).

Table 22-2: Metal Production Quantities

	Units	First Five Years	LOM
Total Tonnes Milled	Mt	6.93	15.64
Average Annual Tonnes Milled	Mt	1.39	1.20
Average Grade			
Gold	g/t	8.52	8.35
Silver	g/t	11.82	59.60
Total Production			
Gold	‘000 oz	1,832	4,046
Silver	‘000 oz	2,296	27,096
Average Annual Production			
Gold	‘000 oz	366.47	311.25
Silver	‘000 oz	459.30	2,084.31

Figure 22-1: Pre-tax Cash Flow



	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
Revenue	$439	$455	$455	$454	$446	$474	$492	$498	$482	$374	$336	$228	$133	$-	$-	$-	$-	$-
Cash flow	$125	$146	$179	$185	$220	$248	$268	$284	$270	$185	$152	$124	$78	$(5)	$(5)	$(9)	$(1)	$(1)
Operating costs	$257	$250	$245	$246	$213	$214	$211	$201	$198	$180	$179	$100	$52	$-	$-	$-	$-	$-
Off site costs	$35	$34	$34	$33	$34	$36	$36	$36	$35	$28	$29	$21	$13	$-	$-	$-	$-	$-
Capital costs	$50	$53	$25	$17	$8	$6	$7	$4	$5	$1	$-	$-	$-	$-	$-	$-	$-	$-
Cummulative cash flow	$125	$272	$451	$636	$856	$1,104	$1,372	$1,656	$1,926	$2,111	$2,263	$2,387	$2,465	$2,460	$2,455	$2,446	$2,445	$2,444

22.2.1 Metal Price Scenarios

Table 22-3 tabulates the economic results at different metal price scenarios.

Table 22-3: Economic Results Summary for Different Metal Price Scenarios

Economic Parameter	Unit	Gold Price (US$/oz)		
		1,300	1,600	1,900
Silver Price	US$/oz	16.90	20.80	24.70
Net Cash Flow	US$ billion	2.44 (pre-tax) 1.95 (post-tax)	3.70 (pre-tax) 2.75 (post-tax)	4.96 (pre-tax) 3.55 (post-tax)
NPV[(1)] (at a 5.0% discount rate)	US$ billion	1.80 (pre-tax) 1.50 (post-tax)	2.75 (pre-tax) 2.13 (post-tax)	3.70 (pre-tax) 2.76 (post-tax)
Exchange Rate	Cdn$:US$	0.76	0.76	0.76

Note: [(1)]The NPV is discounted to January 2020.

22.3 Smelter Terms

The payment, smelting, and refining terms applied in the economic analysis are the current contractual terms in effect.

22.4 Markets and Contracts

The Brucejack Gold Mine produces gold and silver doré and concentrates. Doré is transported to the refineries by air. Concentrate is loaded in customized bulk containers and transported from the mill site to Knipple Transfer Station and then to SBT by a third-party trucking company. The bulk concentrate is then loaded into ocean vessels to international customers.

22.5 Taxation and Royalty Considerations

Pretivm completed the post-tax economic evaluation of the Brucejack Gold Mine, including applicable income and mining taxes.

Based on the metal prices used for this Technical Report, the total estimated taxes payable on Brucejack Gold Mine profits are US$491.5million over the 13-year LOM. Table 22-4 shows the various payable tax components.

The Brucejack Gold Mine was evaluated on an after-tax basis levied as three separate tax contributions at the federal, provincial, and provincial-mining level (BC Mineral Tax). Table 22-4 shows the pre- and post-tax breakdowns for these cash flows and the allowable tax deductions.

Table 22-4: LOM Taxes Summary

Cash Costs	LOM Total (US$ million)
Pre-tax NCF	2,444
Taxable Income	1,307
Federal Taxes	187
Provincial Taxes	157
BC Mineral Tax	148
Post-tax NCF	1,952
Post-tax NPV (at a 5% Discount Rate)	1,496
Post-tax NPV (at an 8% Discount Rate)	1,293

The following general tax regime is recognized as applicable as of the effective date of this Technical Report.

22.5.1 Canadian Income Tax System

The Canadian federal income tax rate is 15%.

22.5.1.1 Machinery and Equipment

Prior to 2021, assets purchased prior to commercial production are added to a Class 41(a) pool and are deducted at an accelerated rate, at up to 100% of the balance, to the extent of taxable income from the mine.

Changes from the 2013 federal budget phases out the accelerated deduction over the years 2017 to 2020. One hundred percent of the accelerated rate will be permitted from 2013 to 2016, 90% in 2017, 80% in 2018, 60% in 2019, and 30% in 2020.

Assets purchased after the start of production are added to a Class 41(b) pool and are deducted at up to 25% of the balance.

22.5.1.2 Mine Acquisition Costs

Mine acquisition costs include costs of land, exploration and mining rights, licenses, permits, and leases.

These costs are added to a Canadian Development Expense (CDE) pool and can be deducted at up to 30% of the balance in a year.

22.5.1.3 Pre-production Mine Expenditures

Pre-production mine expenditures include both exploration and mine development costs.

Prior to 2015, exploration and mine development are added to a Canadian Exploration Expense (CEE) pool. One hundred percent of the balance can be deducted in a year, but the deduction is also limited to the income from the mine.

Pre-production mine development costs incurred subsequent to 2017 are treated as CDE instead of CEE. The transition started to be phased in beginning in 2015, with 20% of costs being allocated proportionately to CDE and 80% to CEE in 2015, 40% to CDE and 60% to CEE in 2016, and 70% to CDE and 30% to CEE in 2017.

22.5.2 Provincial (BC) Mining Tax System

The BC provincial income tax rate is 12%.

22.5.2.1 Net Current Proceeds Tax

A 2% tax is levied on an amount by which gross revenues exceed current operating costs.

Hedging income and losses, royalties, and financing costs are excluded. Capital costs including exploration, pre-production development, and leasing are excluded. Capital costs are relevant for Net Revenue Tax.

The net current proceeds tax is added to a cumulative tax credit account (CTCA) and is available to offset net revenue tax payable.

22.5.2.2 Net Revenue (13%) Tax

Tax is levied at 13% of net revenue. All capital expenditures, both mine development costs and fixed asset purchases, are accumulated in a cumulative expenditure account (CEA). Net revenue is defined as 13% of gross revenues less the current operating costs for the year, less any accumulated CEA balance. Therefore, for net revenue tax, all current and capital expenditures are fully deductible in the year they are incurred or in the following year. Net revenue does not become assessable until the costs of all preproduction capital expenditures have been recovered. A “new mine allowance” is also provided to encourage new mine development in BC. The allowance allows a mine operator to add 133% of its capital expenditures incurred prior to commencing production to the CEA account if the mine began producing minerals in reasonable commercial quantities before January 1, 2016.

BC mineral taxes are deductible for federal and provincial income tax purposes.

22.6 Royalties

The Brucejack Gold Mine was evaluated under the assumption of the following royalties:

- First Nations royalty
- Mineral royalty.

The estimated value of the LOM royalty cost for the First Nation groups is US$14.7 million.

22.7 Sensitivity Analysis

A sensitivity analysis was performed on the financial model considering variations in:

- Metal prices
- Mining, processing, and site services operating costs.

The analysis shows that the Brucejack Gold Mine NPV is most sensitive to changes in gold price and less sensitive to changes in silver price. The Brucejack Gold Mine has similar sensitivity to grade as to metal pricing.

Figure 22-2 illustrates the sensitivity of the Brucejack Gold Mine economics to metal price fluctuations and Figure 22-3 illustrates the sensitivity to operating costs. The economics are most sensitive to operating costs.

Figure 22-2: Post-tax NPV Sensitivity to Metal Prices

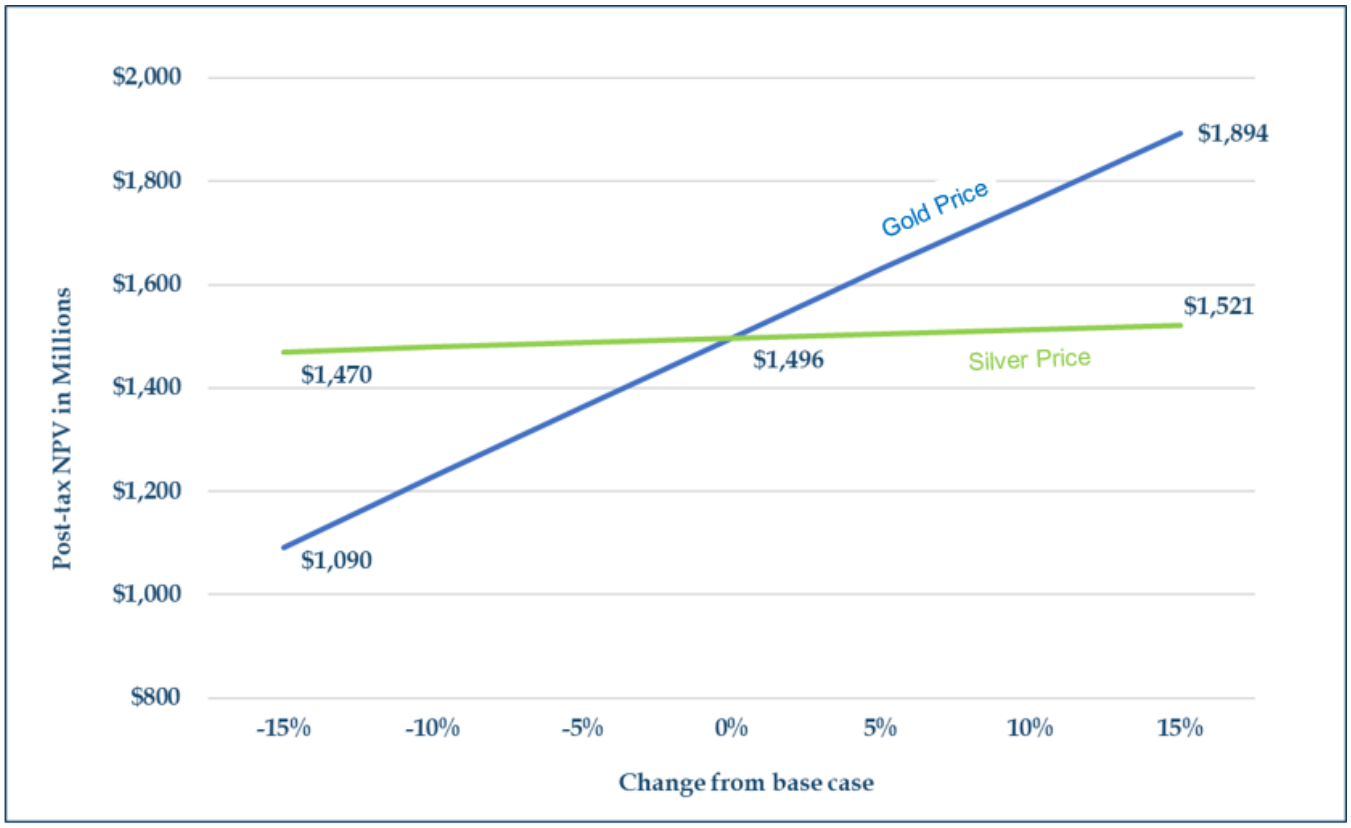
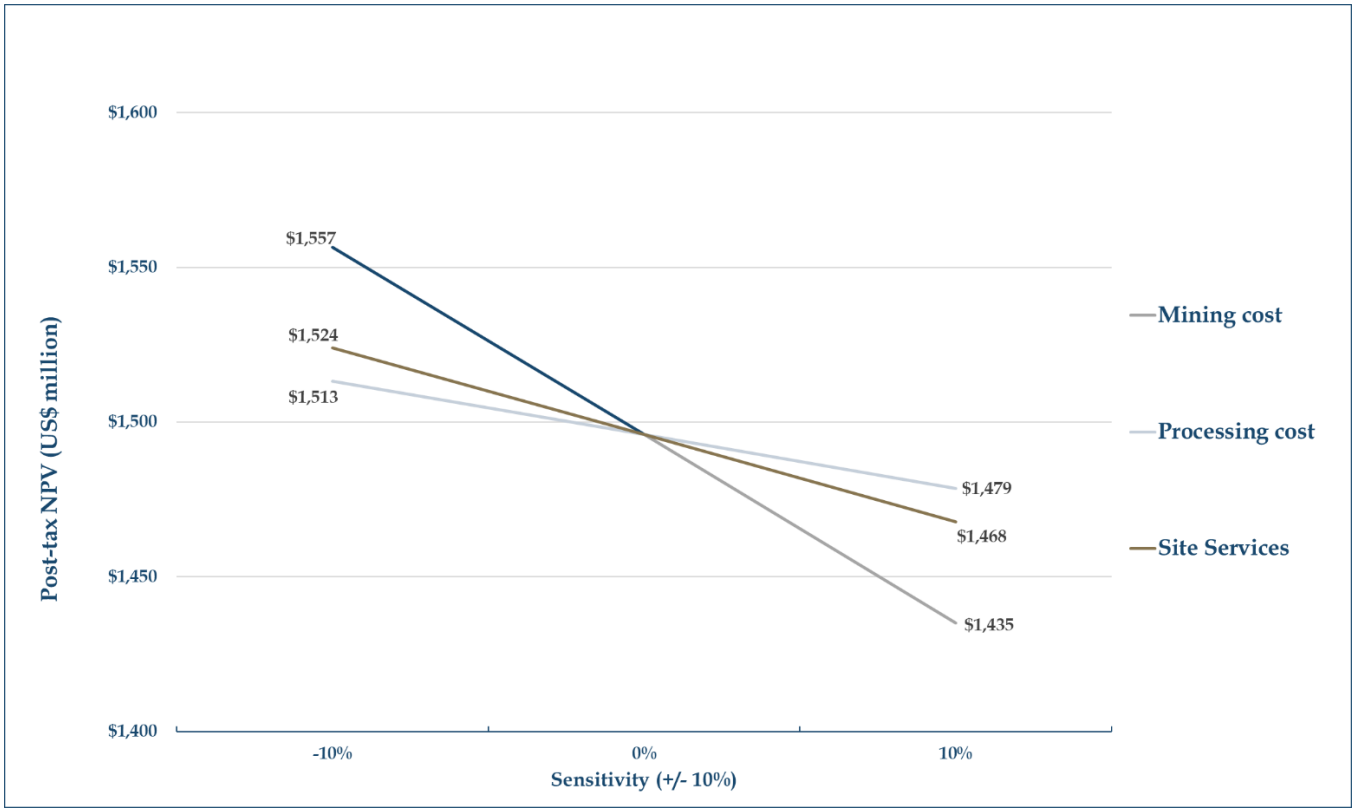


Figure 22-3: Post-tax NPV Sensitivity to Operating Costs



23.0 ADJACENT PROPERTIES

The following subsections describing adjacent properties are based on information publicly disclosed by the Owner or Operator of the adjacent property and were sourced as per the notes in the relevant sections.

The QP has been unable to verify the information for any of the described adjacent properties except against what has been publicly reported, and the information is not necessarily indicative of the mineralization at Brucejack.

23.1 Snowfield Property

The Snowfield Property, held by Pretivm for future development of the Snowfield Deposit, is considered a separate property to the Brucejack Property. It was 100% owned by Newhawk and was not part of the joint venture that explored the Brucejack Property prior to the purchase of Newhawk by Silver Standard. The Snowfield Deposit is located approximately 7 km north of the Brucejack Deposit. This is reported to be a near surface, bulk tonnage gold-copper porphyry deposit with significant credits in silver, molybdenum, and rhenium. Mineral Resources are estimated at 1,370.1 Mt Measured and Indicated with a further 833.2 Mt in the Inferred category (Table 23-1). (Puritch et al. 2011)

Table 23-1: February 2011 Snowfield Mineral Resource

Resource Category	Tonnes (Mt)	Average Grades					Contained Metal				
		Au (g/t)	Ag (g/t)	Cu (%)	Mo (ppm)	Re (ppm)	Au (Moz)	Ag (Moz)	Cu (Blb)	No (Mlb)	Re (Moz)
Measured	189.8	0.82	1.69	0.09	97.4	0.57	4.983	10.332	0.38	40.8	3.5
Indicated	1,180.3	0.55	1.73	0.10	83.6	0.50	20.934	65.444	2.60	217.5	19.0
Measured & Indicated	1,370.1	0.59	1.73	0.10	85.5	0.51	25.917	75.776	2.98	258.3	22.5
Inferred	833.2	0.34	1.90	0.06	69.5	0.43	9.029	50.964	1.10	127.7	11.5

Source: Puritch et al. (2011)

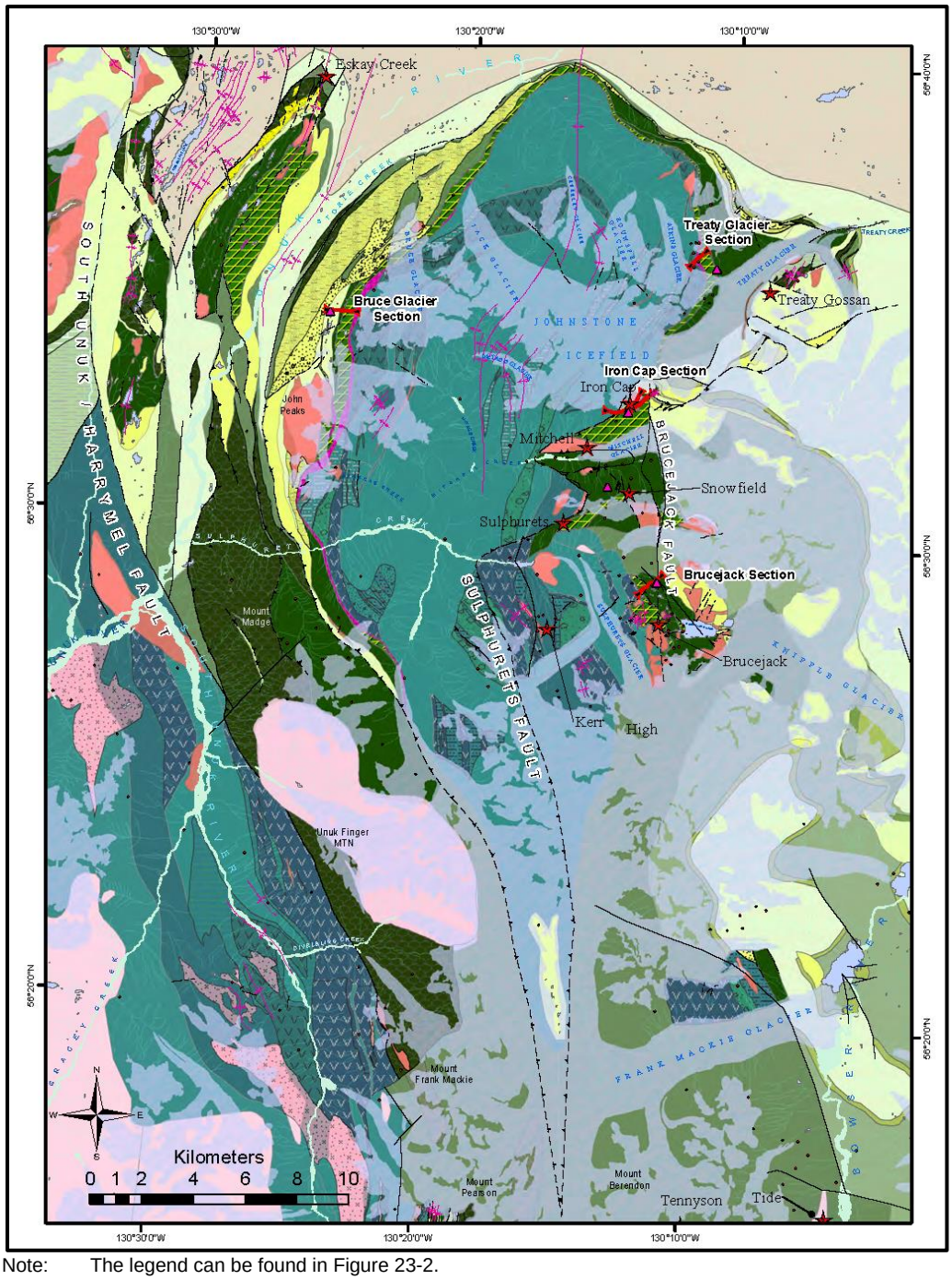
23.2 Bowser Property

The Bowser Property is a group of Pretivm mineral claims covering approximately 1,200 km^2 that extend from the eastern boundary of the Brucejack Property to east of Highway 37 and south from Treaty Creek to Long Lake. Exploration by Pretivm has included airborne electromagnetic, magnetic, hyperspectral, and radiometric geophysical surveys, ground geophysical surveys, extensive sampling, prospecting, and geological mapping over much of the property and diamond drilling on select mineralized zones.

