ERCOSPLAN
Geotechnik und Bergbau

# Technical Report

ERCOSPLAN Ingenieurgesellschaft
Geotechnik und Bergbau mbH
Arnstaedter Strasse 28
99096 Erfurt
Germany

# KCl and $MgCl_2$ Mineral Reserve and Resource Estimate for the Wynyard Carnallite Project, Sub-surface Mineral Leases KL 246, KL 247 and KLSA 010, Saskatchewan, Canada

North Rim
Premium People since 1984
A wholly owned subsidiary of RESPEC

North Rim Exploration Ltd.
2600- 290A 8th Street East
Saskatoon, SK
S7H 0V7
Canada

amec foster wheeler

Amec Foster Wheeler Canada Ltd
4954 Richard Road SW, Bldg 1, Suite 200
Calgary, Alberta
T3E 6L1
Canada

**Client:** **Karnalyte Resources Inc.**
3150B Faithfull Avenue
Saskatoon, SK
S7K 8H3
CANADA

**Consultants:**
EurGeol Dr Henry Rauche and
EurGeol Dr Sebastiaan van der Klauw
**ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH**
Arnstaedter Str. 28
99096 Erfurt, Germany

Lola Piché, P. Geo
**North Rim Exploration Ltd.**
1020-606 Spadina Crescent East
Saskatoon, SK. S7K 3H1 Canada

Ellis Buckner, P. Eng
**Amec Foster Wheeler Canada Ltd**
4954 Richard Road SW, Bldg 1, Suite 200
Calgary, Ab. T3E 6L1 Canada

**Project Reference:** 14-085

**Effective Date:** **June 23, 2016**

This Technical Report contains

| | |
|---|---|
| 251 | pages |
| 02 | enclosures |
| 02 | appendices |

# IMPORTANT NOTICE

This report was prepared as a National Instrument 43-101 Technical Report by ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH (ERCOSPLAN), North Rim Exploration Ltd (NREL) and Amec Foster Wheeler USA Corporation (AmecFW), taken together as Consultants. The quality of information, conclusions, and estimates contained herein is consistent with the level of effort involved in the Consultant's services, based on: i) information available at the time of preparation, ii) data supplied by outside sources, and iii) the assumptions, conditions, and qualifications set forth in this Technical Report. This report is intended to be used by Karnalyte Resources Inc. (KARNALYTE), subject to the terms and conditions of its contracts with the Consultants. Those contracts permit KARNALYTE to file this Technical Report with Canadian Securities Regulatory Authorities pursuant to provincial securities legislation. Except for the purposes legislated under provincial securities law, any use of this Technical Report by any third party is at that party's sole risk.

# CAUTIONS REGARDING FORWARD-LOOKING STATEMENTS

The following NI 43-101 Technical Report includes certain statements and information that contain forward-looking information within the meaning of applicable Canadian securities laws. All statements, other than statements of historical facts, including the requirements and potential output of the KARNALYTE Potash and Magnesium Projects, the likelihood of commercial mining, the likelihood of securing a strategic partner and the ability to fund future mine development are forward-looking statements and include forward-looking information. Such forward-looking statements and forward-looking information specifically include, but are not limited to, statements concerning: Company plans at the KARNALYTE Potash and Magnesium Projects; Company ability to fund the KARNALYTE Potash and Magnesium Projects; the timing of granting of key permits; the estimated potash production and the timing thereto; economic analyses; capital and operating costs; mine development programs; future potash prices; cash flow estimates; and economic indicators derived from the foregoing.

Generally, forward-looking information can be identified by the use of forward-looking terminology such as "intends" or "anticipates", or variations of such words and phrases or statements that certain actions, events or results "may", "could", "should", "would" or "occur".

Forward-looking statements are based on the opinions and estimates set out in this Technical Report as of the date such statements are made and they are subject to known and unknown risks, uncertainties and other factors that may cause the actual results, level of activity, performance or achievements of KARNALYTE to be materially different from those expressed or implied by such forward-looking statements or forward-looking information, including: the receipt of all necessary approvals; the ability to conclude a transaction; uncertainty of future production; capital expenditures and other costs; financing and additional capital requirements; the receipt in a timely fashion of any further permitting for the KARNALYTE Potash and Magnesium Projects; legislative, political, social or economic developments in the jurisdictions in which KARNALYTE carries on business; operating



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

or technical difficulties in connection with mining or development activities; and the risks normally involved in the exploration, development and mining business.

Although the authors have attempted to identify important factors that could cause actual results to differ materially from those contained in forward-looking statements or forward looking information, there may be other factors that cause results not to be as anticipated, estimated or intended. There can be no assurance that such statements will prove to be accurate, as actual results and future events could differ materially from those anticipated in such statements. Accordingly, readers should not place undue reliance on forward-looking statements and forward-looking information. KARNAYLTE and the authors of this Technical Report do not undertake to update any forward-looking statements or forward-looking information that are incorporated by reference herein, except in accordance with applicable securities laws.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

# LIST OF CONTENTS

| | | |
|---|---|---|
| **1** | **Summary** | **16** |
| **2** | **Introduction and Terms of Reference** | **26** |
| 2.1 | Terms of Reference | 26 |
| 2.2 | Qualified Persons | 27 |
| 2.3 | Available Data | 29 |
| **3** | **Reliance on Other Experts** | **31** |
| **4** | **Property Descriptions and Location** | **32** |
| 4.1 | Property Description and Location | 32 |
| 4.2 | Property Titles in Saskatchewan | 36 |
| 4.3 | Types of Mineral Rights | 37 |
| 4.4 | Terms and Obligations of a Permittee | 38 |
| 4.5 | Royalties, Back-In Rights, and Other Agreements and Encumbrances | 39 |
| 4.6 | Environmental Liabilities, Permits, and Risks for the Property | 40 |
| **5** | **Accessibility, Climate, Local Resources, Infrastructure and Physiography** | **40** |
| 5.1 | Topography, Elevation and Vegetation | 40 |
| 5.2 | Access | 41 |
| 5.3 | Local Resources | 42 |
| 5.4 | Climate | 42 |
| 5.5 | Infrastructure | 42 |
| **6** | **History** | **44** |
| 6.1 | General Exploration History | 44 |
| 6.2 | The History of Magnesium Exploration in Central Saskatchewan | 45 |
| **7** | **Geological Setting and Mineralization** | **46** |
| 7.1 | Regional and Property Geology | 46 |
| 7.2 | Local Structure and Stratigraphy of the Potash Members | 50 |
| 7.3 | Geological Anomalies Affecting Potash-Bearing Horizons | 56 |
| 7.4 | Mineralization | 58 |
| 7.4.1 | Carnallite Distribution and Solution Mining of Patience Lake and Belle Plaine Members | 60 |
| 7.4.2 | Sylvite Distribution and Solution Mining of the Esterhazy Member | 63 |
| **8** | **Deposit Types** | **64** |
| **9** | **Exploration** | **65** |
| **10** | **Drilling** | **66** |
| 10.1 | The 2010/2011 Drill Holes | 67 |
| 10.2 | Core Retrieval and Core Handling at the Drill Site | 69 |



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

**11 Sample Preparation, Analysis and Security 71**
11.1 Historical Drill Cores and 2008 Re-Sampling 71
11.2 The 2009 Sampling Method and Approach 73
11.3 The 2011 Sampling Method and Approach 75
11.3.1 Geochemical Assay Sampling 76
11.3.2 Controls on Assay Sample Interval Determination 78
11.3.3 Rock Mechanical and Dissolution Test Samples 79
11.4 Sampling Preparation Analysis and Security 81
11.4.1 Historical and 2008 Sample Preparation, Analysis and Security 81
11.4.2 Sampling Preparation, Analysis and Security for 2009 and 2011 As-says 82
11.4.3 Solution Mining and Rock Mechanical Test Samples 83
11.4.4 Missing Core Sections 84

**12 Data Verification 85**
12.1 Historical Data 86
12.2 Recent Data 87
12.2.1 Assay-to-Gamma Correlation Study 87
12.2.2 Duplicate Analysis of Samples in an Independent Laboratory 87
12.2.3 Calculation of Mineralogy from Assay Data and Comparison with Core Description 88

**13 Mineral Processing and Metallurgical Testing 90**
13.1 Dissolution Testwork 90
13.2 Evaporation and Crystallization Test Work 92
13.3 Milling and Grinding Test 93
13.4 Detailed Thermodynamic Modelling of the Evaporation and Crystallization Circuit 93
13.5 Pilot Test Work on the Pan Granulation Process 94
13.6 Pilot Solution Mining Test Work 94
13.7 Confirmation of the Basic Magnesium Carbonate Production Process in the Laboratory 95
13.8 Brine Disposal Well Test 95

**14 Mineral Resource Estimates 96**
14.1 Assumptions and Methodology 97
14.1.1 Step 1: Build Geologic Model 99
14.1.2 Step 2: Determine Area used In Resource Estimate 100
14.2 Inferred Mineral Resource 109
14.3 Indicated Mineral Resource 113
14.4 Measured Mineral Resource 113
14.5 Additional Criteria for Industrial Minerals 114
14.6 Results of the Resource Verification 114

**15 Mineral Reserve Estimates 117**
15.1 Solution Mining Intervals 117
15.2 Proven Mineral Reserve 123
15.3 Probable Mineral Reserve 130



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

15.4 Factors that Could Affect the Mineral Reserve 139

**16 Mining Methods 142**
16.1 Operating Requirements 142
16.1.1 Cavern Size and Cavern Pillar Configuration 142
16.1.2 Cavern Access 143
16.1.3 Blanket Requirements 145
16.2 Leaching Procedure 147
16.2.1 Solution Mining Concept Esterhazy Member 147
16.2.2 Solution Mining Concept Patience Lake and Belle Plaine Members 148
16.3 Brine Field Dynamics and Cavern Mass and Volume Balances, 151
16.3.1 Production Brine Composition 151
16.3.2 Brine Field Dynamics 155
16.3.3 Cavern Mass and Volume Balances 156
16.3.4 Mine Plan 158
16.4 Solution Mining Recovery 163
16.5 Surface Brine Field Design 164
16.6 Pilot Solution Mining Operation 170
16.6.1 Solution Mining Operations 170
16.6.1.1 Solution Mining Techniques 171
16.6.1.2 Chemistry of Solution Mining Potash Rocks 172
16.6.2 Pilot Solution Mining Boundary Conditions 175
16.6.2.1 Time Frame 175
16.6.2.2 Technical Requirements 176
16.6.3 Information Required for Solution Mining Operation Design 176

**17 Recovery Methods 178**
17.1 Potash Production Design Base 178
17.2 Potash Processing Plant 179
17.2.1 Insolubles Removal 179
17.2.2 Evaporation and Crystallization 180
17.2.3 Sodium Chloride and Potassium Chloride Debrining 181
17.2.4 Drying and Formulation 181
17.2.5 Product Storage and Load-out 182
17.3 Magnesium Products Recovery Method 182
17.3.1 Magnesium Chloride Brine Process 183
17.3.2 Hydromagnesite Process 183
17.3.2.1 Gaseous Reagent Preparation 183
17.3.2.2 Pretreatment of the Potash Plant Waste Brine 185
17.3.2.3 Brine Dilution and Ammoniation 185
17.3.2.4 Hydromagnesite Precipitation 186
17.3.2.5 Hydromagnesite Recovery and Washing 186
17.3.2.6 Hydromagnesite Drying and Packaging 187

**18 Project Infrastructure 187**
18.1 Water Supply 187
18.2 Gas Supply 188



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

18.3 Electrical Power 189
18.4 Railway and Product Transport 189
18.5 Base Chemicals for the Magnesium Facility 190
18.6 Waste Management 190

**19 Market Studies and Contracts 191**
19.1 Potash Products 191
19.1.1 Product and By-Products 191
19.1.2 Potash Market: Historical Development and Present Situation 192
19.1.3 Outlook for Potash Market Development 195
19.1.4 KARNALYTE Market Plan 198
19.1.5 Contracts 199
19.2 Magnesium Products 199
19.2.1 Magnesium Chloride Brine Market 200
19.2.2 Magnesium Carbonate 201
19.2.2.1 Precipitated Calcium Carbonate – Brief Market Overview 203
19.2.2.2 Titanium Dioxide – Brief Market Overview 203
19.2.2.3 Market Development 204
19.2.3 Contracts 205

**20 Environmental Studies, Permitting, and Social or Community Impact 205**
20.1 Introduction EIS 205
20.2 Project Setting 208
20.2.1 Environmental Setting 208
20.2.2 Socio-Economic Setting 209
20.2.3 Aboriginal and Métis setting 210
20.3 Effects Assessment 210
20.3.1 Summary of Biophysical Assessment 211
20.3.2 Summary of Socio-Economic Assessment 212
20.3.3 Cumulative Effects 213
20.4 Monitoring Programs 214
20.5 Remediation Requirement and Closure Fund 214

**21 Capital and Operating Costs 215**
21.1 CAPEX Potash Project 215
21.2 CAPEX Magnesium Product Project 216
21.3 OPEX Potash Project 218
21.4 OPEX Magnesium Products 220

**22 Economic Analysis 222**
22.1 Potash Project 222
22.1.1 Input Parameters and Assumptions 222
22.1.2 Taxation 223
22.1.2.1 Base Payment 224
22.1.2.2 Profit Tax 224
22.1.3 Cash Flow Analysis 225
22.1.4 Sensitivity Analysis 226



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

22.1.5 Estimating Risk 227
22.2 Magnesium Product Project 228
22.2.1 Input Parameters and Assumptions 228
22.2.2 Cash Flow Analysis 230
22.2.3 Sensitivity Analysis 230
22.2.4 Project Risk 231

**23 Adjacent Properties 231**

**24 Other Relevant Data and Information 231**

**25 Interpretation and Conclusions 231**

**26 Recommendations 235**

**27 References 236**

Signature Page of Qualified Persons 240
Statement of Certification by Author 241
Statement of Certification by Author 243
Statement of Certification by Author 245
Statement of Certification by Author 247



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

# LIST OF FIGURES


| | | |
|---|---|---|
| Figure 1 | Property Boundaries and Drill Hole Locations | 30 |
| Figure 2 | KARNALYTE's Historic Disposition of June 30, 2011 and Current Dispositions Area as of May 31, 2016 | 33 |
| Figure 3 | Project Area with Drill Hole Locations and the Table 2 Naming Nomenclature | 35 |
| Figure 4 | Map of Topographic Contours Throughout the Permit Area | 41 |
| Figure 5 | Location of Proposed Plant Site to Infrastructure | 43 |
| Figure 6 | Subsurface Phanerozoic Stratigraphy of Saskatchewan Modified from the Saskatchewan Ministry of Resources Website (Geological Services, Well Information) | 47 |
| Figure 7 | Regional Geological Cross-section of the Middle Devonian Prairie Evaporite Formation in Saskatchewan | 49 |
| Figure 8 | Prairie Evaporite Formation Type Section for Exploration Well KW 3A11-27. | 51 |
| Figure 9 | East-West Geological Cross-Section Through DH-11, DH-20 and DH-21 | 53 |
| Figure 10 | North - South Geological Cross-Section (A-A') Through the KW 2-24, KW 2A11-12, KW 13-36, KW 3A11-27 Wells in the Project Area. | 54 |
| Figure 11 | Second Red Beds Structural Map Indicating the Change in Depth Level of the Deposit in the Investigated Area and Identified Class I Collapse. | 55 |
| Figure 12 | Disturbances Affecting the Continuity of the Potash-bearing Members in Saskatchewan (modified from Halabura and Hardy, 2007, /33/) | 57 |
| Figure 13 | Historical Seismic Contours Within and Around the Project Area and Location of 3D Seismic Investigations | 59 |
| Figure 14 | Carnallite Probability Map Over the 3D Seismic Area for the Patience Lake Member with Updated Collapse Buffers. | 61 |
| Figure 15 | Carnallite Probability Map Over the 3D Seismic Area for the Belle Plaine Member with Updated Collapse Buffers. | 62 |
| Figure 16 | Illustration of the Definition of Collapse Boundary with Buffer | 67 |
| Figure 17 | Re-Evaluation of a Collapse Feature as a Class 2 Anomaly | 68 |
| Figure 18 | Core Samples Placed in Plastic Bags with Ends Sealed | 70 |
| Figure 19 | Individual Wrapped Cores in Core Boxes | 71 |
| Figure 20 | Photograph inside North Rim's Core Lab and Storage Warehouse | 73 |
| Figure 21 | Dry 2-horsepower Band Saw with Dust Collection System Used by North Rim Staff for Core Slabbing. | 75 |
| Figure 22 | Sampling Intervals from Karnalyte Drill Hole KW 4B14-24 (Core 1, Boxes 13 and 14) | 77 |
| Figure 23 | DST Sample 017 from the Karnalyte Drill Hole KW 6-32 (Core 8, Box 17) | 79 |




ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

Figure 24 Comparison of the KCl Content Estimated from ALS and SRC Analysis 88
Figure 25 Comparison of the $MgCl_2$ Content Estimated from ALS and SRC Analysis 89
Figure 26 Determination of Radii of Influence for Mineral Resources and Reserves of the Patience Lake and Belle Plaine Interval 102
Figure 27 Determination of Radii of Influence for Mineral Resources and Reserves of the Esterhazy Interval 103
Figure 28 Area Balance of Caverns Along ROI Edges: Patience Lake and Belle Plaine, Proven Mineral Reserves 105
Figure 29 Area Balance of Caverns Along ROI Edges: Patience Lake and Belle Plaine, Probable Mineral Reserves 106
Figure 30 Area Balance of Caverns Along ROI Edges: Esterhazy Proven Mineral Reserves 107
Figure 31 Area Balance of Caverns Along ROI Edges: Esterhazy Probable Mineral Reserves 108
Figure 32 Area Used for the Inferred Mineral Resource Estimation for the Patience Lake and Belle Plaine Interval 110
Figure 33 Area Used for the Inferred Mineral Resource Estimation for the Esterhazy (Zone 1 and Zone 2) Interval 111
Figure 34 Esterhazy Member Area Comparison Between Resource Estimate Methodologies 116
Figure 35 Map View and Parameters of the Cavern and Pillar Design 144
Figure 36 Section View Along the Long Cavern Axis and Parameters of the Proposed Cavern and Pillar Design 144
Figure 37 Section View Along the Short Cavern Axis and Parameters of the Proposed Cavern and Pillar Design 145
Figure 38 Schematic Casing Scheme for Solution Mining Drill Holes (Depths depend on the actual Situation on the Brine Field) 146
Figure 39 Equilibrium Phase Diagram of Carnallite in the $MgCl_2$– KCl – NaCl – $H_2O$ System, Showing the Relevant Points for Dissolution of Carnallite from Carnallitite Rock and the Design Ranges for Production Brine of the Sylvinitic Esterhazy Member (Red Quadrangles) and the Carnallitic Patience Lake and Belle Plaine Members (Orange Quadrangles). Also Shown Are the Compositions of Average Production Brine Resulting from Mixing Different Amounts of Average Sylvinitic and Average Carnallitic Production Brine 152
Figure 40 Schematic Mine Plan over the Brine Field of Figure 32 showing approximate Development in 3 Year Steps from Start of Operation, Red Numbers Phase 1, Green Numbers Phase 2, Blue Numbers Phase 3 160
Figure 41 Schematic Potash Process Plant Layout for the 625,000 tpy Phase 1 180
Figure 42 Simplified Block Flow Diagram for Potash Production of the Proposed Brine Processing 181



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

Figure 43 Hydromagnesite Precipitation Process Overview (from LYNTEK 2012, /38/) 184
Figure 44 Potassium Chloride Product Types by Producers from Rauche (2015, /44/). Dark Blue on the Left, Standard Product, Pale Blue on the Right, Granular Product, Central Gray, Industrial Product, 192
Figure 45 Worldwide Consumption of Potash Fertilizers in $KCl_{equ}$ (Consumption figures starting in 2016 are forecasted); According to Data from FAO (2015, /25/) and confidential Market Studies 193
Figure 46 Potash Production and Sales According to Regions in 2013 (from Rauche, 2015, /44/) 194
Figure 47 Development of Potash Prices (MOP Granular FOB Vancouver) between 2011 and First Quarter 2016 195

# LIST OF TABLES

Table 1 Mineral Rights Leased to Karnalyte 32
Table 2 Drill Holes Used in Previous Technical Reports and Current Technical Report 34
Table 3 Historical Drill Holes Surrounding the Project Area. Bold Wells are Located within the Project Area 44
Table 4 Geology Interval Thickness and Depth Summary of the Three Potash Members in the Lease Area 52
Table 5 2010-2011 Wells Added to the Database (Refer to Table Table 2 for Drill Hole Locations) 68
Table 6 Project Area Sampling Intervals 76
Table 7 Drill Holes with Identified Missing Core Intervals 84
Table 8 Composition of the Original Brine Sample and the Conditioned Brine Used in the Tests 93
Table 9 Summary of Drill Hole Data Used for the Mineral Resource Calculation 98
Table 10 Summary of the Inferred Mineral Resources 112
Table 11 Comparison of Resource Estimates by Different Methodologies 115
Table 12 Thickness and Composition of the Carnallitite Layer of the Patience Lake Member in the 12 Drill Holes Present in the KARNALYTE Lease Area 119
Table 13 Thickness and Composition of the Upper Part of the Carnallitite Layer of the Belle Plaine Member in the 12 Drill Holes Present in the KARNALYTE Lease Area 120
Table 14 Thickness and Composition of the Lower Part of the Carnallitite Layer of the Belle Plaine Member in the 12 Drill Holes Present in the KARNALYTE Lease Area 121
Table 15 Thickness and Composition of the First Mineable Part of the Sylvinite of the Esterhazy Member in the 12 Drill Holes Present in the KARNALYTE Lease Area 122



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

Table 16 Thickness and Composition of the Second Mineable Part of the Sylvinite of the Esterhazy Member in Some of the 12 Drill Holes Present in the KARNALYTE Lease Area 123

Table 17 Proven Potash Reserves for the Patience Lake Member, Calculated with the Amount of Mineralized Material that Can Be Extracted from a Cavern as Given in Section 16.4 125

Table 18 Proven Potash Reserves for the Upper Belle Plaine Member, Calculated with the Amount of Mineralized Material that Can Be Extracted from a Cavern as Given in Section 16.4 126

Table 19 Proven Potash Reserves for the Lower Belle Plaine Member, Calculated with the Amount of Mineralized Material that Can Be Extracted from a Cavern as Given in Section 16.4 127

Table 20 Proven Potash Reserves for the Upper Layer of the Esterhazy Member, Calculated with the Amount of Mineralized Material that Can Be Extracted from a Cavern as Given in Section 16.4 128

Table 21 Proven Potash Reserves for the Lower Layer of the Esterhazy Member, Calculated with the Amount of Mineralized Material that Can Be Extracted from a Cavern as Given in Section 16.4 129

Table 22 Probable Potash Reserves for the Patience Lake Member, Calculated with the Amount of Mineralized Material that Can Be Extracted from a Cavern as Given in Section 16.4 131

Table 23 Probable Potash Reserves for the Upper Belle Plaine Member, Calculated with the Amount of Mineralized Material that Can Be Extracted from a Cavern as Given in Section 16.4 132

Table 24 Probable Potash Reserves for the Lower Belle Plaine Member, Calculated with the Amount of Mineralized Material that Can Be Extracted from a Cavern as Given in Section 16.4 133

Table 25 Probable Potash Reserves for the Upper Layer of the Esterhazy Member, Calculated with the Amount of Mineralized Material that Can Be Extracted from a Cavern as Given in Section 16.4 134

Table 26 Probable Potash Reserves for the Lower Layer of the Esterhazy Member, Calculated with the Amount of Mineralized Material that Can Be Extracted from a Cavern as Given in Section 16.4 135

Table 27 Probable $MgCl_2$ Reserves for the Patience Lake Member, Calculated with the Amount of Mineralized Material that Can Be Extracted from a Cavern as given in Section 16.4 and the transformation factor for $MgCl_2$ 136

Table 28 Probable $MgCl_2$ Reserves for the Upper Belle Plaine Member, Calculated with the Amount of Mineralized Material that Can Be Extracted from a Cavern as given in Section 16.4 and the transformation factor for $MgCl_2$ 137

Table 29 Probable $MgCl_2$ Reserves for the Lower Belle Plaine Member, Calculated with the Amount of Mineralized Material that Can Be Extracted from a Cavern as given in Section 16.4 and the transformation factor for $MgCl_2$ 138

Table 30 Preliminary Parameters for the Proposed Cavern Design (Depths are typical Depths and may differ up to 100m depending on the Location of a Cavern on the Brine Field) 143



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

Table 31 Casing and Cementation Scheme for the Solution Mining Drill Holes 146

Table 32 Estimated Average Production Brine Composition for Solution Mining of the Sylvinite Esterhazy Member and the Carnallitite Belle Plaine and Patience Lake Members, as well as the Range of Potential Production Brine Compositions Going to the Plant 153

Table 33 Preliminary Mass Balance for the Material from a Single Cavern from the Lower Mineable Esterhazy Member 156

Table 34 Preliminary Mass Balance for the Material from a Single Cavern from the Upper Mineable Esterhazy Member 157

Table 35 Preliminary Mass Balance for the Material from the Carnallitite Cavern from the Bottom of the Belle Plaine Member to the Top of the Patience Lake Member 157

Table 36 Average Hourly Flow Volumes and Proposed Sources for the Water and Brines Going to the Brine Field for Phase 1 158

Table 37 Average Hourly Flow Volumes and Proposed Use Areas for the Brines Going from the Brine Field for Phase 1 158

Table 38 Production Schedule for the different Phases with Ramp Up and Ramp Down and Approximation of New Caverns required Annually. Bold Cavern Preparation Number are CAPEX 161

Table 39 Volume, Size, Tonnage of Mineralized Material as well as Recoverable KCl Tonnage for an Average Cavern on the Exploration and Geotechnical Holes for the Patience Lake Member165

Table 40 Volume, Size, Tonnage of Mineralized Material as well as Recoverable KCl Tonnage for an average Cavern on the Exploration and Geotechnical Holes for the Upper Belle Plaine Member 166

Table 41 Volume, Size, Tonnage of Mineralized Material as well as Recoverable KCl Tonnage for an Average Cavern on the Exploration and Geotechnical Holes for the Lower Belle Plaine Member used for Undercut Leaching 167

Table 42 Volume, Size, Tonnage of Mineralized Material as well as Recoverable KCl Tonnage for an Average Cavern on the Exploration and Geotechnical Holes for the Upper Mineable Sylvinite Layer of the Esterhazy Member 168

Table 43 Volume, Size, Tonnage of Mineralized Material as well as Recoverable KCl Tonnage for An average Cavern on the Exploration and Geotechnical Holes for the Lower Mineable Sylvinite Layer of the Esterhazy Member 169

Table 44 Selected Brownfield Expansions adding to overall Potash Production Capacity between 2009 and 2015 196

Table 45 Selected Greenfield Projects potentially adding to overall Potash Production Capacity between 2016 and 2025 (phased capacities estimated) 197

Table 46 Imports of $MgCl_2$ into Western Canada 202

Table 47 Historic and Anticipated Annual PCC Sales Expressed as Thousands of Tons 204



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

Table 48 US production of $TiO_2$ and $TiO_2$ Pigments expressed as Tons 204
Table 49 Estimated Canadian Exports of $TiO_2$ and $TiO_2$ Pigments in Tonnes and in Million CAD$ as well as average Price per Tonne 204
Table 50 Estimated Direct, Indirect and Other Capital Costs for Construction of Potash Plant, Brine Field and Infrastructure for an Annual Production of 625,000 Tonnes and 2,125 Million Tonnes 216
Table 51 Estimated Magnesium Product Plant Direct and Indirect Capital Expenditure Estimate 217
Table 52 Estimated Annual Production Costs and the Estimated Costs per Tonne of Product for the Potash Project 219
Table 53 Estimated Annual Production Costs and the Estimated Costs per Tonne of Product for the Magnesium Products 220
Table 54 Discount Rate Sensitivity Analysis for the Potash Project 226
Table 55 Sensitivity of IRR and NPV after Tax (Discount Rate fixed at 8%) to Changes in Boundary Conditions as well as the Influence of Changes in Discount Rate 227
Table 56 Discount Rate Sensitivity Analysis for the Magnesium Product Project 229
Table 57 Sensitivity of IRR and NPV after tax (Discount rate fixed at 10%) to changes in the Boundary Conditions 230
Table 58 Estimated Amounts of Mineralized Material and Weighted Average Grade for Proven Mineral Reserves for the Mineable Horizons in the Esterhazy Member and the Mineable Horizons from Belle Plaine and Patience Lake Members 233
Table 59 Estimated Amounts of Mineralized Material and Weighted Average Grade for Probable Mineral Reserves for the Mineable Horizons in the Carnallitite of the Belle Plaine and Patience Lake Members and the Sylvinite of the Esterhazy Member 233
Table 60 Estimated Amounts of Mineralized Material and Weighted Average Grade for Probable Mineral Reserves for the Magnesium Mineralization in the Mineable Horizons in the Carnallitite of the Belle Plaine and Patience Lake Members 234



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

# LIST OF ENCLOSURES

ENCLOSURE A Discounted Cash Flow Model for the KARNALYTE Wynyard Potash Project

ENCLOSURE B Discounted Cash Flow Model for the KARNALYTE Wynyard Magnesium Product Project

# LIST OF APPENDICES

APPENDIX 1 Subsurface Mineral Lease KLSA 010 from Saskatchewan Ministry of Energy and Resources

APPENDIX 2 Subsurface Mineral Leases KL 246 and KL 247 from the Saskatchewan Ministry of Economy



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

# 1 Summary

**Introduction**

Karnalyte Resources Inc. (KARNALYTE) was granted Subsurface Mineral Lease KLSA 010 in 2011 and Subsurface Mineral Leases KL 246 and KL 247, approximately covering the area of former Exploration Permit KP 360A, in 2016, by the Saskatchewan Government. These Leases are located near Wynyard, Saskatchewan. Historical and recent drilling has shown that potash and magnesium salts occur below substantial parts of these leases.

The basis for this Technical Report are

- 1 historical drill hole cored in the potash section with retained core material, and partly re-assayed
- 11 recent drill holes completely cored in the potash section and with described and sampled under supervision of the QPs
- 3D seismic survey from 2008 and 2009 covering about 105 km² of the KARNALYTE Lease area.
- A Feasibility Study for potash production from Foster Wheeler Canada Ltd. (FOSTER WHEELER) and ERCOSPLAN (FOSTER WHEELER & ERCOSPLAN, 2011, /26/), with an update of CAPEX and OPEX by AmecFW (AmecFW, 2016, /4/).
- A Preliminary Feasibility Study by LYNTEK Inc. from Lakewood USA (LYNTEK) on producing different magnesium products from the Magnesium chloride-rich endbrine from potash production (LYNTEK, 2012, /38/), with an update of CAPEX and OPEX by AmecFW (AmecFW, 2016, /4/).
- Further studies on basic/detail engineering level for parts of the brine field and the process plant (see Section 13).

**Location and Property Description**

The KARNALYTE properties are located in central Saskatchewan approximately 175 kilometers east of Saskatoon and some 65 kilometers east of the Potash Corporation of Saskatchewan Lanigan mine. The historic Permit KP 360 was transferred by Mr. Robin Phinney to KARNALYTE on October 24, 2008. On February 14, 2011 (effective September 8, 2010) the west area of Permit KP 360 was converted to a Subsurface Mineral Lease KLSA 010, and the remainder was converted to the KP 360A exploration permit. The KP 360A permit was converted to Subsurface Mineral Leases KL 246 and KL 247 in 2016. Crown mineral rights between the KLSA 010 Lease and the KL 246 and KL 247 cover an aggregate area of approximately 36,900 hectares in portions of Townships 31 and 32 and Ranges 14 to 17 over Sections 1 to 36. The dimensions of the project area are approximately 18 miles (29 kilometers) east to west and 8 miles (12.8 kilometers) north to south.

The exploration lease KLSA 010 was issued February 14, 2011 (effective September 8, 2010) and is subject to rentals and exploration assessment rates prescribed herein. The area of the KLSA 010 Lease is 6,809 hectares.

The KL 246 and KL 247 Leases were issued June 23, 2016 (effective date: March 13, 0216) and are subject to rentals and exploration assessment rates prescribed therein. The aggregate area of KL 246 and KL247 is approximately 30,000 hectares.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

**Geological Setting and Mineralization**

The KARNALYTE deposit is located in the Prairie Evaporite Formation, which is part of the Elk Point Group of Devonian Age. Within the properties, potash occurs in more or less horizontal lying beds in the Esterhazy, the Belle Plaine and the Patience Lake Members of the Prairie Evaporite.

Based on evaluation of historical exploration data (2 drill holes, of which DH-10 was duplicated in the recent campaign), two exploration drill holes from 2009, and 9 new drill holes drilled in 2011, combined with a re-interpretation of the 3D seismic surveys commissioned by KARNALYTE in 2008 and 2009 (Boyd, 2010, /9/), NREL refined the geologic model for the property. Within the western part of the property, potash occurs in the Esterhazy Member mainly as Sylvite (KCl) mineralization and mainly as Carnallite (KCl $MgCl_2$ 6 $H_2O$) mineralization in the Belle Plaine and Patience Lake Members of the Prairie Evaporite.

Three different Intervals are discussed in this Technical Report for each of the three potash members.

**The Geology Interval** – This interval represents the first and last occurrence of Sylvite and Carnallite mineralization as the potash beds transition to Halite.

**The Mineral Resource Interval** – This interval represents a refinement of the geology interval. For the purpose of the mineral resource estimation, the upper and lower bounds of the members were determined using a grade cut-off from the assay results.

**The Mineral Reserve Interval** – This interval represents a further refinement of the Mineral Resource Interval, to ensure that the average production brine composition used in the Feasibility Study for the KCl (FOSTER WHEELER & ERCOSPLAN, 2011, /26/) and the Preliminary Feasibility Study for the $MgCl_2$ (LYNTEK, 2012, /38/) can be achieved during the mining operation. The Upper and Lower Bounds of the Member have been defined using grade cut-off as well as operational requirements.

The layering of the salt dips slightly to the southwest as undisturbed beds with nearly continuous grade and thickness of the members, except near collapse features, where based on seismic information, it is assumed that the potash-bearing members have been partly dissolved.

**Exploration Concept and Status**

The exploration started with a program of 2 holes in 2009 to extend the mineral resource base defined on the basis of two existing historical holes (ERCOSPLAN, NREL & FW, 2010, /18/). In 2011, 9 new holes were drilled, 7 of which were defined as exploration holes, and 2 as geotechnical holes, to extend the area with verifiable information about thickness and grade of the deposit and to provide core material required for rock mechanical investigations and dissolution test work. Based on the data from the new drill holes the existing 3D seismic survey (Boyd, 2010, /9/), covering most of KLSA 010 and part of KL 246 and 247 was re-interpreted to better define the mineralized members and collapse features. With the data from the historical, the 2009 and the seven 2011 exploration holes a mineral resource estimate report was prepared in August 2011 (ERCOSPLAN & NREL, 2011 /20/). Also in 2011, the two geotechnical holes were sampled and analysed and are now included in the mineral resource estimate of this Technical Report. In 2016, all geological data was converted into a 3D grid geologic model that was used for the mineral resource estimate.

**Mining and Processing Methods**

The Potash Feasibility Study (FOSTER WHEELER & ERCOSPLAN, 2011, /26/) uses a combination of hot leaching from high grade parts of the carnallitite layers of the Belle Plaine and Patience Lake Members and cold leaching from high grade parts of the Esterhazy Members in dual well caverns to obtain a production



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

brine with an average KCl content of 115 g/l. This requires that the brine used to dissolve the carnallitite has a pre-concentration of 20 to 25 g/l KCl from mixing of water with brines from preparation leaching in the Lower Belle Plaine Member and the upper layer of the Esterhazy Member.

The production brine is processed in the plant using evaporation and crystallization to a final pellet product with a 97% KCl grade.

The Magnesium Preliminary Feasibility Study (LYNTEK, 2012, /38/) uses the $MgCl_2$ endbrine from potash production to produce a saleable high grade $MgCl_2$ brine and Basic Magnesium Carbonate (Hydromagnesite). This endbrine is the product from evaporation and crystallization of a production brine to a 97% KCl grade product as described in the potash feasibility study (FOSTER WHEELER & ERCOSPLAN, 2011, /26/). The production brine is obtained using a combination of hot leaching from high grade parts of the carnallitite layers of the Belle Plaine and Patience Lake Members and cold leaching from high grade parts of the Esterhazy Members in dual well caverns to obtain a production brine with an average KCl content of 115 g/l and a $MgCl_2$ content of 121.5 g/l (FOSTER WHEELER & ERCOSPLAN, 2011, /26/).

A part of the potash production endbrine is diluted with process water to a 32% $MgCl_2$ brine and cooled to 30°C to prevent precipitation of magnesium chloride from the brine during transportation.

A further part of the potash production endbrine is used for Hydromagnesite production; this involves treating the brine with Epsom salt to remove any calcium from the brine through precipitation of Gypsum. This pre-treated brine is diluted with some process water and ammoniated in an absorption tower. Carbonation of this brine results in the precipitation of hydromagnesite, which is filtered from the spent brine, washed to remove adhering ammonia, dewatered and dried in a Holo-Flite drier to produce dry hydromagnesite ($4MgCO_3\ Mg(OH)_2\ 4H_2O$). In parallel, a limestone calcination process is operated to produce the $CO_2$ required for carbonation. The lime produced is slaked by adding process water and the slaked lime is fed into an ammonia stripping column, which drives the ammonia back in a gaseous anhydrous form, which can be recycled in the process. This part of the operation is similar to the well-known Solvay process for producing soda ash from sodium chloride brine.

In the opinion of the authors, the mining and processing as defined in the Potash Feasibility Study (FOSTER WHEELER & ERCOSPLAN, 2011, /26/) and the Magnesium Preliminary Feasibility (LYNTEK; 2012, /38/) show that the mineralized material can be economically extracted and processed to potash and magnesium products and constitutes a “Mineral Reserve” as defined by National Instrument 43-101 and CIM (2014, /10/).

**CAPEX and OPEX, Economic Evaluation**

Based on the Feasibility Study (FOSTER WHEELER & ERCOSPLAN, 2011, /26/), AmecFW (2016, /4/) has updated the estimate for the Capital Expenditures (CAPEX) and the Operational Expenditures (OPEX) for the mining and processing of the mineral resources in the KARNALYTE property for an original case with 625,000 tpy of 97% KCl product (Case 1) and has expanded this with 2 stages of expansion of 750,000 tpy to a total annual production of 2.125 million tonnes (Case 2). The CAPEX for the potash project includes brine field, plant, infrastructure, as well as product loading and has been estimated (± 15% accuracy) at:

Case 1 $789 million CAD

Case 2 $2,396 million CAD



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

The OPEX of the potash operation from mining to loading in rail cars has been estimated (± 15% accuracy) at:

Case 1 $136.99 CAD/tonne of product,

Case 2 $131.70 CAD/tonne of product.

For Case 1, about 19.5% of the endbrine from potash production would be used in the magnesium product facility. For Case 2, about 5.8% of the endbrine from potash production would be used in the magnesium product facility.

Based on the Magnesium Preliminary Feasibility Study (LYNTEK, 2012, /38/), AmecFW (2016, /4/) has updated the estimates for Capital Expenditures (CAPEX) and Operational Expenditures (OPEX) for the processing of the potash plant endbrine to 100,000 tpy of $MgCl_2$ brine at 32% $MgCl_2$ concentration and 104,000 tpy of 99% pure hydromagnesite product. The CAPEX for the magnesium product project includes plant, reagent unloading and product loading and assumes that $MgCl_2$ endbrine and some infrastructure are provided by the potash production facility. For this study, the magnesium facility can only be constructed together with a potash production facility. The CAPEX for the magnesium facility (± 25% accuracy) contain a contingency of 20% on Direct & Indirect costs and 10% Owner costs and are estimated at

$171.2 million CAD.

The OPEX for the magnesium facility for the processing of the potash endbrine to loading the products in rail cars or trucks has been estimated (± 25% accuracy) at:

$MgCl_2$ Brine $ 7.01 CAD/tonne of product,

Hydromagnesite $302.01 CAD/tonne of product,

with a contingency of 10% on the OPEX estimate for $MgCl_2$ brine and Hydromagnesite.

KARNALYTE plans to market its potash product mainly in the North American Market. Due to the relatively high grade and superior handling qualities at a competitive price compared to conventional compacted granular and standard product, a share of the North American market may be obtained.

KARNALYTE plans to market its hydromagnesite product mainly in the North American Market. There are three main potential markets:

- As high quality precipitated basic magnesium carbonate, which is presently imported, KARNALYTE may have a price advantage due to lower shipping costs. However, this is a relatively small market and therefore the volume produced by KARNALYTE may suppress prices,
- As an alternative to precipitated calcium carbonate in the paper industry and eventually the plastic industry. The total precipitated calcium carbonate market in North America is about 2.5 million tonnes,
- As an extender for titanium oxide in paint pigments, which has an annual production in North America of 1.4 million tonnes.

KARNALYTE has letters of interest (LOI) from prospective customers totalling nearly 50% of the planned production for the last 2 uses and it is a reasonable assumption that KARNALYTE can market its hydromagnesite at competitive prices.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

The $MgCl_2$ brine will be marketed mainly in the western provinces of Canada, which presently import $MgCl_2$ brine at approximately $3.4 million CAD annually. Due to the high cost of transportation associated with a relatively low value product, the potential for KARNALYTE to be able to replace a significant volume of these imports is reasonable.

A discounted cash flow model for Case 2 potash production, taking into account a conservative 60-year mine life, financial provision for closure estimated at 10% of the CAPEX, resulting in $240 million CAD at the end of the life of the project, current Saskatchewan tax and royalty regulations and a potash price US Midwest of $466 CAD/tonne in 2019 provides favourable economic modelling results:

Net Present Value (NPV) after tax at 8% discount rate of $3.39 billion CAD

Internal Rate of Return (IRR) after tax of 19.1%

A discounted cash flow model for the magnesium project, taking into account a conservative 60-year mine life, financial provision for closure estimated at 10% of the CAPEX, resulting in $17.1 million CAD at the end of the life of the project, current Saskatchewan tax, royalty regulations and a hydromagnesite price of $600 CAD/tonne for 50% of production as hydromagnesite and alternative to precipitated calcium carbonate, at $1,800 CAD/tonne for the remaining 50% as titanium oxide extender and a $MgCl_2$ brine price of $40 CAD/tonne provides favourable economic modelling results:

Net Present Value (NPV) after tax at 10% discount rate of $512 million CAD

Internal Rate of Return (IRR) after tax of 26.1%

Based on the detailed geological work and engineering in this Technical Report, the Feasibility Study for potash and the Preliminary Feasibility Study for magnesium products, the authors consider the project technically and economically feasible.

**Resource Estimate**

It is the opinion of the authors that the “Inferred” class of Mineral Resource will be limited to within 6.0 km of the cored and assayed drill holes excluding any established Mineral Reserves and any known seismic anomalies that may be present due to dissolution or collapse features. The mineralization present in the Patience Lake through Belle Plaine Member represents the carnallitite mineral resource. The mineralization present in the Esterhazy Member constitutes the sylvinite mineral resource. The Inferred Mineral Resource was estimated using the Grid Model. Interpolation of member thickness and grades between wells were done using inverse distance squared weighting.

For this Technical Report, most of the Indicated and Measured Mineral Resource (based on proximity to drill holes) have been upgraded to Probable and Proven Mineral Reserves respectively. There are, however, four distinct areas where “Indicated” and “Measured” Mineral Resources have been re-classified to Inferred Mineral Resources in this Technical Report based on the judgement of the qualified persons that there is some impediments or doubt as to the ‘reasonable prospects for economic extraction’ for these areas.

The four areas are:

1. Small parcels of land along the perimeters of ROIs
2. Small parcels of land next to collapse anomalies
3. Small parcels of land next to the property boundary, including the boundaries of Freehold land



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

4. "Restricted Areas" around the plant area and along the major highway, where theoretically some of the mineralization could be mined at the end of the mine life.

For the Inferred Mineral Resource in all defined Inferred Mineral Resource areas the broad definition of the Mineral Resource Estimate Interval was used for thickness. The respective area is transformed to tonnage from the volume (mineralized interval) for each area and zone. The volume is calculated by multiplying the net area by the thickness of the potential solution mining intervals present in the Patience Lake, Belle Plaine and Esterhazy Members. The volume is multiplied by a density factor being calculated from the mineral composition of the carnallitite and sylvinitic rock as determined from assays, typically in the range of 1.8 to 2.1 t/m³ respectively for the in-situ sylvinite and carnallitite tonnage.

The total "inferred mineral resources" for KCl amount to:

| | Average KCl Grade (%)[1] | In Place Tonnage (MMT) | Total Extraction Tonnage (MMT)[2] | Net KCl Tonnage (MMT) | Net KCl Product (MMT)[3] |
|---|---|---|---|---|---|
| Total Carnallitite | 13.71 | 4,240.5 | 1,547.8 | 191.0 | 171.9 |
| Total Sylvinite | 20.87 | 629.3 | 229.7 | 43.1 | 38.8 |
| TOTAL | | 4,869.8 | 1,777.5 | 234.1 | 210.7 |

and for $MgCl_2$ to:

| | Average $MgCl_2$ Grade (%)[3] | In Place Tonnage (MMT) | Total Extraction Tonnage (MMT) | Net $MgCl_2$ Tonnage (MMT) | $MgCl_2$ Product (MMT)[3] |
|---|---|---|---|---|---|
| Total Carnallitite | 14.92 | 4,240.5 | 1,547.8 | 207.8 | 12.1 |
| Total Sylvinite | 3.03 | 629.3 | 229.7 | 6.3 | 0.4 |
| TOTAL | | 4,869.8 | 1,777.5 | 214.1 | 12.5 |

MMT stands for million tonnes.

## Mineral Reserve Estimate and Conclusions

In the opinion of the authors "Proven Mineral Reserves" can be estimated from the areas with "Measured Mineral Resources" and "Probable Mineral Reserves" can be estimated from the areas with "Indicated Mineral Resources" for the potash as a recent feasibility study (FOSTER WHEELER & ERCOSPLAN, 2011, /26/) has been completed. For the magnesium chloride, the engineering is at a preliminary feasibility level and therefore according to the CIM (2014, /10/) guidelines, only "Probable Mineral Reserves" can be estimated for Magnesium Chloride from "Measured Mineral Resources" and "Indicated Mineral Resources". These Mineral Resource areas have been reduced by the "Restricted Areas", where mining should not take place to avoid any problems at the surface due to potential subsidence. Mineral Reserves have been estimated by placing caverns over the license area in a grid as defined by the mining method. For each drill hole a typical cavern recovery of mineralized material at given grade has been

[1] "Average KCl grade" and "Average $MgCl_2$ Grade" refer to weighted averages
[2] Variable Extraction Ratio (27.5% for the Patience Lake and Bell Plaine, 30% for Esterhazy Member)
[3] "Net Product" for KCl and $MgCl_2$ represent current plant design considerations and includes a plant recovery of 90% for KCl from the production brine and 5.8% recovery for $MgCl_2$ from the production brine



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

estimated. This amount was reduced by 10% to account for any anomalies below the resolution of 3D seismic. Reserves were estimated by counting the number of caverns in the “Measured” and “Indicated” Mineral Resource areas for each drill hole and multiplying this number with the typical cavern recovery. This results in the following “Proven Mineral Reserves” for potash (in million tonnes, if not stated differently):

| Proven Mineral Reserves | Mineralized Material | Average KCl Grade (% KCl) | Mineable KCl Tonnage | Product Tonnage |
|---|---|---|---|---|
| Pat. Lake M. | 106.3 | 19.9 | 21.2 | 19.6 |
| UBPM | 131.0 | 19.3 | 25.3 | 23.5 |
| LBPM | 31.3 | 12.1 | 3.8 | 3.5 |
| TOTAL/Average | 268.6 | 18.7 | 50.3 | 46.6 |
| | **Mineralized Material** | **Average KCl Grade (% KCl)** | **Mineable KCl Tonnage** | **Product Tonnage** |
| Upper Esterh. | 32.6 | 26.1 | 8.5 | 7.9 |
| Lower Esterh. | 20.2 | 26.4 | 5.3 | 5.0 |
| TOTAL/Average | 52.8 | 26.2 | 13.8 | 12.9 |

and “Probable Mineral Reserves” (in million tonnes, if not stated differently):

| Probable Mineral Reserves | Mineralized Material | Average KCl Grade (% KCl) | Mineable KCl Tonnage | Product Tonnage |
|---|---|---|---|---|
| Pat. Lake M. | 171.2 | 19.9 | 34.0 | 31.5 |
| UBPM | 204.7 | 19.0 | 38.9 | 36.1 |
| LBPM | 49.2 | 12.2 | 6.0 | 5.6 |
| TOTAL/Average | 425.1 | 18.6 | 78.9 | 73.2 |
| | **Mineralized Material** | **Average KCl Grade (% KCl)** | **Mineable KCl Tonnage** | **Product Tonnage** |
| Upper Esterh. | 38.0 | 25.1 | 9.5 | 8.8 |
| Lower Esterh. | 23.6 | 26.5 | 6.3 | 5.8 |
| TOTAL/Average | 61.6 | 25.6 | 15.8 | 14.6 |

Total amount of KCl product that can be made from the Mineral Reserves at 97% KCl and 90% plant efficiency is 147 million tonnes, which suggests a lifetime of the project at 2.125 million tonnes annual production of 70 years.

For magnesium chloride, the situation is different, because only a part of the magnesium chloride mined together with the potash is transformed into a saleable product, the remaining part is considered waste. Therefore, the magnesium chloride mineral reserve is dependent on the size of the magnesium products plant and the market for the products and a magnesium chloride transformation



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

factor is defined as percentage of magnesium chloride mined that gets transformed to saleable Magnesium products to determine the magnesium chloride mineral reserves. With an average production brine composition from the brinefield, about 191,000 tpy of magnesium chloride is required for the planned annual production of 100,000 tonnes $MgCl_2$ brine and 104,000 tonnes hydromagnesite, which translates to 141,000 tpy of magnesium chloride in the final products. The mineral reserves have been estimated by applying a factor of 5.8% for all phases of the project that will be transformed to product for the annual amount of magnesium chloride mined from Sylvite and Carnallite to produce 2.125 million tpy of potash product.

Assuming that during the first years of potash production only $MgCl_2$ brine will be produced and only when full potash production is reached will hydromagnesite be produced, the following "Probable" $MgCl_2$ Mineral Reserves (in million tonnes, if not stated differently) will result:

| Probable Mineral Reserves | Mineralized Material | Average $MgCl_2$ Grade (% $MgCl_2$) | Mineable $MgCl_2$ Tonnage | Product Tonnage |
|---|---|---|---|---|
| Pat. Lake M. | 277.5 | 22.4 | 62.1 | 3.2 |
| UBPM | 335.7 | 24.7 | 82.8 | 4.3 |
| LBPM | 81.4 | 10.3 | 8.4 | 0.4 |
| TOTAL/Av. | 694.6 | 22.1 | 153.3 | 7.9 |

The total amount of $MgCl_2$ products that can be produced is not dependent on the available mineral reserves but on the capacity of the plant and the market. The $MgCl_2$ mineral reserves can be increased without further exploration by investment in a plant expansion and identification of a market for the additional product.

In the opinion of the authors, the investigated part of the KARNALYTE KLSA 010, KL 246 and KL 247 Leases contain sufficient potassium and magnesium chloride mineral reserves to further develop both projects.

It is also the opinion of the authors that it is reasonable to conclude that potash mineralization as identified in the drill holes may extend to the remainder of the KL 246 Lease (to the east of the current focus area) and that further drilling to confirm the presence of potash and further seismic work to delineate the structure of the deposit is warranted.

The authors see the following risks to the potash project that are considered to be within the estimate accuracy of the estimated CAPEX and OPEX:

- Project funding, which must be secured,
- Scope changes during EPC execution,
- Land purchase and right of way issues,
- Schedule impact due to shipping delay, utilities installation, availability of resources, especially site labor. A labor and logistics survey was performed as part of the Feasibility Study.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

For the magnesium product project that relies on the potash project, the potash project risks apply and further risks identified in the Preliminary Feasibility Study are:

- Brine quality from the potash production plant, especially with regard to sulfate, iron and $CaCl_2$ levels, which might negatively influence the product quality,
- Market size and pricing structure for the use of hydromagnesite as a $TiO_2$ extender,
- Source and pricing magnesium sulfate as an important reagent for the hydromagnesite process. This risk is relatively small as the process can be redesigned for the use of sodium sulfate

**Recommendations**

The authors of this Technical Report recommend continuing separately with both projects with the potash project as most important by taking the following steps:

- Begin detailed engineering and advance it to a point where equipment packages can be awarded,
- Perform detail engineering to support preparation of construction license application.

The cost for the detail engineering work for Phase 1 potash plant of 625,000 tpy are estimated at around $75 million CAD, which are included in EPCM and Owners cost in the CAPEX estimate.

Additionally, full project financing (approximately $790 million CAD for the first phase of the project for a 625,000 tpy potash operation) has to be secured, to start construction.

For the magnesium product project, the following project phases have to be organized:

Phase 1: extensive laboratory and pilot testing program consisting of tests for

- Exact composition of the potash production end brine,
- Ammonia brine dissolution and brine dilution in the selected absorption tower,
- Ammonia reclamation in selected column,
- Carbon dioxide dissolution to properly size equipment
- Hydromagnesite dewatering and drying tests.

Concurrent with the test program, the engineering required for the Magnesium Feasibility Study can be completed. Furthermore, baseline studies for the EIA should be conducted and the EIA finalised and the market and pricing of the hydromagnesite as $TiO_2$ extender has to be firmed. The total costs for this step are estimated at $2 million CAD, and are included in the CAPEX estimate.

Conditional upon a favourable outcome of Phase 1, Phase 2 can be initiated, which consists of

- Detailed engineering and advance it to a point where equipment packages can be awarded,
- Perform detail engineering to support preparation of construction license application.

The costs for this stage are estimated at $12 to 14 million CAD and these costs are included in the development CAPEX.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

Additionally, full project financing (approximately $171 million CAD) for the magnesium product project has to be secured before construction can start, although there is an option to get the $MgCl_2$ brine plant constructed earlier. This of course depends of having the financing for at least Phase 1 of the potash project in place.

It is also the opinion of the authors that it is reasonable to conclude that potash mineralization as identified in the drill holes may extend to the remainder of KL 246 and that further drilling to confirm the mineralization and further seismic work to delineate the structure of the deposit is warranted, but not required for the present projects.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

# 2 Introduction and Terms of Reference

Karnalyte Resources Inc.'s (KARNALYTE) holds the Subsurface Mineral Leases KL 246 and KL 247 and KLSA 010 near Wynyard, Saskatchewan, Canada and plans to become a producer of high quality potash using an established solution mining process. The focus will be to market high purity spherical granular potash pellets initially into the North American markets and ultimately worldwide. KARNALYTE's spherical granular potash pellets offer a grade advantage (97%) and significantly lower sodium content (less than 1%) over typical granular products. The spherical granular potash products offer uniform size distribution which leads to better handling, storage, bulk blending and spreading characteristics. The brine used for production of these potash pellets will be mined using proven solution mining technology from underground potash beds and proven processing methods at the surface production facility.

The changes in management of KARNALYTE in 2014 and 2015, and the press release of the former management stating that the Wynyard Carnallite Project no longer is considered a material mineral property of the corporation, which has been contradicted by the present management, makes an update of the previous estimate for KCl and $MgCl_2$ Mineral Reserves (ERCOSPLAN et al., 2012, /22/) necessary, as the boundary condition that where the basis of the original potash feasibility study (FOSTER WHEELER & ERCOSPLAN, 2011, /26/) and Mg-products pre-feasibility study (LYNTEK, 2012, /38/) have changed significantly. Therefore KARNALYTE has requested end of March 2016 ERCOSPLAN, NREL and AmecFW, to update the cost sections of their studies, to come up with new estimates for CAPEX and OPEX and evaluate the financial viability of the project at present product price forecasts to determine the Mineral Resources and Mineral Reserves in KARNALYTE's Lease Areas. The results of these studies are summarized in this Technical eport.

## 2.1 Terms of Reference

This Technical Report was prepared by Qualified Persons following the format of the National Instrument (NI) 43-101 Standards of Disclosure for Mineral Projects, NI 43-101 CP Companion Policy, and NI 43-101 Technical Report of the Canadian Securities Administrators, effective June 30, 2011 and in accordance with Canadian Institute of Mining ("CIM"), Metallurgy and Petroleum Best Practices and Reporting Guidelines and CIM Definition Standard for Mineral Resources and Mineral Reserves, effective date May 10, 2014.

The overall effective date of this Technical Report is June 23, 2016. This is the cut-off date for confirmation of the conversion of the Karnalyte KP to a KL (mineral Lease) which is used as a cutting edge for the Mineral Resource area. Specifically, on June 23, 2016 the authors received the final notice from the Saskatchewan Government confirming the approval of the lease conversion and the project area used in this Technical Report.

June 23, 2016 is the effective date of the Mineral Resource Estimate and Mineral Reserve Estimate contained in this Technical Report.

Copyright of all text and other matter in this document, including the manner of presentation, is the exclusive property of the authors and Karnalyte Resources as per the MSA signed between the QPs and Karnalyte.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

ERCOSPLAN, NREL, and AmecFW (the Consultants) do not have, at the date of this Technical Report, and have not had within the previous years, any shareholding in or other relationship with the Company and consequently consider themselves to be independent of KARNALYTE. The Consultants will receive a fee for the preparation of this Report in accordance with normal professional consulting practices. This fee is not contingent on the conclusions of this Technical Report and the Consultants will receive no other benefit for the preparation of this Technical Report. The Consultants do not have any pecuniary or other interests that could reasonably be regarded as capable of affecting its ability to provide an unbiased opinion in relation to the Company's Project.

## 2.2 Qualified Persons

The present Technical Report has been prepared by multiple authors: Principal Author is Dr. Henry Rauche EurGeol of ERCOSPLAN. Further authors are Dr. Sebastiaan N.G.C. van der Klauw, EurGeol of ERCOSPLAN, Ms. Lola Piché, P. Geo. of NREL, Mr. Ellis Buckner, P. Eng. of AmecFW. The authors are Qualified Persons as defined in NI 43-101 (the "Qualified Person").

The principal author of this Technical Report is EurGeol, Dr. Henry A.M. Rauche. Dr. Rauche is the Managing Director & C.E.O. of ERCOSPLAN Group of Companies, a consulting company headquartered in Erfurt, Germany. Dr. Rauche has over 25 years of experience with rock salt and potash mining and with risk assessment studies for commercial scale potash projects. His mining experience includes salt (halite), Carnallite, fluorspar, and potash. Dr. Rauche has provided guidance for several pilot test operations in potash. Specific potash experience includes both underground mining and solution mining. Dr. Rauche's expertise is in assessment of rock mechanical and hydrological mining hazard, monitoring of abandoned or flooded mines, selection of extraction methods for potash deposits, rock mechanics of potash and overburden strata and instrumentation. Dr. Rauche holds a Degree as Geologist from the University of Freiberg in Germany and a Ph.D. in Natural Sciences from the University of Freiberg and Bochum. Dr. Rauche has practiced in the area of underground mining since 1985 and has been the Managing Director of ERCOSPLAN since 1997. Dr. Rauche is a registered European Geologist with the EFG. He is a member of the Solution Mining Research Institute, gives lectures at the Friedrich-Schiller-University in Jena.

Dr. Henry Rauche visited the mineral property KP 360 near Wynyard on January 16, 2010, inspected the drill sites of the exploration holes DH-20 and DH-21, the 2-16 water test well drilled for KARNALYTE and the rail facilities at Wynyard. Furthermore discussions with the councils of Wynyard and the nearby rural municipalities were made. They inspected the cores of DH-20 and DH-21 in the NREL core storage at Saskatoon on January 15, 2010. The results of the 3D seismic survey were discussed with Larry Herd and Roger Edgecombe of RPS Boyd Petrosearch on January 13, 2010 in Calgary. Dr. Henry Rauche, did not recently visit the site, because except for the test operation no major changes occurred since his last visit.

Dr. Rauche is responsible for Sections 2, 3, 5, 8, 15, 19, 22, 23, 24, 25 and 26 of the Technical Report.

The co-author for this Technical Report on behalf of ERCOSPLAN is EurGeol, Dr. Sebastiaan van der Klauw. Dr. van der Klauw is a Senior Mining Geologist at ERCOSPLAN. Dr. van der Klauw has more than 15 years of experience in the potash mining industry. His



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

mining experience includes salt (halite), carnallitite, and sylvinite. Dr. van der Klauw's expertise is in the evaluation of the structure of potash deposits and the possible interactions between salt rocks and fluids. Dr. van der Klauw holds a Degree as Geologist from the Rijksuniversiteit Utrecht in the Netherlands and a Ph.D. in Natural Sciences from the University of Bochum in Germany. Dr. van der Klauw has practiced in the area of potash mining since 1996 and has been associated with ERCOSPLAN since 1999. Dr. van der Klauw is a registered European Geologist with the EFG. He is a member of the Solution Mining Research Institute.

Dr. van der Klauw visited the mineral property KP 360 near Wynyard on January 16, 2010, inspected the drill sites of the exploration holes DH-20 and DH-21, the 2-16 water test well drilled for KARNALYTE and the rail facilities at Wynyard. Furthermore, discussions with the councils of Wynyard and the nearby rural municipalities were made. They inspected the cores of DH-20 and DH-21 in the NREL core storage at Saskatoon on January 15, 2010. The results of the 3D seismic survey were discussed with Larry Herd and Roger Edgecombe of RPS Boyd Petrosearch on January 13, 2010 in Calgary. Dr Sebastiaan van der Klauw furthermore visited the site on May 04, 2016 to inspect the start of the ongoing solution mining test at well DH 20, the water well providing the solvent for the operation and the brine disposal well to dispose of the bulk of the produced brine during the test.

Dr van der Klauw is responsible for Sections 6, 12, 13, 16 and 20 of the Technical Report.

The co-author for this Report on behalf of NREL is Ms. Lola Piché. Ms. Piché is the Director and Technical Services and Innovations at NREL a geological and engineering consulting company based out of Saskatoon, Saskatchewan. As a subsurface geologist with NREL since 2001, Ms. Piché has more than ten years of experience in the subsurface geology of Saskatchewan. Ms. Piché has been involved in numerous projects in the Potash and Salt industry of Saskatchewan with a focus on mining of potash in the Prairie Evaporite Formation. Ms. Piché holds an Honors Bachelor of Science Degree from the University of Saskatchewan and is a registered member in good standing with the Professional Engineers and Geoscientists of Saskatchewan (APEGS). Ms. Piché is also a member of the Solution Mining Research Institute (SMRI) and the Canadian Institute of Mining, and Metallurgy and Petroleum (CIM). Ms. Piché has recently been invited by other experts in the field as a member of the Potash Best Practise Sub-Committee for CIM. This subcommittee of experts is working on updating CIM guidelines for Estimation of Mineral Resource and Mineral Reserve for Potash deposits.

Under Ms. Piché's supervision, representatives from NREL were present on site during all core recovery at the drill site and all handling and sampling completed in the NREL core lab facility. All of the core from the new wells were examined, photographed and described in detail in the NREL core lab. Ms Lola Piché, visited the site on May 04, 2016 to inspect the start of the ongoing solution mining test at well DH 20, the water well providing the solvent for the operation and the brine disposal well to dispose of the bulk of the produced brine during the test.

Ms Piché is responsible for Sections 4, 7, 9, 10, 11 and 14 of the Technical report.

The co-author for this Report on behalf of AmecFW is Mr. Ellis Buckner. Mr. Buckner is a Director at AmecFW, an Engineering and Construction Company with an office located at 4954 Richard Road SW, Bldg. 1, Suite 200, Calgary, Alberta, Canada T3E 6L1. Mr. Buckner has more than thirthy years of experience in process plant project management, design and construction. Mr. Buckner is a registered member in good standing of the Association of Professional Engineers and Geoscientists of Saskatchewan (APEGS).



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

For AmecFW, Ellis Buckner was responsible for the process plant, infrastructure of the original Feasibility Study, and project cost estimate. Mr Buckner has been on site October and November 2012 to lead site preparation work for the Phase 1 plant. AmecFW prepared a Class II Definitive CAPEX estimate, for KARNALYTE for a 625,000 tpy High Purity Potash Plant and expansions of two 750,000 tpy production facilities, along with its associated common area and brine field requirements provided by ERCOSPLAN. AmecFW has coordinated with ERCOSPLAN and NREL to develop the estimate for the mining scope. AmecFW also prepared inquiry requisitions and solicited bids to determine equipment pricing. They have also consulted with local subcontractors to develop work activities, schedules and costs.

Mr Buckner is responsible for Sections 17, 18 and 21 of the Technical Report.

## 2.3 Available Data

In estimating mineral resources and mineral reserves in this Technical Report, the authors have relied on the information from recent exploration results from drill holes:

- KW 2-24
- KW 2C6-32
- KW 4B14-24
- KW 4D14-21
- KW 13-36
- KW 3C4-8
- KW 3B4-26
- KW 2A11-12
- KW 3A11-27
- DH 20
- DH 21

as discussed in Sections 9 and 10. They have also relied on information from the historical drill hole DH-11 (Mobil Wynyard). The position of the drill holes is shown in Figure 1.

For DH-11 available information was obtained exclusively from the Geodata Branch, Saskatchewan Ministry of Economy, which is considered a public record source. The data from DH-11 was checked in the following manner: the cores from DH-11 were inspected and where possible, the core was sampled by NREL personnel and assayed by the Saskatchewan Research Council (Section 11.4). Data verification for DH-11 is limited to the new assay program and core descriptions. Therefore, the authors do not take responsibility for the accuracy of the historical data from DH-11 that could not be verified, specifically: the analytical procedures, personnel, and facilities used by the previous evaluators were not necessarily independent, and it is not known if the authors of those reports were “Qualified Persons” as defined by NI 43-101.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

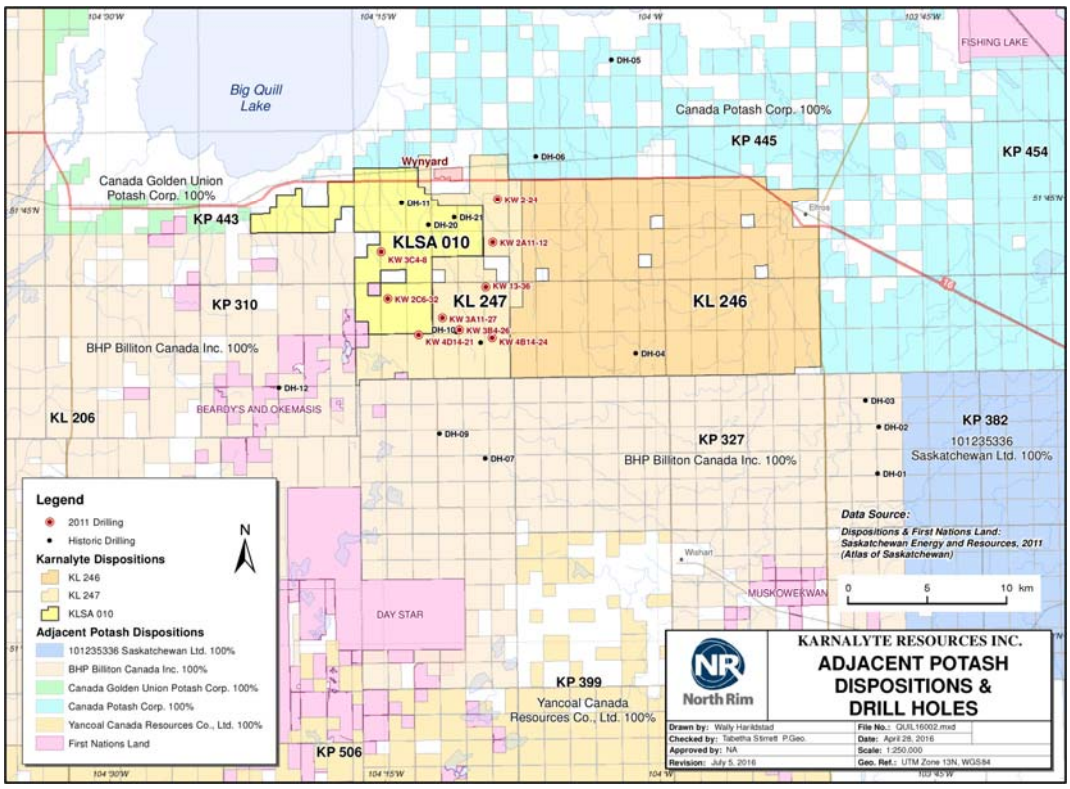



Figure 1 Property Boundaries and Drill Hole Locations

Sources of information on prior exploration work in the general Quill Lakes–Wynyard area are available as technical reports filed with Saskatchewan Ministry of Economy in fulfillment of annual assessment requirements that become non-confidential after 3 years. Drilling records must also be filed with Saskatchewan Ministry of the Economy. Despite the existing historical record, the files may not necessarily provide a complete record of exploration work or drilling results, and it is not possible to know if the material on file represents the complete record of all information collected by the previous exploration companies. This historical information was used to develop the geological modelling of the area, but not directly used for resource and reserve estimation.

As with other Saskatchewan potash deposits, the mineral resource may be affected by subsurface phenomena that have deleterious effects upon the mineral resource, including, but not limited to, leach, washout, and salt collapse anomalies. Such anomalies are identified in certain drill holes (see following sections) and interpreted seismic sections. The present study incorporates estimates as to the extent of such anomalous ground based upon the 2008 and 2009 3D seismic reports (Boyd, 2008, /8/; Boyd, 2010, /9/). About 95% of the measured and indicated resources converted to reserves are within the area covered by 3D seismic. In the areas not covered by 3D seismic only historical 2D seismic data is available for estimation of the extent of anomalous ground and further work, such as regional 2D and extensions to the 3D seismic survey may indicate that anomalies are present on other portions of the Permit and may be more extensive than presented herein. These parts of the Permit contain mostly inferred resources only and the authors have applied a 25% deduction of the area here to account for the uncertainty in the presence of anomalous ground.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

The Phanerozoic stratigraphy in the Quill Lakes Area, and the processes of evaporite precipitation, diagenesis, dissolution, and preservation, are topics of both historical and ongoing research by numerous industry, academic, and government bodies. The detailed stratigraphic correlations that are presented herein are based upon these reports; however, they have been modified as to the authors' personal experiences with the potash deposits of Saskatchewan.

Property descriptions and land status were obtained from the list of lands as set forth in the documents provided by Saskatchewan Ministry of Economy in support of the granting of the permit. No attempt to independently verify the land tenure information was made by the present authors.

The reader is reminded that the term "ore" should not be used, disclosed, or implied unless reserves have been estimated on the property. To be called ore, the economic factor must be taken into account and it must be possible to extract metals or minerals profitably from the ore. Since reserves have been identified during the course of work undertaken to prepare this Technical Report, the term "ore" can be used, but has not been used; however, where the term "ore" is used in this Technical Report, it is in the context of a direct quote taken from third-party reports or papers and as such is not compliant with recommendations set forth in NI 43-101.

# 3 Reliance on Other Experts

The Consultants have not reviewed the property tenure, nor independently verified the legal status or ownership of the properties or underlying surface land option agreements. The results and opinions expressed in this Technical Report are based on the Consultants field observations and the geological, legal and technical data listed in the References and Appendices. While the Consultants have carefully reviewed all of the information provided by the Company and believe the information to be reliable, the Consultants have not conducted an in-depth independent investigation to verify its accuracy and completeness, but have discussed the information with other experts:

- Richard Pope of DILLON CONSULTING, co-author of the Environmental Impact Statement was a discussion partner for the social and environmental impacts studies and assessment.

The results and opinions expressed in this Report are based upon the aforementioned legal, environmental information or tax matters being current, accurate, and complete as of the date of this Report, and the understanding that no information has been withheld from the authors that would affect the conclusions made herein. The Consultants reserve the right, but will not be obliged, to revise this Report and conclusions if additional information becomes known to the Consultants subsequent to the date of this Report. The Consultants will not be responsible for KARNALYTE's actions in distributing this Report.

Except for the purposes legislated under provincial securities laws any use of this Report by any third party is at that party's sole risk.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

# 4 Property Descriptions and Location

Portions of this section were prepared by KARNALYTE in particular the portions concerning property land descriptions and permitting. The contents have been verified by the authors of this Technical Report.

## 4.1 Property Description and Location

Properties currently leased by KARNALYTE are in three separate agreements with the Saskatchewan government are Subsurface Mineral Lease KLSA 010 (APPENDIX 1), KL 246 and KL 247 (APPENDIX 2). The historic Permit KP 360 was granted to Robin L. Phinney, President and Chief Executive Officer of KARNALYTE, as trustee for KARNALYTE by Saskatchewan Ministry of Energy and Resources on March 13, 2008. Subsequently Mr. Phinney transferred the Permit KP 360 to KARNALYTE on October 24, 2008. On February 14, 2011 the west area of Permit KP 360 was converted to an exploration Lease KLSA 010, and the remainder was converted to the KP 360A exploration permit. Early 2016 KARNALYTE applied at the Saskatchewan Ministry of the Economy to transform KP 360A in 2 separate mineral Leases KL 246 and KL 247. (see Figure 2). These leases were granted on June 23, 2016. The granting of these leases represents the effective cut-off date of this technical report. Table 1 shows the approximate area leased to KARNALYTE under KLSA 010. The KLSA 010 Lease, KL 246 Lease and KL 247 Lease, acreage includes road allowances and continuous land for the lease, as per the permits provided in the Appendix material of this Technical Report. The location maps in Figure 2 show the Project Area before and after the creation of the KL 246 and KL 247 Leases. Both figures display the Project Area and surface features, including topography, culture, water courses, townships, major highways and railway right-of-ways.

Table 1 Mineral Rights Leased to Karnalyte

| Lease ID | Area of Mineral Rights (Hectares) |
|---|---|
| KLSA 010 | 6,902 |
| KL 246 | 22,950 |
| KL 247 | 7,112 |
| TOTAL | 36,964 |

Table 2 lists the drill-hole information for historical and current drill holes in the Permit Area and in its vicinity. Figure 3 is a base map that displays the land grid, permit lands, and locations of drill holes using the reference system described herein.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

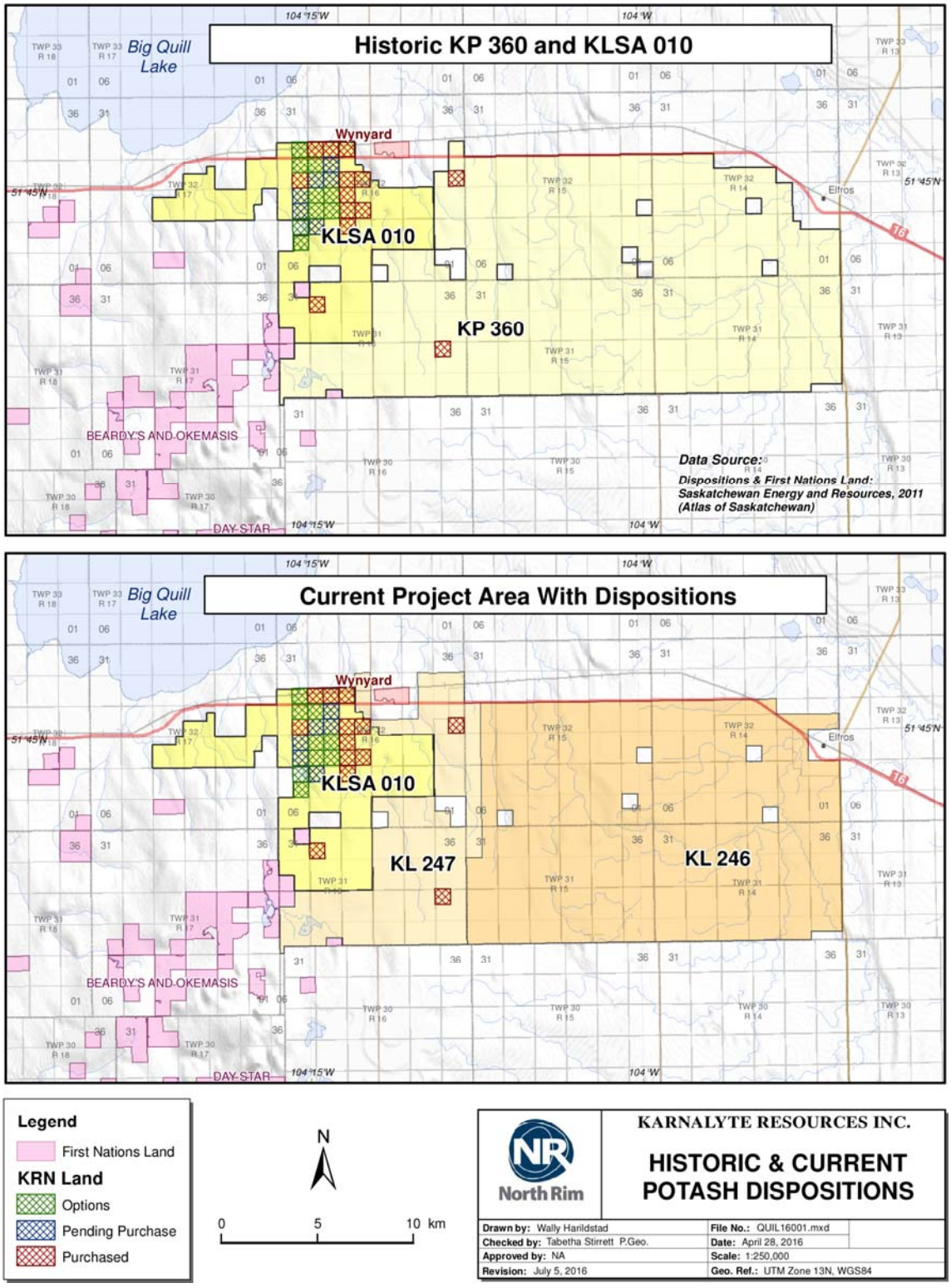



Figure 2 KARNALYTE's Historic Disposition of June 30, 2011 and Current Dispositions Area as of May 31, 2016



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

Table 2 Drill Holes Used in Previous Technical Reports and Current Technical Report

| Historic Wells Used in Preliminary Study | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Well I.D | DRILL HOLE | LSD | SECT | TWP | RGE | MER | Well Name | Formation at Total Depth | Drill Hole Type | Comments |
| DH-01 | 121/04-16-030-13W2/00 | 4 | 6 | 30 | 13 | 2 | Scurry Foam Lake | Ashern | Abandoned Potash Test | Prairie Cored |
| DH-02 | 101/13-21-030-13W2/00 | 13 | 21 | 30 | 13 | 2 | Tide Water Wishart Crown No. 1 | Duperow | Abandoned Dry Unknown | Not deep enough |
| DH-03 | 101/15-29-030-13W2/00 | 15 | 29 | 30 | 13 | 2 | Dome Provo Foam Lake | Precambrian | Abandoned Potash Shaft Hole | Have gamma log |
| DH-04 | 101/01-23-031-15W2/00 | 1 | 23 | 31 | 15 | 2 | Marlea-Kroy-Wynyard No. 1 | Duperow | Abandoned Dry | Not deep enough |
| DH-05 | 121/12-14-033-15W2/00 | 12 | 14 | 33 | 15 | 2 | Sohio et al Quill Lake | Colorado | Abandoned Dry Unknown | Not deep enough |
| DH-06 | 131/13-29-032-15W2/00 | 13 | 29 | 32 | 15 | 2 | USP Wynyard No. 1 | Prairie Evap. | Abandoned Potash Test | Prairie Cored |
| DH-07 | 101/16-14-030-16W2/00 | 16 | 14 | 30 | 16 | 2 | Tide Water Krashne Crown No. 1 | Precambrian | Abandoned Dry Unknown | Prairie Cored |
| DH-08 | 101/09-23-031-16W2/00 | 9 | 23 | 31 | 16 | 2 | Tide Water Rushville Crown No. 1 | Duperow | Abandoned Dry | Not deep enough |
| DH-09 | 101/13-22-030-16W2/00 | 13 | 22 | 30 | 16 | 2 | Miami HB Quill LK | Deadwood | Abandoned Potash Test | Prairie Cored |
| DH-10 | 111/01-27-031-16W2/00 | 1 | 27 | 31 | 16 | 2 | Dominion Potash Kandahar | Prairie Evap. | Abandoned Potash Test | Prairie Cored |
| DH-11 | 101/01-20-032-16W2/00 | 1 | 20 | 32 | 16 | 2 | Mobil Wynyard | Prairie Evap. | Abandoned Potash Test | Prairie Cored |
| DH-12 | 131/13-10-031-17W2/00 | 13 | 10 | 31 | 17 | 2 | N.P.C Wynyard | Prairie Evap. | Abandoned Potash Test | Prairie Cored |

| Wells Used In August 26, 2010 43-101 | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| NREL Well I.D | DRILL HOLE | LSD | SECT | TWP | RGE | MER | Well Name | Formation at Total Depth | Drill Hole Type | Comments |
| DH-10 | 111/01-27-031-16W2/00 | 1 | 27 | 31 | 16 | 2 | Dominion Potash Kandahar | Prairie Evap. | Abandoned Potash Test | |
| DH-11 | 101/01-20-032-16W2/00 | 1 | 20 | 32 | 16 | 2 | Mobil Wynyard | Prairie Evap. | Abandoned Potash Test | |
| DH-20 | 141/01-16-032-16W2/00 | 1 | 16 | 32 | 16 | 2 | Karnalyte Wynyard 1-16-32-16 | Winnipegosis | Abandoned Potash Test | Spud 2009/09/10 |
| DH-21 | 111/09-15-32-16W2/00 | 9 | 15 | 32 | 16 | 2 | Karnalyte Wynyard 9-15-32-16 | Winnipegosis | Abandoned Potash Test | Spud 2009/10/01 |

| Wells Used In August 30, 2011 43-101 | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| NREL Well I.D | DRILL HOLE | LSD | SECT | TWP | RGE | MER | Well Name | Formation at Total Depth | Drill Hole Type | Comments |
| DH-11 | 101/01-20-032-16W2/00 | 1 | 20 | 32 | 16 | 2 | Mobil Wynyard | Prairie Evap. | Abandoned Potash Test | |
| DH-20 | 141/01-16-032-16W2/00 | 1 | 16 | 32 | 16 | 2 | Karnalyte Wynyard 1-16-32-16 | Winnipegosis | Abandoned Potash Test | Spud 2009/09/10 |
| DH-21 | 111/09-15-32-16W2/00 | 9 | 15 | 32 | 16 | 2 | Karnalyte Wynyard 9-15-32-16 | Winnipegosis | Abandoned Potash Test | Spud 2009/10/01 |
| KW 4B14-24 | 111/13-24-031-16W2/00 | 13 | 24 | 31 | 16 | 2 | Karnalyte Wynyard DD 4B14-24-4A13-24-31-16 | Prairie Evap. | Potash Test Well | Spud 2011/03/29 |
| KW 4D14-21 | 131/14-21-031-16W2/00 | 14 | 21 | 31 | 16 | 2 | Karnalyte Wynyard DD 4D14-21-1C14-21-31-16 | Prairie Evap. | Potash Test Well | Spud 2011/04/20 |
| KW 13-36 | 121/13-36-031-16W2/00 | 13 | 36 | 31 | 16 | 2 | Karnalyte Wynyard 13-36-31-16 | Prairie Evap. | Potash Test Well | Spud 2011/04/20 |
| KW 3C4-8 | 191/06-08-032-16W2/00 | 6 | 8 | 32 | 16 | 2 | Karnalyte Wynyard DD 3C4-8-2B6-8-32-16 | Prairie Evap. | Potash Test Well | Spud 2011/05/05 |
| KW 3B4-26 | 191/01-27-031-16W2/00 | 1 | 27 | 31 | 16 | 2 | Karnalyte Wynyard DD 3B4-26-1A1-27-31-16 | Prairie Evap. | Potash Test Well | Spud 2011/05/02 |
| KW 2A11-12 | 111/06-12-032-16W2/00 | 6 | 12 | 32 | 16 | 2 | Karnalyte Wynyard DD 2A11-12-3D6-12-32-16 | Prairie Evap. | Potash Test Well | Spud 2011/05/13 |
| KW 3A11-27 | 111/11-27-031-16W2/00 | 11 | 27 | 31 | 16 | 2 | Karnalyte Wynyard DD 3A11-27-3A11-27-31-16 | Prairie Evap. | Potash Test Well | Spud 2011/05/18 |

| Wells Used In October 21, 2011 43-101 | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| NREL Well I.D | DRILL HOLE | LSD | SECT | TWP | RGE | MER | Well Name | Formation at Total Depth | Drill Hole Type | Comments |
| DH-11 | 101/01-20-032-16W2/00 | 1 | 20 | 32 | 16 | 2 | Mobil Wynyard | Prairie Evap. | Abandoned Potash Test | |
| DH-20 | 141/01-16-032-16W2/00 | 1 | 16 | 32 | 16 | 2 | Karnalyte Wynyard 1-16-32-16 | Winnipegosis | Abandoned Potash Test | Spud 2009/09/10 |
| DH-21 | 111/09-15-32-16W2/00 | 9 | 15 | 32 | 16 | 2 | Karnalyte Wynyard 9-15-32-16 | Winnipegosis | Abandoned Potash Test | Spud 2009/10/01 |
| KW 2-24 | 131/02-24-032-16W2/00 | 2 | 24 | 32 | 16 | 2 | Karnalyte Wynyard 2-24-32-16 | Prairie Evap. | Cased Potash Solutioning | Spud 2010/12/12 |
| KW 2C6-32 | 141/06-32-031-16W2/00 | 6 | 32 | 31 | 16 | 2 | Karnalyte Wynyard DD 2C6-32-4B6-32-31-16 | Prairie Evap. | Cased Potash Solutioning | Spud 2011/01/05 |
| KW 4B14-24 | 111/13-24-031-16W2/00 | 13 | 24 | 31 | 16 | 2 | Karnalyte Wynyard DD 4B14-24-4A13-24-31-16 | Prairie Evap. | Potash Test Well | Spud 2011/03/29 |
| KW 4D14-21 | 131/14-21-031-16W2/00 | 14 | 21 | 31 | 16 | 2 | Karnalyte Wynyard DD 4D14-21-1C14-21-31-16 | Prairie Evap. | Potash Test Well | Spud 2011/04/20 |
| KW 13-36 | 121/13-36-031-16W2/00 | 13 | 36 | 31 | 16 | 2 | Karnalyte Wynyard 13-36-31-16 | Prairie Evap. | Potash Test Well | Spud 2011/04/20 |
| KW 3C4-8 | 191/06-08-032-16W2/00 | 6 | 8 | 32 | 16 | 2 | Karnalyte Wynyard DD 3C4-8-2B6-8-32-16 | Prairie Evap. | Potash Test Well | Spud 2011/05/05 |
| KW 3B4-26 | 191/01-27-031-16W2/00 | 1 | 27 | 31 | 16 | 2 | Karnalyte Wynyard DD 3B4-26-1A1-27-31-16 | Prairie Evap. | Potash Test Well | Spud 2011/05/02 |
| KW 2A11-12 | 111/06-12-032-16W2/00 | 6 | 12 | 32 | 16 | 2 | Karnalyte Wynyard DD 2A11-12-3D6-12-32-16 | Prairie Evap. | Potash Test Well | Spud 2011/05/13 |
| KW 3A11-27 | 111/11-27-031-16W2/00 | 11 | 27 | 31 | 16 | 2 | Karnalyte Wynyard DD 3A11-27-3A11-27-31-16 | Prairie Evap. | Potash Test Well | Spud 2011/05/18 |

The subsurface Mineral Permit KP 360A consisted of 68,301 acres of Crown mineral land which has now been split up into the KL 246 Lease and the KL 247 Lease. The KLSA 010 Lease consists of about 16,825 acres and is located to the West of the KL 247 Lease and spans Townships 31 and 32, and Ranges 16 and 17 West of the Second Meridian. The KL 246 Lease spans a region encompassing Townships 31 and 32, and Ranges 14 to 15 West of the Second Meridian. The KL 247 Lease spans a region encompassing Townships 31 and 32, and Ranges 15 to 16 West of the Second Meridian. The Project Area is located 175 kilometers (188 km by highway) east of Saskatoon Saskatchewan, Canada. It is located 65 kilometers east of the Lanigan mine (owned and operated by the Potash Corporation of Saskatchewan), and 60 kilometers east of the town of Lanigan.

Crown mineral rights between the KLSA 010 Lease and the KL 246 and KL 247 Leases cover an aggregate area of approximately 36,000 hectares in portions of Townships 31 and 32 and Ranges 14 to 17 over Sections 1 to 36 (approximate longitude 51°45'N, latitude 104°10'W). The dimensions of the project area are approximately 18 miles (29 km) east to west and 8 miles (12.8 km) north to south. The boundary for Leases KLSA 010, KL



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

246 and KL247 are shown in Figure 3 and is comprised of approximately 142 sections which was granted by lease for production and exploration purposes.

