

**AVALON ADVANCED MATERIALS INC.**

**NI 43-101 TECHNICAL REPORT  
ON THE  
PRELIMINARY ECONOMIC ASSESSMENT  
OF  
LITHIUM HYDROXIDE PRODUCTION  
SEPARATION RAPIDS LITHIUM PROJECT  
KENORA, ONTARIO**

**Report Date: 10 November, 2016  
Effective Date: 21 October, 2016**

**Report By**

**Steven R. Aiken, P.Eng.  
Richard Gowans, P.Eng.  
Kevin E. Hawton, P.Eng.  
Christopher Jacobs, CEng, MIMMM  
Eur Ing, Bruce Pilcher, CEng, FIMMM, FAusIMM(CP)  
Jane Spooner, P.Geo.  
David L. Trueman, Ph.D., P.Geo.**

**Table of Contents**

|            |   |          |
|------------|---|----------|
| <b>1.0</b> | <b>SUMMARY .....</b>  | <b>1</b> |
| 1.1        | INTRODUCTION .....  | 1        |
| 1.2        | PHYSIOGRAPHY AND CLIMATE .....  | 2        |
| 1.3        | HISTORY .....   | 2        |
| 1.4        | GEOLOGICAL SETTING AND MINERALIZATION .....                               | 2        |
| 1.5        | EXPLORATION .....   | 3        |
| 1.6        | DRILLING.....   | 3        |
| 1.7        | SAMPLE PREPARATION, ANALYSES AND SECURITY .....                           | 3        |
| 1.8        | DATA VERIFICATION .....   | 4        |
| 1.8.1      | Certified Standard .....  | 4        |
| 1.9        | MINERAL PROCESSING AND METALLURGICAL TESTING .....                        | 5        |
| 1.10       | MINERAL RESOURCE ESTIMATES .....  | 7        |
| 1.10.1     | Lithium Mineral Resource Estimate .....                                   | 7        |
| 1.10.2     | Estimated Feldspar Resources .....  | 8        |
| 1.11       | MINERAL RESERVE ESTIMATES .....   | 9        |
| 1.12       | MINING METHODS .....  | 9        |
| 1.12.1     | Pit Optimization.....   | 9        |
| 1.12.2     | Mining Method .....   | 9        |
| 1.13       | RECOVERY METHODS.....   | 10       |
| 1.14       | PROJECT INFRASTRUCTURE .....  | 11       |
| 1.14.1     | Trans-shipment Facility .....   | 12       |
| 1.14.2     | Hydrometallurgical Plant.....   | 13       |
| 1.15       | MARKETS STUDIES AND CONTRACTS .....                                       | 13       |
| 1.15.1     | Lithium.....  | 13       |
| 1.15.2     | Feldspar.....   | 14       |
| 1.15.3     | Contracts .....   | 15       |
| 1.16       | ENVIRONMENTAL STUDIES, PERMITTING AND SOCIAL OR<br>COMMUNITY IMPACT ..... | 15       |
| 1.16.1     | Environmental Baseline .....  | 15       |
| 1.16.2     | Tailings and Concentrate Management .....                                 | 16       |
| 1.16.3     | Mine Rock Aggregate and Mineralized Material Management .....             | 16       |
| 1.16.4     | Water Management.....   | 16       |
| 1.16.5     | Closure and Rehabilitation.....   | 17       |
| 1.16.6     | Community and Indigenous Peoples Engagement .....                         | 17       |
| 1.17       | CAPITAL AND OPERATING COSTS.....  | 18       |
| 1.17.1     | Capital Costs .....   | 18       |
| 1.17.2     | Operating Costs.....  | 19       |
| 1.18       | ECONOMIC ANALYSIS .....   | 19       |
| 1.19       | ADJACENT PROPERTIES .....   | 21       |
| 1.20       | PROJECT DEVELOPMENT SCHEDULE .....  | 21       |
| 1.21       | INTERPRETATION AND CONCLUSIONS.....                                       | 22       |
| 1.22       | RECOMMENDATIONS.....  | 22       |
| 1.22.1     | Geology and Mineral Resources.....  | 23       |

|  | <b>Page</b> |
|--|-------------|
| 1.22.2 Metallurgical Testwork.....   | 24          |
| 1.22.3 Mining Methods.....   | 25          |
| 1.22.4 Marketing.....  | 25          |
| 1.22.5 Environmental/Social.....   | 26          |
| 1.22.6 Proposed Work Program.....  | 27          |
| <b>2.0 INTRODUCTION.....</b>   | <b>28</b>   |
| 2.1 TERMS OF REFERENCE.....  | 28          |
| 2.1.1 Preliminary Economic Assessment.....   | 28          |
| 2.1.2 Mineral Resource Estimate.....   | 28          |
| 2.1.3 Relationship with Avalon.....  | 29          |
| 2.2 QUALIFIED PERSONS, SITE VISITS, AND AREAS OF<br>RESPONSIBILITY.....                      | 30          |
| 2.3 UNITS AND ABBREVIATIONS.....   | 30          |
| <b>3.0 RELIANCE ON OTHER EXPERTS.....</b>  | <b>34</b>   |
| 3.1 MINERAL TENURE AND SURFACE RIGHTS.....   | 34          |
| 3.2 ENVIRONMENTAL LIABILITIES AND SOCIAL AND<br>COMMUNITY IMPACTS.....                       | 34          |
| 3.3 TAXATION AND ROYALTIES.....  | 34          |
| 3.4 OTHER INFORMATION.....   | 34          |
| <b>4.0 PROPERTY DESCRIPTION AND LOCATION.....</b>  | <b>35</b>   |
| 4.1 INTRODUCTION.....  | 35          |
| 4.2 PROPERTY AND OWNERSHIP.....  | 36          |
| 4.3 ENVIRONMENTAL LIABILITIES.....   | 38          |
| 4.4 TRANS-SHIPMENT FACILITY AND HYDROMETALLURGICAL<br>PLANT.....                             | 38          |
| <b>5.0 ACCESSIBILITY, CLIMATE, LOCAL RESOURCES,<br/>INFRASTRUCTURE AND PHYSIOGRAPHY.....</b> | <b>40</b>   |
| 5.1 ACCESSIBILITY.....   | 40          |
| 5.2 PHYSIOGRAPHY.....  | 41          |
| 5.3 VEGETATION.....  | 41          |
| 5.4 CLIMATE.....   | 42          |
| 5.5 LOCAL RESOURCES AND INFRASTRUCTURE.....  | 43          |
| <b>6.0 HISTORY.....</b>  | <b>45</b>   |
| <b>7.0 GEOLOGICAL SETTING AND MINERALIZATION.....</b>  | <b>46</b>   |
| 7.1 INTRODUCTION.....  | 46          |
| 7.2 REGIONAL GEOLOGY.....  | 46          |
| 7.3 PROPERTY GEOLOGY.....  | 48          |
| 7.3.1 Pegmatite Units.....   | 54          |
| 7.4 STRUCTURAL GEOLOGY.....  | 56          |
| 7.5 MINERALIZATION.....  | 57          |

|   | <b>Page</b> |
|---|-------------|
| 7.5.1 Extent of Mineralization .....                                | 57          |
| 7.6 MINERALOGY .....  | 59          |
| 7.6.1 Mineralogy - Pedersen Modal Estimates from Core Logging ..... | 60          |
| 7.6.2 Mineralogy - Studies by Pedersen .....                        | 61          |
| 7.6.3 Mineralogy – Studies by Taylor .....                          | 61          |
| 7.6.4 Mineralogy – ALS (Qemscan®) Study .....                       | 67          |
| 7.6.5 Tantalum, Tin and Niobium.....                                | 71          |
| <b>8.0 DEPOSIT TYPES .....</b>                                      | <b>74</b>   |
| <b>9.0 EXPLORATION.....</b>   | <b>75</b>   |
| 9.1 EARLY EXPLORATION .....   | 75          |
| 9.2 1997-98 EXPLORATION PROGRAM .....                               | 75          |
| 9.2.1 Line Cutting and Magnetometer Survey.....                     | 75          |
| 9.2.2 Geological Mapping and Sampling .....                         | 76          |
| 9.2.3 Trenching.....  | 76          |
| 9.2.4 Diamond Drilling.....   | 77          |
| 9.3 2000-2014 EXPLORATION .....                                     | 77          |
| 9.3.1 Check Assay Program.....                                      | 77          |
| 9.3.2 Rock and Soil Survey.....                                     | 78          |
| <b>10.0 DRILLING .....</b>  | <b>79</b>   |
| 10.1 INTRODUCTION .....   | 79          |
| 10.2 1997-1998 DRILLING PROGRAM .....                               | 80          |
| 10.3 2001 GEOTECHNICAL DRILL PROGRAM.....                           | 81          |
| 10.4 2001 GEOLOGICAL DRILL PROGRAM .....                            | 82          |
| 10.5 2016 RE-ANALYSIS PROGRAM .....                                 | 82          |
| <b>11.0 SAMPLE PREPARATION, ANALYSES AND SECURITY.....</b>          | <b>83</b>   |
| 11.1 SAMPLE HANDLING AND ANALYTICAL METHODS USED –<br>1997/98 ..... | 83          |
| 11.2 SAMPLE HANDLING AND ANALYTICAL METHODS USED –<br>2016 .....    | 84          |
| 11.3 DRILL DATABASE PREPARATION.....                                | 85          |
| 11.4 SPECIFIC GRAVITY .....   | 85          |
| <b>12.0 DATA VERIFICATION .....</b>                                 | <b>88</b>   |
| 12.1 INTRODUCTION .....   | 88          |
| 12.2 QUALITY CONTROL, 1990S.....                                    | 88          |
| 12.3 INDEPENDENT CHECK SAMPLING AND ASSAYING – 1999.....            | 91          |
| 12.4 AVALON 2016 DATA VERIFICATION .....                            | 93          |
| 12.4.1 Database Checks .....  | 93          |
| 12.4.2 Original Assay Certificate Checks.....                       | 93          |
| 12.4.3 Reassay of Drill Core in 2016.....                           | 94          |
| 12.5 DRILL COLLARS AND SURVEY DATA.....                             | 99          |
| 12.6 DRILL HOLE AZIMUTHS .....                                      | 101         |

|             |  |            |
|-------------|--|------------|
| <b>13.0</b> | <b>MINERAL PROCESSING AND METALLURGICAL TESTING.....</b>   | <b>103</b> |
| 13.1        | INTRODUCTION .....   | 103        |
| 13.2        | HISTORICAL METALLURGICAL INVESTIGATIONS (PRE-2014) .....   | 103        |
| 13.2.1      | SGS-L (1997-1999) .....                                    | 103        |
| 13.2.2      | SGS-L (2009).....  | 103        |
| 13.3        | RECENT METALLURGICAL TESTWORK .....                        | 104        |
| 13.3.1      | Mineral Processing.....                                    | 104        |
| 13.3.2      | Preliminary Physical Separation Testwork – ANZAPLAN .....  | 105        |
| 13.3.3      | Magnetic Separation Tests.....                             | 109        |
| 13.3.4      | Filtration Tests .....                                     | 109        |
| 13.3.5      | Ceramic Application Tests.....                             | 110        |
| 13.3.6      | One Tonne Petalite Concentrate Production Test.....        | 111        |
| 13.3.7      | Feldspar Filler Tests.....                                 | 112        |
| 13.3.8      | Hydrometallurgical Testwork .....                          | 112        |
| 13.3.9      | Saskatchewan Research Council Testwork .....               | 113        |
| 13.3.10     | Thibault Process Proof of Concept Study.....               | 114        |
| 13.3.11     | Thibault Hydrometallurgical Bench Scale Test Program ..... | 116        |
| 13.4        | CONCLUSIONS AND RECOMMENDATIONS .....                      | 124        |
| <b>14.0</b> | <b>MINERAL RESOURCE ESTIMATES.....</b>                     | <b>126</b> |
| 14.1        | LITHIUM MINERAL RESOURCE ESTIMATE.....                     | 126        |
| 14.1.1      | Geological Model.....                                      | 127        |
| 14.1.2      | Specific Gravity .....                                     | 128        |
| 14.1.3      | Drill Hole Data and Statistics .....                       | 129        |
| 14.1.4      | Assay Compositing .....                                    | 132        |
| 14.1.5      | Variography .....  | 132        |
| 14.1.6      | Block Model.....   | 133        |
| 14.1.7      | Lithium Resource Block Classification .....                | 136        |
| 14.1.8      | Lithium Mineral Resource Estimate .....                    | 138        |
| 14.1.9      | Grade-Tonnage Curve.....                                   | 144        |
| 14.1.10     | Comparison to Previous Mineral Resource Estimate .....     | 145        |
| 14.2        | ESTIMATED FELDSPAR RESOURCES.....                          | 145        |
| <b>15.0</b> | <b>MINERAL RESERVE ESTIMATES .....</b>                     | <b>148</b> |
| <b>16.0</b> | <b>MINING METHODS .....</b>                                | <b>149</b> |
| 16.1        | PIT OPTIMIZATION.....                                      | 149        |
| 16.1.1      | Optimization Parameters.....                               | 149        |
| 16.1.2      | Results.....   | 150        |
| 16.2        | PIT DESIGN.....  | 152        |
| 16.3        | MINING METHOD .....  | 154        |
| 16.3.1      | Open Pit .....   | 154        |
| 16.4        | CONTRACTOR VERSUS OWNER OPERATED MINING.....               | 154        |
| 16.5        | MINE DEVELOPMENT.....                                      | 154        |
| 16.6        | PRODUCTION SCHEDULE.....                                   | 154        |
| 16.7        | MINING FLEET.....  | 155        |

|   | <b>Page</b> |
|---|-------------|
| 16.7.1 Main Mining Equipment.....   | 155         |
| 16.7.2 Ancillary Equipment.....   | 157         |
| 16.8 LABOUR.....  | 157         |
| <b>17.0 RECOVERY METHODS .....</b>  | <b>158</b>  |
| 17.1 INTRODUCTION .....   | 158         |
| 17.2 PROCESS DESIGN BASIS ASSUMPTIONS .....   | 159         |
| 17.3 CONCENTRATOR PROCESS DESCRIPTION.....  | 160         |
| 17.3.1 Crushing and Sorting of Mineralized Material .....                           | 160         |
| 17.3.2 Comminution, De-sliming and Magnetic Separation .....                        | 160         |
| 17.3.3 Petalite Flotation .....   | 161         |
| 17.3.4 Petalite Concentrate Handling .....  | 162         |
| 17.3.5 Feldspar Flotation .....   | 162         |
| 17.3.6 Feldspar Concentrate Handling.....   | 163         |
| 17.3.7 Tailings and Magnetics Concentrate Storage .....                             | 163         |
| 17.3.8 Reagents.....  | 163         |
| 17.3.9 Metallurgical Accounting.....  | 164         |
| 17.3.10 Plant Services.....   | 164         |
| 17.3.11 Water.....  | 165         |
| 17.4 HYDROMETALLURGICAL PLANT PROCESS DESCRIPTION.....                              | 165         |
| 17.4.1 Pyrometallurgical, Leaching and Impurity Precipitation Circuits .....        | 165         |
| 17.4.2 Ion Exchange, Electrodialysis and Lithium Hydroxide<br>Crystallization ..... | 167         |
| 17.4.3 Residue.....   | 168         |
| 17.4.4 Reagents.....  | 169         |
| 17.4.5 Metal Accounting.....  | 169         |
| 17.4.6 Plant Services.....  | 170         |
| 17.4.7 Water Circuits.....  | 170         |
| <b>18.0 PROJECT INFRASTRUCTURE.....</b>   | <b>172</b>  |
| 18.1 OVERVIEW .....   | 172         |
| 18.2 MINE AND CONCENTRATOR SITE.....  | 173         |
| 18.2.1 Location and Access .....  | 173         |
| 18.2.2 Site Preparation and Haul Roads .....  | 174         |
| 18.2.3 Site Buildings.....  | 174         |
| 18.2.4 Fresh Water .....  | 174         |
| 18.2.5 Sewage .....   | 174         |
| 18.2.6 Power .....  | 174         |
| 18.2.7 Fuel Storage .....   | 175         |
| 18.2.8 Hydrogen Fluoride .....  | 175         |
| 18.2.9 Communications .....   | 175         |
| 18.2.10 Camp.....   | 175         |
| 18.3 TRANS-SHIPMENT FACILITY.....   | 175         |
| 18.3.1 Location .....   | 176         |
| 18.3.2 Facilities.....  | 176         |
| 18.3.3 Hydrofluoric Acid Facilities .....   | 177         |

|   | <b>Page</b> |
|---|-------------|
| 18.3.4 Power .....  | 177         |
| 18.3.5 Water.....   | 177         |
| 18.3.6 Sewage .....   | 177         |
| 18.3.7 Communications .....   | 177         |
| <b>18.4 HYDROMETALLURGICAL PLANT .....</b>  | <b>178</b>  |
| 18.4.1 Location and Access .....  | 178         |
| 18.4.2 Site Services.....   | 178         |
| 18.4.3 Buildings.....   | 178         |
| 18.4.4 Rail Siding .....  | 179         |
| 18.4.5 Communications .....   | 179         |
| <b>19.0 MARKET STUDIES AND CONTRACTS.....</b>   | <b>180</b>  |
| 19.1 LITHIUM.....   | 180         |
| 19.1.1 Introduction.....  | 180         |
| 19.1.2 End-use Sectors.....   | 181         |
| 19.1.3 Lithium Hydroxide.....   | 184         |
| 19.1.4 Lithium Supply .....   | 185         |
| 19.1.5 Lithium Prices.....  | 185         |
| 19.2 FELDSPAR .....   | 187         |
| 19.2.1 Introduction.....  | 187         |
| 19.2.2 End-use Sectors.....   | 188         |
| 19.2.3 Markets and Pricing.....   | 189         |
| 19.3 CONTRACTS.....   | 190         |
| <b>20.0 ENVIRONMENTAL STUDIES, PERMITTING AND SOCIAL OR<br/>COMMUNITY IMPACT.....</b> | <b>191</b>  |
| 20.1 INTRODUCTION .....   | 191         |
| 20.2 PROJECT APPROVALS AND PERMITTING .....   | 191         |
| 20.2.1 Separation Rapids Permitting, July 2016.....                                   | 191         |
| 20.2.2 Advanced Exploration .....   | 193         |
| 20.2.3 Construction, Operations and Closure .....                                     | 194         |
| 20.2.4 Conclusion .....   | 197         |
| 20.3 ENVIRONMENTAL BASELINE .....   | 197         |
| 20.4 TOPOGRAPHY.....  | 198         |
| 20.5 AIR QUALITY.....   | 198         |
| 20.6 NOISE.....   | 199         |
| 20.7 HYDROLOGY .....  | 199         |
| 20.8 WATER QUALITY .....  | 200         |
| 20.9 GROUNDWATER.....   | 202         |
| 20.10 VEGETATION.....   | 202         |
| 20.11 WILDLIFE.....   | 204         |
| 20.12 FISHERIES.....  | 204         |
| 20.13 TAILINGS AND CONCENTRATE MANAGEMENT .....                                       | 205         |
| 20.13.1 Mine Rock Aggregate and Mineralized Material Management .....                 | 206         |
| 20.14 SEWAGE TREATMENT.....   | 208         |
| 20.15 WATER MANAGEMENT .....  | 208         |

|  | <b>Page</b> |
|--|-------------|
| 20.15.1 Water Management Measures.....   | 209         |
| 20.16 CLOSURE AND REHABILITATION .....   | 212         |
| 20.17 COMMUNITY AND INDIGENOUS PEOPLES ENGAGEMENT .....                        | 214         |
| <b>21.0 CAPITAL AND OPERATING COSTS.....</b>                                   | <b>216</b>  |
| 21.1 CAPITAL COSTS .....   | 216         |
| 21.1.1 Mining.....   | 216         |
| 21.1.2 Concentrator.....   | 217         |
| 21.1.3 Hydrometallurgical Facility .....                                       | 218         |
| 21.1.4 Tailings Storage Facility, Waste Rock and Water Management .....        | 219         |
| 21.1.5 Owner’s Costs.....  | 220         |
| 21.1.6 Closure Costs .....   | 220         |
| 21.2 OPERATING COSTS .....   | 220         |
| 21.2.1 Mining.....   | 221         |
| 21.2.2 Concentrator.....   | 222         |
| 21.2.3 Hydrometallurgical Plant.....   | 224         |
| 21.2.4 General and Administration.....   | 225         |
| 21.2.5 Petalite Tails Reclaim and Feldspar Production .....                    | 226         |
| <b>22.0 ECONOMIC ANALYSIS .....</b>  | <b>227</b>  |
| 22.1 MACRO-ECONOMIC ASSUMPTIONS .....  | 227         |
| 22.1.1 Exchange Rate and Inflation.....  | 227         |
| 22.1.2 Weighted Average Cost of Capital .....                                  | 227         |
| 22.1.3 Expected Metal Prices.....  | 228         |
| 22.1.4 Taxation Regime.....  | 228         |
| 22.1.5 Royalty.....  | 228         |
| 22.1.6 Selling Expenses .....  | 228         |
| 22.2 TECHNICAL ASSUMPTIONS .....   | 228         |
| 22.2.1 Mine Production Schedule.....   | 228         |
| 22.2.2 Operating Costs.....  | 230         |
| 22.2.3 Capital Costs.....  | 231         |
| 22.2.4 Base Case Cash Flow.....  | 231         |
| 22.3 SENSITIVITY STUDY.....  | 234         |
| 22.3.1 Capital, Operating Costs and Revenue Sensitivity .....                  | 234         |
| 22.4 CONCLUSION.....   | 234         |
| <b>23.0 ADJACENT PROPERTIES .....</b>  | <b>235</b>  |
| 23.1 INTRODUCTION .....  | 235         |
| 23.2 BIG MACK PEGMATITE.....   | 236         |
| 23.3 EASTERN PEGMATITE SUBGROUP .....  | 237         |
| 23.3.1 Marko’s Pegmatite.....  | 237         |
| 23.3.2 Lou’s Pegmatite and Other Pegmatites.....                               | 238         |
| 23.4 SOUTHWESTERN PEGMATITE SUBGROUP .....                                     | 238         |
| 23.5 WESTERN PEGMATITES INCLUDING GLITTER, WOLF AND<br>RATTLER PEGMATITES..... | 239         |



|  | <b>Page</b> |
|--|-------------|
| <b>24.0 OTHER RELEVANT DATA AND INFORMATION .....</b>    | <b>240</b>  |
| 24.1 PROJECT DEVELOPMENT SCHEDULE .....                  | 240         |
| <b>25.0 INTERPRETATION AND CONCLUSIONS .....</b>         | <b>241</b>  |
| <b>26.0 RECOMMENDATIONS.....</b>                         | <b>244</b>  |
| 26.1 GEOLOGY AND MINERAL RESOURCES .....                 | 244         |
| 26.1.1 Geological Mapping.....                           | 244         |
| 26.1.2 Mineralogy .....                                  | 244         |
| 26.1.3 Exploration and Resource Definition Drilling..... | 244         |
| 26.2 METALLURGICAL TESTWORK.....                         | 245         |
| 26.3 MINING METHODS .....                                | 246         |
| 26.4 MARKETING .....                                     | 246         |
| 26.5 ENVIRONMENTAL/SOCIAL .....                          | 247         |
| 26.6 PROPOSED WORK PROGRAM .....                         | 248         |
| <b>27.0 DATE AND SIGNATURE PAGE.....</b>                 | <b>249</b>  |
| <b>28.0 REFERENCES.....</b>                              | <b>251</b>  |
| <b>29.0 CERTIFICATES.....</b>                            | <b>256</b>  |

**List of Tables**

|            |  |    |
|------------|--|----|
| Table 1.1  | List of Mineral Processing Testwork Reports.....   | 5  |
| Table 1.2  | List of Recent Hydrometallurgical Testwork Reports .....   | 6  |
| Table 1.3  | Separation Rapids, Mineral Resource Estimate at 0.6% Li <sub>2</sub> O Cut-off<br>Grade.....                                     | 7  |
| Table 1.4  | LOM Capital Estimate .....   | 18 |
| Table 1.5  | Summary of LOM Operating Costs .....   | 19 |
| Table 1.6  | LOM Cash Flow Summary .....  | 20 |
| Table 1.7  | Avalon Proposed Budget for Ongoing Work.....   | 27 |
| Table 2.1  | List of Abbreviations .....  | 30 |
| Table 4.1  | Separation Rapids Claim Listing .....  | 37 |
| Table 4.2  | Separation Rapids Mining Lease .....   | 37 |
| Table 5.1  | Average Temperatures, Kenora Weather Station, 1981-2010 .....  | 42 |
| Table 5.2  | Average Precipitation, Kenora Weather Station, 1981-2010.....  | 43 |
| Table 5.3  | Average Wind Speed, Kenora Weather Station, 1981-2010.....   | 43 |
| Table 7.1  | Mapped Lithologies in the Separation Rapids Property .....   | 49 |
| Table 7.2  | Separation Rapids Area Pegmatite Nomenclature .....  | 51 |
| Table 7.3  | Subunits of Unit 6: Petalite Pegmatite .....   | 55 |
| Table 7.4  | Main Zones Comprising the Separation Rapids Pegmatite Area.....  | 58 |
| Table 7.5  | Visual Mineral Estimates from 1997-98 Drill Core Logging .....   | 60 |
| Table 7.6  | Constituent Minerals of the Separation Rapids Pegmatite.....   | 62 |
| Table 7.7  | Petalite Composition .....   | 63 |
| Table 7.8  | Average Li <sub>2</sub> O Content and Estimated Percentage Petalite across Main<br>Pegmatites of Separation Rapids Property..... | 64 |
| Table 7.9  | Representative Samples from Unit 6 of the Separation Rapids<br>Pegmatite.....  | 65 |
| Table 7.10 | Results of the Modal Point Count Analysis of Unit 6 Lithologies .....  | 66 |
| Table 7.11 | X-Ray Diffraction Analysis of Sample 862938 from Separation<br>Rapids .....  | 68 |
| Table 7.12 | Qemscan® Mineralogical Analysis by ALS.....  | 69 |
| Table 7.13 | Mineral Modal Abundance: Comparison of ALS Qemscan® with<br>Pedersen (2016) Visual Core Estimates.....                           | 70 |

|             | <b>Page</b>   |
|-------------|---|
| Table 7.14  | Average Mineral Contents Estimated by Pedersen, Taylor, Lakefield and ALS .....70                 |
| Table 8.1   | Tonnage and Grade for Three Major Complex-type Pegmatites .....74                                 |
| Table 9.1   | Comparison of Subsample Statistics of Li% with Li% of Composite .....77                           |
| Table 10.1  | Summary Drilling Statistics, Separation Rapids Pegmatite .....79                                  |
| Table 11.1  | QA/QC Sample Statistics .....84   |
| Table 11.2  | Analyses of Drill Core Samples, 1997-1999 and 2001 .....84  |
| Table 11.3  | 1998 Specific Gravity Measurements .....86  |
| Table 11.4  | Comparison of SG Measurements, 1998/99 and 2014 .....87   |
| Table 12.1  | Summary Statistics for Figure 12.1 .....89  |
| Table 12.2  | Summary Statistics for Figure 12.2 .....90  |
| Table 12.3  | Independent Check Assay Results .....91   |
| Table 12.4  | Conversion Factors from Element to Oxide .....93  |
| Table 12.5  | Statistics Relevant to Figure 12.7 .....98  |
| Table 12.6  | Statistics Relevant to Figure 12.8 .....99  |
| Table 12.7  | Difference in Database Coordinates and Survey Coordinates .....100                                |
| Table 12.8  | Survey Coordinates for Handheld GPS Unit (2016) Compared to Database UTM Coordinates.....101      |
| Table 12.9  | Drill Hole Azimuths .....102  |
| Table 13.1  | List of Mineral Processing Testwork Reports.....104   |
| Table 13.2  | Analysis of the 2013 Metallurgical Test Sample to ANZAPLAN .....105                               |
| Table 13.3  | Sensor Based Sorting Product Analyses .....106  |
| Table 13.4  | Comparison of FGP and CGO Modal Mineralogical Analyses.....107                                    |
| Table 13.5  | Magnetic Separation Test Results .....109   |
| Table 13.6  | Filtration Test Results .....110  |
| Table 13.7  | Chemical Analysis of the Pilot Plant One Tonne Petalite Concentrate Product .....111              |
| Table 13.8  | List of Recent Hydrometallurgical Testwork Reports .....113                                       |
| Table 13.9  | Summary of SRC Preliminary Petalite Leaching Test 4 Results .....113                              |
| Table 13.10 | High Level Comparison of Hydrometallurgical Process Options to Produce Lithium Hydroxide .....114 |
| Table 13.11 | Petalite Flotation Concentrate Sample Head Sample Analyses .....117                               |

|             | <b>Page</b>   |
|-------------|---|
| Table 14.1  | Separation Rapids, Mineral Resource Estimate at 0.6% Li <sub>2</sub> O Cut-off Grade.....126            |
| Table 14.2  | Lithological Units Used in Resource Estimation .....128   |
| Table 14.3  | Separation Rapids, Statistics for Specific Gravity Measurements.....128                                 |
| Table 14.4  | Average Assay Data Weighted by Interval Length for All Intervals.....129                                |
| Table 14.5  | Average Assay Data Weighted by Interval Length for Single-Lithology Intervals Only .....130             |
| Table 14.6  | Unweighted Li <sub>2</sub> O Assay Statistics for Single-lithology Intervals .....131                   |
| Table 14.7  | Basic Statistics for Composites within the Lithium Pegmatite Geology Model (OREC=6) .....132            |
| Table 14.8  | Block Model Specifications .....134   |
| Table 14.9  | Block Model Data Field Parameters in MineSight 3D .....134  |
| Table 14.10 | Interpolation Parameters for the Separation Rapids Resource Model .....135                              |
| Table 14.11 | Block Model Statistics .....136   |
| Table 14.12 | Separation Rapids, Mineral Resource Classification Scheme .....137                                      |
| Table 14.13 | Separation Rapids, Mineral Resource Estimate at Multiple Cut-off Grades as at 21 October, 2016 .....138 |
| Table 14.14 | Grade-tonnage Data for Measured Plus Indicated Mineral Resources .....144                               |
| Table 14.15 | Micon September 1999 Estimate at 1.0% Li <sub>2</sub> O Cut-off Grade.....145                           |
| Table 14.16 | Average Feldspar Contents at Separation Rapids .....147   |
| Table 14.17 | Feldspar Contents of Metallurgical Bulk Samples.....147   |
| Table 16.1  | Separation Rapids, Open Pit Optimization Parameters.....149   |
| Table 16.2  | Pit Design Parameters .....152  |
| Table 16.3  | Separation Rapids Production Schedule .....156  |
| Table 16.4  | Summary of Ancillary Equipment .....157   |
| Table 16.5  | Labour Requirements .....157  |
| Table 19.1  | Lithium Mineral and Brine Production .....180   |
| Table 19.2  | Approximate LCE Required by some Electric Vehicles.....182  |
| Table 19.3  | Lithium Feedstock Chemical Demand, 2013-2025 .....184   |
| Table 19.4  | Price Forecast Trend for Battery-grade Lithium Hydroxide and Lithium Carbonate .....186                 |
| Table 19.5  | Feldspar, Mine Production by Country.....187  |
| Table 19.6  | United States Market for Potassium Feldspar, 2015 Pricing by End-use Application .....189               |

|             | <b>Page</b>   |
|-------------|---|
| Table 20.1  | Areal Extent of Major Project Components at the Separation Rapids Site .....203 |
| Table 21.1  | LOM Capital Estimate .....216   |
| Table 21.2  | Summary of Initial Capital Costs.....217  |
| Table 21.3  | Summary of the Estimated Concentrator Capital Costs.....217                     |
| Table 21.4  | Summary of the Estimated Hydrometallurgical Plant Capital Costs .....218        |
| Table 21.5  | Summary of the Estimated Hydrometallurgical Plant Capital Costs .....220        |
| Table 21.6  | Summary of LOM Operating Costs .....221   |
| Table 21.7  | Average Estimated Mine Operating Costs (Owner Mining).....222                   |
| Table 21.8  | Average Estimated Concentrator Operating Costs .....222                         |
| Table 21.9  | Average Estimated Hydrometallurgical Plant Operating Costs.....224              |
| Table 21.10 | Summary of Feldspar Production Operating Costs.....226                          |
| Table 22.1  | Operating Cost Estimate .....230  |
| Table 22.2  | LOM Cash Flow Summary .....232  |
| Table 22.3  | Base Case Life-of-Mine Annual Cash Flow .....233                                |
| Table 26.1  | Avalon Proposed Budget for Ongoing Work.....248                                 |

**List of Figures**

|             |  |    |
|-------------|--|----|
| Figure 1.1  | Simplified Process Block Flow Diagram.....   | 11 |
| Figure 1.2  | Annual Sales Revenues by Product.....  | 20 |
| Figure 1.3  | Life-of-Mine Cash Flows.....   | 21 |
| Figure 4.1  | Separation Rapids Property General Location Map.....   | 35 |
| Figure 4.2  | Separation Rapids Property Claim Map.....  | 36 |
| Figure 4.3  | Location of Advance Exploration Approval.....  | 38 |
| Figure 5.1  | Location of the Avalon Separation Rapids Property.....   | 40 |
| Figure 5.2  | Graph of Average Temperatures, Kenora 1982-2012.....   | 42 |
| Figure 7.1  | Location of the Separation Rapids Lithium Deposit.....   | 47 |
| Figure 7.2  | District Geological Map.....   | 48 |
| Figure 7.3  | Generalized Geology – Separation Rapids Lithium Deposit .....  | 50 |
| Figure 7.4  | SRLD, Detailed Outcrop Mapping .....   | 52 |
| Figure 7.5  | SRLD, Extension of the Main Pegmatite Body .....   | 53 |
| Figure 7.6  | Location of Drill Holes Used for Mineralogical Studies .....   | 66 |
| Figure 7.7  | Drill Holes with Samples with Measured Quantitative Mineralogy.....  | 71 |
| Figure 10.1 | Map of Drill Hole Locations, Separation Rapids Property .....  | 79 |
| Figure 12.1 | Scatter Plot of Original Sample (XRAL Analysis) and Reject Duplicate Sample (Chemex Analysis) for Li <sub>2</sub> O..... | 89 |
| Figure 12.2 | Scatter Plot of Original Sample (XRAL Analysis) and Field Duplicate Sample (Chemex Analysis) for Rb <sub>2</sub> O.....  | 90 |
| Figure 12.3 | Plot of XRAL (Original) versus Micon/Chemex (Check) Analyses for Li <sub>2</sub> O.....                                  | 92 |
| Figure 12.4 | Plot of XRAL (Original) versus Micon/Chemex (Check) Analyses for Rb <sub>2</sub> O.....                                  | 92 |
| Figure 12.5 | Run Chart for Lithium for Standard in Round Robin Test – All Results, 2016.....  | 95 |
| Figure 12.6 | Run Chart of Lithium for Standard with One Laboratory Removed (2016).....  | 96 |
| Figure 12.7 | Comparison of Original Lithium Analyses (Pedersen 1998) with Core Duplicates (“Field Resample”) Reanalysis (2016).....   | 97 |
| Figure 12.8 | Comparison of Original Rubidium Analyses (Pedersen 1998a) with Core Duplicates (“Field Resample”) (2016).....            | 98 |
| Figure 12.9 | Lithium Analyses for Lithium Standard SR2016 .....   | 99 |

|   | <b>Page</b> |
|---|-------------|
| Figure 13.1 ANZAPLAN Sample Preparation and Separation Procedure.....   | 106         |
| Figure 13.2 Process Flowsheet to Recover both a Petalite and Feldspar Concentrate .....   | 108         |
| Figure 13.3 Preliminary Flowsheet of the Preferred Lithium Hydroxide Production Process .....   | 115         |
| Figure 13.4 Electrodialysis Cell Schematic.....   | 116         |
| Figure 13.5 Results from Bench Scale Ion Exchange Tests.....  | 120         |
| Figure 14.1 Isometric View of the Unit 6 Geology Model .....  | 127         |
| Figure 14.2 Length-Weighted Average Grades of Single-lithology Samples.....   | 130         |
| Figure 14.3 Separation Rapids, Normal Distribution of Lithium Oxide Grade .....   | 131         |
| Figure 14.4 Correlogram Models of Li <sub>2</sub> O% for Composites within the Lithium Pegmatite Geological Model.....  | 133         |
| Figure 14.5 Composite Selection During the Second Interpolation Pass for Block 10-165-63 (388475 E, 5568993.5 N 300 Z) in Plan View (Left) and Cross-Section Looking Northeast At 015° (Right)..... | 136         |
| Figure 14.6 Measured, Indicated, and Inferred Grade Shells for a Cut-off grade of 0.6% Li <sub>2</sub> O .....  | 137         |
| Figure 14.7 Measured Plus Indicated Resource Grade Shells at 0.3% Li <sub>2</sub> O Cut-off Grade.....  | 139         |
| Figure 14.8 Measured Plus Indicated Resource Grade Shells at 0.6% Li <sub>2</sub> O Cut-off Grade.....  | 140         |
| Figure 14.9 Measured Plus Indicated Resource Grade Shells at 1.0% Li <sub>2</sub> O Cut-off Grade.....  | 140         |
| Figure 14.10 Cross Section 388200 East with Drill Holes and Resource Blocks (looking west) .....  | 141         |
| Figure 14.11 Cross Section 388300 East with Drill Holes and Resource Blocks (looking west) .....  | 142         |
| Figure 14.12 Cross Section 388400 East with Drill Holes and Resource Blocks (looking west) .....  | 142         |
| Figure 14.13 Cross Section 388500 East with Drill Holes and Resource Blocks (looking west) .....  | 143         |
| Figure 14.14 Cross Section 388600 East with Drill Holes and Resource Blocks (looking west) .....  | 143         |
| Figure 14.15 Separation Rapids, Grade-tonnage Curve for the 21 October, 2016 Measured plus Indicated Mineral Resource.....  | 144         |
| Figure 14.16 Locations of Quantitative Mineralogy Samples that Includes Detailed Feldspar Content within Resource Model.....  | 146         |

|   | <b>Page</b> |
|---|-------------|
| Figure 16.1 Pit Optimization Results by Pit Shell.....  | 150         |
| Figure 16.2 Starter Pit Shell .....   | 151         |
| Figure 16.3 Optimum Pit Shell.....  | 151         |
| Figure 16.4 Plan View of the Pit Design .....   | 153         |
| Figure 16.5 West-East Long Section View of the Pit Design .....   | 153         |
| Figure 17.1 Simplified Process Block Flow Diagram.....  | 159         |
| Figure 18.1 Location of the Separation Rapids Property .....  | 172         |
| Figure 18.2 Route of the Avalon Mine Road .....   | 173         |
| Figure 18.3 Location of Rail and Road Infrastructure Around Redditt and Kenora .....                          | 176         |
| Figure 19.1 2015 Lithium Consumption by End-use Application .....   | 181         |
| Figure 19.2 Lithium Demand Growth Forecasts .....   | 182         |
| Figure 19.3 Electric Vehicle LCE Demand Growth.....   | 183         |
| Figure 19.4 Global Lithium Battery Demand - All Applications.....   | 183         |
| Figure 19.5 Lithium Contract Prices .....   | 185         |
| Figure 19.6 Benchmark Mineral Intelligence Project of Lithium Hydroxide and<br>Lithium Carbonate Prices ..... | 186         |
| Figure 19.7 2015 Feldspar Demand End-use Sector .....   | 189         |
| Figure 20.1 Separation Rapids Project Site Layout.....  | 192         |
| Figure 20.2 Site Catchment Boundaries.....  | 200         |
| Figure 20.3 Tailings/Concentrate, Mine Rock and Surface Water Management<br>Layout .....                      | 210         |
| Figure 20.4 Separation Rapids Site Water Balance.....   | 211         |
| Figure 22.1 Annual Mining Schedule .....  | 229         |
| Figure 22.2 Annual Processing Schedule.....   | 229         |
| Figure 22.3 Annual Sales Revenues by Product.....   | 230         |
| Figure 22.4 LOM Cash Operating Costs .....  | 231         |
| Figure 22.5 LOM Cash Flows .....  | 232         |
| Figure 22.6 NPV Sensitivity Diagram.....  | 234         |
| Figure 23.1 Location of Claims in the Separation Rapids Project Area.....                                     | 235         |
| Figure 24.1 Separation Rapids Project Development Schedule.....   | 240         |
| Figure 25.1 Life-of-mine Cash Flows .....   | 242         |



## 1.0 SUMMARY

### 1.1 INTRODUCTION

Micon International Limited (Micon) has been retained by Avalon Advanced Materials Inc. (Avalon) to prepare a Technical Report under Canadian National Instrument 43-101 (NI 43-101) which discloses the results of the preliminary economic assessment (PEA) for the Separation Rapids Lithium Project.

The objective of this PEA is to demonstrate the economic potential for producing a lithium ion battery material from the Separation Rapids Lithium Deposit (SRLD). The deposit was evaluated previously in 1999-2000 as a potential source of the lithium mineral, petalite, for glass-ceramics applications. While this market remains an opportunity, lithium ion battery technology has developed as the energy storage solution of choice for a variety of commercial applications and this has resulted in a significant increase in current and projected demand, for battery materials.

This PEA has been prepared by Micon under the terms of its agreement with Avalon. As discussed in the relevant sections of the report, Micon has prepared a mine plan and schedule and has prepared an economic analysis of the project. Micon has reviewed the metallurgical testwork carried out on the property and the mineral processing flowsheet, has reviewed infrastructure requirements, and has reviewed capital and operating cost estimates prepared by Avalon and its retained consultants.

The PEA is based on mineral resource estimates for lithium and feldspar contained in the Separation Rapids Lithium Deposit (SRLD), prepared by Benjamin Webb, Principal with BMW Resource Consultants LLC, dated 21 October, 2016.

Micon's site visit to the Separation Rapids property was conducted on 21 July, 2016 by Richard Gowans. Benjamin Webb also visited the site on 21 July, 2016. They were accompanied by Chris Pedersen, Senior Geologist with Avalon.

The Separation Rapids property is located in northwestern Ontario, 55 km due north of Kenora and about 70 km by road. It is centred on latitude 50 15' 30" N, longitude 94 35' W (UTM coordinates: 388441E 5568996N in Zone 15, NAD83). The property consists of eight mineral claims and one Mining Lease. The claims comprise 90 claim units, totalling 1,440 ha (3,558 acres). The Mining Lease encompasses the mineralized zone and is referred to as Lease or Licence Number 108395 (Paterson Lake CLM469). The lease covers an area of 421.441 ha over the area of the SRLD and adjacent lands.

Other than minor reclamation requirements that are largely funded under the existing Advanced Exploration Approval (presently called Bulk Sample Permission), there are no known environmental liabilities associated with the Separation Rapids property. Avalon holds all necessary permits required to access the Separation Rapids property and to conduct exploration. Exploration permits will be required for additional drilling in the future. There

are no known factors or risks that may affect access, title or the right or ability to perform work on the property.

Mining and mineral concentration will take place at the Separation Rapids property. Petalite concentrate will be shipped by truck to a hydrometallurgical processing plant planned to be located in the City of Kenora, Ontario. A trans-shipment facility will be required in order to access rail transportation for product shipment and inbound supplies. The trans-shipment facility is planned to be located on the Canadian National Railway (CNR) main line in the vicinity of Redditt, Ontario. Avalon has not made the final site selection for the hydrometallurgical plant and trans-shipment facility and has not acquired ownership or rights to any land for these facilities.

## **1.2 PHYSIOGRAPHY AND CLIMATE**

The Separation Rapids area is typical of much of northwestern Ontario and the Canadian Shield. The property is relatively flat with an average elevation of approximately 350 masl. Local topographic relief is limited to 50 m or less with typical Precambrian glaciated terrain. The English River system is proximal to all claim groups. The area is located within the Boreal Hardwood Transition or Mixed Boreal Forest. A Species at Risk Act assessment was completed and no endangered or at risk species were identified in the area of the proposed project. The climate is typical of Canada's mid-latitudes with long, cold winters and comparatively short spring-summer-fall periods.

The closest centre with significant services is Kenora. Forestry, tourism and mining are the three largest sectors of the Kenora economy.

## **1.3 HISTORY**

Rare-element mineralization in the area was first encountered along the English River near Separation Rapids in 1932. The petalite-bearing SRLD and an associated group of rare-metal pegmatites, were discovered by Dr. Fred Breaks of the Ontario Geological Survey (OGS) as a result of a detailed study of rare-metal pegmatites in the region between 1994 and 1996.

## **1.4 GEOLOGICAL SETTING AND MINERALIZATION**

The Late Archean SRLD belongs to the petalite sub-type of the complex-type class of rare-metal pegmatites. The SRLD, its parent granite, the Separation Rapids Pluton, and associated rare-metal pegmatites occur within the Archean Separation Lake Metavolcanic Belt (SLMB) which forms the boundary between the English River subprovince to the north and the Winnipeg River subprovince to the south. Both subprovinces are part of the larger Archean Superior Province of the Canadian Shield. Avalon has divided the SRLD into the Separation Rapids Pegmatite, the Western Pegmatite and the Eastern Swarm.

Petalite, potassium feldspar and sodium feldspar are the major rock-forming and primary minerals in the Separation Rapids Pegmatite (SRP), with subordinate amounts of other

minerals including spodumene, lithian muscovite, lepidolite, and quartz. The petalite-bearing Unit 6 is the principal unit of interest within the SRP. Geological mapping and assays for surface and drill core samples show that mineralogy and lithium oxide (Li<sub>2</sub>O) grades of the mineralization in the SRP are relatively homogeneous and that the petalite is close to the theoretical (stoichiometric) chemical composition, as well as being very pure, with marked absence of deleterious elements such as iron.

## **1.5 EXPLORATION**

Following the discovery of the SRLD in 1996, Avalon carried out a brief prospecting and sampling program in November, 1996. This was followed by a program of geological mapping, trenching, line-cutting and magnetometry in 1997 and 1998.

In the period from 2000 to 2014, little work of a geoscientific nature was carried out at the property. The main activity relating to advancing the project was metallurgical and, consequently, the main activities at site were collection of samples, up to bulk sample size, for metallurgical testing.

## **1.6 DRILLING**

Avalon undertook a number of drilling campaigns between 1997 and 2001. Since 2001, no further drilling has taken place at the property. The total number of drill holes is 72 for a cumulative total of 10,708 m.

Three of these holes were drilled between 26 April and 4 May, 2001 for the purposes of a geomechanical investigation of the rock mass at the proposed open pit mine and to develop suitable pit slope design parameters. The potential for water inflow into the open pit was also evaluated.

## **1.7 SAMPLE PREPARATION, ANALYSES AND SECURITY**

Surface samples taken in the 1990s were shipped to Chemex Labs Ltd. in Thunder Bay, Ontario for preparation then to Chemex's laboratories in Mississauga, Ontario and Vancouver, British Columbia for subsequent assaying. Surface samples were analysed for lithium and a range of other elements including tin, rubidium, cesium, tantalum, gallium and niobium.

In the 1990s, drill core was logged and split with half of the core being sent for assay and the other half being stored in core boxes on site. Core sample intervals were varied according to the lithology, to a maximum of 3 m. Split core samples were shipped to XRAL Laboratories (XRAL) in Don Mills, Ontario, where they were assayed for lithium, rubidium, cesium and tantalum. A total of 2,516 drill core samples were assayed at XRAL, with an additional 223 duplicate analyses. Check-assaying was routinely carried out for lithium and rubidium by Chemex at its Vancouver, British Columbia, and Mississauga, Ontario facilities.

The drilling database contains 185 specific gravity values for various lithologies on the SRLD. This comprises 118 measurements on pegmatite, 66 on amphibolite and one measurement which was considered an outlier and was rejected. The average SG for pegmatite is 2.62 for the 118 samples (one high outlier at 3.16 removed). The average SG for amphibolite (waste) is 3.04 based on the 66 measurements. The SG measurements show low variability (standard deviation of 0.08, or 3% for pegmatite and 0.05 or 2% for amphibolite) indicating that the risk of significant error is also low.

## **1.8 DATA VERIFICATION**

The mineral resource estimate presented in this report is based on the original drilling by Avalon in 1997 to 2001, and the assay database created in 1999. Quality assurance/quality control procedures were applied and included check assays at a second laboratory and independent assaying. Subsequently, Avalon completed further verification of the drill data, including cross-checking the database against original field records, such as drill logs, cross-checking the assays against laboratory assay certificates and reassaying drill core splits with inserted internally certified lithium standards.

The comparison of the XRAL and Chemex data sets is favourable. Despite some small differences, both the lithium and rubidium analyses from XRAL and Chemex are close and show similar trends with strong  $R^2$  scores for the correlation. This indicates high and acceptable reliability in the analyses.

For the purpose of this PEA, Avalon verified the drill hole database against historic data records such as drill logs, assay certificates, and other original sources of data in order to ensure that there were no errors present in the Maxwell Geoservices DataShed™ (DataShed) database used for resource estimation. Drill hole angle, direction and the maximum hole depth were also verified.

As of 6 July, 2016, the database contained records for 2,790 downhole samples which were assayed for the 1997, 1998 and 2001 drill programs. A random sampling of 12% of the assay values contained in DataShed were compared against the values as reported on the original certificates of analysis provided by XRAL. No errors were found in the downhole assay values as entered into DataShed from the original database.

Trench samples were exported into Excel in the same manner.

### **1.8.1 Certified Standard**

Avalon prepared a certified rock lithium analysis standard by shipping 16 kg of Separation Rapids Pegmatite to CDN Resource Laboratories Ltd. (CDN) in Langley, British Columbia. A Round Robin analysis procedure was then completed with five samples of the material being shipped to each of six laboratories for lithium analysis, with associated analytical methods performed.

It was concluded that the lithium standard was a suitable standard for QA/QC of Separation Rapids drill core samples. The certified value for the standard SR2016 is 1.48% Li<sub>2</sub>O with a standard deviation of 0.03% Li<sub>2</sub>O for future analyses of Separation Rapids samples.

## 1.9 MINERAL PROCESSING AND METALLURGICAL TESTING

A number of phases of metallurgical testing since 1997 have been completed by Avalon using samples obtained from the SRLD. The work prior to 2014 was mainly undertaken by SGS Mineral Services at Lakefield, Ontario (SGS-L). This work not only included the recovery of petalite, but also a number of other mineral products which can be found in the lithium bearing pegmatite as well. The work since 2014 has focussed on the recovery of a petalite flotation concentrate and the subsequent processing of this concentrate to produce a high quality lithium hydroxide product suitable for the lithium battery industry.

Avalon approached Dorfner ANZAPLAN (ANZAPLAN), a German company that specializes in the processing of high purity industrial and strategic minerals, to develop a process for recovering the petalite and achieving target product grade of >4% LiO<sub>2</sub>. ANZAPLAN also investigated the recovery of a low impurity feldspar by-product and tested this product to determine its suitability in a number of industrial applications.

Avalon investigated the potential to use petalite as a source of both lithium carbonate and hydroxide. Initial investigations for producing carbonate were completed by the Saskatchewan Research Council (SRC) and subsequently by Thibault and Associates Inc. (Thibault), which developed the process for producing lithium hydroxide.

Table 1.1 lists all the flotation/concentrator testwork reports issued since the project was re-activated in 2014 and Table 1.2 lists the hydrometallurgical testwork programs.

**Table 1.1**  
**List of Mineral Processing Testwork Reports**

| Date           | Author   | Title  | Remarks  |
|----------------|----------|--|--|
| June 2014      | ANZAPLAN | Processing of Petalite Ore from Separation Rapids                            | Petalite and feldspar flotation testwork on coarse grained mineralized material.                           |
| August 2014    | ANZAPLAN | Physical Processing of Fine Grained Ore from Separation Rapids               | As above but using fine grained mineralized material.  |
| September 2014 | ANZAPLAN | Processing of Petalite Ceramic Application Tests                             | Sample of petalite was tested to determine key physical/chemical characteristics for ceramic applications. |
| September 2014 | ANZAPLAN | Sample Production of Petalite and Feldspar Concentrate                       | 20 kg of both materials were produced for providing samples to potential clients.                          |
| November 2014  | ANZAPLAN | Flowsheet and Core Machinery   | Base flotation flowsheet and preliminary equipment recommendations.  |
| December 2014  | ANZAPLAN | Locked Cycle Petalite Flotation Tests on Fine Grained Ore (FGO)              | Bench scale determination of petalite flotation recovery with locked cycle tests.                          |
| June 2015      | ANZAPLAN | Pretests Pilot Scale Sample Production of Petalite and Feldspar Concentrates | To determine optimum conditions for magnetic separation and product filtration.                            |
| July 2015      | ANZAPLAN | Analysis of Nb/Ta in Magnetic Fraction of Separation Rapids Ore              | Determination of nature of Nb and Ta in magnetics discard stream.  |

| Date          | Author   | Title  | Remarks  |
|---------------|----------|--|--|
| December 2015 | ANZAPLAN | Testing and characterization of a feldspar filler                                | Sample of feldspar was tested to determine key physical/chemical characteristics for flier applications.   |
| May 2016      | ANZAPLAN | Pilot Scale Sample Production of 1t Petalite Concentrate                         | Bulk sample processed to produce a 1 t sample of petalite.   |
| June 2016     | ANZAPLAN | Evaluation of HPQ Potential of Flotation Tailings from the Big Whopper Pegmatite | Testwork investigations to determine if tailings from pilot plant could be used to produce a high purity quartz (HPQ) product.   |
| May 2016      | Dorfner  | Testing of Feldspar sample as potential paint filler                             | Note from Dorfner confirming their tests indicating Avalon feldspar matches existing paint fillers.  |
| 2015/2016     | SRC      | Various flotation tests analyses   | Excel spreadsheets with test results plus various small petalite sample production tests.  |
| October 2016  | ANZAPLAN | Sample Production – Feldspar Filler  | Feldspar concentrate with lower silica content produced by introducing a number of cleaner flotation stages. This was then milled to a d50 of 6 µm and determined to have a SWERF value of 0.6%. |

**Table 1.2**  
**List of Recent Hydrometallurgical Testwork Reports**

| Date                   | Author   | Title  | Remarks   |
|------------------------|----------|--|---|
| May 2015               | SRC      | Preliminary Li leaching, purification and Li carbonate and hydroxide preparation from petalite concentrate | Testwork to determine if battery specification carbonate and hydroxide can be produced from petalite.   |
| December 2015          | SRC      | Li Carbonate Production from Petalite Concentrate  | Bench optimization of process to produce battery specification lithium carbonate.   |
| December 2015          | Thibault | Process Alternatives- High Level Operating Cost Assessment   | Thibault compare various lithium hydroxide production processes to identify most cost efficient.  |
| September/October 2016 | Thibault | Hydrometallurgical Bench Scale Test Program/Process Simulation and Economic Model                          | Bench scale assessment of most favourable conditions for main stream unit operations including electro dialysis and development of process design criteria. |

Through the completion of these testwork programs Avalon was able to demonstrate the following:

- A petalite concentrate assaying over 4% Li<sub>2</sub>O can be produced which, because of its low impurity levels, is potentially an excellent feed material to the specialized glass/ceramics industries.
- A low impurity mixed (sodium/potassium) feldspar concentrate can also be produced which has applications in a number of ceramic applications as well as a filler in paints and other products.

- There is potential to produce other by-products from the mineralized material, including a high purity quartz, and for additional lithium recovery from the magnetic fraction.
- The petalite can be used as a feed source to produce both lithium carbonate and lithium hydroxide for the battery and energy storage industries.
- The use of electro dialysis has been shown as a viable process for producing lithium hydroxide from a lithium sulphate solution.

There remain a number of areas within the process flowsheet that have the potential for improvement and optimization in terms of lower costs and increased process efficiencies.

## 1.10 MINERAL RESOURCE ESTIMATES

Lithium and feldspar mineral resource estimates for the Separation Rapids project have been prepared by Benjamin Webb, P.Geol. (B.C.), Principal of BMW Geoscience LLC. The mineral resource estimates have been reviewed in detail by David L. Trueman, Ph.D., P.Geol., who is the Qualified Person for the resource estimates.

### 1.10.1 Lithium Mineral Resource Estimate

The project database contains 69 drill holes for 10,171 m with 2,790 assay results. The data were used to create a 3D model of the host lithology which was used to constrain the interpolation of assays. The project database is maintained in Maxwell DataShed™ software and the resource estimation utilized MineSight 3D.

The Separation Rapids Lithium Project Measured plus Indicated and Inferred mineral resource are presented in Table 1.3.

**Table 1.3**  
**Separation Rapids, Mineral Resource Estimate at 0.6% Li<sub>2</sub>O Cut-off Grade**  
**As at 21 October, 2016**

| Class                   | Tonnes (Mt) | Li <sub>2</sub> O (%) | Total Feldspar (%) | Ta <sub>2</sub> O <sub>5</sub> (%) | Cs <sub>2</sub> O (%) | Rb <sub>2</sub> O (%) | SG   |
|-------------------------|-------------|-----------------------|--------------------|------------------------------------|-----------------------|-----------------------|------|
| Measured                | 4.03        | 1.32                  | 39                 | 0.006                              | 0.017                 | 0.343                 | 2.66 |
| Indicated               | 3.97        | 1.26                  | 39                 | 0.007                              | 0.025                 | 0.362                 | 2.67 |
| Measured plus Indicated | 8.00        | 1.29                  | 39                 | 0.006                              | 0.021                 | 0.352                 | 2.66 |
| Inferred                | 1.63        | 1.42                  | 39                 | 0.008                              | 0.016                 | 0.360                 | 2.64 |

Notes:

1. CIM Definition Standards for Mineral Resources and Mineral Reserves, 10 May, 2014 were followed for this mineral resource estimate.
2. The Qualified Person for this mineral resource is David L. Trueman, Ph.D.,P.Geol.(MB).
3. The resource estimate is constrained by a 3D geologic model of the mineralized material.
4. Assay intervals for Li<sub>2</sub>O, Ta<sub>2</sub>O<sub>5</sub>, Cs<sub>2</sub>O and Rb<sub>2</sub>O were interpolated using the Inverse Distance Weighted method to create a 3D block model.

5. The resource cut-off grade of 0.6% Li<sub>2</sub>O was chosen to capture mineralization that is potentially amenable to mining, mineral concentration and off-site processing.
6. Li, Ta, Cs and Rb were originally analysed on all samples at XRAL Laboratory (Thunder Bay, Ontario) utilizing ICP (Li, Ta) and AA (Rb and Cs) and check analyses completed at CHEMEX Laboratory (Don Mills, Ontario) utilizing AA (Li) and ICP (Rb).
7. As well as due diligence to verify historic data, Avalon completed additional check analyses of historic drill core in 2016 utilizing ALS Laboratory (Vancouver) with a combination of fusion and ICP (method CCP-PKG01). Included as QA/QC procedures was a lithium rock standard within the check analysis batches.
8. Total Feldspar is the total of potassium feldspar (microcline) and sodium feldspar (albite) and the value reflects the mean and median value of all samples with quantitative mineralogy determined.
9. The percentage of Total Feldspar is based on analyses completed utilizing X-Ray diffraction and Qemscan® instrumentation on samples representing all lithological subunits of the mineral deposit. These analyses were completed at Carleton University in 1999 (XRD) and ALS Global Laboratory in 2016 (XRD and Qemscan®, Kamloops). This is supported by quantitative mineralogy of metallurgical samples determined at SGS Lakefield and Dorfner ANZAPLAN (Germany).
10. All figures are rounded to reflect the relative accuracy of the estimates. Summation of individual columns may not add-up due to rounding.
11. Mineral Resources are not Mineral Reserves and do not have demonstrated economic viability. There is no certainty that all or any part of the Mineral Resource will be converted into Mineral Reserves.
12. In addition, while the terms “measured”, “indicated” and “inferred” mineral resources are required pursuant to National Instrument 43-101, the U.S. Securities and Exchange Commission does not recognize such terms. Canadian standards differ significantly from the requirements of the U.S. Securities and Exchange Commission, and mineral resource information contained herein is not comparable to similar information regarding mineral reserves disclosed in accordance with the requirements of the U.S. Securities and Exchange Commission. U.S. investors should understand that “inferred” mineral resources have a great amount of uncertainty as to their existence and great uncertainty as to their economic and legal feasibility. In addition, U.S. investors are cautioned not to assume that any part or all of Avalon’s mineral resources constitute or will be converted into reserves.

Variographic analysis was undertaken to support the classification of the resource.

A block model covering the entire Separation Rapids Pegmatite consisting of 10 m by 3 m by 10 m blocks was constructed using MineSight 3D software. Blocks were elongated east-west to fit the strike of the deposit and were not rotated.

Interpolation of block values was done in two passes using the Inverse Distance Weighted with a power parameter of 2 (IDW2) method and block matching on ore code (OREC). A mineralization code of 6 was assigned to all blocks at least 1% within the 3D geological model of Unit 6 and a mineralization code of 1 was assigned for all other blocks. This ensures that all blocks containing mineralization received an interpolated grade. The search ellipsoid was rotated 105° to match the strike of the deposit so that the narrowest search distance was at a 15° azimuth perpendicular to strike.

### **1.10.2 Estimated Feldspar Resources**

The Separation Rapids Project is a potential producer of high purity feldspar, a mixture of albite and potassium feldspar, in addition to lithium chemicals and/or petalite. It is considered that Qemscan® measurement of 39% can be accepted as a reasonable estimate of the feldspar content of the whole pegmatite body.



## **1.11 MINERAL RESERVE ESTIMATES**

Mineral reserves estimates have not been undertaken for the Separation Rapids Lithium Project and are not presented herein.

## **1.12 MINING METHODS**

### **1.12.1 Pit Optimization**

Pit optimization was undertaken using the mineral resource block model imported into Surpac™ to create a block model compatible with the pit optimization software. A preliminary optimization was performed using Whittle™ software. Cost parameters were applied to the optimization model to assess the volume of mineral resources available for economic development. The purpose of the modelling was to generate an estimate of the mineable tonnage based on the mineral resources.

As a result of optimization, a number of ultimate pit shells were produced. Pit shell 6 was chosen as the optimum pit. A conceptual pit design was conducted using recommended slope design parameters and the optimum pit shell 6 as a template. The bench to bench face angle is 80°. A safety berm width of 4 m was applied every 10 m bench except where an 8 m safety berm has been used every third bench. A haul road width of 15 m was used from the pit base, to the surface on the assumption that two-way traffic would be operating in the mine.

### **1.12.2 Mining Method**

Conventional open pit methods using drilling and blasting, loading with excavators and shovels and hauling with rigid dump trucks are proposed. Waste from the pit will initially be composed of overburden and will be dumped in the topsoil stockpile.

The project will be undertaken by contractor-operated equipment and labour. This was selected as the base case following a cost comparison of Owner versus contractor mining operations.

Preproduction waste rock will be used to construct site roads, including the main haul roads and will also be used for the construction of tailing, concentrate and settling basin dam walls.

A production schedule has been produced in MineSched™ software. The production schedule is based on mining 700,000 t/y of high grade and 250,000 t/y of low grade material. The life of the mine is expected to be 10 years with approximately 7.0 Mt of high grade ore at 1.41% Li<sub>2</sub>O and 2.4 Mt of low grade ore at 0.66% Li<sub>2</sub>O mined over the length of the project.

### 1.13 RECOVERY METHODS

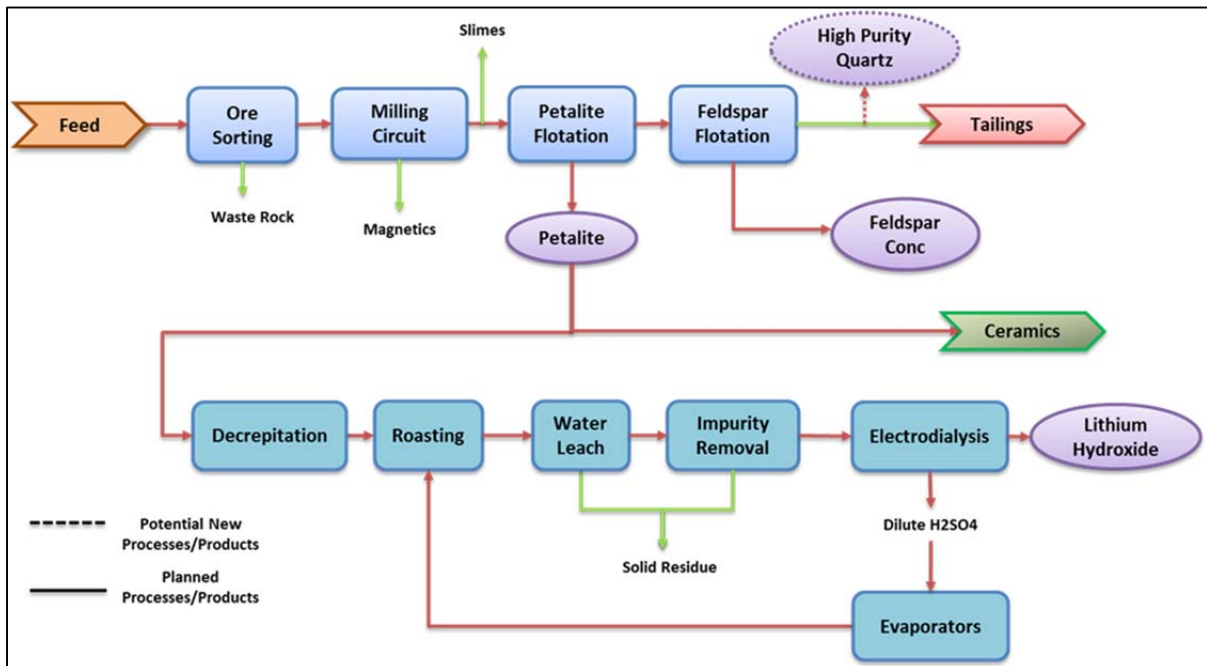
The process selected for the PEA comprises the mineral separation and recovery of a petalite concentrate containing >4.0% Li<sub>2</sub>O and a mixed sodium/potassium feldspar from petalite tailings. The process includes processing of petalite by hydrometallurgical methods to produce battery grade lithium hydroxide.

Results from the extensive testwork programs at ANZAPLAN, SRC and Thibault have been used to develop a processing flowsheet, mechanical equipment list and reagent consumptions. Thibault has also generated a “Metsim” simulation model of the entire process, data from which has been used for sizing process equipment and calculating heat and energy balances. The selected flowsheet is shown in Figure 1.1.

The process design is based on the following assumptions derived from the testwork results and Metsim model from Thibault:

- Optical sorting mass waste rejection is 14.8% with lithium losses of 1.9%.
- Mass pull to slimes after comminution is 6% of sorted ore with 6.5% lithium losses.
- Mass pull to magnetics is 14.6% of sorted ore tonnage with lithium losses of 14.5%.
- The petalite flotation concentrate contains 4.0% Li<sub>2</sub>O% and lithium recovery to petalite is 65.2% of flotation feed content.
- Water leach lithium extraction after decrepitation and roast is 93.8%.
- Lithium losses from impurity removal is 3%.
- A final lithium hydroxide product purity of 99.5% LiOH.H<sub>2</sub>O.
- Plant availabilities of 93% for the concentrator and 85% for the hydrometallurgical plant.

**Figure 1.1**  
**Simplified Process Block Flow Diagram**



## 1.14 PROJECT INFRASTRUCTURE

The Separation Rapids project includes four main facilities:

- Mine.
- Concentrator.
- Trans-shipment facility.
- Hydrometallurgical plant.

Site buildings will include separate buildings for the crusher and concentrator, maintenance facilities and warehousing, change and lunch room facilities, offices and laboratory and a guard house. Heating, ventilation and air conditioning will be provided for all buildings as required. Propane will be used to fuel the heating system. Fresh water and fire water for the site will be provided from the English River. Sanitary waste water treatment will be provided at the site using appropriately sized parallel septic tanks and field bed. The septic tanks will be pumped periodically and material discharged to an appropriately licensed facility.

Approximately 5 MW of electrical power will be required for the mine and concentrator and will be supplied from the existing Whitedog Falls hydro dam. An emergency back-up generator will also be provided at the site fueled either by diesel or propane. Diesel fuel storage facilities will be provided to supply the mine equipment and smaller site vehicles. A propane tank farm will also be installed to accommodate the site heating and back-up power generation.

Hydrogen fluoride is required in the flotation process. A facility will be constructed to receive 49% aqueous hydrogen fluoride by truck and store it as required to meet the process plant requirements.

A telecommunications system will be installed at the site to provide telephone service and internet access, and to support the site security and fire detection systems. Distribution will be provided by a fibre optics system in the concentrator and related facilities and a wireless system for the mine site.

No camp facilities are envisioned for this project. It is anticipated that the work force will live in Kenora and the surrounding area. Buses will be provided to transport workers between Kenora and the mine site.

#### **1.14.1 Trans-shipment Facility**

As there is no rail access to the mine/concentrator site, delivery of reagents to, and shipment of concentrates from, the site will be by truck. However, some of the reagents are likely to be supplied by rail and rail access will be required to get products to market. To accommodate this, a trans-shipment facility will be constructed. Avalon plans to build a trans-shipment facility adjacent to the CNR line in the vicinity of Redditt, Ontario, where there is good road access from both Kenora and the mine site.

A rail siding will be required at the site for the loading and unloading of rail cars. The siding is expected to consist of two tracks approximately 1 km in length with switches to access the mainline at each end.

Provision will be made for offices/change rooms/lunch rooms as required.

Hydrofluoric acid is required for the flotation process at the concentrator. It is expected that anhydrous hydrofluoric acid will be provided by railcar from the United States. The facility will also include the capability to dilute the acid to produce a 49% aqueous hydrogen fluoride solution that will then be loaded on trucks for delivery to the mine site.

Grid power is available in the Redditt area to meet the power requirements for this facility. A small diesel generator will be provided to supply emergency power if required. A small day tank will be provided for diesel storage. Fresh water for the site will be provided either from a well or from access to a local lake. Water treatment facilities will be provided as required. Sanitary waste water treatment requirements will be minimal at the site as only a small staff is required for operations. Sewage treatment facilities will be provided as required.

It is anticipated that the site will access the communications infrastructure in the area for telephone and internet. Back-up will be provided with the use of a cellular modem.

### **1.14.2 Hydrometallurgical Plant**

Avalon has identified several possible sites in or near Kenora that could be used for the hydrometallurgical plant. The preferred location is the site of the former Abitibi paper mill and is approximately 27.5 ha in area providing ample space for the required facilities.

Although the site is currently supplied by power, water, natural gas and city sanitary sewer services, most of these do not have the capacity to meet the requirements of the hydrometallurgical plant. However, the site is located within easy access of the electrical power and natural gas needed for the plant. A diesel generator will be provided at the site to provide emergency standby power.

Plant and fire water requirements will be sourced from the Winnipeg River. Water discharge is expected to be very small. It will be treated as necessary and can be accommodated by the city sewer system.

A new building will be required to house the hydrometallurgical plant. Three existing buildings may be used for offices, laboratories, lunch/wash rooms, warehouses, and product storage and load out facilities.

The site was previously served by a rail siding off the Canadian Pacific Railways (CPR) line. Although the rails have been removed it would be possible to reactivate this line to provide rail service directly to the site if that was required.

Telephone and internet services will be available from local suppliers in the area.

## **1.15 MARKETS STUDIES AND CONTRACTS**

### **1.15.1 Lithium**

The U.S. Geological Survey (USGS) reports production of lithium minerals and products. In terms of gross product weight, Australia is the largest single producer of lithium minerals and chemicals, with output exceeding 400,000 t/y spodumene. Chile is the second ranking producer with a range of lithium chemicals recovered from subsurface brines. In terms of contained lithium. Australia and Chile are also significant producers of lithium.

Lithium consumption in batteries has increased significantly over the past five years, to the point where it now surpasses demand in ceramics and glass. Rechargeable lithium batteries are used in a wide range of applications including cell phones, cameras, portable electronic devices, hand-held tools and increasingly, in electric vehicles and electrical grid storage. It is expected that battery demand will continue to outpace other lithium demand sectors and will drive overall lithium demand. While the automotive sector is expected to show the most rapid growth, projected growth in global lithium demand also includes consumer electronics and grid energy storage sectors.

It is projected that demand for lithium hydroxide will grow at a higher rate than that for lithium carbonate based on changes in battery technologies. Avalon considers that the Separation Rapids Lithium Project will be well-placed to supply new battery production facilities in North America.

#### 1.15.1.1 Lithium Prices

Lithium is not traded on any formally recognized exchange and there are few sources of reliable publicly available price data. Transactions are negotiated directly between seller and buyer and payment terms are rarely reported.

Apart from a sharp correction in 2010, prices for both lithium carbonate and lithium hydroxide have risen steadily over the past decade. Prices reported by Industrial Minerals journal as of mid-August, 2016 were US\$8,500-11,000/t delivered in Europe, or US\$8,300-10,000/t delivered in Europe for Chinese material.

Avalon has reviewed all publicly available lithium price forecasts. Lithium hydroxide prices projected for the period 2019-2020, when Avalon may enter the market, are projected to range as high as US\$25,000/t, with the average price being around US\$16,000-17,000/t. For the purposes of this PEA, Avalon has used a conservative average price assumption of US\$11,000/t FOB plant for lithium hydroxide.

#### 1.15.2 Feldspar

The feldspar group is by far the most abundant group of minerals in the earth's crust, forming about 60% of terrestrial rocks. They are widely produced with global output estimated by the USGS in 2015 at 21.2 Mt. Turkey, Italy, India and China are by far the largest producers. Production in the United States has declined steadily over the past five years. The USGS does not report any production from Canada.

Feldspar is an important ingredient in the manufacture of glass and an important raw material in ceramics because it acts as a fluxing agent, reducing the strength, toughness, and durability of the ceramic body, and cements the crystalline phase of other ingredients, softening, melting and wetting other batch constituents. Feldspars also are used as fillers and extenders in applications such as paints, plastics and rubber. The glass market for feldspar in the United States represents the largest market at around 68% while ceramics account for 23% and filler and other applications, including chemicals, paints, rubber and plastics, represent less than 10%.

It is projected that between 2015 and 2022, feldspar demand in the United States will grow at a compound average annual growth rate of 3.8% to reach nearly 800,000 t/y. Through discussions with market participants and industry experts, and evaluation of data provided in purchased reports and publicly available information, Avalon estimates that 100,000 t/y of feldspar can be sold into the glass, ceramics, frits/glazes and filler markets at an average price of US\$170/t. Sales will be built up to 100,000 t/y over a period of five years.

### **1.15.3 Contracts**

At this stage of development of the Separation Rapids Lithium Project, there are no material contracts in place.

## **1.16 ENVIRONMENTAL STUDIES, PERMITTING AND SOCIAL OR COMMUNITY IMPACT**

The project site lies in an area adjacent to the English River which supports a variety of wildlife and fisheries, as well as tourism. The area surrounding the project site is undeveloped and forested.

The Federal and Ontario Provincial permitting processes are well defined and understood. The Ministry of Northern Development and Mines is responsible for coordinating the various regulatory agencies in the mine permitting process.

The project is small in scale without many of the risks frequently found at other mines such as acid mine drainage. All tailings, mine rock, aggregate and concentrate materials are expected to be inert and air and water quantities utilized and discharged are relatively small and can be managed to acceptable standards with conventional technologies. Meetings have already been held with all key regulators to develop positive relationships early and to review the proposed project. Similarly, positive relationships have already been developed with Indigenous Peoples as well as political and community representatives.

Given the relatively small size and low environmental risk, no permitting problems are expected and all permits should be acquired in a timely manner that will not negatively impact the project schedule.

### **1.16.1 Environmental Baseline**

For the mine and concentrator site, an environmental baseline study program has been conducted, investigating regional and site specific aspects, such as water quality, hydrology, vegetation, wildlife, fisheries, archaeology, and socioeconomics. The ecology of the project area was investigated with field visits carried out in all four seasons during 1998 and 1999. The majority of these data remain valid, and some additional work has been completed related to more recent regulatory changes. Plans are in place to further update or validate this information in the next project phase in consultation with all communities of interest.

Given that the proposed site for the metallurgical facility to be located in Kenora is located at an existing industrially-zoned and previously operated site, an environmental baseline study for the metallurgical site is not required.

### **1.16.2 Tailings and Concentrate Management**

The principal objective of the tailings and concentrate management area (TCMA) is to provide safe and secure storage of the process waste products, while ensuring the protection of the environment during operations and in the long-term after closure.

Approximately 1.2 Mt of magnetic concentrates, 0.5 Mt of tailing slime, 1.4 Mt of hydrometallurgical plant tailings, and 3.8 Mt of feldspar concentrate (partially concentrated material rejected from the petalite circuit that will undergo additional processing in future to produce a low impurity feldspar product) will be produced over the life of the project. The magnetic concentrates and a portion of the feldspar material will be stored separately due to their potential to be reprocessed in the future.

The TCMA will consist of valley impoundment type facilities located approximately 1.5 km southwest of the open pit.

Tailings will be filtered in the concentrator and the hydrometallurgical plant and trucked to the TCMA as solids. The hydrometallurgical tailings will be stored with the combined tailings in the central cell of the TCMA. There will be no long term storage of tailings at the hydrometallurgical plant.

### **1.16.3 Mine Rock Aggregate and Mineralized Material Management**

Given the inert nature of the waste material from the open pit and the scarcity of aggregate in the area, all mine rock is considered as a potentially usable aggregate product. Approximately 52 Mt of coarse mine rock aggregate and 1.3 Mt of crushed and optically sorted rejects (fine aggregate) will be generated during the life of the project. The aggregate materials will consist primarily of amphibolite and pegmatitic granite rock, with a lesser amount of feldspathic material. At this stage, these materials will be managed together. The coarse mine rock aggregate will be placed in two storage areas to the west of the open pit while the fine aggregate will be stored near the concentrator for easy access for road maintenance, storage facility construction and pit road construction.

The mine rock aggregate materials have been characterized as non-acid generating.

### **1.16.4 Water Management**

The design and implementation of a comprehensive water management plan for the mine site will be fundamental to the project. The key water management issues are runoff from and seepage associated with the open pit, the plant site, the waste rock facilities and the TMCA. The principal objectives of the water management plan will be to minimize the volume of potentially impacted water generated from the site and minimize the amount of water extracted from the English River for processing and general mine site use by maximizing the use of reclaimed runoff water (for example, plant site runoff and mine dewatering flows) through internal concentrator recycling and use of filtered tailing and concentrate storage. To



the extent that it is practical, all water that is impacted by processing operations to a single point in order to minimize the locations that require monitoring and treatment.

A simple water balance for the Separation Rapids site was prepared to provide estimates of the volumes of runoff reporting to each pond/basin on the site. There will be a surplus of water from the project.

#### **1.16.5 Closure and Rehabilitation**

Following the cessation of mining, the open pit will be allowed to flood. Flooding will occur primarily through inflows of groundwater and surface water runoff.

The TCMA will be closed and rehabilitated in a safe and secure manner in full accordance with government regulations and good engineering practices. Following closure, the TCMA will be a reclaimed landform that sheds runoff.

Progressive rehabilitation of benches of the coarse rock aggregate storage areas is planned to minimize the potential for aesthetic visual concerns during operations, particularly on the river view sides.

All sediment basins associated with the TCMA and the mine rock aggregate stockpiles will be breached and revegetated as necessary for closure.

All machinery and equipment from the crusher, process plant and other ancillary facilities will be removed for reuse, salvage or disposal, and all buildings and infrastructure will be removed or demolished. All chemicals or hazardous materials will be returned to the supplier or removed to an appropriate waste disposal facility by a licensed contractor. Petroleum storage tanks will be removed in accordance with applicable regulations. General waste materials will be disposed of in an offsite, licensed landfill site.

A 5 year post-closure monitoring program will follow closure of the mine that includes maintenance of the revegetated areas, assessment of the physical stability of the aggregate storage facilities and TCMA, surface water and groundwater quality, and periodic biological monitoring of the aquatic and terrestrial ecosystems in the immediate vicinity of the site. The monitoring program will continue, as required, until the target objectives of the site closure have been achieved.

In the event that alternate feedstocks for the hydrometallurgical plant are not identified, machinery will be removed from the hydrometallurgical plant site. The buildings will continue to be usable in the industrial park setting.

#### **1.16.6 Community and Indigenous Peoples Engagement**

Consultation with local First Nations Bands and the public was initiated during the 1999 baseline study. This continued in a reduced manner during the period of inactivity, but was

increased again in 2013. A Memorandum of Understanding (MOU), initially signed with the Wabaseemoong Independent Nation (WIN) in 1999, was renewed in 2013.

Avalon maintains an engagement log which records the numerous meetings held and summaries of the meeting content, and reports this annually in its Sustainability Report.

An archaeological study was completed in 1998. This will be reviewed with the communities of interest and updated if required. There may be a requirement to complete additional traditional knowledge studies in the next phase of project development. A socioeconomic assessment of the project is included in the 2007 environmental study. This will be updated in the next phase of the project.

Avalon has a full time representative in Kenora who facilitates ongoing engagement with Indigenous Peoples, communities, regulators and politicians and that contributes to the strong support for the project.

## 1.17 CAPITAL AND OPERATING COSTS

### 1.17.1 Capital Costs

The basis for the capital cost estimate is contract mining, a 950,000 t/y concentrator that recovers approximately 145,000 t/y of petalite concentrate and 100,000 t/y of feldspar concentrate, and a hydrometallurgical facility that produces approximately 14,520 t/y of high purity lithium hydroxide product suitable for the battery market. The life-of-mine (LOM) capital cost estimate is summarised in Table 1.4. The estimate is given in Canadian dollars, with a base date of third quarter, 2016. Owing to rounding of the estimates, some totals may not agree.

**Table 1.4**  
**LOM Capital Estimate**

|  | <b>Initial Capital<br/>(\$ millions)</b> | <b>Sustaining Capital<br/>(\$ millions)</b> | <b>Total Capital<br/>(\$ millions)</b> |
|--|--|---|--|
| Mining                                     | 2.0                                      |   | 2.0                                    |
| Concentrator – direct costs                | 112.9                                    |   | 112.9                                  |
| Hydrometallurgical Facility – direct costs | 167.5                                    |   | 167.5                                  |
| Tailings – direct costs                    | 7.3                                      | 6.0   | 13.3                                   |
| Indirect costs                             | 123.9                                    | 0.3   | 124.2                                  |
| Owner’s costs                              | 3.9                                      |   | 3.9                                    |
| Closure Bond                               | 5.5                                      |   | 5.5                                    |
| Contingency                                | 84.7                                     | 0.9   | 85.6                                   |
| <b>Total</b>                               | <b>507.7</b>                             | <b>7.2</b>                                  | <b>514.9</b>                           |

The capital cost estimate for this project presented herein is considered to be at a scoping level with an accuracy of +50%/-35% and carrying a contingency of 20% on total initial estimated capital.

### 1.17.2 Operating Costs

Operating costs have been determined by Avalon with the exception of the mining costs which were determined by Micon. The estimated costs are expressed in Canadian dollars and are based on:

- Total tonnes mined as determined by mining schedule and typical industry rates.
- Anticipated labour complements and appropriate labour rates.
- Reagent consumptions from testwork and budget supply prices.
- Energy estimates calculated from electrical equipment loads and gas consumptions.
- Estimates for miscellaneous minor operating expenses.

The estimated average annual project operating costs assuming a mine life of 9.83 years and unit costs for the first 10 years of production when both petalite and feldspar are produced are summarized in Table 1.5.

**Table 1.5**  
**Summary of LOM Operating Costs**

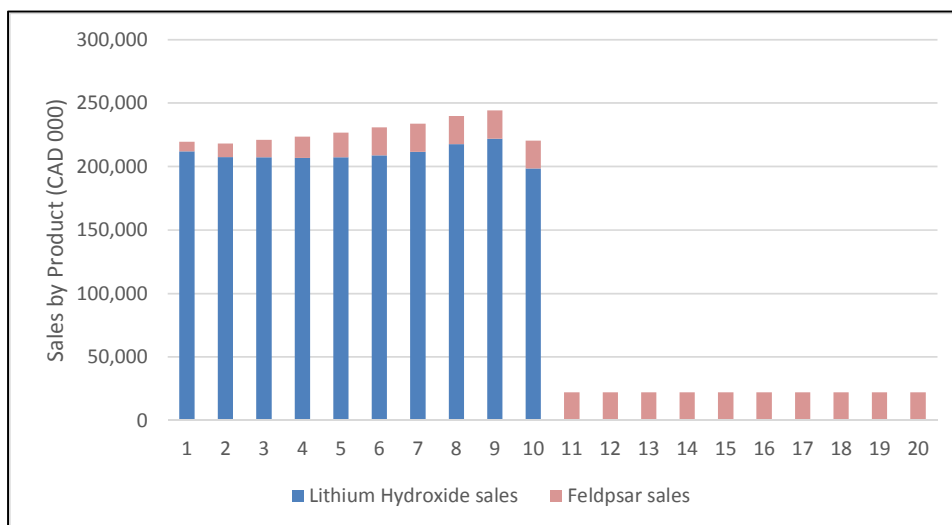
| Category                           | Annual<br>(\$'000) | \$/t<br>Processed | \$/kg<br>Lithium<br>Hydroxide |
|------------------------------------|--------------------|-------------------|-------------------------------|
| Mining                             | 29,416.53          | 30.96             | 1.98                          |
| Concentrator processing            | 36,738.53          | 38.67             | 2.46                          |
| TCMA, waste rock, water management | 1,241.10           | 1.31              | 0.08                          |
| Concentrate transport              | 2,045.42           | 2.15              | 0.14                          |
| Hydrometallurgical processing      | 23,348.68          | 24.58             | 1.56                          |
| General and Administration         | 4,104.78           | 4.32              | 0.27                          |
| <b>Total Cash Production Costs</b> | <b>96,895.05</b>   | <b>101.99</b>     | <b>6.49</b>                   |

### 1.18 ECONOMIC ANALYSIS

Micon has prepared its assessment of the project on the basis of a discounted cash flow model, from which Net Present Value (NPV), Internal Rate of Return (IRR), payback and other measures of project viability can be determined. Assessments of NPV are generally accepted within the mining industry as representing the economic value of a project after allowing for the cost of capital invested. The base case cash flow projection assumes a constant price of US\$11,000/t lithium hydroxide, LiOH.H<sub>2</sub>O. Feldspar sales are at a constant price of US\$170/t.

Annual sales of lithium hydroxide and low impurity feldspar over the LOM period are shown in Figure 1.2. Note that feldspar sales ramp up from 34,000 t in Year 1 to 100,000 t in Year 6, and remain at that level for the remainder of the 20 year project life. On average over that period, feldspar sales represent 16% of total sales revenue.

**Figure 1.2**  
**Annual Sales Revenues by Product**



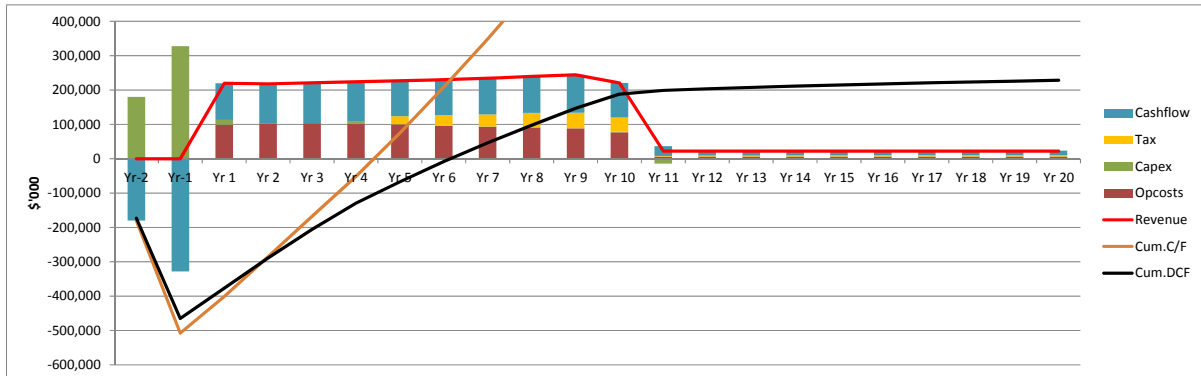
Annual cash flows over the whole LOM period are presented in Table 1.6 and shown graphically in Figure 1.3.

**Table 1.6**  
**LOM Cash Flow Summary**

|                               | LOM total<br>(\$'000) | \$/t milled   | % Gross<br>Revenue | Margin<br>(%) | \$/t<br>LiOH.H <sub>2</sub> O |
|-------------------------------|-----------------------|---------------|--------------------|---------------|-------------------------------|
| Mining (Contractor)           | 291,380               | 31.21         | 14%                |               | 1,985                         |
| Mill/Concentrator             | 410,980               | 44.02         | 20%                |               | 2,799                         |
| Tailings Management           | 12,200                | 1.31          | 1%                 |               | 83                            |
| Conc. Transport               | 20,106                | 2.15          | 1%                 |               | 137                           |
| Hydrometallurgical Plant      | 229,518               | 24.58         | 11%                |               | 1,563                         |
| G&A                           | 51,026                | 5.46          | 2%                 |               | 348                           |
| <b>Direct Site Costs</b>      | <b>1,015,210</b>      | <b>108.73</b> | <b>48%</b>         | <b>52%</b>    | <b>6,915</b>                  |
| Less By-product credits       | (399,458)             | (42.78)       | -19%               |               | (2,721)                       |
| <b>Cash Operating Costs</b>   | <b>615,753</b>        | <b>65.95</b>  | <b>29%</b>         | <b>71%</b>    | <b>4,194</b>                  |
| Royalties                     | -                     | -             | 0%                 |               | -                             |
| Production Taxes              | -                     | -             | 0%                 |               | -                             |
| <b>Total Cash Costs</b>       | <b>615,753</b>        | <b>65.95</b>  | <b>29%</b>         | <b>71%</b>    | <b>4,194</b>                  |
| Depreciation                  | 512,986               | 54.94         | 24%                |               | 3,494                         |
| Mine Closure\Reclamation      | 5,503                 | 0.59          | 0%                 |               | 37                            |
| <b>Total Production Costs</b> | <b>1,134,242</b>      | <b>121.48</b> | <b>54%</b>         | <b>46%</b>    | <b>7,726</b>                  |

This preliminary economic assessment is preliminary in nature; it includes inferred mineral resources that are considered too speculative geologically to have the economic considerations applied to them that would enable them to be categorized as mineral reserves, and there is no certainty that the preliminary economic assessment will be realized.