Exploration results have highlighted several distinct areas for focused exploration. The A6 Zone is located approximately 14 kilometers northeast of the Brucejack Mine, where prospecting and mapping in 2018 outlined an area of pillow basalts and mudstones, consistent with stratigraphy in a paleo-rift environment. Drilling in 2019 identified a buried rhyolite dome capped by mudstones anomalous in arsenic and mercury. The rhyolite dome is intensely sericite altered, hosts pyrite stringer zones, and locally contains anomalous copper and silver. The stratigraphy, alteration, and geochemistry are all consistent with an Eskay-Creek style volcanogenic massive sulphide system in A6.

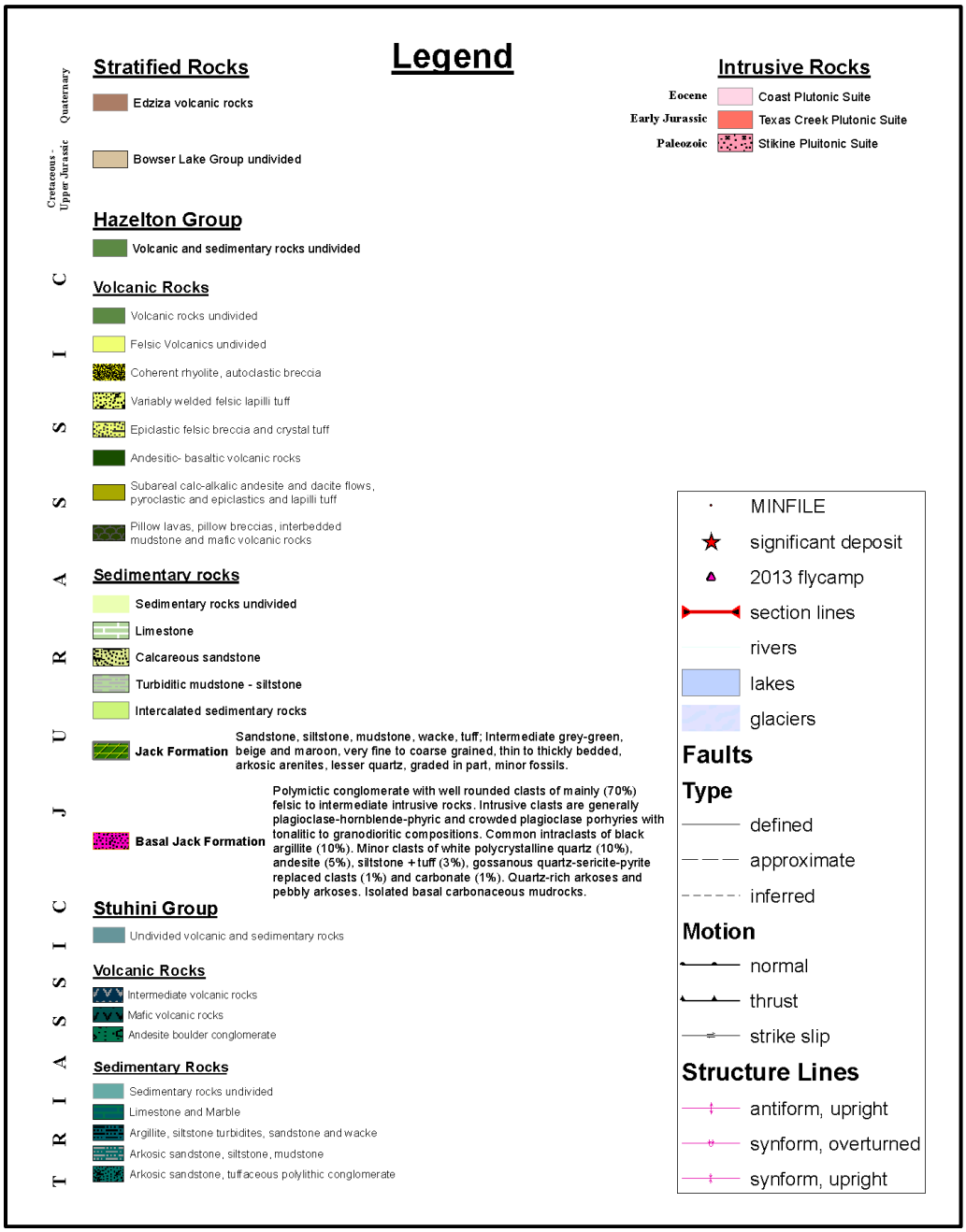
Several gold and silver epithermal targets have been identified in the American Creek Zone located approximately 25 km southeast of the Brucejack Gold Mine. The American Creek valley is dominated by kilometer-scale north-south structures and localized east-west stockworks, which host elevated gold values in rocks of the Lower Hazelton Group, Unuk River Formation, the same formation that hosts the Brucejack Gold Mine. The Koopa Zone, located approximately 30 km east-southeast of the Brucejack Gold Mine, hosts a structurally controlled quartz + pyrite + arsenopyrite vein system in intensely sericite altered Iskut River Formation mafic tuffs. The Bluffy Zone, located 30 km south-southeast of Brucejack Gold Mine, contains broad zones of low-grade gold hosted in shear zones, which contain narrow veins of high-grade gold and base metal values.

Figure 23-1: Detailed Geological Map of KSM-Brucejack Area and McTagg Anticlinorium and Section Locations



Note: The legend can be found in Figure 23-2.
Source: Nelson and Kyba (2014)

Figure 23-2: Legend for Detailed Geological Map of KSM-Brucejack Area and McTagg Anticlinorium and Section Locations



Source: Nelson and Kyba (2014)

23.3 Kerr-Sulphurets-Mitchell Property

Adjacent to the west and north of Brucejack/Snowfield Properties lies the Seabridge Gold Inc. (Seabridge Gold) KSM Property. The KSM Property hosts four copper-gold mineral deposits: Kerr, Mitchell, Sulphurets, and Iron Cap. All of these deposits are situated within the KSM mining lease and claim holdings that are reported to be, at the time of writing this report, 100% owned and operated by Seabridge Gold.

Seabridge Gold acquired the KSM Property from Placer Dome in June 2000.

In March 2019, Seabridge Gold published an updated NI 43-101 Technical Report detailing estimated Mineral Proven and Probable Reserves of 2.2 Bt of gold, copper, silver, and molybdenum ore. Table 23-2 is the published Proven and Probable Reserve Estimate and Table 23-3 is the published Measured plus Indicated Mineral Resource (http://seabridgegold.net). The resource estimate is based upon a combination of open pit and block caving mining methods. Over the entire LOM, ore will be fed to a flotation mill, which will produce a combined gold/copper/silver concentrate. The concentrate will be transported by truck to the nearby deep-water sea port at Stewart, BC for shipment to a Pacific Rim smelter. Extensive metallurgical testing confirmed that KSM could produce a clean concentrate with an average copper grade of 25%, making it readily saleable. Separate molybdenum concentrate and gold-silver doré will be produced at the KSM processing facility. (http://seabridgegold.net)

Table 23-2: March 2019 KSM Property Mineral Reserve

Zone	Reserve Category	Average Grades				Contained Metal			
		Au (g/t)	Cu (%)	Ag (g/t)	Mo (ppm)	Au (Moz)	Cu (Mlb)	Ag (Moz)	Mo (Mlb)
Mitchell	Proven	0.68	0.17	3.1	59.2	10.1	1,767	45	60
	Probable	0.58	0.16	3.1	50.2	17.4	3,325	95	104
Iron Cap	Probable	0.49	0.20	3.6	13.0	3.5	983	26	6
Sulphurets	Probable	0.59	0.22	0.8	51.6	5.8	1,495	8	35
Kerr	Probable	0.22	0.43	1.0	3.4	2.0	2,586	9	2
Total		**0.55**	**0.21**	**2.6**	**42.6**	**38.8**	**10,155**	**183**	**207**

Note: Cut-off values and mining methods used to report the Mineral Reserve Figures were defined based as Cdn$9 NSR for open pits and Cdn$16 NSR for underground. The reader should refer to the information provided by Seabridge Gold to get an accurate appreciation of the definition of the cut-off values for reporting.

Source: http://www.seabridgegold.net/resources.php.

Table 23-3: March 2019 KSM Property Measured and Indicated Mineral Resources

Zone	Tonnes (Mt)	Average Grades				Contained Metal			
		Au (g/t)	Cu (%)	Ag (g/t)	Mo (ppm)	Au (Moz)	Cu (Mlb)	Ag (Moz)	Mo (Mlb)
Mitchell	1,794.7	0.57	0.16	3.1	58	34.31	6,638	179.053	230
Iron Cap	422.6	0.41	0.22	4.6	41.0	5.576	2,051	62.559	38
Sulphurets	381.6	0.58	0.21	0.8	48	7.116	1,766	9.815	40
Kerr	378.4	0.22	0.41	1.1	5	2.692	3,445	13.909	4
KSM Total	2,977.3	0.52	0.21	2.8	54	49.694	13,900	265.336	312

Note: Cut-off values and mining methods used to report the Mineral Reserve Figures were defined based as Cdn $9 NSR for open pits and Cdn$16 NSR for underground. The reader should refer to the information provided by Seabridge Gold to get an accurate appreciation of the definition of the cut-off values for reporting.

Source: http://www.seabridgegold.net/resources.php.

23.4 Treaty Creek Property

Tudor Gold Corp. owns a 60% interest in the Treaty Creek Property, with American Creek Resources Ltd. owning a 20% carried interest, and Teuton Resources Corp. owning a 20% carried interest with a 0.98% royalty interest in the core portion of the property and a 0.49% royalty interest in the periphery claims (http://www.teuton.com; http://www.americancreek.com). The Treaty Creek Property adjoins directly northeast of Seabridge Gold's KSM gold-copper property and is underlain by a similar geology. The Treaty Creek area has a long history of exploration, including extensive sampling and diamond drilling, dating back to its discovery in 1928 (Pardoe 2016). Exploration work uncovered several zones, the most promising of which are the Copper Belle (porphyry-style), GR2 (feeder zone to a VMS), Eureka (porphyry-style with a gold-silver epithermal overprint), and Treaty Ridge (VMS/Sedex?) zones. There are no public reports of Mineral Resources or Mineral Reserves.

23.5 Catear

Catear (Goldwedge) is a small 8.7 ha mining lease, mineral tenure 301579, held by Goldwedge Mines Inc. It is located 2.2 km northwest of Brucejack Gold Mine on the south edge of mineral tenure 509397. Discovered in 1978, gold mineralization is hosted in a quartz vein and veinlet stockwork within andesite tuffs and lapilli tuffs of the Lower to Middle Jurassic Lower Hazelton Group. Although estimates of the contained mineralization are reported for two zones, these have not been prepared in accordance with NI 43-101 guidelines and are therefore not considered as current estimates for Catear. The estimates are presented here for information purposes only, and the reader is cautioned not to rely on them: Discovery Zone 34,451 t, grading 37.0 g/t Ag and 21.5 g/t Au; and Golden Rocket Zone 289,500 t, grading 38.3 g/t Ag and 27.4 g/t Au. Mining of the Golden Rocket Vein reportedly was undertaken in 1988 with ore processing through an on-site mill.

No records of production are available. (http://minfile.gov.bc.ca/Summary.aspx?minfilno=104B%20%20105)

24.0 OTHER RELEVANT DATA AND INFORMATION

24.1 Health, Safety, Environmental and Security

A fully-integrated health, safety, and environmental (HSE) program has been implemented to help achieve a “zero-harm” goal by Brucejack Gold Mine. To achieve this goal, all key project stakeholders have been responsible for providing leadership and committing to the highest HSE standards and values.

The development of HSE practices has required a high level of communication, motivation, and involvement, including alignment with site contractors on topics such as safety training, hygiene, ergonomics, hazard awareness, and risk assessment. Tools have been implemented for performance tracking and accountability, including procedures for incident management.

Established capture and containment guidelines are followed for the responsible management of process flows, effluent, and waste products. Environmental protection is incorporated in the operation of the main processes of the plant as well as in the transportation, storage, and disposal of materials within and outside of the boundaries of the Brucejack Gold Mine.

25.0 INTERPRETATION AND CONCLUSIONS

25.1 Geology

The Brucejack Deposit is interpreted to be a deformed, porphyry-related transitional to intermediate sulphidation epithermal high-grade gold-silver deposit that was formed between 184 and 183 Ma in an active island arc setting similar to the modern-day Philippines. The Brucejack Deposit has many characteristics in common with carbonate-base metal gold deposits from the southwest Pacific Rim. Intermediate sulphidation epithermal deposits are considered to be a sulphide-rich sub-type of carbonate-base metal gold deposits by workers in the southwest Pacific Rim region.

High-grade gold-silver mineralization was formed in association with a telescoped, multi-pulsed magmatic-hydrothermal system beneath an active local volcanic center. This resulted in the overprinting of earlier porphyry alteration and mineralization, which includes low-grade gold mineralization, by later co-spatial epithermal veining and mineralization, including the high-grade gold mineralization. As a result, the precious metal grade distributions at the Brucejack Deposit are inherently mixed and unresolvable by domain generation alone.

Electrum occurs as clots and dendritic aggregates hosted in sub-vertical, nominally east-west trending quartz-carbonate and carbonate vein stockwork. Infill drilling and mine development have shown that there are corridors of higher-grade east-west trending electrum mineralization within the broader stockwork zones. This represents an opportunity for selectively using longitudinal mining.

Recent research has shown that precious metal mineralization was predominantly transported as colloidal suspensions, with transportation as dissolved metal complexes likely accounting for only a small component of the metal flux. Controls on electrum precipitation appear to be fluid mixing, decreasing temperature, local boiling, and local colloidal aggregate destabilization near pyrite-rich zones. Colloidal flocculation as a function of these controls appears to be concentrated along faults, fractures, pre-existing foliation planes, and along lithological contacts. This explains the lack of a geochemical proxy for precious metal mineralization at the Brucejack Deposit.

Brownfields exploration work has indicated the presence of at least two porphyry mineralization targets on the Brucejack Property: the Bridge Zone and the Flow Dome Zone. Recent work suggests that the Flow Dome Zone may be the surface expression of the porphyry system that drove the development of the epithermal mineralization in the Brucejack Deposit. The Bridge Zone porphyry system is older (approximately 191 to 189 Ma) and is similar to the Snowfield-Mitchell system. Additional exploration is currently targeting the Flow Dome Zone.

The Brucejack Deposit is currently focused on the Valley of the Kings Zone and the West Zone. Similar epithermal vein-hosted precious metal mineralization is present throughout the 5 km by 1.5 km wide arcuate band of phyllic alteration on the Brucejack Property (e.g., Gossan Hill Zone, Shore Zone, SG Zone, Golden Marmot Zone, and Hanging Glacier Zone). This alteration and mineralization band has yet to be explored in sufficient detail for resource estimation, and represents upside potential on the property.

25.2 Mineral Resource

An updated Mineral Resource, effective date January 1, 2020 has been prepared for the Brucejack Deposit, incorporating information from additional tightly-spaced infill drilling, mapping of underground geological exposures, and mine production. The Mineral Resource is based on the January 2020 resource model, comprises the April 2012 resource estimate for the West Zone and the January 2020 resource estimate for the Valley of the Kings Zone. The Valley of the Kings Zone herein can be apportioned into three discrete areas: 1) the region where estimates

have been updated with the new drilling, mapping, and mine production information for the year 2019, 2) a region beyond this update but still within the January 2019 update area, where the January 2019 resource estimates remain, and 3) the regions outside of this, where the December 2013 resource estimates have been preserved. The January 2020 Mineral Resource is reported inclusive of Mineral Reserves and exclusive of material mined to December 31, 2019.

Data validation by the QP, as used for the preparation of the Mineral Resource, confirmed that the drilling data were of suitable quality for use in resource estimation. Furthermore, the QP has confirmed that the geological and domain interpretations were representative of the nature and style of mineralization in the deposit, and were appropriate for the estimation of mineral resources.

The same estimation methodology used in the preparation of previous resource estimates for the Brucejack Deposit was followed in the generation of the January 2020 Mineral Resource. The non-linear split population-based approach, which includes the estimation of high-grade, low-grade, and probability of high-grade variables separately using a combination of multiple indicator and ordinary kriging, prior to recombining these into final gold and silver estimates, is currently considered the most appropriate method for estimating the mixed and positively-skewed precious metal mineralization at Brucejack. Alternative techniques are continually evaluated as more information becomes available.