Figure 3 displays all adjacent permit holders as well as the freehold lands that are not part of the permit or lease and do not contribute to the mineral resource estimates presented herein. The sections not included in this permit (displayed as white in Figure 3) are freehold, or under private landholder's mineral ownership and thus not included in the rights granted under the permit. To the best of the author's knowledge all surface land ownership is private, except those displayed in Figure 1 (i.e. the title is owned by individuals or corporations as opposed to the Crown) and, thus, surface access to such lands is by negotiation usually resulting in payment of an access fee. A portion of the lands is owned by the Beardy's and Okemasis Indian Band, The Native Land is displayed in Figure 3 and is on the western portion of the Project Area.

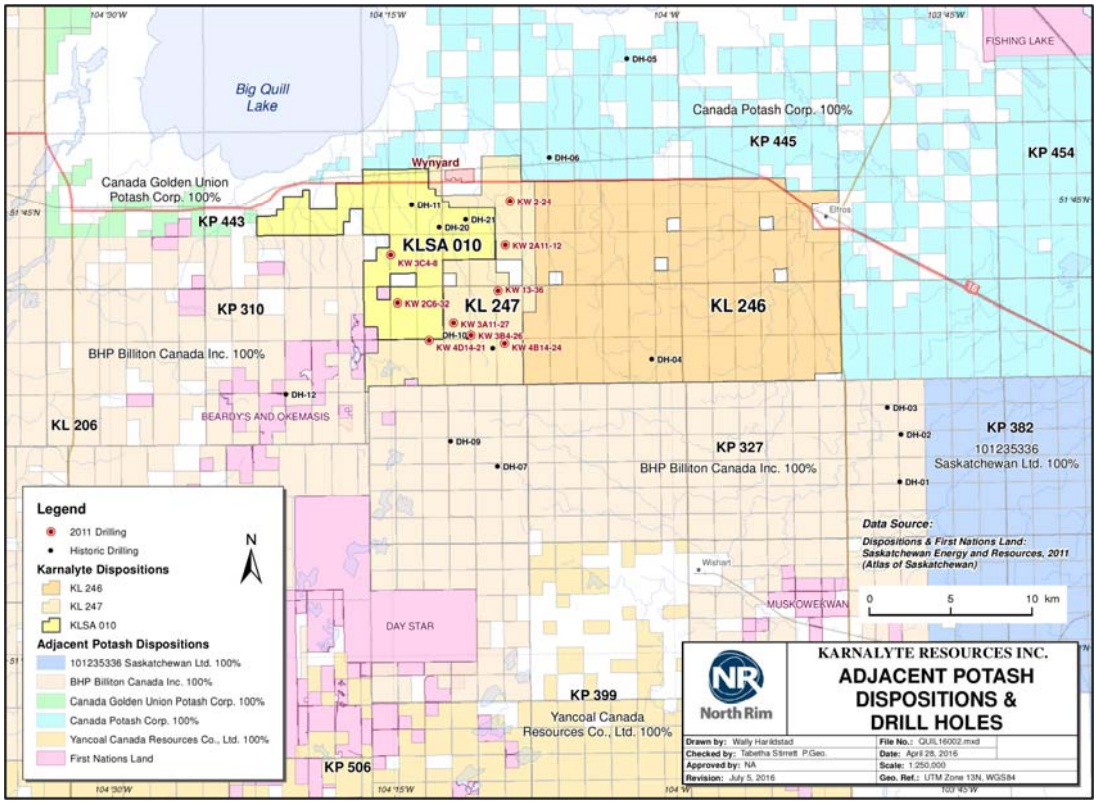



Figure 3 Project Area with Drill Hole Locations and the Table 2 Naming Nomenclature

Subsurface mineral permits held on lands surrounding the Project include, BHP Billiton Diamonds Inc and Canada Potash.

In agricultural areas, surface access must be negotiated with individual landholders, and with the approval of the Rural Municipalities. Rural Municipalities commonly impose heavy vehicle restrictions (road bans) during spring thaw (two to six weeks, depending on run off and temperature) which may restrict exploration activities during the spring. The author is aware that certain lands may be subject to specific environmental liabilities and re-



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

strictions above or beyond those responsibilities assumed under permitting exploration programs; however, no attempt was made for the purposes of this Technical Report to investigate such liabilities or restrictions.

Surface rights in the area of the Saskatchewan Property are, for the most part, privately held and do not belong to the Crown. This means that surface access to the Saskatchewan Property must be negotiated with the private landowners and is not granted automatically as it would be if the Crown owned the surface land. Generally, access is granted for a fee paid to the landowners. KARNALYTE has secured the surface rights to several locations as depicted in Figure 2. All the sites are planned to be used as the plant production site or have other surface facilities located on them. The two 3D seismic surveys completed by Boyd PetroSearch for KARNALYTE Resources in the winter of 2007/2008 and 2009 were completed with full permission from the landowners and no complications were encountered.

Figure 1 is a map depicting the Project Area, roads, rivers, and settlements. The site visits confirmed that almost all of the ground is open and active farmland, and confirms that the Project Area is accessible to wheeled vehicles. There are no active or inactive mines located on the Project Area.

## 4.2 Property Titles in Saskatchewan

In Saskatchewan, provincial legislation governs the issuance and administration of mineral tenure, and was regulated by the Subsurface Mineral Regulations (The Subsurface Mineral Regulations, 1960) and the Crown Minerals Act (The Crown Minerals Act, 1984-85-86). As of March 26th, 2015 the Subsurface Mineral Regulations of 1960 have been updated and replaced in large part by the Subsurface Mineral Tenure Regulations (SMTR). The Subsurface Mineral Regulations of 1960 still remain in force and continue to set out applicable Crown royalty rates which will remain unchanged (Porter, 2015, /42/).

The majority of the following synopsis of the new SMTR regulations is summarized from Porter (2015, /42/); however, the full SMTR regulations should be reference for further clarification and detailed commentary. According to Porter (2015, /42/), the Province of Saskatchewan enacted new legislation to regulate Crown permits and the required leases for potash and salt extraction within the province. The holders of permits or leases were provided with copies of the new regulations from the Ministry of Economy (also available online) and were encourage to carefully review and familiarize themselves with the new provisions. The new regulations apply to all permits and leases, including those issued prior to the new regulations. A period of transition is currently being contemplated in order to bring those issued prior to SMTR into the new framework. Some of the main changes as noted by Porter (2015, /42/), include increases in rental rates for both permits and leases, which are now calculated based on hectares rather than acres, with non-producing lease rentals doubling. Work expenditures have also been shifted away from leases and entirely to permits and permit holders may be eligible to consolidate work expenditures over adjoining permits (Porter, 2015, /42/). Under the new SMTR permits will now be issued for a term of eight years as opposed to the previous five year term with three optional one year extensions. Leases will remain the same at twenty one years (Government of Saskatchewan - Economy, 2015).

Another new concept is the introduction of a land utilization rate (LUR). An LUR is one factor that will be used to determine eligibility of lease lands for renewal after the first year



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

lease term, as SMTR will no longer include mandatory reduction in lease lands. This means, for example, that if a lessee does not meet the 'target LUR' or if their lands are not mined or form part of a unit agreement, they may post a deposit to avoid reduction of the lease block. For subsequent renewals, however, if the lessee does not meet the target LUR or other requirements, there is no option to post a performance deposit and the lease lands would be reduced accordingly. Alternatively, SMTR will allow expansion of the lease lands within a development zone at anytime should they exceed the target LUR (Porter, 2015, /42/). The target LUR in the case of a conventional mine is considered to be 50 tonnes of product/hectare per year, whereas, in the case of solution mining it is considered to be 70 tonnes of product/hectare per year (Saskatchewan Ministry of Economy, 2015). Detailed discussion on fee payment is outlined in section 4.4.

## 4.3 Types of Mineral Rights

Subsurface minerals are defined by the SMRT to include all natural mineral salts of boron, calcium, lithium, magnesium, potassium, sodium, bromine, chlorine, fluorine, iodine, nitrogen, phosphorous, sulphur, and their compounds occurring at depths greater than 60.0 meters.

Four main types of subsurface mineral rights are identified in Saskatchewan, consisting of Crown Mineral Rights, Freehold Mineral Rights, Indian Mineral Rights, and "Split" Mineral Rights.

Crown Mineral Rights are mineral titles that are owned by the Saskatchewan Provincial Government, regardless if the surface rights are the property of the Crown or not (The Crown Minerals Act). In some instances the Federal Government can own Crown Mineral Rights in the cases of national parks or Indian Reservations. The Crown could have acquired the mineral rights in either one of two ways; 1) when ownership of Crown mineral titles were transferred to Saskatchewan by the federal government in 1930, or 2) when freehold mineral titles were acquired due to non-payment of taxes or fees.

In 1945 the "Mineral Taxation Act" was instated, taxing individuals with mineral rights in excess of 3,200 acres. Today Crown Mineral Rights are administered by the Saskatchewan Government Ministry of the Economy. Roughly four-fifths of mineral rights in Saskatchewan are held by the Crown under the jurisdiction of the Saskatchewan Government.

In Saskatchewan, privately held mineral titles are referred to as Freehold Subsurface Mineral Rights and can be disposed of under any terms and conditions the owner chooses. Freehold Mineral Rights originated from events started in 1870, when the Hudson's Bay Company transferred the lands and mineral rights it held in what is now Saskatchewan to the Dominion of Canada. Two years later a policy was passed by the Canadian government that allowed the issuance of homestead grants to settlers. These original homestead grants included both mineral and surface rights. After the late 1800's, however, any homestead grants that were issued by the Canadian government were for surface rights only and the mineral rights remained the property of the Crown under the Federal Government of Canada. In some cases, however, Saskatchewan settlers could still receive both the surface and mineral rights when purchasing land from private holding companies or railways. Over the years most Freehold titles have passed through several owners and in some instances the mineral rights have been separated from the surface title. Fractionally, about one-fifth of Saskatchewan mineral rights currently exist as Freehold Rights.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

After the formal Canadian Government was in place, the Indian Act of 1876 was formed in order to govern matters pertaining to First Nations peoples. This included material which attempted to solve the problem of European and other settlers occupying land initially inhabited by First Nations peoples. Indian Mineral Rights describe lands that were granted to the Saskatchewan First Nations by virtue of the Treaties signed during the 1870's. Original reserve titles given to the First Nations gave them ownership of both the surface and subsurface mineral rights. Since 1876, the Act has been emended several times and is currently administered by Indian and Northern Affairs Canada ("INAC"). In 1930, the Federal Crown transferred the resource ownership of the First Nations peoples to their respective provincial governments under the Natural Resource Transfer Act. At that time Canada agreed to establish reservations based on the First Nation's population, but this did not happen in all cases. Today in order to satisfy the outstanding treaty agreements, the provincial government are legally obligated to make Crown land available to fulfill the Treaty Land Entitlements ("TLE"). Cooperation is required with the First Nations if exploration work is to be conducted within a reservation or band land.

"Split" Mineral Rights are mineral titles where the ownership is split between two separate parties, which may include the Saskatchewan Government or several private owners. This situation initially arose in the 1940's as a factor of the initial petroleum boom.

Today in Saskatchewan, Surface Rights are subject to separate ownership and title from the Subsurface Mineral Rights (i.e. Mineral Rights). Therefore, the acquisition of Mineral Rights does not secure the Surface Rights, unless on Indian Reserve Land. In order to acquire the Surface Rights on Crown Land, Saskatchewan Environment needs to be involved. However, in the case of Freehold Lands, Surface Right regulations are at the discretion of the individual land holder. The Surface Rights Acquisition and Compensation Act of 1978 governs the relationship between the surface and mineral rights owners and outlines the stipulations further, including compensation for disruption of the lands.

## 4.4 Terms and Obligations of a Permittee

In Saskatchewan the majority of mineral rights are owned by either the Crown or Freehold owners. Therefore, companies or individuals wishing to conduct exploration activities must obtain permission to complete their work. Potash Dispositions in Saskatchewan are issued in the form of permits and leases through the Ministry of the Economy and are governed by The Subsurface Mineral Tenure Regulations (2015). The responsibility for managing mineral resources has historically been passed down from the federal level to the provincial level with the exception of Nunavut, the Northwest Territories, and Indian Reserve land. In Saskatchewan, exploration is allowed on all Crown Land except for those protected from mining activities. Access to Aboriginal lands or Indian Reservations is prohibited unless consent and compensation is given to the surface rights holders (Mineral Exploration Webpage, 2010).

Excerpts taken from The Subsurface Mineral Tenure Regulations (2015) and the Ministry of Economy (2015) can be found throughout this section.

Permits are listed as exclusive rights to explore for subsurface minerals. Potash Permits ("KP's") are granted for an eight year term from the date of issue (anniversary date) and, subject to compliance, the permits can be converted to a lease. Permits must comprise one solid block of contiguous land (Crown and freehold) and cannot exceed 40,500 hectares in size.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

Permits can be converted to leases if they are in good standing. Karnalyte has completed this process for all previous permits in the project area, and now holds three leases. Leases entitle the lease owner ("lessee") exclusive rights to explore for, mine, work, recover, procure, remove, carry away and dispose of any subsurface minerals within the lease lands (application fees and royalties apply). Leases are granted for a term of twenty-one years and are renewable for successive twenty-one year terms upon written application and continued good standing. Application approval and approved work expenditures of the permit are required prior to lease issuance. Leases cannot exceed 40,500 hectares and must comprise one solid block of contiguous land similar to a permit. An annual lease fee of $10.00 CAD per hectare/year is required by the provincial government for the initial lease term. Any lease renewed will be charged an annual lease fee of $20.00 CAD per hectare/year unless certain production numbers are met. A $3,000,000.00 CAD expenditure commitment is still required for leases in effect prior to the new 2015 SMTR regulations. As outlined in Section 4.2, leases will be subject to a target land utilization rate (LUR) to determine eligibility of renewal and the required fees for leases with unmet production targets. LURs will be required to be satisfied upon the first renewal of the lease, second renewal of lease, amalgamation of leases and lease expansions.

Confidentiality rules are now governed by SMTR as well and state that well information pertaining to the Prairie Evaporite will remain confidential for five years or until the disposition expires.

A number of other permits are required prior to the commencement of exploration activities beyond the initial land securement, and can apply to both the permit and lease stages. Examples of these include land surveys, well license applications, environmental and heritage approval, tree cutting, temporary work camp construction, drilling programs, road access, fuel storage permits, construction permits, and many others depending on the program stage (Mineral Exploration Webpage, 2010). Information outlining the type of applicable permits can be found through the Saskatchewan Government website or their contact personnel.

Karnalyte currently holds 100% interest in the leases KLSA 010, KL 246 and KL 247with permits and exclusive rights to explore and prospect for subsurface minerals. The rights were registered and recorded through The Saskatchewan Ministry of Energy and Resources in KANRNALYTE's name February 14, 2011. KL 246 and KL 247 have been registered and recorded through The Saskatchewan Ministry of Energy and Resources in KARNALYTE's name June 23, 2016.

## 4.5 Royalties, Back-In Rights, and Other Agreements and Encumbrances

The authors are unaware of any royalties, back-in rights, payments, or other agreements and encumbrances to which the Project Area is subject at this time, other than the work commitments, fees, and rentals as described in the preceding subsections.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

## 4.6 Environmental Liabilities, Permits, and Risks for the Property

Environmental issues and the permits required for an advanced property undergoing development or in production are discussed in Section 20 of this Technical Report. The authors are unaware at this point of any environmental liabilities to which the property is subject, other than the normal licensing and permitting requirements that must be made prior to undertaking certain operations and those environmental restrictions as set forth in Provincial Acts and regulations.

KARNALYTE has produced an Environmental Impact Assessment for the potash project for the NE part of KLSA 010, which has been accepted by federal and provincial institutions, but will need to extend this for the Magnesium products operation and the remaining Lease areas.

# 5 Accessibility, Climate, Local Resources, Infrastructure and Physiography

## 5.1 Topography, Elevation and Vegetation

The Permit Area is located south of Highway 16 and is located south of the town of Wynyard, Saskatchewan, Canada. There are two lakes located to the northwest and north of the Permit Area, Big Quill Lake and Little Quill Lake, respectively. The village of Elfros is located east of the Permit Area. No other towns or villages are located within the bounds of the Permit. The cleared lands are utilized primarily for farming purposes, although there is scattered pasture and grazing lands some of which are unbroken grassland. Overall, the Permit Area consists of flat to gently rolling cleared farmland with local mixed poplar/aspen bluffs at elevations between 560 and 650m above Mean Sea Level. Figure 4 shows topographic contours throughout the Investigation Area and its vicinity.

KARNALYTE owns or has negotiated favourable land acquisition and usage agreements with private landowners for the brine field. KARNALYTE owns the surface rights for lands which will be required for the physical potash plant and product load out. According to the Feasibility Study (FOSTER WHEELER & ERCOSPLAN, 2011, /26/) the operation will include a processing plant, cavern drilling and well pads (Refer to section 17.2 for surface locations), and waste brine will be deep-well injected; therefore no tailings pond management is needed. As the brine field operation evolves KARNALYTE plans to slurry insoluble material and waste salts with $MgCl_2$ brine and inject it into the mined out production caverns in the underground.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

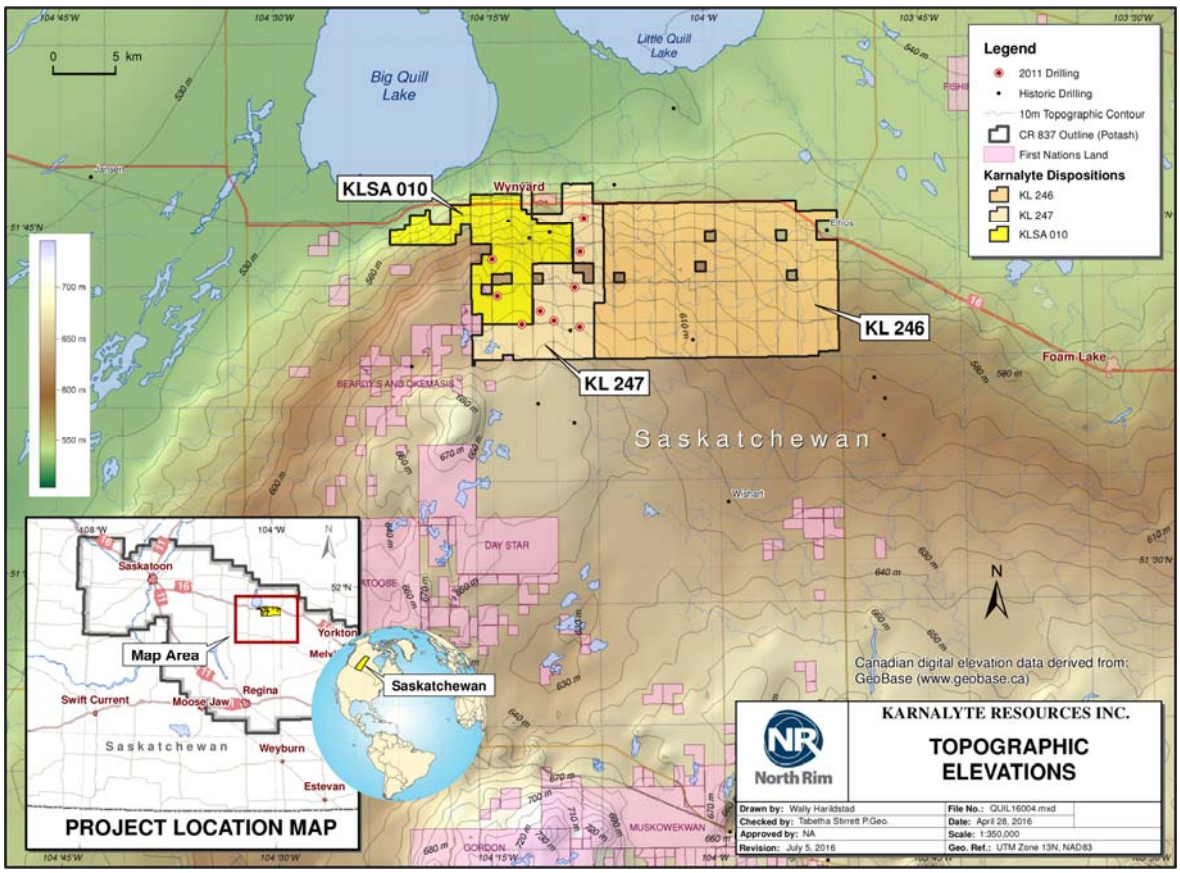



Figure 4 Map of Topographic Contours Throughout the Permit Area

## 5.2 Access

The entire Lease Area is accessible by a network of “grid” section gravel and paved roads, including a major paved highway less than 1 km from KARNALYTE’s proposed load-out facility (Highway #16 connecting the major urban centers of Saskatoon and Yorkton) bounding the northern portion of the Permit. Rail access in the form of trackage is good, with the Canadian Pacific Railway (CP) main-line within 1 km of KARNALYTE’s proposed load-out facility running north of the Permit Area parallel to Highway #16. The Canadian National Railway Company (CN) is within 38 km of KARNALYTE’s load-out facility. Details of costs for installation of rail lines to the Saskatchewan Property have been worked out in the Feasibility Study (FOSTER WHEELER & ERCOSPLAN, 2011, /26/) and have been included in the CAPEX and OPEX estimates in Section 21.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

## 5.3 Local Resources

The large urban population centre of Saskatoon, Saskatchewan, to the west and local rural communities such as Wynyard, Foam Lake, and Lanigan may provide a pool of skilled professional, technical, and trades persons; furthermore, an operating potash mine immediately to the west of the Permit Area means that the local labour force has experience in potash mine construction and operation.

With the lagging economies of the western Canadian provinces, skilled trades' people and technical personnel are becoming easier to identify and hire, as has been demonstrated by the relative ease to find well qualified personnel locally for the test operation. At present, it is felt that manpower for advancement of KL 246, KL 247 and KLSA 010 could be found in the surrounding local areas. That could change very quickly with an economic upturn in western Canadian provinces, however, and may require additional costs to attract the workforce required. The availability of an adequate work force and how to attract them has been studied as part of the potash Feasibility Study by FOSTER WHEELER & ERCOSPLAN (2011, /26/) in a work force survey.

## 5.4 Climate

The climate of the Permit Area is typical of the Canadian prairies with a snowy winter season (November–March) and mean temperatures averaging -12.7°C. The summer season (June to early September) is typically warm, averaging 17.7°C with moderate precipitation. Average rainfall is 299.5 mm and average snowfall is 140.1 cm. The spring (April–May) and autumn (late September to October) is cool with precipitation in the form of rain and occasional snow. Exploration operations, such as seismic acquisition and exploratory drilling, are limited by weather conditions during the spring and fall periods when soft ground conditions due to thawing and/or precipitation create difficulties in moving heavy machinery. KARNALYTE received permission from the local Rural Municipal ("RM") to move equipment and continue exploration operations throughout the 2011 "spring break up" as long as KARNALYTE reimbursed the RM for repairs required thereafter. Access during the winter and summer months is largely restricted only by local conditions, periodic rains or snowfalls, or environmentally sensitive ground conditions such as the nesting grounds for endangered bird species or sites of archaeological significance.

## 5.5 Infrastructure

The region is well served by an electrical distribution network. The Permit Area is relatively close to the main electrical supply grid for SaskPower. The existing lines would be able to supply the required electrical power and a new line to the site will be installed by SaskPower with funding from KARNALYTE.

Natural gas will be purchased from a gas marketer (TBD) and delivered to the site by TransGas, with funding from KARNALYTE. A pipeline from a point on the main delivery line near Jansen, west of the PCS potash operation Lanigan to the planned plant site (Figure 5) is required. Pressure reduction, custody metering and odorant injection will be



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

contracted to SaskEnergy, a sister company of TransGas; their facility will be built adjacent to the KARNALYTE plant.

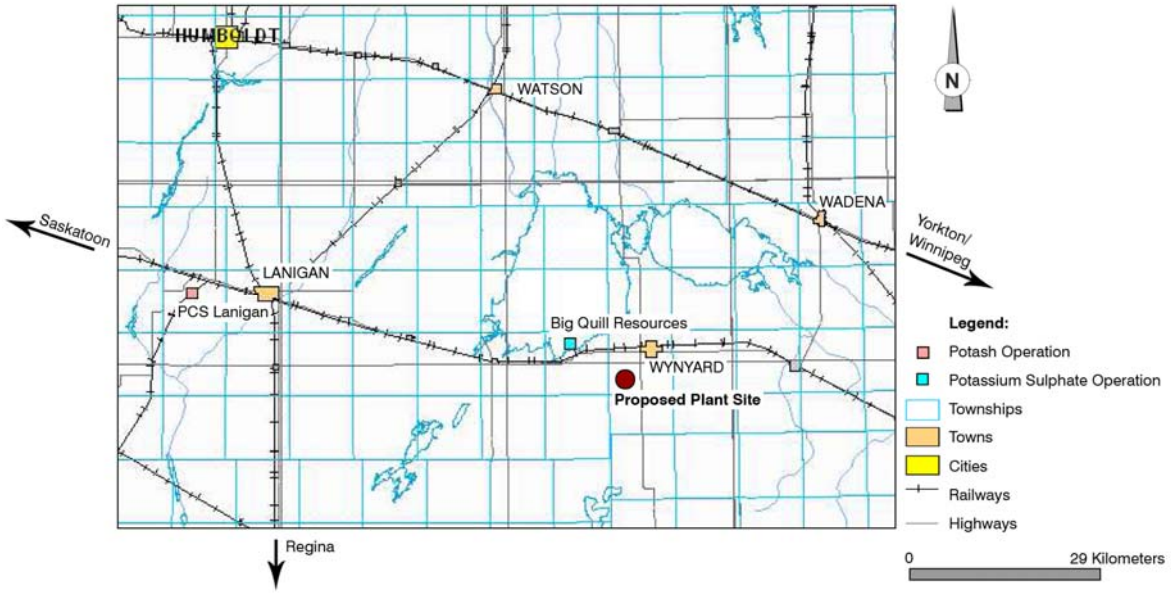



Figure 5 Location of Proposed Plant Site to Infrastructure

Aquifers within the subsurface Lower Cretaceous Mannville Formation some 500 m below the Permit Area could potentially supply the process water required for the operations. The successful water wells already drilled by KARNALYTE, at location 2-16-32-16 W2M and 1-21-32-16 W2M, provide water suitable for solution mining and for most processing steps. One of these water well produces without problems the water required for the pilot test operation. Tests on these wells (GeoEngineers, 2013, /30/), suggests that adequate capacity to meet Phase 1 operational demand for the production of up to 21,600 m³/day should be obtained with six similar water-supply wells, with an additional standby well, if similar yields can be secured at other locations in the aquifer. Wells will need to be widely spaced (estimated between 1,000 and 2,000 m apart) in order to minimize interference drawdowns that could increase pumping costs. KARNALYTE has received permits for Approval to Operate and Water Rights Licenses for both wells from the Saskatchewan Water Security Agency.

The Middle Cambrian – Lower Ordovician Deadwood Formation, some 1,400 to 2,000 m below surface, consists of sandstone beds that are extensively used by other potash mines as a disposal reservoir for waste tailings brine. In the area of the proposed Wynyard plant it is approximately 1,500 m below the surface. A disposal well has been drilled for testing and shows good potential for disposal (GeoEngineers, 2013, /29/). KARNALYTE has received approval from the Saskatchewan Ministry of the Economy, for disposal of brine from potash operations by commingled injection into the Winnipeg and Deadwood Formations through the well (91) 11-16-32-16 W2M. The relative small amounts of brine from the test operation, are taken up even without pumping. The KARNALYTE plant will dispose most of it waste process brines of sodium chloride and magnesium chloride into a number of disposal wells to these formations.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

# 6 History

In this section first the general or potash exploration history will be outlined, followed by a summary of work done in Saskatchewan on production of Mg from Carnallite.

## 6.1 General Exploration History

Within the Project Area, prior to KARNALYTE's exploration programs, there had been limited potash and magnesium exploration. For a complete list of historical drill holes within the permit refer to Table 3. Four wells were drilled within the permit by Marlea Exploration Company Limited (1957), Tide water Oil Company (1953), Dominion Energy (1966), and Mobil Oil Canada Limited (1967), (GeoLOGIC, 2011, /28/). Out of the four historic wells drilled within the Project Area only two wells penetrated the Prairie Evaporite; Mobil Wynyard 1-20 and Dominion Kandahar 1-27 drilled in 1966 and 1958 respectively. Both drill holes have geophysical logs, assay data and core from the Prairie Evaporite extending through the Patience Lake, Belle Plaine and Esterhazy Members. The original well data is stored at the Geodata Branch and core is retained by Saskatchewan Ministry of the Economy, both located in Regina, Saskatchewan.

The southern portion of the Permit was held by William C. Lagos during the 1960s however to the best knowledge of the authors no work was done on the Property. Permits were held north of the property by King Resources Ltd. however to the best knowledge of the author no work was done on these permits. As to Leases KL 246, KL 247 and KLSA 010 it is believed that the ground was held by oil and gas permits prior to exploration undertaken by Mobil Oil but this has not been verified by the authors.

Table 3 Historical Drill Holes Surrounding the Project Area. Bold Wells are Located within the Project Area

| Well I.D | DRILL HOLE | LSD | SECT | TWP | RGE | MER | Well Name | Formation at Total Depth | Drill Hole Type |
|---|---|---|---|---|---|---|---|---|---|
| DH-01 | 121/04-16-030-13W2/00 | 4 | 6 | 30 | 13 | 2 | Scurry Foam Lake | Asthern | Abandoned Potash Test |
| DH-02 | 101/13-21-030-13W2/00 | 13 | 21 | 30 | 13 | 2 | Tide Water Wishart Crown No. 1 | Duperow | Abandoned Dry Unknown |
| DH-03 | 101/15-29-030-13W2/00 | 15 | 29 | 30 | 13 | 2 | Dome Provo Foam Lake | Precambrian | Abandoned Potash Shaft Hole |
| **DH-04** | **101/01-23-031-15W2/00** | **1** | **23** | **31** | **15** | **2** | **Marlea-Kroy-Wynyard No. 1** | **Duperow** | **Abandoned Dry** |
| DH-05 | 121/12-14-033-15W2/00 | 12 | 14 | 33 | 15 | 2 | Sohio et al Quill Lake | Colorado | Abandoned Dry Unknown |
| DH-06 | 131/13-29-032-15W2/00 | 13 | 29 | 32 | 15 | 2 | USP Wynyard No. 1 | Prairie Evap. | Abandoned Potash Test |
| DH-07 | 101/16-14-030-16W2/00 | 16 | 14 | 30 | 16 | 2 | Tide Water Krashne Crown No. 1 | Precambrian | Abandoned Dry Unknown |
| **DH-08** | **101/09-23-031-16W2/00** | **9** | **23** | **31** | **16** | **2** | **Tide Water Rushville Crown No. 1** | **Duperow** | **Abandoned Dry** |
| DH-09 | 101/13-22-030-16W2/00 | 13 | 22 | 30 | 16 | 2 | Miami HB Quill LK | Deadwood | Abandoned Potash Test |
| **DH-10** | **111/01-27-031-16W2/00** | **1** | **27** | **31** | **16** | **2** | **Dominion Potash Kandahar** | **Prairie Evap.** | **Abandoned Potash Test** |
| **DH-11** | **101/01-20-032-16W2/00** | **1** | **20** | **32** | **16** | **2** | **Mobil Wynyard** | **Prairie Evap.** | **Abandoned Potash Test** |
| DH-12 | 131/13-10-031-17W2/00 | 13 | 10 | 31 | 17 | 2 | N.P.C Wynyard | Prairie Evap. | Abandoned Potash Test |

A search of the historical data held by Saskatchewan Ministry of the Economy was conducted in the Project Area to determine the extent potash exploration development. Some of the data found included assay data, drill reports, drill stem tests and other information pertaining to the drilling of the wells.

After a preliminary investigation on the wells listed in Table 3 KARNALYTE completed an initial exploration program that involved the drilling of two potash exploration wells in Sep-



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

tember 2009. Crusader Drilling Corp., a Saskatchewan-based drilling company, was contracted to complete the program utilizing oil-field drilling equipment capable of drilling to depths beyond that of the Prairie Evaporite Formation. Two of the holes, 1-16 (DH-20) and 9-15 (DH-21) were drilled and completed as potash test wells, and the third, 2-16, was drilled as a water-source test well by Andrews & Sons Drilling. Further Exploration drilling for KARNALYTE took place in 2010/2011. The locations of the drill holes within the Project Area are illustrated in Table 2.

## 6.2 The History of Magnesium Exploration in Central Saskatchewan

KARNALYTE was not the first company to take interest in the recovery of carnallite from the Prairie Evaporite. Companies and researchers have studied the magnesium potential in the past, but no attempt to make a commercially viable Magnesium metal business has been made. The following sections are concerned with the production of Magnesium metal from Carnallite which is not comparable to the production of potash from Carnallite or hydromagnesite and $MgCl_2$ brine from potash production endbrine. All remarks about risks and non-economic viability of Carnallite mining in these sections refer to Carnallite mining and processing to Magnesium Metal. The production of potash from Carnallite and Hydromagnesite as well as $MgCl_2$ brine as proposed by KARNALYTE is not comparable to the production of Magnesium metal from Carnallite.

From 1955 to 1958 Loram Group (Manvest Inc.) was the first commercial company to investigate the possibility of recovering magnesium from Saskatchewan's carnallitic Prairie Evaporite near Watrous, about 129 km west of KLSA 010. At the time this project was not feasible, but another attempt 89 km west of KLSA 010, near Nokomis was explored from 1964 to 1966. The exploration work revealed low potash grades, but significant carnallite presence in the region. This project was deferred again because solution mining of magnesium was unproven and uneconomical at the time. A history of this magnesium mining research and exploration was presented in a report by J.M Pryde Company Ltd for an unknown client (J.M. Pryde Company Ltd., 1984, /43/, and Colorado School of Mines Research Institute, 1984, /11/ and 1985, /12/).

In 1974, D.L Surjik and Associates on behalf of the Department of Industry and Commerce of Saskatchewan was commissioned to study the feasibility of carnallite mining for the production of Magnesium (Surijik, 1974, /48/). The authors could not find the original report but found information relating to it explaining the potential of a conventional mine producing 1.9 million tpy at 3% Mg (Gunn et al., 1975, /32/). The report stated this "…could be a very high risk venture. The province would be ill-advised to consider entering into such a venture unless a company with highly developed technology participated" (Storer, 1976, /45/).

By 1983 Manvest Inc. recognized the price of magnesium had increased and new technology was available (Manvest, 1985, /40/), this lead to supplementary engineering and feasibility work by Bechtel Civil and Minerals Inc., under direction of J.M Pryde Company. The study was targeted at preliminary capital required and operating costs for a carnallite mine believed to be in Nokomis, Saskatchewan (Bechtel Civil & Minerals Inc., 1985, /7/). The report proposed "in-situ solution mining of carnallite, recovery of synthetic carnallite, dissolution in methanol to recover fertilizer grade potash and magnesium chloride solution, dehydration of $MgCl_2$ via ethylene glycol, electrolysis to magnesium metal and chlo-



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

rine gas, and liquefaction to produce liquid chlorine" (Bechtel Civil & Minerals Inc., 1985, /7/). This technology was patented in 1977. Further research by J.M Pryde studied "…the technical and economic feasibility of recovering magnesium metal from carnallite" (1984, /43/). Laboratory work was conducted to confirm a pilot project for solution mining of carnallite. The target zone was based on 2.5 million recoverable tonnes of magnesium over 1 square mile based on a 33% recovery.

The authors are unaware of any further projects that proposed mining of carnallite in the Prairie Evaporite of Saskatchewan for the production of potash. Upon review of the historical data by previous parties, it must be noted that the data is historical and thus non 43-101 compliant. The authors were not able to confirm if the above information precluding to pilot testing and whether any production was achieved or if the projects were ever instigated.

# 7 Geological Setting and Mineralization

The potash beds of Saskatchewan's Middle Devonian Prairie Evaporite Formation have been studied and well documented by various geoscientists since their discovery in the 1940's. Much of the following geological material is derived and expanded upon from previous observations outlined in KARNALYTE's 2010 and 2011 Technical Reports (ERCOSPLAN, NREL & FW, 2010, /18/, ERCOSPLAN & NREL, 2011, /21/). Industry accepted concepts and considerations pertaining to potash mining in Saskatchewan that are presented within this section have been adapted in large part from Holter (1969, /35/), and Halabura and Hardy (2007, /33/).

## 7.1 Regional and Property Geology

Saskatchewan's subsurface Phanerozoic geology can be subdivided into three broad stratigraphic intervals (Figure 6), with the listed approximate depths based upon the examination of exploratory wells within the Project Area:

1. an uppermost overburden sequence comprised of Cenozoic glacial tills, gravels and clays. This sequence extends from surface to an approximate subsurface depth of 125.0 – 175.0 m. This sequence that commonly contains fresh water aquifers;
2. a medial sequence of bedded Mesozoic strata extending from the base of the glacial sediments to an approximate subsurface depth of 550.0 m consisting of shales, siltstones and sandstones with aquifers of brackish water; and
3. a lowermost package of Paleozoic strata that extends from the Paleozoic/Mesozoic Unconformity to depths more than 1,900.0 m below surface, consisting primarily of thick successions of carbonate and evaporite rocks punctuated by sandstones and shales.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

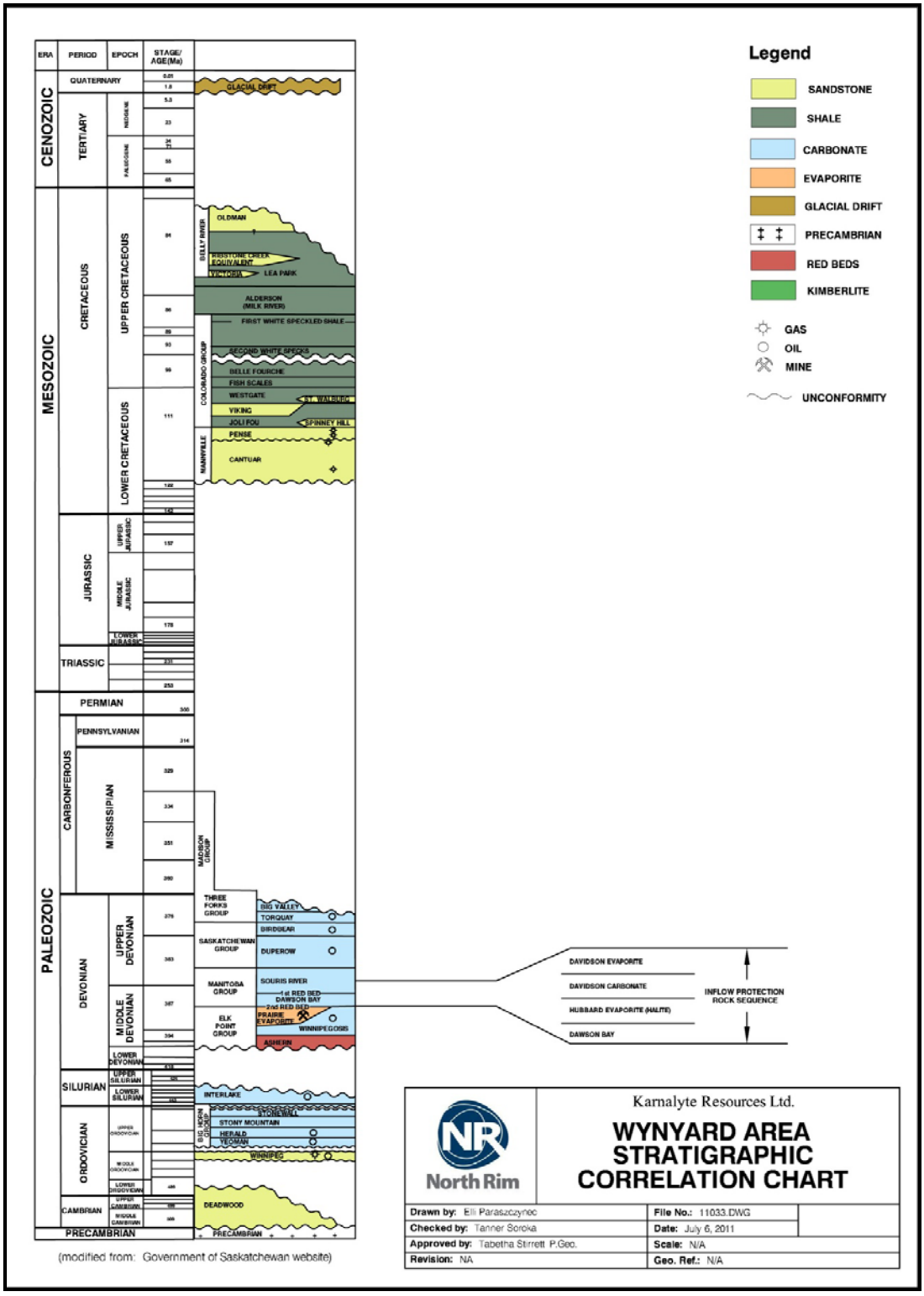



Figure 6 Subsurface Phanerozoic Stratigraphy of Saskatchewan Modified from the Saskatchewan Ministry of Resources Website (Geological Services, Well Information)



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

The above listed sedimentary sequence outlines the simplified subsurface Phanerozoic cover of Saskatchewan, which is itself underlain by Precambrian aged gneisses and granites. A modified version of the Stratigraphic Correlation Chart of Saskatchewan is found in Figure 6. This chart outlines the interpreted Phanerozoic stratigraphy of the Wynyard Project Area.

The potash resources of Saskatchewan are comprised of a remarkably simple mineralogical mixture of bedded Halite, Sylvite, Carnallite and clay that are found as bedded deposits within the generally flat-lying and laterally extensive shallow marine sequences of the Middle Devonian “Elk Point Group”. The Elk Point Group was deposited within a wide intracratonic depositional corridor known as the “Elk Point Seaway” which extended from its southern extremities in North Dakota and northeastern Montana up through southern and central Saskatchewan into northeastern Alberta. North of this point the seaway was divided by tectonic features into a series of sub-basins.

The Elk Point Group strata range in depth from some 2,500m below surface in southern Saskatchewan and rise to surface outcrop exposures in north-western Manitoba.

The Elk Point Group of Saskatchewan can generally be subdivided into three widely distributed formations as illustrated in Figure 6. In ascending stratigraphic order they are; the “Ashern”, “Winnipegosis”, and “Prairie Evaporite” Formations. Potash mineralization exists within the uppermost salts of the Prairie Evaporite Formation. The Prairie Evaporite Formation is found within the lowermost Phanerozoic sequence and is comprised predominantly of bedded halite, anhydrite, and clay. The Formation is unconformably bound at its base by Silurian to Middle Devonian (Givetian) marine carbonate deposits and disconformably bound at its top by the shales and carbonate rocks of the Middle Devonian Dawson Bay Formation.

The Prairie Evaporite Formation is often subdivided into a “Lower Prairie Sequence” and an “Upper Salt” unit. The Upper Salt contains three potash-bearing Members and several regional “marker beds”. In ascending stratigraphic order they are; the Esterhazy Member, the White Bear Marker Beds, the Belle Plaine Member, and the Patience Lake Member. These mineralized beds are generally flat lying interbeds of sylvite, halite, carnallite, clay, and minor amounts of anhydrite.

A regional geological cross-section of the Prairie Evaporite Formation and its potash bearing members in Saskatchewan is provided in Figure 7, with the stratigraphic nomenclature adopted from Holter (1969, /31/). An inset map showing the location of the Project Area in relation to the section line is included in Figure 7. The section demonstrates the lateral extent and consistency of the Prairie Evaporite Formation within the Province through the correlation of clay seams and mineralized beds over hundreds of kilometers. The cross-section trends east to west starting from Saskatoon and ending 160 km southeast of the Project Area.

The Project Area is situated on the northern edge of the basin, the ancient “Elk Point Seaway.” Here the potash-bearing beds range between 950.0m to 1,075.0m below surface. The depth to the top of the Prairie Evaporite Formation within the northern half of the Project Area ranges from 940.0 – 1,015.0m below surface (3,084.0 – 3,330.0ft), deepening slightly towards the south.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

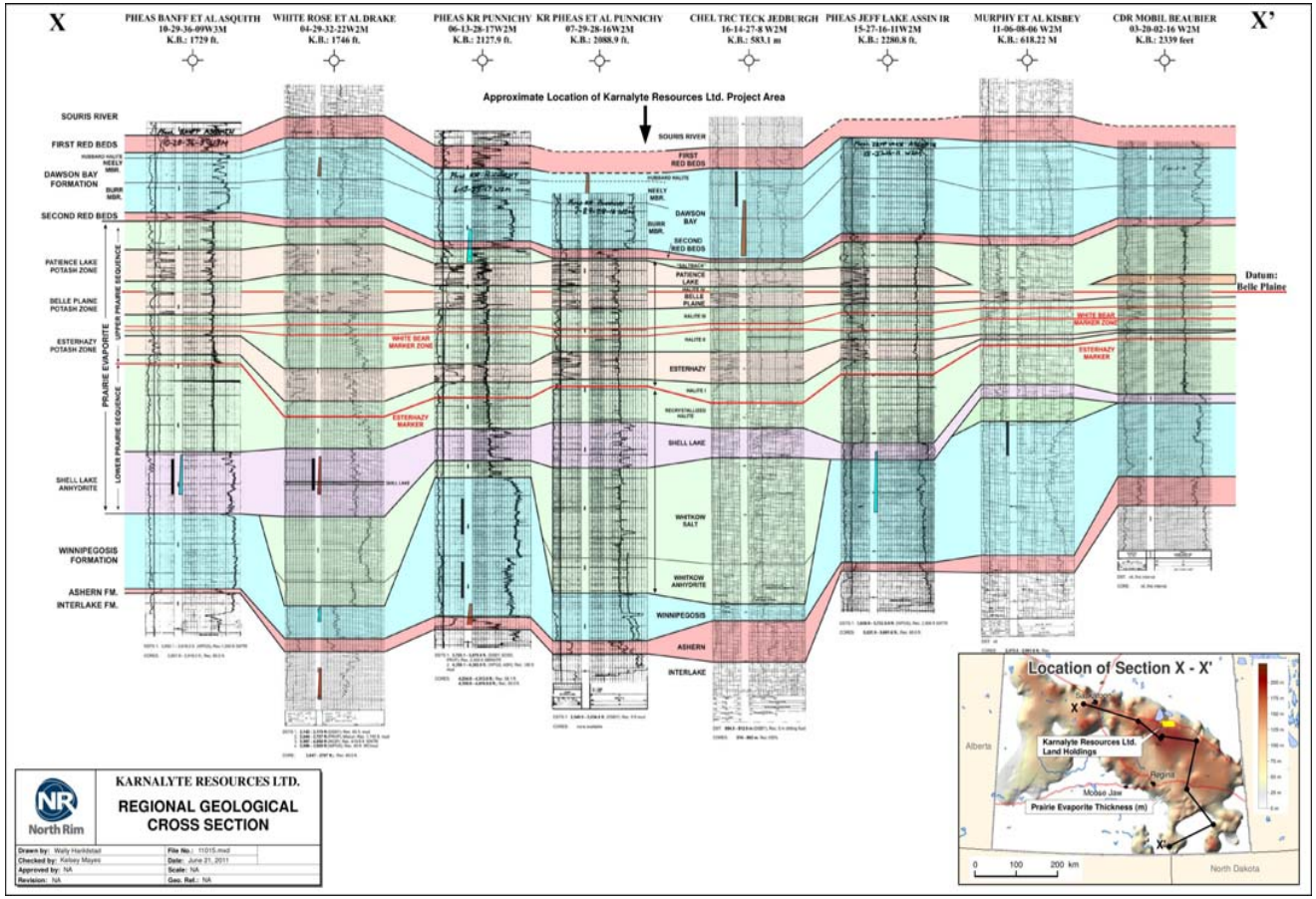



Figure 7 Regional Geological Cross-section of the Middle Devonian Prairie Evaporite Formation in Saskatchewan



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

## 7.2 Local Structure and Stratigraphy of the Potash Members

The following is a summary of the key stratigraphic boundaries as determined within the Project Area (Table 4). For the purposes of this section the KW 4D14-21 exploration well drilled in 2011 is used as a type reference hole for the description of stratigraphic boundaries (Figure 8). All quoted depths are true vertical depth and given in meters. The quoted depths are specific to the Project Area and are identified from well log signatures and visual examination of drill cores. Within the Project Area, the three major Prairie Evaporite Potash Members are present with the Patience Lake and Belle Plaine Members mainly developed as carnallitite and the Esterhazy Member developed as sylvinite (more detailed mineralization discussion can be found in Section 7.4). The Whitebear Marker Beds are poorly developed and not easily identified. Table 4 summarizes the depth and thickness distribution of the potash members for each of the thirteen test and exploration wells considered in this Technical Report. It is important to note that the potash intervals summarized in Table 4 and in this section represent the entire geological thickness of mineralization for each member and that these intervals do not represent specific mining intervals. The specific “mining intervals” used in mineral resource and reserve estimation are defined in Section 14 and Section 15.

**Patience Lake Member**: The Patience Lake Member is stratigraphically the uppermost potash bearing Member of the Prairie Evaporite Formation and dominantly carnallitite. The Member can be subdivided into the Upper Patience Lake and Lower Patience Lake potash Sub-members, which are separated by a thin barren halite interbed. Within the Project Area the Upper Patience Lake Sub-member is only locally present in the west. More commonly within the Project Area, the Patience Lake Member occurs as a single layer of relatively continuous Lower Patience Lake mineralization. The Patience Lake Member averages 9.4m in thickness within the Project Area. The depth to the top of the Patience Lake Member occurs around 910m in the northeast region of the Project Area and increases to depths around 1010m in the southwest. It is thickest in the south; up to 15m in KW 4B14-24 and thinnest at the KW 3B4-26 well with a thickness of 3.0m.

**Belle Plaine Member**: The Belle Plaine Member occurs stratigraphically below the Patience Lake Member and is also predominantly carnallitite. It is separated from the Patience Lake Member by an interval of barren Halite and clay (Interbed). The base of the Belle Plaine is generally marked by a clay seam and a decrease in KCl grade. The depth to the top of the Belle Plaine ranges from 927m in the northeast to 1030m in the south and exhibits a fairly uniform thickness across the project area averaging 15.3m.

**The Esterhazy Member**: In the project area the depth to the top of the Esterhazy ranges from 971m in the north to 1074m in the south. Contrary to the Patience Lake and Belle Plaine Members, the Esterhazy is generally sylvinitic within the Project Area. The Esterhazy is divided into two zones of higher KCl grade. The distribution of grade is used for defining the stratigraphy of the Esterhazy (as opposed to the clay seams used in the Belle Plaine and Patience Lake Members).

Selected wells were used in two detailed geological cross-section to provide a graphical summary of the interpreted subsurface geology of the Prairie Evaporite Formation within the Project Area. The geological cross-section presented in Figure 9 illustrates the stratigraphic relationships between each of the potash members along the northern portion of the Project Area. The E-W cross-section suggests that within the Project Area the Pa-



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

tience Lake Member thins slightly eastwards. Geological Section A-A' shown in Figure 10 illustrates the gentle southwesterly dip of the potash-bearing horizons.

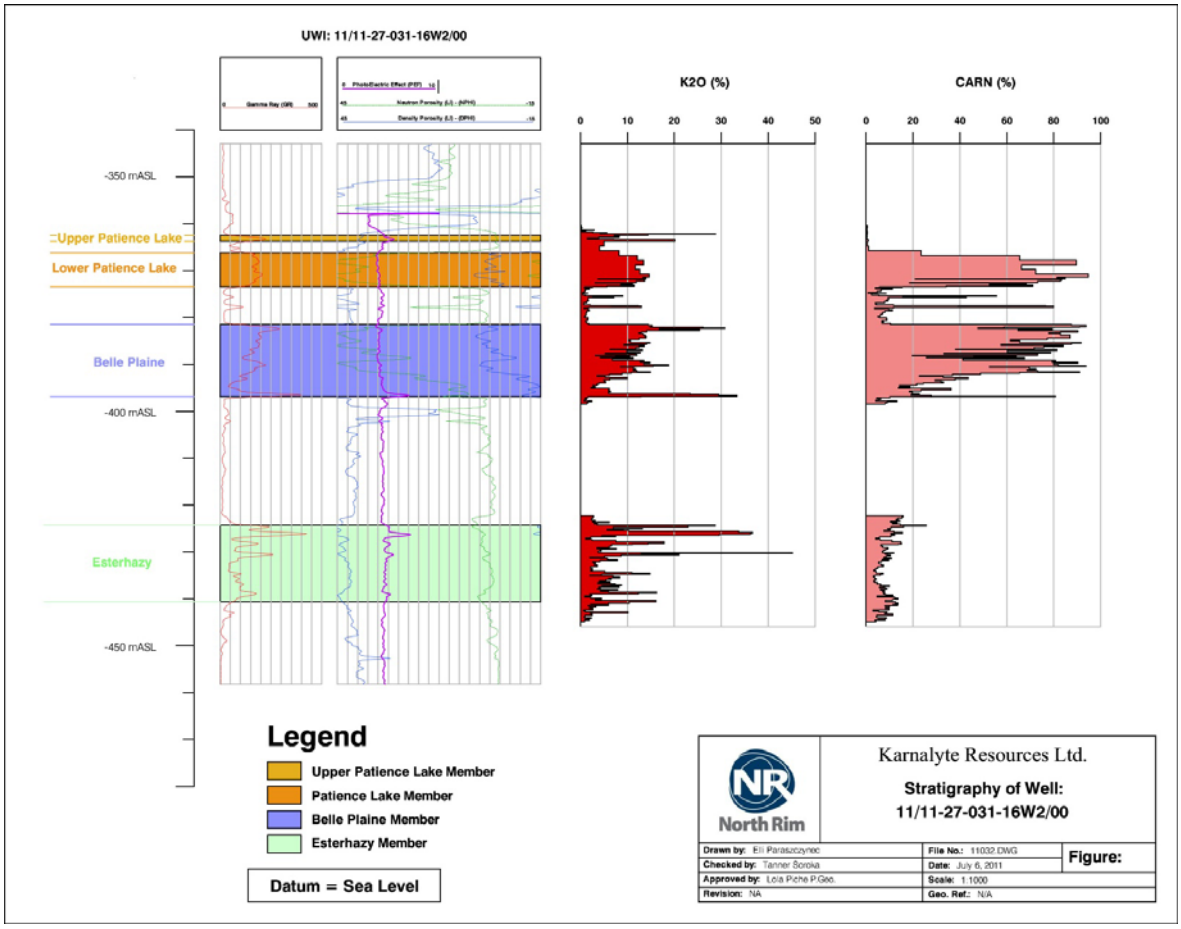



Figure 8 Prairie Evaporite Formation Type Section for Exploration Well KW 3A11-27.

The dip was determined by mapping the change in elevation for each of the three potash members across the Project Area. Mapping the Prairie Evaporite Top illustrated that the Prairie Evaporite Formation is fairly flat with a generalized dip of less than 1%. Local variations in dips of greater magnitude may exist, but the regional dip is very favorable for solution mining with a gas or oil blanket as practiced at Mosaic's Belle Plaine potash mine.

The overall structure of the deposit with its southwesterly dip of the potash bearing horizons is confirmed by the 3D seismic survey of BOYD (2010, /9/) as shown in Figure 11. This figure also illustrates areas of identified Winnipegosis Mounds (hatched area in the southwest) and areas of severe structure lows (dark blue). The severe structural lows are associated with interpreted collapse features discussed in the following section.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

Table 4 Geology Interval Thickness and Depth Summary of the Three Potash Members in the Lease Area

| Well Name | Patience Lake | | | Belle Plaine | | | Esterhazy | | |
|---|---|---|---|---|---|---|---|---|---|
| | From (m)* | To (m)* | Thickness (m) | From (m)* | To (m)* | Thickness (m) | From (m)* | To (m)* | Thickness (m) |
| Mobil Wynyard 1-20-32-16 | 925.61 | 939.47 | 13.86 | 945.93 | 963.5 | 17.57 | 989.32 | 1006.1 | 16.78 |
| Karnalyte Wynyard 1-16-32-16 | 934.83 | 942.83 | 8.00 | 951.43 | 966.4 | 14.97 | 994.48 | 1016.39 | 21.91 |
| Karnalyte Wynyard 9-15-32-16 | 920.58 | 928.39 | 7.81 | 936.28 | 951.8 | 15.52 | 980.57 | 997.26 | 16.69 |
| Karnalyte Wynyard 2-24-32-16 | 909.74 | 919.3 | 9.56 | 927.63 | 942.63 | 15.00 | 971.23 | 988.59 | 17.36 |
| Karnalyte Wynyard DD 2C6-32-4B6-32-31-16 | 995.12 | 1003.1 | 7.98 | 1011.33 | 1026.72 | 15.39 | 1054.65 | 1071.5 | 16.85 |
| Karnalyte Wynyard DD 4B14-24-4A13-24-31-16 | 1007.19 | 1022.19 | 15.00 | 1030.71 | 1045.65 | 14.94 | 1074.21 | 1091.72 | 17.51 |
| Karnalyte Wynyard DD 4D14-21-1C14-21-31-16 | 1010.5 | 1022.9 | 12.40 | 1030.62 | 1045.62 | 15.00 | 1073.65 | 1089.34 | 15.69 |
| Karnalyte Wynyard 13-36-31-16 | 970.79 | 977.29 | 6.50 | 985.2 | 1000.01 | 14.81 | 1028.27 | 1044.75 | 16.48 |
| Karnalyte Wynyard DD 3C4-8-2B6-8-32-16 | 965.12 | 973.78 | 8.66 | 982.15 | 997.26 | 15.11 | 1025.5 | 1042.28 | 16.78 |
| Karnalyte Wynyard DD 3B4-26-1A1-27-31-16 | 1001.14 | 1004.18 | 3.04 | 1012.13 | 1027.45 | 15.32 | 1054.42 | 1072.57 | 18.15 |
| Karnalyte Wynyard DD 2A11-12-3D6-12-32-16 | 942.03 | 950.37 | 8.34 | 959.09 | 973.78 | 14.69 | 1001.31 | 1017.37 | 16.06 |
| Karnalyte Wynyard DD 3A11-27-3A11-27-31-16 | 988.46 | 999.68 | 11.22 | 1007.75 | 1023.2 | 15.45 | 1050.49 | 1066.89 | 16.40 |

***Note: Depths are recorded in True Vertical Depth (TVD).***

***Depths recorded are based on geological intervals, not mining intervals.***

The type section in Figure 8 illustrates the typical distribution pattern of sylvite and carnallite throughout the three potash members within exploration well KW 3A11-27 well and provides a representative model for the general mineralization present within each exploration well. The seismic and drilling data provide confidence to the interpretation that much of the project area is underlain by the Prairie Evaporite salt with persistent Carnallite mineralization within the Patience Lake and Belle Plaine Members and Sylvite mineralization within the Esterhazy Member. It must be noted that within the Project Area, the Carnallite and Sylvite content of the Belle Plaine and Patience Lake Members can vary, and Carnallite may be partially or completely replaced by Sylvite in places. It is the author's experience that such mineralogical variations may be local and quite variable, and suggest that Carnallite-Sylvite relationships observed within the Prairie Evaporite Formation are the product of post-depositional fluid rock-interactions and alterations.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

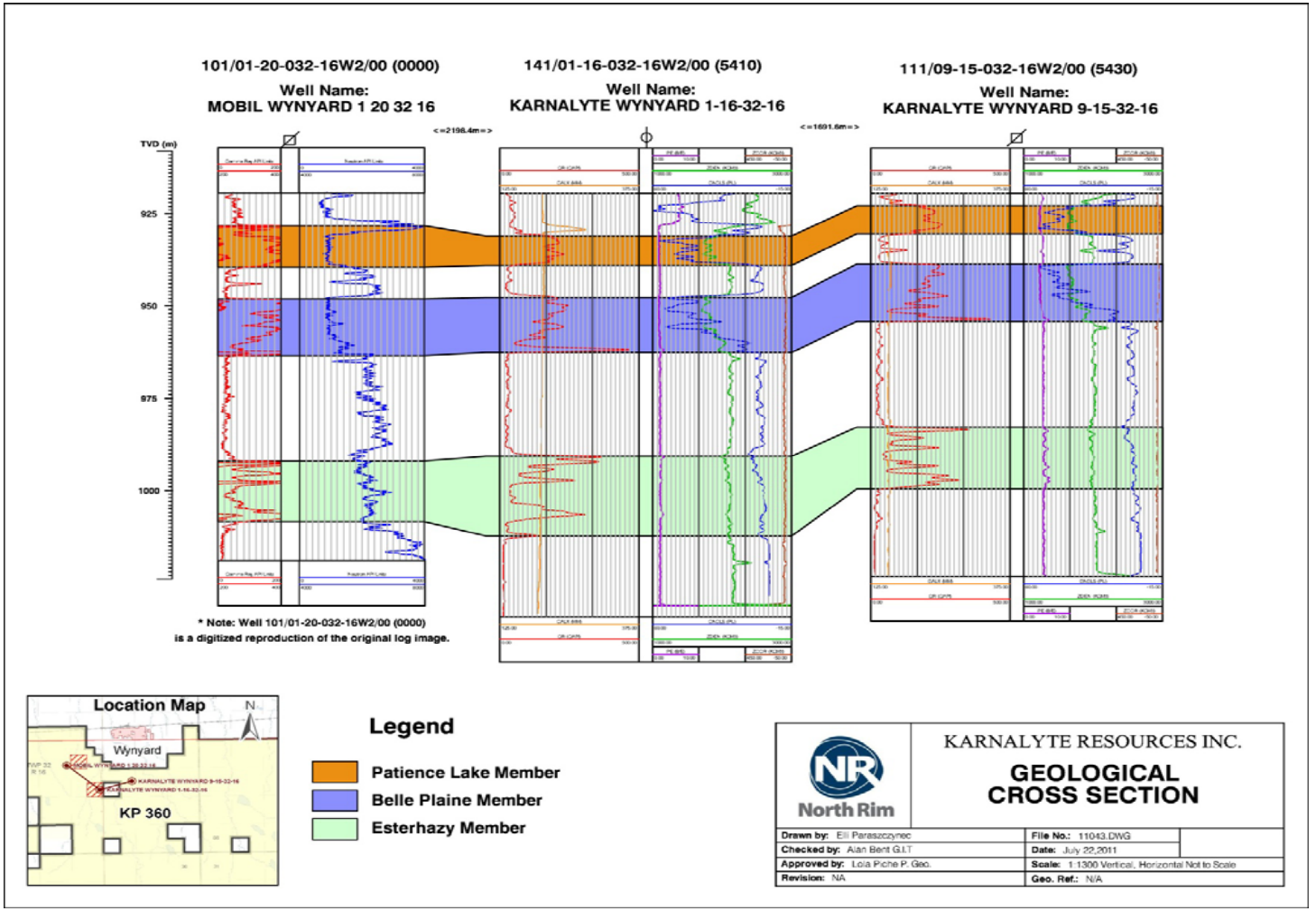



Figure 9 East-West Geological Cross-Section Through DH-11, DH-20 and DH-21



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

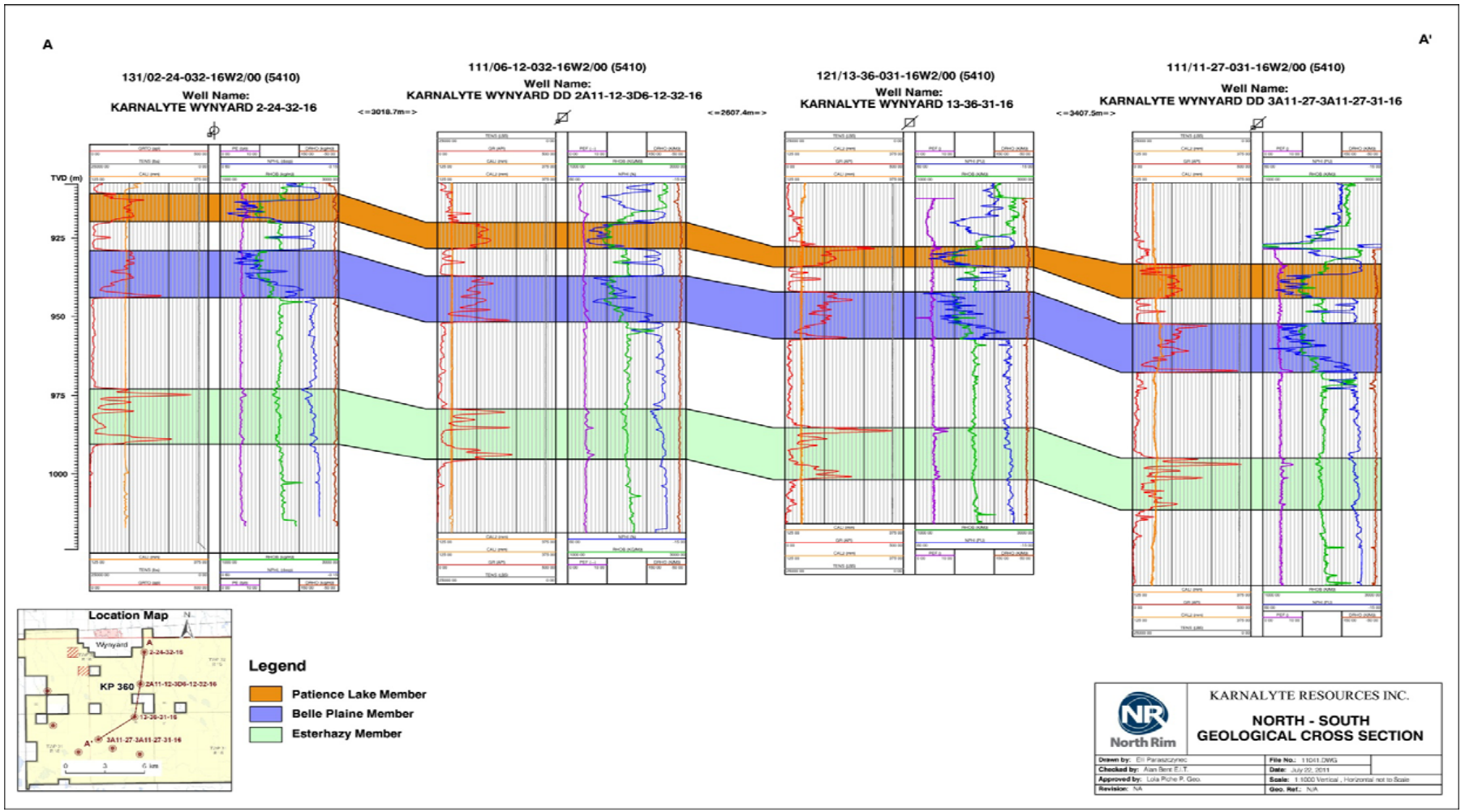



Figure 10 North - South Geological Cross-Section (A-A') Through the KW 2-24, KW 2A11-12, KW 13-36, KW 3A11-27 Wells in the Project Area.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

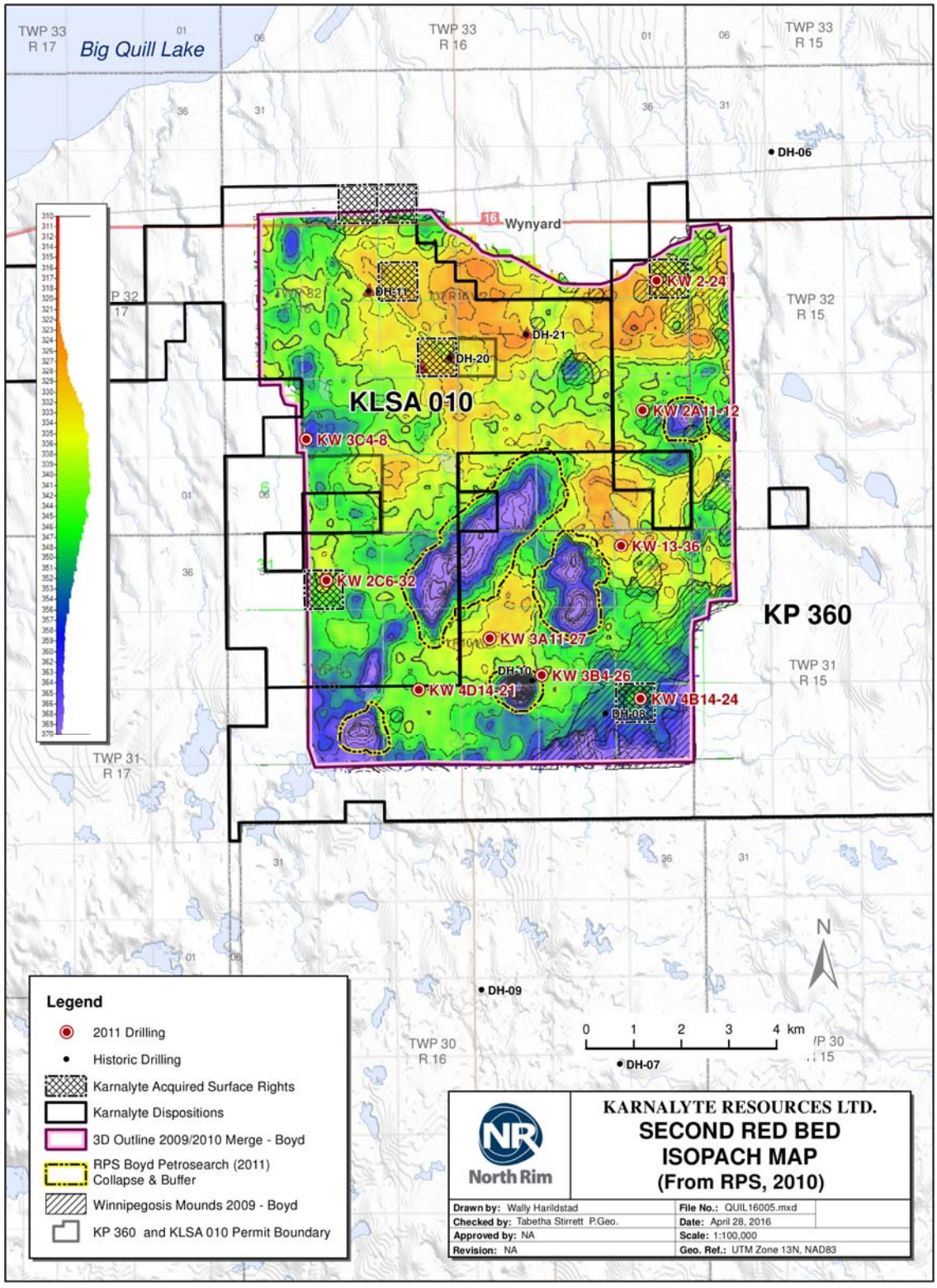



Figure 11 Second Red Beds Structural Map Indicating the Change in Depth Level of the Deposit in the Investigated Area and Identified Class I Collapse.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

## 7.3 Geological Anomalies Affecting Potash-Bearing Horizons

The sylvinite and carnallite bearing beds of the Prairie Evaporite Formation may be affected by three general types of geological “anomaly” (Halabura and Hardy, 2007, /33/). In general, a disturbance that affects the normal character of the sylvinite bearing beds is considered an “anomaly” and, thus, represents an area which is not suitable for mining. Figure 12 illustrates the three types of disturbances that may create anomalously altered zones within the main potash-bearing units which are common occurrences for Saskatchewan potash mining properties. These anomalies range from localized features less than one square kilometer in extent to regional disturbances reaching up to several square kilometers.

A “washout anomaly” occurs where the sylvinite bed has been replaced or substantially altered to a halite mass. The mass consists of medium to large (0.5 to 1.0 cm) euhedral to subhedral halite crystals within a groundmass of smaller intermixed halite and clay insolbles. Clay intraclasts up to 1.0 cm in size may be present and, typically, there is an unusually high concentration of clay at the top and base of the altered zone. This type of disturbance is interpreted by workers in the field to be intraformational (i.e., at the same time as deposition of the primary sylvinite, or shortly after, and are therefore local in nature). An example is provided by Mackintosh and McVittie (1983, /39/) who describe these disturbances as “salt-filled V or U-shaped structures which transect the normal bedded sequence and obliterate the stratigraphy.”

A “leach anomaly” occurs where the sylvinite bed has been altered such that the sylvite mineral has been removed and replaced by euhedral to subhedral halite grains. Such anomalies are also colloquially termed “salt horses” or “salt horsts” by mine operators. If the altered zone crosses any stratigraphic boundaries, these boundaries are commonly unaltered. Workers in the field interpret this type of disturbance as post-depositional (i.e., after deposition of the primary sylvinite). These anomalies are commonly associated with underlying Winnipegosis reefs suggesting that the reefs may have some formative influence upon the anomaly, as described by Mackintosh and McVittie (1983, /39/). At Agrium Inc.’s Vanscoy potash mine located southwest of Saskatoon, workers describe such a disturbance as being characterized by the “partial or complete absence of sylvite in what is otherwise a normal, continuous stratigraphic sequence. Thinning is proportional to sylvite deficiency.” Mackintosh describes these anomalies as being local in extent in that “they range in diameter from a few meters to as much as 400 m, but a few are linear, being up to 20 m wide and greater than 1600 m long.”

The third type of anomaly is a “dissolution and collapse anomaly” formed where the Prairie Evaporite sequence has been removed by dissolution and the resulting void is in-filled with caved materials from above. This type of disturbance may be local (i.e., less than a square kilometer) or it may be regional (i.e., extending over a number of square kilometers) and may affect the entire thickness of the Prairie Evaporite sequence.

An example of an unusual and severe form of this type of anomaly was encountered at the Potash Corp.’s Lanigan potash mining operation and is described in detail by Danyluk et al (1999, /15/). This anomaly was encountered when a mining machine cut through a leach anomaly and encountered down-dropped limestone blocks of the overlying Dawson Bay Formation suspended within the Prairie Evaporite salts.

These types of anomalies are common occurrences in Saskatchewan. The impact of such anomalies upon mining operations is that the grade of the mined potash rock being sent to the mill drops as mining cuts are made through anomalous ground.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

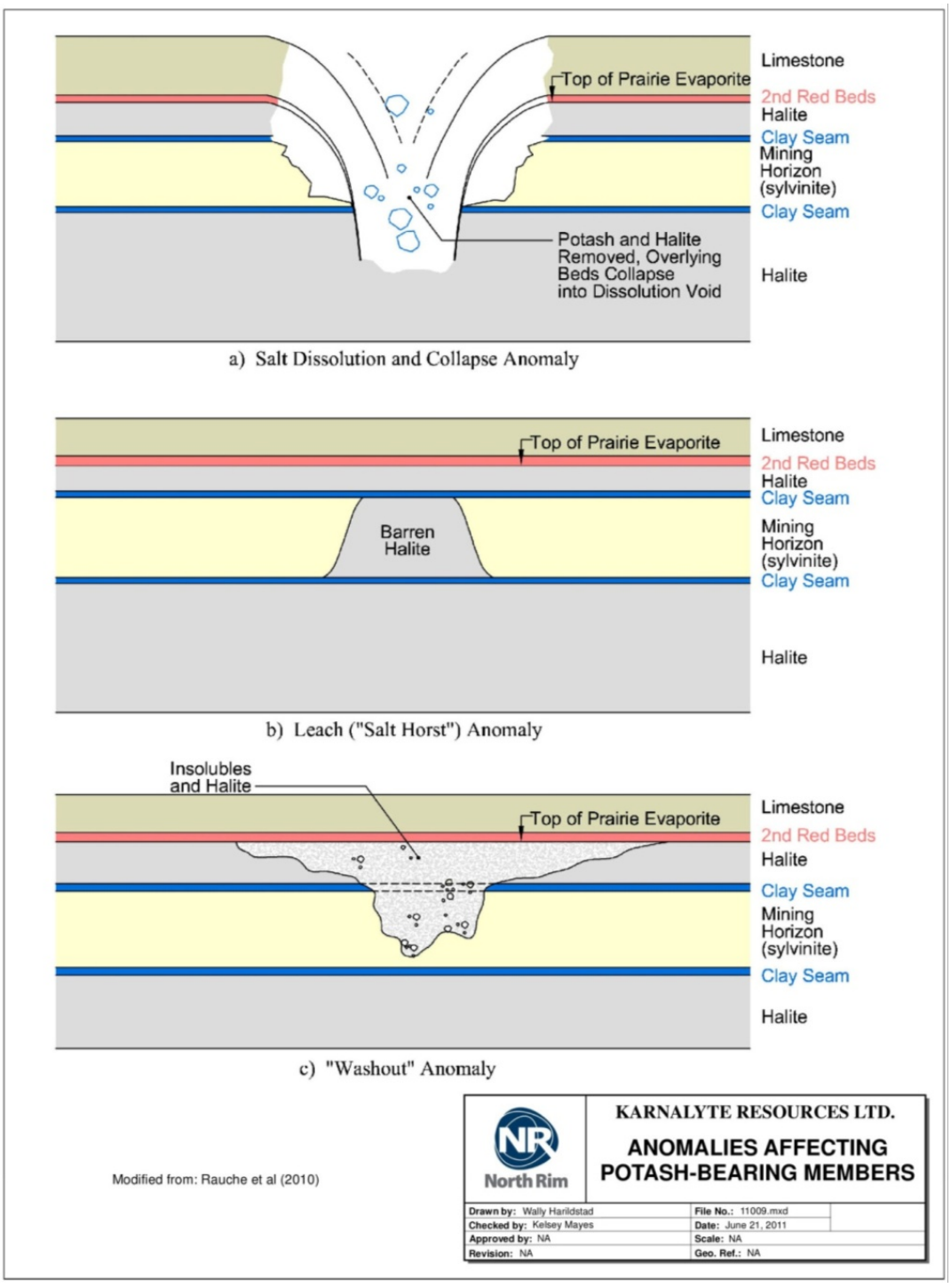



Figure 12 Disturbances Affecting the Continuity of the Potash-bearing Members in Saskatchewan (modified from Halabura and Hardy, 2007, /33/)

A combination of surface reflection seismic surveys (2D and 3D) and careful examination of surface drill holes is often capable of identifying potentially anomalous ground. An important aspect of evaluating any potential potash resource in Saskatchewan is identifying



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

portions of potentially anomalous ground. While drill holes may offer a detailed vertical profile through an anomaly if it happens to penetrate a disturbance, such a drill hole would not provide much information as to the lateral extent of the anomaly. While small local anomalies may go undetected, 3D reflection seismic surveys are able to map the lateral extent of anomalies related to large-scale alterations of the Prairie Evaporite Formation. Dissolution of the main mass of Prairie Evaporite salt and subsequent compensatory thickening or total collapse of the overlying beds into the dissolution cavern is often observable on seismic profile; however, seismic may not necessarily define the lateral extent of more subtle anomalies such as washout or leach anomalies. The authors have prepared a historical seismic summary map presented herein as 0. The seismic contours shown are from a regional seismic compilation map prepared by Dr. Henry Sawatsky of the Saskatchewan Department of Energy and Mines found in Holter (1969, /35/). The figure suggests that areas of potential salt dissolution and collapse occur within the southeastern portion of the project area. These anomalies are expressed as structural “lows” identified and mapped on a reflector within the Upper Devonian. The reader is cautioned that surveys of this vintage do not provide sufficient information to confidently define deleterious anomalies that would affect portions of the potash resource. It is the recommendation of the authors that additional seismic investigations take place when evaluation of the resource potential for the central and eastern part of KL 246 is planned.

In 2008, KARNALYTE undertook a 3D seismic program over the northern portion of the Project Area, which was later augmented in the winter of 2009 to include a 3D seismic program to the south of the previous program. The area included in this survey is also displayed in Figure 13. The seismic data sets were interpreted by Boyd PetroSearch of Calgary (Boyd, 2010, /9/) and anomaly structures identified in this Technical Report are shown in Figure 11. To reduce the risk to the mining operation, the areas identified as anomalous in the 3D seismic are treated as non-potash bearing and no mining is planned in these areas.

## 7.4 Mineralization

Potash mineralization is identified from drill hole data and consists of the Patience Lake, Belle Plaine, and Esterhazy Members.

**Patience Lake Member**: is dominantly carnallitic ($\geqslant$ 40% carnallite) with very little sylvite mineralization, mainly as part of the Upper Patience Lake Member. The Patience Lake Member is typically recognized for its characteristic clay-rich nature, with several laterally extensive clay seams and zones of high insoluble content.

**Belle Plaine Member**: can be divided into a relatively homogeneous Upper Belle Plaine Member (UBPM) consisting of an interlayering of Carnallite rich beds with minor Halite rich beds and a Lower Belle Plaine Member (LBPM) consisting of an interlayering of Halite rich beds with some Carnallite an subordinate Carnallite rich beds. Towards the bottom of this Member, thin Sylvite rich beds usually occur.

**Esterhazy Member**: is generally sylvinitic within the Project Area. Carnallite is present as intercrystalline disseminations. The mineralization is observed to generally occur within two to three distinct high grade Sylvite zones, separated by Sylvite bearing rock salt. Based on the average KCl concentration they can be grouped together in one or two mineralized zones.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

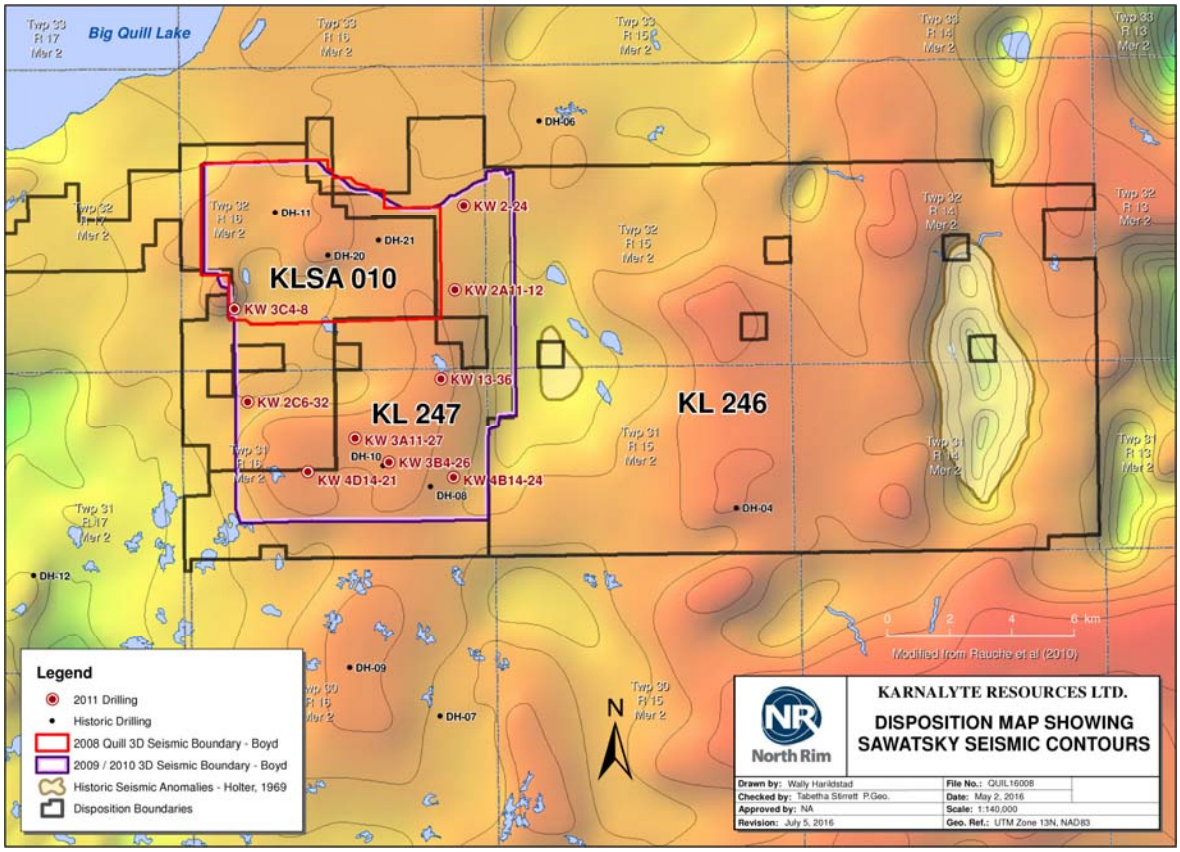



Figure 13 Historical Seismic Contours Within and Around the Project Area and Location of 3D Seismic Investigations

Within the study area, the typical sylvinitic interval consists of a mass of interlocked subhedral to euhedral sylvite crystals that range from reddish orange or pink to translucent in colour. Sylvite may be enveloped by greenish-grey clay or bright red iron oxides, with minor intercrystalline halite disseminated throughout the interval. Local coarse (greater than 2.0–2.5cm) cubic translucent to milky white halite crystals may be present within the sylvinite groundmass. Overall, the sylvinite ranges from a dusky brownish-red color (lower grade, 23.0% to 27.0% $K_2O$ grade with an increase in amount of insolubles) to a bright, almost translucent pinkish-orange color (high grade, 30.0%+ $K_2O$).

Carnallitite consists of aggregated crystal masses of very coarse interlocking amorphous carnallite with minor inclusionary halite and interstitial insolubles. Carnallite commonly exhibits a dark red to bronze color, and may grade locally to shades of very pale pink or may be nearly colorless. Carnallite crystals often display a characteristic variegated color zoning, plastic texture, and vitreous luster along broken and cut core surfaces. Due to its extremely fragile nature, core preservation during drilling varied within the carnallitic intervals ranging from very good to poor and rubbly composition. Intervening barren halite beds between potash members typically consist of brownish red, vitreous to translucent halite with minor sylvite and increased clay content.

Figure 14 and Figure 15 show Boyd's proprietary RMS carnallite probability interpretations for the Patience Lake and Belle Plaine Members that suggest that Carnallite mineralization is continuous over these Members in the project area.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

The type section in Figure 8 illustrates the typical distribution pattern of sylvite and carnallite throughout the three potash members within exploration well KW 3A11-27 well and provides a representative model for the general mineralization present within each exploration well. The seismic and drilling data provide confidence to the interpretation that much of the project area is underlain by the Prairie Evaporite salt with persistent Carnallite mineralization within the Patience Lake and Belle Plaine Members and Sylvite mineralization within the Esterhazy Member. It must be noted that within the Project Area, the Carnallite and Sylvite content of the Belle Plaine and Patience Lake Members can vary, and Carnallite may be partially or completely replaced by Sylvite in places. It is the author's experience that such mineralogical variations may be local and quite variable, and suggest that Carnallite-Sylvite relationships observed within the Prairie Evaporite Formation are the product of post-depositional fluid rock-interactions and alterations.

### 7.4.1 Carnallite Distribution and Solution Mining of Patience Lake and Belle Plaine Members

Conventional or solution mining operations currently operating in Saskatchewan are all based on Sylvinite and consider the presence of appreciable amounts of Carnallite in the deposit as negative because their mining and processing methods are not designed to handle Carnallite. However, the project as proposed by KARNALYTE is designed to recover both potassium and magnesium from high-grade carnallititite and low-grade sylvinite beds using solution mining techniques. The mining and processing methods will be referred to in Sections 16 and 17, respectively. This chapter will discuss the thickness and weighted average grade of the Potash Bearing Members within each drill hole of the mineable solution mining horizons established for the boundaries set by the Feasibility Study (FOSTER WHEELER & ERCOSPLAN; 2011, /26/), for which the more stringent grade cut offs have been confirmed in more recent studies (Section 13).

Up to this point in the report the Potash Members of the Prairie Evaporite Formation have been discussed in terms of the Geology Interval (the first point of potash mineralization). In the discussion to follow the Geology Interval will be refined to the Mining Interval for the purpose of the Mineral Resource and Mineral Reserve Estimation. This interval differs from the Geology interval in that a grade cut-off is used to determine the top and base of the respective intervals (rather than the first sign of potash mineralization).