**Figure 1.3**  
**Life-of-Mine Cash Flows**



The project demonstrates an undiscounted payback of 4.5 years, or approximately 6.2 years when discounted at 8.0%, leaving a tail of over 3.5 years of lithium hydroxide production.

The base case evaluates to an IRR of 19.3% before taxes and 16.5% after tax. At a discount rate of 8.0%, the net present value (NPV<sub>8</sub>) of the cash flow is \$343.8 million before tax and \$228.3 million after tax.

The sensitivity of project returns to changes in all revenue factors (including grades, recoveries, prices and exchange rate assumptions) and also to capital and operating costs, was tested over a range of 30% above and below base case values. The analysis suggests that the project is most sensitive to revenue drivers, and is moderately sensitive to changes in operating costs and capital cost. While the latter remain positive across the range of the sensitivity analysis, NPV falls to zero for product prices of less than 78% of base case assumptions.

Micon concludes that this study demonstrates the potential viability of the project within the targeted range of accuracy of the estimated capital and operating costs, as well as for product prices above 78% of base case values.

### **1.19 ADJACENT PROPERTIES**

Properties immediately adjacent to Avalon’s Separation Rapids property are held by Avalon, Pacific Iron Ore Corporation, GoldON Resources Ltd. and Gossan Resources Ltd.

### **1.20 PROJECT DEVELOPMENT SCHEDULE**

A period of four years has been scheduled for project development. On completion of this PEA, process design will be finalized and pilot plant work is scheduled to start within three months when permitting will also commence. A period of 35 weeks has been allowed for completion of the project feasibility study, followed by engineering and procurement. A period of 78 weeks has been allowed for construction. A period of 21 weeks has been allowed for commissioning and a further 22 weeks for ramp-up to full production.

## **1.21 INTERPRETATION AND CONCLUSIONS**

This PEA demonstrates that the SRLD can be developed into an economically robust mining and processing operation to produce a lithium hydroxide feedstock for the lithium ion battery and energy storage industries.

The environmental impacts of the project are minor as a result of the low levels and nature of impurities in the SRLD material. This is expected to reduce the anticipated permitting requirements and schedule.

The site is well located with easy access to important infrastructure facilities for power supply, skilled labour and material transportation. Engagement to date with local communities has resulted in strong support for the project and the potential exists for greater engagement and utilization of First Nations' resources and businesses.

Given the potential for a range of products to be recovered from the SRLD, the potential also exists to develop a staged approach to project development and financing that will allow Avalon to adapt to market uncertainties as the project advances. Such a staged approach may start with the production of lithium mineral concentrates for glass-ceramics consumers, resulting in cash flow before investing further in a hydrometallurgical plant to produce a derivative battery material from the petalite concentrate. A petalite concentrate may be saleable to a third party battery material producer equipped to process similar lithium mineral concentrates. Such opportunities are likely to emerge over the next few years as the market for battery materials grows. A staged approach has the potential to reduce capital investment risk. A staged approach would also include development of a demonstration plant in order to provide the required volumes of product samples to potential customers for evaluation and acceptance, as well as to provide improved operating and cost parameters, and potentially improved prospects for project financing.

This PEA has shown that the Separation Rapids Lithium Project offers a number of other advantages that will contribute to reduced capital investment risk. These include the relatively low environmental impacts and strong support for the project within the local community due to the long history of engagement and the positive relationships developed with local indigenous communities, notably Wabaseemoong Independent Nation.

## **1.22 RECOMMENDATIONS**

Given the potential for a range of products to be recovered from the SRLD, it is recommended that Avalon develops a staged approach to project development and financing that will allow the Company to adapt to market uncertainties as the project advances.

Recommendations for different areas of the project are set out below.

## 1.22.1 Geology and Mineral Resources

### 1.22.1.1 Geological Mapping

Detailed mapping should be undertaken to the west and east of the SRLD to explore for projected extensions of the lithium deposit to increase potentially recoverable lithium resources and explore for new zones of related rare metal mineralization such as tantalum and cesium.

Further investigations into other potential sources of petalite and lithium minerals in the region which could potentially provide additional feed material.

### 1.22.1.2 Mineralogy

Detailed mineralogical studies should be completed in order to further refine mineralogical zonation patterns within the pegmatite Subunits 6a, b, c and d using complementary methods such as XRD, Qemscan®, electron microprobe, spectral analysis and optical methods. In particular, lithium mineral zonation patterns may be important for maintenance of a consistent feed for the mill.

Further detailed petrography of the feldspathics is required for a better understanding of the potentially economic feldspar content and quality.

### 1.22.1.3 Exploration and Resource Definition Drilling

It is recommended that a minimum 10,000 m diamond drill program be carried out with two main objectives:

1. Expand the known petalite/lithium resources to depth and laterally to increase the confidence level of the inferred resources to the Measured and Indicated categories.
2. Test exploration targets along both the eastern and western extensions of the SRLD, including the undrilled Western Pegmatite to delineate additional lithium resources and discover other rare metal mineralized zones that the geological model predicts could occur in the area.

The program should include:

- Detailed mineralogical mapping.
- Geotechnical logging of the drill holes for open pit design considerations.
- Analysis of representative waste rock for environmental considerations.

### 1.22.2 Metallurgical Testwork

Metallurgical testwork should continue with the overall objectives of optimizing the existing flowsheets and studying variants that will create optionality as to what the final product mix should be, bearing in mind that there are at least four potential lithium products (minerals, carbonate, hydroxide, metal) that can be recovered from the mineralization and multiple potential by-products (feldspars, high purity quartz, tantalum, rubidium and cesium).

Further optimization testwork is recommended in the following areas:

Concentrator:

- Confirm efficiency and performance of ore sorting when processing low grade material from the pit extremities and the “low grade material” introduced into resources by the mining schedule.
- Optimization and re-piloting of the flotation circuit to improve recoveries and reduce reagent consumptions and costs.
- Investigation of alternatives for further pre-concentration ahead of flotation, such as gravity-based processes.
- Investigation into the recovery of lithium micas (including lepidolite) and other potential products from the magnetics material and lepidolite-rich sub-zones in the deposit.
- Determination of what the final lithium product mix should be based on product pricing (determined through ongoing market development work), future market demand and production costs.
- Further work on the recovery of a high purity quartz product from coarse-grained mineralization.

Hydrometallurgical Plant:

There are a number of opportunities to optimize the hydrometallurgical plant process efficiencies and costs. These include:

- Evaluation of fluidized bed roasting as an alternative to the decrepitation kiln.
- Optimization of membrane selection for the electrodialysis cells.
- Piloting of circuit to confirm influence of recycle streams of overall flowsheet and efficiencies.



- Optimization of heat balance and recovery.
- Detailed analysis of the leached solids in order to determine whether this material is of economic value.
- Consideration for optionality in the process flowsheet to produce either a carbonate, hydroxide or possibly another lithium chemical/metal product for the battery market.

#### Demonstration Plant:

Customers in all potential markets will require significant sample material for detailed evaluation before committing to any off-take agreements. Generation of such samples in the required quantities can only be produced through the operation of a demonstration-scale production plant. This also provides assurance of a reliable process and the ability to manufacture products of consistent quality.

In addition, such a facility would provide significant information for reliable scale-up to a full production facility and potentially reduce perceived investor risk in the project.

Finally it can also serve as an interim production facility to begin serving the market at a low level and as a test facility for evaluation of other product opportunities and other new development opportunities.

The optimal scale of such a demonstration plant and the length of operation will need to be determined based on market development work conducted in conjunction with the feasibility study.

#### **1.22.3 Mining Methods**

It is recommended that geotechnical studies are undertaken concurrent with the proposed drilling program to support the overall pit slopes and design of ramps and haulways.

#### **1.22.4 Marketing**

Further work is recommended in the following areas as the project proceeds to prefeasibility and feasibility analysis:

- Continued analysis of lithium markets and prices, and developments in battery technologies and developments in glass-ceramics markets.
- Assessment of opportunities to market lithium mineral (petalite) concentrates in North America.
- More detailed analysis of markets for feldspar in the United States, Europe and Mexico in order to determine if it should be recovered as a co- or by-product of

lithium hydroxide and refine the potential unit revenue from a range of feldspar products.

- Analysis of opportunities in the rubidium chemicals market.
- Assessment of markets for high purity quartz as a potential by-product.
- Assessment of markets for other identified and potential products beyond those included in this study.

These plus other potential by-products currently being investigated not only give the project the potential for further economic enhancement but also provide a strong and flexible production base capable of reducing the impact of any future down turns in any of the markets being targeted.

#### **1.22.5 Environmental/Social**

The following should be undertaken as project development proceeds:

- Continue to engage with the local Indigenous Peoples, community, regulators and government to maximize local development opportunities and minimize undesirable environmental impacts.
- Conclude a partnership arrangement with the Wabaseemoong Independent Nation as committed to under the existing MOU between WIN and Avalon, and accommodate other Aboriginal groups with interests in the area.
- Update socioeconomic studies as part of the proposed Environmental and Social Impact Assessment (ESIA).
- Complete historical environmental baseline validation and fill in identified gaps. Complete a Project Description and ESIA.
- Update the groundwater study and assess the geotechnical design parameters for the pit, mine rock aggregate, concentrate and tailing management facilities. Assess the potential for river water to enter the open pit and make appropriate amendments as required.
- Complete additional ABA and humidity cell leachate studies on the mine rock aggregate, concentrate and tailings as required. Complete biological toxicity testing of effluents and water treatment studies as required on pilot or demonstration plant water and tailing when available.

- Geotechnical and hydrogeological investigations for the TCMA and stockpile locations, including identification and characterization of potential local construction materials (i.e., till, sand and gravel).
- Detailed topographic mapping should be obtained for the full project site. (See geological mapping and drilling, above).
- Additional laboratory testing of the tailings and concentrates to better understand their physical properties as delivered to the TCMA (i.e., filterability, workability, placed density, strength, etc.).
- Trade-off study to determine if filtered tailings is the preferred disposal and storage method. Consideration should be given to operating in a northern climate with long, cold winter months.

### 1.22.6 Proposed Work Program

Avalon’s proposed work program and budget for ongoing project optimization and feasibility studies is summarized in Table 1.7.

**Table 1.7  
Avalon Proposed Budget for Ongoing Work**

| <b>Activity</b>                                  | <b>Budget<br/>(Cdn\$)</b> |
|--|---------------------------|
| Exploration and drilling                         | 1,500,000                 |
| Updated mineral resource estimate                | 35,000                    |
| Metallurgical testwork (bench scale)             | 850,000                   |
| Pilot plant studies                              | 1,700,000                 |
| Access road studies                              | 10,000                    |
| Hydro-electric study                             | 25,000                    |
| TCMA studies and design                          | 35,000                    |
| Geotechnical drill program                       | 30,000                    |
| Geotechnical testing                             | 10,000                    |
| Detailed mine design and planning                | 50,000                    |
| Hydrometallurgical plant site selection          | 10,000                    |
| Evaluate underground mining option               | 30,000                    |
| Hydrogeological study and ground water modelling | 25,000                    |
| Environmental studies and data gathering         | 900,000                   |
| Local community and stakeholder engagement       | 50,000                    |
| Engineering, design, costing and report          | 4,000,000                 |
| Market development                               | 900,000                   |
| <b>Sub-total</b>                                 | <b>10,160,000</b>         |
| <b>Demonstration Plant</b>                       | <b>25,000,000</b>         |

Micon concurs with the proposed work program budget and recommends that it be implemented.

## 2.0 INTRODUCTION

Micon International Limited (Micon) has been retained by Avalon Advanced Materials Inc. (Avalon) to prepare a Technical Report under Canadian National Instrument 43-101 (NI 43-101) which discloses the results of the preliminary economic assessment (PEA) for the Separation Rapids Lithium Project located 70 km north of Kenora, Ontario.

The objective of this PEA is to demonstrate the economic potential for producing a lithium ion battery material from the Separation Rapids Lithium Deposit (SRLD). The deposit was evaluated previously in 1999-2000 as a potential source of the lithium mineral, petalite, for glass-ceramics applications. While this market remains an opportunity, lithium ion battery technology has developed as the energy storage solution of choice for a variety of commercial applications and this has resulted in a significant increase in demand, and projected demand, for battery materials.

### 2.1 TERMS OF REFERENCE

#### 2.1.1 Preliminary Economic Assessment

This PEA has been prepared by Micon under the terms of its agreement with Avalon. As discussed in the relevant sections of the report, Micon has prepared a mine plan and schedule and has prepared an economic analysis of the project. Micon has reviewed the metallurgical testwork carried out on the property and the mineral processing flowsheet, has reviewed infrastructure requirements, and has reviewed capital and operating cost estimates prepared by Avalon and its retained consultants.

#### 2.1.2 Mineral Resource Estimate

The PEA is based on mineral resource estimates for lithium and feldspar contained in the SRLD, prepared by Benjamin Webb, Principal with BMW Resource Consultants LLC, dated 21 October, 2016.

The reserve and resource estimates in this PEA have been prepared in accordance with the requirements of Canadian securities laws, which differ from the requirements of United States securities laws. Unless otherwise indicated, all reserve and resource estimates included in this PEA have been prepared in accordance with NI 43-101. NI 43-101 is a rule developed by the Canadian Securities Administrators which establishes standards for all public disclosure an issuer makes of scientific and technical information concerning mineral projects.

Canadian standards, including NI 43-101, differ significantly from the requirements of the United States Securities and Exchange Commission (the SEC), and reserve and resource information contained in this news release may not be comparable to similar information disclosed by United States companies. In particular, and without limiting the generality of the foregoing, the term “resource” does not equate to the term “reserve”. Under United States

standards, mineralization may not be classified as a “reserve” unless the determination has been made that the mineralization could be economically and legally produced or extracted at the time the reserve determination is made. The SEC’s disclosure standards normally do not permit the inclusion of information concerning “measured mineral resources”, “indicated mineral resources” or “inferred mineral resources” or other descriptions of the amount of mineralization in mineral deposits that do not constitute “reserves” by United States standards in documents filed with the SEC. United States investors should also understand that “inferred mineral resources” have a great amount of uncertainty as to their existence and as to their economic and legal feasibility. It cannot be assumed that all or any part of an “inferred mineral resource” exists, is economically or legally mineable, or will ever be upgraded to a higher category. Under Canadian rules, estimated “inferred mineral resources” may not form the basis of feasibility or pre-feasibility studies except in rare cases. Disclosure of the amount of minerals contained in a resource estimate is permitted disclosure under Canadian regulations; however, the SEC normally only permits issuers to report mineralization that does not constitute “reserves” by SEC standards as in-place tonnage and grade without reference to unit measures. The requirements of NI 43-101 for identification of “reserves” are also not the same as those of the SEC, and reserves reported by Avalon in compliance with NI 43-101 may not qualify as “reserves” under SEC standards. Accordingly, information concerning mineral deposits set forth herein may not be comparable with information made public by companies that report in accordance with United States standards.

### **2.1.3 Relationship with Avalon**

Micon does not have, and has not previously had, any material interest in Avalon or any related entities. The relationship between Micon and Avalon is solely a professional association between the client and the independent consultant. This report is prepared in return for fees based upon agreed commercial rates and the payment of these fees is in no way contingent on the results of this report.

The conclusions and recommendations in this report reflect the authors’ best independent judgment in light of the information available to them at the time of writing. The authors and Micon reserve the right, but will not be obliged, to revise this report and conclusions if additional information becomes known to them subsequent to the date of this report. Use of this report acknowledges acceptance of the foregoing conditions.

This report is intended to be used by Avalon subject to the terms and conditions of its agreement with Micon. That agreement permits Avalon to file this report as a Technical Report with the Canadian Securities Administrators pursuant to provincial securities legislation. Except for the purposes legislated under provincial securities laws, any other use of this report, by any third party, is at that party’s sole risk.

The requirements of electronic document filing on SEDAR necessitate the submission of this report as an unlocked, editable pdf (portable document format) file. Micon accepts no responsibility for any changes made to the file after it leaves its control.

## 2.2 QUALIFIED PERSONS, SITE VISITS, AND AREAS OF RESPONSIBILITY

The primary authors of this report and Qualified Persons are:

- Richard Gowans, P.Eng., President and Principal Metallurgist, Micon.
- Christopher Jacobs, CEng, MIMMM, Vice President, Micon.
- EurIng, Bruce Pilcher, CEng, FIMMM, FAusIMM(CP), Senior Mining Engineer, Micon.
- Jane Spooner, P.Geo., Vice President, Micon.
- Steven R. Aiken, P.Eng., Knight Piésold Limited.
- Kevin E. Hawton, P.Eng., Knight Piésold Limited.
- David L. Trueman, Ph.D., P.Geo.

Micon’s site visit to the Separation Rapids property was conducted on 21 July, 2016 by Richard Gowans. Benjamin Webb also visited the site on 21 July, 2016. They were accompanied by Chris Pedersen, Senior Geologist with Avalon. David Trueman has visited the site numerous times in the period 1996 to 2008.

## 2.3 UNITS AND ABBREVIATIONS

All currency amounts are stated in Canadian dollars, \$ or CAD. Quantities are generally stated in metric units, the standard Canadian, and international practice, including metric tons (tonnes, t) and kilograms (kg) for weight, kilometres (km) or metres (m) for distance, hectares (ha) for area. Wherever applicable, Imperial units have been converted to Système International d’Unités (SI) units for reporting consistency. Metal grades may be expressed as a percentage (%), parts per million (ppm) or parts per billion (ppb). A list of abbreviations is provided in Table 2.1.

**Table 2.1**  
**List of Abbreviations**

| Abbreviation      | Term   |
|-------------------|--|
| AA                | Atomic absorption spectrometry                         |
| ABA               | Acid base accounting                                   |
| A/cm <sup>2</sup> | Amperes per square centimetre                          |
| Al                | Aluminum   |
| AMD               | Acid mine drainage                                     |
| ARD               | Acid rock drainage                                     |
| bcm               | Bank cubic metre(s)                                    |
| Be                | Beryllium  |
| BQ                | Drill core tube size interior diameter 36.5 mm         |
| Ca                | Calcium  |
| CE                | Current efficiency                                     |
| CIM               | Canadian Institute of Mining, Metallurgy and Petroleum |
| cm                | Centimetre(s)  |
| cm <sup>2</sup>   | Square centimetres                                     |

| Abbreviation       | Term   |
|--------------------|--|
| CNR                | Canadian National Railway                            |
| CoV                | Coefficient of variation                             |
| CPR                | Canadian Pacific Railway                             |
| Cr                 | Chromium   |
| Cs                 | Cesium   |
| DFO                | Federal Department of Fisheries and Oceans           |
| DTM                | Digital terrain model                                |
| d50                | 50% passing  |
| EIA                | Environmental Impact Assessment                      |
| EPCM               | Engineering, procurement and construction management |
| ESIA               | Environmental and Social Impact Assessment           |
| FOB                | Free on board  |
| g                  | Gram(s)  |
| g/cm <sup>3</sup>  | Grams per cubic centimetre                           |
| g/L                | Grams per litre                                      |
| Ga                 | Gallium  |
| G&A                | General and administration                           |
| Ge                 | Germanium  |
| GJ                 | Gigajoule(s)   |
| GJ/h               | Gigajoules per hour                                  |
| g/t                | Grams per tonne                                      |
| GPS                | Global positioning system                            |
| h                  | Hour(s)  |
| ha                 | Hectare(s)   |
| h/y                | Hours per year                                       |
| HVAC               | Heating, ventilation, air conditioning               |
| ICP                | Inductively coupled plasma                           |
| ICP-MS             | Inductively coupled plasma-mass spectrometry         |
| in                 | Inch(es)   |
| INAA               | Instrumental neutron activation analysis             |
| IRR                | Internal rate of return                              |
| K                  | Potassium  |
| kg                 | Kilogram(s)  |
| km                 | Kilometre(s)   |
| km/h               | Kilometres per hour                                  |
| kV                 | Kilovolt(s)  |
| kWh                | Kilowatt hour(s)                                     |
| lb                 | Pound(s) weight                                      |
| Li                 | Lithium  |
| Li <sub>2</sub> O  | Lithium oxide, lithia                                |
| LG                 | Lerchs-Grossman                                      |
| LOI                | Loss on ignition                                     |
| Na                 | Sodium   |
| NAA                | Neutron activation analysis                          |
| m                  | Metre(s)   |
| M                  | Million(s)   |
| M                  | Mole per litre                                       |
| mA/cm <sup>2</sup> | Milliamperere per square centimetre                  |
| Mbcm               | Million bank cubic metres                            |
| masl               | Metres above sea level                               |
| Mg                 | Magnesium  |

| Abbreviation     | Term  |
|------------------|---|
| mg/kg            | Milligrams per kilogram                             |
| mg/L             | Milligrams per litre                                |
| mm               | Millimetre(s)                                       |
| Mm <sup>3</sup>  | Million cubic metres <sup>2</sup>                   |
| MNDM             | Ontario Ministry of Northern Development and Mines  |
| MNRF             | Ontario Ministry Natural Resources and Forestry     |
| MOECC            | Ontario Ministry of Environment and Climate Change  |
| mol/L            | Moles per litre                                     |
| MOU              | Memorandum of Understanding                         |
| Moz              | Million ounces                                      |
| Mt               | Million tonnes                                      |
| Mt/y             | Million tonnes per year                             |
| MW               | Megawatt(s)   |
| Na               | Sodium  |
| NAD              | North American Datum                                |
| Nb               | Niobium   |
| NQ               | Drill core tube size interior diameter 47.6 mm      |
| NPV              | Net present value                                   |
| NPV <sub>8</sub> | Net present value at a discount rate of 8% per year |
| NSR              | Net smelter return                                  |
| OGS              | Ontario Geological Survey                           |
| PLS              | Pregnant leach solution                             |
| PLT              | Point load test                                     |
| ppb              | Parts per billion                                   |
| ppm              | Parts per million                                   |
| Q                | Rock tunnelling quality                             |
| QA/QC            | Quality assurance/quality control                   |
| QP               | Qualified Person                                    |
| R <sup>2</sup>   | Coefficient of determination                        |
| Rb               | Rubidium  |
| RMR              | Rock mass rating                                    |
| S                | Sulphur   |
| SARA             | Species at Risk Act                                 |
| SEM              | Scanning electron microprobe                        |
| SG               | Specific gravity                                    |
| SRLD             | Separation Rapids Lithium Deposit                   |
| Si               | Silicon   |
| SiO <sub>2</sub> | Silicon dioxide, silica                             |
| Sn               | Tin   |
| sRPHD            | Relative half percentage difference                 |
| SWERFcs          | Size-weighted respirable crystalline silica         |
| t                | Tonne(s)  |
| Ta               | Tantalum  |
| t/d              | Tonnes per day                                      |
| t/h              | Tonnes per hour                                     |
| Ti               | Titanium  |
| Tl               | Thallium  |
| t/m <sup>3</sup> | Tonnes per cubic metre                              |
| UCS              | Uniaxial compressive strength                       |
| UTM              | Universal Transverse Mercator                       |
| V                | Volt(s)   |



| Abbreviation | Term                  |
|--------------|-----------------------|
| v/v          | Volume for volume     |
| wt%          | Weight percent        |
| XRD          | X-ray diffraction     |
| XRF          | X-ray fluorescence    |
| °            | Degree(s)             |
| °C           | Degrees Centigrade    |
| %            | Percent               |
| %/y          | Percent per year      |
| µm           | Micron(s)             |
| US\$         | United States dollars |
| \$, Cdn\$    | Canadian dollars      |
| 3D           | Three dimensional     |

### **3.0 RELIANCE ON OTHER EXPERTS**

Micon has reviewed and analyzed data provided by Avalon and has drawn its own conclusions therefrom, augmented by its direct field examination. Micon has not carried out any independent exploration work, drilled any holes or carried out an extensive program of sampling and assaying on the property. Micon has not taken any samples to independently verify the mineralization at the Separation Rapids property.

While exercising all reasonable diligence in checking, confirming and testing it, Micon has relied upon Avalon's presentation of the data relating to the Separation Rapids property, in preparing this report.

#### **3.1 MINERAL TENURE AND SURFACE RIGHTS**

Micon and has not reviewed any of the documents or agreements under which Avalon holds title to the Separation Rapids property and offers no opinion as to the validity of the mineral titles claimed. A description of the properties, and ownership thereof, is provided in Section 4.2 for general information purposes only.

#### **3.2 ENVIRONMENTAL LIABILITIES AND SOCIAL AND COMMUNITY IMPACTS**

The existing environmental conditions, liabilities and remediation are described as required by NI 43-101 regulations.

#### **3.3 TAXATION AND ROYALTIES**

Micon has relied on information regarding taxation and royalties provided by Avalon.

#### **3.4 OTHER INFORMATION**

Micon is pleased to acknowledge the helpful cooperation of Avalon which made any and all data requested available and responded openly and helpfully to all questions, queries and requests for material.

## 4.0 PROPERTY DESCRIPTION AND LOCATION

### 4.1 INTRODUCTION

The Separation Rapids property is located in northwestern Ontario, 55 km due north of Kenora and about 79 km by road. It is centred on latitude 50 15' 30" N, longitude 94 35' W (UTM coordinates: 388441E 5568996N in NAD83 Zone 15). It lies approximately 40 km east of the Manitoba-Ontario border.

A general location map is provided in Figure 4.1.

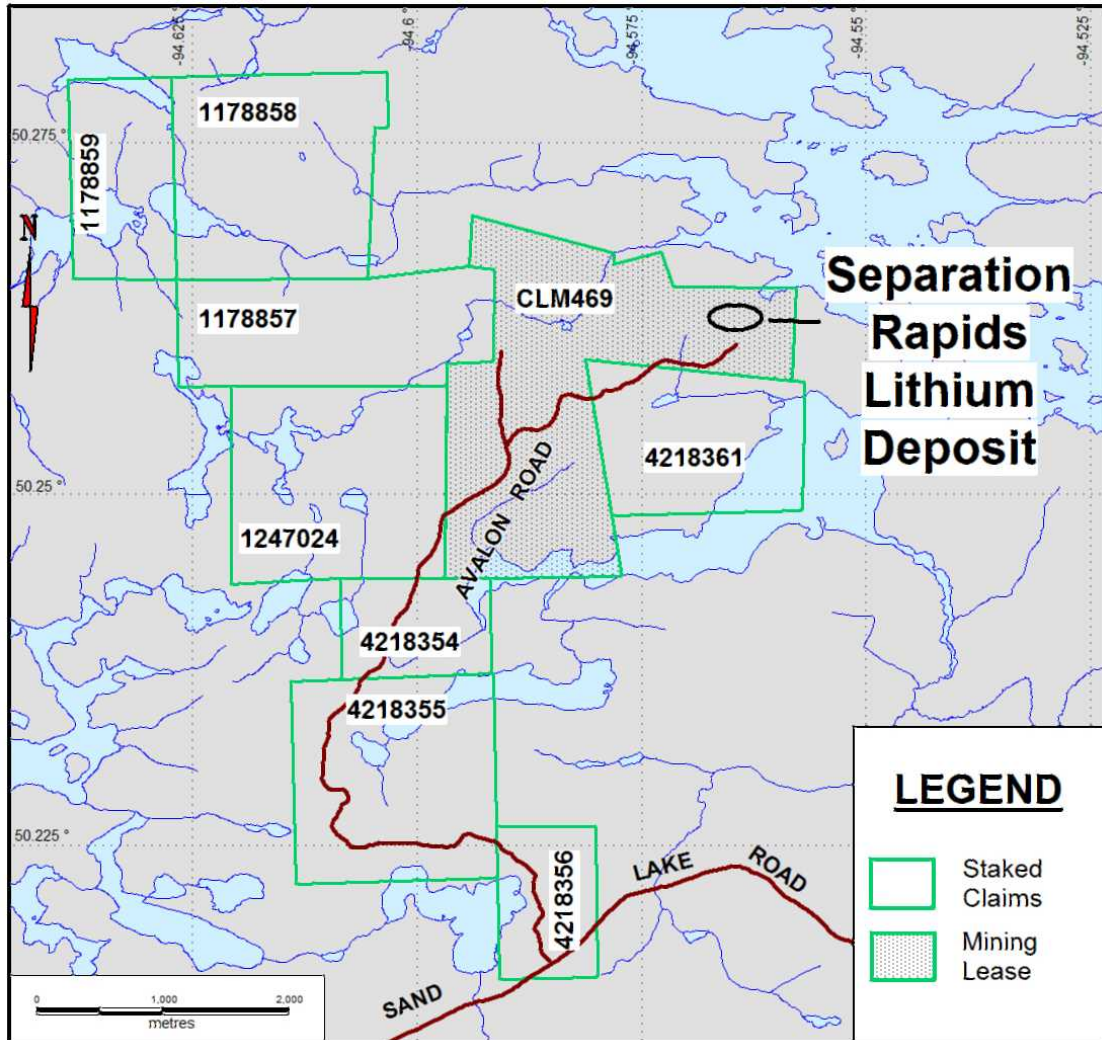
**Figure 4.1**  
**Separation Rapids Property General Location Map**



## 4.2 PROPERTY AND OWNERSHIP

The Separation Rapids property is located in the southeast corner of claim sheet G-2634, Paterson Lake Area, and consists of eight Mining Claims and one Mining Lease as shown in Figure 4.2.

**Figure 4.2**  
**Separation Rapids Property Claim Map**



Avalon, 2016.

The claims comprise 90 claim units, totalling 1,440 ha (3,558 acres). Information on the claims is summarized in Table 4.1.

**Table 4.1**  
**Separation Rapids Claim Listing**

| Claim Number | Location                 | Due Date  | Number of Units | Acres        | Hectares     | Recorded Date | Staked Date |
|--------------|--------------------------|-----------|-----------------|--------------|--------------|---------------|-------------|
| 1247024      | Paterson Lake/Snook Lake | 01-Feb-17 | 16              | 632.6        | 256          | 01-Feb-01     | 28-Jan-01   |
| 4218361      | Paterson Lake/Snook Lake | 19-Jan-17 | 8               | 316.3        | 128          | 19-Jan-10     | 13-Jan-10   |
| 1178857      | Paterson Lake            | 13-Feb-17 | 14              | 553.5        | 224          | 13-Feb-97     | 26-Jan-97   |
| 1178858      | Paterson Lake            | 13-Feb-17 | 16              | 632.6        | 256          | 13-Feb-97     | 26-Jan-97   |
| 1178859      | Paterson Lake            | 13-Feb-17 | 8               | 316.3        | 128          | 13-Feb-97     | 26-Jan-97   |
| 4218354      | Snook Lake               | 16-Mar-18 | 6               | 237.2        | 96           | 16-Mar-16     | 20-Feb-16   |
| 4218355      | Snook Lake (G-2644)      | 16-Mar-18 | 16              | 632.6        | 256          | 16-Mar-16     | 23-Feb-16   |
| 4218356      | Snook Lake (G-2644)      | 16-Mar-18 | 6               | 237.2        | 96           | 16-Mar-16     | 25-Feb-16   |
| <b>Total</b> |                          |           | <b>90</b>       | <b>3,558</b> | <b>1,440</b> |               |             |

In addition, Avalon holds a Mining Lease that encompasses the mineralized zone, referred to as Lease or Licence Number 108395. The lease covers an area of 421.441 ha over the area of the SRLD and adjacent lands. It was formed from Mining Claims K1178304, K1178305, K1178306, K1178349 and K1247023, Parts 1 to 5 on Plan 23R-11732, Paterson and Snook Lake Areas, as of October, 2009. See Table 4.2.

**Table 4.2**  
**Separation Rapids Mining Lease**

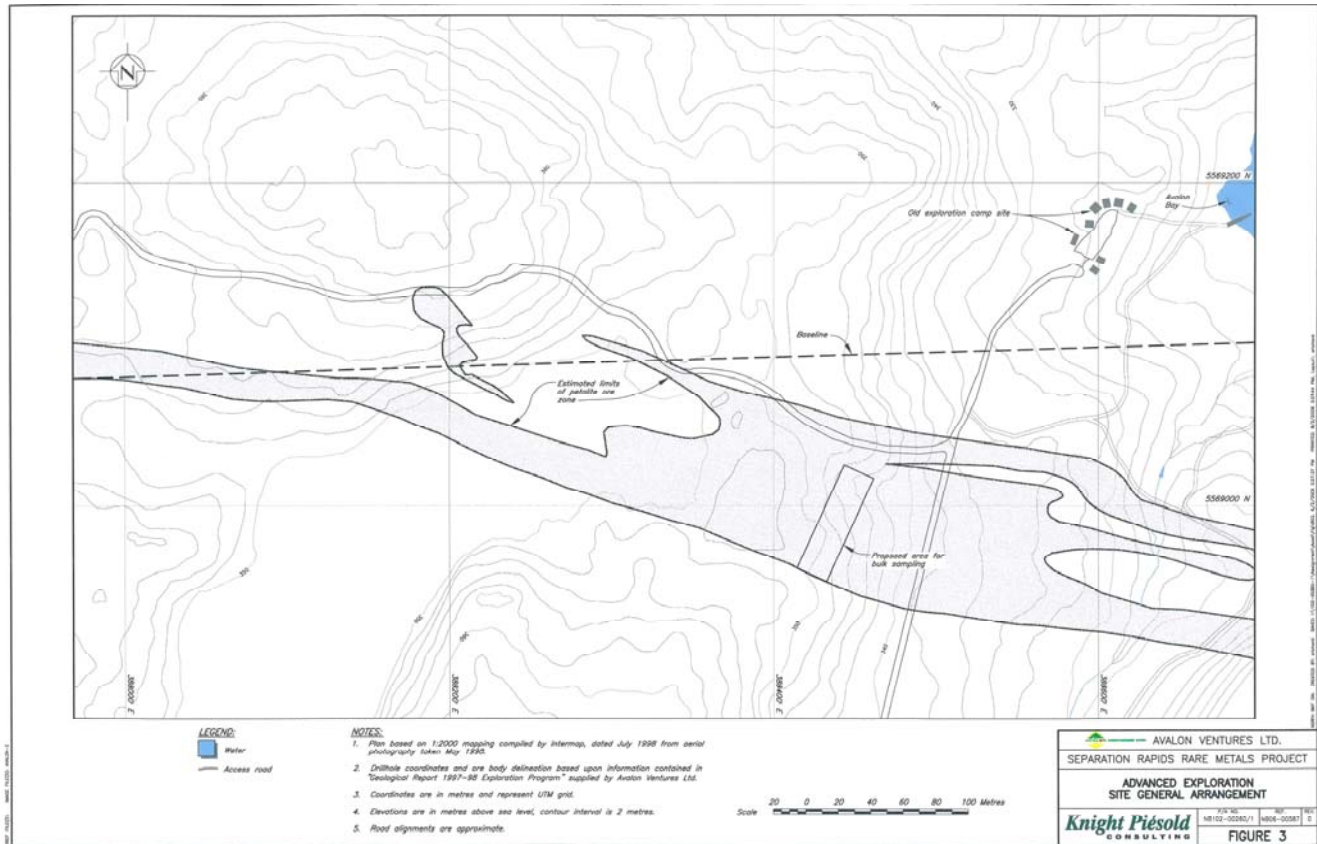
| Mining Lease Number | Location             | Expiry Date | Number of Units | Acres | Hectares |
|---------------------|----------------------|-------------|-----------------|-------|----------|
| 108395              | Paterson Lake CLM469 | 30-Sep-30   | 26              | 1,041 | 421      |

The total area covered by the claims and the lease is 1,861 ha (4,599 acres).

Avalon entered into an option agreement with Robert Fairservice and James Willis, the owners of claims over the mineral deposit, on 18 October, 1996, which was a four-year option from the above-named beneficial owners. Avalon completed all work and payment requirements of this option agreement and vested a 100% interest in the property in October, 1999. The title was transferred by the Government of Ontario from the owners to Avalon in November, 1999. Originally, the property was subject to a 2% NSR royalty retained by the vendors. This NSR was acquired on 23 February, 2012 by a wholly-owned subsidiary of Avalon, 8110131 Canada Inc., for \$220,000.

Avalon has an Advanced Exploration Approval (presently called Bulk Sample Permission), presently in a state of inactivity, covering the areas shown in Figure 4.3. Note that the camp identified in this figure has been removed and the associated area rehabilitated.

**Figure 4.3**  
**Location of Advance Exploration Approval**



Avalon holds two Ministry of Natural Resources and Forestry (MNRF) aggregate permits, numbers 107726 and 207728 which contain small quantities of gravel for construction purposes.

### 4.3 ENVIRONMENTAL LIABILITIES

Other than minor reclamation requirements that are largely funded under the existing Advanced Exploration Approval, there are no known material environmental liabilities associated with the Separation Rapids property.

### 4.4 TRANS-SHIPMENT FACILITY AND HYDROMETALLURGICAL PLANT

Mining and mineral concentration will take place at the Separation Rapids property.

Concentrate will be shipped to a hydrometallurgical processing plant to be located in the City of Kenora, Ontario.

As there is no rail access to the mine/concentrator site, delivery of reagents to, and shipment of concentrates from, the site will be by truck. However, a trans-shipment facility will be

required in order to access rail transportation for product shipment and inbound supplies. The trans-shipment facility is planned to be located on the CNR line in the vicinity of Redditt, Ontario, approximately 55 km by road from the Separation Rapids site.

Avalon has not made the final site selection for the hydrometallurgical plant and trans-shipment facility and has not acquired ownership or rights to any land for these facilities.

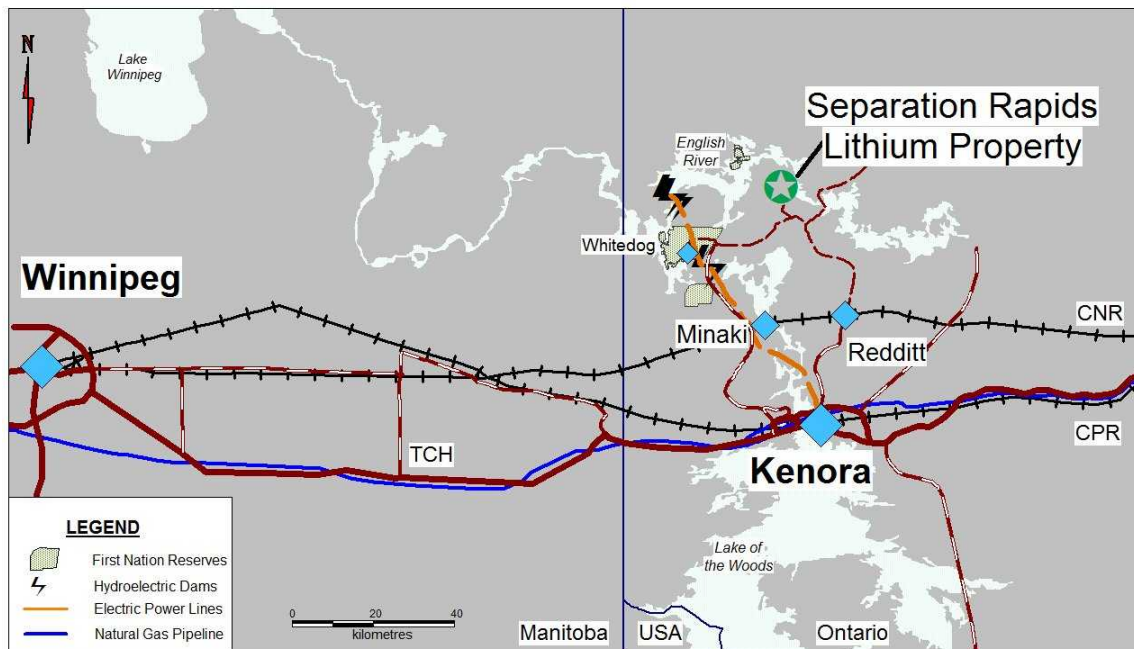
## 5.0 ACCESSIBILITY, CLIMATE, LOCAL RESOURCES, INFRASTRUCTURE AND PHYSIOGRAPHY

### 5.1 ACCESSIBILITY

The Separation Rapids property is readily accessible from Kenora by traveling 27 km north on Highway 658, an all-weather road, to the English River Road, 2 km south of the community of Redditt. Then a further 37 km on the English River Road to the Sand Lake Road, and west on the Sand Lake Road for 5.5 km to East Tourist Lake Road (ETL Road, also known as the Avalon Road), a former forestry access road (marked with a “Road to Avalon” sign). The project site is located approximately 9.5 km north on the ETL or Avalon Road. The total distance from Kenora to the site is 79 km.

The main line of the CNR passes through the village of Redditt 33 km south-southeast of the property and 52 km by road, Figure 5.1. The CPR lines pass through the City of Kenora.

**Figure 5.1**  
**Location of the Avalon Separation Rapids Property**



Avalon, 2016.

The property lies within the traditional land use area of the Wabaseemoong Independent Nations of White dog, Ontario, an Aboriginal community located approximately 31 km southwest of the property. The Swan Lake and One Man Lake reserves are also within approximately 35 km of the property as shown in Figure 5.1.

Avalon constructed the access road in 1999. Over the period 2011 to 2015 almost every year some work was completed relating to maintenance and access to the site. In 2011 new hazard



awareness barricades were installed around the existing excavation and warning signs were installed in designated locations. In 2012, there was no notable site work conducted other than site visits for general site inspection. In 2015, Avalon entered into an Access and Maintenance Agreement (AMA) with the Ministry of Natural Resources and Forestry (MNRF) and obtained a work permit to conduct road repairs. The 1999 site access road was subsequently repaired with the installation of new culverts at the water crossings, allowing access to site with vehicles, rather than just by all-terrain vehicles. Additional signage was installed in accordance with the AMA and a new, more secure barrier was installed around the existing excavation.

Avalon's existing quarry permit areas, located along the access road, were reflagged and new signage installed to ensure compliance with regulations. In 2016 no significant site work was done, other than monitoring road conditions and ensuring hazard awareness signs and barricades remain intact and effective.

Avalon is in the process of purchasing the Nelson Granite aggregate quarry along the access road.

## **5.2 PHYSIOGRAPHY**

The Separation Rapids area is typical of much of northwestern Ontario and the Canadian Shield. The property is relatively flat with an elevation of approximately 350 masl. Local topographic relief is limited to 50 m or less in typical Precambrian glaciated terrain and is mantled by low swamp or muskeg areas. In the low lying areas, often underlain by recessively weathered amphibolite, there is a thin veneer of glacial till, whereas the higher areas are occupied by scoured outcrop of granite or pegmatite. The English River system is proximal to all claim groups.

Outcrop exposure is in general less than 40% in the project area, but the area containing the SRLD has been stripped of ground cover where practicable, or trenched. The remainder of the property is covered by thin glacial regolith and poorly developed soils, local swamps, muskeg, river bottom sediments and varved clays.

## **5.3 VEGETATION**

The Separation Rapids area falls within the Boreal Hardwood Transition or Mixed Boreal Forest. The project area is covered by boreal forest with the dominant species being Jackpine and Black Spruce. Willow shrubs and grasses dominate the low marshy areas and shoreline of the English River. Land adjacent to and within the sphere of influence of the Separation Rapids property is covered by an extensive area of blowdown caused by a wind storm around 2008. As a result of this, the surrounding forest is comprised of non-merchantable timber.

A Species at Risk Act assessment was completed and no endangered or at risk species were identified in the area of the proposed project. Details of the flora and fauna within the Separation Rapids area are provided in Section 20.0.

## 5.4 CLIMATE

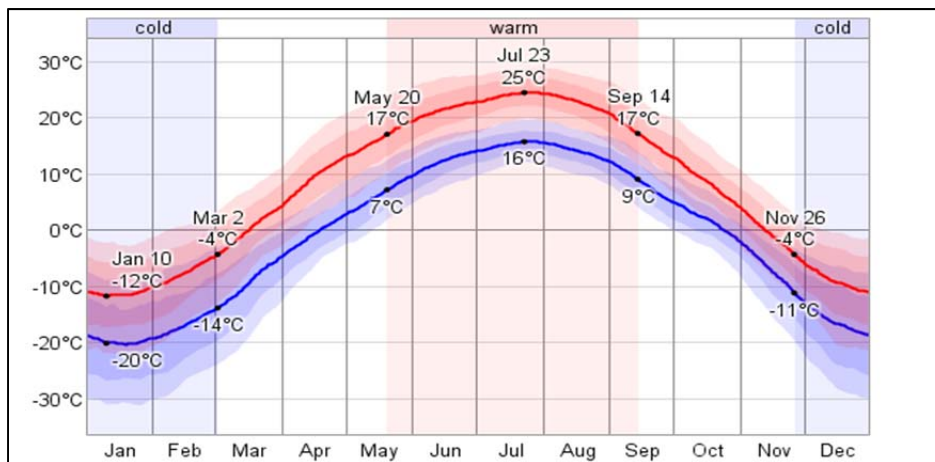
The climate is typical of Canada’s mid-latitudes. Winters are cold and long, stretching from late-October to mid-May with extremes in winter of below -40° C without the wind chill factor. The daily average temperature is below 0° C from November to March and the daily minimum is below 0° C from November to April (see Table 5.1 and Figure 5.2). The spring-summer-fall periods are comparatively short and summer temperatures are typically warm.

**Table 5.1**  
**Average Temperatures, Kenora Weather Station, 1981-2010**

|                      | Jan     | Feb     | Mar     | Apr     | May     | Jun     | Jul     | Aug     | Sep     | Oct     | Nov     | Dec     | Year |
|----------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|------|
| Daily Average (°C)   | -16     | -12.5   | -5.2    | 4.1     | 11.3    | 16.8    | 19.7    | 18.6    | 12.7    | 5.1     | -4.2    | -13.1   | 3.1  |
| Standard Deviation   | 3.8     | 3.9     | 2.7     | 2.7     | 2.2     | 1.9     | 1.5     | 1.8     | 1.8     | 1.8     | 3.2     | 3.9     | 1.1  |
| Daily Maximum (°C)   | -11.4   | -7.6    | -0.2    | 9.4     | 16.7    | 21.7    | 24.4    | 23.4    | 17.1    | 8.8     | -0.9    | -9.2    | 7.7  |
| Daily Minimum (°C)   | -20.5   | -17.4   | -10.1   | -1.3    | 5.8     | 11.8    | 14.9    | 13.9    | 8.3     | 1.4     | -7.4    | -17.1   | -1.5 |
| Extreme Maximum (°C) | 9.1     | 8.8     | 23.3    | 30.6    | 35.4    | 35.6    | 35.8    | 35      | 34.6    | 26.7    | 19.4    | 9.4     |      |
| Date (yyyy/dd)       | 2003/07 | 2000/23 | 1946/27 | 1952/30 | 1986/29 | 1995/17 | 1983/14 | 1955/18 | 1983/02 | 1943/08 | 1975/05 | 1941/03 |      |
| Extreme Minimum (°C) | -43.9   | -41.4   | -36.1   | -27.2   | -12.2   | -0.6    | 3.9     | 1.1     | -6.7    | -13.9   | -31.3   | -38.3   |      |
| Date (yyyy/dd)       | 1943/20 | 1996/02 | 1962/01 | 1954/02 | 1958/01 | 1969/13 | 1972/02 | 1938/28 | 1965/25 | 1951/31 | 1985/28 | 1967/31 |      |

Environment Canada.

**Figure 5.2**  
**Graph of Average Temperatures, Kenora 1982-2012**



Note: the daily average low (blue) and high (red) temperature with percentile bands (inner band from 25<sup>th</sup> to 75<sup>th</sup> percentile, outer band from 10<sup>th</sup> to 90<sup>th</sup> percentile).  
Weatherspark.com.

Average annual precipitation for the region is about 700 mm of which about 160 mm falls as snow. See Table 5.2.

Typical snow accumulations, in the eight-month period September to May, range from 0.8 to 32 cm with typical peak accumulations in the period November to January. However, extreme snow falls of greater than 20 cm have been recorded for September to May. Most

rainfall occurs in the period May to September with monthly average greater than 70 mm. It ranges from 72 to 118 mm, with recorded peak 24-h storms of 150 mm.

**Table 5.2**  
**Average Precipitation, Kenora Weather Station, 1981-2010**

|                             | Jan      | Feb      | Mar      | Apr      | May      | Jun      | Jul      | Aug      | Sep      | Oct      | Nov      | Dec      | Year  |
|-----------------------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-------|
| Rainfall (mm)               | 0.7      | 3        | 8.5      | 22.4     | 77.4     | 118.6    | 103.4    | 84.2     | 84.6     | 49.4     | 12       | 1.1      | 565.3 |
| Snowfall (cm)               | 28.4     | 18.6     | 21.1     | 14.6     | 3.5      | 0.1      | 0        | 0        | 0.8      | 14.2     | 32.2     | 30.6     | 164.1 |
| Precipitation (mm)          | 25.6     | 19.4     | 28.1     | 36.3     | 80.8     | 118.7    | 103.4    | 84.2     | 85.6     | 62.6     | 42.1     | 28.3     | 715   |
| Average Snow (cm)           | 32       | 35       | 23       | 3        | 0        | 0        | 0        | 0        | 0        | 1        | 8        | 20       | 10    |
| Median Snow (cm)            | 32       | 36       | 21       | 2        | 0        | 0        | 0        | 0        | 0        | 0        | 6        | 20       | 10    |
| Extreme Daily Rainfall (mm) | 9.4      | 16.2     | 19.8     | 33.3     | 106.4    | 121.4    | 153.5    | 92.5     | 108      | 46.5     | 23       | 29.7     |       |
| Date (yyyy/dd)              | 2010/ 23 | 2000/ 26 | 1960/ 28 | 1974/ 21 | 2007/ 29 | 1999/ 25 | 1993/ 27 | 1972/ 20 | 1981/ 06 | 1940/ 04 | 2008/ 06 | 1951/ 03 |       |
| Extreme Daily Snowfall (cm) | 24.6     | 26.9     | 33.8     | 36.3     | 35.6     | 1.4      | 0        | 0        | 30       | 26.2     | 32.8     | 22.8     |       |
| Date (yyyy/dd)              | 1975/ 11 | 1955/ 20 | 1966/ 04 | 1957/ 10 | 2004/ 11 | 1998/ 01 | 1939/ 01 | 1938/ 26 | 1964/ 26 | 1970/ 09 | 1977/ 09 | 1984/ 16 |       |
| Extreme Snow Depth (cm)     | 102      | 117      | 145      | 84       | 23       | 1        | 0        | 0        | 20       | 20       | 66       | 91       |       |
| Date (yyyy/dd)              | 1966/ 17 | 1962/ 16 | 1966/ 05 | 1962/ 01 | 1966/ 02 | 1997/ 27 | 1955/ 01 | 1955/ 01 | 1964/ 27 | 2001/ 26 | 1965/ 28 | 1965/ 31 |       |

Environment Canada.

The most frequent wind direction is from the south, with speed averaging 13.7 km/h over the year. The monthly averages are similar with a relatively narrow range (see Table 5.3). The maximum hourly speed is of the order of 50-68 km/h and the maximum gusts up to 120 km/h. These stronger winds can be from a variety of directions and not necessarily the south. Environment Canada wind speeds are quoted for a standard 10 m above ground level.

**Table 5.3**  
**Average Wind Speed, Kenora Weather Station, 1981-2010**

|                         | Jan      | Feb      | Mar      | Apr      | May      | Jun      | Jul      | Aug      | Sep      | Oct      | Nov      | Dec      | Year |
|-------------------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|------|
| Speed (km/h)            | 13.4     | 13.4     | 14.1     | 14.5     | 14.3     | 13.4     | 12.6     | 12.9     | 13.8     | 14.5     | 14.3     | 13.5     | 13.7 |
| Most Frequent Direction | S        | S        | S        | S        | S        | S        | S        | S        | S        | S        | S        | S        | S    |
| Max Hourly (km/h)       | 58       | 51       | 56       | 53       | 56       | 68       | 64       | 64       | 57       | 64       | 58       | 59       |      |
| Date (yyyy/dd)          | 1954/ 03 | 1959/ 15 | 1953/ 22 | 1960/ 15 | 1959/ 12 | 1954/ 07 | 1974/ 27 | 1962/ 28 | 1977/ 09 | 1956/ 24 | 1954/ 02 | 1999/ 25 |      |
| Max Gust (km/h)         | 85       | 76       | 78       | 79       | 104      | 115      | 108      | 129      | 89       | 90       | 83       | 120      |      |
| Date (yyyy/dd)          | 1986/ 11 | 1971/ 27 | 1982/ 13 | 1975/ 28 | 1977/ 28 | 2002/ 10 | 1974/ 27 | 1962/ 27 | 1964/ 26 | 1971/ 19 | 1978/ 05 | 1999/ 25 |      |

Environment Canada.

## 5.5 LOCAL RESOURCES AND INFRASTRUCTURE

The development of the Separation Rapids project is expected to have a positive impact on unemployment in the Kenora, Redditt and the Whitedog First Nations communities. The Whitedog First Nations community, a probable source of mine personnel, lies approximately 30 km west of the property and is accessed via the Sand Lake Road and Route 525.

Water for mineral processing and other needs is available in abundance in the project area. The closest hydroelectric power generating station is located at Whitedog Falls.

Hydro One has an existing 115 kV transmission line from Whitedog Falls to Kenora and has confirmed that sufficient power is available to meet both the mine site and hydrometallurgical plant power requirements. Connection can be made to the transmission system near Whitedog Falls to supply power to the mine site approximately 25 km away and to the Hydro One substation in Kenora to supply the hydrometallurgical plant.

Further details on infrastructure requirements are provided in Section 18.0.

The closest centre with significant services is Kenora. Forestry, tourism and mining are the three largest sectors of the Kenora economy. Tourism can almost double the population of the area in summer.

The Lake of the Woods District Hospital is located in Kenora. Education is provided by seven elementary schools, two high schools and Confederation College, a post-graduate institution.

Kenora is served by Via Rail, Greyhound buses and Bearskin Airlines.

Redditt is a small community with a population of approximately 150 people.

## 6.0 HISTORY

Prior to the discovery of rare-metal pegmatite occurrences, exploration in the Separation Rapids region focused on base and precious metal mineralization. Rare-element mineralization in the area was first encountered along the English River near Separation Rapids by Stockwell in 1932 (Breaks and Tindle, 2001). The petalite-bearing SRLD which forms a prominent hill on the south shore of MacDonald's Bay on the English River, and an associated group of rare-metal pegmatites, were discovered by Dr. Fred Breaks of the Ontario Geological Survey (OGS) as a result of a detailed study of rare-metal pegmatites in the region between 1994 and 1996. Dr. Breaks and the OGS recognized the importance of the SRLD and public disclosure of the discovery was made in July, 1996 in an OGS special release (Breaks and Tindle, 1996).

It should be noted that the SRLD may be referred to in the geological literature and in earlier reports on the property as the Big Whopper Pegmatite or BWP.

The Superior Province of Ontario represents a vast terrain that contains numerous rare-element (Li, Cs, Rb, Ti, Be, Sn, Ta, Nb, Ga and Ge) mineral occurrences, many of which were found during the lithium exploration rush of the 1950s (Mulligan, 1965, cited in Breaks and Tindle, 2001). Mineral exploration for the rare elements in subsequent years, however, was essentially desultory. In 1993, Breaks and Tindle commenced a comprehensive study of rare-element mineralization in northwestern Ontario intended to provide a modern mineralogical, chemical and geochronological database and designed, in part, to encourage mineral exploration. The authors recognized that rare-element class pegmatites of the complex-type (petalite-subtype) are widespread in the Separation Rapids area. Such pegmatites are uncommon and comprise only 2% of lithium-rich pegmatites on a global basis (Černý and Ercit, 1989). Break's work in the area culminated in the 1996 discovery of the SRLD pegmatite (Breaks and Tindle, 1996, 1997).

Subsequent to the discovery and staking of the SRLD, the area has experienced a significant increase in exploration interest for ceramic grade petalite, tantalum and cesium. The principal exploration companies include Avalon, Champion Bear Resources Ltd., Tantalum Mining Corporation of Canada Ltd. (Tanco), Gossan Resources Ltd. and Emerald Fields Resource Corporation (now Pacific Iron Ore Corporation).

Exploration on the SRLD in the late-1990s was accompanied by a scoping level metallurgical study by Lakefield Research Limited and a marketing study by Equapolar Resource Consultants (Pearse, 1998) on the principal mineral commodities to develop. A flowsheet for processing the mineralized material was developed and the size and value of the markets for the principal mineral commodities, petalite and feldspar was identified. Avalon's senior geologist, Mr. Chris Pedersen, geologically mapped the major portion of the cleared outcropping SRLD on the property at a scale of 1:100.

Exploration and drilling programs completed by Avalon are described in Sections 9.0 and 10.0.

## 7.0 GEOLOGICAL SETTING AND MINERALIZATION

### 7.1 INTRODUCTION

The Late Archean-aged SRLD belongs to the petalite sub-type of the complex-type class of rare-metal pegmatites (Černý and Ercit, 2005). The complex-type pegmatites are geochemically the most highly evolved in the spectrum of granitic pegmatites and petalite-bearing pegmatites comprise only 2% of the known complex-type pegmatites.

The SRLD exhibits some significant differences from the norm in its structural setting, preservation of magmatic zonation and overall crystal size. Unlike the Tanco and Bikita deposits (owned by Cabot Corporation and Bikita Minerals Ltd., respectively), which are shallowly dipping, undeformed zoned intrusions, and the Greenbushes deposit (Talison Lithium), which is an approximately 45°-dipping, zoned and locally mylonitized pegmatite, the SRLD dips subvertically, is complexly folded, strongly foliated and locally mylonitized.

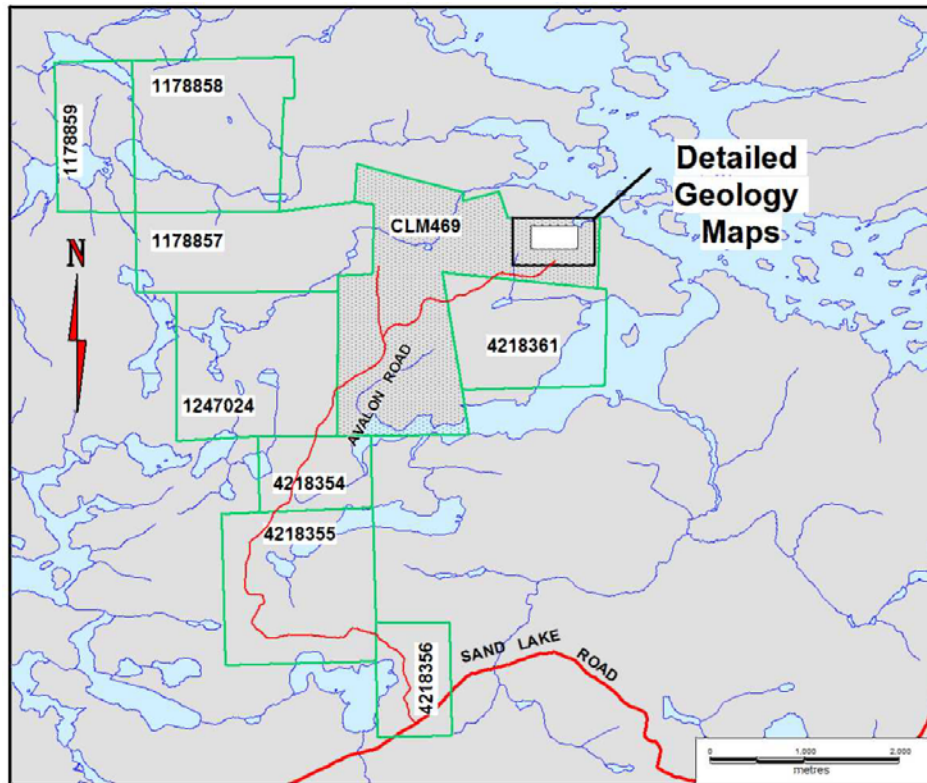
The SRLD exhibits zoning characteristics seen in other highly evolved rare-metal pegmatites, i.e., well-developed wall zones with exo-contact and endo-contact borders and a petalite-rich intermediate zone. However, within the SRLD a significant portion of these zones and zonal features has been tectonically modified. In addition, all three recently producing rare-metal pegmatite deposits (Tanco, Bikita, Greenbushes) contain exceptionally large crystals of spodumene, petalite and feldspars which permit selective mining; at Bikita and Tanco petalite crystals and pseudomorphs are reported to be as large as 2 to 2.5 m in size. The megacrystic zones in the Separation Rapids Pegmatite, on the other hand, contain crystals no larger than 10 to 15 cm.

### 7.2 REGIONAL GEOLOGY

The SRLD, its parent granite, the Separation Rapids Pluton, and associated rare-metal pegmatites occur within the Archean Separation Lake Metavolcanic Belt (SLMB) which forms the boundary between the English River subprovince to the north and the Winnipeg River subprovince to the south. Both subprovinces are part of the larger Archean Superior Province of the Canadian Shield. Figure 7.1 and Figure 7.2 provide the location and a simplified regional geological map of part of Avalon's lease, 108395 (Paterson Lake CLM469).

The SLMB is thought to represent the easterly extension of the Bird River metavolcanic-metasedimentary belt in Manitoba which contains the Tanco, Bernic Lake, Rush Lake and Greer Lake pegmatites, all of which are part of the Winnipeg River-Cat Lake pegmatite field. To date, this belt and pegmatite field combined contain the highest concentration of fertile peraluminous granites and rare-metal pegmatite mineralization in the Superior Province, and the greatest number of complex-type, petalite-subtype pegmatite occurrences in Canada (Breaks and Tindle, 1998).

**Figure 7.1**  
**Location of the Separation Rapids Lithium Deposit**

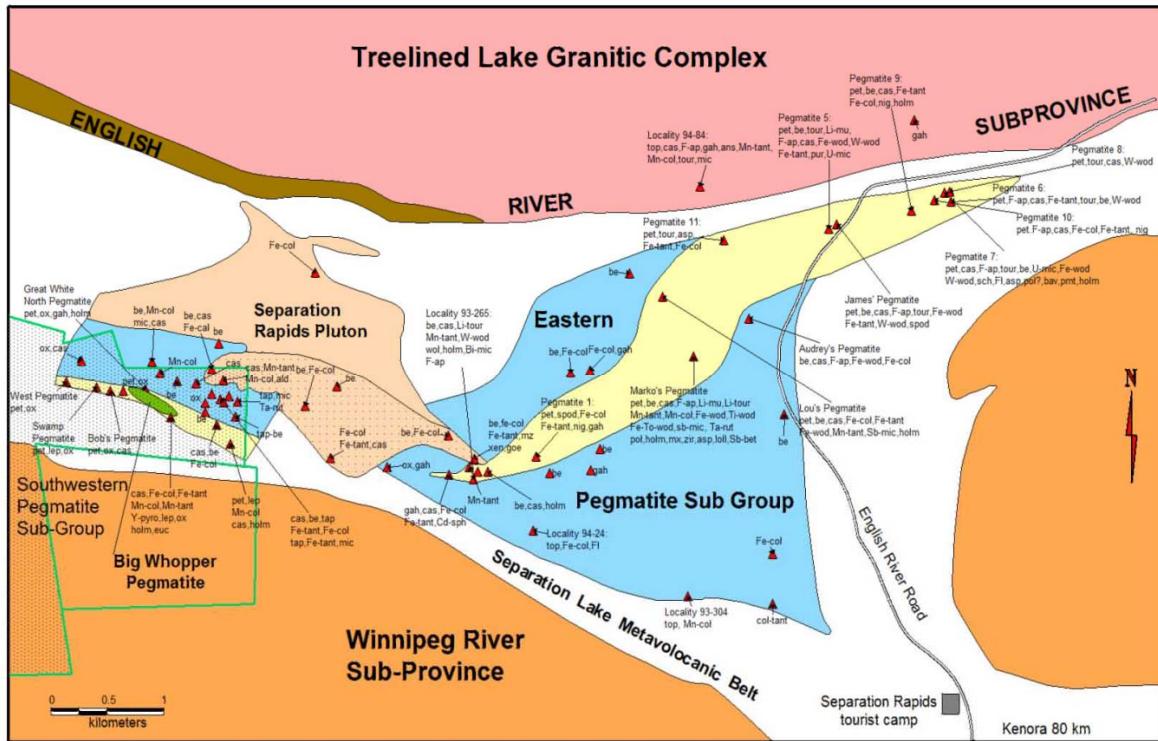


Note: For detailed geology maps, black outline denotes location of Figure 7.3; white box denotes location of Figure 7.4.  
Avalon, 2016.

The currently exposed and mapped areas of the SRLD and associated rare-metal pegmatites occur within an approximately 600 m wide package of predominantly mafic metavolcanic rocks that have been variably deformed and metamorphosed to lower and middle amphibolite facies. This package is bounded to the north by the Separation Rapids Pluton and to the south by pegmatitic granites of the Winnipeg River subprovince, as shown in Figure 7.2.

The SRLD and its associated dykes fall within the southwestern subgroup of the Separation Rapids pegmatite group (Breaks and Tindle 1998) and are located south and west of the English River. The eastern subgroup occurs to the north and east of the English River and contains a number of rare-metal pegmatites, including Marko's pegmatite approximately 5 km east of the SRLD.

**Figure 7.2**  
**District Geological Map**



Note: Nomenclature is per original reference.  
Breaks and Tindle, 1998.

### 7.3 PROPERTY GEOLOGY

Avalon has mapped seven distinct lithological units adjacent to and within the SRLD as described in Table 7.1, below.

The Separation Rapids area is underlain predominantly by a mafic metavolcanic sequence (amphibolite or Avalon's Unit 1), consisting of flows, tuffs, subordinate epiclastic metasediments and rare iron formation horizons and rhyolites. (See Figure 7.3, "Amphibolite Host Rocks"). Locally, on the Avalon property itself, the metavolcanic sequence is restricted to amphibolite (Pedersen, 2016a).

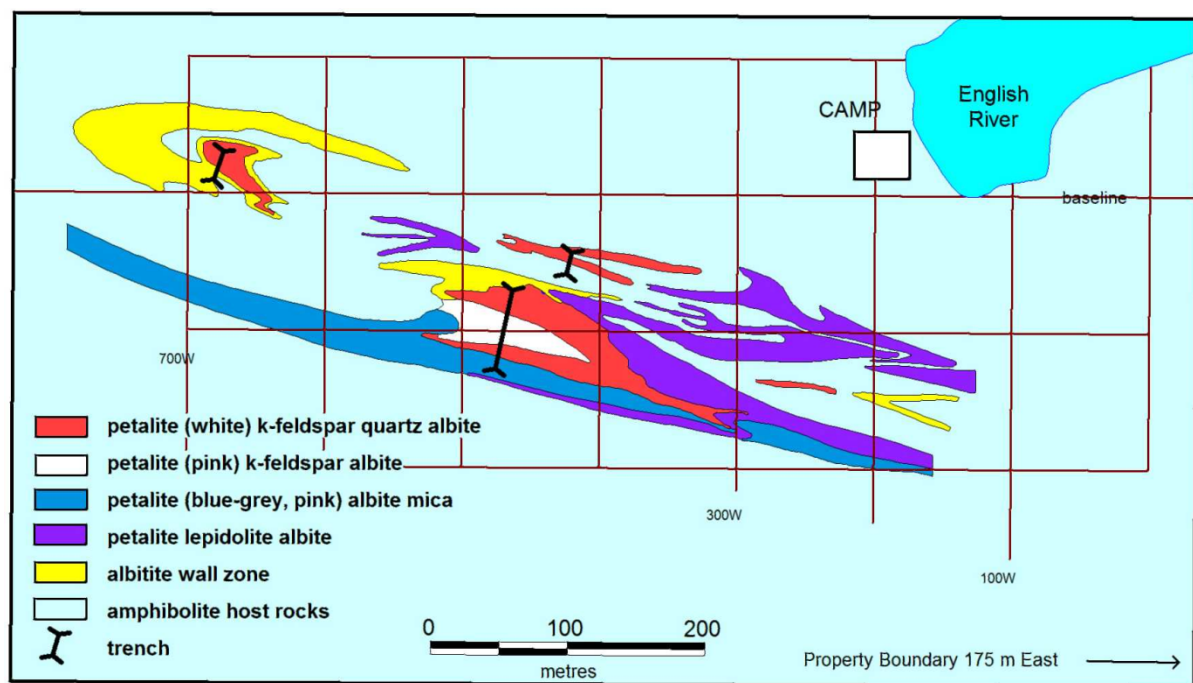


**Table 7.1**  
**Mapped Lithologies in the Separation Rapids Property**

| <b>Lithological Unit/Subunit</b> | <b>Rock Type</b>                               | <b>Physical Characteristics, Size and Distribution</b>                 | <b>Description</b>  |
|----------------------------------|--|--|---|
| 1                                | Amphibolite                                    | Separation Lake<br>Metavolcanic Belt                                   | Dark green-grey, typically fine-grained but locally coarser gabbroic. Strongly foliated and folded. Local preservation of pillow flows. Li and Cs metasomatic alteration adjacent to Separation Rapids Pegmatite dykes produces holmquistite (blue-violet acicular Li-bearing amphibole) and glimmerite (black-brown Cs-rich phlogopite).   |
| 2                                | Pegmatitic granite                             | Winnipeg River<br>Batholith  | Medium-grained to locally megacrystic, massive to poorly foliated, with potassium feldspar predominant, and quartz and albite subordinate. Recent reinterpretation of lithologies mapped as Unit 2, on the south side of the Separation Rapids Pegmatite, indicate that they might be part of the Separation Rapids Pegmatite's petalite-bearing feldspathic zone (Pedersen, personal communication).   |
| 3a and 3b                        | Albite   | SRLD albite-rich wall zone to the petalite bearing pegmatitic subunits | Together, 3a and 3b constitute approximately 25% of the feldspathic units in the Separation Rapids Pegmatite. Zones from several cm to 15 m wide and to a maximum length of 120 m. Subunit 3a albite is generally grey-white to light pink. Fine- to medium-grained, equigranular to seriate textures and locally exhibit pronounced magmatic banding (albite-rich versus potassium feldspar-rich layers, with the former predominating). Aplitic albite is the most common constituent. The abundance of albite and the albite: potassium feldspar is highly variable. Subunit 3b dykes are typically mottled grey, heterogeneous, medium grained to megacrystic albite potassium feldspar rock with light pink-orange potassium feldspar megacrysts in a finer-grained albitic groundmass. The total feldspar content of Subunit 3b is typically greater than 80%, but the ratios of potassium feldspar to albite is heterogeneous. |
| 4                                | Megacrystic potassium feldspar quartz sub-zone | SRLD intermediate zone   | Potassium feldspar-rich (plus albite and mica). Similar to Unit 3b in that Coarse-grained, subhedral potassium feldspar megacrysts (larger than 5 mm) set in a finer-grained matrix (less than 2 mm) of subhedral quartz, albite, potassium feldspar and minor mica. Distinct from Unit 7 in having a lower potassium feldspar to albite ratio. Very minor petalite.  |
| 5                                | Quartz-mica sub-zone                           | SRLD intermediate zone   | Constitutes approximately 17% of the feldspathic units in the Separation Rapids Pegmatite. Coarse grained rock dominated by dark anhedral quartz with subordinate amounts of interstitial mica and potassium feldspar and no obvious petalite.  |
| 6a, 6b, 6c, 6d                   | Petalite-bearing pegmatite zone                | SRLD petalite zone (intermediate zone)                                 | See text.   |
| 7                                | Pegmatite granite zone                         | Separation Rapids Pegmatite feldspathic wall zone                      | Constitutes approximately 31% of the feldspathic units in the Separation Rapids Pegmatite. Similar to Unit 4 being heterogeneous, medium grained and locally containing megacrystic Rb-rich potassium feldspar.   |



**Figure 7.3**  
**Generalized Geology – Separation Rapids Lithium Deposit**



Note: The grid is the original project grid and “camp” refers to original exploration camp. Micon, 1999.

There has been confusion over the naming of various pegmatitic bodies in the Separation Rapids area over the years due to the informal nature of many of the deposit names utilized. The SRLD, as referred to by Avalon and as described in this report, extends for some 1,150 m in outcrops and various parts have had names applied to them over the years.

The drill tested portion is about 750 m in strike length, of which about 300 m is considerably thicker and thus contains the bulk of the presently defined mineral resource. The further continuation of the pegmatite 450 m to the west is thinner and has a few shallow drill holes. This thin portion, drilled in the past, has been informally referred to as Bob’s Pegmatite.

There is yet further extension of the thinner pegmatite in sparse outcrops to the west for approximately 400 m, referred to normally as the “Western Pegmatite” or, rarely, as the “West Pegmatite”. See Figure 7.2. (Breaks and Tindle, 1998; Micon, 1999). This 400 m extension has not been drill tested.

Bob’s Pegmatite and the West or Western Pegmatite are all part of what Breaks and Tindle called the Southwestern Pegmatite Sub-Group to distinguish it from the “Big Whopper” sensu stricto, where the term Big Whopper was used by Breaks and Tindle, and others, originally to refer to the main known portion of the SRLD. Breaks and Tindle’s Southwestern Pegmatite Sub-Group though, appears to include some unnamed pegmatites as well as the Western and Bob’s Pegmatites.

For reference, Table 7.2 sets out the various names for the known pegmatite deposits in terms of their grid and UTM locations using the extent to the west and east of each portion of the pegmatite that comprises the SRLD.

**Table 7.2**  
**Separation Rapids Area Pegmatite Nomenclature**

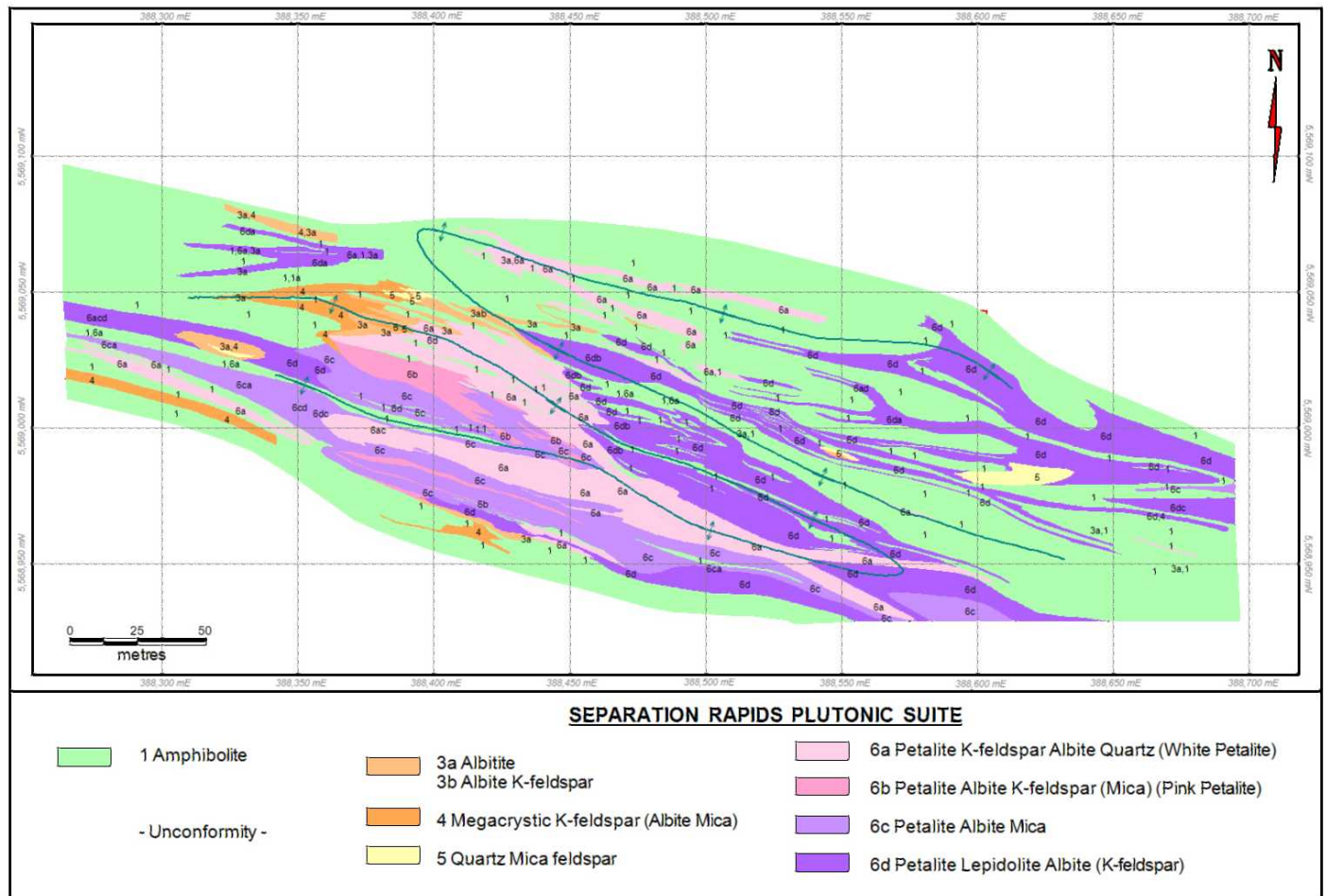
| Deposit | 1999 Fig 3.8 Terminology                              | Other Names                 | Description  | Project Grid |          |            | UTM      |          |            |
|---------|---|-----------------------------|--|--------------|----------|------------|----------|----------|------------|
|         |   |                             |  | Westing      |          |            | Easting  |          |            |
|         |   |                             |  | West End     | East End | Strike (m) | West End | East End | Strike (m) |
| SRLD    | Big Whopper   | Main Mass                   | Thick part of drilled pegmatite  | 550          | 250      | 300        | 388350   | 388650   | 300        |
| SRLD    | Bob's Pegmatite                                       | West extension of Main Mass | Thin part of drilled pegmatite. Part of Breaks' Southwest Pegmatite Sub-unit | 1000         | 550      | 450        | 387900   | 388350   | 450        |
| ?SRLD   | Usually Western Pegmatite or sometimes West Pegmatite | Western Extension           | Undrilled. Part of Breaks' Southwest Pegmatite Sub-unit                      | 1400         | 1000     | 400        | 387500   | 387900   | 400        |

In the northern part of the property, the mafic metavolcanic sequence is intruded by granite, pegmatitic granite and pegmatite dykes associated with the Separation Rapids Pluton, and in the southern part of the property by pegmatitic granite and related dykes of the Winnipeg River batholith. The amphibolite of the mafic metavolcanic sequence and the Winnipeg River granite (Unit 2) are the host lithologies to the SRLD.

As mapped by Avalon, see Figure 7.4 and Figure 7.5, the thickest part of the SRLD, historically referred to as the Big Whopper Pegmatite, forms a large lens-shaped body approximately 400 m long and approximately 70 m at its widest part.

The SRLD narrows to less than 20 m at both its eastern and western ends, and extends along strike in both directions for at least 300 m in the form of relatively narrow tails up to 10 to 15 m wide. Smaller, subparallel, 1 m to 10 m wide, petalite-bearing pegmatite bodies predominantly occur to the northeast, north and northwest of the main SRLD body, with minor occurrences on the southern flank.

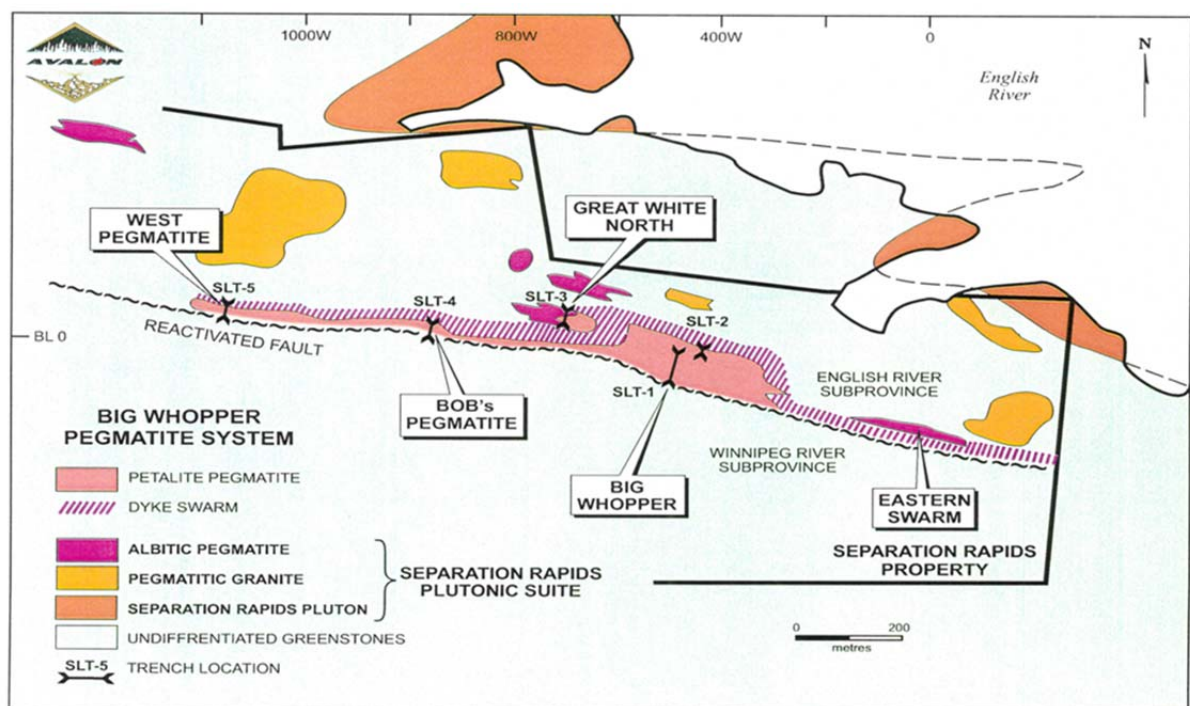
**Figure 7.4**  
SRLD, Detailed Outcrop Mapping



Pedersen, 1998b.

The narrower west-southwest-striking zone of petalite pegmatites extends from the main SRLD for a distance of approximately 750 m to the west and is exposed in four outcrops, namely the Great White North, Bob's, Swamp and West pegmatites, see Figure 7.5.

**Figure 7.5**  
**SRLD, Extension of the Main Pegmatite Body**



Note: 1. Names of deposits are historical, see Table 7.2; 2. Grid reference 1000W in original map is incorrect and should be 1200W3.  
Micon, 1999.

Avalon has further subdivided the SRLD into three sub-zones, namely the Separation Rapids Pegmatite, Western Pegmatite and Eastern Swarm. Based on lithological, mineralogical and textural variations, the Separation Rapids Pegmatite itself has been subdivided into five distinct lithological units and subunits, 3a, 3b, 4, 5 and 6, as shown in Table 7.1 above, that outcrop as irregular dykes and larger irregular to elliptical bodies intruding the amphibolite and granites.

Within the Separation Rapids Pegmatite, Unit 1 amphibolite occurs as narrow, discontinuous screens with strike lengths ranging from tens of metres up to greater than 100 m and widths of predominantly less than 1 m. These screens are preferentially, but not exclusively, concentrated near the north and south margins of the main pegmatite body. Core drilling has confirmed their down-dip continuity and surface mapping shows that they are also locally isoclinally folded with the pegmatite. Outside of the Separation Rapids Pegmatite, recessively-weathering amphibolite forms depressions and valleys adjacent to resistant ridges of granite and pegmatite.

Avalon reports that classification of the Winnipeg River pegmatitic granite (Unit 2) as a separate unit is based on its occurrence south of the Separation Rapids Pegmatite and the boundary fault between the Winnipeg River and Separation Rapids intrusive suites, and its distinct primary mineralogy (potassium feldspar, biotite, quartz, almandine).

### 7.3.1 Pegmatite Units

#### 7.3.1.1 Unit 3: Albitite

The main SRLD is flanked by a swarm of narrower petalite-bearing, highly feldspathic pegmatites, albitite and albite-potassium feldspar zones, subunits, 3a and 3b. These two subunits make up a significant portion of the northwestern part of the SRLD (Albitite Wall Zone in Figure 7.3). Subunit 3a occurs as discrete, strongly foliated aplitic zones proximal to the SRLD and internally as endocontact border zones proximal to the amphibolite. Subunit 3b occurs as medium-grained, potassium feldspar-rich megacrystic dykes, which are somewhat similar to the Subunit 3a dykes and also occur within the same portions of the northwestern SRLD.

#### 7.3.1.2 Unit 4: Megacrystic Potassium Feldspar Quartz Sub-zone

The potassium feldspar-rich zone lithology that constitutes Unit 4 is confined, on surface, to the northwestern and southwestern peripheral zones and two narrow, 20 m to 30 m long zones on the southern margin of the main zone, as shown in Figure 7.4. However, core drilling shows that this unit is more extensive at depth, and overall constitutes approximately 27% of the feldspathic units in the SRLD and forms the major portion of what Avalon has called the “Flame Structure”. This unit resembles Unit 7, but is reported to be distinct from it in having a lower potassium feldspar to albite ratio. The unit typically is strongly foliated to semi-massive, with elongate rounded, sub-lenticular, corroded and rotated potassium feldspar megacrysts in a fine-grained albite-potassium feldspar-mica-quartz ground mass. Avalon reports that Unit 4 has similar grain-size distribution to Subunit 3b and is texturally similar to Unit 6b, but lacks petalite.

#### 7.3.1.3 Unit 5: Quartz-Mica Sub-zone

As mapped by Avalon, Unit 5 occurs as irregular zones commonly associated and interbanded with Unit 4 in the northern and northwestern zone peripheral to the main SRLD. The Unit 5 zones tend to be less than 20 m in length (except for one larger, 60-m long zone on the northwestern flank). See Figure 7.4. At depth, Unit 5 is intersected in drill core, on sections 250 W, 300 W and in sections 450 W 500 W and 550 W in the “Flame Structure”. In total, Unit 5 constitutes 17% of the feldspathic units in the SRLD. See Figure 7.3, Figure 7.4 and Figure 7.5 for project grid locations.

Unit 5 is a poorly foliated to semi-massive, commonly bi-minerallic, medium- to coarse-grained quartz-rich lithology, estimated to contain an average of 50% dark grey, glassy quartz mixed with blebs, patches and stringers of medium- to coarse-grained dark silvery green mica. Avalon reports that the elevated  $\text{Li}_2\text{O}$  and  $\text{Rb}_2\text{O}$  values in Unit 5 are attributable to lithian micas as this unit contains no obvious petalite.

#### 7.3.1.4 Unit 6: Petalite-bearing Pegmatite Zone

Within the intermediate zone of the Separation Rapids Pegmatite the predominant lithology is the petalite-bearing Unit 6, see Figure 7.3, Figure 7.4 and Table 7.3. Avalon has subdivided this unit into four textural and compositional subunits.

**Table 7.3**  
**Subunits of Unit 6: Petalite Pegmatite**

| <b>Subunit</b> | <b>Rock type</b>   |
|----------------|--|
| Subunit 6a     | Pegmatite: petalite - albite - potassium feldspar - quartz                   |
| Subunit 6b     | Pegmatite: petalite - quartz - albite - potassium feldspar – mica            |
| Subunit 6c     | Pegmatite: petalite - quartz - albite - mica - potassium feldspar            |
| Subunit 6d     | Pegmatite: petalite - lepidolite (Li/Rb-rich mica)-albite-potassium feldspar |

Subunits 6a, 6b and 6c form the bulk of the petalite pegmatite.

Subunit 6a: Petalite-potassium feldspar-albite-quartz. This unit is characterized by an intense to protomylonitic foliation containing elongate lenses and layers (schlieren) and ribbon-like white petalite that give this subunit a streaked appearance. The schlieren themselves consist of coarse-grained and megacrystic, white web-textured, petalite, and coarse-grained potassium feldspar megacrysts all enveloped by silver-green lithian mica and a ground mass of fine-grained albite and quartz.

Subunit 6b: The characteristic features of Subunit 6b, the petalite-albite-potassium feldspar-mica zone, are strong to locally protomylonitic foliation, megacrystic to glomeroporphyritic textures, absence of schlieren, and the occurrence of pink petalite that shows an eastwards transition into blue-grey to blue-pink lenticular petalite.

Subunit 6c: Petalite-albite-mica-potassium feldspar. This is the most deformed subunit and is characterized by fine to medium-grained petalite and feldspar, in finely-banded mylonitic layers that locally anastomose around lenses of less-deformed coarse-grained petalite and feldspar. It is essentially a mylonitized version of Subunit 6b.

Subunit 6d: Contains significant proportions of petalite and between 10% to 25% lepidolite, a lithium- and rubidium-rich mica. This lepidolite-rich petalite and albite-petalite pegmatite phase occurs in a series of west-northwest striking, folded and interfingered dykes along the northern and eastern flank of the main SRLD petalite zone. It also occurs as a series of lenses and subparallel zones occurring to the northeast of the main SRLD petalite zone and connected to the aforementioned series, as a small zone to the northwest of the main SRLD, and as subordinate narrow dykes along the southern margin of the SRLD (Figure 7.3). Subunit 6d is also found proximal to amphibolite screens as continuous narrow vertical zones, showing an eastward increase in thickness of the zones and lepidolite content.