The most significant variations to the resource model for 2020 are new drill data, updates to the estimation parameters, and the use of a 10 m by 10 m by 10 m block size for reporting the Mineral Resource. The change in block size reflects an appropriate scale to the block size being considered for mining.

The resource model was validated against input drillhole data and mine production for the year 2019 and found to provide a reasonable to good representation of the input data and production information. The resource model was classified as Measured, Indicated, and Inferred in accordance with CIM (2014) Definition Standards. In addition, Pretivm expects that Measured Resources are to be within 15% of mine production on a quarterly basis, and Indicated Resources are expected to be within 15% of mine production on an annual basis. Shorter-term reconciliation is not considered appropriate given the highly variable and nuggety nature of the precious metal mineralization at Brucejack. Inferred Resources cannot be converted to Mineral Reserves as there is insufficient confidence in the estimate to support mine planning. They are, however, useful for resource definition drill targeting. Looking at the January 2020 resource model retrospectively, the overall tonnes and grade reported from production in 2019 were within 10% of those reported from the 2020 resource model from within the mined outlines.

The January 2020 Mineral Resource effectively overwrites the January 2019 Mineral Resource inside the newest update area. Comparisons between these models (inclusive of mine production) show that the new estimate is lower by approximately 0.7 Mt, 2.2 Moz Au, and 1.1 Moz Ag in the Measured + Indicated Resource at similar estimated gold and silver grades, using the same cut-off grade of 5 g/t AuEq (AuEq = Au + Ag / 53) and after depletion. The differences between the two models are largely driven by additional tightly-spaced infill drilling.

The January 2020 Mineral Resource of the Valley of the Kings Zone is reported above a cut-off grade of 3.5 g/t gold; differing from the previous reporting above a gold equivalent of 5 g/t AuEq cut-off (calculated as AuEq = Au + Ag / 53) used in the November 2012 (Jones, 2012c), December 2013 (Jones, 2014), July 2016 (Board et al., 2017), and January 2019 (Pretivm, 2019) Mineral Resources. The decision to report the Mineral Resource at a lower cut-off grade is based on a comparison between actual mining practice and results and the resource model.

25.3 Mineral Reserves

The revision to Mineral Reserves is driven by the updated Mineral Resources. Measured and Indicated Mineral Resources that fall within planned mining shapes have been converted to Mineral Reserves. Adjustment factors applied to the Mineral Resources to convert to Mineral Reserves include estimation of mineable shapes, dilution, and mining losses alongside grade reconciliation calculations. Mineral Reserves are delineated using a cut-off grade of US$180/t.

In the 2020 Mineral Reserve update, a MCF was included in Reserve calculations. As the MCF is based upon historic mining data of previous resources, it is only applied to the areas of the current resource that have not been updated. The MCF is based on the stope grade and drillhole spacing within each designed stope. Areas with closer drillhole spacing, and therefore higher grade confidence, are capped at a higher grade than areas with lower drillhole spacing to avoid potentially overstating grades in areas with lower statistical confidence. This MCF calculation has shown an improvement in reconciliation between resource estimated and mined grades prior to recovery and dilution estimates.

25.4 Mining

25.4.1 Underground Mine Geotechnical

SRK undertook a geotechnical review and evaluation of the Brucejack Gold Mine Project that included a review of historic geotechnical data, underground excavation conditions, stope performance, and structural geology to support the confirmation of underground mine design and geotechnical design guidelines. These guidelines included excavation design parameters, estimates of dilution, as well as ground support requirements.

The stopes and underground infrastructure excavations are performing well. The design excavation dimensions are appropriate for the observed and anticipated ground conditions. Major structural features, such as the Rainy Fault, and associated secondary structures are impacting excavation performance, but ground conditions are managed well using the ground support described in this report and through local geotechnical assessment by mine personnel when required.

25.4.2 Mining Methods

The current mining operation has proven mining performance at 3,800 t/d. The mine is equipped and staffed to continue mining of the reserves as planned. Ongoing reconciliation, cavity monitoring, and data collection provide feedback to the geology, mine planning, and operational teams to improve mining performance. The current mine plan includes accelerated development in the Valley of the Kings Zone in order to sustain sufficient working areas for targeted production.

The nature of the mineralization results in a degree of variance between planned tonnes and grade over short time periods. As mining continues, the nature of the mineralization and degree of variance will be better understood, which will enable better forecasting of short- and long-term production. Continued use of MCF calculations going forward is expected to further improve grade reconciliation during mine planning.

25.4.3 Waste Rock

Bathymetric surveys, geotechnical site characterization, numerical assessment, back analysis, and continuous observation has been used to design the waste rock dump, including deposition on tailings. The observational method (Terzaghi and Peck 1967; Peck 1969) coupled with rigorous SOPs and QPOs documented in a comprehensive OMS Manual ensures continued safe operation of the dump.

This dumping procedure is independent of the Brucejack Lake bed sediment (and tailings) thickness or strength, because it assumes that the foundation cannot initially carry the load whether it is due to sediment (and tailings) thickness or strength (or both).

Annual geotechnical inspections have been carried out by SRK on the waste rock dump (and tailings deposition) between 2016 and 2019. In addition, an Independent Tailings Review Board (ITRB), appointed by Pretivm, completed annual inspections at this same time. All inspections have consistently confirmed that the operational practices by Pretivm was appropriate for the site conditions, and that Pretivm staff was well informed of the procedures necessary to continue safe waste rock dumping.

25.5 Mineral Processing and Metallurgical Testing

25.5.1 Metallurgical Testing

The Brucejack Deposit mineralization typically consists of a significant portion of gold and silver present in the form of nugget or metallic gold and silver, especially for the Valley of the Kings ore. Extensive metallurgical testing programs have been conducted on the Property since 1988, with major metallurgical test work performed between 2009 and 2014 to support the design and construction of the 2,700 t/d process plant for the Brucejack Gold Mine. The mill began commercial operation at the designed capacity in Q4 2017. In general, the mill feed is amenable to the process flowsheet designed, including gravity concentration and flotation concentration to produce a doré product and a flotation concentrate. On average, the gravity concentration circuit produced a much better gold recovery, compared to the results produced from the laboratory trials.

In 2018, to increase the mill feed rate to 3,800 t/d, various test work, circuit simulations, and review work were conducted to assess the opportunities and bottlenecks for further improvement of the mill performance and throughput.

25.5.2 Mineral Processing

The 2018 mill capacity review work and the 2019 operation indicate that with some modifications, the process plant is capable of achieving the planned throughput of 3,800 t/d. The new third cleaner cell and the new flocculant preparation system are being installed and it is expected the upgrading would improve cleaner circuit and tailings and concentrate dewatering circuit performances. The upgraded flowsheet is same as the existing operation, including the following components:

- One stage of crushing in underground
- A 2,500 t SAG mill feed surge bin on surface
- A SABC primary grinding circuit equipped with a gravity concentration circuit
- Rougher flotation and scavenger flotation of hydrocyclone overflow

- Three stages of cleaner flotation on combined rougher and scavenger concentrates
- Flotation concentrate dewatering
- Flotation tailings dewatering circuits.

The mill feed ore is crushed and ground to the particle size of 80% passing approximately 90 to 100 µm. Two gravity centrifugal concentrators, together with two upgrading tables and associated one gravity centrifugal concentrator, recover the free nugget gold grains from the ball mill discharge. The resulting gravity concentrate is further refined in the gold room on site to produce gold-silver doré.

The hydrocyclone overflow, containing gold and silver bearing sulfide minerals, from the primary grinding circuit is floated by rougher and scavenger flotation. The resulting rougher flotation concentrate and scavenger flotation concentrate are further upgraded in three stages of cleaner flotation. The first cleaner scavenger flotation tailings report to the rougher scavenger flotation for further recovering the residual gold and silver bearing sulphides. The third cleaner concentrate, or the final flotation concentrate, is dewatered by a high-rate thickener and a tower-type filter press prior to being loaded in customized bulk containers for shipping.

The final rougher scavenger flotation tailings are dewatered in a deep cone thickener. Approximately 30 to 40% of the flotation tailings is used to make paste for backfilling the excavated stopes in the underground mine, and the balance is pumped to Brucejack Lake where the tailings is stored under water. The concentrate and tailings thickener overflows are recycled as process make-up water.

25.6 Environmental

25.6.1 Geochemistry

The geochemistry of Brucejack Gold Mine rocks has been and continues to be assessed through comprehensive characterization studies (refer to Section 20.3.2) and ongoing monitoring programs. The geochemical data sets have been used to inform waste management plans and to predict associated water quality. The main conclusions of the geochemistry assessment are summarized as follows:

- A significant portion (49%) of surface waste rock samples are characterized as PAG with enrichments (greater than 10x average continental crust) in silver, gold, manganese, antimony, and selenium. Saturated column tests indicate that subaqueous storage of surface waste rock in Brucejack Lake will minimize any potential leaching and changes to Brucejack Lake water quality.
- The majority of underground waste rock samples (83%) at the Brucejack Gold Mine are PAG; however, most of the rocks have considerable neutralization potential, which is predicted to delay the onset of ARD for decades or more. Leachate results from humidity cell tests and field bin studies confirm this assertion. This is also supported by the observation of alkaline mine waters and no indication of increasing concentrations of dissolved metals associated with the onset of ARD (e.g., cadmium, cobalt, copper, iron, zinc, as predicted by kinetic tests) since gold production commenced in June 2017.
- The Brucejack Gold Mine ore is characterized as PAG, whereas tailings generated from the mill are generally characterized as NPAG. The tailings samples have elevated concentrations of silver, arsenic, cadmium, manganese, and selenium, compared to continental crust; however, saturated column test results indicate that subaqueous storage of tailings in Brucejack Lake or in the underground mine below the post-closure final water table elevation will minimize metal leaching.
- NPAG quarry rock samples are consistently NPAG with low metal leaching potential.

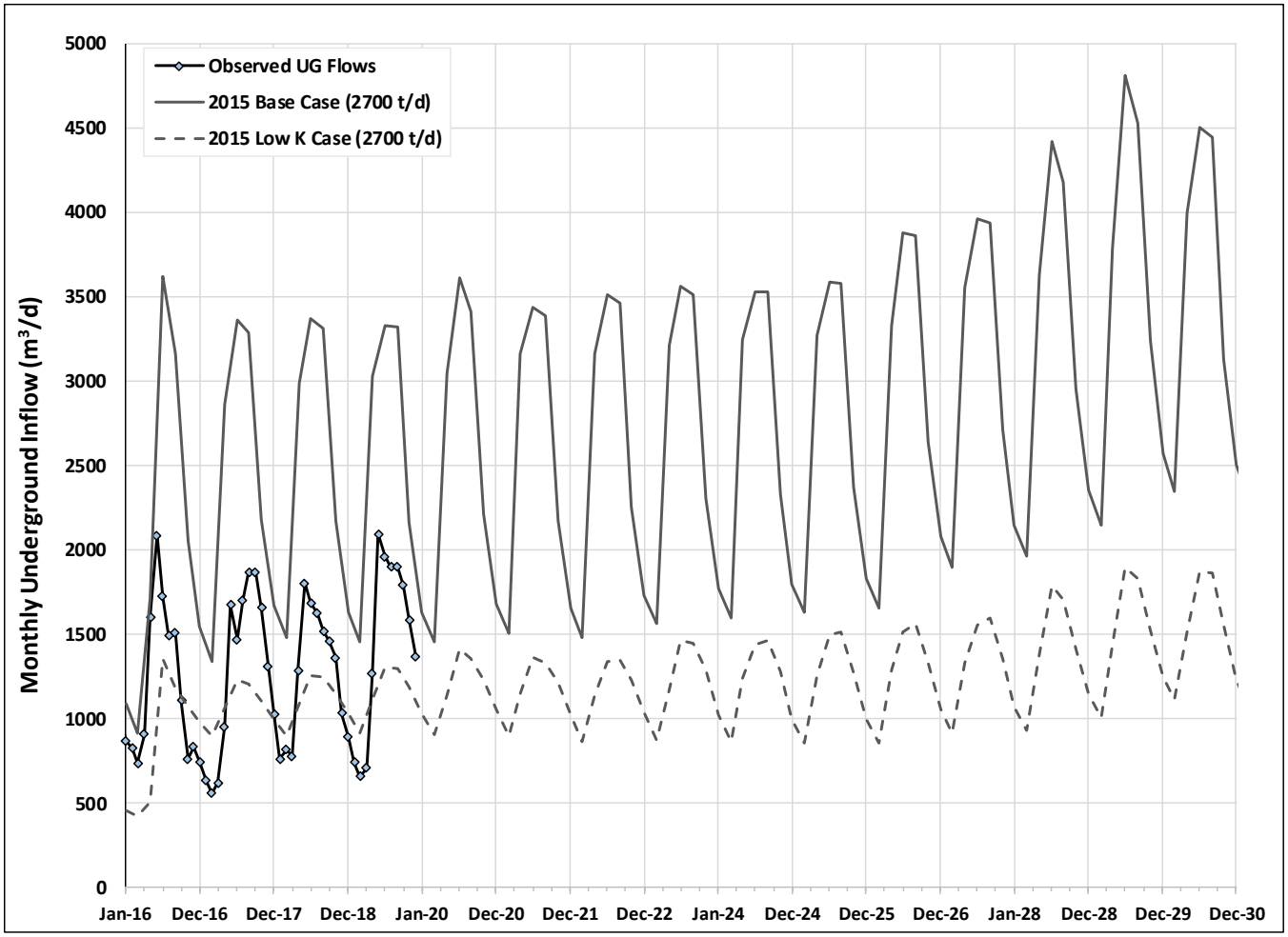
- WTP sludge is characterized as NPAG with elevated concentrations (greater than 10× average continental crust) of silver, arsenic, cadmium, manganese, molybdenum, antimony, and selenium. Based on static and kinetic tests, WTP sludge is predicted to be stable over a range of pH and redox conditions.

The results of the geochemistry assessment indicate that water, waste rock, and tailings are being managed appropriately to minimize environmental risk.

25.6.2 Hydrogeology

A calibrated, three-dimensional, numerical hydrogeologic model, developed for environmental assessment and permitting applications in 2015, was used to estimate the inflow of groundwater to the Brucejack Gold Mine underground mine workings. These flow estimates were based on a 2700 t/d mine plan as presented in the 2014 FS (Ireland et al. 2014). The average annual rate of groundwater inflow to the underground workings was predicted to vary between 2,500 and 2,900 m^3/d and to increase to between 2,900 to 3,500 m^3/d with initiation of mining in the West Zone (Section 20.3.3). However, the observed average annual underground dewatering rate (a proxy for measuring groundwater inflow rate to the mine) from 2016 to 2019 was 1,280 m^3/d, which suggests that actual inflow rates may remain between the simulated base case and the low K scenarios (Figure 25-1).

Figure 25-1: Simulated vs. Observed Inflow Rates



Potential factors causing the difference between the 2015 calibrated base case simulated inflows and observed inflows include but are not limited to the following:

- The bulk rock mass hydraulic conductivity is lower than simulated for the base case
- Differences between simulated and actual rates and depth of mine development
- Seepage mitigation measures employed during mining (e.g., grouting of higher producing zones)
- Some combination of these factors.

The groundwater model is currently being updated to support the 2020 5-Year Mine Plan and Reclamation Program Update pursuant to permit requirements. The 2020 groundwater model will be re-calibrated to a longer record of dewatering and groundwater levels (up to the end of 2018), incorporating accurate as-built data and the current mine plan (Jones et al. 2019). The recalibration will include adjustments to recharge and bedrock K and consideration of grouting of faults.

25.6.3 Water Management

There are three sources of contact runoff during operations:

- Waste rock deposited in Brucejack Lake
- Surface contact water from PAG bedrock exposed during infrastructure construction, the most significant being rock excavation to create the pad areas for the mill and the Phase 2 camp
- Groundwater seepage to the underground mine.

Runoff from the latter two sources is managed by storage and treatment. All runoff within the Brucejack Gold Mine site contact water management system is collected in the CWP. This pond has been sized to contain the runoff volume (50,000 m^3) associated with the 24-hour, 200-year return period rain on snow event (the 24-hour, 200-year rainfall has been estimated at 226 mm, while snowmelt potential has been estimated at 43 mm). The contact water pond runoff is pumped to the mine WTP for treatment prior to use in process or for discharge to Brucejack Lake.

The Brucejack Gold Mine process plant requires process water for the tailings slurry to the lake, the underground paste backfill, the concentrate slurry, and the underground mine supply. Process water is sourced from:

- Treated underground seepage water
- Treated contact water from the CWP
- Recovered ore moisture
- Water withdrawal from Brucejack Lake at its outlet.

Average annual groundwater seepage is sent to the WTP, and then the process plant, where its use is maximized in process.

The water management assessment indicates that Brucejack Gold Mine surface and underground contact and non-contact waters are being managed appropriately, and that water inputs, including fresh water supplies, are adequate to support milling operations and other mine requirements.

25.6.4 Water Balance

The main sources of water for ore processing at the Brucejack Gold Mine include water that is conveyed by contact water ditches and surface sumps and reports to the CWP, water that reports to sumps of the Underground Mine and is pumped to surface, and permitted water withdrawals that are sourced from Brucejack Creek adjacent the BJ 3.10 weir. Water that is withdrawn from CWP storage is treated prior to being used in the mill. Surplus treated water may be discharged to Brucejack Lake when mill water requirements are fully met or it is necessary to manage pond volumes at a certain level. Operational water data collected in 2018 and 2019 indicates releases of treated effluent to the lake are necessary between May and October because the majority of annual runoff is realized during these months and water surpluses are encountered at the CWP.

Water that reports to the Underground Mine is captured in sumps and pumped to surface. Like water used from the CWP, sump water is treated prior to being used in the mill or discharged to the lake when freshwater supply exceeds mill water demand. A major component of underground sump water is groundwater recharge that daylights in the mine due to dewatering activities. In addition to groundwater recharge, water from the FW Tank in the mill building is also directed below ground to support mining activities, such as drilling and dust suppression. Water that is circulated to the underground mine reports back to underground sumps and is pumped to surface for treatment, then used in the mill or released to the lake.

Mill water supply that relies on either CWP storage or groundwater recharge is subject to seasonal changes, and in the case of groundwater recharge, measured inflows are lower than originally projected. However, Pretivm has demonstrated an ability to operate at a 3,800 tpd production level while remaining within permitted reclaim limits and within the constraints of the existing water management system.