The mineable carnallititite part of the Patience Lake Member is defined as the upper mineralized seam below the second red bed with a thickness over 2m. Coming from the second red bed, rocks are attributed to this horizon at the first sample with KCl content over 15%, where the length weight average with previous and next samples (3 to 5 samples in total about 1m length) provides a KCl content above 15% and the following average samples further down also have an average KCl content above 15%. The lower boundary of the Patience Lake Member is located at the first sample where the length weight average with previous and next samples (in total 3 to 5 samples about 1m in length) no longer provides a KCl content above 15%.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

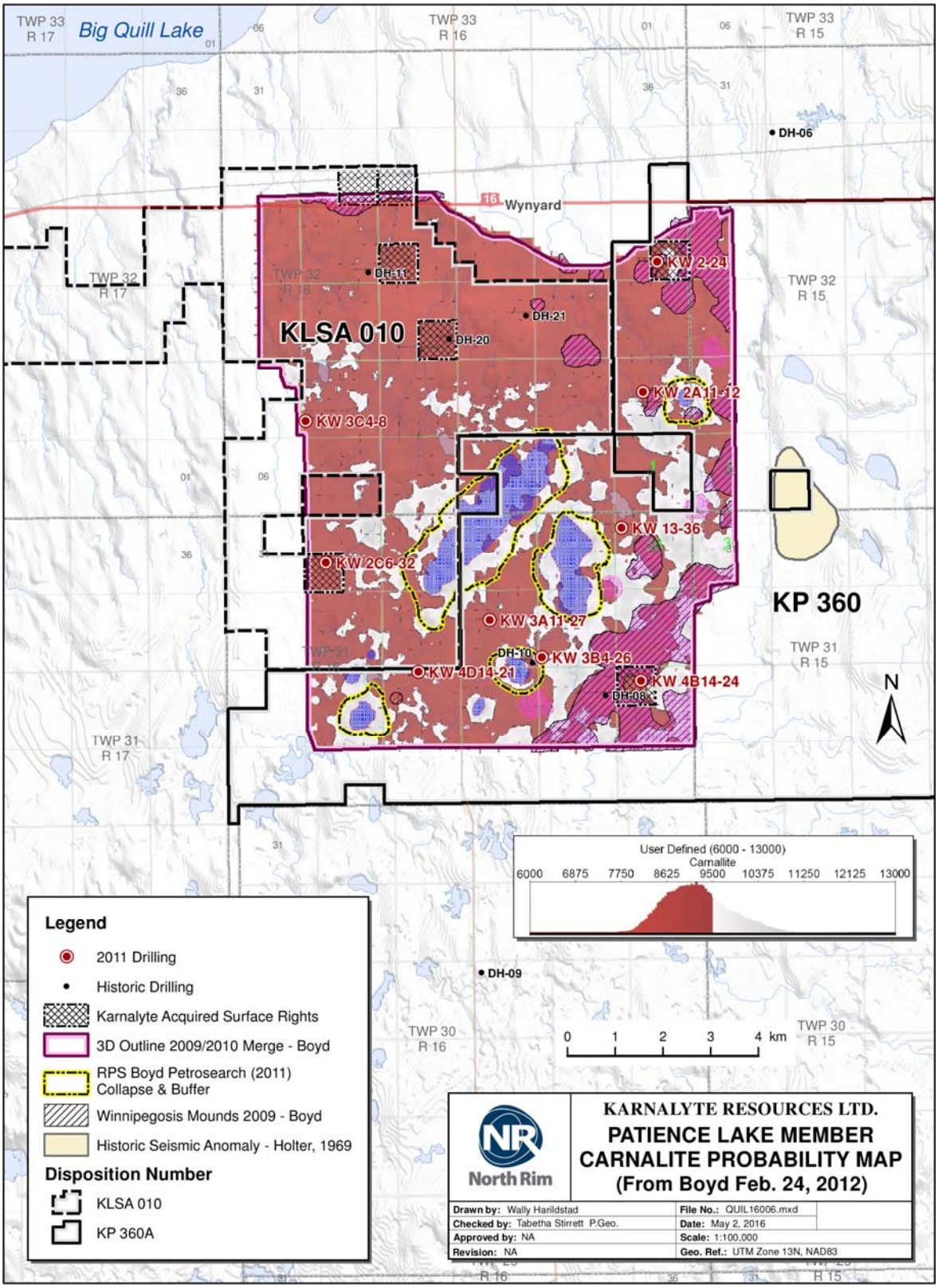



Figure 14 Carnallite Probability Map Over the 3D Seismic Area for the Patience Lake Member with Updated Collapse Buffers.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

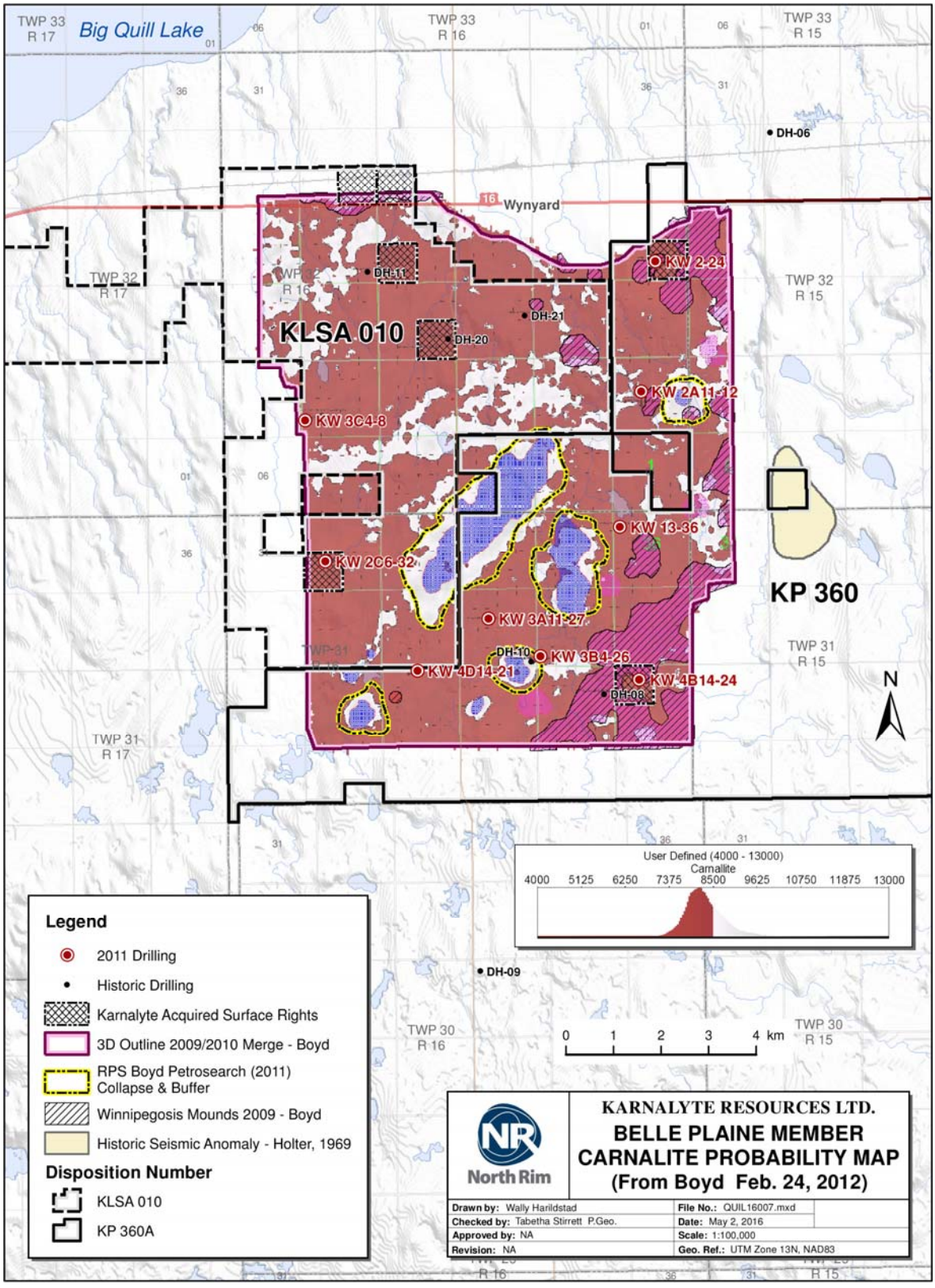



Figure 15 Carnallite Probability Map Over the 3D Seismic Area for the Belle Plaine Member with Updated Collapse Buffers.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

Especially in the southern half of the investigation area, appreciable amounts of Sylvite occur in the upper part of the Patience Lake Member and locally the Patience Lake Member is sylvinitic with traces of Carnallite only. In these areas the thickness of the Patience Lake Member is reduced.

The mineable carnallitite horizon of the Belle Plaine Member for the Feasibility Study (FOSTER WHEELER & ERCOSPLAN, 2011, /26/) is defined as the Upper Belle Plaine Member (UBPM). The Lower Belle Plaine Member (LBPM) will be used for undercut leaching, but has been extended to below the geological boundary to have adequate thickness for the undercut. The lower boundary is located just above the first insoluble rich seam that occurs below the geological boundary. The brine from the undercut leaching will be recycled to pre-concentrate the dissolution brine for the solution mining of the UBPM and the Patience Lake Member, and therefore should be considered part of the resource. For this reason the Belle Plaine Member for solution mining is divided into a productive layer and a cavern preparation layer that has lower grades and lower recovery rates.

Solution mining operation as described for the Feasibility Study (FOSTER WHEELER & ERCOSPLAN, 2011, /26/) is considered technically and economically feasible with the definition of Patience Lake Member and UBPM as well as the LBPM.

### 7.4.2 Sylvite Distribution and Solution Mining of the Esterhazy Member

The mineralization in the Esterhazy Member is developed as Sylvite. The Esterhazy Member has a relatively large thickness (15.0 to 18.0 m). The top of the Esterhazy Member (Geology Interval) is defined at the top of the first sylvinite bed occurring immediately below the “Interbed 2” salt, which separates the Esterhazy from the overlying Belle Plaine and is approximately 30.0 m in thickness. The Esterhazy lower boundary is placed at the base of the lowermost sylvinite bed. Commonly the contact is fairly abrupt and noticeable based on crystal sizes and texture, but is not bounded by distinct clay marker beds. The examination of assays for the drill holes within the permit areas shows that in the Esterhazy Member, the concentration of Sylvite (KCl) is highly variable and ranges from less than 5% to locally over 60% in a sample from 20 cm length.

The Esterhazy Member has been divided into zones that are considered technically and economically suitable for solution mining when:

- Thickness of the productive mineralized zone exceeds 2 m and
- Average KCl content over the productive horizon exceeds 20%, which is required to obtain a brine rich enough in KCl to stay within the specifications of the planned process in the feasibility study (FOSTER WHEELER & ERCOSPLAN, 2011, /26/).

With this strict KCl grade criterion, the number and thickness of the one or two mineable zones is reduced and the drill holes 3C4-8 and 3B4-26 do not contain mineable Esterhazy Member. The drill holes 3A11-27, 2A11-12 and 4D14-21 contain one mineable layer within the Esterhazy Member, whereas for the drill holes DH-11, DH-20, DH-21, 4B14-24 and 13-36 two mineable layers could be identified in the Esterhazy Member.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

# 8 Deposit Types

Potash has been historically used in the manufacturing of many commercial and industrial products including soap, glass, textiles, ceramics and many more, however; the most common use for potash is as the primary ingredient in the production of agricultural fertilizers. The term potash is an informal term used to describe “muriate of potash” (MOP) which is expressed with the chemical formula $K_2O$ or potassium oxide. The terms potash and muriate of potash are often used in the Saskatchewan potash industry to describe the sales product resulting from the mining and milling of sylvite bearing rocks. Sylvite is the potassium bearing mineral (KCl or potassium chloride) which is the most common source for producing potassium in Saskatchewan. Potassium chloride is the product that is mined and sold. To be able to compare these products the grade of potassium products is usually expressed as $K_2O$, however the KARNALYTE potash project proposes to produce KCl through solution mining. A tonne of KCl contains an equivalent of 0.632 tonnes of K2O, which permits comparison of the nutrient levels of various forms of potash including potassium sulfate ($K_2SO_4$).

The Project Area contains mainly two potash bearing minerals;

- Sylvite, chemical formula KCl (63.2% $K_2O$)
- Carnallite, chemical formula $KMgCl_3 \times 6\ H_2O$ (17.0% $K_2O$)

In this Technical Report, the term “sylvinite” is used to describe the mineralogical character of a potash-bearing rock, predominantly comprised of the minerals sylvite and halite (NaCl). The term “carnallitite” in this Technical Report is used to describe the mineralogical character of the magnesium-bearing rock when it is composed primarily of the minerals carnallite and halite. For the purposes of nomenclature when completing the detailed description of the drill holes, sylvinite is considered to have $\geqslant$ 20% Sylvite and carnallitite is considered to have $\geqslant$40% Carnallite within the core. Sylvinite and carnallitite may also contain variable concentrations of “impurities” including anhydrite, dolomite crystals and clay minerals that are jointly identified in chemical assay reports as “water insolubles”. Other substances regarded as “impurities” that are commonly found in sylvinite include carnallite and kieserite ($MgSO_4 \times H_2O$).

In contrast to potash with a single major use, the use of magnesium bearing products is much larger and the sources for production of magnesium bearing products is much larger, ranging from Mg bearing salts like, Carnallite, Bischofite and Magnesium Sulfates (Epsomite, Kieserite) over natural occurring Magnesite ($MgCO_3$) to serpentinite, but occasionally also sea water has been used. KARNALYTE’s magnesium product project plans to use the $MgCl_2$ present in Carnallite as basis for Hydromagnesite and $MgCl_2$ brines.

Magnesium concentrations are reported in chemical assay reports as weight percent (wt. %) magnesium oxide (MgO). Carnallite is a calculated equivalent value based on the present MgO content rather than a direct laboratory chemical analysis. The equivalent Carnallite content can be calculated by multiplying the MgO content by 6.89 and similarly the equivalent magnesium chloride ($MgCl_2$) content can be described as 2.36 times the MgO content. Throughout this Technical Report the magnesium content is reported both as equivalent Carnallite ($KMgCl_3 \times 6H_2O$) and equivalent magnesium chloride ($MgCl_2$).

Potash mining in Saskatchewan is based on Sylvite bearing deposits. Generally the presence of Carnallite is considered undesirable in these operations as the processing plants can only handle up to 6% Carnallite in the mill feed or even less in solution mining operations. There are no Carnallite based potash operations in Saskatchewan, but that has no



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

consequence for the feasibility of KARNALYTE's project as the use of Carnallite is a basis for KCl production has a long history and uses proven technology.

The international potash industry started in 1861 in the Stassfurt area in Central Germany, by extraction of carnallitite from the Stassfurt Member, Upper Permian. While carnallitite was used almost exclusively as the source of raw material for potash production during the first two decades, with increasing success in exploration, sylvinite was used more and more frequently in production, as this has a higher KCl content than the parts of deposits that contained carnallitite. However, for the German potash industry, carnallitite was an important source for potash production over the whole period of 160 years of production history: Up until today, Germany's potash production is in total about 300,000,000 metric tonnes of $K_2O$. About one-third of this amount was refined from carnallitite. Today, Germany's most important potash production centre, the Werra plant, mines about 20,000,000 metric tonnes ROM, of which about 7,000,000 metric tonnes ROM is carnallitite ore.

Besides Germany, in Israel, Jordan, China and Iran, carnallitite is used as a source material for potash production. The Israeli potash producer, Dead Sea Works (DSW), and the Jordanian producer, Arab Potash Company (APC), both of which produce together about 4,700,000 metric tonnes of $K_2O$, use only the carnallitic brine of the Dead Sea. Typical magnesium products obtained as by product from carnallite mining are $MgCl_2$ brines, Bischofite flakes, Magnesite in different qualities, all in relative modest quantities when compared to potash production.

Recent carnallitite based potash projects are in progress in Brazil (e.g. Vale S.A. and others), Republic of Congo (MagIndustries and others), Thailand (ASEAN Potash Mining Public Company Inc. and others), and Laos (VINACHEM Vietnam National Chemical Group, Lao Kaiyuan Mining Co., SINOHYDRO Corporation and others).

Based on 100 years of proven and optimized process design used in Germany today, which is proposed for this project, and the sizeable thickness of carnallitite within the Project Area, the deposit is considered ideal for solution mining. The brine can be processed into potash and magnesium products.

# 9 Exploration

The Project Area is being explored for potash and has had no production of potash within its boundary. The closest production of potash occurs within the bounds of Project Area KL 100, which is The Potash Corporation of Saskatchewan's Lanigan potash mine some 75 km to the west. Historic exploration has been discussed in section 6.1.

KARNALYTE first shot a 3D seismic program in 2008 that covered some 34.5 square kilometres (13.3 square miles). The information from this survey was utilized to determine drill hole locations and identify any major subsurface anomalies. Following this 3D survey, KARNALYTE drilled two cored holes and one water-test well in the period of September to October of 2009. In 2009 the second 3D seismic program was completed and extended the 3D seismic data to the south and east of the 2008 program (Figure 12). This program covered 71 square kilometers (27.4 square miles). The results of the two 3D seismic surveys were reported by Boyd (2008, /8/; 2010, /9/). There has been no additional seismic shot within the lease or permit area under review since the 43-101 report of 2012 (ERCOSPLAN, NREL & FW, 2010 /18/).



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

### Carnallite Probability

In February 2012 Boyd provided updated interpretations of the probability of carnallite using the results of the 9 additional wells (Figure 14 and Figure 15). It is the QP's opinion that the probability maps available are more than sufficient for this Technical Report. The Wynyard 3D seismic data is of sufficient quality to qualitatively map the presence of carnallite. As carnallite has a significantly lower density than sylvinite or halite, carnallite will often cause a seismic reflection to appear when present in sufficient thickness and grade. However, RMS amplitude mapping is an approach that allows only a qualitative interpretation. Resources or reserves are not included or excluded based on carnallite probability maps, due to the lack of information on grade and thickness. The probability maps are a tool used only to qualitatively assess the likelihood of carnallite mineralization.

The probability maps included in this Technical Report were compared with the drilling results for verification of the carnallite probability interpretations. The probability maps were com-pared to the summary of grades determined from drill hole data. The percentage of car-nallite determined for each well correlate very well with the probability maps for the re-spective members.

### Risks Collapse Anomalies

For the purpose of this Technical Report Boyd has worked directly with the authors to evaluate the risk from the collapse anomalies for a solution mining operation, which is lower than the risk from a collapse anomaly for a conventional mining operation.

As a result of these discussions a boundary containing a buffer around a collapse features was defined based on the transition of the seismically inferred dip of the layering from a regional trend to the steep dip of the collapse (Figure 16). This definition shifts the historical well DH-10, which has a slightly reduced Patience Lake thickness to be within the buffer zone. There is, however, not enough data preserved from this hole to determine whether or not there is any other influence from the interpreted collapse on this hole. Nearby recent well KW 3B4-26, which is just outside the buffer zone, also shows a reduction in Patience Lake thickness, which in core section does not look different from Patience Lake sections from other wells. It is, therefore inferred that the new defined collapse feature boundary provides enough safety margin around the collapse feature for a solution mining operation.

Furthermore, the 8 collapse features defined in Boyd (2010, /9/), were further detailed and 3 features, that were originally classified as class 1 features (Class 1" anomalies are characterized by substantial removal of the Prairie Evaporite salts with significant breakage in the overlying Second Red Beds), were re-defined as class 2 features, which were interpreted as karst features in the overlying Devonian carbonates (e.g. Figure 17) and as such not likely to affect the deposit.

# 10 Drilling

Note that historic drilling is summarized and discussed in Section 6.1, this section is focused on recent drilling completed since the NI 43-101 Report of 2010 (ERCOSPLAN, NREL & FW, 2010, /18/). Drill hole locations of both Historic and new drill holes are illustrated in Figure 1 and Figure 3.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

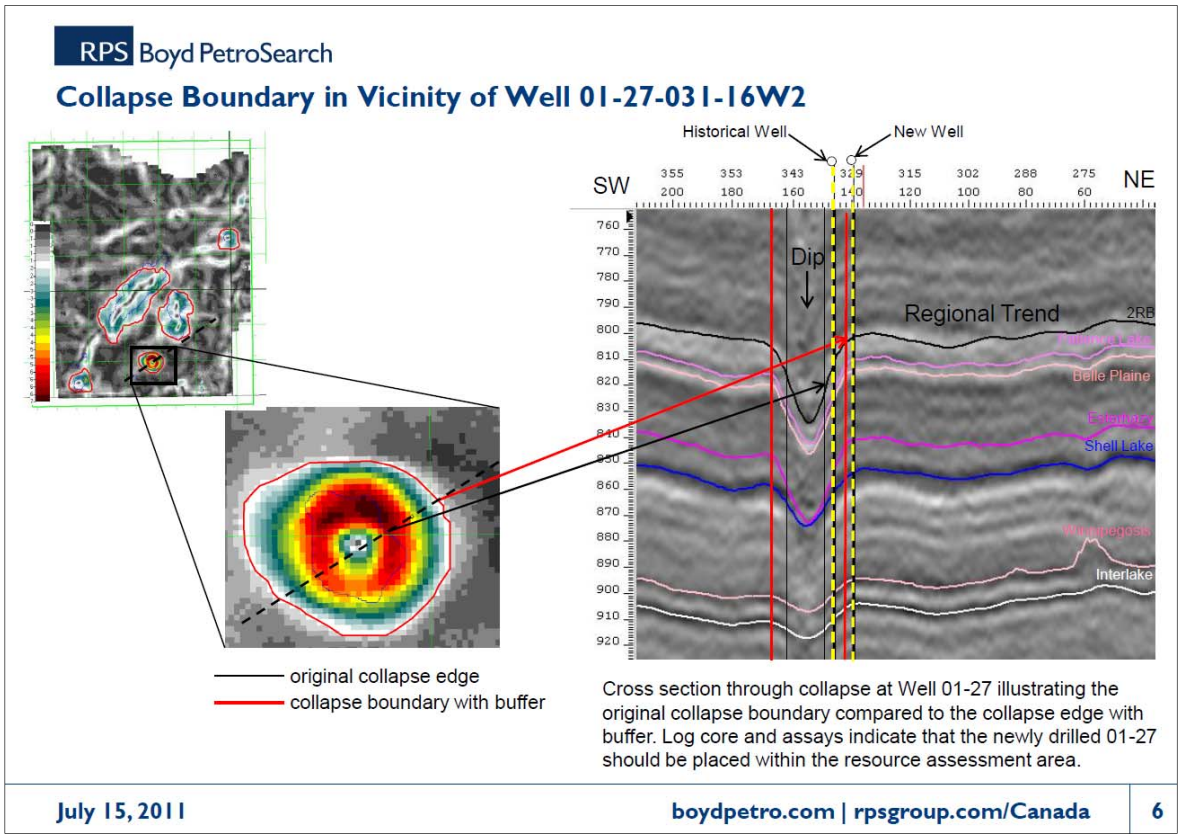



Figure 16 Illustration of the Definition of Collapse Boundary with Buffer

## 10.1 The 2010/2011 Drill Holes

KARNALYTE's 2010 and 2011 drilling program had 9 wells drilled through the western portion of the Project Area. The 9 wells drilled in the 2010/2011 drilling programs are illustrated in Figure 1. The wells drilled since the 2010 43-101 report are summarized below in Table 5.

A two-hole exploration program was completed December 2010 to January 2011. The primary purpose of the two-hole program was to recover whole core samples to determine Carnallite mineral potential and to recover core samples for geochemical (dissolution) and rock mechanical testing. The results of the geochemical and rock mechanical testing are intended to be used for cavern stability and subsidence modelling as well as for confirmation of the attainable production brine composition for the project.

The two-hole program drilled the wells KW 2-24 and KW 2C6-32 (see Table 2 for well locations). These two wells were drilled and licensed as solution mining wells and are currently suspended, but could be used for future production/injection testing. Each of the wells had approximately 145 meters of core recovered with approximately 10 meters of core being selected by ERCOSPLAN for rock mechanical and geochemical testing.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

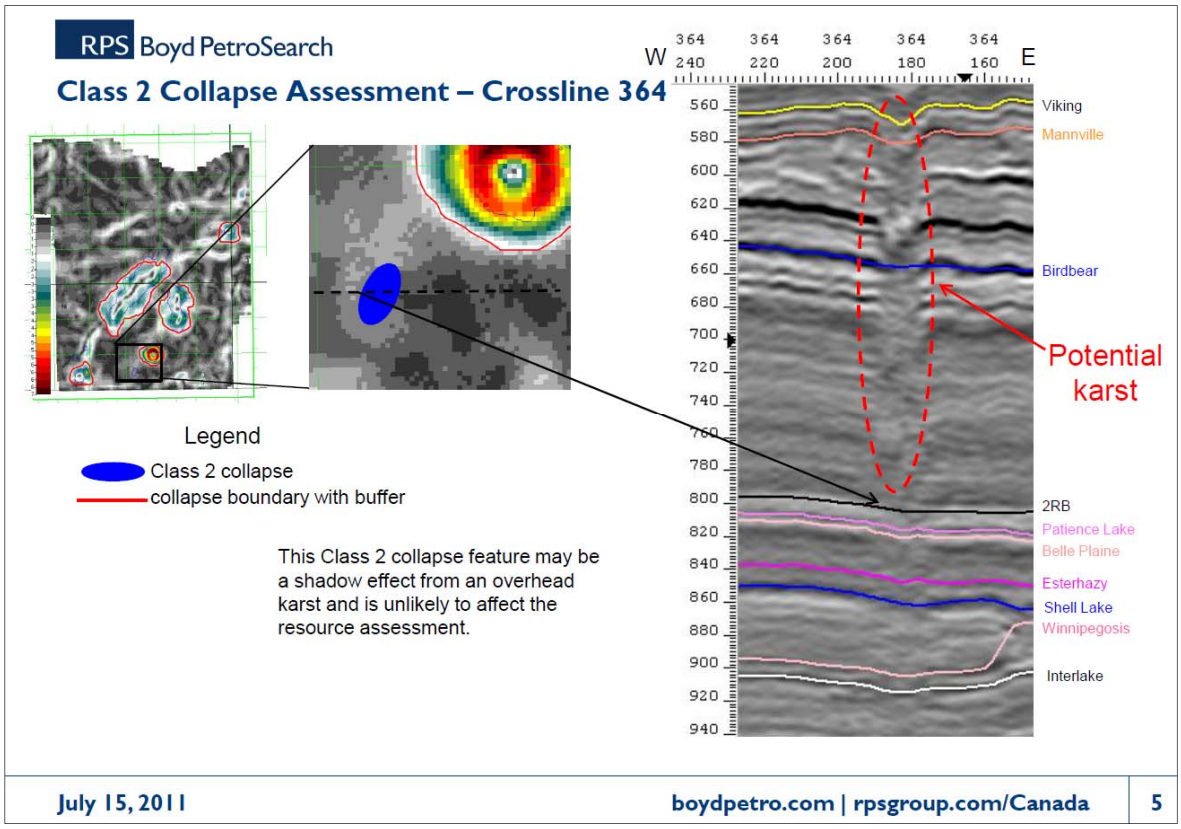



Figure 17 Re-Evaluation of a Collapse Feature as a Class 2 Anomaly

Table 5 2010-2011 Wells Added to the Database (Refer to Table Table 2 for Drill Hole Locations)

| 2010-2011 Wells Added to 43-101 Update 2011 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Well I.D | Coring Start (T.V.D) | Coring Stop (T.V.D) | Recovery Factor (%) | Max Deviation (Degree) | Upper P.L Thickness (T.V.D) | Lower. P.L Thickness (T.V.D) | Belle Plaine Thickness (T.V.D) | Esterhazy Thickness (T.V.D) | Spud Date: |
| KW 2-24 | 859.91 | 1001.38 | 100.0 | 8.8 | - | 9.56 | 15.00 | 17.36 | 12/12/2010 |
| KW 2C6-32 | 929.56 | 1078.45 | 99.3 | 8.5 | - | 7.98 | 15.39 | 16.85 | 1/5/2011 |
| KW 4B14-24 | 994.37 | 1102.11 | 92.9 | 25.7 | 5.10 | 7.77 | 14.94 | 17.51 | 3/29/2011 |
| KW 4D14-21 | 995.49 | 1102.53 | 99.8 | 26.4 | 2.00 | 8.79 | 15.00 | 15.69 | 4/20/2011 |
| KW 13-36 | 953.9 | 1065.38 | 100.0 | 1.7 | - | 6.50 | 14.81 | 16.48 | 4/20/2011 |
| KW 3B4-26 | 983.35 | 1092.07 | 100.0 | 28.4 | - | 3.04 | 15.32 | 18.15 | 5/2/2011 |
| KW 3C4-8 | 940 | 1046.39 | 97.5 | 46.5 | - | 8.66 | 15.11 | 16.78 | 5/5/2011 |
| KW 2A11-12 | 925.46 | 1032.68 | 100.0 | 10.2 | - | 8.34 | 14.69 | 16.06 | 5/13/2011 |
| KW 3A11-27 | 983.78 | 1088.03 | 95.1 | 11.8 | 1.54 | 7.18 | 15.45 | 16.40 | 5/18/2011 |

The drilling season in Saskatchewan is usually suspended throughout April, May and June as Rural Municipalities place weight restrictions on the roads, “road bans”. KARNALYTE worked with the local Rural Municipalities and received permission to move equipment through the road bans as long as the roads were restored to their original condition.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

Upon receiving permission KARNALYTE completed a seven-hole drilling program throughout these months in 2011.

The seven-hole drilling program consisted of one vertical well and six directional wells drilled. The six wells were drilled using directional drilling due to unfavorable drilling conditions at surface, such as a slough or low lying area. The directional wells were drilled as “S” style wells which allowed for the correct bottom-hole locations to be reached, while remaining vertical throughout the Prairie Evaporite. The “S” style well allowed for the cored interval lengths to be the same as the true vertical thickness. Table 5 summarizes the true vertical depth of each well through the Prairie Evaporite Formation. The max deviation in all wells was throughout the upper sections of the well in the “S” curve of the wells.

After all cores were recovered from the well, geophysical logging tools were run from total depth to intermediate casing point. These geophysical logs were completed to provide the client with detailed down-hole information that can be used to cross-reference lithology, mineralogy, geochemical assay data, and to depth correct all cores. Geophysical wireline logging conducted throughout the drilling program included; the gamma-ray log, induction resistivity log, neutron density logs, imager log and dipole sonic log.

## 10.2 Core Retrieval and Core Handling at the Drill Site

Coring operations were completed successfully on the new wells with exceptions on the KW 4B14-24 and KW 3A11-27. The wells had 8.07 m of unrecovered core through the Belle Plaine and 7.64 m missing through the Patience Lake Member, respectively. Upon completing wire-line logs all wells were plugged and abandoned as per Saskatchewan Oil and Gas Regulations, 1985.

Coring and core retrieval was completed by Blackie’s Coring Services of Estevan, Saskatchewan and Superior Coring of Calgary, Alberta. Upon completion of coring, the retrieval of core from the core barrel was carried out. Due to the highly carnallitic nature of the core, special core retrieval and handling procedures were completed to ensure the core integrity. A routine set of procedures were strictly followed to ensure the stratigraphic sequence of the core was maintained and to prevent loss of material. In addition to the core hands, the Drill Supervisor, well-site Geologist and a North Rim Project Geologist/Engineer supervised each core retrieval process for all wells.

The core retrieval and shipment procedures followed for all 2010-2011 drill holes are consistent with those followed during the 2009 drill program. These procedures are summarized below.

1. Waxed cardboard core boxes were sequentially numbered and labelled with the drill-hole name, land location, depth interval, and core number. The empty boxes were stacked in ascending numeric order in the doghouse, ready to be filled upon core retrieval.
2. A safety meeting was held with the core hands, drill crew, and geologists prior to core retrieval. This meeting was a forum to review the retrieval process and to identify safety concerns.
3. The core was retrieved from the barrel and was broken by hammer into lengths approximately equivalent to that of the core boxes. Upon retrieving a length of



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

core, the core hand would make a mark on the stratigraphic bottom of each core length.

4. The individual core lengths were immediately wrapped in plastic wrap inside the dog-house. The core was then placed in a plastic bag along with a desiccant (rice). The plastic bags were sealed by heat sealing the ends or by tightly taping the ends closed. (See Figure 18 and Figure 19).



Figure 18 Core Samples Placed in Plastic Bags with Ends Sealed

5. The core was then ready to be boxed. Individual core lengths were fit into core boxes in stratigraphic order
6. Upon completion of core retrieval procedures, the core was ready for shipment to Saskatoon for sampling and detailed logging. The core boxes were carried down from the rig and were organized into a hot-shot trailer or van.
7. The core was trucked to North Rim Exploration's Saskatoon core laboratory by Superior Coring or Blackie's Coring hotshot service. Core sampling and detailed logging was completed at the Saskatoon lab. Please refer to Section 11.3 for sampling procedures at the lab.

In the opinion of the authors the drilling and core handling was performed in such way that any potential non recognized recovery problems will not materially affect the accuracy of the results reported (see also next section).



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com



Figure 19 Individual Wrapped Cores in Core Boxes

# 11 Sample Preparation, Analysis and Security

Samples were taken from the current drill holes (2010 and 2011) for the purpose of chemical analysis. The assay results from this testing was added to the results of sampling reported in the 2010 report as the basis for the mineral resource calculations included in this Technical Report. The boundary conditions for current sampling procedures differ from historical core sampling, therefore slightly different methods and approaches were used. The sampling approach in 2009 also varies slightly from the procedures employed in the 2011 assay sampling procedures. All sampling methods and approaches are commented on within this section.

## 11.1 Historical Drill Cores and 2008 Re-Sampling

The historical drill core sampling procedures are originally referenced in KARNALYTE's 2010 NI 43-101 Technical Report prepared by ERCOSPLAN, NREL and FW (2010, /18/), where two drill holes Mobil Wynyard 1-20-032-16W2 (DH-11) and Dominion Kandahar 1-27-31-16W2 (DH-10) were re-sampled. A summary of the sampling procedures is described below (ERCOSPLAN, NREL and FW 2010, /18/).

Both of the historical drill holes mentioned above (DH-11 and DH-10) were examined by North Rim personnel. The cores were approximately 8.89 cm (3.5 inches) in diameter and



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

in variable states of preservation. The historical record states that all of the coring was done with an oil emulsion mud or diesel fuel which remained in the hole when borehole geophysical logs were taken. Theoretically this drilling fluid should not dissolve any of the evaporite minerals and examination of the outer surfaces of cores from DH-10 and DH-11 confirmed that there is very little evidence of dissolution of minerals that can be attributed to the drilling process. There were small intervals of etching and disaggregation in the DH-10 drill core, which may have been due to dissolution of a highly soluble mineral such as carnallite. In other locations, there was evidence of minor dissolution, but it is likely that this may have occurred when samples were cut for assay. In general, the condition of the core was excellent, indicating good drilling and core storage practices.

The historical assays of the Mobil Wynyard wells were not adequate to completely assess the entire mineralized drill-core interval; therefore, a supplementary sampling and assay program was undertaken by North Rim staff in August 2008.

The following procedures were used in the 2008 sampling program for selecting and packaging the new samples chosen for analysis:

- Drill core was measured and noted along with the historical samples. The intervals for new assay samples were selected to fill-in gaps left from the original historical sampling program. The new analysis combined with the historical data resulted in relatively comprehensive documentation of drill-core chemistry
- Samples were selected on the basis of drill core measurement only. The core was in variable states of preservation ranging from excellent to poor condition. The sample in-tervals, where possible, were determined from lithological boundaries, but in other cases on the basis of the set intervals. In total 117 new assay samples were collected;
- The samples taken for assay were numbered. The sample numbers were written in permanent ink on the inside of the core boxes;
- The samples were placed in standard polypropylene sample bags which were labelled with the well name followed by a three digit sample number (e.g. MW-000 where MW is an abbreviation for Mobil Wynyard);
- Labels were placed on the inside and outside of the bags; and
- The samples were heat sealed after bagging to prevent the influx of moisture.

The following procedures were used in the 2008 sampling program for preparing and shipping the new samples chosen for analysis:

- ADM Consulting of Saskatoon, SK was contracted to cut and label the samples for chemical assay. The cutting of the core was done at the Subsurface Core Laboratory in Regina, SK;
- After the samples were cut and bagged, personnel from ADM Consulting shipped the samples directly to the Saskatchewan Research Council's Geoanalytical Laboratory (SRC) in Saskatoon, SK;
- Upon SRC's receipt of the samples, a packing slip was sent to SRC by North Rim personnel to confirm the sample numbers of the submitted samples;
- North Rim personnel signed the packing slip to confirm the accuracy of the listed samples. Both North Rim and SRC retained a copy of the slip for their records;
- SRC provided written documentation of the job number indicating that the samples were entered into the processing queue and



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

- Upon completion of the processing and assaying, the results of the analysis were compiled into tables by SRC and sent to North Rim for review.

## 11.2 The 2009 Sampling Method and Approach

Two drill holes were completed during the 2009 exploration program, which were logged and sampled by North Rim. In 2009 the core was sampled only in the Patience Lake and Belle Plaine Members, whereas in 2011 all three carnallite bearing members of the Prairie Evaporite were sampled including the Esterhazy Member. In KARNALYTE's 2010 Technical Report prepared by ERCOSPLAN, NREL and FW (2010, /18/), the original 2009 sampling method and approach is referenced and can be found summarized below.

The core from the 2009 exploration program was carefully transported from the drill site to the North Rim core laboratory located at 2834 Millar Avenue in Saskatoon, SK (e.g. Figure 20). Upon arrival at the lab, the core boxes were removed from the core van and laid out in strati-graphic order on tables. Core boxes remained sealed until the sampling process commenced. Upon consultation with the geophysical wireline logs, the overall geochemical sampling intervals were determined.

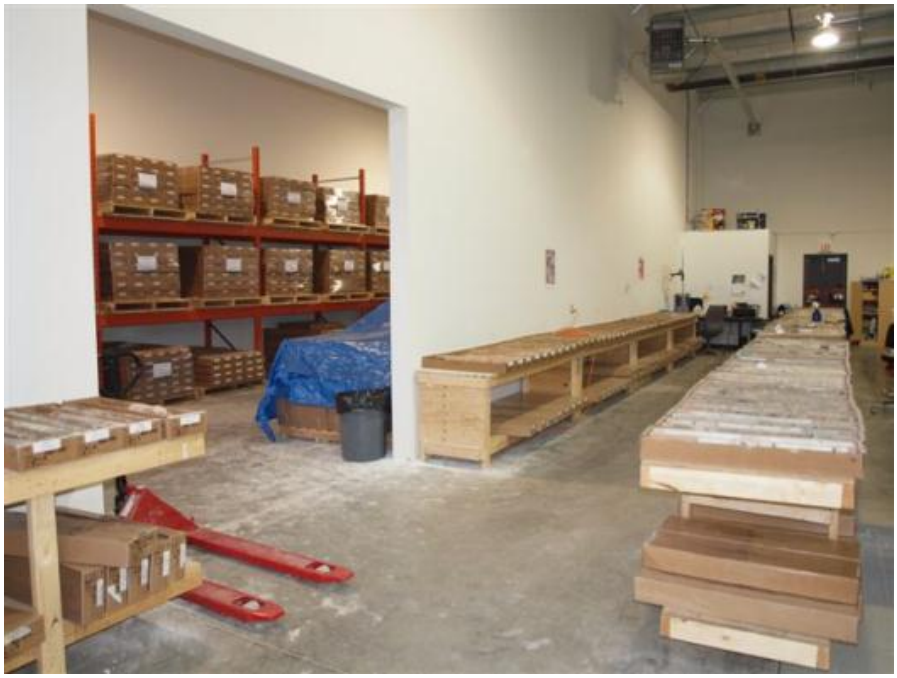


Figure 20 Photograph inside North Rim's Core Lab and Storage Warehouse

The geochemical sampling interval of interest for the two drill cores ranged from several meters above the uppermost sylvinitic bed of the Patience Lake Member to approximately 15.0 m below the base of the Belle Plaine Member into the underlying interbed salt. The upper sampling boundary was set to capture the first mineralization of the Patience Lake



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

Member and the lower boundary was chosen to provide geochemical information for cavern design purposes should the property be amenable to solution mining. Therefore, not all of the core was sampled for assaying including the Dawson Bay, Second Red Beds and the uppermost Salt Back.

In DH-20, 357 samples were taken over 90.6 m from 934.0 m to 1024.60 m and in DH-21, 373 samples were taken over 90.3 m from 920.8 m to 1011.1 m.

The core was examined, slabbed (i.e. cut in half lengthwise), marked for sampling, photographed, and cross cut on a box-by-box basis, which facilitated the integrity of the highly carnallitic core and minimized exposure to the atmosphere. Upon selection of the sampling interval, the plastic wrapping was removed from the individual core lengths and then was slabbed. Slabbing was completed in-house at the North Rim Core Lab facility with a dry 2 horsepower band saw (see Figure 21). Saw blades were replaced when any breach of core integrity was noted (e.g. fracturing of crystals). After slabbing, the two complimentary core halves were placed back in the box in stratigraphic sequence with both cut surfaces facing up. The cut surfaces were wiped down with a damp cloth to remove any rock powder generated by the cutting process and to enhance the appearance of the rock during visual inspection. The upper core half was divided into sample intervals by drawing a straight line across the diameter of the core in permanent marker. The determination of sample intervals was based on several parameters outlined in the next section.

As the sample intervals were chosen, they were labelled using a numbering scheme that detailed the drill-hole number and sample number. For example, sample “Q1-023” indicates it was the 23rd sample from KARNALYTE drill hole DH-20, which was the first KARNALYTE well drilled. Sample numbers for each interval were written on the slabbed core in permanent marker and a sample number tag was prepared. The core was photographed after the sample selection, marking and tagging of the sample intervals in each core length was completed. Two photos of the core were taken: one with and one without the sample tags. Photos without the tag were necessary as the tag obscured some thin sample intervals (e.g. a 2.0 cm clay seam). After photographing the core each sample was measured to the nearest tenth of a centimeter (e.g. 25.4 cm). The length of each sample interval was recorded in a geological logging spreadsheet and a “depth from” and “depth to” was established for each sample number. The geologic formation, member names (following established nomenclature), lithology, crystal sizes, and geological descriptions were recorded for each sample. Upon measurement of all sample lengths, the sample intervals and corresponding sample numbers were duplicated on the cut surface of the other core half with permanent marker. This preserved the sample interval information on the remaining core halves for future geological investigations after the other half was sent for assay. One of the marked core halves was then cut into the designated sample intervals with the band saw. Each sample and corresponding sample tag were wrapped twice in kitchen wrap to ensure the samples were not exposed to the atmosphere. Each wrapped core sample was then placed in a waterproof plastic bag, labelled with the sample number and put in pails for shipment. The prepared samples were sent to SRC’s Geoanalytical Laboratory in Saskatoon, SK. At SRC, the samples were crushed, split, and analyzed according to the parameters of the SRC basic potash analysis package. Quality assurance and quality control (QA/QC) measures were strictly adhered to, including the use of standards, blanks and repeats throughout the analysis.

It is worth noting that the core recovery was excellent (with exception of Core 1 in DH-21), and cutting of the drill core for slabbing and sampling purposes did not result in any notable material loss. Therefore, the accuracy and reliability of assay results were not compromised by these procedures. It is the opinion of the Project Geologist that the samples chosen for geochemical assay in 2009 were representative.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com



Figure 21 Dry 2-horsepower Band Saw with Dust Collection System Used by North Rim Staff for Core Slabbing.

## 11.3 The 2011 Sampling Method and Approach

All geochemical sampling activities were carried out at North Rim's Core Lab facility located at 2834 Millar Avenue in Saskatoon, Saskatchewan. Prior to sampling the following steps were systematically carried out:

- Upon arrival at the lab, the core boxes were carefully unloaded from the transport vehicle and laid out in sequential order onto the examining tables.
- North Rim staff counted the core boxes to verify that all of the core delivered matched the core that was listed on the shipping sheet.
- The core boxes were removed from their protective plastic bags and their lids were re-moved and stored under the examining tables in proper order. The core bags remained sealed until sampling procedures or logging processes commenced. If carnallite was present the plastic bags were replaced when the core was not being examined to minimize exposure to the atmosphere.
- Using a cloth or shop towel wetted with a saturated brine solution, the core was cleaned thoroughly by wiping mud and debris from the surface. This step is necessary to correctly identify potash beds, clay seams, and mineralogical changes within the core.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

### 11.3.1 Geochemical Assay Sampling

The following points summarize the steps taken by the laboratory staff during the geochemical sampling of potash core from the Project Area:

- Selection of the correct assay intervals was conducted by North Rim geologists and subsequently confirmed by the client prior to slabbing. The formation contacts were chosen from the geophysical logs as the tops of the formations were occasionally ambiguous in the core making them difficult to identify. The core was then depth corrected by matching intervals of core to their corresponding intervals on the geophysical wireline logs which were collected at the well site.
- Geochemical assay sampling was separated into two separate intervals after depth correcting was completed. The first began at the top of the Prairie Evaporite Formation and extended to the base of the Belle Plaine Member. The second interval included the entire Esterhazy Member. The salt interbed between the Belle Plaine and the Esterhazy Members was not sampled. The first and last samples taken over the two separate potash intervals were intended to capture the initial and final presence of sylvite. In order to make sure all mineralization was captured in sampling, 1.5 – 2.0 m of core was sampled below the Belle Plaine Member and above and below the Esterhazy Member. The first sampling interval was extended beyond the 1.5 – 2.0 m shoulder above the Patience Lake Member and included all of the salt from the base of the Second Red Beds to the top of the Patience Lake Member. This was done in order to capture all the sylvite, as several of the holes contained minor mineralization in the salt above the Patience Lake Member. Sample intervals are clearly outlined in Table 6.

Table 6 Project Area Sampling Intervals

| Sampling Interval | Sampling Interval Top | Sampling Interval Base |
|---|---|---|
| First | Base of Second Red Beds/Top of Prairie Evaporite Formation | 1.5 - 2.0 m below Belle Plaine Member |
| Second | 1.5 - 2.0 m above Esterhazy Member | 1.5 - 2.0 m below Esterhazy Member |

- Once all parties agreed upon the placement of the intervals to be assayed, the core was slabbed lengthwise into halves by laboratory assistants with a dry, 2-horsepower band saw equipped with a dust collection system (Figure 21). Only one piece of core was removed from the assay interval and slabbed at any one time. Once slabbed, the two complimentary core halves were placed back into their respective box in proper stratigraphic order, with both cut surfaces facing up. The cutting process was supervised at all times by a North Rim Geologist. Saw blades were replaced frequently when any breach of core integrity was noted (i.e. crystal fracturing or splintering of core).
- Once the entire assay interval was slabbed, the cut surfaces were wiped down with a cloth wetted with a brine saturated solution to remove any rock powder generated by the cutting process.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

- The upper core half was divided into individual samples by drawing straight lines across the core diameter in permanent black marker, utilizing natural core breaks where possible. The determination of individual samples was based on several parameters outlined in Section 11.3.2. Once the samples were marked out, they were peer reviewed and confirmed prior to any further work.
- As the samples were chosen they were labelled using a numbering scheme that incorporated both the drill hole number and a sample number.

  *For example, sample "KW1336-001" indicates it was the 1st sample from the Karnalyte Wynyard drill hole 13-36-31-16.*
- The sample number was written on the top piece of the core half in permanent black marker. A sample tag bearing this number was prepared to be used for identification in the core photo. Figure 24 illustrates an example of the core photography and sampled core.
- The core was then photographed with a high resolution digital camera (Figure 22).




Figure 22 Sampling Intervals from Karnalyte Drill Hole KW 4B14-24 (Core 1, Boxes 13 and 14)

- Each sample within the assay interval was carefully measured to the nearest centimeter (e.g. 24 cm) and the sample length was recorded into the appropriate assay and logging spreadsheets. The sample intervals and numbers were then transposed onto the cut surface of the underlying second half of the core in the box. This preserves the sample data on one core half, as the other half was destroyed during the sampling process at SRC.
- The upper core half was cross-cut into the designated sample intervals with the band saw by the lab assistants under the direct supervision of the North Rim Geologist. Each sample and its corresponding sample tag were placed into a labelled, waterproof, plastic sample bag and stapled to enclose the sample within the bag.
- Samples were placed into plastic pails or shipping boxes and sealed with lids. The well ID, sample interval, and pail number were labelled on the lids of the pails.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

Shipping sheets were completed that included well information, pail numbers, sample numbers, and contact information, which accompanied the samples to the SRC

It is worth noting that the core recovery was generally excellent for all wells and that the cutting and slabbing of the drill core did not result in any notable material loss. The accuracy and reliability of the assay samples was not compromised during the sampling procedure. It is the opinion of the authors that the samples chosen for geochemical analyses are representative of the selected intervals based on the above discussed parameters and guidelines.

North Rim Geologists delivered the samples to Saskatchewan Research Council Geoanalytical Laboratories (SRC) at 125 – 15 Innovation Boulevard in Saskatoon, Saskatchewan for analysis. There, the samples were crushed, split and analyzed according to the parameters stated in SRC's basic potash analysis package. Quality assurance and quality control (QA/QC) measures were strictly adhered to, including the use of standards, blanks and duplicates throughout the analysis period. North Rim was not involved in procedures performed at SRC once the samples were delivered, nor was North Rim there to supervise the analysis process. Assay results generated were reviewed and approved by SRC prior to release.

### 11.3.2 Controls on Assay Sample Interval Determination

The determination of individual samples collected in 2009, 2010 and 2011 within an assayed interval was based on the following geological parameters:

- Changes in lithology, mineralogy, $K_2O$ grade, crystal size, or insoluble content warranted a new sample. Clay seams were broken out as individual samples, with approximately 1-2 cm of overlap on either side of the seam.
- Samples did not span geological contacts including the upper and lower boundaries of the potash members.
- When possible, existing breaks within the core were used.
- Samples were restricted to approximately 30.0 cm in length.

Visual inspection of the core in conjunction with consultation of the respective gamma, density, and photoelectric curves for the drill holes provided North Rim Geologists with sufficient information to accurately assess changes in mineralogy, lithology, and grade. Within mineralized zones, new sampling intervals were established where changes in grade occurred; low-grade, moderate-grade and high-grade mineralized zones are set at $K_2O$ percentages of >10%, >20% and >30% respectively, estimated from the gamma curves. These $K_2O$ percentages correlate to approximately 140, 270, and 390 API units.

The 2009 sampling controls as stated in KARNALYTE's 2010 NI 43-101 Technical Report prepared by ERCOSPLAN, NREL and FW (2010, /18/) followed the above sampling conditions, but also included two additional conditions:

1. Barren halite and insoluble zones could be sampled at intervals greater than 30 cm, but could not exceed approximately 65 cm in length.
2. The limited amount of core exposed at one time, due to the carnallite content, controlled the sample interval selection. It was undesirable to open more than one core box at a time, resulting in a larger number of samples overall.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

Sampling in 2011 did not include the above two conditions. The first condition did not apply as barren halite beds were not sampled. For the second condition, in 2011 environmental conditions in the laboratory were monitored and controlled at ⩽ 35 – 40 % humidity with a regulated temperature of ~ 20˚C in order to maintain the integrity of the core, making it possible to open more than one box at a time.

### 11.3.3 Rock Mechanical and Dissolution Test Samples

Two KARNALYTE drill holes, KW 2-24 and KW 6-32 were chosen to be sampled for Rock Mechanic Testing and Dissolution Testing in Germany in January of 2011. Samples for rock mechanical testing were selected in such way that representative samples from the different deposit horizons as well as from the rocks that will form the roof of the cavern were available for testing. For dissolution testing a suite of samples with a range in Sylvite and Carnallite content were selected from the drill holes, in order to obtain a reliable estimate about the dissolution behaviour of the rock.

Thirty-two samples were selected from KW 2-24 and 35 samples were chosen from KW 6-32 for testing. The following steps were completed by North Rim personnel at the North Rim Core Lab facility in Saskatoon, SK:

1. As the samples were chosen they were labelled using a numbering scheme that incorporated both the drill hole number and a sample number.

   *For example, sample "02-24-RM013" indicates it was the 13th sample from the Karnalyte Wynyard drill hole 02-24-32-16. The RM prefix signifies it is a Rock Mechanics sample, whereas the DST prefix that was also used, signifies the sample is for Dissolution Test-work.*

2. The core boxes with samples were photographed in a similar manner and using the same equipment as in Section 11.3.1 (Figure 23).




Figure 23 DST Sample 017 from the Karnalyte Drill Hole KW 6-32 (Core 8, Box 17)



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

3. Samples were measured to the nearest centimeter (e.g. 55 cm) and recorded in sample spreadsheets by North Rim personnel. The samples were whole core samples and were selected and removed prior to the assaying and slabbing of the remaining potash intervals which followed the steps outlined in Section 11.3.
4. The whole core samples were individually removed from boxes and cut, if required, by the band saw to the selected size.
5. Place markers were put into the boxes identifying the depth and number of the removed core sample for future reference.
6. Each sample was individually wrapped in plastic wrap, bagged in water proof plastic bags with the appropriate sample tag inside and heat sealed to ensure protection from moisture due to the delicate carnallitic nature of the core.
7. The bagged core samples were then wrapped in small bubble wrap followed by large bubble wrap and placed in waxed cardboard boxes. Newspaper or Styrofoam packing peanuts were packed around the edges of the core to ensure that there would be no shifting during transportation.
8. The sample boxes were labelled on the exterior with the sample number(s) in permanent black marker.
9. 8Samples from KW 2-24 and KW 6-32 were stacked on pallets separately. The pallets were reinforced with wooden supports on all sides and banded together with plastic banding strips. The pallets were also wrapped tightly with plastic wrap to ensure that the stacked boxes were as stable as possible for transport. Signs were posted onto the core pallets stating that the core was “Fragile”, “Needs to be Kept Dry” and to “Keep in Original Packaging” to maintain the core’s integrity. These directions were also noted on the packing slip sent with the shipment.
10. The core was picked up at the North Rim Core Lab facility and shipped through UPS to Erfurt, Germany, accompanied by all the appropriate shipping documents prepared by North Rim and UPS personnel.
11. Upon arrival at the ERCOSPLAN office in Erfurt, Germany, ERCOSPLAN personnel verified the completeness of the shipped samples, divided the samples in RM and DST samples and transported them to the Institute for Rock Mechanics (IfG) Leipzig, who have a special low humidity storage room for salt samples.
12. At the IfG laboratory the samples for dissolution testing were prepared, sealed in plastic and transported to the laboratory of NG-consulting in Sondershausen.
13. The DST samples were unpacked directly before testing, weighted, measured and photographed and put in the dissolution cell. During the experiment the samples were completely dissolved.
14. From RM samples a representative number was selected for Rock Mechanical Test work. These samples were cut (cut off sections were put uniquely in a marked plastic bag) and further prepared for test work. After the test the test samples were re-united with the cut off sections and send to the laboratory for assaying.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

## 11.4 Sampling Preparation Analysis and Security

Samples were taken from historical and new drill core material to verify the reported results and complete the assayed potash sections. Because the boundary conditions for preparation, sampling and security were different for historical core material and new core material, slightly different methods and approaches were used, and are commented on in the following sections.

### 11.4.1 Historical and 2008 Sample Preparation, Analysis and Security

As outlined in full in KARNALYTE's 2010 NI 43-101 Technical Report prepared by ERCOSPLAN, NREL and FW (2010, /18/) examination of the historical data for the Mobil Wynyard DH-11 and Dominion Kandahar DH-10 drill holes offered no information as to sample preparation methods or quality control measures employed prior to dispatch of samples to an analytical or testing laboratory, the method or process of sample splitting and reduction, and the security measures taken to ensure the validity and integrity of samples taken, including:

- If any aspect of the sample preparation was conducted by an employee, officer, direc-tor, or associate of the issuer;
- Any details regarding sample preparation, assaying and analytical procedures used, including the sub-sample size, the name and location of the analytical or testing laboratories;
- Whether the laboratories are certified by any standards association and the particulars of any certification; or
- Any information pertaining to the nature and extent of quality control measures employed, check assays and any analytical and testing procedures which might have been utilized, including any results and corrective actions taken.

Due to the lack of information concerning the adequacy of sampling, sample preparation methods, security and analytical procedures, it was not possible for the authors to offer an opinion as to these aspects other than to state that examination of cores and analytical results suggests that the sampling preparation, analytical procedures, and results achieved by Mobil and Dominion is consistent, in the authors' experience, with those from other exploration permits evaluated at or about the same time.

Since the authors were unable to determine the drill-core cutting procedures, there is the possibility that cores may have been cut by a saw using a water-based fluid as a cooling fluid for the blade. If this were the method employed, then the assay samples may have been affected by preferentially leaching of carnallite and sylvite relative to halite during sampling. This may produce results suggestive of a lower than accurate sylvite and carnallite content. The re-sampled section of DH-11 was treated similarly to the samples from the recent holes as described in the next section.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

### 11.4.2 Sampling Preparation, Analysis and Security for 2009 and 2011 Assays

The following procedures were closely followed to ensure that the core was under the supervision of qualified personnel at all times:

- From the retrieval of the core at the drill site to the shipment of the core to the North Rim Exploration Core Lab in Saskatoon, the core was under the care and supervision of the Drilling Supervisor, Wellsite Geologist or North Rim's Core Supervisor.
- Following the core retrieval, the core was wrapped in plastic, boxed and secured on site under the supervision of the North Rim Core Supervisor or Wellsite Geologist. Immediately following the completion of coring, a hotshot courier (Blackie's Coring or Superior Coring) from the coring company delivered the locked core trailer to North Rim's Core facility in Saskatoon, SK. A detailed shipping slip was sent with the core outlining the shipment contents, date and emergency contact information.
- As soon as the core arrived at the core laboratory, North Rim core lab staff inspected the shipment, signed the shipment invoice and unloaded the core onto the tables in stratigraphic order. From this point forward, North Rim Geologists were responsible for the supervision of the core. The North Rim Core Lab is equipped with an alarm system to ensure the security and integrity of the core when the lab is not under direct surveil-lance. North Rim's core lab is temperature and humidity controlled to prevent rapid deterioration of the core. All samples were selected, cut, and packaged as quickly as possible under the supervision of a North Rim Geologist.
- Samples collected for geochemical assay sampling were secured in plastic bags to ensure they were not exposed to moisture. To preserve sample identification, the sample number was written on the sample in permanent ink, on a sample tag placed inside the bag, and on the bag the core was placed in. The sample bags were sealed and packed into labelled pails or containers and remained sealed until they were opened for processing at the SRC Lab.
- Samples were delivered by North Rim staff to the SRC Laboratories at 125 - 15, Innovation Boulevard in Saskatoon, Saskatchewan, for analysis. Information sent along with the sample shipment included the client name, address, distribution email list, type of geochemical analyses required, and a sample list clearly explaining which samples were stored in each pail.
- When SRC received the core samples at their lab, they signed, dated and returned the North Rim Packing Slip to the North Rim employee who delivered them. After confirming that the sample list matched the samples in the pails, a Sample Receipt Report was e mailed to a pre-determined distribution list.

The following sample preparation procedures were reported as being carried out by SRC employees (Modified from the SRC Geoanalytical Laboratories Sample Report outlining work carried out on samples submitted by North Rim):

- Prepared an in-house sample list and group number for the shipment.
- Labelled sample vials with the appropriate sample numbers.
- Individually crushed all samples in the group.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

- Evenly distributed each sample in the splitter to avoid sample bias. Cleaned the crusher and splitter equipment between each sample using compressed air.
- Split the crushed sample and inserted one portion into the appropriate sample vial.
- All material that did not get analyzed ("reject") was resealed in original labelled plastic bags and stored in plastic pails with appropriate group number marked on the pail.
- Sent vials of material for grinding. The material was placed in a pot, ground for 1 minute then returned to the vial. Vials were visually inspected to ensure fineness of material. Grinding pots were cleaned with compressed air between each sample and cleaned with silica sand and rinsed with water between each group.
- The pulverized samples were placed in a tray and sample paperwork was submitted to the Main Office. Worksheets were created detailing the samples to be analyzed, the type of analyses requested as well as the standards, blanks and split replicates to be completed.
- The samples and paperwork were sent to the Geochemical Laboratory and samples were analyzed using SRC's Basic Potash Package (Soluble Inductively Coupled Plasma [ICP], % Insolubles and % Moisture).
- With each set of 40 samples, 2 potash standards, 1 quartz blank, and 1 sample pulp replicate analysis was completed. After processing the entire group of samples, a split sample replicate was completed. After receiving all results from the Geoanalytical Lab, the QA/QC department completed checks to ensure accuracy.
- Upon completion of the assaying and QA/QC procedures, the geochemical results were e-mailed to the North Rim contact list in a password-protected zip file.

The authors did not directly supervise or observe the above procedures and have relied on the credibility of the SRC Laboratory for the accuracy of the results. According to the SRC Geoanalytical Laboratories Customer Quality Control policy the sample preparation and analytical procedures are of the highest quality and are NI 43-101-compliant. SRC is an International Organization for Standardization (ISO) accredited to 17025 and is independent from North Rim. SRC is Saskatchewan's leading provider of applied research and development and technology commercialization. It is the authors' opinion that the security of the core and analytical procedures performed on the assay samples met with industry standards and best practices and were more than adequate.

### 11.4.3 Solution Mining and Rock Mechanical Test Samples

The samples from dissolution test work were completely dissolved at the end of the test and the resulting brine has been gathered. The remaining insoluble material was also gathered, rinsed with distilled water and the material was dried and weighted for determination of the insoluble content. The brines were analysed by the laboratory of DEUSA International, a small potash producing company in Germany using solution mining of Carnallite, which therefore have good experience in analysis of high mineralized brines.

The samples from rock mechanical analysis were after the tests sent to Kali-Umwelttechnik laboratory (KUTEC) Sondershausen[1], which have extensive experience in

[1] Kali-Umwelttechnik GmbH



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

the analysis of polymineralic and sulfatic salt rock and brine samples and are certified according to DIN EN ISO/IEC 17025 by the Deutsche Akkreditierungssystem Prüfwesen GmbH (DAR). The following parameters were determined at the KUTEC laboratory:

$K^+$, DIN ISO 9964-3 1996-08 (flame emission spectrometry)

$Na^+$, DIN ISO 9964-3 1996-08 (flame emission spectrometry)

$Mg^{2+}$, DIN 38406-E3 2003-03 (atomic absorption spectroscopy)

$Ca^{2+}$, DIN 38406-E3 2003-03 (atomic absorption spectroscopy)

$Cl^-$, DIN 38405-D 1-2 1985-12 (ionchromatography)

$SO_4^{2-}$, DIN 38405-D 1-2 1985-01 (ionchromatography)

Insoluble Content, dissolution and weighing.

The parameters provide the main components for all normal salt rocks. It is the authors opinion that the analytical procedures on these samples met with industry standards and best practices and were more than adequate to allow the use in resource and reserve estimation.

### 11.4.4 Missing Core Sections

Few holes had core losses in the deposit sections (Table 7). For these holes the mineralogy of the missing sections has been estimated from the geophysical logging data. The results of the estimation procedure were verified for consistency using deposit sections that had assaying data and if necessary corrections were made to the procedure to obtain reasonable consistency.

Table 7 Drill Holes with Identified Missing Core Intervals

| Well Name | Member | Intervall from (m below Surface) | Intervall to (m below surface) | Length (m) |
|---|---|---|---|---|
| KW 3A11-27 | Upper Belle Plaine | 988.94 | 988.99 | 0.05 |
| KW 3A11-27 | Upper Belle Plaine | 989.58 | 997.62 | 8.04 |
| KW 4B14-24 | Upper Belle Plaine | 1030.78 | 1038.85 | 8.07 |
| KW 4D14-21 | Patience Lake | 1010.25 | 1012.66 | 2.41 |

The procedure was also used to estimate the sections of KW 2-24 and KW 6-32 for which no assaying data were available as some of the core was kept in store for future rock mechanical test work and not available for assaying.

For the procedure three logs have been used, the density log, the porosity log and the natural gamma log. A first division was made based on the density log. Depth intervals with densities above 2.2 were assigned the mineralogy clay, Anhydrite and Halite. For

these intervals the natural gamma ray count and neutron porosity were taken to be due to the presence of clay and the relative amounts of these minerals were estimated using the density of these three minerals. The relatively low gamma ray counts and low neutron porosity in these samples suggest that this did not result in major divergence.

For all other intervals the following procedure was used:

1. The $K_2O$ content of the rock was estimated using the relation that Bannatyne (1983, /6/) developed for potash bearing rocks of the Elk Point Basin. Originally the Crain & Anderson (1966, /14/) relation was used, but this produced consistently too low $K_2O$ content.
2. Assuming the absence of clay and brine, the neutron porosity relation of Crain & Anderson (1966, /14/) was used to estimate the amount of Carnallite present.
3. The Sylvite content was estimated using total $K_2O$ minus Carnallite K2O.
4. Using the density log and the amounts of Sylvite and Carnallite, the relative amounts of insoluble material and Halite were calculated.
5. A section along the holes was selected for which assays showed high insoluble content and minimal Sylvite and Carnallite content and this was used to derive a linear relation between insoluble content, natural gamma value and neutron porosity value.
6. The measured natural gamma and neutron porosity were corrected for the insoluble amount estimated in step 4 and steps 1 to 3 were repeated to come up with a final mineralogical composition
7. Based on the mineralogy boundaries were defined for deposit and non-deposit and the missing parts the average mineralogy was calculated.
8. The averaged KCl and $MgCl_2$ content over the missing sections were estimated using (0.268*amount of Carnallite + amount of Sylvite) for KCl and (0.343 * amount of Carnallite) for $MgCl_2$.

Care was taken to keep corrections to a minimum and in general the estimated mineralogy was slightly lower in Carnallite and Sylvite than the mineralogy calculated from the assays, resulting in a conservative estimate. The authors suggest that the overall error in Carnallite content estimate for these sections is below 15% for complex sections with the minerals, Carnallite, Halite, Sylvite, Anhydrite and insoluble material and below 5% for sections with relatively simply mineralogy (e.g. Carnallite, Halite or Sylvite, Halite). The resulting error in K2O content estimation is at maximum in the range of 4% and these sections can be included in the resource estimate.

It is the opinion of the authors of this Report that the assays from the samples represent a good and faithful estimate of the chemical composition of the part of the core sampled.

# 12 Data Verification

In this section first the verification of the historical data will be presented followed by a discussion of the 2009/2010 and the 2010/2011 data.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

## 12.1 Historical Data

As the recent drill hole KW 3B4-26 is nearly a duplicate of the drill hole DH-10, the historical hole DH-10 is no longer used for Resource and Reserve Estimation and data verification is not necessary. The new hole confirms the general outline of the historical hole except for the Patience Lake Member.

For DH-11, historical data were used for the sylvinite sections of Patience Lake and Esterhazy Member that were sampled in the 1960s. No comment can be made by the author as to the employment of quality control measures and data verification procedures applied by the initial assayer.

Examination of the drill core from drill hole DH-11 was made by the authors (ERCOSPLAN, NREL & FW 2010, /18/); from that examination the authors are able to state the following:

1. That the drill cores examined show evidence of sampling and analysis as described in the well file reports;
2. That the drill cores have been preserved in cardboard boxes in the core and sample repository of the Saskatchewan Subsurface Geological Laboratory;

and

3. That measurement of assay intervals and stratigraphic markers present in cores generally correlates well with measurements reported in core assays and depths determined from examination of borehole gamma ray-neutron logs.

Certain exploration results and potash mineral resources referred to in this Technical Report (e.g. DH 11) must be considered historical in nature, as calculations of weighted-average grade, thickness etc. is dependent upon original data that has not been duplicated. While the authors have reviewed the original data and are confident that the interpretations based on the data and provided herein are reasonable, the author has not independently verified the data by redoing laboratory assays; however, the new assay program undertaken in 2008 show that new assay results are consistent with the results obtained from the initial historical assays.

Furthermore, a review of the assay program was undertaken by ERCOSPLAN, who found that the “NREL data for the Belle Plaine and Patience Lake Members contained internal laboratory standards and duplicate samples, which showed good agreement indicating good quality, accurate and reproducible results for the analysis. A comparison between the analysis of samples for overlapping intervals from historical and NREL data, show high consistency, suggesting that also the historical data are of good quality” (ERCOSPLAN, 2009, /17/).Because of the good correlation between historical and new assay results and the availability of internal standards and duplicate sample for the more recent dataset, the assay results of DH-11 are taken by the authors to be reliable and representative.

As in all historical assays, data quality will vary and this may slightly affect the estimation of the grade and tonnage of mineral resources. Missing assays and/or intervals where no sample was collected or no assay completed will have an impact on the resource estimation.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

## 12.2 Recent Data

The authors are able to provide verification of the KARNALYTE 2009, 2010 and 2011 exploration program and all associated geochemical data as they were involved in the sampling process and carried out quality control measures to ensure the security and integrity of the core. The sampling and assaying procedures detailed in Sections 10 and 11 of this Technical Report were of the highest quality and are compatible with procedures typically undertaken in industry. There are, however, differences between the 2009/2010 and the 2010/2011 data that will be discussed in the following sections.

### 12.2.1 Assay-to-Gamma Correlation Study

A correlation study between the assay-derived % $K_2O$ data and the associated gamma curves for each hole of the 2009 to 2011 drilling program has been completed. The objective of this study was to cross-reference the two data sets as a data verification procedure. In this study, the two data sets were plotted on the same chart for each hole, with potash grade along the x-axis and depth along the y-axis. The depths recorded by the gamma wireline curve were taken as true depths and the assay sample intervals were adjusted to these curves using a best-fit approach. These adjustments were completed on a per-Member basis over the sampled intervals for each drill hole. There was good overall correlation between the assay and gamma data over all drill holes.

Furthermore for all drill holes a mineralogical interpretation of the geophysical logging was made comparable to section 11.4.4. For all drill holes a satisfactory comparison between mineralogy determined from assaying and from geophysical logging could be obtained.

### 12.2.2 Duplicate Analysis of Samples in an Independent Laboratory

For DH-20 from the 2009/2010 exploration campaign material was sent to the ALS Laboratory in Calgary for verification. The components Na, K, Mg, Ca, Cl, $SO_4$, $H_2O$ as well as insoluble material were analyzed. The relatively large errors in the ionic balance calculated for these analytical results, suggest that the ALS laboratory encountered problems analyzing the very high chloride concentrations of the samples. Chloride was therefore not further used, but assumed to be required to achieve ionic balance. A comparison of the results of the ALS Laboratory with the KCl contents derived from analysis of the same sample by SRC (Figure 24) shows in general a relatively good agreement, with a tendency to slightly lower KCl content in the samples of SRC. A comparison for the $MgCl_2$ content is shown in Figure 25 and shows in general also a good agreement.

This suggest that the analytical results for the new samples provide a good estimate of the KCl and $MgCl_2$ content of the samples, which is on the conservative side if compared to the ALS analysis.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

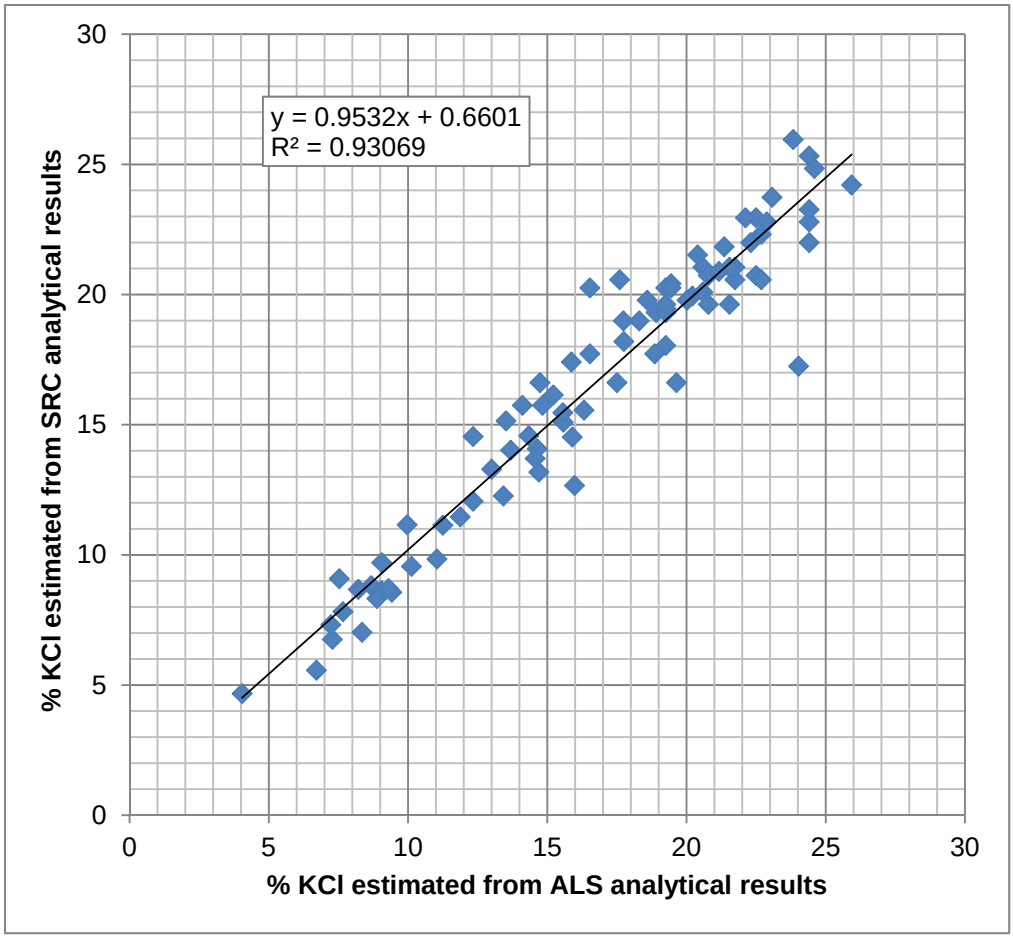



Figure 24 Comparison of the KCl Content Estimated from ALS and SRC Analysis

### 12.2.3 Calculation of Mineralogy from Assay Data and Comparison with Core Description

For the 2010/2011 analyses the main components for salt minerals were reported and as first quality check the charge balance between positive ions ($Mg^{2+}$, $Ca^{2+}$, $Na^{+}$, $K^{+}$) and negative ($Cl^{-}$ and $SO_4^{2-}$, calculated from S) ions is determined for each analysis. If the absolute difference in moles 2*(cations – anions)/(cations+anions) * 100% is larger than 5.0% the analysis is classified as an outlier and should be considered suspect. All 2010/2011 analysis passed this test. This test was not possible for the 2009/2010 analysis as Cl was not analyzed. The Cl content was estimated based on charge balance.

With the chemical analysis the mineralogical composition of the sample was calculated after recalculating the elements from weight % to mol and rearranging them to the basic salts according to following scheme:

(1) Combine cations and anions to simple salts according to the following scheme

1. combine with Cl, in the following order: Na, K, Mg, Ca
2. combine with $SO_4$ in the following order: Ca, Mg, K, Na



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

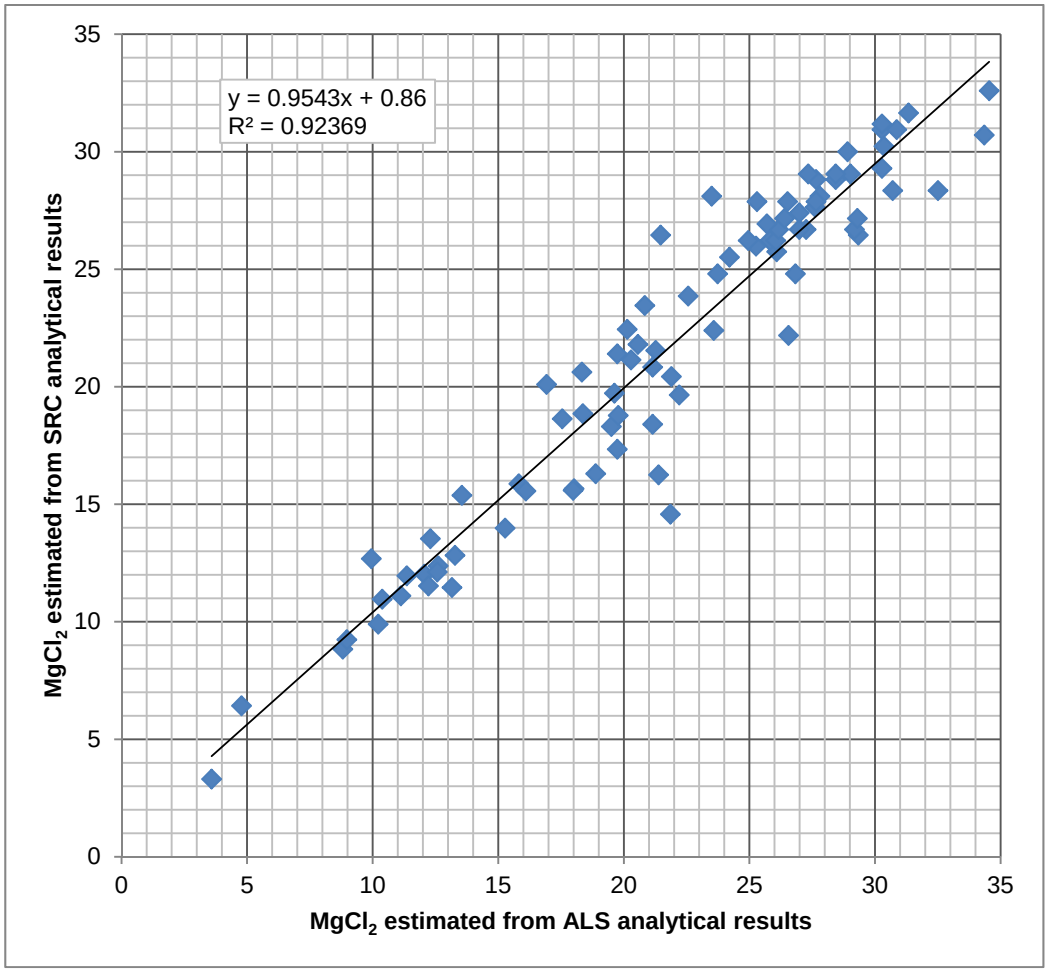



Figure 25 Comparison of the $MgCl_2$ Content Estimated from ALS and SRC Analysis

3. Based on experience with potash deposits, the analyses should be either $MgCl_2$ or $K_2SO_4$ normative, meaning that if $CaCl_2$ or $Na_2SO_4$ results from these combinations, the analysis is suspect.

(2) Combine the simple salts to salt mineralogy according to the following simplified scheme:

1. All NaCl is Halite
2. If $CaCl_2$ is present combine with $MgCl_2$ to Tachyhydrite
3. The remaining $MgCl_2$ is combined 1:1 with KCl to Carnallite
4. If $MgCl_2$ > KCl, remaining $MgCl_2$ to Bischofite
5. If KCl > $MgCl_2$ and $MgSO_4$ available, combine remaining KCl 1:1 to Kainite
6. If $K_2SO_4$ > $MgSO_4$ or$CaSO_4$/2, Arcanite, otherwise with $CaSO_4$ and $MgSO_4$ to Polyhalite
7. If remaining KCl > $MgSO_4$, remaining KCl after Kainite to Sylvite, otherwise remaining $MgSO_4$ to Kieserite



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

8. Remaining $CaSO_4$ to Anhydrite

The mineralogy was recalculated to masses of elements, including the crystal water content. The sum of these elements together with the insoluble content should be close to 100.

Using this procedure all 2009 to 2011 analyses provided results with a mineralogy which is comparable to the mineralogy from the core descriptions. Only minor amounts (< 1 %) of minerals not expected in the deposit (e.g. Tachyhydrite, Kieserite, Kainite and Polyhalite) result, suggesting that the analysis is consistent. The occurrence of some calculated Bischofite could mean that $MgCl_2$ is overestimated or KCl underestimated, but can also be explained by assuming that minor brine filled porosity existed in the samples. The deposit, being a Carnallite deposit, requires such porosity brine to be $MgCl_2$ rich.

The authors of the Report consider the assays for $K^+$ and $Mg^{2+}$ to be sufficiently precise and accurate to be used for carnallititte and sylvinite resource and reserve estimation purposes.

# 13 Mineral Processing and Metallurgical Testing

To the knowledge of the authors, seven types of mineral processing and metallurgical test work have been performed:

- Dissolution testing of samples from the deposit (ERCOSPLAN, 2011, /19/);
- Evaporation and crystallization test work with the assumed production brine composition (SWENSON, 2011, /47/);
- Milling and grinding tests on crystallized KCl (ALSTOM, 2011, /1/,/2/) and a mixture of KCl and wheat for pan granulation (ALSTOM 2012, /3/);
- Detail thermodynamic modelling of the Evaporation and Crystallization circuit and updated of Mass Balances and Process Flow Sheets (Whiting, 2013, /51/);
- Pilot test work on the MOP pan granulation process (Mars Mineral, 2013, /41/);
- Pilot solution mining test work (ERCOSPLAN; 2016, /23/);
- Confirmation of the Basic Magnesium Carbonate Production Process in the Laboratory (SRC, 2014, /46/);
- Test on a brine disposal well to the deadwood formation to determine potential capacity (GeoEngineers, 2013, /29/);

which will be summarized below.

## 13.1 Dissolution Testwork

Dissolution test work dissolves typical core material from the deposit to obtain design data for the development of a Sylvite/Carnallite solution mining operation. The results received from the dissolution test work confirm the deposit compositions inside the cavern. The



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

influences of cavern operation like depth of the injection and production point, the blanket level as well as the geological structures that will also have an impact on the brine grade cannot be tested, but these influences are principally well known and will require optimization of the proposed process during the pre-production preparation stage of the first generation of caverns.

For dissolution testing the test sample is placed in the leaching cell. The sample is dissolved in the leaching cell primarily at its vertical surfaces in a rising flow of water or brine. In this process the insoluble components sink to the bottom of the cell while the brine flows out through the top of the cell. Leaching is carried out at constant solvent temperature of 50 °C and constant solvent flow rate of 10.0 l/h. During the dissolution process the out flowing brine shows an increasing density. The leaching process is terminated when the out flowing brine increases less than 0.001 g/cm³ during the last 30 minutes.

During the dissolution test, following data are measured as functions of time:

- Weight loss of the specimen,
- Density of brine,
- Temperature of the solvent and the brine,
- Volume flow of solvent or brine (inflow = outflow).

All these data have been automatically recorded every 30 sec. During the test in total 4 brine samples were taken from each run at different densities. The brine samples are used to estimate the brine composition produced in future full size caverns as well as for calculation of the composition of the Carnallite/Sylvinite core sample. The dissolution test quantified the decrease of the dissolution rate with increasing brine concentration.

For the KARNALYTE project in total 19 samples have been investigated:

- 4 Patience Lake Member samples,
- 7 Belle Plaine Member samples,
- 8 Esterhazy Member samples.

The evaluation of the data from these tests can be summarized regarding the dissolution kinetics as follows:

- At 50°C the dissolution rates of Carnallite are approx. 5 times higher compared to Halite and approx. 2.5 times higher compared to Sylvinite.
- The dissolution rates vary as expected between Halite, Sylvinite (40%) and Carnallitite (70%) and correlate with theoretical data from other deposits
- Most samples show a low content of insolubles. However the dissolution residues (insolubles) can have a considerable impact on the dissolution rate and subsequently on (irregular) cavern shape development. The available drill hole data suggest that deposit horizons chosen for production solution mining do not contain significant amounts of insolubles. Further dissolution test work should detail the relation between dissolution rate and insoluble content for different Carnallitite/Sylvinite ore grades, for eventual addition of such horizons to the resources or reserves and in this way to optimize the operation as this extends the lifetime of a cavern and decreases the number of new caverns annually required.
- The dissolution test results establish a correlation between dissolution rate and KCl/Carnallite content of the Carnallitite ore and which will aid in better control of the cavern shape development. This relation can be used at each future well.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

- Based on the gamma log and the relation between dissolution rate and Carnallite/KCl content found at the dissolution test a “dissolution rate log “ can be generated for each future well which indicates fast growing and slow growing areas inside the cavern.

Regarding the phase chemistry the dissolution test work can be summarized as follows:

- The data from the dissolution test work covered the typical dissolution path for Carnallite ore containing some amount of Sylvinite.
- The dissolution path of all KARNALYTE Carnallitite samples is a more or less a straight line following the KCl content of the Carnallitite sample (no over proportional KCl enrichment or KCl-reduction).
- The KARNALYTE Carnallitite gives KCl values of approx. 80% of the 50°C saturation level and stoichiometric $MgCl_2$ values.
- The NaCl value reaches a super saturation of approx. 106%.
- A sufficient correlation between the KCl brine grade and the Carnallite/Sylvite content of the Carnallitite was found,
- The sufficient correlation of the KCl brine grade with the Carnallite/Sylvite content of the Carnallitite ore is able to provide a KCl brine grade log and subsequently adjusted by the dissolution rate log provides an estimate of KCl brine grade over the height of the potash layer.
- This allows optimization of the mining cuts and prediction of the KCl brine grade for each well (dual well cavern) and for each mining cut.

In the opinion of the authors of this Report, the dissolution test work shows that the carnallitite in the project area behaves the same as the carnallitite in other carnallitite deposits and can be used for potash production through solution mining of the carnallitite and sylvinite is feasible.

Detailed evaluation of the dissolution tests for the definition of the mining method and production brine composition, show that to obtain a production brine from the brine field with a continuous high KCl grade, that reduces the requirements for evaporation of water from the brine before KCl crystallization it is necessary that only the portions of the deposit that contain on average high grade carnallitite (>50% Carnallite) and high grade sylvinite (> 20% Sylvite + Carnallite) are mined as discussed in section 7.4

## 13.2 Evaporation and Crystallization Test Work

Two sets of laboratory experiments were performed in the Swenson Test Center in Harvey, Illinois to maximize the KCl product yield and purity using the processing methods as described in section 17.2.

Brine provided by KARNALYTE was used in the experiments but was conditioned with further salts (i) to match the initial feed composition and (ii) to match the evaporator feed composition by using process recycle brines. The brine compositions are given in Table 8.

The experimental laboratory runs were thermodynamically modeled using OLI MSE aqueous chemistry software. The results of the thermodynamic modeling were used to optimize the conditions to maximize product yield and purity.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

Table 8 Composition of the Original Brine Sample and the Conditioned Brine Used in the Tests

| | Original Sample | Initial Feed | Evaporator Feed |
|---|---|---|---|
| NaCl (%) | 15.80 | 12.2 | 9.1 |
| KCl (%) | 6.11 | 9.2 | 7.9 |
| $MgCl_2$ (%) | 6.80 | 8.6 | 14.7 |

The tests produced crystal crops consisting of KCl crystals with purity of 93.9% for Sample 1 and 88.7% for Sample 2. The overall results of the tests agreed reasonably well with the predicted values but are below the typical yield and recovery values for a typical plant operation. Additional development of the model should be done including minimization of recycles and purges, to produce a more robust operating design.

The test was designed for KCl production from crystallization only and no data for the composition of the Magnesium Chloride rich end brine was obtained, as no flash evaporation stage was included.

## 13.3 Milling and Grinding Test

Two types of test were performed at the ALSTOM Power Raymond Operations pilot test facility to obtain background information on the equipment design for the KARNALYTE operation.

A first series of Abrasion and Grindability test was performed to determine the “Raymond” number (grindability) and the wear index (Wi). The Raymond number relates to the ease in which a mineral can be ground and relates to mill capacity and product size, the wear index provides one with insight as to the expected wear rate on mill components.

The data obtained on samples of crystallized potash are in the range used in the original design and validate the CAPEX and OPEX estimates for the milling and grinding facility.

A second series of test was performed to optimize the preparation of the “prill production feed”, which requires grinding crystallized potash with soft wheat to a 200 mesh powder. These grinding tests were done separately and after the FEED preliminary design by FOSTER WHEELER. They confirmed that the general type of grinding equipment tested is adequate for the process as well as that the grinding produces an intimate mixture of potash and wheat required for next treatment steps.

## 13.4 Detailed Thermodynamic Modelling of the Evaporation and Crystallization Circuit

As basis for the detailed design phase, the evaporation and crystallization process circuit from the feasibility study (FOSTER WHEELER & ERCOSPLAN, 2011, /26/), has been



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

thermodynamically modelled by WHITING EQUIPMENT CANADA INC. to provide more detailed material balances and improved process flow sheets (e.g. WHITING, 2013, /51/). These modelling calculations confirmed the overall design from the feasibility study, but have resulted in minor changes to the process flow sheets. An important outcome of this study has been that it sets relatively stringent boundary conditions on the overall composition of the production brine coming from the brine field. The proposed design will not perform to design parameters, when the production brine composition differs significantly from the design brine. This limits the relation between Sylvinite and Carnallitite Production Brine to stay within the boundaries 25:75 % and 10:90% Sylvinite:Carnallitite. Production brine compositions outside this compositional range can still be processed, but at a significantly lower recovery.

## 13.5 Pilot Test Work on the Pan Granulation Process

The pan granulation process had been tested by KARNALYTE (internal report) on a laboratory scale, and material was provided to Mars Mineral pelletizing technology, to test the process on a larger scale.

In the tests about 400 liters of KCl with small amount of wheat as binder was brought in different amounts in a 3 foot diameter by 8 inch deep rotating pan to produce pellets. All tests at different % of rated capacity of the pan produced at minimum 75 % of durable pellets in the required range between 2 to 4 mm.

The test work indicate that the pan granulation process works also at larger scale equipment, but further test work to industrial scale will be required.