Avalon has also recognized a crude north-to-south lateral zonation in petalite character from white ribbon-like petalite, seen in Subunit 6a, grading into coarse-grained pink and white

petalite, seen in Subunit 6b, and the latter grading into blue-grey to pink-grey petalite in Subunit 6c. Transitional zones and interlayering are common between each subunit and the results of recent surface geological mapping show that folding has produced a repetition of Subunit 6a on the south side of Subunit 6b. The central and north portions of the main SRLD (Unit 6) end abruptly to the west, and thin to the east.

The petalite zone rock units are characterized by a heterogeneous texture and locally a strong to mylonitic foliation developed parallel to the primary compositional banding. Grain size and textural features vary from fine- to medium-grained (as seen in Subunits 6c and 6d), ribbon-like (as seen in Subunit 6a), and locally coarse and megacrystic (Subunits 6b and 6c). In many of the finer grained and mylonitized zones, as in Subunits 6c and 6b, petalite either resembles potassium feldspar or is too fine-grained to permit visual identification.

Through surface geological mapping and core drilling, Avalon has identified two petalite-deficient zones within the main petalite zone. One at the west end centred on 460W and the other to the east end centred on 350W (these lines are the original project grid lines shown on Figure 7.3). The western unit is a combination of Units 4 and 5, whereas the eastern unit is reported to be texturally and mineralogically identical to the enclosing petalite zone but abruptly becomes completely devoid of petalite.

Discontinuous albitic dykes, commonly with petalite cores, occur in boudinaged, pinch-and-swell swarms proximal to the northern contact of the SRLD and the Western Pegmatite. Most are narrow and less than 1 m wide, with exceptions reaching 12 to 15 m in width and 150 m in length, including a lepidolite-rich dyke encountered in diamond drilling, and referred to as the Lepidolite Dyke.

Avalon reports that the SRLD and its proximal dykes exhibit zoning characteristics seen in other highly evolved rare-metal pegmatites, i.e., well-developed wall zones with exo- and endocontact borders and an internal intermediate petalite-rich zone. The exocontact border zones are discontinuous and narrow (1 to 10 cm), and comprise recrystallized amphibolite with abundant fine- to coarse-grained acicular holmquistite and cesium-rich biotite-phlogopite (glimmerite).

Pegmatitic granite dykes and larger elliptical intrusions related to the Separation Rapids Pluton outcrop at several locations on the property. These rocks (Unit 7) consist predominantly of white rubidium-rich potassium feldspar, with subordinate amounts of albite, green lithian muscovite, quartz, accessory garnet (spessartine), cassiterite, apatite, tantalum oxides and granite.

#### **7.4 STRUCTURAL GEOLOGY**

Lithological units making up the SRLD, the amphibolite and Separation Rapids Pluton (see Figure 7.2) are characterized by a strong to locally mylonitic subvertically-dipping foliation. This foliation and associated ductile shear zones are heterogeneously developed parallel to the primary compositional banding and regional trend of the rare-metal pegmatite dykes and



the SLMB during north-northeast to south-southwest regional compression. Centimetre- and metre-scale, tight to isoclinal folding and boudinage of dykes is abundant in the amphibolite and the SRLD.

A zone of intense deformation, indicated by well-developed mylonite, bifurcating and anastomosing around smaller less-deformed zones, occurs within the southern third of the Separation Rapids Pegmatite along an inferred reactivated regional-scale fault structure (see Figure 7.4). This deformation zone continues westwards into the compositionally-similar Western Pegmatite and eastwards into albitite dykes of the Eastern Swarm.

A significant proportion of the original pegmatite minerals in the SRLD has been modified by ductile shearing and deformation. The tectonic modification of the original pegmatitic zoning and local obliteration of primary textures, secondary alteration and replacement textures, greatly hinders visual identification of such features in outcrop and drill core. In addition, deformation within the SRLD has also produced localized recrystallization and conversion of petalite into a polygonal, net-like (web-textured), mosaic of secondary medium- to coarse-grained petalite enveloped by fine-grained (100 µm) intergrowths of quartz+petalite+spodumene. This phenomenon might locally constitute as much as 20% of the petalite zone. However, the multiphase nature of the SRLD, the primary magmatic zonation and banding, and original petalite and feldspar crystals are all locally preserved.

Pegmatite and amphibolite screens within the main zone of the SRLD, and especially along its east flank, are complexly interfolded. Fold axial planes lie subparallel and parallel to the prominent foliation in the pegmatite. In pegmatite and amphibolite within the main zone of the SRLD and amphibolite outside of the main zone of the SRLD, these folds plunge steeply east-southeast, subparallel to all observed linear fabrics, i.e., mineral and intersection lineations. However, elongation of boudins is reported to be vertically oriented. The intensity of fold development and local variation in strain intensity are associated with local variation in composition and lithology.

Avalon has inferred that the widest part of the SRLD consists of a series of coeval zoned units that have been tectonically coalesced through isoclinal folding in a dilatant flexure.

Avalon reports that there are no large-scale faults parallel or crosscutting the SRLD and small-scale joints or faults are discontinuous, few in number and have insignificant offsets. The fold pattern is, on the scale of the whole pegmatite area, classic Type III interference as reported by Ramsay (1962).

## **7.5 MINERALIZATION**

### **7.5.1 Extent of Mineralization**

Geological mapping and diamond drilling show that the SRLD system has a strike length of over 1.5 km, and widths ranging from 10 to 70 m (see Figure 7.5). To date, the SRLD has been intersected by drilling to a vertical depth of almost 275 m. The petalite-bearing

pegmatite zones show little variation in true width between surface outcrop, up to 70 m, and up to 45 m for near-surface and the deepest intersected levels. These petalite zones are open to depth.

The central portion of the SRLD is a low, dome-shaped hill, formed by the well-exposed main mineralized zone. It has a strike length of 600 m with a drill-tested vertical depth of at least 250 m. It forms the widest portion of the SRLD, averaging 55 m over a 300 m strike length.

As noted above, the SRLD has been divided into three sub-zones, namely the Separation Rapids Pegmatite, Western Pegmatite and Eastern Swarm (see Table 7.4 and Figure 7.5).

**Table 7.4**  
**Main Zones Comprising the Separation Rapids Pegmatite Area**

| Zone                        | Areal Extent  | Length (m) | Width (m)                      | Geological Notes <sup>1</sup>  |
|-----------------------------|---------------|------------|--------------------------------|--|
| Separation Rapids Pegmatite | 300W to 550W  | 250        | up to 70                       | See text.  |
| Western Pegmatite           | 550W to 1400W | 850        | up to 15, averaging 10         | Pervasive mylonitic fabrics obscure primary textures   |
| Eastern Swarm               | 100E to 300W  | 400        | vertically continuous, 5 to 10 | Narrow, discontinuous albitic and petalite-rich dykes occurring in a swarm averaging 40 m in width. Wall rock to pegmatite ratios is in the order of 4:1 or greater. |

<sup>1</sup> The areal extent refers to the original exploration grid coordinates, see Figure 7.3, Figure 7.4 and Figure 7.5.

Surface geological mapping and diamond drilling carried out by Avalon between lines 550W and 700W (Figure 7.3, Figure 7.4 and Figure 7.5) show that the Western Pegmatite is the western continuation of the Separation Rapids Pegmatite, with the width narrowing significantly to 10 m and less. The western limit for the Separation Rapids Pegmatite is not definitively established due to poor exposure beyond the mapped portion of the Western Pegmatite. However, holmquistite is reported to occur in lithium-exomorphic haloes where it coats fractures in amphibolite outcrops west of Avalon's claim block 1178306, indicating the likely proximity and westward continuation of the lithium-rich pegmatites.

The Eastern Swarm is interpreted by Avalon to represent the bifurcated extension of the southern part of the Separation Rapids Pegmatite.

Folded and deformed, discontinuous, albitic dykes and stringers are common to the north of the Separation Rapids Pegmatite, especially in proximity to the northwestern boundary in the vicinity of the Great White North pegmatite (see Figure 7.5).

## 7.6 MINERALOGY

Companies currently mining rare-metal deposits containing spodumene, petalite and the other lithium-bearing silicate minerals commonly quote reserves and resources in tonnes and percent  $\text{Li}_2\text{O}$  rather than the proportion of minerals present. However, unlike the chemical industry, which is interested in  $\text{Li}_2\text{O}$  and lithium carbonate, the glass and ceramics industry is predominantly interested in the major lithium-bearing minerals, which can be used directly in glass and ceramic production. In the case of the Separation Rapids Pegmatite, Avalon recognized that the modal content of the primary mineral petalite is critical to establishing the resources for the deposit, with  $\text{Li}_2\text{O}$  content important in defining the grade of the final product.

Geological mapping and assays for surface and drill core samples show that mineralogy and  $\text{Li}_2\text{O}$  grades of the mineralization in the Separation Rapids Pegmatite are relatively homogeneous throughout the petalite-bearing body. An example of this is seen in trench SLT-1 which extends across the widest part of the exposed zone;  $\text{Li}_2\text{O}$  grades in this trench vary from 0.97 to 2.00% and average 1.58% over the 58.9-m width. Mineralogy is obviously a critical concern for the Separation Rapids project. A number of mineralogical studies have been carried out during the exploration of the project including by commercial laboratories and also academic studies, such as those by Taylor, 1999a.

Rare-element pegmatites are a major source of lithium-bearing minerals (spodumene, petalite, amblygonite/montebrazite, eucryptite and lepidolite and lithian micas) used in the glass and ceramics industries. Lepidolite is also a major source for rubidium metal and formates. Sodium and potassium feldspars, also important to the glass and ceramics industry, are ubiquitous in these deposits. As well, rare-metal pegmatites are also the major source of tantalum, cesium and beryllium, found in oxide minerals such as wodginite, manganocolumbite and manganotantalite, pollucite and beryl, respectively.

In the Separation Rapids Pegmatite, petalite, potassium feldspar and sodium feldspar are major rock-forming minerals, with subordinate amounts of other minerals including spodumene, lithian muscovite, lepidolite, and quartz of which some occur as potentially economically recoverable minerals (see Table 7.5). Other potentially economic minerals present in the Separation Rapids Pegmatite that occur as accessory mineral phases include the tantalum bearing minerals, manganocolumbite and manganotantalite, and the tin bearing oxide, cassiterite. The tantalum minerals are finely dispersed through much of the petalite zones.

Rare accessory mineral phases in the Separation Rapids Pegmatite include topaz and zircon, while the tantalum-bearing minerals ferrocolumbite and microlite, rare earth-bearing minerals thorite, monazite, and xenotime, the zinc-aluminum oxide granite, an unidentified uranium-lead oxide, calcite, and the sulphides bismuthinite, sphalerite and arsenopyrite occur as very rare accessory minerals.

**Table 7.5**  
**Visual Mineral Estimates from 1997-98 Drill Core Logging**

| Unit/Subunit | Lithology        | Petalite (Pet) (%) | Potassium Feldspar (Ksp) (%) | Albite (Alb) (%) | Quartz (Qtz) (%) | Spodumene (%) | Lepidolite (Lep) (%) | Li-Mica (Mica) (%) | Tantalum Minerals (%) | Cassiterite (%) |
|--------------|------------------|--------------------|------------------------------|------------------|------------------|---------------|----------------------|--------------------|-----------------------|-----------------|
| 3a           | Albite           |                    | 10                           | 80               | 10               |               |                      |                    | trace                 | trace           |
| 3b           | Albite-Ksp       |                    | 20                           | 70               | 10               |               |                      | trace              | trace                 | trace           |
| 4            | Megacrystic Ksp  |                    | 55                           | 30               | 10               |               |                      | 5                  |                       |                 |
| 5            | Qtz-Mica-Fspar   |                    | 10                           | 10               | 50               |               |                      | 30                 |                       |                 |
| 6a           | Pet-Ksp-Alb-Qtz  | 30                 | 20                           | 20               | 15               | 10            |                      | 5                  |                       | trace           |
| 6b           | Pet-Alb-Ksp-Mica | 35                 | 25                           | 20               | 15               |               |                      | 5                  |                       |                 |
| 6c           | Pet-Alb-Mica-Ksp | 30                 | 20                           | 20               | 15               | 10            | 5                    | 5                  | trace                 |                 |
| 6d           | Pet-Lep-Alb-Ksp  | 30                 | 25                           | 15               | 15               |               | 15                   |                    | <1                    |                 |

### 7.6.1 Mineralogy - Pedersen Modal Estimates from Core Logging

During the core logging completed in 1997-1998 Pedersen estimated the modal percentages of the minerals present in the mineralized body (see Table 7.5). The estimates were collated into a Microsoft Excel spreadsheet and submitted to Avalon (Pedersen, 2016a).

Pedersen's drill report notes the following (Pedersen, 1998a):

“Four core samples from the Big Whopper were submitted to Lakefield Research of Lakefield, ON, for polished thin sectioning and petrographic study. Specifically, the study identified the mineralogy and textural relationships of four recognizable subunits of the Petalite Zone. In addition, a search to identify the presence of fluid inclusions was requested due to the presence of a strong propane-like odour emanating from certain petalite types when struck or broken. Lastly, the study was to identify any secondary or alteration features.

Thin sections verified to a large degree the macroscopically determined mineralogy and cataclastic fabrics. Interestingly, K-feldspar was not identified in these samples; it is highly probable that due to the coarse to megacrystic nature of the K-feldspar, core was deliberately cut to avoid megacrysts, to the exclusion of K-feldspar in the sample. This indicates that K-feldspar can be expected to be found as coarse crystals and not as fine interstitial grains.

Albite was found to be very common and primary, with no recognized secondary albite typically found in the tantalum zones of Tanco. Quartz was another common interstitial mineral, belying the field observed paucity of this mineral. Petalite is found as the most abundant constituent in three of the four samples, averaging 30% by volume. It is partially altered along cleavage boundaries locally, generally by mechanical grinding with lesser hydrothermal alteration to clay in one sample. Two samples show abundant fluid inclusions, which are likely the source of the propane-like odour.

Only minor secondary features were noted, mainly as alteration along petalite cleavage planes. One sample identified eucryptite as an alteration product of albite.

Li-bearing (postulated) mica is seen to be a significant constituent in the samples submitted, averaging 15% in interstitial aggregates and enclosed in albite.

Trace fine grained Ta-Nb-Mn oxides, likely manganotantalite, were observed in three samples in various associations: inclusions in petalite; interstitial to quartz, albite, and petalite; and with mica.”

## **7.6.2 Mineralogy - Studies by Pedersen**

Specific X-ray diffraction (XRD) and scanning electron microprobe (SEM) studies were also reported by Pedersen, 1998a:

“Seven samples, three from outcrop at the centre of trench SLT-1, and four from drill core, were collected for specific mineral phase identification by X-ray diffraction (XRD) by Pedersen. One sample from trench SLT-1 was further investigated by scanning electron microprobe (SEM). This work was done using the facilities of the Department of Geological Sciences at the University of Manitoba in Winnipeg.

Minerals identified or confirmed by XRD include:

- Petalite, pink
- Petalite, green
- Petalite, blue-grey
- Cassiterite, lustrous red-black with flat diamond shaped cross section
- Spodumene, greenish grey, splintery, pearly lustre
- Nontronite, a pink Fe-clay of the Smectite group (Montmorillonites). This may not be a correct identification because of the difficulty of determining clay structures by XRD. Associated with petalite, likely a cleavage plane alteration.

The sample investigated by SEM contained pink petalite, fine green mica, albite, and K-feldspar.

Single points were tested on petalite, K-feldspar, and albite, and three points on mica. No elemental substitution was identified in petalite; iron and manganese were not detected, indicating the pink variety of petalite to be very pure. K-feldspar was found to be highly enriched in rubidium, with 1.5 wt% Rb. Mica is significantly enriched in Rb and F, with an average 2.14 wt% Rb and 1.369 to 4.139 wt% F. Iron (Fe<sub>2</sub>O<sub>3</sub>) ranges from 2.8 to 5.4 wt% Fe<sub>2</sub>O<sub>3</sub>, and manganese from 0.661 to 1.659 wt% Mn. No gallium (Ga) or Rb was detected in albite.

One polished thin section was examined by XRD by Lakefield, which confirmed constituent minerals to be petalite, quartz, albite, plagioclase, mica, and K-feldspar.”

## **7.6.3 Mineralogy – Studies by Taylor**

### **7.6.3.1 Mineralogical and Geochemical Determination of Petalite Content**

In 1999, Avalon, through Dr. Richard Taylor at Carleton University in Ottawa, carried out a comprehensive mineralogical and geochemical study of Separation Rapids Pegmatite drill core, surface samples and some sub-samples of mineral concentrates. Forty samples from drill holes SR97-02, SR97-03 and SR98-57 from section 460W, the widest portion of the

Separation Rapids Pegmatite, and two samples from the lepidolite dyke, Subunit 6d, were analysed.

This study identified and chemically characterized the essential and accessory mineral phases present in the petalite-bearing lithologies of the Separation Rapids Pegmatite. Analytical techniques used are listed in Taylor (1999a).

The average modal abundance of petalite in Subunits 6a, 6b, 6c and 6d as estimated by Taylor in this preliminary study were:

|                    |     |
|--------------------|-----|
| Subunits 6a and 6b | 30% |
| Subunit 6c         | 34% |
| Subunit 6d         | 37% |

**Table 7.6**  
**Constituent Minerals of the Separation Rapids Pegmatite**

| Mineral               | Chemical Formula  | Relative Abundance  | Physical Characteristics  |
|-----------------------|---|---|---|
| <b>Major Minerals</b> |   |   |   |
| Petalite              | LiAlSi <sub>4</sub> O <sub>10</sub>   | 30% <sup>1</sup> , 22-47% with an average of 37% <sup>2</sup> , 20-35% <sup>5</sup> .   | Typically, translucent, light pink on fresh surfaces and light brown on weathered surfaces. Avalon has recognized five varieties of petalite. (a) Milky-white to grey web-textured, (b) pink coarse lenticular, c) blue-grey to blue-pink lenticular, (d) Green to blue green associated with orange potassium feldspar, (e) Clear to glassy green, rare and associated with lepidolite and coarse-grained segregations of white petalite. Grey milky-white petalite occurs in zones of extensive recrystallization. Pink petalite is rare. SG 2.41-2.42. |
| Spodumene             | LiAlSi <sub>2</sub> O <sub>6</sub>  | 0-13% in Subunit 6a.  | Visual estimation of outcrops and core indicate that primary spodumene is rare in the Separation Rapids Pegmatite. Very difficult to tell in Units 6c and 6a probably contains the most spodumene (Pedersen, 2016b). Average intergrowth grain size is <500 m. SG 3.03-3.22.  |
| Lepidolite            | (K, Rb)(Li, Al) <sub>2</sub> (Al, Si) <sub>4</sub> O <sub>10</sub> (OH, F) <sub>2</sub> | (15% <sup>1</sup> ), 10-25% <sup>4</sup> in Subunit 6d.   | All micas contain lithium. The lepidolite (fine-grained and purple) and lithian micas are predominantly in unit 6d but occur throughout the Separation Rapids Pegmatite. Lakefield study included lithian mica and lepidolite. SG 2.80-2.90.  |
| Lithian muscovite     | K(Al, Li) <sub>2</sub> (Al, Si) <sub>4</sub> O <sub>10</sub> (OH, F) <sub>2</sub>       | 4-7% in the petalite zone. <sup>5</sup>   | Fine-grained green mica. SG 2.90-3.02.  |
| Microcline            | (K,Rb)AlSi <sub>3</sub> O <sub>8</sub>  | 15-20% <sup>4</sup> , >20% <sup>3</sup> , 35-40% in Units 4 and 7, 5-20% in Subunit 3b, lower in 3a. 15-20% in Unit 5. 2 - 33% in Unit 4 and Subunits 3a, 3b <sup>6</sup> mean value 21% <sup>5</sup> | White to grey and containing between 1 and 4% Rb. Taylor's study shows an average of 1.82%. SG 2.56-2.63. Mean content for potassium feldspar in Unit 4 and Subunits 3a and 3b is 21% These are high-purity end-member feldspars evidenced by low iron (less than 0.03%   |

| Mineral                          | Chemical Formula   | Relative Abundance  | Physical Characteristics  |
|----------------------------------|--|---|---|
|                                  |  |   | Fe <sub>2</sub> O <sub>3</sub> , extremely low sodium (average 0.38% Na <sub>2</sub> O) and low phosphorus (0.06 - 0.24% P <sub>2</sub> O <sub>5</sub> ).                                     |
| Albite                           | NaAlSi <sub>3</sub> O <sub>8</sub>                                   | 20-25% in Units 4 and 7, 50-80% in Subunit 3b, higher in 3a. 0% in unit 5. <sup>5</sup><br>21-77% in Unit 4 and Subunits 3a, b <sup>6</sup><br>25-30% in Unit 6   | SG 2.62-2.63.<br>Mean content for albite in Units 4, 3a, 3b is 44%.<br>As with the potassium feldspars, the albites are high-purity end members with very low concentrations of Fe, Ca and K. |
| Quartz                           | SiO <sub>2</sub>   | 5-10% <sup>3</sup> in the potassium feldspar-petalite and aplite units. Recently <sup>6</sup> : 20-30% in Unit 6. 10-20% in Subunits 3a and 3b. 35-40% in Units 4 and 7 and up to 60% in Unit 5. <sup>5</sup> | SG 2.65.  |
| Spessartine garnet               | (Mn>Fe) <sub>3</sub> Al <sub>2</sub> Si <sub>3</sub> O <sub>12</sub> |   | Light orange to red brown and pervasively disseminated throughout the Separation Rapids Pegmatite   |
| <b>Common Accessory Minerals</b> |  |   |   |
| Manganocolumbite                 | (Mn>Fe)(Nb>Ta) <sub>2</sub> O <sub>6</sub>                           |   | Tin- tantalum- and niobium-bearing oxide phases occur as sparsely disseminated brown to black specks and aggregates that may reach up to 0.5 by 1.2 cm in size.                               |
| Manganotantalite                 | (Mn>Fe)(Ta>Nb) <sub>2</sub> O <sub>6</sub>                           |   |   |
| Cassiterite                      | SnO <sub>2</sub>   |   |   |
| Fluorapatite                     | (Ca, Mn) <sub>5</sub> (PO <sub>4</sub> ) <sub>3</sub> F              |   |   |

<sup>1</sup> Results from SGS, 2013 study of four core samples.

<sup>2</sup> Inferred petalite content for the Separation Rapids Pegmatite based on visual estimates and Li<sub>2</sub>O assay extrapolation (Pedersen 1998a).

<sup>3</sup> Breaks and Tindle, 1997.

<sup>4</sup> Visually estimated by Avalon.

<sup>5</sup> Visually estimated by Avalon from thin sections (Taylor 1999a).

<sup>6</sup> Taylor, 1999a.

Petalite from the Separation Rapids Pegmatite is remarkably close to the ideal theoretical chemical composition, as well as being very pure, with marked absence of deleterious elements such as iron. An average petalite analysis is provided in Table 7.7.

**Table 7.7**  
**Petalite Composition**

| Oxide | SiO <sub>2</sub> | Al <sub>2</sub> O <sub>3</sub> | Total Fe | MnO  | CaO  | N <sub>2</sub> O | K <sub>2</sub> O | Li <sub>2</sub> O |
|-------|------------------|--------------------------------|----------|------|------|------------------|------------------|-------------------|
| wt%   | 77.93            | 16.24                          | 0.01     | 0.01 | 0.02 | 0.01             | 0.01             | 4.78              |

Taylor 1999a.

The average Li<sub>2</sub>O content of 4.78% for Separation Rapids Pegmatite compares to the stoichiometric value of pure petalite at 4.88% Li<sub>2</sub>O.

As reported in Micon, 1999, the petalite content in the Separation Rapids Pegmatite was originally determined by using a combination of visual estimates, observations from outcrops

and drill core, and stoichiometric extrapolation of  $\text{Li}_2\text{O}$  whole rock assays. Avalon determined that the  $\text{Li}_2\text{O}$  grades in its preliminary resource estimation were consistent with the main zone of the Separation Rapids Pegmatite containing a chemically-derived modal petalite content ranging from 22% to 47%. This modal content range was corroborated by  $\text{Li}_2\text{O}$  and  $\text{Rb}_2\text{O}$  assays from continuous chip samples from trenches SLT-1 to SLT-5, which were reported to be consistent with visual estimates of petalite and potassium feldspar contents of approximately 30% each. The average  $\text{Li}_2\text{O}$  content and estimated percent petalite in the four main pegmatite masses, representing most of the strike length of the SRLD, shown in Table 7.8, are also remarkably consistent. However, the latter values are higher than those obtained for the chip samples from trenches SLT-1 to SLT-5.

**Table 7.8**  
**Average  $\text{Li}_2\text{O}$  Content and Estimated Percentage Petalite across Main Pegmatites of Separation Rapids Property**

| Pegmatite                   | Percent $\text{Li}_2\text{O}$ /Width in metres | Calculated Petalite Content (%) |
|-----------------------------|--|---------------------------------|
| Separation Rapids Pegmatite | 1.58/59.8                                      | 37                              |
| Great White North           | 1.78/1.43                                      | 41                              |
| Bob's Pegmatite             | 1.67/15.2                                      | 39                              |
| Western Pegmatite           | 1.56/8.3                                       | 36                              |

Breaks and Tindle, 1997.

Although the results of Avalon's preliminary work and Taylor's studies in 1998 and 1999 show a good correlation of average  $\text{Li}_2\text{O}$  grades determined for the Separation Rapids Pegmatite, chemically-derived modal abundances are imprecise. Taylor, (1999a) reported that whole-rock analyses might not necessarily be indicative of the true petalite content in the Separation Rapids Pegmatite due to the following:

- No attempt was made to adjust calculations to take into account the presence of other lithium-bearing minerals, e.g., spodumene, lepidolite and lithian micas in the Separation Rapids Pegmatite.
- Representativeness of samples is difficult to maintain when the lithologies are coarse-grained (pegmatitic).
- Visual identification of petalite, both in drill core and outcrop, is difficult due to similarities between petalite and sodium feldspar, with which it is intimately associated, and the effects of cataclasis and grain size reduction.
- $\text{Li}_2\text{O}$  content has been shown to decrease in petalite that has undergone incipient or mechanical alteration, and clay-altered petalite might produce and account for lower than expected  $\text{Li}_2\text{O}$  values in drill core where visual estimation indicated the potential for higher than normal  $\text{Li}_2\text{O}$  assays.



- Taylor’s preliminary results should be applied to section 460W of the Separation Rapids Pegmatite alone, even though samples from section 460W are considered by Avalon to be representative of the entire petalite zone of the Separation Rapids Pegmatite.
- The obtained modal abundances from Taylor’s preliminary mineralogical and geochemical study were intended to provide broad estimates of the mineral content.

### 7.6.3.2 Quantitative Modal Analysis

A petrographic and mineralogical study of eleven drill core samples spanning the length and width of Unit 6 of the Separation Rapids Pegmatite, with both near surface and deeper intercepts, was undertaken by Taylor and the results shown in Table 7.9 (Taylor, 1999b). The locations of drill holes used for mineralogical studies are shown in Figure 7.6.

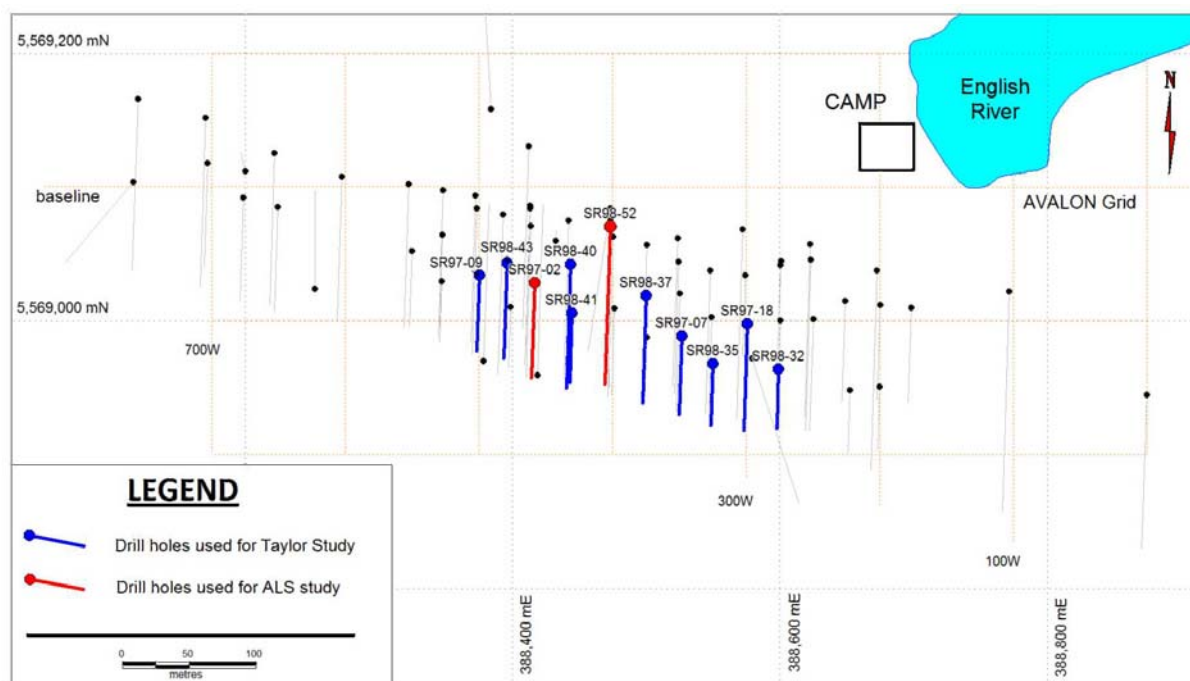
**Table 7.9**  
**Representative Samples from Unit 6 of the Separation Rapids Pegmatite**

| Sample Number | Section | DDH   | From – To (m)   | Length (m) | Subunit | Li <sub>2</sub> O (%) |
|---------------|---------|-------|-----------------|------------|---------|-----------------------|
| 236562        | 450 W   | 97-02 | 23.00 -26.00    | 3          | 6a      | 1.66                  |
| 236829        | 350 W   | 97-07 | 34.00 - 36.00   | 2          | 6b      | 1.51                  |
| 236940        | 500 W   | 97-09 | 12.00 - 14.00   | 2          | 6b      | 1.31                  |
| 237017        | 500 W   | 97-09 | 56.00 - 58.00   | 2          | 6b      | 1.84                  |
| 237200        | 300 W   | 97-18 | 71.00 - 73.00   | 2          | 6c, 6a  | 1.89                  |
| 51044         | 275 W   | 98-32 | 48.00 - 50.00   | 2          | 6c      | 1.41                  |
| 51138         | 325 W   | 98-35 | 38.80 - 40.00   | 1.2        | 6a      | 1.05                  |
| 51239         | 375 W   | 98-37 | 79.00 - 81.00   | 2          | 6c      | 1.52                  |
| 51385         | 425 W   | 98-40 | 100.00 - 102.00 | 2          | 6a, 6c  | 1.54                  |
| 51400         | 425 W   | 98-41 | 14.00 - 17.00   | 3          | 6a      | 1.36                  |
| 51486         | 475 W   | 98-43 | 34.00 - 36.00   | 2          | 6a, 6c  | 1.48                  |

Taylor, 1999b.

This study consisted of detailed point counting, using a scanning electron microprobe, of polished grain mounts of aliquots from the original drill core assay samples. The investigation was undertaken to establish the modal abundance of the primary minerals petalite, potassium feldspar, albite, mica, spodumene and quartz. The detailed results of the study are given in Taylor (1999b) and are summarized below in Table 7.10. Note that these data exclude Subunit 6d which is high in lepidolite.

**Figure 7.6**  
**Location of Drill Holes Used for Mineralogical Studies**



Note: “Camp” refers to location of original exploration camp. Avalon, 2016.

**Table 7.10**  
**Results of the Modal Point Count Analysis of Unit 6 Lithologies**

| Mineral                        | Modal Range (%) | Mean ( $\pm 5\%$ ) | Lakefield Study Feed (%) |
|--------------------------------|-----------------|--------------------|--------------------------|
| Petalite                       | 19 - 36         | 25                 | 21.8                     |
| Potassium feldspar             | 7 - 17          | 10                 | 9                        |
| Sodium feldspar (albite)       | 22 - 30         | 27                 | 30.7                     |
| Mica (lepidolite and Li-micas) | 8 - 16          | 11                 | 11.1                     |
| Spodumene                      | 0 - 13          | 1                  | 3.9                      |
| Quartz                         | 18 - 33         | 25                 | 23.5                     |

Taylor 1999b, Lakefield, 1998, Micon, 1999.

The spodumene content is typically low, from 0 to 2%, but highly variable; where petalite has been replaced by spodumene, it can be as much as 13%. This replacement phenomenon appears to be randomly distributed throughout the Separation Rapids Pegmatite. All the micas identified in the above study are fluorine-rich and therefore considered to be lepidolite or lithian micas (muscovite does not contain fluorine). Although limited to eleven samples, the results nevertheless show that petalite content in the Separation Rapids Pegmatite is laterally and vertically consistent, with minimal significant changes apart from local increases in spodumene as a result of petalite replacement. While the error on the mean values for modal contents of these minerals is reported to be in the region of  $\pm 5\%$ , the means



(ALS, 2016). ALS completed Qemscan® analysis of the eight samples and submitted the data to Avalon as an Excel spreadsheet. In addition, one XRD analysis was completed of an individual sample for comparison purposes. The XRD analysis was completed at Department of Earth, Ocean and Atmospheric Sciences at University of British Columbia. The XRD results are presented below (Table 7.11). The XRD diffraction data is useful because the method can identify petalite whereas Qemscan® cannot definitively identify petalite due to its inability to analyse light elements like lithium.

**Table 7.11**  
**X-Ray Diffraction Analysis of Sample 862938 from Separation Rapids**  
**(Percent mineral content)**

|     | <b>SAMPLE_ID</b> | <b>Petalite</b>  | <b>Plagioclase</b>       | <b>K-Feldspar</b> | <b>Total Feldspar</b> | <b>Illite-Muscovite</b> | <b>Quartz</b> |
|-----|------------------|------------------|--------------------------|-------------------|-----------------------|-------------------------|---------------|
| XRD | 862938           | 33.00            | 31.00                    | 8.40              | 39.40                 | 6.20                    | 18.30         |
|     |                  |                  |                          |                   |                       |                         |               |
|     | <b>SAMPLE_ID</b> | <b>Pargasite</b> | <b>Dolomite/Ankerite</b> | <b>Calcite</b>    | <b>Schorl</b>         | <b>Sillimanite</b>      |               |
| XRD | 862938           | 1.20             | 0.60                     | 0.50              | 0.40                  | 0.40                    |               |

Note: Sample from drill hole SR98-52 at 163.78-166 m.  
ALS, 2016.

The analyses for XRD account for 100% of the mineral content, a satisfactory total considering that some minerals such as tantalite, topaz and others are not measured by this method.

Table 7.12 below gives the results of the Qemscan® analysis for the eight samples, with the lithological subunit specified.

**Table 7.12**  
**Qemscan® Mineralogical Analysis by ALS**  
**(Percent mineral content)**

| Hole Number | From (m) | To (m) | Interval (m) | Lithological Subunit | Sample Number (2016) | Sample Number (1997-8) | Quartz  | Muscovite | Albite | Potassium Feldspar          | Aluminum Silicate (Petalite) |
|-------------|----------|--------|--------------|----------------------|----------------------|------------------------|---------|-----------|--------|-----------------------------|------------------------------|
| SR98-52     | 157.10   | 158.65 | 1.55         | 6a                   | 862932               | 51800                  | 32.5    | 10.0      | 30.1   | 8.8                         | 17.0                         |
| SR97-2      | 5.00     | 8.00   | 3.00         | 6a                   | 862944               | 236555                 | 31.3    | 8.5       | 24.0   | 12.4                        | 21.9                         |
| SR97-2      | 32.00    | 35.00  | 3.00         | 6b                   | 862947               | 236566                 | 24.1    | 12.1      | 26.5   | 11.4                        | 24.6                         |
| SR97-2      | 35.00    | 37.90  | 2.90         | 6b                   | 862948               | 236567                 | 23.1    | 13.2      | 25.1   | 9.3                         | 28.0                         |
| SR97-2      | 47.40    | 48.30  | 0.90         | 6c                   | 862953               | 236574                 | 22.2    | 9.7       | 33.2   | 10.1                        | 23.8                         |
| SR97-2      | 80.70    | 81.90  | 1.20         | 6c                   | 862964               | 236591                 | 25.5    | 14.1      | 28.9   | 8.1                         | 22.6                         |
| SR98-52     | 84.05    | 86.05  | 2.00         | 6d                   | 862922               | 51762                  | 24.0    | 14.5      | 30.5   | 8.9                         | 21.0                         |
| SR98-52     | 163.78   | 166.00 | 2.22         | 6d                   | 862938               | 51807                  | 18.9    | 7.9       | 27.6   | 10.0                        | 31.7                         |
| Hole Number | From (m) | To (m) | Interval (m) | Lithological Subunit | Sample Number (2016) | Topaz                  | Apatite | Others    | Total  | Elemental Iron (Tramp Iron) |                              |
| SR98-52     | 157.10   | 158.65 | 1.55         | 6a                   | 862932               | -                      | 0.1     | 0.6       | 99.9   | 0.5                         |                              |
| SR97-2      | 5.00     | 8.00   | 3.00         | 6a                   | 862944               | <0.1                   | 0.1     | 1.0       | 99.9   | 0.3                         |                              |
| SR97-2      | 32.00    | 35.00  | 3.00         | 6b                   | 862947               | <0.1                   | 0.1     | 0.4       | 99.9   | 0.4                         |                              |
| SR97-2      | 35.00    | 37.90  | 2.90         | 6b                   | 862948               | -                      | 0.2     | 0.3       | 100.0  | 0.4                         |                              |
| SR97-2      | 47.40    | 48.30  | 0.90         | 6c                   | 862953               | -                      | 0.1     | 0.3       | 100.0  | 0.3                         |                              |
| SR97-2      | 80.70    | 81.90  | 1.20         | 6c                   | 862964               | -                      | 0.1     | 0.3       | 99.9   | 0.3                         |                              |
| SR98-52     | 84.05    | 86.05  | 2.00         | 6d                   | 862922               | 0.1                    | 0.2     | 0.4       | 99.9   | 0.2                         |                              |
| SR98-52     | 163.78   | 166.00 | 2.22         | 6d                   | 862938               | 1.3                    | 0.2     | 0.4       | 99.9   | 0.3                         |                              |

ALS, 2016.

**Table 7.13**  
**Mineral Modal Abundance: Comparison of ALS Qemscan® with Pedersen (2016) Visual Core Estimates**

| Subunit | Lithology        | Pedersen Estimates |                      |                  |                |                  |               | ALS Qemscan® and XRD |              |                |              |
|---------|------------------|--------------------|----------------------|------------------|----------------|------------------|---------------|----------------------|--------------|----------------|--------------|
|         |                  | Petalite (Pet) (%) | K-Feldspar (Ksp) (%) | Albite (Alb) (%) | Total Feldspar | Quartz (Qtz) (%) | Spodumene (%) | K-Feldspar (Ksp)     | Albite (Alb) | Total Feldspar | Quartz (Qtz) |
| 6a      | Pet-Ksp-Alb-Qtz  | 30                 | 20                   | 20               | 40             | 15               | 10            | 10.68                | 26.55        | 37.23          | 32.95        |
| 6b      | Pet-Alb-Ksp-Mica | 35                 | 25                   | 20               | 45             | 15               |               | 11.75                | 28.36        | 40.11          | 22.48        |
| 6c      | Pet-Alb-Mica-Ksp | 30                 | 20                   | 20               | 40             | 15               | 10            | 10.62                | 35.14        | 45.76          | 20.20        |
| 6d      | Pet-Lep-Alb-Ksp  | 30                 | 25                   | 15               | 40             | 15               |               | 7.97                 | 30.32        | 38.29          | 21.33        |

Pederson, 2016a; ALS, 2016.

Comparison of the averages for Pedersen, Taylor, Lakefield and ALS are given in the table below (Table 7.14) averaged for Subunits 6a, 6b and 6c. Subunit 6d is excluded because of its enhanced lepidolite content. In viewing this data, it must be noted that the number of samples in each study is relatively small and the range of results may simply be due to the inherent variability in the material and the small sample number.

**Table 7.14**  
**Average Mineral Contents Estimated by Pedersen, Taylor, Lakefield and ALS**

| Mineral                        | Pedersen Average 2016a (%) | Taylor Modal Range 1999a (%) | Mean Taylor (+5) | Lakefield 1999 (%) | ALS Qemscan® 2016 (%) |
|--------------------------------|----------------------------|------------------------------|------------------|--------------------|-----------------------|
| Number of samples              | NAP <sup>1</sup>           | 11                           | 11               | 4                  | 16                    |
| Petalite                       | 31.3                       | 19 - 36                      | 25.0             | 21.8               | 24.2                  |
| Potassium feldspar             | 22.5                       | 7 - 17                       | 10.0             | 9.0                | 10.3                  |
| Albite                         | 18.8                       | 22 - 30                      | 27.0             | 30.7               | 30.1                  |
| Total feldspar                 | 43.3                       | 29 - 47                      | 37               | 39.7               | 40.4                  |
| Mica (lepidolite and Li-micas) | 15.0                       | 8 - 16                       | 11.0             | 11.1               | 9.4                   |
| Spodumene                      | 5.0                        | 0 - 13                       | 1.0              | 3.9                | NA <sup>2</sup>       |
| Quartz                         | 15.0                       | 18 - 33                      | 25.0             | 23.5               | 24.2                  |

<sup>1</sup> Not applicable.

<sup>2</sup> Not available.

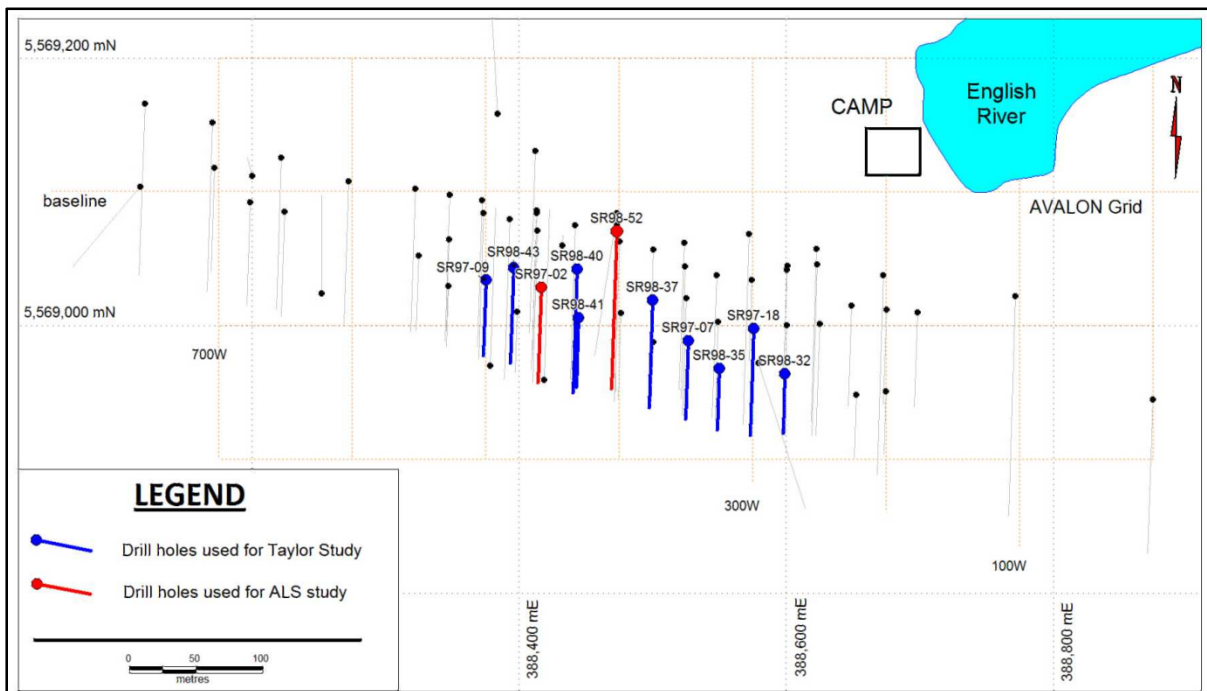
In conclusion, the various mineralogical investigations show similar estimates of mineral content for a range of samples. In particular the mean estimates of Taylor, Lakefield and ALS of the total feldspar content average 39% for the two means, and representing a total of 28 samples examined of four different lithologies of Subunits 6a, 6b, 6c and 6d. This average of 39% for individual samples can be compared to two metallurgical bulk samples of Unit 6 that averaged 40.7% total feldspar when analysed by Qemscan®.

Pedersen's average of 43.3% total feldspar is higher, but illustrates the difficulty of accurately estimating mineral percentages during visual examination of drill core using a hand lens where some minerals in some cases have been subjected to shearing and mylonite

textures. In particular, when albite and potassium feldspar are fine-grained distinguishing the two is challenging.

The representativity of the feldspar content measurements given in this report can be considered by reference to Figure 7.7. Eleven drill holes have had quantitative mineralogy of which Taylor (1999a) examined SR97-02, -07, -09, -18 and SR98-32, 35, 37, 40, 41, 43 while ALS analysed SR97-02 and SR98-52. Lithologies were covered to the extent of seven samples of Subunit 6a, five samples of Subunit 6b, five samples of Subunit 6c and three samples of Subunit 6d. As a result, it can be considered that the drill holes studied cover most of the strike length of the deposit and all subunits of Unit 6 were studied. Thus the conclusions are considered to be representative of the deposit.

**Figure 7.7**  
**Drill Holes with Samples with Measured Quantitative Mineralogy**



Note: “Camp” refers to location of original exploration camp. Avalon, 2016.

### 7.6.5 Tantalum, Tin and Niobium

Tantalum occurs in a number of different, fine-grained tantalum bearing minerals (see Table 7.5), but discrete tantalum-rich zones have not been encountered. To date, trace to minor amounts of tantalum have been found in albite-rich rocks and in the lepidolite-rich zones within the Separation Rapids Pegmatite.

Metallogenic zoning within the Separation Rapids Pegmatite is closely related to mineralogical zoning. Lithium and rubidium enrichment occurs in zones where tantalum and

cesium are excluded. The exception to this is in Subunit 6d where the tantalum content is elevated to several hundred ppm. Tantalum is also sporadically elevated in the albitic dykes wherever lithium and rubidium values are depressed.

Preliminary mineralogical and geochemical studies (Taylor, 1999a) showed that the mineral columbite-tantalite,  $(\text{Mn,Fe})(\text{Nb,Ta})_2\text{O}_6$ , is typically manganese-rich, widespread and comprises about half of the accessory mineral population in any given sample. Taylor (1999a) also identified the presence of microlite as an important mineral in terms of abundance, and this is also a manganese-rich tantalum mineral.

The average  $\text{Ta}_2\text{O}_5$  contents for the petalite zone lithologies are:

|                  |                                |
|------------------|--------------------------------|
| Subunits 6a & 6b | 0.009% $\text{Ta}_2\text{O}_5$ |
| Subunit 6c       | 0.009% $\text{Ta}_2\text{O}_5$ |
| Subunit 6d       | 0.010% $\text{Ta}_2\text{O}_5$ |
| Unit 6 combined  | 0.009% $\text{Ta}_2\text{O}_5$ |

Importantly, the instrumental neutron activation analysis (INAA) tantalum results from Taylor's 1998 study were as much as 30% higher than those obtained by ICP in the original assaying program. Taylor suggests that the INAA results are more accurate and indicate that tantalum values in the Separation Rapids Pegmatite might be higher than originally thought.

The study also showed that cassiterite ( $\text{SnO}_2$ ) is locally abundant and represents from 4% to 70% of the accessory mineral population in the samples analysed and it appears to be relatively more abundant in near surface samples from section 460W. Taylor reported that the  $\text{Ta}_2\text{O}_5$  content of the tin mineral cassiterite is typically low (less than 1.5%). Cassiterite distribution is much more irregular than that of columbite-tantalite. Note that cassiterite occurs largely within peripheral albitic dykes.

#### 7.6.5.1 Micas

Preliminary mineralogical and geochemical studies (Taylor, 1998) showed that the Separation Rapids Pegmatite micas carry very high concentrations of rubidium (2.46 - 3.92%  $\text{Rb}_2\text{O}$  in silvery mica and 4.36-4.54%  $\text{Rb}_2\text{O}$  in purple micas). The commercial potential for lepidolite will be further evaluated in the course of feasibility studies.

#### 7.6.5.2 Potentially Deleterious Elements

The Separation Rapids Pegmatite petalite is very pure and chemically close to that of the stoichiometric petalite composition. Importantly, the iron content is extremely low, averaging 0.01%  $\text{Fe}_2\text{O}_3$ , with a maximum of 0.4%  $\text{Fe}_2\text{O}_3$ . Fluorapatite occurs as an accessory phase within the Separation Rapids Pegmatite and is the major source of the phosphorus detected in drill core assays. The Separation Rapids Pegmatite has very low  $\text{P}_2\text{O}_5$  content as shown by bulk analyses of trench STL-1 samples (range 0.02 to 0.09%  $\text{P}_2\text{O}_5$ , and average 0.04%  $\text{P}_2\text{O}_5$  with one sample of albitic wall-rock assaying 0.22%  $\text{P}_2\text{O}_5$ ). A  $\text{P}_2\text{O}_5$  content of greater than



1% is considered deleterious in feldspar, spodumene and petalite concentrates used in the ceramics industry.

## 8.0 DEPOSIT TYPES

The Late Archean SRLD belongs to the petalite sub-type, complex-type class of rare-metal pegmatites (Černý and Ercit, 2005). The complex-type pegmatites are geochemically the most highly evolved in the spectrum of granitic pegmatites, and petalite-bearing pegmatites comprise only 2% of the known complex-type pegmatites.

Complex-type pegmatites are found in many areas of the world and are economically important as resources for the rare metals, including lithium, tantalum, cesium and rubidium. Bradley and McCauley (2013) and Kesler et al. (2012) have published comprehensive overviews of lithium pegmatite deposits. Except for the former producer, Tanco in Manitoba, Canada, and the Bikita operation in Zimbabwe and Greenbushes in Western Australia, (see Table 8.1), most complex-type pegmatites are too small to be profitably mined. With the presently estimated resources The Separation Rapids property is comparable in size and grade to the former and currently producing deposits.

The SRLD exhibits some significant differences from the norm in its structural setting, preservation of magmatic zonation and overall crystal size. Unlike Tanco and Bikita, which are shallow dipping, undeformed zoned intrusions, and Greenbushes, which is an approximately 45°-dipping, zoned and locally mylonitized pegmatite, the SRLD is subvertically-dipping, complexly folded, strongly foliated and locally mylonitized.

As described in Section 7.0, the SRLD exhibits zoning characteristics seen in other highly evolved rare-metal pegmatites, i.e., well-developed wall zones with exo- and endo-contact borders and petalite-rich intermediate zone. However, within the SRLD a significant portion of these zones and zonal features has been tectonically modified. In addition, all three currently producing rare-metal pegmatite deposits contain exceptionally large crystals of spodumene, petalite and feldspars which permit selective mining; at Bikita and Tanco, petalite crystals and pseudomorphs are reported to be as large as 2 to 2.5 m in size. The megacrystic zones in the SRLD, on the other hand, contain crystals no larger than 10 to 15 cm. The true widths and strike extent of the SRLD and the petalite-producing Al Hyat sector of Bikita are almost identical (Garret, 2004).

**Table 8.1**  
**Tonnage and Grade for Three Major Complex-type Pegmatites**

| Deposit                  | Million Tonnes | Grade<br>(Li <sub>2</sub> O %) |
|--------------------------|----------------|--------------------------------|
| Tanco <sup>1</sup>       | 2.1            | 0.215                          |
| Greenbushes <sup>2</sup> | 70.4           | 2.6                            |
| Bikita <sup>2</sup>      | 12             | 1.4                            |

<sup>1</sup> Galeschuk and Vanstone, 2007.

<sup>2</sup> Bradley and McCauley, 2013.

## **9.0 EXPLORATION**

### **9.1 EARLY EXPLORATION**

As noted in Section 6.0, prior to the discovery of rare-metal pegmatite occurrences, exploration in the Separation Rapids region focused on base and precious metal mineralization. The petalite-bearing SRLD which forms a prominent hill on the south shore of MacDonald's Bay on the English River, and an associated group of rare-metal pegmatites, were discovered by Dr. Fred Breaks of the Ontario Geological Survey (OGS) as a result of a detailed study of rare-metal pegmatites in the region between 1994 and 1996.

Avalon entered into an option agreement with Robert Fairservice and James Willis in October, 1996 and carried out a brief prospecting and sampling program in November, 1996. Dr. David Trueman, a consulting geologist experienced in rare-metal pegmatite deposits, carried out a preliminary study of the property and recommended a comprehensive exploration program. Avalon subsequently carried out a Cdn\$1.1 million exploration program from May, 1997 to March, 1998. This program is described below with the information from the assessment report prepared by Pedersen (Pedersen, 1998a).

### **9.2 1997-98 EXPLORATION PROGRAM**

#### **9.2.1 Line Cutting and Magnetometer Survey**

Line cutting and ground magnetometer survey work were conducted on the Separation Rapids property in two stages, the first during May 1997, and the second in January 1998. Both stages of work were completed by Gibson and Associates of Sault Ste. Marie, Ontario.

During the first stage of work, a north-south oriented grid totalling 30.9-line km was cut on 50 to 100 m line spacing and 25 m station intervals. The magnetometer survey was carried out over 28.5 km of the grid during May, 1996, with readings taken at 12.5 m intervals. During the second stage of work, a total of 6.9 km of line were cut over areas that were not accessible during the previous stage and consisted of 50 m fill-in lines between the existing 100 m lines on the west end of the grid. This portion was surveyed by magnetometer during January, 1998.

The magnetic survey was performed using two Scintrex Envi-Mag portable total-field magnetometers. The purpose of the survey was to assist with geological interpretation and, in particular, to determine the magnetic signature of pegmatite bodies, and to delineate structural features, such as faults or folds, which may indicate an appropriate host structure for pegmatite bodies.

The results identified a number of breaks in the contours across the entire area, indicating faulting or tight open to isoclinal fold patterns. A large reactivated fault, along which the SRLD was emplaced, is interpreted from the magnetic data as a sharp contact between a linear magnetic high that trends southeasterly across the grid area and a large area of

moderate magnetic susceptibility. The SRLD is represented as a magnetic low adjacent to a linear magnetic high, which is the host amphibolite. Larger granitic pegmatites and pegmatitic granite also have a low magnetic susceptibility compared to the host amphibolite.

### **9.2.2 Geological Mapping and Sampling**

Geological mapping was conducted over the grid during June and July, 1997 at a scale of 1:1000 by Pedersen, with the assistance of Jacob Willoughby and Richard Brett. Mapping was conducted between the eastern claim boundary at L0+50E and L18+00W.

A second detailed surface geological mapping program was carried out during the summer of 1998, at a scale of 1:100, over the stripped main Separation Rapids Pegmatite outcrop area and some of the adjacent pegmatite zones. This second phase of mapping identified the various phases of the Separation Rapids Pegmatite, delineated the areal extent of petalite-bearing units and the Separation Rapids Pegmatite, expanded the known area containing the lepidolite zone (Subunit 6d), identified the structural controls on the emplacement of the Separation Rapids Pegmatite and some of the complexities due to folding, and outlined areas of further potential petalite-bearing units, especially the lepidolite-bearing Subunit 6d along the east and northeast part of the main Separation Rapids Pegmatite body. Outcrop stripping, trenching and systematic sampling were also carried out in conjunction with both phases of surface geological mapping.

Twenty representative samples of various pegmatitic outcrops were collected and assayed for Li, Ta, Nb, Cs, Rb, and Sn. Most samples were representative grab samples, with a few chip samples where outcrop allowed. Because of the smooth glaciated nature of most pegmatite outcrops, good samples are generally difficult to obtain without trenching or sawing.

Samples were sent to Chemex Labs (Chemex) in Thunder Bay, Ontario, for preparation and then assayed in Vancouver, British Columbia, and Mississauga, Ontario using atomic absorption (AA) for Li and Sn, neutron activation (NAA) for Ta, Cs and Rb, X-ray fluorescence (XRF) for Nb, and inductively coupled plasma analysis (ICP) for phosphorus reported as P<sub>2</sub>O<sub>5</sub>. Results were reported in parts per million and converted to oxide values by Avalon with the exception of phosphate, which was reported by Chemex.

### **9.2.3 Trenching**

Five outcrop exposures of the SRLD and other pegmatites were trenched by blasting and hand-stripping following completion of field mapping, for the purpose of obtaining continuous chip samples across the width of the pegmatites, i.e., trenches SLT-1 through SLT-5.

A total of 47 continuous chip samples were collected from the five trenches, with a maximum sample length of 3.0 m. The results of assays of samples from the trenches were consistent both from trench to trench and along each trench. Assuming that the lithium is largely contained in petalite averaging 4.2% Li<sub>2</sub>O and the rubidium in potassium feldspar

averages 1.0-1.5% Rb<sub>2</sub>O, then these levels are consistent with visual estimates of petalite and potassium feldspar contents of about 30-35% and 20-25%, respectively (Pederson, 2016a).

### 9.2.4 Diamond Drilling

The history and statistics of diamond drilling on the property is covered in Section 10.0.

## 9.3 2000-2014 EXPLORATION

In the period from 2000 to 2014, little work of a geoscientific nature was carried out at the property. The main activity relating to advancing the project was metallurgical and, consequently, the main activity at the site was collection of samples, up to and including bulk sample sizes, for metallurgical testing.

The principal bulk sample was obtained during Avalon's work program in 2006 when approximately 300 t of a bulk sample was extracted from the property, crushed to 5/8-in size, and packed in storage bags. This included material down to very fine grain size. This finely ground material is very important to retain since it contains most of the petalite mineral of interest.

A relatively small sample was shipped to a prospective customer in Europe, but the interest for this type of product declined due to market conditions at that time.

Some of the sample bags had started to split as a result of deterioration due to outdoor storage prior to the sample being shipped to Europe. Therefore, the material contained in the bags was cleaned and any organic material (plants, moss, wood particles) was removed, then dried prior to shipment. The decision was made to clean and re-bag all of the sample material.

### 9.3.1 Check Assay Program

An assaying program was undertaken at the same time as sample preparation, as a check on the material in storage. A total of 259 subsamples were collected from the bulk sample material. In order to reduce the number of analyses required, these subsamples were combined to create 40 composites each of between five and seven subsamples. The summary statistics of the composite samples are given in Table 9.1.

**Table 9.1**  
**Comparison of Subsample Statistics of Li% with Li% of Composite**

| Subsample Set | Mean Li (%) <sup>1</sup> | Median Li (%) | Standard Deviation | Standard Deviation (%) | Minimum Li (%) | Maximum Li (%) | Composite Li (%) |
|---------------|--------------------------|---------------|--------------------|------------------------|----------------|----------------|------------------|
| 1             | 0.7278                   | 0.7290        | 0.0346             | 4.8                    | 0.685          | 0.769          | 0.740            |
| 2             | 0.6358                   | 0.6465        | 0.0766             | 12.0                   | 0.534          | 0.733          | 0.659            |
| 3             | 0.7282                   | 0.7240        | 0.0655             | 9.0                    | 0.644          | 0.828          | 0.697            |

<sup>1</sup>Original data presented in terms of Li%, rather than Li<sub>2</sub>O%.

Various other analyses were completed, including comparison of washed and unwashed samples, which importantly demonstrated that washing did not significantly change the lithium grade.

### **9.3.2 Rock and Soil Survey**

In September, 2009 a brief rock and soil survey was undertaken at the property by geologist Angela Martin (Avalon, 2009) for assessment work credit purposes. The survey area was limited to claim number 4221036. The objective of the soil/rock survey was to detect a potential extension of the mineralized zone of the SRLD pegmatite system to the north.

As reported by Avalon in 2009, the pegmatite rock descriptions and the mineral assemblages, biotite and garnet in particular, imply that the rocks are poorly fractionated and unlikely to be lithium mineral bearing. The assay results, and more specifically the rubidium values, while interesting, indicated the level of fractionation that might be expected in a pegmatite or a pegmatitic granite. No further work has been completed in this area.

In the period 2011 to 2015, there was little geological field work and, generally, site visits were either connected with collecting samples for metallurgical work or maintenance of access roads and the site.

In 2014, Avalon undertook a program of rehabilitation of the drill core stored at the project site. This comprised reboxing core that was in core boxes that had deteriorated, building new racks to replace any in danger of collapse and clearing brush and other vegetation growing around the core racks.

#### **9.3.2.1 Acid Rock Drainage**

For the purpose of examining acid rock drainage potential of waste rock at Separation Rapids, four NQ whole core samples out of 21 collected in November, 2013, were submitted for ARD tests to SGS Canada in March, 2015 (Pedersen, 2016c). These core samples were chosen as “typical” amphibolite from the main mass area of the SRLD. Visible sulphides were difficult to discern in the great majority of amphibolite samples; sample 98-47 is an exceptional anomaly, having minor visible pyrrhotite along fractures. Thus, sample 98-47 is not chemically representative of typical amphibolite but was chosen to indicate what a sample with exceptional visible sulphides, and so a “worst case” may indicate. The initial results indicated rocks with low ARD potential. Sulphide percentage ranges from 0.02% to 0.04%, with total sulphur ranging from 0.05% to 0.101%. The single higher value of 0.101% S coincides with a single high carbonate % (0.824%), both of which occur in sample 98-47.

## 10.0 DRILLING

### 10.1 INTRODUCTION

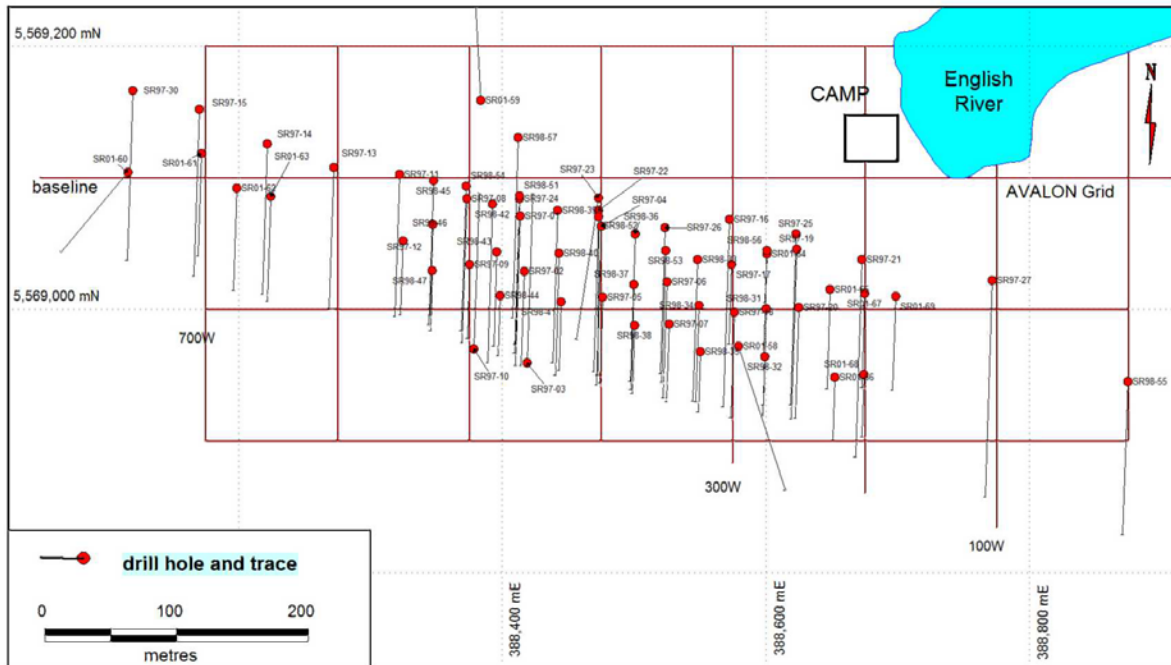
Avalon has drilled at the Separation Rapids Lithium Project in a number of campaigns between 1997 and 2001. Since 2001, no further drilling has taken place at the property. The total number of drill holes is 72 for a cumulative total of 10,708 m, as summarized in Table 10.1. The locations of all holes drilled on the property, including geotechnical holes SR01-58, SR01-59 and SR01-60, are shown in Figure 10.1.

**Table 10.1**  
Summary Drilling Statistics, Separation Rapids Pegmatite

| Year         | Purpose              | Number of Holes | Metres        | Size |
|--------------|----------------------|-----------------|---------------|------|
| 1997         | Geological/resources | 30              | 4,922         | NQ   |
| 1998         | Geological/resources | 27              | 3,829         | NQ   |
| 2001         | Geotechnical         | 3               | 537           | NQ   |
| 2001         | Geological/resources | 12              | 1,420         | NQ   |
| <b>Total</b> |                      | <b>72</b>       | <b>10,708</b> |      |

All core is stored in racks on site. In 2014, new core racks adjacent to the original core storage were installed. Drill core was transferred to new boxes and stored in the new racks.

**Figure 10.1**  
Map of Drill Hole Locations, Separation Rapids Property



Note: “Camp” refers to location of original exploration camp.  
Avalon, 2016.

## 10.2 1997-1998 DRILLING PROGRAM

A first phase diamond drilling program was initiated in early October, 1997 (Pedersen, 1998) with the objectives of defining the physical parameters of the SRLD pegmatite, its tenor of mineralization, and testing of peripheral pegmatites for potential economic size and grade coincident with the SRLD. Thirty holes totalling 4,922 m were completed by early December, 1997 by Bradley Brothers of Rouyn-Noranda, Quebec. All core drilled was NQ diameter and logged on site by Pedersen, with the assistance of Jeff Morgan. With the exception of isolated narrow albitic dykelets, all pegmatite core was split on site and sent to X-Ray Assay Laboratories (XRAL) of Don Mills, Ontario for analysis for Li, Rb, Ta, and Cs with some check analyses completed at Chemex Labs. Sample preparation was carried out at Chemex's Thunder Bay facilities and assays at its Vancouver, BC and Mississauga, Ontario facilities.

Narrow amphibolite screens in areas of abundant pegmatite and internally in the SRLD were also split and assayed. With the exception of two holes (SR97-3 and SR97-10) which were drilled north (azimuth 000°), all holes were drilled to the south (azimuth 180°). Most were drilled at an inclination of -45°, with the exception of several holes, designed to intersect pegmatite at a deeper level, which were inclined -50° to -67°. Down hole surveys were completed with a Pajari instrument for both dip and azimuth; all were surveyed at the bottom of the hole, with longer holes also surveyed below the casing and at the midpoint. Holes ranged in length from 80 to 281 m. Drill hole collar locations were surveyed by Ross Johnson Surveying of Kenora, Ontario with UTM coordinates applied, and elevations established to within 1.0 m.

The rationale for the 30 holes of the first phase of drilling was as follows:

- 23 holes were drilled to delineate the SRLD on approximately 50 m spacing: SR97-1 to SR97-12 and SR97-16 to SR97-26.
- 6 holes were drilled to outline the eastern portion of the Western Pegmatite: SR97-13 to SR97-15 (originally to test the Great White North outcrop as an extension of the SRLD), SR98-28 and SR97-29 (under Bob's Pegmatite), and SR97-30.
- 1 hole was drilled to test the Eastern Swarm: SR97-27.

A second phase definition drilling program commenced in February, 1998 with the objectives of reducing average hole spacing in the SRLD pegmatite to 25 m, extending the known geological resource of the SRLD to 300 m below surface, testing the eastern continuation of the Eastern Swarm, and testing two magnetic lows in the northwest quadrant of the Fairservice-Willis claims for hidden pegmatites. A total of 27 NQ holes totalling 3,829 m were drilled by Bradley Brothers of Rouyn-Noranda between early February and the middle of March, 1998. All holes were drilled to the south (180°) with the exception of three holes in the northwest quadrant which were drilled to the north to test magnetic low



anomalies. Most holes were drilled at an inclination of  $-45^{\circ}$ , except for deeper holes which were inclined  $-50^{\circ}$  to  $-72^{\circ}$ . Holes ranged from 63 to 350 m in length.

The rationale for the 27 holes of the second phase of drilling was:

- 20 holes were drilled to provide in-fill control for mineral resource estimation on the SRLD on 25 m centres: SR98-31 to SR98-47, SR98-51 to SR98-53.
- 2 holes were drilled to test for vertical continuity of the SRLD: SR98-54 and SR98-57.
- 3 holes were drilled to test magnetic low anomalies in the northwest quadrant of the Fairservice claims: SR98-48 to SR98-50.
- 1 hole was drilled to test the eastern limit of the Eastern Swarm: SR98-55.
- 1 hole was drilled to test the vertical continuity of a lepidolite-bearing dyke uncovered by stripping during the on-going drill program: SR98-56.

### **10.3 2001 GEOTECHNICAL DRILL PROGRAM**

Between 26 April and 4 May, 2001, three oriented core diamond drill holes, designated SR01-58, SR01-59 and SR01-60, were drilled using a Boyles 35 diamond drill equipped with a wireline core retrieval system and supervised by Knight Piésold (Knight Piésold, 2001). Knight Piésold was retained to complete a geomechanical investigation of the rock mass at the proposed open pit mine and to develop suitable pit slope design parameters to comply with a feasibility level study. The potential for water inflow into the open pit was also evaluated. Packer tests were completed in each hole.

The drill was supplied and operated by Bradley Brothers Limited of Timmins, Ontario. Drilling was completed using an NQ triple-tube core barrel. Core orientation was performed with the clay imprint method. For this method, an eccentrically weighted core tube was lowered down the hole with the wire line equipment. The lifter case at the base of the orienter tube was filled with plasticene clay, which is pushed down the hole to obtain an impression of the core stub at the bottom of the hole.

Upon retrieval of the following drill run, the clay impression was matched with the top of the run. This was used to determine the top of the core. The core was then assembled and a reference line was drawn on the core to indicate the top of the core. Work completed included:

- Logging and photographing by Avalon of all core prior to being split for assaying.
- Measurements of the discontinuity orientations.

- Point Load Tests (PLT) on representative samples of the core to obtain an estimate of the Uniaxial Compressive Strength (UCS) of the rock types encountered.
- Packer testing: at selected intervals in the drill holes, measurements of the hydraulic conductivity of the rock mass were made using an NQ diameter double packer system.
- Rock mass classification: in order to quantify the engineering properties of rock masses, two separate rock mass classification systems were used for the study - the Rock Tunnelling Quality Index (Q) and the Rock Mass Rating (RMR) system.

As noted by Knight Piésold, 2001, Avalon assayed the core from the geotechnical holes. The data are included in the Separation Rapids drill database.

#### **10.4 2001 GEOLOGICAL DRILL PROGRAM**

In May, 2001, 12 diamond drill holes totalling 1,401 m were completed (Avalon News Release 25 July, 2001), including the three geotechnical drill holes noted above, i.e., holes SR01-58 through SR01-69. The drilling of nine non-geotechnical holes was east of the main mass of the SRLD to delineate the depth and Ta-Cs potential of a series of anastomosing narrow lepidolite-rich petalite-dykes which represent the eastern extension of the pegmatite. The results indicated a continuous vertical extent of the dyke swarm, but no thickening with depth. Tantalum and cesium values were slightly elevated relative to those in the main mass of the SRLD. In general, the results from this program were consistent with those from previous drilling, which indicated zones of relative tantalum enrichment on both the eastern and western extremities of the deposit, ranging from 0.009% Ta<sub>2</sub>O<sub>5</sub> to 0.022% Ta<sub>2</sub>O<sub>5</sub> (0.2 to 0.5 lb/t) compared to 0.007% to 0.009% Ta<sub>2</sub>O<sub>5</sub> within the main mass of the SRLD pegmatite.

#### **10.5 2016 RE-ANALYSIS PROGRAM**

In June, 2016, 45 intervals from two previous drill holes (SR97-2 and SR98-52) were selected and quartered for re-analysis as part of an updated QA/QC program, with standards inserted every tenth sample. This is reported in more detail in Section 12.0.

## 11.0 SAMPLE PREPARATION, ANALYSES AND SECURITY

### 11.1 SAMPLE HANDLING AND ANALYTICAL METHODS USED – 1997/98

This section, reporting on past drill core sampling, is largely taken from the reports of Pedersen (1998a) and Micon (1999), with some addition relating to later work.

Surface samples taken in the 1990s were shipped to Chemex Labs Ltd. in Thunder Bay, Ontario for preparation and then to Chemex's laboratories in Mississauga, Ontario and Vancouver, British Columbia for subsequent assaying.

The surface samples from the SRLD were analysed for lithium and tin using atomic absorption spectroscopy (AA), and for rubidium, cesium and tantalum using instrumental neutron activation analysis (INAA). The trench samples were also analysed for phosphorus using Inductively Coupled Plasma Spectroscopy (ICP). Surface samples collected from the Lepidolite and Fairservice dykes in the winter of 1997 were analysed for gallium, niobium and tin by X-ray fluorescence spectrometry (XRF) in addition to lithium, rubidium, cesium and tantalum by AA and INAA.

In the 1990s, drill core was logged and split with half of the core being sent for assay and the other half being stored in core boxes on site. Core sample intervals were varied, depending on lithology, to a maximum of 3 m.

Split core samples were shipped to XRAL Laboratories in Don Mills, Ontario, where they were assayed for lithium, rubidium, cesium and tantalum using ICP for lithium and tantalum and AA for rubidium and cesium.

A total of 2,516 drill core samples were assayed at XRAL, with an additional 223 duplicate analyses. Avalon's check sampling program consists of 163 samples from the Separation Rapids Pegmatite and associated pegmatites. This included 19 surface grab samples, 47 continuous chip trench samples from trenches SLT-1 to SLT-5, nine trench, chip and surface grab samples from the Lepidolite dyke, three surface grab samples from the Fairservice dyke, and 85 drill core check assay samples.

Check-assaying was routinely carried out for lithium and rubidium by Chemex at its Vancouver, British Columbia, and Mississauga, Ontario facilities.

As reported in the section on quality control, additional independent analyses were completed by Micon (1999). Also, as reported below, in 2016, Avalon completed additional splitting of the original drill core to complete check analyses after preparation of a lithium analytical standard from Separation Rapids mineralized rock.

**Table 11.1**  
**QA/QC Sample Statistics**

| QC Category     | Year      | Drill Hole Sample Count         | QC Sample Count | Ratio of QC Samples to Drill Hole Samples |
|-----------------|-----------|---------------------------------|-----------------|---|
| Field duplicate | 1997-2001 | 2,790                           | 84              | 1:33                                      |
| Field resample  | 2016      | 2,790 original database records | 42              | 1:66                                      |
| Standards       | 2016      | 2,790 original database records | 4               | 1:700                                     |

**Table 11.2**  
**Analyses of Drill Core Samples, 1997-1999 and 2001**

| Laboratory/Operator | Number of Samples | Notes                                      |
|---------------------|-------------------|--|
| XRAL                | 2,491             | Original analyses of drill core, 1990s     |
| XRAL                | 221               | 1990s pulp duplicate analyses <sup>1</sup> |
| Chemex              | 84                | Reject duplicate analyses                  |
| XRAL                | 299               | Original analyses of drill core, 2001      |
| Chemex <sup>2</sup> | 6                 | Core duplicates                            |

<sup>1</sup> Not in DataShed database.

<sup>2</sup> Check assays by Micon, 1999.

## 11.2 SAMPLE HANDLING AND ANALYTICAL METHODS USED – 2016

In 2016, Avalon resampled drill core from the 1990s programs stored at the project site. The objective was to reassay the core with modern methods and inserted lithium rock standards for comparison to the historic data.

There was no evidence that the drill core had been tampered with in the interim period. The work was personally supervised by Chris Pedersen who also supervised the drilling in the 1997-1998 period. Pedersen also supervised the re-boxing and re-racking of the drill core in 2015. Thus, Pedersen could observe whether the core appeared to be undisturbed in terms of being correctly labelled and complete.

In July, 2016, under the supervision of Pedersen, the half core of two 1998 drill holes was quartered using a core saw at Ontario government facilities in Kenora. Samples were bagged according to identical intervals to the samples collected in the 1990s. This enables direct comparison between original analytical values and 2016 assays. The two drill holes, SR97-02 and SR98-52, were sampled across the complete intercept of the pegmatite body. Lithium rock analytical standards developed internally by Avalon were inserted into the sample stream (see Section 12.0 for details).

The 2016 quarter-core samples were sent to ALS Laboratory in Sudbury, Ontario with a request for the following preparation and analyses:

- Preparation
  - CRU21 – preliminary crushing with fine crushing of rock chip and drill samples to 70% nominal -2 mm.
  - SPL22Y – premium splitting procedure producing split sample using a Boyd crusher/rotary splitter combination.
  - PUL31 - Pulverize a split or total sample up to 250 g to 85% passing 75 µm.
  - CCP-PKG01 involving five different analytical methods
  - ME-ICO06 – whole rock analysis
  - ME-MS81 – 31 elements by lithium metaborate fusion, acid digestion and ICP-MS
  - ME-4ACD81 – 10 elements including lithium by four-acid digestion – ICP
  - ME-MS42 – 9 gold-related elements with aqua regia digestion
  - ME-IR08 – carbon and sulphur

The core analysis results are discussed in Section 12.0.

### **11.3 DRILL DATABASE PREPARATION**

For the drill programs in the 1990s, data compilation and drafting of sections and level plans were carried out on site by the project geologist with subsequent modification at Avalon's Thunder Bay office. All field logging was done on paper and data were not digitized.

The original drill hole database for the Separation Rapids Lithium Project was developed for the 1999 Micon Preliminary Feasibility Study by Pearson, Hoffman and Associates Ltd. (PHA). The database was created from the drill logs with lithologies, provided by Avalon to PHA as well as laboratory analysis certificates and surveying data. There is no information in the PHA (1999) report or the prefeasibility study as to what quality control measures were implemented on the database.

The database was provided by Micon to Avalon as a series of Excel worksheets in 2011. These data were then imported into the Avalon corporate drill database in the Maxwell Geoservices DataShed data management software. This is the major database that Avalon utilizes for all its drilling projects and to provide organised drill data for resource estimation.

Avalon then completed verification of this database against historic data records such as drill logs, assay certificates, and other original sources of data. The objective is to ensure that errors are not present in the DataShed database. The results of this work are given in Section 12.0.

### **11.4 SPECIFIC GRAVITY**

The drill database contains 185 specific gravity (SG) values for various lithologies on the SRLD. This comprises 118 measurements on pegmatite, 66 on amphibolite and one measurement which was considered an outlier and was rejected.

As part of the original drill program (Pedersen, 1998a), Avalon carried out SG measurements on 20 representative drill core samples of the pegmatite using a Mettler Toledo PB 1501 Electronic Balance at the University of Manitoba. The balance was calibrated at the beginning of the procedure with a 1,000 g sample and checked on a regular basis. A microcline (potassium feldspar) sample measured at 2.53 was deemed an acceptable test, as the SG of the sample fell within the range of published data.

The original data for 20 samples have not been identified, however PHA (1999) provides the data shown in Table 11.3 for the SG of the various lithologies.

**Table 11.3**  
**1998 Specific Gravity Measurements**

| <b>Rock Type</b>           | <b>Specific Gravity</b> |
|----------------------------|-------------------------|
| Petalite Zone              | 2.57                    |
| Feldspar Zone              | 2.62                    |
| Internal Amphibolite Waste | 2.90                    |
| Host Rock Waste            | 2.90                    |
| Air                        | 0.00                    |

PHA, 1999.

In October, 2014, Pedersen completed a further 185 specific gravity determinations on core samples using the same equipment at the University of Manitoba. These core samples were from eight drill holes that covered both pegmatite (118 measurements) and amphibolite (66 measurements). Holes covered were SR97-08, -09 and -10 and SR98-33, -34, -35, -36 and -37. One additional measurement was rejected during resource estimation as an outlier.

Based on the measurements completed in 2014, the average SG for pegmatite is 2.62 for the 118 samples (one high outlier at 3.16 removed). The average SG for amphibolite (waste) is 3.04 based on the 66 measurements. The SG measurements show low variability (standard deviation of 0.08, or 3% for pegmatite and 0.05 or 2% for amphibolite) indicating that the risk of significant error is also low.

The details of the SG statistics are given in Section 14. Table 11.4 gives a comparison between the original data utilized in resource estimation in 1999 and the SG values obtained in 2014. The data for the pegmatite illustrates that the two sets of data are identical statistically with the 1999 values lying within one standard deviation of the 2014 values. The values used for the mineral resource estimate presented in this report are those for the 2014 measurements, see Section 14.1.2.

**Table 11.4**  
**Comparison of SG Measurements, 1998/99 and 2014**

| Unit                   | 2014 Data <sup>1</sup> |               |             |
|------------------------|------------------------|---------------|-------------|
|                        | Pegmatite              | Feldspar Zone | Amphibolite |
| Number                 | 118                    |               | 66          |
| Average                | 2.62                   |               | 3.04        |
| Median                 | 2.62                   |               | 3.04        |
| Standard deviation     | 0.08                   |               | 0.05        |
| 1998 Data <sup>2</sup> |                        |               |             |
| Values used in 1999    | 2.57                   | 2.62          | 2.90        |

<sup>1</sup> Pedersen, 2016a.

<sup>2</sup> Micon, 1999.

## 12.0 DATA VERIFICATION

### 12.1 INTRODUCTION

The resource estimation completed in 2016 is based largely on the original drilling by Avalon in 1997 to 2001, and assay database created by Micon in 1999. There were certain quality assurance/quality control (QA/QC) procedures applied and reported on at the time of creation of the database as summarized in Section 12.2 below. These procedures included check assays at a second laboratory and independent assaying by Micon.

Subsequently, Avalon completed further verification of the drill data, given below in Section 12.4. This included cross-checking the database against original field records such as drill logs, cross-checking the assays against laboratory assay certificates and reassaying drill core splits with inserted internally certified lithium standards.

### 12.2 QUALITY CONTROL, 1990s

As reported in Section 11.0, during the original drill program, 84 duplicate coarse rejects samples from drill core were submitted to Chemex, as a check laboratory. The results can then be compared with the primary samples analysed by XRAL (Pedersen, 1998a).

Figure 12.1, Table 12.1, Figure 12.2 and Table 12.2 show the comparison of the XRAL and Chemex data sets. The two sets compare favourably for  $\text{Li}_2\text{O}$  grades when  $\text{Li}_2\text{O}$  grade is lower than approximately 1.5%, but show an increasing amount of scatter above this grade. XRAL's  $\text{Rb}_2\text{O}$  data were consistently lower than Chemex's.

Avalon reported at the time (Pedersen, 1998a) that the discrepancies in lithium and rubidium assays may be due to differences in analytical techniques, especially for lithium, which was analysed by ICP at XRAL and by AA at Chemex. As rubidium was analysed by AA at both laboratories, Pedersen, 1998a, suggested that incomplete sample digestion and/or the use of different standards might be the reason for the differences in these results.

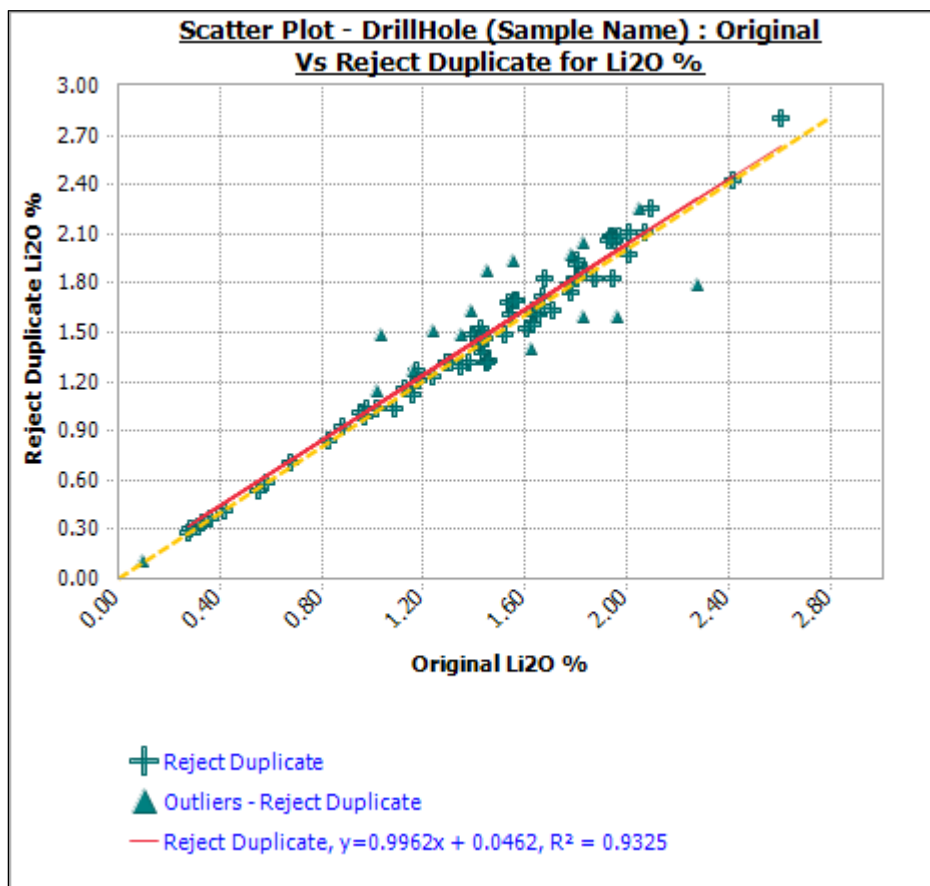
However, there were other differences in the methods utilized besides the instruments. The XRAL analysis method utilized sodium peroxide fusion followed by ICP for Li and Ta and perchloric-nitric-HF digestion followed by AA for Rb and Cs. Chemex applied "Preparation Method 232" to the samples, where procedure 232 is reported as perchloric-nitric-HF acids digestion. Lithium was then analysed by AA and Rb by ICP-MS. The difference in initial steps of fusion (XRAL) and acid digestion (Chemex) was not discussed originally as a possible influence on differences between XRAL and Chemex analyses, but it is possible that different lithium bearing minerals, petalite, spodumene and lepidolite, may respond differently to fusion versus acid digestion.

Assays classed as outliers (or 'bad repeats') in the graphs below, generated by DataShed and the associated Maxwell Geoservices software "QAQCReporter", meet the following criteria:



1. Assay value is 10 times the lower detection limit and
2. Assay Value is  $\geq 10\%$  different than the original assay.

**Figure 12.1**  
Scatter Plot of Original Sample (XRAL Analysis) and Reject Duplicate Sample (Chemex Analysis) for  $\text{Li}_2\text{O}$



**Table 12.1**  
Summary Statistics for Figure 12.1

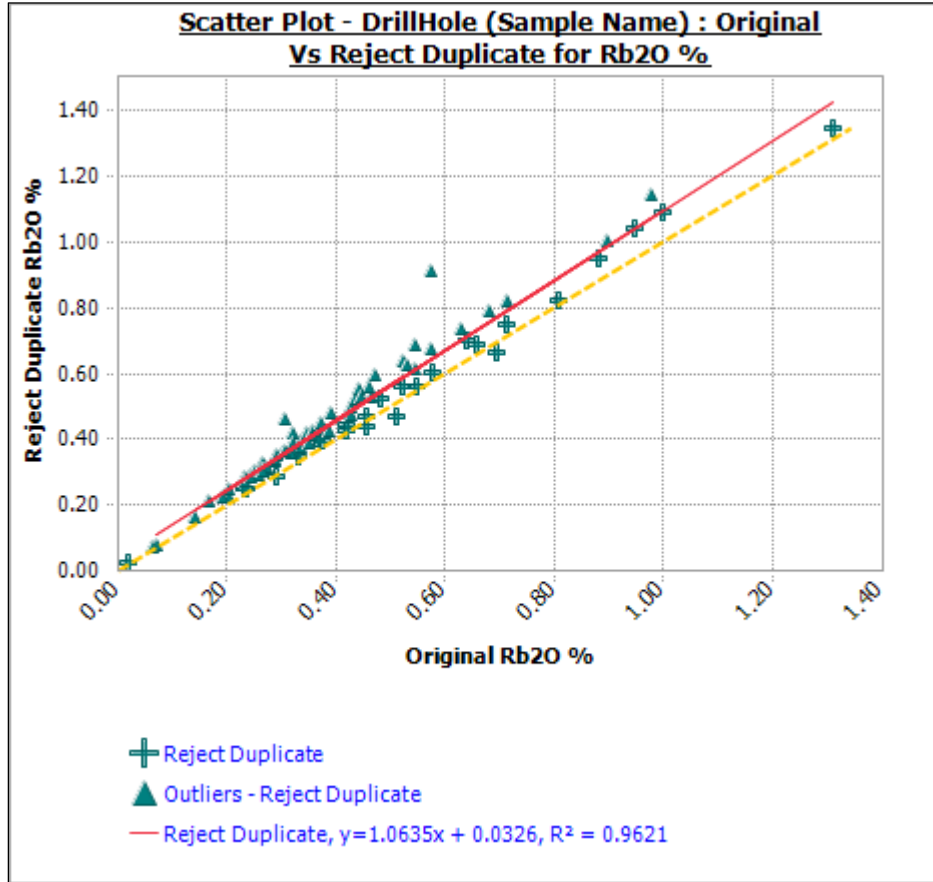
| Number of Samples | Mean $\text{Li}_2\text{O}$ XRAL | Mean $\text{Li}_2\text{O}$ Chemex | Standard Deviation $\text{Li}_2\text{O}$ XRAL | Standard Deviation $\text{Li}_2\text{O}$ Chemex | CoV $\text{Li}_2\text{O}$ XRAL | CoV $\text{Li}_2\text{O}$ XRAL | sRPHD <sup>1</sup> (mean) |
|-------------------|---------------------------------|-----------------------------------|---|---|--------------------------------|--------------------------------|---------------------------|
| 84                | 1.42                            | 1.46                              | 0.52  | 0.53  | 0.36                           | 0.36                           | -1.44                     |

<sup>1</sup> Relative percent half difference.