A site-wide water balance model was constructed for the Brucejack Gold Mine in Excel using a monthly time-step (BGC 2017a,b). The major components of the Brucejack Mine water management system, including sump, pumps, ponds, tanks, ditches, and treatment plants, are all encoded in the water balance model. Furthermore, the model provides a robust accounting of background and surface water flows from the headwaters of the Brucejack Lake watershed, downstream to the BJ 1.74 monitoring location, which is below Brucejack Lake. The site-wide water balance model is currently being updated as part of the 5-Year Mine Plan and Reclamation Program Update pursuant to permit requirements to consider several years of high-quality climate, streamflow, and operational water data that have been collected at the mine site since the water balance was developed.

25.6.5 Water Quality

Key mitigation measures to minimize Brucejack Gold Mine effects on water quality include collection of underground mine waters and surface waters that contact disturbed PAG rock and treatment of this collected water in the mine WTP, a sewage treatment plant to treat domestic wastewater, and subaqueous deposition of waste rock. Discharge of mine contact water to the aquatic receiving environment is regulated under the conditions in Effluent Permit 107835 (PE-107835), most recently amended on December 14, 2018. Effluent permits in British Columbia are issued pursuant to the provisions in British Columbia's *Environmental Management Act* for the protection of the environment.

Water quality monitoring results have shown that water has and is continuing to be managed to meet the requirements of PE-107835, including with respect to water quality limits for the mine effluent discharge. Concentrations of metals and other parameters monitored at the outlet of Brucejack Lake are below the current limits in PE-107835 and/or below BC WQGs for the protection of aquatic life. The Brucejack Gold Mine water quality model was updated in 2018 (Lorax 2018) and incorporated monitoring results from construction and operation phases of the mine, as well as recent geochemical test results. The updated model predicts that water quality will continue to meet the discharge limits and other conditions set out in PE-107835.

25.7 Capital Cost and Operating Cost Estimates

The total estimated LOM sustaining capital cost for the Brucejack Gold Mine was estimated to be US$176.7 million, including related costs for mining, processing, and site infrastructure and services. A foreign exchange rate of Cdn$1.00:US$0.76 was used for the cost estimate.

The estimated LOM average operating cost for the Brucejack Gold Mine is US$162.82/t milled. Table 25-1 shows the cost breakdown for each area.

Table 25-1: LOM Average Operating Cost Summary

Area	Unit Operating Cost (US$/t milled)
Mining	70.83
Processing	21.34
Overall Site Services, including Office[(1)]	35.89
G&A	34.76
Total Operating Cost	**162.82**

Note: [(1)] Including the costs for off-site and satellite offices.

The operating costs exclude shipping charges and sale costs for the gold-silver doré and gold-silver concentrate and royalties, which are included in the financial analysis.

All operating cost estimates exclude taxes unless otherwise specified.

25.8 Economic Analysis

Tetra Tech prepared an economic evaluation of the Brucejack Gold Mine based on a discounted cash flow model for the remaining 13 year LOM and 15.64 Mt of ore included in the mine plan. For this mine plan, a post-tax NPV of US$1,496 million, at a discount rate of 5%, was calculated based on the following assumptions:

- Gold price of US$1,300/oz
- Silver price of US$16.90/oz
- Foreign exchange rate of Cdn$1.00:US$0.76.

The production schedule was incorporated into the pre-tax financial model to develop annual recovered metal production. Capital expenditures include remaining capital expenditures for mine throughput expansion to 3,800 t/d and ongoing sustaining capital costs for mining and milling additions and equipment replacement.

The NPV was estimated at the beginning of the mining schedule and therefore has an effective date of January 1, 2020.

Table 25-2 summarizes the forecast for the economic performance of the Brucejack Gold Mine operation for the remaining LOM.

Table 25-2: Brucejack Gold Mine Economic Performance Forecast

	Unit	Amount
Tonnes Mined and Processed	kt	15,637
Gold Head Grade	g/t	8.4
Silver Head Grade	g/t	59.6
Total Project Revenue	US$ million	5,266
Operating Costs	US$ million	(2,546)
Royalties	US$ million	(63)
Sustaining Capital Costs	US$ million	(177)
Other Expenses	US$ million	(21)
Taxes Payable	US$ million	(492)
Post-tax NPV (5% Discount Rate)	US$ million	1,496
Post-tax NPV (8% Discount Rate)	US$ million	1,293

The 2.5 years of operations that have been completed at the Brucejack Gold Mine provides confidence in the project economics, particularly with regard to understanding operating costs. The Brucejack Gold Mine is most sensitive to metal prices, with opportunities to improve profitability through cost management.

25.9 Project and Operation Risks

There are no known environmental liabilities or other significant risks or factors that may affect access, title, or the ability or right to operate the mine or perform work on the Brucejack Property, beyond the geopolitical, economic, permitting, and legal climate that Pretivm operates in and Pretivm's ability to secure any required approvals, consents, and permits under applicable legislation.

26.0 RECOMMENDATIONS

26.1 Introduction

This Technical Report indicates that the Brucejack Gold Mine is considered to be economically viable. The mine has a demonstrated capability of processing 3,800 t/d of ore, or higher.

26.2 Geology

Faults, fractures, foliation planes, and lithological contact structures are considered key features controlling the distribution of electrum within the Brucejack Deposit. It is therefore recommended that all occurrences of visible electrum in the underground workings are calibrated to, and combined with drillhole data to create a predictive tool to assist in delineating more detailed corridors of higher-grade mineralization within the broader stockwork zones. This will assist in improved local resolution of high-grade zones for resource estimation. This should be completed as a part of the standard underground geological mapping and other observations, and as such, does not need a separate budget.

Fluid mixing, utilizing various structural elements, appears to have been the primary cause of colloidal suspension destabilization and electrum precipitation. The presence of numerous phreatomagmatic breccia bodies, immature volcaniclastic lithological units, and carbonate-dominated veins, vein stockwork, and vein breccia, opens up the possibility of caldera collapse and seawater ingress as being a trigger for ubiquitous fluid mixing. It is recommended that a surface mapping campaign be conducted across the Flow Dome Zone, eastern parts of the Valley of the Kings Zone, as well as to the north and east of Brucejack Lake to test this possibility. Available drillhole logs, core, and core photos should be reviewed to augment this process. This should be completed as a part of the on-going exploration process, and as such, it is not expected that this needs a separate budget.

The geology at depth, to the west, and to the east of the Valley of the Kings Zone appears different to the part currently being mined: VSF volcanosedimentary rocks become the primary host, being replaced by P1 latite flows at depth and to the east; veins, vein breccia, and vein stockwork change from quartz-carbonate to carbonate only veining (at least three generations of calcite, including manganoan). Recent research has shown, through the use of Transmission Electron Microscopy, that all of the electrum is hosted in carbonate as opposed to quartz. The changing geology needs to be characterized to assess the significance of these changes and to characterize appropriate structural-lithological mineralization traps. Revisions to the existing mine stratigraphy and mineralized vein classification scheme will be required for these areas as drilling and mining expand into them. It is understood that this work is being completed as a part of the on-going near-mine exploration process, and as such, it is not expected that this needs a separate budget to the existing near-mine exploration budget.

Additional drill exploration of the Bridge Zone should be reviewed in light of the results of the 2019 geophysical programs. Additional near-mine exploration, including targeted surface drilling and geophysics, is warranted on the mineralized zones closest to the current mine to test the potential for additional high-grade precious metal resources proximal to the mill. A large gap in drill data exists between the Valley of the Kings and the West Zone deposits. This area requires a systematic drilling approach to test for mineralization.

26.3 Mineral Resource

Reconciliation of the January 2020 resource model to the 2019 mill production was within 10% on an annual production volume. Areas mined during this period were generally informed by drilling on up to 15 m centers. It is therefore recommended, going forward, that resource definition (infill) drilling be conducted at 15 m centers or tighter. This should be budgeted within the mine grade control process on an as-needed basis.

All future drilling to be conducted on the Valley of the Kings Zone and the West Zone should be as close to perpendicular to the main mineralized trend as possible. This includes drilling for exploration, resource definition drilling, and drilling for grade control purposes. All efforts should be made to avoid drilling parallel or close-to-parallel to the main mineralized trend.

Although it is impractical not to drill in fan patterns from underground drill bays, efforts should be made to minimize excessive clustering at resource definition drillhole collars in drill fans. Drilling parallel fans from spaced drill bays versus multiple oriented fans from the same collar location is recommended to minimize the clustering of samples at fan collars.

Additional infill drilling should be conducted in zones of interest, particularly the Indicated Mineral Resource outside of the January 2020 update area to improve the confidence in the estimates within the Resource model. A budget for this will need to be determined on an as-needed basis, and as the requirements of the mine change.

An updated simulation-based drillhole spacing study is recommended for the Valley of the Kings Zone considering the quantity of new drilling and mining information that has been generated subsequent to the previous study, conducted in 2016. Studies to-date using simulation show that the simulations thus far have not been able to reproduce the entropy of the mineralisation displayed in the drill data, and alternative strategies need to be explored. No separate budget is required as the work should be completed internally by Pretivm's Resource Geology team.

The current Mineral Resource is, in practical terms, a bulk mining model. This is particularly the case for that part of the Mineral Resource outside of the update area. In order to improve model selectivity and enhance local estimation resolution, in conjunction with infill drilling (which is critical for local mine planning), alternative approaches to volume-variance adjustments are recommended. In addition to the current re-blocking-based approach as part of MIK post-processing, other techniques like generating re-blocked local simulations should be tested.

An updated simulation-based stope risk assessment study is recommended once a suitable simulation strategy has been defined. This will establish within-stope grade uncertainty to inform and improve mine scheduling, as well as highlight areas that require additional information. No separate budget is required as the work should be completed internally by Pretivm's Resource Geology team.

Improved material tracking techniques should be investigated to enhance annual reconciliation. It is recommended that the mine source commercial software for the development of tracking requirements. The cost of the software and its set-up should be budgeted accordingly.

More detailed information should be collected on the individual performance of stopes from within the Measured Resource so that confidence in the relevant grade estimates can be assessed. This is because, even though the resource mined has good reconciliation, the local estimates continue to show some variability with production, and Pretivm needs to understand whether or not the local estimates are accurate enough to be consistent with the requirements of a Measured Resource. Pretivm needs to understand the confidence in these estimates for the future classification of mineral resources. At the time of this report, there remain less than 1.5 million tonnes of Proven Reserve (i.e., derived from the Measured Resource).

Near-mine Inferred Mineral Resources in the eastern parts of the Valley of the Kings Zone represent a proximal target for adding to the existing Measured + Indicated Mineral Resource base. Additional infill drilling is recommended for the near term. The appeal of this area is underlined by the results from the deep underground exploration drilling conducted in 2018, which demonstrated the continuation of Valley of the Kings Zone style mineralization towards the east and under the Flow Dome Zone. It is expected that this would be included in the exploration and near-mine exploration budgets as the company sees fit, and as such, it is not expected that this needs an additional budget.

In 2011, Pretivm produced a Mineral Resource, in support of testing the open pit potential of other zones at Brucejack, including Shore Zone, Bridge Zone and the Galena Hill Zone. As open pit mining is currently not considered an option at Brucejack, that Mineral Resource is no longer current. It is recommended that Pretivm revisit these zones to examine the potential for estimating a Mineral Resource suitable for underground extraction. No separate budget is required as the work should be completed internally by Pretivm's Resource Geologist.

26.4 Mining

26.4.1 Underground Mine Geotechnical

SRK makes the following recommendations for additional rock mechanics assessment work:

- Further work should be completed on the interpretation and modelling of large and intermediate scale faults. The presence of unknown major structures or splays off known faults have the potential to significantly affect rock mass stability (potential wedge formation). Zones of sericiitc alteration are associated with geologic structures, which also impact the rock mass. Defining and understanding the spatial distribution of these features has the potential to optimize development excavation ground support design and ore recovery. Reduction of rock mass quality associated with major structures and strong alteration is considered to be of particular risk to the recovery of secondary stopes. The updated structural model should be reviewed to determine if updates to the geotechnical assessments are required.

- SRK recommends that the Brucejack Gold Mine review actual stope performance and recovered volumes against planned stope volumes to identify any potential stope performance patterns associated with specific geotechnical domains, rock mass alteration, or geologic structures. Stope dimensions and ground support can then be modified to optimize safe ore recovery.

- Now that the mine has been operating for several years, valuable geotechnical and excavation performance data is available for calibration of a numerical model. SRK recommends the construction of a numerical model utilizing Map3D to assess rock mass stability, potential impacts on major structural features (i.e., the Brucejack, Rainy, and VOK faults), and areas of the mine in which elevated stresses may develop as a result of the expansion of the mining footprint.

The estimated cost for the above-mentioned recommended work is $350,000.

26.4.2 Mining Methods

Recommendations for Brucejack's current mining method are centered around optimisation of stope parameters and improving dilution and recovery. Control and reduction of dilution to improve mining performance at Brucejack is related to both geotechnical factors and mining methods. Stopes that are planned in poorer-quality rock in areas bounded by mine-scale fault zones are recommended to be assessed and designed on an individual basis, with the following tasks undertaken:

- Alteration of stope dimensions, including shortening of stope lengths, towards fault zones or areas of poorer rock quality to improve stability
- Continued reconciliation of planned and recovered stope volumes to identify areas of higher dilution
- Spot assaying of blasted muck to further track dilution and recovery estimates on an ongoing basis
- Blast control techniques including drillhole surveys, blast damage monitoring, and blast design modifications based on reconciliation of localised recovered stope volumes to reduce any potential drill and blast-related dilution
- In-situ strength testing of paste fill in primary stopes to determine the quality of updated paste fill mixtures, which were recommended from previous strength testing studies.

Increased operational experience will give further confidence in the application of the Mine Call Factor combined with monthly reconciliations to the short and long range mine plans. Further definition of the capping parameters applied to the overall stope grade will provide more continuity between the scheduled grades and reconciliation on a monthly, quarterly, and annual basis. No separate budget is required for the mining work as this can be completed internally by the Pretivm Engineering and Geology teams.

26.4.3 Waste Rock

Waste rock and tailings deposition is governed by the OMS Manual, the last version having been updated in February 2020 (SRK 2020b). Specifically, waste rock dumping is done in accordance with a standard operating procedure (Brucejack Lake Waste Rock Disposal, SOP 011), which is an appendix to the OMS Manual. Pretivm's engineering team manages the day-to-day waste rock deposition and follow-up monitoring and surveillance following procedures outlined in the OMS Manual. The OMS Manual has been developed in accordance with SRK's design recommendations and undergoes updates as necessary. All employees working on the WRTSF are provided training on the OMS Manual, specifically the WRTSF SOP.

The required surveillance procedures for waste rock and tailings deposition is explicitly outlined in the OMS Manual, as are the QPOs.

A daily report is produced by the Pretivm on-site geotechnical engineers that outlines all activities pertaining the waste rock dumping. This report is circulated internally to Pretivm staff, including senior management, all off-shift geotechnical personnel to ensure continuity, as well as to the EOR. If the EOR identifies any anomalies or areas of concern based on the daily report, they reach out to the on-site geotechnical engineers.

It is recommended that Pretivm continue to operate in accordance with these procedures outlined as it has been demonstrated to ensure safe waste rock and tailings deposition practices.

26.5 Mineral Processing and Metallurgical Testing

Further metallurgical tests are commended to optimize metallurgical performances and support the operations.

Installation of a regrinding and gravity concentration circuit to recover fine gravity recoverable gold and silver from the rougher flotation concentrate should be investigated to further improve gold and silver recoveries to the doré. The concentrate should be reground to release locked fine gold and silver grains. However, a comprehensive technical and economic review should be conducted, including investigating the effects of the additional gold and silver recovery to doré on capital costs, operating costs, and gold and silver payment of the flotation concentrate.

Tailings and flotation concentrate thickener performances should be further assessed for the increased mill feed rate. The review work should include further flocculant type and dosage evaluation and bypassing the coarse fraction of the final flotation tailings to the tailings surge tank by cycloning to reduce the tailings thickener loads. Also, the cyclone classification arrangement is expected to increase solid density and improve particle size distribution of the paste plant feed, which may save paste binder material consumption.

Further optimization of crushing and grinding circuits should be conducted in an effort to reduce comminution circuit energy consumption and steel ball consumption, including better utilizing the installed pebble crusher.

The mill optimization is a part of daily process operation improvements. The costs associated with these optimizations have been included in the mill operating costs.

26.6 Environmental

26.6.1 Geochemistry

The geochemistry of Brucejack Gold Mine waste rock, ore, and tailings has been well characterized through baseline studies and ongoing confirmatory sampling programs. The environmental management plans in effect outline sampling recommendations, management triggers, and corrective actions that are expected to minimize potential adverse effects on water quality. It is recommended that, as planned, confirmatory sampling and ongoing site monitoring data for waste rock, NPAG quarry rock, tailings, paste backfill, and mine water continue to be evaluated on an ongoing basis to identify potential environmental issues, to improve understanding of site-specific geochemical behaviour, and to verify the site-wide water quality model.

Recommendations for future geochemical studies at Brucejack Gold Mine include the following:

- Additional saturated column tests on WTP sludge if the chemistry of mine water changes significantly or if modifications are made to the water treatment process
- Additional kinetic tests on tailings if changes are made to the milling process such that the chemistry of the tailings changes significantly
- Continued geochemical and mineralogical studies to predict mine water quality during closure when the mine is flooded.

The estimated cost for this recommended work is $300,000.

26.6.2 Hydrogeology

The numerical groundwater model is being updated to support water balance and water quality modeling for the 2020 5-Year Mine Plan and Reclamation Program update. The update will incorporate accurate as-built mine workings and reflect a 3,800 t/d mine plan described in Jones et al. (2019).

The 2020 groundwater model will be recalibrated to current underground dewatering rates and groundwater level data to the end of 2018. Water level data records from 2018 monitoring wells are limited for this data period. It is recommended that the 2020 groundwater model be validated against 2019 dewatering rates and water levels as this data becomes available. Ongoing collection of groundwater levels from all wells and pumping rate data from underground per *Environmental Management Act* Permit PE-107835 and *Mines Act* Permit M-243 requirements will continue to be important for ongoing refinement of the conceptual and numerical hydrogeologic models.