## 13.6 Pilot Solution Mining Test Work

Management of Karnalyte advised the authors of the Technical Report that two small scale solution mining tests were conducted by the company in September 2010 and the fall of 2011 (the "Tests"). The Tests were conducted without the input or supervision of the Qualified Persons and since the results could not be independently verified by the QP were not considered to be in compliance with NI 43-101. The Tests were not designed to obtain production brine concentrations and were conducted at temperatures lower than those recommended in the Technical Report. The Tests provided brine concentrations that varied from 6% to 12% KCl. The September 2010 test was run in such way that it was not possible to determine which parts of the deposit were dissolved. The fall 2011 test was deposit Member specific but limited in scope and scale and therefore the results of the Tests were not used by the authors in preparing the Technical Report as in the opinion of the authors the Tests did not provide relevant information for the estimation of the production brine composition, except that the composition of the brines indicate that Carnallite dissolution was taking place.

In 2015 a plan was developed to change the completion of this well (DH-11) and use this for a small scale pilot solution mining test operation on the carnallitite of the Belle Plaine Member. This test operation has been designed as a controlled solution mining operation with a blanket at elevated solvent temperatures during the production leaching phase The



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

pilot test has been designed and is supervised by ERCOSPLAN (2016, /23/). The goal of this small scale pilot test is twofold:

- To provide brine temperature development data combined with flow rate and brine composition data that allow calibration of a numerical cavern temperature model for the deposit, which can be used for extrapolation under different conditions.
- To establish the KCl saturation that can be reached at a reasonable flow rate during production leaching.

The completion of the well and the required surface infrastructure for the operation was finished early in May 2016 and the operation started. The operation is ongoing as of the date of the report and will continue till at least September 2016. Only at that time a complete evaluation of the results is possible.

## 13.7 Confirmation of the Basic Magnesium Carbonate Production Process in the Laboratory

The LYNTEK (2012, /38/) pre-feasibility study, described a process for the production of basic Magnesium Carbonate (BMC) that has a fine grain size and large surface area, developed by LYNTEK and KARNALYTE engineers. To confirm the suitability of this process KARNALYTE has requested the Saskatchewan Research Council Mining and Mineral Division to duplicate and confirm the overall process and to determine product qualities.

The test work by SRC (2014, /46/) shows that proposed process allows to produce > 99 % purity BMC.

The products have either a block like or a rod like habitus and a high BET surface area, making it suitable for a number of applications as described in section 19.2.2.

SRC proposes further test work to:

- Define process parameters to produce a range of surface areas
- Tailor the crystal morphologies
- Optimize particle size distribution
- Optimize bulk density
- To determine calcination parameters for producing in later stage high purity, medium to high reactive magnesium oxide powder.

## 13.8 Brine Disposal Well Test

To test, whether the planned disposal of excess $MgCl_2$ brine and NaCl- brine from redissolved solid NaCl in the Deadwood formation is feasible, KARNALYTE requested GeoEngineers (2013, /29/) to perform an injection test in this formation. The results from GeoEngineering (2013, /29/) of the high pressure injection testing in the first deep disposal Well 91/11-16-032-16W2M (Well 91/11-16), authorized under Well License #13B033, located to the northwest of the planned processing facility are summarized below.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

Water supply required for the injection testing was obtained by groundwater abstraction from the Blairmore Aquifer water supply Well 121/02-16-032-16W2M/00 (Well 2-16). Injection was performed through a 177.8 millimetre (mm) diameter liner slotted over the full thickness of the Deadwood Formation to a total depth of 1,560 metres (m). In summary:

The fluid level in Well 91/11-16 prior to testing was logged at 144 m below the kelly bushing (m KB), equivalent to a downhole pressure of 14.2 megapascals (MPa) at the formation midpoint.

- A step-rate injection test was completed in increasing injection rate increments of 1.5 cubic metres per minute (m³/min) up to a maximum rate of 9 m³/min.
- Each step was targeted to last 15 minutes, but was continued until the requisite total fluid volume had been injected.
- The maximum surface injection pressure of 12.4 MPa was attained during the sixth and final step.
- The instantaneous shut-in pressure recorded after injection ceased at the end of the step-rate test was 8.6 MPa at the surface.
- Downhole pressures were monitored throughout injection at a depth of 1,440m KB.
- Pressure fall-off was monitored during post-injection temperature logging, and had declined to zero (vacuum) at the surface by the following morning (20 hours after the end of the step-rate test).

The step-rate injection test of the Deadwood Formation in Well 91/11-16 was completed successfully within the constraints of the Ministry of Economy approval number MRO 777/12 dated 26 November 2012 under Licence No. 13B033. A maximum injection rate of 9 m³/min (12,960 m³/day) was sustained for 10 minutes during the final step at constant pressure with no indication that the formation parting pressure had been exceeded.

The injectivity testing of Well 91/11-16 confirmed that the Deadwood Formation at the Wynyard Carnallite Project site has sufficient injection capacity to accept the deep disposal of waste brine fluids via injection wells at rates of at least 12,960 m³/day. Additional injection capacity may be possible by comingling injection simultaneously into both the Winnipeg and Deadwood Formations.

Adequate capacity to meet Phase 1 operational demand for the disposal of up to 21,600 m³/day should be obtained with two such disposal wells, with a third required as standby.

# 14 Mineral Resource Estimates

In preparing any estimates presented in this Technical Report, the authors were guided by the following definition used in the CIM Definition Standards (CIM, 2014, /10/):

> ‘A Mineral Resource is a concentration or occurrence of solid material of economic interest in or on the Earth’s crust in such form, grade or quality and quantity that there are reasonable prospects for eventual economic extraction.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

> The location, quantity, grade or quality, continuity and other geological characteristics of a Mineral Resource are known, estimated or interpreted from specific geological evidence and knowledge, including sampling."

The term "Mineral Resource" covers mineralization and natural material of intrinsic economic interest that has been identified and estimated through exploration and sampling and within which mineral reserves may subsequently be defined by the consideration and application of modifying factors. The phrase 'reasonable prospects for economic extraction' implies a judgment by the Qualified Person in respect of the technical and economic factors likely to influence the prospect of economic extraction.

It is the opinion of the authors that historical drilling and subsequent 3D exploration drilling in 2009 and 2011 by KARNALYTE are sufficient to confirm that Subsurface Mineral Leases KLSA 010, KL 247 and the western portion of KL 246 have substantial sylvinite and/or carnallitite beds within the Patience Lake, Belle Plaine, and Esterhazy Members.

The extraction of potash by solution mining by Mosaic Inc. at its Belle Plaine potash solution mine since 1964 from sylvinite and by DEUSA in Germany since 1989 at its carnallitite deposit demonstrates that commercial recovery of potash from carnallitite and sylvinite is possible. In the case of carnallitite deposits, it is also feasible to recover magnesium chloride from the highly concentrated magnesium chloride stream remaining after potash production as it is done by DEUSA in Germany and planned by KARNALYTE.

In the opinion of the authors, there exists a reasonable prospect for eventual economic extraction of the sylvinite carnallitite from Esterhazy, Belle Plaine and Patience Lake Members of the Prairie Evaporite. Therefore, Subsurface Mineral Leases KLSA 010, KL 247 and the western portion of KL 246 contain a Mineral Resource of sylvinite and carnallitite.

Two versions of the Mineral Resource Estimate were calculated. A grid model was created in Vulcan software and a resource estimate was calculated as the primary, reported estimate. A second estimate was calculated using a Polygon Resource Estimate methodology. This second estimate was completed as a verification and check for the Vulcan tonnage calculation. Both resource estimates used the intervals and grades reported below in Table 9.

## 14.1 Assumptions and Methodology

A Mineral Resource Estimate is a volume of rock at a specific grade. The volume (tonnage) calculation uses the density of the rock, thickness and area. Density used for the project is in the range of 1.8t/m³ for carnallitite interval or 2.1t/m³ for sylvinite interval, which was calculated from the mineral composition of the rock as determined from assays. Thickness is determined from the geologic model and areas are determined in a phased deduction process. The following is a summary of assumptions and methodologies used to estimate the thickness and area of the Resource Estimate. Both the primary (Grid Model) and verification (Polygon Model) estimates are discussed below.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

## Table 9 Summary of Drill Hole Data Used for the Mineral Resource Calculation

| Patience Lake | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Drill Hole** | **From (m)** | **To (m)** | **Thickness (m)** | **%$K_2O$** | **%KCl** | **%Carnallite** | **%$MgCl_2$** | **%Insolubles** |
| Mobil Wynyard 1 20 32 16 | 926.52 | 939.47 | 12.95 | 9.26 | 14.66 | 45.06 | 15.44 | 3.54 |
| Karnalyte Wynyard 1-16-32-16 | 934.83 | 942.64 | 7.81 | 10.70 | 16.93 | 63.37 | 21.71 | 7.37 |
| Karnalyte Wynyard 9-15-32-16 | 920.58 | 928.14 | 7.56 | 12.56 | 19.91 | 70.13 | 24.05 | 3.91 |
| Karnalyte Wynyard 2-24-32-16 | 911.40 | 919.03 | 7.63 | 12.70 | 20.11 | 67.82 | 23.23 | 3.99 |
| Karnalyte Wynyard DD 2C6-32-4B6-32-31-16 | 998.53 | 1008.79 | 10.26 | 10.56 | 16.71 | 63.11 | 21.63 | 3.31 |
| Karnalyte Wynyard DD 4B14-24-4A13-24-31-16 | 1006.70 | 1022.10 | 15.40 | 12.39 | 19.62 | 37.47 | 12.84 | 5.70 |
| Karnalyte Wynyard DD 4D14-21-1C14-21-31-16 | 1010.21 | 1022.25 | 12.04 | 9.79 | 15.49 | 56.57 | 19.39 | 5.14 |
| Karnalyte Wynyard 13-36-31-16 | 970.79 | 977.29 | 6.50 | 13.78 | 21.81 | 60.86 | 20.86 | 0.10 |
| Karnalyte Wynyard DD 3C4-8-2B6-8-32-16 | 965.12 | 973.21 | 8.09 | 11.91 | 18.85 | 72.13 | 24.72 | 4.53 |
| Karnalyte Wynyard DD 3B4-26-1A1-27-31-16 | 1000.80 | 1003.95 | 3.15 | 18.64 | 29.49 | 35.43 | 12.14 | 5.08 |
| Karnalyte Wynyard DD 2A11-12-3D6-12-32-16 | 940.41 | 950.13 | 9.72 | 10.80 | 17.09 | 66.59 | 22.82 | 3.83 |
| Karnalyte Wynyard DD 3A11-27-3A11-27-31-16 | 988.18 | 999.68 | 11.50 | 9.38 | 14.85 | 37.21 | 12.76 | 6.63 |
| ***Interbedded Salt*** | | | | | | | | |
| **Drill Hole** | **From (m)** | **To (m)** | **Thickness (m)** | **%$K_2O$** | **%KCl** | **%Carnallite** | **%$MgCl_2$** | **%Insolubles** |
| Mobil Wynyard 1 20 32 16 | 939.81 | 945.93 | 6.12 | 1.62 | 2.56 | 7.39 | 2.53 | 2.93 |
| Karnalyte Wynyard 1-16-32-16 | 942.64 | 951.14 | 8.50 | 1.21 | 1.91 | 9.18 | 3.14 | 4.15 |
| Karnalyte Wynyard 9-15-32-16 | 928.14 | 936.26 | 8.12 | 1.94 | 3.07 | 11.54 | 3.95 | 2.39 |
| Karnalyte Wynyard 2-24-32-16 | 919.03 | 927.40 | 8.37 | 1.67 | 2.64 | 9.95 | 3.41 | 3.39 |
| Karnalyte Wynyard DD 2C6-32-4B6-32-31-16 | 1008.79 | 1017.12 | 8.33 | 2.45 | 3.88 | 14.85 | 5.09 | 3.33 |
| Karnalyte Wynyard DD 4B14-24-4A13-24-31-16 | 1022.10 | 1030.78 | 8.68 | 2.40 | 3.80 | 14.91 | 5.11 | 4.02 |
| Karnalyte Wynyard DD 4D14-21-1C14-21-31-16 | 1022.25 | 1030.38 | 8.13 | 2.39 | 3.79 | 14.56 | 4.99 | 2.12 |
| Karnalyte Wynyard 13-36-31-16 | 977.29 | 985.44 | 8.15 | 2.51 | 3.97 | 15.50 | 5.31 | 3.88 |
| Karnalyte Wynyard DD 3C4-8-2B6-8-32-16 | 973.21 | 982.15 | 8.94 | 1.75 | 2.75 | 10.75 | 3.68 | 3.83 |
| Karnalyte Wynyard DD 3B4-26-1A1-27-31-16 | 1003.95 | 1011.90 | 7.95 | 2.27 | 3.60 | 14.03 | 4.81 | 3.09 |
| Karnalyte Wynyard DD 2A11-12-3D6-12-32-16 | 950.13 | 959.20 | 9.07 | 2.03 | 3.21 | 12.36 | 4.23 | 3.45 |
| Karnalyte Wynyard DD 3A11-27-3A11-27-31-16 | 999.68 | 1007.53 | 7.85 | 2.06 | 3.26 | 12.25 | 4.20 | 2.63 |
| ***Upper Belle Plaine*** | | | | | | | | |
| **Drill Hole** | **From (m)** | **To (m)** | **Thickness (m)** | **%$K_2O$** | **%KCl** | **%Carnallite** | **%$MgCl_2$** | **%Insolubles** |
| Mobil Wynyard 1 20 32 16 | 945.93 | 955.23 | 9.30 | 11.12 | 17.60 | 65.67 | 22.50 | 2.20 |
| Karnalyte Wynyard 1-16-32-16 | 951.14 | 961.18 | 10.04 | 11.28 | 17.86 | 69.65 | 23.87 | 2.89 |
| Karnalyte Wynyard 9-15-32-16 | 936.26 | 948.70 | 12.44 | 12.08 | 19.12 | 66.27 | 22.71 | 2.49 |
| Karnalyte Wynyard 2-24-32-16 | 927.40 | 936.84 | 9.44 | 11.86 | 18.78 | 72.50 | 24.84 | 3.04 |
| Karnalyte Wynyard DD 2C6-32-4B6-32-31-16 | 1017.12 | 1026.51 | 9.39 | 11.49 | 18.16 | 70.35 | 24.12 | 2.86 |
| Karnalyte Wynyard DD 4B14-24-4A13-24-31-16 | 1030.78 | 1042.12 | 11.34 | 10.94 | 17.32 | 59.62 | 20.43 | 4.59 |
| Karnalyte Wynyard DD 4D14-21-1C14-21-31-16 | 1030.38 | 1041.04 | 10.66 | 11.54 | 18.26 | 68.57 | 23.50 | 3.52 |
| Karnalyte Wynyard 13-36-31-16 | 985.44 | 991.16 | 5.72 | 12.60 | 19.94 | 68.57 | 23.50 | 2.49 |
| Karnalyte Wynyard DD 3C4-8-2B6-8-32-16 | 982.15 | 993.62 | 11.47 | 11.51 | 18.22 | 70.78 | 24.25 | 2.89 |
| Karnalyte Wynyard DD 3B4-26-1A1-27-31-16 | 1011.90 | 1023.58 | 11.68 | 10.80 | 17.10 | 66.98 | 22.96 | 3.03 |
| Karnalyte Wynyard DD 2A11-12-3D6-12-32-16 | 959.20 | 970.69 | 11.49 | 10.75 | 17.01 | 60.82 | 20.84 | 3.96 |
| Karnalyte Wynyard DD 3A11-27-3A11-27-31-16 | 1007.53 | 1019.77 | 12.24 | 12.02 | 19.02 | 67.47 | 23.13 | 2.60 |
| ***Lower Belle Plaine*** | | | | | | | | |
| **Drill Hole** | **From (m)** | **To (m)** | **Thickness (m)** | **%$K_2O$** | **%KCl** | **%Carnallite** | **%$MgCl_2$** | **%Insolubles** |
| Mobil Wynyard 1 20 32 16 | 955.23 | 961.05 | 5.82 | 7.49 | 11.86 | 29.66 | 10.16 | 2.25 |
| Karnalyte Wynyard 1-16-32-16 | 961.18 | 966.40 | 5.22 | 11.21 | 17.74 | 28.54 | 9.78 | 2.96 |
| Karnalyte Wynyard 9-15-32-16 | 948.70 | 951.92 | 3.22 | 12.51 | 19.81 | 22.90 | 7.84 | 1.84 |
| Karnalyte Wynyard 2-24-32-16 | 936.84 | 942.60 | 5.76 | 8.42 | 13.35 | 36.27 | 12.42 | 2.91 |
| Karnalyte Wynyard DD 2C6-32-4B6-32-31-16 | 1026.51 | 1032.52 | 6.01 | 6.20 | 9.87 | 37.11 | 12.72 | 3.31 |
| Karnalyte Wynyard DD 4B14-24-4A13-24-31-16 | 1042.12 | 1045.65 | 3.53 | 7.02 | 11.11 | 20.87 | 7.15 | 1.44 |
| Karnalyte Wynyard DD 4D14-21-1C14-21-31-16 | 1041.04 | 1045.62 | 4.58 | 5.46 | 8.63 | 26.84 | 9.20 | 2.55 |
| Karnalyte Wynyard 13-36-31-16 | 991.16 | 1000.01 | 8.85 | 7.35 | 11.63 | 44.13 | 15.13 | 2.87 |
| Karnalyte Wynyard DD 3C4-8-2B6-8-32-16 | 993.62 | 997.26 | 3.64 | 10.32 | 16.33 | 20.02 | 6.86 | 2.06 |
| Karnalyte Wynyard DD 3B4-26-1A1-27-31-16 | 1023.58 | 1027.30 | 3.72 | 8.13 | 12.86 | 23.85 | 8.17 | 1.64 |
| Karnalyte Wynyard DD 2A11-12-3D6-12-32-16 | 970.69 | 973.78 | 3.09 | 9.54 | 15.10 | 22.56 | 7.73 | 1.27 |
| Karnalyte Wynyard DD 3A11-27-3A11-27-31-16 | 1019.77 | 1023.20 | 3.43 | 9.60 | 15.20 | 24.94 | 8.55 | 0.92 |



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

| *Esterhazy - Z1* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Drill Hole** | **From (m)** | **To (m)** | **Thickness (m)** | **%$K_2O$** | **%KCl** | **%Carnallite** | **%$MgCl_2$** | **%Insolubles** |
| Mobil Wynyard 1 20 32 16 | 989.33 | 996.34 | 7.01 | 9.85 | 15.59 | 8.48 | 2.91 | 2.15 |
| Karnalyte Wynyard 1-16-32-16 | 994.48 | 999.12 | 4.64 | 12.68 | 20.07 | 13.28 | 4.55 | 2.50 |
| Karnalyte Wynyard 9-15-32-16 | 980.57 | 986.49 | 5.92 | 9.77 | 15.46 | 8.86 | 3.04 | 1.80 |
| Karnalyte Wynyard 2-24-32-16 | 971.21 | 978.65 | 7.44 | 11.71 | 18.54 | 11.11 | 3.80 | 1.40 |
| Karnalyte Wynyard DD 2C6-32-4B6-32-31-16 | 1060.38 | 1062.85 | 2.47 | 16.83 | 26.61 | 16.71 | 5.72 | 1.46 |
| Karnalyte Wynyard DD 4B14-24-4A13-24-31-16 | 1074.51 | 1082.36 | 7.85 | 13.81 | 21.85 | 9.63 | 3.30 | 1.63 |
| Karnalyte Wynyard DD 4D14-21-1C14-21-31-16 | 1073.65 | 1075.65 | 2.00 | 12.74 | 20.17 | 15.53 | 5.32 | 1.68 |
| Karnalyte Wynyard 13-36-31-16 | 1028.10 | 1030.32 | 2.22 | 14.63 | 23.17 | 10.95 | 3.76 | 1.67 |
| Karnalyte Wynyard DD 3C4-8-2B6-8-32-16 | 1025.65 | 1030.12 | 4.47 | 9.60 | 15.18 | 12.36 | 4.23 | 1.42 |
| Karnalyte Wynyard DD 3B4-26-1A1-27-31-16 | 1055.05 | 1062.02 | 6.97 | 9.92 | 15.70 | 11.17 | 3.83 | 2.02 |
| Karnalyte Wynyard DD 2A11-12-3D6-12-32-16 | 1001.08 | 1003.25 | 2.17 | 10.59 | 15.62 | 17.74 | 6.08 | 1.77 |
| Karnalyte Wynyard DD 3A11-27-3A11-27-31-16 | 1050.49 | 1057.15 | 6.66 | 13.38 | 21.17 | 10.32 | 3.54 | 2.28 |
| *Esterhazy - Z2* | | | | | | | | |
| **Drill Hole** | **From (m)** | **To (m)** | **Thickness (m)** | **%$K_2O$** | **%KCl** | **%Carnallite** | **%$MgCl_2$** | **%Insolubles** |
| Mobil Wynyard 1 20 32 16 | 1003.66 | 1005.79 | 2.13 | 14.62 | 23.15 | 6.35 | 2.19 | 0.44 |
| Karnalyte Wynyard 1-16-32-16 | 1008.30 | 1011.86 | 3.56 | 12.65 | 20.02 | 6.23 | 2.14 | 0.55 |
| Karnalyte Wynyard 9-15-32-16 | 989.89 | 996.95 | 7.06 | 12.74 | 20.17 | 5.74 | 1.97 | 0.87 |
| Karnalyte Wynyard 2-24-32-16 | 985.99 | 989.06 | 3.07 | 16.61 | 24.76 | 7.36 | 2.52 | 0.22 |
| Karnalyte Wynyard DD 2C6-32-4B6-32-31-16 | 1073.96 | 1076.49 | 2.53 | 8.24 | 13.04 | 8.67 | 2.98 | 0.35 |
| Karnalyte Wynyard DD 4B14-24-4A13-24-31-16 | 1088.37 | 1091.71 | 3.34 | 12.93 | 20.45 | 6.66 | 2.28 | 0.31 |
| Karnalyte Wynyard DD 4D14-21-1C14-21-31-16 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Karnalyte Wynyard 13-36-31-16 | 1040.74 | 1044.75 | 4.01 | 11.30 | 17.89 | 5.89 | 2.02 | 0.25 |
| Karnalyte Wynyard DD 3C4-8-2B6-8-32-16 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Karnalyte Wynyard DD 3B4-26-1A1-27-31-16 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Karnalyte Wynyard DD 2A11-12-3D6-12-32-16 | 1013.95 | 1017.99 | 4.04 | 14.03 | 22.21 | 4.94 | 1.70 | 0.18 |
| Karnalyte Wynyard DD 3A11-27-3A11-27-31-16 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

### 14.1.1 Step 1: Build Geologic Model

For the Polygon Method verification, results from drilling programs completed within the Project Area, including historical drilling and subsequent 3D exploration drilling in 2009 and 2011 by KARNALYTE, were used, together with drill hole collar locations. There is no grid surfaces generated in the Polygon Method, as those by Grid Model, so there is no interpolation of thickness or dip changes over the distance of a polygon. All elevation, grade or thicknesses changes are abrupt changes at the polygon boundaries.

For the Grid Model, a geological model was constructed from drill hole data derived from the drilling programs as presented here. The model was developed with the Vulcan Software Package, using the Integrated Stratigraphic Modeling Tool, which integrates the stratigraphic and assay data into a comprehensive 3-D Grid Model. Quality grids (i.e. grids displaying the distribution of variable grades) were developed for all key stratigraphic intervals (Table 9) three potash members, the salt back, and interbeds and for all variables, including $K_2O$, MgO, insolubles, and carnallite. Interpolation for assay values and potash member distribution was done using inverse distance squared weighting. Thickness interpolation for the stratigraphic intervals between wells was done using inverse distance squared weighting. Any missing or unavailable assays were ignored by the software (treated as lost core).

The following is a list of the data used to compile the geological model and their uses:

- Data for bed thickness and orientation:
    - Drill hole collar locations (bottom hole locations were used for the directional drilling wells, i.e., KW13-24, KW14-21, KW06-32, KW01-27, KW06-12, and KW11-27).
    - All holes are assumed vertical at the time of this Technical Report.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

  - Detailed geological interpretations for definition of bed boundaries (note, core descriptions were already corrected to wireline log depths and confirmed with assay results).
  - Table 9 bed boundary values were used in the geological model.
- Data for Mineralization:
  - Drill hole assay data is the main source of all grade values stated in the Resource Estimate, except for a few wells (KW06-32, KW02-24) and the missing core, where grades have been estimated from gamma ray equivalent calculation techniques over intervals.

### 14.1.2 Step 2: Determine Area used In Resource Estimate

The area used in the Resource Estimate is developed in the following manner:

- Draw Radius of Influence (ROI) around each drill hole
  - Measured Mineral Resource:
    - Inside the 3D area: Within 1.0 km of a cored and assayed well in the Esterhazy interval, Patience lake and Belle Plaine intervals.
    - Outside the 3D area: Within 0.8 km area of a cored and assayed well in the Esterhazy interval, Patience lake and Belle Plaine intervals.
  - Indicated Mineral Resource:
    - Inside the 3D area: Between 1.0 km and 2.2 km from a cored and assayed well in the Patience Lake and Belle Plaine interval, and between 1.0 km and 1.6 km for the Esterhazy Interval.
    - Outside the 3D area: Between 0.8 km and 1.6 km from a cored and assayed well for all intervals.
  - Inferred Mineral Resource:
    - Inside the 3D area: Between 2.2 km and 6.0 km from a cored and assayed well for the Patience Lake and Belle Plaine interval, and between 1.6 km and 6.0 km maximum radius for the Esterhazy interval.
    - Outside the 3D area: Between 1.6 km and 6.0 km from a cored and assayed well for all intervals.
- Deduct lands not part of KARNALYTE's permits
  - Deduct all free hold lands
  - Trim to property boundaries
- Deduct all known seismic collapse anomalies, as provided by RPS as shape files. No further buffers to the anomaly outlines have been applied.
- For areas outside the 3D seismic boundary a 25% deduction was used for undetectable anomalies. Within 3D seismic areas a 10% deduction was used.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

The areas listed in Table 10 and Table 11 includes the areas illustrated on the maps, as well as the above listed deductions.

- In determining the potential extent, quality, and volume of potash mineral resource, the authors were guided by the following principles of exploration techniques and sampling methods commonly employed by other Saskatchewan potash mine operators:
- The primary method to determine thickness and concentration of the potash mineralization is drill core obtained from conventional oil well drilling equipment. The 2009 and 2011 drilling exploration programs were designed with a spacing that allows radius of influence to cover most of Leases KLSA 010, KL 247 and the western part of KL 246 and provided sufficient core to confirm thickness and grade of potash mineralization in these areas.
- A Radius of Influence (ROI) is defined around each drill hole or underground mine working with information about interpolated thickness and grade of the deposit between them. The size of the ROI depends on the resource category and the confidence in the continuity of the deposit.
- As described in the guidelines for mineral resource estimation for potash (CIM, 2014, /10/), potash deposits typically display consistency of grade and thickness over large ar-eas and it is more important to define areas, where the potash mineralization is absent, which is typically done in Saskatchewan using 3D seismic.
- 3D Seismic surveys confirmed the continuity of the sylvinite and carnallitite mineralization on KLSA 010, KL 246 and the western portion of KL 247.

The definition of the mineralized zones and defining cut offs has been listed previously in Section 7.4 and in Table 9.

The township fabric used to determine areas in ArcMap (GIS) was from Information Services Corporation (ISC). The geological features were taken from the Geological Atlas of Saskatchewan (extracted from the atlas in 2011) produced by the Saskatchewan Geological Survey. The well base map is correlated to the Geoscout based NAD83 coordinates, however these were not verified. There is the possibility that this may introduce a small error into the area calculation; however, it is the opinion of the authors that the error is insignificant for the purposes of this Technical Report.

Work completed to date allows for the estimation of the potash mineralization in terms of “Inferred”, “Indicated” and “Measured” Resources as defined by the CIM Guidelines. Using those parameters the data is sufficient to classify mineralization into the Inferred, and Indicated Mineral Resource estimate categories. A Feasibility Study (FOSTER WHEELER & ERCOSPLAN, 2011, /26/) has been completed, allowing for the identification of a Measured Mineral Resource. Due to the completion of the Feasibility report, the Measured and Indicated Mineral Resources have been converted to Proven and Probable Mineral Reserves. Therefore, this Technical Report will present estimations for the “Inferred” Resource Category and Proven and Probable Mineral Reserves.

The process followed for determination of areas used in the Resource and Reserve Estimate is explained below. Please also refer to the following figures: Figure 26 shows the extent of the ROI for each drill hole for the Patience Lake and Belle Plaine Interval and the associated Reserves, and Figure 27 shows the extend of the ROI for each drill hole for the Esterhazy Interval and the associated Reserves. The area for calculation is determined by measuring the total area of KARNALYTE- granted Crown mineral lands within the drill hole radii of influence and deducting areas not held by KARNALYTE such as freehold



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

mineral title lands, and areas deemed to have been affected by salt dissolution and collapse anomalies.

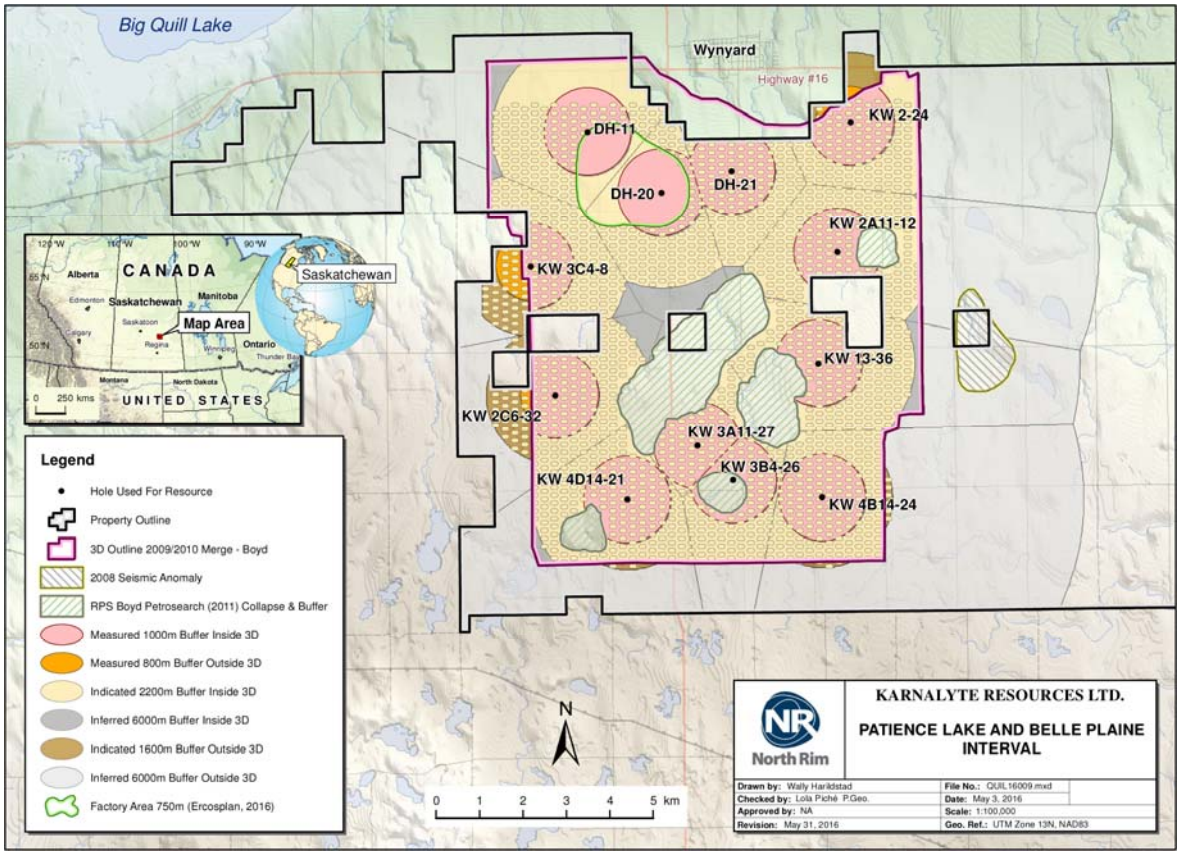



Figure 26 Determination of Radii of Influence for Mineral Resources and Reserves of the Patience Lake and Belle Plaine Interval

For conventional mining operations, a ROI for the inferred category in the order of 3.2 km is usually taken, as the presence of an undetected anomalous zone, poses severe problems for the mining operation. For solution mining, the restrictions on lateral and vertical continuity of the deposit are less severe, because with the detection of an anomalous zone during cavern preparation, it is relatively straightforward to abandon that cavern and drill a new well away from the anomalous zone, without negative influence on the overall operation. Furthermore, solution mining takes material from all three members instead of only from a single member as conventional mines and therefore is more flexible in case of barren zones in a single member. For these reasons, the ROI has been extended to 6 km, in line with other solution mining resource estimates (Potash One Technical Report October 2010 and its Revised November, 2010 Report, Western Potash Technical Report, 2011).



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

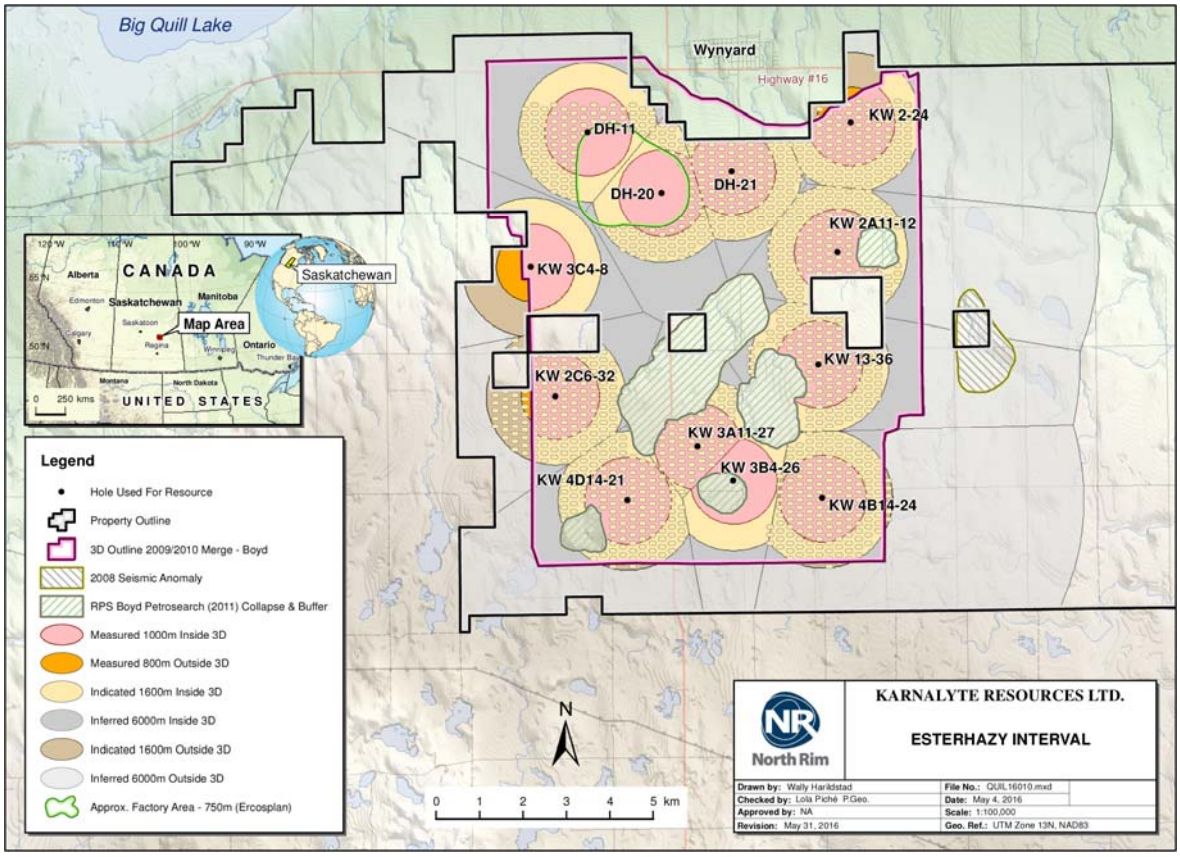



Figure 27 Determination of Radii of Influence for Mineral Resources and Reserves of the Esterhazy Interval

The ROIs used for the Resources are comparable to those used by Potash One in their 2010 October Report. The ROI for the Carnallite-rich Patience Lake and Belle Plaine Members is slightly larger than for other operations that use Sylvite because the carnallite probability maps provide a tool not available to the other operation. The probability maps provide a tool not available to the other operations to have a positive indication of the presence of the mineral explored for away from a drill hole. It is the opinion of the authors, based on their experience with other projects and their interpretations of the data re-viewed in detail that the ROIs used are acceptable and appropriate and are consistent with industry practice in Saskatchewan for this particular project.

- Conversion of Resources to Reserves:
  - For the areas with ROI for Measured and Indicated Mineral Resources, a proposed cavern layout was provided by ERCOSPLAN. All caverns from the original cavern plan that had a centroid residing in the ROI of Measured and Indicated Mineral Resources were used. Any caverns with centroids residing outside of the Indicated ROI were removed.
  - Caverns with centroids in the ROI of Indicated Mineral Resources were designated Probable Mineral Reserves even if portions of the caverns overlapped with the Inferred Mineral Resources ROI.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

  - Caverns with centroids in the ROI of Measured Mineral Resources were designated Proven Mineral Reserves even if portions of the caverns overlapped with the Indicated Mineral Resources ROI. After completing the above steps an area balance was calculated for all caverns that overlapped ROI edges to ensure that no excess tonnes were being moved up in classification. 0, Figure 29, Figure 30, and Figure 31 illustrate the results of the area balance conducted for the proven and probable reserves for Patience Lake and Belle Plaine and the Esterhazy. In all cases the total acres removed from inside an ROI exceeded the acres added from outside the ROI. This area balance and the provided figures shows that the total acres added from outside the ROIs is minimal, and is balanced by the areas of caverns that were removed from the inside of the ROIs. The above process resulted in a net result of more caverns (by area) being moved down into a less favorable resource/reserve category, and thus the authors were satisfied with this process.

- Determination of Remaining Mineral Resources:
  - After the cavern layout for proven and probable reserves was finalized, an 80 m buffer distance was drawn around all caverns for ground support.
  - All areas within the area of caverns (including the 80 m buffer) were removed from the mineral resource calculation. The areas between the individual caverns are required for ground support and subsidence control and will not be mined.
  - All remaining areas were used to calculate the Mineral Resource.

The mineral resource estimated in this Technical Report is classified as an Inferred Mineral Resource. A small portion of the Inferred Mineral Resource includes some areas that were originally within the Indicated and Measured ROIs. These areas were excluded from the Proven and Probable Mineral Reserves for a variety of reasons. The exclusion of these areas from the current mine plan is the reason for changing the classification of these resources to inferred. The exclusion of these resources from the reserves highlights the judgement of the qualified persons that there are some impediments or doubt as to the ‘reasonable prospects for economic extraction’ for these areas. These areas are termed the “restricted areas” and will be discussed in more detail in the coming sections.

The estimation of the amount of KCl and $MgCl_2$ that can be mined and processed from these in-situ resources requires further steps:

1. The in-situ tonnage is multiplied by the KCl concentration and in case of the carnallitite with the $MgCl_2$ concentration to obtain in situ KCl tonnage and $MgCl_2$ tonnage;
2. A deduction for overall solution mining recovery is included as detailed in section 16.4 to provide the amount of mineable KCl and MgCl2, these are not reported as resources;
3. A typical 90% recovery of the process plant for KCl (i.e. no refinery runs at 100% recovery) and 5.8% for $MgCl_2$ is used, to provide an estimate of the amount of KCl and $MgCl_2$ product that can be produced from the resource.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

| | Area Type | Caverns Affected | Area Sum ($m^2$) | Area Sum (hectares) | Area Sum (acres) |
|---|---|---|---|---|---|
| | | | | | |
| Inside ROI: | Included in Proven Reserve | 81 | 936741.07 | 93.67 | 231.47 |
| | Excluded from Proven Reserve | 78 | 272944.40 | 27.29 | 67.45 |
| | | | | | |
| Outside ROI: | Included in Proven Reserve | 81 | 266302.25 | 26.63 | 65.80 |
| | Excluded from Proven Reserve | 78 | 885541.77 | 88.55 | 218.82 |
| | | | | | |
| Area Balance: Area included from outside ROI minus area excluded from inside ROI | | | | | -1.65 |

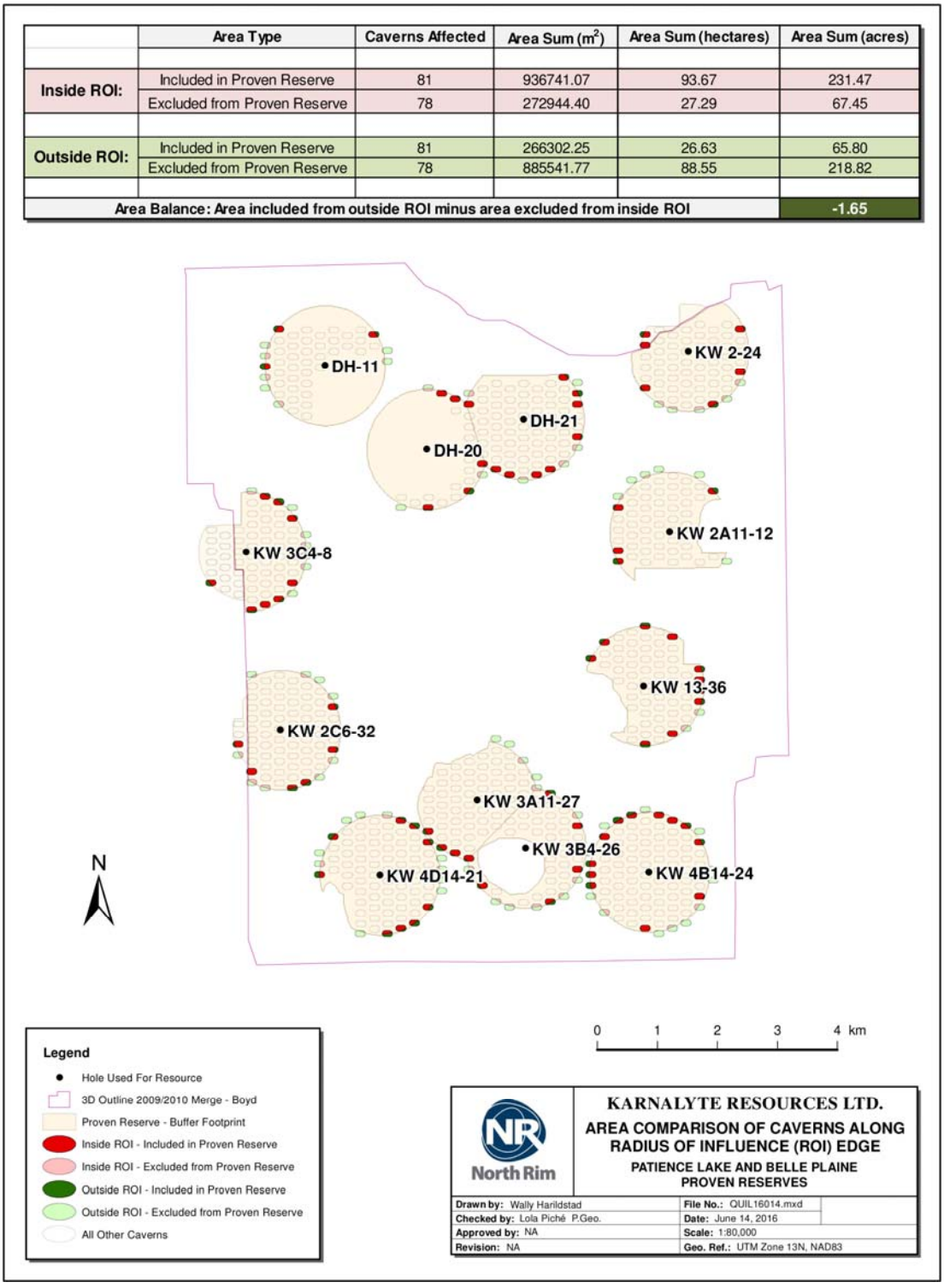



Figure 28 Area Balance of Caverns Along ROI Edges: Patience Lake and Belle Plaine, Proven Mineral Reserves



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

| | Area Type | Caverns Affected | Area Sum ($m^2$) | Area Sum (hectares) | Area Sum (acres) |
|---|---|---|---|---|---|
| | | | | | |
| **Inside ROI:** | Included in Probable Reserve | 129 | 1521814.29 | 152.18 | 376.05 |
| | Excluded from Probable Reserve | 81 | 266302.25 | 26.63 | 65.80 |
| | | | | | |
| **Outside ROI:** | Included in Probable Reserve | 125 | 394143.60 | 39.41 | 97.40 |
| | Excluded from Probable Reserve | 81 | 936741.07 | 93.67 | 231.47 |
| | | | | | |
| **Area Balance: Area included from outside ROI minus area excluded from inside ROI** | | | | | **31.60** |

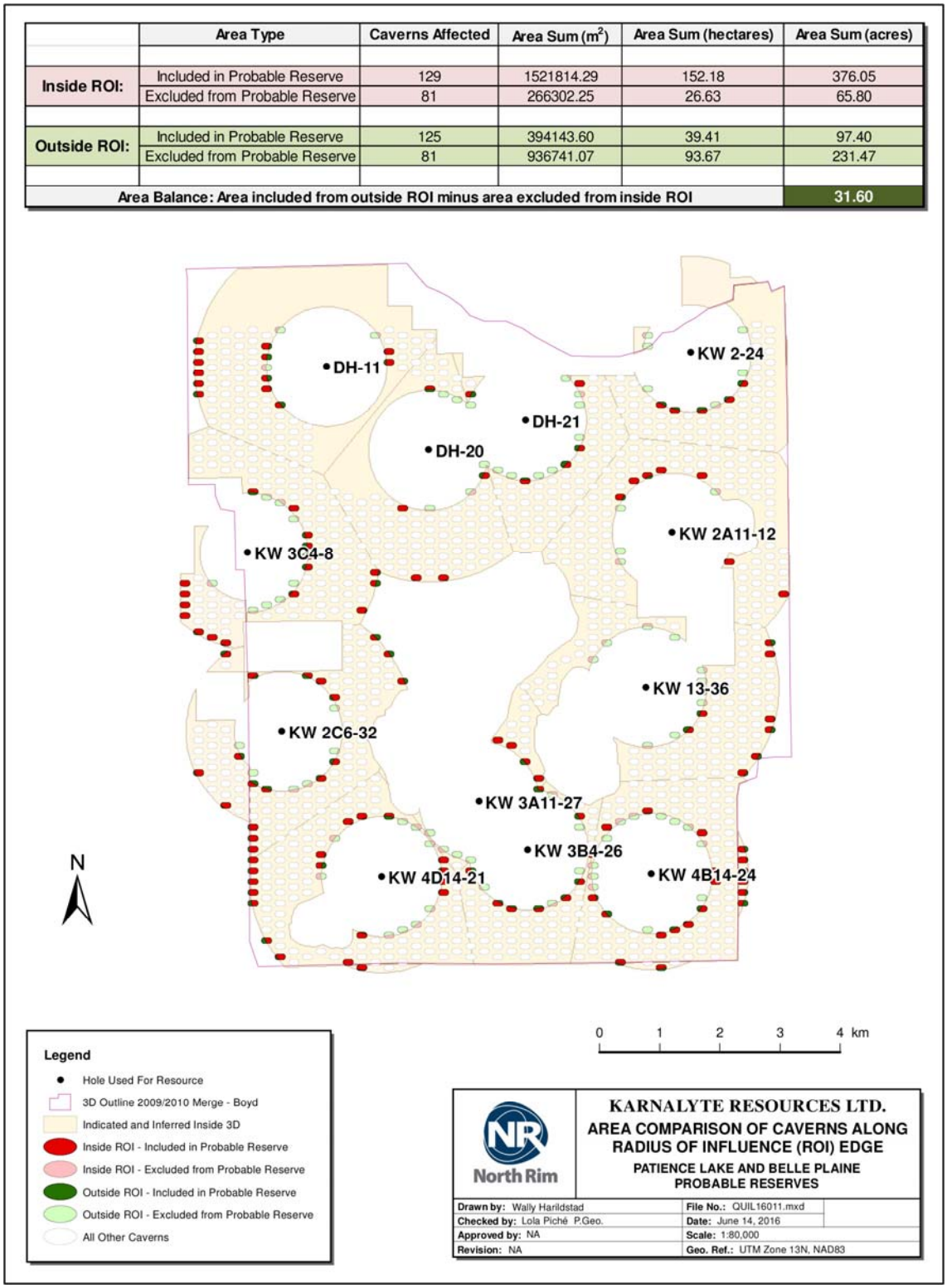



Figure 29 Area Balance of Caverns Along ROI Edges: Patience Lake and Belle Plaine, Probable Mineral Reserves



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

| | Area Type | Caverns Affected | Area Sum ($m^2$) | Area Sum (hectares) | Area Sum (acres) |
|---|---|---|---|---|---|
| | | | | | |
| **Inside ROI:** | Included in Proven Reserve | 67 | 769731.32 | 76.97 | 190.20 |
| | Excluded from Proven Reserve | 63 | 200620.45 | 20.06 | 49.57 |
| | | | | | |
| **Outside ROI:** | Included in Proven Reserve | 67 | 225378.59 | 22.54 | 55.69 |
| | Excluded from Proven Reserve | 63 | 735079.92 | 73.51 | 181.64 |
| | | | | | |
| **Area Balance: Area included from outside ROI minus area excluded from inside ROI** | | | | | **6.12** |

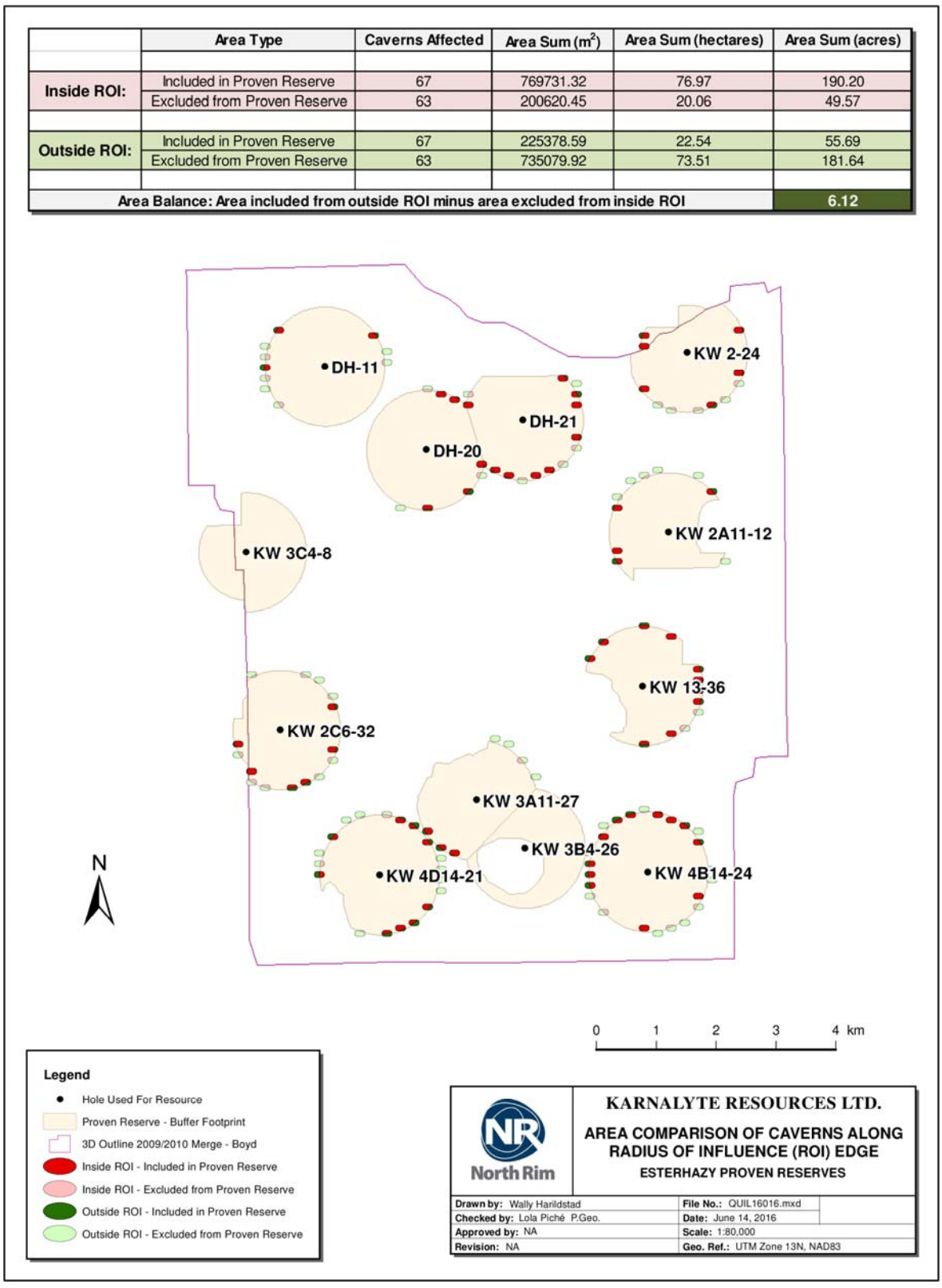



Figure 30 Area Balance of Caverns Along ROI Edges: Esterhazy Proven Mineral Reserves



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

| | Area Type | Caverns Affected | Area Sum ($m^2$) | Area Sum (hectares) | Area Sum (acres) |
|---|---|---|---|---|---|
| | | | | | |
| **Inside ROI:** | Included in Probable Reserve | 127 | 1477929.87 | 147.79 | 365.20 |
| | Excluded from Probable Reserve | 67 | 225378.59 | 22.54 | 55.69 |
| | | | | | |
| **Outside ROI:** | Included in Probable Reserve | 127 | 408323.25 | 40.83 | 100.90 |
| | Excluded from Probable Reserve | 67 | 769731.32 | 76.97 | 190.20 |
| | | | | | |
| **Area Balance: Area included from outside ROI minus area excluded from inside ROI** | | | | | **45.21** |

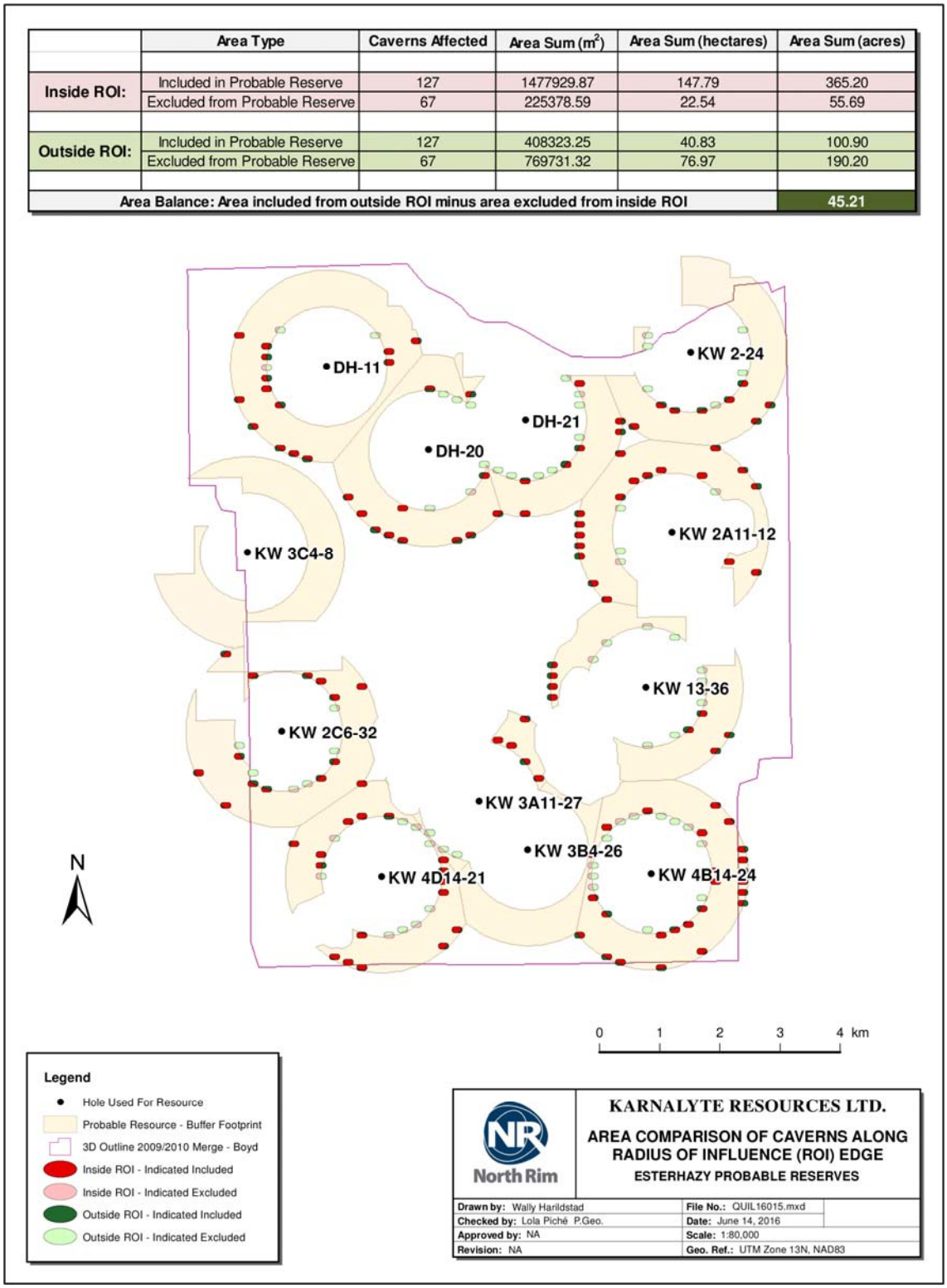



Figure 31 Area Balance of Caverns Along ROI Edges: Esterhazy Probable Mineral Reserves



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

The transformation/recovery factors for $MgCl_2$ are relatively low and variable depending on the planned potash production because the magnesium products are made from the potash production endbrine and the present magnesium product plant design requires only a part of the total endbrine for an annual production of 100,000 tonnes of $MgCl_2$ brine and 104,000 tpy of hydromagnesite. The remaining end brine from potash production is considered waste and not part of the resources or reserves.

## 14.2 Inferred Mineral Resource

In preparing this Technical Report, the authors were guided by the following definition (CIM, 2014, /10/):

> "An 'Inferred Mineral Resource' is that part of a Mineral Resource for which quantity and grade or quality are estimated on the basis of limited geological evidence and sampling. Geological evidence is sufficient to imply but not verify geological and grade or quality continuity."

It is the opinion of the authors that the "Inferred" class of Mineral Resource will be limited to the resource in the Patience Lake and Belle Plaine Members within 6.0 km of the cored and assayed drill holes excluding any established Reserves and any known seismic anomalies that may be present due to dissolution or collapse features. The Inferred Resource was estimated using the Grid Model. Interpolation of member thickness and grades between wells were done using inverse distance squared weighting according the method described in Section 14.1. Figure 32 and Figure 33 show the area of influence for each cored well for the Inferred Mineral Resource estimation. The inferred Mineral Resource for the Patience Lake, Belle Plaine and Esterhazy members are summarized in Table 10.

It cannot be assumed that all or any part of the Inferred Mineral Resource as presented herein will be upgraded to an Indicated or Measured Mineral Resource because of additional exploration. Since confidence in the estimate is insufficient to allow the meaningful application of technical and economic parameters, or to enable an evaluation of economic viability worthy of public disclosure, any form of mineral resource estimation, including Inferred Mineral Resource, must be excluded from estimates forming the basis of feasibility or other economic studies. In general, Inferred Mineral Resources are considered too specula-tive geologically to be included in any economic considerations such as preliminary feasibility or feasibility studies.

For this Technical Report, most of the Indicated and Measured Mineral Resource (based on proximity to drill holes) have been upgraded to Probable and Proven Mineral Reserves respectively. There are however four distinct areas where "Indicated" and "Measured" Resources have been re-classified to Inferred resources in this Technical Report based on the judgement of the qualified per-sons that there is some impediments or doubt as to the 'reasonable prospects for eco-nomic extraction' for these areas.

The four areas are (Refer to Figure 26, Figure 27, Figure 32 and Figure 33):

- Small parcels of land along the perimeters of ROIs
- Small parcels of land next to collapse anomalies
- Small parcels of land next to the property boundary, including the boundaries of Freehold land



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

- "Restricted Areas" around the plant area, which can theoretically be mined at the end of the operation and the major highway in the area

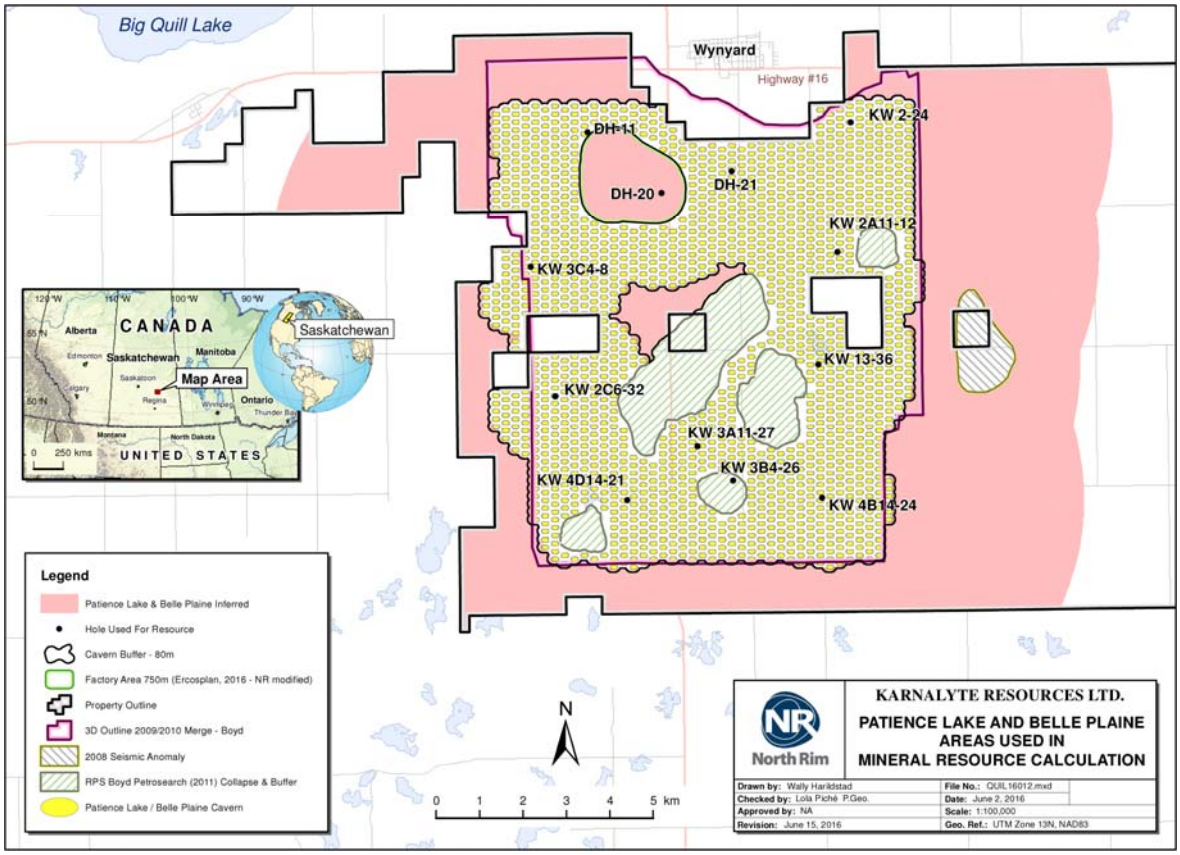



Figure 32 Area Used for the Inferred Mineral Resource Estimation for the Patience Lake and Belle Plaine Interval

For areas along the perimeters of ROIs (such as west of KW2C6-32), there are some areas of the ROI for Indicated Mineral Resources that were not large enough for additional probable reserve cavern placement. The deduction of these areas is generally balanced by addition of some Inferred ROI areas where caverns extent slightly past the Indicated Mineral Resource ROI. Again, the decision was made to include cavern fields that had a centroid residing in the Indicated Mineral Resource ROI in the Probable Mineral Reserve category.

Small parcels of land next to collapse anomalies and next to the outer property boundary that were too small for cavern placement are also being included in the Inferred Mineral Resource category. There is still confidence in the presence of the in-situ resource in these areas, but the close proximity to the collapse features brings doubt to the 'prospect for economic extraction' in these areas.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

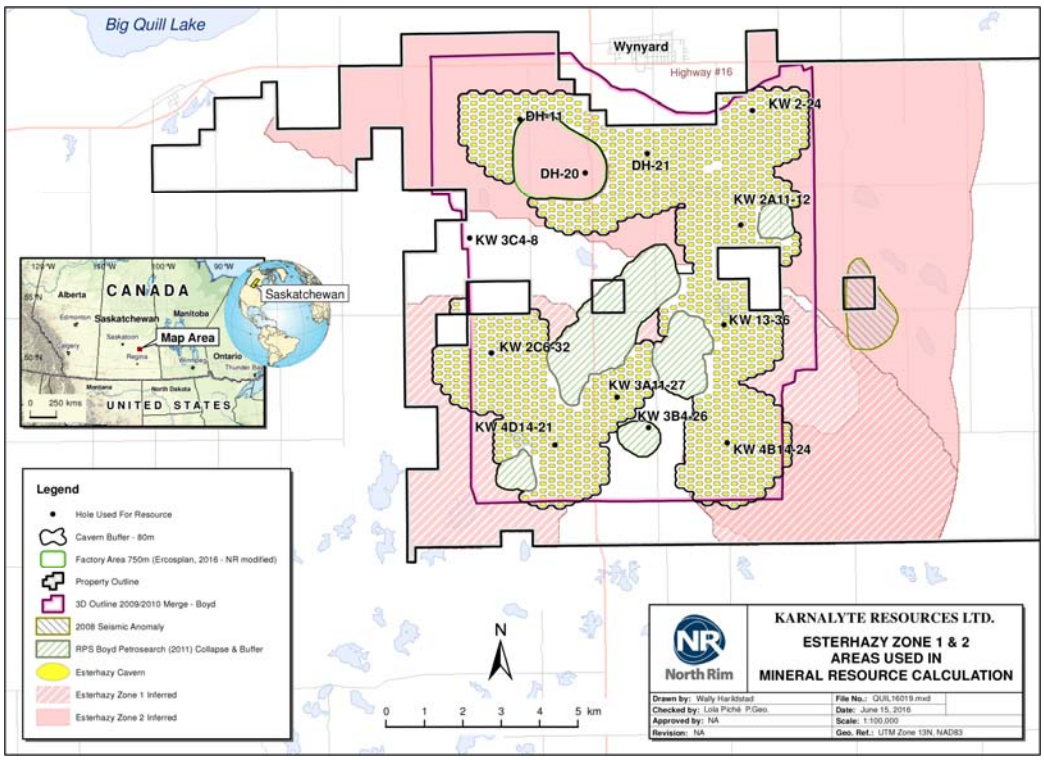



Figure 33 Area Used for the Inferred Mineral Resource Estimation for the Esterhazy (Zone 1 and Zone 2) Interval

A small parcel of land near the property boundary next to the freehold lands are also being classified as inferred resources for the same reasons listed above. However, if KARNALYTE were able to acquire rights to these freehold areas these areas could easily be upgraded to Indicated Mineral Resources or Reserves, based on the proximity to current drill holes. Without acquisition of the freehold lands there is not enough room for additional caverns, and thus doubtful that the in-situ resource could be extracted for these small areas.

The final area of inferred resources under discussion is the “restricted areas” around the plant and immediately adjacent to the major highway in the area (Highway #16) and the buffered distance along the western edge of the property. At the request of KARNALYTE, a buffer distance of 0.5 miles was added around the highway in order to ensure subsidence from solution mining does not affect the highway. Similarly, a buffer of approximately 900 m has been requested by ERCOSPLAN around the plant area and associated surface infrastructure (near DH-20). For both of these areas there is confidence in the presence of the in-situ resource, but again there is doubt as to the mineability of this resource because of the proximity to the highway and the processing site. There is no current mine plan for either of these areas. However, according to ERCOSPLAN, at the end of the mine life, it is theoretically possible to mine economically at least a part of the pillar around the plant before differential subsidence will start to impede operations. It is also possible that as the mine progresses, and further study of the subsidence history is made that some of the restricted buffer area near the highway may be deemed extractable. It is therefore reasonable to assume that some of the restricted areas may be mined in the future, but not all. For this reason, these areas are being reported as an inferred resource.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

Table 10 Summary of the Inferred Mineral Resources

**INFERRED RESOURCE SUMMARY TABLE**

| Member | Area with Additional Exclusions[1-3] ($km^2$) | Weighted Thickness[4] (m) | Average[6] KCl Grade (%) | Average[6] $MgCl_2$ Grade (%) | In-Place Tonnage[7] (MMT)[5] | Total Extraction Tonnage[8] (MMT)[5] | Gross KCl Tonnage (MMT)[4] | Gross $MgCl_2$ Tonnage (MMT)[4] | Net[9] KCl Tonnage (MMT)[5] | Net[9] $MgCl_2$ Tonnage (MMT)[5] | Net KCl Product[10] (MMT)[5] | Net $MgCl_2$ Product[10] (MMT)[5] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Patience Lake** | 92.03 | 9.58 | 18.81 | 19.22 | 1,191.2 | 434.8 | 224.1 | 228.9 | 73.6 | 75.2 | 66.2 | 4.4 |
| **Interbedded Salt** | 92.03 | 8.19 | 3.20 | 4.20 | 1,103.9 | 402.9 | 35.3 | 46.4 | 11.6 | 15.2 | 10.4 | 0.9 |
| **Upper Belle Plaine** | 92.03 | 10.30 | 18.13 | 22.90 | 1,273.9 | 465.0 | 231.0 | 291.7 | 75.9 | 95.8 | 68.3 | 5.6 |
| **Lower Belle Plaine** | 92.03 | 4.83 | 13.58 | 9.76 | 671.5 | 245.1 | 91.2 | 65.5 | 30.0 | 21.5 | 27.0 | 1.2 |
| **Carnallitite Subtotal** | 92.03 | 32.90 | 13.71 | 14.92 | 4,240.5 | 1,547.8 | 581.5 | 632.6 | 191.0 | 207.8 | 171.9 | 12.1 |
| **Esterhazy Zone 1** | 35.49 | 4.90 | 20.57 | 4.15 | 276.4 | 100.9 | 56.8 | 11.5 | 18.7 | 3.8 | 16.8 | 0.2 |
| **Esterhazy Zone 2** | 74.79 | 2.92 | 21.11 | 2.16 | 352.9 | 128.8 | 74.5 | 7.6 | 24.5 | 2.5 | 22.0 | 0.1 |
| **Sylvinite Subtotal** | 74.79 | 7.82 | 20.87 | 3.03 | 629.3 | 229.7 | 131.3 | 19.1 | 43.1 | 6.3 | 38.8 | 0.4 |
| ***Total*** | | | ***14.64*** | ***13.38*** | ***4869.8*** | ***1777.5*** | ***712.9*** | ***651.7*** | ***234.2*** | ***214.1*** | ***210.8*** | ***12.4*** |

[1] Inferred Resource area Radius of Influence (ROI) is 1.6 to 6.0 km for Patience Lake, Interbed and Belle Plaine inside the 3D seismic area and 2.2 - 6.0 km outside of the 3D Seismic area, and 1.6 - 6.0 km for the Esterhazy (both inside and outside the 3D seismic area).

[2] The "restricted areas" are areas located within the ROI's defined for "Indicated" and Measured" Resources that have been reclassified to an inferred resource based on the QPs judgement that there is some impediments or doubt as to the 'reasonable prospects for economic extraction' for these areas (despite the confidence in the geology provided by closer proximity to drill holes). These areas include: 1) small parcels of land along the perimeters of ROIs 2) Small parcels of land next to collapse anomalies 3) Small parcels of land next to the property boundary 4) areas around the plant area and the major highway in the area.

[3] Additional exclusions include 10% of the area for unknown anomalies inside 3D Seismic, 25% of the area for anomalies outside 3D Seismic.

[4] Resource includes the entire proposed solution mining interval or proposed production zone. A grade cutoff of 10% KCl for the production zone of the Carnallitite and a 20% grade cut-off for the Sylvinite production zone were

[5] MMT = Million Metric Tonnes

[6] "Average KCl Grade" and "Average$MgCl_2$ Grade" refer to weighted averages.

[7] Density factors used were calculated from the mineral composition of the carnallitite and sylvinite as determined from assays.

[8] Extraction Ratio (36.5 % for the Patience Lake, Belle Plaine, and Esterhazy Member)

[9] "Net KCl Tonnage" and 'Net $MgCl_2$ Tonnage" refer to total amount of extractable KCl and $MgCl_2$ resource in the Project Area plus a cavern recovery factor of 90% (i.e. Area **x** Thickness **x** Density (Sylvite or Carnallite) **x** Grade **x** Deductions)

[10] "Net Product"for KCl and MgCl2 represents current plant design considerations and includes a plant recovery of 90% for KCl from the production brine and 5.8% recovery for $MgCl_2$ from the production brine.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany

Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

## 14.3 Indicated Mineral Resource

In preparing this Technical Report, the authors were guided by the following definition (CIM, 2014, /10/):

> ”An ‘Indicated Mineral Resource’ is that part of a Mineral Resource for which quantity, grade or quality, densities, shape and physical characteristics are estimated with sufficient confidence to allow the application of Modifying Factors in sufficient detail to support mine planning and evaluation of the economic viability of the deposit.
>
> Geological evidence is derived from adequately detailed and reliable exploration, sampling and testing and is sufficient to assume geological and grade or quality continuity between points of observation.”

It is the opinion of the authors that the “Indicated” class of Mineral Resource requires a higher level of confidence than the broader description of “Inferred Mineral Resource.” In the case of a bedded sedimentary deposit that is not revealed in outcrop but only testable through drilling, one key determinant that elevates a portion of the deposit to the “Indicated” category is proximity to a cored and assayed drill hole. In determining whether any portion of the KLSA 010, KL 247 and KL 246 Leases can be classed as “Indicated Mineral Resource,” the criteria as described in the previous sections (data quality, the re-sampling and re-assaying of core, and the presence of a modern 3D seismic program) were all criteria used to gain confidence in deposit continuity and quality in the vicinity of recent and historic drilling. Those deductions as discussed in the previous section also have been applied in the estimate of the Indicated Mineral Resource.

Most of the Indicated Mineral Resource, as defined by proximity to drill holes has been upgraded to Probable Mineral Reserves. There are four areas where some of the “Indicated” Resource has been reclassified to Inferred Mineral Resource (as discussed in the previous section).

## 14.4 Measured Mineral Resource

In preparing this Technical Report, the authors were guided by the following definition (CIM, 2014, /10/):

> “A ‘Measured Mineral Resource’ is that part of a Mineral Resource for which quantity, grade or quality, densities, shape, and physical characteristics are estimated with confidence sufficient to allow the application Modifying Factors to support detailed mine planning and final evaluation of the economic viability of the deposit. Geological evidence is derived from detailed and reliable exploration and testing and is sufficient to confirm geological and grade or quality continuity between points of observation.”

Further to the above instruction, the following guideline was considered in forming an opinion:



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

> "Mineralization or other natural material of economic interest may be classified as a Measured Mineral Resource by the Qualified Person when the nature, quality, quantity and distribution of data are such that the tonnage and grade of the mineralization can be estimated to within close limits and that variation from the estimate would not significantly affect potential economic viability. This category requires a high level of confidence in, and understanding of, the geology and controls of the mineral deposit."

The completion of the Feasibility Report has allowed a Measured Mineral Resource to be defined. Most of the Measured Mineral Resource, (as defined by proximity to drill holes described in section 14.1) has been upgraded to Proven Mineral Reserves. There are four areas where some of the "Measured" Resource has been reclassified to Inferred Mineral Resources (as discussed in the previous section )

## 14.5 Additional Criteria for Industrial Minerals

Potash is a fertilizer, but is commonly considered an "industrial mineral" in the sense that it is a mineral resource that is of massive tonnage whose economic development is more a function of market and mining profitability than the identification, control, and development of high-grade potash bearing rock. The market for potash and by-products from Carnallite solution mining is discussed in section 19.

## 14.6 Results of the Resource Verification

The completed Mineral Resources using the Vulcan Grid Model was verified with a Polygonal method (Table 11). The estimated results by both methods are very similar for Belle Plaine and Patience Lake (less than 10% difference), but slightly different for the Esterhazy (approximately 14% difference).

The resultant discrepancies are associated with use of two different methods and how the same data and parameters are managed within the two different models. The primary difference for the Esterhazy is the difference in areas from a polygon model to a 20% KCl contour in a grid model (see Figure 34). With the grid model 20% contour for EZ1, the tonnages are within 2.8 MMT (14%) of the Vulcan model's numbers. The areas are within 0.7 $km^2$ (2%) of the Vulcan model's area for EZ1. Explanation is as follows:

- Due to the particular wells that made the 20% cut-off, EZ1's 20% contoured area was different from the area using the polygon method.
- The wells were impacted in the following ways:
    - 1-16 area was not contiguous with the rest of the wells that made the cutoff resulting in the entire area being removed.
        - 5662784.63 $km^2$



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

Table 11 Comparison of Resource Estimates by Different Methodologies

| INFERRED RESOURCE COMPARISONS BY DIFFERENT METHODOLIGIES | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Polygon Method** | | | | | | | | | | |
| **Member** | **Area With Additional Exclusions[1-3] ($km^2$)** | **Weighted Thickness[4] (m)** | **Average[6] KCl Grade (%)** | **Average[6] $MgCl_2$ Grade (%)** | **In-Place Tonnage[7] (MMT)[5]** | **Total Extraction Tonnage[8] (MMT)[5]** | **Gross KCl Tonnage (MMT)[4]** | **Gross $MgCl_2$ Tonnage (MMT)[4]** | **Net KCl Product[10] (MMT)[5]** | **Net $MgCl_2$ Product[10] (MMT)[5]** |
| **Patience Lake** | 92.03 | 10.75 | 18.08% | 17.96% | 1,355.5 | 445.3 | 245.1 | 243.4 | 72.5 | 4.6 |
| **Interbedded Salt** | 92.03 | 8.23 | 3.22% | 4.21% | 1,037.9 | 341.0 | 33.4 | 43.7 | 9.9 | 0.8 |
| **Upper Belle Plaine** | 92.03 | 10.19 | 17.86% | 22.52% | 1,260.7 | 414.1 | 225.2 | 283.9 | 66.6 | 5.4 |
| **Lower Belle Plaine** | 92.03 | 4.81 | 12.52% | 10.36% | 670.5 | 220.2 | 83.9 | 69.5 | 24.8 | 1.3 |
| **Esterhazy Zone 1** | 36.19 | 5.20 | 22.05% | 3.63% | 300.3 | 98.6 | 66.2 | 10.9 | 19.6 | 0.2 |
| **Esterhazy Zone 2** | 71.36 | 3.24 | 22.05% | 2.16% | 375.0 | 123.2 | 82.7 | 8.1 | 24.5 | 0.2 |
| **Resource Grid Model** | | | | | | | | | | |
| **Member** | **Area With Additional Exclusions[1-3] ($km^2$)** | **Weighted Thickness[4] (m)** | **Average[6] KCl Grade (%)** | **Average[6] $MgCl_2$ Grade (%)** | **In-Place Tonnage[7] (MMT)[5]** | **Total Extraction Tonnage[8] (MMT)[5]** | **Gross KCl Tonnage (MMT)[4]** | **Gross $MgCl_2$ Tonnage (MMT)[4]** | **Net KCl Product[10] (MMT)[5]** | **Net $MgCl_2$ Product[10] (MMT)[5]** |
| **Patience Lake** | 92.03 | 9.58 | 19% | 19% | 1,191.2 | 434.8 | 224.1 | 228.9 | 66.2 | 4.4 |
| **Interbedded Salt** | 92.03 | 8.19 | 3% | 4% | 1,103.9 | 402.9 | 35.3 | 46.4 | 10.4 | 0.9 |
| **Upper Belle Plaine** | 92.03 | 10.30 | 18% | 23% | 1,273.9 | 465.0 | 231.0 | 291.7 | 68.3 | 5.6 |
| **Lower Belle Plaine** | 92.03 | 4.83 | 14% | 10% | 671.5 | 245.1 | 91.2 | 65.5 | 27.0 | 1.2 |
| **Esterhazy Zone 1** | 35.49 | 4.93 | 21% | 4% | 276.4 | 100.9 | 56.8 | 11.5 | 16.8 | 0.2 |
| **Esterhazy Zone 2** | 74.79 | 2.92 | 21% | 2% | 352.9 | 128.8 | 74.5 | 7.6 | 22.0 | 0.1 |
| **Arithmetic Difference** | | | | | | | | | | |
| **Member** | **Area With Additional Exclusions[1-3] ($km^2$)** | **Weighted Thickness[4] (m)** | **Average[6] KCl Grade (%)** | **Average[6] $MgCl_2$ Grade (%)** | **In-Place Tonnage[7] (MMT)[5]** | **Total Extraction Tonnage[8] (MMT)[5]** | **Gross KCl Tonnage (MMT)[4]** | **Gross $MgCl_2$ Tonnage (MMT)[4]** | **Net KCl Product[10] (MMT)[5]** | **Net $MgCl_2$ Product[10] (MMT)[5]** |
| **Patience Lake** | 0.00 | 1.17 | -0.01 | -0.01 | 164.30 | 10.51 | 21.03 | 14.45 | 6.25 | 0.24 |
| **Interbedded Salt** | 0.00 | 0.04 | 0.00 | 0.00 | -66.00 | -61.92 | -1.88 | -2.66 | -0.53 | -0.08 |
| **Upper Belle Plaine** | 0.00 | -0.11 | 0.00 | 0.00 | -13.20 | -50.87 | -5.78 | -7.85 | -1.69 | -0.16 |
| **Lower Belle Plaine** | 0.00 | -0.02 | -0.01 | 0.01 | -1.00 | -24.90 | -7.30 | 3.95 | -2.16 | 0.05 |
| **Esterhazy Zone 1** | 0.70 | 0.27 | 0.01 | -0.01 | 23.90 | -2.29 | 9.35 | -0.56 | 2.79 | -0.02 |
| **Esterhazy Zone 2** | -3.43 | 0.32 | 0.01 | 0.00 | 22.10 | -5.61 | 8.22 | 0.47 | 2.48 | 0.05 |
| **Percent Difference** | | | | | | | | | | |
| **Member** | **Area With Additional Exclusions[1-3] ($km^2$)** | **Weighted Thickness[4] (m)** | **Average[6] KCl Grade (%)** | **Average[6] $MgCl_2$ Grade (%)** | **In-Place Tonnage[7] (MMT)[5]** | **Total Extraction Tonnage[8] (MMT)[5]** | **Gross KCl Tonnage (MMT)[4]** | **Gross $MgCl_2$ Tonnage (MMT)[4]** | **Net KCl Product[10] (MMT)[5]** | **Net $MgCl_2$ Product[10] (MMT)[5]** |
| **Patience Lake** | 0% | 11% | -4% | -7% | 12% | 2% | 9% | 6% | 9% | 5% |
| **Interbedded Salt** | 0% | 0% | 1% | 0% | -6% | -18% | -6% | -6% | -5% | -10% |
| **Upper Belle Plaine** | 0% | -1% | -2% | -2% | -1% | -12% | -3% | -3% | -3% | -3% |
| **Lower Belle Plaine** | 0% | 0% | -8% | 6% | 0% | -11% | -9% | 6% | -9% | 4% |
| **Esterhazy Zone 1** | 2% | 5% | 7% | -14% | 8% | -2% | 14% | -5% | 14% | -9% |
| **Esterhazy Zone 2** | -5% | 10% | 4% | 0% | 6% | -5% | 10% | 6% | 10% | 27% |

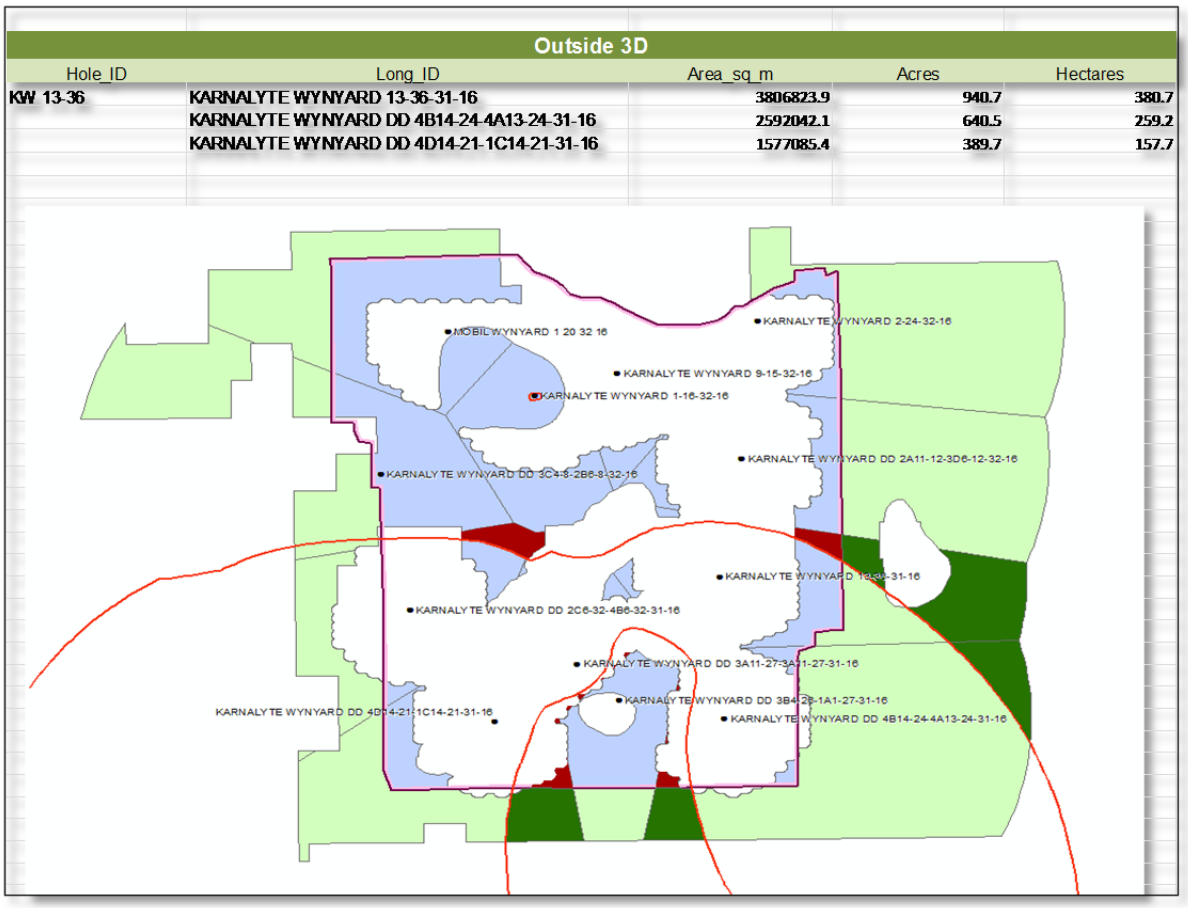
- Part of 13-36 area was removed to reflect the adjacent well not making the 20% cutoff.
  - 351672 $km^2$ inside the 3D
  - 3806823.9 $km^2$ outside the 3D
- Part of 4B14 area was removed to reflect the adjacent wells not making the 20% cutoff.
  - 139029.7 $km^2$ inside the 3D
  - 2592042.1 $km^2$ outside the 3D



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

- Part of 4D14 area was removed to reflect the adjacent wells not making the 20% cutoff.
  - 200375.8 km$^2$ inside the 3D
  - 1577085.4 km$^2$outside the 3D
- Part of 2C6 area was removed to reflect the adjacent wells not making the 20% cutoff.
  - 609258.1 km$^2$ inside the 3D
- Part of 3A11 area was removed to reflect the adjacent wells not making the 20% cutoff.
  - 131426.9 km$^2$ inside the 3D

It is the author's opinion that with the explanation above the verification of the resource calculation is complete and acceptable. The Vulcan Model is the more conservative estimate for tonnage so it remains the primary, reported resource.



Outside 3D

| Hole_ID | Long_ID | Area_sq_m | Acres | Hectares |
|---|---|---|---|---|
| KW 13-36 | KARNALYTE WYNYARD 13-36-31-16 | 3806823.9 | 940.7 | 380.7 |
| | KARNALYTE WYNYARD DD 4B14-24-4A13-24-31-16 | 2592042.1 | 640.5 | 259.2 |
| | KARNALYTE WYNYARD DD 4D14-21-1C14-21-31-16 | 1577085.4 | 389.7 | 157.7 |



Figure 34 Esterhazy Member Area Comparison Between Resource Estimate Methodologies



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

# 15 Mineral Reserve Estimates

According to the definition of “Mineral Reserve” by the National Instrument 43-101 and CIM (2014, /10/):

> “A Mineral Reserve is the economically mineable part of a Measured and/or Indicated Mineral Resource. It includes diluting materials and allowances for losses, which may occur when the material is mined or extracted and is defined by studies at Pre-Feasibility or Feasibility level as appropriate that include application of Modifying Factors. Such studies demonstrate that, at the time of reporting, extraction could reasonably be justified.”