Comparison of the original 1997 and 1998 XRAL assays versus the field duplicates assayed by Chemex in 1998 yields a 2.8% difference in the means of the two laboratories' data for  $\text{Li}_2\text{O}$  with Chemex higher than XRAL. Along with this small difference in the means, the

coefficient of determination,  $R^2$ , is high, at 93.25%, indicating strong correlation, and from the graph, there is almost no bias at any concentration level.

**Figure 12.2**  
Scatter Plot of Original Sample (XRAL Analysis) and Field Duplicate Sample (Chemex Analysis) for  $Rb_2O$



**Table 12.2**  
Summary Statistics for Figure 12.2

| Number of Samples | Mean $Rb_2O$ XRAL | Mean $Rb_2O$ Chemex | Standard Deviation $Rb_2O$ XRAL | Standard Deviation $Rb_2O$ Chemex | CoV $Rb_2O$ XRAL | CoV $Rb_2O$ XRAL | sRPHD <sup>1</sup> (mean) |
|-------------------|-------------------|---------------------|---------------------------------|-----------------------------------|------------------|------------------|---------------------------|
| 84                | 0.42              | 0.48                | 0.23                            | 0.24                              | 0.53             | 0.51             | -6.96                     |

Comparison of the 1997 and 1998 XRAL assays with the field duplicates assayed by Chemex yields a 12.5% difference in the means of the two laboratories' data for  $Rb_2O$ . This is a rather high difference in means, however, the  $R^2$  is high, at 96.21%, very strongly correlated, and from Figure 12.2, a small positive bias exists in Chemex compared to XRAL. This positive bias appears to increase at higher concentrations of  $Rb_2O$ .

In conclusion, despite some small differences, both the lithium and rubidium analyses from XRAL and Chemex are close and show similar trends with strong R<sup>2</sup> scores for the correlation. This indicates high and acceptable reliability in the analyses.

### 12.3 INDEPENDENT CHECK SAMPLING AND ASSAYING – 1999

As an independent check on the results reported by Avalon, Micon collected a total of eight samples as due diligence portion of the original prefeasibility study (Micon, 1999). Of these check samples, five samples were of previously logged and assayed drill core and thus were drill core duplicates, two were of continuous chip samples from trench SLT-1 and one sample from Subunit 3b. These eight samples were regarded as being representative of the Separation Rapids Pegmatite petalite-bearing Subunits 6a, 6c and 6d.

For the core samples, Micon removed the core from the boxes, noting the interval and box number and placed the sampled core into new plastic bags along with sequentially numbered assay tags. Trench samples were collected directly by Micon from trench SLT-1. The samples were hand carried by Micon’s representative to Winnipeg and shipped by air as baggage to Toronto (Micon, 1999).

Micon submitted the samples by courier to Chemex in Mississauga for check assay using ICP-MS for tantalum and rubidium and using AA for lithium. The results are shown in Table 12.3.

**Table 12.3**  
**Independent Check Assay Results**

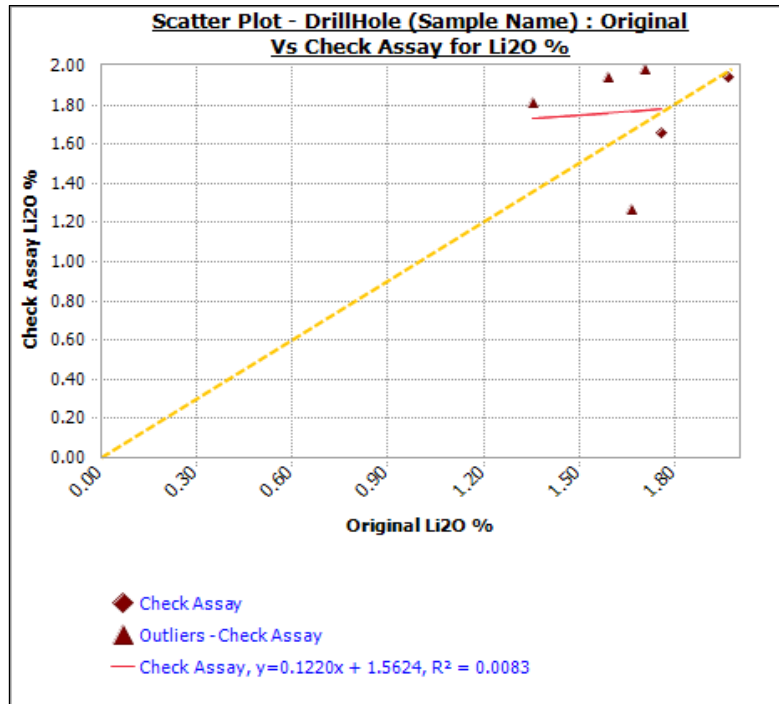
| Micon Sample Number | Subunit | Li <sub>2</sub> O (%) | Rb <sub>2</sub> O (%) | Ta <sub>2</sub> O <sub>5</sub> (%) | Sample Location              | Avalon Sample Number | Li <sub>2</sub> O (%) | Rb <sub>2</sub> O (%) | Ta <sub>2</sub> O <sub>5</sub> (%) |
|---------------------|---------|-----------------------|-----------------------|------------------------------------|------------------------------|----------------------|-----------------------|-----------------------|------------------------------------|
| 57951               | 6a      | 1.66                  | 0.38                  | 0.01                               | Drill hole 97-1              | 236532               | 1.76                  | 0.36                  | 0                                  |
| 57952               | 6d      | 1.94                  | 0.44                  | 0.01                               | Drill hole 97-4              | 236676               | 1.59                  | 0.59                  | 0                                  |
| 57953               | 6a      | 1.98                  | 0.15                  | 0.00                               | Drill hole 97-4              | 236699               | 1.71                  | 0.17                  | 0                                  |
| 57954               | 6a      | 1.94                  | 0.3                   | 0.01                               | Drill hole 97-9              | 237946               | 1.97                  | 0.47                  | 0                                  |
| 57955               | 3b      | 1.81                  | 0.0                   | 0.01                               | Drill hole 97-9              | 237004               | 1.36                  | 0.00                  | 0.01                               |
| 57956               | 6a      | 1.27                  | 0.29                  | 0.01                               | Drill hole 97-3              | 236603               | 1.67                  | 0.49                  | 0.01                               |
| 57957               | 6a      | 1.55                  | 0.24                  | 0.01                               | Trench SLT-1/10 <sup>1</sup> |                      |                       |                       |                                    |
| 57958               | 6c      | 0.52                  | 0.17                  | 0.01                               | Trench SLT-1/20 <sup>2</sup> |                      |                       |                       |                                    |

<sup>1</sup> 14 m from the western wall zone.

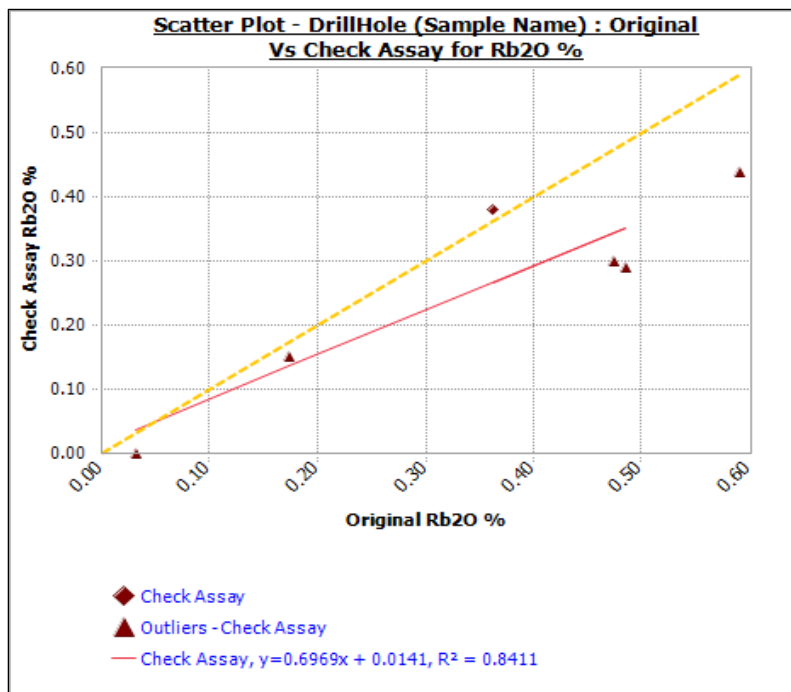
<sup>2</sup> 1.2 m wide zone.

The mean values for the drill core samples are 1.77% Li<sub>2</sub>O (Micon samples) and 1.68% Li<sub>2</sub>O (Avalon samples), which is a 5% difference. This is considered a very low level of difference for drill core duplicates. Micon stated in the 1999 Prefeasibility Study report (Micon, 1999) that it was satisfied that its check assay results corroborated, overall, the assay data reported by Avalon. The data are given as scatter plots in Figure 12.3 for lithium and Figure 12.4 for rubidium.

**Figure 12.3**  
Plot of XRAL (Original) versus Micon/Chemex (Check) Analyses for Li<sub>2</sub>O



**Figure 12.4**  
Plot of XRAL (Original) versus Micon/Chemex (Check) Analyses for Rb<sub>2</sub>O



## 12.4 AVALON 2016 DATA VERIFICATION

### 12.4.1 Database Checks

Historic data currently contained in Avalon’s Maxwell GeoServices DataShed database was sourced digitally from a database created by Micon in 1999. Micon provided the data to Avalon in Excel spreadsheets in 2011. A data verification process was undertaken to confirm that the source data from Micon are accurate and complete once they were imported into DataShed. The verification included comparison of assay values in DataShed versus the values reported on the original Certificates of Analysis, verification of values in the ‘DH Collars’ table of DataShed against the original drill hole logs and verification of locational survey values.

### 12.4.2 Original Assay Certificate Checks

As of 6 July, 2016 the database contained records for 2,790 downhole samples which were assayed for the 1997, 1998 and 2001 drill programs. A random sampling of 12% of the assay values contained in DataShed were compared against the values as reported on the original certificates of analysis provided by XRAL. No errors were found in the downhole assay values as entered into DataShed from the original Micon database.

It is to be noted that the assays entered in DataShed are reported as oxide percentages, while the original assays for drill programs are reported by element in parts per million (ppm). The conversion factors and calculations from element to oxide were also checked and accepted as accurate.

The DataShed oxide entries, original assay element assays, and conversion factors are summarized in Table 12.4.

**Table 12.4**  
**Conversion Factors from Element to Oxide**

| DataShed Units (%)             | Certificate of Analysis Units (ppm) | Conversion Element to Oxide |
|--------------------------------|-------------------------------------|-----------------------------|
| Li <sub>2</sub> O              | Li                                  | 2.1528/10000*Element        |
| Ta <sub>2</sub> O <sub>5</sub> | Ta                                  | 1.221/10000*Element         |
| Cs <sub>2</sub> O              | Cs                                  | 1.06/10000*Element          |
| Rb <sub>2</sub> O              | Rb                                  | 1.094/10000*Element         |

The assay values were exported from DataShed into an Excel spreadsheet which was used for the remainder of the verification work. Oxides converted to their elemental form were compared with the values as reported on the original Certificate of Analysis. A total of 271 sample assays were selected for verification in this manner, over all four of the reported elements.

Trench samples were exported into Excel in the same manner. The trench samples begin with a global positioning system (GPS) location for the start of the trench, then a reading in metres, of distance to the next sample. As such, the trench samples were entered into DataShed as though they were drill holes.

### 12.4.3 Reassay of Drill Core in 2016

#### 12.4.3.1 Certified Standard

Avalon prepared a certified rock lithium analysis standard by shipping 16 kg of Separation Rapids Pegmatite to CDN Resource Laboratories Ltd. (CDN) in Langley, British Columbia. CDN is a commercial laboratory that specializes in preparation of standards for the mineral exploration industry. The procedure included drying, crushing, grinding, screening and packaging the 16 kg sample. The result was 665 packages each containing 25 g of the standard material. A Round Robin analysis procedure was then completed with five samples of the material being shipped to each of six laboratories for lithium analysis, with associated analytical methods performed, with methods in bold font below applying to Li<sub>2</sub>O:

1. Actlabs, Ancaster, Ontario
  - a. Ultratrace-7 Na<sub>2</sub>O<sub>2</sub> fusion, both ICP-OES and ICP-MS finish
  - b. **Code-8**, 4-Acid Digestion with ICP-OES Finish
2. Bureau Veritas, Vancouver, BC
  - a. **PF370**, Peroxide fusion ICP-ES finish
  - b. LF200 (Whole rock extended), Aqua Regia digest followed by ICP-ES/MS finish
3. AGAT Lab, Burnaby, BC
  - a. 201079 (Na<sub>2</sub>O<sub>2</sub> digestion, ICP-OES finish)
  - b. 201676 (whole rock),
4. ALS, Vancouver, BC
  - a. CCP-PKG01, Trace elements reported from three digestions with either ICP-AES or ICP-MS finish: lithium borate fusion for the resistive elements (ME-MS81), a four acid digestion for the base metals (ME-4ACD81) and an aqua regia digestion for gold related trace elements (ME-MS42)
  - b. **ME-ICP82b**, Na<sub>2</sub>O<sub>2</sub> Digestion, ICP Finish
5. SGS, Lakefield, Ontario
  - a. GE ICM90A, Na<sub>2</sub>O<sub>2</sub> Fusion, combined ICP-AES and ICP-MS finish
6. Intertek Genalysis, Perth, Australia
  - a. FB1/XRF, Fused Disk preparation for XRF, Analysed by XRF Spectrometry
  - b. **FP1/MS**, Sodium peroxide fusion (Zirconia crucibles) and Hydrochloric acid, ICP-MS finish

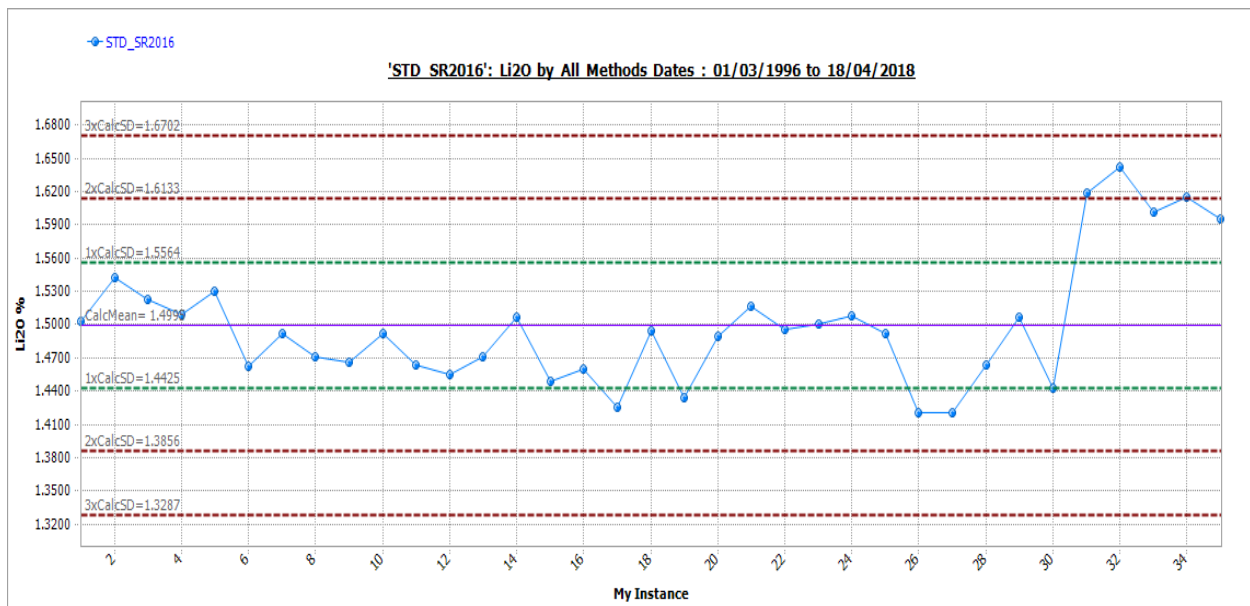
Previously certified Avalon rock standards, which have significant lithium values (developed for the East Kemptville Tin-Indium Project) were included with the subsamples of the proposed standard. However, these are rather low in lithium, of the order of 500 ppm, to be a future suitable standard for Separation Rapids Lithium Project analyses. However, these standards served as an additional quality control check on the Round Robin analysis results.

The Round Robin yields the following results for the new Separation Rapids lithium rock analysis standard, using all laboratory assay values:

|                                |            |
|--------------------------------|------------|
| Standard:                      | STD_SR2016 |
| Calculated mean:               | 1.4995     |
| Calculated standard deviation: | 0.057      |
| Lower limit:                   | 1.3856     |
| Upper limit:                   | 1.6133     |

Figure 12.5 shows the results of the 2016 Round Robin test.

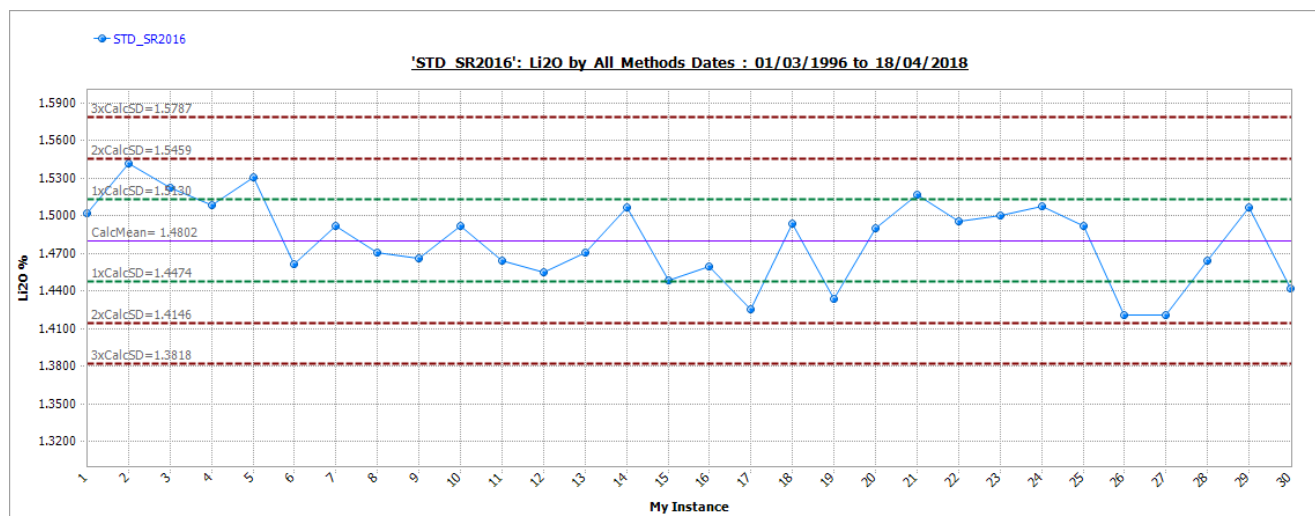
**Figure 12.5**  
**Run Chart for Lithium for Standard in Round Robin Test – All Results, 2016**



As can be seen in Figure 12.5, all the assay values, with the exception of instances 31-35, are within a narrow band of 1.421% Li<sub>2</sub>O to 1.542% Li<sub>2</sub>O, which is itself well within 2 standard deviations as calculated using all 35 data points. Instances 31-35 were provided by one laboratory (referred to here as Lab E) which exceeded 2 standard deviations from the statistics for all six laboratories.

The analysis was rerun, removing instances 31-35 from Lab E, and the run chart provided as Figure 12.6.

**Figure 12.6**  
**Run Chart of Lithium for Standard with One Laboratory Removed (2016)**



This yielded the following aggregate statistics:

|                                |            |
|--------------------------------|------------|
| Standard:                      | STD_SR2016 |
| Calculated mean:               | 1.4802     |
| Calculated standard deviation: | 0.033      |
| Lower limit:                   | 1.3818     |
| Upper limit:                   | 1.5787     |

In the case with Lab E removed, the difference in the means of each remaining laboratory is small, a 1.29% decrease with removal of Lab E from the data set of all laboratories. The standard deviation also decreases by 42%, a significant change. All remaining laboratories' assay values used in Figure 12.6 are within two standard deviations of the mean of all data.

The decision was made to accept the recalculated statistics for the values shown in Figure 12.6 as the certified values for standard STD\_SR2016. These certified values are reported in the table above as accepted mean 1.48% Li<sub>2</sub>O and a standard deviation of 0.03% Li<sub>2</sub>O, a relative standard deviation of 2% compared to 4% with all six laboratories (including Lab E).

It was then concluded that the lithium standard was a suitable standard for QA/QC of Separation Rapids drill core samples. The certified value for the standard SR2016 is 1.48% Li<sub>2</sub>O with a standard deviation of 0.03% Li<sub>2</sub>O for future analyses of Separation Rapids samples.

#### 12.4.3.2 Core Re-analysis Using Certified Standard (2016)

As the original assay procedure did not include the insertion of certified assay standards for lithium, Avalon completed a program of re-assaying a limited amount of drill core with the



insertion of the certified lithium standard prepared as described above. The key points of this re-analysis involved:

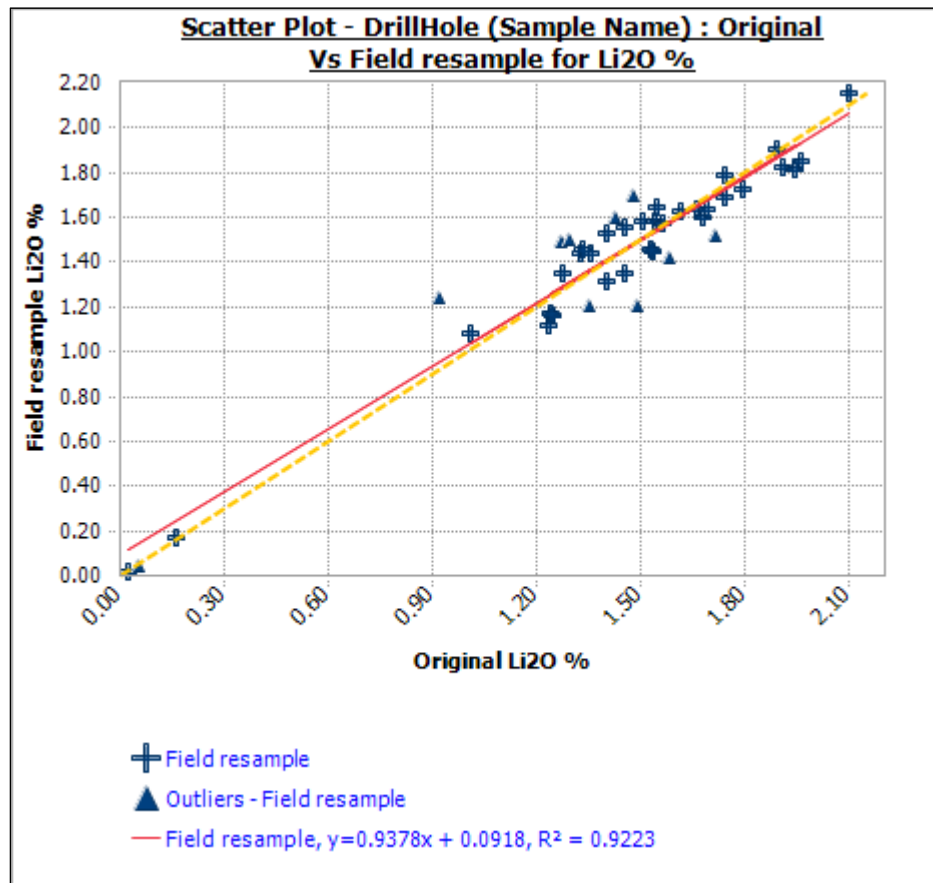
- At least 30 drill core samples
- Cover all subunits of the pegmatite lithology
- Samples would correspond to the sample intervals originally sampled

As long as these points were adhered to, it was considered that the results would be valid for comparing original assays with the 2016 assays.

The procedure is described in Section 11.2 above and resulted in 42 quarter core samples which were submitted to ALS for analysis, and can be compared to the assays from the 1990s.

The comparison is shown in Figure 12.7 with the statistics given in Table 12.5.

**Figure 12.7**  
**Comparison of Original Lithium Analyses (Pedersen 1998) with Core Duplicates (“Field Resample”) Reanalysis (2016)**



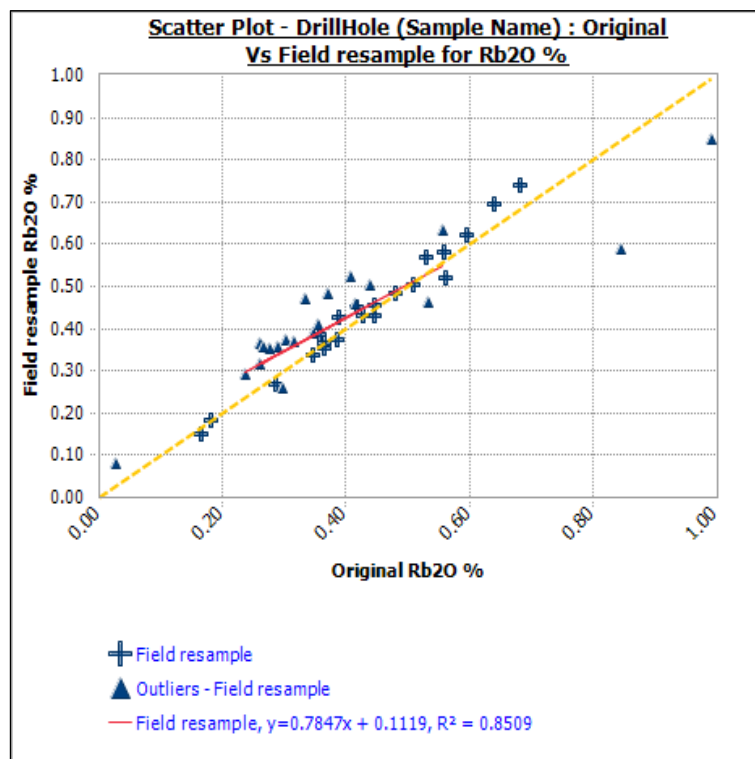
**Table 12.5**  
**Statistics Relevant to Figure 12.7**

| Number of Samples | Mean Li <sub>2</sub> O XRAL | Mean Li <sub>2</sub> O Chemex | Standard Deviation Li <sub>2</sub> O XRAL | Standard Deviation Li <sub>2</sub> O Chemex | CoV Li <sub>2</sub> O XRAL | CoV Li <sub>2</sub> O XRAL | sRPHD <sup>1</sup> (mean) |
|-------------------|-----------------------------|-------------------------------|---|---|----------------------------|----------------------------|---------------------------|
| 42                | 1.42                        | 1.42                          | 0.44                                      | 0.43  | 0.31                       | 0.31                       | -0.08                     |

The comparison of the original XRAL assay values reported by Pedersen (1998a) to the 2016 core duplicates (“field resample”) shows a small positive bias for the 2016 samples at smaller Li<sub>2</sub>O concentrations, crossing to an even smaller negative bias at higher Li<sub>2</sub>O concentrations. The regression line is virtually identical to the 45° line between 1.2% and 2% Li<sub>2</sub>O, which is where the majority of the mineralized samples lie. The mean values for each laboratory are identical at 1.42% Li<sub>2</sub>O, with a high R<sup>2</sup> of 92.23%. Further, the sRPHD, at 0.08, is an extremely low number compared to the mean values. This results in confirmation of the historic data by the subsequent re-analysis with inserted certified standards.

Figure 12.8 and Table 12.6 provide the comparison for rubidium analyses.

**Figure 12.8**  
**Comparison of Original Rubidium Analyses (Pedersen 1998a) with Core Duplicates (“Field Resample”) (2016)**



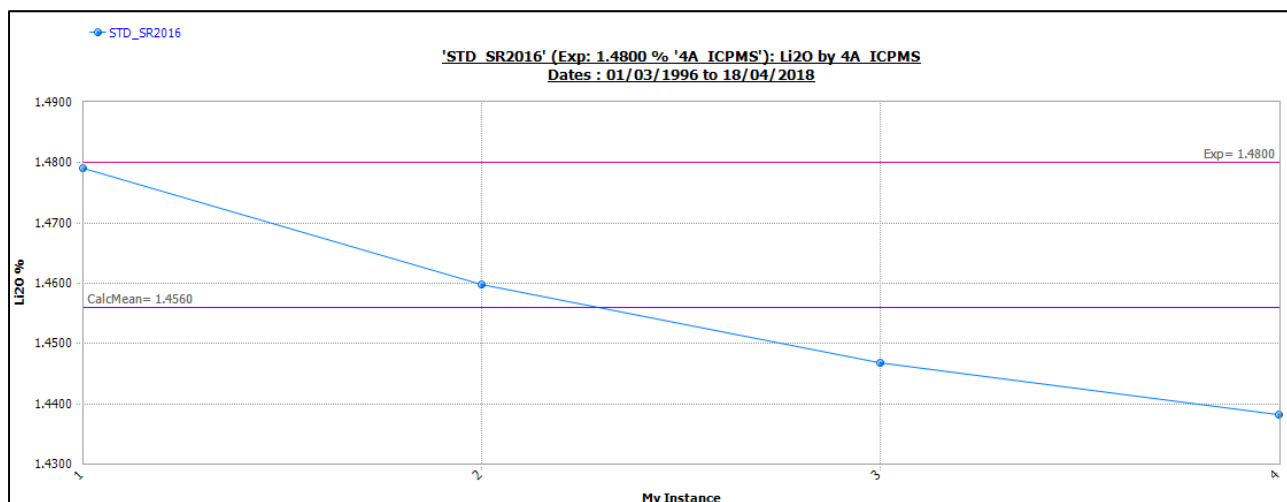
**Table 12.6**  
**Statistics Relevant to Figure 12.8**

| Number of Samples | Mean Rb <sub>2</sub> O XRAL | Mean Rb <sub>2</sub> O Chemex | Standard Deviation Rb <sub>2</sub> O XRAL | Standard Deviation Rb <sub>2</sub> O Chemex | CoV Rb <sub>2</sub> O XRAL | CoV Rb <sub>2</sub> O XRAL | sRPHD <sup>1</sup> (mean) |
|-------------------|-----------------------------|-------------------------------|---|---|----------------------------|----------------------------|---------------------------|
| 42                | 0.41                        | 0.43                          | 0.17                                      | 0.15  | 0.42                       | 0.34                       | -4.66                     |

Comparison of the original XRAL assays with 2016 core duplicates for Rb<sub>2</sub>O shows the same bias trend as Li<sub>2</sub>O, positive at low Rb<sub>2</sub>O concentrations, turning negative at high concentrations. The mean of the two laboratories' data shows a small 5% difference (Table 12.6), with an acceptable R<sup>2</sup> of 85.09%. This is a higher difference than for lithium but is still very low and within acceptable range for core duplicates assayed at different laboratories with different methods.

Along with the resampled drill core, four samples of the SR2016 internal certified standard were included with the 42 samples as part of the QA/QC process. The analyses are plotted in Figure 12.9. Note that the certified, acceptable results for the standard, as noted above, should lie within 1.48% Li<sub>2</sub>O with a standard deviation of 0.33, thus between 1.447% Li<sub>2</sub>O and 1.513% Li<sub>2</sub>O to be within one standard deviation. All of these values comply with this criterion.

**Figure 12.9**  
**Lithium Analyses for Lithium Standard SR2016**



## 12.5 DRILL COLLARS AND SURVEY DATA

As noted in Section 10.0, all drilling was undertaken in the period 1997 to 2001. Between the 1997, 1998 and 2001 drill campaigns, 69 holes were drilled and sampled on the Separation Rapids property, as well as samples taken from five trenches. The drill hole data (hole number, depth, UTM location, azimuth, dip) in the DataShed database were compared to the

data originally published in the 1998 Assessment Report (Pedersen, 1998a). The majority of the data were found to be identical and complete, however there were some differences between the two data sources, which are discussed below.

Holes were drilled using NQ-wireline (47.6 mm core). The holes, spaced 50 m apart, were drilled in the central and widest part of the Separation Rapids Pegmatite between sections 240W and 460W. All drill holes were inclined at either 45° or 60°.

Downhole surveys, using a Tropari instrument, were carried out by Avalon, with measurements being taken at two or more regular down-hole intervals, with one of the measurements at the end of each hole. Infrequent acid tests were also completed.

In the review of the Avalon database, drill hole angle and the maximum hole depth were both verified as being the same in the original report of Pedersen in 1998 and in the DataShed database. Elevation readings in metres in the database and drill logs are identical, with the exception of the third decimal place, which is not considered material.

The comparison is summarized in Table 12.7.

**Table 12.7**  
**Difference in Database Coordinates and Survey Coordinates**  
**(Difference = Original Survey - Database)**

|                       | <b>Easting<br/>(Difference)</b> | <b>Northing<br/>(Difference)</b> |
|-----------------------|---------------------------------|----------------------------------|
| Mean                  | 40.94                           | -6.34                            |
| Standard deviation    | 1.17                            | 7.69                             |
| Standard deviation, % | 3                               | -121                             |

None of the data sources state whether the UTM coordinates are in NAD83 or another standard. The differences do not correspond to the difference between NAD27 and NAD83.

The location of the drill hole collars is noted in a number of available data sets. First, the original typed drill logs for the holes from 1997 to 1999 give the collar location both in the project grid and UTM coordinates. Second, data comprising project grid locations produced by a surveyor at the time is available from the data supplied by Micon from the original project digital drill database. Copies of hand written surveyor's notations of UTM locations are available that appear to be surveyed UTM locations. Easting and northing coordinates were reported on original drill logs based on the local project grid ("mine grid") referred to as "AVL97", while the 2001 drill holes were reported both in AVL97 and UTM coordinates. In the database, all northings and eastings are tabulated in UTM coordinates.

The latter records, representing 30 of the drill holes, when compared to the coordinates within the database, indicate some consistent differences that average 40.9 m in the easting and 3 m in the northing. The northing differences, at 3 m, are considered not to be material, but the easting difference is material. However, records indicate that this table of UTM

locations was, in fact, derived by manually plotting the drill holes on a government topographic map and scaling off the UTM coordinates. This method is not considered accurate or precise and, thus, it is the likely explanation of the UTM discrepancy.

In 2016, Avalon identified four drill holes in the field by locating the drill collar casing protruding from the ground. Utilizing a hand held GPS, the UTM location of each drill hole was measured. These locations are compared with the surveyed coordinates in the DataShed database as per Table 12.8.

**Table 12.8**  
**Survey Coordinates for Handheld GPS Unit (2016) Compared to Database UTM Coordinates**

| Hole Number     | Measured in Field, July, 2016 (NAD83) |           | DataShed Database |           | UTM Difference |           |
|-----------------|---------------------------------------|-----------|-------------------|-----------|----------------|-----------|
|                 | UTM East                              | UTM North | UTM East          | UTM North | UTM East       | UTM North |
| 97-26           | 388520                                | 5569065   | 388523.3          | 5569062.1 | -3.3           | 2.9       |
| 98-53           | 388519                                | 5569048   | 388524.1          | 5569044.5 | -5.1           | 3.5       |
| 98-38           | 388497                                | 5568990   | 388500.2          | 5568987.9 | -3.2           | 2.1       |
| 98-43           | 388393                                | 5569045   | 388395.7          | 5569043.4 | -2.7           | 1.6       |
| Mean difference |                                       |           |                   |           | -3.6           | 2.5       |

As can be seen, the difference between the database coordinates and handheld GPS are minor, being in the range of 1.6 m to 5.1 m, which considering the inherent inaccuracies of a handheld GPS are acceptable. According to the USGS ([www2.water.usgs.gov/osw/gps/](http://www2.water.usgs.gov/osw/gps/)), the accuracy of a handheld GPS is within 3 m to 10 m depending on the model. In addition, the differences given here are systematic with a slight negative for the easting and positive for northing. It is important to note that the handheld GPS was set to give UTM readings in NAD83. As a result, it was verified that the readings in the database are NAD83 readings, which was the system current at the time of its creation.

This concordance between the database UTM location and the check readings in 2016 results in the conclusion that the drill hole locations in the digital database are correct and reliable. It also demonstrates that the UTM coordinates on the hand-written surveyor sheets that have the 40 m consistent difference are in error due to the manual scaling methodology utilized. However, it is recommended that further effort be made to check these survey locations.

## **12.6 DRILL HOLE AZIMUTHS**

Azimuths in the DataShed database were found to be consistently 1.8794° higher than the readings as reported in Pedersen 1998a. On examining the data from the original 2002 database, it was clear that the azimuths were referred to as “corrected” and 1.8794° were added to all originally recorded azimuths. This is very close to the correction for magnetic north in December, 1999 in the Separation Rapids area. However, it is not clear that the correction should have been applied as the azimuths in the original drill logs are reportedly

true azimuths relative to true north (Pedersen, 2016b). At present this is not considered a material issue as a difference of two degrees in azimuth is not material to resource estimation and, also, the difference is consistent for all drill holes.

In 2016, for the same four drill holes as discussed above (Table 12.8) with regards to survey locations, and using the casing still present, the azimuths were measured using a clinometer-equipped Suunto compass (Pedersen, 2016b), and the results are compared in Table 12.9 with the azimuths in the drill logs and those in the database information provided by Micon. The Suunto compass had been adjusted by the appropriate magnetic declination.

**Table 12.9**  
**Drill Hole Azimuths**

| Hole Number | 1<br>Field, Suunto,<br>2016<br>(°) | 2<br>Original Drill<br>Log<br>(°) | 3<br>DataShed<br>Database<br>(°) | Difference<br>(column 2-1)<br>(°) | Difference<br>(column 3-1)<br>(°) |
|-------------|------------------------------------|-----------------------------------|----------------------------------|-----------------------------------|-----------------------------------|
| 97-26       | 180                                | 180                               | 181.88                           | 0                                 | 1.88                              |
| 98-38       | 178                                | 180                               | 181.88                           | 2                                 | 3.88                              |
| 98-43       | 176                                | 180                               | 181.88                           | 4                                 | 5.88                              |
| 98-53       | 174                                | 180                               | 181.88                           | 6                                 | 7.88                              |

The accuracy and precision of the Suunto compass is not sufficient to compare the azimuths quantitatively in detail. In addition, it is possible that the casings are not in their original orientations. However, it is worth noting that the orientations measured in 2016 are closer to those in the drill logs than the “corrected” database readings. Avalon believes that it was assumed that the azimuths on the original drill logs from the 1990s drilling were relative to magnetic north and that 1.8794° was the declination adjustment at the time. However, Avalon now considers this to be an error and that the drill holes were in fact intended to be oriented due south, not magnetic south. Notwithstanding, the potential error of around 2° is considered negligible.

## **13.0 MINERAL PROCESSING AND METALLURGICAL TESTING**

### **13.1 INTRODUCTION**

A number of phases of metallurgical testing since 1997 have been completed by Avalon using samples obtained from of the Separation Rapids deposit. The work prior to 2014 was mainly undertaken by SGS Mineral Services at Lakefield, Ontario (SGS-L). This work not only included the recovery of petalite, but also a number of other mineral products which also can be found in the lithium bearing pegmatite.

The work since 2014 has focussed on the recovery of a petalite flotation concentrate and the subsequent processing of this concentrate to produce a high quality lithium hydroxide product suitable for the lithium battery industry.

### **13.2 HISTORICAL METALLURGICAL INVESTIGATIONS (PRE-2014)**

#### **13.2.1 SGS-L (1997-1999)**

An initial metallurgical testwork program was undertaken at SGS-L between 1997 and 2009.

The initial phase of this work began in November, 1997, with the objective of producing a high grade petalite product. The following information was gleaned from this testwork program:

- Overgrinding the feed and producing large amounts of fines would be detrimental to flotation recoveries. Thus, comminution and classification are important unit operations of the flotation plant.
- Iron is an important impurity in the final product and use of steel grinding media may increase the amount iron in the circuit.
- Use of hydrofluoric acid (HF) as a collector for petalite during flotation was required although a sodium fluoride and hydrochloric acid mix was potentially a suitable replacement for HF.

The flowsheet developed recovered both a high and low grade petalite concentrate from the SRLD at 4.63% and 2.47% Li<sub>2</sub>O respectively, as well as a 5% Li<sub>2</sub>O spodumene concentrate.

#### **13.2.2 SGS-L (2009)**

Avalon successfully completed a metallurgical process research project in 2009 to develop a modified petalite process flowsheet, using sodium fluoride and hydrochloric acid as an alternative to hydrofluoric acid. This work was carried out at SGS-L using a 660 kg mineralized sample with an average grade of 1.52% Li<sub>2</sub>O. This program developed a

flotation process to recover separate concentrates of mica, petalite, sodium feldspar, potassium feldspar and spodumene from the Separation Rapids deposit.

### 13.3 RECENT METALLURGICAL TESTWORK

Following renewed interest in the Separation Rapids Lithium Project in 2013 and 2014, Avalon was requested by potential customers to provide fresh samples of petalite concentrate. However, attempts by SGS-L to reproduce the results from 2009 were unsuccessful.

Avalon approached Dorfner ANZAPLAN (ANZAPLAN), a German company that specializes in the processing of high purity industrial and strategic minerals, to develop a process for recovering the petalite and achieving target product grade of >4% LiO<sub>2</sub>. ANZAPLAN also investigated the recovery of a low impurity feldspar by-product and tested these products to determine their suitability in a number of industrial applications.

With the increasing demand for lithium chemicals to satisfy the growth in the battery and energy storage industries, Avalon investigated the potential to use petalite as a source of both lithium carbonate and hydroxide. Initial investigations for producing carbonate were completed by the Saskatchewan Research Council (SRC) and subsequently by Thibault and Associates Inc. (Thibault), which developed the process for producing lithium hydroxide.

#### 13.3.1 Mineral Processing

Table 13.1 lists all the flotation/concentrator testwork reports issued since the project was re-activated in 2014:

**Table 13.1**  
**List of Mineral Processing Testwork Reports**

| Date           | Author   | Title  | Remarks  |
|----------------|----------|--|--|
| June 2014      | ANZAPLAN | Processing of Petalite Ore from Separation Rapids                            | Petalite and feldspar flotation testwork on coarse grained mineralized material.                           |
| August 2014    | ANZAPLAN | Physical Processing of Fine Grained Ore from Separation Rapids               | As above but using fine grained mineralized material.  |
| September 2014 | ANZAPLAN | Processing of Petalite Ceramic Application Tests                             | Sample of petalite was tested to determine key physical/chemical characteristics for ceramic applications. |
| September 2014 | ANZAPLAN | Sample Production of Petalite and Feldspar Concentrate                       | 20 kg of both materials were produced for providing samples to potential clients.                          |
| November 2014  | ANZAPLAN | Flowsheet and Core Machinery   | Base flotation flowsheet and preliminary equipment recommendations.  |
| December 2014  | ANZAPLAN | Locked Cycle Petalite Flotation Tests on Fine Grained Ore (FGO)              | Bench scale determination of petalite flotation recovery with locked cycle tests.                          |
| June 2015      | ANZAPLAN | Pretests Pilot Scale Sample Production of Petalite and Feldspar Concentrates | To determine optimum conditions for magnetic separation and product filtration.                            |
| July 2015      | ANZAPLAN | Analysis of Nb/Ta in Magnetic Fraction of Separation Rapids Ore              | Determination of nature of Nb and Ta in magnetics discard stream.  |
| December 2015  | ANZAPLAN | Testing and characterization of a feldspar                                   | Sample of feldspar was tested to determine   |



| Date         | Author   | Title  | Remarks  |
|--------------|----------|--|--|
|              |          | filler   | key physical/chemical characteristics for filler applications.   |
| May 2016     | ANZAPLAN | Pilot Scale Sample Production of 1t Petalite Concentrate                         | Bulk sample processed to produce a 1 t sample of petalite.   |
| June 2016    | ANZAPLAN | Evaluation of HPQ Potential of Flotation Tailings from the Big Whopper Pegmatite | Testwork investigations to determine if tailings from pilot plant could be used to produce a high purity quartz product.   |
| May 2016     | Dorfner  | Testing of Feldspar sample as potential paint filler                             | Note from Dorfner confirming their tests indicating Avalon feldspar matches existing paint fillers.  |
| 2015/2016    | SRC      | Various flotation tests' analyses  | Excel spreadsheets with test results plus various small petalite sample production tests.  |
| October 2016 | ANZAPLAN | Sample Production – Feldspar Filler  | Feldspar concentrate with lower silica content produced by introducing a number of cleaner flotation stages. This was then milled to a d50 of 6 µm and determined to have a SWERF value of 0.6%. |

The results and conclusions generated by this work are summarized as follows:

### 13.3.2 Preliminary Physical Separation Testwork – ANZAPLAN

In late 2013, Avalon sent a small mineralized sample to ANZAPLAN to investigate producing a petalite concentrate containing >4.0% Li<sub>2</sub>O with a low iron content (<100ppm). An analysis of the sample is presented in Table 13.2.

**Table 13.2**  
**Analysis of the 2013 Metallurgical Test Sample to ANZAPLAN**

| Description          | Formula                        | Assay (%) |
|----------------------|--------------------------------|-----------|
| Lithium oxide        | Li <sub>2</sub> O              | 1.64      |
| Rubidium oxide       | Rb <sub>2</sub> O              | 0.34      |
| Silicon oxide        | SiO <sub>2</sub>               | 74.9      |
| Aluminum oxide       | Al <sub>2</sub> O <sub>3</sub> | 16.2      |
| Iron oxide           | Fe <sub>2</sub> O <sub>3</sub> | 0.25      |
| Titanium dioxide     | TiO <sub>2</sub>               | <0.01     |
| Potassium oxide      | K <sub>2</sub> O               | 2.29      |
| Sodium oxide         | Na <sub>2</sub> O              | 3.26      |
| Calcium oxide        | CaO                            | 0.10      |
| Magnesium oxide      | MgO                            | 0.04      |
| Manganese oxide      | MnO                            | 0.24      |
| Phosphorus pentoxide | P <sub>2</sub> O <sub>5</sub>  | 0.05      |
| LOI 1,000°C          |                                | 0.65      |

The sample was a mix of coarse and fine grained pegmatitic rock. Since the degree of mineral inter-growth for the coarse and fine grained texture differed, ANZAPLAN used

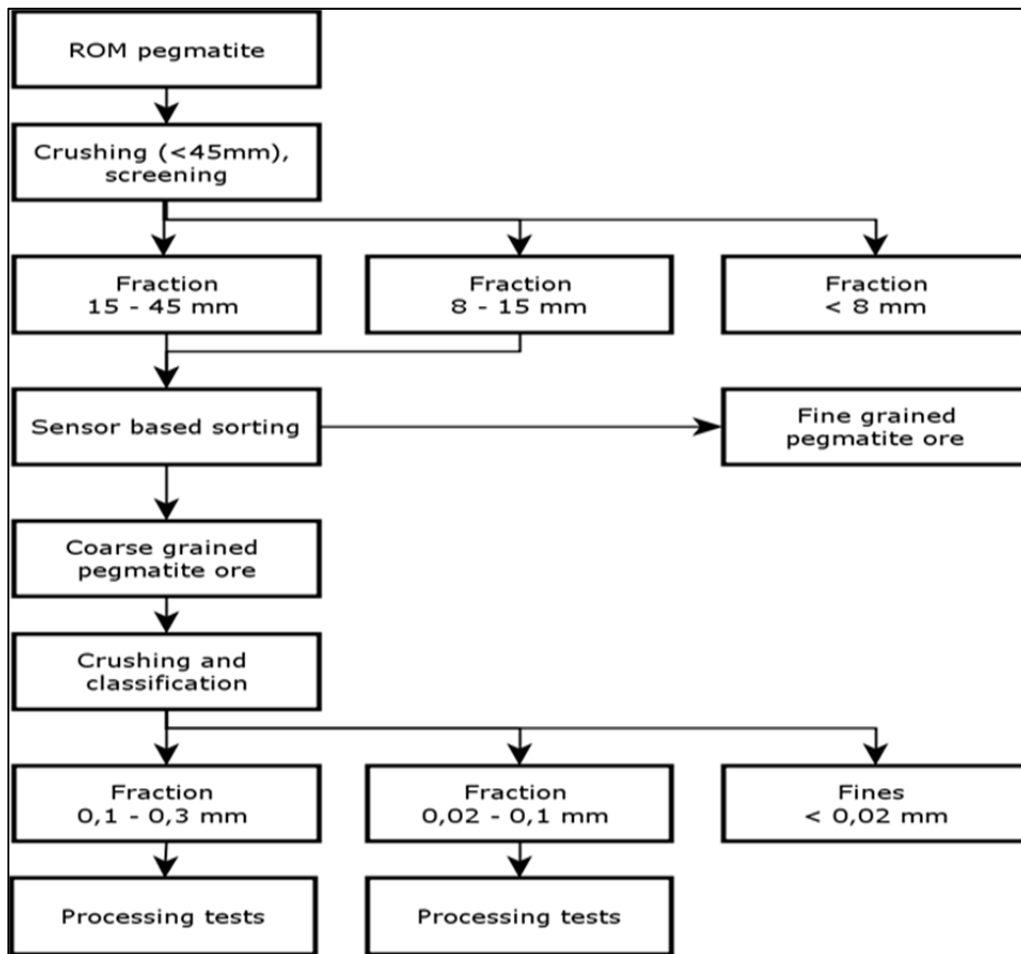
sensor based sorting in order to separate coarse grained material (CGO) from the fine grained material (FGO).

Figure 13.1 presents the procedure used by ANZAPLAN to separate the CGO and FGO.

**Table 13.3**  
**Sensor Based Sorting Product Analyses**

| Process                  | Mass Recovery (%) | Analyses (%)      |                                | Recovery (%)      |
|--------------------------|-------------------|-------------------|--------------------------------|-------------------|
|                          |                   | Li <sub>2</sub> O | Fe <sub>2</sub> O <sub>3</sub> | Li <sub>2</sub> O |
| FGO plus < 8 mm fraction | 57.3              | 1.27              | 0.32                           | 46.4              |
| Combined CGO fraction    | 46.4              | 1.95              | 0.20                           | 53.6              |
| Feed sample              | 100.0             | 1.58              | 0.27                           | 100.0             |

**Figure 13.1**  
**ANZAPLAN Sample Preparation and Separation Procedure**



A comparison of the FGO and CGO modal mineralogy for two size fractions is presented in Table 13.4. For both size fractions the modal analysis shows higher proportions of petalite

and K-feldspar and lower proportions of mica, quartz and Na-feldspar in the CGO compared to FGO.

**Table 13.4**  
**Comparison of FGP and CGO Modal Mineralogical Analyses**

| Mineral     | Size Fraction 0.02-0.1 mm |      | Size Fraction 0.1-0.3 mm |      |
|-------------|---------------------------|------|--------------------------|------|
|             | CGO                       | FGO  | CGO                      | FGO  |
| Petalite    | 37.8                      | 22.1 | 38.3                     | 23.0 |
| Spodumene   | 0.2                       | 0.1  | 0.1                      | 0.1  |
| Mica        | 6.8                       | 11.0 | 9.0                      | 11.5 |
| Quartz      | 18.8                      | 23.0 | 16.9                     | 20.3 |
| Na-feldspar | 24.3                      | 34.6 | 25.6                     | 37.0 |
| K-feldspar  | 11.6                      | 8.5  | 9.8                      | 7.5  |
| Other       | 0.5                       | 0.7  | 0.3                      | 0.6  |

A comparison of the liberation showed >90% liberation for all minerals for the fine size fraction and around 90% liberation of petalite and feldspar in the coarser fraction (0.1-0.3 mm) for both the FGO and CGO.

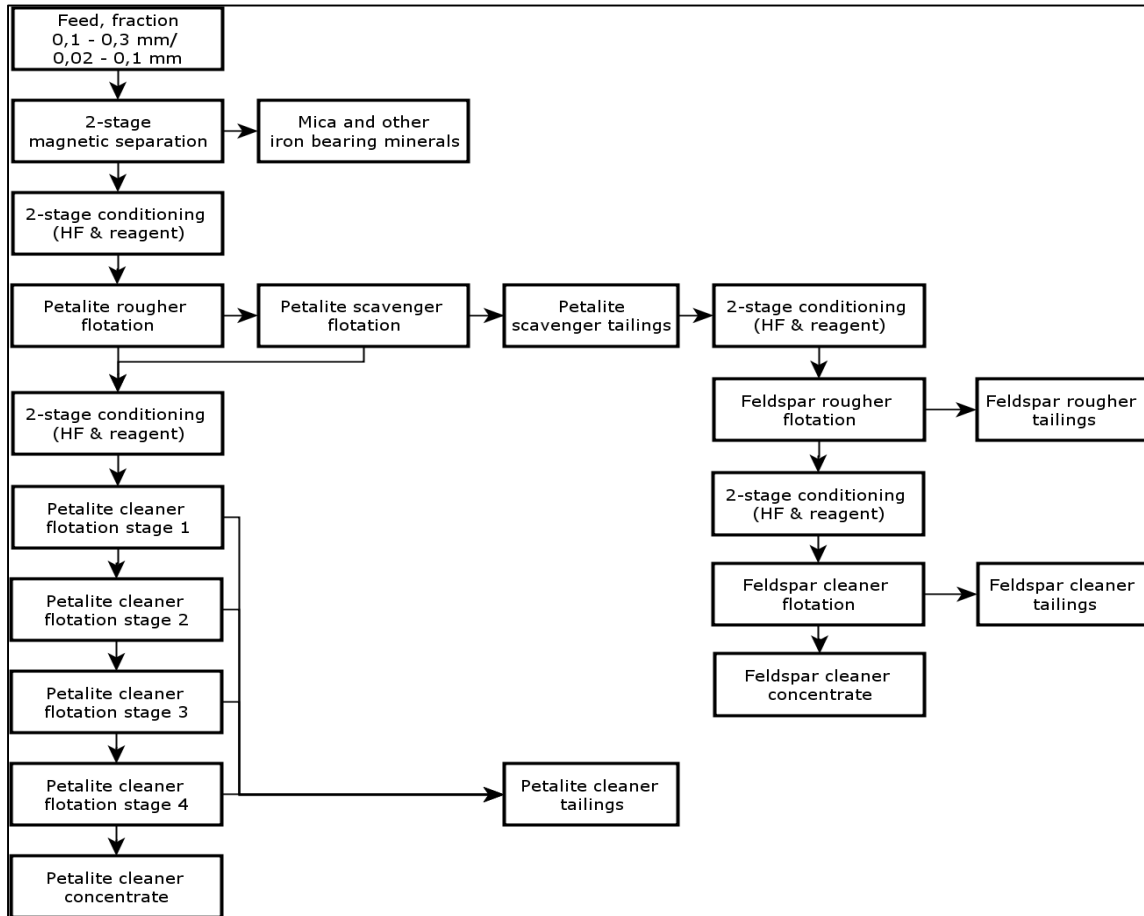
#### 13.3.2.1 Tests Using CGO

Following some scoping tests ANZAPLAN developed a magnetic separation plus flotation circuit which was able to produce a petalite concentrate grading 4.09% Li<sub>2</sub>O with iron content below 0.01% Fe<sub>2</sub>O<sub>3</sub>. The flotation recovery of petalite to this product for both the 0.1-0.3 mm fraction and the 0.02 to 0.1 mm fraction were approximately 74-75%, based on the flotation feed.

The recovery of feldspar from the petalite tailings was investigated using a specific reagent suite and approximately 84% and 72% of the feldspar feeding this circuit were recovered into a feldspar concentrate for the coarse fraction and fine fraction, respectively.

A copy of the flowsheet developed by ANZAPLAN to recover a petalite and a feldspar concentrate is presented in Figure 13.2.

**Figure 13.2**  
**Process Flowsheet to Recover both a Petalite and Feldspar Concentrate**



### 13.3.2.2 Tests Using FGO

Since the degree of intergrowth of iron bearing and valuable minerals is higher in the fine grained mineralization, a separate set of testwork was conducted by ANZAPLAN to process this material. A beneficiation process based on the CGO tests was used as the basis for the FGO test program. Using a similar flowsheet to the coarse grained mineralization, a petalite concentrate assaying 4.0% Li<sub>2</sub>O and <0.01% Fe<sub>2</sub>O<sub>3</sub> was achieved, albeit with relatively low flotation recoveries of around 20% and 41% for the 0.1-0.3 mm and 0.02-0.3 mm size fractions, respectively.

The feldspar flotation tests, using the CGO test procedure, were also completed using the FGO sample fraction. These results were similar to the CGO tests with high feldspar yields into a concentrate containing <0.01% Fe<sub>2</sub>O<sub>3</sub>.

It was concluded during this phase of the flowsheet development testwork that optical sorting will be required to remove the gangue mineral amphibolite ahead of the flotation process as this also reports to the petalite concentrate making target grade difficult to achieve.

### 13.3.2.3 FGO Locked Cycle Tests

The two size fractions (0.1-0.3 mm and 0.02-0.3 mm) were combined for the Locked Cycle Tests (LCT) using FGO material. The objective of the LCT was to try and improve the relatively low petalite recoveries achieved during the FGO flotation static tests.

Using a slightly modified flowsheet, the LCT did produce a 4.0% Li<sub>2</sub>O petalite concentrate with less than 0.01% Fe<sub>2</sub>O<sub>3</sub>. The flotation recovery was approximately 50%, which was an improvement.

### 13.3.3 Magnetic Separation Tests

In order to optimize the magnetic separation process, samples of Separation Rapids mineralization were sent to Metso in Sala, Sweden, for extensive testing to determine optimal magnetic separator machine settings and matrix selection. A total of 28 tests were carried out on 3 samples at different size fractions, at varying matrix loads and flushing rates. Table 13.5 compares the best Metso results with the results achieved by ANZAPLAN using similar material.

The test results suggest that combining the two size fractions for magnetic separation yields similar results to feeding each size fraction separately and that a setup based on Metso Test HGMS 24-1 using single stage unit with medium matrix will provide the best results.

**Table 13.5  
Magnetic Separation Test Results**

|                      | Li <sub>2</sub> O (%)                        | Fe <sub>2</sub> O <sub>3</sub> (%) | Mass (%) | Li <sub>2</sub> O Recovery (%) | Matrix Load (g/cm <sup>3</sup> ) |
|----------------------|--|------------------------------------|----------|--------------------------------|----------------------------------|
| Fraction 0.1-0.3 mm  |  |                                    |          |                                |                                  |
| Feed                 | 1.5  | 0.27                               | 100.0    | 100.0                          | -                                |
| Metso non-mag        | 1.5  | <0.01                              | 83.5     | 83.5                           | 1.6                              |
| ANZAPLAN             | 1.4  | <0.01                              | 68.7     | 67.6                           | -                                |
| Fraction 0.02-0.1 mm |  |                                    |          |                                |                                  |
| Feed                 | 1.4  | 0.37                               | 100.0    | 100.0                          | -                                |
| Metso non-mag        | 1.4  | <0.01                              | 85.6     | 85.6                           | 1.6                              |
| ANZAPLAN             | 1.5  | 0.01                               | 85.8     | 82.2                           |                                  |
| Fraction 0.02-0.3 mm |  |                                    |          |                                |                                  |
| Feed                 | 1.5  | 0.30                               | 100.0    | 100.0                          | -                                |
| Metso non-mag        | 1.4  | <0.01                              | 85.5     | 85.5                           | 0.8                              |
| ANZAPLAN             | Tests not done using combined size fractions |                                    |          |                                |                                  |

### 13.3.4 Filtration Tests

There are a number of key filtration stages in the flowsheet, including filtration for reagent recycle as well as dewatering of flotation feed, petalite rougher tails, petalite second cleaner concentrate and petalite fourth cleaner concentrate. Washing of the final concentrates during filtration was also deemed important to remove extra salt and reduce final fluorine levels.

Materials for testing were prepared by ANZAPLAN in Germany, and the tests were conducted at an equipment manufacturer in Germany.

The filtration testwork results are presented in Table 13.6.

**Table 13.6**  
**Filtration Test Results**

| Number | Description                                    | Particle Size (mm) | Washing                         | Moisture (%) |
|--------|--|--------------------|---------------------------------|--------------|
| 1      | Tailings petalite rougher-scavenger flotation  | 0.02-0.3           | Reduction of brine content      | 11.9-13.3    |
| 2      | Concentrate petalite cleaner flotation stage 2 | 0.02-0.3           | Reduction of brine content      | 10.5-13.5    |
| 3      | Petalite product                               | 0.02-0.3           | Reduction of acid and F Content | 8.0-9.1      |
| 4      | Feldspar product                               | 0.02-0.3           | Reduction of acid and F Content | 6.6-7.7      |
| 5      | Quartz (Tailings FS Flot.)                     | 0.02-0.1           | Reduction of acid and F Content | 9.6-10.5     |
| 6      | Feed magnetic separator                        | 0.02-0.1           | Not Required                    | 16.4-17.8    |
| 7      | Non-magnetic fraction                          | 0.02-0.1           | Not Required                    | 16.2-19.7    |

### 13.3.5 Ceramic Application Tests

To review the suitability of using Avalon's petalite and feldspar in the ceramic market, ANZAPLAN conducted the following ceramic application tests:

- Hot Stage Microscopy: to analyze melting behavior of the material.
- Dilatometry: to measure volume changes in the material as it melts at high temperatures.
- Firing colour: to determine firing colour of the material as it melts.

Based on the results of these tests on the petalite and feldspar concentrates, the samples were deemed suitable for the following possible applications in ceramics:

- Glazes and frits within the respective range of firing temperature between 1,150°C and 1,300°C.
- A source of lithium for heat-resistant glass and cookware.
- Sintering agent in ceramic body material for the production of stoneware and porcelain.
- A non-plastic material or as alternative/replacement of chamotte in ceramic bodies for earthenware or other low-fired ceramic materials.

A potential additional application for petalite is to reduce the coefficient of thermal expansion in ceramic bodies and glazes.

### 13.3.6 One Tonne Petalite Concentrate Production Test

In August, 2015, Avalon engaged ANZAPLAN to produce one tonne of petalite concentrate, using the flowsheet and conditions developed from previous tests. For this test program, the coarse and fine grained mineralized samples were combined.

Approximately 30 t of crushed mineralized sample, sized 8-25 mm, was delivered to Germany for processing in a pilot plant facility. The sample was first wet screened to remove any -6 mm material, optically sorted to remove dark coloured gangue minerals then crushed to -0.3 mm and classified to remove -0.1 mm fines before undergoing magnetic separation to remove iron minerals using a Metso unit. Non-magnetic material was then forwarded to petalite flotation with the objective to produce a >4.0% Li<sub>2</sub>O low iron petalite product.

The flotation pilot plant was initially set-up to recycle the brine streams to minimize flotation reagent consumptions. However, selectivity issues in the rougher flotation stages prevented the production of a suitable petalite product at reasonable recoveries. Following some additional bench scale testing the pilot test continued with reduced collector dosages and open circuit production without brine recirculation and the 1 tonne sample of petalite concentrate was successfully produced. The analysis of the petalite concentrate is presented in Table 13.7.

**Table 13.7**  
**Chemical Analysis of the Pilot Plant One Tonne Petalite Concentrate Product**

| Description          | Formula                        | Assay (%) | Trace elements |      |
|----------------------|--------------------------------|-----------|----------------|------|
|                      |                                |           | Element        | ppm  |
| Lithium oxide        | Li <sub>2</sub> O              | 4.0       | Fe             | 44   |
| Rubidium oxide       | Rb <sub>2</sub> O              | 0.06      | Cr             | 0.6  |
| Silicon oxide        | SiO <sub>2</sub>               | 77.8      | Mn             | 22   |
| Aluminum oxide       | Al <sub>2</sub> O <sub>3</sub> | 16.6      | Ti             | 2.5  |
| Iron oxide           | Fe <sub>2</sub> O <sub>3</sub> | <0.01     | Co             | <0.5 |
| Titanium dioxide     | TiO <sub>2</sub>               | <0.01     | Ni             | <0.5 |
| Potassium oxide      | K <sub>2</sub> O               | 0.6       | Cu             | 1.0  |
| Sodium oxide         | Na <sub>2</sub> O              | 0.4       | V              | <0.5 |
| Calcium oxide        | CaO                            | <0.01     | F              | 500  |
| Magnesium oxide      | MgO                            | <0.01     |                |      |
| Manganese oxide      | MnO                            | <0.01     |                |      |
| Phosphorus pentoxide | P <sub>2</sub> O <sub>5</sub>  | <0.01     |                |      |
| LOI 1,000°C          |                                | 0.5       |                |      |

Subsequent investigations identified a number of key recommendations which need to be incorporated into the flotation circuit. These include the following:

- Grind top size should be reduced from 0.3 mm to around 0.25 mm.

- HF dosage to be controlled by flotation feed tonnage and not simply by slurry pH.
- Some of the recycled water will need to be neutralized before recycling in order to control pH.
- It will be necessary to partially remove dissolved ions (especially Al, S, Mg, Ca) in the recycle water as these tend to interfere with the flotation chemistry as their concentration increases.
- Collector dosage needs to be reduced.

Confirmation of the effectiveness of these changes will be determined during the next program of flotation testing.

### **13.3.7 Feldspar Filler Tests**

The potential to use the feldspar concentrate filler for the paint and other industries was investigated by ANZAPLAN. The material was milled to three different product sizes (50% passing size (d50) of 2.5, 6.3 and 23  $\mu\text{m}$ ) and analyzed for a number of physical characteristics.

The results from these tests were considered promising although the two finer products contained slightly elevated amounts (1.3% and above) of size-weighted respirable crystalline silica (SWERFcs) which could possibly be reduced during flotation by introducing additional cleaner stages. A SWERFcs value greater than 1% means that the material is classified as hazardous.

A sample of the d50 6.3  $\mu\text{m}$  material was also tested as filler in a number of actual commercial indoor paint recipes (2 German and 1 US) and compared to a commercially available material currently being used as paint filler. Avalon's material compared favourably showing almost the same results with regards rheology, density, brightness, colour, scrub resistance and gloss.

The feldspar used to produce the above filler products was recovered from a simple rougher-only flotation circuit so ANZAPLAN then produced a feldspar concentrate through a process involving cleaner stages. The impact of this was a reduction in silica content of the concentrate from 2% to 1.5%, plus a final SWERFcs value of 0.6% after grinding to a d50 of 6 $\mu\text{m}$ .

### **13.3.8 Hydrometallurgical Testwork**

Table 13.8 lists the hydrometallurgical testwork reports issued since the project was re-activated in 2014.



**Table 13.8**  
**List of Recent Hydrometallurgical Testwork Reports**

| Date          | Author                | Title  | Remarks   |
|---------------|-----------------------|--|---|
| May 2015      | SRC                   | Preliminary Li leaching, purification and Li carbonate and hydroxide preparation from petalite concentrate | Testwork to determine if battery specification carbonate and hydroxide can be produced from petalite.   |
| December 2015 | SRC                   | Li Carbonate Production from Petalite Concentrate  | Bench optimization of process to produce battery specification lithium carbonate.   |
| December 2015 | Thibault & Associates | Process Alternatives- High Level Operating Cost Assessment   | Thibault compare various lithium hydroxide production processes to identify most cost efficient.  |
| October 2016  | Thibault & Associates | Hydrometallurgical Bench Scale Test Program/Process Simulation and Economic Model                          | Bench scale assessment of most favourable conditions for main stream unit operations including electrodialysis and development of process design criteria . |

### 13.3.9 Saskatchewan Research Council Testwork

#### 13.3.9.1 Preliminary Petalite Leaching Test

Saskatchewan Research Council (SRC) completed four preliminary bench scale tests for Avalon in 2014 to investigate effective methods for the leaching of petalite to recover lithium. Each of the four tests included calcination, roasting and water leaching. The best test result was from Test 4 where the petalite was calcined for two hours at 1,100°C before roasting at 300°C for 1 hour and leached with water. The results from Test 4 are summarized in Table 13.9. The lithium extraction achieved was 96.6%.

**Table 13.9**  
**Summary of SRC Preliminary Petalite Leaching Test 4 Results**

| Component                      | Feed Analysis (%) | Extraction (%) |
|--------------------------------|-------------------|----------------|
| Solids mass                    | 100.0             | 0.32           |
| Li <sub>2</sub> O              | 4.0               | 96.6           |
| Rb <sub>2</sub> O              | 0.06              | 5.8            |
| SiO <sub>2</sub>               | 77.8              | 1.5            |
| Al <sub>2</sub> O <sub>3</sub> | 16.6              | 5.0            |
| Fe <sub>2</sub> O <sub>3</sub> | <0.01             | 0.3            |
| TiO <sub>2</sub>               | <0.01             | 0              |
| K <sub>2</sub> O               | 0.6               | 0              |
| Na <sub>2</sub> O              | 0.4               | 34.5           |
| CaO                            | <0.01             | 0              |
| MgO                            | <0.01             | 0              |
| MnO                            | <0.01             | 0.06           |
| P <sub>2</sub> O <sub>5</sub>  | <0.01             | -              |
| LOI                            | 0.5               | -              |

### 13.3.9.2 Preliminary Leaching, Purification and Lithium Carbonate and Hydroxide Preparation

SRC conducted further leaching testing using samples of petalite concentrate and investigated the preparation of lithium carbonate and hydroxide from lithium sulphate solutions.

These tests concluded that 180 kg/t of concentrate of sulphuric acid is required to achieve 96% lithium extraction during roasting. To remove impurities such as iron and aluminum, a two-step impurity removal circuit using calcium hydroxide followed by sodium carbonate was required. To further purify the lithium sulphate solution, ion exchange treatment was required in order to meet the lithium carbonate minimum purity target of 99.5%.

### 13.3.10 Thibault Process Proof of Concept Study

In November, 2015, Thibault issued a proof of concept hydrometallurgical study that reviewed four different alternative methods to produce lithium hydroxide from petalite concentrate. The objective of the study was to review process alternatives and compare preliminary costs for production to provide an outline for future testwork direction. The four alternatives considered were:

1. Flowsheet 1 - Decrepitation and roasting using sodium hydroxide for hydroxide ion source.
2. Flowsheet 2A - Decrepitation and roasting using electro dialysis for hydroxide ion source.
3. Flowsheet 2B - Decrepitation and roasting using electro dialysis for hydroxide ion source but recycling the sulphuric acid regenerated from electro dialysis.
4. Flowsheet 3 - Decrepitation and roasting using calcium oxide as hydroxide ion source.

Table 13.10 provides a high level summary of the comparative assessment results.

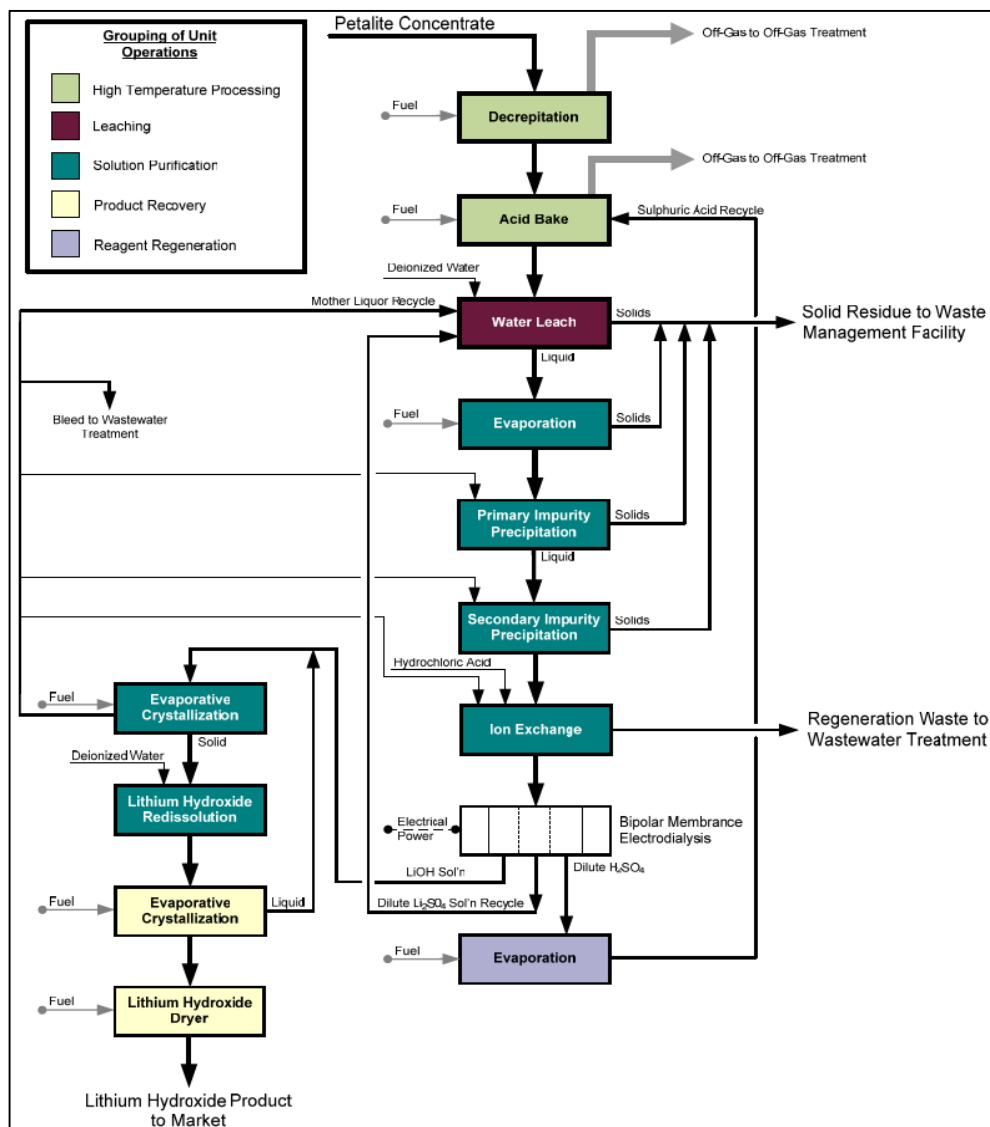
**Table 13.10**  
**High Level Comparison of Hydrometallurgical Process Options to Produce Lithium Hydroxide**

| Description/Parameter    | Units | Flowsheet 1                   | Flowsheet 2A                   | Flowsheet 2B                   | Flowsheet 3                             |
|--------------------------|-------|-------------------------------|--------------------------------|--------------------------------|---|
| Thermal Process          | -     | Decrepitation/<br>Roasting    | Decrepitation/<br>Roasting     | Decrepitation/<br>Roasting     | Decrepitation/<br>Limestone<br>Roasting |
| Source of Hydroxide Ions | -     | NaOH                          | Electro dialysis               | Electro dialysis               | CaO                                     |
| Sulphuric Acid Recycle   | -     | Not Applicable                | No                             | Yes                            | Not Applicable                          |
| Solid Waste By-product   | -     | Sodium<br>Sulphate<br>6.2 t/h | Calcium<br>Sulphate<br>3.5 t/h | Calcium<br>Sulphate<br>0.3 t/h | Sodium<br>Chloride<br>6.2 t/h           |

| Description/Parameter | Units                      | Flowsheet 1 | Flowsheet 2A | Flowsheet 2B | Flowsheet 3 |
|-----------------------|----------------------------|-------------|--------------|--------------|-------------|
| Reagent Costs         | \$/t LiOH.H <sub>2</sub> O | 1,659       | 714          | 26           | 2,934       |
| Electricity Costs     | \$/t LiOH.H <sub>2</sub> O | 9           | 329          | 329          | 0           |
| Natural Gas Costs     | \$/t LiOH.H <sub>2</sub> O | 639         | 666          | 781          | 1,733       |
| Contingency (5%)      | \$/t LiOH.H <sub>2</sub> O | 115         | 85           | 57           | 233         |
| Total Costs           | \$/t LiOH.H <sub>2</sub> O | 2,423       | 1,795        | 1,193        | 4,890       |

Of the four different alternatives investigated, option 2B was considered the most economic. Figure 13.3 shows the flowsheet suggested by Thibault for the preferred hydrometallurgical process option.

**Figure 13.3**  
**Preliminary Flowsheet of the Preferred Lithium Hydroxide Production Process**

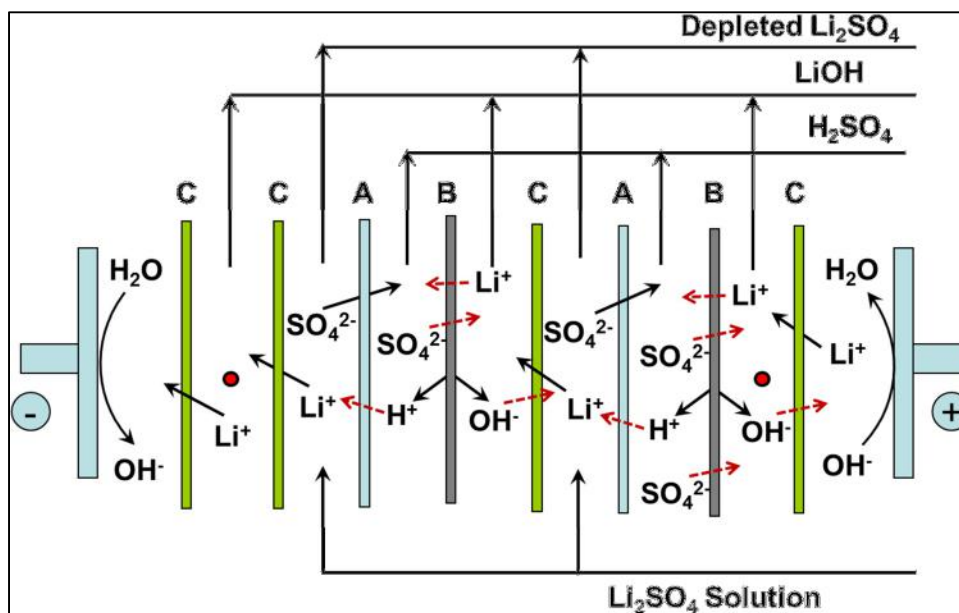


Thibault, 2016.

### 13.3.10.1 Evaluation of Lithium Sulphate Bipolar Membrane Electrodialysis for Production of Lithium Hydroxide

In order to validate the flowsheet recommended by Thibault, the bipolar membrane electrodialysis process was tested on a bench scale. The objective of this testwork was to evaluate the effectiveness of the process as well as review possibilities of scaling up. Thibault provided lithium sulphate solution generated from Avalon's petalite concentrate to Electrosynthesis in Buffalo for the tests. Testing was done in five batches and the concentration of sulphuric acid and lithium hydroxide solution were evaluated to determine the overall efficiency of the process. Figure 13.4 shows a schematic of the cells.

**Figure 13.4**  
**Electrodialysis Cell Schematic**



Test results showed that process efficiency was influenced by anion membrane efficiency. Dilute lithium hydroxide and sulphuric acid solution were generated from this testwork which will need to be concentrated and crystallized before solid lithium hydroxide crystals are produced. The report recommended further testing with alternative anion membranes to improve efficiency and also suggested that a batch process rather than continuous would work better for Avalon's application.

### 13.3.11 Thibault Hydrometallurgical Bench Scale Test Program

Approximately 35 kg of petalite concentrate was received by Thibault, 4.5 kg from SRC (referred to as PCS1) and another 30 kg from ANZAPLAN (referred to as PCS2). The samples were used in a series of bench scale tests to review conditions for decrepitation, acid bake, water leach, impurity removal, ion exchange and electrodialysis as suggested in the proof of concept study by Thibault.

The average head grade analyses for PCS1 and PCS2 are presented in Table 13.11.

**Table 13.11**  
**Petalite Flotation Concentrate Sample Head Sample Analyses**

| Element | PCS1 Average (mg/kg) | PCS2 Average (mg/kg) |
|---------|----------------------|----------------------|
| Ag      | <0.5                 | <0.5                 |
| Al      | 83,646               | 85,314               |
| As      | <50                  | <25                  |
| Ba      | 4.6                  | 16.1                 |
| Be      | 61.9                 | 30.5                 |
| Bi      | <50                  | <25                  |
| Ca      | 124.8                | 278.1                |
| Cd      | <5                   | <2                   |
| Ce      | <5                   | <2                   |
| Co      | <5                   | <2                   |
| Cr      | 2.8                  | 2.0                  |
| Cu      | 1.5                  | 1.0                  |
| Fe      | 75.8                 | 57.0                 |
| Ga      | 17.1                 | 16.1                 |
| Ge      | <50                  | <50                  |
| In      | <100                 | <100                 |
| K       | 3,402                | 5,547                |
| La      | <2                   | <2                   |
| Li      | 20,674               | 19,152               |
| Mg      | 56.7                 | 283.3                |
| Mo      | <5                   | <5                   |
| Mn      | 39.5                 | 29.0                 |
| Na      | 4,136                | 2,914                |
| Nb      | <10                  | <10                  |
| Ni      | <10                  | <5                   |
| P       | <100                 | <100                 |
| Pb      | <10                  | <10                  |
| S       | <100                 | <100                 |
| Sb      | <50                  | <25                  |
| Se      | <50                  | <50                  |
| Si      | 314,022              | 381,000              |
| Sn      | <100                 | <100                 |
| Sr      | 5.8                  | 16.0                 |
| Ta      | <10                  | <10                  |
| Te      | <50                  | <25                  |
| Ti      | 45.6                 | 47.7                 |
| V       | <10                  | <5                   |
| W       | <10                  | -                    |
| Zn      |                      | 12.4                 |
| Zr      |                      | 11.2                 |

#### 13.3.11.1 Assessment of Water Leach Parameters

The initial 4.5 kg petalite flotation concentrate sample (PCS2) was subjected to decrepitation tests using a laboratory muffle furnace followed by roasting using concentrated sulphuric acid at a ratio of 180 kg H<sub>2</sub>SO<sub>4</sub>/t of dry concentrate and a laboratory muffle furnace. Six bench scale water leach tests were conducted using the roasted solids to assess the impact of liquid to solid ratio and residence time on the leachability of lithium. Unfortunately, these six tests produced low lithium extractions suspected to be due to low decrepitation temperatures.

A similar test program was undertaken using PCS2 with careful attention paid to maintaining the target operating conditions during decrepitation. The lithium leach extraction for these tests ranged between 88.1% and 89.3%. These results suggested that varying the liquid to solid ratio in the water leach from 1.5 to 5.0 g of liquid per g of petalite concentrate did not significantly impact the lithium extraction and neither did increasing the leach time from 1 h to 2 h.

Sodium was the most significantly extracted impurity, with approximately 45% of the sodium contained in the petalite concentrate reporting to the pregnant leach solution (PLS). Potassium, iron and manganese were all extracted to an extent of approximately 15% from the concentrate, while only minor portions of the calcium (approximately 10%), magnesium (approximately 5%) and aluminum (approximately 0.5%) were recovered to the PLS.

As a result of the completion of the bench scale water leach test program, a liquid to solid mass ratio of 1.5 g of liquid per g of petalite concentrate was selected for the batch mini-plot program at the standard conditions of 50°C and 1 hour batch leach duration. The simulated recycle of spent electrolyte from the proposed electro dialysis unit operation was eliminated as a potential cause for reducing lithium recoveries.

#### 13.3.11.2 Assessment of Impurity Precipitation Parameters

The pregnant leach solutions from the first program of tests were combined and evaporated to approximately one quarter of the original volume. The purpose of evaporating the solution prior to impurity precipitation was to concentrate the impurities in order to maximize their removal based on minimum solubility levels of impurities as hydroxides in solution and to reduce the physical size of downstream unit operations.

The first round of primary impurity precipitation tests was designed to evaluate the efficiency of using pure lithium hydroxide and sodium hydroxide solutions as neutralizing agents for impurity precipitation and to determine the optimum pH range for maximum removal of aluminum. Each test was completed at ambient temperature and allowed for a 30 minute reagent addition period followed by a 60 minute reaction period at the pH control set-point.

The results from this initial test program successfully demonstrated that Al, Fe, Cr, Be and Zr could all be removed from the PLS to an extent of 95% or greater in the first reaction stage at a pH set-point in the range of 6.33 to 7.00. Dissolved Si, Cu and Zn were all removed with

somewhat lower efficiency in the first stage of impurity precipitation. Both lithium and sodium hydroxide solutions were determined to be effective neutralizing agents for pH control in the primary impurity precipitation step.

The second round of primary impurity precipitation tests was completed using a mixture of lithium, sodium and potassium hydroxide solution as the neutralizing agent to approximate the expected composition of the crude mother liquor bleed stream from the first stage lithium hydroxide crystallization circuit.

Results from the second round of primary impurity precipitation tests, Al was removed to very low levels in the range of 0.4 to 0.2 mg/L for all pH set-points between 6.10 and 6.80, with the optimum pH set-point for primary impurity precipitation being selected as 6.80 based on maximizing the removal of aluminum. At this pH set-point, the removal efficiencies of the other impurities were also maximized.

The first round of secondary impurity precipitation tests involved assessment of the efficiency of impurity removal using pure lithium and sodium hydroxide solutions over the pH range from 9.5 to 11.0. Using the primary impurity precipitation filtrates and feed, the main focus of the secondary impurity precipitation stage was on the removal of Mg and residual trace impurities not completely removed in the primary stage.

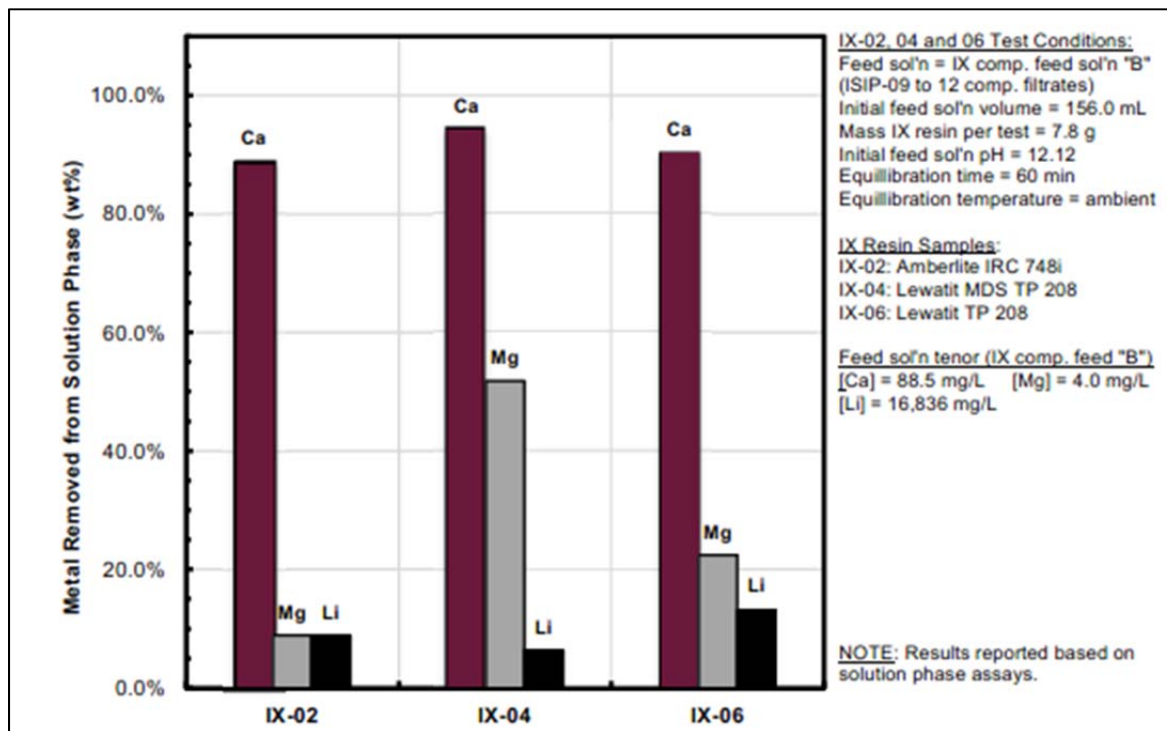
With the exception of dissolved Si, the removal of most residual impurities increased with increasing pH set-point in the range of pH 9.5 to 11.0. The removal of residual Fe, Al and Be was greater than 80% within the pH range tested; however, the removal efficiency of Mg was less than 40% at pH 11.0.

The second round of secondary precipitation tests also used synthetic crude mother liquor bleed stream for neutralization and filtrates from second round of primary impurity precipitation tests. For this series of tests, the pH set-point range was varied from 10.75 to 12.50. The removal efficiency for Mg reached a maximum between pH 12.0 and 12.5, however, the removal efficiency was limited to approximately 60%. A target pH set-point of 12.25 was selected for completion of the secondary impurity precipitation reaction.

### 13.3.11.3 Assessment of Ion Exchange Parameters

For the bench scale assessment of ion exchange unit operation efficiency, three alternative resins were initially selected for screening-level testing based on an independent review of the application requirements. These reagents were Amberlite™ IRC748i (Dow Chemical Company), Lewatit® TP-260 (Lanxess Chemical Company) and Lewatit® TP-208 (Lanxess Chemical Company), all of which are also used commercially for brine purification in the chlor-alkali (electrochemical production of acid and base) industry. Following the initial phase of testing, Lewatit® TP-260 was replaced by monodisperse version of Lewatit® TP-208. The monodisperse version of the resin is designated as Lewatit® MDS TP-208. The results of the second round bench scale ion exchange test program are given in Figure 13.5.