26.6.3 Water Management

Water management is a critical component of the Brucejack Gold Mine. Pretivm employs a site-wide water management plan that includes monitoring procedures for climate, streamflows, CWP levels, and flows being pumped around the mine site or discharged to the environment. Monitoring data allows Pretivm to optimize the operation in terms of water levels in the CWP, and discharges to the environment. The basis to maintain the functionality of the water management plan are the following:

- Existing climate and hydrometric stations must continue to be monitored and maintained with an appropriate level of quality control.
- The following levels/flows must continue to be monitored and maintained with an appropriate level of quality control:
  - CWP levels
  - CWP water pumped to the plant site
  - Effluent discharged from the WTP to the CWP that does not meet the WTP water quality limits for discharge to Brucejack Gold Lake
  - Fresh water pumped from the low-level weir to the plant site
  - Water pumped from the fresh water tank to underground
  - Underground water pumped to the WTP
  - Treated effluent from the WTP discharged to Brucejack Lake
  - Routine inspections as recommended in the OMS.

26.6.4 Water Balance

Collection of baseline and operational water data affords Pretivm the opportunity to assess and optimize the Brucejack Gold Mine water management system over the LOM. Section 26.6.3 “Water Management” outlines baseline and operational water monitoring activities that are core to the functionality of the Brucejack Gold Mine water management system. These same data and activities provide Pretivm with the information necessary to periodically update the site-wide water balance model. The model is being revised in 2020 as part of the 5-Year Mine Plan and Reclamation Program Update pursuant to permit requirements. The last substantive update to the

BGC water balance model was completed in autumn 2017 and several years of high-quality climate and streamflow data have been collected at the mine site since that time.

As part of the planned water balance model update, it is recommended that operational data for the underground mine, the CWP, the WTP, and Mill Circuit collected since summer 2017 be thoroughly reviewed and the site-wide water balance model updated with revised assumptions and data inputs, where appropriate. Further, a proposed task under the update is to encode the site-wide water balance model within a GoldSim environmental modelling framework rather than using MS-Excel software. The Brucejack Gold Mine water quality model is encoded in GoldSim and there are efficiencies to be gained by adopting a common software platform for the water balance and water quality models.

26.6.5 Water Quality

Water quality should continue to be monitored in compliance with mine authorizations and environmental management plans to verify that water is being managed to meet regulatory conditions for the protection of the environment. The Brucejack water quality model provides estimates of water quality through the operations, closure, and post-closure phases of the Brucejack Gold Mine. This model will be updated in July 2020 as part of the 5-Year Mine Plan and Reclamation Program Update. It is recommended that, as planned, this update incorporate the latest water quality monitoring data, geochemical test results, water balance, and mine plan.

27.0 REFERENCES

27.1 General

Jones, I. W.O., Huang, J., Horan, M., Schmid, C., Carey, E., Ghaffari, H., Rykaart, M., Schmitt, R., Weatherly, H., Crozier, T., Shaw, A., 2019. Technical Report on the Brucejack Gold Mine, Northwest British Columbia. NI 43-101 Technical Report prepared for Pretium Resources Inc., by Ivor Jones Pty Ltd., Tetra Tech Canada Inc., BGC Engineering Inc., Environmental Resources Management (ERM), SRK Consulting (Canada) Inc., Lorax Environmental Services Ltd. 365 pp. Effective Date April 4, 2019.

27.2 Geology

Alldrick, D.J., 1993. Geology and metallogeny of the Stewart mining camp, northwestern British Columbia. B.C. Ministry of Energy, Mines and Petroleum Resources, British Columbia Geological Survey. Bulletin 85. 105 p.

Armstrong, T., Brown, F., Puritch, E., and Vallat, C., 2011. Technical report and resource estimate on the Brucejack Project, Skeena Mining Division, British Columbia, Canada, Latitude 56˚28'20"N by Longitude 130˚11'31"W. P+E Mining Consultants Inc. NI 43-101 Technical Report No. 229 for Pretium Resources Inc., Effective Date November 28, 2011. 170 p.

Board, W.S., 2015a. Geology update on the Brucejack High Grade Au-Ag deposit Northwestern British Columbia, Canada. Pretium Resources Inc. internal technical presentation. Vancouver, Canada.

Board, W.S., 2015b. Targeted exploration on the Brucejack Property: Recommendations for the 2015 exploration program. Unpublished Pretium Memorandum Report dated January 27, 2015. 65 p.

Board, W.S., and McNaughton, K.C., 2013. The Brucejack high-grade gold project, northwest British Columbia, Canada. NewGenGold Conference, Perth, Australia, 2013, Proceedings, p. 177-191. West Perth, Paydirt Pty Ltd.

Board, W.S., McLeish, D.M., Greig, C.J., Bath, O.E., Ashburner, J.E., Murphy, T.M., and Friedman, R.M., Submitted. The Brucejack Au-Ag Deposit, Northwest British Columbia, Canada: Multistage porphyry to epithermal alteration, mineralization, and deposit formation in an island arc setting. Submitted to Economic Geology, 45 p.

Board, W.S., Mooney, C.R., Senger, N.D., and Jones, I.W.O., 2017. 2016 Valley of the Kings Mineral Resource Update Summary Report, Brucejack Project, BC, Canada. Unpublished summary report prepared for Pretivm under supervision by external QP Ivor Jones, 5 June 2017, 137 p.

Boyd, G., and Poon, J., 2015. Airborne 1TEM Survey Report: Brucejack Project. Unpublished report prepared for Pretium Resources Inc. by Precision GeoSurveys Inc. Dated December 2015. 74 p.

Budinski D., McKnight R and Wallis C., 2001. Sulphurets-Bruceside Property British Columbia technical report. Pincock Allen & Holt Ltd. report for Silver Standard Resources.

Campbell, M.E., and Dilles, J.H., 2017. Magmatic History of the Kerr-Sulphurets-Mitchell Copper-gold Porphyry District, Northwestern British Columbia (NTS 104B). Geoscience BC Summary of Activities 2016. Geoscience BC. Report 2017-1. p. 233–244.

Carvalho, D., and Deutsch, C. V., 2017. An Overview of Multiple Indicator Kriging. In J. L. Deutsch (Ed.),Geostatistics Lessons. Retrieved from http://www.geostatisticslessons.com/lessons/mikoverview.

CIM, 2014. CIM Definition Standards. Prepared by the CIM Standing Committee on Reserve Definitions: https://mrmr.cim.org/media/1088/cim_definition_standards_may10_2014.pdf, Adopted by CIM Council May 10, 2014. 12 p.

Corbett, G., 2013. Pacific Rim Epithermal Au-Ag. Australasian Institute of Mining and Metallurgy: World Gold Conference, Brisbane 26-27 September 2013, 14 p.

Corona Corporation, 1990. Newhawk Gold Mines Ltd., Sulphurets Project, Feasibility Study, dated October 1990.

Davis, B., 2017. Foliation history and development of N-S structures at Brucejack. Field visit observation report, prepared for Pretium Resources Inc. by OREFIND. 32 p.

Evenchick, C.A., 1991. Geometry, evolution, and tectonic framework of the Skeena Fold Belt, north-central British Columbia. Tectonics, v. 10. p. 527-546.

Evenchick, C.A., McMechan, M.E., McNicoll, V.J., and Carr, S.D., 2007. A synthesis of the Jurassic-Cretaceous tectonic evolution of the central and southeastern Canadian Cordillera: Exploring links across the orogen, In: J.A. Sears, T.A. Harms, and C.A. Evenchick (Eds.), Whence the Mountains?: Inquiries Into the Evolution of Orogenic Systems: A Volume in Honor of Raymond A. Price, Special paper 433, The Geological Society of America, Boulder, Colorado. 419 p.

Farley, L., Olssen, L., and Jones, I., 2014. Brucejack Resource Estimate. Report Prepared for Pretium Resources Inc. by Snowden Mining Industry Consultants Pty Ltd. Project No. AU4015. March 2014. Effective date: December 19, 2013. 248p.

Febbo, G.E., Kennedy, L.A., Savell, M., Creaser, R.A., and Friedman, R.M., 2015. Geology of the Mitchell Au-Cu-Ag-Mo porphyry deposit, northwestern British Columbia, Canada: Geological Fieldwork 2014, British Columbia Ministry of Energy and Mines, British Columbia Geological Survey. Paper 2015-1. p.59–86.

Flasha, S.T., 2016. Diamond drilling report of the 2015 Brucejack Off Mining Leases Exploration Program, Brucejack Property, Mineral Tenures 509397 & 1027399. Skeena Mining Division, British Columbia, Canada, NTS 104B/9E. Geographic coordinates: 56˚27’26”N/130˚10’23”W; 427700E, 6257600N, NAD83 Zone 9. Event Number: 5605577. BC Geological Survey Assessment Report No. 36214. Prepared for Pretium Resources Inc. Dated June 2, 2016. 1151 p.

Flasha, S.T., 2017a. Diamond drilling report of the 2016 Bowser Property Exploration Program. BC Geological Survey Assessment Report No. 36712. Prepared for Pretium Resources Inc. Dated January 27, 2017. 939 p.

Flasha, S.T., 2017b. 2016 Bowser Property Magnetometer and Radiometrics Airborne Survey by Precision GeoSurveys Inc. BC Geological Survey Assessment Report No. 36793. Prepared for Pretium Resources Inc. Dated March 21, 2017. 135 p.

Flasha, S.T., 2017c. 2016 Bowser Property DCIP & MT Surveys by Quantec Geoscience Ltd. BC Geological Survey Assessment Report No. 36790. Prepared for Pretium Resources Inc. Dated April 4, 2017. 174 p.

Gagnon, J.-F., Barresi, T., Waldron, J.W.F., Nelson, J.L., Poulton, T.P., and Cordey, F., 2012. Stratigraphy of the upper Hazelton Group and the Jurassic evolution of the Stikine terrane, British Columbia. Canadian Journal of Earth Sciences, v.49, p.1027-1052.

Ghaffari, H., Huang, J., Narciso, H., Cameron, M.M., Cowie, S., Sweeney, D.J., Hollet, G.R., Brown, F., Armstrong, T., Boyle, J.M., Wilchek, L-A., Newcomen, H.W., and Greisman, P., 2010a. Technical Report and Preliminary Economic Assessment of the Snowfield-Brucejack Project. Wardrop NI 43-101 Technical Report (No. 1053750400-REP-R0001-03) for Silver Standard Resources Inc., Effective Date September 10, 2010, 376 p.

Ghaffari, H., Huang, J., Narciso, H., Cameron, M.M., Cowie, S., Sweeney, D.J., Hollet, G.R., Brown, F., Armstrong, T., Boyle, J.M., Wilchek, L-A., Newcomen, H.W., and Greisman, P., 2010b. Technical Report and Preliminary Economic Assessment of the Snowfield-Brucejack Project. Wardrop NI 43-101 Technical Report (No. 1053750400-REP-R0001-04) for Pretium Resources Inc., Effective Date October 28, 2010, 376 p.

Ghaffari, H., Huang, J., Pelletier, P., Armstrong, T., Brown, F., Newcomen, H.W., Wetherly, H., Logue, C., and Mokos, P., 2011. Technical Report and Preliminary Economic Assessment of the Brucejack Project. Wardrop NI 43-101 Technical Report for Pretium Resources Inc., Effective Date June 3, 2011. 309 p.

Glacken, I., and Blackney, P., 1998. A Practitioners Implementation of Indicator Kriging. In: Beyond Ordinary Kriging: Non-Linear Geostatistical Methods of Practice, Symposium Proceedings. Geostatistical Association of Australasia. 30 October 1998. Perth, Australia. p.26-39.

Graindorge, J., and Carlson, R., 2014. QAQC Review: Brucejack Project. Unpublished report prepared for Pretium Resources Inc. by Snowden Mining Industry Consultants Pty Ltd. Project No. AU4015. March 2014. 61p.

Harrichhausen, N.J., Rowe, C.D., Board, W.S., and Greig, C.J., 2016. Structural setting of a high-grade, electrum-bearing, quartz-carbonate vein stockwork at the Brucejack deposit, northwestern British Columbia (NTS 104B). Geoscience BC Summary of Activities 2015. Geoscience BC. Report 2016-1. p. 127–138.

Heinrich, C.A., Driesner, T., Stefánsson, A., and Seward, T.M., 2004. Magmatic vapor contraction and the transport of gold from the porphyry environment to epithermal ore deposits. Geological Society of America. v. 32. p. 761-764.

Ireland, D., Jones, I.W.O., Huang, J., Pelletier, P., Weatherly, H., Stoyko, H.W., Hafez, S.A., Keogh, C., Schmid, C., Cullen, V., McGuiness, M., McAfee, B., Chin, M., Gould, B., Wise, M., Greisman, P., Richards, C., Scott, W.E., Farah, A., Halisheff, K., Sriskandafumar, S., and Molavi, M., 2013. Feasibility Study and Technical Report on the Brucejack Project, Stewart, BC. Tetra Tech NI 43-101 Technical Report for Pretium Resources Inc. Effective Date June 21, 2013. 492 p.

Ireland, D., Olssen, L., Huang, J., Pelletier, P., Weatherly, H., Stoyko, H.W., Hafez, S.A., Keogh, C., Schmid, C., McAfee, B., Chin, M., Gould, B., Wise, M., Greisman, P., Scott, W.E., Farah, A., Zazzi, G., Crozier, T., and Blackmore, S., 2014. Feasibility Study and Technical Report Update on the Brucejack Project, Stewart, BC. Tetra Tech NI 43-101 Technical Report for Pretium Resources Inc. Effective Date June 19, 2014. 460 p.

Jones, I.W.O., 2012a. Pretium Resources Inc: Brucejack Project, Mineral Resources Update Technical Report. NI 43-101 Technical Report prepared by Snowden Mining Industry Consultants on behalf of Pretium Resources Inc. Effective Date April 3, 2012. 143 p.

Jones, I.W.O., 2012b. Pretium Resources Inc: Brucejack Project, Mineral Resources Update Technical Report. NI 43-101 Technical Report prepared by Snowden Mining Industry Consultants on behalf of Pretium Resources Inc. Effective Date September 18, 2012. 118 p.

Jones, I.W.O., 2012c. Pretium Resources Inc.: Brucejack Project, Mineral Resources Update Technical Report. NI 43-101 Technical Report prepared by Snowden Mining Industry Consultants on behalf of Pretium Resources Inc. Effective Date November 20, 2012. 106 p.

Jones, I.W.O., 2014. Pretium Resources Inc: Brucejack Project, Mineral Resources Update Technical Report. NI 43-101 technical report prepared by Snowden Mining Industry Consultants on behalf of Pretium Resources Inc. Effective Date December 19, 2013. 194 p.

Kirkham, R.V. and Margolis, J., 1995. Overview of the Sulphurets area, northwestern British Columbia, in: .Porphyry Deposits of the Northwestern Cordillera of North America. CIMM Special Volume 46, T.G. Schroeter, ed., p.473–482.

Kyba, J., 2014. The Stuhini-Hazelton unconformity of Stikinia, Investigations at KSM-Brucejack, Snip-Johnny Mountain, and Red Chris areas. Conference abstract presented in T27. Triassic-Jurassic Tectonics and Tectonic-Structural Controls on Porphyry and Related Mineralization in the Northern Cordillera. https://gsa.confex.com/gsa/2014AM/webprogram/Paper248935.html. Geological Society of America Annual Meeting 2014. Vancouver, BC, Canada.

Leary, S., Sillitoe, R.H., Stewart, P.W., Roa, K.J., and Nicolson, B.E., 2016. Discovery, geology, and origin of the Fruta del Norte epithermal gold-silver deposit, southeastern Ecuador. Economic Geology, v.111, p.1043-1072.

Macdonald, A.J., 1993. Lithostratigraphy and geochronometry, Brucejack Lake, northwestern British Columbia (104B/08E). Geological Fieldwork 1992, British Columbia Ministry of Energy and Mines, British Columbia Geological Survey. Paper 1993-1. p. 315-323.

Margolis, J., 1993. Geology and intrusion-related copper-gold mineralization, Sulphurets, British Columbia. Unpublished Ph.D. Dissertation. University of Oregon. 394 p.

McLeish, D.F., Williams-Jones, A.E., Board, W.S., and Clark, J.R., 2018. Nature and origin of the Brucejack high-grade epithermal gold deposit, northwestern British Columbia (NTS 104B) 2017 update. Geoscience BC Summary of Activities 2017. Minerals and Mining. Geoscience BC Report 2018-1. p. 31–40.

McLeish, D.F., Williams-Jones, A.E., Board, W.S., Stern, R.A., Clark, J.R., and Vasyukova, O.V., 2019. The formation and origin of ultra-high grade gold ore at the Brucejack Deposit, Northwest British Columbia: Insights from nanoscale imaging of electrum and high-resolution trace element and sulphur isotope analyses of pyrite. Poster session presented at AME Roundup (January 28, 2019), Vancouver, BC.

McPherson, M., 1994. 1994 assessment report on the North Bruce Group, Sulphurets Property – Bruceside Project, Newhawk Gold Mines Ltd. British Columbia Ministry of Energy, Mines and Petroleum Resources, Geological Branch Assessment Report 23613, 64 p.

Monger, J.W.H., and Price, R., 2002. The Canadian Cordillera; geology and tectonic evolution. Canadian Society of Exploration Geophysicists Recorder. v. 27. p. 17-36.

Mooney, C., 2015. Brucejack Gold Deposit: 2014 and 2015 Drilling QAQC Review. Pretium Resources Inc. internal report. Dated November 27, 2015. 28p.

Narciso, N., Huang, J., Iakovlev, I., Cameron, M., Bosworth, G., Brown, F., Armstrong, T., Boyle, M., Wilchek, L-A, Newcomen, W., and Pelletier, P., 2010. Technical Report and Preliminary Assessment on The Snowfield Property. Wardrop NI 43-101 Technical Report for Silver Standard Resources Inc. Effective Date June 1, 2010. 281 p.

Nelson, J., and Colpron, M., 2007. Tectonics and metallogeny of the British Columbia, Yukon and Alaskan Cordillera, 1.8 Ga to the present. In: Goodfellow, W.D., ed. Mineral Deposits of Canada: A Synthesis of Major Deposit-Types, District Metallogeny, the Evolution of Geological Provinces, and Exploration Methods. Geological Association of Canada, Mineral Deposits Division, Special Publication No. 5, p. 755-791.

Nelson, J., and Kyba, J., 2014. Structural and stratigraphic control of porphyry and related mineralization in the Treaty Glacier – KSM – Brucejack – Stewart trend of western Stikinia. Geological Fieldwork 2013.British Columbia Ministry of Energy and Mines. British Columbia Geological Survey. Paper 2014-1. p. 111-140.