In the opinion of the authors, the exploration undertaken by KARNALYTE is sufficient to confirm that in the investigated part of the KLSA 010, KL 246 and KL 247 leases carnallitite and sylvinite resources occur in the Esterhazy Member, Belle Plaine Member and Patience Lake Member, which can be economically extracted using solution mining methods. The information available about, mining, processing and modifying factors as described in the Feasibility Study of FOSTER WHEELER & ERCOSPLAN (2011, /26/) on the Wynyard Carnallite project is summarized in the following chapters and an update of the CAPEX and OPEX estimate (AmecFW 2016, /4/) as well as a new economic model (section 22.1), show that even at lower potash prices than $450 CAD/metric tonne, economic extraction of the deposit is justified.

The Preliminary Feasibility study of LYNTEK (2012, /38/) has provided the processing scheme to use the $MgCl_2$ rich end brine from potash production for production of different Mg-products. The update of the CAPEX and OPEX estimate (AmecFW 2016, /4/) as well as a new economic model (section, 22.2), show that this can be done economically. Therefore, the KARNALYTE KLSA 010, KL 246 and KL 247 leases contain a Potassium and Magnesium Chloride Mineral Reserve in the form of Carnallite and Sylvite. Before the different reserve categories will be presented below, the intervals for solution mining of the Patience Lake Member, Belle Plaine Member and Esterhazy Member will be presented.

## 15.1 Solution Mining Intervals

The original feasibility study (FOSTER WHEELER & ERCOSPLAN, 2011, /26/) as well as studies performed last years (e.g. WHITING; 2013, /51/), show that for an efficient plant operation the brine feed to the plant requires that the production brine has continuous high KCl content and that the $MgCl_2$ content of the brine is kept within well defined limits (section 16.3.4).

The high KCl content of the brine requires that solution mining is concentrated on the parts of the geological Members that have relatively high concentrations of the minerals Carnallite and/or Sylvite. The $MgCl_2$ content requires that in the mine plan the number of caverns producing from Carnallite and Sylvite is kept well balanced (e.g. 16.3.4).

For the Carnallite dominated Members, the boundaries can be relatively easy determined by defining the mineable seam as a mineralized seam with a thickness over 2m, that contain rocks with over 50% Carnallite/Sylvite. Rocks are attributed to this horizon at the first sample with KCl content over 15%, where the length weight average with previous and next samples (3 to 5 samples in total about 1 m length) provides a KCl content above 15% and the following average samples further down also have an average KCl content above



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

15%. The lower boundary is located at the first sample where the length weight average with previous and next samples (in total 3 to 5 samples about 1 m in length) no longer provides a KCl content above 15%.

This separates the Patience Lake Member from the Belle Plaine Member, by a Halite dominated Interbed, with low average Carnallite content. This Interbed will be solution mined through, but brine produced is such low KCl grade, that is not considered for recycling but is disposed of as waste brine.

For the Patience Lake Member, this method usually slightly reduces the thickness, but increases the average KCl grade when compared to the geological determined boundaries and the average mineralogical composition for the solution mining interval of the Patience Lake Member is given in Table 12. For the Belle Plaine Member this defines a higher Carnallite grade Upper Belle Plaine Member, suitable for production of a high KCl grade Carnallite brine (Table 13) and a lower Carnallite grade Lower Belle Plaine Member, which is not considered suitable for production of a high KCl grade Carnallite brine. The boundary between UBPM and LBPM defined this way is not a stratigraphic boundary, as its position really depends on mineralogy and therefore the boundary often differs from geological/stratigraphic defined boundary.

The LBPM will be used for undercut leaching, but has been extended to below the geological boundary to have adequate thickness for the undercut. The lower boundary is located just above the first insoluble rich seam that occurs below the geological boundary. The brine from the undercut leaching will be recycled to pre-concentrate the dissolution brine for the solution mining of the UBPM and the Patience Lake Member, and therefore should be considered part of the Reserve. For this reason the Belle Plaine Member for solution mining is divided into a productive layer with thickness and average mineralogical composition given in Table 13 (UBPM) and an undercut development layer (LBPM) with average thickness and composition as given in Table 14.

The examination of assays for the drill holes within the permit areas shows that in the Esterhazy Member, the concentration of Sylvite (KCl) is highly variable and ranges from less than 5% to locally over 60% in a sample from 20 cm length. The Esterhazy Member has been divided into zones that are considered technically and economically suitable for solution mining when:

- Thickness of the productive mineralized zone exceeds 2 m and
- Average KCl content over the productive horizon exceeds 20%

With this strict KCl grade criterion, the number and thickness of the one or two mineable zones is reduced and the drill holes 3C4-8 and 3B4-26 do not contain mineable Esterhazy Member. The drill holes 3A11-27, 2A11-12 and 4D14-21 contain one mineable layer within the Esterhazy Member, whereas for the drill holes DH-11, DH-20, DH-21, 4B14-24 and 13-36 two mineable layers could be identified in the Esterhazy Member.

The average thickness and composition of these mineralized intervals are given in Table 15 and Table 16.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

Table 12 Thickness and Composition of the Carnallitite Layer of the Patience Lake Member in the 12 Drill Holes Present in the KARNALYTE Lease Area

| **Drill Hole** | **DH – 20** | **DH - 21** | **DH-11** | **4B14-24** | **13-36** | **3A11-27** | **2A11-12** | **4D14-21** | **3C4-8** | **3B4-26** | **2C6-32** | **2-24** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth from (m) | 934.83 | 921.33 | 929.90 | 1007.97 | 970.79 | 992.94 | 942.03 | 1014.11 | 965.12 | 1000.80 | 1000.92 | 911.40 |
| Depth to (m) | 942.51 | 926.84 | 937.44 | 1020.98 | 976.90 | 999.54 | 950.13 | 1022.06 | 973.11 | 1003.85 | 1008.79 | 919.03 |
| Thickness (m) | 7.68 | 5.51 | 7.54 | 13.01 | 6.11 | 6.60 | 8.10 | 7.95 | 7.99 | 3.05 | 7.87 | 7.63 |
| Carnallite (%) | 61.25 | 68.80 | 70.42 | 37.70 | 60.54 | 63.97[2] | 71.69 | 68.27 | 70.92 | 33.84 | 70.81 | 66.18 |
| Sylvite (%) | 0.74 | 0.05 | 0.35 | 11.38 | 6.56 | 0.31 | 0.01 | 0.03 | 0.02 | 21.24 | 0.10 | 2.36 |
| Halite (%) | 27.39 | 25.07 | 23.59 | 43.76 | 26.16 | 28.81 | 20.91 | 23.15 | 22.34 | 37.67 | 22.60 | 25.52 |
| Bischofite/ Tachyhydrite (%) | 2.36 | 1.58 | 2.53 | 2.20 | 1.95 | 1.91 | 2.91 | 2.70 | 1.49 | 1.67 | 2.59 | 1.23 |
| Anhydrite (%) | 0.85 | 0.57 | 0.46 | 0.80 | 0.62 | 0.48 | 0.53 | 0.66 | 0.58 | 0.66 | 0.50 | 0.45 |
| Insoluble Material (%) | 7.39 | 3.90 | 3.43 | 4.65 | 4.55 | 5.24 | 3.86 | 5.35 | 4.57 | 5.18 | 3.80 | 3.96 |

[2] Composition is partly estimated from Geophysical Logging



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany

Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

Table 13 Thickness and Composition of the Upper Part of the Carnallitite Layer of the Belle Plaine Member in the 12 Drill Holes Present in the KARNALYTE Lease Area

| **Drill Hole** | **DH–20** | **DH–21** | **DH-11** | **4B14-24** | **13-36** | **3A11-27** | **2A11-12** | **4D14-21** | **3C4-8** | **3B4-26** | **2C6-32** | **2-24** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth from (m) | 951.14 | 936.48 | 946.27 | 1030.78 | 985.20 | 1007.75 | 959.26 | 1030.62 | 982.15 | 1012.13 | 1017.57 | 927.40 |
| Depth to (m) | 960.83 | 946.93 | 956.14 | 1039.96 | 993.82 | 1018.18 | 968.40 | 1039.64 | 992.13 | 1021.26 | 1026.51 | 936.52 |
| Thickness (m) | 9.69 | 10.45 | 9.88 | 9.18 | 8.62 | 10.43 | 9.14 | 9.02 | 9.98 | 9.13 | 8.94 | 9.12 |
| | | | | | | | | | | | | |
| Carnallite (%) | 66.99 | 70.72 | 66.04 | 60.30[3] | 64.81 | 70.58 | 62.24 | 69.90 | 70.66 | 68.68 | 69.61 | 70.83 |
| Sylvite (%) | 0.20 | 0.77 | 0.31 | 5.19 | 1.42 | 1.71 | 1.22 | 0.77 | 0.09 | 0.02 | 0.02 | 0.05 |
| Halite (%) | 27.00 | 25.30 | 29.82 | 34.48 | 29.48 | 23.66 | 30.90 | 24.22 | 24.23 | 25.41 | 25.34 | 24.57 |
| Bischofite/ Tachyhydrite (%) | 2.92 | 1.41 | 2.13 | - | 1.76 | 2.01 | 1.68 | 2.30 | 2.50 | 3.38 | 2.09 | 2.02 |
| Anhydrite (%) | 0.39 | 0.84 | 0.38 | 0.17 | 0.38 | 0.36 | 0.53 | 0.45 | 0.37 | 0.28 | 0.36 | 0.33 |
| Insoluble Material (%) | 2.96 | 1.84 | 2.46 | - | 2.41 | 1.85 | 3.56 | 2.57 | 2.25 | 2.33 | 2.37 | 2.88 |

[3] Composition is estimated from geophysical logging.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany

Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

Table 14 Thickness and Composition of the Lower Part of the Carnallitite Layer of the Belle Plaine Member in the 12 Drill Holes Present in the KARNALYTE Lease Area

| **Drill Hole** | **DH–20** | **DH–21** | **DH-11** | **4B14-24** | **13-36** | **3A11-27** | **2A11-12** | **4D14-21** | **3C4-8** | **3B4-26** | **2C6-32** | **2-24** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth from (m) | 960.83 | 946.93 | 956.14 | 1039.96 | 993.82 | 1018.18 | 968.40 | 1039.64 | 992.13 | 1021.26 | 1027.29 | 936.52 |
| Depth to (m) | 966.40 | 953.28 | 962.80 | 1045.65 | 1000.01 | 1023.20 | 973.78 | 1045.62 | 997.26 | 1027.45 | 1032.52 | 942.60 |
| Thickness (m) | 5.57 | 6.35 | 6.66 | 5.69 | 6.19 | 5.02 | 5.38 | 5.98 | 5.13 | 6.19 | 5.23 | 6.08 |
| | | | | | | | | | | | | |
| Carnallite (%) | 27.78 | 22.64 | 15.75 | 29.89 | 34.84 | 28.07 | 32.02 | 30.95 | 27.25 | 31.89 | 32.86 | 36.09 |
| Sylvite (%) | 9.73 | 9.00 | 4.30 | 3.89 | 0.32 | 6.21 | 5.91 | 1.30 | 7.94 | 4.42 | 0.38 | 3.78 |
| Halite (%) | 58.71 | 65.36 | 78.20 | 62.45 | 60.24 | 62.83 | 57.73 | 63.03 | 59.83 | 59.66 | 61.93 | 55.64 |
| Bischofite/ Tachyhydrite (%) | 1.01 | 0.81 | 0.00 | 1.22 | 1.01 | 0.55 | 1.03 | 1.18 | 1.05 | 1.30 | 1.12 | 1.20 |
| Anhydrite (%) | 0.47 | 0.58 | 0.66 | 0.33 | 0.44 | 0.33 | 0.39 | 0.42 | 0.35 | 0.25 | 0.56 | 0.45 |
| Insoluble Material (%) | 2.83 | 2.09 | 1.55 | 2.46 | 3.20 | 2.12 | 2.81 | 3.09 | 3.56 | 2.54 | 2.90 | 3.18 |



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany

Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

Table 15 Thickness and Composition of the First Mineable Part of the Sylvinite of the Esterhazy Member in the 12 Drill Holes Present in the KARNALYTE Lease Area

| **Drill Hole** | **DH – 20** | **DH – 21** | **DH-11** | **4B14-24** | **13-36** | **3A11-27** | **2A11-12** | **4D14-21** | **3C4-8** | **3B4-26** | **2C6-32** | **2-24** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth from (m) | 994.48 | 989.89 | 989.63 | 1074.51 | 1028.10 | 1050.49 | 1013.95 | 1073.65 | | | 1060.38 | 971.21 |
| Depth to (m) | 997.05 | 992.14 | 993.60 | 1076.82 | 1030.32 | 1052.74 | 1017.37 | 1076.65 | | | 1062.41 | 974.38 |
| Thickness (m) | 2.57 | 2.25 | 3.96 | 2.31 | 2.22 | 2.25 | 3.42 | 2.00 | | | 2.03 | 3.17 |
| | | | | | | | | | | | | |
| Carnallite (%) | 15.06 | 4.97 | 2.66 | 13.27 | 10.77 | 12.45 | 4.42 | 15.23 | | | 16.64 | 11.91 |
| Sylvite (%) | 22.44 | 23.87 | 20.16 | 19.77 | 20.27 | 31.67 | 23.55 | 16.08 | | | 25.90 | 27.36 |
| Halite (%) | 59.64 | 69.64 | 74.18 | 65.86 | 66.71 | 51.89 | 71.26 | 65.71 | | | 55.59 | 59.45 |
| Bischofite/ Tach-yhydrite (%) | 0.25 | 0.66 | [4] | 0.00 | 0.10 | 0.43 | 0.00 | 0.18 | | | 0.61 | 0.05 |
| Anhydrite (%) | 0.74 | 0.24 | -[5] | 0.61 | 0.79 | 0.35 | 0.46 | 0.96 | | | 0.18 | 0.22 |
| Insoluble Material (%) | 2.39 | 1.54 | 3.00 | 1.14 | 1.66 | 2.81 | 0.18 | 1.68 | | | 1.29 | 1.21 |

[4] Not enough components reported in the chemical analysis to estimate



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany

Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

Table 16 Thickness and Composition of the Second Mineable Part of the Sylvinite of the Esterhazy Member in Some of the 12 Drill Holes Present in the KARNALYTE Lease Area

| Drill Hole | DH–20 | DH–21 | DH-11 | 4B14-24 | 13-36 | 2-24 |
|---|---|---|---|---|---|---|
| Depth from (m) | 1008.30 | 993.95 | 1003.35 | 1080.37 | 1041.77 | 985.99 |
| Depth to (m) | 1011.58 | 997.27 | 1005.79 | 1082.36 | 1044.45 | 989.06 |
| Thickness (m) | 3.28 | 3.32 | 2.44 | 1.99 | 2.68 | 3.07 |
| | | | | | | |
| Carnallite (%) | 6.19 | 5.16 | 6.21 | 6.76 | 6.06 | 7.10 |
| Sylvite (%) | 19.12 | 23.84 | 25.25 | 36.22 | 19.06 | 22.88 |
| Halite (%) | 73.38 | 69.54 | 68.11 | 55.90 | 73.81 | 69.46 |
| Bischofite/ Tachyhydrite (%) | 0.00 | 0.31 | - | 0.15 | 0.00 | 0.11 |
| Anhydrite (%) | 0.77 | 0.36 | - | 0.31 | 0.73 | 0.59 |
| Insoluble Material (%) | 0.56 | 0.61 | 0.43 | 1.13 | 0.26 | 0.26 |

## 15.2 Proven Mineral Reserve

For “Proven Mineral Reserve” NI 43-101 uses the definition of CIM (2014, /10/):

> “A Proven Mineral Reserve is the economically mineable part of a Measured Mineral Resource. A Proven Mineral Reserve implies a high degree of confidence in the Modifying Factors.”

Furthermore it is stated CIM (2014, /10/):

> “Application of the Proven Mineral Reserve category implies that the Qualified Person has the highest degree of confidence in the estimate with the consequent expectation in the minds of the readers of the report. The term should be restricted to that part of the deposit where production planning is taking place and for which any variation in the estimate would not significantly affect the potential economic viability of the deposit. Proven Mineral Reserve estimates must be demonstrated to be economic, at the time of reporting, by at least a Pre-Feasibility Study. Within the CIM Definition standards the term Proved Mineral Reserve is an equivalent term to a Proven Mineral Reserve.”

Proven mineral reserves have been derived from the measured mineral resources by using the number of caverns planned in each area defined by the drill hole polygons for measured mineral resources. As the Preliminary Feasibility study of LYNTEK (2012, /38/) still defines some areas requiring further investigations that could influence the economics of the magnesium products and these have not yet been resolved, the authors of this



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

Technical Report will not define Proven $MgCl_2$ reserves yet. Furthermore, technical exclusion zones consisting of safety pillars along the highway and around the plant have been applied. Figure 32 and Figure 33 show the Polygons for measured resources for each drill hole and the location of the caverns for the future brine field for the Patience Lake/Belle Plaine Members and Esterhazy Member, respectively. It is assumed that within the extrapolated drill hole area the grade and thickness of the mineralized members are uniform.

For each exploration drill hole the proven reserves for the extrapolated area of influence is shown for Patience Lake Member in Table 17, for Upper Belle Plaine Member in Table 18, for Lower Belle Plaine Member in Table 19, for the upper layer of the Esterhazy Member in Table 20, and for the lower layer of the Esterhazy Member in Table 21. The number of Esterhazy caverns takes into account over the mine plan (section 16.3.4), that in order to maintain at most time the balance between the amount of sylvinite and carnallitite brine optimal for the plant operation, especially at the onset of the operation, not develops caverns in the Esterhazy Member, although mineral resources are available in that Member at that location.

Total KCl that can be mined from the Proven carnallitite Reserves taking into account modifying factors like, cavern recovery and resource estimate uncertainty amounts to:

| | |
|---|---|
| Patience Lake | 21.15 million tonnes of KCl |
| Upper Belle Plaine | 25.29 million tonnes of KCl |
| Lower Belle Plaine | 3.80 million tonnes of KCl |
| Total | 50.24 million tonnes of KCl |

Total KCl that can be mined from the Proven sylvinite Reserves of the Esterhazy Member taking into account modifying factors like, cavern recovery, resource estimate uncertainty amount to:

| | |
|---|---|
| Upper Esterhazy layer | 8.50 million tonnes of KCl |
| Lower Esterhazy layer | 5.34 million tonnes of KCl |
| Total | 13.84 million tonnes of KCl |

making a total of 64 million tonnes of KCl that can be mined from all Proven Mineral Reserves, which at 90% plant efficiency and 97% KCl product quality makes in the order of 59 million tonnes of product.

In the opinion of the authors potential variations in this estimate are minor only and will not significantly affect the economic viability of the project.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

Table 17 Proven Potash Reserves for the Patience Lake Member, Calculated with the Amount of Mineralized Material that Can Be Extracted from a Cavern as Given in Section 16.4

| Hole | Caverns | Mineralized Tonnage/Cavern (1000 t)[a] | Cavern Recovery Factor (%) | Average KCl Grade (%) | Total Mineralized Tonnage (million t) | Mineable Tonnage[b] (million t) | Total Mineable KCl (million t) | Total KCl Product[c] (million t) |
|---|---|---|---|---|---|---|---|---|
| DH-20 | 20 | 204.3 | 89.84 | 17.16 | 4.09 | 3.30 | 0.6 | 0.5 |
| DH-21 | 67 | 142.9 | 90.68 | 18.49 | 9.58 | 7.82 | 1.4 | 1.3 |
| DH-11 | 40 | 194.3 | 89.04 | 19.22 | 7.77 | 6.23 | 1.2 | 1.1 |
| 4B14-24 | 76 | 367.4 | 84.47 | 21.48 | 27.92 | 21.22 | 4.6 | 4.2 |
| 13-36 | 61 | 161.7 | 87.55 | 22.78 | 9.86 | 7.77 | 1.8 | 1.6 |
| 3A11-27 | 55 | 174.0 | 89.27 | 17.45 | 9.57 | 7.69 | 1.3 | 1.2 |
| 2A11-12 | 50 | 207.6 | 91.28 | 19.22 | 10.38 | 8.53 | 1.6 | 1.5 |
| 4D14-21 | 69 | 206.5 | 87.23 | 18.33 | 14.25 | 11.18 | 2.0 | 1.9 |
| 3C4-8 | 58 | 206.3 | 90.57 | 19.03 | 11.96 | 9.75 | 1.9 | 1.7 |
| 3B4-26 | 39 | 86.7 | 91.22 | 30.31 | 3.38 | 2.77 | 0.8 | 0.8 |
| 2C6-32 | 66 | 202.6 | 91.26 | 18.82 | 13.37 | 10.98 | 2.1 | 1.9 |
| 2-24 | 56 | 199.2 | 90.35 | 20.10 | 11.15 | 9.07 | 1.8 | 1.7 |
| Total/*Av.* | 657 | *202.9* | *88.64* | *19.90* | 133.28 | 106.32 | 21.15 | 19.63 |

[a] t is metric tonnes,

[b] taking into account 10% anomalies below resolution of the seismic and cavern recovery factor

[c] plant efficiency of 90% and a KCl content of the product of 97%



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany

Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

Table 18 Proven Potash Reserves for the Upper Belle Plaine Member, Calculated with the Amount of Mineralized Material that Can Be Extracted from a Cavern as Given in Section 16.4

| Hole | Caverns | Mineralized Tonnage/Cavern (1000 t)[a] | Cavern Recovery Factor (%) | Average KCl Grade (%) | Total Mineralized Tonnage (million t) | Mineable Tonnage[b] (million t) | Total Mineable KCl (million t) | Total KCl Product[c] (million t) |
|---|---|---|---|---|---|---|---|---|
| DH-20 | 20 | 251.5 | 90.05 | 18.15 | 5.03 | 4.08 | 0.7 | 0.7 |
| DH-21 | 67 | 269.5 | 89.21 | 19.72 | 18.05 | 14.49 | 2.9 | 2.7 |
| DH-11 | 40 | 257.8 | 89.17 | 18.01 | 10.31 | 8.28 | 1.5 | 1.4 |
| 4B14-24 | 76 | 242.7 | 91.70 | 21.35 | 18.45 | 15.22 | 3.3 | 3.0 |
| 13-36 | 61 | 225.4 | 90.27 | 18.79 | 13.75 | 11.17 | 2.1 | 1.9 |
| 3A11-27 | 55 | 267.8 | 91.36 | 20.63 | 14.73 | 12.11 | 2.5 | 2.3 |
| 2A11-12 | 50 | 241.3 | 89.93 | 17.90 | 12.07 | 9.77 | 1.7 | 1.6 |
| 4D14-21 | 69 | 232.3 | 90.05 | 19.50 | 16.03 | 12.99 | 2.5 | 2.4 |
| 3C4-8 | 58 | 256.2 | 91.95 | 19.03 | 14.86 | 12.30 | 2.3 | 2.2 |
| 3B4-26 | 39 | 235.1 | 90.59 | 18.43 | 9.17 | 7.48 | 1.4 | 1.3 |
| 2C6-32 | 66 | 230.4 | 90.86 | 18.70 | 15.20 | 12.43 | 2.3 | 2.2 |
| 2-24 | 56 | 234.8 | 90.29 | 19.03 | 13.15 | 10.69 | 2.0 | 1.9 |
| Total/*Av.* | 657 | *244.7* | *90.52* | *19.31* | 160.79 | 131.00 | 25.29 | 23.47 |

[a] t is metric tonnes,

[b] taking into account 10% anomalies below resolution of the seismic and cavern recovery factor

[c] plant efficiency of 90% and a KCl content of the product of 97%



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany

Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

Table 19 Proven Potash Reserves for the Lower Belle Plaine Member, Calculated with the Amount of Mineralized Material that Can Be Extracted from a Cavern as Given in Section 16.4

| Hole | Caverns | Mineralized Tonnage/Cavern (1000 t)[a] | Cavern Recovery Factor (%) | Average KCl Grade (%) | Total Mineralized Tonnage (million t) | Mineable Tonnage[b] (million t) | Total Mineable KCl (million t) | Total KCl Product[c] (million t) |
|---|---|---|---|---|---|---|---|---|
| DH-20 | 20 | 162.5 | 32.26 | 17.18 | 3.25 | 0.94 | 0.2 | 0.2 |
| DH-21 | 67 | 188.4 | 32.19 | 15.07 | 12.62 | 3.66 | 0.6 | 0.5 |
| DH-11 | 40 | 203.3 | 32.33 | 8.52 | 8.13 | 2.37 | 0.2 | 0.2 |
| 4B14-24 | 76 | 165.3 | 31.24 | 11.09 | 12.57 | 3.53 | 0.4 | 0.4 |
| 13-36 | 61 | 177.9 | 32.63 | 9.66 | 10.85 | 3.19 | 0.3 | 0.3 |
| 3A11-27 | 55 | 146.7 | 31.65 | 13.83 | 8.07 | 2.30 | 0.3 | 0.3 |
| 2A11-12 | 50 | 155.2 | 30.21 | 14.49 | 7.76 | 2.11 | 0.3 | 0.3 |
| 4D14-21 | 69 | 173.7 | 31.22 | 9.59 | 11.99 | 3.37 | 0.3 | 0.3 |
| 3C4-8 | 58 | 150.2 | 30.25 | 15.24 | 8.71 | 2.37 | 0.4 | 0.3 |
| 3B4-26 | 39 | 178.6 | 31.38 | 12.97 | 6.96 | 1.97 | 0.3 | 0.2 |
| 2C6-32 | 66 | 151.1 | 30.94 | 9.19 | 9.97 | 2.78 | 0.3 | 0.2 |
| 2-24 | 56 | 173.5 | 30.89 | 13.45 | 9.72 | 2.70 | 0.4 | 0.3 |
| Total/*Av.* | 657 | *168.3* | *31.42* | *12.14* | 110.60 | 31.28 | 3.8 | 3.5 |

[a] t is metric tonnes,

[b] taking into account 10% anomalies below resolution of the seismic and cavern recovery factor

[c] plant efficiency of 90% and a KCl content of the product of 97%



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany

Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

Table 20 Proven Potash Reserves for the Upper Layer of the Esterhazy Member, Calculated with the Amount of Mineralized Material that Can Be Extracted from a Cavern as Given in Section 16.4

| Hole | Caverns | Mineralized Tonnage/Cavern (1000 t)[a] | Cavern Recovery Factor (%) | Average KCl Grade (%) | Total Mineralized Tonnage (million t) | Mineable Tonnage[b] (million t) | Total Mineable KCl (million t) | Total KCl Product[c] (million t) |
|---|---|---|---|---|---|---|---|---|
| DH-20 | 20 | 77.5 | 89.62 | 26.48 | 1.55 | 1.25 | 0.3 | 0.3 |
| DH-21 | 67 | 69.8 | 88.92 | 25.20 | 4.68 | 3.74 | 0.9 | 0.9 |
| DH-11 | 16 | 124.8 | 88.28 | 20.87 | 2.00 | 1.59 | 0.3 | 0.3 |
| 4B14-24 | 76 | 70.1 | 88.62 | 23.33 | 5.33 | 4.25 | 1.0 | 0.9 |
| 13-36 | 61 | 68.0 | 91.67 | 22.46 | 4.15 | 3.42 | 0.8 | 0.7 |
| 3A11-27 | 55 | 67.8 | 91.64 | 35.01 | 3.73 | 3.08 | 1.1 | 1.0 |
| 2A11-12 | 50 | 106.4 | 89.78 | 24.73 | 5.32 | 4.30 | 1.1 | 1.0 |
| 4D14-21 | 69 | 60.6 | 88.23 | 20.16 | 4.18 | 3.32 | 0.7 | 0.6 |
| 2C6-32 | 66 | 60.5 | 90.67 | 30.36 | 3.99 | 3.26 | 1.0 | 0.9 |
| 2-24 | 56 | 95.9 | 90.55 | 30.57 | 5.37 | 4.38 | 1.3 | 1.2 |
| Total/Av. | 536 | *75.2* | *89.84* | *26.10* | 40.30 | 32.58 | 8.50 | 7.89 |

[a] t is metric tonnes,

[b] taking into account 10% anomalies below resolution of the seismic and cavern recovery factor

[c] plant efficiency of 90% and a KCl content of the product of 97%



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany

Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

Table 21 Proven Potash Reserves for the Lower Layer of the Esterhazy Member, Calculated with the Amount of Mineralized Material that Can Be Extracted from a Cavern as Given in Section 16.4

| Hole | Caverns | Mineralized Tonnage/Cavern (1000 t)[a] | Cavern Recovery Factor (%) | Average KCl Grade (%) | Total Mineralized Tonnage (million t) | Mineable Tonnage[b] (million t) | Total Mineable KCl (million t) | Total KCl Product[c] (million t) |
|---|---|---|---|---|---|---|---|---|
| DH-20 | 20 | 102.0 | 88.22 | 20.78 | 2.04 | 1.62 | 0.3 | 0.3 |
| DH-21 | 67 | 102.9 | 89.98 | 25.22 | 6.90 | 5.58 | 1.4 | 1.3 |
| DH-11 | 16 | 75.3 | 90.25 | 26.91 | 1.20 | 0.98 | 0.3 | 0.2 |
| 4B14-24 | 76 | 60.8 | 91.18 | 38.03 | 4.62 | 3.79 | 1.4 | 1.3 |
| 13-36 | 61 | 83.3 | 88.29 | 20.68 | 5.08 | 4.04 | 0.8 | 0.8 |
| 2-24 | 56 | 94.7 | 89.31 | 24.78 | 5.30 | 4.26 | 1.1 | 1.0 |
| Total/Av. | 296 | *85.0* | *89.59* | *26.35* | 25.15 | 20.28 | 5.34 | 4.96 |

[a] t is metric tonnes,

[b] taking into account 10% anomalies below resolution of the seismic and cavern recovery factor

[c] plant efficiency of 90% and a KCl content of the product of 97%



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany

Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

## 15.3 Probable Mineral Reserve

For “Probable Mineral Reserve” NI 43-101 uses the definition of CIM (2014, /10/):

> “A Probable Mineral Reserve is the economically mineable part of an Indicated, and in some circumstances, a Measured Mineral Resource. The confidence in the Modifying Factors applying to a Probable Mineral Reserve is lower than that applying to a Proven Mineral Reserve.”

Furthermore it is stated CIM (2014, /10/):

> “The Qualified Person(s) may elect, to convert Measured Mineral Resources to Probable Mineral Reserves if the confidence in the Modifying Factors is lower than that applied to a Proven Mineral Reserve. Probable Mineral Reserve estimates must be demonstrated to be economic, at the time of reporting, by at least a Pre-Feasibility Study.”

For Potash Probable Mineral Reserves have been derived from the indicated resources and for the Magnesium Chloride from indicated and measured resources (see Section 15.2). Probable Mineral Reserves have been derived from indicated and/or measured resources by using the number of caverns planned in each area defined by the drill hole polygons for indicated resources. Furthermore, technical exclusion zones consisting of safety pillars along the highway and around the plant have been applied. Figure 32 and Figure 33 show the polygons for indicated resources for each drill hole and the location of the caverns for the future brine field. It is assumed that within the extrapolated drill hole area the grade and thickness of the mineralized members are uniform.

For each exploration drill hole the probable reserves for the extrapolated area of influence is shown for Patience Lake Member in Table 22, for Upper Belle Plaine Member in Table 23, for Lower Belle Plaine Member in Table 24, for the upper layer of the Esterhazy Member in Table 25, and for the lower layer of the Esterhazy Member in Table 26. The number of Esterhazy caverns takes into account over the mine plan (section 16.3.4), that in order to maintain at most time the balance between the amount of sylvinite and carnallitite brine optimal for the plant operation, especially at the onset of the operation, not develops caverns in the Esterhazy Member, although mineral resources are available in that Member at that location.

Total KCl that can be mined from the Probable carnallitite Reserves amount to:

| | |
|---|---|
| Patience Lake | 33.97 million tonnes of KCl |
| Upper Belle Plaine | 38.93 million tonnes of KCl |
| Lower Belle Plaine | 5.99 million tonnes of KCl |
| Total | 78.89 million tonnes of KCl |



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

Table 22 Probable Potash Reserves for the Patience Lake Member, Calculated with the Amount of Mineralized Material that Can Be Extracted from a Cavern as Given in Section 16.4

| Hole | Caverns | Mineralized Tonnage/Cavern (1000 t)[a] | Cavern Recovery Factor (%) | Average KCl Grade (%) | Total Mineralized Tonnage (million t) | Mineable Tonnage[b] (million t) | Total Mineable KCl (million t) | Total KCl Product[c] (million t) |
|---|---|---|---|---|---|---|---|---|
| DH-20 | 88 | 204.3 | 89.84 | 17.16 | 17.98 | 14.54 | 2.5 | 2.3 |
| DH-21 | 61 | 142.9 | 90.68 | 18.49 | 8.72 | 7.12 | 1.3 | 1.2 |
| DH-11 | 80 | 194.3 | 89.04 | 19.22 | 15.54 | 12.46 | 2.4 | 2.2 |
| 4B14-24 | 113 | 367.4 | 84.47 | 21.48 | 41.51 | 31.56 | 6.8 | 6.3 |
| 13-36 | 107 | 161.7 | 87.55 | 22.78 | 17.30 | 13.63 | 3.1 | 2.9 |
| 3A11-27 | 14 | 174.0 | 89.27 | 17.45 | 2.44 | 1.96 | 0.3 | 0.3 |
| 2A11-12 | 122 | 207.6 | 91.28 | 19.22 | 25.32 | 20.80 | 4.0 | 3.7 |
| 4D14-21 | 106 | 206.5 | 87.23 | 18.33 | 21.88 | 17.18 | 3.1 | 2.9 |
| 3C4-8 | 116 | 206.3 | 90.57 | 19.03 | 23.93 | 19.51 | 3.7 | 3.4 |
| 3B4-26 | 55 | 86.7 | 91.22 | 30.31 | 4.77 | 3.91 | 1.2 | 1.1 |
| 2C6-32 | 108 | 202.6 | 91.26 | 18.82 | 21.88 | 17.97 | 3.4 | 3.1 |
| 2-24 | 65 | 199.2 | 90.35 | 20.10 | 12.95 | 10.53 | 2.1 | 2.0 |
| Total/*Av.* | 1035 | *207.0* | *88.78* | *19.85* | 214.21 | 171.15 | 33.97 | 31.52 |

[a] t is metric tonnes,

[b] taking into account 10% anomalies below resolution of the seismic and cavern recovery factor

[c] plant efficiency of 90% and a KCl content of the product of 97%



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany

Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

Table 23 Probable Potash Reserves for the Upper Belle Plaine Member, Calculated with the Amount of Mineralized Material that Can Be Extracted from a Cavern as Given in Section 16.4

| Hole | Caverns | Mineralized Tonnage/Cavern (1000 t)[a] | Cavern Recovery Factor (%) | Average KCl Grade (%) | Total Mineralized Tonnage (million t) | Mineable Tonnage[b] (million t) | Total Mineable KCl (million t) | Total KCl Product[c] (million t) |
|---|---|---|---|---|---|---|---|---|
| DH-20 | 88 | 251.5 | 90.05 | 18.15 | 22.13 | 17.94 | 3.3 | 3.0 |
| DH-21 | 61 | 269.5 | 89.21 | 19.72 | 16.44 | 13.20 | 2.6 | 2.4 |
| DH-11 | 80 | 257.8 | 89.17 | 18.01 | 20.63 | 16.55 | 3.0 | 2.8 |
| 4B14-24 | 113 | 242.7 | 91.70 | 21.35 | 27.43 | 22.64 | 4.8 | 4.5 |
| 13-36 | 107 | 225.4 | 90.27 | 18.79 | 24.12 | 19.59 | 3.7 | 3.4 |
| 3A11-27 | 14 | 267.8 | 91.36 | 20.63 | 3.75 | 3.08 | 0.6 | 0.6 |
| 2A11-12 | 122 | 241.3 | 89.93 | 17.90 | 29.44 | 23.83 | 4.3 | 4.0 |
| 4D14-21 | 106 | 232.3 | 90.05 | 19.50 | 24.62 | 19.96 | 3.9 | 3.6 |
| 3C4-8 | 116 | 256.2 | 91.95 | 19.03 | 29.72 | 24.59 | 4.7 | 4.3 |
| 3B4-26 | 55 | 235.1 | 90.59 | 18.43 | 12.93 | 10.54 | 1.9 | 1.8 |
| 2C6-32 | 108 | 230.4 | 90.86 | 18.70 | 24.88 | 20.35 | 3.8 | 3.5 |
| 2-24 | 65 | 234.8 | 90.29 | 19.03 | 15.26 | 12.40 | 2.4 | 2.2 |
| Total/*Av.* | 1035 | *242.8* | *90.48* | *19.02* | 251.34 | 204.66 | 38.93 | 36.12 |

[a] t is metric tonnes,

[b] taking into account 10% anomalies below resolution of the seismic and cavern recovery factor

[c] plant efficiency of 90% and a KCl content of the product of 97%



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany

Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

Table 24 Probable Potash Reserves for the Lower Belle Plaine Member, Calculated with the Amount of Mineralized Material that Can Be Extracted from a Cavern as Given in Section 16.4

| Hole | Caverns | Mineralized Tonnage/Cavern (1000 t)[a] | Cavern Recovery Factor (%) | Average KCl Grade (%) | Total Mineralized Tonnage (million t) | Mineable Tonnage[b] (million t) | Total Mineable KCl (million t) | Total KCl Product[c] (million t) |
|---|---|---|---|---|---|---|---|---|
| DH-20 | 88 | 162.5 | 32.26 | 17.18 | 14.30 | 4.15 | 0.7 | 0.7 |
| DH-21 | 61 | 188.4 | 32.19 | 15.07 | 11.49 | 3.33 | 0.5 | 0.5 |
| DH-11 | 80 | 203.3 | 32.33 | 8.52 | 16.27 | 4.73 | 0.4 | 0.4 |
| 4B14-24 | 113 | 165.3 | 31.24 | 11.09 | 18.68 | 5.25 | 0.6 | 0.5 |
| 13-36 | 107 | 177.9 | 32.63 | 9.66 | 19.04 | 5.59 | 0.5 | 0.5 |
| 3A11-27 | 14 | 146.7 | 31.65 | 13.83 | 2.05 | 0.58 | 0.1 | 0.1 |
| 2A11-12 | 122 | 155.2 | 30.21 | 14.49 | 18.93 | 5.15 | 0.7 | 0.7 |
| 4D14-21 | 106 | 173.7 | 31.22 | 9.59 | 18.42 | 5.17 | 0.5 | 0.5 |
| 3C4-8 | 116 | 150.2 | 30.25 | 15.24 | 17.42 | 4.74 | 0.7 | 0.7 |
| 3B4-26 | 55 | 178.6 | 31.38 | 12.97 | 9.82 | 2.77 | 0.4 | 0.3 |
| 2C6-32 | 108 | 151.1 | 30.94 | 9.19 | 16.32 | 4.54 | 0.4 | 0.4 |
| 2-24 | 65 | 173.5 | 30.89 | 13.45 | 11.28 | 3.14 | 0.4 | 0.4 |
| Total/*Av.* | 1035 | *168.1* | *31.39* | *12.18* | 174.01 | 49.16 | 5.99 | 5.55 |

[a] t is metric tonnes,

[b] taking into account 10% anomalies below resolution of the seismic and cavern recovery factor

[c] plant efficiency of 90% and a KCl content of the product of 97%



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany

Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

Table 25 Probable Potash Reserves for the Upper Layer of the Esterhazy Member, Calculated with the Amount of Mineralized Material that Can Be Extracted from a Cavern as Given in Section 16.4

| Hole | Caverns | Mineralized Tonnage/Cavern (1000 t)[a] | Cavern Recovery Factor (%) | Average KCl Grade (%) | Total Mineralized Tonnage (million t) | Mineable Tonnage[b] (million t) | Total Mineable KCl (million t) | Total KCl Product[c] (million t) |
|---|---|---|---|---|---|---|---|---|
| DH-20 | 48 | 77.5 | 89.62 | 26.48 | 3.72 | 3.00 | 0.8 | 0.7 |
| DH-21 | 47 | 69.8 | 88.92 | 25.20 | 3.28 | 2.63 | 0.7 | 0.6 |
| DH-11 | 48 | 124.8 | 88.28 | 20.87 | 5.99 | 4.76 | 1.0 | 0.9 |
| 4B14-24 | 97 | 70.1 | 88.62 | 23.33 | 6.80 | 5.43 | 1.3 | 1.2 |
| 13-36 | 56 | 68.0 | 91.67 | 22.46 | 3.81 | 3.14 | 0.7 | 0.7 |
| 3A11-27 | 12 | 67.8 | 91.64 | 35.01 | 0.81 | 0.67 | 0.2 | 0.2 |
| 2A11-12 | 76 | 106.4 | 89.78 | 24.73 | 8.09 | 6.53 | 1.6 | 1.5 |
| 4D14-21 | 72 | 60.6 | 88.23 | 20.16 | 4.36 | 3.46 | 0.7 | 0.6 |
| 2C6-32 | 80 | 60.5 | 90.67 | 30.36 | 4.84 | 3.95 | 1.2 | 1.1 |
| 2-24 | 57 | 95.9 | 90.55 | 30.57 | 5.47 | 4.46 | 1.4 | 1.3 |
| Total/*Av.* | 593 | *79.5* | *89.57* | *25.06* | 47.17 | 38.03 | 9.53 | 8.84 |

[a] t is metric tonnes,

[b] taking into account 10% anomalies below resolution of the seismic and cavern recovery factor

[c] plant efficiency of 90% and a KCl content of the product of 97%



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany

Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

Table 26 Probable Potash Reserves for the Lower Layer of the Esterhazy Member, Calculated with the Amount of Mineralized Material that Can Be Extracted from a Cavern as Given in Section 16.4

| Hole | Caverns | Mineralized Tonnage/Cavern (1000 t)[a] | Cavern Recovery Factor (%) | Average KCl Grade (%) | Total Mineralized Tonnage (million t) | Mineable Tonnage[b] (million t) | Total Mineable KCl (million t) | Total KCl Product[c] (million t) |
|---|---|---|---|---|---|---|---|---|
| DH-20 | 48 | 102.0 | 88.22 | 20.78 | 4.89 | 3.89 | 0.8 | 0.7 |
| DH-21 | 47 | 102.9 | 89.98 | 25.22 | 4.84 | 3.92 | 1.0 | 0.9 |
| DH-11 | 48 | 75.3 | 90.25 | 26.91 | 3.61 | 2.93 | 0.8 | 0.7 |
| 4B14-24 | 97 | 60.8 | 91.18 | 38.03 | 5.90 | 4.84 | 1.8 | 1.7 |
| 13-36 | 56 | 83.3 | 88.29 | 20.68 | 4.66 | 3.71 | 0.8 | 0.7 |
| 2-24 | 57 | 94.7 | 89.31 | 24.78 | 5.40 | 4.34 | 1.1 | 1.0 |
| Total/Av. | 353 | *83.0* | *89.57* | *26.53* | 29.31 | 23.62 | 6.27 | 5.82 |

[a] t is metric tonnes,

[b] taking into account 10% anomalies below resolution of the seismic and cavern recovery factor

[c] plant efficiency of 90% and a KCl content of the product of 97%



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany

Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

Table 27 Probable $MgCl_2$ Reserves for the Patience Lake Member, Calculated with the Amount of Mineralized Material that Can Be Extracted from a Cavern as given in Section 16.4 and the transformation factor for $MgCl_2$

| Hole | Caverns | Mineralized Tonnage/Cavern (1000 t)[a] | Cavern Recovery Factor (%) | Average $MgCl_2$ Grade (%) | Total Mineralized Tonnage (million t) | Mineable Tonnage[b] (million t) | Total Mineable $MgCl_2$ (million t) | Total $MgCl_2$ Product[c] (million t) |
|---|---|---|---|---|---|---|---|---|
| DH-20 | 108 | 204.3 | 89.84 | 24.27 | 22.06 | 17.84 | 4.3 | 0.2 |
| DH-21 | 128 | 142.9 | 90.68 | 24.29 | 18.30 | 14.93 | 3.6 | 0.2 |
| DH-11 | 120 | 194.3 | 89.04 | 25.32 | 23.31 | 18.68 | 4.7 | 0.2 |
| 4B14-24 | 189 | 367.4 | 84.47 | 13.95 | 69.43 | 52.78 | 7.4 | 0.4 |
| 13-36 | 168 | 161.7 | 87.55 | 21.64 | 27.16 | 21.40 | 4.6 | 0.2 |
| 3A11-27 | 69 | 174.0 | 89.27 | 22.82 | 12.00 | 9.64 | 2.2 | 0.1 |
| 2A11-12 | 172 | 207.6 | 91.28 | 25.91 | 35.70 | 29.33 | 7.6 | 0.4 |
| 4D14-21 | 175 | 206.5 | 87.23 | 24.62 | 36.13 | 28.36 | 7.0 | 0.4 |
| 3C4-8 | 174 | 206.3 | 90.57 | 24.97 | 35.89 | 29.26 | 7.3 | 0.4 |
| 3B4-26 | 94 | 86.7 | 91.22 | 12.37 | 8.15 | 6.69 | 0.8 | 0.0 |
| 2C6-32 | 174 | 202.6 | 91.26 | 27.48 | 35.25 | 28.95 | 8.0 | 0.4 |
| 2-24 | 121 | 199.2 | 90.35 | 23.23 | 24.10 | 19.60 | 4.6 | 0.2 |
| Total/*Av.* | 1692 | *205.4* | *88.72* | *22.38* | 347.49 | 277.47 | 62.1 | 3.2 |

[a] t is metric tonnes,

[b] taking into account 10% anomalies below resolution of the seismic and cavern recovery factor

[c] plant efficiency of 90% and a recovery of 4.48% for first 6 years with brine only, 5.80% after 6 years, brine and hydromagnesite



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany

Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

Table 28 Probable $MgCl_2$ Reserves for the Upper Belle Plaine Member, Calculated with the Amount of Mineralized Material that Can Be Extracted from a Cavern as given in Section 16.4 and the transformation factor for $MgCl_2$

| Hole | Caverns | Mineralized Tonnage/Cavern (1000 t)[a] | Cavern Recovery Factor (%) | Average $MgCl_2$ Grade (%) | Total Mineralized Tonnage (million t) | Mineable Tonnage[b] (million t) | Total Mineable $MgCl_2$ (million t) | Total $MgCl_2$ Product[c] (million t) |
|---|---|---|---|---|---|---|---|---|
| DH-20 | 108 | 251.5 | 90.05 | 23.17 | 27.16 | 22.01 | 5.1 | 0.3 |
| DH-21 | 128 | 269.5 | 89.21 | 24.58 | 34.49 | 27.69 | 6.8 | 0.4 |
| DH-11 | 120 | 257.8 | 89.17 | 23.63 | 30.94 | 24.83 | 5.9 | 0.2 |
| 4B14-24 | 189 | 242.7 | 91.70 | 28.24 | 45.88 | 37.86 | 10.7 | 0.6 |
| 13-36 | 168 | 225.4 | 90.27 | 23.00 | 37.87 | 30.76 | 7.1 | 0.4 |
| 3A11-27 | 69 | 267.8 | 91.36 | 25.12 | 18.47 | 15.19 | 3.8 | 0.2 |
| 2A11-12 | 172 | 241.3 | 89.93 | 22.06 | 41.50 | 33.59 | 7.4 | 0.4 |
| 4D14-21 | 175 | 232.3 | 90.05 | 25.00 | 40.65 | 32.94 | 8.2 | 0.4 |
| 3C4-8 | 174 | 256.2 | 91.95 | 25.36 | 44.58 | 36.89 | 9.4 | 0.5 |
| 3B4-26 | 94 | 235.1 | 90.59 | 25.08 | 22.10 | 18.02 | 4.5 | 0.2 |
| 2C6-32 | 174 | 230.4 | 90.86 | 24.80 | 40.08 | 32.78 | 8.1 | 0.4 |
| 2-24 | 121 | 234.8 | 90.29 | 24.96 | 28.41 | 23.09 | 5.8 | 0.3 |
| Total/*Av.* | 1692 | *243.6* | *90.50* | *24.66* | 411.13 | 335.66 | 82.8 | 4.3 |

[a] t is metric tonnes,

[b] taking into account 10% anomalies below resolution of the seismic and cavern recovery factor

[c] plant efficiency of 90% and a recovery of 4.48% for first 6 years with brine only, 5.80% after 6 years, brine and hydromagnesite



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany

Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

Table 29 Probable $MgCl_2$ Reserves for the Lower Belle Plaine Member, Calculated with the Amount of Mineralized Material that Can Be Extracted from a Cavern as given in Section 16.4 and the transformation factor for $MgCl_2$

| Hole | Caverns | Mineralized Tonnage/Cavern (1000 t)[a] | Cavern Recovery Factor (%) | Average $MgCl_2$ Grade (%) | Total Mineralized Tonnage (million t) | Mineable Tonnage[b] (million t) | Total Mineable $MgCl_2$ (million t) | Total $MgCl_2$ Product[c] (million t) |
|---|---|---|---|---|---|---|---|---|
| DH-20 | 108 | 220.5 | 28.14 | 7.90 | 23.81 | 6.03 | 0.5 | 0.0 |
| DH-21 | 128 | 188.4 | 32.19 | 8.06 | 24.11 | 6.99 | 0.6 | 0.0 |
| DH-11 | 120 | 203.3 | 32.33 | 5.40 | 24.40 | 7.10 | 0.4 | 0.0 |
| 4B14-24 | 189 | 165.3 | 31.24 | 10.74 | 31.25 | 8.79 | 0.9 | 0.1 |
| 13-36 | 168 | 177.9 | 32.63 | 12.37 | 29.89 | 8.78 | 1.1 | 0.1 |
| 3A11-27 | 69 | 146.7 | 31.65 | 9.85 | 10.12 | 2.88 | 0.3 | 0.0 |
| 2A11-12 | 172 | 155.2 | 30.21 | 11.38 | 26.69 | 7.26 | 0.8 | 0.0 |
| 4D14-21 | 175 | 173.7 | 31.22 | 11.10 | 30.40 | 8.54 | 0.9 | 0.1 |
| 3C4-8 | 174 | 150.2 | 30.25 | 9.74 | 26.13 | 7.11 | 0.7 | 0.0 |
| 3B4-26 | 94 | 178.6 | 31.38 | 11.47 | 16.78 | 4.74 | 0.5 | 0.0 |
| 2C6-32 | 174 | 151.1 | 30.94 | 11.72 | 26.30 | 7.32 | 0.9 | 0.1 |
| 2-24 | 121 | 173.5 | 30.89 | 12.88 | 21.00 | 5.84 | 0.8 | 0.0 |
| Total/*Av.* | 1692 | *171.9* | *31.08* | *10.27* | 290.88 | 81.37 | 8.4 | 0.4 |

[a] t is metric tonnes,

[b] taking into account 10% anomalies below resolution of the seismic and cavern recovery factor

[c] plant efficiency of 90% and a recovery of 4.48% for first 6 years with brine only, 5.80% after 6 years, brine and hydromagnesite



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany

Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

Total KCl that can be produced from the Probable sylvinite Reserves of the Esterhazy Member amount to:

| | |
|---|---|
| Upper Esterhazy layer | 9.53 million tonnes of KCl |
| Lower Esterhazy layer | 6.27 million tonnes of KCl |
| Total | 15.80 million tonnes of KCl |

making a total of 95 million tonnes of KCl that can be mined from all Probable Mineral Reserves, which at 90% plant efficiency and 97% KCl product quality in the order of 88.0 million tonnes of product.

In the opinion of the authors of this Technical Report the Probable Mineral Reserves will be transformed to Proven Mineral Reserves with the continuing exploration and development of the brine field.

In the opinion of the authors the potential variations in the estimate are minor only and will not materially affect the economic viability of the project.

The probable $MgCl_2$ reserves for the area of influence around each exploration drill hole are shown for the Patience Lake Member in Table 27, for Upper Belle Plaine Member in Table 28, and for Lower Belle Plaine Member in Table 29. This takes into account a variable amount of the $MgCl_2$ between 19.7% for a 625,000 tpy potash production and 5.8% for the 2.125 million tpy potash production that is used, to provide an estimate of the amount of $MgCl_2$ product that can be produced from the mined brine.

The transformation/recovery factors for $MgCl_2$ are relatively low and variable depending on the planned potash production, because the Magnesium products are made from the potash production endbrine and the present magnesium product plant design requires only a part of the total endbrine for an annual production of 100,000 tonnes of $MgCl_2$ brine and 104,000 tpy of hydromagnesite. The remaining end brine from potash production is considered waste and not part of the resources or reserves, as there are no plans for further production of Mg-products.

Total Magnesium chloride that can be processed to saleable products from the Probable carnallitite Reserves amount to:

| | |
|---|---|
| Patience Lake | 3.2 million tonnes of $MgCl_2$ |
| Upper Belle Plaine | 4.3 million tonnes of $MgCl_2$ |
| Lower Belle Plaine | 0.4 million tonnes of $MgCl_2$ |
| Total | 7.9 million tonnes of $MgCl_2$ |

In the opinion of the authors that at the given boundary conditions the potential variations in the estimate are minor only and will not materially affect the economic viability of the project.

## 15.4 Factors that Could Affect the Mineral Reserve

There are a number of technical, legal and environmental issues that could affect the mineral reserve estimation, which will be discussed in the following.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

The mineral Reserve Estimation has over the Resource area a 10% reduction of amount of Potash and Magnesium Chloride that can be extracted from a cavern on top of accounting for known geological reasons for excluding areas from the reserve estimate. This is a blanket reduction of the reserves for barren zones below the resolution of 3D seismics that might occur. Technical progress in 3D seismics might at a certain point result in better resolution, allowing a more detailed mapping of such barren zones that could in the opinion of the authors have some minor effects on the reserve estimate.

The Reserve Estimation has been based on a cavern distribution according to a fixed cavern grid that has been projected over the resource areas. Caverns that with their centre of gravity fell outside the area, have not been included in the reserve estimate. This grid has been projected over the resource areas nearly randomly and there is a theoretical opportunity to optimize the location of this grid to increase the number of caverns that can be placed in the resource areas. Furthermore, at some locations caverns that were discarded, could have been slightly shifted or rotated, staying within the limits given by the rock mechanical modelling, to be acceptable. All this could have had in the opinion of the authors, a minor positive influence on the reserve estimate, but this work has not been done as this would require additional engineering and add costs during future implementation.

The reserve estimation is based on the mine plan. The mine plan allows that the required relation between carnallitite and sylvinite brine for the plant, is balanced over the 3 phases. A different project implementation scheme can change the time plan between the phases and it will be required to re-do the mine plan to ensure that the required relation between carnallitite and sylvinite brine for the plant is also balanced in the new plan. This could require that in some caverns the Esterhazy Member sylvinite will not be mined, but alternatively some caverns where Esterhazy Member sylvinite will not be mined in the present plan, actually will be mined. In the opinion of the authors this can have some minor effects on the reserve estimate (less than 10 Esterhazy Member caverns influenced).

Caverns are accessed from a central platform using directional drilling. Due to the presence of wetlands, that for environmental reasons cannot be used for platform construction or pipeline routing, as well as due to the presences of dwelling, road off-sets and shallow pipelines, the ideal positioning of platforms is not always possible. This has been studied in detail for the first 6 years of phase 1, and here platforms could be positioned in such a way that all planned caverns could be reached. This has not been done in detail yet for the whole brine field area. Because of the flexibility given by the directional drilling used for cavern preparation there is always the opportunity to relocate drilling platform and pipeline routes and in the opinion of the authors the inability to reach planned caverns from a centralized drilling platform should not materially affect the reserve estimate.

Within the leases held by KARNALYTE a relatively small number of freehold properties are present, which are not included in the Reserve Estimate, that are surrounded by KARNALYTE mining rights. KARNALYTE has started work on negotiation with owners to purchase the rights. Acquiring these rights would increase the reserve base of the project. If these rights for some reason cannot be obtained the Ministry of Economy has indicated that KARNALYTE should leave a boundary of at least 80m between caverns and the lease boundary. This would impact the reserve estimate by taking out in the worst case, if no rights are obtained, in the range of 25 caverns on a total of near 1700.

The Environmental Impact Statement (EIS) that KARNALYTE has made and which has been accepted by the authorities, does not cover all lease areas or the whole of the planned brine field area, but concentrates on the central and northern part of the Lease KLSA 010. For the first 5 years of the planned mining operation the area is covered by the



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

EIS. Beyond this time period, the mine plan will extend part of the brine field outside the EIS boundaries. KARNALYTE will have to get an EIS for the remaining parts of the planned brine field, to continue mining. Because the area not yet covered does not differ significantly from the area already covered by the approved EIS, it is the opinion of the authors that there is no reason to assume that KARNALYTE will not get an EIS for the extension approved. In case KARNALYTE would not get an approved EIS for the remaining area the reserve estimate would be significantly reduced.

The drilling of a well within 600m of an outer lease boundary, requires permission of the Ministry of the Economy. This rule comes from the oil and gas industry and is important to prevent uncontrolled mining of oil and gas from a neighboring lease. The interpretation of this rule is that freehold lands at the outer lease boundary are part of the outer lease boundary and that this 600m buffer zone applies there too. For most outer lease boundaries, this has been accounted for in the mine plan, but there are still a number of locations within the mine plan, where KARNALYTE would need permission of the Ministry for drilling cavern wells. These locations and the potential impact on the reserve estimate will be discussed in the following:

- At the boundary of lease KLSA 010 towards the town of Wynyard, the present outer lease boundary has already been set half mile back from the present border of the town, when compared to the original KP 360 permit, to prevent influence of subsidence from the mining on the town. Since this boundary is not to a neighboring production lease KARNALYTE has received confirmation from the Ministry of Economics that drilling for caverns will be in principle allowed in this 600m zone, or that this area is actually included in the new Lease. If for some reason the permission would not be granted this would impact the reserve estimate by taking out in the order of 40 caverns on a total of nearly 1700.
- KARNALYTE owns 3 neighboring leases, and in principle at the boundary between these leases the 600m buffer zone also applies. Because at these locations the motive of the buffer zone does not apply, there is no reason why the ministry should not give permission for cavern drilling here. If for some reason the permission would not be granted this would in the opinion of the authors severely impact the reserve estimate as several 100 caverns could be affected in later years of the project.
- KARNALYTE is in the process of negotiating freehold mineral rights for areas within their lease boundaries, including some freehold areas at the outer lease boundary. If KARNALYTE does not obtain the freehold mineral rights at these outer lease boundary freehold areas and would not get permission to drill within the 600m buffer zone, this could impact the reserve estimate by taking out in the order of 60 caverns on a total of nearly 1700.

For the $MgCl_2$ reserve estimate, the capacity and market for Magnesium products beyond the present design capacity of the $MgCl_2$ processing facility and the potential market as described in section 19, could influence the reserve estimate.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

# 16 Mining Methods

As discussed in Sections 7.4 and 13.1, carnallitite from Belle Plaine and Patience Lake Members, as well as sylvinite of the Esterhazy members and part of the Patience Lake member will be solution mined separately, because mixing of the brine produced by mining the different mineralogical horizons would probably result in crystallization of Halite in the pipeline system, the solution mining operation has been designed in such way that these brines are mixed only at the plant site.

The relative amounts of production brine from the sylvinite and the carnallitite depend on the relative mineable thickness of the different horizons and the average grade of these horizons. As shown in Section 7.4, most drill holes have a relative constant and significant thickness of carnallitite from the Belle Plaine and Patience Lake Members, whereas there are large differences in the number of horizons in the Esterhazy Member with thickness and average grade suitable for mining. For this reason most of the production brine will come from the solution mining of the carnallitite of the Belle Plaine and Patience Lake Members and only a subordinate and variable amount of the overall production brine will come from the sylvinite of the Esterhazy Member.

The operating requirements for solution mining will be presented first, followed by a description of the solution mining procedure with explanation why certain decisions were taken. This is followed by a description of a mass volume balance for a single cavern as well as the overall brine field dynamics and the general brine field design.

## 16.1 Operating Requirements

Cavern size, approximate location, cavern access and required blanket material will be discussed in the following sections.

### 16.1.1 Cavern Size and Cavern Pillar Configuration

The average design parameters for the caverns in the KARNALYTE potash project are listed in Table 30 and the dimensions are visualized in Figure 35, Figure 36, and Figure 37. The cavern configuration consists of (a) lower cavern(s) in the Esterhazy Member and an upper cavern in the Belle Plaine and Patience Lake Members, separated by a thick layer of rock salt. Rock Mechanical modeling, using parameters derived from test work on the deposit rock (IfG, 2011, /36/) have shown that the proposed configuration results in long term stable caverns.

The rock mechanical modelling was also used to estimate the potential for subsidence. The initial study (IfG, 2011, /36/), was based on the assumption that during or shortly after leaching the Patience Lake Formation hydraulic contact between cavern and Dawson Bay formation would occur, and that maximal pressure in the cavern would be pressure of the brine column. This resulted in relatively fast subsidence rates and total subsidence in the range of 5.4m after about 100 years of mining. Information available from the Dawson Bay formation in the region, indicate that the formation actually is a non aquifer in the investigation area, which has been confirmed by permeability tests on core material from the



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

Dawson Bay formation that were selected based on visual inspection to have highest porosity (e.g. CoreLab, 2013, /13/). This new information means that as long as the cavern is properly sealed, the cavern will stay a closed system even in contact with the Dawson Bay formation, and the pressure inside the cavern will rise to near hydrostatic. At that point the actual cavern closure rate, determining subsidence rate is controlled by the ability of the brine to move out of the sealed cavern and this is a very slow process. The long term subsidence rates over the brine field have been estimated using this approach and most subsidence will take place during mining of the caverns and shortly after (~0.5m) with afterwards rates as low as 0.006 mm/year (IfG, 2013, /37/). This indicates that the maximum subsidence after 100 years after mining will be in the range of 1.0m only, with no significant damage for surface infrastructure expected.

Table 30 Preliminary Parameters for the Proposed Cavern Design (Depths are typical Depths and may differ up to 100m depending on the Location of a Cavern on the Brine Field)

| | **Esterhazy Member** | **Belle Plaine and Patience Lake Members** |
|---|---|---|
| Max. Length | 170 m | 170 m |
| Max. Width | 100 m | 100 m |
| Max. Height | 7 m | 35 m |
| Max. Area | 14,850 m² | 14,850 m² |
| Min. Horizontal Distance between Caverns | 80 m | 80 m |
| Depth of Cavern Top | 978 m | 915 m |
| Vertical Distance between Caverns | 28 m | |

## 16.1.2 Cavern Access

The caverns will be accessed by directional drilling from a central drilling/production pad, but the drill holes will be vertical from 900m depth downward to below the deepest part of the cavern. For up to 6 caverns per pad the design of the single wells that can be reached from a central pad, can be achieved with the maximum defined curvature parameters of 3°/100m. This even leaves the opportunity to shift the pad from a central position if required for environmental reasons.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

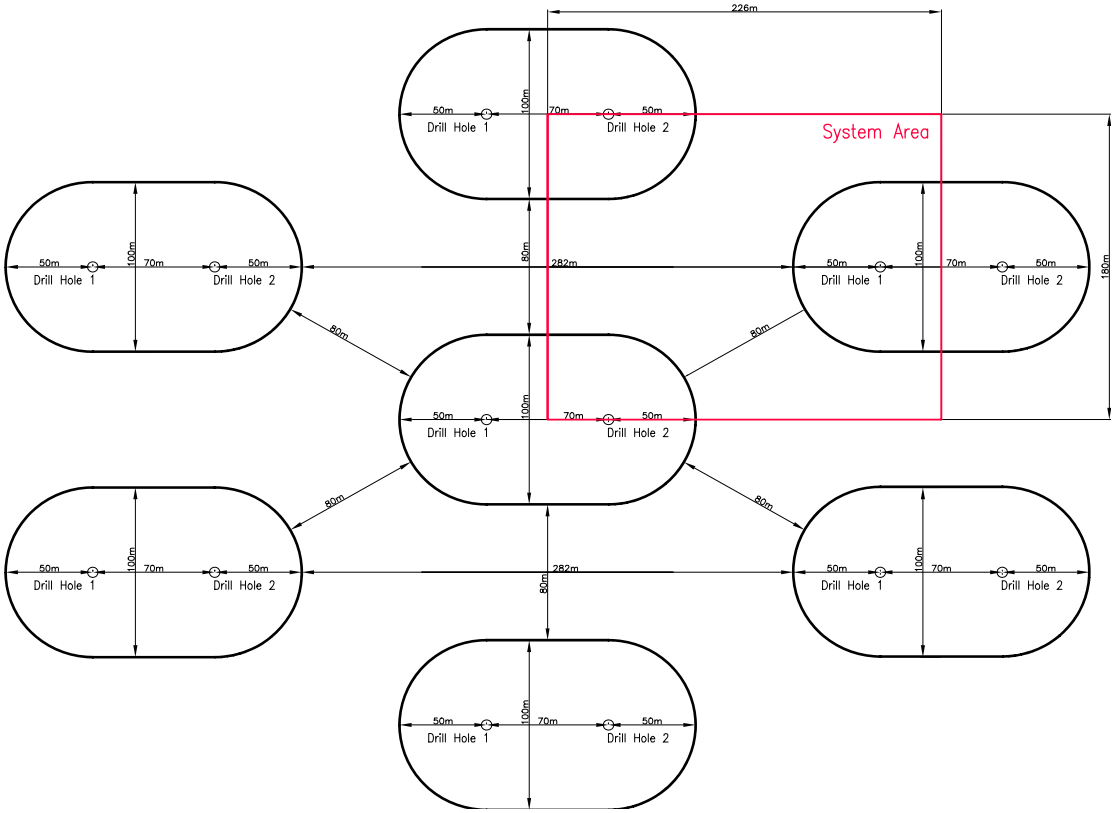



Figure 35 Map View and Parameters of the Cavern and Pillar Design

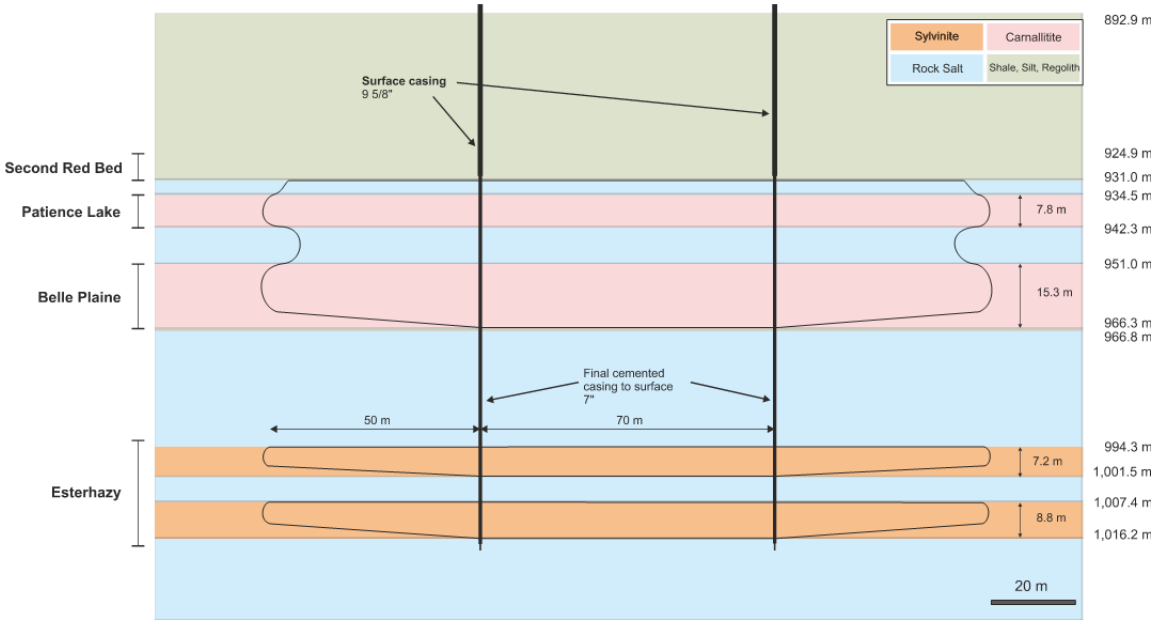



Figure 36 Section View Along the Long Cavern Axis and Parameters of the Proposed Cavern and Pillar Design



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

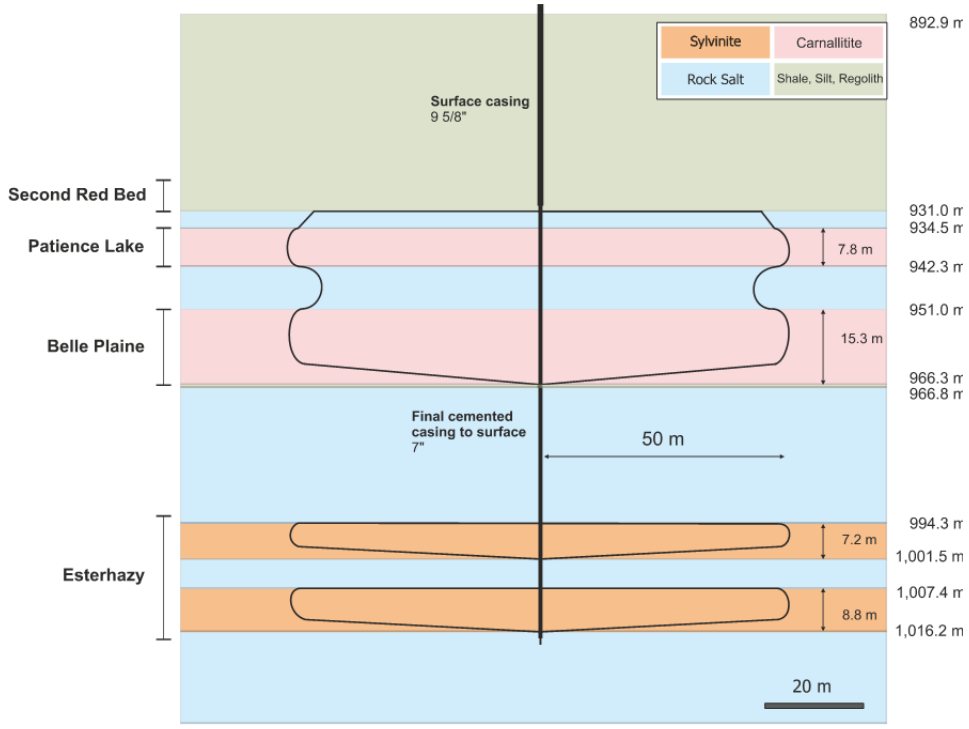



Figure 37 Section View Along the Short Cavern Axis and Parameters of the Proposed Cavern and Pillar Design

Because of the required directional drilling, the use of a continuously controlled blanket system is not feasible (the lowering of a non-damaged cable on the outer leach string to allow for a continuous control cannot be guaranteed). Furthermore, the insertion of a double leach string, offering 3 separate pathways between cavern and surface in a deviated well, is considered an operation with a high probability of failure of leach strings during work over operations that can block the cavern access. For these reasons a well design offering only two pathways with a discontinuous blanket operation is preferred, that only requires the operation of a leach string during cavern preparation. The preliminary well design is listed in Table 31 and schematically depicted in Figure 38. All casing is cemented from bottom to surface. The leach string hangs unsupported (except for centralizers) from the well head at the surface down to about 5m above the bottom of the open hole.

### 16.1.3 Blanket Requirements

The depth of the deposit in the range of 1,000m would require high pressure for a gas blanket, which would require high pressure armatures for the wells. To avoid this, an oil blanket is chosen. As discussed before, the requirement of directional drilling precludes using a continuous blanket system and for blanket operation the method of reverse flushing is chosen. To control the blanket level, regular geophysical logging will be required.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

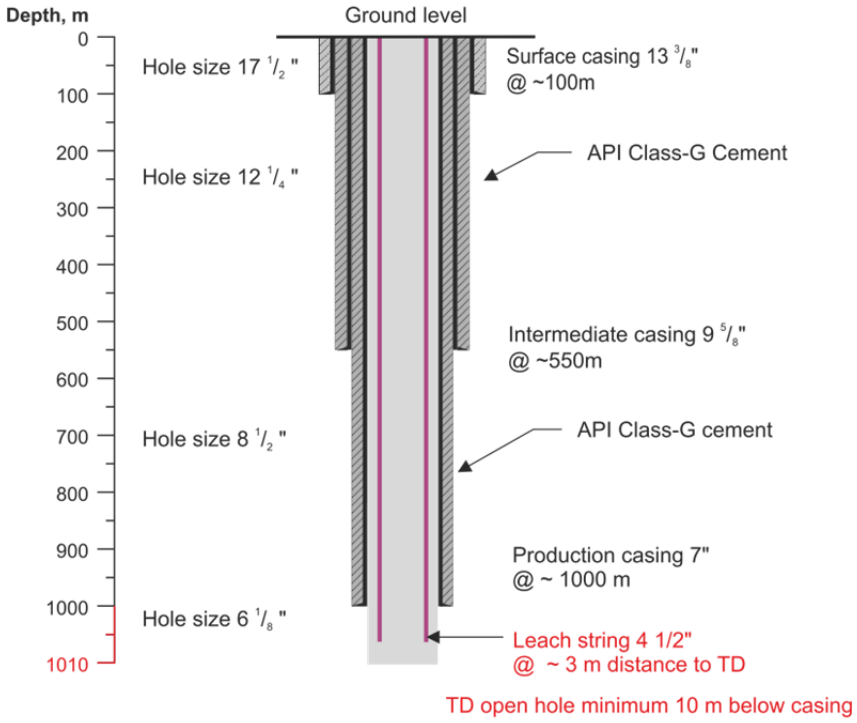



Figure 38 Schematic Casing Scheme for Solution Mining Drill Holes (Depths depend on the actual Situation on the Brine Field)

Table 31 Casing and Cementation Scheme for the Solution Mining Drill Holes

| | **Geological Position** | **Depth Range** | **Hole Size** | **Casing Size** |
|---|---|---|---|---|
| Conductor Casing | Below overburden | ~100 m | 17 ½” | 13 3/8” |
| Surface Casing | Below Groundwater Section | 500 – 600 m | 12 ¼” | 9 5/8” |
| Production/Final Casing | ~2 m below Esterhazy Member | 950 – 1050 m | 8 ½” | 7” |
| Leach String | ~7 m below Esterhazy Member | 960 – 1060 m | 6 5/8” | 4 ½” |



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

## 16.2 Leaching Procedure

The leaching procedure is divided into separate procedures for solution mining of the Sylvite dominated rocks and Carnallite dominated rocks. This section first discusses the general boundary conditions for both leaching procedures, before detailing the procedures for both rock types.

For Sylvite solution mining of the Esterhazy Member at maximum two mineable horizons with grade > 20%KCl and mineable thickness > 2m considered suitable for mining have been identified (e.g. section 7.4.2). Each of these horizons will be mined separately with preparation leaching followed by a single phase of production leaching. Cavern heights as shown in Figure 36 and Figure 37, show preparation leaching and production leaching height, whereas only the height of the production leaching mining cut has been used in the reserve estimation. Mass/volume balances suggest that the brine from at least one preparation leaching phase can be recycled into the hot solvent for carnallitite solution mining. Further preparation phase brine has to be disposed off.

Because of the low height and small volume of these caverns, modeling shows that hot leaching is not very effective in significantly raising the production brine temperature (and KCl saturation %) in these caverns. Therefore cold leaching is considered for the sylvinite caverns in the Esterhazy Member to optimize energy requirement.

The Esterhazy Member solution mining concept presented has been designed for at maximum two mineable sylvinite Horizons each of at minimum 2m thickness in the Esterhazy Member, which are separated by rock salt layers. It can be easily adapted for areas where the exploration drill holes only have shown 1 mineable Horizon for the Esterhazy Member and is not required for 2 drill holes in the license area that have no mineable Esterhazy Member at all. The mining method used is cold non selective leaching in double well caverns with 70m distance between the caverns and with a 50m radius.

The Carnallite solution mining of the Patience Lake and Belle Plaine Members concentrates on the high grade Carnallite parts of these Members. These two members will be leached in five (5) phases discussed in a later section. The brine from the preparation leaching phase of the LBPM (e.g. section 7.4.1), will be recycled as the hot solvent for the carnallitite solution mining. The mining method used is hot non selective leaching in double well caverns with 70m distance between the caverns and with a 50m radius.

### 16.2.1 Solution Mining Concept Esterhazy Member

a) Preparation Leaching Esterhazy Member Horizon 1

In the preparation leaching stage the cavern is prepared for production leaching. The two different steps that are required are discussed below.

**Sump Leaching**: Sump leaching is required for both of the drill holes of a single cavern, which are not yet connected in the underground. For sump leaching water as solvent is injected through the inner leach string, which is positioned approximately 5 m below the last cemented casing positioned about 1m below the lowermost mineable horizon. The brine formed is extracted through the annulus between last cemented casing and leach string. Because at this stage the available dissolution surface is small, only small flows (5 to 10 $m^3/h$) are necessary to develop a pear shaped cavern below and behind the cemented casing. After about two weeks oil is injected to fill the cavern behind the casing.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

**Undercut Leaching**: With the start of undercut leaching the flow regime is changed and the annulus between last cemented casing and leach string is used for solvent injection. The solvent volumes used for undercut leaching will increase initially from about 10 m³/h to up to 25 m³/h. Undercut leaching for the drill hole continues till the undercut has reached a radius of approximately 35m and the two drill holes are connected in the underground. This will take up to 8 months. During this time the blanket oil volume has to be increased regularly to ensure that the undercut develops at the level as planned. When the two drill holes are connected, one drill hole will be used for injection and the other for extraction, until an undercut radius of about 50m is reached, which might take another 3 to 4 months. At the end of this stage the leach strings of both holes are extracted and for the hole with highest blanket level the casing is cut to release the blanket oil.

b) Production Leaching of the Esterhazy Member, Horizon 1

At the onset of production leaching of horizon 1, again a small cavern is leached behind the casing of the hole where the casing was cut, over the height of the mining layer (injection well). Then blanket oil is injected to start production leaching. Production leaching starts, with cold solvent (water) flow rates of 25 m³/h, that over development of the mining cut increase to up to 45 m³/h towards the end of the mining cut. In between oil has to be added to keep the blanket in the required level. To develop a more symmetric cavern, the casing of the former extraction well is cut near the top of the deposit, with eventual release of some blanket oil and this well is then used as injection well. When mass and volume balances indicate that the mining cut has reached its volume, solvent injection is stopped. The casing of the last injection well of the cavern is cut near the top of the deposit to release the blanket oil. Through the last extraction well heavy $MgCl_2$ brine from the plant is pumped down to displace the remaining production brine. Then the cavern can be abandoned.

c) Preparation Leaching Esterhazy Member Horizon 2

With the top of the Horizon 1 cavern near the planned bottom of the undercut, sump leaching is probably not required during this preparation stage and only undercut leaching is relevant.

**Undercut Leaching**: Before the start of undercut leaching the casings of both wells are cut near the bottom of Horizon 2 and the leach strings are re-inserted about 5m below the horizon 2. The further procedure is comparable to undercut leaching during Horizon 1.

d) Production Leaching of the Esterhazy Member, Horizon2

Production leaching of Horizon 2 is similar to production leaching of Horizon 1. This being the uppermost mineable Esterhazy Horizon, care is taken to make this cavern as large as possible to produce “sagging” of the Halite Interbed between Esterhazy and Belle Plaine Member and decoupling of Belle Plaine Member from the Halite Interbed at the clay layer below the Belle Plaine Member. This is standard procedure in solution mining in Saskatchewan and when successful saves time in preparation leaching of the Belle Plaine Member.

### 16.2.2 Solution Mining Concept Patience Lake and Belle Plaine Members

a) Preparation Leaching Belle Plaine Member



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

In the preparation leaching stage the cavern is prepared for production leaching. The three different steps that are required are discussed below, assuming that the decoupling of the Belle Plane Member from the Halite Interbed has not occurred.

**Sump Leaching**: Sump leaching is required for both of the drill holes of a single cavern, which are not yet connected in the underground. For sump leaching cold water as solvent is injected through the leach string, which is positioned approximately 4m below the cemented casing, which is situated about 5m above the clay layer below the Belle Plaine Member. The brine formed is extracted through the annulus between leach string and cemented casing. Because at this stage the available dissolution surface is small, only small flows (5 to 10 m³/h) are necessary to develop a pear shaped cavern below and behind the cemented casing. After about two weeks oil is injected to fill the cavern behind the casing.

**Undercut Leaching –Drill Hole Connection**: With the start of undercut leaching the flow regime is changed and the annulus between last cemented casing and leach string is used for solvent injection. The solvent volumes used for undercut leaching will increase from initially about 10 m³/h to up to 25 m³/h. Undercut leaching for the drill hole continues till the undercut has reached a radius of approximately 35m and the two drill holes are connected in the underground. This will take up to 8 months. During this time the blanket oil volume has to be increased regularly to ensure that the undercut develops at the level as planned.

**Further Undercut Development**: When the drill holes are connected in the underground, the operation is changed. One drill hole is used for injection of warm/hot solvent (80°C) through the cemented casing and the other is used for extraction of brine through the leach string. The solvent and brine volumes involved will be in the range of 15 to 30 m³/h. It is expected that this period of further undercut development will take about three months. Hot solvent is used in this stage to heat up the cavern surroundings to reduce heat losses during the onset of production leaching. To ensure symmetric cavern development the injection and extraction will be changed several times between the drill holes. Further undercut development will end, when mass and volume balances indicate that the undercut has reached a radius of about 50m. Oil is injected regularly to force the development of the undercut in the lower part of the deposit Horizon. At the end of this stage the leach strings of the holes are removed and for the hole with highest blanket level the casing is cut to release the blanket oil. Than the low grade brine from undercut leaching is replaced by warm $MgCl_2$ rich disposal brine from the plant to a level just below the uncut casing of the extraction well to prevent uncontrolled dissolution of Carnallite with potential crystallization of KCl from the brine standing in the cavern.

Preparation leaching of the Belle Plaine Member takes place in the lower part of the Belle Plaine Member, which contains appreciable amounts of potash bearing minerals. The brines produced during preparation leaching, therefore will contain potash and will be recycled as hot solvent for production leaching.

b) Production Leaching of the Belle Plaine Member Mining Cut 1

At the onset of production leaching of mining cut 1, the 7” cemented casing is cut for the hole where it is deepest about 5m below the top of the Belle Plaine Member for the injection well (injection well). At the onset of production leaching of mining cut 1, again a small cavern is leached behind the casing over the height of the mining cut. Then blanket oil is injected to start production leaching. Production leaching starts, initially with hot solvent flow rates of 30 m³/h, that over development of the mining cut increase to up to 50 m³/h towards the end of the mining cut. In between oil has to be added through the injection well to keep the blanket in the required level. When mass and volume balances indicate



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

that the mining cut has reached its volume, solvent injection is stopped and in preparation for production leaching of the second mining cut the 7" cemented casing is than cut at the extraction well near the top of the cut to release the oil (new injection well).

c) Production Leaching of the Belle Plaine Member Mining Cut 2

At the onset of production leaching of mining cut 2, again a small cavern is leached behind the casing over the height of the mining cut. Then blanket oil is injected to start production leaching. The leaching procedure is repeated in the same way as for mining cut 1. After blanket oil has been released by cutting the extraction drill hole casing at the top of the Belle Plaine Member, a $MgCl_2$ waste brine is introduced to displace the production brine in the cavern. A sonar survey can be run from the injection hole to determine the size and shape of the cavern. After the survey, the available volume for disposal of solid NaCl waste from the plant is known and the material can be introduced in the lower part of the cavern, displacing $MgCl_2$ waste brine, which is returned to the plant for disposal.

If the first cavern generation show regular cavern development during these production stages the a sonar survey is necessary only in every fourth or fifth cavern and the displacement of hot production brine from the cavern can be done using a slurry of solid NaCl and $MgCl_2$ rich waste brine, reducing the number of operations at the cavern.

d) Leaching of the Intermediate Rock Salt

For the leaching of the Intermediate Rock Salt, the casing of the former injection well is cut about 1m below the Patience Lake Member (injection well). Again a small cavern is leached behind the casing over the height of the mining cut. Than blanket oil is injected to start production leaching. Rock Salt leaching starts, initially with flow rates in the range of 30 to 40 m³/h, which will be increased to 60 to 70 m³/h (depends on capacity of leach strings and pipeline connections). All brine produced during this stage will have high NaCl content and low KCl content and is disposed of as it would dilute the normal production brine. Initially solvent will be cold, but during the last stage of this mining cut hot solvent will be used to pre-heat the surroundings of the cavern and reduce temperature losses during the onset of production leaching in the Patience Lake Member. In between oil has to be added through the injection well to keep the blanket in the required level. To reduce the amount of waste brine for this mining cut an effective cavern radius of 40 to 45m is made during this stage. When mass and volume balances indicate that the mining cut has reached its volume, solvent injection is stopped. The casing of the extraction well is cut near the bottom of the Patience Lake Member to release the blanket oil. The remaining NaCl rich brine is displaced by $MgCl_2$ rich disposal brine from the plant to prevent mixture of NaCl rich brine with production quality brine during production leaching. The cavern is than ready for the next mining cut.

Alternatively, to reduce the amount of NaCl rich disposal brine a new Preparation phase can be started below the Patience Lake Member, comparable to the Preparation Leaching of the Belle Plaine Member. This, however, will take longer than leaching through the Intermediate Rock Salt and further increase the number of operational caverns on the brine field.

e) Production Leaching of the Patience Lake Member Mining Cuts

The procedures for Production Leaching of the Patience Lake Mining Cuts are similar to the procedure for mining of the Belle Plaine Mining Cuts.

f) Cavern Backfill and Abandonment

After finalization of production leaching of the Patience Lake Member and displacement of the remaining production brine with $MgCl_2$ brine as much of the remaining cavern space



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

as possible will be filled with solid NaCl from the plant operation. This reduces the amount of solid NaCl that needs to be disposed of in the Deadwood formation and solid material in the cavern reduces the final overall subsidence over a cavern. The displaced $MgCl_2$ brine is transported back to the plant and disposed of.

## 16.3 Brine Field Dynamics and Cavern Mass and Volume Balances,

The composition of the production brines has been designed for the project based on temperature modeling and dissolution test work on samples from the deposit (ERCOSPLAN, 2011, /19/) and will be discussed first, followed by a discussion of the brine field dynamics and cavern mass volume balances.

### 16.3.1 Production Brine Composition

The solution mining method assumes that cold water will be used for solution mining of the sylvinite of the Esterhazy Member as well as for most part of the rock salt interbed between Patience Lake and Belle Plaine Member. It is assumed that the production brine from this leaching operation will have an ambient temperature near 25°C.

For the design of the average production brine from the Esterhazy Member following considerations have been made:

#### KCl saturation level

The KCl saturation level for production brine coming from the cavern should ideally be as high as possible. Theoretically 100% saturation can be reached, but because dissolution velocity decreases to near zero close to saturation, this would require a long residence time from the solvent in the cavern and flow rates in the cavern that would not produce significant amount of brine. Depending on the composition of the deposit KCl saturation in the order of 80% (best case) to 70% (worst case) are necessary to achieve brine production levels in the range of 25 to 40 m³/h, that allow a relatively small number of caverns to supply the necessary amount of brine for KCl production to the plant.

#### Carnallite Concentration in Sylvinite

The presence of variable amounts (between 2 and 15% per mass) of Carnallite in the sylvinite of the Esterhazy member, will give rise to a $MgCl_2$ content in the brine from the cavern. Since an increase in $MgCl_2$ concentration in the production brine results in a lower KCl saturation at given temperature this will result in a reduction of the KCl content of the brine. Because, Carnallite dissolves more easily than Sylvite, there will always be a slightly higher $MgCl_2$ concentration in the brine than expected from the Carnallite content of a certain part of the deposit. For the best case it has been assumed that 10% of the KCl in the brine is due to Carnallite dissolution and the magnesium content is estimated based on the $MgCl_2$ and KCl content of Carnallite. For the worst case it has been assumed that 25% of the KCl in the brine is due to Carnallite dissolution.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

The red dotted quadrangle in Figure 39 depicts the range of potential compositions based on these two best case and worst case considerations. As high Carnallite content in the sylvinite part of the Esterhazy Member occurs relatively seldom (compare Section 7.4.2) and there are numerous caverns producing brine from the Esterhazy Member the compositional range of the production brine to be expected from the brine field will be closer to the red quadrangle shown in Figure 39. For calculations the average production brine composition from the Esterhazy Member given in Table 32 is expected (blue dot in Figure 39) has been used, the variation in KCl content from the design quadrangle is minor only and will not significantly influence the results of the calculations.