**Figure 13.5**  
**Results from Bench Scale Ion Exchange Tests**



The tests showed that calcium removal was relatively high for all three ion exchange resins; however, magnesium removal seemed to be limited, possibly due to higher than expected calcium loadings in the feed solution. Lewatit® MDS TP-208 was selected to be used for the batch mini-pilot test program.

#### 13.3.11.4 Assessment of Electrodialysis Process for Production of Lithium Hydroxide Solution

A 20 L sample of purified lithium sulphate solution was sent to a specialist company, Electrosynthesis Company, Inc., for evaluation of lithium sulphate conversion to lithium hydroxide and sulphuric acid using bipolar membrane electrodialysis technology. This company has extensive experience with electrochemical production of chemicals and provides bench scale/pilot scale assessment of electrodialysis processing. The lithium sulphate solution composition based on an ion balance was characterized as 3.07 molar lithium (21.309 g/L Li), 0.40 molar sodium (9,916 mg/L Na), 0.12 molar potassium (4,692 mg/L K) and 1.79 molar sulphate (171.94 g/L SO<sub>4</sub>).

The electrodialysis test program objectives included i) an assessment of electrodialysis using a representative ion matrix produced by the hydrometallurgical process flowsheet, ii) a preliminary assessment of the conversion efficiency for lithium sulphate conversion to lithium hydroxide (including electrical efficiency as defined by current efficiency (CE)) and



iii) a quantitative assessment of both acid and base produced by bipolar membrane electro dialysis.

A mini-pilot electro dialysis cell with six working cells (a typical prototype of a commercial unit) was constructed with commercially available anion membranes, bipolar membranes and cation membranes. Each cell had a membrane surface area of 200 cm<sup>2</sup> per membrane for a total of 1,200 cm<sup>2</sup>.

A total of five batch tests were conducted to assess current density feed concentrate, pH and run time. Each test was done at 40°C and the barren solution was recycled to the feed to simulate batch operation of a commercial system. A constant voltage on the cell was defined as 2.0 V (based on the cell manufacturer's recommendations) per cell and the current density was varied from 87.0 to 92.4 A/cm<sup>2</sup>.

It was noted from the test program that the anion membrane may have limited the current efficiency and should be subject of further review. Nevertheless, based on an assessment of the test results, the process conditions for cell operation were identified and are summarized as follows:

- Feed pH control at 3.8.
- Current Density: 87.8 mA/cm<sup>2</sup>.
- Sulphate removal of 96.8%.
- Lithium hydroxide concentration: 3.0 M at 65.9 % CE.
- Sulphuric acid concentration: 1.47 M at 63.7% CE.
- Barren solution: 0.10 M SO<sub>4</sub>/0.26 M Li/0.013 M Na/pH 1.57.
- Barren solution recovery relative to feed: 56.12% v/v.

#### 13.3.11.5 Assessment of Crystallization and Product Recovery Parameters

Lithium hydroxide solution, sulphuric acid solution and barren solution (end feed) from the bipolar membrane electro dialysis mini-pilot tests were sent to Thibault for further assessment of crystallization and crystalline lithium hydroxide monohydrate product recovery. Products of electro dialysis were characterized using ion chromatography analytical methods, summarized as follows:

- Lithium hydroxide solution: 25 L, 2.2 M Li, 0.27 M Na, 0.08 M K and 0.004 M SO<sub>4</sub>.
- Sulphuric acid solution: 30 L, 0.017 M Li, 0.002 M Na, <0.001 M K.
- Barren solution (end feed): 15 L, 0.28 M Li, 0.012 M Na, <0.001 M K and 0.22 M SO<sub>4</sub>.

The initial test program to assess crystallization and product recovery was based on i) preliminary scoping - bench scale tests to define the saturation limits for lithium and quantify selective rejection of impurities, ii) defining the impurity matrix solubility, iii) preliminary

lock cycle tests and iv) semi-continuous feed batch crystallization tests to improve on population density and crystal growth.

#### Scoping crystallization tests, CRY-01 to CRY-10

Initial batch crystallization scoping tests were conducted to assess product quality and yield relative to crystallization cooling time and boil-off volume (volume of solution evaporated).

Crystallization tests (CRY-01 to -04) were conducted at 85°C and the heat-up time was in the range of one to two hours. Solutions were allowed to cool for 15 hours after the heat-up time and analysis of solution concentration and solid phase yield of lithium, sodium and potassium.

Additional batch crystallization tests (CRY-05 to -08) were conducted at 85°C (two to three hour heat-up time) and stirred for an additional two hours to promote crystal nucleation. The yield of solids was limited and the white solids were defined as a non-crystalline powder and difficult to filter. The solids recovered by the initial batch test are defined as nucleation solids and crystal growth was limited. All analysis of solid and liquid phase samples was done by ICP analytical methods. It was noted that the analytical balance of test results was reasonable for lithium, sodium and potassium.

The preliminary tests results indicated that lithium solubility ranges from 24.0 g/L to 29.0 g/L at 85°C for boil-off in the range of 55% to 85% (by volume). The best yield of lithium to the solid phase was 75%. Both sodium and potassium have a solid phase yield of 10% to 25% for a solution boil-off range of 55% to 85%. The difference in the yield curves for both sodium and potassium below theoretical solubility suggest that selective separation of lithium and sodium/potassium may be achieved by multi-staged crystallization and the number of stages to comply with product specifications would be dependent on both boil-off volume and crystallization kinetics relative to impurity levels.

Results from initial/preliminary “batch-staged” crystallization tests are summarized as follows.

- 1) Cooling crystallization would not be cost effective for a two stage process and a single stage crystallization process is not selective enough to comply with product quality specification with respect to sodium and potassium.
- 2) Two hour crystallization without nucleation time or crystal growth will limit lithium yield. A lithium yield of less than 1.5% is not considered technically viable. First stage crystallization will require operation of the crystallizer in excess of lithium saturation limits and second stage crystallization may require further assessment of the operating conditions within the metastable zone for sodium, to optimize lithium yield. Concentrations near saturation limits for impurities were not achieved by the test program without solution recycle. The concentration of lithium in the mother

liquor (magna) should be near or in excess of the saturation limits to improve on overall yield of lithium, with higher boil-off volumes (in excess of 85%).

- 3) Rejection of impurities (sodium and potassium) within the first stage crystallization was in excess of 93%.

#### Solubility Curves (Crystallization Tests CRY-11 TO 17)

Batch evaporation tests were conducted to quantify the solubility of a lithium, sodium and potassium matrix, based on adjustment to concentrations by solution boil-off in the range 0% to 95% (by volume). To simulate the crystallization circuit feed solution matrix (with recycle of solution) as predicted by process simulation-mass balance, sodium hydroxide was added to the electrolysis lithium hydroxide solution. The test solution was prepared to achieve a relative concentration matrix containing 15.9 g/L lithium, 9.8 g/L sodium and 3.8 g/L potassium.

The solubility curves define a metastable zone for lithium in the range of 65% to 80% (volume) boil-off. Within the boil-off range of 80% to 95% (volume), the concentration of both sodium and potassium increases in the solid phase, in excess of 10,000 ppm. Both sodium and potassium remain fairly soluble at 120 g/L and 40 g/L, respectively, well below the theoretical solubility of sodium (431.1 g/L) and potassium (418.0 g/L). A metastable zone for both sodium and potassium has not been defined by the batch tests. A higher concentration of both sodium and potassium would be required based on a continuous recycle of solution.

#### Lock Cycle Crystallization Test (Crystallization Tests CRY-19 to 24)

A number of batch crystallization tests were conducted to assess the impact of solution recycle. These tests ran both crude and final product crystallization as per the process flowsheet configuration but final analyses were impacted by the crystals produced being very fine and difficult to wash and filter.

#### Semi-Continuous Feed – Batch Crystallization (Crystallization Tests CRY 25 and 26)

Batch crystallization tests were conducted to improve on the crystal size distribution, to increase population density and to assess limitations with final product composition with respect to battery grade specifications. Sample analyses of products from crude and final product crystallization were analyzed by glow discharge mass spectrometry (GDMS) to define product grade.

Evaporation of the electro dialysis solution to achieve a 30% boil-off (to simulate evaporation prior to crystallization) was performed at 75°C. The volume for crystallization feed solution was 0.8 L for crystallization tests CRY-25 and 1.6 L for crystallization test CRY-26 at a feed crystallization concentration of 23.8 g/L Li. Two stage crystallization tests were performed at 80°C and with intermediate dissolution and product filter cake washing.

The boil-off by crystallization was 63% (by volume) and the total boil-off of solution (based on evaporation prior to crystallization and crystallization boil-off) was 93% (by volume).

A wash displacement of three times the weight of entrained solution in filter cake was used on both crude and final product filter cake although this needs to be optimized. Re-dissolution of the crude using distilled water was based on controlling the concentration of lithium at 29.0 g/L. Solids that did not dissolve by the re-dissolution at 40°C (in trace amount less than 0.1 gram) were removed by vacuum filter clarification of the solution.

Crude and final product solids were filter to near dryness and dried at 60°C before being analysed by GDMS.

It is noted from the bench scale crystallization that a population density of 168 g/L of solids and a crystal growth time or batch reaction time of four to six hours (crystallization growth time is defined as time from nucleation observed within mother liquor) improved on the crystal size distribution. Under a microscope, crystal size was estimated to be in the range 0.25 mm to 0.40 mm and filtration time of solids improved dramatically, allowing for optimum washing of the crystals.

An assessment of the bench scale product grade was completed by the sum of impurities (present in product as oxide or hydroxide complexes). Assuming that carbonate as carbon dioxide is less than 0.35% (by weight), the final product from the bench scale crystallization tests is calculated by difference of impurities to be in excess of 99.5% lithium hydroxide monohydrate.

### 13.4 CONCLUSIONS AND RECOMMENDATIONS

The testwork has resulted in development of a flowsheet capable of producing a petalite concentrate suitable both for supplying specialised ceramics industry and for further processing to a lithium hydroxide material for the lithium ion battery business. The petalite recovery circuit is based around froth flotation technology but also includes optical sorting to remove waste rock ahead of grinding and magnetic separation to enable very low levels of iron to be achieved. After conventional roasting, leaching and impurity removal the hydroxide circuit uses a novel electrolysis bases process to convert lithium sulphate solution to lithium hydroxide from which a low impurity final product can be crystallized.

The recoveries and product grades used in the PEA, based on the testwork described above, are as follows:

- Solids mass pull to magnetics: 14.5% of mill feed
- Lithium losses to magnetics: 14.5% of mill feed
- Lithium recovery to petalite concentrate: 65.3%
- Grade of the petalite flotation concentrate: 4.0% Li<sub>2</sub>O
- Iron concentration in petalite concentrate: <0.01% Fe<sub>2</sub>O<sub>3</sub>

- Feldspar concentrate grade: >11% total  $K_2O + Na_2O$
- Lithium hydrometallurgical recovery to hydroxide product: 91%

The feldspar product is also sufficiently pure to be used in a number of ceramic/glass applications including as filler in paints and fibreglass.

Further optimization testwork is recommended, particularly with regards the following:

- Reduction of flotation reagent consumption.
- Further pre-concentration ahead of flotation.
- Processing of the magnetics to recover additional lithium and, potentially, rubidium and niobium.
- Further development of a process to also produce a high purity quartz product.
- Evaluate use of fluidized bed roasting instead of rotary kiln technology.
- Evaluate alternative membranes in the electro dialysis cells.

The processes need to be tested further at pilot plant scale and it is recommended that a demonstration plant be established to produce sufficient test material for evaluation by potential customers, to provide proof of process, to generate detailed engineering design data and to significantly reduce the project risk profile.

## 14.0 MINERAL RESOURCE ESTIMATES

Lithium and feldspar mineral resource estimates for the Separation Rapids Lithium Project have been prepared by Benjamin Webb, P.Geol. (B.C.), Principal of BMW Geoscience LLC. The mineral resource estimates have been reviewed in detail by David L. Trueman, Ph.D., P.Geol., who is the Qualified Person for the resource estimates.

### 14.1 LITHIUM MINERAL RESOURCE ESTIMATE

The Separation Rapids Lithium Project Measured plus Indicated mineral resource is estimated to be 8.00 Mt at a grade of 1.29% Li<sub>2</sub>O using a 0.6% Li<sub>2</sub>O cut-off grade, as summarized in Table 14.1. The inferred mineral resource is 1.63 Mt at a grade of 1.42% Li<sub>2</sub>O. The total feldspar content of the mineralized zone is estimated at 39%.

The primary lithium-bearing minerals, petalite and lepidolite, are found within the 400 m by 70 m Separation Rapids Pegmatite. Surface mapping and results from 69 diamond drill holes were used to create a 3D model of the host lithology which was used to constrain the interpolation of assays. The project database is maintained in Maxwell DataShed™ software and the resource estimation utilized MineSight 3D.

**Table 14.1**  
**Separation Rapids, Mineral Resource Estimate at 0.6% Li<sub>2</sub>O Cut-off Grade**  
**As at 21 October, 2016**

| Class                   | Tonnes (Mt) | Li <sub>2</sub> O (%) | Total Feldspar (%) | Ta <sub>2</sub> O <sub>5</sub> (%) | Cs <sub>2</sub> O (%) | Rb <sub>2</sub> O (%) | SG   |
|-------------------------|-------------|-----------------------|--------------------|------------------------------------|-----------------------|-----------------------|------|
| Measured                | 4.03        | 1.32                  | 39                 | 0.006                              | 0.017                 | 0.343                 | 2.66 |
| Indicated               | 3.97        | 1.26                  | 39                 | 0.007                              | 0.025                 | 0.362                 | 2.67 |
| Measured plus Indicated | 8.00        | 1.29                  | 39                 | 0.006                              | 0.021                 | 0.352                 | 2.66 |
| Inferred                | 1.63        | 1.42                  | 39                 | 0.008                              | 0.016                 | 0.360                 | 2.64 |

Notes:

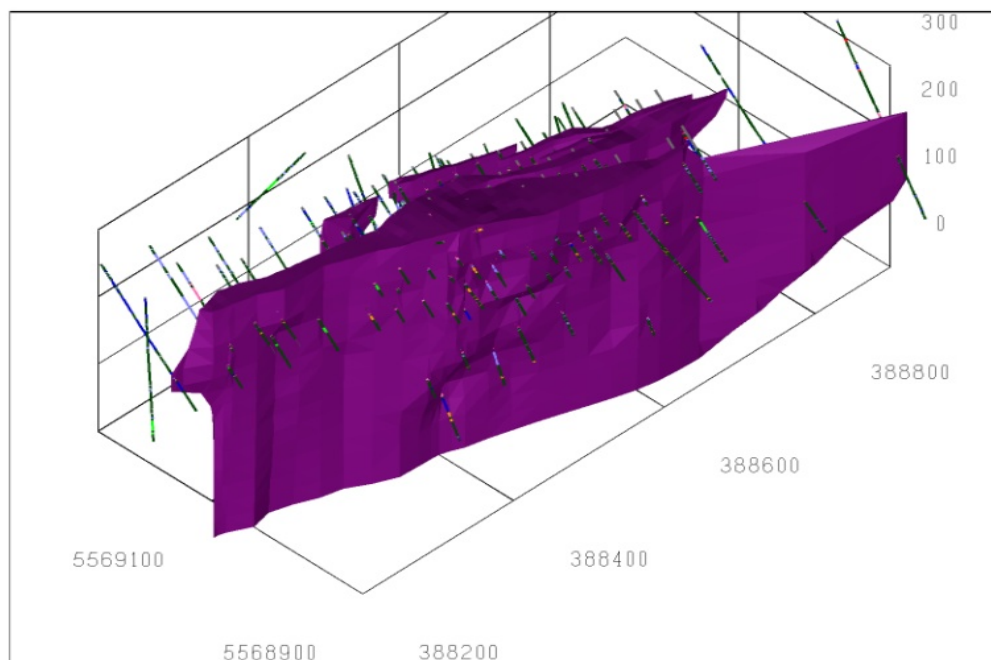
1. CIM Definition Standards for Mineral Resources and Mineral Reserves, 10 May, 2014 were followed for this mineral resource estimate.
2. The Qualified Person for this mineral resource is David L. Trueman, Ph.D., P.Geol.(MB).
3. The resource estimate is constrained by a 3D geologic model of the mineralized material.
4. Assay intervals for Li<sub>2</sub>O, Ta<sub>2</sub>O<sub>5</sub>, Cs<sub>2</sub>O and Rb<sub>2</sub>O were interpolated using the Inverse Distance Weighted method to create a 3D block model.
5. The resource cut-off grade of 0.6% Li<sub>2</sub>O was chosen to capture mineralization that is potentially amenable to mining, mineral concentration and off-site processing.
6. Li, Ta, Cs and Rb were originally analysed on all samples at XRAL Laboratory (Thunder Bay, Ontario) utilizing ICP (Li, Ta) and AA (Rb and Cs) and check analyses completed at CHEMEX Laboratory (Don Mills, Ontario) utilizing AA (Li) and ICP (Rb).
7. As well as due diligence to verify historic data, Avalon completed additional check analyses of historic drill core in 2016 utilizing ALS Laboratory (Vancouver) with a combination of fusion and ICP (method CCP-PKG01). Included as QA/QC procedures was a lithium rock standard within the check analysis batches.
8. Total Feldspar is the total of potassium feldspar (microcline) and sodium feldspar (albite) and the value reflects the mean and median value of all samples with quantitative mineralogy determined.

9. The percentage of Total Feldspar is based on analyses completed utilizing X-Ray diffraction and Qemscan® instrumentation on samples representing all lithological subunits of the mineral deposit. These analyses were completed at Carleton University in 1999 (XRD) and ALS Global Laboratory in 2016 (XRD and Qemscan®, Kamloops). This is supported by quantitative mineralogy of metallurgical samples determined at SGS Lakefield and Dorfner ANZAPLAN (Germany).
10. All figures are rounded to reflect the relative accuracy of the estimates. Summation of individual columns may not add-up due to rounding.
11. Mineral Resources are not Mineral Reserves and do not have demonstrated economic viability. There is no certainty that all or any part of the Mineral Resource will be converted into Mineral Reserves.
12. In addition, while the terms “measured”, “indicated” and “inferred” mineral resources are required pursuant to National Instrument 43-101, the U.S. Securities and Exchange Commission does not recognize such terms. Canadian standards differ significantly from the requirements of the U.S. Securities and Exchange Commission, and mineral resource information contained herein is not comparable to similar information regarding mineral reserves disclosed in accordance with the requirements of the U.S. Securities and Exchange Commission. U.S. investors should understand that “inferred” mineral resources have a great amount of uncertainty as to their existence and great uncertainty as to their economic and legal feasibility. In addition, U.S. investors are cautioned not to assume that any part or all of Avalon’s mineral resources constitute or will be converted into reserves.

### 14.1.1 Geological Model

A 3D model of the Unit 6 lithium pegmatite lithology was made by interpreting drill-hole intercepts along north-south and plan sections spaced at 25 m while honoring the detailed surface map created by project geologist Chris Pedersen (1998). This model combines the 6a, 6b, 6c, and 6d subunits and is used as a single mineral resource estimation domain. The plan sections were used for making the 3D wireframe. An isometric view of the Unit 6 geological model, including locations of drill holes is shown in Figure 14.1.

**Figure 14.1**  
**Isometric View of the Unit 6 Geology Model**



Lithological units used in the mineral resource estimate are shown in Table 14.2.

**Table 14.2**  
**Lithological Units Used in Resource Estimation**

| Lithological Unit/Subunit | Resource Estimation Code (OREC) | Rock Type                                      | Unit Name   |
|---------------------------|---------------------------------|--|---|
| 1                         | 1                               | Amphibolite                                    | Separation Lake Metavolcanic Belt   |
| 2                         | 3                               | Pegmatitic granite                             | Winnipeg River Batholith  |
| 3a, 3b                    | 3                               | Albitite                                       | Separation Rapids Pegmatite Albitite-rich wall zone to the petalite-bearing pegmatitic subunits |
| 4                         | 3                               | Megacrystic Potassium feldspar quartz sub-zone | Separation Rapids Pegmatite intermediate zone   |
| 5                         | 3                               | Quartz-mica sub-zone                           | Separation Rapids Pegmatite intermediate zone   |
| 6a, 6b, 6c, 6d            | 6                               | Petalite-bearing pegmatite zone                | Separation Rapids Pegmatite petalite zone (intermediate zone)                                   |
| 7                         | 3                               | Pegmatite granite zone                         | Separation Rapids Pegmatite feldspathic wall zone   |

#### 14.1.2 Specific Gravity

The average pegmatite specific gravity (SG) is 2.62 based on 118 samples (one high outlier at 3.16 removed) while the average amphibolite (waste) specific gravity is 3.04 based on 66 samples, see Table 14.3. The samples were chosen from seven drill holes at the centre of the deposit and were measured by project geologist Chris Pedersen. The SG measurements show low variability. The coefficient of variance (CoV) is approximately 0.03 reducing the risk of significant error.

Specific gravity was interpolated in the block model using the same approach as for Li<sub>2</sub>O. Where no measured samples are available, the interpolation used the average SG values which were assigned to drill hole intervals based on lithology. The block model field DENO was used to store the SG of the mineralized material (Unit 6 lithium pegmatite) and the field DENW was used to store the SG of the waste and potential by-product materials (amphibolite and barren pegmatite).

**Table 14.3**  
**Separation Rapids, Statistics for Specific Gravity Measurements**

| Parameter          | Pegmatite | Amphibolite |
|--------------------|-----------|-------------|
| Number             | 118       | 66          |
| Minimum            | 2.46      | 2.89        |
| Maximum            | 2.92      | 3.20        |
| Average            | 2.62      | 3.04        |
| Median             | 2.62      | 3.04        |
| Standard Deviation | 0.08      | 0.05        |



| Parameter                | Pegmatite | Amphibolite |
|--------------------------|-----------|-------------|
| 1 <sup>st</sup> Quartile | 2.57      | 3.02        |
| 3 <sup>rd</sup> Quartile | 2.66      | 3.06        |
| CoV                      | 0.030     | 0.015       |

### 14.1.3 Drill Hole Data and Statistics

The project database contains 69 drill holes for 10,171 m with 2,790 assay results. Assay intervals often mix lithologies due to lithology units that are narrower than assay sample core length. Assay statistics were calculated for all intervals, as shown in Table 14.4, and also for single-lithology intervals, as shown in Table 14.5 to provide a clear view of the dataset and valid averages for each lithology. Single-lithology intervals of amphibolite (Unit 1) show a 16% lower average Li<sub>2</sub>O grade than all intervals logged as “majority amphibolites”. This indicates inclusion of lithium pegmatite within some intervals designated as “majority amphibolite”. The combined Unit 6 (all units designated 6, including 6, 6a, 6b, 6c, 6d) data show 30% higher average Cs<sub>2</sub>O grade for all samples indicating inter-mixing of amphibolite within some intervals.

The normal distribution and low standard deviation of Li<sub>2</sub>O grades within the Unit 6 lithium pegmatite indicates a consistent resource grade across the deposit averaging 1.4% Li<sub>2</sub>O (1.42% weighted by interval length, 1.44% unweighted). This is consistent with a homogenous magma source for the Unit 6 lithium pegmatite. This consistent Li<sub>2</sub>O grade of pegmatitic material means that within the resource model, block grades lower than 0.9% Li<sub>2</sub>O (one standard deviation below the mean) will most likely be due to dilution by amphibolite bands and not low tenor in the lithium pegmatite. This can be observed in the original drill logs (Pedersen, 1998).

While the Li<sub>2</sub>O grade of the four subunits of the lithium pegmatite is consistent at 1.4%, the average Rb<sub>2</sub>O grade increases from 0.3% in Subunit 6a to 0.5% in Subunit 6d. If, in future, the identification of areas of high lepidolite is required, the Li<sub>2</sub>O/Rb<sub>2</sub>O ratio should be a quantitative way to define lepidolite-bearing material.

**Table 14.4**  
**Average Assay Data Weighted by Interval Length for All Intervals**

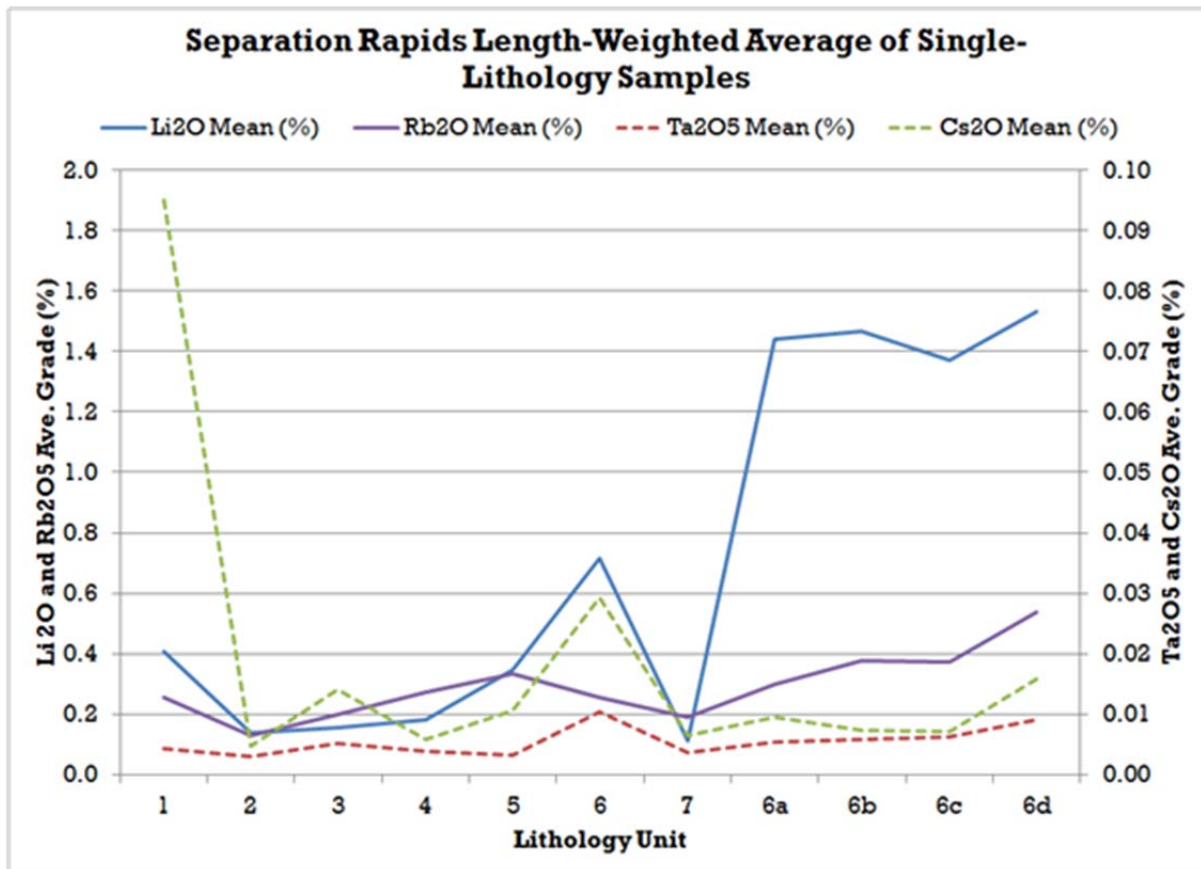
| Lithology Code | Number of Intervals | Length (m) | Li <sub>2</sub> O Mean (%) | Ta <sub>2</sub> O <sub>5</sub> Mean (%) | Cs <sub>2</sub> O Mean (%) | Rb <sub>2</sub> O Mean (%) |
|----------------|---------------------|------------|----------------------------|---|----------------------------|----------------------------|
| 1              | 613                 | 396.30     | 0.482                      | 0.005                                   | 0.096                      | 0.274                      |
| 2              | 21                  | 28.35      | 0.123                      | 0.003                                   | 0.005                      | 0.137                      |
| 3              | 458                 | 520.47     | 0.166                      | 0.005                                   | 0.018                      | 0.206                      |
| 4              | 118                 | 228.78     | 0.181                      | 0.004                                   | 0.006                      | 0.272                      |
| 5              | 52                  | 91.77      | 0.344                      | 0.003                                   | 0.011                      | 0.326                      |
| 6              | 38                  | 41.89      | 0.728                      | 0.010                                   | 0.044                      | 0.281                      |
| 7              | 181                 | 319.27     | 0.112                      | 0.004                                   | 0.007                      | 0.192                      |
| 6a             | 845                 | 1,184.29   | 1.403                      | 0.006                                   | 0.014                      | 0.306                      |
| 6b             | 220                 | 370.85     | 1.451                      | 0.006                                   | 0.010                      | 0.378                      |
| 6c             | 400                 | 669.87     | 1.371                      | 0.006                                   | 0.008                      | 0.371                      |
| 6d             | 420                 | 600.56     | 1.513                      | 0.009                                   | 0.019                      | 0.532                      |
| 6 (combined)   | 1,923               | 3.10       | 1.415                      | 0.007                                   | 0.013                      | 0.378                      |

**Table 14.5**  
Average Assay Data Weighted by Interval Length for Single-Lithology Intervals Only

| Lithology Code | Number of Intervals | Length (m) | Li <sub>2</sub> O Mean (%) | Ta <sub>2</sub> O <sub>5</sub> Mean (%) | Cs <sub>2</sub> O Mean (%) | Rb <sub>2</sub> O Mean (%) |
|----------------|---------------------|------------|----------------------------|---|----------------------------|----------------------------|
| 1              | 227                 | 220.99     | 0.405                      | 0.004                                   | 0.095                      | 0.255                      |
| 2              | 19                  | 24.05      | 0.139                      | 0.003                                   | 0.005                      | 0.130                      |
| 3              | 351                 | 470.20     | 0.154                      | 0.005                                   | 0.014                      | 0.199                      |
| 4              | 110                 | 222.43     | 0.180                      | 0.004                                   | 0.006                      | 0.271                      |
| 5              | 45                  | 80.62      | 0.347                      | 0.003                                   | 0.010                      | 0.333                      |
| 6              | 32                  | 37.78      | 0.714                      | 0.010                                   | 0.029                      | 0.256                      |
| 7              | 166                 | 305.21     | 0.111                      | 0.004                                   | 0.006                      | 0.191                      |
| 6a             | 636                 | 1,057.87   | 1.441                      | 0.005                                   | 0.010                      | 0.300                      |
| 6b             | 179                 | 334.33     | 1.466                      | 0.006                                   | 0.007                      | 0.376                      |
| 6c             | 353                 | 625.80     | 1.370                      | 0.006                                   | 0.007                      | 0.372                      |
| 6d             | 348                 | 547.58     | 1.532                      | 0.009                                   | 0.016                      | 0.539                      |
| 6 (combined)   | 1,548               | 2,603.36   | 1.436                      | 0.006                                   | 0.010                      | 0.376                      |

Length-weighted average grades of single-lithology samples are illustrated by lithology unit in Figure 14.2.

**Figure 14.2**  
Length-Weighted Average Grades of Single-lithology Samples



Unweighted Li<sub>2</sub>O% assay statistics for single-lithology intervals showing low CoV of Li<sub>2</sub>O grades. Subunits 6a, 6b, 6c, and 6d were occasionally simplified to a single Unit 6 lithology in the database. Combining the subunits gives a larger statistical sample of the lithology and a better statistical evaluation of the deposit as a whole. See Table 14.6.

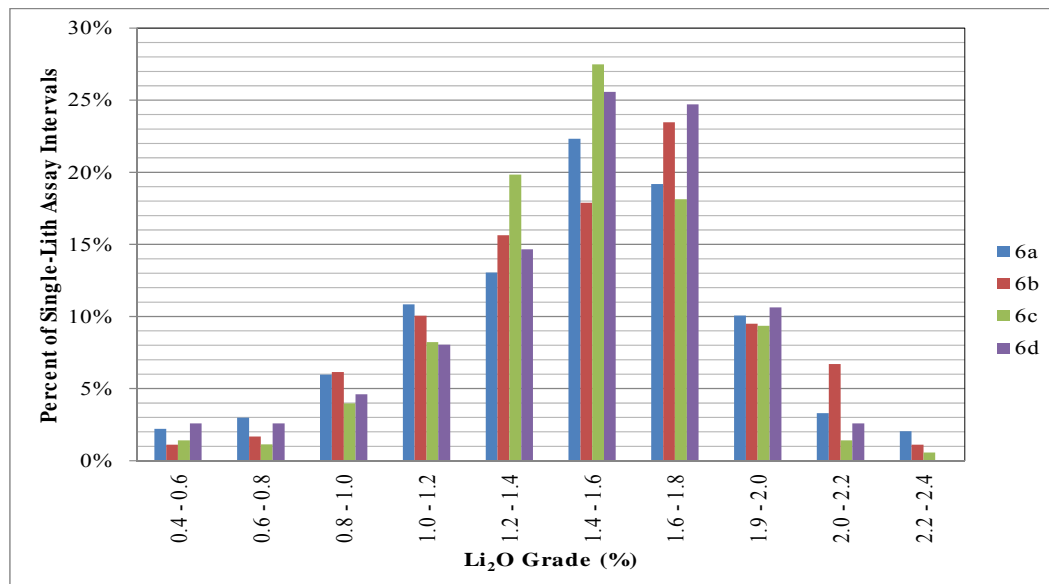
**Table 14.6**  
Unweighted Li<sub>2</sub>O Assay Statistics for Single-lithology Intervals

| Lithology Unit/Subunit | 6a Li <sub>2</sub> O% | 6b Li <sub>2</sub> O% | 6c Li <sub>2</sub> O% | 6d Li <sub>2</sub> O% | Single Unit 6 Li <sub>2</sub> O% | Unit 6 (combined) Li <sub>2</sub> O% |
|------------------------|-----------------------|-----------------------|-----------------------|-----------------------|----------------------------------|--------------------------------------|
| Number                 | 636                   | 179                   | 353                   | 348                   | 32                               | 1,548                                |
| Mean                   | 1.41                  | 1.45                  | 1.38                  | 1.47                  | 0.99                             | 1.41                                 |
| Standard Deviation     | 0.52                  | 0.47                  | 0.45                  | 0.41                  | 0.92                             | 0.49                                 |
| Median                 | 1.47                  | 1.51                  | 1.45                  | 1.54                  | 0.91                             | 1.48                                 |
| 25 Percentile          | 1.14                  | 1.22                  | 1.25                  | 1.32                  | 0.21                             | 1.20                                 |
| 75 Percentile          | 1.71                  | 1.73                  | 1.63                  | 1.71                  | 1.39                             | 1.69                                 |
| CoV                    | 0.37                  | 0.33                  | 0.33                  | 0.28                  | 0.93                             | 0.35                                 |

The distribution of lithium oxide grades by subunit for single-lithology intervals is shown in Figure 14.3.

The normal distribution (Figure 14.3) and consistent standard deviation of Li<sub>2</sub>O grades (Table 14.5 and Table 14.6) within the Unit 6 lithium pegmatite and all subunits indicates a consistent resource grade across the deposit averaging 1.4% Li<sub>2</sub>O (1.42% Li<sub>2</sub>O weighted by interval length).

**Figure 14.3**  
Separation Rapids, Normal Distribution of Lithium Oxide Grade



#### 14.1.4 Assay Compositing

Assay intervals were composited into 2 m lengths honouring the Unit 6 geology model code assigned to the OREC data field in MineSight 3D using the Unit 6 lithium pegmatite three-dimensional geological model. While the geology model is generally tied to drill holes, assay intervals need to be a minimum of 25% within the geology model to be assigned an OREC value of 6. This prevents any small overlaps between the geology model and unmineralized assay intervals from affecting the interpolated grade. The block model field OREC was used in MineSight 3D to store the mineralization code for all blocks at least 1% within the geology model of Unit 6. This ensures that all blocks containing lithium pegmatite are assigned an interpolated grade. Small intervals of less than 1.0 m are merged with the previous interval. Basic statistics for composites within OREC=6 are shown in Table 14.7.

**Table 14.7**  
**Basic Statistics for Composites within the Lithium Pegmatite Geology Model (OREC=6)**

| Composites                     | Valid Composites | Minimum | Maximum | Mean   | Standard Deviation | Variance | CoV   |
|--------------------------------|------------------|---------|---------|--------|--------------------|----------|-------|
| LENGTH                         | 1,744            | 1.0     | 2.96    | 2.00   | 0.15               | 0.022    | 0.074 |
| Li <sub>2</sub> O              | 1,744            | 0.0     | 2.844   | 1.1835 | 0.5609             | 0.315    | 0.474 |
| Ta <sub>2</sub> O <sub>5</sub> | 1,744            | 0.0     | 0.024   | 0.0057 | 0.0040             | 0.000    | 0.693 |
| Cs <sub>2</sub> O              | 1,744            | 0.0     | 0.276   | 0.0181 | 0.0311             | 0.001    | 1.723 |
| Rb <sub>2</sub> O              | 1,744            | 0.0     | 1.200   | 0.3321 | 0.1688             | 0.029    | 0.508 |
| OREC                           | 1,744            | 1       | 1       | 1      | 0                  | 0        | 0     |

#### 14.1.5 Variography

The Separation Rapids resource is interpreted as a single domain of lithium pegmatite. Surface mapping shows a change in strike at the western end of mineralization from 105° to 95°, but this affects only seven drill holes. MineSight DataAnalyst software was used to calculate and fit the correlograms for Li<sub>2</sub>O, Ta<sub>2</sub>O<sub>5</sub>, Cs<sub>2</sub>O, and Rb<sub>2</sub>O for 2-m composites within the lithium pegmatite 3D model (OREC = 6).

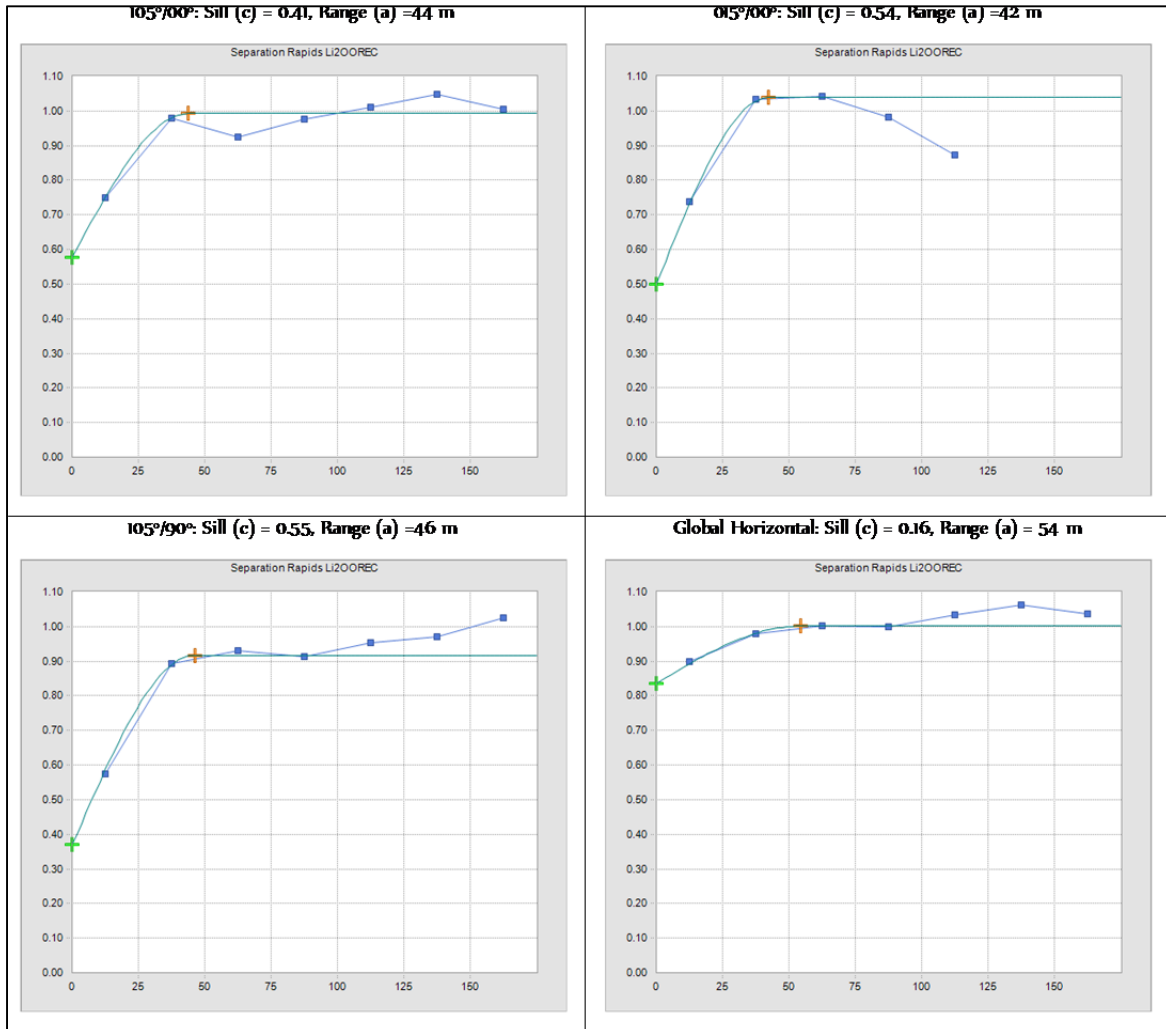
The continuity along strike at 105° is observed in mapping and drilling. Horizontal correlograms with a 15° window were plotted every 15° from 75° to 135° for 2 m composites to bracket the mapped strike of the deposit. Each correlogram was then fitted with a spherical model. Variography shows a range of 44 m at 105°/00° parallel to the mapped strike. Perpendicular to the strike at 015°/00°, the range is similar at 42 m. The vertical correlogram at 105°/90° indicates a range of 46 m. Correlogram models are illustrated in Figure 14.4.

The correlograms are parallel to strike (105°), perpendicular to strike (015°) and vertical along with the global horizontal correlogram.

This indicates a reasonable Measured classification search distance of 40 m by 40 m by 40 m. The previously established search strategy was reasonable with 75 m by 25 m by 50 m for the first pass for Inferred and Indicated class material and 30 m by 10 m by 20 m for the second pass for Measured material (ellipsoids rotated 105°). Extrapolation along strike

during the first pass is tightly constrained by the geologic model. However, the minor-axis width of 10 m combined with the north-south drilling pattern caused selection of composites along an east-west strike instead of at the 105° strike of the deposit. A search ellipse with a narrower minor-axis was chosen for this resource estimate to constrain selection of composites along the 105° strike.

**Figure 14.4**  
**Correlogram Models of Li<sub>2</sub>O% for Composites within the Lithium Pegmatite Geological Model**



### 14.1.6 Block Model

A block model covering the entire Separation Rapids Pegmatite consisting of 10 m by 3 m by 10 m blocks was constructed using MineSight 3D software. Blocks were elongated east-west to fit the strike of the deposit and were not rotated. The block size is the same as, and is thus consistent with, previous resource estimates, although the minimum minable block will likely be smaller. Blocks were assigned a mineralization percent item (ORE%) value based on the 3D model of Unit 6 and a mineralized material SG (DENO) and waste SG (DENW). A

mineralization percent item based on a 3D model of Subunit 6d (ORE%D) and a mineralization percent item based on the 3D model of lithium-poor pegmatite (ORE%3) were also assigned. Block model specifications are shown in Table 14.8 and block model fields are shown in Table 14.9.

**Table 14.8**  
**Block Model Specifications**

|               | Minimum   | Maximum   | Extent (m) | Block Size (m) | Num. of Blocks |
|---------------|-----------|-----------|------------|----------------|----------------|
| Easting (X)   | 387,850   | 389,300   | 1,450      | 10             | 145            |
| Northing (Y)  | 5,568,500 | 5,569,310 | 810        | 3              | 270            |
| Elevation (Z) | 0         | 400       | 400        | 10             | 40             |

**Table 14.9**  
**Block Model Data Field Parameters in MineSight 3D**

| Label                          | Description                               | Minimum | Maximum | Numerical Precision |
|--------------------------------|---|---------|---------|---------------------|
| TOPO                           | Percent below topography                  | 0       | 100     | 1                   |
| Li <sub>2</sub> O              | Grade                                     | 0       | 100     | 0.001               |
| Ta <sub>2</sub> O <sub>5</sub> | Grade                                     | 0       | 100     | 0.001               |
| Cs <sub>2</sub> O              | Grade                                     | 0       | 100     | 0.001               |
| Rb <sub>2</sub> O              | Grade                                     | 0       | 100     | 0.001               |
| OREC                           | Mineralization code                       | 0       | 10      | 1                   |
| LITH                           | Lithology code                            | 0       | 10      | 1                   |
| PASS1                          | Interpolation pass flag                   | 0       | 1       | 1                   |
| PASS2                          | Interpolation pass flag                   | 0       | 1       | 1                   |
| NDDH                           | Number of drill holes interpolated        | 0       | 100     | 1                   |
| DENO                           | SG, mineralized material                  | 0       | 5       | 0.01                |
| ISV                            | In-situ Value                             | 0       | 1,000   | 0.01                |
| DISTC                          | Composite distance, closest               | 0       | 1,000   | 0.01                |
| DISTF                          | Composite distance, farthest              | 0       | 1,000   | 0.01                |
| DISTA                          | Composite distance, average               | 0       | 1,000   | 0.01                |
| NCOMP                          | Number of composites interpolated         | 0       | 100     | 1                   |
| CALC1                          | Calculation field                         | 0       | 100,000 | 0.01                |
| CALC2                          | Calculation field                         | 0       | 100,000 | 0.01                |
| CALC3                          | Calculation field                         | 0       | 100,000 | 0.01                |
| CALC4                          | Calculation field                         | 0       | 100,000 | 0.01                |
| ORE%6                          | Mineralization percent, Unit 6            | 0       | 100     | 1                   |
| ORE%D                          | Mineralization percent, Subunit 6d        | 0       | 100     | 1                   |
| ORE%3                          | Mineralization percent, barren pegmatite  | 0       | 100     | 1                   |
| LIRB                           | Li <sub>2</sub> O/Rb <sub>2</sub> O Ratio | 0       | 100     | 0.01                |
| DENW                           | SG, waste                                 | 0       | 5       | 0.01                |
| DIST                           | Distance                                  | 0       | 500     | 0.1                 |
| CONF                           | Confidence classification                 | 0       | 3       | 1                   |

Interpolation of block values was done in two passes using the Inverse Distance Weighted with a power parameter of 2 (IDW2) method and block matching on mineralization code (OREC). A mineralization code of 6 was assigned to all blocks at least 1% within the 3D

geological model of Unit 6 and a mineralization code of 1 was assigned for all other blocks. This ensures that all blocks containing mineralization received an interpolated grade. The search ellipsoid was rotated 105° to match the strike of the deposit so that the narrowest search distance was at a 15° azimuth perpendicular to strike.

The search ellipse for the first pass was X=75 m, Y=12 m, Z=60 m rotated 105° so that the narrow axis of the search ellipse is perpendicular to strike. This search ellipse was larger than the range suggested by variography, but interpolation is tightly constrained by the 3D model except at depth. Each block was interpolated based on a minimum of two and maximum of 12 composites per block and a maximum of three composites per hole. This resulted in a minimum of one and a maximum of four drill holes per block on the first pass. This pass was consistent with previous search ellipses, See Section 14.1.10 below. Use of a maximum of three composites per drill hole resulted in an interval of 6 m for interpolation of a block.

The second pass overwrites the first pass where at least six composites were selected using a narrower (Y=4 m) search ellipse. The search ellipse for the second pass was X=75 m, Y=4 m, Z=60 m rotated 105° so that the narrow axis of the search ellipse was perpendicular to strike. Each block was interpolated based on a minimum of six and maximum of 12 composites per block and a maximum of two composites per hole. This results in a minimum of three and a maximum of six drill holes per block on the second pass. The second pass interpolated the blocks which will be classified as Measured using a very narrow search ellipse of 4 m to model the strike of mineralization. Use of a maximum of two composites per drill hole resulted in an interval of 4 m from each drill hole for interpolation of a block.

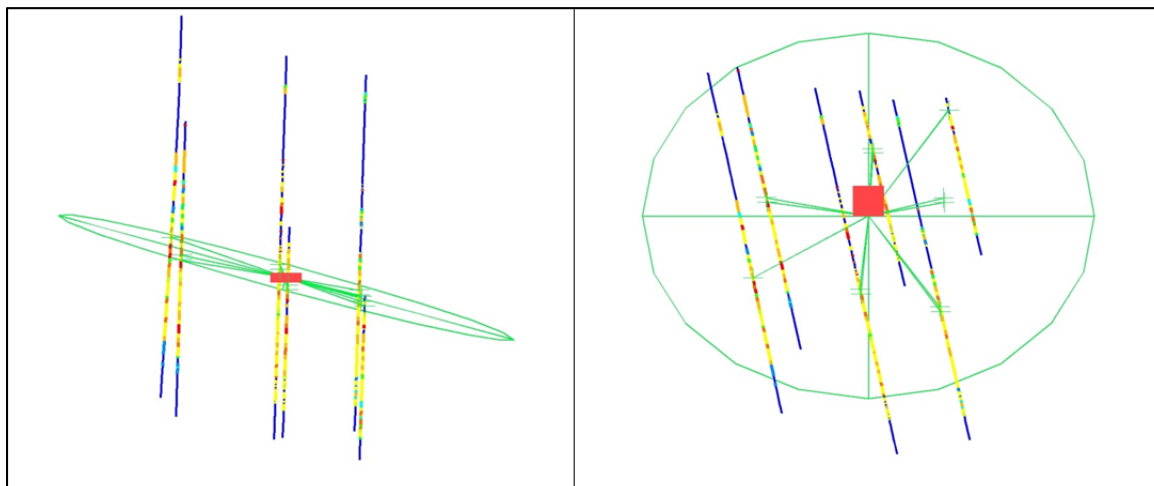
Table 14.10 provides the interpolation parameters for the first and second passes.

**Table 14.10**  
**Interpolation Parameters for the Separation Rapids Resource Model**

|                         | <b>First Pass</b> | <b>Second Pass</b> |
|-------------------------|-------------------|--------------------|
| Method                  | IDW2              | IDW2               |
| X Distance (m)          | 75                | 75                 |
| Y Distance (m)          | 12                | 4                  |
| Z Distance (m)          | 60                | 60                 |
| Rotation                | 105°              | 105°               |
| Minimum Composites      | 2                 | 6                  |
| Maximum Composites      | 12                | 12                 |
| Max Composites per Hole | 3 (6 m)           | 2 (4 m)            |
| Minimum Drill Holes     | 1                 | 3                  |
| Maximum Drill Holes     | 4                 | 6                  |

As an example, Figure 14.5 shows the results of the second interpolation pass for Block 10-165-63.

**Figure 14.5**  
Composite Selection During the Second Interpolation Pass for Block 10-165-63 (388475 E, 5568993.5 N  
300 Z) in Plan View (Left) and Cross-Section Looking Northeast At 015° (Right)



Block size is 10 m by 10 m by 3 m and search ellipse is 75 m by 4 m by 60 m rotated 105°.

Block model statistics are provided in Table 14.11.

**Table 14.11**  
**Block Model Statistics**

| Block                          | Valid Blocks | Minimum | Maximum | Mean   | Standard Deviation | Variance | CoV   |
|--------------------------------|--------------|---------|---------|--------|--------------------|----------|-------|
| Li <sub>2</sub> O              | 19,158       | 0.002   | 2.313   | 1.1907 | 0.4097             | 0.1678   | 0.344 |
| Ta <sub>2</sub> O <sub>5</sub> | 19,158       | 0.000   | 0.020   | 0.0061 | 0.0027             | 0.0000   | 0.445 |
| Cs <sub>2</sub> O              | 19,158       | 0.000   | 0.206   | 0.0195 | 0.0218             | 0.0005   | 1.118 |
| Rb <sub>2</sub> O              | 19,158       | 0.001   | 0.994   | 0.3366 | 0.1088             | 0.0118   | 0.323 |
| DENO                           | 28,441       | 2.54    | 3.04    | 2.66   | 0.08               | 0.01     | 0.03  |
| DENW                           | 28,441       | 3.04    | 3.04    | 3.04   | 0                  | 0        | 0     |

### 14.1.7 Lithium Resource Block Classification

Resource block confidence was assigned based on the number of drill holes (NDDH) used to interpolate each block. Blocks using a single drill hole for interpolation were classified as Inferred, blocks using two to five drill holes were classified as Indicated, and blocks using the maximum of six drill holes were classified as Measured. No blocks were reclassified based on visual inspection. The classification is shown in Table 14.12.

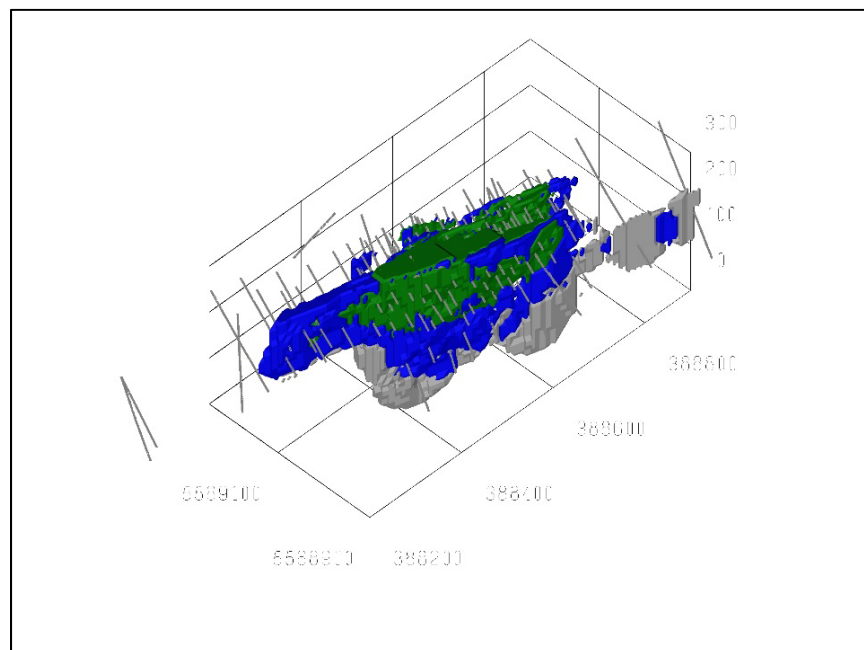


**Table 14.12**  
**Separation Rapids, Mineral Resource Classification Scheme**

| Measured Blocks   | Valid Blocks | Minimum | Maximum | Mean | Standard Deviation | Variance | CoV  |
|-------------------|--------------|---------|---------|------|--------------------|----------|------|
| Li <sub>2</sub> O | 7,231        | 0.004   | 2.289   | 1.2  | 0.4                | 0.2      | 0.36 |
| NDDH              | 7,231        | 6       | 9       | 6.3  | 0.5                | 0.2      | 0.10 |
| NCOMP             | 7,231        | 8       | 12      | 11.9 | 0.4                | 0.2      | 0.00 |
| DISTC             | 7,231        | 0.3     | 48.7    | 13.5 | 7.1                | 51.0     | 0.53 |
| DISTF             | 7,231        | 25.0    | 74.6    | 52.0 | 9.9                | 97.1     | 0.19 |
| DISTA             | 7,231        | 18.8    | 57.0    | 34.2 | 6.6                | 43.9     | 0.19 |
| Indicated Blocks  | Valid Blocks | Minimum | Maximum | Mean | Standard Deviation | Variance | CoV  |
| Li <sub>2</sub> O | 8,316        | 0.004   | 2.313   | 1.1  | 0.4                | 0.2      | 0.36 |
| NCOMP             | 8,316        | 2       | 12      | 7.5  | 1.8                | 3.4      | 0.20 |
| NDDH              | 8,316        | 2       | 5       | 3.3  | 1.1                | 1.2      | 0.30 |
| DISTC             | 8,316        | 0.9     | 64.0    | 24.0 | 12.2               | 147.6    | 0.51 |
| DISTF             | 8,316        | 15.7    | 75.0    | 56.8 | 10.1               | 101.8    | 0.18 |
| DISTA             | 8,316        | 11.1    | 66.9    | 40.7 | 8.5                | 72.9     | 0.21 |
| Inferred Blocks   | Valid Blocks | Minimum | Maximum | Mean | Standard Deviation | Variance | CoV  |
| Li <sub>2</sub> O | 3,611        | 0.002   | 2.145   | 1.2  | 0.5                | 0.2      | 0.38 |
| NDDH              | 3,611        | 1       | 1       | 1.0  | 0.0                | 0.0      | 0.00 |
| NCOMP             | 3,611        | 2       | 3       | 3.0  | 0.2                | 0.0      | 0.10 |
| DISTC             | 3,611        | 1.4     | 74.7    | 38.4 | 16.1               | 260.5    | 0.42 |
| DISTF             | 3,611        | 2.5     | 74.7    | 39.9 | 16.3               | 265.8    | 0.41 |
| DISTA             | 3,611        | 2.1     | 74.7    | 39.1 | 16.2               | 263.0    | 0.42 |

The classification and distribution of resource blocks is shown graphically in Figure 14.6.

**Figure 14.6**  
**Measured, Indicated, and Inferred Grade Shells for a Cut-off grade of 0.6% Li<sub>2</sub>O**



Green=measured, blue=indicated, inferred=grey.

### 14.1.8 Lithium Mineral Resource Estimate

The 21 October, 2016 Measured plus Indicated resource estimate for Separation Rapids is 8.00 Mt at an average grade of 1.29% Li<sub>2</sub>O at a cut-off grade of 0.6% Li<sub>2</sub>O. See Table 14.13. The cut-off grade is considered to be a reasonable economic cut-off prior to the establishment of detailed operating costs and revenue. It is lower than the previous estimate (Micon, 1999) which used a 1.0% Li<sub>2</sub>O cut-off grade.

The resource outcrops at the surface. An additional Inferred resource of 1.63 Mt at 1.42% Li<sub>2</sub>O is mostly located greater than 150 m below surface.

**Table 14.13**  
**Separation Rapids, Mineral Resource Estimate at Multiple Cut-off Grades as at 21 October, 2016**

| Class                   | Cut-off Grade (Li <sub>2</sub> O %) | Tonnes (Mt) | Li <sub>2</sub> O (%) | Total Feldspar (%) | Ta <sub>2</sub> O <sub>5</sub> (%) | Cs <sub>2</sub> O (%) | Rb <sub>2</sub> O (%) | Specific Gravity |
|-------------------------|-------------------------------------|-------------|-----------------------|--------------------|------------------------------------|-----------------------|-----------------------|------------------|
| Measured                | 0.3                                 | 4.31        | 1.26                  | 39                 | 0.006                              | 0.017                 | 0.337                 | 2.67             |
|                         | 0.6                                 | 4.03        | 1.32                  | 39                 | 0.006                              | 0.017                 | 0.343                 | 2.66             |
|                         | 1                                   | 3.42        | 1.41                  | 39                 | 0.006                              | 0.015                 | 0.351                 | 2.65             |
| Indicated               | 0.3                                 | 4.23        | 1.21                  | 39                 | 0.007                              | 0.025                 | 0.352                 | 2.68             |
|                         | 0.6                                 | 3.97        | 1.26                  | 39                 | 0.007                              | 0.025                 | 0.362                 | 2.67             |
|                         | 1                                   | 3.13        | 1.24                  | 39                 | 0.007                              | 0.021                 | 0.381                 | 2.66             |
| Measured plus Indicated | 0.3                                 | 8.54        | 1.24                  | 39                 | 0.006                              | 0.020                 | 0.344                 | 2.65             |
|                         | 0.6                                 | 8.00        | 1.29                  | 39                 | 0.006                              | 0.021                 | 0.352                 | 2.66             |
|                         | 1                                   | 6.55        | 1.40                  | 39                 | 0.006                              | 0.018                 | 0.365                 | 2.65             |
| Inferred                | 0.3                                 | 1.78        | 1.33                  | 39                 | 0.007                              | 0.017                 | 0.372                 | 2.65             |
|                         | 0.6                                 | 1.63        | 1.42                  | 39                 | 0.008                              | 0.016                 | 0.360                 | 2.64             |
|                         | 1                                   | 1.43        | 1.49                  | 39                 | 0.008                              | 0.014                 | 0.369                 | 2.63             |

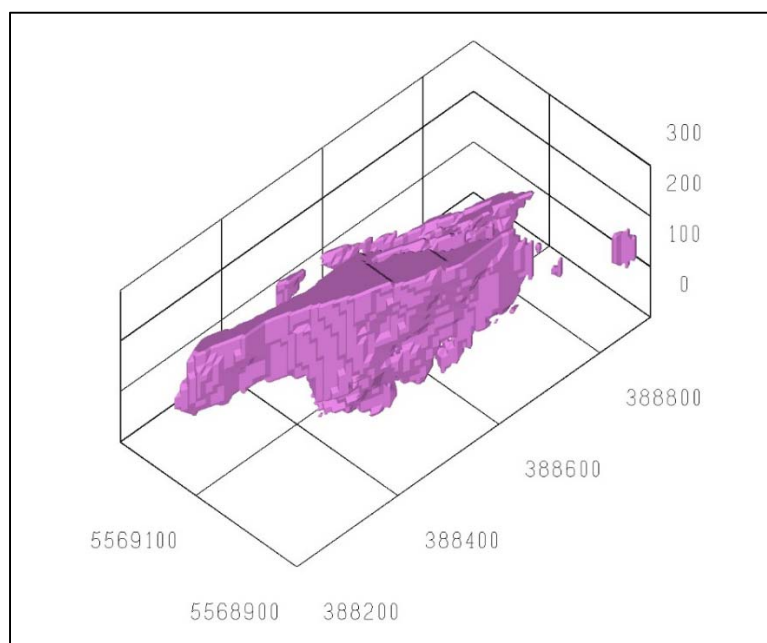
Notes:

1. CIM Definition Standards for Mineral Resources and Mineral Reserves, 10 May, 2014 were followed for this mineral resource estimate.
2. The Qualified Person for this mineral resource is David L. Trueman, Ph.D.,P.Geo.(MB).
3. The resource estimate is constrained by a 3D geologic model of the mineralized material.
4. Assay intervals for Li<sub>2</sub>O, Ta<sub>2</sub>O<sub>5</sub>, Cs<sub>2</sub>O and Rb<sub>2</sub>O were interpolated using the Inverse Distance Weighted method to create a 3D block model.
5. The resource cut-off grade of 0.6% Li<sub>2</sub>O was chosen to capture mineralization that is potentially amenable to mining, mineral concentration and off-site processing.
6. Li, Ta, Cs and Rb were originally analysed on all samples at XRAL Laboratory (Thunder Bay, Ontario) utilizing ICP (Li, Ta) and AA (Rb and Cs) and check analyses completed at CHEMEX Laboratory (Don Mills, Ontario) utilizing AA (Li) and ICP (Rb).
7. As well as due diligence to verify historic data, Avalon completed additional check analyses of historic drill core in 2016 utilizing ALS Laboratory (Vancouver) with a combination of fusion and ICP (method CCP-PKG01). Included as QA/QC procedures was a lithium rock standard within the check analysis batches.
8. Total Feldspar is the total of potassium feldspar (microcline) and sodium feldspar (albite) and the value reflects the mean and median value of all samples with quantitative mineralogy determined.
9. The percentage of Total Feldspar is based on analyses completed utilizing X-Ray diffraction and Qemscan® instrumentation on samples representing all lithological subunits of the mineral deposit. These analyses were completed at Carleton University in 1999 (XRD) and ALS Global Laboratory in

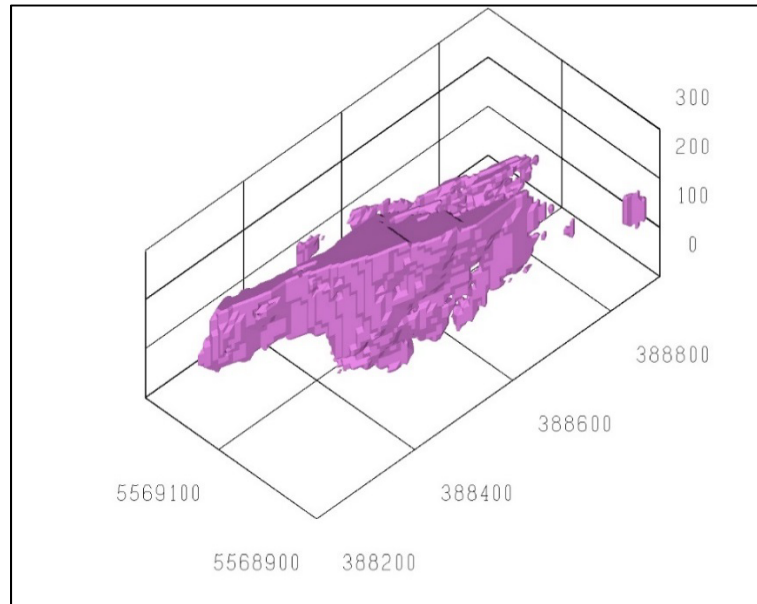
- 2016 (XRD and Qemscan®, Kamloops). This is supported by quantitative mineralogy of metallurgical samples determined at SGS Lakefield and Dorfner ANZAPLAN (Germany).
10. All figures are rounded to reflect the relative accuracy of the estimates. Summation of individual columns may not add-up due to rounding.
  11. Mineral Resources are not Mineral Reserves and do not have demonstrated economic viability. There is no certainty that all or any part of the Mineral Resource will be converted into Mineral Reserves.
  12. In addition, while the terms “measured”, “indicated” and “inferred” mineral resources are required pursuant to National Instrument 43-101, the U.S. Securities and Exchange Commission does not recognize such terms. Canadian standards differ significantly from the requirements of the U.S. Securities and Exchange Commission, and mineral resource information contained herein is not comparable to similar information regarding mineral reserves disclosed in accordance with the requirements of the U.S. Securities and Exchange Commission. U.S. investors should understand that “inferred” mineral resources have a great amount of uncertainty as to their existence and great uncertainty as to their economic and legal feasibility. In addition, U.S. investors are cautioned not to assume that any part or all of Avalon’s mineral resources constitute or will be converted into reserves.

The Measured plus Indicated resource grade shells at cut-off grades of 0.3% Li<sub>2</sub>O, 0.6% Li<sub>2</sub>O and 1.0% Li<sub>2</sub>O are shown in Figure 14.7, Figure 14.8 and Figure 14.9.

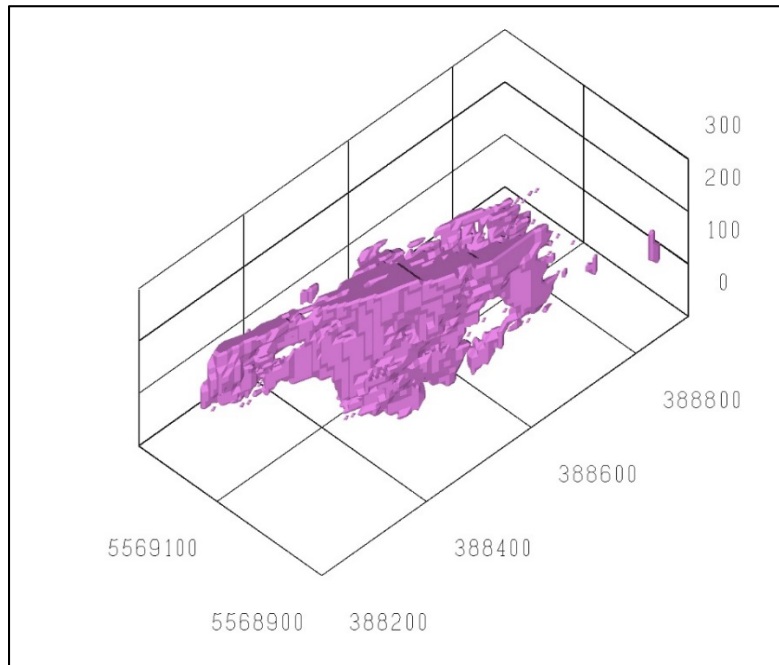
**Figure 14.7**  
**Measured Plus Indicated Resource Grade Shells at 0.3% Li<sub>2</sub>O Cut-off Grade**



**Figure 14.8**  
**Measured Plus Indicated Resource Grade Shells at 0.6% Li<sub>2</sub>O Cut-off Grade**

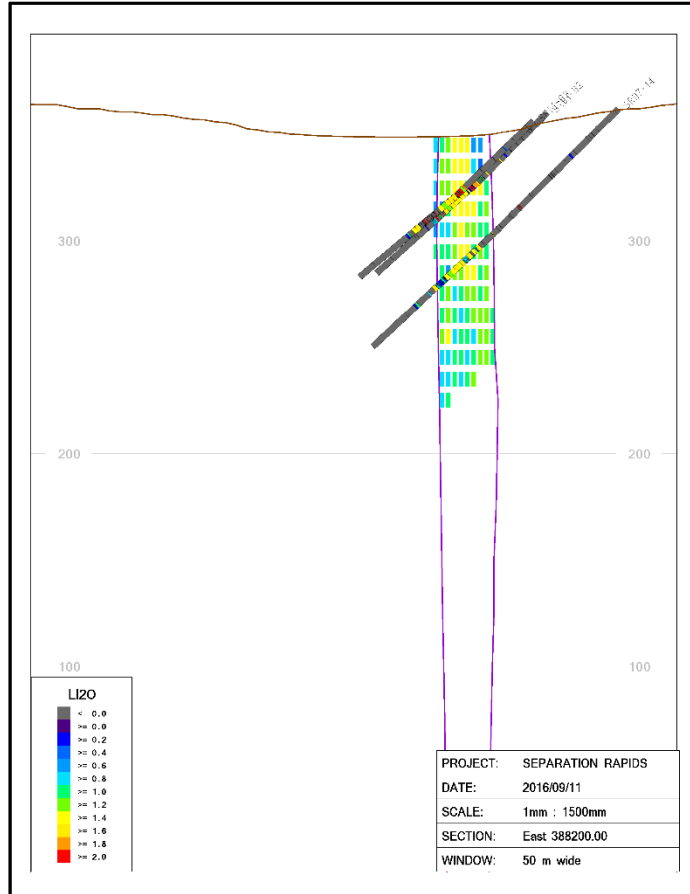


**Figure 14.9**  
**Measured Plus Indicated Resource Grade Shells at 1.0% Li<sub>2</sub>O Cut-off Grade**

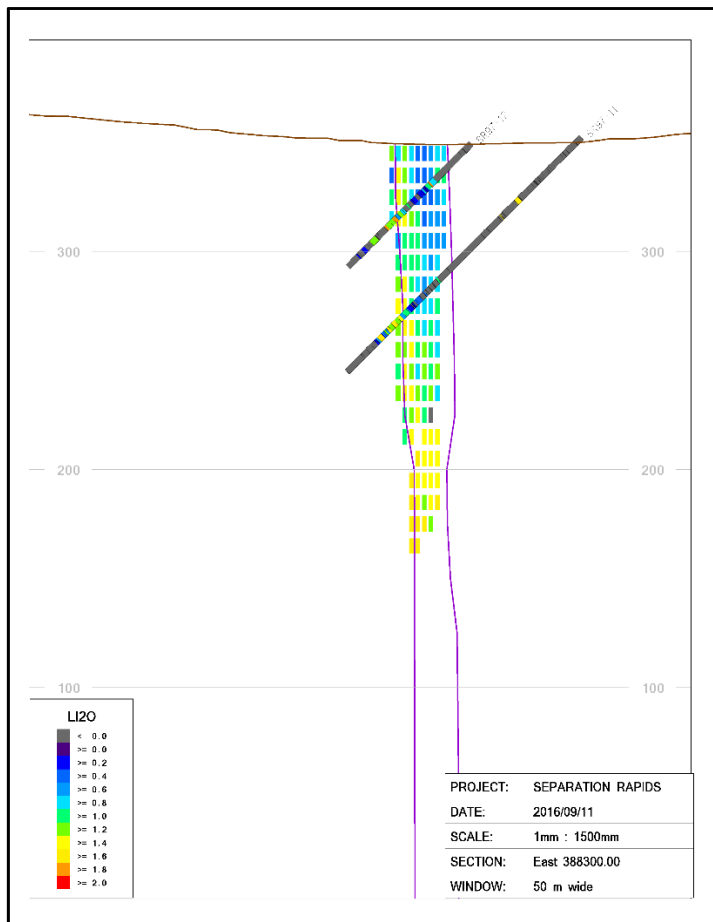


Cross-sections illustrating the nature of the block model are shown in Figure 14.10 to Figure 14.14. The sections show the grades in the drill hole samples and blocks with the same colour scheme.

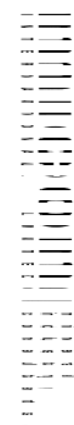
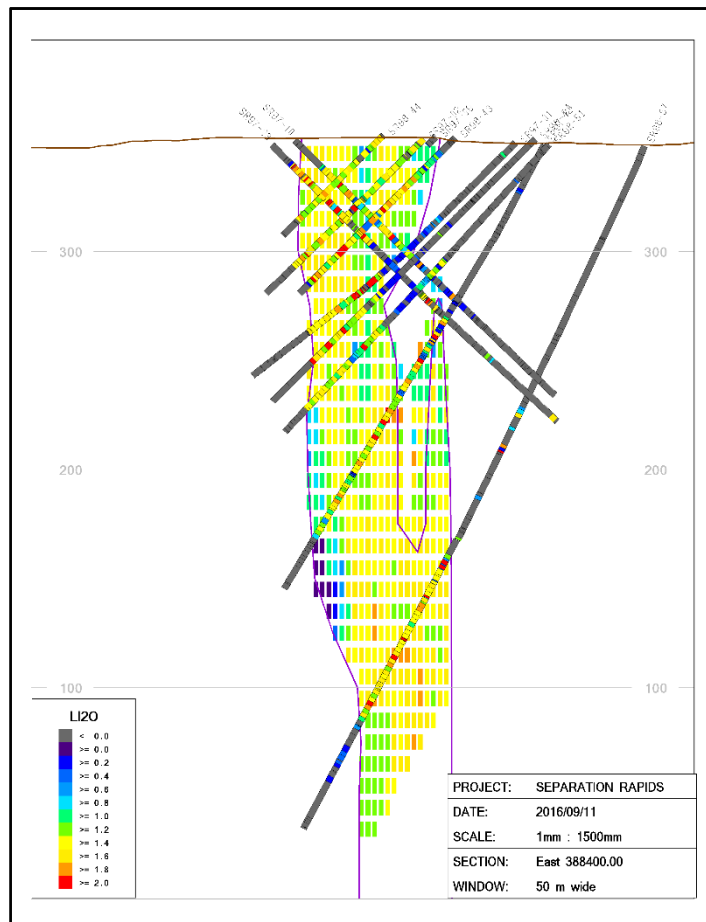
**Figure 14.10**  
**Cross Section 388200 East with Drill Holes and Resource Blocks (looking west)**



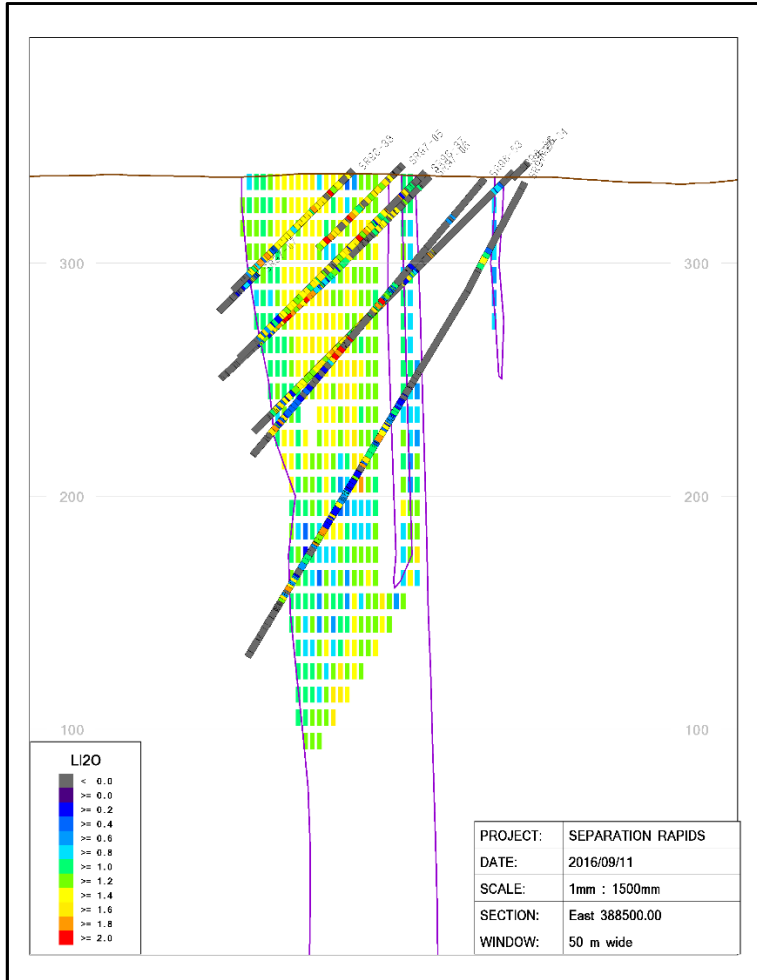
**Figure 14.11**  
**Cross Section 388300 East with Drill Holes and Resource Blocks**  
**(looking west)**



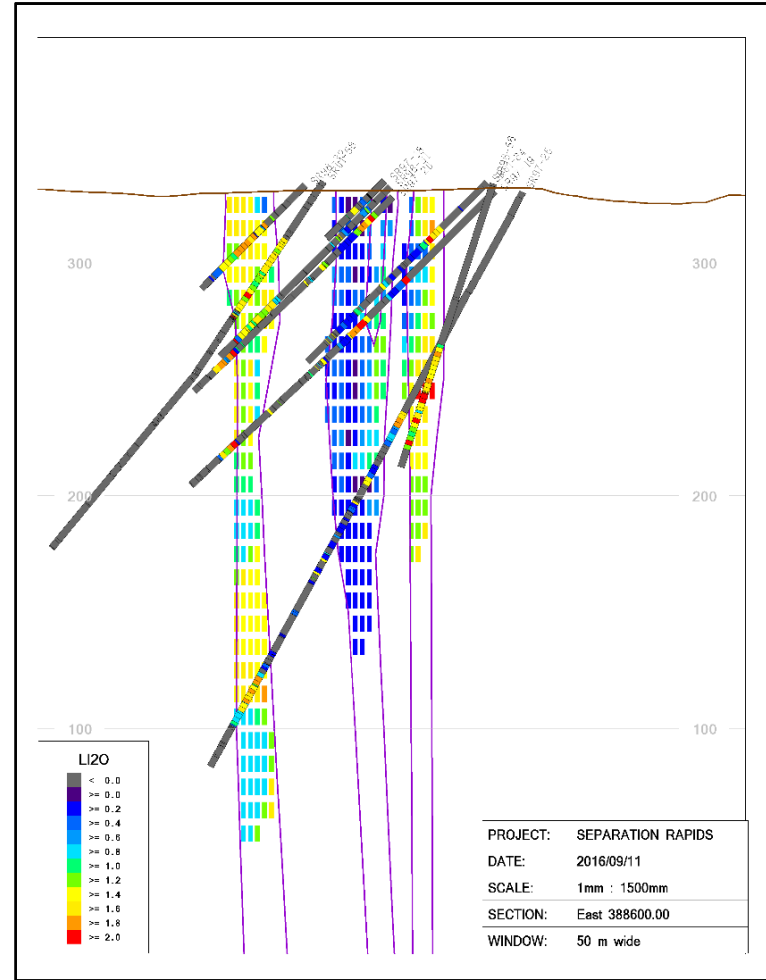
**Figure 14.12**  
**Cross Section 388400 East with Drill Holes and Resource Blocks**  
**(looking west)**



**Figure 14.13**  
**Cross Section 388500 East with Drill Holes and Resource Blocks**  
**(looking west)**



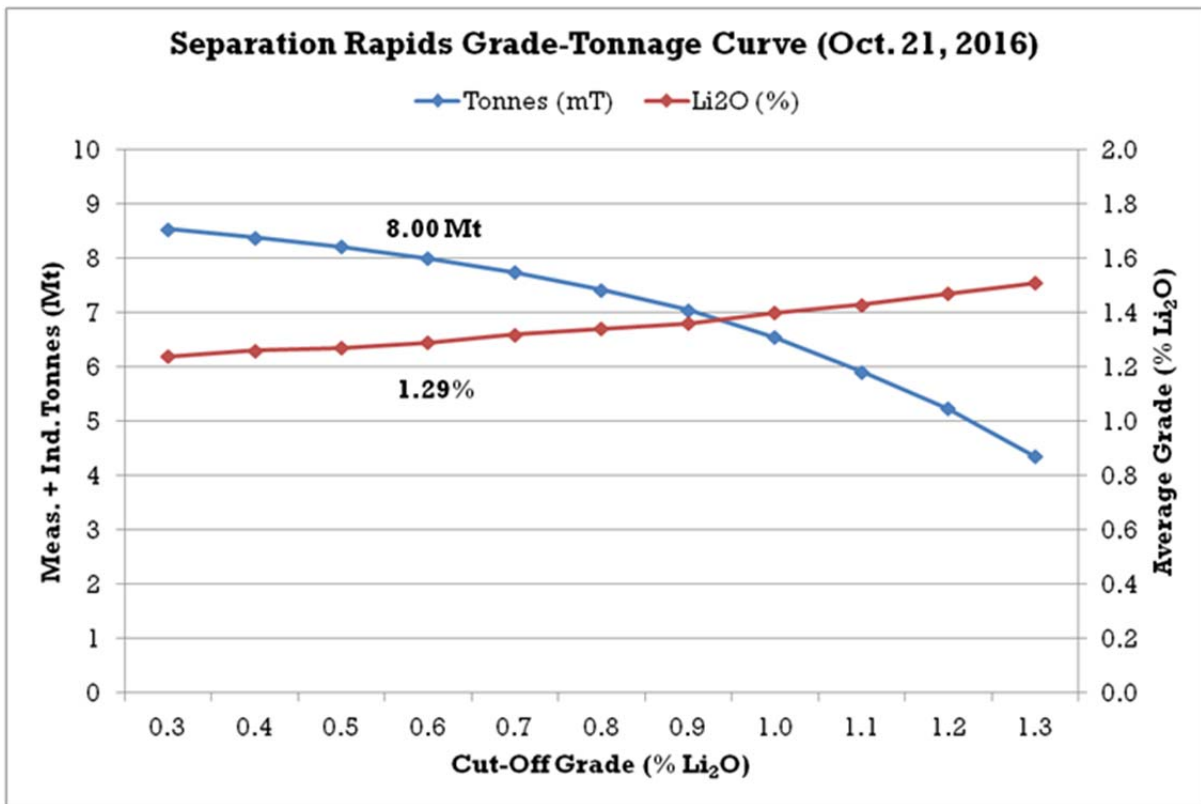
**Figure 14.14**  
**Cross Section 388600 East with Drill Holes and Resource Blocks**  
**(looking west)**



### 14.1.9 Grade-Tonnage Curve

The grade-tonnage curve for the Separation Rapids resource estimate shows that additional tonnes are available at lower cut-off grades, as shown in Figure 14.15. However, cut-off grades below about 0.9% Li<sub>2</sub>O will increase the amount of dilution by amphibolite within the resource since, as noted above, block grades lower than 0.9% Li<sub>2</sub>O are most likely due to dilution and not low tenor in the lithium pegmatite.

**Figure 14.15**  
Separation Rapids, Grade-tonnage Curve for the 21 October, 2016 Measured plus Indicated Mineral Resource



The corresponding statistics are provided in Table 14.14.

**Table 14.14**  
Grade-tonnage Data for Measured Plus Indicated Mineral Resources

| Cut-off Grade (Li <sub>2</sub> O %) | Tonnes (Mt) | Li <sub>2</sub> O (%) |
|-------------------------------------|-------------|-----------------------|
| 0.3                                 | 8.54        | 1.24                  |
| 0.4                                 | 8.38        | 1.26                  |
| 0.5                                 | 8.21        | 1.27                  |
| <b>0.6</b>                          | <b>8.00</b> | <b>1.29</b>           |
| 0.7                                 | 7.74        | 1.32                  |



| Cut-off Grade<br>(Li <sub>2</sub> O %) | Tonnes<br>(Mt) | Li <sub>2</sub> O<br>(%) |
|--|----------------|--------------------------|
| 0.8                                    | 7.42           | 1.34                     |
| 0.9                                    | 7.05           | 1.36                     |
| 1.0                                    | 6.55           | 1.40                     |
| 1.1                                    | 5.91           | 1.43                     |
| 1.2                                    | 5.23           | 1.47                     |
| 1.3                                    | 4.35           | 1.51                     |

#### 14.1.10 Comparison to Previous Mineral Resource Estimate

A previous mineral resource estimate for the Separation Rapids property was completed by Micon in September, 1999 (Micon, 1999). See Table 14.15. The current resource estimate utilizes updated geological models, new specific gravity data, and the use of fractional blocks (ORE%6) for resource estimation.

The present resource tonnage is 26% lower than the 1999 Micon estimate. However, 6% percent of the resource blocks in the 1999 estimate were assigned an average grade rather than an interpolated grade, so the tonnage difference of interpolated blocks in the current estimate is 20% lower.

**Table 14.15**  
Micon September 1999 Estimate at 1.0% Li<sub>2</sub>O Cut-off Grade

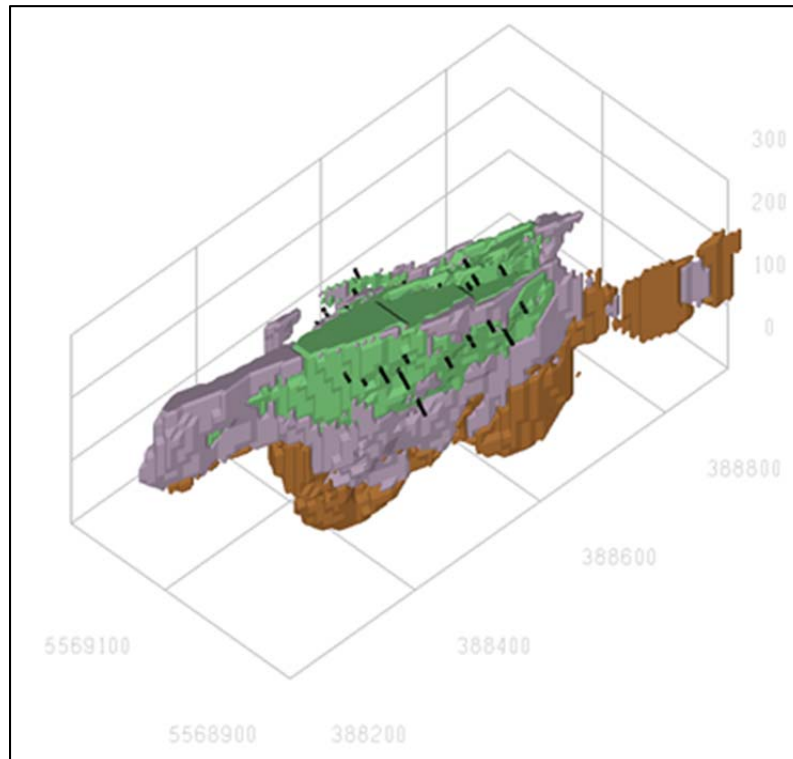
| Class                          | Tonnes<br>(Mt) | Li <sub>2</sub> O<br>(%) |
|--------------------------------|----------------|--------------------------|
| Indicated                      | 8.9            | 1.34                     |
| Inferred                       | 2.7            | 1.34                     |
| Resource above 200 m elevation |                |                          |
| Indicated                      | 7.9            | 1.40                     |

## 14.2 ESTIMATED FELDSPAR RESOURCES

The Separation Rapids Lithium Project is a potential producer of high purity feldspar, a mixture of albite and potassium feldspar, in addition to lithium chemicals and/or petalite. The feldspar content of the pegmatite is described in detail in Section 7.0 which covers the mineralogy of the deposit.

Figure 14.16 shows the locations of the samples for which quantitative mineralogy, including feldspar content, has been determined. It is important to note that these samples are well distributed throughout the deposit and that the figure can thus be considered a good spatial representation of the deposit.

**Figure 14.16**  
**Locations of Quantitative Mineralogy Samples that Includes Detailed Feldspar Content within Resource Model**



Green – Measured Blocks, Grey – Indicated Blocks, Brown – Inferred Blocks

Table 14.16 is an abbreviated version of the overall mineralogy table from Section 7.0 (Table 7.14) which shows four studies of mineralogy totalling 31 samples. The ALS samples represent drill core assay intervals and are determinations on pulverized samples, thus representing intervals of core rather than individual hand samples. Most of the samples are located within blocks designated as Measured resources.

These studies, with the addition of Pedersen (2016) which covered all drill core logging but not a specific number of samples, show a range of feldspar contents from 29-47% and mean values of 37-43%. The data show that the feldspar is 9-10% potassium feldspar and 27-30% albite. As discussed in Section 7.0, the visual estimates of drill core (Pedersen 2016a) underestimate the albite content and overestimate the potassium feldspar content. It is important to note that these studies do not show a significant difference in feldspar content for Subunits 6a, 6b, 6c, and 6d of Unit 6.