Nelson, J., Colpron, M., and Israel, S., 2013. The Cordillera of British Columbia, Yukon, and Alaska: Tectonics and Metallogeny. In: Colpron, M., Bissig, T., Rusk, B.G., and Thompson, J.F.H., eds. Tectonics, Metallogeny and Discovery: The North American Cordillera and Similar Accretionary Settings. Society of Economic Geologists, Special Publication No. 17, p.53-109.

Payie, G.J., 2017. British Columbia Geological Survey MINFILE report no. 104B 193 on the Brucejack area: http://minfile.gov.bc.ca/Summary.aspx?minfilno=104B++193.

Pezzot, E.T., 2015. Brucejack Project Airborne Magnetometer and Radiometric Survey. Unpublished Geophysical Interpretation Report prepared for Pretium Resources Inc by Precision GeoSurveys Inc. January 2015. 51 p.

Poon, J., 2015. Brucejack Project Airborne Magnetic and Radiometric Survey. Unpublished Airborne Geophysical Survey Report prepared for Pretium Resources Inc. by Precision GeoSurveys Inc. Dated December 2015. 81 p.

Pretivm, 2016b. Positive Valley of the Kings Mineral Reserve Update; Senior Management Changes. Pretivm press release dated 12/15/2016: https://www.pretivm.com/news/news-details/2016/Pretium-Resources-Inc-Positive-Valley-of-the-Kings-Mineral-Reserve-Update-Senior-Management-Changes/default.aspx.

Richards, J.P., and Kerrich, R., 1993. The Porgera Gold Mine, Papua New Guinea: Magmatic Hydrothermal to Epithermal Evolution of an Alkalic-type Precious Metal Deposit. Economic Geology, v.88, p.1017-1052.

Roach, S., and Macdonald, A.J., 1992, Silver-gold vein mineralization, West Zone, Brucejack Lake, northwestern British Columbia (104B/8E). British Columbia Geological Survey. Geological Fieldwork 1991. Paper 1992-1. p. 503-511.

Ronacher, E., Richards, J.P., Reed, M.H., Nray, C.J., Spooner, E.T.C., and Adams, P.D., 2004. Characteristics and Evolution of the Hydrothermal Fluid in the North Zone High-Grade Area, Porgera Gold Deposit, Papua New Guinea. Economic Geology, v.99, p.843-867.

Schroeter, T. G., 1994. British Columbia mining, exploration, and development 1993 highlights: British Columbia Mineral Exploration Review 1993. British Columbia Geological Survey Information Circular 1994-1, 27 p.

Sherman, D., and Candy, C., 2019, Geophysical Exploration Program; Bell II Area. Prepared for Pretium Resources Inc. by Frontier Geosciences Inc. Dated December 13, 2019. 22 p.

Sillitoe, R.H., 2015. Comments on geology and exploration potential of the Brucejack Gold-Silver Deposit and environs, British Columbia, Canada. Unpublished report prepared for Pretium Resources Inc. 16 p.

Sillitoe, R.H., and Hedenquist, J.W., 2003. Linkages between volcanotectonic settings, ore fluid compositions, and epithermal precious metal deposits. Society of Economic Geologists Special Publication 10, p. 315–343.

Stephen., J., Personal communication. Quantec Geoscience. Dated November 5, 2019.

Sykora, S., Cooke, D.R., Meffre, S., Stephanov, A.S., Gardner, K., Scott, R., Selley, D., and Harris, A.C., 2018. Evolution of pyrite trace element compositions from porphyry style and epithermal conditions at the Lihir gold deposit: Implications for ore genesis and mineral processing. Economic Geology. v. 113. p. 193-208.

Tombe, S.P., 2015. Age and origin of the Brucejack epithermal Au-Ag deposit, northwestern British Columbia. Unpublished M.Sc. thesis. Edmonton. University of Alberta. 201 p.

Tombe, S.P., Richards, J.P., Greig, C.J., Board, W.S., Creaser, R.A., Muehlenbachs, K.A., Larson, P.B., DuFrane, S.A., and Spell, T., 2018. Origin of the high-grade Early Jurassic Brucejack epithermal Au-Ag deposits, Sulphurets Mining Camp, northwestern British Columbia. Ore Geology Reviews, v.95, p.480-517.

Tuncer, V., 2014a. Spartan Magnetotelluric Survey Geophysical Report: Snowfield and Brucejack Projects, British Columbia, Canada. Unpublished report prepared for Pretium Resources Inc. by Quantec Geoscience Ltd. Dated December 12, 2014. 345 p.

Tuncer, V., 2014b. Spartan Magnetotelluric Survey Geophysical Report – Addendum (Topography included 3D Inversion): Snowfield and Brucejack Projects, British Columbia, Canada. Unpublished report prepared for Pretium Resources Inc. by Quantec Geoscience Ltd. Dated December 12, 2014. 182 p.

Turkoglu, E., Young, C., and Gregory, W., 2011. Spartan Magnetotelluric Survey Geophysical Report: Snowfield & Brucejack Project, British Columbia, Canada. Unpublished report prepared for Pretium Resources Inc. by Quantec Geoscience Ltd. Dated December 14, 2011. 223 p.

Vallat, C., 2009. Quality Assurance and Quality Control Report on Brucejack pre-Silver Standard Resources Inc. Analytical Results, Brucejack Project, Skeena Mining Division, British Columbia, Canada. Unpublished report prepared for Silver Standard Resources Inc. by GeoSpark Consulting Inc. Dated October 7, 2009. 142 p.

Vallat, C., 2011. Quality Assurance and Quality Control Report on Brucejack 2011 Analytical Results, Brucejack Project, Skeena Mining Division, British Columbia, Canada. Unpublished report prepared for Pretium Resources Inc. by GeoSpark Consulting Inc. Dated December 22, 2011. 53 p.

Vallat, C., 2012. Quality Assurance and Quality Control Report on Brucejack 2012 Analytical Results, Brucejack Project, Skeena Mining Division, British Columbia, Canada. Unpublished report prepared for Pretium Resources Inc. by GeoSpark Consulting Inc. Dated September 13, 2012. 39 p.

Vallat, C., 2013. Quality Assurance and Quality Control Report on Brucejack 2012 Analytical Results, Brucejack Project, Skeena Mining Division, British Columbia, Canada. Unpublished report prepared for Pretium Resources Inc. by GeoSpark Consulting Inc. Dated January 4, 2013. 60 p.

Vallat, C., 2014. Quality Assurance and Quality Control Report on Brucejack 2013 Analytical Results, Brucejack Project, Skeena Mining Division, British Columbia, Canada. Unpublished report prepared for Pretium Resources Inc. by GeoSpark Consulting Inc. Dated April 9, 2014. 74 p.

Vallat, C., 2015. Quality Assurance and Quality Control Report on Brucejack 2014 Analytical Results, Brucejack Project, Skeena Mining Division, British Columbia, Canada. Unpublished report prepared for Pretium Resources Inc. by GeoSpark Consulting Inc. January 21, 2015. 60 p.

Vallat, C., 2016a. Quality Assurance and Quality Control Report on Brucejack 2015 Analytical Results, Brucejack Project, Skeena Mining Division, British Columbia, Canada. Unpublished report prepared for Pretium Resources Inc. by GeoSpark Consulting Inc. Dated March 24, 2016. 72 p.

Vallat, C., 2016b. Quality Assurance and Quality Control Report on Brucejack 2016 Analytical Results, Brucejack Project, Skeena Mining Division, British Columbia, Canada. Unpublished report prepared for Pretium Resources Inc. by GeoSpark Consulting Inc. August 12, 2016. 41 p.

Vallat, C., 2018. Quality Assurance and Quality Control Report on Brucejack 2017 and 2018 Analytical Results: Brucejack Project, Skeena Mining Division, British Columbia, Canada. Unpublished report prepared for Pretivm Resources Inc. by GeoSpark Consulting Inc. Dated September 21, 2018. 77 p.

Vallat, C., 2019. Quality Assurance and Quality Control Report on Brucejack 2018 Analytical Results: Brucejack Project, Skeena Mining Division, British Columbia, Canada. Unpublished draft report prepared for Pretivm Resources Inc. by GeoSpark Consulting Inc. Dated February 15, 2019. 67 p.

Wafforn, S.R., 2018a. Geological, Geochemical and Prospecting Program on the Bowser Property. BC Geological Survey Assessment Report No. 37435. Prepared for Pretium Resources Inc. Dated February 1, 2018. 514 p.

Wafforn, S.R., 2018b. Geological, Geochemical and Prospecting Program on the Bowser Property. BC Geological Survey Assessment Report No. 37443. Prepared for Pretium Resources Inc. Dated February 5, 2018. 1238 p.

27.3 Metallurgy and Recovery Methods

ALS Metallurgy-Kamloops, 2018. Metallurgical Testing for the Brucejack Project. June 18, 2018.

Bureau Veritas Commodities Canada Ltd. BC Minerals – Metallurgical Division, 2017. Mineralogical Assessment of Two Concentrate Samples. August 31, 2017.

Bureau Veritas Commodities Canada Ltd. BC Minerals – Metallurgical Division, 2016. Metallurgical Testing for Concentrate Production. March 3, 2016.

Clay Speciation Analysis of Samples, 2019, Process Mineralogical Consulting Ltd., March 22, 2019.

Cominco Engineering Services Ltd., 1990. Feasibility Study Sulphurets Property Newhawk Gold Mines Ltd. March 1990.

Contract Support Services, Inc., 2012. JK Simulation Results for Brucejack Project. November 29, 2012.

Daily Mill Reports, 2018 to 2019, Brucejack Mine, Pretivm Resources Inc.

Diagnostic Leach Report, 2019, B V Minerals, Bureau Veritas Commodities Canada Ltd. November 18, 2019.

Dawson Metallurgical Laboratories, FLSmidth Ltd., 2014. Letter Report - Brucejack Tabling and Smelting. May 29, 2014.

F. Wright Consulting Inc., 2013. Gravity/Flotation Response - Valley of the Kings, Brucejack Project. May 7, 2013.

F. Wright Consulting Inc., 2013. Metallurgical Data - Brucejack Gold Silver Project. February 08, 2013.

F. Wright Consulting Inc., 2014. Low Grade Response - Valley of the Kings, Brucejack Project. June 10, 2014.

FLSmidth Knelson, A Division of FLSmidth Ltd., 2012a. Gravity Modeling Report. July 11, 2012.

FLSmidth Knelson, A Division of FLSmidth Ltd., 2012b. Gravity Test Work Report. August 9, 2012.

FLSmidth Ltd., 2018. Gravity Circuit Modeling Report. April 20, 2018.

Gekko Metallurgical Laboratory, 2017. Intensive Cyanidation of Knelson Concentrate Testwork Report. August 31, 2017.

Gekko Systems Pty Ltd., 2014. Brucejack Python Study Update. May 06, 2014.

Gekko Systems Pty Ltd., 2014. Metallurgical Testwork Reports (Low Grade, Medium and High Grade Samples). April 28, 2014.

Gold Recovery from Brucejack Concentrate, 2019, XPS, A GLENCORE Company, October 31, 2019.

Hazen Research Inc., 2012. Comminution Testing with SMC Results. July 13, 2012.

Head Assay Report, 2019, B V Minerals, Bureau Veritas Commodities Canada Ltd. November 18, 2019.

Joe Zhou Mineralogy Ltd., 2012. Deportment Study of Gold and Silver in Cyanide Leach Residues from Brucejack Lake Project, Part I, Part II and Part III. February 20, 2012.

Metallurgical Division at Inspectorate America Corp., December 2009 to July 2010. Data Reports.

Metallurgical Division at Inspectorate America Corp., September 2010 to April 2011. Data Reports.

Metallurgical Division at Inspectorate Exploration and Mining Services Ltd., 2014. Mineralogical Assessments on the Process Stream Samples. May 15, 2014.

Met-Solve Laboratories Inc., 2012. Gravity Test Report - MS1399. July 10, 2012.

Met-Solve Laboratories Inc., 2013. Gravity Circuit Modeling - MS1418. March 14, 2013.

Met-Solve Laboratories Inc., 2014b. Letter Report - MS1542. June 2, 2014.

Met-Solve Laboratories Inc.,2014a. Letter Report - MS1542. May 21, 2014.

Pocock Industrial Inc., 2019. Solids-Liquid Separation Testing Report. January 2019.

Pocock Industrial, Inc., 2012. Sample Characterization, Particle Size Analysis, Flocculant Screening, Gravity Sedimentation, Pulp Rheology/Paste Vacuum Filtration and Pressure Filtration Studies. November 2012.

Process Mineralogical Consulting Ltd., 2012. A Mineralogical Description of Six Samples from the Brucejack Project, Northwestern British Columbia. June 1, 2012.

Process Mineralogical Consulting Ltd., 2018. A Mineralogical Description and Gold Deportment Analysis of One Concentrate Sample. October 1, 2018.

SNF Canada, 2016. Polymer cylinder Test Report. November 18, 2016.

SNF Canada, 2017a. Site Service Visit Report. October 19, 2017.

SNF Canada, 2017b. Tailings Thickener Polymer Treatment Review. December 20, 2017.

Solids-Liquid Separation Testing Report, 2019, Pocock Industrial, Inc., January 2019.

27.4 Mining

AMC Mining Consultants (Canada) Ltd., 2015. Brucejack Underground Feasibility Study Update; Backfill Design and Test Work Report. May 5, 2015.

AMC Mining Consultants (Canada) Ltd., 2018. Brucejack Backfill Management Plan. October 8, 2018.

Ghaffari, H., Huang, J, Pelletier, P., Armstrong, T., Brown, F.H., Newcomen, H.W., Weatherly, H., Logue, C., Mokos, P., 2011: Technical Report and Preliminary Economic Assessment of the Brucejack Project. NI43-101 Technical Report prepared for Pretium Resources Inc., by Tetra Tech, Wardrop, P&E Mining Consultants Inc., BGC Engineering Inc., Rescan Environmental Services Ltd., AMC Mining Consultants (Canada) Ltd. 309 pp. Effective Date 3 Jun 2011.

Ghaffari, H., Huang, J., Hafez, S. A., Pelletier, P., Armstrong, T., Brown, F.H., Vallat, C.J., Newcomen, H.W., Weatherly, H., Wilchek, L., Mokos, P., 2012: Technical Report and Updated Preliminary Economic Assessment of the Brucejack Project. NI43-101 Technical Report prepared for Pretium Resources Inc., by Tetra Tech, Wardrop, Rescan Environmental Services Ltd., P&E Mining Consultants Inc., Geospark Consulting Inc., BGC Engineering Inc., AMC Mining Consultants (Canada) Ltd. 328pp. Effective Date 20 Feb 2012.

Ireland, D., Olssen, L., Huang, J., Pelletier, P., Weatherly, H., Stoyko, H.W., Hafez, S.A., Keogh, C., Schmid, C., McAfee, B., Chin, M., Gould, B., Wise, M., Greisman, P., Scott, W.E., Farah, A., Zazzi, G., Crozier, T., and Blackmore, S., 2014. Feasibility Study and Technical Report Update on the Brucejack Project, Stewart, BC. Tetra Tech NI 43-101 Technical Report for Pretium Resources Inc. Effective Date June 19, 2014. 460 p.

Jones, I. W.O., Huang, J., Horan, M., Schmid, C., Carey, E., Ghaffari, H., Rykaart, M., Schmitt, R., Weatherly, H., Crozier, T., Shaw, A., 2019. Technical Report on the Brucejack Gold Mine, Northwest British Columbia. NI 43-101 Technical Report prepared for Pretium Resources Inc., by Ivor Jones Pty Ltd., Tetra Tech Canada Inc., BGC Engineering Inc., Environmental Resources Management (ERM), SRK Consulting (Canada) Inc., Lorax Environmental Services Ltd. 365 pp. Effective Date April 4, 2019.

27.5 Mining Geotechnical

Bieniawski, Z.T., 1976. Rock mass classification in rock engineering. In Exploration for rock engineering, proc. of the symp., (ed. Z.T. Bieniawski) 1, 97-106. Cape Town: Balkema.

Clark, L.M., 1998. Minimizing Dilution in Open Stope Mining with a Focus on Stope Design and Narrow Vein Longhole Blasting. MSc thesis, University British Columbia, Canada.

ERSi (Earth Resource Surveys Inc.), 2010. KSM Project Area Structural Geology Assessment – Draft.

Grimstad, E. and Barton, N., 1993. Updating of the Q-system for NMT. Proceedings of the International Symposium on Sprayed Concrete. Modern Use of Wet Mix Sprayed Concrete for Underground Support, Fagemes. Norwegian Concrete Association, Oslo.

International Society of Rock Mechanics (ISRM), 1985. Suggested Method for Determining Point Load Strength.

Ireland, D., Jones, I.W.O., Huang, J., Pelletier, P., Weatherly, H., Stoyko, H.W., Hafez, S.A., Keogh, C., Schmid, C., Cullen, V., McGuiness, M., McAfee, B., Chin, M., Gould, B., Wise, M., Greisman, P., Richards, C., Scott, W.E., Farah, A., Halisheff, K., Sriskandafumar, S., and Molavi, M., 2013. Feasibility Study and Technical Report on the Brucejack Project, Stewart, BC. Tetra Tech NI 43-101 Technical Report for Pretium Resources. Effective Date June 21, 2013. 492 pp.

Ireland, D., Olssen, L., Huang, J., Pelletier, P., Weatherly, H., Stoyko, H.W., Hafez, S.A., Keogh, C., Schmid, C., McAfee, B., Chin, M., Gould, B., Wise, M., Greisman, P., Scott, W.E., Farah, A., Zazzi, G., Crozier, T., and Blackmore, S., 2014. Feasibility Study and Technical Report Update on the Brucejack Project, Stewart, BC. Tetra Tech NI 43-101 Technical Report for Pretium Resources Inc. Effective Date June 19, 2014. 460 p.

Mawdesley, C., Trueman, R., Whiten, W., 2001. Extending the Mathews Stability Graph for Open Stope Design. Trans. IMM (Section A). Volume 110, p. A27–39.

Ouchi, A., Pakalnis, R., Brady, E., 2004. Update of Span Design Curve for Weak Rock Masses. Proc. of the 99th Annual AGM-CIM Conference.

Rocscience Inc., 2003. Unwedge Version 3.0 – Underground Wedge Stability Analysis. https://www.rocscience.com, Toronto, Ontario, Canada.

Stewart, S. B.V., Forsyth, W.W., 1995. The Matthews Method for Open Stope Design. CIM Bull., 88, No. 992, p. 45–53.

27.6 Waste Rock Disposal

British Columbia Mine Waste Rock Pile Research Committee (BCMWRP), 1991. Mined Rock and Overburden Piles Investigation and Design Manual. Interim Guidelines. May.