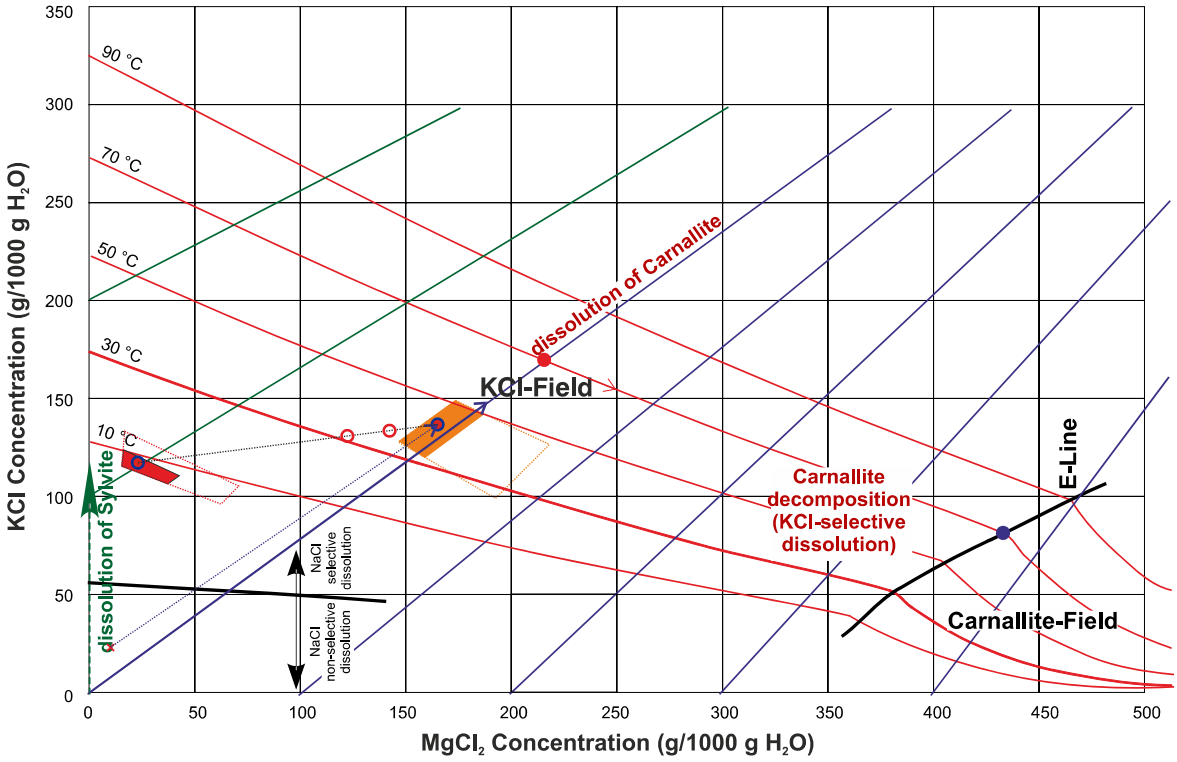



Figure 39 Equilibrium Phase Diagram of Carnallite in the $MgCl_2$– KCl – NaCl – $H_2O$ System, Showing the Relevant Points for Dissolution of Carnallite from Carnallitite Rock and the Design Ranges for Production Brine of the Sylvinitic Esterhazy Member (Red Quadrangles) and the Carnallitic Patience Lake and Belle Plaine Members (Orange Quadrangles). Also Shown Are the Compositions of Average Production Brine Resulting from Mixing Different Amounts of Average Sylvinitic and Average Carnallitic Production Brine

The carnallitic Belle Plaine and Patience Lake Members will be leached using a solvent consisting of water or a low grade brine of 95°C. Cavern mass-volume balancing suggest that for a mature brine field (with caverns in preparation and production for the Esterhazy Member, Belle Plaine Member and Patience Lake Member) a solvent with at maximum 170 g/l NaCl and a KCl pre-concentration of about 23 g/l and 10 g/l of $MgCl_2$ can be used in the solution mining process. For the design of the average production brine composition



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

from the Patience Lake and Belle Plaine Members following further considerations have been made:

Table 32 Estimated Average Production Brine Composition for Solution Mining of the Sylvinite Esterhazy Member and the Carnallitite Belle Plaine and Patience Lake Members, as well as the Range of Potential Production Brine Compositions Going to the Plant

| | **Esterhazy Sylvinitic** | **Belle Plaine/ Patience Lake Carnallitic** | **Carnallitic Brine only** | **Mixture 15% Sylvinitic with 85% Carnallitic Brine** |
|---|---|---|---|---|
| Temperature (°C) | 25 | 55 | 55 | ~50 |
| Density (g/cm³) | 1.232 | 1.232 | 1.232 | 1.232 |
| KCl (g/l) | 100.7 | 116.9 | 116.9 | 114.5 |
| NaCl (g/l) | 252.8 | 119.3 | 119.3 | 139.3[6] |
| $MgCl_2$ (g/l) | 19.7 | 140.7 | 140.7 | 122.6 |
| $CaSO_4$ (g/l) | 3.0 | 3.0 | 3.0 | 3.0 |
| H2O (g/l) | 855.2 | 852.0 | 852.0 | 853.0 |

**Production Brine Temperature**

Based on a comparison with other hot leaching it has been estimated that for a solvent of 95°C, during steady state production a production brine with a temperature between 50°C (worst case) and about 60°C (best case) can be expected.

**KCl Saturation Level**

The KCl saturation level for production brine coming from the cavern should ideally be as high as possible. For a Carnallite solution mining operation the limiting factor for the KCl saturation it is not the dissolution rate, which decrease with increasing salt concentration of the brine, that limits the saturation level that can be reached with a reasonable flow rate, because KCl saturation is well away from Carnallite saturation, but it is the risk of KCl crystallization:

- in the extraction well and pipeline system because of cooling of the brine during transport from cavern to the surface and from well to brine tank at the plant, which would hinder operations;

and

- in the cavern, due to local Carnallite decomposition, in areas of the cavern where the brine has a longer residence time or the deposit is more Carnallite rich. This decomposition results in a higher $MgCl_2$ concentration in the production brine and a lower KCl recovery from the resource. Since an increase in $MgCl_2$ concentration in the production brine results in a lower KCl saturation at given temperature, local Carnallite decomposition in the cavern also influences the maximum KCl content that could be achieved from the cavern.

[6] Not taking into account the potential crystallization of NaCl when mixing these brines.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

The results for dissolution testing of carnallitite from Belle Plaine and Patience Lake Members show reasonably fast dissolution of the carnallitite indicate that local KCl oversaturation cannot be ignored, but should not be considered a major loss issue (section 13.1).

For these reasons the KCl saturation from production brine coming from the cavern, which consists of brine mixed from various locations in the cavern has to be below 100% at given temperature. For the best case an 85% KCl saturation at temperatures between 50 and 60°C is assumed, which allows cooling down to about 40°C before crystallization of KCl starts. For the worst case an average saturation of 75% only is assumed to avoid local KCl crystallization taking place in the cavern, which could occur for example due to an inhomogeneous deposit.

Even though the average brine from the cavern does not exceed the KCl saturation, localized KCl crystallization may have occurred resulting in an increased $MgCl_2$ content of the average production brine. Best case is the assumption that no KCl crystallization has occurred, worst case that the crystallization resulted in a loss of about 15% of the KCl from the Carnallite dissolved.

The orange dotted quadrangle in Figure 39 depicts the range of potential compositions based on these two best case and worst case considerations. As the dissolution testing shows that even at low flow rates Carnallite decomposition should not be considered a major loss issue a production brine composition within the orange quadrangle is the design average production brine composition from the Patience Lake and Belle Plaine Members. The detail cavern temperature development modeling shows that an average production brine temperature of 55°C is conservative estimate and for this reason the design average production brine composition has been estimated for a production brine of 55°C which is given in Table 32 and depicted by the blue dot in the orange field in Figure 39.

The brine coming from carnallitite caverns and the brine coming from sylvinite caverns are routed through separate pipelines to the feed tank for the plant, where they are mixed and provide the plant feed brine. The plant feed brine will not be of constant composition because:

- there is not a constant composition of “carnallitite” brine and “sylvinite” brine;
- the relative proportions of “carnallitite” and “sylvinite” brine to the feed brine are variable.

The relative proportions of “carnallitite” and “sylvinite” brine that result in an average production brine depend on the amount of KCl that can be derived from the carnallite part of a cavern and from the sylvinite part of a cavern. Based on present understanding of the geology the proportion carnallitite:sylvinite brine will be between 85:15 or 80:20 depending on which exploration drill hole is used to estimate this ratio. These compositions are depicted as red circles in Figure 39.

The proportion is not fixed as the several cavern preparation phases for sylvinite solution mining and the “waste leaching” of the Intermediate Rock Salt will not allow a continuous production brine flow from single caverns and the different time frames for each solution mining phase in such cavern horizons will result in changing proportions between “carnallitite” versus “sylvinite” brine production.

Furthermore, the risk of KCl crystallization in the cavern, either due to cooling of the brine or due to Carnallite decomposition, precludes a pause in operation of the carnallitite caverns. To reduce KCl losses in the cavern it has to be operational practice that when a carnallite mining cut has been started, there is no pause in the leaching operation till the mining cut has been ended (displacement of production brine with $MgCl_2$ brine). Sylvinite



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

caverns do not show this critical “behavior” and it is therefore from an operational point of view advantageous to have the spare cavern capacity on the brine field in sylvinite caverns that can be switched on or off, depending on production brine requirements.

For these reasons the proportion of sylvinite brine to the production brine feed for the plant can be rather variable but the mine plan has to be designed in such way that it is kept between 25:75 and 10:90 Sylvinite:Carnallitite, to ensure optimal plant operation. The best estimate for the variation of average production brine composition is given in Table 32.

### 16.3.2 Brine Field Dynamics

The dimensions of the producing brine field can be estimated based on the average brine composition. It is designed that about 15 % of the brine will be coming from sylvinite caverns and 85% from Carnallite caverns resulting in average KCl content of the brine of 115g/l. This is based on the assumption that the initial brine field will be developed in the region defined by drill holes, DH-11, DH-20 and DH-21, which have 2 mineable Esterhazy beds. The efficiency of the plant has been designed to be 90%. For a production of 625,000 tpy of 97% KCl this means that about 673,600 tonnes of KCl has to be present in the production brine. This means an annual volume of brine of

~5.9 million m³

Assuming an annual brine field operation time of 8,000 hours this requires a necessary production brine volume of

~ 736 m³/hour

The dissolution test works suggest that an average flow rate of 45 m³/hour over the lifetime of a cavern is a realistic estimate. At the onset of a mining cut flow rates will be lower, at the end of a mining cut flow rates will be higher, so this number is valid for a “mature” brine field. The number of caverns that on average must be operated in parallel producing production quality brine, therefore amounts to 17 caverns with two caverns on stand-by that have to produce pre-production brine, when a cavern has a work over and does not produce or a cavern produces a below grade production brine, which makes for

19 active producing caverns

On a mature brine field on average 6 caverns will be producing from sylvinite caverns at a flow rate near 40 m³/hour, whereas the remaining caverns can produce from carnallitite at an average flow rate between 45 and 50 m³/hour. For a mature brine field, furthermore on average

- 5 to 6 caverns will be producing NaCl waste brine from the Halite Interbed between Patience Lake and Belle Plaine Member
- 4 to 5 caverns will be in the preparation phase for the Belle Plaine Member
- about 9 caverns will be in the preparation phase for one of the two mineable parts of the Esterhazy Member

The initial brine field, starting with production from the carnallitite, therefore, will require a minimum 18 caverns, to ensure that in the first year enough production brine can be delivered to the plant. For a mature brine field annually about 7 new caverns need to be prepared (14 drill holes), but for the onset of production from the Esterhazy Member with ongoing continuous production from the initial carnallitite wells, it will be required that the



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

number of active caverns and caverns in preparation on the brine field is raised from 18 to 38 within the first three years of production., which requires additional drilling

For each 750,000 tpy extension of the plant 808,000 tonnes of KCl has to be present in the production brine. This means an annual volume of brine of

7.1 million m³

Assuming an annual brine field operation time of 8,000 hours this requires a necessary production brine volume of

~ 882 m³/hour

At an average brine flow rate of 45 m³/hour this translates to about 20 caverns. On a mature brine field annually 8 to 9 new caverns need to be prepared.

### 16.3.3 Cavern Mass and Volume Balances

Based on the cavern dimensions presented in section 16.1.1, the thickness and compositions presented in chapter (geology) and the estimates for production brine composition of section 16.3.1 the mass and volume balances for the single cavern horizons can be estimated. This will be done in the following and is based on the assumption that 5% of the KCl in the cavern volume, will not be available for dissolution. This can have several reasons e.g. of shielding of the Sylvite and Carnallite crystals by Halite crystals or drop of a Sylvite/Carnallite crystal to the cavern bottom before dissolution. Based on these assumptions the cavern balances are reported with hole DH-20 as base case. Table 33 shows the balance for the lower cavern in the Esterhazy member, Table 34 for the upper cavern in the Esterhazy Member and Table 35 shows the balance for the cavern extending from the bottom of the Belle Plaine Member to the top of the Patience Lake Member with their respective undercuts in low grade parts of the Esterhazy Member and the LPBM.

The remaining open volume in the sylvinite Esterhazy caverns is relatively small and only a minor portion of the Halite dissolved from this unit can be returned to the cavern. Part of the Halite dissolved during preparation leaching will be recycled to the carnallitite caverns.

Table 33 Preliminary Mass Balance for the Material from a Single Cavern from the Lower Mineable Esterhazy Member

| | **Volume [in 1,000m³}** | **Sylvite [in 1,000t]** | **Halite [in 1,000t]** | **Carnallite [in 1,000t]** | **Anhydrite [in 1,000t]** | **Insoluble Material [in 1,000t]** |
|---|---|---|---|---|---|---|
| Real Cavern | 80.6 | 20.5 | 136.2 | 10.7 | 1.2 | 1.1 |
| Dissolved Material | 70.1 | 19.5 | 111.9 | 10.1 | 1.0 | - |
| Remains in Cavern | 10.5 | 1.0 | 24.3 | 0.6 | 0.2 | 1.1 |



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

Table 34 Preliminary Mass Balance for the Material from a Single Cavern from the Upper Mineable Esterhazy Member

| | Volume [in 1,000m³} | Sylvite [in 1,000t] | Halite [in 1,000t] | Carnallite [in 1,000t] | Anhydrite [in 1,000t] | Insoluble Material [in 1,000t] |
|---|---|---|---|---|---|---|
| Real Cavern | 76.3 | 23.1 | 112.1 | 18.1 | 1.0 | 0.3 |
| Dissolved Material | 72.0 | 21.9 | 108.8 | 17.2 | 1.0 | - |
| Remains in Cavern | 4.3 | 1.2 | 3.3 | 0.9 | 0.0 | 0.3 |

Table 35 Preliminary Mass Balance for the Material from the Carnallitite Cavern from the Bottom of the Belle Plaine Member to the Top of the Patience Lake Member

| | Volume [in 1,000m³} | Sylvite [in 1,000t] | Halite [in 1,000t] | Carnallite [in 1,000t] | Anhydrite [in 1,000t] | Insoluble Material [in 1,000t] |
|---|---|---|---|---|---|---|
| Real Cavern | 386.7 | 7.8 | 337.9 | 341.5 | 5.0 | 31.3 |
| Dissolved Material | 328.4 | 7.4 | 302.1 | 325.2 | 4.4 | - |
| Remains in Cavern | 58.3 | 0.4 | 35.8 | 16.3 | 0.6 | 31.3 |

The NaCl pre-concentration of the solvent (from undercut brines), reduces the amount of Halite that can be dissolved from the carnallitite members, but the large caverns over the Belle Plaine and Patience Lake Members still have a large open volume, which might be used to dispose solid Halite produced at the plant from the production brine, which otherwise has to be dissolved and deep well injected. The volume of solid material in the cavern amounts to 99.5 m³, but the volume of the cavern filled by the solids is larger as this, because of the porosity between the grains of solid material, which usually is about 40% of the solid volume. Furthermore, about 10% of the open cavern volume will not be available because of irregular cavern shape. The volume balance looks as follows:

| | | |
|---|---|---|
| Open Volume | | 328,400 m³ |
| Porosity | - | 23,300 m³ |
| Irregular shape | - | 32,800 m³ |
| Effective Open Space | | 272,300 m³ |

The total amount of Halite that is produced in the plant from the brine of a single cavern amounts to approximately 88,000 tonnes from carnallitite brine and 99,000 tonnes from sylvinite brine. This is a solid volume of about 86,000 m³, and with porosity requires about 121,000 m³ of available cavern space. Taking into account that the cavern can only be



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

filled from two centrally located drill holes, during full scale operation it should be possible to dispose of all Halite in the cavern and only during onset of operation, some will have to be dissolved in the non NaCl saturated waste brine coming from dissolution of the rock salt interbed between Patience Lake and Belle Plaine Member. During operation in a mature brine field it will probably not be necessary to have a separate NaCl disposal system for solid material from the plant.

The average flows per hour for the streams coming to the brine field and the potential sources of these flows are given in Table 36. The average flows coming from the brine field and their further uses are given in Table 37.

Table 36 Average Hourly Flow Volumes and Proposed Sources for the Water and Brines Going to the Brine Field for Phase 1

| | **Total Flow Volume($m^3$/hour)** | **Source 1 ($m^3$/hour)** | **Source 2 ($m^3$/hour)** |
|---|---|---|---|
| Cold Solvent Cavern Preparation, Sylvinite Leaching | 730 | Fresh Water 570 | Condensates 160 |
| Warm Solvent, Carnallitite Leaching | 650 | Weak Brine 280 | Condensates 370 |
| $MgCl_2$ Brine, Slurry | 160 | Plant 160 | |

Table 37 Average Hourly Flow Volumes and Proposed Use Areas for the Brines Going from the Brine Field for Phase 1

| | **Total Flow Volume $m^3$/h** | **Use Area** |
|---|---|---|
| Hot Carnallitite Brine | 500 | Plant for production |
| Sylvinite Brine | 250 | Plant for production |
| Weak Mineralized Brine | 280 | To hot solvent for carnallitite leaching |
| Disposal Brines | 560 | Plant for NaCl dissolution or $MgCl_2$ brine dilution |

### 16.3.4 Mine Plan

Based on the cavern size and cavern pillar configuration of section 16.1.1 and the outline of areas with measured and indicated resources, the brine field over the lifetime of the mine has been defined (e.g. Figure 32 and Figure 33). On the basis of this brine field, the resources per cavern and the requirement to maintain a certain relation between amount of carnallitite and sylvinite brine, a general mine plan has been developed for the 3 production phases (e.g. Figure 40), each with a separate pipeline system. The overall mine plan assumes that with 3 phases operating the brine going to the 3 plant sections will be a



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

mixture of all brines, therefore the mine plan does not balance at all times the relative required amounts of carnallititite and sylvinite brine from the single pipeline systems, but the overall balance is kept.

The phase 1 brine field is developed from the plant area in NW direction, using mainly DH-11 type caverns. During the initial years of phase 1, the Esterhazy Member is not mined in all caverns in order to produce the relative required amounts of carnallititite and sylvinite brine. Over the years phase 1 brine field will be extended W and S and produce from caverns of DH-11 and 3C4-8 type, where no sylvinite resources are present. At this stage the phase 1 brine field will produce mainly carnallititite brine. After about 49 years there are no further caverns available on the phase 1 pipeline system and all brine will come from phase 2 and phase 3 pipeline systems.

The phase 2 brine field is developed from the plant area in S direction, using initially a combination of DH-20 and 3C4-8 type caverns. Because 3C4-8 caverns are planned to produce carnallititite brine only, the balance between the relative required amounts of carnallititite and sylvinite brine can be maintained without leaving Esterhazy Member from type DH-20 caverns in the ground. The phase 2 pipeline system will then be extended southern direction to develop type 2C6-32 caverns and later 4D14-21 type caverns. Than the brine field will be extended in western direction to mine 3A11-27 and 3B4-26 caverns as well after nearly 60 years some 4B14-24 caverns.

The phase 3 brine field is developed from the plant area in E direction, using initially mainly type DH-21 caverns. Because at development of phase 3, there are adequate numbers of carnallititite only caverns available from phase 1 and phase 2, the relative required amounts of carnallititite and sylvinite brine can be maintained without leaving Esterhazy Member from type DH-21 caverns in the ground. Over time the brine field will develop further E and incorporate type 2A11-12 caverns, followed by type 2-24 caverns. At that point further cavern development will be towards the S with type 13-36 and later type 4B14-24 and some type 3A11-27 caverns being developed.

The approximate production and drilling schedules for the different phases according to the mine plan are given in Table 38. According to the mine plan, last caverns will be drilled about 69 years after start of operation, with last year of full production 72 years after start up and a ramp down of production to zero over 2 years, when last caverns are mined out.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

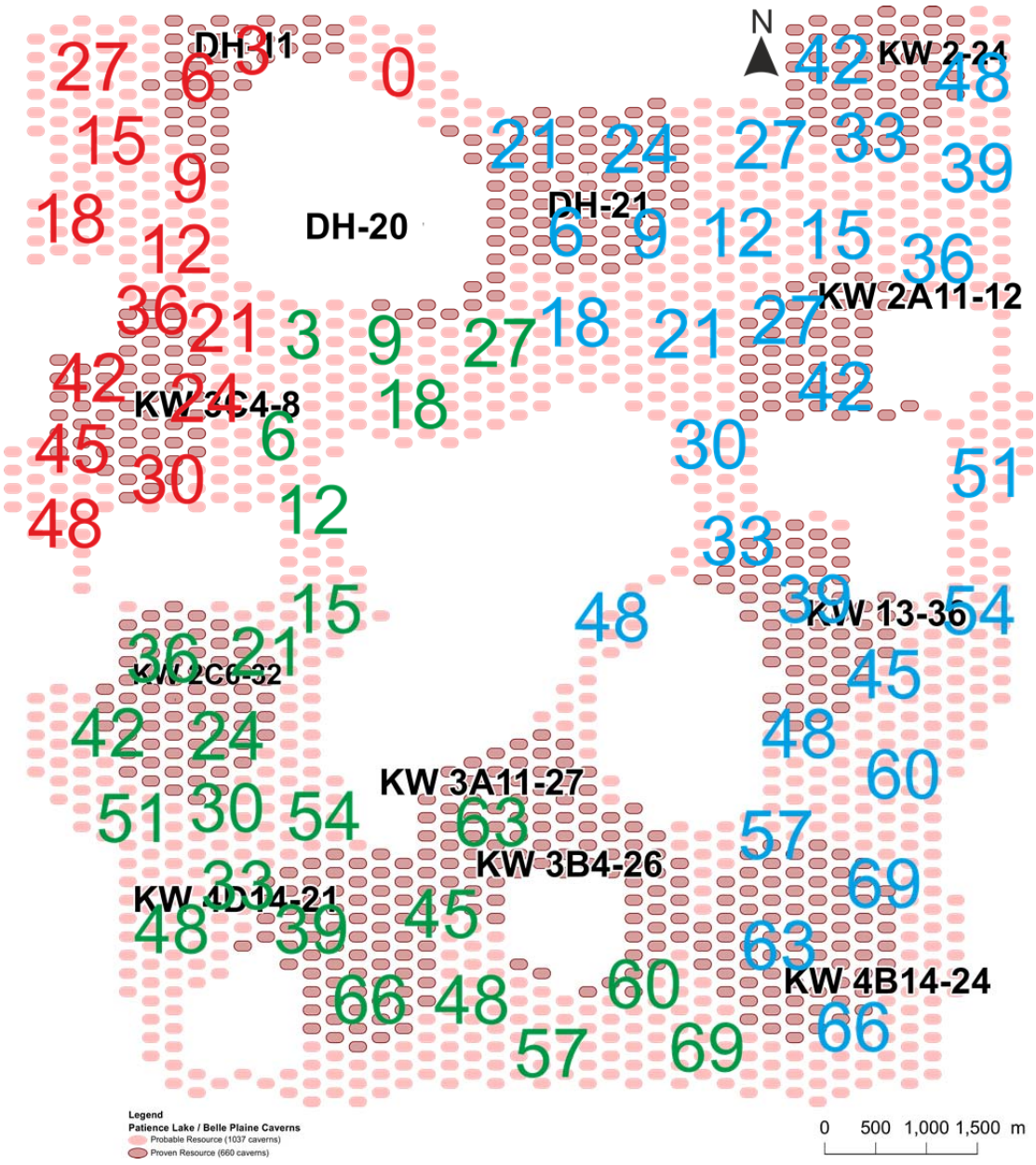



Figure 40 Schematic Mine Plan over the Brine Field of Figure 32 showing approximate Development in 3 Year Steps from Start of Operation, Red Numbers Phase 1, Green Numbers Phase 2, Blue Numbers Phase 3



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

Table 38 Production Schedule for the different Phases with Ramp Up and Ramp Down and Approximation of New Caverns required Annually. Bold Cavern Preparation Number are CAPEX

| | Production (in 1000 tonnes per year) | | | | Cavern Preparation Number | | | |
|---|---|---|---|---|---|---|---|---|
| **Year** | **Phase 1** | **Phase 2** | **Phase 3** | **Total** | **Phase 1** | **Phase 2** | **Phase 3** | **Total** |
| 0 | | | | | **21** | | | 21 |
| 1 | 390.0 | | | 390.0 | 16 | | | 16 |
| 2 | 608.8 | | | 608.8 | 5 | **14** | | 19 |
| 3 | 625.0 | 325.0 | | 950.0 | 20 | **9** | | 29 |
| 4 | 625.0 | 741.7 | 0 | 1,366.7 | 10 | 10 | **19** | 39 |
| 5 | 625.0 | 750.0 | 375.0 | 1,750.0 | 8 | 8 | **4** | 20 |
| 6 | 625.0 | 750.0 | 745.8 | 2,120.8 | 9 | 16 | 15 | 40 |
| 7 | 625.0 | 750.0 | 750.0 | 2,125.0 | 7 | 12 | 7 | 26 |
| 8 | 625.0 | 750.0 | 750.0 | 2,125.0 | 8 | 9 | 9 | 26 |
| 9 | 625.0 | 750.0 | 750.0 | 2,125.0 | 1 | 5 | 6 | 12 |
| 10 | 625.0 | 750.0 | 750.0 | 2,125.0 | 7 | 10 | 14 | 31 |
| 11 | 625.0 | 750.0 | 750.0 | 2,125.0 | 4 | 4 | 10 | 18 |
| 12 | 625.0 | 750.0 | 750.0 | 2,125.0 | 9 | 10 | 14 | 33 |
| 13 | 625.0 | 750.0 | 750.0 | 2,125.0 | 5 | 11 | 6 | 22 |
| 14 | 625.0 | 750.0 | 750.0 | 2,125.0 | 2 | 5 | 8 | 15 |
| 15 | 625.0 | 750.0 | 750.0 | 2,125.0 | 2 | 8 | 3 | 13 |
| 16 | 625.0 | 750.0 | 750.0 | 2,125.0 | 6 | 12 | 11 | 29 |
| 17 | 625.0 | 750.0 | 750.0 | 2,125.0 | 4 | 15 | 5 | 24 |
| 18 | 625.0 | 750.0 | 750.0 | 2,125.0 | 14 | 5 | 10 | 29 |
| 19 | 625.0 | 750.0 | 750.0 | 2,125.0 | 7 | 5 | 6 | 18 |
| 20 | 625.0 | 750.0 | 750.0 | 2,125.0 | 12 | 4 | 12 | 28 |
| 21 | 625.0 | 750.0 | 750.0 | 2,125.0 | 2 | 2 | 8 | 12 |
| 22 | 625.0 | 750.0 | 750.0 | 2,125.0 | 9 | 6 | 14 | 29 |
| 23 | 625.0 | 750.0 | 750.0 | 2,125.0 | 6 | 12 | 12 | 30 |
| 24 | 625.0 | 750.0 | 750.0 | 2,125.0 | 2 | 10 | 7 | 19 |
| 25 | 625.0 | 750.0 | 750.0 | 2,125.0 | 3 | 3 | 19 | 25 |
| 26 | 625.0 | 750.0 | 750.0 | 2,125.0 | 10 | 3 | 7 | 20 |
| 27 | 625.0 | 750.0 | 750.0 | 2,125.0 | 4 | 4 | 11 | 19 |
| 28 | 625.0 | 750.0 | 750.0 | 2,125.0 | 2 | 12 | 14 | 28 |
| 29 | 625.0 | 750.0 | 750.0 | 2,125.0 | 1 | 12 | 10 | 23 |
| 30 | 625.0 | 750.0 | 750.0 | 2,125.0 | 14 | 13 | 12 | 39 |



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

| | Production (in 1000 tonnes per year) | | | | Cavern Preparation Number | | | |
|---|---|---|---|---|---|---|---|---|
| Year | Phase 1 | Phase 2 | Phase 3 | Total | Phase 1 | Phase 2 | Phase 3 | Total |
| 31 | 625.0 | 750.0 | 750.0 | 2,125.0 | 1 | 4 | 12 | 17 |
| 32 | 625.0 | 750.0 | 750.0 | 2,125.0 | 3 | 17 | 14 | 34 |
| 33 | 625.0 | 750.0 | 750.0 | 2,125.0 | 1 | 6 | 5 | 12 |
| 34 | 625.0 | 750.0 | 750.0 | 2,125.0 | 2 | 18 | 8 | 28 |
| 35 | 625.0 | 750.0 | 750.0 | 2,125.0 | 6 | 24 | 22 | 52 |
| 36 | 625.0 | 750.0 | 750.0 | 2,125.0 | 2 | 3 | 8 | 13 |
| 37 | 625.0 | 750.0 | 750.0 | 2,125.0 | 6 | 12 | 10 | 28 |
| 38 | 625.0 | 750.0 | 750.0 | 2,125.0 | 1 | 6 | 6 | 13 |
| 39 | 625.0 | 750.0 | 750.0 | 2,125.0 | 2 | 7 | 14 | 23 |
| 40 | 625.0 | 750.0 | 750.0 | 2,125.0 | 4 | 4 | 12 | 20 |
| 41 | 625.0 | 750.0 | 750.0 | 2,125.0 | 3 | 19 | 23 | 45 |
| 42 | 625.0 | 750.0 | 750.0 | 2,125.0 | 2 | 10 | 15 | 27 |
| 43 | 625.0 | 750.0 | 750.0 | 2,125.0 | 2 | 6 | 4 | 12 |
| 44 | 625.0 | 750.0 | 750.0 | 2,125.0 | 2 | 5 | 4 | 11 |
| 45 | 625.0 | 750.0 | 750.0 | 2,125.0 | 2 | 16 | 17 | 35 |
| 46 | 625.0 | 750.0 | 750.0 | 2,125.0 | 2 | 19 | 14 | 35 |
| 47 | 625.0 | 750.0 | 750.0 | 2,125.0 | 2 | 12 | 22 | 36 |
| 48 | 625.0 | 750.0 | 750.0 | 2,125.0 | 0 | 3 | 4 | 7 |
| 49 | 625.0 | 750.0 | 750.0 | 2,125.0 | 3 | 12 | 10 | 25 |
| 50 | 625.0 | 750.0 | 750.0 | 2,125.0 | | 21 | 4 | 25 |
| 51 | 625.0 | 750.0 | 750.0 | 2,125.0 | | 23 | 12 | 35 |
| 52 | 625.0 | 750.0 | 750.0 | 2,125.0 | | 14 | 14 | 28 |
| 53 | 625.0 | 750.0 | 750.0 | 2,125.0 | | 12 | 11 | 23 |
| 54 | 625.0 | 750.0 | 750.0 | 2,125.0 | | 3 | 5 | 8 |
| 55 | 625.0 | 750.0 | 750.0 | 2,125.0 | | 12 | 11 | 23 |
| 56 | 625.0 | 750.0 | 750.0 | 2,125.0 | | 14 | 12 | 26 |
| 57 | 625.0 | 750.0 | 750.0 | 2,125.0 | | 12 | 12 | 24 |
| 58 | 625.0 | 750.0 | 750.0 | 2,125.0 | | 14 | 8 | 22 |
| 59 | 625.0 | 750.0 | 750.0 | 2,125.0 | | 12 | 8 | 20 |
| 60 | 625.0 | 750.0 | 750.0 | 2,125.0 | | 12 | 6 | 18 |
| 61 | 625.0 | 750.0 | 750.0 | 2,125.0 | | 20 | 19 | 39 |
| 62 | 625.0 | 750.0 | 750.0 | 2,125.0 | | 12 | 8 | 20 |
| 63 | 625.0 | 750.0 | 750.0 | 2,125.0 | | 9 | 9 | 18 |
| 64 | 625.0 | 750.0 | 750.0 | 2,125.0 | | 18 | 8 | 26 |
| 65 | 625.0 | 750.0 | 750.0 | 2,125.0 | | 14 | 8 | 22 |



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

| | Production (in 1000 tonnes per year) | | | | Cavern Preparation Number | | | |
|---|---|---|---|---|---|---|---|---|
| Year | Phase 1 | Phase 2 | Phase 3 | Total | Phase 1 | Phase 2 | Phase 3 | Total |
| 66 | 625.0 | 750.0 | 750.0 | 2,125.0 | | 12 | 3 | 15 |
| 67 | 625.0 | 750.0 | 750.0 | 2,125.0 | | 10 | 9 | 19 |
| 68 | 625.0 | 750.0 | 750.0 | 2,125.0 | | 22 | 24 | 46 |
| 69 | 625.0 | 750.0 | 750.0 | 2,125.0 | | 10 | | 10 |
| 70 | 625.0 | 750.0 | 750.0 | 2,125.0 | | | | |
| 71 | 437.5 | 750.0 | 750.0 | 1,937.50 | | | | |
| 72 | 312.5 | 112.0 | 750.0 | 1,174.5 | | | | |
| 73 | 312.5 | | 450.0 | 762.0 | | | | |
| 74 | 250.0 | | | 250.0 | | | | |

## 16.4 Solution Mining Recovery

The solution mining recovery is reduced from 100% by the losses of mineable material due to the solution mining method. These losses can be subdivided into two groups of losses:

- direct mineralized material losses, that can be subdivided into losses due to

a) Safety pillars between caverns

b) Geometry of cavern and Carnallite/Sylvite distribution
    - Undercut development
    - Irregular cavern wall
    - Carnallite/Sylvite distribution

and

- losses of brine produced by dissolution of the mineralized material due to

c) Incomplete brine replacement from cavern

d) Transport losses.

The major factor is a) safety pillars between caverns, which for the configuration chosen provide an overall (area) recovery of 36.5% (Figure 35).

The cavern geometric factor and incomplete brine replacement factor depend on the composition of the material being mined and the overall height of the cavern and are about the same order of magnitude, whereas transport losses can be considered minor.

For determination of the inferred resources, for carnallitite caverns an overall mining recovery of 27.5% is estimated, because the local geology requires development of the undercut in the lower part of the Belle Plane Member, reducing the overall recovery from this part of the cavern. For sylvinite caverns an overall mining recovery of 30% is estimated as the undercut can be developed in low grade material, which has not been considered part of the deposit.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

For reserve estimation the cavern balances for each exploration drill hole have been calculated taking these factors into account and the average production of a single cavern from each mineable member is given in Table 39 for the Patience Lake Member, Table 40 for the Upper Belle Plaine Member, Table 41 for the Lower Belle Plaine Member, Table 42 for the upper mineable Sylvinite Layer of the Esterhazy Member and Table 43 for the Lower mineable Sylvinite Layer of the Esterhazy Member.

## 16.5 Surface Brine Field Design

The brine field design assumes that there will be a single operating brine field adequate for brine production to guarantee an annual production of 625,000 tonnes of solid product per year. The brine field will require in steady state operation:

17 production caverns

2 stand by caverns

7 caverns in development

For start-up in total 21 caverns have to be drilled, 17 for direct production ramp-up, two spare and 2 for initial development. In the first 3 years of production the number of active caverns will be increased rapidly to over 40, to allow establishment of a stable operation of the brine field.

For each 750,000 tonnes of solid product per year expansion the brine field will require in steady state operation additional:

20 production caverns

2 stand by caverns

8.5 caverns in development

For start-up of these phases in total 23 caverns have to be drilled, 20 for direct production ramp-up, two spare and 1 for initial development. These phases actually profit in their ramp-up from the available capacity of the brine field of the earlier phases.

On the brine field the solvent is transported from the tank farm to the caverns with on average 6 caverns located on a single drill pad (between 5 and 7) and the resulting brines are gathered and transported back to the tank farm. The above surface part of the brine field consists from cavern to tank farm of

- well heads
- brine distribution system on the drill pad
- pipeline network
- pump house
- tank farm.

All equipment required for the solution mining operation has been specified in detail in FOSTER WHEELER & ERCOSPLAN Feasibility Study (2011, /26/) and in opinion of the author the mining method and equipment is adequately defined.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

Table 39 Volume, Size, Tonnage of Mineralized Material as well as Recoverable KCl Tonnage for an Average Cavern on the Exploration and Geotechnical Holes for the Patience Lake Member

| Hole | Thickness | Volume | Average Density | Mineralized Tonnage | Average KCl Grade | Average Recovery | Mineable Tonnage | Recoverable KCl |
|---|---|---|---|---|---|---|---|---|
| | (m) | (1000 m³) | (t/m³) | (1000 t) | (%) | (%) | (1000 t) | (1000 t) |
| DH-20 | 7.68 | 114.08 | 1.791 | 204.3 | 17.16 | 89.84 | 183.53 | 31.48 |
| DH-21 | 5.51 | 81.85 | 1.747 | 142.9 | 18.49 | 90.68 | 129.63 | 23.97 |
| DH-11 | 7.54 | 112.00 | 1.735 | 194.3 | 19.22 | 89.04 | 172.99 | 33.25 |
| 4B14-24 | 13.01 | 193.25 | 1.901 | 367.4 | 21.48 | 84.47 | 310.30 | 66.65 |
| 13-36 | 6.11 | 90.76 | 1.782 | 161.7 | 22.78 | 87.55 | 141.56 | 32.25 |
| 3A11-27 | 6.60 | 98.04 | 1.774 | 174.0 | 17.45 | 89.27 | 155.30 | 27.10 |
| 2A11-12 | 8.10 | 120.32 | 1.725 | 207.6 | 19.22 | 91.28 | 189.47 | 36.42 |
| 4D14-21 | 7.95 | 118.09 | 1.748 | 206.5 | 18.33 | 87.23 | 180.09 | 33.01 |
| 3C4-8 | 7.99 | 118.68 | 1.738 | 206.3 | 19.03 | 90.57 | 186.83 | 35.55 |
| 3B4-26 | 3.05 | 45.30 | 1.913 | 86.7 | 30.31 | 91.22 | 79.05 | 23.96 |
| 2C6-32 | 7.87 | 116.90 | 1.733 | 202.6 | 18.82 | 91.26 | 184.87 | 34.79 |
| 2-24 | 7.63 | 113.34 | 1.757 | 199.2 | 20.10 | 90.35 | 179.94 | 36.17 |



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany

Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

Table 40 Volume, Size, Tonnage of Mineralized Material as well as Recoverable KCl Tonnage for an average Cavern on the Exploration and Geotechnical Holes for the Upper Belle Plaine Member

| Hole | Thickness | Volume | Average Density | Mineralized Tonnage | Average KCl Grade | Average Recovery | Mineable Tonnage | Recoverable KCl |
|---|---|---|---|---|---|---|---|---|
| | (m) | (1000 m³) | (t/m³) | (1000 t) | (%) | (%) | (1000 t) | (1000 t) |
| DH-20 | 9.69 | 143.94 | 1.747 | 251.5 | 18.15 | 90.05 | 226.47 | 41.10 |
| DH-21 | 10.45 | 155.22 | 1.736 | 269.5 | 19.72 | 89.21 | 240.38 | 47.40 |
| DH-11 | 9.88 | 146.76 | 1.757 | 257.8 | 18.01 | 89.17 | 229.88 | 41.40 |
| 4B14-24 | 9.18 | 136.36 | 1.780 | 242.7 | 21.35 | 91.70 | 222.58 | 47.52 |
| 13-36 | 8.62 | 128.04 | 1.760 | 225.4 | 18.79 | 90.27 | 203.47 | 38.23 |
| 3A11-27 | 10.43 | 154.93 | 1.728 | 267.8 | 20.63 | 91.36 | 244.63 | 50.47 |
| 2A11-12 | 9.14 | 135.77 | 1.777 | 241.3 | 17.90 | 89.93 | 217.01 | 38.84 |
| 4D14-21 | 9.02 | 133.98 | 1.734 | 232.3 | 19.50 | 90.05 | 209.17 | 40.79 |
| 3C4-8 | 9.98 | 148.24 | 1.728 | 256.2 | 19.03 | 91.95 | 235.57 | 44.83 |
| 3B4-26 | 9.13 | 135.62 | 1.734 | 235.1 | 18.43 | 90.59 | 212.98 | 39.25 |
| 2C6-32 | 8.94 | 132.79 | 1.735 | 230.4 | 18.70 | 90.86 | 209.31 | 39.14 |
| 2-24 | 9.12 | 135.47 | 1.733 | 234.8 | 19.03 | 90.29 | 212.01 | 40.34 |



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany

Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

Table 41 Volume, Size, Tonnage of Mineralized Material as well as Recoverable KCl Tonnage for an Average Cavern on the Exploration and Geotechnical Holes for the Lower Belle Plaine Member used for Undercut Leaching

| Hole | Thickness | Volume | Average Density | Mineralized Tonnage | Average KCl Grade | Average Recovery | Mineable Tonnage | Recoverable KCl |
|---|---|---|---|---|---|---|---|---|
| | (m) | (1000 m³) | (t/m³) | (1000 t) | (%) | (%) | (1000 t) | (1000 t) |
| DH-20 | 5.57 | 82.74 | 1.964 | 162.5 | 17.18 | 32.26 | 52.41 | 9.00 |
| DH-21 | 6.35 | 94.32 | 1.997 | 188.4 | 15.07 | 32.19 | 60.65 | 9.14 |
| DH-11 | 6.66 | 98.93 | 2.055 | 203.3 | 8.52 | 32.33 | 65.73 | 5.60 |
| 4B14-24 | 5.69 | 84.52 | 1.956 | 165.3 | 11.09 | 31.24 | 51.65 | 5.73 |
| 13-36 | 6.19 | 91.95 | 1.935 | 177.9 | 9.66 | 32.63 | 58.05 | 5.61 |
| 3A11-27 | 5.02 | 74.57 | 1.967 | 146.7 | 13.83 | 31.65 | 46.42 | 6.42 |
| 2A11-12 | 5.38 | 79.91 | 1.942 | 155.2 | 14.49 | 30.21 | 46.88 | 6.79 |
| 4D14-21 | 5.98 | 88.83 | 1.956 | 173.7 | 9.59 | 31.22 | 54.24 | 5.20 |
| 3C4-8 | 5.13 | 76.20 | 1.971 | 150.2 | 15.24 | 30.25 | 45.43 | 6.92 |
| 3B4-26 | 6.19 | 91.95 | 1.942 | 178.6 | 12.97 | 31.38 | 56.03 | 7.27 |
| 2C6-32 | 5.23 | 77.69 | 1.945 | 151.1 | 9.19 | 30.94 | 46.76 | 4.30 |
| 2-24 | 6.08 | 90.31 | 1.921 | 173.5 | 13.45 | 30.89 | 53.60 | 7.21 |



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany

Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

Table 42 Volume, Size, Tonnage of Mineralized Material as well as Recoverable KCl Tonnage for an Average Cavern on the Exploration and Geotechnical Holes for the Upper Mineable Sylvinite Layer of the Esterhazy Member

| Hole | Thickness | Volume | Average Density | Mineralized Tonnage | Average KCl Grade | Average Recovery | Mineable Tonnage | Recoverable KCl |
|---|---|---|---|---|---|---|---|---|
| | (m) | (1000 m³) | (t/m³) | (1000 t) | (%) | (%) | (1000 t) | (1000 t) |
| **DH-20** | 2.57 | 38.17 | 2.031 | 77.5 | 26.48 | 89.62 | 69.47 | 18.40 |
| **DH-21** | 2.25 | 33.42 | 2.090 | 69.8 | 25.20 | 88.92 | 62.10 | 15.65 |
| **DH-11** | 3.96 | 58.82 | 2.121 | 124.8 | 20.87 | 88.28 | 110.15 | 22.99 |
| **4B14-24** | 2.31 | 34.31 | 2.044 | 70.1 | 23.33 | 88.62 | 62.16 | 14.50 |
| **13-36** | 2.22 | 32.98 | 2.062 | 68.0 | 22.46 | 91.67 | 62.33 | 14.00 |
| **3A11-27** | 2.25 | 33.42 | 2.029 | 67.8 | 35.01 | 91.64 | 62.16 | 21.76 |
| **2A11-12** | 3.42 | 50.80 | 2.094 | 106.4 | 24.73 | 89.78 | 95.51 | 23.62 |
| **4D14-21** | 2.00 | 29.71 | 2.039 | 60.6 | 20.16 | 88.23 | 53.43 | 10.77 |
| **2C6-32** | 2.03 | 30.15 | 2.006 | 60.5 | 30.36 | 90.67 | 54.84 | 16.65 |
| **2-24** | 3.17 | 47.09 | 2.038 | 95.9 | 30.57 | 90.55 | 86.88 | 26.56 |



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany

Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

Table 43 Volume, Size, Tonnage of Mineralized Material as well as Recoverable KCl Tonnage for An average Cavern on the Exploration and Geotechnical Holes for the Lower Mineable Sylvinite Layer of the Esterhazy Member

| Hole | Thickness | Volume | Average Density | Mineralized Tonnage | Average KCl Grade | Average Recovery | Mineable Tonnage | Recoverable KCl |
|---|---|---|---|---|---|---|---|---|
| | (m) | (1000 m³) | (t/m³) | (1000 t) | (%) | (%) | (1000 t) | (1000 t) |
| **DH-20** | 3.28 | 48.72 | 2.093 | 102.0 | 20.78 | 88.22 | 89.95 | 18.69 |
| **DH-21** | 3.32 | 49.32 | 2.087 | 102.9 | 25.22 | 89.98 | 92.61 | 23.36 |
| **DH-11** | 2.44 | 36.24 | 2.077 | 75.3 | 26.91 | 90.25 | 67.94 | 18.28 |
| **4B14-24** | 1.99 | 29.56 | 2.057 | 60.8 | 38.03 | 91.18 | 55.45 | 21.09 |
| **13-36** | 2.68 | 39.81 | 2.092 | 83.3 | 20.68 | 88.29 | 73.54 | 15.21 |
| **2-24** | 3.07 | 45.60 | 2.077 | 94.7 | 24.78 | 89.31 | 84.59 | 20.96 |



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany

Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

## 16.6 Pilot Solution Mining Operation

In this section, it will be discussed which information can be obtained from a full scale pilot solution mining operation and the reasons are given, why a pilot solution mining operation is not required to establish feasibility of the project, but is still recommended even on a smaller scale to make project more efficient during later design phases.

In the first part of the section information about existing (potash) solution mining operations will be given as basis to get an understanding about the information that can be obtained from a full scale pilot solution mining operation. In a next section the boundary conditions for a minimal pilot solution mining operation will be discussed, followed in a further section by a discussion of alternative ways to obtain the required information. The section will end with an explanation about the recommendation for a pilot operation to test any enhancements that may be considered in the future by management.

### 16.6.1 Solution Mining Operations

About 8 underground solution mining operations for Potash and/or Magnesium and Trona from salt rocks are at present operational. Several others are planned, but have not yet gone into production. Existing operations are:

- Belle Plaine, Canada; Potash production from solution mining of caverns from a sylvinite deposit at ~1600 m depth below surface.
- Patience Lake, Canada; Potash production from solution mining of a flooded mine from a sylvinite deposit at ~1000 m depth below surface.
- Hersey (Michigan), USA; Potash production from solution mining of caverns from a sylvinite deposit at ~2300 m depth below surface, closed down in 2015.
- Veendam, Netherlands; Magnesium chloride production from solution mining of caverns from a Bischofite/carnallitite deposit at ~1500 m depth below surface.
- Moab (Utah), USA; Potash production from a drowned mine as well as solution mining of caverns from a sylvinite deposit at ~1100 m depth below the surface
- Bleicherode/Kehmstedt, Germany; Potash production from solution mining of caverns from a carnallitite deposit at ~400 m depth below surface
- Parachute (Colorado) USA; Nahcolite solution mining for soda ash production using horizontally drilled holes at ~ 500 m depth below surface,
- Beypazari, Turkey; soda ash production from solution mining of Trona at depths larger than 400 m below the surface.

This list shows that in contrast to solution mining in Halite for brine production or storage cavern construction, there is a limited number of operations for the solution mining of non-Halite salt minerals. However, in most of the operations, more than four decades of operational experience were gathered and an industrial standard for applications of solution mining for these non-Halite salt deposits was established.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

The solution mining for soda ash production will not be discussed as the phase chemistry is very different from that of potash salts and has no direct relation to potash solution mining.

Based on the proven technology of Halite solution mining, experiments with solution mining of potash started in the late 1950s, and resulted in the establishment of the Belle Plaine Sylvite solution mining operation in Saskatchewan, Canada. Several years later, the East German potash industry started a Research and Development project applying similar techniques to the more soluble mineral carnallitite resulting in the Carnallite solution mining operation in Bleicherode/Kehmstedt. Therefore, nearly 50 years of operational experience for Sylvite solution mining at Belle Plaine and other operations and over 20 years of operational experience in Carnallite solution mining exist.

The following sections will deal with (i) general solution mining techniques and (ii) chemistry of solution mining of potash rocks respectively.

#### 16.6.1.1 Solution Mining Techniques

The solution mining operations in potash salt use the same technical principles as operations in Halite. These are the most important technological operations:

- control of the cavern roof by oil or gas blanket and blanket control,
- cementation of casing in salt at large depths,
- casing cutting in deep wells,
- installation of leach strings and casing at prescribed depths,
- lifting and lowering of leach strings on solution mining wells,
- controlling and changing injection and extraction pathways in wells.

With the long history of Halite solution mining and the large number of Halite solution mining operations, the techniques required to construct and to operate solution mining wells are well established.

Also from Halite operations, the general flow paths developing in a cavern depending on injection and extraction depth, horizontal and vertical distance between injection and extraction leach string and changing flow rates are well established. This information can be used for an initial prediction of the flow regime that will be established in a cavern and to predict how the flow regime will change when flow rate, and/or distance between injection and extraction well are changed. These principles are well established and modeling of solution mined cavern in Halite has confirmed these principles.

All these techniques and operations can be adapted to potash solution mining without the necessity of a pilot solution mining operation for any individual project. Moreover, on the drilling market, there are several drilling companies with specialized solution mining experience, which are available as contractors for the entire brine field development.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

### 16.6.1.2 Chemistry of Solution Mining Potash Rocks

The difference between rock salt solution mining and potash solution mining is the chemistry of the brine, whereas solution mining in rock salt can be described in the simple system

- NaCl, $H_2O$

Solution mining of sylvinite can be described in the system

- KCl, NaCl, $H_2O$,

whereas the description of solution mining of carnallitite requires a minimum the four component system

- $MgCl_2$, KCl, NaCl, $H_2O$.

Using equilibrium thermodynamics, these systems provide all the required physicochemical background to calculate mass balances, physical material values and saturation behavior. These systems have been very well studied because of their economic importance for the early potash industry, which relied on the hot leaching process and a large amount of thermodynamic information is available for these systems (e.g. D'Ans, 1933, /16/; Autenrieth, 1955, /5/; Eugster et al., 1980, /24/; Voigt, 2001, /50/) and all potential reactions in the KCl rich parts are well understood.

As solution mining of Sylvite takes place in the simplified system NaCl – KCl - $H_2O$, the solution mining operations for Carnallite and Sylvite cannot be directly compared. Comparison of the KARNALYTE operation is only possible with the Veendam operation, and the Bleicherode/Kehmstedt operations. Since, the Veendam operation for $MgCl_2$ has different priorities than KCl production, only the Bleicherode/Kehmstedt operation has been used for reference. Consequently, the rest of this section will refer solely to the solution mining of carnallitite.

The Bleicherode/Kehmstedt operation is the commercial operation of an industrial scale pilot operation of the former East German potash industry that was, until 1989, the third largest potash producer worldwide. Investigations on solution mining of Carnallite were started in East Germany as a research and development program in the 1970s with theoretical studies and laboratory test work. At the end of the 1970s, the theories were tested in a number of relatively small (~ thousands $m^3$) cavern operations in an underground potash mine. These test caverns were afterwards accessed from the mine in order to verify the theoretical predictions about shape development and dissolution and crystallization in the cavern with in-situ observations and confirmed that these theoretical considerations based on limited laboratory experiments were correct. In the mid-1980s, first pilot cavern operations were successfully completed, showing that solution mining of Carnallite could produce brine with KCl concentration as predicted at flow rates that allow commercial operation.

The carnallitite at the Bleicherode/Kehmstedt operation consists approximately of a homogeneous mixture Carnallite (~60%), Halite (~30%), Sulfate Minerals (~7%) and insoluble material (~3%). All minerals occur as lenses in a matrix of Carnallite, no continuous Halite bands occur in the Carnallite. This homogeneity results from the cataclastic structure of the Bleicherode/Kehmstedt deposit. The Belle Plaine Member and the Patience Lake Member also show a relatively homogeneous distribution of large Carnallite crystals acting as a matrix for the remaining minerals. So far, this homogenous distribution of the different minerals in the deposit is comparable to the carnallitite of Bleicherode/Kehmstedt. For this reason, it is expected that the dissolution behavior both



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

deposits will be similar. The results of the dissolution testing confirm that this assumption is correct.

The relevant points for the dissolution of Carnallite in the $MgCl_2$, KCl, NaCl, $H_2O$ system are depicted in Figure 39, which requires the simplifying assumption that the brine in the cavern is NaCl saturated (Halite present in the carnallititite will achieve this). Typically what occurs in solution mining of carnallititite is that with water as solvent, Carnallite and Halite will dissolve and the brine composition will change its KCl and $MgCl_2$ content along the Carnallite dissolution line (blue line through the origin in (Figure 39). Dissolution continues until at a certain temperature KCl saturation is reached (red lines, red dot at 50°C) and from that point onwards, KCl will crystallize upon dissolution from Carnallite (decomposition) and the brine composition will change along the red line to higher $MgCl_2$ content and lower KCl content, until equilibrium is reached between Carnallite, Halite and solution (blue dot). These theoretical considerations have been confirmed in practice in the Bleicherode/Kehmstedt operation for many years.

From a processing point of view, the optimum KCl concentration should be as high as possible (e.g. 100% at given temperature), but for solution mining, a lower saturation is preferred. For a Carnallite solution mining operation, the limiting factor for the KCl saturation is not the dissolution rate, which decreases with increasing salt concentration of the brine, limiting the saturation level that can be reached with a reasonable flow rate, because KCl saturation is well away from $MgCl_2$ saturation, which determines the dissolution rate of Carnallite, but rather, it is the risk of KCl crystallization:

- In the extraction well and pipeline system because of cooling of the brine during transport from cavern to the surface and from well to brine tank at the plant, which would hinder operations;

and

- In the cavern, due to local Carnallite decomposition, in areas of the cavern where the brine has a longer residence time or the deposit is more Carnallite rich. This decomposition results in a higher $MgCl_2$ concentration in the production brine and a lower KCl recovery from the resource. Since an increase in $MgCl_2$ concentration in the production brine results in a lower KCl saturation at given temperature, local Carnallite decomposition in the cavern also influences the maximum KCl content that could be achieved from the cavern.

For these reasons, the KCl saturation from production brine coming from the cavern, which consists of brine mixed from various locations in the cavern should be kept below 100% saturation at given temperature. These theoretical considerations have been confirmed in practice at the Bleicherode/Kehmstedt operation for many years.

For every solution mining operation, the dissolution kinetics of the material is one the determining factors in the production brine concentration. The dissolution kinetics of all salt rocks is influenced by following boundary conditions:

  - pre-concentration of solvent,
  - solvent temperature,
  - available mineral dissolution surface,
  - residence time of solvent at the dissolution surface.

How these parameters can be changed and how these changes influence the dissolution rate and/or the KCl concentration of the brine will be discussed in the following based on experiences from the Bleicherode/Kehmstedt operation.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

- pre-concentration of solvent, influences the Carnallite dissolution rate significantly, only if a high $MgCl_2$ pre-concentration is present. The dissolution rate is reduced and the KCl content at 100% saturation that can be reached will be lower than without pre-concentration. At higher $MgCl_2$ pre-concentrations, the amount of Halite and other non-Carnallite salt minerals that can be dissolved decreases to nearly zero and Carnallite will be selectively dissolved.
- solvent temperature, an increase in solvent temperature, increases the temperature of the production brine and at higher temperatures the KCl saturation is at higher KCl concentrations. An increase in solvent temperature increases the KCl content of the production brine.
- available mineral dissolution surface determines at constant flow rate the residence time of solvent at the carnallitite interface; a longer residence time translates to higher KCl concentrations. The dissolution surface depends on the height of a mining cut and the developing radius of the cavern. As the oil blanket prevents contact between cavern roof and solvent and the cavern bottom is prevented from dissolution by concentrated insoluble material and saturated brine at the bottom of the cavern, the mineral dissolution surface changes during a mining cut with increasing radius of the cavern. The dissolution surface at a given radius depends on the distance between injection point and extraction point as well as on the blanket level. Both can be changed within relatively narrow bounds during operation, without major work-overs. Large changes require major work-overs and should be avoided. Instead of changing the effective dissolution surface, the flow rates can be adapted to achieve the same effect.
- residence time of solvent at the dissolution surface is, at given dissolution surface, dependent on the flow rate. At a constant mining cut height, the flow rate has to be increased constantly to keep the average residence time constant as the increase in cavern diameter results in an increase in dissolution surface. Flow rate can be easily adapted by opening or closing of the inflow valve at the well head.

As caverns after preparation have relatively large effective volumes (several 10,000 $m^3$) and flow rates are in the range of 25 to 60 $m^3$/hour, residence time is relatively long and it will take a period between one week and one month before a change in conditions will have a significant influence on the brine composition.

The initial conditions (e.g. distance between injection and extraction point, initial flow rates, timing of blanket additions) can be relatively well estimated based on experience with other operations, but will have to be optimized within a certain range for each cavern individually in order to achieve production brine with a composition in an acceptable range. Most of these optimizations require only minor changes to the set up and do not significantly interrupt operation. These theoretical considerations have been confirmed in practice at the Bleicherode/Kehmstedt operation for many years.

The theoretical considerations and the results of the dissolution testing indicate that there is no significant difference between the dissolution behaviour of the Bleicherode/Kehmstedt carnallitite and the KARNALYTE carnallitite and, therefore, that the operational experience from Bleicherode/Kehmstedt can be applied to the KARNALYTE deposit to design the solution mining operation and estimate the OPEX for the operation.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

## 16.6.2 Pilot Solution Mining Boundary Conditions

The boundary conditions for a pilot solution mining operation will depend on the requirements to the test. The minimum information expected from a solution mining pilot test are:

- development of the brine composition over time,
- development of brine temperature over time,
- specific flow rates for the cavern configuration tested,
- changes to brine composition/temperature if cavern is operated with different techniques from standard techniques.

For this information to be relevant without much interpretation to the production solution mining operation the cavern size should be in the same magnitude as the production caverns. With a planned production cavern having a final open cavern volume in the order of 400,000 m³ and single mining cuts reaching volumes of up to 60,000 m³, the pilot test operation should have at minimum a final planned cavern volume in the range of 100,000 m³. The cavern radius therefore should be in the range of 30 to 40 m at minimum to obtain all this information, but a smaller cavern operation still can provide important boundary conditions for temperature development and the relation between flow rates and brine composition.

A double well cavern would allow direct comparison with the planned production caverns, however, will require two drill holes and is therefore more expensive. Except for the specific flow rates that can be reached a single well cavern provides the relevant information required and therefore is the preferred option as it reduces costs.

### 16.6.2.1 Time Frame

For a full scale single well pilot cavern operation the exploration wells 6-32 and 2-24 can be used as they were drilled and completed with minor additional cost as a basis for a potential future solution mining test program. Assuming that all equipment and regulatory approvals are in place (6 to 9 months), the pilot operation for a complete carnallitite cycle from bottom Belle Plaine to top Patience Lake would take at minimum following approximate optimistic time frame:

- preparation leaching 5 to 6 months
- test leaching first cut 2 to 3 months
- test leaching second cut 2 to 3 months
- Halite leaching 4 to 5 months
- test leaching third cut 2 to 3 months

This time frame assumes standard solution mining techniques and no experiments with different equipment and can be reduced if tests are restricted to single horizons.

The boundary conditions listed here have been derived from the many years of the experience gained from the Bleicherode/Kehmstedt operation, theoretical calculations as well as experience with other carnallitite projects.

Alternatively DH-20, where infrastructure from a previous test is available can be upgraded to a smaller scale operation, which could be used to mine only a part of the carnallitite



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

sequence. For a smaller cavern (~20m diameter) the whole test operation could be completed in 5 to 6 months.

#### 16.6.2.2 Technical Requirements

For the duration of the test the following infrastructure must be available

- water source capable of delivery of up to 50 m³/h for a period of weeks and an average volume of 35 m³/h for the test period,
- brine disposal facility for a volume in the range of 400,000 m³,
- electricity to run pumps (e.g. water well, water injection in cavern, brine injection, blanket oil injection) and eventual brine heating equipment (alternative gas),
- facilities to handle a volume of 1800 m³ of blanket oil,
- work over rig availability on short (2 weeks) notice
- storage and pipeline system for water to cavern and brine to injection well (or alternative disposal)

No detail design is yet available for the pilot solution mining operation and the costs of $15 million CAD for a full test program are an approximation only.

The boundary conditions listed here have been derived from the many years of the experience gained from the Bleicherode/Kehmstedt operation, theoretical calculations as well as experience with other carnallitite projects.

### 16.6.3 Information Required for Solution Mining Operation Design

As discussed in the previous section a solution mining pilot test operation can provide important information required for the design of a solution mining operation. However, there are other ways to obtain this information that have been presented in previous sections, but these will be discussed in some detail here. As emphasized above, the information given in this section is based on many years of the experience gained from the Bleicherode/Kehmstedt operation, theoretical calculations as well as experience with other carnallitite projects and variations in these standard specific parameters will not result in a need for a changed design.

**Expected Brine Composition**

Information about the expected brine composition can be obtained from dissolution test work in combination with theoretical considerations based on thermodynamic modeling. Dissolution test work was carried out on 19 samples from the deposit at a brine temperature of 50°C (ERCOSPLAN, 2011, /19/). Based on dissolution test work on carnallitite from Germany, ROC, Brazil, Thailand/Laos, and now from Canada at a range of temperatures, no difference is observed comparing the dissolution behavior and dissolution rate of carnallitite with low insoluble content from these different deposits when normalized to the Carnallite content of the rock and a fixed temperature. The majority of the data come from the detail investigations on the dissolution behavior of carnallitite from Germany as preparation for the solution mining of carnallitite (see Section 16.6.1.2). Because salt rocks are



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

relatively simple chemical systems, the physics and chemistry of dissolution of such systems are expected to be comparable and with Carnallite in most cases being the mineral that dissolves fastest the Carnallite content of a sample determines in low insoluble content carnallitite the dissolution behavior.

These investigations have shown that the composition of the production brine is only dependant on the mineralogical composition of the section exposed to a defined volume of the solvent (water or weak brine) and varies with a fixed relation between KCl and $MgCl_2$ (Carnallite), until KCl saturation is reached. The dissolution rate depends on the mineralogical composition of the section and to a minor extent (scale between crystal size (cm) and dissolution section (m)) on the crystal size. This relation, however, can only be used when the test work shows that the deposit rocks conform to this relation. For this reason, a limited number of tests on deposit material are adequate to confirm whether or not a carnallitite deposit conforms to the general relation.

As the data from the carnallitite deposit near Wynyard conform to the general relation, this relation can be used to predict the relation between mineralogical composition and expected brine composition. Based on these relations it is possible to calculate the expected composition of a production brine from (i) temperature of the brine, and (ii) mineralogical composition, based on the thermodynamic properties of minerals and fluids, for which ERCOSPLAN has an in-house database that has been validated using over 100 years of experience with processing of potash bearing brines.

**Production Brine Temperature**

As discussed before, the temperature is an important factor determining the overall KCl content of the production brine. Cavern temperature modeling (W&T Geoingenieure, 2011, /51/) was performed to assess the influence of the use of a hot solvent on the average production brine temperature.

The temperature of the production brine depends on

1. temperature of the solvent at the well head
2. thermal interaction of the solvent with the wall rock of the drill hole,
3. thermal interaction of the solvent with the blanket medium on top of the cavern, the wall rock of the cavern where Carnallite is dissolved and the brine present in the cavern taking into account the undisturbed deposit temperature
4. flow path of the brine/solvent in the cavern
5. heat of dissolution of Carnallite and Halite in the cavern walls
6. flow rate of solvent (and brine)
7. thermal interaction between the production brine and the wall rock of the drill hole back to the surface

Several of these interactions change during the development of the cavern (change in cavern size due to dissolution and changing flow rates). For this reason, several scenarios were modeled to a steady state using a finite element cavern flow model that takes into account density driven flow, mass transfer (NaCl, KCl and $MgCl_2$), dissolution kinetics, saturation equilibriums and heat transfer (heat of dissolution and heat exchange with host rock). For a single cavern, several scenarios with different flow rates for selected development stages were calculated.

The results show that the average temperature of 55°C for production brine from carnallite from Belle Plaine and Patience Lake is a relatively conservative estimate. The modeling suggests that already at the end of the undercut leaching, the brine coming from the cav-



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

ern has this temperature. During the production leaching, therefore, higher temperatures are expected. A conservative lower estimate has been used in the design as the parameters used for modeling are general parameters for Carnallite, Halite and Sylvite, which might vary slightly for the KARNALYTE deposit. The results of a small scale pilot test operation at elevated temperatures, can be used to adapt parameters to local conditions and calibrate the model, in this way allowing less conservative temperature estimates.

The model used has been validated by comparing measurements and calculations for the Bleicherode/Kehmstedt operation over many years.

**Cavern Flow Rates**

Average flow rates for a cavern operation can be estimated with confidence from the results of the dissolution testing, combined with information about the Carnallite distribution along the deposit.

**New Solution Mining Techniques**

New solution mining techniques are not implemented in the design of the solution mining operation presented in this Technical Report. Implementation of unproven technology will require test work to verify that the techniques provide the predicted results and advantages over the implemented standard techniques.

Should KARNALYTE's management want to investigate the use of non standard solution mining techniques in the future, the authors recommend a full scale pilot test to ensure that these techniques optimize the operation.

# 17 Recovery Methods

The brine processing method for the Potash operation is summarized from the Feasibility Study (FOSTER WHEELER & ERCOSPLAN, 2011, /26/) on the project in the first sections, whereas the processing for the Magnesium Products from the $MgCl_2$ rich end brine from potash production is summarized from the Preliminary Feasibility study of LYNTEK (2012, /38/) in the later sections.

## 17.1 Potash Production Design Base

The design basis for the KARNALYTE plant is a first stage production of 625,000 tpy of KCl product with a KCl grade of 97%. The plant will operate 7,500 hours annually.

In a second stage the project will be expanded with a 750,000 tpy (97% KCl) production line and in a third stage with another 750,000 tpy (97% KCl) production line. These last 2 expansions should come on line within 5 to 6 years after the start of the project.

The first stage feed of the plant is provided from the brine field and consists of approximately 5.9 million m³ of brine annually with an average composition of:



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

| | |
|---|---|
| 121.5 g/l MgCl2 | 9.86 wt% |
| 114.5 g/l KCl | 9.29 wt% |
| 139.4 g/l NaCl | 11.31 wt% |
| 3.0 g/l CaSO4 | 0.24 wt % |

at a density of 1.232 g/cm$^3$ and temperature of about 50°C. The sensitivity of the project for a production brine with lower average KCl content is discussed in section 22.1.4.

## 17.2 Potash Processing Plant

The Potash Processing Plant includes the following principal facilities:

- Main Process Building – to house the majority of the process equipment.
- Utility Building
- Administration Building
- Maintenance Workshop (Mechanical/Electrical/Instrumentation) – Inside the Main Process Building
- Control Room – Inside the Main Process Building
- Electrical Building (MCC/Switchgear Room) - Inside the Main Process Building
- Substation Building
- Product Loading Structures - (Agricultural Grade)

The plant area will also include the wellheads from the production water wells extracting saline water from the Blairmore Aquifer and the disposal wells; discharging brine to the Deadwood and Winnipegosis Formations. The storm water detention pond will receive surface run-off, roof run-off and non-segregated drainage. Potentially contaminated storm water will be collected in curbed/diked areas and used in the process.

The process plant layout is illustrated in Figure 41. The pump enclosure and tank farm can be considered as extensions of the solution mining operations. The first step of the potash production process is the removal of “insolubles” from the production brine. Insolubles removal is followed by evaporation, crystallization and product drying with the final step being the formulation of the high purity spherical granular agricultural grade products (pellets). A simplified flow sheet for the process is shown in Figure 42.

### 17.2.1 Insolubles Removal

The brine contains fine particulates or “insolubles” suspended within it. Removal of the insolubles is accomplished using flocculants and an inclined plate separator. The brine flows into the separator where a flocculant is added, then through the inclined plates where the solid and liquid separation occurs. The insolubles are separated from the brine and sent to the sludge dewatering area. In the dewatering area, the sludge solution is fed to a filter press where the liquid is removed from the sludge. The separated insolubles are considered as a process by-product and may eventually be sold. Alternatively, collected



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

insolubles may be mixed with brine and returned to the brine field caverns as part of the progressive cavern decommissioning process.

### 17.2.2 Evaporation and Crystallization

Using a variety of thermodynamic techniques, the evaporators remove the water from the production brine. Evaporating water increases the concentration of $MgCl_2$ in the brine, and super saturates the KCl and NaCl, causing most to precipitate out. The solid salts are separated by centrifuge from $MgCl_2$ brine, which goes to disposal. The solid salts are re-pulped and passed to three crystallizers, which operate in series to separate the potassium chloride (potash) from the sodium chloride by means of their differing solubility characteristics.

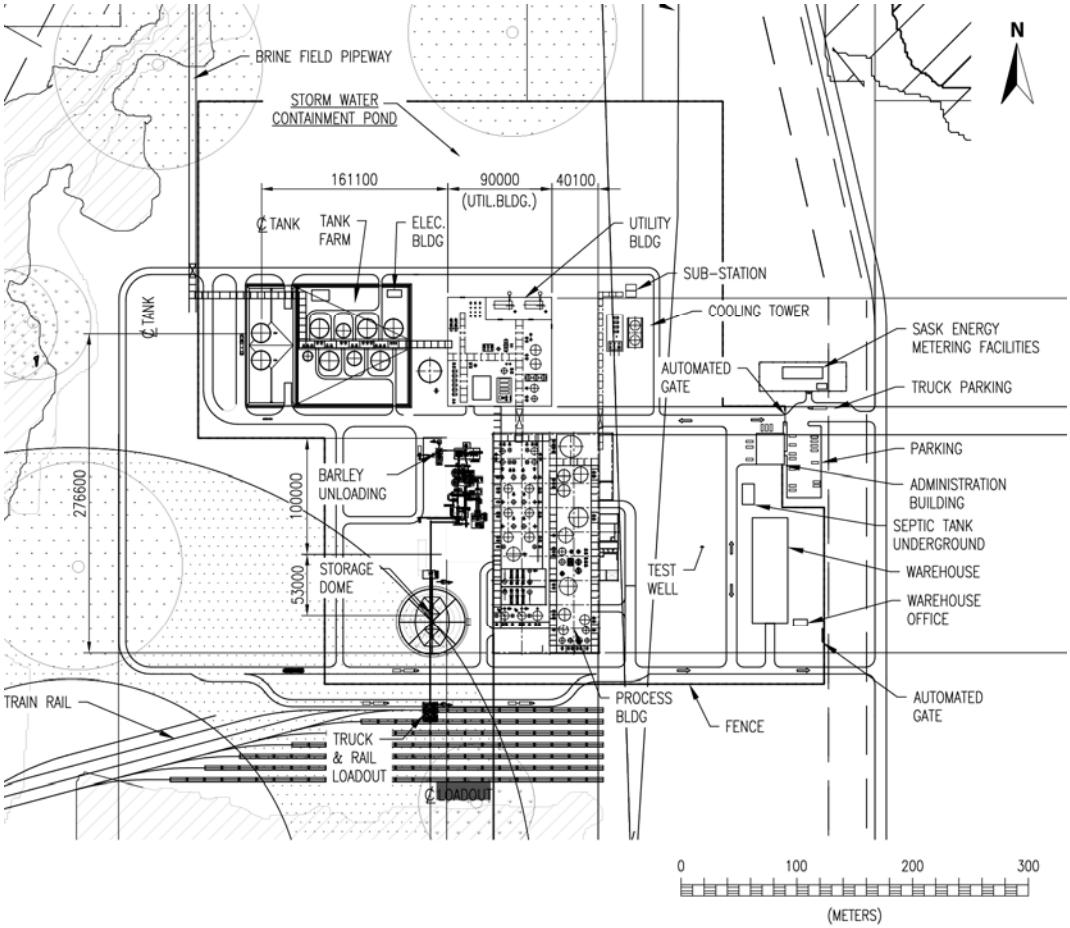



Figure 41 Schematic Potash Process Plant Layout for the 625,000 tpy Phase 1



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

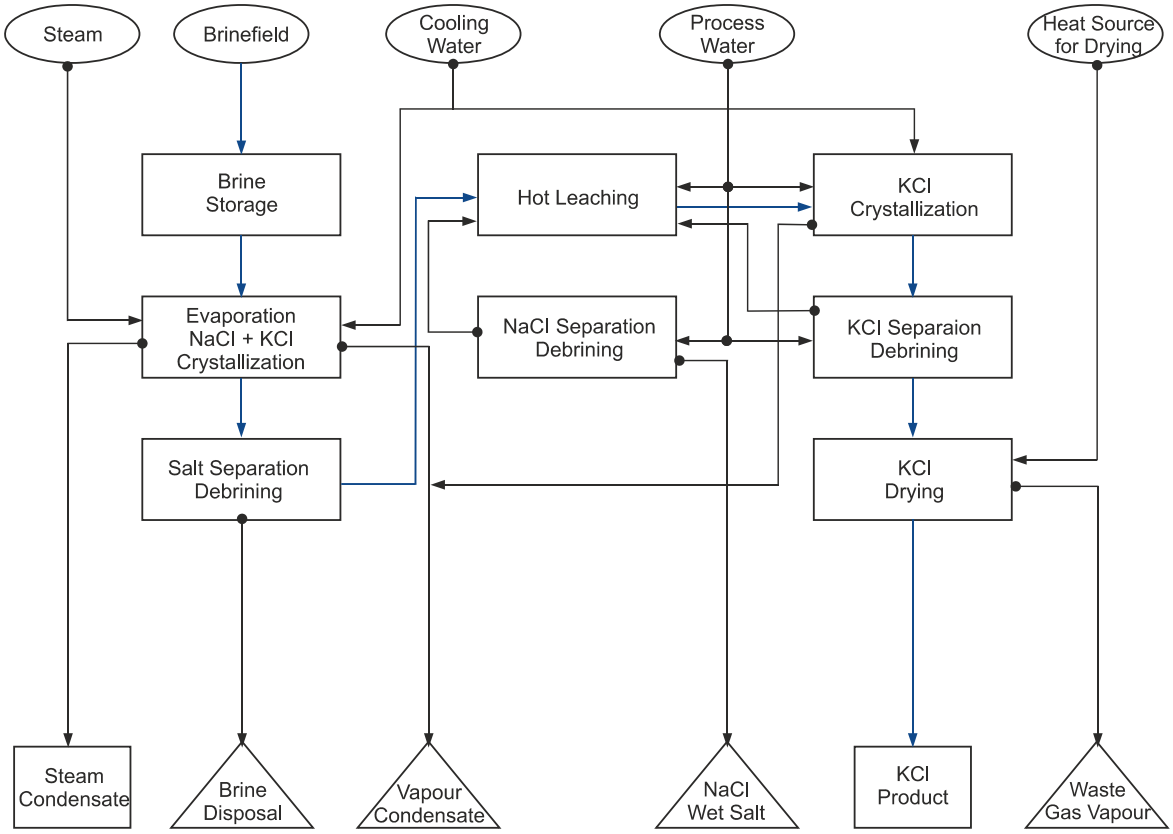



Figure 42 Simplified Block Flow Diagram for Potash Production of the Proposed Brine Processing

The crystallizers remove approximately 6% of the water from the feed liquid. In the adiabatic flash evaporation process, the feed liquid is cooled from approximately 93°C to 32°C and the potash crystals are formed. The potash solids are separated by centrifuges, then conveyed to the rotary dryer to remove residual liquid from the solid product.

### 17.2.3 Sodium Chloride and Potassium Chloride Debrining

Debrining is the process by which potassium chloride (potash) is recovered from the slurry during the crystallizer separation. The principal debrining technique is via centrifuge with sub-sequent re-solution of sodium chloride which is transferred to the tailings tank for disposal to the Deadwood and Winnipegosis Formations. The separated solution is recycled back to the crystallizer circuit.

### 17.2.4 Drying and Formulation

The rotary drum dryer receives the solid potash from the crystallizer centrifuges and provides drying of the solids to remove liquid from a concentration of 5% in the feed stream to



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

a concentration of approximately 0.1%. The dry solids are then conveyed to a screen, where the dried product will be delivered to the pulverizer. The vent gas from the rotary drum dryer goes to a cyclone to remove some of the particulate and then to an electrostatic precipitator to remove most of the solids in the vent gas stream. The vent gas is sent through a stack to atmosphere. All of the solids particulate collected in the cyclone and baghouse are collected and recycled to the pulverizer feed bin. The particulate control system has been designed to meet the Saskatchewan Potash Refining Air Emissions Regulation limit of 0.57 grams per dry reference cubic meter. Any dust lost through the stacks would be a loss of product; therefore it is advantageous to collect all of the dust. The dryers will be high efficiency, low NOx burners to limit the amount of NOx in the exhaust. The heat for the rotary drum dryer is provided by a natural gas burner and a blower provides the hot combustion gas to the drum to perform the drying operation.

### 17.2.5 Product Storage and Load-out

The dried potash is pulverized and conveyed to a pelletizer where the final high purity spherical granular agricultural product (pellets) is formed. After pelletization the product is re-dried and sent through a screen to eliminate fines and oversized material from going to the product hoppers. The product hoppers are mounted high in the structure to allow direct loading into the railcars and trucks.

## 17.3 Magnesium Products Recovery Method

The design basis for the Magnesium product plant is an annual production of 100,000 tpy of 32% MgCl2 brine and 104,000 tpy of Hydromagnesite with a 99% purity. The plant will operate 7,500 hours annually.

The first stage feed of the plant is provided from potash facility and consists of approximately 545,000 tonnes of brine annually with an average composition of:

| | |
|---|---|
| 445 g/l $MgCl_2$ | 35 wt% |
| 10 g/l KCl | 0.8 wt% |
| 8 g/l NaCl | 0.6 wt% |
| <25 g/l $CaCl_2$ | <2 wt% |
| <30 g/l $CaSO_4$ | <2.5 wt % |

at an average temperature of about 56°C.

The Magnesium product plant can be divided into two main units:

- the magnesium chloride brine production
- the Hydromagnesite production facility

that will be shortly described in the following



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

### 17.3.1 Magnesium Chloride Brine Process

The potash plant waste magnesium brine is diluted from 35% to 32% $MgCl_2$ concentration using process water and then is cooled to 30 °C using a heat exchanger. Dilution prevents precipitation of the magnesium chloride by reducing the concentration of $MgCl_2$ from the solubility limit. Brine will be stored in a 100 m³ tank (9.5 operational hours of storage). 12.4 tonnes per hour of waste brine is diluted to 32% $MgCl_2$ which produces 13.5 tonnes per hour of saleable product.

### 17.3.2 Hydromagnesite Process

A simplified process flow chart of the hydromagnesite process is given in Figure 43 The overall hydromagnesite process consists of 6 steps, but a 7$^{th}$ step is required to produce gaseous reagents for the process and will be described first.

#### 17.3.2.1 Gaseous Reagent Preparation

The proposed process for carbonation of the magnesium brine uses carbon dioxide ($CO_2$) and anhydrous ammonia ($NH_3$) gases to reduce the overall cost of the process. The cost savings are realized by reclaiming ammonia gas using slaked lime. The slaked lime is produced from the residue of the production of $CO_2$ from calcining limestone. This portion of the process closely mirrors the proven Solvay process for producing soda ash from salt brine with high concentration $CO_2$ exhaust gas from a lime kiln, and subsequent ammonia regeneration using slaked lime.

Limestone is first fed to a natural gas fired kiln to produce two products, $CO_2$ gas and quicklime (CaO), as shown below.

$$CaCO_3\ (s) = CaO\ (s) + CO_2\ (g)$$

Air for combustion is fed in 20% excess by an integrated blower. The exhaust gas from the kiln is air-cooled to 120°C and pressurized to 12 psig. Increased pressure is required to compensate for the pressure maintained in the headspace and the fluid head from the tank contents. Pressurized gas is split in a manifold and distributed, via spargers, to the six carbonation tanks. The remaining quicklime from the kiln is slaked using process water in a vertical ball mill to produce $Ca(OH)_2$ as below.

$$CaO + H_2O = Ca(OH)_2$$

The slaking reaction is exothermic and will be need to be cooled to maintain appropriate temperature for the equipment.

The final destination for the slaked lime is the ammonia stripping column. Ammonia is dissolved in the magnesium chloride brine to buffer the solution in subsequent reactions and provide an additional driving force for magnesium carbonate precipitation during the carbonation step in the processing. The ammonia stripping column accepts various magnesium plant effluents which are mixed with the slaked lime to drive the ammonia back into the gaseous anhydrous form and recycle the gas. The reaction is between the ammonium chloride formed in the carbonation reactors and slaked lime which produces ammonia gas as shown below.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

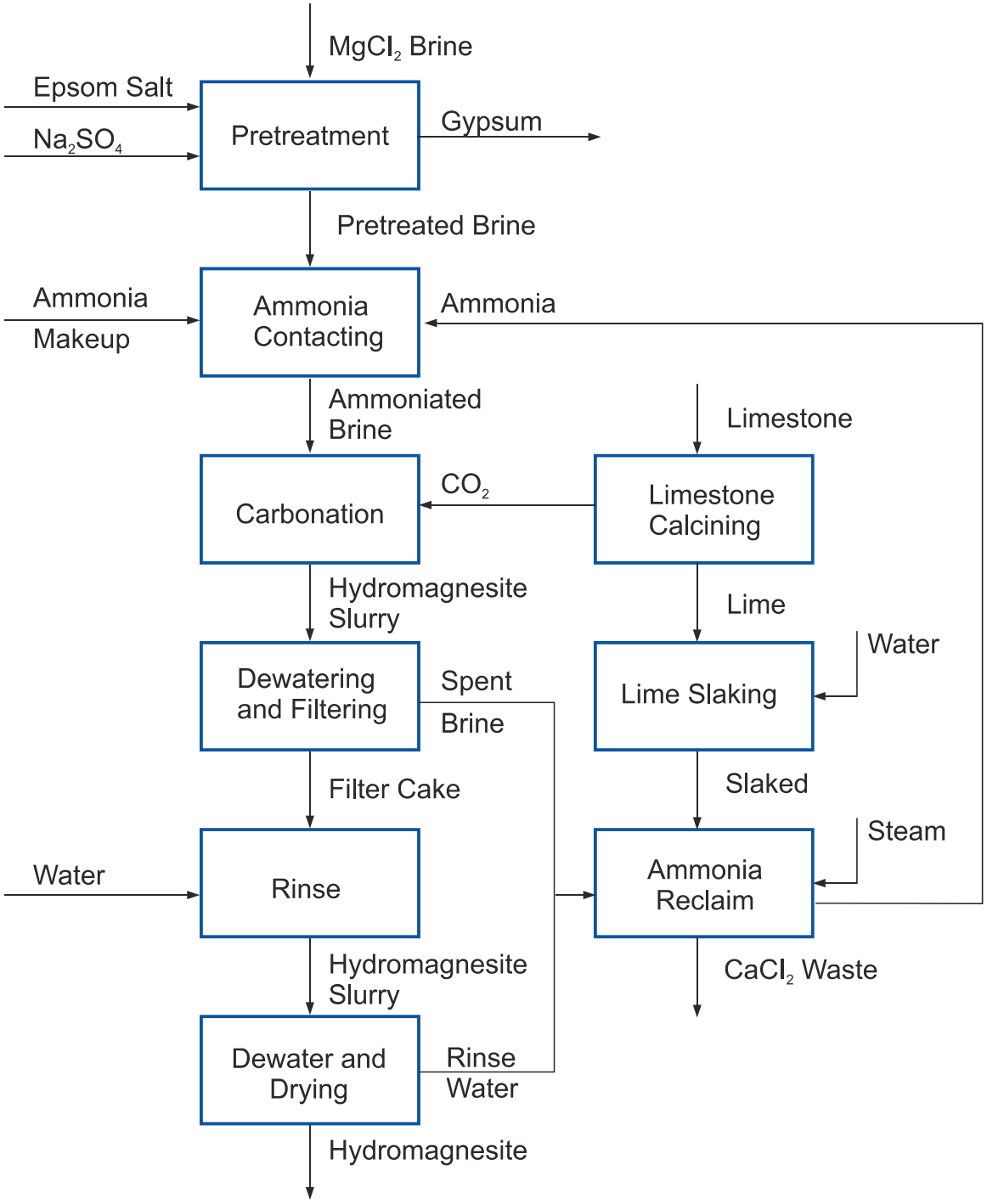



Figure 43 Hydromagnesite Precipitation Process Overview (from LYNTEK 2012, /38/)

$$Ca(OH)_2 + 2NH_4Cl = CaCl_2 + 2\ H_2O + 2NH_3\ (g)$$

Heat from steam injection and the high pH from the slaked lime addition reduce the solubility of the ammonia to very low levels, allowing for high recovery. The preliminary design



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

assumes an ammonia recovery efficiency of 98% in this unit operation, but this can be improved. Ammonia to make up the losses is supplied from a pressurized storage tank. Expected losses are estimated at 1,300 metric tonnes per year. Ammonia capture in the process could be improved with testing and detailed design, which would improve both the operational costs and reduce environmental impacts.

### 17.3.2.2 Pretreatment of the Potash Plant Waste Brine

$MgCl_2$ brine at 56°C from the KCl plant is stored in a heated tank that raises the temperature to 80°C. The brine is then diluted to 32% $MgCl_2$ concentration using process water heated to 80°C. Dilution and heating prevent precipitation of salts by reducing the concentration from the solubility limit for $MgCl_2$. The diluted $MgCl_2$ brine is sent to the gypsum precipitation tank where Epsom Salt ($MgSO_4$•7($H_2O$)) will be added in agitated mixing tanks. The addition of the $MgSO_4$ results in the precipitation of calcium in the brine as gypsum ($CaSO_4$ •2($H_2O$)) as seen below:

$$CaCl_2\ (aq) + MgSO_4\ (aq) + 2\ H_2O\ (l) = CaSO_4 \bullet 2(H_2O)\ (s) + MgCl_2\ (aq)$$

Using Sodium Sulfate ($Na_2SO_4$) as a replacement pretreatment reagent produces gypsum but increases NaCl concentration in brine, see below.

$$CaCl_2\ (aq) + Na_2SO_4\ (aq) + 2\ H_2O\ (l) = CaSO_4 \bullet 2(H_2O)\ (s) + 2NaCl\ (aq)$$

The increased NaCl concentration is not expected to affect product quality as its reaction products are highly soluble and will be removed during dewatering processes.

Calcium is removed in a pretreatment step because calcium carbonate is less soluble than magnesium carbonate, therefore, any calcium in the brine feeding the plant will precipitate with the product. $MgSO_4$ additions will be adjusted to match the $CaCl_2$ concentration in the feed. Excess Epsom salt (or alternatively Sodium Sulfate), somewhat more than the amount needed to precipitate the calcium present, should be fed to account for variations in the feed and to ensure minimum calcium solubility.

This reaction will be performed in two tanks in series for better residence time distribution. Calcium will be removed to a level representing the solubility of gypsum in the process brine. The slurry with the $CaSO_4$ •2($H_2O$) will be sent to a thickener where the gypsum particles are allowed to settle. The settled solids will be removed as the thickener underflow and sent to be combined with other waste fluids from the KCl operations for deep well disposal, and eventually to spent caverns. The overflow from the thickener is sent to a filter to ensure complete removal of the gypsum particles. Backwash from the filter will be combined with the thickener underflow for disposal.