**Table 14.16**  
**Average Feldspar Contents at Separation Rapids**

| Mineral Estimate   | Pedersen<br>Average<br>2016<br>(%) | Taylor, 1999<br>Modal Range<br>(%) | Mean Taylor<br>1999<br>(± 5) | ALS<br>Qemscan®<br>2016<br>(%) |
|--------------------|------------------------------------|------------------------------------|------------------------------|--------------------------------|
| Number of samples  | NAP                                | 11                                 | 11                           | 16                             |
| Potassium feldspar | 22.5                               | 7-17                               | 10.0                         | 10.25                          |
| Albite             | 18.8                               | 22-30                              | 27.0                         | 30.09                          |
| Total feldspar     | 43.3                               | 29-47                              | 37                           | 40.35                          |

NAP – not applicable.

Table 14.17 presents mineralogical determinations in metallurgical bulk samples that represent large samples for metallurgical testwork. The samples were all collected from the excavation located within the surface outcrop of the deposit. Thus, the samples represent near-surface material, but also material that is within the Measured resources of the deposit. The mean and median are close to, but are all greater than 39% total feldspar, which is the average value from the individual samples described above.

**Table 14.17**  
**Feldspar Contents of Metallurgical Bulk Samples**

| Laboratory     | ANZAPLAN<br>Bulk Sample<br>(2016) | SGS                   |                      |       |        |
|----------------|-----------------------------------|-----------------------|----------------------|-------|--------|
|                |                                   | Bulk Sample<br>(1999) | BulkSample<br>(2013) | Mean  | Median |
| Na-Feldspar    | 30.38                             | 30.70                 | 28.18                | 29.75 | 30.38  |
| K-Feldspar     | 9.35                              | 9.00                  | 16.29                | 11.55 | 9.35   |
| Total Feldspar | 39.73                             | 39.70                 | 44.47                | 41.30 | 39.73  |

The mean and median total feldspar contents of 28 determinations throughout the SRLD are 39.1% and 39.0%, respectively. Thus, the estimated Measured plus Indicated feldspar resource presented in Table 14.1 and Table 14.13 is 8.0 Mt at 39% total feldspar.

## **15.0 MINERAL RESERVE ESTIMATES**

Mineral reserves estimates have not been undertaken for the Separation Rapids project and are not presented herein.

## 16.0 MINING METHODS

The property is relatively flat with an average elevation of approximately 350 masl. Local topographic relief is limited to about 50 m. Outcrop exposure is in general less than 40% in the project area, but the area containing the SRLD has been stripped of ground cover or trenched. The remainder of the property is covered by thin glacial till deposits and soils, local swamps and marshes and river bottom sediments.

### 16.1 PIT OPTIMIZATION

Micon has undertaken pit optimization calculations for the PEA using the mineral resource block model prepared by BMW Geoscience LLC. Micon imported the block model into Surpac™ to create a block model compatible with the pit optimization software.

A preliminary optimization was performed using Whittle™ software. Cost parameters, derived from the operating cost estimate (see Section 21.0), were applied to the optimization model to assess the volume of mineral resources available for economic development. The purpose of the modelling was to generate an estimate of the mineable tonnage based on the mineral resources presented in Section 14.0.

The Whittle™ programme comprises three components, the ultimate pit shell generator, a push back generator, and the optimizing scheduler. The ultimate pit generator is the first stage of the optimization process and utilises a Lerchs-Grossman (LG) algorithm to generate an economic open pit shell from the mineral resource block model based on the initial input parameters. The second component is the push back generator which sequences a series of pushbacks according to the LG phases. The third component is the scheduler and is used to create optimum mining schedules.

#### 16.1.1 Optimization Parameters

The MineSight™ block model for the Separation Rapids deposit was imported into Surpac™ and then imported in Whittle™. The pit optimization iterations were based on a single processing method targeting only the lithium oxide (Li<sub>2</sub>O) as the final product. The input parameters are summarized in Table 16.1.

**Table 16.1**  
**Separation Rapids, Open Pit Optimization Parameters**

| Category                 | Unit             | Value   |
|--------------------------|------------------|---------|
| Production rate          | t/y              | 800,000 |
| Slope angle              | °                | 55      |
| Mineralization density   | t/m <sup>3</sup> | 2.62    |
| Waste density            | t/m <sup>3</sup> | 3.04    |
| Mining costs             | \$/t mined       | 3.00    |
| Incremental mining costs | \$/t mined       | 0.007   |
| Mining recovery          | %                | 100     |
| Mining Dilution          | %                | 0.0     |

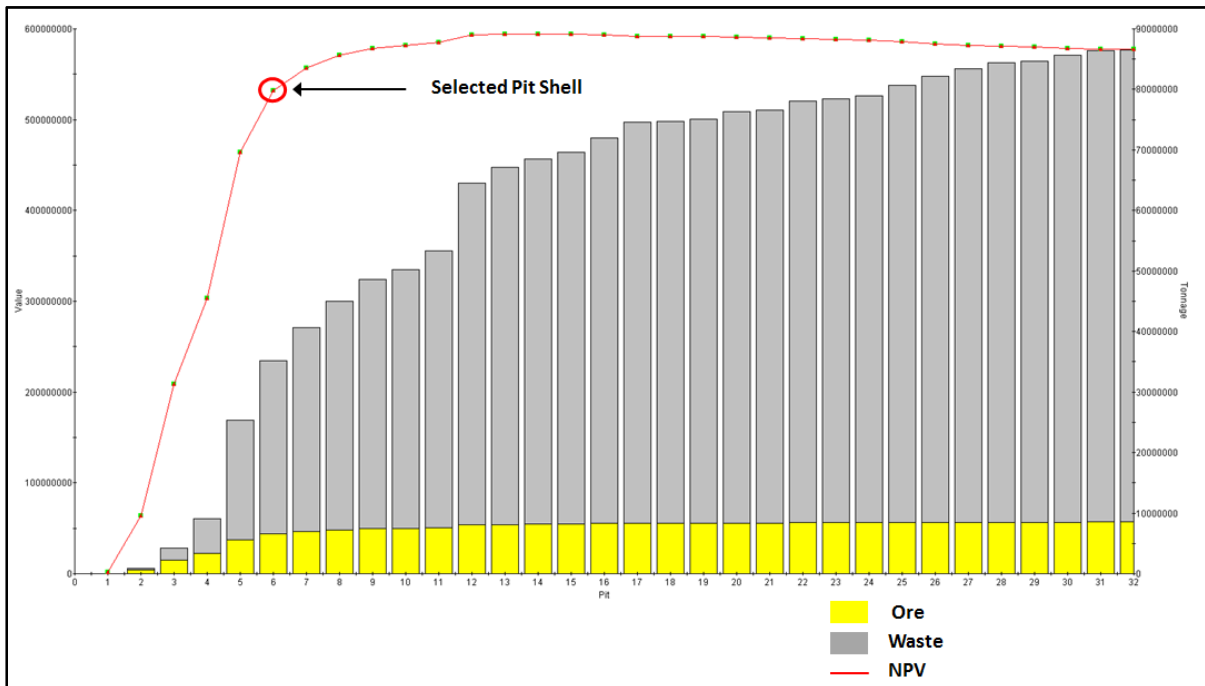
| Category                    | Unit             | Value  |
|-----------------------------|------------------|--------|
| Processing Costs            | \$/t milled      | 81.80  |
| G&A Costs                   | \$/t milled      | 5.04   |
| Transport                   | \$/t concentrate | 15.15  |
| Process Recovery            | %                | 42.90  |
| Product Grade               | %                | 35.60  |
| Price LiOH.H <sub>2</sub> O | \$/t             | 12,350 |
| Price Li <sub>2</sub> O     | \$/t             | 34,580 |
| Exchange Rate               |                  | 1.30   |

### 16.1.2 Results

The pit optimization calculations using the above parameters indicated that the cut-off grade was approximately 0.83% Li<sub>2</sub>O and the initial optimization run resulting in mill feedstock tonnes of 9.4 Mt at a grade of 1.2% Li<sub>2</sub>O.

Avalon expressed a desire to extract over the life of mine a resource of 8.0 Mt at 1.4% Li<sub>2</sub>O. This was achieved by applying an artificial cut-off grade of 1% Li<sub>2</sub>O and provided a reliable outcome. As a result of optimization, a number of ultimate pit shells were produced, as shown in Figure 16.1.

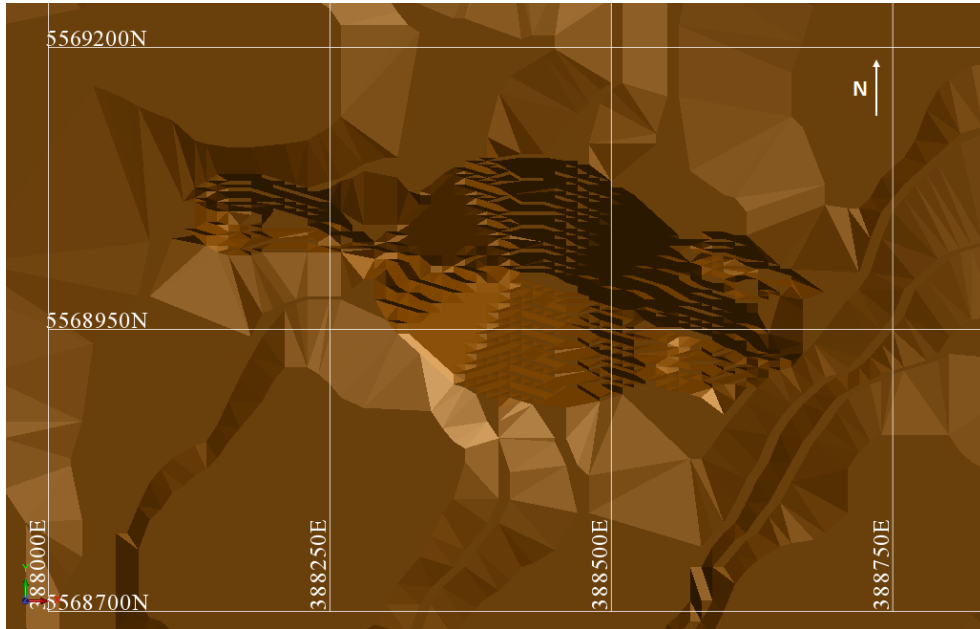
**Figure 16.1**  
**Pit Optimization Results by Pit Shell**



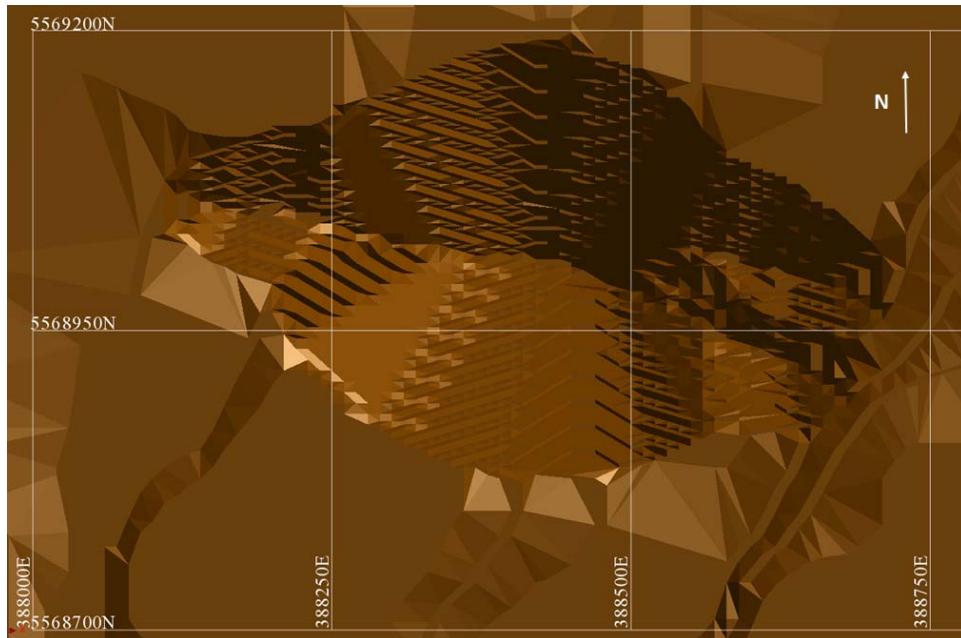
Each of the ultimate pit shells (final pit envelope) contains the maximum mineable resources for the given economic criteria, based upon maximizing NPV. The NPV in these models consider operating costs, but not capital costs. Pit shell 6 was chosen as the optimum pit

because it is the inflection point of the pit shell graph. Beyond that point, there is a significant increase in waste tonnage. Figure 16.2 and Figure 16.3 show the starter and the optimum pit shells.

**Figure 16.2**  
**Starter Pit Shell**



**Figure 16.3**  
**Optimum Pit Shell**



As a consequence of Pit 6 being selected, it was determined that material below the 1% Li<sub>2</sub>O cut-off grade will need to be extracted to achieve the full life of mine resource, approximately 2.0 Mt with a grade of 0.66% Li<sub>2</sub>O.

The production rate was amended to 700,000 t/y of the higher grade material in conjunction with 250,000 t/y of the lower grade material, below 1% Li<sub>2</sub>O. This change did not have any effect on the selection of the optimum pit shell; Pit 6 was used as a template for the pit design.

## 16.2 PIT DESIGN

A conceptual pit design was conducted from the bottom up using the recommended slope design parameters shown in Table 16.2 and the optimum pit shell 6 as a template. The bench to bench face angle is 80°. A safety berm width of 4 m was applied every 10 m bench except where an 8 m safety berm has been used every third bench. A haul road width of 15 m was used from the pit base, 95 level to the surface on the assumption that two-way traffic would be operating in the mine.

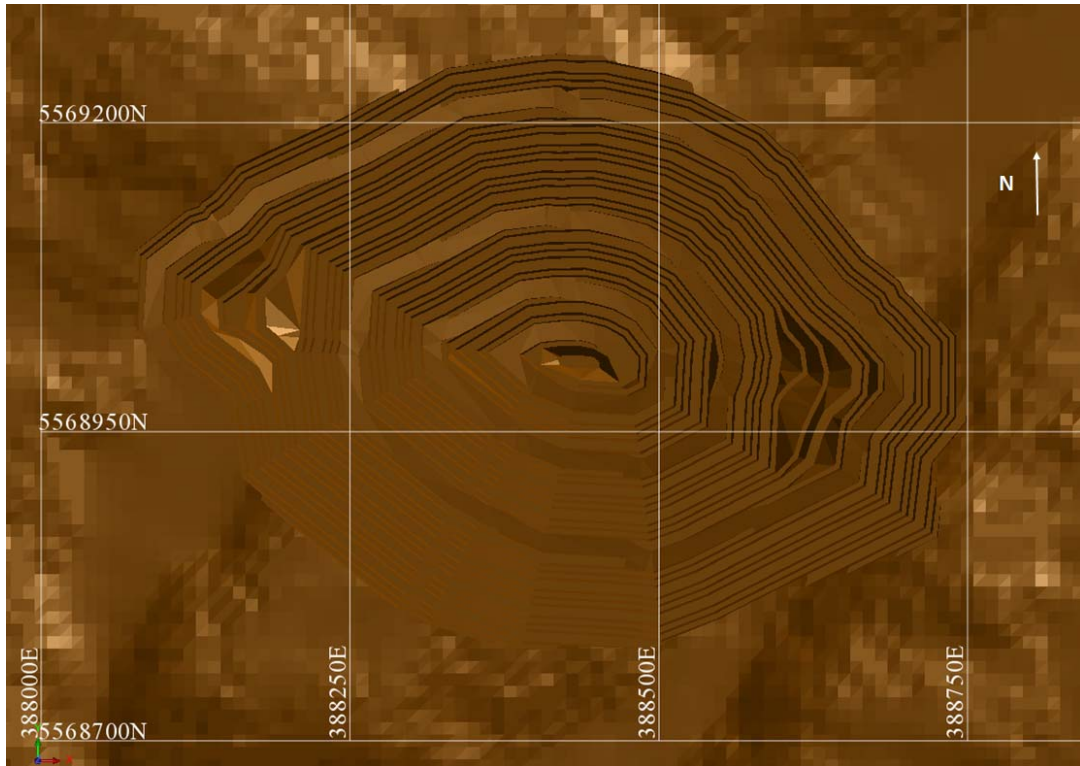
**Table 16.2**  
**Pit Design Parameters**

| Category  | Value    |
|---|----------|
| Pit Base  | 95 level |
| Wall Angle Between Benches                      | 80°      |
| Height of Bench                                 | 10 m     |
| Safety Berm Width                               | 4 m      |
| Safety Berm Width (every 3 <sup>rd</sup> bench) | 8 m      |
| Haul Road Gradient                              | 1:10     |
| Haul Road Width                                 | 15 m     |

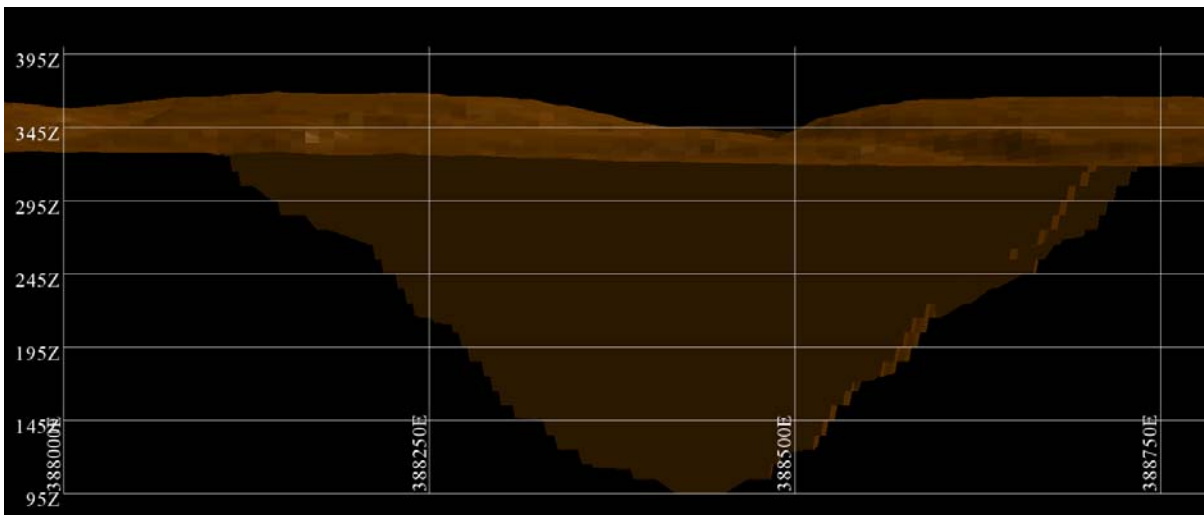
During the pit design process, the pit contours were extended beyond the topography to enable the pit and digital terrain model (DTM) and the topography DTM to intersect. Figure 16.4 and Figure 16.5 show a plan and long section view of the pit design.



**Figure 16.4**  
**Plan View of the Pit Design**



**Figure 16.5**  
**West-East Long Section View of the Pit Design**



## **16.3 MINING METHOD**

### **16.3.1 Open Pit**

The proposed method of mining is by conventional open pit methods using drilling and blasting, loading with excavators and shovels and hauling with rigid dump trucks. The mineralization will be excavated by hydraulic excavator to allow selectivity and the waste will be loaded by dedicated hydraulic excavators to allow for high outputs.

The deposit is near surface and suitable for conventional truck and shovel open pit mining. The topsoil and any sensitive material will be removed and stockpiled in a specific site. This material will be used in the rehabilitation of mine site at the end of operations. Waste from the pit will initially be composed of overburden and will be dumped in the topsoil stockpile. As the pit is developed harder waste rock will be excavated and will be stored on a separate aggregate stockpile.

There will be a requirement for a low and high grade mineralized material stockpiles to be positioned adjacent to the primary crusher.

## **16.4 CONTRACTOR VERSUS OWNER OPERATED MINING**

The project will be undertaken by contractor-operated equipment and labour. This was selected as the base case following a cost comparison of Owner versus contractor mining operations.

## **16.5 MINE DEVELOPMENT**

The mine development activities will commence with the removal of the trees. Topsoil will then be excavated and stockpiled.

A new site access road is to be built; the preproduction stripping of waste will be used to construct site roads, including the main haul roads. Waste material will also be used for the construction of concentrate, settling pond and tailing dam walls.

## **16.6 PRODUCTION SCHEDULE**

A production schedule has been produced in MineSched™ software. This program uses block model information, together with pit locations, mining strategy, constraints, production data and targets to produce a schedule in tabular form of quantities and qualities.

Production data in the form of annual rates are input, as well as the locations of where and in what sequence mining is to take place. Quality and material ratio targets can be specified to guide the program to achieve the best schedule.

The production schedule shown in Table 16.3 is based on mining 700,000 t/y of high grade and 250,000 t/y of low grade material. The life of the mine is expected to be 10 years with approximately 7.0 Mt of high grade mineralized material at 1.41% Li<sub>2</sub>O and 2.4 Mt of low grade mineralized material at 0.66% Li<sub>2</sub>O mined over the length of the project.

## **16.7 MINING FLEET**

The majority of the mining and support equipment will be diesel powered. The main loading equipment will be hydraulic backhoe excavators. A front-end loader will be used for bench and haul management as well as providing backup support in the pit.

The assumptions for the fleet calculation were based on 22 hours per day, 7 days per week and 50 weeks per year.

### **16.7.1 Main Mining Equipment**

For this level of study, the main mining equipment selection is based on a Caterpillar 6020 diesel hydraulic backhoe excavator with a 12 m<sup>3</sup> bucket capacity. This excavator was selected for its reliability and performance. Two units will be required for both mineralized mill feed and waste excavation which is based on each unit working 7,700 h/y with 95% availability and 75% operator efficiency.

The haul trucks selected are Caterpillar 777 rigid body trucks with a 60.4 m<sup>3</sup> capacity and capable of moving 90 t loads. These trucks were selected for their reliability and performance, combined with good size matching to the Caterpillar 6020 excavator. It is estimated that eight trucks will be required during the peak activity period in Years 2 and 3 (including one service spare). This is based on each unit working 7,700 h/y with 85% availability and 85% operator efficiency.

**Table 16.3  
Separation Rapids Production Schedule**

| Category              | Unit /Year                | 1                | 2                | 3                | 4                | 5                | 6                | 7                | 8                | 9                | 10               | Total             |
|-----------------------|---------------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|-------------------|
| <b>High Grade</b>     | Tonnes                    | 700,000          | 700,000          | 700,000          | 700,000          | 700,000          | 700,000          | 700,000          | 700,000          | 700,000          | 700,000          | <b>6,956,112</b>  |
|                       | Grade % Li <sub>2</sub> O | 1.39             | 1.38             | 1.38             | 1.37             | 1.37             | 1.38             | 1.41             | 1.43             | 1.46             | 1.53             | <b>1.41</b>       |
| <b>Low Grade</b>      | Tonnes                    | 250,000          | 250,000          | 250,000          | 250,000          | 250,000          | 250,000          | 250,000          | 250,000          | 250,000          | 131,46           | <b>2,381,046</b>  |
|                       | Grade % Li <sub>2</sub> O | 0.70             | 0.64             | 0.63             | 0.63             | 0.66             | 0.65             | 0.65             | 0.71             | 0.72             | 0.55             | <b>0.66</b>       |
| <b>Combined Total</b> | Tonnes                    | 950,000          | 950,000          | 950,000          | 950,000          | 950,000          | 950,000          | 950,000          | 950,000          | 950,000          | 787,158          | <b>9,337,158</b>  |
|                       | Grade % Li <sub>2</sub> O | 1.21             | 1.18             | 1.18             | 1.18             | 1.18             | 1.19             | 1.21             | 1.24             | 1.27             | 1.36             | <b>1.22</b>       |
| <b>Waste</b>          | Tonnes                    | 6,175,000        | 7,125,000        | 7,125,000        | 6,840,000        | 6,175,000        | 5,225,000        | 4,512,500        | 3,800,000        | 3,040,000        | 2,114,349        | <b>52,131,849</b> |
| <b>Strip Ratio</b>    | t:t                       | 6.5              | 7.5              | 7.5              | 7.2              | 6.5              | 5.5              | 4.8              | 4.0              | 3.2              | 2.7              | <b>5.6</b>        |
| <b>Total Material</b> | <b>Tonnes</b>             | <b>7,125,000</b> | <b>8,075,000</b> | <b>8,075,000</b> | <b>7,790,000</b> | <b>7,125,000</b> | <b>6,175,000</b> | <b>5,462,500</b> | <b>4,750,000</b> | <b>3,990,000</b> | <b>2,901,507</b> | <b>61,469,007</b> |

## 16.7.2 Ancillary Equipment

The ancillary equipment required to support the mining activities includes drill rigs, explosives plant and trucks, tracked dozers, fuel and lubrication truck, a motor grader, water trucks for dust suppression, light vehicles and lighting plant. Table 21.7 summarizes the specifications of the ancillary equipment and the number of units required.

**Table 16.4**  
**Summary of Ancillary Equipment**

| <b>Ancillary Equipment</b>     | <b>Number</b> |
|--------------------------------|---------------|
| Front End Loader (Cat 992)     | 1             |
| Drill Rig (Sandvik D45KS)      | 2             |
| Blast Truck (Tread 4216)       | 1             |
| AN and Emulsion Plant (10 t/d) | 1             |
| Dozer (Cat D9T)                | 1             |
| GP Tool Handler (Cat ITH 62)   | 1             |
| Fuel/Lube Truck (Bell 35D)     | 1             |
| Water Truck (Bell 35D)         | 1             |
| Telehandler (Cat TH580B)       | 1             |
| Excavator/Secondary Breaker    | 1             |
| Grader (Cat 16M)               | 1             |
| Light Vehicles                 | 8             |
| Lighting sets                  | 8             |

## 16.8 LABOUR

Labour costs have been broken down by department. These are management, technical services and tradesmen, supervisors and production. The shift rotation would be based on two, twelve-hour shifts with three crews, two-on and one-off at any one time. Senior management and administration will work a five to six-day week on day shift only roster. Table 16.5 summarises the labour requirements for the project.

**Table 16.5**  
**Labour Requirements**

| <b>Department</b>             | <b>Number Required</b> |
|-------------------------------|------------------------|
| Management and Administration | 6                      |
| Technical Services            | 24                     |
| Supervisors                   | 7                      |
| Production                    | 57                     |
| <b>Total</b>                  | <b>94</b>              |

## 17.0 RECOVERY METHODS

### 17.1 INTRODUCTION

The Separation Rapids Lithium Project PEA metallurgical process is based on the testwork that is described in Section 13.0. The process selected for the PEA comprises the mineral separation and recovery of a petalite concentrate containing >4.0% Li<sub>2</sub>O and less than 0.01% iron, as well as a mixed Na/K-feldspar from petalite tailings. The process also includes the hydrometallurgical petalite processing facility to produce battery grade lithium hydroxide.

The petalite and feldspar recovery process was developed and tested by ANZAPLAN in Germany. Various testwork programs were undertaken by ANZAPLAN between 2014 and 2016 including the production of 1 t of petalite concentrate in a pilot program conducted earlier this year. ANZAPLAN also developed the process to recover a mixed Na/K-feldspar product and completed preliminary testwork on this material which indicated the suitability of this product in not only the ceramics industry but also as filler in paint, fibreglass and other products.

The development of a process to convert petalite to battery quality lithium carbonate was successfully undertaken by the SRC. Further work was then recently completed by Thibault to develop and demonstrate a process for producing battery grade lithium hydroxide.

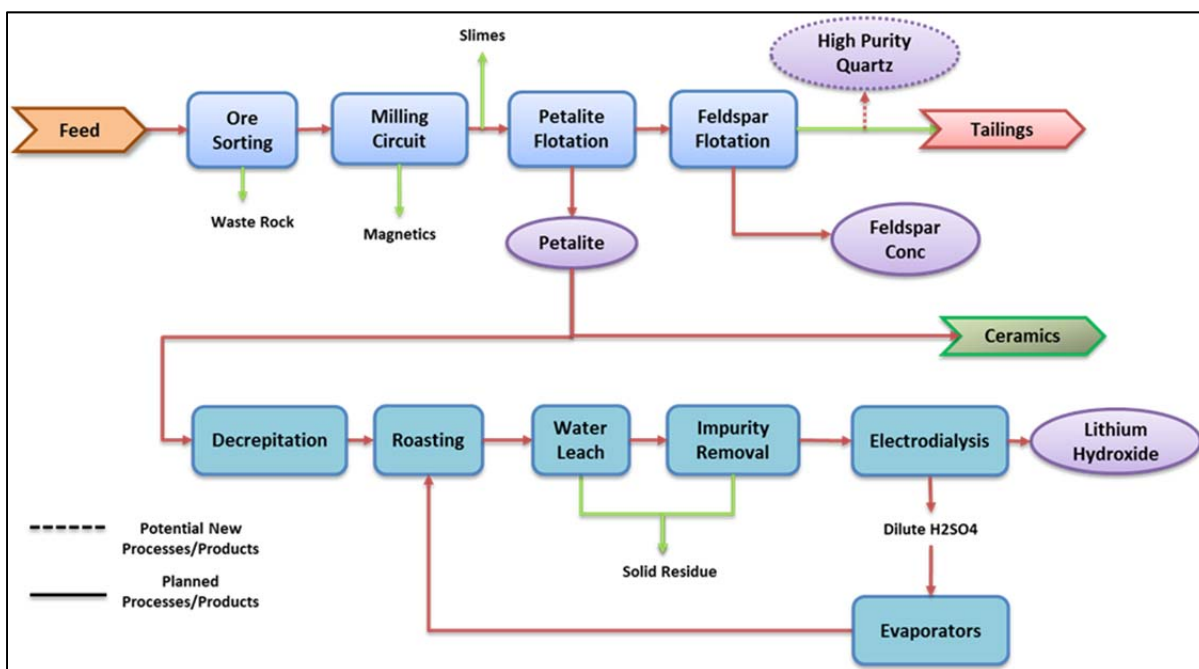
The PEA is based on the processing of 950,000 t/y of mineralized material through a concentrator located at the mine site to produce 144,300 t/y of petalite and 100,000 t/y of feldspar. The petalite is then transported by road to a hydrometallurgical plant located in Kenora, where it is processed to produce 14,520 t/y of lithium hydroxide (LiOH.H<sub>2</sub>O).

Feldspar concentrate will be stored in a separate stockpile area and will be reprocessed in Years 11-20. Similarly, magnetic concentrate will be stored in a separate stockpile for potential reprocessing in the future. No value has been attributed to this material in this PEA. Concentrator and hydrometallurgical plant tailings will be stored together.

Results from the extensive testwork programs at ANZAPLAN, SRC and Thibault (See Section 13.0) have been used to develop a processing flowsheet, mechanical equipment list and reagent consumptions. Thibault has also generated a “Metsim” simulation model of the entire process, data from which has been used for sizing process equipment and calculating heat and energy balances.

A simplified block flow diagram showing the main process steps within the overall Separation Rapids flowsheet is presented in Figure 17.1.

**Figure 17.1**  
**Simplified Process Block Flow Diagram**



## 17.2 PROCESS DESIGN BASIS ASSUMPTIONS

The PEA report and financial evaluation are based on the following assumptions derived from the testwork results and Metsim model from Thibault.

- Optical sorting mass waste rejection is 14.8% with lithium losses of 1.9%.
- Mass pull to slimes after comminution is 6% of sorted mineralized material ore with 6.5% lithium losses.
- Mass pull to magnetics is 14.6% of sorted mineralized material tonnage with lithium losses of 14.5%.
- The petalite flotation concentrate contains 4.0%  $\text{Li}_2\text{O}$  and lithium recovery to petalite is 65.2% of flotation feed content.
- Water leach lithium extraction after decrepitation and roast is 93.8%.
- Lithium losses from impurity removal are 3%.
- A final lithium hydroxide product purity of 99.5%  $\text{LiOH}\cdot\text{H}_2\text{O}$ .

- Plant availabilities of 93% for the concentrator and 85 % for the hydrometallurgical plant.

### **17.3 CONCENTRATOR PROCESS DESCRIPTION**

#### **17.3.1 Crushing and Sorting of Mineralized Material**

Run-of-mine (ROM) mineralized material is fed to multi-stage crushing and optical sorting before proceeding to the comminution circuit. The circuit is designed to process 240 t/h of material to facilitate either a reduced operating time and/or future expansions of capacity.

ROM mineralized material is delivered to a stockpile at the plant by truck. A front-end loader then reclaims the material and feeds it into a bin equipped with a 400 mm square static grizzly. From this bin it is fed at a rate of 161 t/h by a vibrating grizzly feeder the oversize of which (+150 mm) feeds a jaw crusher. Crusher product is mixed with the feeder undersize and conveyed to a vibrating screen. The oversize (+50mm) of this screen is fed to a secondary cone crusher with crusher product being combined with the screen undersize which then feeds a second vibrating screen. The second screen separates the mineralized material into three size fractions, these are:

- +25 mm: This material is fed by conveyor to an optical sorter where waste rock (mainly amphibolite) is rejected onto a conveyor and transported to a stockpile from which it is then transferred by truck to the main waste stockpile. The non-waste rock is fed by conveyor to a tertiary cone crusher.
- -25 +8 mm: This material is fed to a second optical sorter. Waste rejects are combined on the same waste conveyor as that for the first sorter, non-waste rock is combined with that of the first sorter non-waste and sent to the tertiary crusher.
- -8 mm: This material is transported by conveyor to a crushed mineralized material storage silo sized to hold 24 hours of crusher product.

The amount of material rejected by the sorter has been estimated at  $\pm 14.8\%$  of crusher plant feed.

Tertiary crusher product is combined with the product from the secondary cone crusher and recycled to the second of the vibrating screens.

#### **17.3.2 Comminution, De-sliming and Magnetic Separation**

The grinding and classification circuit consists of two vertical shaft impact (VSI) crushers, a wet classification screening process, a cluster of desliming cyclones and a multi-stage magnetic separation circuit.



The feed to the VSIs is drawn from the crushed mineralized material silo by one of three vibrating feeders and conveyor at a rate of 93.4 t/h (dry basis). Feed rate is controlled by a weightometer on this belt and the conveyor discharge is split to feed both VSIs operating in parallel. VSI product is slurried with water and pumped to a primary vibrating screen cutting at 1 mm, the oversize of which then feeds a dewatering screen before being returned to the VSI feed conveyor. Underflow from both the primary screen and the dewatering screen feeds a secondary screen cutting at 300  $\mu\text{m}$ . The oversize from this secondary screen feeds a second dewatering screen before also returning to the VSI feed conveyor. The underflow from both these screens gravitates to a de-sliming feed tank from which it is pumped to a cluster of desliming cyclones cutting at 20  $\mu\text{m}$ . The slimes from these are pumped to a slimes thickener while the cyclone underflow (-300 + 20  $\mu\text{m}$ ) is pumped to the magnetic separation circuit.

The magnetic separation is made up of a low intensity unit (LIMS) and two stages (rougher, scavenger and cleaner) of high intensity (HGMS) magnetic separation. The feed slurry is pumped to the first stage rougher magnetic separator. The non-magnetic slurry is then held in an agitated tank before being pumped to the petalite flotation circuit. The magnetic material from the rougher magnetic separator is fed into a cleaner magnetic separator. The non-magnetic material from the cleaner magnetic separator and the rougher magnetic separator are combined before being sent to the flotation circuit. The magnetic reject material from both separators is pumped to a belt filter and the dewatered magnetics at 90% solids are then conveyed to the magnetics stockpile. Filtrate from this belt filter is collected in a holding tank and pumped back to the comminution process water circuit.

### **17.3.3 Petalite Flotation**

The non-magnetic slurry from the comminution circuit is first filtered on a belt filter before being re-pulped in a 10% (50:50) NaCl/KCl brine solution and then pumped to the petalite flotation circuit. A recycled stream of cleaner scavenger tailings is also added here after being densified by dewatering cyclones.

The petalite flotation circuit consists of a rougher and rougher scavenger flotation banks and four stages of cleaner flotation. The non-magnetic slurry is first fed to two stages of conditioning where hydrofluoric acid (HF) is added to the first conditioner and a mix of flotation reagents K2C and PEG is added the second conditioner. Conditioned feed then gravitates to the rougher flotation cells and a rougher petalite concentrate is produced. The tails from the rougher flotation cells are conditioned with additional brine and flotation reagents added before being fed to a rougher-scavenger bank where a rougher-scavenger concentrate is produced. This gets combined with the rougher concentrate before being pumped to the first petalite cleaner flotation stage. The tails from the rougher scavenger flotation cells are sampled before being pumped to a filter press for dewatering and washing. A portion of this dewatered material (approximately 25%) is re-pulped and sent to the feldspar flotation circuit while the balance is sent to the tailings area for storage. (This material will be reclaimed in later years for recovery of the contained feldspar).

The petalite cleaner flotation circuit consists of four cleaner flotation stages and a belt filter for dewatering the cleaner 2 petalite concentrate ahead of cleaner 3. The petalite rougher concentrate is fed to two stages of conditioning where additional brine and flotation reagents are added. The conditioned feed is then fed into the first stage of petalite cleaners. Primary petalite cleaner concentrate is pumped to the second cleaner stage via one stage of conditioning and reagent addition. The tails from primary cleaner are recycled back to the head of the rougher circuit via dewatering cyclones.

Concentrate from the secondary cleaner is pumped into an agitated holding tank before it is pumped into a belt filter for dewatering and washing to remove excess brine. Cleaner 2 tailings are pumped back to the head of cleaner 1 via dewatering cyclones for densification. The secondary concentrate is filtered to approximately 10% moisture and the brine filtrate is recycled as petalite flotation process water. The filter cake is transferred to an agitated holding tank and re-slurried with fresh process water. This step is necessary since the chemistry and reagents used in the final two stages of petalite flotation differ from those in the first two stages. The re-pulped concentrate is then pumped to cleaner 3 via two stages of conditioning (it is also mixed with cleaner 4 flotation tails). The petalite tertiary cleaner concentrate is produced and pumped into cleaner 4, while the cleaner flotation 3 tails are dewatered and washed in a filter press before being transported to the TCMA. A final petalite concentrate is produced in cleaner flotation 4 and is sampled and pumped to a holding tank before being filtered and dried.

#### **17.3.4 Petalite Concentrate Handling**

The petalite concentrate is dewatered and washed on a belt filter before feeding a collection hopper from which it is extracted by a screw feeder and fed into a rotary drier. On leaving the drier the petalite is cooled and fed to a hopper ahead of a bulk-bag (2 t) packaging facility where the material is placed into bulk bags which are standing on pallets. These bags are then transported by road to the hydrometallurgical plant in Kenora.

Filtrate from the concentrate filter is re-cycled back to the petalite cleaner process water circuit.

#### **17.3.5 Feldspar Flotation.**

The feldspar flotation circuit consists of a rougher and two cleaner stages of flotation. The feldspar flotation circuit has been designed to produce 100,000 t/y of feldspar concentrate which corresponds to approximately 25% of the feldspar in the petalite flotation tailings. As such, only a portion of the filtered petalite tailings are re-pulped and pumped to the feldspar circuit, the remainder is transported to the TCMA.

The re-pulped petalite tailings are first conditioned with flotation reagents HF and DAT in two stages of conditioning before being fed into the feldspar rougher flotation bank. The feldspar rougher concentrate is pumped to a conditioner before being fed to the first stage of cleaning while the rougher tails are pumped to a tailings thickener. Cleaner 1 concentrate is

fed to a second stage of cleaning with the tailings from both cleaner stages being pumped to the tailings thickener. Cleaner 2 concentrate is pumped to the feldspar dewatering circuit. Additional reagents are added ahead of each cleaner stage.

### **17.3.6 Feldspar Concentrate Handling**

The feldspar concentrate is dewatered and washed on a belt filter before being dried in a rotary drier. The dried feldspar concentrate is cooled and fed to a hopper ahead of a bulk-bag (2-t) packaging facility. The bags are covered and strapped to the pallets ready for transporting to customers.

Filtrate from the filter is re-cycled back to the feldspar process water circuit.

Avalon has identified a market of approximately 40,000 t/y for the feldspar product as filler in both the paint and potentially the fibreglass industries. This material has a premium price but first needs to be milled to a d50 size of 6.3  $\mu\text{m}$ . It is intended that material destined for the filler market will be fed after the cooler to an air-swept ball mill (with ceramic balls and liners). Milled product will be classified to the correct size in an air classifier with oversize being returned to the ball mill. Final product will report to a dedicated hopper and bagging facility.

### **17.3.7 Tailings and Magnetics Concentrate Storage**

The tailings treatment circuit consists of thickeners and a plate and frame filter to thicken and dewater tailings suitable for dry stacking. There are two sections to tailings and concentrate treatment, the first processes the slimes and feldspar flotation tails and the second handles the rejected magnetics from the magnetic separation circuit.

Slimes from the comminution circuit feed a slimes thickener (high rate or Lamella type) to be pre-thickened. The overflow is recycled back to the comminution process water circuit while the thickened slimes at about 40% solids by weight is pumped to the main tailing thickener. Feldspar flotation tailings are combined with the thickened slimes in the main tailings thickener. The material is thickened to 60% solids, sampled and pumped to an agitated holding tank. Tailings thickener overflow is pumped to either the feldspar process water circuit or to the petalite tails filter as wash water. The final thickened tailings are pumped from the tank to feed a plate and frame filter where the solids are dewatered to  $\pm 90\%$  solids by weight. Filtrate is collected in a holding tank before being recycled back to the feldspar process water circuit. The filtered solids are collected by dump trucks and trucked to the TCMA where they will be dry stacked.

### **17.3.8 Reagents**

There are a number of reagents used in the flotation process that come in solid or liquid form with various safety concerns. These reagents will be handled and stored, mixed and pumped

to specific addition points within the process in a safe manner. Some of the reagents will arrive on site in bulk and some will be in drums. The reagents include the following:

- Hydrofluoric acid (HF).
- PEG collector.
- K2C flotation collector.
- D14 flotation reagent.
- Sodium chloride (NaCl).
- Potassium chloride (KCl).
- DAT flotation reagent.
- Flocculant.

Individual dosing pumps with variable speed drives will be employed for each reagent dosing point.

### **17.3.9 Metallurgical Accounting**

Weightometers will be installed on the primary crusher product conveyor, mineralized material sorter rejects conveyor and the crushed mineralized material reclaim/VSI feed conveyor.

Mass flow systems and automatic samplers will be installed on the following process streams:

- Slimes tailings.
- Magnetics tailings.
- Crushed petalite after VSIs
- Petalite flotation circuit feed after magnetic separation.
- Petalite flotation rougher scavenger tailings.
- Petalite concentrate.
- Petalite cleaner 3 tailings.
- Feldspar flotation circuit feed.
- Feldspar flotation tailings.
- Feldspar flotation concentrate.

Samples will be taken several times per hour (frequency will vary depending on sample) and eight hour composites will be sent to the laboratory for analysis.

### **17.3.10 Plant Services**

The concentrator will utilize compressed air and low pressure blower air. Compressed air will be split into plant air, and instrument air (which will also be filtered and dried). The low pressure blowers will supply air for the petalite and feldspar flotation cells.

### **17.3.11 Water**

#### **17.3.11.1 Fresh Water**

Fresh water will be obtained from the nearby English River and pumped to a storage tank. Fresh water will be used to provide gland service water, potable water (after treatment in the potable water plant), reagent make-up water and filter wash water for the concentrate and tailings filter washing. If required, fresh water will also be used as a source of fire water.

#### **17.3.11.2 Process Water**

The water balance within the flotation plant is very complex; there will be a number of separate process water circuits at the flotation plant that will have their own dedicated process water storage tank and distribution systems. These circuits include:

- Comminution, classification, desliming and magnetic separation circuits.
- Petalite rougher, scavenger, primary cleaning and secondary cleaning circuits.
- Petalite third and fourth stage flotation cleaning circuits.
- Feldspar flotation circuit.

#### **17.3.11.3 Water Treatment**

Final water treatment testwork has not yet been concluded but for the PEA it is assumed that the treatment process will concentrate the contained salts into a high concentration brine, which may need to be stored and evaporated at the mine site or, preferably, sent to an approved waste facility. However, the potential exists for this solution to be utilized in part as brine make-up water for the petalite flotation circuit depending on residual flotation reagent levels. Cleaned, treated water will be recycled back to plant as much as practical with any excess being discharged to the environment (the treatment plant will be designed to ensure the water meets all necessary discharge criteria).

## **17.4 HYDROMETALLURGICAL PLANT PROCESS DESCRIPTION**

The hydrometallurgical facility will be located close to Kenora, approximately 70 km south of the mine site. The petalite flotation concentrate will be dried and loaded into 2 t bulk bags at the concentrator and delivered by truck from which it will be off-loaded at the hydrometallurgical plant into a bulk bag delivery hopper system.

### **17.4.1 Pyrometallurgical, Leaching and Impurity Precipitation Circuits**

From the feed bin, petalite concentrate is fed at a controlled rate into a direct fired rotary kiln operating at a temperature of 1,100°C to cause “decrepitation” of the petalite mineral. The decrepitation kiln is equipped with an integrated dust collection system to recover petalite dust and minimize particulate emissions with the kiln off-gasses. The decrepitated material is then cooled to approximately 200°C by direct and indirect water cooling in a rotary cooler

before being mixed with concentrated sulphuric acid in a paddle blender to prepare the material for roasting.

The roaster kiln is an indirect fired rotary kiln designed to provide residence time at 300°C to cause the conversion of the decrepitated petalite mineral to solid phase lithium sulphate. The roaster kiln is equipped with a wet scrubber system to remove any particulate and acid mist from the off-gas prior to release to the atmosphere. Roasted solids discharged from the kiln are leached in recycled spent electrolyte from electrodialysis as well as recycled leach residue wash filtrate and distilled water.

The final roast solids are cooled and discharged to the water leach circuit where soluble sulphates of lithium, sodium, potassium, aluminum, iron, calcium and magnesium are dissolved into the solution phase, leaving behind a barren leach residue containing primarily alumina-silicates. The leach residue is separated from the pregnant leach solution (PLS) using a combination of a thickener and a vacuum belt filter with counter-current washing capability. The washed leach residue filter cake is loaded into trucks for transport back to the Separation Rapids mine site for co-disposal with concentrator tailings in the dry stacked tailings management facility. (The possibility that this material may be of economic value is also to be investigated).

The PLS is fed into a steam-driven triple effect falling film evaporator to increase the lithium concentration to a target value of approximately 25 g/L (as Li), which has been defined as the initial specification for advance electrolyte feed to electrodialysis. Concentrating the PLS upstream of solution purification unit operations also improves on the efficiency of impurity precipitation. A PLS storage tank having a surge residence time is provided upstream of the PLS evaporation system to buffer any short-term fluctuations or interruptions in PLS flow.

The concentrated PLS is pumped to the primary impurity precipitation (PIP) circuit, where a bleed stream of crude mother liquor (containing a mixture of lithium, sodium and potassium hydroxides) from the crude lithium hydroxide crystallizer is used to neutralize acidity and adjust the pH of the PLS to a suitable range for precipitation of soluble aluminum as aluminum hydroxide (target pH range of 6 to 7). A total reaction time is provided for in the PIP circuit, which allows for gradual pH adjustment to avoid encapsulation of lithium ions in the freshly formed precipitate and to avoid post-precipitation of residual impurities after filtration. Effluent from the PIP circuit is filtered using a plate and frame style filter press and the filtrate is collected and pumped to the secondary impurity precipitation (SIP) circuit.

In the SIP circuit, crude mother liquor is once again used to adjust the pH of the solution, this time to an optimum range for precipitation of magnesium (target pH range of >12). A batch reaction time is provided in the SIP circuit to optimize on precipitation reactions and the resulting precipitate is filtered using a plate and frame style filter press, complete with pre-coat system. The solid residue from both the PIP and SIP circuits is combined with the filtered and washed leach residue for transport back to the mine site for final disposal. Since the impurity loadings are relatively low and the neutralizing reagent has high solubility in aqueous solutions, the amount of solid residue generated in the impurity precipitation steps is

minimal (represents approximately 0.1 wt/% of the total solid residue generated from the hydrometallurgical process).

#### **17.4.2 Ion Exchange, Electrodialysis and Lithium Hydroxide Crystallization**

Minor metallic impurities such as chromium, copper, iron, nickel and zinc are also removed to low part per million (ppm) levels by the PIP and SIP unit operations, leaving calcium, residual magnesium and manganese as the main impurities to be removed in the ion exchange unit operation. The ion exchange resin is designed to be selective for removal of calcium and magnesium, and the equipment configuration is similar to that used for industrial water softening and calcium and magnesium removal from brine solutions used in the chlor-alkali industry.

The ion exchange columns are operated on a lead-lag basis, with redundant columns provided to improve on the overall process reliability. The ion exchange resin is stripped/regenerated using purchased sulphuric acid and is conditioned/neutralized with crude mother liquor from the crude lithium hydroxide crystallizer. It should be noted that this waste stream (effluent generated from re-conditioning of the ion exchange resin) is the only bleed stream from the hydrometallurgical circuit where impurities such as sodium and potassium, which are not removed in other solution purification steps, are removed from the circuit. Since this stream also contains soluble lithium hydroxide, there is a small associated loss of lithium with this effluent that represents approximately 0.1% w/% of lithium contained in the petalite flotation concentrate.

The purified solution from the ion exchange circuit represents the advance electrolyte feed to electrodialysis. A solution storage surge tank provides buffer capacity for the advance electrolyte solution. In the electrodialysis cells, an applied electrical current and ion selective membranes are used to convert lithium sulphate to lithium hydroxide and dilute sulphuric acid. Similar transformations occur for other monovalent sulphates in the advance electrolyte, such as sodium and potassium sulphate, resulting in the contamination of the lithium hydroxide solution with sodium and potassium hydroxide. Three separate solutions are produced from electrodialysis, these are:

- i) A relatively dilute lithium/sodium/potassium hydroxide solution (maximum total hydroxide ion concentration of approximately 2.5 mol/L).
- ii) A relatively dilute sulphuric acid solution (maximum acid concentration of approximately 10 wt% as H<sub>2</sub>SO<sub>4</sub>).
- iii) A relatively dilute spent electrolyte solution containing unconverted lithium/sodium/potassium sulphate. The spent electrolyte solution is recycled to the water leach unit operations.

The dilute sulphuric acid stream is concentrated back to 93% H<sub>2</sub>SO<sub>4</sub> in a dedicated spent acid concentration plant using multi-stage evaporation technology and is reused in the acid

roasting stage of the hydrometallurgical process. With the proposed process configuration, it is possible to regenerate sufficient acid to satisfy approximately 80% of the total demand for sulphuric acid within the hydrometallurgical process.

The lithium hydroxide solution enters a two-stage evaporative crystallization circuit for production of battery grade lithium hydroxide monohydrate (minimum 99.5%  $\text{LiOH}\cdot\text{H}_2\text{O}$ ). The first stage is referred to as the “crude” crystallization stage in which water is evaporated from the lithium hydroxide solution produced from electro dialysis until a significant portion of the lithium hydroxide crystallizes in the form of lithium hydroxide monohydrate. Since both sodium and potassium hydroxide have much higher solubility in aqueous solution than lithium hydroxide, a bulk separation between lithium hydroxide and sodium/potassium hydroxide can be completed using selective crystallization techniques. The lithium hydroxide monohydrate crystals from the crude crystallization stage are dewatered in a centrifuge and washed with mother liquor from the “product” lithium hydroxide crystallization stage to remove excess sodium and potassium hydroxide remaining in the aqueous phase after dewatering the crude crystals.

The crude lithium hydroxide crystals are re-dissolved in a minimal amount of distilled water before entering the “product” lithium hydroxide crystallization stage. In the product crystallization stage, water is once again removed from the solution by evaporation, causing the majority of the lithium hydroxide to crystallize in the monohydrate form. Due to the limited carryover of sodium and potassium impurities from the crude to the pure crystallization stage, the resulting lithium hydroxide monohydrate crystals produced in the “ultra-pure” crystallization stage contain very low levels of impurities.

The crystals are dewatered in a centrifuge and washed with a minimal amount of distilled water (to minimize re-dissolution) before being dried under nitrogen atmosphere. Drying under nitrogen atmosphere is necessary to avoid adsorption of carbon dioxide from the air as the product is dried. The final lithium hydroxide monohydrate product is packaged in bags for shipment to the end user.

### **17.4.3 Residue**

Solid waste will be generated from the following areas in the hydrometallurgical plant:

- Water Leach.
- Primary Impurity Removal.
- Secondary Impurity Removal.
- Wastewater Treatment Solids.

Solids generated from these areas will be washed and filtered separately before being transported by truck back to the mine site to be dry-stacked with feldspar tailings solids in the TCMA.



#### 17.4.4 Reagents

There are a number of reagents used in the hydrometallurgical process. These reagents will be safely offloaded, stored and distributed to the various usage points within the plant. These reagents include:

- Sulphuric acid (93%).
- Sodium hydroxide (50%).
- Filter pre-coat, diatomaceous earth.
- Water Treatment chemicals.

#### 17.4.5 Metal Accounting

The following measurements and samples will be automatically taken on a shift basis for metallurgical accounting and quality control purposes:

- A truck scale will be used to weigh trucks arriving and leaving the plant. The loads on these trucks will include petalite concentrate, lithium hydroxide, waste solids returning to mine site, sulphuric acid and caustic soda.
- Each bag of petalite fed into the plant and each bag of hydroxide produced will be labelled and weighed individually.
- Flowmeters and samplers will be installed at off-gas scrubbers and vents to detect the amount of water vapour and off-gas generated and general off-gas quality.
- A weightometer on the discharge conveyor of the petalite silo will measure daily tonnage treated and a small sample will be taken for assays for metallurgical accounting.
- Primary impurity removal feed (PLS): the impurity removal feed stream will be measured by a flow meter and an automated pipe sampler will produce a sample for metallurgical accounting.
- Secondary impurity removal feed: the impurity removal stream will be measured by a flowmeter and an automated pipe sampler will produce a sample for metallurgical accounting.
- Ion exchange feed: the feed stream will be measured by a flowmeter and an automated pipe sampler will produce a sample for metallurgical accounting.
- Membrane electrodialysis: the feed stream will be measured by a flowmeter and an automated pipe sampler will produce a sample for metallurgical accounting.

## **17.4.6 Plant Services**

### 17.4.6.1 Compressed Air

The site will utilize compressed air, instrument air and blower air. Compressed air will be split into plant air, and instrument air (which will also be filtered and dried). Low pressure blowers will supply air for the combustion fans in the decrepitation kiln and roaster kiln.

### 17.4.6.2 Natural Gas

Natural gas will be used in a number of areas, most notably for the kilns and evaporation circuits. A supply line from the local distribution network will supply gas to the plant.

### 17.4.6.3 Steam

Steam will be used in a number of areas in the plant such as the product drier and sulphuric acid evaporator. There will be two natural gas powered steam boilers to create the steam. Off-gas from the boilers will be sent to a boiler stack which will be continuously cooled by cooling water. De-ionized water will be used as the boiler feed water to reduce future scaling during operations.

### 17.4.6.4 Nitrogen Generation System

Nitrogen is used for lithium hydroxide drying after the second crystallization stage. Avalon will work with a supplier to design a package system for the nitrogen generation area to meet this requirement.

## **17.4.7 Water Circuits**

### 17.4.7.1 Fresh Water

Potable fresh water will be obtained from the municipality supply system. Process water will be stored in a stock tank. Large volumes of process water may be obtained from the nearby river. From here it will be used to provide gland service water, filter wash water for the water leach and impurity removal filter washing as well as reagent make-up. If required, potable water will also be used as a source of fire water.

### 17.4.7.2 Distilled Water

Distilled water is required for several purposes through the hydrometallurgical process including the water leach, electrodialysis (to control the concentration of the dilute acid and hydroxide solution streams), redissolution of the crude crystallization product, washing of solids residues, and washing of the final lithium hydroxide monohydrate product. Approximately 95% of the distilled water requirement for the hydrometallurgical facility can be met by condensing and recycling process vapours generated by the PLS evaporator, the

spent acid concentration plant, and the lithium hydroxide crystallization circuit. Makeup high purity water is generated by a packaged reverse osmosis plant.

#### 17.4.7.3 Cooling water

Cooling water is used in a number of areas in the plant, such as roaster cooling and in the product drier. It is expected that cooling water will be obtained from the Winnipeg River near the site. The cooling water will be pumped to the various areas as required from a supply tank. Returning cooling water will be stored in a tank before being cooled in a series of cooling towers and returned to the supply tank.

#### 17.4.7.4 Water Treatment

A reverse osmosis system will be used to clean and treat waste water generated at the plant. Waste water will come from a number of areas such as ion exchange regeneration and boiler blowdown. The water will be collected and neutralized before it is sent to a wastewater clarifier. The clarifier underflow is pumped to a wastewater solids filter to dewater the solids (which are subsequently returned to the mine site for disposal). Clarifier overflow volume will be very small and sufficiently clean such that it can be accepted by the local municipal sewage system.

## 18.0 PROJECT INFRASTRUCTURE

### 18.1 OVERVIEW

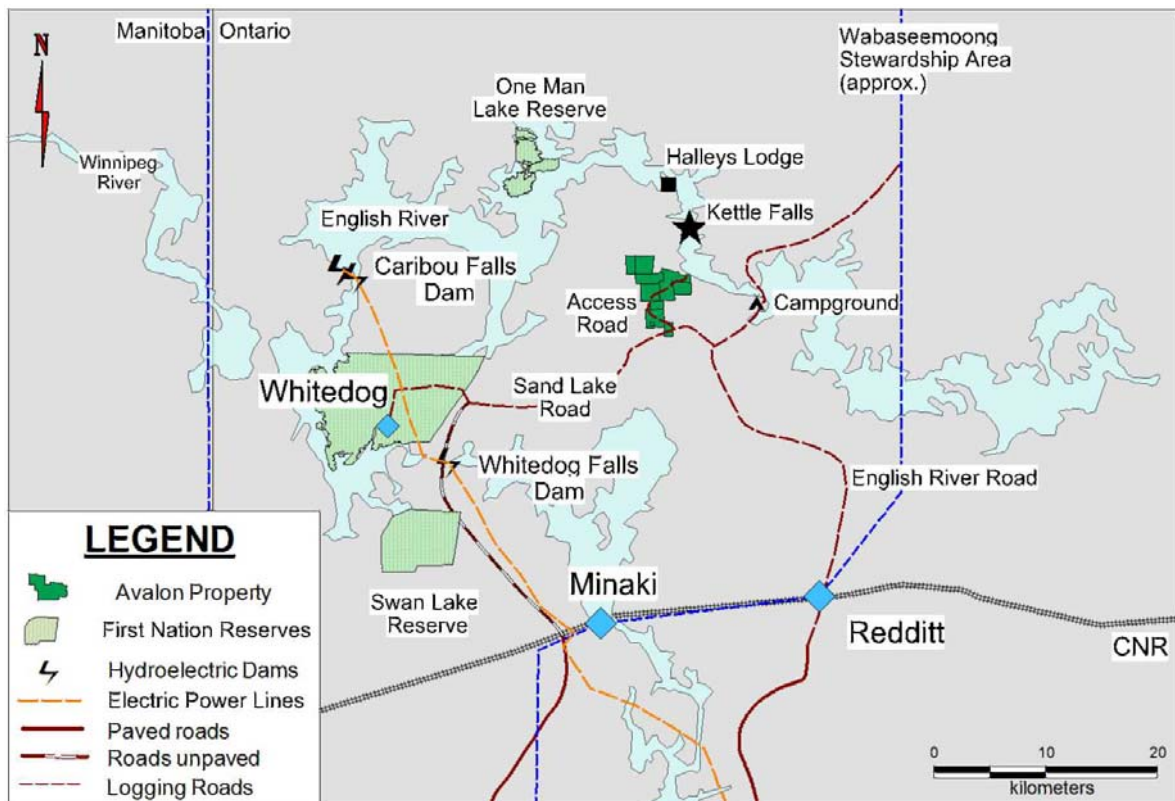
The Separation Rapids project includes four main facilities:

- Mine.
- Concentrator.
- Trans-shipment facility.
- Hydrometallurgical plant.

The concentrator will be located at the mine site. Concentrate will be shipped to the hydrometallurgical plant located in the city of Kenora, Ontario.

Figure 18.1 shows the location of the Separation Rapids Property in relation to principal supporting infrastructure.

**Figure 18.1**  
**Location of the Separation Rapids Property**



Avalon, 2016.

As there is no rail access to the mine/concentrator site, delivery of reagents to and shipment of concentrates from the site will be by truck. However, a trans-shipment facility will be

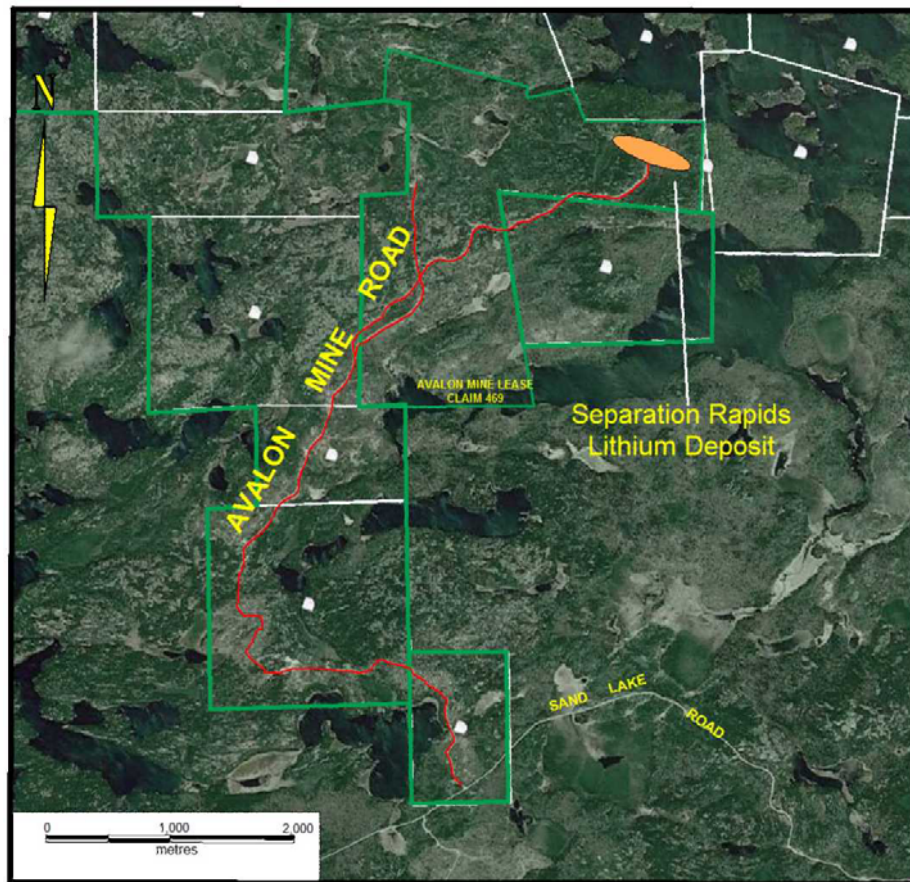
required in order to access rail transportation for product shipment and inbound supplies. The trans-shipment facility will be located on the CNR in the vicinity of Redditt, Ontario.

## 18.2 MINE AND CONCENTRATOR SITE

### 18.2.1 Location and Access

The property is readily accessible from Kenora by traveling 27 km north on Highway 658, an all-weather road, to the English River Road, 2 km south of the community of Redditt. Then a further 37 km on the English River Road to the Sand Lake Road, and west on the Sand Lake Road for 5.5 km to East Tourist Lake Road (ETL Road, also known as the Avalon Mine Road), a former forestry access road (marked with a “Road to Avalon” sign). The project site is located approximately 9.5 km north on the ETL or Avalon Road. The total distance from Kenora to the site is 79 km. See Figure 18.2.

**Figure 18.2**  
**Route of the Avalon Mine Road**



Avalon, 2016.

Development of the project will require upgrading of the Avalon Road to accommodate the supply of fuel and reagents to the site and the shipment of petalite concentrate to the hydrometallurgical plant and feldspar product to the trans-shipment facility

### **18.2.2 Site Preparation and Haul Roads**

The site is predominately rock with a minimum of top soil or organic cover. Existing soil and organics will be stripped and retained to be used later for site restoration. Some of the waste rock that will need to be removed as part of the mining operation will be crushed and used as fill for the site development.

### **18.2.3 Site Buildings**

Site buildings are anticipated to include:

- Crusher building.
- Concentrator building.
- Maintenance facilities.
- Wash room/change room/lunch room.
- Warehouse.
- Guard house.
- Offices and laboratory.

Heating, ventilation and air conditioning will be provided for all buildings as required. Propane will be used to fuel the heating system.

### **18.2.4 Fresh Water**

Fresh water and fire water for the site will be provided from the English River. An intake line will be installed to a sufficient depth in the river to be below the ice level. Water treatment facilities will be provided as required to supply potable water to the site.

### **18.2.5 Sewage**

Sanitary waste water treatment will be provided at the site using appropriately sized parallel septic tanks and field bed. Waste water from the treatment unit will be discharged to the environment. Arrangements will be made with a local contractor for the periodic pumping of the septic tanks for removal and disposal of the sludge as required.

### **18.2.6 Power**

Approximately 5 MW of power will be required for the mine and concentrator. Power will be supplied from the existing 115 kV system near the Ontario Power Generation Whitedog Falls hydro dam. A stepdown transformer will be installed at the connection point to the 115 kV line and approximately 25 km of transmission line will be installed to bring the power to the

mine site. An additional stepdown transformer will be installed at the site to supply power to the local electrical distribution system.

An emergency back-up generator will also be provided at the site fueled either by diesel or propane.

#### **18.2.7 Fuel Storage**

Diesel fuel storage facilities will be provided to supply the mine equipment and smaller site vehicles. Two double-wall diesel tanks will be provided on a concrete foundation.

A propane tank farm will also be installed to accommodate the site heating and back-up power generation.

#### **18.2.8 Hydrogen Fluoride**

Hydrogen fluoride is required in the flotation process. A facility will be constructed to receive 49% aqueous hydrogen fluoride by truck and store it as required to meet the process plant requirements.

#### **18.2.9 Communications**

A telecommunications system will be installed at the site to provide telephone service and internet access, and to support the site security and fire detection systems. A mobile radio system will be installed to provide local communication to all parts of the mine and site facilities.

A microwave link will be installed to provide access to an internet service provider. A back-up system will be provided using a cellular modem. Distribution will be provided by a fibre optics system in the concentrator and related facilities and a wireless system for the mine site.

#### **18.2.10 Camp**

No camp facilities are envisioned for this project. It is anticipated that the work force will live in Kenora and the surrounding area. Buses will be provided to transport workers between Kenora and the mine site.

### **18.3 TRANS-SHIPMENT FACILITY**

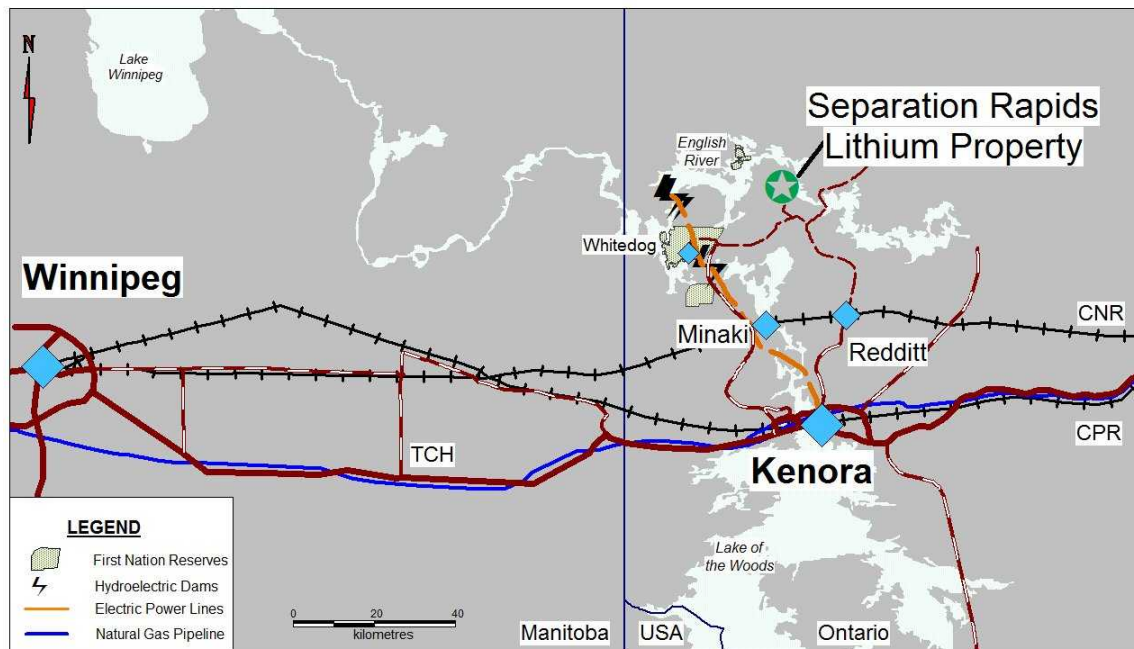
As there is no rail access to the mine/concentrator site, delivery of reagents to and shipment of concentrates from the site will be by truck. However, some of the reagents are likely to be supplied by rail and rail access will be required to get products to market. To accommodate this, a trans-shipment facility will be constructed.

### 18.3.1 Location

The area is served by both CNR and CPR. The CPR line runs through the city of Kenora while the CNR line is approximately 30 km north of Kenora. The closer proximity to the mine site makes CNR the preferred rail service for the Separation Rapids Lithium Project.

Avalon plans to build a trans-shipment facility adjacent to the CNR line at a site to be selected north of Kenora, approximately 55 km by road from the Separation Rapids site, where there is good road access from both Kenora and the mine site.

**Figure 18.3**  
**Location of Rail and Road Infrastructure Around Redditt and Kenora**



Avalon, 2016.

### 18.3.2 Facilities

A rail siding will be required at the site for the loading and unloading of rail cars. The siding is expected to consist of two tracks approximately 1 km in length with switches to access the mainline at each end.

A building will be constructed on the siding so that trucks and railcars can be loaded and unloaded in all weather conditions.

Product to be shipped out by rail will be delivered to the site by truck and stored in the trans-shipment building allowing the loading/shipping of multiple rail cars at a time.



Reagents delivered by rail will be unloaded and stored at the site for future delivery by truck to the mine site or hydrometallurgical plant.

Provision will be made for offices/wash rooms/change rooms/lunch rooms as required. HVAC will be provided as required for the operation of the facility.

### **18.3.3 Hydrofluoric Acid Facilities**

Hydrofluoric acid is required for the flotation process at the concentrator. It is expected that anhydrous hydrofluoric acid will be provide by railcar from the United States. A facility will be required at the trans-shipment point to unload and store the acid when it is received. The facility will also include the capability to dilute the acid to produce a 49% aqueous hydrogen fluoride solution that will then be loaded on trucks for delivery to the mine site to minimize safety risks.

### **18.3.4 Power**

Grid power is available in the Redditt area to meet the power requirements for this facility. Depending on the final location, a short power line may be required to deliver power to the trans-shipment site.

A small diesel generator will be provided to supply emergency power if required. A small day tank will be provided for diesel storage.

### **18.3.5 Water**

Fresh water for the site will be provided either from a well or from access to a local lake, such as Corn Lake, to supply fire water, process water, and potable water for the site. Water treatment facilities will be provided as required.

### **18.3.6 Sewage**

Sanitary waste water treatment requirements will be minimal at the site as only a small staff is required to operate the site. Sewage treatment facilities will be provided as required to accommodate the site needs.

### **18.3.7 Communications**

It is anticipated that the site will access the communications infrastructure in the area for telephone and internet. Back-up will be provided with the use of a cellular modem.

## **18.4 HYDROMETALLURGICAL PLANT**

### **18.4.1 Location and Access**

Avalon has identified several possible sites in or near Kenora that could be used for the hydrometallurgical plant. The preferred location is the site of the former Abitibi paper mill located south of Ninth Street North, roughly between Rupert Road and Eleventh Avenue North. The site is approximately 27.5 ha in area providing ample space for the required facilities.

Ninth Avenue extends directly from the south end of Redditt Road providing excellent access to the site for the delivery of concentrate from the mine site. There is also easy access to the TransCanada Highway for receipt of incoming deliveries by truck.

The paper mill operated on the site until a few years ago. The site is currently zoned for industrial development. Avalon has been in discussions with the current owner who has expressed a willingness to work with Avalon on the re-development of the site for the Separation Rapids Lithium Project.

### **18.4.2 Site Services**

Although the site is currently supplied by power, water, natural gas and city sanitary sewer services, most of these do not have the capacity to meet the requirements of the hydrometallurgical plant. However, the site is located within about 1 km of the Hydro One 115 kV substation and a similar distance from the Union Gas Town station, providing easy access to the electrical power and natural gas needed for the plant. A diesel generator will be provided at the site to provide emergency standby power.

There is also easy access on the west side of the property to the Winnipeg River to supply the plant and fire water requirements. Potable water can be obtained from the city water system. Water discharge is expected to be very small. It will be treated as necessary and can be accommodated by the city sewer system.

### **18.4.3 Buildings**

A new building will be required to house the hydrometallurgical plant.

Three existing buildings may be used for offices, laboratories, lunch/wash rooms, warehouses, and product storage and load out facilities.

#### **18.4.4 Rail Siding**

The site was previously served by a rail siding off the CPR line. Although the rails have been removed it would be possible to reactivate this line to provide rail service directly to the site if that is required.

#### **18.4.5 Communications**

Telephone and internet services will be available from local suppliers in the area.

## 19.0 MARKET STUDIES AND CONTRACTS

Avalon’s marketing team is led by Pierre Neatby, Vice President Sales and Marketing, who has over 25 years of experience in metals and industrial minerals marketing.

### 19.1 LITHIUM

Material on which this section of the report is based is presented in more detail in Neatby et al., 2016.

#### 19.1.1 Introduction

Lithium is the lightest of all metals, appearing at the top left hand corner of the periodic table (atomic mass 6.9 and atomic number 3). It does not occur in nature in the metallic form but in the silicate minerals, spodumene, petalite, lepidolite and amblygonite, contained in pegmatites as at Separation Rapids.

The U.S. Geological Survey (USGS) reports production of lithium minerals and products as shown in Table 19.1. In terms of gross product weight, Australia is the largest single producer of lithium minerals and chemicals, with output exceeding 400,000 t/y spodumene. Chile is the second ranking producer with a range of lithium chemicals recovered from subsurface brines.

**Table 19.1**  
**Lithium Mineral and Brine Production**  
**(Tonnes gross weight)**

|                             | 2009    | 2010    | 2011    | 2012    | 2013 <sup>1</sup> |
|-----------------------------|---------|---------|---------|---------|-------------------|
| Argentina, subsurface brine |         |         |         |         |                   |
| Lithium carbonate           | 8,574   | 11,178  | 10,000  | 9,700   | 9,500             |
| Lithium chloride            | 4,279   | 6,644   | 4,480   | 4,350   | 4,200             |
| Australia, spodumene        | 197,482 | 295,000 | 421,391 | 456,921 | 421,000           |
| Brazil, concentrates        | 15,929  | 15,733  | 7,820   | 7,084   | 8,000             |
| Canada, spodumene           | 10,000  |         |         |         |                   |
| Chile, subsurface brine     |         |         |         |         |                   |
| Lithium carbonate           | 25,154  | 44,025  | 59,933  | 62,002  | 52,358            |
| Lithium chloride            | 2,397   | 3,725   | 3,864   | 4,145   | 4,091             |
| Lithium hydroxide           | 2,987   | 5,101   | 5,800   | 5,447   | 4,197             |
| China, lithium carbonate    | 20,000  | 21,000  | 22,000  | 24,000  | 25,000            |
| Portugal, lepidolite        | 37,359  | 40,109  | 37,534  | 20,698  | 38,000            |
| United States               | w       | w       | w       | w       | w                 |
| Zimbabwe <sup>3</sup>       | 50,000  | 47,000  | 48,000  | 53,000  | 50,000            |

<sup>1</sup> Latest data available.

<sup>2</sup> Amblygonite, eucryptite, lepidolite, petalite, spodumene.

w – withheld.

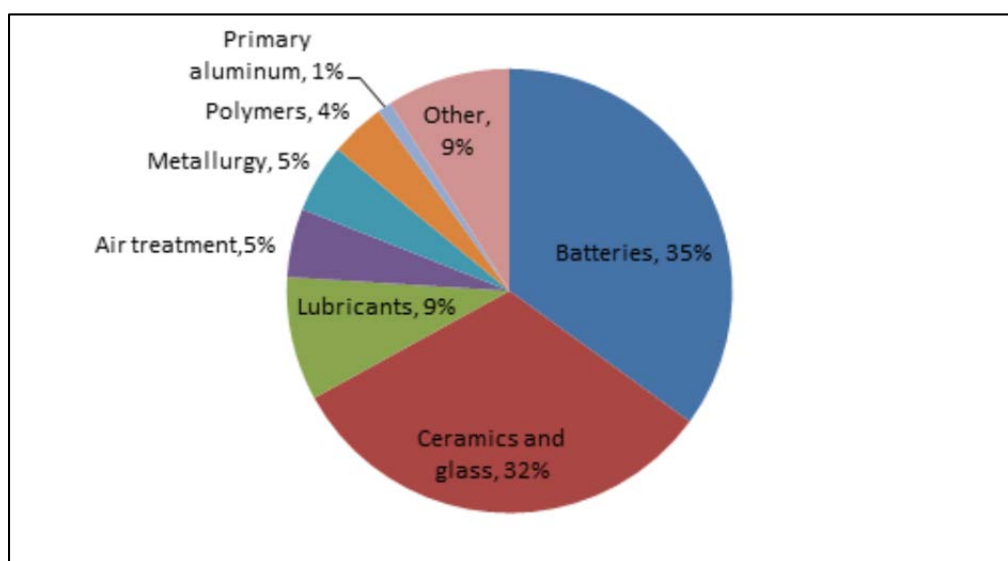
USGS, 2015a.

Data reported by the USGS for 2014 and 2015 are provided in terms of contained lithium in the Mineral Commodity Summaries; on this basis, Australia and Chile are also the first and second largest producers, followed by Argentina and China. The USGS estimated that lithium minerals and lithium-bearing brines contributed approximately equally to lithium supply in 2015 (USGS, 2016a).

### 19.1.2 End-use Sectors

The USGS estimates global demand for lithium broken down by end-use sector as shown in Figure 19.1. Consumption in batteries has increased significantly over the past five years, to the point where it now surpasses demand in ceramics and glass. Rechargeable lithium batteries are used in a wide range of applications including cell phones, cameras, portable electronic devices and hand-held tools and, increasingly in electric vehicles and electricity storage.

**Figure 19.1**  
**2015 Lithium Consumption by End-use Application**

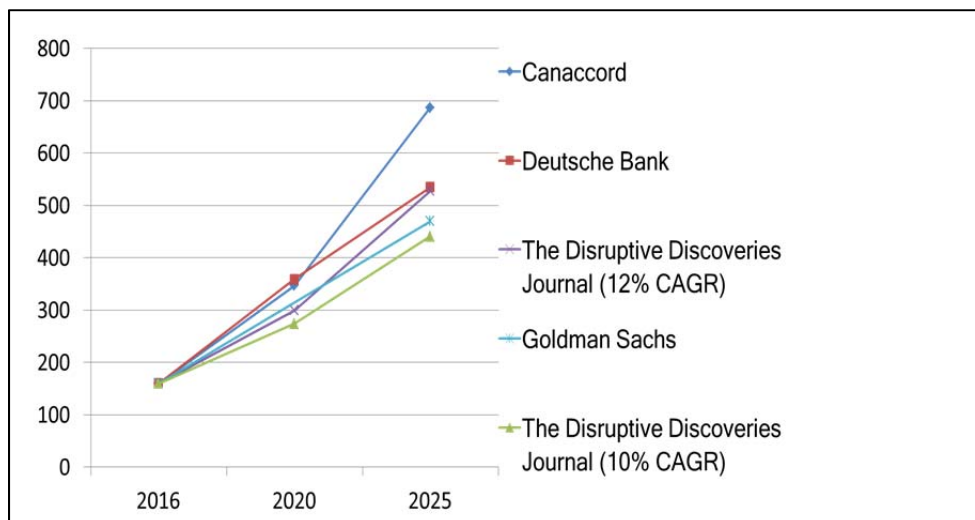


USGS, 2016a.

Lithium demand and supply may be expressed in terms of lithium carbonate equivalent (LCE) in order to compare lithium sources and products.

It is expected that battery demand will continue to outpace other lithium demand sectors and will drive overall lithium demand. Figure 19.2 illustrates the projections of four groups which follow the market.

**Figure 19.2**  
**Lithium Demand Growth Forecasts**  
(Thousand tonnes LCE/y)



Canaccord, 2016; Deutsche Bank, 2016; Goldman Sachs, 2015; The Disruptive Discoveries Journal, 2016.

These projections are based on the anticipation that as governments support the transition from a hydrocarbon-based economy, electric vehicles and renewable energy storage systems will become increasingly important.

It is clear from multiple recently published reports that significant volumes of lithium will be needed to feed the electric vehicle battery market. The needs of individual models and types of car differ quite significantly, as shown in Table 19.2. Table 19.2 also illustrates the higher battery size, lithium requirements and range for the battery electric vehicles (BEV), such as the Nissan Leaf S and the Tesla Model S. As manufacturers continue to improve the range of batteries for BEV, and as charging infrastructure also improves, it is anticipated that larger batteries with significant lithium requirements will replace the lower kWh types.

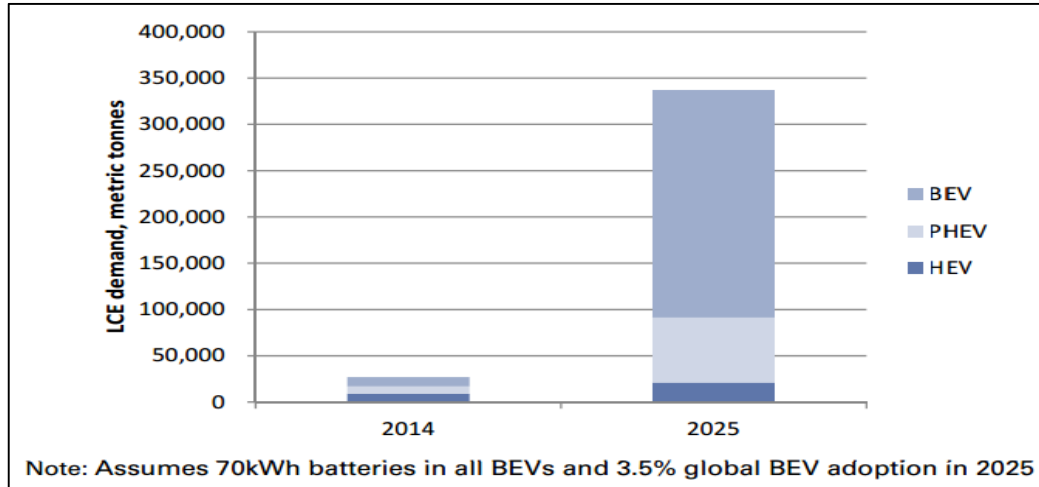
**Table 19.2**  
**Approximate LCE Required by some Electric Vehicles**

| Model   | Type                            | Battery Size (kWh) | LCE Required (kg) | Range (miles) |
|---|---------------------------------|--------------------|-------------------|---------------|
| 2016 Ford Fusion Hybrid                           | Hybrid Electric Vehicle         | 1.4                | 1.3               | -             |
| 2016 Chevy Volt                                   | Plug-in Hybrid Electric Vehicle | 18.4               | 16.6              | 53            |
| 2016 Nissan Leaf S                                | Battery Electric Vehicle        | 24.0               | 21.6              | 84            |
| 2016 Tesla Model S                                | Battery Electric Vehicle        | 70.0               | 63.0              | 240           |
| Assumes 0.9 kg LCE per kWh for all batteries.     |                                 |                    |                   |               |
| Actual ranges generally vary from 0.7-1.3 kg/kWh. |                                 |                    |                   |               |
| HEVs do not guarantee electric only range.        |                                 |                    |                   |               |

Goldman Sachs, 2015.

Goldman Sachs noted that a 1% increase in BEV penetration will increase lithium demand by a significant 45%, or by 70,000 t/y LCE/year. See Figure 19.3.

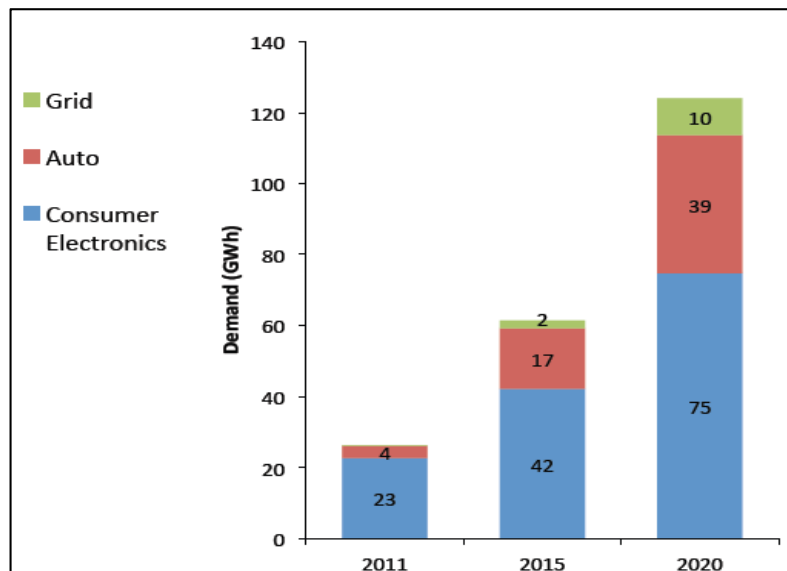
**Figure 19.3**  
**Electric Vehicle LCE Demand Growth**



Goldman Sachs, 2015.

While the automotive sector is expected to show the most rapid growth, Figure 19.4 presents projected growth in global lithium demand in terms of electrical energy for the key consumer electronics, automotive and grid energy storage sectors and shows that consumer electronics will continue to account for over 50% of total battery demand. Figure 19.4 also illustrates the potential contribution of grid storage for solar and wind renewable energy systems.

**Figure 19.4**  
**Global Lithium Battery Demand - All Applications**



Chung et al., 2015.

In the United States, GTM Research, reported by CleanTech Canada in Canadian Manufacturing online, noted that total deployment of grid energy storage systems across the residential and utility markets reached 221 MW in 2015. This was up sharply, by 243%, from 2014. By 2020, GTM Research expects the total to reach 1,662 MW (CleanTech Canada, 2016). The report noted that lithium technology accounted for 96% of all deployments over the year.

### 19.1.3 Lithium Hydroxide

In order to assist in the evaluation of the primary product for the Separation Rapids Lithium Project, Avalon commissioned a study from Stormcrow Capital Ltd. (Stormcrow) in August 2015. Stormcrow's analysis, summarized in Table 19.3, indicates that demand for lithium hydroxide will grow at a higher rate than that for lithium carbonate based on changes in battery technologies.

Table 19.3 also shows that demand for lithium hydroxide, in terms of LCE, has been higher than demand for lithium carbonate since before 2013. Stormcrow's data are based on its assessment of the volumes of lithium carbonate purchased for conversion to hydroxide so that the figures in Table 19.3 reflect Stormcrow's assessment of actual demand for the two products by end-users.

Lithium carbonate was used for the cathode in lithium cobalt oxide (LCO) batteries, but the LCO technology is being surpassed by lithium manganese (LMO) and lithium nickel manganese cobalt (NMC) batteries which use lithium hydroxide, particularly for electric vehicles. These offer higher power density and a longer life cycle than lithium carbonate-based battery systems.

**Table 19.3**  
**Lithium Feedstock Chemical Demand, 2013-2025**  
**(Tonnes LCE)**

|                        | 2013   | 2014   | 2015   | 2016   | 2017   | 2018    | 2019    | 2020    | 2021    | 2022    | 2023    | 2024    | 2025    |
|------------------------|--------|--------|--------|--------|--------|---------|---------|---------|---------|---------|---------|---------|---------|
| Li mineral concentrate | 58,135 | 61,504 | 65,149 | 69,076 | 73,238 | 77,635  | 82,315  | 87,298  | 92,604  | 98,254  | 104,272 | 110,683 | 117,512 |
| Lithium carbonate      | 38,956 | 40,431 | 42,471 | 44,021 | 47,269 | 49,139  | 53,028  | 55,816  | 57,028  | 60,488  | 66,744  | 71,835  | 78,875  |
| Lithium hydroxide      | 51,403 | 60,755 | 71,035 | 82,035 | 92,574 | 105,213 | 115,197 | 127,541 | 141,680 | 153,789 | 164,181 | 176,059 | 186,832 |
| Lithium chloride       | 17,607 | 18,106 | 18,692 | 19,353 | 20,018 | 20,667  | 21,336  | 20,027  | 22,741  | 23,478  | 24,239  | 25,025  | 25,836  |

Stormcrow Capital, 2015.

Traditionally, lithium hydroxide has been used in lubricating greases but, since the commercial introduction of batteries using hydroxide, it has found increasing use in batteries.



### 19.1.4 Lithium Supply

The market for lithium was considered by Deutsche Bank to be in deficit to the extent of 13,000 t LCE in 2015 (Deutsche Bank, 2016). At a conservative compound average annual growth rate (CAGR) of 8%, lithium demand will expand approximately 20,000 LCE every year until 2025 (Berry, 2016).