Peck, R. B., 1969. Advantages and limitations of the observational method in applied soil mechanics. Geotechnique 19.2: 171–187.

SRK Consulting (Canada) Inc., 2014. Brucejack Gold Mine Project – Waste Rock Stability and Settlement Analysis – UPDATED. Technical memo prepared for Pretium Resources Inc. December 23.

SRK Consulting (Canada) Inc., 2015. Brucejack Gold Mine Project – Waste Rock and Tailings Data Review – UPDATED. Technical memo prepared for Pretium Resources Inc. January 8.

SRK Consulting (Canada) Inc., 2016. Tailings and Waste Rock Subaqueous Deposition Management Plan Design Report, Brucejack Project, British Columbia. Report prepared for Pretium Resources Inc. February.

SRK Consulting (Canada) Inc., 2018. Brucejack Gold Mine: Updated Subaqueous Waste Rock Dump Design. Report prepared for Pretium Resources Inc., October.

SRK Consulting (Canada) Inc., 2020. Operation, Maintenance and Surveillance Manual: Brucejack Gold Mine Subaqueous Waste Rock and Tailings Deposition. Version 7. Report prepared for Pretium Resources Inc., March.

Terzaghi, K. and Peck, R. B., 1967. Soil Mechanics in Engineering Practice. 566–566.

27.7 Avalanche Hazard Assessment

Gould, B. and Campbell, C, 2019. Remote Avalanche Control Systems (RACS) – Field Visit Summary and Updated Layout for the KM59 Glacier Access Route and Sluicebox Avalanche Area. Memorandum by Alpine Solutions, February 28, 2019.

Ireland, D., Olssen, L., Huang, J., Pelletier, P., Weatherly, H., Stoyko, H.W., Hafez, S.A., Keogh, C., Schmid, C., McAfee, B., Chin, M., Gould, B., Wise, M., Greisman, P., Scott, W.E., Farah, A., Zazzi, G., Crozier, T., and Blackmore, S., 2014. Feasibility Study and Technical Report Update on the Brucejack Project, Stewart, BC. Tetra Tech NI 43-101 Technical Report for Pretium Resources Inc. Effective Date June 19, 2014. 460 p.

27.8 Environmental

2006.pdf (accessed December 2014).

2006/dp-pd/prof/92-594/Index.cfm?Lang=E (accessed February 2014).

BC ILMB, 2000. Cassiar Iskut-Stikine Land and Resource Management Plan, prepared by the BC Integrated Land Management Bureau, 2009.

BC MFLNRO, 1995. Forest Practices Code Biodiversity Guidebook.

BC MFLNRO, 2012. Nass South Sustainable Resource Management Plan.

BC MEMPR, Mines Act permit M-243, Permit Approving Mine Plan and Reclamation Program.

BC Ministry of Environment and BC Ministry of Energy and Mines, 2015. Environmental Assessment Certificate #M15-01 – Brucejack Gold Mine.

BC Bill 41. BC Declaration on the Rights of Indigenous Peoples Act.

Business Corporations Act, SBC., 2002a. C. 57.

Canada Impact Assessment Act, S.C. 2019, c. 28, s.1.

Canada Environmental Assessment Act, S.C., 2012. c. 19. s. 52.

Concurrent Approval Regulation, BC Reg. 371/2002.

Environmental Assessment Act, SBC, 2002b. C. 43. – 2002.

Environmental Assessment Act [SBC 2018] c. 51, s. 81 – 2019.

Environmental Impact Assessment. Prepared for Pretium Resources Inc. by ERM Consultants Environmental Management Act, SBC., 2003. C. 53.

ERM Rescan, 2014. Brucejack Gold Mine Project: Application for an Environmental Assessment Certificate.

Forest Act, RSBC., 1996a. C. 157.

Forest Practices Code of British Columbia Act [RSBC 1996] C. 159.

Health Act, RSBC., 1996b. C. 179.

http://www.for.gov.bc.ca/tasb/slrp/lrmp/smithers/cassiar/plan/files/CIS-LRMP-November- http://www.ilmb.gov.bc.ca/slrp/srmp/south/nass/index.html (accessed September 2009).

http://www.ilmb.gov.bc.ca/slrp/srmp/south/nass/index.html (accessed November 2012).

Land Act, RSBC., 1996c. C. 245.

Mines Act, RSBC., 1996d. C. 293.

Regulations Designating Physical Activities, SOR/2012-147.

Reviewable Project Regulation, BC Reg. 370/2002. http://www12.statcan.gc.ca/censusrecensement/Water Act

Statistics Canada, 2007. 2006 Aboriginal Population Profile. http://www12.statcan.gc.ca/censusrecensement/Water Act, RSBC., 1996e. C. 483.

Statistics Canada, 2016 Census of Canada.

27.9 Water Management

BGC Engineering Inc. and Pretium Resources Inc., 2018. Brucejack Gold Mine – Operation, Maintenance & Surveillance Manual. Water Management Plan. Version 004, December 15, 2018.

BGC Engineering Inc., 2017. Water Balance Model 3800 tpd Permit Amendment Applications [Report]. Prepared for Pretium Resources Inc. Doc. No. BJ-2017-57, December 13, 2017.

27.10 Water Balance

BGC Engineering Inc., 2017a. Brucejack WBM, 3800 tpd, Operations MS-Excel Water Balance Model. Prepared for Pretium Resources Inc., October 2, 2017.

BGC Engineering Inc., 2017b. Water Balance Model 3800 tpd Permit Amendment Applications [Report]. Prepared for Pretium Resources Inc. Doc. No. BJ-2017-57, December 13, 2017.

27.11 Water Quality

ERM Rescan, 2014. Brucejack Gold Mine Project: Cumulative Water Quality Baseline Report. Prepared for Pretivm Resources Inc. by ERM Consultants Canada Ltd. Vancouver, BC. January 2014.

Lorax Environmental Services Ltd. (Lorax), 2018. Brucejack Gold Mine: 2018 Water Quality Model Report in Support of Amendment Applications for Ore Production Increase to 3800 tpd. Prepared by Lorax Environmental Services Ltd. for Pretium Resources Ltd. April 11, 2018.

Pretium Resources Inc. (Pretivm), 2015. Applications for Mines Act and Environmental Management Act Permits. Submitted May 2015.

Pretivm Resources Inc. (Pretivm), 2018b. 3800 tpd Amendment Application for Permits M-243 and PE-107835. April 2018.

27.12 Geochemistry

BGC Engineering Inc., 2014b. Brucejack Environmental Assessment – ML/ARD Baseline Report. Prepared for Pretivm Resources Inc. June 2014.

Lorax Environmental Service Ltd. (Lorax), 2016b. Brucejack Gold Mine: Assessment of Long-Term Sludge Stability for In-lake and Underground Deposition, Report submitted to Pretium Resources Inc., December 19, 2016.

Lorax Environmental Services Ltd. (Lorax), 2016a. Brucejack Mine: Proposed Extension for Waste Rock Storage on Surface. Prepared by Lorax Environmental Services Ltd. for Pretium Resources Ltd. November 9, 2016.

Lorax Environmental Services Ltd. (Lorax), 2017. Assessment of an Increased Volume of Exposed PAG Waste Rock on the Subaerial Platform at the Brucejack Gold Mine. Prepared by Lorax Environmental Services Ltd. for Pretium Resources Ltd. July 21, 2017.

Lorax Environmental Services Ltd. (Lorax), 2018. Brucejack Gold Mine: 2018 Water Quality Model Report in Support of Amendment Applications for Ore Production Increase to 3800 tpd. Prepared by Lorax Environmental Services Ltd. for Pretium Resources Ltd. April 11, 2018.

Pretium Resources Inc. (Pretivm), 2015. Applications for Mines Act and Environmental Management Act Permits. Submitted May 2015.

Pretium Resources Inc. (Pretivm), 2016a. 2015 Annual Report for Mines Act Permit M-243, Effluent Permit 107835, Air Permit 107025. Submitted March 2016.

Pretium Resources Inc. (Pretivm), 2017. 2016 Annual Report for Mines Act Permit M-243, Effluent Permit 107835, Air Permit 107025. Submitted March 2017.

Pretium Resources Inc. (Pretivm), 2018a. 2017 Annual Report for Mines Act Permit M-243, Effluent Permit 107835, Air Permit 107025. Submitted March 2018.

Pretium Resources Inc. (Pretivm), 2019. 2018 Annual Report for Mines Act Permit M-243, Effluent Permit 107835, Air Permit 107025. Submitted March 2019.

Pretivm Resources Inc. (Pretivm), 2018b. 3800 tpd Amendment Application for Permits M-243 and PE-107835. April 2018.

27.13 Hydrogeology

BGC Engineering Inc., 2013. Brucejack Project Environmental Assessment – Numerical Hydrogeologic Model. June 18, 2013.

BGC Engineering Inc., 2014a. Brucejack Project Environmental Assessment – Numerical Hydrogeologic Model. June 6, 2014.

BGC Engineering Inc., 2015. Brucejack Project MA/EMA Permitting Phase – Numerical Hydrogeologic Model Update Report. April 27, 2015.

BGC Engineering Inc., 2018. Brucejack Gold Mine – 2017 Annual Groundwater Monitoring Report. March 19, 2018.

BGC Engineering Inc., 2017. Contact Water Pond Hydrogeological Assessment – DRAFT. Report submitted to Pretium Resources Inc. January 12, 2017.

BGG Engineering Inc., 2019a. 2018 Groundwater Monitoring Well Installation and Site Investigation Report – FINAL. Report submitted to Pretium Resources Inc. March 6, 2019.

BGG Engineering Inc., 2019b. 2018 Groundwater Monitoring Report – FINAL. Report submitted to Pretium Resources Inc. March 6, 2019.

DHI, 2020. FEFLOW v7.2. https://www.mikepoweredbydhi.com/products/feflow.

Environmental Simulations Inc. 2011. Groundwater Vistas – Version 6. http://www.groundwatermodels.com/Groundwater_Vistas.php.

Harbaugh, A.W., E.R. Banta, M.C. Hill & M.G. McDonald., 2000. Modflow 2000. The U.S. Geological Survey Modular Ground-water Model – User Guide to the Modularization Concepts and Ground-water Flow Process. U.S. Geological Survey Open File Report 00-92, 130 pp.

HydroGeoLogic Inc., 2012. Modflow-Surfact – A Code for Analyzing Subsurface Systems. http://www.hglsoftware.com/Modflow.cfm.

Jones, I.W.O., Huang, J., Horan, M., Schmid, C., Carey, E., Ghaffari, H., Rykaart, M., Schmitt, R., Weatherly, H., Crozier, T., and Shaw, A., 2019. Feasibility Study and Technical Report on the Brucejack Project, Stewart, BC. Tetra Tech NI 43-101 Technical Report for Pretium Resources. Effective Date April 4, 2019. 340 pp.

27.14 Adjacent Properties

American Creek Resources Ltd. website http://www.americancreek.com.

BC MEMPR MINFILE No. 104B 105 http://minfile.gov.bc.ca/Summary.aspx?minfilno=104B%20%20105.

Brucejack Project Overview http://www.pretivm.com/projects/snowfield/overview/default.aspx (March 29, 2019).

Nelson, J., and Kyba, J., 2014. Structural and stratigraphic control of porphyry and related mineralization in the Treaty Glacier – KSM – Brucejack – Stewart trend of western Stikinia. In: Geological Fieldwork 2013, British Columbia Ministry of Energy and Mines, British Columbia Geological Survey Paper 2014-1, pp. 111–140.

Pardoe, J., 2016. NI43-101 Technical Report on the Treaty Creek Property, Skeena Mining Division British Columbia, Canada. Report prepared for Tudor Gold Corp. May 21, 2016.

Puritch, E., Brown, F.H., and Armstrong, T., 2011. Technical Report and Updated Resource Estimate on the Snowfield Property. February 18, 2100.

Seabridge Gold Inc. website http://www.seabridgegold.net/resources.php.

Teuton Resources Corporation website http://www.teuton.com.

Alison Shaw, Ph.D., P.Geo.

I, Alison Shaw, Ph.D., P.Geo. of Vancouver, British Columbia, do hereby certify:

- I am a Senior Geochemist with Lorax Environmental Services Ltd. with a business address at 2289 Burrard Street, Vancouver, British Columbia, V6J 3H9.
- This certificate applies to the technical report entitled “Technical Report on the Brucejack Gold Mine, Northwest British Columbia” with effective date of March 9, 2020 (the “Technical Report”).
- I am a graduate of McGill University (B.Sc. Environmental Geosciences, 1996) and the University of California San Diego (Ph.D. Geochemistry, 2003). I am a member in good standing of Engineers and Geoscientists British Columbia (# 47412). My relevant experience includes management, analysis, and interpretation of geochemical data sets from mine sites, development of site-specific water quality models, and analysis of water quality data in mine-impacted receiving environments.
- I am a “Qualified Person” for purposes of National Instrument 43-101 (the “Instrument”).
- I visited the Property that is the subject of the Technical Report from June 3 to June 6, 2019, to review environmental monitoring programs, assess new water quality sampling locations and tour new site infrastructure and facilities.
- I am independent of Pretivm Resources Inc. as defined by Section 1.5 of the Instrument.
- My previous experience with the Property that is the subject of this Technical Report includes acting as the independent Technical Lead and Qualified Professional for geochemistry and water quality, responsible for directing the implementation of geochemistry and water quality monitoring programs; interpretation and assessment of site monitoring data, including for permit applications and annual reports; and development and maintenance of the site-specific water quality model.
- I am responsible for Sections 20.3.2, 20.3.6, 25.6.1, 25.6.5, 26.6.1, 26.6.5, 27.11, 27.12 of this Technical Report.
- I have read the Instrument and the sections of the Technical Report that I am responsible for has been prepared in compliance with the Instrument.
- As of the date of this certificate, to the best of my knowledge, information, and belief, the sections of the Technical Report that I am responsible for contain all scientific and technical information that is required to be disclosed to make the Technical Report not misleading.

Signed and dated this 21st day of April 2020, in Vancouver, British Columbia.

“original document signed and sealed”

Alison Shaw, Ph.D., P.Geo.
Senior Geochemist
Lorax Environmental Services Ltd.

Calvin Boese, P.Eng., M.Sc.

I, Calvin Boese, P.Eng., M.Sc., of Saskatoon, Saskatchewan, do hereby certify:

- I am a Principal Consultant (Geotechnical Engineering) with SRK Consulting (Canada) Inc. with a business address at Suite 600, 350 3rd Ave North, Saskatoon, SK, S7K 6G7.
- This certificate applies to the technical report entitled "Technical Report on the Brucejack Gold Mine, Northwest British Columbia" with effective date of March 9, 2020 (the "Technical Report").
- I am a graduate of the University of Saskatchewan with a B.Sc. in Civil Engineering (1999) and a M.Sc. in Geo-Environmental Engineering (2004). I am a member in good standing of the Association of Professional Engineers, Geologists of British Columbia (P.Eng. #29478). I am also a registered Professional Engineer in Alberta and Saskatchewan.
- I have practiced my profession for over 20 years. I have been directly involved in geotechnical aspects of mining, including the site selection, design, permitting, operation, and closure of mine waste facilities in Canada, the US, Indonesia, and Turkey.
- I am a "Qualified Person" for the purposes of National Instrument 43-101 (the "Instrument").
- I visited the Property that is the subject of the Technical Report on August 19 to 21, 2019 to complete the annual geotechnical inspection.
- I am independent of Pretivm Resources Inc. as defined by Section 1.5 of the Instrument.
- My previous experience with the Property that is the subject of this Technical Report includes Engineer of Record (EoR) responsibilities for the Waste Rock Tailings Storage Facility (WRTSF) beginning in Q3 of 2019.
- I am responsible for Sections 18.2.2.1, 25.4.3, 26.4.3, and 27.6 of this Technical Report.
- I have read the Instrument and the sections of the Technical Report that I am responsible for has been prepared in compliance with the Instrument.
- As of the date of this certificate, to the best of my knowledge, information, and belief, the sections of the Technical Report that I am responsible for contain all scientific and technical information that is required to be disclosed to make the Technical Report not misleading.

Signed and dated this 21st day of April 2020, in Burnaby, British Columbia.

"original document signed and sealed"

Calvin Boese, P.Eng., M.Sc.
Principal Consultant
SRK Consulting (Canada) Inc.

Colin Fraser, P.Geo., M.Sc.

I, Colin Fraser, P.Geo., M.Sc., of Vancouver, British Columbia, do hereby certify:

- I am a Senior Hydrologist with Lorax Environmental Services Ltd. with a business address at 2289 Burrard Street, Vancouver, British Columbia, Canada, V6J 3H9.
- This certificate applies to the technical report entitled "Technical Report on the Brucejack Gold Mine, Northwest British Columbia" with effective date of March 9, 2020 (the "Technical Report").
- I am a graduate of McMaster University (Hon. B.Sc., 1997) and McGill University (M.Sc., 1999). I am a member in good standing with Engineers and Geoscientists British Columbia (License #36348). I am a scientist with experience working on industry-, academic-, and government-led hydrology and environmental regulatory initiatives in the forestry, agriculture, oil/gas, and mining sectors. My academic background is rooted in the hydrology and biogeochemistry of boreal ecosystems, and I have experience conducting hydrological, meteorological and water balance studies at mine sites in northern locations.
- I am a "Qualified Person" for the purposes of National Instrument 43-101 (the "Instrument").
- I visited the Property that is the subject of the Technical Report between August 19 to August 22, 2019. The objectives of the site visit were several-fold, and included: meeting site staff who carry out water and environmental management activities at the Brucejack Mine; liaising with SRK water engineers; completing a tour of water management infrastructure and baseline climate/flow monitoring stations at the property; as well, completing a tour of the Brucejack mill and water treatment plant.
- I am independent of Pretivm Resources Inc. as defined by Section 1.5 of the Instrument.
- My experience with the Property that is the subject of this Technical Report is limited to technical review and update of water balance information for the Brucejack mine site.
- I am responsible for Sections 20.3.5, 25.6.4, 26.6.4, and 27.10 of this Technical Report.
- I have read the Instrument and the sections of the Technical Report that I am responsible for have been prepared in compliance with the Instrument.
- As of the date of this certificate, to the best of my knowledge, information, and belief, the sections of the Technical Report that I am responsible for contain all scientific and technical information that is required to be disclosed to make the Technical Report not misleading.

Signed and dated this 21st day of April 2020, in Vancouver, British Columbia.

"original document signed and sealed"

Colin Fraser, P.Geo., M.Sc.
Senior Hydrologist
Lorax Environmental Services Ltd.