### 17.3.2.3 Brine Dilution and Ammoniation

Filtered brine and process water are sprayed into an absorption tower where ammonia gas is fed from the bottom. The process water dilutes the brine and the diluted brine absorbs the ammonia gas. The clear liquid from the clarifying filter is chilled to 25°C to be used as feed to the ammonia contacting tower. The ammonia contacting tower will have two liquid feeds, clarified brine and treated process water from the main plant. The gas feed from the bottom of the tower is ammonia gas, 22°C. Dilution water is used in addition



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

to the brine to more effectively absorb the ammonia. Ammonia addition buffers the solution from the $CO_2$ absorption which results in moderate carbonic acid generation in solution. Composition of the solution prior to carbonation is 12% $MgCl_2$ and 4% $NH_3$, by weight in the design.

### 17.3.2.4 Hydromagnesite Precipitation

The ammoniated solution will be carbonated in a circuit of six tanks arranged in series. The carbonation reaction will occur in two steps, $CO_2$ dissolution and $MgCl_2$ carbonation. Exhaust gas from the lime kiln will provide the $CO_2$ necessary for the magnesium chloride carbonation reaction. As the $CO_2$ dissolves, carbonic acid ($H_2CO_3$) will be generated. Carbonic acid exists in equilibrium with two ionic forms; bicarbonate ($HCO_3^-$) and carbonate ($CO_3^{2-}$).

The carbonic acid will be consumed throughout the $MgCl_2$ precipitation reaction which will drive additional $CO_2$ dissolution and carbonic acid regeneration as the solution attempts to reach equilibrium. Carbonation will result in a slurry of precipitated Hydromagnesite in an ammonium chloride brine according to the following reaction.

$$5MgCl_2 + 4CO_2 + 10NH_3 + 10H_2O = Mg_5(CO_3)_4(OH_2)\bullet 4(H_2O) + 10NH_4Cl$$

Without ammonium ion in solution, a successful carbonation reaction would yield hydrochloric acid instead of ammonium chloride. This would tend to re-dissolve the magnesium and cause corrosion problems in the equipment. The ammonium ions in solution allow the reaction to proceed at lower activation energies and buffers acidic solution.

The carbonic acid in solution will also be consumed by NaCl in the brine producing sodium bicarbonate ($NaHCO_3$) as in the Solvay Process according to the following reaction:

$$NaCl + H_2CO_3 + NH_3 = NaHCO_3 + NH_4Cl$$

Excess $CO_2$ gas is fed to the process for dissolution which should account for any losses to the NaCl carbonation reaction. $NaHCO_3$ is highly soluble and will stay in solution during the dewatering step and is not expected to affect product quality.

### 17.3.2.5 Hydromagnesite Recovery and Washing

The slurry from the carbonation system will feed a thickener as the first separation step. The thickened underflow slurry containing the settled Hydromagnesite solids will be pumped from the thickener to a horizontal belt vacuum filter to remove more of the entrained liquid. The filter cake will be washed on the filter with treated water to remove additional water containing NaCl and other salts. The filter cake will then be dried on the filter to relatively low moisture content. Thickener overflow and filtrate liquid from the vacuum filter will be sent to the ammonia stripping column to recover the ammonia.

The Hydromagnesite filter cake will be further washed by mixing it with treated water in a “re-pulping” tank, to dilute the remaining ammonia and salts remaining in the belt filter solids. That slurry will be dewatered in a centrifuge to remove the wash water. The wash water recovered from the centrifuge will be sent to the ammonia stripping column, while the solids recovered from the centrifuge will be dried in a ”Holo-Flite” type dryer.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

#### 17.3.2.6 Hydromagnesite Drying and Packaging

The Holo-Flite drier consists of four hollow screws running in a rectangular chamber. Hot fluid is circulated through the screws and optionally through the walls of the chamber to provide heat for drying. The Hydromagnesite will be heated to a temperature of 100°C in the drier to drive off free water (surface moisture). Thermogravimetric analysis (TGA) data suggests that carbonate groups are lost from Hydromagnesite at temperatures above 300°C; therefore the temperature of the heating fluid for the dryer will be limited to a maximum temperature of 300°C. The heating fluid will be fed concurrent with the solid material to minimize deformation of the product. Continuous operational testing at an appropriate scale is required to confirm the amount of mass loss from the drying operation as the Hydromagnesite product begins to dehydrate at temperatures just above 100°C. Excessive heat in the drying process could remove up to 15% of the mass of the product. The current process design uses the superheat to determine a 4.3% mass loss due to dehydration.

After cooling, the dry hydromagnesite powder will be transferred to a storage bin. The dry hydromagnesite product will be transferred to a loading system for dry bulk semi-trailer trucks. The off gas from the dryer will be treated to remove any particulates and discharged to the atmosphere.

# 18 Project Infrastructure

The following major utilities and infrastructures are required to support the potash as well as the magnesium chloride operations.

## 18.1 Water Supply

The raw water required for the potash and magnesium projects will be drawn from underground from the Blairmore Aquifer (approximately 475 m depth) and will be used for solution mining, process utility water requirements within the plant and cooling water. An analysis of this water has shown that it is not suitable for agricultural purposes.

Based on the material balance and the cavern mass balances, the following requirements for process water are identified for the 625,000 tpy steady state potash production:

| | |
|---|---|
| Cold Solvent for Sylvite Caverns and Cavern Preparation | 690 m³/hour |
| Warm Solvent for Carnallite Caverns (580 m³/hour, however, partly sourced from condensates from the plant and recycling of selected cavern preparation brines) | |
| Wash Water in Processing | 80 m³/hour |
| Added for Disposal of $MgCl_2$ Brine | 8 m³/hour |
| Make Up Water for Cooling Tower | 136 m³/hour |



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

| | |
|---|---|
| Miscellaneous for Plant and Steam | 12 m³/hour |
| Added for NaCl Disposal | 100 m³/hour |

Potable water for plant and office use is expected to come from the Town of Wynyard, which has indicated that it would be able to provide up to11 m³/h, which is more than the volumes required.

For each 750,000 tpy expansion of the potash production capacity process water requirements are as follows:

| | |
|---|---|
| Cold Solvent for Sylvite Caverns and Cavern Preparation | 828 m³/hour |
| Warm Solvent for Carnallite Caverns | (696 m³/hour |
| however, partly sourced from condensates from the plant and recycling of selected cavern preparation brines) | |
| Wash Water in Processing | 96 m³/hour |
| Added for Disposal of $MgCl_2$ Brine | 10 m³/hour |
| Make Up Water for Cooling Tower | 163 m³/hour |
| Miscellaneous for Plant and Steam | 14 m³/hour |
| Added for NaCl Disposal | 120 m³/hour |

For the Magnesium facility approximate water requirements are estimated as follows:

Clean Process Water 314 m³/hour,

from reverse osmosis of Blairmore water at 25% recovery of Blairmore water

Cooling Water 17 m³/hour,

about 5% of first fill.

Steam is generated by two 800 hp steam generators which provide a total of 18,800 kg (41,500 pounds) of steam per hour with a capacity of 25,000 kg (55,200 pounds). Water sent to the boilers is Blairmore water run through a reverse osmosis system. Steam is used in the ammonia reclamation tower. Steam is injected into the tower to mix the material at the bottom of the tower and to provide heat for the evaporation of the ammonia in that solution.

## 18.2 Gas Supply

Natural gas is required for the heater in the Hot Oil System and product drying, as well as, for heating office space and control room at the site. The total amount of energy required from natural gas for the 625,000 tpy potash facility is estimated at 1,125 GJ/hour. The plant annual operation time is 7,500 hours.

The energy required from natural gas for every 750,000 tpy expansion is estimated at 1,350 GJ/hour.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

The Magnesium Product Facility will use natural gas to heat feed brine and process water for pretreatment. Furthermore the kiln, product dryers and the steam generators (two 800 hp steam generators capable of delivering 25,000 kg (18.800 kg required) of steam). Overall heat demand of the operation is 141 GJ/Hour.

Natural gas will be purchased from a gas marketer and delivered to the site by TransGas, a Provincial Crown-owned gas transmission company with funding from KARNALYTE (TransGas, 2016, /49/). The funding of the infrastructure for the gas transportation by KARNALYTE will be off-set by a rebate on gas prices for the first 5 years of operation. Pressure reduction, custody metering and odorant injection will be contracted to Sask Energy, a sister company of TransGas; their facility will be built adjacent to the KARNALYTE plant.

The delivery of the gas is done via a TransGas pipeline. KARNALYTE would buy the gas from an external supplier and deliver it to the TransGas Energy Pool (TEP). Averaged Natural Gas prices in 2019, the year of expected start of production are estimated to be at about $2.91 CAD per GJ (Gasalberta, 2016, /27/). TRANSGAS would charge a monthly delivery rate of $ 0.1865 CAD/GJ for gas delivered from the TEP to site. The delivered cost of natural gas to site of $3.0965 CAD/GJ is used in the OPEX estimate for the Potash and Magnesium Products plants.

## 18.3 Electrical Power

SaskPower, the provincial Crown-owned power generation and transmission utility company, will supply power to the plant site from the main power grid. A new line to the site will be installed by SaskPower with funding from KARNALYTE.

Total installed capacity for the complete plant and brine field is in the order of 30 MVA and continuous power demand is estimated to be 23 MW for the initial 625,000 tpy plant. The industrial rates for large commercial and industrial operations of SaskPower for users having their own transformation at a power line of 138 kV are:

- Basic Monthly Charge at $6,757 CAD
- Monthly Demand Charge of $7.35 CAD per maximum kVA
- Energy Charge of $0.05421 CAD/kWh

Annual operation time for the plant is 7,500 hours and for the brine field is 8,000 hours.

The additional power required for each 750,000 tpy expansion is 27.6 MW.

The Magnesium facility requires an estimated continuous power draw of roughly 2.1 MW.

## 18.4 Railway and Product Transport

A plant site rail loading facility will be constructed and a spur track of about 3 km will be constructed to connect the plant rail loadout to the CPR line.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

The magnesium facility will be constructed south of the 625,000 tpy potash plant. Magnesium brine will be transported to the customers by tanker truck. When the railway facility for the potash plant is in place an extension will be made for the magnesium facility.

The hydromagnesite will be transported in dry bulk hopper trailers per truck.

## 18.5 Base Chemicals for the Magnesium Facility

In contrast to the potash facility which requires no large amounts of further base chemicals for the process, the magnesium plant requires facilities for transport and storage of:

- Epsom Salt that will be transported to the facility in 20 tonnes trucks and stored on site in silos. Silo capacity is such that about 9 days can be produced (307 tonnes/day) from completely filled silos.
- Limestone and Lime will be transported to site in trucks or later eventually by rail. Storage capacity on site will be around 4,100 tonnes, which should be adequate to guarantee 9 days of production at full silos.
- Anhydrous ammonia gas will be kept in a pressurized storage tank. A storage capacity of 40 tonnes will be built (maximum allowed size). A full tank has adequate capacity for more than 2 weeks of production. It is expected that every two weeks a standard shipment of 31 tonnes of anhydrous ammonia will be brought to site by truck.

## 18.6 Waste Management

A number of large and small waste streams will result from the solution mining and brine processing to KCl product:

- solid NaCl from brine processing,
- NaCl brines from cavern preparation,
- concentrated $MgCl_2$ brine,
- flocculated insoluble solids
- dust,
- gas emissions from steam boilers and driers,
- domestic waste.

For the magnesium facility following waste streams are expected:

- solid gypsum from pretreatment,
- concentrated $CaCl_2$ brine,
- dust,
- gas emissions from steam boilers and driers,
- domestic waste.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

The disposal routes for the different waste materials will be as follows:

The solid NaCl from brine processing will be dissolved in water; the resulting brine will be injected into the Deadwood Formation. After the first five years, when caverns are available for final disposal, a major portion of the solid NaCl can be disposed in the mined out caverns, reducing the brine injection volume.

The solid gypsum from pre-treatment and the solid insoluble can be mixed with the solid NaCl and backfilled in mined out caverns.

The concentrated $MgCl_2$ brine will be diluted and injected into the Deadwood and Winnipegosis formations. The same will happen with the $CaCl_2$ brine, but different injection wells will be used.

Dust emission from the plant is minimized by using best industry practice equipment to gather dust. Heavily travelled roads could be paved and road surfaces will be treated to minimize dust generation.

Gas emissions from boilers and drying cannot be avoided but equipment will be installed to stay within the limits given by the Saskatchewan Clean Air Regulations.

The resources of the local area will be used for domestic waste management. A septic truck service would be hired to haul waste off site for disposal at the Town of Wynyard sewage lagoons.

# 19 Market Studies and Contracts

This section is divided in a Potash and Magnesium Products section and will start with the Potash section and end with the Magnesium products section.

## 19.1 Potash Products

This section will first give an overview about the different potash products followed by a general introduction into the historical developments on the potash market compared to the 2009/2011 situation and an outlook to the developments on the potash market KARNALYTE's marketing plan and eventual contracts in place are briefly discussed in the last section.

### 19.1.1 Product and By-Products

The potash products supplied by international producers are different in colour, grade and particle size. Almost all potash producers use KCl as the base for several final products. Many permutations are possible, especially for the bigger producers with several operations. Most of the producers offer fine/standard and additionally granular MOP in red or white forms, some offer industrial grades (KCl 98 and KCl 99) (Figure 44). Only few are able to produce K/Mg sulfates and SOP to make premium products.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

Most of the potassium chloride is produced with a purity of 60% $K_2O$ or 95% KCl respectively. KARNALYTE however intends to produce potassium chloride with a purity of 97% KCl. Fertilizer companies are usually willing to pay extra for higher concentrations of nutrient in the product which gives KARNALYTE the opportunity to supply its products to the agricultural markets as well as to premium markets of the chemical and industrial sectors. Sodium chloride (NaCl) and magnesium chloride ($MgCl_2$) are possible by-products for the KARNALYTE operation.

### 19.1.2 Potash Market: Historical Development and Present Situation

The structure of potash demand is a relatively simple one, with a single end-use dominating it – some 95% of all potash production is used as fertilizer. The remaining 5% are used as base material in the chemical industry of which the largest is the manufacture of potassium hydroxide, which is itself the intermediate for a variety of other applications. With non-fertilizer uses being so small, it is the demand for fertilizers that determines the trend of potash demand.

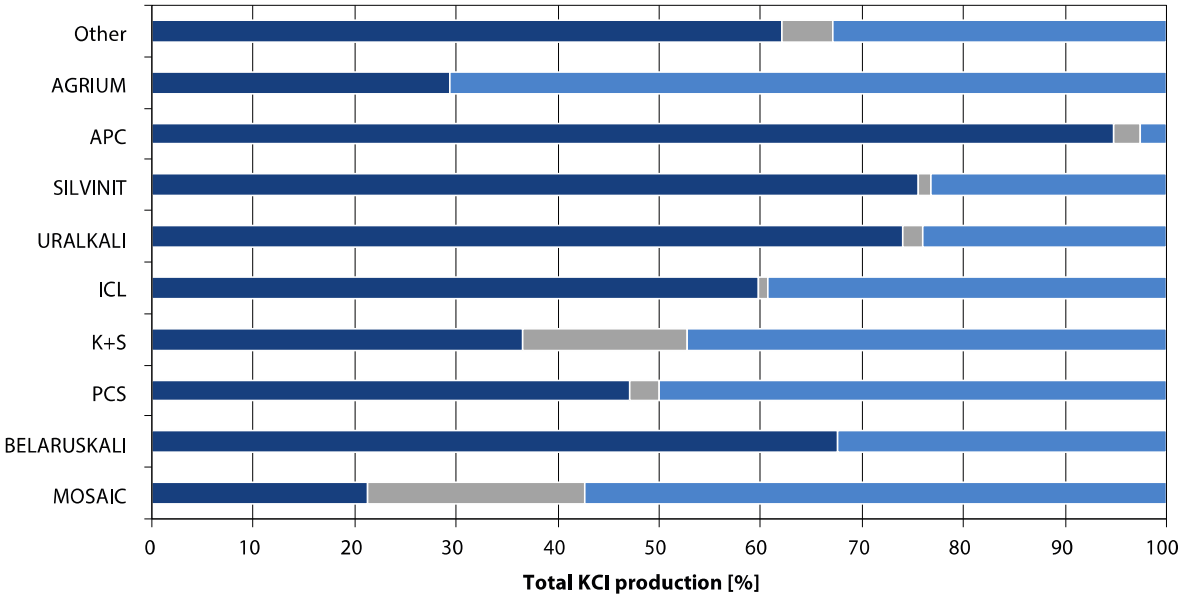



Figure 44 Potassium Chloride Product Types by Producers from Rauche (2015, /44/). Dark Blue on the Left, Standard Product, Pale Blue on the Right, Granular Product, Central Gray, Industrial Product,

The worldwide overall consumption in potash products ranged in 2013 at approximately. 58.5 million tonnes KCl (37 million tonnes $K_2O$). Further to the consumption of potassium chloride (MOP, KCl or Muriate of Potash) with a share of about 94% of the world-wide demand in potash products, also potassium sulfate (SOP, Sulfate of Potash) and further mostly Mg containing potash products are demanded for fertilization. An overview about



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

the development of the potash fertilizer consumption in $KCl_{equ}$[7] for the last and the coming years is given in Figure 45.

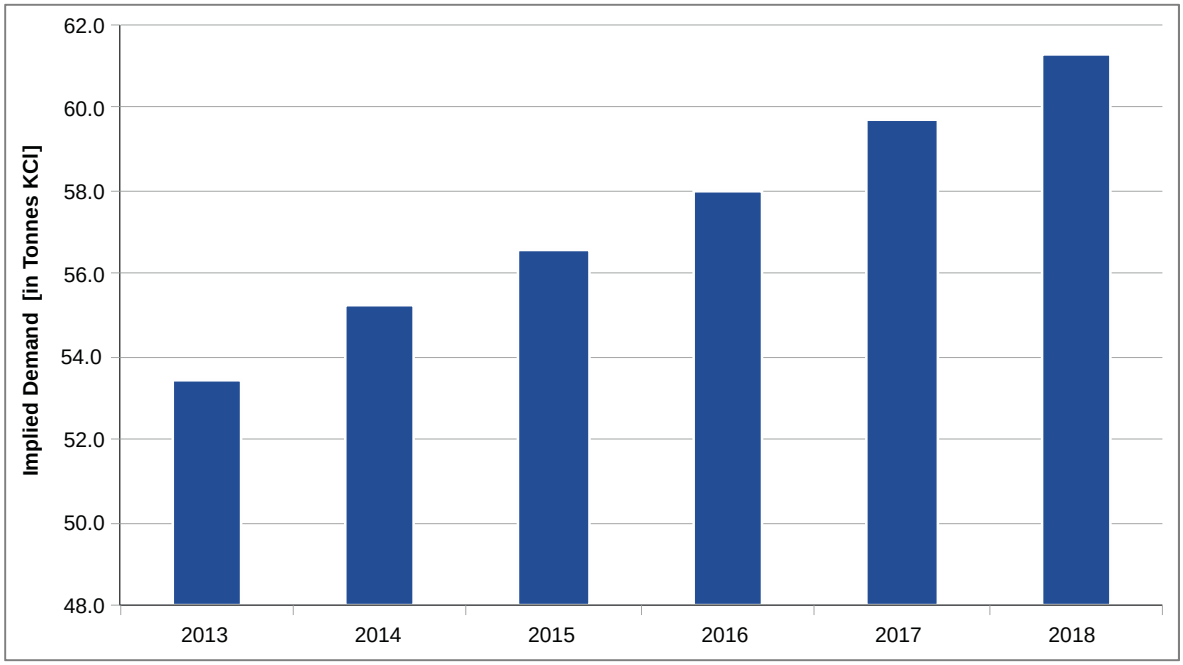



Figure 45 Worldwide Consumption of Potash Fertilizers in $KCl_{equ}$ (Consumption figures starting in 2016 are forecasted); According to Data from FAO (2015, /25/) and confidential Market Studies

Ten companies operate 35 production plants and supply approximately 90% of the total world production; these major producers are, Potash Corporation of Saskatchewan (PCS), MOSAIC and AGRIUM, all located and operating in Canada and US; BELARUSKALI and URALKALI, all located and operating in the Former Soviet Union (one in Belarus, and one in Russia,); and the ICL group, located in Israel and operating in Israel, Spain and UK; the Arab Potash Company, located and operating in Jordan, SQM, located and operating in Chile and K+S KALI, located and presently operating only in Germany, but starting production from their Legacy Project in Saskatchewan Canada. Five more minor producers, including two more in North America, account for most of the rest.

The main consequence of the spatial distribution of the major potash production units is the non-balance between production and demand by regions (Figure 46), which lead to relatively long shipping routes from the suppliers to the consumers.

Although twelve countries produce potassium chloride, only six of these export large quantities to the international market. Many of the areas of high potash demand are remote from the production area. The consequence of this fact is long-distance ocean trade routes. Subordinated are the rail-only routes (Canada to USA and Russia to China).

[7] $KCl_{equ}$ is KClequivalent and is used to describe the content of the nutrient potassium in a potash product independently from the anionic matter chloride or sulfate.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

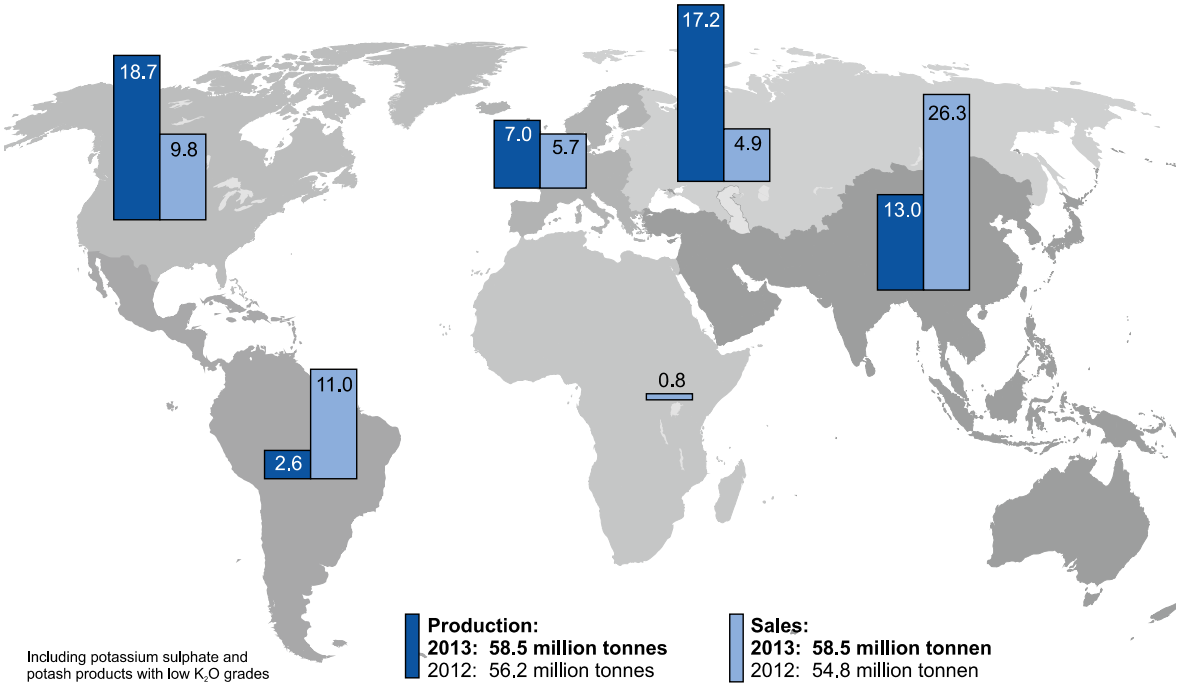



Figure 46 Potash Production and Sales According to Regions in 2013 (from Rauche, 2015, /44/)

The main destinations of MOP exports from the largest producers are Latin America (approx. 16 – 22%) and Asia with 38% to 88%.

For distribution of all exports outside the USA the producers from Saskatchewan, PCS, MOSAIC and AGRIUM have formed a joint sales organization CANPOTEX. The main exports from Canada are shipped out of Vancouver (Neptune Terminals) and Portland (Bulk Terminal No. 5), both managed by CANPOTEX. The major part of export for local use in the USA is by trucks and train.

In general, Russia and Belarus sell a larger proportion of their product domestically than the Canadian producers. Till 2014 BELARUSKALI and URALKALI also had a joint sales organization, that sold about 75 % of exports from the former Soviet Union. Seaborne exports from BELARUSKALI and URALKALI are from various ports on the Baltic Sea and the Black Sea. The modern Baltic Bulk Terminal in St. Petersburg handles large portions of the exports of URALKALI.

The other large exporters are K+S via the Kali Terminal at the port of Hamburg, Germany, DSW via terminals at Eilat, Red Sea, and several ports at the Mediterranean Sea in Israel, and APC via port of Aqaba, Red Sea, Jordan.

Historically potassium product prices were rather stable with two small peaks in the middle of the 1970s and early 1980s due to the commodity price shocks at international trading places. The few potash producers however started to cut back production to meet the demand for minimizing the costs of storing. Hence prices steadily increased in the late 1980s and remained at a level of $100 USD to $115 USD per tonne of MOP fob for the next ten years. In 2003 increasing freight costs caused the potash producers to raise their prices by about $100 USD per tonne for covering freight cost volatility in cfr sales. This



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

increase had no significant impact on demand. Contrary demand rose during the coming years as countries such as Brazil and China were heavily demanding fertilizer products. When agricultural commodity prices strongly increased in 2008, potash prices were at a new peak of $1,000 USD per tonne at spot markets. This high price combined with a world finance crises halted trade in 2009, since fertilizer traders feared not to be able to sell at comparable price they acquired the potash for and potash sales were down nearly 50% from the 58 million tonnes $KCl_{equ}$ of 2007. This deadlock broke in the last quarter of 2009, with a new fob price stabilizing around $400 USD per tonne. Sales and production of potash also stabilized and increased over the last 5 years to near pre-crash levels.

The break-up of the trade organization of URALKALI and BELARUSKALI in 2013 that combined with CANPOTEX controlled about 75% of the export market trade for potash, resulted in a further decrease of the prices, that from Q3 2013 dropped to $300 USD down from the $400 USD per tonne and since Q4 2015 have further slipped to about $240 USD per tonne in early 2016 (Figure 47).

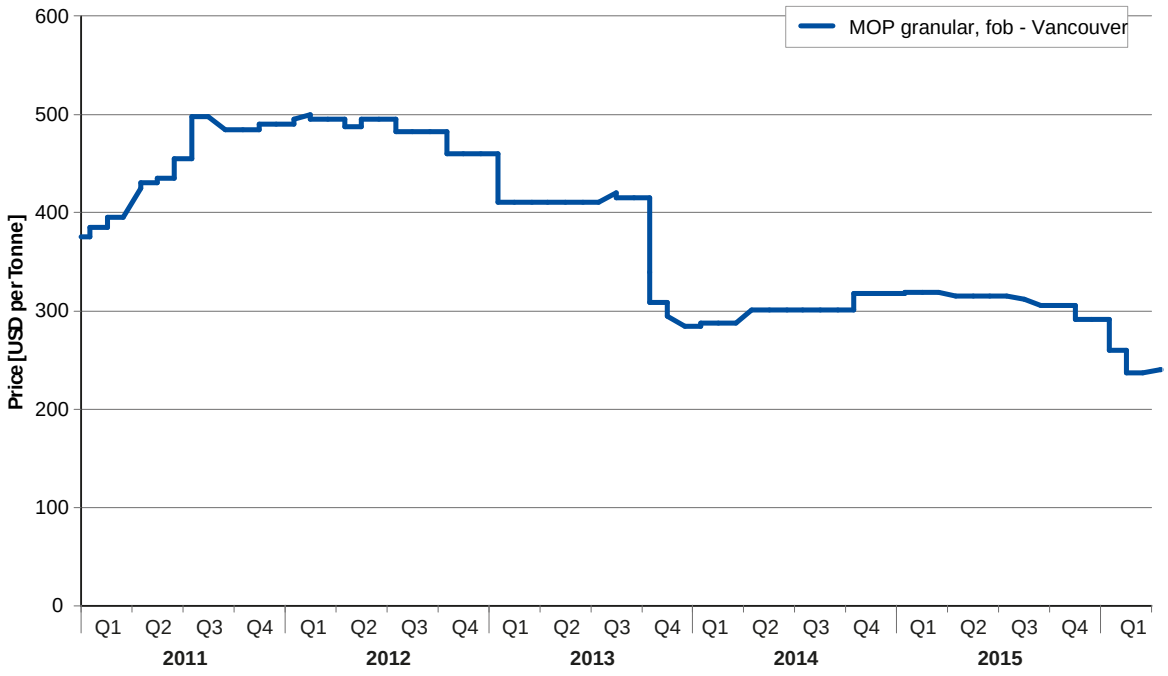



Figure 47 Development of Potash Prices (MOP Granular FOB[8] Vancouver) between 2011 and First Quarter 2016

### 19.1.3 Outlook for Potash Market Development

Although the potash market crashed in 2009, the fundamentals for the market are good, as consumption of potash as fertilizer is bound to increase due to the simple fact that there is the need to feed an increasing number of people from a smaller amount of available arable land. This can only be achieved if the available land is more efficiently used and

[8] FOB Free on Board, price of product loaded on a ship in port



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

requires besides developing more effective crop plants, fertilization of the land for optimal plant growth. This trend is compounded by the legislation put forward in western countries to exchange a % of fossil fuel with bio-fuels (e.g. Renewable Energy Directive 2009/28/EC from the EU). Plants suitable for bio-fuel production, require intense fertilization and by using arable land for bio-fuel production the amount of land available for food production is further reduced. Different analysts and organizations estimate for the coming years and annual growth of potash demand in the range of 1.5 to 4 % (e.g. Figure 45) and to reach 64 million tonnes of KCl by 2020 and estimated 70 million tonnes by 2025.

This increase in potash market, however, is off-set by an increase in production capacity that has been started off by the higher potash prices between 2006 and 2008.

In 2009, potash industry worldwide capacity came up to 64.1 million metric tonnes KCl annual production capacity, produced by 32 conventional mining operations, 5 solution based operations, 6 brine based mines as well as some smaller, mostly brine based mining operations located in China. The largest share of growth in capacity has come from North America, owing to Canada's introduction of favourable potash mining legislation especially with regard to taxation, resulting in significant expansions of existing operations (brownfield developments).

Table 44 shows a selection of added name plate production capacity due to brownfield expansions since 2009, that were finished before 2015. World wide annual capacity for KCl production in 2014 is estimated to have expanded to about 80 million tonnes (e.g. FAO, 2015, /25/). Some brownfield projects are still under construction, like PCS Rocanville with an added annual capacity of 2.9 million tonnes. Besides brownfield expansions, which usually have a shorter planning and development time, also existing producers have pushed a number of Greenfield projects that have already been completed or are nearing completion, or are at such state of development that their completion is relatively certain. A selection of such Greenfield projects, together with some Greenfield projects from junior producers are listed in Table 45.

Table 44 Selected Brownfield Expansions adding to overall Potash Production Capacity between 2009 and 2015

| Country | Producer | Operation | Annual Capacity Increase | Last Expansion Operational |
|---|---|---|---|---|
| Canada | PCS | Lanigan | 1.1 million tonnes | 2011 |
| | | Allan | 2.0 million tonnes | 2014 |
| | | Cory | 0.6 million tonnes | 2014 |
| | Agrium | Vanscoy | 1.0 million tonnes | 2015 |
| | Mosaic | Colonsay | 0.7 million tonnes | 2013 |
| | | Esterhazy | 2.7 million tonnes | 2013 |
| Russia | Uralkali | Berezniki Plants | ~ 2.8 million tonnes | 2013 |
| | | Solikamsk Plants | ~ 1.0 million tonnes | 2011 |

The number of greenfield potash projects is much larger than the few shown in Table 45, but the probability that a significant number of these projects will go beyond the planning



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

phase is considered minor, especially at the present low potash prices. For a greenfield project to have a chance to go in production it needs backing by a fertilizer company that can provide part of the financing (e.g. Legacy project of K+S), and/or to be already quite far developed (e.g. EUROCHEM, Gremiachinsk). Greenfield projects from junior companies will need to have at least a significant part of the financing provided by a major shareholder, to have a chance of success (e.g. MagIndustries, Mengo project, which has partial funding over Evergreen Resources).

Table 45 Selected Greenfield Projects potentially adding to overall Potash Production Capacity between 2016 and 2025 (phased capacities estimated)

| **Country** | **Company** | **Project** | **Planned Capacity and Start of Operation** | | |
|---|---|---|---|---|---|
| | | | Phase 1 | Phase 2 | Phase 3 |
| Canada | K+S | Legacy | 2.0 million tonnes in 2017 | 0.86 million tonnes in 2022 | |
| | Karnalyte | Wynyard | 0.625 million tonnes in 2019 | 0.75 million tonnes in 2021 | 0.75 million tonnes in 2024 |
| | Yancoal | Southey | 2.0 million tonnes in 2020 | 0.8 million tonnes in 2025 | |
| Russia | Uralkali | Ust-Yaiva | 2.8 million tonnes starting in 2020 ramping up over 4 years | | |
| | Uralkali | Polovodovski | 2.5 million tonnes starting in 2022 ramping up over 5 years | | |
| | EuroChem | Usolye | 3.4 million tonnes starting in 2019 ramping up over 4 years | | |
| | EuroChem | Gremiachinsk | 2.3 million tonnes starting in 2017 with 2 years ramp up | | 2.3 million tonnes after 2020 |
| | Acron | Talitsky | 1.0 million tonnes in 2021 | 1.0 million tonnes in 2023 | |
| ROC | MagIndustries | Mengo | 0.6 million tonnes in 2019 | 0.6 million tonnes 2020 | |
| Ethiopia | YARA | Dallol | 0.6 million tonnes of SOP in 2020 | | |
| Thailand | APCPC | Bamnet | 1.2 million tonnes starting in 2019 ramping up over 2 years | | |

Capacity increase due to brownfield and greenfield projects is counteracted by closure of operations and/or replacement of operations. For example BELARUSKALI has opened new capacity, but closed older operations, having no net effect on name plate production capacity, but being more efficient. PCS in Sussex, opened their Picadilly operation with an annual capacity of 1.2 million, but therefore closed down the neighboring Penobsquis operation, so overall only an annual capacity increase of 0.4 million tonnes only was achieved. In conjunction with the relative low potash price since 2014, (but eventually not the only reason), a number of operations have been closed, reduced production or production shifted from MOP to other fertilizer products. Examples are:



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

- Cessation of potash production at the Hersey solution mine;
- Cessation of MOP production and concentration of KMg-Sulfate products by MOSAIC and INTREPID in Carlsbad;
- Planned cessation of MOP production at ICL's Boulby facility and focus on production of Polyhalite;
- Closure of mine Solikamsk 2 by URALKALI due to water inflow problems;
- Indefinite suspension of production at the new Picadilly operation in New Brunswick by PCS.

These changes have only a marginal effect on the overall production capacity and with further brownfield projects adding to production and with the first greenfield projects that are under construction (e.g. Table 45) in the medium term (up to 5 years), it is certain that production capacity for potash fertilizers will increase and that utilization of capacity (demand/production capacity * 100) will stay close to the present 70%. Therefore, analysts agree, that in the intermediate term till between 2020 - 2025 no significant rise in potash price will occur, but that afterwards price rises are relatively certain.

The excess capacity that is present and will remain in the market in the coming years is still mostly in the hands of the same players that dominated the market the last 25 years. A return to the strategy price over volume that the major producers PCS and to a lesser extent URALKALI operated successfully with production curtailments by the market leaders and market discipline by the other producers till 2013 is not impossible, but the best chance of success of this strategy is when no new large players with annual production capacities of several million tonnes come on the global market.

The result of the near future expected low MOP prices could, therefore be, that the development of greenfield potash projects is financially relatively unattractive and that greenfield MOP projects are shelved. Greenfield MOP projects that are under construction could be delayed in finalization and go into production later than planned. Looking beyond 2020, this could mean that from this time onward the growth in demand will outpace the growth in production capacity and that utilization of capacity will increase, which could warrant an increase in MOP price.

Different scenarios for the development of MOP demand, the MOP production capacity and in this way the MOP price are possible and, except that prices will start to rise between 2020 and 2025, there is no clear consensus between analysts about the developments in the potash market. Still for the American Mid-West, the market targeted by KARNALYTE (see Section 19.1.4), markets analysts estimate a potash price in metric tonne in the range of $370 USD in 2019, the year first product from KARNALYTE would come onto the market.

Based on a potash price for granular MOP for the US Midwest of $370 USD per tonne for 2019, an annual price increase of 3.0% is assumed, which conforms approximately to the average price of forecasts by different analysts till 2030.

### 19.1.4 KARNALYTE Market Plan

KARNALYTE's primary focus will be to produce high purity spherical granular potash pellets (brand name KCl 97), initially into the North American agricultural markets and ultimately worldwide.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

KARNALYTE's KCl 97 spherical granular potash pellets offer a grade advantage (97% purity) and significantly lower sodium chloride content (less than 1%) over typical granular products. Product offered by current suppliers is typically 95% KCl purity (3.5 – 4.5% sodium chloride content) with irregular shape. The KCl 97 spherical granular potash product offers higher quality pellets, which leads to better handling, storage and bulk blending characteristics because of uniform size distribution.

Compared to the Asian Market the US market initially targeted by KARNALYTE is quality oriented. The US farmers currently receive up to 10 million tpy of granular potash with a grade of 95% KCl (minimum) with a size guide number (SGN) of 285. This product line is typically -4 to +12 mesh with a d50 of 7 mesh and has 3.5% to 4.5% sodium chloride as an impurity.

KARNALYTE's product will be competitively priced and offer higher grade KCl (potash) with an improved size distribution compared to its peers. (SGN 285 size distribution of -5 to +10 mesh with a d50 of 7.0 mesh). KARNALYTE will target main distributors and co-operators in the US as well as Canada.

Internationally, there has been interest from both end users as well as large trading companies. KARNALYTE will develop relationships to pursue off-take agreements.

**Industrial Potash Market**

Part of the production could be industrial grade (KCl 99%) potash. The North American industrial market for high grade soluble potassium chloride has an estimated demand of 940,000 tonnes. KARNALYTE has been in contact with potential industrial customers. They have confirmed that KARNALYTE's product will fit their specifications and that they are open for a new source of supply.

### 19.1.5 Contracts

KARNALYTE has entered an off-take agreement with Gujarat State Fertilizer Company (GFSC) one of their main shareholders, for a purchase of approximately 350,000 tpy from Phase 1 (625,000 tpy). The offtake commences with commercial production from Phase 1 with the result that KARNALYTE has secured sales for approximately 56% of its potash production from Phase 1 for approximately 20 years. The Offtake Agreement also provides GSFC with the option to increase its off-take by 250,000 tpy to 600,000 tpy from the date of commencement of Phase 2 commercial production. The Offtake Agreement provides GSFC the potential to increase its offtake by up to 400,000 tpy from Phase 3 such that the total annual quantity of potash to be sold pursuant to the Offtake Agreement shall be up to 1,000,000 tpy.

## 19.2 Magnesium Products

This section will provide information about the potential market for Magnesium products and is taken from the LYNTEK (2012, /33/) study and a review of the data has shown that no major changes have occurred. This section includes information on traditional and intended uses of these products and where available, provides information on the market



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

values of these products. The sources for the information include various commercial market reports, internal study reports commissioned by Karnalyte, information available in the public domain, and letters of interest (LOI) from prospective customers of the Magnesium Chloride and Magnesium Carbonate products.

These reports include;

- Magnesium Chloride Brine: Preliminary Marketing Study, September 2011, by Earl Rubin (Commissioned by Karnalyte Resources Inc.)
- Magnesium Chloride Trade Statistics, update June 2011, by Earl Rubin
- September 2011 Magnesium Compounds and Chemicals: Global Industry Markets and Outlook, Eleventh Edition, 2010 by Roskill Information Services.
- Calcium Carbonate, A Global Strategic Business Report, MCP-2033, Global Industry Analysts Inc., August 2011.

The Magnesium product facility has two product lines that can be marketed and will be discussed separately.

### 19.2.1 Magnesium Chloride Brine Market

MgCl2 can be sold either as a brine, or as a solid (flakes). This Preliminary Feasibility Study considers only the production of a $MgCl_2$ brine, but initial indications are that $MgCl_2$ flakes are a viable alternative product with good profit potential that can be considered as an additional revenue stream in the future, requiring further investments.

Potential customers for $MgCl_2$ brine include:

- Road service contractors
- Municipalities and counties (roads)
- Mining
- Salt block (mineral supplement producers)
- Oil well drilling fluids (drilling contractors)

Uses for Magnesium Chloride brine include;

- Dust control for gravel roads (summer)
- De-icing agent for roads (winter)
- Sewage treatment
- Textiles and paper
- Components in cements
- Drilling mud / completion fluid.

Standard trade statistics provide limited information on the market for $MgCl_2$ brine. Market studies combine statistics on different grades, and across a diverse range of $MgCl_2$ products. Statistics on the import and export volumes, and regional sales or consumption figures, are not readily available for specific products. Similarly, price data is averaged across a wide variety of products and are not specific to $MgCl_2$ brine.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

General trade statistics do however show a long term trend of regular imports of $MgCl_2$ brine and flakes into Canada from the USA and even Mexico. 0 shows the imports of $MgCl_2$ into Western Canada for the years 2006 to 2011. These statistics have been compiled from data from Statistics Canada.

Regular imports of brine into the four western provinces of Canada are therefore approximately $ 3.4 CAD million per year, with the sales quantities showing stability in terms of both tonnages as well as value. Due to the high costs of transportation associated with a relatively low value product, the potential for Karnalyte to be able to replace a significant volume of these imports is reasonable.

As brines contain a significant volume of water, shipping costs are significant, and limit the sale of brine to markets reasonably close to the plant. Current sales estimates are therefore based on the markets in the four western provinces. The primary market for the $MgCl_2$ brine is expected to be for de-dusting and de-icing of roads, and is therefore the center of focus for the initial sale of brine. Other markets will be developed, and production can be increased to meet demand.

Data provided in a preliminary marketing study referenced above commissioned by Karnalyte for $MgCl_2$ products indicates that a potential market exists in the 4 western provinces for approximately 60,000 tpy of 32% $MgCl_2$ brine for chemical and related uses, in addition to local sales of brine for road de-dusting and de-icing estimated at 50,000 tpy to 100,000 tpy. The price for brine imports was estimated for recent shipments at $30 to $40 CAD per ton FOB pricing. For 2016 the upper range of this price estimated is still considered reasonable.

Additional interest has been indicated in the form of a LOI for use of $MgCl_2$ brine for sewage treatment. The volumes are still limited but a price of approximately $50 CAD per ton is indicated for this market.

### 19.2.2 Magnesium Carbonate

Magnesite ($MgCO_3$) is a naturally occurring mineral used in a wide range of applications, the most important of which is as feedstock for magnesia production. Synthetic magnesium carbonate is used to produce high purity magnesium compounds for the paint and printing industries as well as in fireproofing, fire-extinguishing, flooring, polishing compounds, and as fillers and smoke suppressants in the paper, plastics and rubber industries. High purity magnesium carbonate is also used as an anti-caking agent in salt, as a bulking compound in powder formulations and as an antacid.

The Magnesium Carbonate that will be produced at the Magnesium Products plant will be a precipitated synthetic Basic Magnesium Carbonate.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

Table 46 Imports of $MgCl_2$ into Western Canada

| Origin | Year | Importing province | Tonnes | Value, C$ | $/m.t. [1] |
|---|---|---|---|---|---|
| All | 2006 | AB | 5314 | 536,977 | 101 |
| All | 2007 | AB | 4664 | 380,072 | 81 |
| All | 2008 | AB | 4891 | 350,932 | 72 |
| All | 2009 | AB | 7570 | 450,247 | 59 |
| All | 2010 | AB | 7096 | 455,158 | 64 |
| All | 2011 | AB | 10340 | 637,510 | 62 |
| USA | 2007 | AB | 4511 | 343,391 | 76 |
| USA | 2008 | AB | 4846 | 268,017 | 55 |
| USA | 2009 | AB | 7558 | 432,509 | 57 |
| USA | 2010 | AB | 7090 | 441,215 | 62 |
| USA | 2011 | AB | 10336 | 628,734 | 61 |
| All | 2006 | BC | 5663 | 429,071 | 75 |
| All | 2007 | BC | 17267 | 745,712 | 43 |
| All | 2008 | BC | 14,750 | 660,492 | 48 (USA 39) |
| All | 2009 | BC | 14,147 | 856,109 | 61 (USA 55) |
| All | 2010 | BC | 18,163 | 987,919 | 54 (USA 50) |
| All | 2011 | BC | 15,109 | 1,143,311 | 76 (USA 71) |
| All (99% US) | 2006 | SK | 619 | 26,254 | 42 |
| All | 2007 | SK | 2806 | 148,607 | 53 |
| All | 2008 | SK | 2343 | 144,062 | 61 |
| All | 2009 | SK | 3218 | 150,285 | 47 |
| All | 2010 | SK | 5000 | 178,885 | 36 |
| All | 2011 | SK | 2367 | 181,792 | 76 |
| All | 2006 | MB | 28003 | 1,652,788 | 59 |
| All | 2007 | MB | 35056 | 1,647,137 | 46 |
| All | 2008 | MB | 35503 | 1,308,464 | 37 (USA 37) |
| All | 2009 | MB | 35198 | 1,250,785 | 36 (USA 35) |
| All | 2010 | MB | 39680 | 1,271,648 | 32 (USA 32) |
| All | 2011 | MB | 36729 | 1,416,266 | 39 (USA 38) |
| USA[2] | 2011 Oct. | MB | 723 | 40,178 | 55.5 |



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

General trade statistics as presented in marketing studies such as the Roskill study referenced earlier, the USGS Minerals Yearbook, and other minerals market resources, concentrate on crude magnesite, which is the naturally occurring mineral. The market for synthetic or precipitated Magnesium Carbonate is a specialized market which is very closely correlated to the product quality, and is not included in general market reports. The authors were not able to find definitive world production or consumption figures for hydromagnesite. Pricing currently available for high quality Precipitated Basic Magnesium Carbonate range from US$600 per ton to US$1200 per ton ex-works China. The potential to achieve prices in the upper part of this range is good as the equivalent MgO content of the Karnalyte hydromagnesite significantly exceeds the highest values quoted for the magnesium carbonates referenced above, but the planned production volumes of the magnesium products plant will potentially suppress prices by a margin. Lower shipping costs into Canada and the USA could provide additional pricing advantages. Even when considering the lower price range, it appears likely that the product will withstand a reasonable transportation charge and yet allow moderate profitability. For the initial price point the lower range of $ 600 CAD CIF, should be readily achievable and is the basis for the economic analysis.

The lack of manufacturing data is indicative of the specialized nature of this product and the confidentiality of typical trade contracts. It is probable that the production tonnages for hydro-magnesite anticipated for the Karnalyte Magnesium Products facility will equal or exceed traditional market volumes. The material properties are however such that the hydromagnesite produced will allow other market sectors to be exploited. In particular, two primary bulk markets are anticipated for the Magnesium Carbonate product to be produced at Karnalyte, these being as an alternative to precipitated $CaCO_3$ for use as a filler in paper products and as a $TiO_2$ extender for paint pigments. The mechanical properties, purity and whiteness, of the hydromagnesite produced have generated interest with prospective customers and Letters of Interest totalling approximately 50% of the planned production have been received by Karnalyte.

#### 19.2.2.1 Precipitated Calcium Carbonate – Brief Market Overview

This section is based on “Calcium Carbonate, A Global Strategic Business Report, MCP-2033, Global Industry Analysts Inc., August 2011” and has been updated with further data. The paper industry currently is the largest user of Precipitated Calcium Carbonate (PCC), estimated at approximately 6.0 million tons for 2013 occupying about 43.3% of the global PCC market. The plastics industry is the second largest user of PCC estimated at 3.9 million tons for 2014 occupying about 27.8% of the global PCC market. Table 47 shows historic and projected annual sales figures for the world, US and Canada for PCC indicating a strong increase in demand for PCC, which, however, is concentrated in Asian countries. The price of PCC depends strongly on the quality and varies between $200 to 500 CAD.

#### 19.2.2.2 Titanium Dioxide – Brief Market Overview

The primary use of Titanium Dioxide is as a paint pigment. Annual production tonnages of Titanium Dioxide and Titanium Dioxide based pigments for the USA are provided in Table 48based on data obtained from the USGS Minerals Information database, which valued



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

the total production in 2014 at nearly 4.4 billion USD, which is considered highly optimistic. Canadian trade statistics are recorded as the value of the traded commodity and tonnage export tonnages provided and indicates a price per tonne in the range if $3100 to 3400 CAD (Table 49). The use of Basic Magnesium Carbonate as a Titanium Dioxide extender in pigments is therefore attractive to end users.

Table 47 Historic and Anticipated Annual PCC Sales Expressed as Thousands of Tons

| Country / Region | 2010 | 2014 | 2017 |
|---|---|---|---|
| World | 12,041 | 14,697 | 18,330 |
| USA | 2,226 | 2,420 | 2,690 |
| Canada | 368 | 394 | 436 |

Table 48 US production of $TiO_2$ and $TiO_2$ Pigments expressed as Tons

| Classification | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|
| Production | 1,320,000 | 1,290,000 | 1,114,000 | 1,280,000 | 1,310,000 |
| Imports | 204,000 | 200,000 | 203,000 | 213,000 | 235,000 |
| Exports | 758,000 | 789,000 | 624,000 | 670,000 | 685,000 |
| Consumption | 767,000 | 706,000 | 722,000 | 826,000 | 860,000 |

Table 49 Estimated Canadian Exports of $TiO_2$ and $TiO_2$ Pigments in Tonnes and in Million CAD$ as well as average Price per Tonne

| | 2013 | 2014 | 2015 | 2016[9] |
|---|---|---|---|---|
| Export | 8,325,488 | 8,564,448 | 10,880,601 | 2,849,846 |
| Value | 26.62 | 29.67 | 36.35 | 9.08 |
| Price/Tonne | 3,197 | 3,464 | 3,340 | 3,186 |

### 19.2.2.3 Market Development

As a large volume producer, Karnalyte would need to develop new markets for their precipitated basic magnesium carbonate, beyond traditional markets for this product. The diversity of potential markets and the apparent material properties of the hydromagnesite produced to date do however offer a reasonable expectation that such markets can be developed.

[9] First quarter only



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

These indications of market provide an insight to the potential economic value of the magnesium products, however, more comprehensive work is absolutely required to better describe product quality, demand, potential sales regions, transportation costs, and pricing variables. This market analysis will need to be completed with products produced in continuous testing in the Feasibility Study phase of the Magnesium products project.

### 19.2.3 Contracts

Contracts are not yet in place for KARNALYTE's Magnesium products, but several letters of interest (LOI) from 2012 and 2015 for

- 100,000 tonnes of Magnesium Chloride Brine for different uses at about $40 CAD/tonne
- 20,000 tonnes of Hydromagnesite for use in the paper industry at about $600 CAD/tonne
- 20,000 tonnes of Hydromagnesite for use as $TiO_2$ extender for about $1800 CAD/tonne

provide an indication of price range for the products.

# 20 Environmental Studies, Permitting, and Social or Community Impact

Together with the Feasibility Study a comprehensive Environmental Impact Statement (EIS) has been developed with GEOENGINEERS and DILLON in coordination with the regulatory authorities. A short outline and important aspects of this study are summarized below. This EIS the potash facility has received approval of the Ministry of Environment February 07, 2013. In the next phase of the project a similar study will be made for the Magnesium products facility.

The section is divided into a general introduction, a description of the overall project setting, summary of assessment and the potential effects and ends with mitigation measures and closure fund. The EIS has not been made for all license areas, but concentrates on the central and northern part of the Lease KLSA 010.

## 20.1 Introduction EIS

KARNALYTE proposes to develop an underground potash solution mine with a design capacity to produce approximately 625,000 tonnes of saleable potassium chloride (KCl) per year. As currently planned the anticipated mine life within the EIS investigation area, which is smaller than the KARNALYTE Lease areas, is approximately 63 years for the 625,000 tonnes per year of phase 1.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

There are three principal phases for the Project: construction, operation, and decommissioning/closure. It is estimated that the Project will take 2 years to construct, and then, following an initial year-long establishment period, produce potash for an estimated 28 years. The Project will include surface facilities (processing plant and rail loadout facility) as well as a large number of solution mining wells and associated underground caverns and a small number of process water extraction and waste brine injection wells.

The Project will rely on upgrades of existing transportation and utility infrastructure to achieve both construction and operational requirements. During project operation the final potash product will be transported over a dedicate spur line and rail car loading facility to the CP Rail Mainline west of Wynyard.

Unlike other potash mines in Saskatchewan, KARNALYTE's mining process will not require the construction of tailings piles or tailing ponds; waste brine will be disposed of through deep well injection to appropriate locations within the Deadwood and Winnipeg formations. The proposed production process would use brackish groundwater deep below the Project Area (i.e., the Blairmore formation at approximately 475 metres below the surface) as process water, thereby avoiding any need for extraction of shallow potable water. KARNALYTE's drinking water and start-up boiler feed water would be provided through normal purchase from available supplies in Wynyard.

KARNALYTE's mining and potash production processes are designed to support the eventual return of the Project Area to productive agricultural use when solution mining activities have been completed, consistent with local land use needs at the time of closure.

### Project Benefits

The Project will produce high quality, low sodium, uniformly sized granular potash pellets for the agricultural market. The use of solution mining techniques will also allow the production of potash with minimal environmental impacts. Most importantly, the proposed solution mining and processing plan does not generate surface salt tailings piles or tailings ponds. The Project eliminates the need for such facilities by pumping waste brine underground to spent mining caverns and/or deep underground formations amenable to brine disposal. In addition rather than using fresh water from aquifer-wells or surface supplies, the Project will use brackish water or weak brine from the Blairmore Formation for process water supply. Other advantages include:

- With no underground operations and a relatively simple production process, energy use will be lower than conventional mining;
- Very few process chemicals are required when compared to conventional flotation processes;
- Backfilling of caverns to arrest any further dissolution in the depleted cavern, which creates a stable local environment, reduces the extent of subsidence.

Once approvals are received and the Project moves forward, KARNALYTE will pay applicable resource production taxes to the Province as well as local taxes in regards to the proposed production plant in the RM of Big Quill and an office building in Wynyard.

KARNALYTE employment forecasts indicate the potential creation of approximately 70 new full time operating jobs at the brine field, production plant, rail loadout, plus administrative and management positions at the Wynyard Karnalyte office. In addition, contractors will be hired to truck product from the plant to the rail loadout, and to perform ongoing drilling and service operations in the brine field. During construction KARNALYTE estimates



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

that on average there will be between 250-300 people working at the site for a period of up to 2 years.

**Environmental, Social, Health and Safety (ESHS) Management System**

In keeping with KARNALYTE's commitment to the implementation of sustainable approaches to the design, construction, operation, decommissioning and closure of the Wynyard Carnallite Project, an ESHS Management System based on widely recognized best management practices that have been proven effective in the international mining and agricultural chemical processing industries. The ESHS Management System will include a range of management and mitigation plans such as:

- Construction Management Plan;
- Community Relations and Communications Plan;
- Spill Prevention, Control, and Countermeasures Plan;
- Emergency Preparedness and Response Plan;
- Biodiversity Preservation Plan;
- Water Monitoring Plan;
- Transportation Management Plan;
- Solution Mining Operations Plan; and
- Decommissioning and Closure Plan.

**Regulatory Approvals**

The Wynyard Project is a development subject to the Saskatchewan Environmental Assessment Act and was reviewed as part of the Environmental Assessment Program administered by the Saskatchewan Environmental Assessment Branch (EAB). In 2009, the Canadian Environmental Assessment Agency (Agency) conducted a survey of federal departments to determine interest in the Project and to determine if there were potential federal triggers. The Agency concluded that a federal review of the Project under the Canadian Environmental Assessment Act was not triggered based on survey responses from the federal departments.

This Environmental Impact Statement (EIS) has been developed based on guidance provided by the EAB including Project Specific Guidelines which were provided to KARNALYTE in June of 2010 and the EIS has received approval by the Ministry of Environment February 07, 2013.

**Consultation**

KARNALYTE is committed to creating and sustaining relationships and dialogue with regulators, communities and stakeholders to support the environmental, social, and economic sustainability of the Project. Consultation has therefore been a key component of Project development and has focused on three broad groups: First Nations and Métis; government and regulatory agencies; and local communities and other stakeholders. Project consultation activities have been ongoing since the summer of 2008 when KARNALYTE initially engaged representatives of the Rural Municipality of Big Quill. Since then consultation has been ongoing with the regulators (e.g., Saskatchewan EAB), First Nations and Métis communities, the public, and other stakeholders. Consultation activities have included Public Information Sessions held in October 2009 and again in June 2011 in



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

Wynyard and a public review of the EIS between December 30, 2012 and January 29, 2013.

## 20.2 Project Setting

### 20.2.1 Environmental Setting

The Project is located in the Prairie Ecozone of Canada which covers much of Alberta, Saskatchewan, and Manitoba. The Prairie Ecozone is relatively dry with significant seasonal variability and extreme temperatures. The Project is generally surrounded by cultivated agricultural lands and an existing network of municipal roads. This environment is reflected in background noise data collected which indicates that the sound environment is characterized by vehicular and rail traffic noise as well as noise from farm-related activities and from the natural environment.

The area is of mixed physiography combining agricultural areas, where water bodies have been drained, with naturally vegetated areas of extensive depressional water storage. Topography can be described as primarily level to very gently rolling land with some areas with gently undulating to gently rolling landscapes. Surface water features within the area are limited to Wynyard Creek (and associated tributaries and the Wynyard Reservoir), Magnusson Creek (south of the Town of Wynyard) and an unnamed watercourse west of Wynyard Creek. In many cases watercourses have been significantly altered by agricultural practices in the area. Baseline studies concluded that the Project area does not contain highly sensitive fish species or habitat. Where fish communities were found they were limited to small-bodied species (fathead minnows, brook stickleback, and lake chub). No large-bodied fish species were observed.

The surficial geology in the Wynyard area consists of glacial till, alluvial lacustrine, glaciofluvial, and alluvial parent material. The predominant soil type in the area is dark brown chernozemic soils which are characterized by the presence of organics and the black or dark brown colour. Topsoil within the Project area and surrounding properties overlays a till which contains clay, silt, and/or sand. Soils within the Project area are likely well-to-imperfectly drained and contain decomposed grasses and forbs.

The bedrock sequence underlying the Wynyard region of southern Saskatchewan includes the Prairie evaporite beds at depths approaching 1,000 m below the surface. There is one notable aquifer at depth (approximately 500 m) called the Blairmore Formation. Due to limited water movement within this formation water quality is considered poor (elevated salinity) and it is not used as a drinking water source.

Fresh groundwater resources are confined to shallow aquifers that occur within an unconsolidated sequence of predominantly glacial deposits. A large proportion of the glacial deposits are till which results in a low permeability that tends to inhibit or restrict local groundwater movement. Within the glacial sequence are alluvial sand and gravel layers, of which the larger and more connected zones, form reservoirs or aquifers that both store and transmit groundwater. The more prevalent of the sandy zones occurs between two glacial till formations, the Sutherland till and the Saskatoon till, and is known locally as the “intertill aquifer”. This represents a source aquifer for domestic and farm wells in the Wynyard area, as well as for a number of the town’s municipal water supply wells. Under-



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

neath the till formations a deeper aquifer occurs in the vicinity of Wynyard and is known as the Lower Wynyard Formation. This relatively thin sand and gravel aquifer is also used locally as a source of drinking water. Regionally the groundwater moves slowly down-gradient in a generally northward direction. Water quality is generally good within these aquifers, which are used as local sources for domestic and municipal supply, but pockets of poorer quality groundwater exists within the till that exhibit somewhat elevated mineral content.

Terrestrial habitat within the Project area is dominated by cropland/hayland, followed in decreasing order by grassland treed/brushland, water/wetland, and disturbed areas. Vegetative communities are characterized by a wide-variety of vascular plants, of which three are considered provincially rare: red elderberry; western red lily; and striped coral-root. Numerous small wetlands also occur within the Project area with the most common wetland classes being Class 8 (tillage basin) and Class 2 (temporary pond). These two classes of wetlands comprised almost 80% of the sites observed in the area. Only 16% of the surveyed wetlands were considered to be semi-permanent or permanent. Some of the wetlands also provide habitat for amphibians including the provincially listed (rare-uncommon) plains spadefoot toad.

The area supports a variety of wildlife including various large and small mammals, birds, and amphibians. Mammals include larger ungulates such as deer and moose, various furbearers such as snowshoe hare, white-tailed jackrabbit, red squirrel, weasel, and red fox, and semi-aquatic mammals such as muskrat and beaver. Raptors and their nests were observed in and around the Project area, with recorded species including great horned owl, Cooper's hawk, red-tailed hawk, northern harrier, bald eagle, merlin, and turkey vulture. A range of waterbird species were also observed in and around the project area including a number of species of interest (federally listed – Species at Risk Act or considered rare within the province). Numerous species of uplands birds were also observed including three species, that are federally listed as threatened: barn swallow, bobolink, and olive-sided flycatcher.

No archaeological resources were identified in the Project area, although two historic foundations were noted. Discussions with the Heritage Branch indicated that they are not considered to be of archaeological significance, and thus they were not recorded as archaeological sites. One other finding of note was the remnants of an old school ground. A historical marker denotes the property as being the former location of Nordra School, which operated between 1909 and 1962. This site was deemed to have local heritage value and as such will be avoided by Project development.

### 20.2.2 Socio-Economic Setting

The proposed Project is located entirely within the RM of Big Quill No 308. Land use in and around the Project is predominantly agricultural. The Project itself will be situated on three quarters of existing agricultural land consisting of two land parcels owned by KARNALYTE. The lands adjacent to the project area are all agricultural with the exception of Wynyard Regional Park which is situated to the southeast the final footprint of the Project.

The nearest community is the Town of Wynyard with a population of approximately 1,700 residents. Municipal services include a small hospital and a small RCMP detachment. Existing commercial services include six motels/hotels/Bed & Breakfasts, two grocery stores, and nine restaurants. Other major communities identified in the general area are Leroy, Quill Lake, Raymore, and Wadena.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

Residents in the RM of Big Quill rely on wells for water supply. Sewage is typically contained in private residential septic tanks/fields. Water in Wynyard is pumped from wells and sewage is contained in a sewage disposal lagoon with primary and secondary cells. Wynyard operates a licensed landfill approximately 3 km north of the town which handles industrial, commercial and residential wastes.

Agriculture is directly (farming, animal rearing) or indirectly (processing, services) responsible for the majority of employment in the region. Many residents in the region also work in the resource industry. Big Quill Resources, near Kandahar, is expanding its potassium sulfate plant; while BHP Billiton is currently in the process of developing the Jansen Project. The nearest operating mine to the proposed Project is Potash Corporation's Lanigan Mine located approximately 65 km west of the Project.

Subsurface mineral permits held on lands surrounding the Project include, BHP Billiton Diamonds Inc and Canada Potash.

### 20.2.3 Aboriginal and Métis setting

The Project is not located on or immediately adjacent to any First Nations and/or Métis lands, except for one quarter in the SW. First Nations and Métis communities located within the surrounding area include: the Beardy's and Okemasis First Nation, Kawacatoose First Nation, Muskowekwan First Nation, Fishing Lake First Nation, Day Star First Nation, and the George Gordon First Nation.

KARNALYTE has established an open dialogue with the noted First Nations and the Métis Nation of Saskatchewan, Eastern Region II. In addition, the Touchwood Agency Tribal Council (TATC) Labour Force Development Program was also consulted and several meetings have been held between KARNALYTE and the TATC to discuss potential employment opportunities.

## 20.3 Effects Assessment

A detailed assessment of potential Project effects on the environment and socio-economic setting was completed. The process involved the selection of key valued components (VCs) which are defined as features of the regional and socio-economic setting that have an ecological, social, and/or economic value and are potentially affected by the Project. To assist in determining appropriate impact mitigation, VCs were initially screened to ensure that all potential issues are addressed appropriately in the EIS and to allow the effects assessment to focus and identify issues that are potentially directly or indirectly impacted by the proposed development as well as those components that are important to regulators, First Nations and Métis, local communities, and other stakeholders. The screening process identified the following VCs for detailed assessment in the EIS:

Biophysical VCs

- Air quality
- Noise
- Soils



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

- Terrain (focus on potential subsidence)
- Groundwater
- Terrestrial Vegetation (including rare plants)
- Wetlands (including listed species)
- Raptors
- Water birds (including listed species)
- Upland Birds (including listed species)

Socio-Economic VCs

- Employment, Business and Training Opportunities
- Municipal Services

Each of these VCs was evaluated in detail to identify and predict the nature, extent and significance of potential impacts related to the Project. The assessment also took into account potential differences during specific project phases and activities. For each component or activity related to the project, the benefits and impacts were identified and the potential significance of the projected effects were assessed in the context of the existing environmental or societal setting, as determined through baseline studies. The duration of the benefit or impact, as well as indirect effects, were also evaluated. Where possible and appropriate, mitigative measures and strategies were identified to reduce Project impacts or to enhance Project benefits. The assessment for each VC was summarized using a customized matrix approach. The matrix evaluates three project phases: construction, operation, and closure/reclamation. The closure/reclamation phase considers progressive reclamation that would be expected to begin once caverns are depleted and well pads are decommissioned. The matrix also evaluates two distinct project components: extraction: solution mining and processing; and product storage and shipment. The matrix summarizes potential environmental effects, outlines planned mitigation measures, and where applicable assesses the significance of the effect, assigns the effect an overall rating, and indicates the level of confidence in this rating.

### 20.3.1 Summary of Biophysical Assessment

The assessment concluded that there would be no significant adverse effects to biophysical VCs as a result of the Project. In most cases, overall impacts from Project activities are expected to be confined to local occurrences, and are expected to be reversible upon Project closure. In addition, it is expected that with good project planning, impacts can be avoided, or at the very least substantially minimized through the proper implementation of appropriate mitigative measures and the proponent's proposed policies, plans, and procedures.

One of the key strategies to prevent and/or minimize potential environmental impacts is the in-place adaptive management process which will be used to guide brine field development over the life of the project. Given that the brine field will be developed over the 60 year life-span of the Project (estimating approximately one additional well-pad per year following initial start-up) there is an opportunity to continue to improve and modify the surface layout to minimize potential environmental impacts. Prior to the development of well pads and associated infrastructure, site specific surveys will be completed to evaluate the



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

terrestrial environment including the presence of rare plants, presence of significant species, and other features or issues. This will help avoid potential environmental impacts through the design process; specific infrastructure components can be scheduled, or set back, or locations otherwise adjusted to avoid conflicts or critical life-cycle requirements of particular species of interest.

In addition to the biophysical VCs identified, other environmental components were reviewed from a potential affects assessment perspective. Components reviewed included surface water quality and hydrology, fish and fish habitat, other wildlife (ungulates, furbearers, semi-aquatic mammals, and Sharp-tailed grouse leks), and heritage resources. The review concluded that with the implementation of appropriate mitigative measures and best management practices (e.g., the Department of Fisheries and Ocean's Operational Statement for Clear-Span Bridges) there would no significant impacts to these biophysical components.

### 20.3.2 Summary of Socio-Economic Assessment

The evaluation of socio-economic VCs concluded that overall, the proposed Project will generate significant positive economic impacts due to the creation of employment and business opportunities for local and regional residents, businesses, and suppliers. In addition, municipal, provincial, and federal governments are all expected to gain substantially through project tax revenues. KARNALYTE is committed to supporting the employment of qualified local trades, contractors, and service companies. The company is committed to providing First Nation and Métis communities, businesses, and individuals with fair opportunities to participate in the Project.

For the small scale pilot operation, local people have been employed for the day to day operation of the pilot cavern.

With regards to municipal services, the assessment determined that due to the relatively low number of outside workers required for the different phases of the Project, and the enforcement of strict behavioural policies for workers, minimal impacts to existing municipal services and community well-being are expected. KARNALYTE is committed to working closely with representatives from Town of Wynyard and RM of Big Quill and will keep the community regularly informed on the progress of the Project and the measures being implemented to ensure community health and safety and the protection of environmental interests. Agreements in Principle are already in place with the Town of Wynyard for specific services, such as potable water. Where possible, KARNALYTE will work with the local representatives to coordinate efforts related to the strengthening of other municipal services. In other areas of service (e.g. temporary accommodations of construction workers) where the Town does not have sufficient capacity, KARNALYTE will ensure self-sufficiency in its operations so as not to compromise or burden the delivery of municipal services to local residents. In the area of accommodation, the Project is expected to have a positive economic impact on local businesses and service providers.

In addition to the socio-economic VCs identified, other socio-economic components were reviewed from a potential affects assessment perspective. Components reviewed included surrounding land use, First Nations and Métis settlements, transportation infrastructure and traffic volumes, and community infrastructure (emphasis on Wynyard water system). The review concluded that there would no significant impacts to these socio-economic components.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

### 20.3.3 Cumulative Effects

Potential cumulative effects were also evaluated, defined as changes to the biophysical environment or socio-economic setting caused by an activity in association with other, past, pre-sent, and reasonably predictable or publicly known or expected future natural and human activities. The assessment of cumulative effects focused on those VCs where there is the potential for the effects of the Project to potentially overlap either temporally or spatially with other activities/developments/projects in the area such as agricultural activities, industrial developments, other mining, transportation-related activities, and natural processes.

Although the Project effects assessment concluded that there would be no significant adverse or residual effects on biophysical VCs, each VC was further evaluated with regards to cumulative effects, with an emphasis the identification of areas where the effects of the Project could potentially overlap with residual effects from other projects or activities in the region. The evaluation concluded that no significant cumulative effects are expected related to air quality, noise, soils, terrain, groundwater, vegetation, wetlands, and birds.

The assessment of potential economic impacts associated with the project concluded that overall, the proposed Project will generate significant positive economic impacts due to the creation of employment and business opportunities for local and regional residents, businesses, suppliers, and other stakeholders. In addition, municipal, provincial, and federal governments are expected to gain substantially from project tax revenues. The residual effects of the Project on employment, business opportunities and economic development are expected to occur primarily at the local and regional levels.

From a human resources, goods, and services perspective, the Wynyard Carnallite Project is expected to overlap with BHP’s Jansen Project. Having two new potash projects in the area is expected to have a significant positive impact on the continued pursuit of long-term, sustainable, social, cultural, and economic activities in the local area, however, the two projects are expected to cumulatively result in an increased demand for labour, goods, and services (particularly during the construction phases of the projects). Increased labour demand could be exacerbated by an overlap with the existing PCS mine at Lanigan. The increased demand for labour, goods, and services, while positive for the overall economics of the region and the province, could potentially contribute to wage inflation and shortages in the labour supply (particularly in skilled trades or professions). Positive effects of an increased demand for labour include the potential to attract younger, experienced individuals and their families to rural areas and a requirement for increased training and education to increase the availability of skilled labour.

Overall, with the implementation of appropriate mitigative and management measures (e.g. development and implementation of a corporate recruitment strategy) it is expected that cumulative effects related to employment, goods, and services will not be significant or negative.

Potential cumulative effects related to municipal services were also evaluated. The assessment concluded that with appropriate planning and ongoing discussions with local communities, no significant cumulative effects related to municipal services should be expected.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

## 20.4 Monitoring Programs

Once the Project receives approval, detailed monitoring programs to ensure regulatory compliance will be designed in consultation with regulatory agencies during licensing and would be subject to periodic review during operations. The established monitoring programs will also assist in the evaluation of the EIS process, specifically the accuracy of predictions and the adequacy of proposed mitigation measures. The monitoring programs, in evaluating the prediction of the EIS, will also facilitate the confirmation of the overall objectives and planning procedures for site closure and decommissioning.

For the Project a wide range of monitoring will be undertaken and fall under the following categories:

- operational and compliance monitoring (includes containment system monitoring, waste management monitoring, and operation and maintenance inspections)
- environmental monitoring (includes noise, air quality, surface and groundwater quality, vegetation, wetlands, wildlife, and reclamation monitoring)
- socio-economic monitoring (includes community engagement)
- post-closure monitoring (includes subsidence and groundwater)

One of the key monitoring programs will be for subsidence. Potential subsidence will be monitored during operations and following decommissioning. The monitoring program will be based on a LiDAR survey completed every 5 years until closure (final survey schedule to be determined in consultation with regulators). The results of each survey will be compared to the initial LiDAR baseline survey of the original entire KP 360 Permit completed in November 2009.

## 20.5 Remediation Requirement and Closure Fund

Over the planned lifetime of the operation the brine field will develop and caverns will be mined out. When all caverns from a drilling pad are mined out and have been backfilled the caverns can be securely sealed and the upper meters of casing can be removed. When the brine field infrastructure is removed, it is than possible to use the land again for agricultural purposes.

At the planned end of the operation after 60 years only the area of the remaining brine field of about 40 caverns, the plant site with rail loading facility have to be reclaimed. KARNALYTE plans to provide a fund of 10% of the initial CAPEX totaling $240 million CAD for the reclamation and further remediation measures, which will be financed from the earnings during the last year of operation.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

# 21 Capital and Operating Costs

The capital cost estimates (CAPEX) will be discussed in the first part of this section first for the Potash Project followed by the Magnesium Products Project and the operating cost estimates (OPEX) in the second part in a similar way as the CAPEX.

## 21.1 CAPEX Potash Project

The capital cost estimates provided in the Feasibility Study (FOSTER WHEELER & ER-COSPLAN, 2011, /26//) were recently updated by AmecFW (2016, /4/). The updated cost estimates for the 625,000 tpy plant (Phase I) and the 2 expansions (Phases II and III), each of 750,000 tpy to a total annual production of 2.125 million tonnes of agricultural product, have a level of accuracy of +/- 15% (Class II).

These cost estimates are based on the following work break-down structure for the mining and process description presented in Sections 16 and 17:

100 – Process Building Area/Truck Loading

200 – Common Areas

300 – Utility Building

350 - Cooling Tower Area

400 – Rail Loading

500 – Railroad System – Phase 1

600 – Rerouting of Gas Line and Telephone Cable Company

650 – Power and Natural Gas to the Site by Utility Company

700 – Brine Field

750 – Tank Farm Area

900 – Expansion II – 750,000 tonnes per year Facility

1000 – Expansion III - 750,000 tonnes per year Facility

The updated capital cost estimate for the 625,000 tpy operation (Phase I) and for the 2.125 million tpy operation (Phases II and III) are summarized in 0 The estimated cost for Phase II is $809,622,000 million CAD and $798,112,000 for Phase III. .

The CAPEX of $1,262 CAD and $1,128 CAD per tonne of capacity for the annual production of 625,000 tonnes and 2.125 million tonnes respectively are in the range of comparable sized projects and considered realistic by the authors. In the opinion of the authors the CAPEX estimate can be used for an economic evaluation of the project.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

Table 50 Estimated Direct, Indirect and Other Capital Costs for Construction of Potash Plant, Brine Field and Infrastructure for an Annual Production of 625,000 Tonnes and 2,125 Million Tonnes

| | Annual Production of 625,000 tonnes ($1,000 CAD) | Annual Production of 2,125,000 tonnes ($1,000 CAD) |
|---|---|---|
| **Direct Costs Estimated** | | |
| Process Equipment and Facilities | 343,070 | 1,103,662 |
| Infrastructure | 37,050 | 98,934 |
| Utility Equipment and Facilities | 71,553 | 222,124 |
| Rail Loading Facilities | 23,100 | 23,100 |
| Solution Mining Facilities | 119,061 | 379,755 |
| **Subtotal Direct Costs** | **593,834** | **1,827,575** |
| **Indirect Costs Estimated** | | |
| EPCM Services | 52,502 | 130,441 |
| Owner Costs | 63,087 | 77,099 |
| Miscellaneous | 1,761 | 5,673 |
| **Subtotal Indirect Costs** | **117,350** | **213,213** |
| **Other Costs** | | |
| ..PST Tax | 17,719 | 48,859 |
| Escalation | 26,464 | 158,493 |
| Contingency | 33,184 | 148,146 |
| **Subtotal Other Costs** | **77,367** | **355,498** |
| **TOTAL ESTIMATED COSTS** | **788,551** | **2,396,286** |
| **Costs/Tonne of installed capacity** | **1.262** | **1.128** |

## 21.2 CAPEX Magnesium Product Project

The Preliminary Feasibility study of Lyntek (2012, /38/) provides the basis for an updated capital cost estimate for the 100,000 tpy Magnesium Chloride brine and 104,000 tpy Basic Magnesium Carbonate production level at an accuracy of ± 25% by AmecFW (2016, /4/). An exchange rate between CAD and USD of 1:1.26 has been used in these estimates.

Pre-requisite for the estimate is that the Magnesium Products Facility is integrally linked to the Potash Production facility, not only in terms of the availability of feedstock, but also to provide ongoing administrative and support functions. Capital cost, operating cost and Life of Mine (LoM) estimates therefore assume the existence and operation of the primary Potash Production facility. The CAPEX for the magnesium product project include plant, reagent unloading and product loading and assume that $MgCl_2$ endbrine and some infra-



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

structures are provided by the potash production facility. Capital allowance is included for tie in and expansion for infrastructures in the owner costs. Power and natural gas distribution is assumed to be available on site and is incorporated into the Potash Production facility cost estimates.

The CAPEX estimate is based on the processing route for the Magnesium products as delineated in section 17.3 and is detailed in **Fehler! Verweisquelle konnte nicht gefunden werden.**. Where feasible, all major equipment has been selected and budget level pricing obtained. All other costs are included as factors based on the equipment costs. Factors have been determined from industry standard figures as well as data extracted from AmecFW databases.

The total direct and indirect CAPEX of $ 171,165,000 CAD for the Magnesium product operation is considered reasonable by the authors and can be used for an economic evaluation of the Magnesium Project, with the assumption that the Potash Production Facility is in operation.

Table 51 Estimated Magnesium Product Plant Direct and Indirect Capital Expenditure Estimate

| Category | Item | Total Capital |
|---|---|---|
| **Direct Costs** | | |
| | Mechanical Equipment | |
| | General Plant Equipment | $6,543,000 |
| | Mag Chloride Production | $177,000 |
| | Pretreatment | $20,464,000 |
| | Mag Carbonate Production | $6,803,000 |
| | Ancillaries and Miscellaneous | $1,428,000 |
| | *Subtotal Equipment* | *$35,414,000* |
| | Equipment Installation | $28,331,000 |
| | Plant Building (Metal Building, Includes Concrete and Steel) | $6,783,000 |
| | Structural Concrete | $7,018,000 |
| | Structural and Plate Steel and Walkways | $1,400,000 |
| | Plant Electrical (Bulk Materials & Labor) (% Equipment Cost) | $4,958,000 |
| | Instrumentation (Bulk Materials & Labor) (% Equipment Cost) | $2,833,000 |
| | Plant Piping (Bulk Materials & Labor) (% Equipment Cost) | $4,250,000 |
| | Vehicles and Mobile Equipment | $500,000 |
| | **Subtotal Direct Costs** | **$91,488,000** |
| **Indirect Costs** | | |
| | Engineering (% Total Direct Cost) | $11,894,000 |
| | Construction Management (% Total Direct Cost) | $4,574,000 |
| | Process Control System Programming | $648,000 |



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

| Category | Item | Total Capital |
|---|---|---|
| | Freight (% Equipment Cost) | $3,541,000 |
| | Reagent First Fill | $360,000 |
| | Construction Equipment Rental (% Installation) | $1,417,000 |
| | Contractor Small Tools and Consumables (% Installation) | $1,417,000 |
| | Startup and First Year Spare Parts | $1,771,000 |
| | Mobilization and De-Mobilization (% Installation Cost) | $850,000 |
| | Startup and Commissioning | $1,258,000 |
| | Project Insurances (% Total Direct Costs) | $686,000 |
| | **Subtotal Indirect Costs** | **$28,416,000** |
| Owner Costs | | $24,800,000 |
| Contingency (20% Direct & Indirect Costs, 10% Owner Costs) | | $26,461,000 |
| **Total Base Estimate of Process Capital Cost** | | **$171,165,000** |

## 21.3 OPEX Potash Project

The operating costs (OPEX) for the Potash Project have been estimated based on the utility requirements from the material balances and equipment consumption in the plant and brine field in full operation. The OPEX estimates for both production scenarios are given in Table 52 and are discussed below.

**Personnel Costs**

It has been estimated that a total of 71 persons are required to run the brine field and the plant operation continuously in the 625,000 tpy scenario and 174 persons for the 2.125 million tpy scenario. The personnel required have been divided into 5 salary/wage groups that have been used to determine annual personnel costs:

- General Plant Manager $200,000 CAD
- Specialized Supervisors $168,000 CAD
- Engineers or General Supervisors $134,000 CAD
- Senior Operators $92,400 CAD
- Junior Operators $82,900 CAD

The salary/wage estimate includes an 8% over time allowance. Salaries include a 25% overhead for benefit plans, employment insurance, workers compensation etc. Annual personnel costs amount to $7.55 million CAD for the 625,000 tpy case and $17.80 million CAD for the 2.125 million tpy case.

**Natural Gas and Electricity** requirements have been discussed in sections 18.2 and 18.3 respectively.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

Table 52 Estimated Annual Production Costs and the Estimated Costs per Tonne of Product for the Potash Project

| | 625,000 tonnes annual production | | 2,125 million tonnes annual production | |
|---|---|---|---|---|
| | **Annual [Million $CAD]** | **[$CAD/Tonne]** | **Annual [Million $CAD]** | **[$CAD/Tonne]** |
| Personnel | 7.55 | 12.08 | 17.90 | 8.42 |
| Natural Gas | 27.96 | 44.74 | 95.08 | 44.74 |
| Electricity | 11.46 | 18.34 | 38.97 | 18.34 |
| Brine Field Expansion | 19.92 | 31.86 | 68.28 | 32.13 |
| Maintenance and Spare Parts | 10.77 | 17.23 | 33.48 | 15.76 |
| Blanket Oil Replacement | 3.23 | 5.17 | 11.00 | 5.17 |
| Contingency and Others | 4.73 | 7.57 | 15.15 | 7.14 |
| TOTAL direct OPEX | 85.62 | 136.99 | 279.86 | 131.70 |

### Brine Field Expansion

The brine field expansion is based on developing 7 caverns per year for the 625,000 tpy Facility and 8.5 caverns per year for Expansions II and III, 750,000 tpy Facilities each. This includes drilling wells and providing well pads and pipeline extensions as required.

### Maintenance and Spare Parts

The annual maintenance and repair costs are estimated at 1.5% of the CAPEX and spare parts and consumables are estimated at 0.75% of the CAPEX, which is common for this project type. Included in these costs are the work overs required on the brine field.

### Blanket Oil Replacement

The distillate oil used as a blanket must be replaced as its properties change over time. Also it will not be possible to recover all blanket material completely from a cavern. It is assumed that annually about 7% of the total volume of blanket oil has to be exchanged. This amounts to approximately 4,200 $m^3$ of distillate oil per year for the 625,000 tpy Facility and 5,040 $m^3$ for each of the Expansions II and III at 750,000 tpy each. A special oil mixture is used for this purpose at a price of $0.77 CAD/l.

### Other Costs and Contingency

An estimating contingency of 5% of the OPEX cost has been included. Other costs include:

- Process Chemicals- An allowance of $242,400 CAD was included based on “first-fill” costs for cooling tower treatments, flocculants, etc. to replenish chemicals required to operate each of the 3 facilities.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

- Services from Wynyard - An allowance of $200,000 CAD was included for potable water, waste water treatment and solid waste disposal services provided by the Town of Wynyard for each of the 3 facilities.
- Outside Services - An allowance of $48,300 CAD was included for vendor services, office equipment services, consultants, janitorial, environmental testing, etc. for each of the 3 facilities
- Vehicle Operating Expense - Vehicle operating and maintenance expense was taken as 5% of the cost of vehicles and mobile equipment included in the CAPEX.
- Other Expenses - An allowance of $35,100 CAD was used for telephone, office supplies, etc. for each of the 3 facilities.

In the opinion of the authors the OPEX estimate is reasonable and will be used as basis for an economic evaluation of the project.

## 21.4 OPEX Magnesium Products

The operating costs (OPEX) for the magnesium facility has been estimated based on the utility requirements from the material balances and equipment consumption in the plant and brine field in full operation. The OPEX estimate for the operation of the Magnesium Product facility is given in Table 53 and is discussed below.

Table 53 Estimated Annual Production Costs and the Estimated Costs per Tonne of Product for the Magnesium Products

| | **$MgCl_2$ Brine** | | **Hydromagnesite** | |
|---|---|---|---|---|
| | **Annual (1000 $CAD)** | **$CAD/Tonne** | **Annual (1000 $CAD)** | **$CAD/Tonne** |
| Electric Power | 2.8 | 0.03 | 1,043 | 10.03 |
| Maintenance (5% of Equipment Capital) | 9.4 | 0.10 | 2,703 | 25.99 |
| Natural Gas | | | 3,279 | 31.53 |
| Reagents | | | 13,637 | 131.13 |
| Process Water | 0.1 | 0.0 | 34 | 0.33 |
| Administration | | | 1,723 | 16.57 |
| Labour | 624.1 | 6.24 | 4,892 | 47.04 |
| Contingency (10%) | 63.6 | 0.64 | 4,097 | 39.39 |
| TOTAL | 700.0 | 7.01 | 31,409 | 302.01 |

**Natural Gas and Electricity** requirements for the Magnesium products production have been discussed in Sections 18.2 and 18.3 respectively.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

### Maintenance

The annual cost of routine maintenance has been estimated at 5% of the cost of the capital equipment for that section of the plant. This is intended to cover material costs for normal inspections, preventative maintenance, replacement of wear parts and lubrication. Maintenance labor is included in the labor category

### Reagents

No reagents are used in the production and packaging of $MgCl_2$ brine for sale, but the basic magnesium carbonate production process uses three purchased reagents; Epsom Salt (or as an alternative reagent, Sodium Sulfate), Limestone and Anhydrous (gaseous) Ammonia.

> KARNALYTE has obtained following quotes for these reagents: Epsomite $130 CAD/tonne, Limestone $60 CAD/tonne and anhydrous ammonia $690 CAD/tonne, delivered to the plant, which were used as basis for this OPEX estimate.

### Process Water

There is no naturally occurring fresh water source on the site that is suitable as process water for the purposes as described in section 17.3.2, so brackish well water must treated to produce the necessary clean water. Water treatment for the brackish well water is done using several prefilters and five reverse osmosis units. Operational cost for the process water includes the electricity necessary to run the 320 hp booster pumps attached to each unit, the electrical cost of the well pump.

### Administration

Allowances have been made for administration buildings, office space, wash facilities, maintenance facilities etc. in the owners cost. Personnel required to handle administrative tasks are included. This includes an accountant, administrative assistant, logistics coordinator, receptionist, and a human resources clerk. Management and Engineering staff to support plant operation are also included. Other facilities at this level are considered to be provided by the primary Potash Production facility. The KARNALYTE potash plant will provide access to existing infrastructure for Magnesium Products facility.

### Labour

The operation of the brine dispensing system is projected to need 2 operators per shift. The basic magnesium carbonate plant will require a total of 65 operators, labourers and maintenance personnel. The labour rates used in this estimate are the same as for the potash operation.

### Contingency

There are several areas of some uncertainty in these estimates. While the accuracy provisions will cover the uncertainties in the costs listed, some provision must be made for items that are presently unknowable or have been missed at this level of study. Contingency has been determined using engineering judgment for individual cost items dependent on usage, risk, etc. The resulting overall contingency is 10% for the $MgCl_2$ brine facility and 15% for the basic magnesium carbonate facility



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

# 22 Economic Analysis

The economic analysis discussed in this section represents forward-looking information as defined under Canadian securities law. The results depend on inputs that are subject to a number of known and unknown risks, uncertainties, and other factors that may cause actual results to differ materially from those presented here. Such risks include commodity price, and availability of rail capacity, and project financing.

A common approach for the economic evaluation of a mining project is the Income Approach which is based on the principle of anticipated benefits. As such the Income Approach considers potential cash flows generated by a mineral property. Because the Magnesium product Project functions as a satellite plant to the Potash Project both projects will be analysed separately, with the Magnesium product project getting the Magnesium rich potash waste brine for free. Each section will firstly describe the input parameters and assumptions made during the compilation of a cash flow model for the project, with details about the tax situation. Afterwards an analysis of the results of the cash flow model is given and finally a sensitivity analysis is carried out for each project.

## 22.1 Potash Project

For the Potash Project the model has been run for the 2.125 million tonnes per year production scenario as it is planned to continue with expansion of the operation after finalization of Phase 1.