Avalon follows approximately 30 projects around the world (mostly in Australia, Canada and Argentina/Chile). Among the most advanced are the restart of the Mt. Cattlin operation of Galaxy Resources Limited in Western Australia and the Mt. Marion project of Neometals Ltd., also in Western Australia and under construction. A few others have completed feasibility studies: for example, the Whabouchi project of Nemaska Lithium in Quebec, and the Cauchari brine project of Lithium Americas Corp. in Argentina. The majority are less advanced.

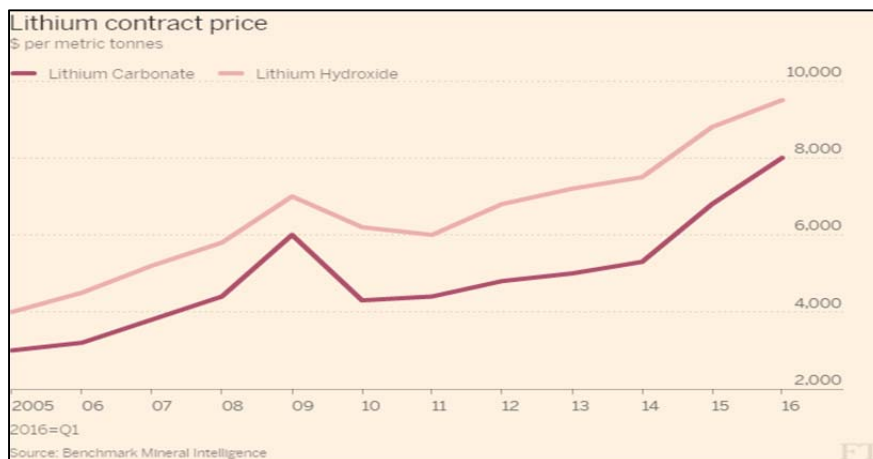
Avalon considers that the Separation Rapids Lithium Project will be well-placed to supply new battery production facilities in North America, i.e., the plant of LG Chem in Michigan and the “gigafactory” of Tesla Motors Inc. in Nevada that is expected to consume 25,000 t/y of lithium hydroxide when it is completed in 2018 (Desjardins, 2016).

### 19.1.5 Lithium Prices

Lithium is not traded on any formal or recognized exchange and there are few sources of reliable publicly available price data. Transactions are negotiated directly between seller and buyer and payment terms are rarely reported.

The trend of historical lithium carbonate and hydroxide prices is shown in Figure 19.5. Apart from the sharp correction in 2010, prices for both products have risen steadily over the past decade.

**Figure 19.5**  
**Lithium Contract Prices**



Benchmark, 2016a.

Prices reported by Industrial Minerals as of mid-August, 2016 were US\$8,500-11,000/t delivered in Europe, or US\$8,300-10,000/t delivered in Europe for Chinese material. Both quotes are for material under large contract.

Roskill’s projection of battery grade lithium hydroxide and lithium carbonate is shown in Table 19.4.

**Table 19.4**  
**Price Forecast Trend for Battery-grade Lithium Hydroxide and Lithium Carbonate**  
**(US\$/t CIF)**

| Year | Lithium Hydroxide | Lithium Carbonate |
|------|-------------------|-------------------|
| 2015 | 8,640             | 5,575             |
| 2016 | 9,473             | 6,292             |
| 2017 | 9,892             | 6,854             |
| 2018 | 10,210            | 7,410             |
| 2019 | 10,750            | 7,750             |
| 2020 | 11,115            | 8,115             |
| 2021 | 11,495            | 8,495             |
| 2022 | 11,895            | 8,895             |
| 2023 | 12,315            | 9,315             |
| 2024 | 12,750            | 9,750             |
| 2025 | 13,210            | 10,210            |

Nemaska, 2016

Benchmark’s analysis of projected lithium hydroxide prices is shown in Figure 19.6.

**Figure 19.6**  
**Benchmark Mineral Intelligence Project of Lithium Hydroxide and Lithium Carbonate Prices**

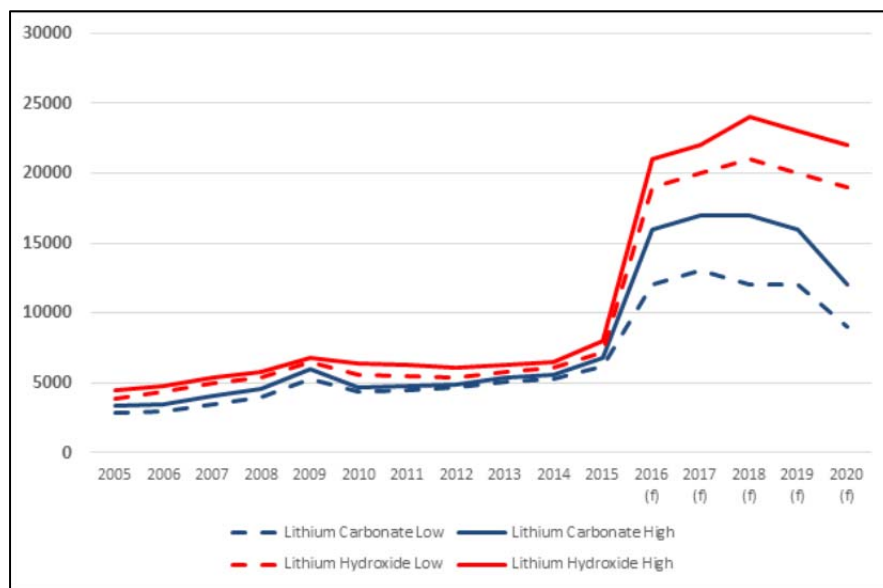


Figure compiled and provided by Benchmark Mineral Intelligence to Avalon, October, 2016.

High demand and restricted supply in 2016 have caused reported spot prices to increase significantly. Prices for material under contract have also increased and, through meetings and at conferences, Avalon understands that current and medium term availability is a significant issue among buyers and believes that this is likely to continue to put upward pressure on prices.

Avalon has reviewed all publicly available lithium price forecasts. While they all project increasing prices, there is considerable variation in absolute price levels predicted for battery grade lithium chemicals in the future. Lithium hydroxide prices projected for the period 2019-2020, when Avalon may enter the market, are projected to range from current price levels of around US\$10,000/t to as high as US\$25,000/t, with the average being around US\$16,000-17,000/t.

For the purposes of this PEA, Avalon has used a relatively conservative average price assumption of US\$11,000/t FOB plant for lithium hydroxide. This is consistent with the projection prepared by Roskill as shown in Table 19.4 for the period 2019-2020.

## 19.2 FELDSPAR

### 19.2.1 Introduction

The feldspar group is by far the most abundant group of minerals in the earth's crust, forming about 60% of terrestrial rocks.

They are widely produced with global output estimated by the USGS in 2015 at 21.2 Mt as summarized in Table 19.5.

**Table 19.5**  
**Feldspar, Mine Production by Country**  
(Thousand tonnes)

| Country         | 2011          | 2012          | 2013          | 2014          | 2015 <sup>1</sup> |
|-----------------|---------------|---------------|---------------|---------------|-------------------|
| China           | 2,100         | 2,100         | 2,500         | 2,500         | 2,500             |
| Czech Republic  | 407           | 445           | 411           | 420           | 430               |
| Korea, Republic | 384           | 360           | 343           | 340           | 340               |
| India           | 763           | 1,178         | 1,200         | 1,410         | 1,500             |
| Iran            | 577           | 580           | 580           | 550           | 600               |
| Italy           | 4,700         | 4,700         | 4,700         | 4,700         | 4,700             |
| Spain           | 622           | 530           | 603           | 600           | 600               |
| Thailand        | 1,041         | 1,102         | 1,100         | 1,100         | 1,500             |
| Turkey          | 4,355         | 4,525         | 4,545         | 4,600         | 5,000             |
| United States   | 580           | 560           | 550           | 530           | 510               |
| Others          | 5,071         | 3,720         | 3,068         | 3,250         | 3,520             |
| <b>Total</b>    | <b>20,600</b> | <b>19,800</b> | <b>19,600</b> | <b>20,000</b> | <b>21,200</b>     |

<sup>1</sup> Estimated.

U.S. Geological Survey, 2015, 2016b.

Turkey, Italy, India and China are by far the largest producers although it should be noted that the figures shown in Table 19.5 essentially represent the high volume, relatively low value bulk products. Production in the United States has declined steadily over the past five years. The USGS does not report production from Canada.

Avalon has purchased specialist market analysis from Hains Technology Associates (Hains, 2015) and Global Industry Analysts Inc. (GIAI, 2016) and subscribes to Industrial Minerals, published by Euromoney Institutional Investor PLC.

### **19.2.2 End-use Sectors**

Feldspar is an important ingredient in the manufacture of glass and an important raw material as well, because it acts as a fluxing agent, reducing the melting temperature of the glass batch and helping to control the viscosity of glass.

In the manufacture of ceramics, feldspars are used as fluxing agents to form a glassy phase at low temperatures and as a source of alkali elements and alumina in glazes. They improve the strength, toughness, and durability of the ceramic body and cement the crystalline phase of other ingredients, softening, melting and wetting other batch constituents.

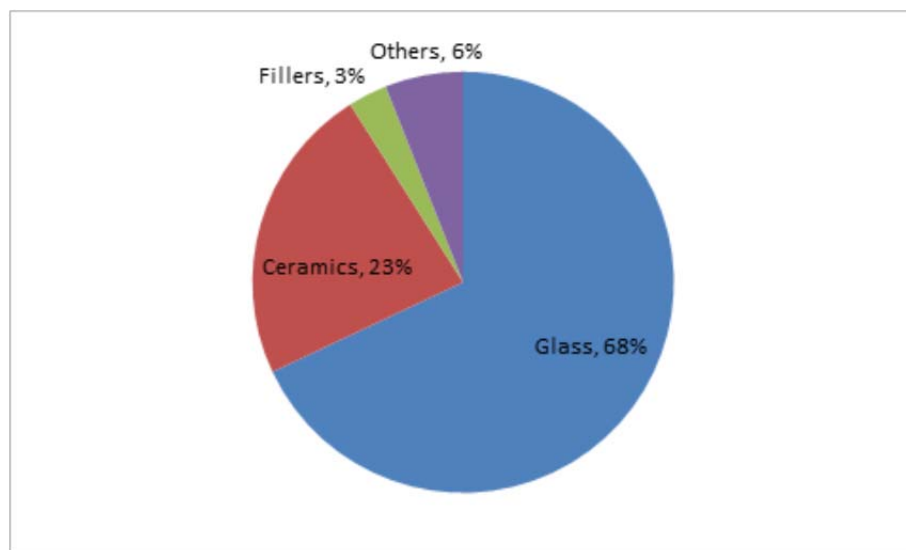
Feldspars also are used as fillers and extenders in applications, such as paints, plastics and rubber. Beneficial properties of feldspars include good dispersability, high chemical inertness, stable pH, high resistance to abrasion, low viscosity at high filler loading, interesting refractive index and resistance to frosting. The products used in such applications are generally fine-milled grades.

In enamels and frits, feldspar assists the enamel composition, ensuring the absence of defects and the finish of the end product, such as ceramic tiles, sanitaryware, tableware, electrical porcelain and giftware. Further end-uses are in paints, mild abrasives, urethane, welding electrodes, latex foam and road aggregate.

The glass market for feldspar in the United States represents the largest market at around 68% while ceramics account for 23% and filler and other applications, including chemicals, paints, rubber and plastics, represent less than 10%. See Figure 19.7 for the breakdown of feldspar demand by end-use sector.

GIAI projects that between 2015 and 2022, feldspar demand in the United States will grow at a CAGR of 3.8% to reach nearly 800,000 t/y. The glass sector is expected to show the highest rate of growth at 3.9%/y, followed by ceramics at 3.6%/y. Filler applications are expected to grow at 3.0%/y and other sectors at 3.2%/y.

**Figure 19.7**  
**2015 Feldspar Demand End-use Sector**



GIAI, 2016.

### 19.2.3 Markets and Pricing

Testwork carried out by ANZAPLAN indicates that feldspar from the Separation Rapids property has a very low iron content and has similar chemical composition to the feldspars marketed by major North American producers.

Table 19.6 presents the price range for feldspar by end-use application.

**Table 19.6**  
**United States Market for Potassium Feldspar, 2015 Pricing by End-use Application**

| End-use Application | Price Range (US\$/t) |
|---------------------|----------------------|
| Sanitary            | 175-225              |
| Tiles               | 170-235              |
| Fillers/Glazes      | 180-250              |

GIAI, 2016.

Through discussions with market participants and industry experts, and evaluation of data provided in purchased reports and publicly available information, Avalon estimates that 100,000 t/y of feldspar can be sold into the glass, ceramics, frits/glazes and filler markets in the United States and European markets and, potentially, in Mexico, at an average price of US\$170. Sales will be built up to 100,000 t/y over a period of five years.

### 19.3 CONTRACTS

At this stage of development of the Separation Rapids property, there are no material contracts in place.

## **20.0 ENVIRONMENTAL STUDIES, PERMITTING AND SOCIAL OR COMMUNITY IMPACT**

The information in this section has been abstracted from the March, 2007 Project Description and Environmental Baseline Study Report (Knight Piésold, 2007), the September, 2013 Species at Risk Assessment (Knight Piésold, 2013), 2016 Tailing, Waste Rock and Water Management Plan (Knight Piésold, 2016a), 2016 PEA Conceptual Closure Plan (Knight Piésold, 2016b), prepared by Avalon's environmental consultant, Knight Piésold Ltd. The 2007 report was based largely on information collected in the late 1990s, and additional data collection to validate the conclusions of this study is planned in the next project phase. Discussions with regulators have been initiated.

### **20.1 INTRODUCTION**

The project site lies in an area adjacent to the English River, a regionally significant waterbody which supports a variety of wildlife and fisheries as well as tourism. The area surrounding the mine site is undeveloped and forested. Presented below is a summary of the environmental setting, potential impacts and mitigation measures for the project. The general arrangement of proposed mine development components is shown on Figure 20.1.

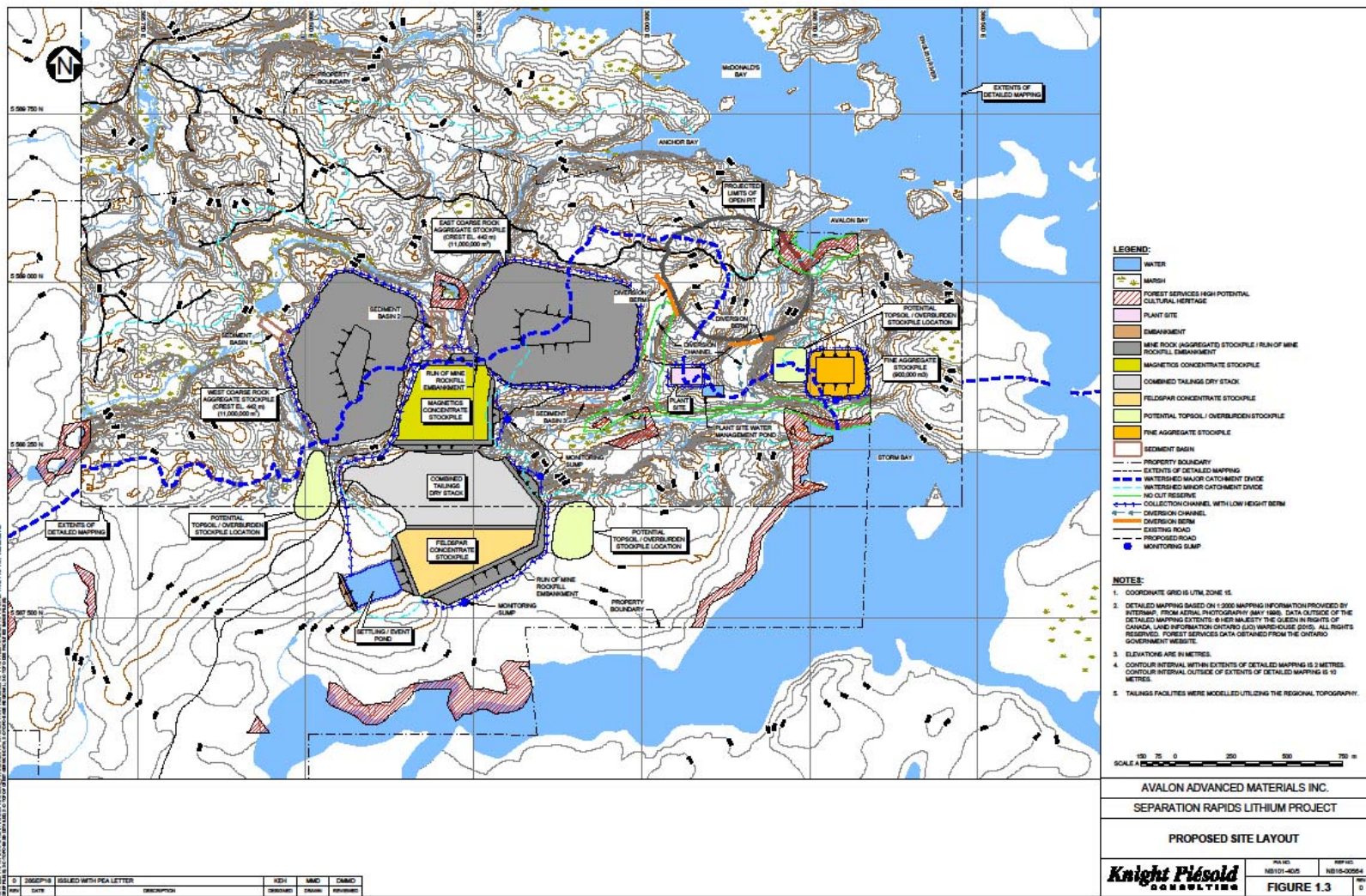
### **20.2 PROJECT APPROVALS AND PERMITTING**

#### **20.2.1 Separation Rapids Permitting, July 2016**

The Federal and Ontario Provincial permitting processes are well defined and understood. The Ministry of Northern Development and Mines (MNDM) is responsible for coordinating the various regulatory agencies in the mine permitting process.

A Project Description and comprehensive Environmental Baseline Report of the mine and concentrator site was completed in March 2007, updated from the July, 1999 draft. The report included a preliminary environmental impact assessment, although based on a different project development model to that presently envisaged. It is expected that given there has been little development activity at the site since 1999, the vast majority of the baseline assessment work will be adequate for the foundation of an Environmental and Social Impact Assessment (ESIA) and associated permitting work with only minor work required to validate the data. A Species at Risk Act (SARA) study for the mine and concentrator site area was completed in September, 2013 (Knight Piésold, 2013) that confirmed that no endangered or at risk animal or plant species exist at site. Discussions with responsible Ministries regarding potential additional updates are expected in the fourth quarter of 2016. A Memorandum of Understanding has been signed with the Wabaseemoong First Nation and preliminary discussions with the Métis Nation of Ontario, as well as political and community representatives, have been initiated. Engagement is expected to continue through the life of the project. The project has strong community support.

Figure 20.1  
Separation Rapids Project Site Layout





There will be a two phase permitting and approvals process. The first phase will be completed for the Advanced Exploration (demonstration plant) phase of the project, and the second phase will be for the construction, operation and closure phases of the full project.

### **20.2.2 Advanced Exploration**

Should Avalon decide to proceed with a demonstration plant, an Advanced Exploration Approval (Application for Bulk Sample Approval) will be required. These permits are approved by MNDM and are designed for relatively low impact activities to allow for large scale testing (over 1,000 t) of the mineralized body and associated refining processes. As a result, they are relatively easy and quickly obtained. Avalon already has an Advanced Exploration Approval based on an approved closure plan, though it is presently in a state of inactivity and is permitted for 15,000 t of material.

A description of the planned activities is required as well as a certified update to the existing closure plan. This includes filed financial assurance to complete the rehabilitation of the site once the project is completed. Depending on whether or not additional engagement is required, the time line for this will range from 45 days to 2-3 months. Financial assurance is in place for the initial plan and, given the extent of the rehabilitation work completed to date (camp removed, signage installed, pit egress improved, significant areas already self-re-vegetated), only a minor change in the quantity of assurance is expected.

At the mine site, due to the low volume of water required, a water taking permit is not required. However, an Environmental Compliance Approval to discharge even small volumes of water will be required from the Ontario Ministry of Environment and Climate Change (MOECC) and can take 3-6 months for approval from the time of application. A work permit to upgrade the access road to an all-weather road for ore transport will be required, but given the existing work permit, the time line for this should be less than a month from the time of application. Approval for a small containment facility on site for the long term disposal of the tailings is planned.

Going forward, Avalon is contemplating the establishment of a small demonstration plant which will operate for a limited time period to produce bulk samples of products. If this is the case, it is likely that this temporary plant will be located in Kenora, at or near the Abitibi site. For this operation, the petalite will be roasted in a facility offshore, so no air permits will be required for that process. Water supply will be from the town, so no water taking permit is required. The small quantity of treated effluent can be discharged to the Kenora sewage treatment system. Therefore, no formal permitting is expected for the water discharge, but Avalon will be required to provide water quality criteria and an agreement with the City of Kenora to compensate for water treatment costs associated with the effluent may be required that is adjusted based on volume of discharge.

Avalon proposes to acquire the existing Nelson Granite quarry and associated permit along the present access road to ensure ongoing road access. No additional quarry or aggregate permits will be required.

An exploration permit for any additional drilling on site will be required from MNDM. Given the existing site conditions and ongoing engagement activity, this is anticipated to take less than three months to acquire.

### **20.2.3 Construction, Operations and Closure**

The Separations Rapids Lithium Project approval time line is governed by the Federal Canadian Environmental Assessment Act process from Environment and Climate Change Canada (ECCC). Given that the mine and concentrator are small and the mineralized material, rock and tailings are inert, and there is significant support for the project, the overall time line following the submission of an updated ESIA is expected to take approximately 18 months.

The following key permits and approvals are expected to be required:

- Certified Closure Plan under the Mining Act from the Ontario MNDM for the full project.
- Environmental Compliance Approvals (ECA) under the Ontario Environmental Protection Act and Ontario Water Resources Act for effluent waste water and sewage treatment management from the MOECC and Ontario Ministry of Health (MOH) for the mine site.
- An ECA will be required for all significant air discharges from the MOECC. The significant air discharges requiring permits will be those associated with the fluid bed roaster at the metallurgical plant and for discharges from dust collection systems site and for emissions from back-up power generation at the concentrator.
- Permit for explosives storage on site from the Ontario Ministry of Labour (MOL).
- Permit to take water for process and potable (drinking) water from the MOECC for the mine site. Water for the hydrometallurgical plant will be obtained from the City of Kenora. Should there be future limitations, the nearby English River is an alternate source of supply, but would require a water taking permit.
- A Waste Generator Approval is required under the Ontario Environmental Protection Act. This will include permits to temporarily store wastes on site prior to sending to an appropriate licensed disposal/landfill facility. As a landfill site is not presently contemplated at site, an associated permit is not required.
- Additional Work Permits under the Forest Fires Prevention Act, Lakes and Rivers Improvement Act and Public Lands Act will be required from the MNRF for use of public lands, lake and river crossings and forest fire prevention.

- While no formal permitting is expected, and assuming the metallurgical plant is located at the Abitibi site, access to and capacity exists in the City of Kenora sewage system. Avalon will discharge to this system. Avalon will be required to provide water quality acceptable to the system, and negotiate an agreement with the City of Kenora to compensate for water treatment costs. In addition, an existing alternate discharge to the English River also exists at the site where high flow provides excellent assimilative capacity. An ECA from the MOECC for a treated effluent discharge to the environment will be required only if there is a discharge to the river.
- An approval under the Federal Environmental Assessment Act will be required from Environment and Climate Change Canada (ECCC). Consideration is also being given to voluntarily applying for a provincial Individual Environmental Assessment that will bring all the provincial environmental approvals under one umbrella rather than applying for them individually. However, given that there will not be many provincial approvals required, should this have the potential to slow the permitting process, the alternative is to apply for individual permits as required.

Other permits may or may not be required. Depending on whether or not the Tailing and Concentrate Management Area (TCMA) impacts on fisheries habitat, authorization under the Fisheries Act from the Department of Fisheries and Oceans (DFO) may be required if fish habitat is altered. An approval under the SARA from ECCC or MNRF is not expected to be required based on a study under SARA. This study was completed in 2013 and no species listed under the act were identified as living on site, though Little Brown Bats are known to visit (Knight Piésold, 2013).

Authorizations under the Navigation Act will not be required as a dock is already at the mine site and no additional work that could cause an obstruction to the waterway is planned. Depending on design and final metallurgical plant location, an Environmental Compliance Approval (ECA) may be required from the MOECC for noise if there is potential to impact on the community.

An approval for an electrical power line to supply hydroelectric power to the site will also be required but is envisioned to be done by the supplier, with only support from Avalon. Similarly, should a run-of-river power generation system be economic, approvals for this system would also be obtained by the supplier, with support from Avalon.

Additional minor approvals with short approval time lines will also periodically be required such as those necessary for small radiation sources for monitoring or laboratory analytical equipment for example.

The key steps and time line for the permitting process include the following:

- 1) Complete and submit the Project Description to the Federal Agency: This is the first step of the permitting process and includes all aspects of the project including the tailing and mine rock aggregate management strategy and closure plan. Avalon will

- prepare a compilation of potential impacts and a cumulative effects assessment with recommended mitigations, including socio economic impacts. Given that the tailing and mine rock aggregate are expected to be inert, a cost effective environmental management program and “walk-away” closure strategy will be developed to minimize financial assurance costs. No significant environmental impacts are expected.
- 2) The Agency will review and decide on the need for an Environmental Impact Assessment (EIA) within 45 days of the submission of the Project Description. EIS Guidelines for the study will be developed. If the voluntary provincial Individual Environmental Assessment is decided on as a preferred option, a similar Terms of Reference will be developed.
  - 3) Finalize and submit the EIA: On the assumption that an EIA is required, the key steps are:
    - i) Development of the Environmental (and Social) Impact Assessment guidelines by the agency. These guidelines are largely similar in all mining projects and allow work to start in advance;
    - ii) Following a public comment period, the guidelines will be finalized and Avalon will finalize the EIA report. Given that these guidelines are similar for all mining projects, this work is already well advanced.
  - 4) Complete and submit the final report EIA: Given the historical data available, this can then be completed in approximately 3 to 6 months following receipt of the EIA guidelines. It is planned that a limited update of the baseline data will be required to validate the historical data and fill minor identified gaps. If new areas are impacted, additional baseline data will be collected. This can be completed following the project description submission to minimize schedule risk.
  - 5) Public and Agency Review: Responses will be prepared by Avalon related to any required updates, clarifications or modifications.
  - 6) A draft EIA Report is then prepared by the agency.
  - 7) Comment Period on the draft EIA Report. This will also include comments from Avalon if there are any.
  - 8) EIA Decision (Project Approval)

Given the advanced exploration that has been completed, this relatively simple and low risk development which to date has had positive community support, a 365 day Agency approval process is assumed following the submission of the project description. Periodic periods of stop time where the proponent (Avalon) will be required to respond to questions or concerns, is estimated to add six months to this process. All provincial regulatory requirements will be

aligned and occur concurrently with the Federal environmental assessment process to the extent practical and with careful management and frequent communication, should not negatively impact on project approval time lines.

Following the Project Approval, Provincial permits may take up to a year to complete, but known key critical path permits may be initiated during the approval process. As such, final site specific permits can be completed during the detailed engineering phase and prior to construction and should not impact overall project schedule.

#### **20.2.4 Conclusion**

The Avalon Separation Rapids Lithium Project is a small scale mining project without many of the risks frequently found at other mines such as acid mine drainage. All tailings mine rock aggregate and concentrate materials are expected to be inert, air and water quantities utilized and discharged are relatively small and can be managed to acceptable standards with conventional technologies. Meetings have already been held with all key regulators to develop positive relationships early and to review the proposed project. Through this early engagement, specific concerns are identified and all required studies can be completed in a timely manner so that there are no surprises during the permitting process. Similarly, positive relationships have already been developed with Indigenous Peoples, political and community representatives. The mine site is approximately 70 km from the city of Kenora where there is an educated workforce knowledgeable and supportive of the project. The permitting project is being managed by Avalon's Vice President, Sustainability who has extensive permitting experience and a track record of successful permitting with support from similarly experienced consultants. An external gap analysis regarding the information required to permit the project has been completed by a qualified consultant and all requirements have been identified.

Given the relatively small size and low environmental risk, no permitting problems are expected and all permits should be acquired in a timely manner that will not negatively impact the project schedule.

#### **20.3 ENVIRONMENTAL BASELINE**

Given that the proposed site for the metallurgical facility to be located in Kenora is located at an existing industrially-zoned and previously operated site, an environmental baseline study for the metallurgical site is not required.

For the mine and concentrator site, an environmental baseline study program has been conducted, investigating regional and site specific aspects such as water quality, hydrology, vegetation, wildlife, fisheries, archaeology, and socioeconomics. The ecology of the project area was investigated with field visits carried out in all four seasons during 1998 and 1999. The majority of these data are still valid and utilizable and some additional work has been completed related to regulatory changes since this study. Plans are in place to further update or validate this information in the next project phase, in consultation with all communities of

interest. This is based in part on a gap analysis that has been completed by Knight Piésold to ensure the data will be comprehensive, historical data are validated and to ensure all potential areas impacted by the project are evaluated in line with present regulatory requirements.

## **20.4 TOPOGRAPHY**

The English River is located within the Severn Upland region of the Canadian Shield, which generally comprises low rolling bedrock hills overlain by a mantle of Wisconsinan glacial deposits. Elevations on the project site range from approximately 310 masl to 370 masl, while elevations within 5 km of the site range between 310 and 410 masl. The Separation Rapids Pegmatite and the Great White North deposits immediately to the northwest are prominent topographic features of the project site, with elevations of 352 m and 366 m, respectively. (See Figure 20.2, below).

The deposit topographic feature will be removed in the process of developing the open pit, however, the Great White North deposit will remain adjacent to the pit at this time. Two mine rock aggregate stockpiles (waste rock) located west of the open pit will reach a maximum elevation of 442 masl, which are marginally higher than the range of elevations found within 5 km of the project site. Several potential mine rock aggregate storage facility arrangements were investigated in order to minimize both the areal extent and the final height of the facilities, within a reasonable haul distance of the open pit. A third crushed aggregate stockpile (fine aggregate) consisting of the rejects from the mineralized material sorting will be stockpiled near the concentrator and will be ideal material for ongoing infrastructure construction such as the concentrate and tailing storage facilities, road maintenance and pit road construction.

## **20.5 AIR QUALITY**

Due to the mine site location, air quality is considered to be good and is not affected by long range atmospheric pollutants. Air quality will be potentially affected primarily by dust emissions from haulage roads, blasting, mine rock aggregate stockpiles, and the Tailing and Concentrate Management Area (TCMA), of which the tailing and concentrate storage poses the greatest potential risk. There will also be some intermittent emission from the back-up power generation system. Wind erosion of tailings should be minimized due to the location of the TCMA in a valley bottom, shielded by higher hills and the mine rock aggregate management facility, and the generally moderate winds in the locality of the site. Dust control, such as the use of water or recycled water, will be utilized as appropriate to mitigate potential impacts. Dust monitoring will be implemented.

State of the art dust management will be implemented at the fluid bed roaster in the hydrometallurgical plant, with collected dust re-introduced into the process.

## 20.6 NOISE

With the exception of light motor boat traffic on the English River in summer and snow machine traffic in winter, background noise levels are low. Noise will be generated during construction and operational phases of the mine due to blasting, mill operation and vehicular traffic. Potential mitigation measures include natural sound ‘baffles’ (i.e., locating the concentrator site behind hills), the use of sound insulation in building construction, enforcement of speed limits on access roads, and suitable timing of blasting. The nearest permanent residences are sufficiently distant to not be impacted by the site.

## 20.7 HYDROLOGY

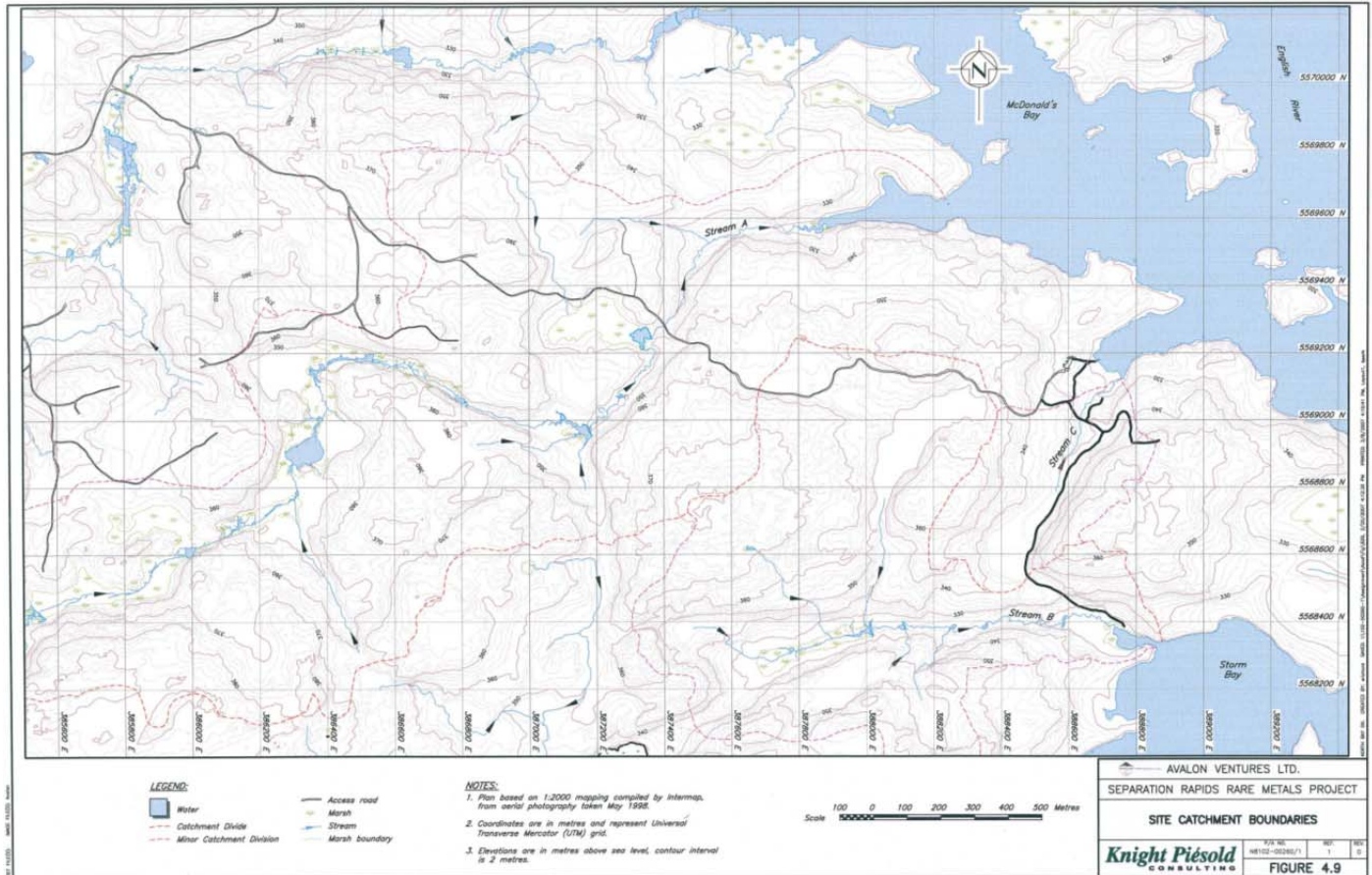
The major receiving water for surface water flow from the mine site is the English River, which flows from near the town of Dryden for approximately 420 km in a northwesterly direction, through a chain of lakes extending from Wabigoon Lake in Ontario, to Lake Winnipeg in Manitoba. In 1957, a hydroelectric dam was constructed at Caribou Falls, approximately 60 km downstream of the project site, and this had a major influence upon the physical characteristics of the English River, forming Umphreville Lake, with flooding extending upstream to near the project site.

The property is drained by two small streams. Stream C, a small intermittent drainage flows from the proposed open pit location north into Avalon Bay and is not identified as fish habitat. A swamp located at the southwest edge of the deposit also did not contain fish and intermittently drains south into an abandoned beaver pond, and then east into a stream (Stream B) leading into Storm Bay. Storm Bay is a large, shallow water body with a constricted mouth, which leads into the main English River channel. A stream further to the southwest of the pit (Stream D) also drains the area to the south west. The environmental status of this stream has not yet been studied, but the TCMA is believed to be located sufficiently far upstream as to not directly impact on fish habitat, though treated runoff from the inert tailing will contribute to the downstream flows. Stream A, also known to be fish habitat and located to the north and west of the project, will not be utilized for storage of mine rock aggregate, concentrate or tailing.

Construction of the proposed mine site will have an effect on site hydrology. Significant efforts to minimize this impact have been made, including the use of dry stacked tailing. Due to the fisheries habitat located in Stream B, it will not be utilized for tailing, mine rock aggregate or concentrate management. The northern and part of the intermittent component of this stream and the wetland on the southwest edge of the deposit that is not considered fish habitat will be consumed by the pit and mine rock aggregate management area. The components south of the existing access road (and small waterfall that acts as a fish barrier) that eventually becomes fish habitat will not be disturbed by the project. The proposed open pit will occupy most of the drainage area of the small intermittent non fish bearing stream flowing into Avalon Bay.

Local and regional hydrology will not be affected by mine development, as the proposed mine will occupy less than 2 km<sup>2</sup> in area. This is not significant in terms of total size of the English River and the Storm Bay watersheds and, since no significant effluent discharge quantities are projected from mine operations, no hydrological impacts are predicted. The site drainage system is shown in Figure 20.2.

**Figure 20.2**  
**Site Catchment Boundaries**



## 20.8 WATER QUALITY

Results of a 12-month surface water quality monitoring program on the English River during 1998-1999 revealed that median concentrations of the majority of parameters monitored are comparable to those expected in a river free of major contaminant inputs. Provincial Water Quality Objectives (PWQO) were at times exceeded for aluminum, cadmium, copper, mercury, lead, silver and zinc, which is not unusual for catchments containing mineralized zones.

A baseline water quality monitoring program was initiated in streams on the proposed mine site. Aluminum was found to exceed PWQO which, in the absence of known anthropogenic



sources, is most likely due to natural weathering of soils and bedrock. PWQO concentrations for cadmium, copper, iron, lead and zinc were also exceeded. Baseline water quality data will be used to define water quality goals on closure of the proposed mine.

The preliminary characterization testing indicates that the mine rock and mineralized material will not be acid generating. Additional work in 2015 analyzed selected “worst case” mine rock samples. Even the single highest and rare sulphide bearing samples with visible sulphidic material had a carbonate: sulphur ratio of 8:1, further supporting this conclusion. Impacts to the water quality of receiving waters could potentially result from runoff from the waste rock storage facilities or TCMA. Parameters of potential concern may include suspended solids, organic reagents and brine used during processing, and residual trace metals from weathering of waste rock and tailings. However, the preliminary Synthetic Precipitation Leaching Procedure (SPLP) tests on mineralized material, mine rock and tailing suggest that runoff would not contain any parameters that would exceed the Metal Mining Effluent Regulations. All mine rock will thus be stored as aggregate for future utilization.

Nitrate is a potential nutrient of concern that can be generated by the use of ammonium nitrate blasting agents. Phosphorus is not a concern from the mineralized material, mine rock aggregate, processing or the minor quantities of treated sewage. On this basis, eutrophication from nitrate is unlikely due to the fact that phosphorus is normally the limiting nutrient in northern Ontario waters. Regardless, best management practices for blasting will be incorporated, and monitoring of nitrate concentrations will be part of the ongoing monitoring plans. In the event that nitrates approach concentrations of concern, strategies can include the use of emulsions, mine employee retraining in ammonium nitrate management and investigation of the maintenance of ammonium nitrate storage and/or loading equipment or using wetland treatment.

Several measures to mitigate impacts to water quality will be incorporated into the project plan, including:

- 1) Recycling and potentially treating process water to minimize fresh water requirements and the rate of discharge to the environment.
- 2) Diversion of non-impacted site runoff away from the site to reduce impacted water volume.
- 3) To significantly reduce the risk from tailing water at the TCMA, tailings will not be hydraulically placed and will be filtered and trucked to the TCMA as solids.
- 4) Collection and treatment of process and pit water in the concentrator.
- 5) Construction of a final clarification pond to remove suspended solids and facilitate treatment from the TCMA and mine rock aggregate surface runoff (if necessary) prior to discharge to the environment.

- 6) Installation of a submerged pipe fitted with an end diffuser to discharge water from the settling/event pond and/or the treated water from the concentrator into the main channel of the English River in order to maximize mixing and the assimilative capacity of the river. This would reduce potential impacts to water quality in Storm Bay, which has a relatively small catchment area and outflow, and therefore would have a low assimilative capacity for effluent.

During the next phase of the project when additional water and waste products are available from the final process flow sheet, including internal recycle and/or water treatment, additional water quality testing will be completed on all waste streams. Humidity cell and additional water quality and biological toxicity studies are proposed on additional mine rock aggregate, concentrate and tailing samples. A water treatment process will be developed and tested if necessary to meet regulatory requirements. Impacts to water quality as a result of mine development are considered to be mitigable and not significant.

## **20.9 GROUNDWATER**

Groundwater hydrogeology will be of major importance during mine development due to the close proximity of the planned open pit to the English River. A detailed hydrogeological assessment of the mine site is scheduled for completion during the next phase of the project, including an assessment of groundwater and an evaluation of the hydrogeological conditions near the proposed open pit. A key focus will be on the future pit dewatering requirements, pit stability and the engineering requirements for the mine rock aggregate, tailings and concentrate management areas.

Existing data suggests that bedrock underlying the site is relatively impermeable, which would reduce the risk of groundwater impacts. As the tailing/concentrate and mine rock aggregate will also not be acid generating, acid mine drainage is not considered an issue at this site. Dry stacking of tailing and concentrate further reduces this risk.

Dewatering of the open pit will create a groundwater drawdown cone in the vicinity of the pit. The planned detailed hydrogeological investigation will evaluate the potential impacts of the drawdown cone between the pit and the river. This may result in elevated flows from the river into the pit that will require management and to ensure the safe operation of the pit. During development and operation of the pit, water inflow from the English River to the open pit via groundwater will be monitored. Significant groundwater inflows to the pit may be controlled by grouting.

## **20.10 VEGETATION**

The project is located in the boreal forest region. The dominant tree species found on the project site are jack pine and black spruce. The site is characterized by thin soils and dry site vegetation communities, as well as several wetland communities, including a black spruce swamp immediately adjacent and to the southwest of the deposit, as well as several marsh communities adjacent to the English River. Upland vegetation communities observed

included conifer, mixed wood and hardwood forests, and blowdown areas, while wetland vegetation communities include treed and shrub swamp, marsh, sand shrub or graminoid fens. Some additional work may be required following additional engagement or to address potential new areas impacted. No unique, rare or endangered plant species or vegetation community types were observed or are expected.

Development of the proposed mine will result in direct impacts to the vegetation of the site. Vegetation will be removed from the project development area, including the open pit, plant site and waste storage areas. The major components of impact and their areal extent are listed in Table 20.1.

**Table 20.1**  
**Areal Extent of Major Project Components at the Separation Rapids Site**

| Item                                     | Area<br>(ha) |
|--|--------------|
| Open pit                                 | 25.0         |
| Concentrator site                        | 1.1          |
| Tailings and concentrate management area | 57.0         |
| East coarse rock aggregate stockpile     | 34.0         |
| West coarse rock aggregate stockpile     | 32.0         |
| Fine aggregate stockpile                 | 3.8          |
| Settling/event pond                      | 2.9          |

Thus, the total impacted area, excluding roads, will be approximately 1.56 km<sup>2</sup>. In a regional context, this is not considered to be significant since the project site is surrounded by un-impacted forested land.

The mine site will be revegetated on closure to restore the disturbed area to as close to pre-mine conditions as possible, and thus reduce long term impacts. Three topsoil stockpiles have been proposed during initial mine construction to facilitate mine site revegetation after closure.

The potential surficial impacts to the mine site will be minimized by containing mine rock, tailing and concentrate products within engineered storage facilities, such as the TCMA and the mine rock aggregate storage facilities.

The Kenora 2012-2017 Forest Management Plan identified a 90 m “No Cut Zone” between the mineralized zone and the English River. This plan is being updated in the third and fourth quarters of 2016. These zones are identified based on a computer-generated algorithm based on land slope and other factors, and are not substantiated by site visits. These plans do not hold authority over mining applications. While Avalon wishes to maintain a treed visual barrier between the mine site and the river, the edge of this no cut zone could potentially be impacted by the open pit. As a precaution, a submission to the plan developers to correct the zone from 90 m width to a 30 m width as required, based on the actual slope of the area, was requested. This will avoid overlap of the pit and the no cut zone and provide a protected area to help mitigate runoff from the site.

## **20.11 WILDLIFE**

Wildlife in the project area is abundant, with the species observed typical of Ontario's boreal forests. Large flocks of common mergansers were observed at Separation Rapids during spring migration, while common mergansers, common goldeneyes, buffleheads and mallards were observed breeding in the project area. Moose were the most common ungulate observed on the project site, while black bear, wolf, fisher, red fox, marten, mink, and otter are common carnivorous species. Small mammals, rodents and lagomorphs observed included deer mouse, beaver, red squirrel, muskrat and snowshoe hare. Wood frog, leopard frog and American toad were the most common amphibian species, while painted turtles were observed in Avalon Bay, and garter snakes were observed on site. Woodland caribou were not observed.

As noted above, a SARA was completed in 2013 (Knight Piésold, 2013). Bald eagles and white pelicans, which are on the Ontario Endangered Species list, were encountered in the project area. Bald eagles and white pelicans are both piscivores and no feeding opportunities for these species exist on the project site. Bald eagles nest in close proximity to water in conspicuous large stick nests that are used year after year and are usually located in trees a few metres from the shores of large water bodies. The closest bald eagle nest is over 1 km east of the proposed mine development. The white pelicans observed on the English River near the project site had likely moved into the area for summer feeding from the main pelican population and breeding ground on the Three Sisters Island in Lake of the Woods. It is concluded that mine development will not adversely impact bald eagle or white pelican populations. Little Brown Bats were identified on site, but no nesting habitat was identified. Some additional SARA work may be required following additional engagement or to address potential new areas impacted.

The project site is relatively small in a regional context, and contains no rare or significant wildlife habitat components. Most of the mammals inhabiting the site, with the possible exception of small mammals, will simply be displaced to the adjacent abundant suitable habitat. Since small mammals are generally prolific breeders, they are not sensitive to extirpation, and populations will re-expand to the capacity of the environment very quickly. The proposed mine development is not predicted to have a significant impact on wildlife.

## **20.12 FISHERIES**

A significant recreational fishery exists on the English River in the project area, providing income to local tourism outfitters and recreation for local anglers. The use of the fishery for subsistence by local First Nation communities has been restricted following historical contamination of the river with mercury, discharged from a pulp and paper mill located upstream. The major target species were identified as walleye, northern pike, and smallmouth bass. A benthic macroinvertebrate community monitoring program was conducted in 1998 to characterize fish habitat.

A northern pike spawning site was observed in Goose Bay, at the mouth of the stream flowing south of the proposed mine site into Storm Bay. The streams immediately to the north and the south of the project site both have populations of baitfish, including finescale dace, northern redbelly dace, fathead minnow, bluntnose minnow and ninespine stickleback. Since these streams are within a licensed baitfish block, there is a potential for commercial exploitation of the bait fishery, and therefore, the streams would be classified as fisheries habitat by the DFO. For this reason, no deposits of any mine rock or tailings are planned in these streams.

A third stream further south and west of the project has been selected for the TMCA. This facility is planned to be located in the upper intermittent reaches of this stream in an effort to avoid direct impacts on fisheries habitat. Additional study is required to validate this. Potential for impacts are low given that the tailings are non-acid generating and are not hydraulically deposited. Further, preliminary SPLP tests suggest little potential to impact streams. Unanticipated impacts to the downstream area dominated by wetland also have water quality polishing capability. Significant impacts to fisheries are expected to be mitigable. Similarly, the mine rock aggregate is not expected to generate leachates of concern, and simple settling of solids will be completed to mitigate this risk. Additional testing is planned, including toxicity testing, in the next project phase.

### **20.13 TAILINGS AND CONCENTRATE MANAGEMENT**

The principal objective of the TCMA is to provide the safe and secure storage of the process waste products while ensuring the protection of the environment during operations and in the long-term (after closure). The conceptual level design of the TCMA has taken into account the following requirements:

- Permanent, secure and total confinement of all process waste products within an engineered facility.
- Control, collection and removal of free draining liquids from the tailings during operations for recycling as process water to the maximum practical extent.
- The inclusion of monitoring features for all aspects of the facility to ensure performance goals are achieved and design criteria and assumptions are met.
- Secure reclamation and closure of the impoundment after mining is complete.
- The flexibility to reprocess select by-products (concentrates) at a future date.

The TCMA design includes the initial starter arrangement and ongoing raises to the facility throughout the life of the operation.

Approximately 1.2 Mt of magnetics concentrate, 0.5 Mt of tailing slime, 1.4 Mt of hydrometallurgical plant tailings, and 3.8 Mt of feldspar concentrate will be produced over

the life of the project. (Feldspar concentrate is the name given to partially concentrated material rejected from the petalite circuit that will undergo additional processing in the future to produce a marketable feldspar product). The magnetics and a portion of the feldspar material will be stored separately due to their potential to be re-processed in the future. Some feldspar production is planned, limited by annual markets for this material. The TCMA will consist of valley impoundment type facilities located west and southwest of the plant site as shown above in Figure 20.1. Tailings will be filtered in the concentrator and hydrometallurgical plant and trucked to the TCMA as solids. A quantity of the feldspar concentrate may be mixed with the slimes material to aid in the filtration process.

The TCMA is located approximately 1.5 km southwest of the open pit as shown on Figure 20.1. The facility will be constructed as three distinct cells as previously noted. The Magnetics Concentrate cell will be located at the north side of the area, while the Feldspar Concentrate cell will be located toward the south, with the Combined Tailings located in the central portion of the TCMA. The tailings and concentrates, to be filtered at the plant, will be transported to the TCMA by truck, placed and compacted in horizontal lifts starting at the base of the cells and advanced up slope of the basin floor and side slopes. In areas not confined by natural ground, the tailings/concentrates will be buttressed with 20 m wide (min) mine rock berms around the perimeter.

There will be no long term storage of tailing at the hydrometallurgical plant. Filtered tailing will be trucked to the mine site utilizing the same trucks that transport the concentrate to the plant on the return trip. The hydrometallurgical tailings will be stored with the combined tailings in the central cell of the TCMA.

### **20.13.1 Mine Rock Aggregate and Mineralized Material Management**

Given the inert nature of the waste material from the open pit and the scarcity of aggregate in the area, all mine rock is considered as utilizable aggregate product. Approximately 52 Mt of coarse mine rock aggregate and 1.3 Mt of crushed and optically sorted rejects (fine aggregate) will be generated during the life of the project. (Note that the fine aggregate stockpile is marginally oversized for 2 Mt). The aggregate materials will consist primarily of amphibolite and pegmatitic granite rock, with a lesser amount of feldspathic material. At this stage, these materials will be managed together. The coarse mine rock aggregate will be placed in two storage areas to the west of the open pit while the fine aggregate will be stored near the concentrator for easy access for road maintenance, storage facility construction and pit road construction.

The mine rock aggregate materials have been characterized as non-acid generating based upon the results of the preliminary laboratory testwork carried out in the Environment Baseline Study (Knight Piésold, 2007), and in additional recent assessments of “worst case” materials, it is not expected that the mine rock aggregate storage areas will require any facilities for control or adjustment of pH in relation to acid rock drainage. In general, the rock is expected to be benign (although there is the potential for some minor leaching of metals as a result of natural weathering). For the purposes of this preliminary economic assessment

therefore, sediment control and closure issues have been determined to be the key environmental design factors.

Current planning of the mine rock aggregate storage facilities includes the following considerations:

- 1) Minimum surficial and environmental impacts, including not utilizing fisheries habitat.
- 2) Minimum visual impacts.
- 3) Minimum impact on potential sites of heritage value.
- 4) Close proximity to the pit to minimize the haul distances and grades.
- 5) Maximum integration with other project facilities where this is beneficial.
- 6) Minimum of 100 m from the edge of the open pit.
- 7) Ensuring that the facilities can be safely and securely rehabilitated in accordance with best available practices at the end of the mine life.

For the purposes of this PEA, the volumes of mine rock aggregate materials that will be generated by the project have been estimated using a specific gravity of 2.9 and an excavation swell factor of 1.3, giving a placement density of  $2.23 \text{ t/m}^3$ . Based on this density, the total volumes of feldspathic material and pegmatitic granite mine rock aggregate that are expected to be generated over the mine life are approximately  $23.4 \text{ Mm}^3$ . An updated estimate of the placement density should be completed at a subsequent stage in the design of the project.

Figure 20.1, above, shows the general arrangement of the three mine rock aggregate storage facilities for the project. The two coarse aggregate management areas will occupy an area of about 66 ha. They will be developed to a maximum elevation of 442 m which will give them a maximum height of about 70 m. It is planned that the coarse aggregate produced during the initial years of mining will be placed in the nearest facility due to its shorter haul distance from the pit, moving to more distant facilities as the nearer site reaches its capacity. The maximum elevation will not be substantially different to similar topography located within 5 km of the site. The relatively small volume ( $1.3 \text{ Mm}^3$ ) of crushed fine aggregate material will be stored next to the plant site.

Small quantities of run of mine mineralized material will be stored in contained areas adjacent to or within the plant site

There will be no waste material located at the metallurgical plant site. All concentrate feed will be stored inside the facility.

## **20.14 SEWAGE TREATMENT**

Domestic sewage will be generated from the mine dry, processing plant, and office areas. The daily loading of sewage and grey water can be expected to be approximately 20,000 L, based on a total of 135 contractor and full time employees using the facilities during three shifts over a 24 h period.

The sewage and grey water will be conveyed in sanitary sewer pipes to a permitted septic system located adjacent to the processing plant. Two suitably sized septic tanks, operating in parallel, will provide the necessary capacity and the flexibility for system maintenance. Grey water will be decanted from the septic tanks and discharged into a septic field. The sludge which accumulates in the bottom of the septic tanks will be regularly pumped out and transported offsite for disposal by a licensed contractor.

Sewage from the hydrometallurgical plant will be discharged to the Kenora sewage treatment system.

## **20.15 WATER MANAGEMENT**

The design and implementation of a comprehensive water management plan for the mine site will be fundamental to the project. The key water management issues will centre around handling the following:

- Open pit runoff and seepage.
- Runoff from the plant site.
- Runoff from the mine rock aggregate management facilities.
- Runoff from the TCMA.

The principal objectives of the water management plan for the project will be:

- 1) To minimize the volume of potentially impacted water generated from the site.
- 2) To minimize the amount of water extracted from the English River for processing and general mine site use by maximizing the use of reclaimed runoff water plant site runoff, mine dewatering flows, through internal concentrator recycling and use of filtered tailing and concentrate storage.
- 3) To the extent practical, direct all water that is impacted by processing operations to a single point in order to minimize the locations that require monitoring and treatment.



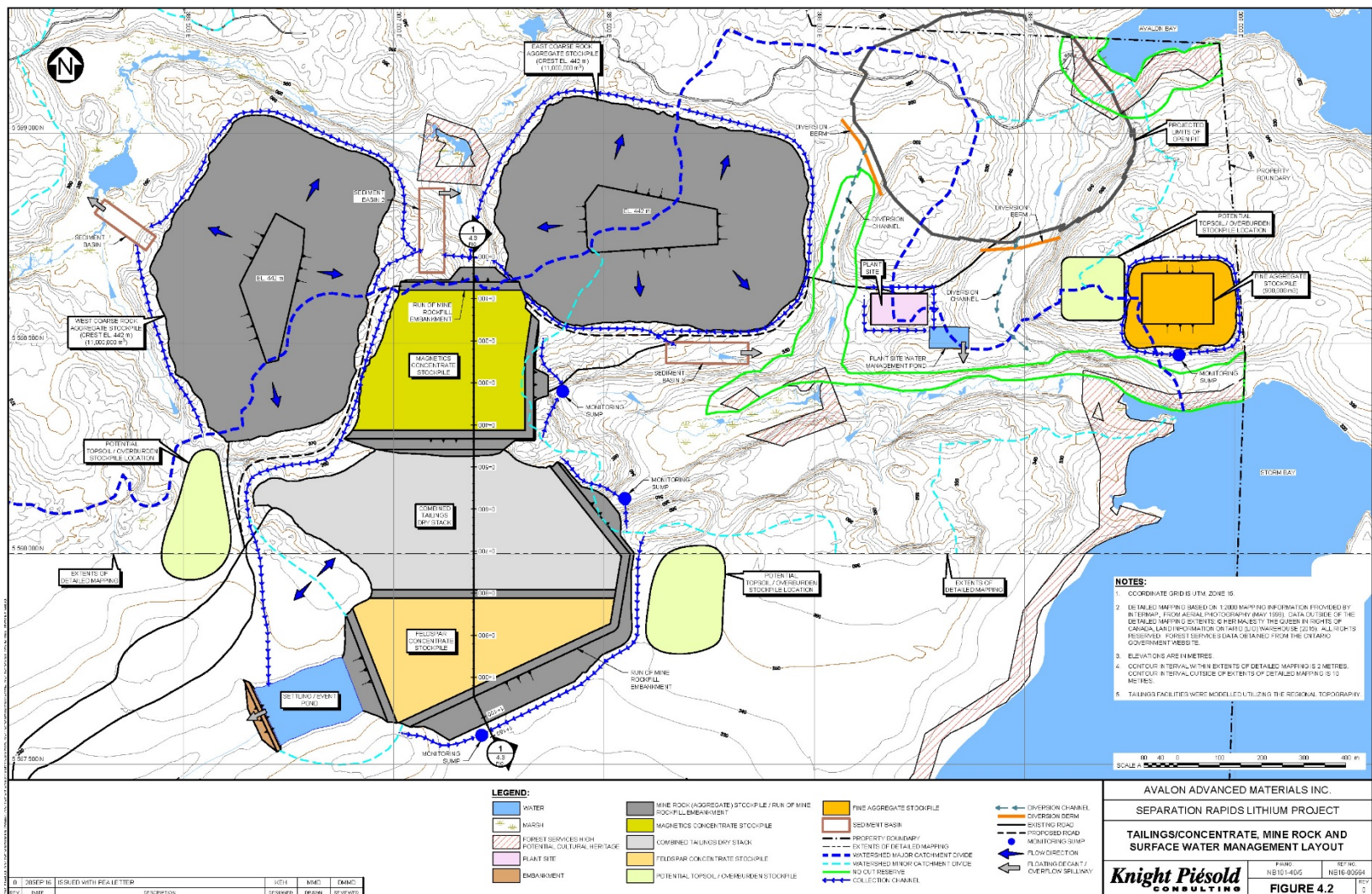
### 20.15.1 Water Management Measures

In general, the runoff management measures will include a series of low height berms, collection/diversion channels, collection basins and sumps. Runoff from the various catchment areas in and around the site will be managed as follows:

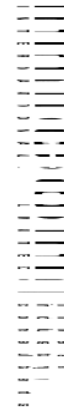
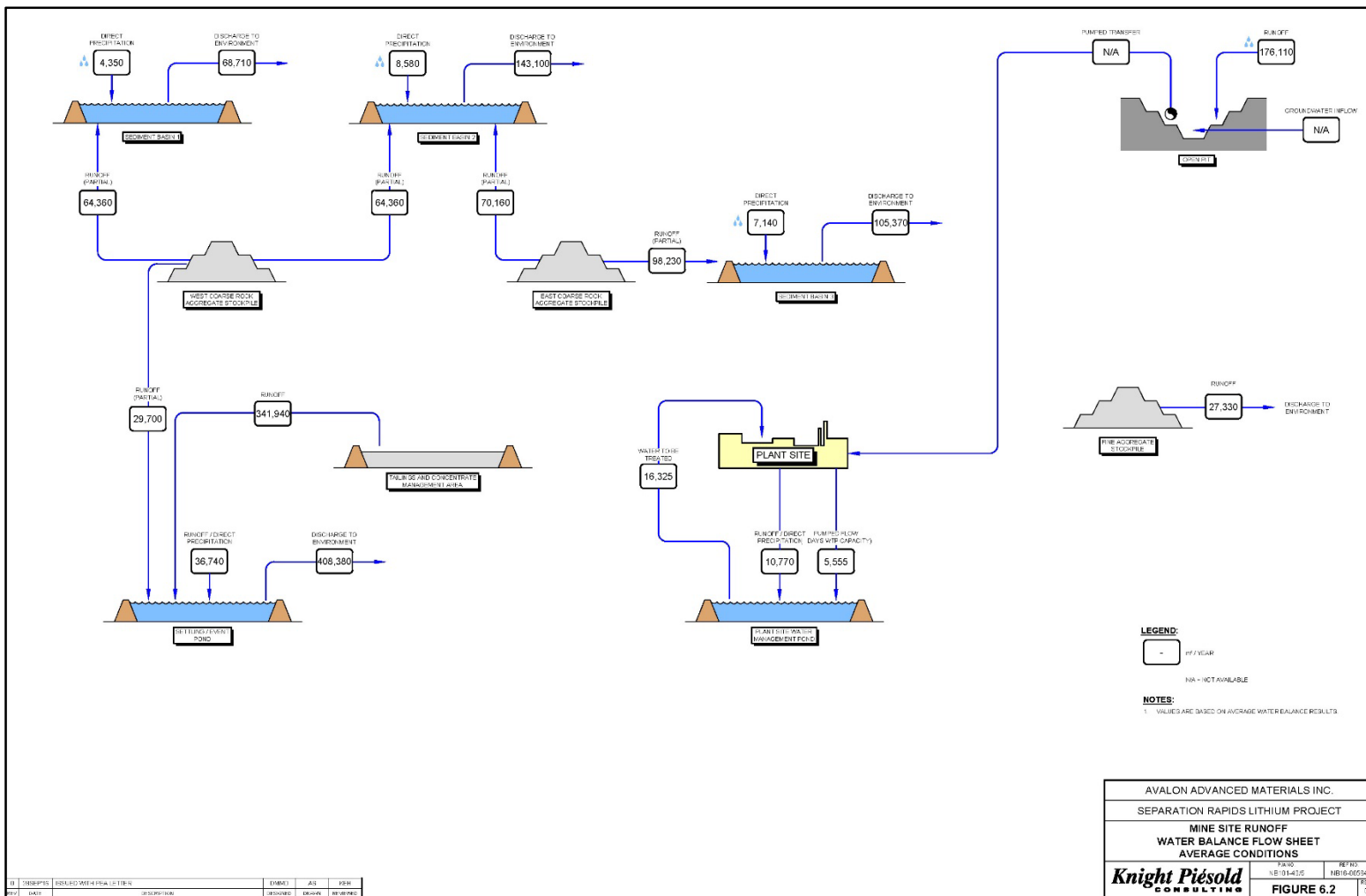
- Topsoil/Overburden Stockpiles – Runoff will be directed to temporary perimeter ditches, and sediment and erosion control measures (i.e., silt fences, straw bales) will be incorporated into the ditches until vegetation is established.
- Fine Aggregate Stockpile – Runoff from this stockpile will be directed to perimeter collection channels that will drain to a monitoring sump. Runoff reporting to the sump will be monitored periodically to ensure it is acceptable for discharge to the environment.
- Coarse Mine Rock Aggregate Stockpiles – Runoff originating within each of these stockpiles will be directed to perimeter collection channels. These channels will drain to one of three sediment basins where the majority of sediment will be allowed to settle prior to the runoff being decanted out of the basin and discharged to the downstream environment. The exception to this is the southeastern portion of the west coarse rock aggregate stockpile, which will have its runoff directed to the settling/event pond.
- Plant Site – Runoff originating within the plant site will be directed to a series of perimeter collection channels which will drain to the plant site water management pond. Water from this basin will be pumped to the water treatment plant for treatment prior to discharge to the environment.
- TCMA – Runoff originating within the TCMA will be directed to the settling/event pond at the southwest end of the facility. The majority of sediment will be allowed to settle out of the runoff before the runoff is decanted out of the basin and discharged to the downstream environment. Runoff originating from the downstream embankment slopes of the TCMA will report to collection channels that drain to small monitoring sumps. Runoff reporting to the sumps will be monitored periodically to ensure it is acceptable for discharge to the environment.

Low height berms will be constructed adjacent to the collection channels to help direct disturbed areas runoff to the channels and sediment basins, and also to help divert undisturbed areas runoff from upstream areas away from the sediment basins. Diversion berms will also be constructed on the west and south sides of the open pit to divert runoff away from the pit. The locations and schematic of the proposed water management measures are shown on Figure 20.3. A simple water balance was prepared to provide estimates of the volumes of runoff reporting to each pond/basin on the site. See Figure 20.4.

**Figure 20.3  
Tailings/Concentrate, Mine Rock and Surface Water Management Layout**



**Figure 20.4  
Separation Rapids Site Water Balance**



The water balance was prepared for one year of operations, based on average annual precipitation conditions. The total annual precipitation value was 715 mm, which includes rainfall and snowfall water equivalent. The figure shows that there will be a surplus of water from the project.

The natural downstream receiver from the settling/event pond is Storm Bay. However, due to its relatively shallow depth and flow rate and the limited potential for mixing and assimilation of the flows, if required, the potential exists to discharge the water from the settling/event pond through a submerged pipe, with an end diffuser, into the main channel of the English River. Notwithstanding this, some infrequent flows which result from excessive snowmelt and precipitation events may be released directly to Storm Bay through engineered overflow spillways.

Water management at the hydrometallurgical plant site is planned to be discharged to the Kenora sewage treatment system where there is significant capacity for the small volumes expected.

## **20.16 CLOSURE AND REHABILITATION**

The Ontario Mining Act requires that, upon cessation of operations, mining lands are to be restored to their former use or condition, or are to be made suitable for a use approved by the Director of the Ministry of Northern Development and Mines. The primary objectives of mine decommissioning are to ensure that public safety and security are not compromised and that any environmental impacts are reduced to an acceptable level or eliminated. An additional objective is to rehabilitate any disturbed areas and integrate them into the naturally surrounding landscape.

For mines located on previously undisturbed sites, ecological restoration is a fundamental component of site reclamation. The main aspects of the closure and reclamation plans for the project are described in the following paragraphs.

Following the cessation of mining, the open pit will be allowed to flood. Flooding will occur primarily through inflows of groundwater and surface water runoff. It is currently unknown if the pit will become completely filled with water, however if this occurs, excess water will be discharged through a high level overflow channel into the English River after demonstration that the water is of good quality. Given that the mineralized material and pit wall rock is expected to be inert, an alternative being considered is to generate a direct link to the river to facilitate the development of aquatic and fisheries habitat in the pit. A barrier, consisting of boulders, will be placed around the perimeter of the open pit at closure to prevent access. Signs warning of the open pit will also be erected.

The TCMA will be closed and rehabilitated in a safe and secure manner in full accordance with government regulations and good engineering practice. Testwork done to date indicates that the tailings and concentrate will be non-acid generating, and as such acid mitigation measures are not expected to be necessary for closure. (Knight Piésold, 2016b). This will be

fully confirmed by testwork in subsequent stages of the project planning. As a precaution, the concentrate storage facilities are also planned to be rehabilitated at the end of the mine life. Once sufficient tailing and concentrate is available, reclamation testing will be completed in order to demonstrate that direct seeding is feasible for vegetation of the TCMA.

Following closure, the TCMA will be a reclaimed landform that sheds runoff. Some ditching may be required, but no water ponds or spillways will be necessary. The tailings and any remaining concentrate will be vegetated.

Progressive rehabilitation of benches of the coarse rock aggregate storage areas is planned to minimize the potential for aesthetic visual concerns during operations, particularly on the river view sides. Benches and the top of the first aggregate storage area will be progressively covered with a layer of seedbed material and revegetated when completed, assuming the aggregate is not being utilized for other purposes. The seedbed material will be obtained from the topsoil stockpile which will be developed from stripping various areas prior to mining. It is expected that some areas of the mine rock aggregate management area will be filled to capacity before operations are completed. As part of a progressive decommissioning plan, vegetation test plots will be established on the completed management area to determine the optimum revegetation procedure. Once this is determined, the completed portions of both aggregate facilities will be reclaimed progressively during the life of the mine. The top of the second aggregate storage area will be revegetated following mine closure, assuming no markets or alternate use for this material have been identified.

All sediment basins associated with the TCMA and the mine rock aggregate stockpiles will be breached and revegetated as necessary for closure.

All machinery and equipment from the crusher, process plant and other ancillary facilities will be removed for reuse, salvage or disposal, and all buildings and infrastructure will be removed or demolished. Every practical effort will be made to maximize the salvage or recycling of the materials. Inert demolition materials that cannot be salvaged will be broken up and used to fill any below-grade openings. All chemicals or hazardous materials will be returned to the supplier or removed to an appropriate waste disposal facility by a licensed contractor. Petroleum storage tanks will be removed in accordance with applicable regulations. General waste materials will be disposed of in an offsite licensed site landfill.

The mine access road will be maintained to provide access during the closure and post-closure monitoring period. Following completion of post-closure monitoring, the road will be scarified and revegetated and culverts removed. All other mine roads and disturbed areas will be scarified and revegetated. In the event that ongoing engagement on the project and closure plan identifies an alternate user (e.g., a forestry company) that wishes to maintain and take responsibility for all or parts of the road, this option can be utilized, in consultation with applicable regulators.

A 5 year post-closure monitoring program will follow closure of the mine that includes maintenance of the revegetated areas. The monitoring program will include assessment of the

physical stability of the aggregate storage facilities, and TCMA, surface water and groundwater quality, and periodic biological monitoring of the aquatic and terrestrial ecosystems in the immediate vicinity of the site. The monitoring program will continue, as required, until the target objectives of the site closure have been achieved.

Machinery will be removed from the hydrometallurgical plant site. The buildings will continue to be usable in the industrial park setting.

## **20.17 COMMUNITY AND INDIGENOUS PEOPLES ENGAGEMENT**

Consultation with local First Nations Bands and the public was initiated during the 1999 baseline study. This continued in a reduced manner during the period of inactivity, but was again ramped up in 2013. A memorandum of understanding initially signed with the Wabaseemoong Independent Nation (WIN) in 1999 was renewed in 2013. This agreement commits Avalon to maximize opportunities for WIN and to facilitate business partnerships. To this end, Avalon has utilized Indigenous personnel and companies to the extent practical during work completed to date.

Avalon has also reached out to the Métis Nation of Ontario (MNO) in an effort to engage with them. While a formal engagement meeting with their full area engagement committee has not yet occurred, relationships with the MNO remain positive.

In discussions with the MNDM, no additional First Nations are required to be engaged with. This is due in part to the Isslington Agreement that was signed between the Province of Ontario and the WIN. This agreement was developed following the relocation of many community members due to the flooding of the English River associated with hydroelectric dam construction. This agreement gives the WIN exclusive control over the area that includes the Avalon site. The Métis rights have recently been granted to a wide area of the north and overlap the Isslington Agreement.

Avalon maintains an engagement log which records the numerous meetings held and summaries of the meeting content, and reports this annually in its Sustainability Report.

An archaeological study was completed in 1998 (Adams, 1998). This will be reviewed with the communities of interest and updated if required. There may be a requirement to complete additional traditional knowledge studies in the next phase of project development. A socioeconomic assessment of the project is included in the 2007 environmental study. This will be updated in the next phase of the project.

It is also noted that the Kenora 2012-2017 Forest Management Plan identified sites of High Potential Cultural Heritage. While the plan does not have the authority to enforce its requirements on mining and mining has different approval processes, these sites were a concern. In these plans, cultural heritage sites are identified based on a computer-generated algorithm and are not based or substantiated by site visits. Heritage sites may be added or removed by site investigations by qualified archeologists or by extensive study and artifact

recovery in consultation with Indigenous Peoples. This plan was prepared without the benefit of the Avalon archeological study. While efforts have been made to avoid these theoretical sites, there is a small unavoidable area of overlap in the proposed pit outline and part of a potential heritage area along the English River. The Avalon archaeological study did not identify this area as a heritage site. Avalon is in the process of providing this information to those responsible, and who are presently updating this information for the next 5 year Forest Management Plan, in order to have this area removed as an area of potential cultural heritage. In the highly unlikely event that this area remains a concern, Avalon is prepared to initiate a detailed study and if necessary, artifact recovery of this area, in consultation with appropriate Aboriginal groups.

Avalon has a full time representative in Kenora who facilitates ongoing engagement with Indigenous Peoples, communities, regulators and politicians that contributes to the strong support for the project.

## 21.0 CAPITAL AND OPERATING COSTS

### 21.1 CAPITAL COSTS

The basis for the capital cost estimate is contract mining, a 950,000 t/y concentrator that recovers approximately 145,000 t/y of petalite concentrate and 100,000 t/y of feldspar concentrate, and a hydrometallurgical facility that produces approximately 14,520 t/y of high purity lithium hydroxide product suitable for the battery market. Descriptions of the areas of the project are included in the previous sections of this PEA.

The LOM capital cost estimate is summarised in Table 21.1. The estimate is given in Canadian dollars (\$), with a base date of third quarter, 2016. Owing to rounding of the estimates, some totals may not agree.

**Table 21.1**  
**LOM Capital Estimate**

|  | <b>Initial Capital<br/>(\$ millions)</b> | <b>Sustaining Capital<br/>(\$ millions)</b> | <b>Total Capital<br/>(\$ millions)</b> |
|--|--|---|--|
| Mining                                     | 2.0                                      |   | 2.0                                    |
| Concentrator – direct costs                | 112.9                                    |   | 112.9                                  |
| Hydrometallurgical Facility – direct costs | 167.5                                    |   | 167.5                                  |
| Tailings – direct costs                    | 7.3                                      | 6.0   | 13.3                                   |
| Indirect costs                             | 123.9                                    | 0.3   | 124.2                                  |
| Owner’s costs                              | 3.9                                      |   | 3.9                                    |
| Closure Bond                               | 5.5                                      |   | 5.5                                    |
| Contingency                                | 84.7                                     | 0.9   | 85.6                                   |
| <b>Total</b>                               | <b>507.7</b>                             | <b>7.2</b>                                  | <b>514.9</b>                           |

The capital cost estimate for this project presented herein is considered to be at a scoping level with an accuracy of +50%/-35% and carrying a contingency of 20% on total initial estimated capital.

#### 21.1.1 Mining

##### 21.1.1.1 Contract Mining

A budget cost of \$4.40/t mined was received by Avalon from a local mining contractor. This cost is included in the mining operating costs. An allowance of \$2 million has been included to allow for contractor mobilization.

##### 21.1.1.2 Owner Mining

The capital costs have been estimated by Micon from first principles according to the fleet requirement over the course of the mine life. The capital cost requirements for the peak production Year 4 is summarized in Table 21.2.



**Table 21.2**  
**Summary of Initial Capital Costs**

| Category                     | Cost (Cdn\$)      |
|------------------------------|-------------------|
| Excavators                   | 8,424,000         |
| Front End Loader             | 2,558,400         |
| Haul Trucks                  | 18,200,000        |
| Bulldozers                   | 1,297,000         |
| Drill Rigs                   | 3,567,200         |
| Explosives Plant and Trucks  | 1,560,000         |
| Ancillary Fleet              | 4,608,000         |
| Offices, Mine Infrastructure | 3,380,000         |
| Grade Control                | 455,000           |
| <b>Total Capital Cost</b>    | <b>44,050,000</b> |

Micon believes that most of the mining fleet will see out the life of the mine. The mining equipment demobilized after the peak production period will be reinstated towards the end of the mine life to replace the machinery that will have been in continuous use throughout.

For the Owner mining case, Micon recommends including a contingency equivalent to 20% of the initial capital costs (\$8.8 million) as the sustaining capital costs.

### 21.1.2 Concentrator

A breakdown of the capital costs estimate for the concentrator is given in Table 21.3. Since maintenance costs are included in operating expenses, no sustaining capital is included.

**Table 21.3**  
**Summary of the Estimated Concentrator Capital Costs**

| Project Area                                | Initial Capital (\$ '000) |
|---|---------------------------|
| <b>Direct Costs</b>                         |                           |
| Site earthworks - general                   | 2,600                     |
| On-site roads                               | 125                       |
| Crushing                                    | 11,808                    |
| Grinding and classification                 | 6,626                     |
| Magnetic separation                         | 22,629                    |
| Feldspar flotation                          | 12,139                    |
| Petalite flotation                          | 27,380                    |
| Reagents                                    | 2,083                     |
| Tailings dewatering                         | 3,391                     |
| Water circuits                              | 3,085                     |
| Utilities and services                      | 2,092                     |
| On-site infrastructure and mobile equipment | 18,968                    |
| <b>Subtotal Direct Costs</b>                | <b>112,925</b>            |
| <b>Indirect Costs</b>                       |                           |
| EPCM  | 11,292                    |

| Project Area                                 | Initial Capital (\$ '000) |
|--|---------------------------|
| Off-site infrastructure and mobile equipment | 18,700                    |
| Commissioning and start-up                   | 1,540                     |
| Vendor reps                                  | 500                       |
| First fills-3 months consumables             | 2,000                     |
| Spare parts                                  | 3,080                     |
| Freight and transportation                   | 5,045                     |
| Contractor indirects                         | 2,258                     |
| Insurance                                    | 1,129                     |
| Construction indirects                       | 5,646                     |
| <b>Subtotal Indirect Costs</b>               | <b>51,192</b>             |
| Contingency (20%)                            | <b>32,823</b>             |
| <b>Total Concentrator Costs</b>              | <b>196,940</b>            |

The processing capital cost estimate is a factored estimate based on the process mechanical equipment supply costs. The equipment was sized and selected by Avalon and the equipment costs are based on budget quotes received for all the major units and over 80% of the smaller equipment items, such as pumps and agitators.

Factors for each area of the processing facility were applied by Micon to estimate the associated costs for civil and earthworks, concrete, structural steel, platework, piping and instrumentation and electrical. The estimated process equipment selection, sizing and supply costs were based on the process design criteria and the process flowsheet discussed in Section 17.0 of this report. The factors used for the estimate are based on Micon's experience and in-house database.

Included in the offsite infrastructure are the power supply and site distribution, and an allowance to upgrade the existing access road.

### 21.1.3 Hydrometallurgical Facility

A breakdown of the estimated capital costs for the hydrometallurgical plant is given in Table 21.4. Since maintenance costs are included in operating expenses, no sustaining capital is required.

**Table 21.4**  
**Summary of the Estimated Hydrometallurgical Plant Capital Costs**

| Project Area                          | Initial Capital (\$'000) |
|---------------------------------------|--------------------------|
| <b>Direct Costs</b>                   |                          |
| Site Earthworks - General             | 1,500                    |
| On-Site roads                         | 50                       |
| Concentrate Storage and Decrepitation | 31,494                   |
| Roasting                              | 9,574                    |
| Water Leach                           | 6,552                    |
| Solution Purification                 | 5,359                    |

| Project Area                                 | Initial Capital (\$'000) |
|--|--------------------------|
| Solution Purification - Ion Exchange         | 2,290                    |
| Bipolar Membrane Electrodialysis             | 32,050                   |
| Crude Crystallization                        | 8,283                    |
| Product Crystallization                      | 7,925                    |
| Lithium Hydroxide Product Drier              | 4,711                    |
| Sulfuric Acid Staged Evaporator              | 22,202                   |
| Off-Gas Scrubber Process                     | 917                      |
| Cooling Water / Condenser Process            | 5,286                    |
| Process and Deionized Water Process          | 1,178                    |
| Hydromet Wastewater Treatment Process        | 690                      |
| Steam Generation and Compressed Air          | 7,603                    |
| On-Site Infrastructure and mobile equipment  | 19,811                   |
| <b>Subtotal Plant Direct Costs</b>           | <b>167,473</b>           |
| <b>Indirect Costs</b>                        |                          |
| EPCM   | 25,121                   |
| Off-site infrastructure and mobile equipment | 13,425                   |
| Commissioning and start-up                   | 2,279                    |
| Vendor reps                                  | 500                      |
| First fills-3 months consumables             | 2,000                    |
| Spare parts                                  | 4,557                    |
| Freight and transportation                   | 10,357                   |
| Contractor indirects                         | 3,349                    |
| Insurance                                    | 1,675                    |
| Construction Indirects                       | 8,374                    |
| <b>Subtotal Plant Indirect Costs</b>         | <b>71,637</b>            |
| Contingency (20%)                            | <b>47,822</b>            |
| <b>Total Hydrometallurgical Plant Costs</b>  | <b>286,932</b>           |

The processing capital cost estimate is a factored estimate based on the process design described in Section 17.0 of this report and the supply costs for the selected mechanical equipment for the plant. The mechanical equipment was sized, selected and costed by Thibault. The estimated process equipment selection, sizing and supply costs were based on the process design criteria and the process flowsheet which were developed by Thibault. The design is discussed in Section 17.0 of this report.

Factors for each area of the processing facility were applied by Micon to estimate the associated costs for civil and earthworks, concrete, structural steel, platework, piping and instrumentation and electrical. The factors used for the estimate are based on Micon's experience and in-house database.

#### **21.1.4 Tailings Storage Facility, Waste Rock and Water Management**

The PEA cost estimates for the tailings and concentrate management area (TCMA), the waste rock facility and the site water management system are summarized in Table 21.5.

**Table 21.5**  
**Summary of the Estimated Hydrometallurgical Plant Capital Costs**

| Description                    | Initial Capital<br>(\$'000) | Sustaining Capital<br>(\$'000) | LOM Capital<br>(\$'000) |
|--------------------------------|-----------------------------|--------------------------------|-------------------------|
| Mobilization                   | 281                         | 136                            | 417                     |
| Earthworks                     | 3,462                       | 3,294                          | 6,756                   |
| Concrete                       | 14                          | 0                              | 14                      |
| Geo-synthetic linings          | 240                         | 14                             | 254                     |
| Pipework                       | 100                         | 20                             | 120                     |
| Instrumentation.               | 20                          | 40                             | 60                      |
| Misc.                          | 3,165                       | 10                             | 3,175                   |
| TSF reclaim facility           | -                           | 2,500                          | 2,500                   |
| <b>Subtotal Direct Costs</b>   | <b>7,282</b>                | <b>6,014</b>                   | <b>13,296</b>           |
| Engineering                    | 1,051                       | 338                            | 1,389                   |
| <b>Subtotal Indirect Costs</b> | <b>1,051</b>                | <b>338</b>                     | <b>1,389</b>            |
| Contingency                    | 1,821                       | 879                            | 2,700                   |
| <b>Total</b>                   | <b>10,154</b>               | <b>7,231</b>                   | <b>17,385</b>           |

The cost estimates for the TCMA, waste rock and water management areas were developed by Knight Piésold. The costs are based on the preliminary designs discussed in Section 20.0 of this report and estimates of quantities and unit rates.

#### **21.1.5 Owner's Costs**

Pre-production Owner's costs have been estimated at \$3.875 million comprising mainly Owner's pre-production labour. An additional 20% was included for contingency.

#### **21.1.6 Closure Costs**

A provision has been made for a closure bond of \$5.5 million to be deposited during the construction phase. On closure, it is assumed that the refund of this bond will be applied to any remedial works required at that time.

### **21.2 OPERATING COSTS**

Operating costs have been determined by Avalon with the exception of the mining costs which were determined by Micon. The costs are expressed in Canadian dollars and are based on:

- Total tonnes mined as determined by mining schedule and typical industry rates.
- Anticipated labour complements and appropriate labour rates.
- Reagent consumptions from testwork and budget supply prices.
- Energy estimates calculated from electrical equipment loads and gas consumptions.
- Estimates for miscellaneous minor operating expenses.

The estimated average annual project operating costs assuming a mine life of 9.83 years and unit costs for the first ten years of production when both petalite and feldspar are produced are summarized in Table 21.6.

**Table 21.6**  
**Summary of LOM Operating Costs**

| Category                           | Annual<br>(\$'000) | \$/t<br>Processed | \$/kg<br>Lithium<br>Hydroxide |
|------------------------------------|--------------------|-------------------|-------------------------------|
| Mining                             | 29,416.53          | 30.96             | 1.98                          |
| Concentrator processing            | 36,738.53          | 38.67             | 2.46                          |
| TCMA, waste rock, water management | 1,241.10           | 1.31              | 0.08                          |
| Concentrate transport              | 2,045.42           | 2.15              | 0.14                          |
| Hydrometallurgical processing      | 23,348.68          | 24.58             | 1.56                          |
| General and Administration         | 4,104.78           | 4.32              | 0.27                          |
| <b>Total Cash Production Costs</b> | <b>96,895.05</b>   | <b>101.99</b>     | <b>6.49</b>                   |

## 21.2.1 Mining

### 21.2.1.1 Contract Mining

The PEA base case includes contract mining rather than Owner mining. The LOM average estimated unit costs for this case equate to \$30.96 /t of mineralized material processed or \$4.70/t of material mined.

A budget cost of \$4.40/t mined was received by Avalon from a local mining contractor. The additional costs of around \$0.30/t mined or \$1.9 million per year account for the Owner's supervisory team and technical services.

### 21.2.1.2 Owner Mining

Micon estimated the mining operating costs for the Owner mining case from first principles. The basis for the estimate is the preliminary mine design and schedule that is discussed in Section 16.0.

The drilling and blasting costs are based on a mineralized material density of 2.62 t/m<sup>3</sup> and waste density of 3.04 t/m<sup>3</sup>. It is anticipated that approximately 180 blasts will be required annually to break and extract a maximum combined mineralized material and waste tonnage of 8.1 Mt/y; this is equivalent to 2.70 Mbcm.

The loading costs include the operating costs for the excavators, front end loader and tracked dozers mining mineralized material and waste, pit bench and stockpile management. Table 21.7 shows the estimate of mining operating costs.

**Table 21.7**  
**Average Estimated Mine Operating Costs (Owner Mining)**

| <b>Category</b>                        | <b>Annual Cost (\$'000)</b> |
|--|-----------------------------|
| Management, Administration, Technical  | 3,963                       |
| Drilling                               | 1,683                       |
| Blasting                               | 2,715                       |
| Loading, Pit and Stockpile Maintenance | 4,137                       |
| Hauling                                | 7,348                       |
| Ancillary Equipment                    | 1,285                       |
| Grade Control Cost                     | 677                         |
| <b>Total Cost</b>                      | <b>21,808</b>               |
| <b>\$/t Material Processed</b>         | <b>22.96</b>                |
| <b>\$/t Material Mined</b>             | <b>3.49</b>                 |

### 21.2.2 Concentrator

The concentrator operating cost estimate was prepared by Avalon and reviewed by Micon. A summary of the annual average costs for the first ten years of the operation are presented in Table 21.8.

**Table 21.8**  
**Average Estimated Concentrator Operating Costs**

| <b>Description</b>                      | <b>Annual Costs (\$'000)</b> |
|---|------------------------------|
| Labour and supervision                  | 7,632                        |
| Power                                   | 3,581                        |
| Reagents and consumables                | 22,506                       |
| Maintenance spares                      | 1,493                        |
| Equipment rental                        | 1,017                        |
| Other costs                             | 509                          |
| <b>Total</b>                            | <b>36,739</b>                |
| <b>\$/t Material Processed</b>          | <b>38.67</b>                 |
| <b>\$/kg Lithium Hydroxide Produced</b> | <b>2.46</b>                  |

#### 21.2.2.1 Power

The operating power (kW) has been estimated from the total installed load as determined by the Mechanical Equipment List and the design utilization factor. It is assumed that all operating drives draw 80% of their installed motor power with the exception of certain intermittent operating equipment items such as filter presses, samplers and spillage pumps, and standby equipment.

An average power cost of \$0.0923/kWh has been used for the PEA. This rate is calculated using a number factors which make up the Ontario power costs.

#### 21.2.2.2 Labour

Labour requirements for the concentrator are estimated at 84 personnel, comprising 51 in operations, 26 in maintenance and 7 in technical services, for a total annual cost of approximately \$7.6 million. The majority of the staff positions (60 in total) will be to service the petalite production area, while the remaining 24 members are allotted for the feldspar production area. However, it is expected that some positions will work on both areas such as the plant metallurgist and laboratory technician.

The labour costs have been estimated based on typical salary rates for the specified position and location. These rates are inclusive of benefits and other costs.

It is expected that there will be four teams of operators for each of the units. Each team will have their own supervisor/foreman. The shifts will be 12 hours and each team will rotate between day and night shift on a four on, four off basis. Other staff members such as an operations day crew, metallurgists and engineering/maintenance will work day shifts only during Monday to Friday.

Senior operations management costs are included under General and Administration.

#### 21.2.2.3 Reagents and Consumables

The estimated reagent consumptions for the concentrator are based on the testwork which is reported in Section 13.0. Recycle factors were included with each of the reagents since it is anticipated that the process water will be recycled in the plant, reducing overall reagent consumption. The total average annual cost of reagents for the concentrator is \$22.0 million.

Other consumables included in the estimate comprise grinding media, crusher liners and bulk concentrate bags.

#### 21.2.2.4 Maintenance

Annual maintenance supplies costs for the concentrator have been estimated using 1.3% of the direct capital costs, equivalent to \$1.49 million per annum.

#### 21.2.2.5 Equipment Rental

Estimated equipment rental costs include the cost for renting occasional cranes and other miscellaneous equipment during operations. This estimate of \$1 million per annum was determined by reviewing industry data and comparing similarly sized operations.

### 21.2.3 Hydrometallurgical Plant

The hydrometallurgical plant operating cost estimate was prepared by Avalon and reviewed by Micon. A summary of the annual average costs are presented in Table 21.9.