Hassan Ghaffari, P.Eng., M.A.Sc.

I, Hassan Ghaffari, P.Eng., M.A.Sc., of Vancouver, British Columbia, do hereby certify:

- I am a Director of Metallurgy with Tetra Tech Canada Inc. with a business address at Suite 1000 – 10th Floor, 885 Dunsmuir Street, Vancouver, British Columbia, V6C 1N5.
- This certificate applies to the technical report entitled "Technical Report on the Brucejack Gold Mine, Northwest British Columbia" with effective date of March 9, 2020 (the "Technical Report").
- I am a graduate of the University of Tehran (M.A.Sc. Mining Engineering, 1990) and the University of British Columbia (M.A.Sc., Mineral Process Engineering, 2004). I am a member in good standing of Engineers and Geoscientists British Columbia (#30408). My relevant experience with respect to mineral engineering includes 27 years of experience in mining and plant operation, project studies, management, and engineering. As the lead metallurgist for the Pebble Copper-Gold Moly Project in Alaska, I was coordinating all metallurgical test work and preparing and peer reviewing the technical report and the operating and capital costs of the plant and infrastructure for both the scoping and prefeasibility studies. For the Ajax Copper-Gold Project in British Columbia, I was the project manager responsible for process, infrastructure, and overall management of the 60,000 t/d mill. As well, I was the project manager responsible for ongoing metallurgical test work and technical assistance for the La Joya Copper-Silver-Gold Project in Durango, Mexico.
- I am a "Qualified Person" for the purposes of National Instrument 43-101 (the "Instrument").
- I visited the Property that is the subject of the Technical Report on March 13, 2019. The purpose of the site visit was to oversee the overall site surface infrastructures including access roads, warehouses, workshops and process plant.
- I am independent of Pretivm Resources Inc. as defined by Section 1.5 of the Instrument.
- My previous experience with the Property that is the subject of this Technical Report includes Preliminary Economic Assessments in 2010 (Effective Date: September 10, 2010).
- I am responsible for Sections 1.1, 1.9, 1.14, 3.1, 18.1, 18.2 (except 18.2.2.1 and 18.2.3.6), 18.3, 18.4, 18.5, 21.1 (except 21.1.2.4), and 27.7 of this Technical Report.
- I have read the Instrument and the sections of the Technical Report that I am responsible for has been prepared in compliance with the Instrument.
- As of the date of this certificate, to the best of my knowledge, information and belief, the sections of the Technical Report that I am responsible for contain all scientific and technical information that is required to be disclosed to make the Technical Report not misleading.

Signed and dated this 21st day of April 2020, in Vancouver, British Columbia.

"original document signed and sealed"

Hassan Ghaffari, P.Eng., M.A.Sc.
Director of Metallurgy
Tetra Tech Canada Inc.

Ivor W.O. Jones, M.Sc., P.Geo., FAusIMM

I, Ivor W.O. Jones, M.Sc., P.Geo., FAusIMM of Robina, Queensland, Australia, do hereby certify:

- I am a Principal Consultant with Ivor Jones Pty Ltd with a business address at 16 Ringwood Court, Robina, 4226, Queensland, Australia.
- This certificate applies to the technical report entitled "Technical Report on the Brucejack Gold Mine, Northwest British Columbia" with effective date of March 9, 2020 (the "Technical Report").
- I am a graduate of Macquarie University (B.Sc. Geology, 1984, (Honours), 1986) and the University of Queensland (M.Sc. Resource Estimation, 2001). I am licensed as a Professional Geoscientist with Engineers and Geoscientists British Columbia (Licence No. 197172), and I am a Fellow of the Australasian Institute of Mining and Metallurgy (AusIMM) (Member No. 111429). I have worked as a geologist continuously for a total of 35 years since graduation. I have been involved in resource evaluation for 30 years and consulting for 21 years, including resource estimation of hydrothermal gold deposits for at least 15 years. I have been involved in gold exploration and mining operations for at least 20 years.
- I am a "Qualified Person" for the purposes of National Instrument 43-101 (the "Instrument").
- My most recent personal inspections of the Property that is the subject of the Technical Report was from August 20 to August 24, 2018 and April 18, 2020.
- I am independent of Pretivm Resources Inc. as defined by Section 1.5 of the Instrument.
- I have had on-going, but periodic involvement with the Property that is the subject of this Technical Report since 2010. This includes preparation and sign-off on all Mineral Resources reported by the company since January 2012 with the exception of the 2014 Feasibility Study report.
- I am responsible for Sections 1.2, 1.3, 1.4, 1.13, 3.2, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0, 10.0, 11.0, 12.0, 14.0, 23.0, 25.1, 25.2, 25.9, 26.1, 26.2, 26.3, 27.2, and 27.14 of this Technical Report.
- I have read the Instrument and the sections of the Technical Report that I am responsible for has been prepared in compliance with the Instrument.
- As of the date of this certificate, to the best of my knowledge, information, and belief, the sections of the Technical Report that I am responsible for contain all scientific and technical information that is required to be disclosed to make the Technical Report not misleading.

Signed and dated this 21st day of April 2020, in Burnaby, British Columbia.

"original document signed and sealed"

Ivor W.O. Jones, M.Sc., P.Geo., FAusIMM
Principal Consultant
Ivor Jones Pty Ltd

Jianhui (John) Huang, Ph.D., P.Eng.

I, Jianhui (John) Huang, Ph.D., P.Eng., of Burnaby, British Columbia, do hereby certify:

- I am a Senior Metallurgist with Tetra Tech Canada Inc. with a business address at Suite 1000 – 10th Floor, 885 Dunsmuir Street, Vancouver, British Columbia, V6C 1N5.
- This certificate applies to the technical report entitled "Technical Report on the Brucejack Mine, Northwest British Columbia" with effective date of March 9, 2020 (the "Technical Report").
- I am a graduate of North-East University (B.Eng., 1982), Beijing General Research Institute for Non-ferrous Metals (M.Eng., 1988), and Birmingham University (Ph.D., 2000). I am a member in good standing of Engineers and Geoscientists British Columbia (License #30898). My relevant experience with respect to mineral engineering includes more than 30 years of involvement in mineral process for base metal ores, gold and silver ores, and rare metal ores.
- I am a "Qualified Person" for purposes of National Instrument 43-101 (the "Instrument").
- I visited the Property that is the subject of the Technical Report from on March 6 and March 7, 2018 and on June 5 and June 6, 2018 to witness the operation, review the mill operation and mill throughput expansion upgrading, and review mill operation data.
- I am independent of Pretivm Resources Inc. as defined by Section 1.5 of the Instrument.
- My previous experience with the Property that is the subject of this Technical Report includes Preliminary Economic Assessment in 2010 (Effective Date: September 10 2010), Feasibility Study in 2013 (Effective Date: June 21 2013), Feasibility Study Update (Effective Date: June 19, 2014), Technical Report on the Brucejack Gold Mine (Effective Date: April 4, 2019), mill upgrading evaluations and technical support during 2017 and 2019.
- I am responsible for Sections 1.7, 1.8, 1.11, 2.0, 3.4, 13.0, 17.0, 19.0, 21.2 (except 21.2.2), 24.0, 25.5, 25.7, 26.5, 27.1, and 27.3 of this Technical Report.
- I have read the Instrument and the sections of the Technical Report that I am responsible for has been prepared in compliance with the Instrument.
- As of the date of this certificate, to the best of my knowledge, information, and belief, the sections of the Technical Report that I am responsible for contain all scientific and technical information that is required to be disclosed to make the Technical Report not misleading.

Signed and dated this 21st day of April 2020, in Vancouver, British Columbia.

"original document signed and sealed"

Jianhui (John) Huang, Ph.D., P.Eng.
Senior Metallurgist
Tetra Tech Canadian Inc.

Laura-Lee Findlater, B.Sc., P.Geo.

I, Laura-Lee Findlater, B.Sc., P.Geo. of Vancouver, British Columbia, do hereby certify:

- I am a Project Hydrogeologist with Lorax Environmental Services Ltd. with a business address at 2289 Burrard Street, Vancouver, British Columbia, V6J 3H9.
- This certificate applies to the technical report entitled “Technical Report on the Brucejack Mine, Northwest British Columbia” with effective date of March 9, 2020 (the “Technical Report”).
- I am a graduate of the University of British Columbia (B.Sc. Honours Geological Sciences, 2001). I am a member in good standing of Engineers and Geoscientists British Columbia (License #38298). My relevant experience with respect to hydrogeology includes more than 15 years of management, analysis and interpretation of physical and chemical hydrogeological data sets from mine sites. I have both developed and provided oversight for development of numerical groundwater models for mine sites.
- I am a “Qualified Person” for purposes of National Instrument 43-101 (the “Instrument”).
- I visited the Property that is the subject of the Technical Report between October 7 and October 9, 2019 to observed and provide feedback on groundwater monitoring practices at the site.
- I am independent of Pretivm Resources Inc. as defined by Section 1.5 of the Instrument.
- My previous experience with the Property that is the subject of this Technical Report includes acting as the independent Technical Lead and Qualified Professional for hydrogeology, responsible for directing the implementation of groundwater quality and quantity monitoring programs; providing interpretation and assessment of site monitoring data, including for annual reports; and providing oversight for the development of the site-specific numerical groundwater model.
- I am responsible for Sections 20.3.3, 25.6.2, 26.6.2, and 27.13 of this Technical Report.
- I have read the Instrument and the sections of the Technical Report that I am responsible for has been prepared in compliance with the Instrument.
- As of the date of this certificate, to the best of my knowledge, information and belief, the sections of the Technical Report that I am responsible for contain all scientific and technical information that is required to be disclosed to make the Technical Report not misleading.

Signed and dated this 21st day of April 2020, in Vancouver, British Columbia.

“original document signed and sealed”

Laura-Lee Findlater, B.Sc., P.Geo.
Project Hydrogeologist
Lorax Environmental Services Ltd.

Maureen Phifer, P.Eng., B.Sc.

I, Maureen Phifer, P.Eng., B.Sc., of Richmond, British Columbia, do hereby certify:

- I am the Mining Division Manager with Tetra Tech Canada Inc. with a business address at Suite 1000, 10th Floor, 885 Dunsmuir St., Vancouver, BC, V6C 1N5.
- This certificate applies to the technical report entitled "Technical Report on the Brucejack Gold Mine, Northwest British Columbia" with effective date of March 9, 2020 (the "Technical Report").
- I graduated in 2013 from the Montana Technical University with a B.Sc. in Mining Engineering. I am a member in good standing of with Engineers and Geoscientists British Columbia (#176335). My relevant experience includes 10 years of experience working in precious metals, onsite operational experience, and in consulting.
- I am a "Qualified Person" for purposes of National Instrument 43-101 (the "Instrument").
- I have visited the Property that is the subject of the Technical Report on January 20 to January 22, 2020.
- I am independent of Pretivm Resources Inc. as defined by Section 1.5 of the Instrument.
- I have no prior involvement with the Property that is the subject of this Technical Report.
- I am responsible for the following sections: 1.5, 1.6, 1.12, 3.5, 15.0, 16.0 (except 16.5), 21.1.2.4, 21.2.2, 22.0, 25.3, 25.4.2, 25.8, 26.4.2, and 27.4 of this Technical Report.
- I have read the Instrument and the sections of the Technical Report that I am responsible for has been prepared in compliance with the Instrument.
- As of the date of this certificate, to the best of my knowledge, information, and belief, the sections of the Technical Report that I am responsible for contain all scientific and technical information that is required to be disclosed to make the Technical Report not misleading.

Signed and dated this 21st day of April 2020, in Vancouver, British Columbia.

"original document signed and sealed"

Maureen Phifer, P.Eng., B.Sc.
Manager, Mining Division
Tetra Tech Canada Inc.

Mauricio Herrera, P.Eng., Ph.D.

I, Mauricio Herrera, P.Eng., Ph.D., of Vancouver, British Columbia, do hereby certify:

- I am a Principal Consultant (Water Resources Engineering) with SRK Consulting (Canada) Inc. with a business address at Suite 2200, 1066 West Hastings St., Vancouver, BC, V6E 3X2.
- This certificate applies to the technical report entitled "Technical Report on the Brucejack Gold Mine, Northwest British Columbia" with effective date of March 9, 2020 (the "Technical Report").
- I am a graduate of Universidad del Norte (Colombia) with a B.Sc. in Civil Engineering (1997), a M.Sc. in Water Resources Engineering (1998) from Universidad de los Andes (Colombia), and a Doctorate in Water Resources Engineering from the University of Guelph (Ontario). I am a member in good standing of Engineers and Geoscientists British Columbia (P.Eng. #34942). I am also a registered Professional Engineer in Alberta and in the Yukon. I have practiced my profession for over 20 years. I have been directly involved in surface water management aspects of mining, including the site selection, design, permitting, operation, and closure of mine waste facilities in Canada.
- I am a "Qualified Person" for the purposes of National Instrument 43-101 (the "Instrument").
- I visited the Property that is the subject of the Technical Report on August 19 to August 21, 2019 to complete the Annual Surface Water Management Inspection.
- I am independent of Pretivm Resources Inc. as defined by Section 1.5 of the Instrument.
- My previous experience with the Property that is the subject of this Technical Report includes Engineer of Record (EoR) responsibilities for the Surface Water Management beginning in Q3 of 2019.
- I am responsible for Sections 18.2.3.6, 20.3.4, 25.6.3, 26.6.3, and 27.9 of this Technical Report.
- I have read the Instrument and the sections of the Technical Report that I am responsible for has been prepared in compliance with the Instrument.
- As of the date of this certificate, to the best of my knowledge, information, and belief, the sections of the Technical Report that I am responsible for contain all scientific and technical information that is required to be disclosed to make the Technical Report not misleading.

Signed and dated this 21st day of April 2020, in Vancouver, British Columbia.

"original document signed and sealed"

Mauricio Herrera, P.Eng., Ph.D.
Principal Consultant
SRK Consulting (Canada) Inc.

Rolf Schmitt, M.Sc., P.Geo

I, Rolf Schmitt, M.Sc., P.Geo, of Victoria, British Columbia, do hereby certify:

- I am a Technical Director - Permitting with Environmental Resources Management (ERM) with a business address at 15th Floor, 1111 West Hastings Street, Vancouver, British Columbia, Canada V6E 2J3.
- This certificate applies to the technical report entitled "Technical Report on the Brucejack Gold Mine, Northwest British Columbia" with effective date of March 9, 2020 (the "Technical Report").
- I am a graduate of University of Ottawa (M.Sc., 1993 – Geology), University of British Columbia (M.Sc., 1985 Regional Planning), and University of British Columbia (B.Sc., Hons. Geology, 1977). I am a member in good standing of the Engineers and Geoscientists of British Columbia (License #19824). My relevant experience with respect to environmental assessment, mine permitting and geology includes more than 40 years of involvement in BC mine policy and regulation, including 16 years as BC Senior Land Use Geologist, 14 years leading Environmental Assessment and permitting of mines in BC as a consultant, and 15 years previously of mineral exploration and exploration geochemical research in northwestern BC and eastern Canada.
- I am a "Qualified Person" for the purposes of National Instrument 43-101 (the "Instrument").
- I visited the Property that is the subject of the Technical Report on April 1 to April 3, 2019 to examine environmental management systems at the Brucejack Mine Site.
- I am independent of Pretivm Resources Inc. as defined by Section 1.5 of the Instrument.
- My previous experience with the Property that is the subject of this Technical Report includes contributions, reviews and amendments to the applications for EA Project Certificate, Mines Act permit M-243, and Environmental Management Act waste discharge permits, crown land tenure, related permits.
- I am responsible for Sections 1.10, 3.3, 20.1 to 20.3.1, 20.3.7 to 20.3.9, and 27.8 of this Technical Report.
- I have read the Instrument and the sections of the Technical Report that I am responsible for have been prepared in compliance with the Instrument.
- As of the date of this certificate, to the best of my knowledge, information, and belief, the sections of the Technical Report that I am responsible for contain all scientific and technical information that is required to be disclosed to make the Technical Report not misleading.

Signed and dated this 21st day of April 2020, in Vancouver, British Columbia.

"original document signed and sealed"

Rolf Schmitt, M.Sc., P.Geo
Technical Director
Environmental Resources Management (ERM)

Timothy James Coleman, P.Eng., BEng(Hons), ACSM, M.Sc.

I, Timothy James Coleman, P.Eng., of Coquitlam, British Columbia, do hereby certify:

- I am a Principal Consultant with SRK Consulting (Canada) Inc with a business address at Suite 2200 – 1066 West Hastings Street, Vancouver, British Columbia, V6E 3X2, Canada.
- This certificate applies to the technical report entitled "Technical Report on the Brucejack Gold Mine, Northwest British Columbia" with effective date of March 9, 2020 (the "Technical Report").
- I am a graduate of Imperial College of Science, Technology and Medicine, UK in where I obtained my M.Sc. Engineering Rock Mechanics in 1997. I obtained a BEng (Honours) Mining Engineering in 1994, and a Diploma in Minerals Engineering (1st Class) in 1992, both from The Camborne School of Mines, University of Exeter, UK. I have been involved in mining since 1997 and have practised my profession continuously since then. I have been involved in mining operations, mining-related rock mechanics and consulting covering a wide range of mineral commodities in the United Kingdom, Europe, North and South America, Africa, and Asia. I am a registered Professional Engineer (#46105) with EGBC and also registered in the provinces of Ontario and Saskatchewan.
- I am a "Qualified Person" for the purposes of National Instrument 43-101 (the "Instrument").
- I visited the Property that is the subject of the Technical Report on September 24, 2019 to conduct a review of the underground workings and rock mass conditions.
- I am independent of Pretivm Resources Inc. as defined by Section 1.5 of the Instrument.
- My previous experience with the Property that is the subject of this Technical Report includes the annual underground inspection, the annual review of the GCMP, and review of the waste rock pastefill barricade design.
- I am responsible for Sections 16.5, 25.4.1, 26.4.1, and 27.5 of this Technical Report.
- I have read the Instrument and the sections of the Technical Report that I am responsible for has been prepared in compliance with the Instrument.
- As of the date of this certificate, to the best of my knowledge, information, and belief, the sections of the Technical Report that I am responsible for contain all scientific and technical information that is required to be disclosed to make the Technical Report not misleading.

Signed and dated this 21st day of April 2020, in Burnaby, British Columbia.

"original document signed and sealed"

Tim Coleman, P.Eng., BEng(Hons), ACSM, M.Sc.
Principal Consultant, Mining Rock Mechanics
SRK Consulting (Canada) Inc.