**Table 21.9**  
**Average Estimated Hydrometallurgical Plant Operating Costs**

| Description                                | Annual Costs<br>(\$'000) |
|--|--------------------------|
| Labour and supervision                     | 4,883                    |
| Power                                      | 13,405                   |
| Reagents and consumables                   | 2,846                    |
| Maintenance spares                         | 2,215                    |
| <b>Total</b>                               | <b>23,349</b>            |
| <b>\$/t Mined Material Processed</b>       | <b>24.58</b>             |
| <b>\$/t Petalite Concentrate Processed</b> | <b>159.81</b>            |
| <b>\$/kg Lithium Hydroxide Produced</b>    | <b>1.56</b>              |

#### 21.2.3.1 Labour

Labour requirements for the hydrometallurgical plant are estimated at 48 personnel, comprising 24 in operations, 18 in maintenance and 6 in technical services, for a total annual cost of approximately \$4.9 million per year. The labour costs have been estimated based on current typical salaries for the specified position and location. Each salary estimate is inclusive of all benefits etc.

It is expected that there will be four teams of operators for each of the units. Each team will have their own supervisor/foreman. The shifts will be approximately 12 hours and each team will rotate between day and night shift on a four on, four off basis. Other staff members such as the plant metallurgist and millwrights will be present for eight hours during Monday to Friday.

Costs for senior management are included in the General and Administration labour costs.

#### 21.2.3.2 Power

The operating power has been estimated from the equipment load list using the same criteria as used for the concentrator.

The estimated total installed electrical power is 12.6 MW and the average power draw estimated at 9.3 MW.

The supply cost of electricity at the hydrometallurgical plant will be the same as at the concentrator i.e., \$0.0923/kWh.



Natural gas consumption was estimated at 232 GJ/h and will be delivered at a cost of \$4.448/GJ.

#### 21.2.3.3 Reagents and Consumables

The total estimated annual cost of reagents for the hydrometallurgical plant is \$1.8 million. The major cost items are sulphuric acid and filter pre-coat, the balance being small quantities of caustic soda and water treatment chemicals.

A sulphuric acid regeneration system has been incorporated into the electro dialysis circuit. This regeneration system accepts a dilute acid stream from electro dialysis and concentrates it up to 93% acid by evaporation. As a consequence, only  $\pm 22.4\%$  of acid requirements is sourced from fresh/new acid.

Miscellaneous consumables include bulk bags for the lithium hydroxide, packaging supplies, safety supplies and other costs. This was determined by reviewing industry data and comparing similarly sized operations and estimated at \$1 million per annum.

#### 21.2.3.4 Maintenance Supplies

Maintenance supplies costs for the hydrometallurgical plant has been estimated to be \$2.2 million per annum. This figure was estimated by applying an appropriate factor to the direct capital costs.

#### 21.2.3.5 TCMA and Water Management

The costs for operating the TCMA and site water management system were estimated by Knight Piésold. These costs are estimated at approximately \$1.2 million per year and comprise mainly spreading and compaction of the dry-stacked tailings.

#### 21.2.3.6 Concentrate Transportation

A rate of \$14/t has been used for truck transportation of petalite flotation from the concentrator site to the hydrometallurgical facility in Kenora. This rate is based on budget quotes from local transportation providers. The average annual cost is approximately \$2 million.

### 21.2.4 General and Administration

The annual estimated general and administration operating costs amount to \$4,035,000 per year.

The majority of the estimated General and Administration (G&A) costs is associated with labour, which includes the senior operations management as well as administration personnel. Total labour is estimated to be \$3.2 million per annum and includes 26 people.

In addition to labour there is a \$300,000 per year provision for corporate expenses (legal, financial etc.) and a \$500,000 per year provision for additional miscellaneous expenses.

### 21.2.5 Petalite Tails Reclaim and Feldspar Production

At the end of the mining operation production, the concentrator will continue to operate with the production of 100,000 t/y of feldspar. The PEA assumes that this phase of only feldspar production will continue for 10 years starting in Year 11.

Stored feldspar concentrate that will be stockpiled in a separate location from the rest of the residue streams will be re-claimed by mechanical loader, re-pulped and processed through the feldspar flotation circuit. A summary of the average annual costs during this phase of the operation are presented in Table 21.10.

**Table 21.10**  
**Summary of Feldspar Production Operating Costs**

| Category                           | Annual<br>(\$'000) | \$/t<br>Processed | \$/t<br>Feldspar |
|------------------------------------|--------------------|-------------------|------------------|
| Feldspar concentrate reclaim       | 222                | 1.84              | 2.22             |
| Feldspar processing                | 4,984              | 41.32             | 49.84            |
| General and Administration         | 1,068              | 8.85              | 10.68            |
| <b>Total Cash Production Costs</b> | <b>6,273</b>       | <b>52.00</b>      | <b>62.73</b>     |

## 22.0 ECONOMIC ANALYSIS

Micon has prepared its assessment of the project on the basis of a discounted cash flow model, from which Net Present Value (NPV), Internal Rate of Return (IRR), payback and other measures of project viability can be determined. Assessments of NPV are generally accepted within the mining industry as representing the economic value of a project after allowing for the cost of capital invested.

The objective of the study was to determine the potential viability of the proposed development of the Separation Rapids open pit mine and on-site concentrator, and the establishment of an off-site hydrometallurgical processing plant to further refine the product. In order to do this, the cash flow arising from the base case has been forecast, enabling a computation of the NPV to be made. The sensitivity of this NPV to changes in the base case assumptions is then examined.

### 22.1 MACRO-ECONOMIC ASSUMPTIONS

#### 22.1.1 Exchange Rate and Inflation

Lithium hydroxide and feldspar price assumptions are given in United States dollar (US\$) terms but, unless otherwise stated, financial results are expressed in Canadian dollars (\$) or Cdn\$). Cost estimates and other inputs to the cash flow model for the project have been prepared using constant, third quarter 2016 money terms, i.e., without provision for escalation or inflation.

An exchange rate of \$1.30/US\$ is applied in the base case, approximately equal to current rates and to the trailing average over the past two years.

#### 22.1.2 Weighted Average Cost of Capital

In order to find the NPV of the cash flows forecast for the project, an appropriate discount factor must be applied which represents the weighted average cost of capital (WACC) imposed on the project by the capital markets. The cash flow projections used for the valuation have been prepared on an all-equity basis. This being the case, WACC is equal to the market cost of equity, and can be determined using the Capital Asset Pricing Model (CAPM):

$$E(R_i) = R_f + \beta_i(E(R_m) - R_f)$$

where  $E(R_i)$  is the expected return, or the cost of equity.  $R_f$  is the risk-free rate (usually taken to be the real rate on long-term government bonds),  $E(R_m) - R_f$  is the market premium for equity (commonly estimated to be around 5%), and beta ( $\beta$ ) is the volatility of the returns for the relevant sector of the market compared to the market as a whole.

Micon has taken a real discount rate of 8% as its base case, and provides the results at alternative rates of discount for comparative purposes.

### **22.1.3 Expected Metal Prices**

The base case cash flow projection assumes a constant price of US\$11,000/t lithium hydroxide, LiOH.H<sub>2</sub>O. Feldspar sales are at a constant price of US\$170/t. The basis for these price assumptions are discussed in Section 19 of this report.

### **22.1.4 Taxation Regime**

Ontario mining tax, and Canadian federal and provincial income taxes payable on the project have been provided for in the cash flow forecast. Mining tax is charged at 10% of net income, after deductions for depreciation and a processing allowance. Depreciation is deductible on a straight-line basis at 30% on mining assets and 15% on processing assets. The processing allowance is set at 8% of processing capital (subject to the allowance falling between minimum and maximum percentages of profit of 15% and 65%, respectively).

Provincial and federal income tax rates are 10% and 15%, respectively. Depreciation allowances for income tax are generally limited to 25% on a declining balance basis, with only a small proportion of initial capital assumed to be eligible for the accelerated allowance that may be claimed during the transition period ending in 2020.

### **22.1.5 Royalty**

No royalty has been provided for in the cash flow model.

### **22.1.6 Selling Expenses**

Concentrate transport between the mine and the hydrometallurgical plant is included within cash operating costs. Both lithium hydroxide and feldspar are assumed to be sold on FOB basis at the refinery and mine site, respectively.

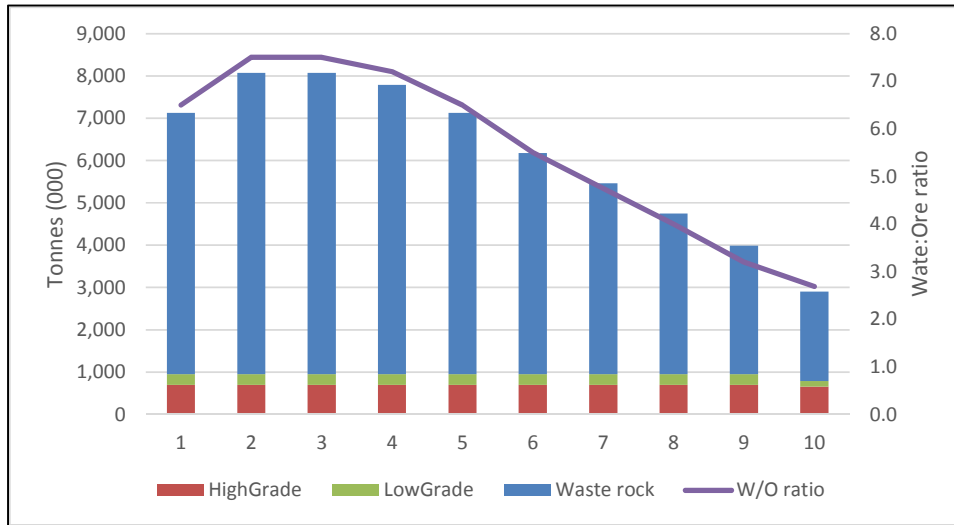
## **22.2 TECHNICAL ASSUMPTIONS**

The technical parameters, production forecasts and estimates described elsewhere in this report are reflected in the base case cash flow model. These inputs to the model are summarised below. The measures used in the study are metric throughout.

### **22.2.1 Mine Production Schedule**

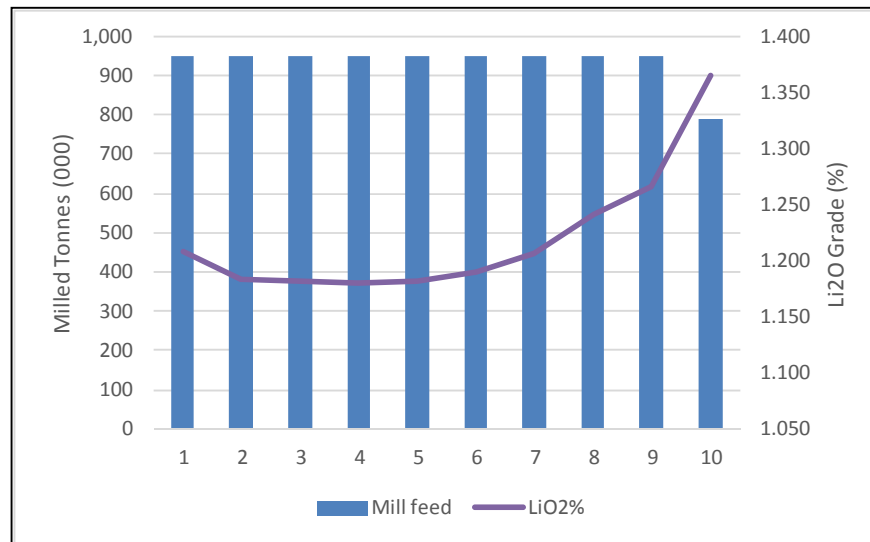
Figure 22.1 shows the annual tonnage of mill-feed material mined from the open pit, as well as the waste rock tonnage. Mill-feed reclaimed from the stockpile is also shown.

**Figure 22.1**  
**Annual Mining Schedule**



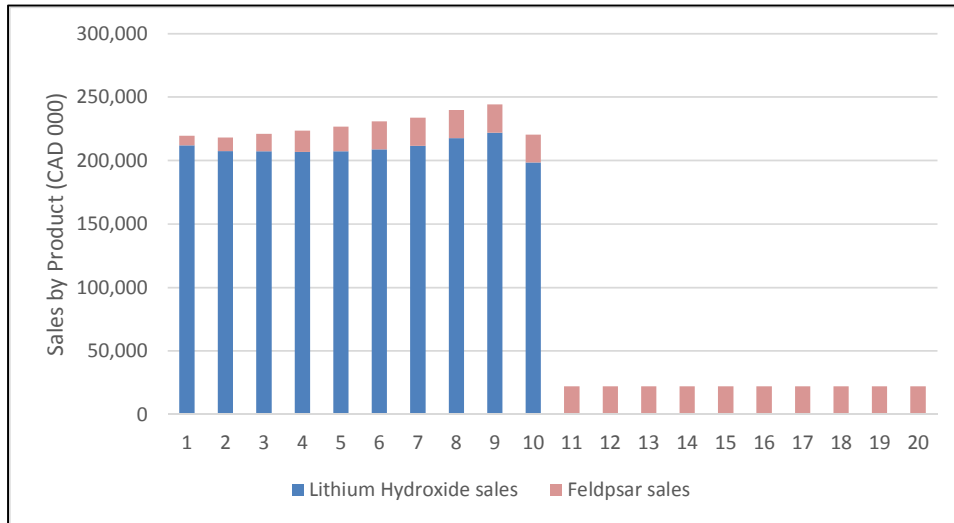
In Figure 22.2, the lithium oxide (Li<sub>2</sub>O) grades of the mill feed are shown, indicating an overall improvement in grade towards the bottom of the open pit.

**Figure 22.2**  
**Annual Processing Schedule**



Annual sales of lithium hydroxide and low impurity feldspar over the LOM period are shown in Figure 22.3. Note that feldspar sales ramp up from 34,000 t in Year 1 to 100,000 t in Year 6, and remain at that level for the remainder of the 20-year project life. On average over that period, feldspar sales represent 16% of total sales revenue.

**Figure 22.3**  
**Annual Sales Revenues by Product**



### 22.2.2 Operating Costs

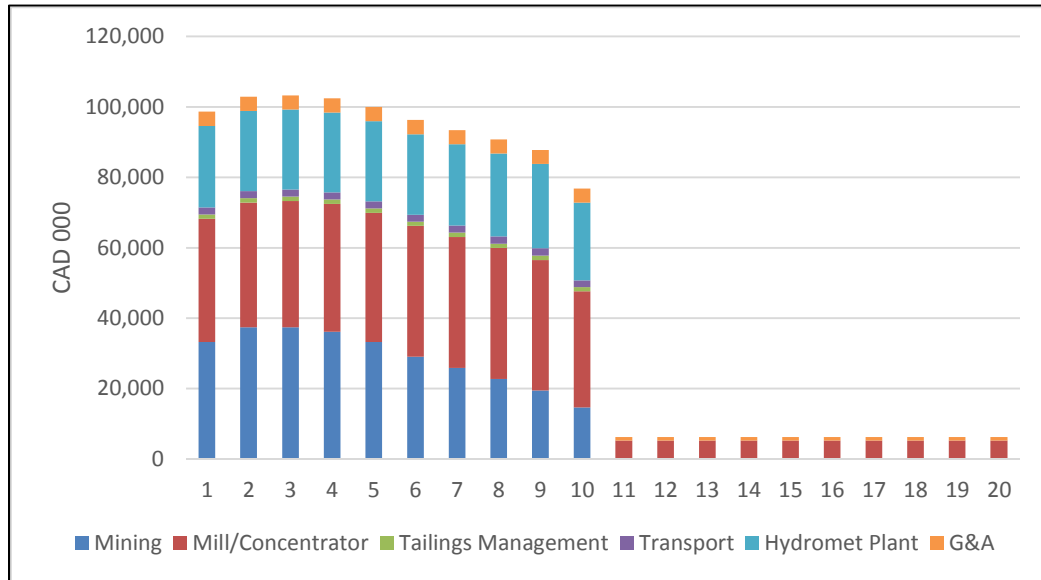
Cash operating costs over the LOM period average \$108.73/t milled, a breakdown of these is presented in Table 22.1.

**Table 22.1**  
**Operating Cost Estimate**

| Area                         | \$/t milled   |
|------------------------------|---------------|
| Mining                       | 31.21         |
| Mill/Concentrator            | 44.02         |
| Tailings Management          | 1.31          |
| Transport                    | 2.15          |
| Hydrometallurgical Plant     | 24.58         |
| G&A                          | 5.46          |
| <b>Total Operating Costs</b> | <b>108.73</b> |

Figure 22.4 shows these expenditures over the LOM period, with all mining and milling taking place in the initial 10 year period, followed by a further 10 years during which feldspar is reclaimed from petalite flotation tailings generated earlier.

**Figure 22.4**  
**LOM Cash Operating Costs**



### 22.2.3 Capital Costs

Pre-production capital expenditures are estimated to total \$507.7 million. This sum includes \$2.0 million for mining contractor mobilization, \$112.9 million in the milling/concentrator plant, \$167.5 million in the hydrometallurgical plant, \$7.3 million for infrastructure, \$127.8 million indirect costs and owner’s costs, a provision of \$5.5 million for closure bonding and contingencies totalling \$84.7 million.

Sustaining capital is estimated at \$7.2 million over the LOM period.

Working capital has been estimated to include 30 days allowance for product inventory on site, in transit, and accounts receivable on concentrates delivered. Stores provision is for 30 days of consumables and spares inventory, less 60 days accounts payable. On this basis, an average of \$15.0 million of working capital is required during the mine/mill operating period.

### 22.2.4 Base Case Cash Flow

The base case project LOM costs, margin and unit costs are summarized in Table 22.2. In this table, feldspar revenues are treated as a by-product credit against the cost of lithium hydroxide production.

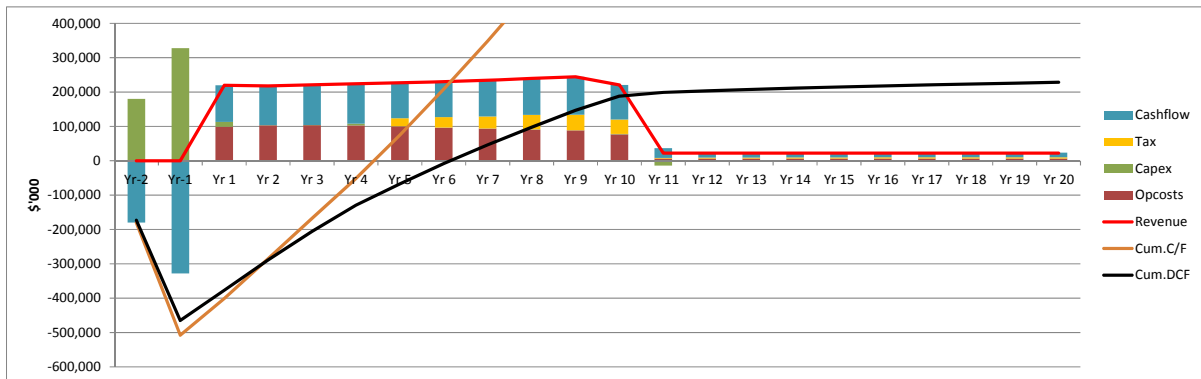
Annual cash flows over the whole LOM period are presented in Table 22.3 (over) and summarized in Figure 22.5 (following page).

**Table 22.2**  
**LOM Cash Flow Summary**

|                                | LOM total<br>(\$'000) | \$/t milled   | % Gross<br>Revenue | Margin<br>(%) | \$/t<br>LiOH.H <sub>2</sub> O |
|--------------------------------|-----------------------|---------------|--------------------|---------------|-------------------------------|
| Mining (Contractor)            | 291,380               | 31.21         | 14%                |               | 1,985                         |
| Mill/Concentrator              | 410,980               | 44.02         | 20%                |               | 2,799                         |
| Tailings Management            | 12,200                | 1.31          | 1%                 |               | 83                            |
| Conc. Transport                | 20,106                | 2.15          | 1%                 |               | 137                           |
| Hydrometallurgical Plant       | 229,518               | 24.58         | 11%                |               | 1,563                         |
| G&A                            | 51,026                | 5.46          | 2%                 |               | 348                           |
| <b>Direct Site Costs</b>       | <b>1,015,210</b>      | <b>108.73</b> | <b>48%</b>         | <b>52%</b>    | <b>6,915</b>                  |
| <i>Less</i> By-product credits | (399,458)             | (42.78)       | -19%               |               | (2,721)                       |
| <b>Cash Operating Costs</b>    | <b>615,753</b>        | <b>65.95</b>  | <b>29%</b>         | <b>71%</b>    | <b>4,194</b>                  |
| Royalties                      | -                     | -             | 0%                 |               | -                             |
| Production Taxes               | -                     | -             | 0%                 |               | -                             |
| <b>Total Cash Costs</b>        | <b>615,753</b>        | <b>65.95</b>  | <b>29%</b>         | <b>71%</b>    | <b>4,194</b>                  |
| Depreciation                   | 512,986               | 54.94         | 24%                |               | 3,494                         |
| Mine Closure\Reclamation       | 5,503                 | 0.59          | 0%                 |               | 37                            |
| <b>Total Production Costs</b>  | <b>1,134,242</b>      | <b>121.48</b> | <b>54%</b>         | <b>46%</b>    | <b>7,726</b>                  |

This preliminary economic assessment is preliminary in nature; it includes inferred mineral resources that are considered too speculative geologically to have the economic considerations applied to them that would enable them to be categorized as mineral reserves, and there is no certainty that the preliminary economic assessment will be realized.

**Figure 22.5**  
**LOM Cash Flows**



The project demonstrates an undiscounted payback of 4.5 years, or approximately 6.2 years when discounted at 8.0%, leaving a tail of over 3.5 years of lithium hydroxide production.

The base case evaluates to an IRR of 19.3% before taxes and 16.5% after tax. At a discount rate of 8.0%, the net present value (NPV<sub>8</sub>) of the cash flow is \$343.8 million before tax and \$228.3 million after tax.



**Table 22.3**  
**Base Case Life-of-Mine Annual Cash Flow**

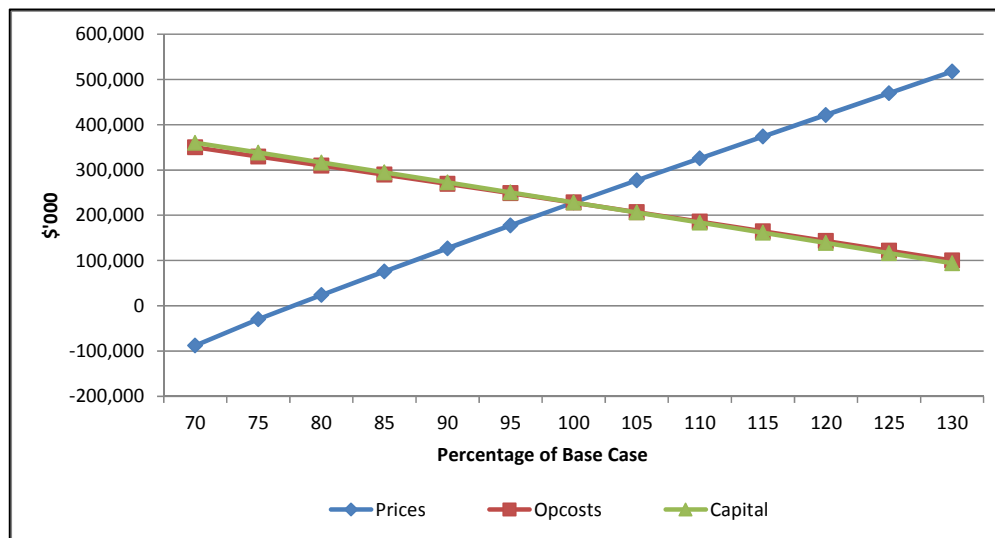
| CASH FLOW PROJECTION | Item                       | Units  | Period         | LOM TOTAL | Yr-2     | Yr-1     | Yr1     | Yr 2    | Yr3     | Yr4     | Yr5     | Yr6     | Yr7     | Yr8     | Yr9     | Yr 10   | Yr11    | Yr12   | Yr13   | Yr14   | Yr15   | Yr16   | Yr17   | Yr18   | Yr19   | Yr20   |
|----------------------|----------------------------|--------|----------------|-----------|----------|----------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| REVENUE              | Gross Revenue              | \$'000 |                | 2,498,787 | 0        | 0        | 219,477 | 218,042 | 220,993 | 223,608 | 226,792 | 230,853 | 233,671 | 239,786 | 244,136 | 220,429 | 22,100  | 22,100 | 22,100 | 22,100 | 22,100 | 22,100 | 22,100 | 22,100 | 22,100 | 22,100 |
| OPERATING COSTS      | Mining                     |        |                | 291,380   | 0        | 0        | 33,216  | 37,396  | 37,396  | 36,142  | 33,216  | 29,036  | 25,901  | 22,766  | 19,422  | 14,675  | 222     | 222    | 222    | 222    | 222    | 222    | 222    | 222    | 222    | 222    |
|                      | Mill/Concentrator          |        |                | 410,980   | 0        | 0        | 35,030  | 35,479  | 35,927  | 36,359  | 36,760  | 37,144  | 37,182  | 37,155  | 37,143  | 32,962  | 4,984   | 4,984  | 4,984  | 4,984  | 4,984  | 4,984  | 4,984  | 4,984  | 4,984  | 4,984  |
|                      | Tailings                   |        |                | 12,200    | 0        | 0        | 1,220   | 1,220   | 1,220   | 1,220   | 1,220   | 1,220   | 1,220   | 1,220   | 1,220   | 1,220   | 0       | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0      |
|                      | Transport                  |        |                | 20,106    | 0        | 0        | 2,030   | 1,987   | 1,985   | 1,982   | 1,986   | 1,999   | 2,026   | 2,085   | 2,127   | 1,900   | 0       | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0      |
|                      | Hydromet Plant             |        |                | 229,518   | 0        | 0        | 23,106  | 22,762  | 22,751  | 22,723  | 22,755  | 22,862  | 23,076  | 23,542  | 23,873  | 22,069  | 0       | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0      |
|                      | G&A                        |        |                | 51,026    | 0        | 0        | 4,035   | 4,035   | 4,035   | 4,035   | 4,035   | 4,035   | 4,035   | 4,035   | 4,035   | 4,035   | 1,068   | 1,068  | 1,068  | 1,068  | 1,068  | 1,068  | 1,068  | 1,068  | 1,068  |        |
|                      | Total Cash Operating Costs | \$'000 |                | 1,015,210 | 0        | 0        | 98,637  | 102,878 | 103,314 | 102,460 | 99,971  | 96,296  | 93,441  | 90,802  | 87,819  | 76,860  | 6,273   | 6,273  | 6,273  | 6,273  | 6,273  | 6,273  | 6,273  | 6,273  | 6,273  | 6,273  |
|                      | Operating Margin (EBITDA)  |        |                | 1,483,577 | 0        | 0        | 120,839 | 115,165 | 117,680 | 121,148 | 126,821 | 134,557 | 140,230 | 148,984 | 156,317 | 143,569 | 15,827  | 15,827 | 15,827 | 15,827 | 15,827 | 15,827 | 15,827 | 15,827 | 15,827 | 15,827 |
| CAPITAL COSTS        | Initial Capital            |        |                | 507,678   | 179,974  | 327,705  | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0      |
|                      | Sustaining Capital         |        |                | 7,231     | 0        | 0        | 0       | 0       | 0       | 4,731   | 0       | 0       | 0       | 0       | 0       | 2,500   | 0       | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0      |
|                      | Working Capital Mvmt       |        |                | 0         | 0        | 0        | 14,066  | -509    | 220     | 301     | 494     | 677     | 504     | 788     | 655     | -1,300  | -14,255 | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0      | -1,642 |
|                      | Capital Invested           |        |                | 514,909   | 179,974  | 327,705  | 14,066  | -509    | 220     | 5,032   | 494     | 677     | 504     | 788     | 655     | 1,200   | -14,255 | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0      | -1,642 |
| CASH FLOW            | Net Cash Flow before tax   | \$'000 |                | 968,667   | -179,974 | -327,705 | 106,773 | 115,673 | 117,459 | 116,116 | 126,327 | 133,880 | 139,726 | 148,196 | 155,661 | 142,369 | 30,082  | 15,827 | 15,827 | 15,827 | 15,827 | 15,827 | 15,827 | 15,827 | 15,827 | 17,469 |
|                      | Taxation Payable           | \$'000 |                | 251,389   | 0        | 0        | 0       | 51      | 38      | 0       | 22,964  | 29,627  | 34,783  | 41,666  | 45,280  | 41,878  | 2,144   | 2,677  | 3,078  | 3,415  | 3,659  | 3,828  | 3,955  | 4,050  | 4,121  | 4,174  |
|                      | Net Cash Flow after tax    | \$'000 |                | 717,278   | -179,974 | -327,705 | 106,773 | 115,622 | 117,421 | 116,116 | 103,363 | 104,253 | 104,943 | 106,530 | 110,381 | 100,491 | 27,938  | 13,149 | 12,749 | 12,411 | 12,168 | 11,999 | 11,872 | 11,777 | 11,706 | 13,294 |
| CUMULATIVE C/F       | Cum. Cash Flow before tax  |        | <b>IRR</b>     |           |          |          |         |         |         |         |         |         |         |         |         |         |         |        |        |        |        |        |        |        |        |        |
|                      |                            |        | <b>19.3%</b>   |           |          |          |         |         |         |         |         |         |         |         |         |         |         |        |        |        |        |        |        |        |        |        |
|                      |                            |        | <b>Payback</b> |           |          |          |         |         |         |         |         |         |         |         |         |         |         |        |        |        |        |        |        |        |        |        |
|                      |                            |        | <b>4.4 yrs</b> |           |          |          |         |         |         |         |         |         |         |         |         |         |         |        |        |        |        |        |        |        |        |        |
|                      | Cum. Cash Flow after tax   |        | <b>16.5%</b>   |           |          |          |         |         |         |         |         |         |         |         |         |         |         |        |        |        |        |        |        |        |        |        |
|                      |                            |        | <b>4.5 yrs</b> |           |          |          |         |         |         |         |         |         |         |         |         |         |         |        |        |        |        |        |        |        |        |        |
| DISCOUNTED           | Net Cash Flow before tax   |        | <b>NPV</b>     |           |          |          |         |         |         |         |         |         |         |         |         |         |         |        |        |        |        |        |        |        |        |        |
|                      |                            |        | <b>343,879</b> |           |          |          |         |         |         |         |         |         |         |         |         |         |         |        |        |        |        |        |        |        |        |        |
|                      | Net Cash Flow after tax    |        | <b>228,311</b> |           |          |          |         |         |         |         |         |         |         |         |         |         |         |        |        |        |        |        |        |        |        |        |
|                      |                            |        | <b>8%</b>      |           |          |          |         |         |         |         |         |         |         |         |         |         |         |        |        |        |        |        |        |        |        |        |
| CUMUL. DISCOUNTED    | Cum DCF before tax         |        | <b>Payback</b> |           |          |          |         |         |         |         |         |         |         |         |         |         |         |        |        |        |        |        |        |        |        |        |
|                      |                            |        | <b>5.7 yrs</b> |           |          |          |         |         |         |         |         |         |         |         |         |         |         |        |        |        |        |        |        |        |        |        |
|                      | Cum DCF after tax          |        | <b>6.2 yrs</b> |           |          |          |         |         |         |         |         |         |         |         |         |         |         |        |        |        |        |        |        |        |        |        |

## 22.3 SENSITIVITY STUDY

### 22.3.1 Capital, Operating Costs and Revenue Sensitivity

The sensitivity of project returns to changes in all revenue factors (including grades, recoveries, prices and exchange rate assumptions) and also to capital and operating costs was tested over a range of 30% above and below base case values. See Figure 22.6, showing NPVs.

**Figure 22.6**  
**NPV Sensitivity Diagram**



The chart suggests that the project is most sensitive to revenue drivers and is moderately sensitive to changes in operating costs and capital cost. While the latter remain positive across the range of the sensitivity analysis, NPV falls to zero for product prices of less than 78% of base case assumptions.

## 22.4 CONCLUSION

Micon concludes that this study demonstrates the potential viability of the project within the targeted range of accuracy of the estimated capital and operating costs, as well as for product prices above 78% of base case values.

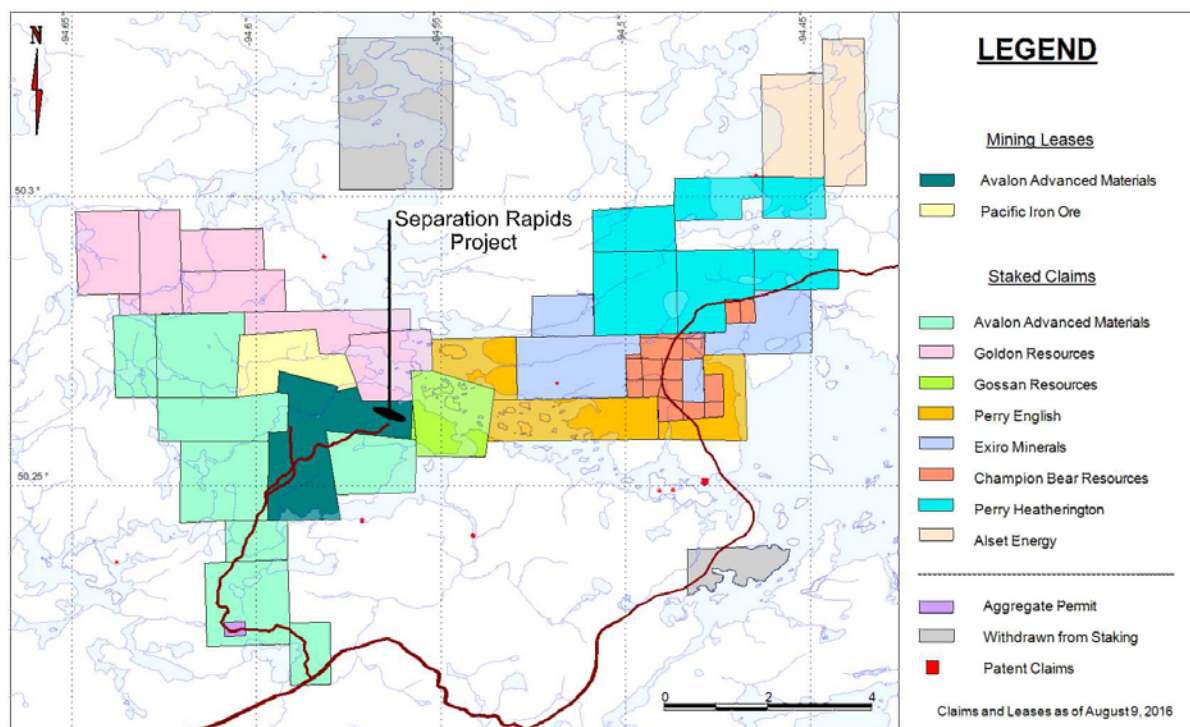
## 23.0 ADJACENT PROPERTIES

### 23.1 INTRODUCTION

Although the SRLD is described by Breaks in numerous publications as the largest rare metal pegmatite of the petalite sub-type discovered in Ontario, there are a large number of other rare metal pegmatite occurrences within a few kilometres of the Separation Rapids property. As noted by Breaks and Tindle, 1998, “most rare metal mineralization occurs within 5 km of the Separation Rapids Pluton, the postulated parent granite for two distinct clusters of pegmatites”. These have been designated by Breaks and Tindle, 1998, as the Eastern Pegmatite Subgroup and the Southwestern Pegmatite Subgroup. See Figure 23.1.

The principal occurrences are the Big Mack Pegmatite, the Southwestern Pegmatite Subgroup which includes the SRLD, Great White North and the Swamp pegmatites, and the Eastern Pegmatite Subgroup which includes Marko’s Pegmatite, Lou’s Pegmatite and others as described in Breaks and Tindle, 1998. The grouping references as given by Breaks and Tindle, 2001, are used in the text below, with the exception of the Western Pegmatites. This group is added here since the individual mineralized bodies were not clearly discussed in various publications by Breaks. Most of these were mapped and sampled during the period 1996-2002 and have received little or no attention since.

**Figure 23.1**  
**Location of Claims in the Separation Rapids Project Area**



Avalon, 2016.

## 23.2 BIG MACK PEGMATITE

The Big Mack Pegmatite is about 2 km west of the SRLD system. The system has been described in the report by Breaks et al. (1999), for the Ontario government and Chastko (2001) as a NI 43-101 technical report. The occurrence is located on mining lease CLM 428 held by Pacific Iron Ore Corporation (formerly Emerald Fields Resource Corporation) as of 5 August, 2016. This lease has an expiry date of 28 February, 2021. The information was obtained from the Ontario government online claim database as of 5 August, 2016 ([www.mci.mndm.gov.on.ca/claims](http://www.mci.mndm.gov.on.ca/claims)).

According to Breaks et al. (1999) the Big Mack Pegmatite system contains four known petalite occurrences on one set of claims and a fifth occurrence (referred to briefly as the Glitter Pegmatite). Locally, there are additional occurrences of rare-element mineralization consisting of numerous oxide mineral-bearing pegmatites and aplite dykes.

The Big Mack Pegmatite and the SRLD are thought to be “early pegmatites” and are complexly folded. The pegmatite has been stripped over its entire surface area and has been tested by three short narrow diameter Winkie drill holes and nine BQ sized drill holes for a total of 1,261 m. The surface expression of the Big Mack Pegmatite measures 30 by 150 m. The petalite content is stated by Chastko, 2001, to average 30.5%. The pegmatite is mainly confined to the nose area of a tight to isoclinal, macroscopic fold (Breaks et al., 1999). Boudinage of pegmatite dykes is widely noted on a mesoscopic scale throughout the entire Big Mack Pegmatite system. This subsequent structural event likely applies on a macroscopic scale to the Big Mack Pegmatite, as this mass exhibits a plan view suggestive of boudinage.

The Big Mack Pegmatite represents the largest petalite-bearing mass on CLM 428 and is exposed over an 80 by 225 m area (Breaks et al., 1999). The pegmatite comprises a 30 by 100 m main mass coupled with several prominent, narrow apophyses that taper towards the south and southeast. These apophyses consist of non-petalite-bearing sodic pegmatites and similar units. The Big Mack Pegmatite exhibits an internal zonation expressed by a continuous wall zone, 0.5 to 3 m thick, that grades into a main core mass of petalite-rich pegmatite. Petalite-rich pegmatite comprises most of the body and contains areas up to 56 to 60% light brown weathering petalite. Chrysoberyl-bearing petalite pegmatite is confined to a 2 to 6 by 25 m unit that is exposed within a trench.

Diamond drill holes established the continuity of the Big Mack Pegmatite zone to at least 50 m below surface. However, holes below this level encounter petalite-free pegmatite that may or may not correlate with the petalite-bearing zone of the Big Mack Pegmatite. It is the opinion of Pedersen, 2016, based on logging the holes, that the petalite-free lower pegmatite is a barren continuation of the upper petalite-bearing pegmatite, and it is simply the termination through boudinage of the pegmatite. The Big Mack Pegmatite zone is speculated to extend down plunge to the west at a moderate angle (Chastko, 2001).

Chastko (2001) reports a mineral resource estimate of 275,700 t with an estimated content of 30.5% petalite at an SG of 2.6).

### **23.3 EASTERN PEGMATITE SUBGROUP**

#### **23.3.1 Marko's Pegmatite**

Marko's Pegmatite was explored by Champion Bear Resources Ltd. (Champion Bear) and described by Breaks and Tindle, 2001, who noted that it is the largest petalite-bearing pegmatite in the Eastern Pegmatite Subgroup. They emphasize the strong zoning with the Marko's Pegmatite noting that the wall zone is pollucite-bearing, unique to the area, but has no petalite, while the core zone contains strong petalite enrichment. It is about 5 km east of the SRLD system.

In a report prepared for Champion Bear, Hinzer, 2003, stated that:

“Detailed surface sampling and initial diamond drilling has identified anomalous lithium, tantalum, rubidium, cesium, tin and beryllium values at the Marco's [sic] pegmatite.

“Early exploration at the main Marcos zone showed the 170 m long pegmatite to be made up of two to 12 m wide boudinaged lens, dipping steeply to the south and with a shallow plunge to the west. Petalite was encountered both on surface and in drilling over width of up to 5.3 m. The parallel, north Marcos pegmatite, a 10 to 30 m wide pegmatite dyke, unmineralized at surface, also contains several petalite lenses of similar dimensions. The north Marcos dyke at depth appears to be of larger dimension than the main Marcos dyke.

“Diamond drilling shows an apparent flattening to approximately 20° of the pegmatite down dip and to the east. The pegmatite is zoned with two petalite horizons and two oxide-bearing zones.”

Early exploration reported by Hinzer, 2003, encountered 0.1 to 0.2% Li over up to 5.3 m in surface samples. Hinzer also, at an uncertain date, but possibly in 1977, reported higher grades from previous drilling including drill holes:

SR-11 1.48% LiO over 3.5 m.

SR-13 3.76% LiO over 4 m and 3.9% LiO over 1.5 m.

SR-16 1.89% LiO over 3.9 m.

SR-17 1.02% LiO over 7.9 m.

SR-20 1.09% LiO over 1.5 m, 1.05% LiO over 2.1 m and 1.11% LiO over 2.8 m.

It should be noted that Hinzer quotes lithium values consistently as LiO, as opposed to the conventional Li<sub>2</sub>O, and it is not known whether this is a typographical or conversion error. Holes not listed did not have significant lithium values greater than 1% LiO. The 2002 program added four more drill holes, none of which indicated greater than 1% lithium intercepts.

### **23.3.2 Lou's Pegmatite and Other Pegmatites**

The Ontario Mineral Deposit Inventory ([www.geologyontario.mndm.gov.on.ca](http://www.geologyontario.mndm.gov.on.ca), Mineral Deposits and Occurrences/Mineral Deposit Inventory (MDI)) notes that the minerals present at Lou's Pegmatite include "abundant" petalite, ferrocolumbite, ferrotantalite, wodginite, cassiterite and beryl. Alteration types observed include lithium metasomatism, biotitization and tourmalinization.

Breaks and Tindle (2001), note that among the eight other known pegmatites within the Eastern Pegmatite Subgroup, most tend to display ductile shear fabrics that makes petalite difficult to recognise in hand specimen as their Pegmatites 10 and 11. They also state that Pegmatite 8 of the Eastern Pegmatite Subgroup has unique second generation petalite with deformation and recrystallization.

There are notes on the Eastern Pegmatite Subgroup in Breaks and Tindle, (1998), on the Gossan Resources Ltd. (Gossan) property. According to this poster reference, the subgroup has preliminary indications of the highest potential for tantalum and rock grab values reportedly range from 0.07 to 0.22% TaO. Note that the publication refers to TaO and not Ta<sub>2</sub>O<sub>5</sub> as the tantalum content. The reference also notes significant Li, Cs and Rb values.

### **23.4 SOUTHWESTERN PEGMATITE SUBGROUP**

Breaks and Tindle, 2001, describe the Southwestern Pegmatite Subgroup of approximately 30 beryl-type and complex-type pegmatites that occupy an area of 0.3 to 0.8 by 6.5 km adjacent to the southwestern part of the Separation Rapids Pluton. Within this subgroup they defined two zones that respectively contain beryl-type and complex-type (petalite subtype) pegmatites. Note that in Breaks and Tindle, 2001, the Southwestern Pegmatite Subgroup as published includes the SRLD and also extends immediately east of it. As a result, the Gossan property immediately east of the Avalon Mine Lease would also be included within the Southwestern Subgroup of Breaks and Tindle, 2001.

The "Beryl zone" is said to consist of a profusion of narrow dykes of aplite and albitite up to 3 m thick and larger dikes and ovoid masses, up to 250 by 300 m that are composed of pegmatitic leucogranite, subordinate potassic pegmatite and quartz-rich patches with blocky potassium feldspar and sparse green beryl. Despite the beryl in the name, Breaks and Tindle, 2001, state that beryl, chrysoberyl, gahnite and ferrowodginite are rare. They state that the "Petalite zone" has nine relatively large, deformed pegmatite lenses, and incorporates, as the largest, the SRLD pegmatite. A swarm of much smaller petalite pegmatites accompany the larger lenses. The majority of petalite pegmatites, regardless of size, display an internal zonation. This zonation comprises a relatively narrow wall, zone rich in plagioclase and a core unit of muscovite-quartz-potassium feldspar-petalite.

The SRLD system continues to the east from the main outcrop, also with narrow petalite bearing pegmatite dykes on ground owned currently by Gossan Resources.

### 23.5 WESTERN PEGMATITES INCLUDING GLITTER, WOLF AND RATTLER PEGMATITES

This group of pegmatites is about 5 km west of the SRLD, or about 3 km west of the Big Mack Pegmatite system and is described in the publication by Clark, 2016, for GoldON Resources Ltd. (GoldON). It was not specifically identified as a group by Breaks and Tindle, 2001, and it lies west of any pegmatites referred to by those authors.

Clark states that the Glitter petalite bearing pegmatite is exposed for 75 m and has a maximum width of 25 m.

The Glitter Pegmatite exhibits internal zonation as four distinct units (Breaks et al., 1999):

1. Discontinuous wall zone of garnet+muscovite+quartz+plagioclase aplite.
2. Main mass of muscovite+quartz+potassium feldspar+petalite pegmatite.
3. Holmquistite+cordierite+muscovite+biotite granitic pegmatite.
4. Replacement stage garnet+muscovite aplite as irregular patches and anastomosing vein network.

Considerable deformation is obvious in the form of lenses of biotite-rich, metasomatized mafic metavolcanic rock along the contact which locally are traceable into tight folds contained within the petalite-rich pegmatite zone. A similar structural history to the Big Mack Pegmatite was observed. Notable thickening of petalite-bearing pegmatite within an adjacent apophysis was developed during the isoclinal folding stage.

Clark and Siemieniuk (2016) reported that Breaks' trenching and channel sampling of 1 m samples returned values of 1.03% Li<sub>2</sub>O to 1.64% Li<sub>2</sub>O, accompanied by trace levels of other rare metals (Breaks' sampling reported by Clark). Samples collected by GoldON have a maximum of 1.02% Li<sub>2</sub>O over 1.90 m in trench and channel sampling.

The Wolf and the Rattler pegmatites are reported as moderately evolved beryl-type pegmatites (Breaks et al., 1999). These pegmatites can clearly be genetically linked to a small mass of muscovite-biotite-bearing, peraluminous granite, herein named the Skidder pluton. The Wolf pegmatite is exposed over 40 by 100 m and has relatively low values of lithium. No petalite is reported to be present (Clark, 2016). The Rattler pegmatite is described as exposed over 7 by 12 m and also has low lithium values. Beryl is reportedly present but petalite was not noted in Clark's report.

As of the date of the report by Clark and Siemieniuk, 2016, none of these pegmatites have been drilled. Breaks et al., 1999 recommended further exploration around the Skidder pluton.

## 24.0 OTHER RELEVANT DATA AND INFORMATION

### 24.1 PROJECT DEVELOPMENT SCHEDULE

Avalon’s proposed development schedule for the Separation Rapids project is shown in Figure 24.1.

The process design will be finalized in the three months following completion of the PEA and pilot plant work will start at the beginning of Year 2. Permitting will also commence at the beginning of Year 2. A period of 35 weeks has been allowed for completion of the project feasibility study. Engineering is scheduled to commence at the beginning of Year 3, with procurement starting before the end of the first quarter in Year 3. A period of 78 weeks has been allowed for construction, which is scheduled to be completed by the end of Year 4. A period of 21 weeks has been allowed for commissioning and a further 22 weeks for ramp-up to full production.

**Figure 24.1**  
**Separation Rapids Project Development Schedule**

| Task Name                                | Duration | Start    | Finish   | Year 1 |       |       |       | Year 2 |       |       |       | Year 3 |       |       |       | Year 4 |       |       |       | Year 5 |       |       |  |
|--|----------|----------|----------|--------|-------|-------|-------|--------|-------|-------|-------|--------|-------|-------|-------|--------|-------|-------|-------|--------|-------|-------|--|
|  |          |          |          | Qtr 2  | Qtr 3 | Qtr 4 | Qtr 1 | Qtr 2  | Qtr 3 | Qtr 4 | Qtr 1 | Qtr 2  | Qtr 3 | Qtr 4 | Qtr 1 | Qtr 2  | Qtr 3 | Qtr 4 | Qtr 1 | Qtr 2  | Qtr 3 | Qtr 4 |  |
| <b>Separation Rapids Lithium Project</b> |          |          |          |        |       |       |       |        |       |       |       |        |       |       |       |        |       |       |       |        |       |       |  |
| Develop/Issue PEA                        | 13 wks   | 04/07/16 | 30/09/16 | █      |       |       |       |        |       |       |       |        |       |       |       |        |       |       |       |        |       |       |  |
| Finalize Process Design                  | 14 wks   | 19/09/16 | 23/12/16 |        | █     |       |       |        |       |       |       |        |       |       |       |        |       |       |       |        |       |       |  |
| Pilot Plant                              | 17 wks   | 02/01/17 | 28/04/17 |        |       | █     |       |        |       |       |       |        |       |       |       |        |       |       |       |        |       |       |  |
| Site Drilling Program                    | 17.8 wks | 01/05/17 | 31/08/17 |        |       |       | █     |        |       |       |       |        |       |       |       |        |       |       |       |        |       |       |  |
| Feasibility Study                        | 35 wks   | 01/05/17 | 29/12/17 |        |       | █     | █     |        |       |       |       |        |       |       |       |        |       |       |       |        |       |       |  |
| Permitting                               | 78 wks   | 02/01/17 | 29/06/18 |        |       | █     | █     | █      | █     |       |       |        |       |       |       |        |       |       |       |        |       |       |  |
| Engineering                              | 52 wks   | 01/01/18 | 28/12/18 |        |       |       |       | █      | █     | █     | █     |        |       |       |       |        |       |       |       |        |       |       |  |
| Procurement                              | 60 wks   | 05/03/18 | 26/04/19 |        |       |       |       |        | █     | █     | █     | █      | █     |       |       |        |       |       |       |        |       |       |  |
| Construction                             | 78 wks   | 02/07/18 | 27/12/19 |        |       |       |       |        |       | █     | █     | █      | █     | █     | █     |        |       |       |       |        |       |       |  |
| Commissioning                            | 21 wks   | 06/01/20 | 29/05/20 |        |       |       |       |        |       |       |       |        |       |       |       |        |       |       | █     |        |       |       |  |
| Ramp-Up                                  | 22 wks   | 01/06/20 | 30/10/20 |        |       |       |       |        |       |       |       |        |       |       |       |        |       |       |       | █      |       |       |  |



## 25.0 INTERPRETATION AND CONCLUSIONS

The objective of this PEA was to evaluate the economic potential for producing a lithium ion battery material from the SRLD. The lithium ion battery has emerged as an energy storage solution of choice for a variety of commercial applications and has resulted in significantly increased demand, and projected demand, for lithium battery materials over the past few years.

This PEA is based on mineral resource estimates for lithium and feldspar contained in the Separation Rapids Lithium Deposit (SRLD), prepared by Benjamin Webb, Principal with BMW Resource Consultants LLC, dated 21 October, 2016. Measured plus Indicated resources total 8 Mt at a grade of 1.29%  $\text{Li}_2\text{O}$  and 39% total feldspar.

Avalon's metallurgical testwork programs have demonstrated the following:

- A petalite concentrate assaying over 4%  $\text{Li}_2\text{O}$  can be produced which, because of its low impurity levels, is potentially an excellent feed material to the specialised glass/ceramics industries.
- A low impurity mixed (sodium/potassium) feldspar concentrate can also be produced which has applications in a number of ceramic applications as well as a filler in paints and other products.
- There is potential to produce other by-products from the mineralized material, including a high purity quartz, and for additional lithium recovery from the magnetic fraction.
- The petalite can be used as a feed source to produce both lithium carbonate and lithium hydroxide for the battery and energy storage industries.
- The use of electrodialysis has been shown as a viable process for producing lithium hydroxide from a lithium sulphate solution.

There remain a number of areas within the process flowsheet that have the potential for improvement and optimization in terms of lower costs and increased process efficiencies.

Other potential by-products have been identified, such as rubidium chemicals. These provide the potential for additional revenue streams but also the potential for a flexible production base capable of reducing investment risk associated with a single commodity business or single market product.

Avalon's market research has demonstrated that it has the opportunity to supply battery grade lithium hydroxide to the energy storage sector, as well as to supply feldspar concentrates in a range of filler applications. Potential customers are likely to require substantial bulk samples

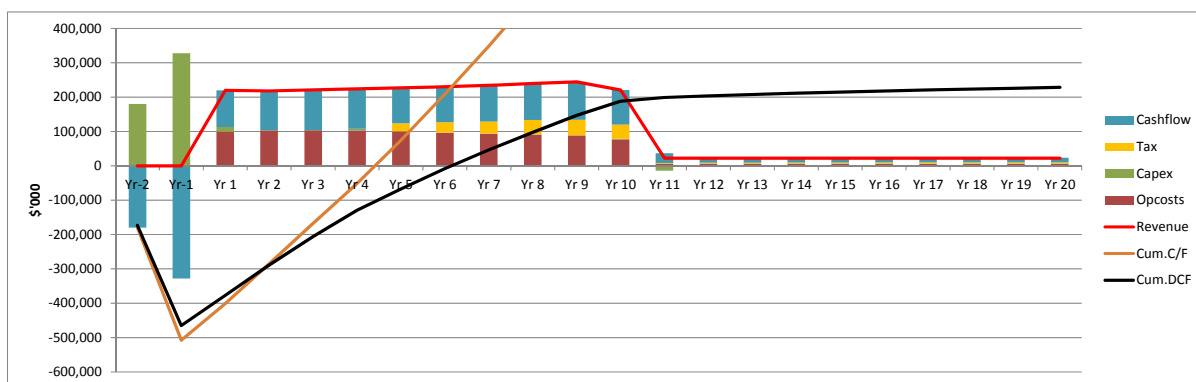
for industrial scale testing before committing to any purchase agreements. To satisfy this requirement it may be necessary for Avalon to invest initially in a demonstration plant before proceeding to the full scale operation.

The project capital cost estimate is based on contract mining, a 950,000 t/y concentrator that recovers approximately 145,000 t/y of petalite concentrate and 100,000 t/y of feldspar concentrate, and a hydrometallurgical facility that produces approximately 14,520 t/y of high purity lithium hydroxide product suitable for the battery market. Total LOM capital costs total \$514.9 million of which \$7.2 million is sustaining capital.

Operating costs are based on a mine life of 9.83 years. Annual LOM operating costs total \$96.9 million, equivalent to \$102/t material processed and \$6.49/kg lithium hydroxide.

LOM cash flows are shown in Figure 25.1.

**Figure 25.1**  
**Life-of-mine Cash Flows**



This PEA demonstrates that the Separation Rapids deposit can be developed into an economically viable mining and processing operation to produce a lithium hydroxide feedstock for the lithium ion battery and energy storage industries. Project economics are robust with a post-tax IRR of 16.5% (19.3% pre-tax) and a post-tax NPV of Cdn\$228 million (Cdn\$344 million pre-tax).

The environmental impacts of the project are minor as a result of the low levels and nature of impurities in the SRLD. This is expected to reduce the anticipated permitting requirements and schedule.

The site is well located with easy access to important infrastructure facilities for power supply, skilled labour and material transportation. Engagement to date with local communities has resulted in strong support for the project and the potential exists for greater engagement and utilization of First Nations' resources and businesses.

A period of four years has been scheduled for project development. On completion of this PEA, process design will be finalized and pilot plant work is scheduled to start within three months when permitting will also commence. A period of 35 weeks has been allowed for completion of the project feasibility study, followed by engineering and procurement. A period of 78 weeks has been allowed for construction. A period of 21 weeks has been allowed for commissioning and a further 22 weeks for ramp-up to full production.

Given the potential for a range of products to be recovered from the SRLD, the potential also exists to develop a staged approach to project development and financing that will allow the Company to adapt to market uncertainties as the project advances. Such a staged approach may start with the production of lithium mineral concentrates for glass-ceramics consumers, resulting in cash flow before investing further in a hydrometallurgical plant to produce a derivative battery material from the petalite concentrate. A petalite concentrate may be saleable to a third party battery material producer equipped to process similar lithium mineral concentrates. Such opportunities are likely to emerge over the next few years as the market for battery materials grows. A staged approach has the potential to reduce capital investment risk. A staged approach would also include development of a demonstration plant in order to provide the required volumes of product samples to potential customers for evaluation and acceptance, as well as to provide improved operating and cost parameters, and potentially improved prospects for financing.

This PEA has shown that the Separation Rapids Lithium Project offers a number of other advantages that will contribute to reduced capital investment risk. These include the relatively low environmental impacts and strong support for the project within the local community due to the long history of engagement and the positive relationships developed with local indigenous communities, notably Wabaseemoong Independent Nations.

## 26.0 RECOMMENDATIONS

Given the potential for a range of products to be recovered from the SRLD, it is recommended that Avalon develops a staged approach to project development and financing that will allow the Company to adapt to market uncertainties as the project advances.

Recommendations for different areas of the project are set out below.

### 26.1 GEOLOGY AND MINERAL RESOURCES

#### 26.1.1 Geological Mapping

Detailed mapping should be undertaken to the west and east of the SRLD to explore for projected extensions of the lithium deposit to increase potentially recoverable lithium resources and explore for new zones of related rare metal mineralization such as tantalum and cesium.

Further investigations into other potential sources of petalite and lithium minerals in the region which could potentially provide additional feed material.

#### 26.1.2 Mineralogy

Detailed mineralogical studies should be completed in order to further refine mineralogical zonation patterns within the pegmatite Subunits 6a, b, c and d using complementary methods such as XRD, Qemscan®, electron microprobe, spectral analysis and optical methods. In particular, lithium mineral zonation patterns may be important for maintainance of a consistent feed for the mill.

Further detailed petrography of the feldspathic zones is required for a better understanding of the potentially economic feldspar content and quality.

#### 26.1.3 Exploration and Resource Definition Drilling

It is recommended that a minimum 10,000 m diamond drill program be carried out with two main objectives:

3. Expand the known petalite/lithium resources to depth and laterally to increase the confidence level of the inferred resources to the Measured and Indicated categories.
4. Test exploration targets along both the eastern and western extensions of the SRLD, including the undrilled Western Pegmatite to delineate additional lithium resources and discover other rare metal mineralized zones that the geological model predicts could occur in the area.

The program should include:

- Detailed mineralogical mapping.
- Geotechnical logging of the drill holes for open pit design considerations.
- Analysis of representative waste rock for environmental considerations.

## **26.2 METALLURGICAL TESTWORK**

Metallurgical testwork should continue with the overall objectives of optimizing the existing flowsheets and studying variants that will create optionality as to what the final product mix should be, bearing in mind that there are at least four potential lithium products (minerals, carbonate, hydroxide, metal) that can be recovered from the mineralization and multiple potential by-products (feldspars, high purity quartz, tantalum, rubidium and cesium).

Further optimization testwork is recommended in the following areas:

Concentrator:

- Confirm efficiency and performance of mineralized material sorting when processing low grade material from the pit extremities and the “low grade material” introduced into resources by the mining schedule.
- Optimization and re-piloting of the flotation circuit to improve recoveries and reduce reagent consumptions and costs.
- Investigation of alternatives for further pre-concentration ahead of flotation, such as gravity-based processes.
- Investigation into the recovery of lithium micas (including lepidolite) and other potential products from the magnetics material and lepidolite-rich sub-zones in the deposit.
- Determination of what the final lithium product mix should be based on product pricing (determined through ongoing market development work), future market demand and production costs.
- Further work on the recovery of a high purity quartz product from coarse-grained mineralization.

Hydrometallurgical Plant:

There are a number of opportunities to optimize the hydrometallurgical plant process efficiencies and costs. These include:

- Evaluation of fluidized bed roasting (FBR) as an alternative to the decrepitation kiln.

- Optimization of membrane selection for the electrolysis cells.
- Piloting of circuit to confirm influence of recycle streams of overall flowsheet and efficiencies.
- Optimization of heat balance and recovery.
- Detailed analysis of the leached solids in order to determine whether this material is of economic value.
- Consideration for optionality in the process flowsheet to produce either a carbonate, hydroxide or possibly another lithium chemical/metal product for the battery market.

#### Demonstration Plant:

Customers in all potential markets will require significant sample material for detailed evaluation before committing to any off-take agreements. Generation of such samples in the required quantities can only be produced through the operation of a demonstration-scale production plant. This also provides assurance of a reliable process and the ability to manufacture products of consistent quality.

In addition, such a facility would provide significant information for reliable scale-up to a full production facility and potentially reduce perceived investor risk in the project.

Finally it can also serve as an interim production facility to begin serving the market at a low level and as a test facility for evaluation of other product opportunities and other new development opportunities.

The optimal scale of such a demonstration plant and the length of operation will need to be determined based on market development work conducted in conjunction with the feasibility study.

### **26.3 MINING METHODS**

It is recommended that geotechnical studies are undertaken concurrent with the proposed drilling program to support the overall pit slopes and design of ramps and haulways.

### **26.4 MARKETING**

Further work is recommended in the following areas as the project proceeds to prefeasibility and feasibility analysis:

- Continued analysis of lithium markets and prices, and developments in battery technologies and developments in glass-ceramics markets.

- Assessment of opportunities to market lithium mineral (petalite) concentrates in North America.
- More detailed analysis of markets for feldspar in the United States, Europe and Mexico in order to determine if it should be recovered as a co- or by-product of lithium hydroxide and refine the potential unit revenue from a range of feldspar products.
- Analysis of opportunities in the rubidium chemicals market.
- Assessment of markets for high purity quartz as a potential by-product.
- Assessment of markets for other identified and potential products beyond those included in this study.

These plus other potential by-products currently being investigated not only give the project the potential for further economic enhancement but also provide a strong and flexible production base capable of reducing the impact of any future down turns in any of the markets being targeted.

## **26.5 ENVIRONMENTAL/SOCIAL**

The following should be undertaken as project development proceeds:

- Continue to engage with the local Indigenous Peoples, community, regulators and government to maximize local development opportunities and minimize undesirable environmental impacts.
- Conclude a partnership arrangement with the Wabaseemoong Independent Nation as committed to under the existing MOU between WIN and Avalon, and accommodate other Aboriginal groups with interests in the area.
- Update socioeconomic studies as part of the proposed ESIA.
- Complete historical environmental baseline validation and fill in identified gaps. Complete a Project Description and ESIA.
- Update the groundwater study and assess the geotechnical design parameters for the pit, mine rock aggregate, concentrate and tailing management facilities. Assess the potential for river water to enter the open pit and make appropriate amendments as required.
- Complete additional ABA and humidity cell leachate studies on the mine rock aggregate, concentrate and tailings as required. Complete biological toxicity testing of effluents and water treatment studies as required on pilot or demonstration plant water and tailing when available.

- Geotechnical and hydrogeological investigations for the TCMA and stockpile locations, including identification and characterization of potential local construction materials (i.e., till, sand and gravel).
- Detailed topographic mapping should be obtained for the full project site. (See geological mapping and drilling, above).
- Additional laboratory testing of the tailings and concentrates to better understand their physical properties as delivered to the TCMA (i.e., filterability, workability, placed density, strength, etc.).
- Trade-off study to determine if filtered tailings is the preferred disposal and storage method. Consideration should be given to operating in a northern climate with long, cold winter months.

## 26.6 PROPOSED WORK PROGRAM

Avalon’s proposed work program and budget for ongoing project optimization and feasibility studies is summarized in Table 26.1.

**Table 26.1**  
**Avalon Proposed Budget for Ongoing Work**

| <b>Activity</b>                                  | <b>Budget<br/>(Cdn\$)</b> |
|--|---------------------------|
| Exploration and drilling                         | 1,500,000                 |
| Updated mineral resource estimate                | 35,000                    |
| Metallurgical testwork (bench scale)             | 850,000                   |
| Pilot plant studies                              | 1,700,000                 |
| Access road studies                              | 10,000                    |
| Hydro-electric study                             | 25,000                    |
| TCMA studies and design                          | 35,000                    |
| Geotechnical drill program                       | 30,000                    |
| Geotechnical testing                             | 10,000                    |
| Detailed mine design and planning                | 50,000                    |
| Hydrometallurgical plant site selection          | 10,000                    |
| Evaluate underground mining option               | 30,000                    |
| Hydrogeological study and ground water modelling | 25,000                    |
| Environmental studies and data gathering         | 900,000                   |
| Local community and stakeholder engagement       | 50,000                    |
| Engineering, design, costing and report          | 4,000,000                 |
| Market development                               | 900,000                   |
| <b>Sub-total</b>                                 | <b>10,160,000</b>         |
| <b>Demonstration Plant</b>                       | <b>25,000,000</b>         |

Micon concurs with the proposed work program budget and recommends that it be implemented.



## 27.0 DATE AND SIGNATURE PAGE

*“Steven R. Aiken” {signed and sealed}*

Steven R. Aiken, P.Eng.  
Knight Piésold Ltd.  
Effective Date: 21 October, 2016  
Signing Date: 10 November, 2016

*“Richard Gowans” {signed and sealed}*

Richard Gowans, P.Eng.  
Micon International Limited  
Effective Date: 21 October, 2016  
Signing Date: 10 November, 2016

*“Kevin E. Hawton” {signed and sealed}*

Kevin E. Hawton, P.Eng.  
Knight Piésold Ltd.  
Effective Date: 21 October, 2016  
Signing Date: 10 November, 2016

*“Christopher Jacobs” {signed and sealed}*

Chrisopher Jacobs, CEng, MIMMM  
Micon International Limited  
Effective Date: 21 October, 2016  
Signing Date: 10 November, 2016

*“Bruce Pilcher”            {signed and sealed}*

Eur Ing, Bruce Pilcher, CEng, FIMMM, FAusIMM(CP)  
Micon International Limited  
Effective Date: 21 October, 2016  
Signing Date: 10 November, 2016

*“Jane Spooner”            {signed and sealed}*

Jane Spooner, P.Geol.  
Micon International Limited  
Effective Date: 21 October, 2016  
Signing Date: 10 November, 2016

*“David L. Trueman”            {signed and sealed}*

David L. Trueman, Ph.D., P.Geol.  
Effective Date: 21 October, 2016  
Signing Date: 10 November, 2016

## 28.0 REFERENCES

Adams Heritage Consultants, 1998: An Archeological Assessment (Stages 1 & 2) of the proposed Avalon Ventures Ltd. Separation Rapids Project, English River, Ontario, prepared on behalf of Knight Piésold, October, 1998.

ALS, 2016: Whole rock geochemistry from holes 97-02 and 98-52 (Spreadsheet with whole rock data for about 50 samples in two drill holes).

Avalon Rare Metals Inc., 2009: Report on Work – Claim 4221036, Separation Rapids Property, Kenora Mining Division, Assessment report filed with Ontario Government 7 December, 2009.

Avalon Ventures Ltd., 2001: Exploration Update: Drilling commences on Raleigh Lake tantalum project, new PGE prospect acquired, News release No. 01-10, 25 July, 2001.

Benchmark Mineral Intelligence, 2016a: Chart from Valentina Romei, Lithium price on the rise, Financial Times, 14 April, 2016. (Available by subscription to <http://blogs.ft.com/ftdata/2016/04/14/lithium-price-on-the-rise/>).

Benchmark Mineral Intelligence, 2016b: Lithium Hydroxide – A Perfect Price Storm: Revised for 2016, by Joe Lowry, 23 June, 2016. <https://www.linkedin.com/pulse/lithium-hydroxide-perfect-price-storm-revised-2016-joe-lowry>.

Berry, C., 2016: Lithium Strategy: Repositioning in a Bull Market in The Disruptive Discoveries Journal, 10 April, 2016

Bloomberg New Energy Finance, 2016: Electric Vehicles to be 35% of Global New Car Sales By 2040, 25 February, 2016

Bradley, D. and McCauley, A., 2013: A preliminary Deposit Model for Lithium-Cesium-Tantalum (LCT) Pegmatites, USGS Open File Report 2013-1008.

Breaks, F. and Tindle, A.G., 1996: New discovery of rare-element pegmatite mineralization, Separation Lake area, Northwestern Ontario. Ontario Geological Survey, Open File Report 5946.

Breaks, F. and Tindle, A.G., 1997: Rare-metal Exploration Potential of the Separation Lake Area: an Emerging Target for Bikita-type Mineralization in the Superior Province of Ontario. Ontario Geological Survey, Open File Report 5966.

Breaks, F. and Tindle, A.G., 1998: Discovery of the Big Whopper Pegmatite, Separation Lake Area of the Kenora District. Poster presented at PDAC Convention. Download at [http://www.geologyontario.mndm.gov.on.ca/mndmaccess/mndm\\_dir.asp?type=pub&id=MRD037](http://www.geologyontario.mndm.gov.on.ca/mndmaccess/mndm_dir.asp?type=pub&id=MRD037).

Breaks, F.W. and Tindle A.G., 2001: Rare-element mineralization of the Separation Lake area, northwest Ontario: characteristics of a new discovery of complex-type, petalite subtype, Li-Rb-Cs-Ta pegmatite. CIM Special Volume 53, Industrial Minerals in Canada Vol 1.

Breaks, F., Tindle, A.G., and Smith, S.R., 1999: Geology, Mineralogy and Exploration Potential of the Big Mac Pegmatite System: A Newly Discovered Western Extension of the Separation Rapids Pegmatite Group, NW Ontario. Ontario Geological Survey Open File 6000 Summary of Field Work and Other Activities.

Černý, P., and Ercit, T.S., 1989: Mineralogy of Niobium and Tantalum: Crystal Chemical Relationships, Paragenetic Aspects and Their Economic Implications. In: Lanthanides, Tantalum and Niobium, Springer-Verlag.

Černý, P., and Ercit, T.S., 2005: The Classification of Granitic Pegmatites Revisited, The Canadian Mineralogist, Vol. 43, pp. 2005-2026.

Chastko, L.C., 2001: Report on Rare Element Pegmatite Properties in the Separation, Huston and Linklater Lakes Areas of Northwestern Ontario, Rush Lake-Birse Lake of Southeastern Manitoba for Emerald Fields Resource Corporation.

Canaccord Genuity, 2016: referenced in, Pure Energy's Robinson Surveys the World's Lithium Deposits, in The Northern Miner, 1 June, 2016.

Chung, D., Elgqvist, E. and Santhanagopalan, S., 2015: Automotive Lithium-ion Battery (LIB) Supply Chain and U.S. Competitiveness Considerations, Clean Energy Manufacturing Analysis Centre, June, 2015 (<http://www.nrel.gov/docs/fy15osti/63354.pdf>).

Clark, J.G. and Siemieniuk, S., 2016: NI 43-101 Technical Report on the Paterson Lake Property, Prepared for GoldON Resources Ltd., 29 March, 2016.

Clean Tech Canada, 2016: Energy storage market booming as U.S. installations jump 243 per cent in 2015, 7 March, 2016, online <http://www.canadianmanufacturing.com/technology/energy-storage-market-booming-u-s-installs-jump-243-per-cent-2015-163810>

Deutsche Bank, 2016: Deutsche Bank Market Research, Lithium 101, 9 May, 2016.

Desjardins, J., 2016: These 9 Slides Put the New Tesla Gigafactory in Perspective, Visual Capitalist, 26 July, 2016.

Galeschuk, C. J., and Vanstone, P. J., 2007: Exploration Techniques for Rare-Element Pegmatite in the Bird River Greenstone Belt, Southeastern Manitoba in, Ore Deposits and Exploration Technology, Paper 55, (<http://www.dmec.ca/ex07-dvd/E07/proceedings.html>).

Garrett, Donald E., 2004: Handbook of Lithium and Natural Calcium Chloride, Elsevier Academic Press.

Global Industry Analysts, Inc., 2016: Feldspar, a Global Strategic Business Report, April, 2016.

Goldman Sachs, 2015: What if I told you ... Lithium is the New Gasoline?, Goldman Sachs Equity Research, 2 December, 2015 (<http://www.goldmansachs.com/our-thinking/pages/macroeconomic-insights-folder/what-if-i-told-you/report.pdf>).

Hains Technology Associates, 2015: Feldspar Markets and Applications Separation Rapids Petalite Project, July 2015, prepared for Avalon Rare Metals Inc.

Hinzer, J.B., 2003: Report on the July 2002 Diamond Drilling Program on the Marcos Pegmatite Zone, Separation Rapids Property of Champion Bear Resources Ltd., 9 October, 2003.

Kesler, S.E., Gruberb, P.W., Medinac, P.A., Keoleianc, G.A., Eversond, M.P. and Wallington, T.J., 2012: Global Lithium Resources: Relative importance of pegmatite, brine and other deposits, Ore Geology Reviews, v.48, p55-69.

Knight Piesold, Consulting Engineers and Environmental Scientists, 1999: Separation Rapids Project, Project Description and Environmental Baseline Study Report, July, 1999.

Knight Piesold Ltd., 2007: Avalon Ventures Ltd., Separation Rapids Rare Metals Project, Project Description and Environmental Baseline Study Report (NB102-00260/1-1), 16 March, 2007.

Knight Piesold Ltd., 2013: Species at Risk Assessment for the Separation Rapids Project, letter report NB13-00523, 25 September, 2013.

Knight Piesold Ltd., 2016a: Separation Rapids Lithium Project - PEA for Tailings, Waste Rock and Water Management, letter report NB16-00564, 28 September, 2016.

Knight Piesold Ltd., 2016b: Separation Rapids PEA Conceptual Closure Plan, October, 2016.

Lakefield Research Limited, 1998: An Investigation of the Recovery of Petalite & Spodumene from the Big Whopper Deposit ore samples submitted by Avalon, Progress Report No.1, December 16, 1998

Lakefield Research Limited, 1999: An Investigation of the Recovery of Soda and Potassium Feldspars From the Big Whopper Deposit Petalite Tailings Submitted by Avalon Ventures Limited, Progress Report 2, 18 May, 1999.

McCormik, Myles, 2016: Grid energy storage: The next big thing for Li-ion?, Industrial Minerals, 22 April, 2016.

Micon International Limited, 1999: Prefeasibility Study, The Big Whopper Petalite Deposit, Separation Rapids Project, Kenora, Ontario, prepared for Avalon Ventures Ltd.

Neatby, P.P., London, I.M. and St. Louis, B., 2016: Electric Vehicle Growth Dependent on Lithium Supply, presented at EVS29 International Battery, Hybrid and Fuel Cell Electric Vehicle Symposium, 19-22 June, 2016.

Nemaska Lithium Inc., 2016: How to profit from the booming lithium markets, corporate presentation, 19 April, 2016.

Pearse, G., 1998: Market Study For Separation Rapids Rare-Metal Pegmatite Products. Confidential Report for Avalon. Prepared by Equapolar Resources Consultants, Ottawa.

Pearson, Hofman and Associates Ltd., 1999: Big Whopper Deposit, Separation Rapids, Ontario Evaluation of In Situ Resources. Report to Micon International Limited, April 1999, Confidential Unpublished Report.

Pedersen, J.C., 1997: X-ray Diffraction and Electron Microprobe Analysis of Four Samples of Petalite Pegmatite from the Big Whopper Pegmatite; internal company report for Avalon Ventures Ltd.

Pedersen, J.C., 1998a: Geological Report 1997-98 Volume 1, Exploration Program, The Big Whopper Rare Metals Pegmatite, Separation Rapids Property, Kenora Mining Division, Ontario, Volumes II-VI appendices.

Pedersen, J.C., 1998b: Detailed Outcrop Map of Separation Rapids Lithium Deposit. Unpublished map.

Pedersen, J.C., 2016a: Compilation of estimated mineral contents for Unit 6, Subunits 6a, 6b, 6c, 6d, Internal Avalon Confidential Information.

Pedersen, J.C., 2016b: Personal communication.

Pedersen, J.C., 2016c: Memo on Acid Rock Drainage (ARD) Core Samples from Separation Rapids, January, 2016.

Ramsay, J.G., 1962: Interference patterns produced by the superposition of folds of similar types, J. Geol., 70: 466-481.

SGS Canada Inc., 2013: An Investigation by High Definition Mineralogy into the Mineralogical Characteristics of one REE [sic, incorrect] Sample, Prepared For Avalon Rare

Metals -Separation Rapids, (Report On One Bulk Sample 0274 With Qemscan) Project CALR-14051-001, MI5010-MAR13.

Stormcrow Capital Ltd., 2015: Avalon Lithium Report, prepared for Avalon, May, 2015.

Taylor, R. P., 1998: A preliminary mineralogical and geochemical study of the Big Whopper Pegmatite. Confidential report for Avalon.

Taylor, R.P., (1999a): Modal Mineralogy of Selected Drill Core Samples from Big Whopper Pegmatite. Date of report: May 31st, 1999 (Mineralogy of 11 drill core samples).

Taylor, R.P., (1999b): Feldspar Analyses from Samples of the Megacrystic Feldspar Zone (Unit 4) and the Wall Zone and Related Albite-rich Dykes (Unit 3A,B), internal memo to Avalon Ventures, dated May 18, 1999.

Thibault & Associates Inc., 2016: Phase 1: Process Alternatives High-Level Operating Cost Assessment (Project No. 6541), prepared for Avalon Advanced Materials Inc.

U.S. Geological Survey, 2016a: Lithium in Mineral Commodity Summaries, January, 2016.

U.S. Geological Survey, 2016b: Feldspar in Mineral Commodity Summaries, January, 2016.

U.S. Geological Survey, 2015a: Lithium in 2013 Minerals Yearbook, January, 2015.

U.S. Geological Survey, 2015b: Feldspar in 2013 Minerals Yearbook, August, 2015.

U.S. Geological Survey, 2014: Feldspar in Mineral Commodity Summaries, February, 2014.

## 29.0 CERTIFICATES

### CERTIFICATE OF AUTHOR

**Steven R. Aiken**

As a co-author of this report entitled “NI 43-101 Technical Report on the Preliminary Economic Assessment of Lithium Hydroxide Production, Separation Rapids Lithium Project, Kenora, Ontario” dated November 10, 2016, I, Steven R. Aiken, P.Eng., do hereby certify that:

1. I am employed by, and carried out this assignment for  
Knight Piésold Ltd  
1650 Main Street West  
North Bay, Ontario  
P1B 8G5  
tel. (705) 476-2165 fax (705) 474-8095  
e-mail: [saiken@knightpiesold.com](mailto:saiken@knightpiesold.com)
2. I hold the following academic qualifications:  
B.A.Sc. (Honours) Geological Engineering, University of Waterloo, Waterloo, ON. 1990
3. I am a licenced member of the Association of Professional Engineers of Ontario (Registration No. 90340902) and with The Association of Professional Engineers, Geologists and Geophysicists of the Northwest Territories (Registration No. L1651); as well, I am a member in good standing of the following organizations; Prospectors and Developers Association of Canada (PDAC) and the Ontario Mining Association (OMA).
4. I have worked as an engineer servicing the mining industry for over 26 years.
5. I do, by reason of education, experience and professional registration, fulfill the requirements of a Qualified Person as defined in NI 43-101. My work experience includes engineering, environmental site assessments, waste characterization studies, contaminated site remediation, hydrogeological studies, environmental baseline studies, community consultation, landfill design and monitoring, environmental permitting, mine closure planning, ESIA's, site supervision and project management.
6. I have not visited the project site.
7. I am responsible for the preparation of Sections 1.16, 20.1, 20.2, 20.3, 20.4, 20.5, 20.6, 20.7, 20.8, 20.9, 20.10, 20.11, 20.12, 20.14, 20.16, 20.17 and parts of 26.5 of this report entitled “NI 43-101 Technical Report on the Preliminary Economic Assessment of Lithium Hydroxide Production, Separation Rapids Lithium Project, Kenora, Ontario”, dated November 10, 2016.
8. I am independent of Avalon Advanced Materials Inc., as described in Section 1.5 of NI 43-101.
9. I have had no prior involvement with the mineral property in question.
10. I have read NI 43-101 and the portions of this report for which I am responsible have been prepared in compliance with the instrument.
11. As of the date of this certificate, to the best of my knowledge, information and belief, the sections of this Technical Report for which I am responsible contain all scientific and technical information that is required to be disclosed to make this report not misleading.

Signing Date: 10 November, 2016

Effective date of report, 21 October, 2016

*“Steven R. Aiken” {signed and sealed}*

Steven R. Aiken, P.Eng.



**CERTIFICATE OF AUTHOR**  
**Richard M. Gowans**

As the co-author of this report for Avalon Advanced Materials Inc. entitled “NI 43-101 Technical Report on the Preliminary Economic Assessment of Lithium Hydroxide Production, Separation Rapids Lithium Project, Kenora, Ontario” dated 10 November, 2016 with an effective date of 21 October, 2016, I, Richard Gowans do hereby certify that:

1. I am employed by, and carried out this assignment for, Micon International Limited, Suite 900, 390 Bay Street, Toronto, Ontario M5H 2Y2.  
tel. (416) 362-5135, e-mail [rgowans@micon-international.com](mailto:rgowans@micon-international.com).
2. I hold the following academic qualifications:  
B.Sc. (Hons) Minerals Engineering, The University of Birmingham, U.K. 1980.
3. I am a registered Professional Engineer of Ontario (membership number 90529389); as well, I am a member in good standing of the Canadian Institute of Mining, Metallurgy and Petroleum.
4. I am familiar with NI 43-101 and by reason of education, experience and professional registration, fulfill the requirements of a Qualified Person as defined in NI 43-101. My work experience includes over 30 years of the management of technical studies, management of numerous metallurgical testwork programs, design metallurgical processing plants and due diligence reviews of a number of lithium projects.
5. I have read NI 43-101 and this Technical Report has been prepared in compliance with the instrument.
6. I visited the mine site on 21 July, 2016.
7. I have participated in the preparation of a prior Technical Report on the Separation Rapids Lithium Project.
8. I am independent of Avalon Advanced Materials Inc. and related entities as defined in Section 1.5 of NI 43-101.
9. I am responsible for Sections 1.9, 1.13, 1.14, 1.17, 1.20, Sections 13, 17, 18, 21, 24, 25, 26.2 and 26.6 of this Technical Report.
10. As of the date of this certificate, to the best of my knowledge, information and belief, the Technical Report contains all scientific and technical information that is required to be disclosed to make this technical report not misleading.

Report date this 10th day of November, 2016: Effective Report Date: 21 October, 2016.

*“Richard Gowans” {signed and sealed}*

Richard Gowans P.Eng.



**CERTIFICATE OF AUTHOR**  
**Christopher Jacobs**

As the co-author of this report for Avalon Advanced Materials Inc. entitled “NI 43-101 Technical Report on the Preliminary Economic Assessment of Lithium Hydroxide Production, Separation Rapids Lithium Project, Kenora, Ontario” dated 10 November, 2016 with an effective date of 21 October, 2016, I, Christopher Jacobs, do hereby certify that:

1. I am employed by, and carried out this assignment for, Micon International Limited, Suite 900 - 390 Bay Street, Toronto, Ontario M5H 2Y2.  
tel. (416) 362-5135, email: [cjacobs@micon-international.com](mailto:cjacobs@micon-international.com).
2. I hold the following academic qualifications:  
B.Sc. (Hons) Geochemistry, University of Reading, 1980;  
M.B.A., Gordon Institute of Business Science, University of Pretoria, 2004.
3. I am a Chartered Engineer registered with the Engineering Council of the U.K. (registration number 369178).
4. Also, I am a professional member in good standing of: The Institute of Materials, Minerals and Mining; and The Canadian Institute of Mining, Metallurgy and Petroleum (Member).
5. I have worked in the minerals industry for 30 years; my work experience includes 10 years as an exploration and mining geologist on gold, platinum, copper/nickel and chromite deposits; 10 years as a technical/operations manager in both open-pit and underground mines; 3 years as strategic (mine) planning manager and the remainder as an independent consultant when I have worked on a variety of deposits including lithium.
6. I do, by reason of education, experience and professional registration, fulfill the requirements of a Qualified Person as defined in NI 43-101.
7. I have not visited the Property.
8. I am responsible for the preparation of Section 1.18 and Section 22 of this Technical Report.
9. I am independent of Avalon Advanced Materials Inc. and related entities, as defined in Section 1.5 of NI 43-101.
10. I have had no previous involvement with the Property.
11. I have read NI 43-101 and the portions of this report for which I am responsible have been prepared in compliance with the instrument.
12. As of the date of this certificate to the best of my knowledge, information and belief, the sections of this Technical Report for which I am responsible contain all scientific and technical information that is required to be disclosed to make this report not misleading.

Report date this 10th day of November, 2016: Effective Report Date: 21 October, 2016.

*“Christopher Jacobs” {signed and sealed}*

Christopher Jacobs, CEng, MIMMM



**CERTIFICATE OF QUALIFIED PERSON  
JANE SPOONER, M.Sc., P.Geo.**

As a co-author of this report entitled “NI 43-101 Technical Report on the Preliminary Economic Assessment of Lithium Hydroxide Production, Separation Rapids Lithium Project, Kenora, Ontario,” dated 10 November, 2016, I, Jane Spooner, P.Geo., do hereby certify that:

1. I am employed by, and carried out this assignment for  
Micon International Limited  
Suite 900, 390 Bay Street  
Toronto, Ontario  
M5H 2Y2  
tel. (416) 362-5135 fax (416) 362-5763  
e-mail: [jspooner@micon-international.com](mailto:jspooner@micon-international.com)
2. I hold the following academic qualifications:  
  
B.Sc. (Hons) Geology, University of Manchester, U.K. 1972  
M.Sc. Environmental Resources, University of Salford, U.K. 1973
3. I am a member of the Association of Professional Geoscientists of Ontario (membership number 0990); as well, I am a member in good standing of the Canadian Institute of Mining, Metallurgy and Petroleum.
4. I have worked as a specialist in mineral market analysis for over 30 years.
5. I do, by reason of education, experience and professional registration, fulfill the requirements of a Qualified Person as defined in NI 43-101. My work experience includes the analysis of markets for base and precious metals, industrial and specialty minerals, coal and uranium.
6. I have not visited the project site.
7. I am responsible for the preparation of Section 1.1, 1.15, Sections 2, 3, 19 and Section 26.4 of this report entitled “NI 43-101 Technical Report on the Preliminary Economic Assessment of Lithium Hydroxide Production, Separation Rapids Lithium Project, Kenora, Ontario,” dated 10 November, 2016.
8. I am independent of Avalon Advanced Materials Inc., as described in Section 1.5 of NI 43-101.
9. I have had no prior involvement with the mineral property in question.
10. I have read NI 43-101 and the portions of this report for which I am responsible have been prepared in compliance with the instrument.
11. As of the date of this certificate, to the best of my knowledge, information and belief, the sections of this Technical Report for which I am responsible contain all scientific and technical information that is required to be disclosed to make this report not misleading.

Signing Date: 10 November, 2016

Effective date of report, 21 October, 2016

*“Jane Spooner” {signed and sealed}*

Jane Spooner, M.Sc., P.Geo.

**CERTIFICATE OF AUTHOR**  
**David L. Trueman**

As a co-author of this report entitled “NI 43-101 Technical Report on the Preliminary Economic Assessment of Lithium Hydroxide Production, Separation Rapids Lithium Project, Kenora, Ontario”, dated November 10<sup>th</sup>, 2016, I, David L. Trueman, P.Ge., do hereby certify that:

I am an independent consultant and carried out this assignment on behalf of Avalon Advanced Materials Inc.  
I reside at:

5360 Bunting Avenue, Richmond, British Columbia V7E 5W1, Canada  
Telephone +1 604 448 8867 Email: [dtrueman@telus.net](mailto:dtrueman@telus.net)

1. I hold the following academic qualifications:  
  
Ph.D. University of Manitoba (1980)
2. I am a member of the Association of Professional Engineers and Geoscientists of the Province of Manitoba bearing Certificate No. 3365.
3. I have worked as in the mineral industry for 54 years and as professional geologist for over 43 years. I have spent the last 39 years specializing in the alkaline metals.
4. I do, by dint of education, experience and professional registration, fulfill the requirements of a Qualified Person as defined in NI 43-101. My work experience includes specializing in the metals Li, Rb, and Cs as found in granitic pegmatites, salar lithium deposits, lithium brines, lithium clays, and lithium geysers and I have reviewed/audited mineral resource estimates thereto.
5. I have visited the project site repeatedly from discovery of the Separation Rapids Pegmatite in September, 1996 to May, 2008. No drilling has been conducted at the project site since 2001 and I believe my most recent site visit to be current.
6. I am responsible for the preparation of Sections 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.10, 1.19, and Sections 4, 5, 6, 7, 8, 9, 10, 11, 12, 14 and 23, and 26.1 of this report entitled "NI 43-101 Technical Report on the Preliminary Economic Assessment of Lithium Hydroxide Production, Separation Rapids Project, Kenora", dated November 10<sup>th</sup>, 2016.
7. I am independent of Avalon Advanced Materials Inc., as described in Section 1.5 of NI 43-101.
8. As a consulting geologist I wrote the qualifying report for the Separation Rapids pegmatites for Avalon Ventures Ltd. in 1996.
9. I have read NI 43-101 and the portions of this report for which I am responsible have been prepared in compliance with the instrument.
10. As of the date of this certificate, to the best of my knowledge, information and belief, the sections of this Technical Report for which I am responsible contain all scientific and technical information that is required to be disclosed to make this report not misleading.

Signing Date: 10 November, 2016

Effective date of report, 21 October, 2016

“David L. Trueman” {Signed and sealed}

David L. Trueman, Ph.D., P.Ge.