### 22.1.1 Input Parameters and Assumptions

The discounted cash flow model (DCFM) for KARNALYTE's Potash Project as it is given in ENCLOSURE A uses the following input parameters and is based on the assumptions as described below:

- Financial provision for closure must be made during operation. The amount of closure provision is estimated for facilitation according to World Bank standards as 10% of the CAPEX, which results in $240 million CAD. This corresponds to experiences from the German potash industry. This closure provision has been included in the financial model at the final year of the projection.
- Annual sustaining capital has been estimated at a changing % of equipment CAPEX with year 1 – 5, 0.5%, year 6 – 10, 0.75%, year 11 – 15, 1.25%, year 16 – 25, 1.5%, year 26 – 30, 2.0%, year 31 – end of project, 3.0%. The costs for brine field pipeline replacement and extension have been incorporated as 6% of brine field CAPEX from year 6 onward.
- The estimated OPEX includes $60.00 CAD/tonne for transport and marketing and $5 CAD/tonne for administrative and general expenditures.
- To maintain the comparability of the results of the DCFM as given in ENCLOSURE A, only the first 60 years of mine lifetime were considered for the valuation. The



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

"probable and proven reserves" are adequate to sustain the project at the planned production capacity with ramp up and ramp down for 74 years.

- For taxation, the model incorporates the royalty and mining taxes as described in Section 22.1.2. Further taxation information has been provided by HERGOTT DUVAL STACK LLP in the original report (FOSTER WHEELER ERCOSPLAN, 2012, /26/).
- The determination of the discount rate basically depends on the project-related risks. These relate to the stage of project development (early exploration, feasibility study, producing mine) as well as to the respective country or regional risk. These factors are added to the interest rate of a long-term risk-free asset giving the following formula for KARNALYTE's project:

  Interest rate of risk-free bond (Govt. of Canada marketable bonds, avg. yield: +10 year, rate of 15 May 2016) 2.0%

  Project risk (Feasibility Study to Basic Design) 4.0%

  Country risk Canada (low political or economic risk) 1.5%

  Project specific discount rate at 100% equity financing 7.5%

  Since a mining project is usually financed with a share of equity and debt financing of less than 30:70, the discount rate could even be slightly reduced. The risk factors noted above are based on the authors opinions and when compared to the Company's peers who have published financial evaluations of their project, appear reasonably conservative. Although there are no directly comparable mining companies targeting Carnallite in North America this is not considered a significant risk. Project conditions are well defined and hence the reserve risk, which is usually the most decisive risk of a mineral project, is comparably low, as also with the mining, process, construction and environmental risks.

  Based on this comparison the authors have utilized a discount rate of 8% in the financial analysis. The authors have also included a sensitivity table of different discount rates to illustrate the impact of different rates on the NPV of the project (Table 54).
- The product price of $466 CAD per tonne in 2019 as used in the DCFM is based on the US Midwest Potash price (section 19.1.3) as a consensus price of different analysts. An annual price rise of 3% was included.

### 22.1.2 Taxation

Once Phase 1 is operational and KARNALYTE becomes a potash producer, it will be subject to the potash production tax system of Saskatchewan. The Potash Production System was introduced January 1, 1990 and is set out in The Potash Production Tax Schedule of The Mineral Taxation Act and The Potash Production Tax Regulations. Potash production taxes (base payment and profit tax) apply to all potash that is produced from Saskatchewan lands.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

#### 22.1.2.1 Base Payment

The Base Payment is a monthly payment based on an estimate for the entire year. Producers pay net base payment as follows:

Net Base Payment = Gross Base Payment – [Crown Royalties + Freehold Royalties + Saskatchewan Resource Credit – Excess Deductions] - Tax Credits (prior year)

1. Gross Base Payment is 35% of resource profits, subject to minimum and maximum payments:

   Minimum: $11.00 CAD x (total $K_2O$ tonnes sold – base payment holiday tonnes)

   Maximum: $12.33 CAD x (total $K_2O$ tonnes sold – base payment holiday tonnes)

   A $K_2O$ tonne is the quantity of potash that contains the equivalent amount of potassium as one tonne of potassium oxide.
2. Tonnes produced from approved new capacity that commences on or after January 1, 2005 are not subject to the base payment for ten years. The increase in capacity must exceed 122,000 $K_2O$ tonnes for the new tonnes to be eligible for the base payment holiday.
3. Crown Royalties are payable under The Subsurface Mineral Regulations, and are based on the value of potash produced from Crown lands. The effective royalty rate generally ranges from 2.1% to 4.5%, depending on the grade of ore.
4. The Saskatchewan Resource Credit is 1% of the value of sales.
5. Excess deductions are the amount by which the total of crown and freehold royalties and the Saskatchewan Resource Credit exceed the Gross Base Payment.

#### 22.1.2.2 Profit Tax

Producers pay profit tax on a quarterly basis, based on an annual estimate. Producers can elect to pay this tax on profits of individual mines or on the consolidated profits of the producer's Saskatchewan potash operations.

Net Profit Tax = Gross Profit Tax - Base Payment Credits - Tax Credits

Tonnes sold in excess of a producer's average of 2001 and 2002 sales tonnes are not subject to profit tax. Gross Profit Tax is calculated by multiplying the profit per tonne by a producer's average of 2001 and 2002 sales tonnes or its total tonnes sold, whichever is the lesser. Gross Profit Tax is determined by rates which increase with profits per tonne sold, with tax brackets indexed for inflation, as follows:

| 2005 Brackets | Rate |
|---|---|
| ($CAD profit per $K_2O$ tonne sold) | % |
| 0.00 – 53.33 | 15% |
| Over 53.33 | 35% |

The profit tax is leveled on the producer's Adjusted Base Tonnes, which are the producer's Base Tonnes multiplied by the Common Industry Adjustment Factor. For a new producer the base tonnes are:



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

- 75% of the producer's sales in the year if the annual sales were below 1,333,333 tonnes of K2O; or
- 1 million $K_2O$ tonnes if the annual sales were above 1,333,333 tonnes of $K_2O$

Based on Base Tonnes in the previous year, the Common Industry Adjustment Factor is:

(total industry Base Tonnes of 2001-2002 + 35% of base tonnes for new producers in Saskatchewan) divided by (total industry Base Tonnes).

Assuming that besides KARNALYTE there will be one other large (over 1,333,333 tonnes of $K_2O$ annually) new potash producer in Saskatchewan (e.g. K+S) the adjustment factor becomes:

(7.993 million tonnes of 2001/2002 production + 0.7 million tonnes of new producers)/ (9.993 million tonnes)

- Profits = Gross Revenue - Mine Operating Costs - Marketing Costs - Storage Costs - Railcar Costs - Taxes and Assessments - Corporate Allowance - Depreciation Allowances;
- The Corporate Allowance is 2% of gross revenue, in lieu of nondeductible corporate administrative, overhead, financial, and general management expenses;
- Companies receive a depreciation rate of 120% in the profit tax calculation on new capital expenditures in excess of 90% of a company's 2002 capital expenditures. A company's base capital expenditures (below 90% of 2002 expenditures) are eligible for depreciation at 35% per annum;
- Losses may be carried forward for application against future profits for a maximum of five years;
- Companies receive a credit for base payments against profit tax. The base payment credit is:

  Base Payment Tax Rate ($11.00 to $12.33 CAD) x Lesser of (Actual Tonnes Sold or Average of 2001 and 2002 sales) – 50% of Crown and Freehold Royalties + Excess Deductions from the Base Payment Calculation.

Producers who participate in approved market development or research and development programs may claim a Tax Credit of 40% of the approved expenditure. If there is no profit tax otherwise payable, the Tax Credit may be deducted from the Base Payment in the following year.

### 22.1.3 Cash Flow Analysis

For assessing the value of the project the following three key figures were determined using the cash flow model:

- net present value (NPV)

  The NPV compares the present value of all cash inflows with the present value of all cash outflows. A positive NPV indicates that a project is expected to give a return in ex-cess of the cost of capital.

- internal rate of return (IRR)



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

The IRR is the cost of capital or required rate of return which when used to discount the cash flows of a project produces a zero NPV.

and

- return on investment (ROI)

  The ROI is a performance measure to evaluate the efficiency of an investment.

Under consideration of the assumptions described in section 22.1.1 the project results are favorable and the authors of the report are of the opinion that the project is economically viable. The project NPV at a discount rate of 8% after tax is $3.39 billion CAD which means that the project will give a return. The IRR is 19.1% after tax. As such the project would, even with significantly higher associated risks, be economically viable. Cumulative cash flows of the project at the end of the 9th year are estimated at $2.68 billion CAD, based on a total capital cost of $2.40 billion CAD.

Table 54 Discount Rate Sensitivity Analysis for the Potash Project

| | | |
|---|---|---|
| Discount Rate | 8% | 10% |
| NPV | 3.39 billion CAD | 2.01 billion CAD |

### 22.1.4 Sensitivity Analysis

As with most mining operations the cash flows of the project for an annual production of 2.125 million tonnes are sensitive not only to commodity process, but also to other scenarios. The DCFM has been varied to evaluate sensitivities to

- a reduction in potash price over the project life,

  the potash price has been estimated from an evaluation of potash prices by a number of independent analysts. Their price estimates till 2020 are in a relatively small range, but diverge towards 2030, with an upward trend. With a large number of greenfield and brownfield projects being in different stages of development there is no realistic possibility to reliably forecast the future development of the potash price over a longer period of time. The sensitivity for the project to a 10% decrease in potash price has been evaluated

- an increase in OPEX,

  the OPEX have been estimated based on an extrapolation of present day price levels with a price escalation of 3%. Changes in the world energy market that have not been foreseen can result in a stronger increase in the price for natural gas, which is a major factor in the OPEX of the present operation. To evaluate the influence of a significant price increase for natural gas the sensitivity for the project to a 15% increase in OPEX is evaluated

- an increase in CAPEX

  CAPEX has been estimated to 15% accuracy. As a worst case scenario the influence of a 15% increase in CAPEX has been evaluated

- a decrease in planned production



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

a decrease in planned production can occur when some of the basic assumptions that have been explained in this study do not apply. For example an average KCl grade of the brine over the lifetime of the mine that is in the order of 105 g/l instead of the planned 114.5 g/l would mean for the plant operating with the same CAPEX and OPEX a production decrease of 10%.

The simple scenarios run (Table 55) show the expected decreases in IRR and NPV of the project by changing the boundary conditions and indicate that the project will be capable of servicing its debt under these new conditions. Depending on the scenario, the payback period of the CAPEX shifts only slightly to a later date.

Table 55 Sensitivity of IRR and NPV after Tax (Discount Rate fixed at 8%) to Changes in Boundary Conditions as well as the Influence of Changes in Discount Rate

| | **NPV [in Billion $CAD]** | **IRR [in %]** |
|---|---|---|
| Base DCFM | 3.40 | 19.1 |
| 10% Decrease in Product Prices | 2.52 | 16.4 |
| 15% Increase in OPEX | 3.05 | 18.1 |
| 15% Increase in CAPEX | 3.14 | 17.1 |
| 10% Decrease in Sales Volume (Planned Production) | 2.66 | 16.9 |

The major factor to jeopardize the economic viability of the project is falling potash product prices.

### 22.1.5 Estimating Risk

The authors have applied their best professional judgment and effort in evaluating and recommending escalation and contingency factors for equipment, material and labour in the CAPEX and OPEX projections. However, the actual increase of these items at the time of execution could deviate significantly from their valuations and result in a material impact on the estimates provided. In addition, no allowances were anticipated outside of “normal” occurrences, such as unusual or unlikely weather related events. Equipment escalation and contingencies estimates were based on reasonable increases in price of inputs such as steel and any unusual increase in these input costs could have a material impact on the estimates provided. Finally, the increased potash industry projects reported in the local area have been considered in developing the labour estimates. Although the company and contractors will continue to attempt to mitigate the impact of the increased work in the region, which could create a shortage of skilled labour, through execution strategy and timing, rather than incurring additional costs, there is no guarantee that significant additional costs will not occur.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

## 22.2 Magnesium Product Project

The Magnesium Products Facility is integrally linked to the Potash Production facility, not only in terms of the availability of feedstock, but also to provide ongoing administrative and support functions. Capital cost, operating cost and Life of Mine (LoM) estimates therefore assume the existence and operation of the primary Potash Production facility. The CAPEX for the magnesium product project include plant, reagent unloading and product loading and assume that $MgCl_2$ endbrine and some infrastructures are provided by the potash production facility.

### 22.2.1 Input Parameters and Assumptions

A common approach for the economic evaluation of a mining project is the Income Approach which is based on the principle of anticipated benefits. As such the Income Approach considers potential cash flows generated by a mineral property.

The Discounted Cash Flow Model (DCFM) for KARNALYTE's Magnesium Project uses the following input parameters and is based on the assumptions as described below. The DCF model used in this analysis is provided by Karnalyte and uses similar assumptions and tax rates as that used for the Potash Plant feasibility study (FOSTER WHEELER & ERCOSPLAN, 2011, /26/).

- Capital costs estimates for the Magnesium Products facility have been made at an accuracy of ± 25%. Specifically, all major equipment has been selected and budget level pricing obtained. All other costs are included as factors based on the equipment costs. Factors have been determined from industry standard figures as well as data extracted from archives.
- The total capital cost estimate for the 100,000 tpy Magnesium Chloride Brine and 104,000 tpy Basic Magnesium Carbonate production is estimated at $ 171 million CAD which includes owners costs estimated at $ 24,800,000 CAD, and includes a 20% contingency on all direct and indirect costs, and a 10% contingency on owners costs.
- A 10% contingency has been included in the OPEX used in the financial model based on engineering judgement given the individual risks for respectively the Hydromagnesite and $MgCl_2$ brine production.
- All funding is based on 2014 / 2015 costs and assume an US$ : CAD$, exchange rate of 1: 1.26.
- Financial provision for closure has been made for the final year of the 60-year planned life of production. The amount of closure provision is estimated for facilitation according to World Bank standards as 10% of the CAPEX, which results in $17,100,000 CAD.
- An annual sustaining capital of 1.5% of the Equipment CAPEX has been allowed for.
- For transport and marketing costs of $65.00 CAD/tonne have been added to the OPEX. An escalation of 3 % has been included for the operating costs and the commodity prices.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

- Crown Royalties have been allowed for at the rate of 5% of net profit till 1,000,000 tonnes of cumulative Magnesium products sales have been achieved and 10% afterwards.
- Federal and provincial Tax has been allowed for at a rate of 15% and 12% respectively.
- For the DCFM the first 60 years of mine lifetime were considered for the valuation.
- The determination of the discount rate basically depends on the project-related risks. These relate to the stage of project development (early exploration, Feasibility Study, producing mine) as well as to the respective country risk. These factors are added to the interest rate of a long-term risk-free asset giving the following formula for KARNALYTE's Magnesium Project:

  Interest rate of risk-free bond (Govt. of Canada marketable bonds,
  - avg. yield: +10 year, rate of 15 May 2016) 2.0%
  - Project risk (based on completed Preliminary Feasibility Study) 7.0%
  - Country risk Canada (low political or economic risk) 1.5%
  - Project specific discount rate at 100% equity financing 10.5%

  For the present valuation a discount rate of 10% is used. The sensitivity of the project to discount rate is shown in Table 56
- Multiple price points have been used in the DCFM.
  - The $MgCl_2$ price point has been set at $40 CAD per ton of 32% brine as indicated by letters of interest and estimates of the price for $MgCl_2$ brine imports as obtained from Statistics Canada that would indicate a price point of $40 CAD per tonne is achievable.
  - The Basic Magnesium Carbonate product has two potential price points. The first being as a replacement for precipitated calcium carbonate (PCC) or for use in traditional precipitated magnesium carbonate (PMC) markets, as a filler. In traditional PMC markets, or as a substitute for PCC, the expected value of the product would be in the range of $600 CAD per ton as indicated in a letter of interest. The second price point would be as an extender for $TiO_2$ in paint pigments. In this market, the price point would be in the range of $1,800 CAD per ton as indicated in a letter of interest. As the production volumes are substantial, and the markets still have to be established, a 50/50 split between these two price points has been used in the DCFM.

Table 56 Discount Rate Sensitivity Analysis for the Magnesium Product Project

| Discount Rate | 10 % | 11% | 12% |
|---|---|---|---|
| NPV | 512 million CAD | 417 million CAD | 343 million CAD |



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

### 22.2.2 Cash Flow Analysis

For assessing the value of the project the following the same three key figures as for the potash project (section 22.1.3) were determined using the cash flow model:

The DCFM run for this analysis is consistent with the model developed for the primary Potash Production facility. Under consideration of the assumptions described in section 22.2.1 the project results are favorable (ENCLOSURE B). The project NPV at a discount rate of 10% after tax is $512 million CAD which means that the project will give a return. The IRR is 26.1% after tax. As such the project is economically viable.

### 22.2.3 Sensitivity Analysis

As with most mining operations, the cash flows of the project are sensitive not only to commodity process. The DCFM has been varied to evaluate sensitivities to

- a reduction in product prices over the project life,
- an increase in OPEX,
- an increase in CAPEX
- a decrease in planned production.

The scenarios run (Table 57) show the expected decreases in the IRR and the NPV of the project by changing the boundary conditions, and indicate that the project will be capable of servicing its debt under these new conditions. The major factor determining the viability of the plant is the ability to penetrate the $TiO_2$ markets. At the planned production volumes, the tonnages equal approximately 10% of the US production volumes. Penetration into these markets is therefore feasible provided that the quality levels required for the use of the basic magnesium carbonate (hydromagnesite) as a $TiO_2$ extender are met.

Table 57 Sensitivity of IRR and NPV after tax (Discount rate fixed at 10%) to changes in the Boundary Conditions

| | **NPV [in Million $CAD]** | **IRR [in %]** |
|---|---|---|
| Base DCFM | 512 | 26.1 |
| 10% Decrease in Product Prices | 419 | 23.7 |
| 15% Increase in OPEX | 477 | 25.2 |
| 15% Increase in CAPEX | 488 | 23.9 |
| 10% Decrease in Sales Volume (Planned Production) | 445 | 24.4 |

As is evident, project financial indicators show the project to provide a favourable rate of return. This financial analysis assumes that the Potash plant is operational, and able to provide a $MgCl_2$ brine of the purity and quality used for the design of the Magnesium Products plant.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

### 22.2.4 Project Risk

The items below are risks which have not been addressed in the Preliminary Feasibility Study. These risks should be read in conjunction with the risks associated with the primary Potash Production facility.

- Brine quality from the Potash Production plant meets the required standard for the production of high whiteness precipitated basic magnesium carbonate. In particular but not limited to, Fe and Sulfate contamination must remain at acceptable levels.
- Market size and pricing structure for the use of the product as a $TiO_2$ extender needs to be further developed and established.
- $CaCl_2$ levels in the brine must remain below 2% to avoid increases in the OPEX.
- Anhydrous Sodium sulfate can be used in place of Epsom salts (magnesium sulfate) at similar cost provides long term stability in the OPEX.

# 23 Adjacent Properties

Subsurface mineral permits held on lands surrounding the Project include, KP 310A to the west and KP 327 to the south held by BHP Billiton Diamonds Inc and KP 445B held Canada Potash to the north and east.

# 24 Other Relevant Data and Information

To the knowledge of the authors, there is at present no other relevant data and information that would affect the resource and reserve estimate in this Technical Report.

# 25 Interpretation and Conclusions

KARNALYTE holds the Mineral Leases KLSA 010, KL 246 and KL 247 Wynyard, Saskatchewan, Canada. Based on the evaluation of one historical drill hole (Mobil Wynyard), for which the mineralization could be verified, two drill holes commissioned by KARNALYTE in 2009/2010 and described in detail in ERCOSPLAN, NREL & FOSTER WHEELER (2010, /18/) and 9 drill holes commissioned by KARNALYTE in 2011 that were sampled and assayed, as well as a re-interpretation of the 3D seismic data from surveys commissioned by KARNALYTE in 2008 and 2009, the continuity in thickness and grade as well as the discontinuities due to the presence of collapse structures were assessed for the KLSA 010 and KL 247 lease and for the western part of the KL 246 Lease. The authors conclude that a Potassium mineralization, in the form of Sylvite-bearing salt rock and potassium magnesium mineralization, in the form of Carnallite-bearing salt rocks, under-



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

lies substantially all of the KLSA 010 and KL 247 lease areas and the western part of the KL 246 Lease area, except where collapse anomalies have modified and removed the evaporite rock.

Based on the investigations reported herein it is the opinion of the authors that resources of carnallitite and sylvinite can be defined for the investigated area. The authors are of the opinion that based on the geological knowledge about continuity and grade of the deposit that following ROIs can be applied:

- Measured Mineral Resource:
    - Inside the 3D area: Within 1.0 km of a cored and assayed well in the Esterhazy interval, Patience Lake and Belle Plaine intervals.
    - Outside the 3D area: Within 0.8 km area of a cored and assayed well in the Esterhazy interval, Patience Lake and Belle Plaine intervals.
- Indicated Mineral Resource:
    - Inside the 3D area: Between 1.0 km and 2.2 km from a cored and assayed well in the Patience Lake and Belle Plaine interval, and between 1.0 km and 1.6 km for the Esterhazy Interval.
    - Outside the 3D area: Between 0.8 km and 1.6 km from a cored and assayed well for all intervals.
- Inferred Mineral Resource:
    - Inside the 3D area: Between 2.2 km and 6 km from a cored and assayed well for the Patience Lake and Belle Plaine interval, and between 1.6 km and 6.0 km maximum radius for the Esterhazy interval.
    - Outside the 3D area: Between 1.6 km and 6.0 km from a cored and assayed well for all intervals.

In the opinion of the authors “Proven Mineral Reserves” for the Potassium mineralization can be estimated from the areas with “Measured Mineral Resources” and “Probable Mineral Reserves” can be estimated from the areas with “Indicated Mineral Resources” for the Potassium mineralization and from areas with “Measured Mineral Resources” and “Indicated Mineral Resources” for the Magnesium Chloride mineralization. These Resource areas have been reduced by the definition of technical exclusion zones, where mining should not take place to avoid any problems at the surface due to potential subsidence.

Mineral Reserves have been estimated by placing caverns over the license area in grid as defined by the mining method. For each drill hole a typical cavern recovery of mineralized material at given grade has been estimated. This amount was reduced by 10% to account for any anomalies below the resolution of 3D seismic. Reserves were estimated by counting the number of caverns in the “Measured” and “Indicated” Resource areas for each drill hole and multiplying this number with the typical cavern recovery. For the Potash Plant a typical plant recovery of 90% has been applied to come to the amount of KCl in the product that can be produced. For Magnesium Chloride a factor of 5.8% is used for all 3 phases of the project, which takes into account the relation between plant capacity and $MgCl_2$ availability from the Potash plant as well as Magnesium plant recovery. The $MgCl_2$ brine that comes from the Potash plant in excess of the Magnesium plant capacity is considered waste. This results in ”Proven Mineral Reserves” for Potassium mineralization as in Table 58 and “Probable Mineral Reserves” for .Potassium mineralization as in Table 59 and “Probable Mineral Reserves for Magnesium Chloride mineralization in Table 60.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

The total amount of KCl product that can be produced from the Reserves is 147.3 million tonnes, which suggests a lifetime of the project at 2.125 million tonnes annual production of 70 years.

Table 58 Estimated Amounts of Mineralized Material and Weighted Average Grade for Proven Mineral Reserves for the Mineable Horizons in the Esterhazy Member and the Mineable Horizons from Belle Plaine and Patience Lake Members

| | Mineralized Material (million tonnes) | Average KCl Grade (% KCl) | Mineable KCl Tonnage (million tonnes) | Product Tonnage (million tonnes) |
|---|---|---|---|---|
| Patience Lake M | 106.3 | 19.9 | 21.2 | 19.6 |
| UBPM | 131.0 | 19.3 | 25.3 | 23.5 |
| LBPM | 31.3 | 12.1 | 3.8 | 3.5 |
| TOTAL/Average | 268.6 | 18.7 | 50.3 | 46.6 |

| | Mineralized Material (million tonnes) | Average KCl Grade (% KCl) | Mineable KCl Tonnage (million tonnes) | Product Tonnage (million tonnes) |
|---|---|---|---|---|
| Upper Esterhazy | 32.6 | 26.1 | 8.5 | 7.9 |
| Lower Esterhazy | 20.2 | 26.4 | 5.3 | 5.0 |
| TOTAL/Average | 52.8 | 26.2 | 13.8 | 12.9 |

Table 59 Estimated Amounts of Mineralized Material and Weighted Average Grade for Probable Mineral Reserves for the Mineable Horizons in the Carnallitite of the Belle Plaine and Patience Lake Members and the Sylvinite of the Esterhazy Member

| | Mineralized Material (million tonnes) | Average KCl Grade (% KCl) | Mineable KCl Tonnage (million tonnes) | Product Tonnage (million tonnes) |
|---|---|---|---|---|
| Patience Lake M | 171.2 | 19.9 | 34.0 | 31.5 |
| UBPM | 204.7 | 19.0 | 38.9 | 36.1 |
| LBPM | 49.2 | 12.2 | 6.0 | 5.6 |
| TOTAL/Average | 425.1 | 18.6 | 78.9 | 73.2 |

| | Mineralized Material (million tonnes) | Average KCl Grade (% KCl) | Mineable KCl Tonnage (million tonnes) | Product Tonnage (million tonnes) |
|---|---|---|---|---|
| Upper Esterhazy | 38.0 | 25.1 | 9.5 | 8.8 |
| Lower Esterhazy | 23.6 | 26.5 | 6.3 | 5.8 |
| TOTAL/Average | 61.6 | 25.6 | 15.8 | 14.6 |



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

Table 60 Estimated Amounts of Mineralized Material and Weighted Average Grade for Probable Mineral Reserves for the Magnesium Mineralization in the Mineable Horizons in the Carnallitite of the Belle Plaine and Patience Lake Members

| | **Mineralized Material (million tonnes)** | **Average $MgCl_2$ Grade (% $MgCl_2$)** | **Mineable $MgCl_2$ Tonnage (million tonnes)** | **Product Tonnage (million tonnes)** |
|---|---|---|---|---|
| Patience Lake M | 277.5 | 22.4 | 62.1 | 3.2 |
| UBPM | 335.7 | 24.7 | 82.8 | 4.3 |
| LBPM | 81.4 | 10.3 | 8.4 | 0.4 |
| TOTAL/Average | 694.6 | 22.1 | 153.3 | 7.9 |

The total amount of $MgCl_2$ products that can be produced is not dependent on the available reserves but on the capacity of the plant and the market. The $MgCl_2$ reserves can be increased without further exploration by investment in a plant expansion and identification of a market for the additional product.

In the opinion of the authors the investigated part of the KARNALYTE KLSA 010, KL 246 and KL 247 Leases contain sufficient Potassium and Magnesium Chloride reserves to further develop both projects.

It is also the opinion of the authors that it is reasonable to conclude that potash mineralization as identified in the drill holes may extend to the remainder of the KL 246 Lease (to the East of the current focus area) and that further drilling to confirm the presence of potash and further seismic work to delineate the structure of the deposit is warranted.

The authors see the following risks to the Potash project that are considered to be within the estimate accuracy of the estimated CAPEX and OPEX:

- Project funding, which must be secured,
- Scope changes during EPC execution,
- Land Purchase and right of way issues,
- Schedule impact due to shipping delay, utilities installation, Availability of resources, especially site labour. A labour and logistics survey was performed as part of the Feasibility Study.

For the Magnesium product project that relies on the Potash Project the Potash Project risks apply and further risks identified in the Preliminary Feasibility Study that are:

- Brine quality from the potash production plant, especially with regard to sulfate, iron and $CaCl_2$ levels, which might negatively influence the product quality,
- Market size and pricing structure for the use of hydromagnesite as a $TiO_2$ extender,
- Source and pricing Magnesium Sulfate as an important reagent for the hydromagnesite process. This risk is relatively small as the process can be redesigned for the use of sodium sulfate



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

# 26 Recommendations

The authors of this Technical Report recommend continuing separately with both projects with the Potassium project as most important by taking the following steps:

- Begin detailed engineering and advance it to a point where equipment packages can be awarded,
- Perform detail engineering to support preparation of construction license application.

The cost for the detail engineering work for phase 1 potash plant of 625,000 tpy are estimated at around $75 million CAD, which are included in EPCM and Owners cost in the CAPEX estimate.

Additionally, full project financing (approximately $790 million CAD for the first phase of the project for a 625,000 tpy potash operation) has to be secured, to start construction.

For the Magnesium product Project following project phases have to be organized:

Phase 1: extensive laboratory and pilot testing program consisting of tests for

- Exact composition of the potash production end brine,
- Ammonia brine dissolution and brine dilution in the selected absorption tower,
- Ammonia reclamation in selected column,
- Carbon Dioxide dissolution to properly size equipment
- Hydromagnesite dewatering and drying tests.

Concurrent with the test program the engineering required for the Magnesium feasibility study can be completed. Furthermore, base line studies for the EIA should be conducted and the EIA finalised and the market and pricing of the Hydromagnesite as $TiO_2$ extender has to be firmed. The total costs for this step are estimated at $2 million CAD, and are included in the CAPEX estimate.

Conditional upon a favourable outcome of phase 1, phase 2 can be initiated which consists of

- detailed engineering and advance it to a point where equipment packages can be awarded,
- Perform detail engineering to support preparation of construction license application.

The costs for this stage are estimated at $12 to 14 million CAD and these costs are included in the development CAPEX.

Additionally, full project financing (approximately $171 million CAD) for the magnesium product project has to be secured before construction can start, although there is an option to get the $MgCl_2$ brine plant constructed earlier. This of course depends of having the financing for at least phase 1 of the Potash project in place.

It is also the opinion of the authors that it is reasonable to conclude that potash mineralization as identified in the drill holes may extend to the remainder of KL 246 and that further drilling to confirm the mineralization and further seismic work to delineate the structure of the deposit is warranted, but not required for the present projects.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

# 27 References

/1/ ALSTOM Power Raymond Operations Test Report Pilot Test Facility (2011): Test Number RM-2014 for Karnalyte Resources, October 28 2011, 5 pages.

/2/ ALSTOM Power Raymond Operations Test Report Pilot Test Facility (2011): Abrasion and Grindability Test Report Test Number RMS-1814 for Karnalyte Resources October 24 2011, 3 pages.

/3/ ALSTOM Power Raymond Operations Test Report Pilot Test Facility (2011): Abrasion and Grindability Test Report Test Number RMS-2028 for Karnalyte Resources December 28 2012, 4 pages.

/4/ Amec Foster Wheeler (2016): Update of CAPEX and OPEX of the Potash and Magnesium Operation of the Wynyard Carnallite project ro KARNALYTE Resources inc.

/5/ Autenrieth H. (1955): Neue für die Kalirohsalzverarbeitung wichtige Untersuchungen im quinären, NaCl-gesättigten System der Salze ozeanische Salzablagerungen. - Kali Steinsalz 1, 18-32.

/6/ Bannatyne, Barry B. (1983): Devonian Potash Deposits in Manitoba. - Open File Report OF83-3 of Manitoba Department of Energy and Mines, Mineral Resource Division. - 20 pages, 11 figures, 4 tables, 1 Appendix.

/7/ Bechtel Civil & Minerals, Inc., (1985), "Manvest Magnesium Project Preliminary Cost Study For Manvest Ltd., Calgary, Canada"

/8/ BOYD (2008): 2008 Wynyard 3D Seismic Interpretation Draft Final Report, Wynyard, Saskatchewan, prepared for Karnalyte Resources Inc. (Date: 1 November 2008).Calgary, 68 pages.

/9/ BOYD (2010): 2009 Wynyard 3D Merge Seismic Interpretation Final Report for Karnalyte Resources Inc. (Date 23 March 2010). Calgary, 42 pages, 33 figures, 3 appendices.

/10/ CANADIAN INSTITUTE OF MINING, METALLURGY AND PETROLEUM CIM (2014): CIM definition standards on Mineral Resources and Mineral Reserves. - standing committee on reserve definitions of the Canadian Institute of Mining, Metallurgy and Petroleum.

/11/ Colorado School of Mines Research Institute, (1984), "Magnesium from Carnallite" CSMRI Project NP-842076-88

/12/ Colorado School of Mines Research Institute, (1985), "Carnamag Project Proposal to Recover Carnallite in a Single-Well Test and Surface-Recovery Facility".

/13/ Core Lab Petroleum Services (2013): Core Analysis Report for KARNALYTE RESOURCES INC. for well KARNALYTE WYNYARD 2-24-32-16. (2013-02-07). 3 pages

/14/ E. R. Crain, W.B. Anderson (1966): Quantitative Log Evaluation of the Prairie Evaporite Formation of Saskatchewan. - Journal of Canadian Petroleum Technology, Quebec City and Edmonton, July-September, 1966.

/15/ Danyluk, T. K., Phillips G.D., Prugger, A.F & Pesowski M.S. (1999): Geophysical analysis of an unusual collapse structure at PCS Potash, Lanigan Division. Proceedings of the CIM Meeting, "Calgary '99".

/16/ D'Ans J. (1933): Die Lösungsgleichgewichte der Systeme der Salze ozeanischer Salzablagerungen. 254 pp. Kali-Forschungsanstalt.

/17/ ERCOSPLAN (2009 a): MEMO to KARNALYTE - Core assay evaluation and modeling of dissolution brine composition. - 11 pages, 6 tables.

/18/ ERCOSPLAN, NREL and FW (2010): Technical Report - Preliminary Assessment Study, Wynyard Carnallite Project, Subsurface Mineral Permit KP 360, Saskatchewan,



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

Canada, issued 26 August 2010 for Karnalyte Resources Inc. - 220 pages, 49 figures, 39 tables, 3 Enclosures, 5 Appendix.

/19/ ERCOSPLAN (2011): Dissolution Tests on Carnallitite, Carnallite Sylvinite Samples. Issued 10 June 2011 to Karnalyte Resourcs Inc. - 68 pages, 41 figures, 5 Enclosures.

/20/ ERCOSPLAN and NREL (2011): TECHNICAL REPORT Resource Estimate for the Wynyard Carnallite Project, Subsurface Mineral Permit KP 360A and Subsurface Mineral Lease KLSA 010, Saskatchewan, Canada, August 2011, prepared for KARNALYTE Resources Inc. 140 pages, 33 figures, 26 tables, 1 Enclosure, 7 Appendix.

/21/ ERCOSPLAN and NREL (2011): "Technical Report, Reserve and Resource Estimate for the Wynyard Carnallite Project, Subsurface Mineral Permit KP 360A and Subsurface Mineral Lease KLSA 010, Saskatchewan, Canada, October 2011, prepared for KARNALTYE Resource inc. 168 pages, 42 figures, 48 tables, 1 Enclosure, 6 Appendix

/22/ ERCOSPLAN, NREL, FOSTER WHEELER and LYNTEK (2012): Technical Report, KCl and $MgCl_2$ Reserve and Resource Estimate for the Wynyard Carnallite Project, Subsurface Mineral Permit KP 360A and Subsurface Mineral Lease KLSA 010, Saskatchewan, Canada prepared for KARNALTYE Resource inc. 228 pages, 49 figures, 62 tables, 2 Enclosures, 6 Appendix

/23/ ERCOSPLAN (2016): Report:Plan and Operating Procedures for the KARNALYTE Pilot Solution mIning Operation, prepared for KARNAYLTE Resources Inc., 32 pages, 1 figure, 4 tables, 3 Enclosures, 1 Appendix.

/24/ Eugster H.P., Harvie C.E. & Weare J.H. (1980): Mineral Equilibria in a six-component seawater system, Na-K-Mg-Ca-SO4-Cl-H2O, at 25°C. - Geochemica et Cosmochemica Acta 44, 1335 - 1347.

/25/ FAO (2015): Current world fertilizer trends and outlook to 2018 - by Food and Agriculture Organization of the United Nations (FAO). 30 pages, 9 figures, 14 tables, 8 annex.

/26/ FOSTER WHEELER and ERCOSPLAN (2011):Feasibility Study Report for Wynyard Carnallite Project, Wynyard, Saskatchewan, Canada, October 2011, prepared for KARNALYTE Resources Inc. 82 pages, Appendix

/27/ GasAlberta (2016): Market Prices. Accessed at http://www.gasalberta.com/pricing-market.htm on 31/05/2016.

/28/ GeoLOGIC Systems, GeoScout, July 28th 2011

/29/ GeoEngineers Inc. (2013): Deadwood Disposal Well 91/11-16-032-16W2M Well License # 13B033 Injectivity Testing Report for the Wynyard Carnallite Project at Wynyard, Saskatchewan, Canada. 15 July 2013 for Karnalyte Resources Inc. 14 pages, 8 figures, 2 tables, 3 appendix.

/30/ Geo Engineers Inc. (2013): Blairmore Water Supply Well 1-21, 121/01-21-032-16W2/00 Well License # 13C112 Production Testing Report for Karnalyte Resources Inc. delivered 20 December 2013. 17 pages, 21 figures, 2 tables and 1 appendix.

/31/ GLJ Petroleum Consultants (2010): Product Price and Market Forecasts for the Canadian Oil and Gas Industry, January 1 2010. 5 pages, 2 Figures, 2 Tables.

/32/ Gunn, Brad H. and Storer, D. K., 1975, "Experimental Studies on Carnallite Processing", A Report for the Department of Industry and Commerce, Province of Saskatchewan.

/33/ Halabura, S., & Hardy, M. (October 8 - 9, 2007). An Overview of the Geology of Solution Mining of Potash in Saskatchewan: Solution Mining Research Institute Technical Conference.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

/34/ Hardy, M.P & Halabura, S.P. (2008): Technical Report Concerning Subsurface Mineral Per-mit KP 289, Findlater Area, Saskatchewan. 77 pages, 15 Figures, 7 Tables, 3 Appendix

/35/ Holter, M.E. (1969), The Middle Devonian Prairie Evaporite of Saskatchewan, Saskatchewan Department of Mineral Resources, Report No. 123, Figure 4 "Middle Devonian Evaporite Cycles and Prairie Evaporite Formation Nomenclature".

/36/ Institut für Gebirgsmechanik GmbH Leipzig (2011): Rock Mechanical Investigations for the Dimensioning of Solution Mining Caverns in the Elk Point Basin, Saskatchewan, Canada. August 2011. - 51 pages, 25 figures, 15 tables, 55 enclosures.

/37/ Institut für Gebirgsmechanik GmbH Leipzig (2011): Prediction of convergence and subsidence rate in the case of a violation of the surrounding barrier, taking into consideration pressure build-up within the caverns after sealing. July 2013. - 32 pages, 13 figures, 6 tables, 2 Appendix

/38/ LYNTEK Inc. (2012): Magnesium Preliminary Feasibility Report, Wynyard, Saskatchewan, Canada, delivered April 2010 to KARNALYTE RESOURCES Inc. 91 pages, 3 figures, 17 tables, 19 Appendix

/39/ Mackintosh, A.M., and McVittie, G.A., (1983): Geological anomalies observed at the Cominco Ltd. Saskatchewan potash mine: Proceedings of the First International Potash Technology Conference, "Potash '83": Potash Technology - Mining, Processing, Maintenance, Transportation, Occupational Health and Safety, Environment" edited by R.M. McKercher, Pergamon Press, Toronto, pp.59-64.

/40/ Manvest Ltd., (1985), "Carnamag: A Proposal to Dow Chemicals Inc., for the Production of Magnesium from Carnallite Ore"

/41/ Mars Mineral (2013): Test no. 5040-12 Karnalyte Resources Inc. Summary. 4 pages, 5 tables , 1 appendix

/42/ Porter, C. (2015): Recent Amendments to Saskatchewan Regulations Administering Subsurface Crown Minerals (Potash and Salt). From http://www.mckercher.ca/blog/recent-amendments-to-saskatchewan-regulations-administering-subsurface-crown-minerals-potash-and-salt. Accessed 15 October 2015.

/43/ J. M. Pryde Company Ltd., (1984), "An Overview Magnesium from Carnallite"

/44/ Rauche, H. (2015): Die Kaliindustrie im 21. Jahrhundert. Stand der Technik bei der Rohstoffgewinnung und der Rohstoffaufbereitung sowie bei der Entsorgung der dabei anfallenden Rückstände. Springer-Verlag Berlin Heidelberg, October 2015, 580 pages, 291 figures, 99 tables.

/45/ Letter dated April 12 1976 from Dennis K. Storer, Research Scientist Engineering Division Saskatchewan Research Council to Mr. T. W. Field, Head Non Renewable Resources Industry Development Branch Saskatchewan Department of Industry and Commerce

/46/ SRC (2014): Basic Magnesium Carbonate Production Laboratory Test, prepared for Karnalyte Resources Inc October 2014, 12 pages, 7 figures, 9 tables and 3 Appendix.

/47/ SWENSON Technology Inc. (2011): Test report on Crystallization of Potassium Chloride from Brine for Karnalyte Resources, Inc., - by J. Majors Swenson Technology Inc. T2010-08 delivered March 21, 2011, - 17 pages

/48/ Surjik, D. L. 1974, "Magnesium Chemicals Plant - Study 1"

/49/ TRANSGAS (2016): Conceptual Estimate Wynyard - Karnalyte - our file: 2016-02-014. to Ron Olchowski, Karnalyte Resources Inc. 3 pages.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

/50/ Voigt W. (2001): Solubility equilibria in multicomponent oceanic salt systems from T = 0 to 200 °C. Model parameterization and databases. - Pure Applied Chemistry 73, 831-844.

/51/ Whiting (2013): Update on PFD's and Mass Balances for the Evaporation nad Crystallization Section of the 625,000 tpy Karnalyte Potash Plant.

/52/ W&T GeoIngenieure (2011): Mathematical Cavern Temperature Modelling using Computational Fluid Dynamics.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

# Signature Page of Qualified Persons

**Principal Author** of the "Technical Report, KCl and $MgCl_2$ Reserve and Resource Estimate for the Wynyard Carnallite Project, Subsurface Mineral Leases KL 246, KL 247 and KLSA 010, Saskatchewan, Canada," effective date: June 23, 2016**.**

Erfurt, July 06, 2016

(signed and sealed)

EurGeol, Dr Henry A M Rauche

**Authors** of the "Technical Report, KCl and $MgCl_2$ Reserve and Resource Estimate for the Wynyard Carnallite Project, Subsurface Mineral Leases KL 246, KL 247 and KLSA 010, Saskatchewan, Canada," effective date: June 23, 2016**.**

Erfurt, July 06, 2016

(signed and sealed)

EurGeol, Dr Sebastiaan van der Klauw

Saskatoon, July 06, 2016

(signed and sealed)

Lola Piché, P. Geo. (Saskatchewan)

Houston, July 06, 2016

(signed and sealed)

Nathan Ellis Buckner, P. Eng., P.E., M.S., M.B.A



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

# Statement of Certification by Author

I, EurGeol, Dr. Henry A M Rauche, as the principal author of the Technical Report titled "KCl and $MgCl_2$ Reserve and Resource Estimate for the Wynyard Carnallite Project, Subsurface Mineral Leases KL 246, KL 247 and KLSA 010, Saskatchewan, Canada," effective date: June 23, 2016, do hereby certify that:

1. I am a consulting geologist and General Manager of ERCOSPLAN Ingenieurgesell-schaft Geotechnik und Bergbau mbH, with an office located in Arnstaedter Strasse 28, 99096 Erfurt, Germany.
2. I have been with the mining industry since 1976.

   I am a professional geologist and have been practicing in this capacity since July 1986. As a professional geologist, I have been involved with in potash exploration and potash mining geology since 1986, firstly in East Germany and the former Soviet Union, and after 1990 also in Argentine, Brazil, Canada, China, Iran, Israel, Laos, Spain, Ethiopia and Thailand.

   I am a graduate of the Bergakademie Freiberg (Mining Academy Freiberg) and earned a Degree in Geology in 1986 and a Doctorate at the Ruhr-Universität Bochum (Ruhr University Bochum) in 1991.

   I am a member in good standing of the European Federation of Geologists registered as "European Geologist" (Registration Number 729).

   I am a member of the following international professional associations: European Federation of Geologists, American Geophysical Union, Geological Society of America, and the Geologische Vereinigung (Geological Association). I am a member of the following national professional associations: Berufsverband Deutscher Geowissenschaftler, Gesellschaft für Geowissenschaften, Thüringischer Geologischer Verein.

   As a result of my experience and qualifications, I am a Qualified Person as defined in National Instrument 43-101.
3. I did undertake a site visit of the permit lands/properties between January 13 and 17, 2010.
4. I am responsible for Sections 2, 3, 5, 8, 15, 19, 22, 23, 24, 25 and 26 of the Technical Report and had the overall supervision.
5. I am independent of the issuer applying all of the tests in Section 1.5 of National Instrument 43-101.
6. My previous involvement with the property was in 2008 and 2009 assisting North Rim Exploration Ltd. on the potential of solution mining of the deposit and a resource evaluation, in 2010 as principle author of the Technical Report, "Preliminary Assessment Study Wynyard Carnallite Project Subsurface Mineral Permit KP 360, Saskatchewan, Canada", in 2011 as principal author of the Technical Report, "Resource Estimate for the Wynyard Carnallite Project, Subsurface Mineral Permit KP 360A and Subsurface Mineral Lease KLSA 010, Saskatchewan, Canada" and as a principal author of the Technical Report, "Reserve and Resource Estimate for the Wynyard Carnallite Project, Subsurface Mineral Permit KP 360A and Subsurface Mineral Lease KLSA 010, Saskatchewan, Canada." as well as an author of the Technical Report, "Amended and Restated Reserve and Resource Estimate for



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

the Wynyard Carnallite Project, Subsurface Mineral Permit KP 360A and Subsurface Mineral Lease KLSA 010, Saskatchewan, Canada", delivered 30 March 2012.

7. I have read National Instrument 43-101 and Form 43-101 F1, and the portions of the Technical Report for which I am responsible have been prepared in compliance with National Instrument 43-101 and Form 43-101 F1.
8. 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 the Technical Report not misleading.

Dated the 6th day of July 2016
(signed and sealed)

EurGeol, Dr Henry A M Rauche



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

# Statement of Certification by Author

I, EurGeol, Dr. Sebastiaan N G C van der Klauw, as an author of the Technical Report titled "KCl and $MgCl_2$ Mineral Reserve and Resource Estimate for the Wynyard Carnallite Project, Subsurface Mineral Leases KL 246, KL 247 and KLSA 010, Saskatchewan, Canada," effective date: June 23, 2016, do hereby certify that:

1. I am a consulting geologist of ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH, with an office located in Arnstaedter Strasse 28, 99096 Erfurt, Germany.
2. I am a professional geologist and have been practicing in this capacity since July 1992.

   I have been with the mining industry since 1996. As a professional geologist, I have been involved with in potash and salt exploration and potash mining geology since 1996, firstly in Germany and later in Russia, Brazil, Canada, Republic of Congo, Saudi Arabia, Ethiopia and Thailand.

   I am a graduate of the Rijksuniversiteit Utrecht and earned a Degree in Geology in 1990 and a Doctorate at the Ruhr-Universität Bochum (Ruhr University Bochum) in 1999.

   I am a member of the KNGMG Royal Dutch Geologic and Mining Society.

   I am a member in good standing of the European Federation of Geologists registered as "European Geologist" (Registration Number 756).

   As a result of my experience and qualifications, I am a Qualified Person as defined in National Instrument 43-101.
3. I did undertake a site visit of the permit lands/properties between January 13 and 17, 2010 and May 04, 2016 to inspect the solution mining test operation.
4. I am responsible for Sections 6, 12, 13, 16 and 20 of the Technical Report and the overall compilation.
5. I am independent of the issuer applying all of the tests in Section 1.5 of National Instrument 43-101.
6. My previous involvement with the property was in 2008 and 2009 assisting North Rim Exploration Ltd. on the potential of solution mining of the deposit for their resource estimation in 2010 as author of the Technical Report, "Preliminary Assessment Study Wynyard Carnallite Project Subsurface Mineral Permit KP 360, Saskatchewan, Canada", in 2011 as author of the Technical Report, "Resource Estimate for the Wynyard Carnallite Project, Subsurface Mineral Permit KP 360A and Subsurface Mineral Lease KLSA 010, Saskatchewan, Canada", and as an author of the Technical Report, "Reserve and Resource Estimate for the Wynyard Carnallite Project, Subsurface Mineral Permit KP 360A and Subsurface Mineral Lease KLSA 010, Saskatchewan, Canada." as well as an author of the Technical Report, "Amended and Restated Reserve and Resource Estimate for the Wynyard Carnallite Project, Subsurface Mineral Permit KP 360A and Subsurface Mineral Lease KLSA 010, Saskatchewan, Canada", delivered 30 March 2012.
7. I have read National Instrument 43-101 and Form 43-101 F1, and the portions of the Technical Report for which I am responsible have been prepared in compliance with National Instrument 43-101 and Form 43-101 F1.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

8. 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 the Technical Report not misleading.

Dated the 6th day of July 2016
(signed and sealed)

EurGeol, Dr Sebastiaan N G C van der Klauw



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

# Statement of Certification by Author

I, Lola Piché, P. Geo, as an author of the Technical Report titled "KCl and $MgCl_2$ Mineral Reserve and Resource Estimate for the Wynyard Carnallite Project, Subsurface Mineral Leases KL 246, KL 247 and KLSA 010, Saskatchewan, Canada," effective date: June 23, 2016, do hereby certify that:

1. I am a consulting geologist of North Rim Exploration Ltd., with an office located in Suite 1020 – 606 Spadina Crescent East, Saskatoon, Saskatchewan, Canada S7K 3H1.
2. I am a professional geologist and have been practicing in this capacity since September 11, 2001.

   I am a member in good standing of the Association of Professional Engineers and Geoscientists of Saskatchewan (Member #11830).

   I have been working in the potash exploration and development geology industry since 2001 with the majority of focus on the Potash Deposits of the Williston Basin in Canada.

   As a result of my experience and qualifications, I am a Qualified Person as defined in National Instrument 43-101.
3. I did undertake a site visit of the Property on May 04, 2016 to inspect the solution mining test operation, the water wells and the disposal wells.
4. I am responsible for Sections 4, 7, 9, 10, 11 and 14 of the Technical Report.
5. I am independent of the issuer applying all of the tests in Section 1.5 of National Instrument 43-101.
6. My previous involvement with the property was in 2011 as author of the Technical Report, "Resource Estimate for the Wynyard Carnallite Project, Subsurface Mineral Permit KP 360A and Subsurface Mineral Lease KLSA 010, Saskatchewan, Canada", and as an author of the Technical Report, "Reserve and Resource Estimate for the Wynyard Carnallite Project, Subsurface Mineral Permit KP 360A and Subsurface Mineral Lease KLSA 010, Saskatchewan, Canada." as well as an author of the Technical Report, "Amended and Restated Reserve and Resource Estimate for the Wynyard Carnallite Project, Subsurface Mineral Permit KP 360A and Subsurface Mineral Lease KLSA 010, Saskatchewan, Canada", delivered 30 March 2012.
7. Under my supervision, representatives from North Rim Exploration Ltd. were present on site during all core recovery at the drill site during the 2011 drilling. I witnessed and reviewed core handling and sampling completed in the North Rim Exploration Ltd. core lab facility in Saskatoon.
8. I have read National Instrument 43-101 and Form 43-101 F1, and the portions of the Technical Report for which I am responsible have been prepared in compliance with National Instrument 43-101 and Form 43-101 F1.
9. 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 the Technical Report not misleading.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

Dated the 6th day of July 2016
(signed and sealed)

Lola Piché, P. Geo



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

# Statement of Certification by Author

I, Nathan Ellis Buckner, as an author of the Technical Report titled "KCl and $MgCl_2$ Mineral Reserve and Resource Estimate for the Wynyard Carnallite Project, Subsurface Mineral Leases KL 246, KL 247 and KLSA 010, Saskatchewan, Canada," effective date: June 23, 2016, do hereby certify that:

1. I am a Project Director with Amec Foster Wheeler Canada Ltd. (Amec Foster Wheeler), with an office located at 4954 Richard Road SW, Bldg 1, Suite 200, Calgary, Alberta, Canada T3E 6L1.
2. I am a professional engineer with over 30 years of experience in project management, design and construction of process facilities.

   I am a member in good standing of the Association of Professional Engineers and Geoscientists of Saskatchewan (Member # 23522)

   I am a registered professional engineer in nine states in the U.S.A. including, IL (License # 062-048311), IN (License # PE10910374), KS (License #12300), LA (License # 22156), NC (License # 041126), OH (License # 80847), TX (License # 60099), WA (License # 51403), WV (License # 21887).

   I earned Bachelor and Master of Science degrees in Civil Engineering from Louisiana State University in 1980 and 1982, respectively. I earned a Master of Business Administration degree from the University of Houston in 1987.

   As a result of my experience and qualifications, I am a Qualified Person as defined in National Instrument 43-101.
3. I am responsible for Sections 17, 18 and 21 of the Technical Report.
4. I am independent of the issuer applying all of the tests in Section 1.5 of National Instrument 43-101.
5. My previous involvement with the property was in 2011 to 2013 as project manager for the Feasibility Study & EIS and the initial EPC for Phase 1 of the Project. In 2011, I was an author of the Feasibility Study Report for the Wynyard Carnallite Project dated October 2011.
6. In October and November 2012, I was resident at the project site, leading the initial site preparations.
7. I have read National Instrument 43-101 and Form 43-101 F1, and the portion of the Technical Report for which I am responsible have been prepared in compliance with National Instrument 43-101 and Form 43-101 F1.
8. 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 the Technical Report not misleading.

Dated the 6th day of July 2016
(signed and sealed)

_____

Nathan Ellis Buckner, P. Eng., P.E., M.S., M.B.A.



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

# ENCLOSURE A



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

**Discounted Cash Flow model for the KARNALYTE Solution Mining Project with a maximum 2.125MMTA Production**

| | TOTALS | YEAR: | 2017 -1 | 2018 0 | 2019 1 | 2020 2 | 2021 3 | 2022 4 | 2023 5 | 2024 6 | 2025 7 | 2026 8 | 2027 9 | 2028 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Produced Amount (Midwest)** | 122,750,000 | Tonnes | | | 375,000 | 625,000 | 1,375,000 | 1,375,000 | 2,125,000 | 2,125,000 | 2,125,000 | 2,125,000 | 2,125,000 | 2,125,000 |
| **Price (fob, bulk) [1]** | Midwest | CAD/Tonne | | | 453 | 466 | 480 | 495 | 509 | 525 | 540 | 557 | 573 | 591 |
| **Operating Revenue** | **43,536,534,247** | **CAD** | | | **169,733,010** | **291,375,000** | **660,255,750** | **680,063,423** | **1,082,537,321** | **1,115,013,440** | **1,148,463,844** | **1,182,917,759** | **1,218,405,292** | **1,254,957,450** |
| **Opening Balance** | 35,000,000 | CAD | 35,000,000 | | | | | | | | | | | |
| **Initial Capital Expenditures** | 2,361,285,000 | CAD | 359,275,500 | 394,275,500 | 323,848,800 | 482,320,200 | 562,131,400 | 239,433,600 | | | | | | |
| **Sustaining CAPEX based on Brinefield** | | | | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 6.00% | 6.00% | 6.00% | 6.00% | 6.00% |
| **Sustaining capex equipment%** | | | | 0.50% | 0.50% | 0.50% | 0.50% | 0.50% | 0.50% | 0.75% | 0.75% | 0.75% | 0.75% | 0.75% |
| **Sustaining Capital Expenditures (Total)** | 3,263,370,100 | CAD | | 2,373,865 | 2,373,865 | 2,373,865 | 4,806,480 | 4,806,480 | 7,239,095 | 36,851,783 | 36,851,783 | 36,851,783 | 36,851,783 | 36,851,783 |
| **Operating Expenditures [3]** | 37,325,124,891 | CAD | | | 102,912,129 | 79,014,129 | 123,822,879 | 196,768,960 | 184,807,210 | 279,862,310 | 288,258,179 | 296,905,925 | 305,813,102 | 314,987,495 |
| **Closure Provision** | 236,128,500 | CAD | | | | | | | | | | | | |
| **Calcs: Transport/Marketing Escalation** | | CAD/Tonne | | | 60.00 | 61.80 | 63.65 | 65.56 | 67.53 | 69.56 | 71.64 | 73.79 | 76.01 | 78.29 |
| **Transportation and Marketing Costs (Midwest) [2]** | 20,496,199,977 | CAD | 500,000 | 1,000,000 | 22,500,000 | 38,625,000 | 87,524,250 | 90,149,978 | 143,502,373 | 147,807,444 | 152,241,668 | 156,808,918 | 161,513,185 | 166,358,581 |
| **Calcs: Gen/Admin Expense Escalation** | | CAD/Tonne | | | 5.00 | 5.15 | 5.30 | 5.46 | 5.63 | 5.80 | 5.97 | 6.15 | 6.33 | 6.52 |
| **General and Administrative Expenses [2]** | 1,715,797,915 | CAD | 3,000,000 | 3,000,000 | 3,500,000 | 3,500,000 | 7,293,688 | 7,512,498 | 11,958,531 | 12,317,287 | 12,686,806 | 13,067,410 | 13,459,432 | 13,863,215 |
| **Operating Profit before Royalties, Depreciation and Taxes** | **94,835,898,060** | **CAD** | **(3,500,000)** | **(4,000,000)** | **40,820,881** | **170,235,871** | **441,614,934** | **385,631,987** | **742,269,206** | **675,026,399** | **695,277,191** | **716,135,507** | **737,619,572** | **759,748,159** |
| **Crown Royalties** | 3,865,141,234 | 2.5% | | | 4,243,325 | 7,284,375 | 16,506,394 | 17,001,586 | 27,063,433 | 27,875,336 | 28,711,596 | 29,572,944 | 30,460,132 | 31,373,936 |
| **Sask. Resource Surcharge** | 4,638,169,480 | 3.0% | | | 5,091,990 | 8,741,250 | 19,807,673 | 20,401,903 | 32,476,120 | 33,450,403 | 34,453,915 | 35,487,533 | 36,552,159 | 37,648,724 |
| **Potash Production Tax -- Base Tax** | - | CAD | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Potash Production Tax -- Profits Tax** | 9,618,917,107 | CAD | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 45,478,577 | 69,526,563 | 71,821,315 |
| **Operating Profit before Taxes** | | | **(3,500,000)** | **(4,000,000)** | **31,485,565** | **154,210,246** | **405,300,867** | **348,228,499** | **682,729,654** | **613,700,660** | **632,111,679** | **605,596,452** | **601,080,717** | **618,904,184** |
| **Income Tax** | 19,181,474,799 | CAD | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 96,738,050 | 153,561,061 | 152,341,812 | 157,154,148 |
| **Net Income *** | **75,654,423,260** | **CAD** | **(3,500,000)** | **(4,000,000)** | **40,820,881** | **170,235,871** | **441,614,934** | **385,631,987** | **742,269,206** | **675,026,399** | **598,539,141** | **562,574,446** | **585,277,759** | **602,594,010** |

(*) Does not represent 'Net Income' as calculated under Generally Accepted Accounting Principles as no provision for items such as amortization, deferred taxes, etc. have been accounted for.

| **Cash Flow** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Capital Expenditures** | (359,275,500) | (396,649,365) | (326,222,665) | (484,694,065) | (566,937,880) | (244,240,080) | (7,239,095) | (36,851,783) | (36,851,783) | (36,851,783) | (36,851,783) | (36,851,783) |
| **Operating Profit Before Tax** | (3,500,000) | (4,000,000) | 31,485,565 | 154,210,246 | 405,300,867 | 348,228,499 | 682,729,654 | 613,700,660 | 632,111,679 | 605,596,452 | 601,080,717 | 618,904,184 |
| **Unleveraged free cash flow (before taxes)** | **(362,775,500)** | **(400,649,365)** | **(294,737,100)** | **(330,483,819)** | **(161,637,013)** | **103,988,419** | **675,490,559** | **576,848,877** | **595,259,897** | **568,744,670** | **564,228,935** | **582,052,402** |
| **Income Taxes** | - | - | - | - | - | - | - | - | (96,738,050) | (153,561,061) | (152,341,812) | (157,154,148) |
| **Unleveraged free cash flow (after taxes)** | **(362,775,500)** | **(400,649,365)** | **(294,737,100)** | **(330,483,819)** | **(161,637,013)** | **103,988,419** | **675,490,559** | **576,848,877** | **498,521,847** | **415,183,609** | **411,887,122** | **424,898,253** |

NOTES:

1 : Assumes cost/price increase of 3.0% per annum

2 : Assumes cost/price increase of 3.0% per annum

3 : Assumes cost/price increase of 3.0% per annum

| **INTERNAL RATE OF RETURN (IRR)** | | |
|---|---|---|
| IRR before income taxes | % | 21.4% |
| IRR after taxes (incl. Royalties) | % | 19.1% |

| | |
|---|---|
| Discount Factor | 8% |

| **NET PRESENT VALUE (NPV, discounted at 8%)** | CAD $ 000's |
|---|---|
| NPV (before taxes) | 4,829,683,973 |
| NPV (after taxes) | 3,390,789,512 |
| NPV (after taxes) at 10% | 2,005,348,399 |

Potash Price (USD Midwest) $ 482.77 $ 497.25 $ 512.17 $ 527.53 $ 543.36 $ 559.66 $ 576.45 $ 593.74 $ 611.55 $ 629.90 $ 648.80 $ 668.26 $ 688.31 $ 708.96

opexiii_BF 32,179,930

opexiii 95,918,724

6-72

**Discounted Cash Flow model for the KARNALYTE Solution Mining Project with a maximum 2.125MMTA Production**

| | 2029 | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 | 2036 | 2037 | 2038 | 2039 | 2040 | 2041 | 2042 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **11** | **12** | **13** | **14** | **15** | **16** | **17** | **18** | **19** | **20** | **21** | **22** | **23** | **24** |
| **Produced Amount (Midwest)** | 2,125,000 | 2,125,000 | 2,125,000 | 2,125,000 | 2,125,000 | 2,125,000 | 2,125,000 | 2,125,000 | 2,125,000 | 2,125,000 | 2,125,000 | 2,125,000 | 2,125,000 | 2,125,000 |
| **Price (fob, bulk) [1]** | 608 | 627 | 645 | 665 | 685 | 705 | 726 | 748 | 771 | 794 | 817 | 842 | 867 | 893 |
| **Operating Revenue** | **1,292,606,174** | **1,331,384,359** | **1,371,325,890** | **1,412,465,667** | **1,454,839,637** | **1,498,484,826** | **1,543,439,370** | **1,589,742,552** | **1,637,434,828** | **1,686,557,873** | **1,737,154,609** | **1,789,269,247** | **1,842,947,325** | **1,898,235,745** |
| **Opening Balance** | | | | | | | | | | | | | | |
| **Initial Capital Expenditures** | | | | | | | | | | | | | | |
| **Sustaining CAPEX based on Brinefield** | 6.00% | 6.00% | 6.00% | 6.00% | 6.00% | 6.00% | 6.00% | 6.00% | 6.00% | 6.00% | 6.00% | 6.00% | 6.00% | 6.00% |
| **Sustaining capex equipment%** | 1.25% | 1.25% | 1.25% | 1.25% | 1.25% | 1.50% | 1.50% | 1.50% | 1.50% | 1.50% | 1.50% | 1.50% | 1.50% | 1.50% |
| **Sustaining Capital Expenditures (Total)** | 44,090,878 | 44,090,878 | 44,090,878 | 44,090,878 | 44,090,878 | 47,710,425 | 47,710,425 | 47,710,425 | 47,710,425 | 47,710,425 | 47,710,425 | 47,710,425 | 47,710,425 | 47,710,425 |
| **Operating Expenditures [3]** | 324,437,120 | 334,170,234 | 344,195,341 | 354,521,201 | 365,156,837 | 376,111,542 | 387,394,889 | 399,016,735 | 410,987,237 | 423,316,854 | 436,016,360 | 449,096,851 | 462,569,756 | 476,446,849 |
| **Closure Provision** | | | | | | | | | | | | | | |
| Calcs: Transport/Marketing Escalation | 80.63 | 83.05 | 85.55 | 88.11 | 90.76 | 93.48 | 96.28 | 99.17 | 102.15 | 105.21 | 108.37 | 111.62 | 114.97 | 118.42 |
| **Transportation and Marketing Costs (Midwest) [2]** | 171,349,338 | 176,489,819 | 181,784,513 | 187,238,048 | 192,855,190 | 198,640,846 | 204,600,071 | 210,738,073 | 217,060,215 | 223,572,022 | 230,279,182 | 237,187,558 | 244,303,185 | 251,632,280 |
| Calcs: Gen/Admin Expense Escalation | 6.72 | 6.92 | 7.13 | 7.34 | 7.56 | 7.79 | 8.02 | 8.26 | 8.51 | 8.77 | 9.03 | 9.30 | 9.58 | 9.87 |
| **General and Administrative Expenses [2]** | 14,279,112 | 14,707,485 | 15,148,709 | 15,603,171 | 16,071,266 | 16,553,404 | 17,050,006 | 17,561,506 | 18,088,351 | 18,631,002 | 19,189,932 | 19,765,630 | 20,358,599 | 20,969,357 |
| **Operating Profit before Royalties, Depreciation and Taxes** | **782,540,604** | **806,016,822** | **830,197,326** | **855,103,246** | **880,756,344** | **907,179,034** | **934,394,405** | **962,426,237** | **991,299,024** | **1,021,037,995** | **1,051,669,135** | **1,083,219,209** | **1,115,715,785** | **1,149,187,259** |
| **Crown Royalties** | 32,315,154 | 33,284,609 | 34,283,147 | 35,311,642 | 36,370,991 | 37,462,121 | 38,585,984 | 39,743,564 | 40,935,871 | 42,163,947 | 43,428,865 | 44,731,731 | 46,073,683 | 47,455,894 |
| **Sask. Resource Surcharge** | 38,778,185 | 39,941,531 | 41,139,777 | 42,373,970 | 43,645,189 | 44,954,545 | 46,303,181 | 47,692,277 | 49,123,045 | 50,596,736 | 52,114,638 | 53,678,077 | 55,288,420 | 56,947,072 |
| **Potash Production Tax -- Base Tax** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Potash Production Tax -- Profits Tax** | 84,029,002 | 86,466,518 | 88,978,690 | 91,567,787 | 94,236,149 | 96,542,791 | 99,376,985 | 102,297,893 | 105,308,152 | 108,410,475 | 111,607,661 | 114,902,591 | 118,298,233 | 121,797,648 |
| **Operating Profit before Taxes** | **627,418,262** | **646,324,164** | **665,795,712** | **685,849,847** | **706,504,014** | **728,219,577** | **750,128,255** | **772,692,504** | **795,931,957** | **819,866,837** | **844,517,970** | **869,906,809** | **896,055,449** | **922,986,645** |
| **Income Tax** | 157,498,394 | 162,602,987 | 167,860,305 | 173,274,922 | 178,851,547 | 183,737,471 | 189,652,814 | 195,745,161 | 202,019,814 | 208,482,231 | 215,138,037 | 221,993,024 | 229,053,156 | 236,324,579 |
| **Net Income *** | **625,042,210** | **643,413,835** | **662,337,021** | **681,828,324** | **701,904,797** | **723,441,563** | **744,741,591** | **766,681,076** | **789,279,210** | **812,555,764** | **836,531,098** | **861,226,185** | **886,662,629** | **912,862,679** |
| (*) Does not represent 'Net Income' as calculated under Generally Accep | | | | | | | | | | | | | | |
| **Cash Flow** | | | | | | | | | | | | | | |
| **Capital Expenditures** | (44,090,878) | (44,090,878) | (44,090,878) | (44,090,878) | (44,090,878) | (47,710,425) | (47,710,425) | (47,710,425) | (47,710,425) | (47,710,425) | (47,710,425) | (47,710,425) | (47,710,425) | (47,710,425) |
| **Operating Profit Before Tax** | 627,418,262 | 646,324,164 | 665,795,712 | 685,849,847 | 706,504,014 | 728,219,577 | 750,128,255 | 772,692,504 | 795,931,957 | 819,866,837 | 844,517,970 | 869,906,809 | 896,055,449 | 922,986,645 |
| **Unleveraged free cash flow (before taxes)** | **583,327,384** | **602,233,286** | **621,704,835** | **641,758,970** | **662,413,137** | **680,509,152** | **702,417,830** | **724,982,079** | **748,221,532** | **772,156,412** | **796,807,545** | **822,196,384** | **848,345,024** | **875,276,220** |
| **Income Taxes** | (157,498,394) | (162,602,987) | (167,860,305) | (173,274,922) | (178,851,547) | (183,737,471) | (189,652,814) | (195,745,161) | (202,019,814) | (208,482,231) | (215,138,037) | (221,993,024) | (229,053,156) | (236,324,579) |
| **Unleveraged free cash flow (after taxes)** | **425,828,991** | **439,630,299** | **453,844,529** | **468,484,048** | **483,561,590** | **496,771,681** | **512,765,016** | **529,236,917** | **546,201,718** | **563,674,181** | **581,669,508** | **600,203,361** | **619,291,867** | **638,951,641** |

NOTES:

1 : Assumes cost/price increase of 3.0% per annum

2 : Assumes cost/price increase of 3.0% per annum

3 : Assumes cost/price increase of 3.0% per annum

**INTERNAL RATE OF RETURN (IRR)**

IRR before income taxes

IRR after taxes (incl. Royalties)

Discount Factor

**NET PRESENT VALUE (NPV, discounted at 8%)**

NPV (before taxes)

NPV (after taxes)

NPV (after taxes) at 10%

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Potash Price (USD Midwest) | $ 730.23 | $ 752.13 | $ 774.70 | $ 797.94 | $ 821.88 | $ 846.53 | $ 871.93 | $ 898.09 | $ 925.03 | $ 952.78 | $ 981.36 | $ 1,010.80 | $ 1,041.13 | $ 1,072.36 |

**Discounted Cash Flow model for the KARNALYTE Solution Mining Project with a maximum 2.125MMTA Production**

| | 2043 | 2044 | 2045 | 2046 | 2047 | 2048 | 2049 | 2050 | 2051 | 2052 | 2053 | 2054 | 2055 | 2056 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **25** | **26** | **27** | **28** | **29** | **30** | **31** | **32** | **33** | **34** | **35** | **36** | **37** | **38** |
| **Produced Amount (Midwest)** | 2,125,000 | 2,125,000 | 2,125,000 | 2,125,000 | 2,125,000 | 2,125,000 | 2,125,000 | 2,125,000 | 2,125,000 | 2,125,000 | 2,125,000 | 2,125,000 | 2,125,000 | 2,125,000 |
| **Price (fob, bulk) [1]** | 920 | 948 | 976 | 1,005 | 1,036 | 1,067 | 1,099 | 1,132 | 1,166 | 1,201 | 1,237 | 1,274 | 1,312 | 1,351 |
| **Operating Revenue** | **1,955,182,817** | **2,013,838,301** | **2,074,253,450** | **2,136,481,054** | **2,200,575,486** | **2,266,592,750** | **2,334,590,533** | **2,404,628,249** | **2,476,767,096** | **2,551,070,109** | **2,627,602,212** | **2,706,430,279** | **2,787,623,187** | **2,871,251,883** |
| **Opening Balance** | | | | | | | | | | | | | | |
| **Initial Capital Expenditures** | | | | | | | | | | | | | | |
| **Sustaining CAPEX based on Brinefield** | 6.00% | 6.00% | 6.00% | 6.00% | 6.00% | 6.00% | 6.00% | 6.00% | 6.00% | 6.00% | 6.00% | 6.00% | 6.00% | 6.00% |
| **Sustaining capex equipment%** | 1.50% | 2.00% | 2.00% | 2.00% | 2.00% | 2.00% | 3.00% | 3.00% | 3.00% | 3.00% | 3.00% | 3.00% | 3.00% | 3.00% |
| **Sustaining Capital Expenditures (Total)** | 47,710,425 | 54,949,520 | 54,949,520 | 54,949,520 | 54,949,520 | 54,949,520 | 69,427,710 | 69,427,710 | 69,427,710 | 69,427,710 | 69,427,710 | 69,427,710 | 69,427,710 | 69,427,710 |
| **Operating Expenditures [3]** | 490,740,255 | 505,462,462 | 520,626,336 | 536,245,126 | 552,332,480 | 568,902,454 | 585,969,528 | 603,548,614 | 621,655,072 | 640,304,724 | 659,513,866 | 679,299,282 | 699,678,261 | 720,668,608 |
| **Closure Provision** | | | | | | | | | | | | | | |
| Calcs: Transport/Marketing Escalation | 121.97 | 125.63 | 129.40 | 133.28 | 137.28 | 141.39 | 145.64 | 150.00 | 154.50 | 159.14 | 163.91 | 168.83 | 173.90 | 179.11 |
| **Transportation and Marketing Costs (Midwest) [2]** | 259,181,249 | 266,956,686 | 274,965,387 | 283,214,348 | 291,710,779 | 300,462,102 | 309,475,965 | 318,760,244 | 328,323,051 | 338,172,743 | 348,317,925 | 358,767,463 | 369,530,487 | 380,616,401 |
| Calcs: Gen/Admin Expense Escalation | 10.16 | 10.47 | 10.78 | 11.11 | 11.44 | 11.78 | 12.14 | 12.50 | 12.88 | 13.26 | 13.66 | 14.07 | 14.49 | 14.93 |
| **General and Administrative Expenses [2]** | 21,598,437 | 22,246,391 | 22,913,782 | 23,601,196 | 24,309,232 | 25,038,509 | 25,789,664 | 26,563,354 | 27,360,254 | 28,181,062 | 29,026,494 | 29,897,289 | 30,794,207 | 31,718,033 |
| **Operating Profit before Royalties, Depreciation and Taxes** | **1,183,662,876** | **1,219,172,763** | **1,255,747,946** | **1,293,420,384** | **1,332,222,995** | **1,372,189,685** | **1,413,355,376** | **1,455,756,037** | **1,499,428,718** | **1,544,411,580** | **1,590,743,927** | **1,638,466,245** | **1,687,620,232** | **1,738,248,839** |
| **Crown Royalties** | 48,879,570 | 50,345,958 | 51,856,336 | 53,412,026 | 55,014,387 | 56,664,819 | 58,364,763 | 60,115,706 | 61,919,177 | 63,776,753 | 65,690,055 | 67,660,757 | 69,690,580 | 71,781,297 |
| **Sask. Resource Surcharge** | 58,655,485 | 60,415,149 | 62,227,604 | 64,094,432 | 66,017,265 | 67,997,783 | 70,037,716 | 72,138,847 | 74,303,013 | 76,532,103 | 78,828,066 | 81,192,908 | 83,628,696 | 86,137,556 |
| **Potash Production Tax -- Base Tax** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Potash Production Tax -- Profits Tax** | 125,403,984 | 128,233,701 | 132,063,721 | 136,010,701 | 140,078,190 | 144,269,846 | 146,815,858 | 151,267,265 | 155,854,488 | 160,581,646 | 165,452,985 | 170,472,875 | 175,645,824 | 180,976,470 |
| **Operating Profit before Taxes** | **950,723,837** | **980,177,955** | **1,009,600,285** | **1,039,903,225** | **1,071,113,154** | **1,103,257,238** | **1,138,137,038** | **1,172,234,218** | **1,207,352,040** | **1,243,521,077** | **1,280,772,821** | **1,319,139,704** | **1,358,655,133** | **1,399,353,515** |
| **Income Tax** | 243,813,621 | 249,811,677 | 257,755,706 | 265,937,500 | 274,364,181 | 283,043,084 | 288,551,519 | 297,757,757 | 307,239,569 | 317,005,209 | 327,063,180 | 337,422,238 | 348,091,404 | 359,079,967 |
| **Net Income *** | **939,849,255** | **969,361,085** | **997,992,239** | **1,027,482,883** | **1,057,858,814** | **1,089,146,601** | **1,124,803,857** | **1,157,998,280** | **1,192,189,149** | **1,227,406,371** | **1,263,680,747** | **1,301,044,007** | **1,339,528,828** | **1,379,168,872** |
| (*) Does not represent 'Net Income' as calculated under Generally Accep | | | | | | | | | | | | | | |
| **Cash Flow** | | | | | | | | | | | | | | |
| **Capital Expenditures** | (47,710,425) | (54,949,520) | (54,949,520) | (54,949,520) | (54,949,520) | (54,949,520) | (69,427,710) | (69,427,710) | (69,427,710) | (69,427,710) | (69,427,710) | (69,427,710) | (69,427,710) | (69,427,710) |
| **Operating Profit Before Tax** | 950,723,837 | 980,177,955 | 1,009,600,285 | 1,039,903,225 | 1,071,113,154 | 1,103,257,238 | 1,138,137,038 | 1,172,234,218 | 1,207,352,040 | 1,243,521,077 | 1,280,772,821 | 1,319,139,704 | 1,358,655,133 | 1,399,353,515 |
| **Unleveraged free cash flow (before taxes)** | **903,013,412** | **925,228,435** | **954,650,765** | **984,953,705** | **1,016,163,634** | **1,048,307,718** | **1,068,709,328** | **1,102,806,508** | **1,137,924,330** | **1,174,093,367** | **1,211,345,111** | **1,249,711,994** | **1,289,227,423** | **1,329,925,805** |
| **Income Taxes** | (243,813,621) | (249,811,677) | (257,755,706) | (265,937,500) | (274,364,181) | (283,043,084) | (288,551,519) | (297,757,757) | (307,239,569) | (317,005,209) | (327,063,180) | (337,422,238) | (348,091,404) | (359,079,967) |
| **Unleveraged free cash flow (after taxes)** | **659,199,791** | **675,416,757** | **696,895,058** | **719,016,205** | **741,799,453** | **765,264,634** | **780,157,810** | **805,048,751** | **830,684,761** | **857,088,158** | **884,281,931** | **912,289,756** | **941,136,019** | **970,845,838** |

NOTES:

1 : Assumes cost/price increase of 3.0% per annum

2 : Assumes cost/price increase of 3.0% per annum

3 : Assumes cost/price increase of 3.0% per annum

**INTERNAL RATE OF RETURN (IRR)**

IRR before income taxes

IRR after taxes (incl. Royalties)

Discount Factor

**NET PRESENT VALUE (NPV, discounted at 8%)**

NPV (before taxes)

NPV (after taxes)

NPV (after taxes) at 10%

| | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 | 2036 | 2037 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Potash Price (USD Midwest) | $ 1,104.53 | $ 1,137.67 | $ 1,171.80 | $ 1,206.95 | $ 1,243.16 | $ 1,280.46 | $ 1,318.87 | $ 1,358.44 | $ 1,399.19 | $ 1,441.17 | $ 1,484.40 | $ 1,528.93 | $ 1,574.80 | $ 1,622.05 |

**Discounted Cash Flow model for the KARNALYTE Solution Mining Project with a maximum 2.125MMTA Production**

| | 2057 | 2058 | 2059 | 2060 | 2061 | 2062 | 2063 | 2064 | 2065 | 2066 | 2067 | 2068 | 2069 | 2070 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **39** | **40** | **41** | **42** | **43** | **44** | **45** | **46** | **47** | **48** | **49** | **50** | **51** | **52** |
| **Produced Amount (Midwest)** | 2,125,000 | 2,125,000 | 2,125,000 | 2,125,000 | 2,125,000 | 2,125,000 | 2,125,000 | 2,125,000 | 2,125,000 | 2,125,000 | 2,125,000 | 2,125,000 | 2,125,000 | 2,125,000 |
| **Price (fob, bulk)** [1] | 1,392 | 1,433 | 1,476 | 1,521 | 1,566 | 1,613 | 1,662 | 1,712 | 1,763 | 1,816 | 1,870 | 1,926 | 1,984 | 2,044 |
| **Operating Revenue** | **2,957,389,439** | **3,046,111,122** | **3,137,494,456** | **3,231,619,290** | **3,328,567,868** | **3,428,424,904** | **3,531,277,651** | **3,637,215,981** | **3,746,332,460** | **3,858,722,434** | **3,974,484,107** | **4,093,718,630** | **4,216,530,189** | **4,343,026,095** |
| **Opening Balance** | | | | | | | | | | | | | | |
| **Initial Capital Expenditures** | | | | | | | | | | | | | | |
| **Sustaining CAPEX based on Brinefield** | 6.00% | 6.00% | 6.00% | 6.00% | 6.00% | 6.00% | 6.00% | 6.00% | 6.00% | 6.00% | 6.00% | 6.00% | 6.00% | 6.00% |
| **Sustaining capex equipment%** | 3.00% | 3.00% | 3.00% | 3.00% | 3.00% | 3.00% | 3.00% | 3.00% | 3.00% | 3.00% | 3.00% | 3.00% | 3.00% | 3.00% |
| **Sustaining Capital Expenditures (Total)** | 69,427,710 | 69,427,710 | 69,427,710 | 69,427,710 | 69,427,710 | 69,427,710 | 69,427,710 | 69,427,710 | 69,427,710 | 69,427,710 | 69,427,710 | 69,427,710 | 69,427,710 | 69,427,710 |
| **Operating Expenditures** [3] | 742,288,667 | 764,557,327 | 787,494,047 | 811,118,868 | 835,452,434 | 860,516,007 | 886,331,487 | 912,921,432 | 940,309,075 | 968,518,347 | 997,573,897 | 914,794,894 | 942,238,741 | 970,505,904 |
| **Closure Provision** | | | | | | | | | | | | | | |
| Calcs: Transport/Marketing Escalation | 184.49 | 190.02 | 195.72 | 201.59 | 207.64 | 213.87 | 220.29 | 226.90 | 233.70 | 240.71 | 247.94 | 255.37 | 263.03 | 270.93 |
| **Transportation and Marketing Costs (Midwest)** [2] | 392,034,893 | 403,795,940 | 415,909,818 | 428,387,113 | 441,238,726 | 454,475,888 | 468,110,165 | 482,153,470 | 496,618,074 | 511,516,616 | 526,862,115 | 542,667,978 | 558,948,017 | 575,716,458 |
| Calcs: Gen/Admin Expense Escalation | 15.37 | 15.84 | 16.31 | 16.80 | 17.30 | 17.82 | 18.36 | 18.91 | 19.48 | 20.06 | 20.66 | 21.28 | 21.92 | 22.58 |
| **General and Administrative Expenses** [2] | 32,669,574 | 33,649,662 | 34,659,152 | 35,698,926 | 36,769,894 | 37,872,991 | 39,009,180 | 40,179,456 | 41,384,839 | 42,626,385 | 43,905,176 | 45,222,332 | 46,579,001 | 47,976,371 |
| **Operating Profit before Royalties, Depreciation and Taxes** | **1,790,396,304** | **1,844,108,194** | **1,899,431,439** | **1,956,414,383** | **2,015,106,814** | **2,075,560,018** | **2,137,826,819** | **2,201,961,624** | **2,268,020,472** | **2,336,061,086** | **2,406,142,919** | **2,591,033,426** | **2,668,764,429** | **2,748,827,362** |
| **Crown Royalties** | 73,934,736 | 76,152,778 | 78,437,361 | 80,790,482 | 83,214,197 | 85,710,623 | 88,281,941 | 90,930,400 | 93,658,312 | 96,468,061 | 99,362,103 | 102,342,966 | 105,413,255 | 108,575,652 |
| **Sask. Resource Surcharge** | 88,721,683 | 91,383,334 | 94,124,834 | 96,948,579 | 99,857,036 | 102,852,747 | 105,938,330 | 109,116,479 | 112,389,974 | 115,761,673 | 119,234,523 | 122,811,559 | 126,495,906 | 130,290,783 |
| **Potash Production Tax -- Base Tax** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Potash Production Tax -- Profits Tax** | 186,469,597 | 192,130,128 | 197,963,139 | 203,973,857 | 210,167,668 | 216,550,119 | 223,126,928 | 229,903,981 | 236,887,346 | 244,083,271 | 251,498,195 | 272,945,262 | 281,232,476 | 289,771,617 |
| **Operating Profit before Taxes** | **1,441,270,289** | **1,484,441,954** | **1,528,906,105** | **1,574,701,465** | **1,621,867,914** | **1,670,446,529** | **1,720,479,620** | **1,772,010,763** | **1,825,084,841** | **1,879,748,081** | **1,936,048,098** | **2,092,933,640** | **2,155,622,793** | **2,220,189,310** |
| **Income Tax** | 370,397,496 | 382,053,846 | 394,059,167 | 406,423,914 | 419,158,855 | 432,275,081 | 445,784,016 | 459,697,424 | 474,027,425 | 488,786,500 | 503,987,505 | 546,346,601 | 563,272,673 | 580,705,632 |
| **Net Income *** | **1,419,998,808** | **1,462,054,348** | **1,505,372,273** | **1,549,990,469** | **1,595,947,959** | **1,643,284,937** | **1,692,042,803** | **1,742,264,199** | **1,793,993,047** | **1,847,274,586** | **1,902,155,414** | **2,044,686,825** | **2,105,491,757** | **2,168,121,730** |
| (*) Does not represent 'Net Income' as calculated under Generally Accep | | | | | | | | | | | | | | |
| **Cash Flow** | | | | | | | | | | | | | | |
| **Capital Expenditures** | (69,427,710) | (69,427,710) | (69,427,710) | (69,427,710) | (69,427,710) | (69,427,710) | (69,427,710) | (69,427,710) | (69,427,710) | (69,427,710) | (69,427,710) | (69,427,710) | (69,427,710) | (69,427,710) |
| **Operating Profit Before Tax** | 1,441,270,289 | 1,484,441,954 | 1,528,906,105 | 1,574,701,465 | 1,621,867,914 | 1,670,446,529 | 1,720,479,620 | 1,772,010,763 | 1,825,084,841 | 1,879,748,081 | 1,936,048,098 | 2,092,933,640 | 2,155,622,793 | 2,220,189,310 |
| **Unleveraged free cash flow (before taxes)** | **1,371,842,579** | **1,415,014,244** | **1,459,478,395** | **1,505,273,755** | **1,552,440,204** | **1,601,018,819** | **1,651,051,910** | **1,702,583,053** | **1,755,657,131** | **1,810,320,371** | **1,866,620,388** | **2,023,505,930** | **2,086,195,083** | **2,150,761,600** |
| **Income Taxes** | (370,397,496) | (382,053,846) | (394,059,167) | (406,423,914) | (419,158,855) | (432,275,081) | (445,784,016) | (459,697,424) | (474,027,425) | (488,786,500) | (503,987,505) | (546,346,601) | (563,272,673) | (580,705,632) |
| **Unleveraged free cash flow (after taxes)** | **1,001,445,082** | **1,032,960,398** | **1,065,419,229** | **1,098,849,841** | **1,133,281,349** | **1,168,743,738** | **1,205,267,895** | **1,242,885,629** | **1,281,629,706** | **1,321,533,871** | **1,362,632,883** | **1,477,159,329** | **1,522,922,411** | **1,570,055,968** |

NOTES:

1 : Assumes cost/price increase of 3.0% per annum

2 : Assumes cost/price increase of 3.0% per annum

3 : Assumes cost/price increase of 3.0% per annum

**INTERNAL RATE OF RETURN (IRR)**

IRR before income taxes

IRR after taxes (incl. Royalties)

Discount Factor

**NET PRESENT VALUE (NPV, discounted at 8%)**

NPV (before taxes)

NPV (after taxes)

NPV (after taxes) at 10%

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Potash Price (USD Midwest) | $ 1,670.71 | $ 1,720.83 | $ 1,772.45 | $ 1,825.63 | $ 1,880.39 | $ 1,936.81 | $ 1,994.91 | $ 2,054.76 |

**Discounted Cash Flow model for the KARNALYTE Solution Mining Project with a maximum 2.125MMTA Production**

| | 2071 | 2072 | 2073 | 2074 | 2075 | 2076 | 2077 | 2078 |
|---|---|---|---|---|---|---|---|---|
| | **53** | **54** | **55** | **56** | **57** | **58** | **59** | **60** |
| **Produced Amount (Midwest)** | 2,125,000 | 2,125,000 | 2,125,000 | 2,125,000 | 2,125,000 | 2,125,000 | 2,125,000 | 2,125,000 |
| **Price (fob, bulk) [1]** | 2,105 | 2,168 | 2,233 | 2,300 | 2,369 | 2,440 | 2,514 | 2,589 |
| **Operating Revenue** | **4,473,316,878** | **4,607,516,384** | **4,745,741,876** | **4,888,114,132** | **5,034,757,556** | **5,185,800,283** | **5,341,374,291** | **5,501,615,520** |
| **Opening Balance** | | | | | | | | |
| **Initial Capital Expenditures** | | | | | | | | |
| **Sustaining CAPEX based on Brinefield** | 6.00% | 6.00% | 6.00% | 6.00% | 6.00% | 6.00% | 6.00% | 6.00% |
| **Sustaining capex equipment%** | 3.00% | 3.00% | 3.00% | 3.00% | 3.00% | 3.00% | 3.00% | 3.00% |
| **Sustaining Capital Expenditures (Total)** | 69,427,710 | 69,427,710 | 69,427,710 | 69,427,710 | 69,427,710 | 69,427,710 | 69,427,710 | 69,427,710 |
| **Operating Expenditures [3]** | 999,621,081 | 1,029,609,713 | 1,060,498,004 | 1,092,312,945 | 1,125,082,333 | 1,158,834,803 | 1,193,599,847 | 1,229,407,842 |
| **Closure Provision** | | | | | | | | 236,128,500 |
| **Calcs: Transport/Marketing Escalation** | 279.05 | 287.42 | 296.05 | 304.93 | 314.08 | 323.50 | 333.20 | 343.20 |
| **Transportation and Marketing Costs (Midwest) [2]** | 592,987,952 | 610,777,590 | 629,100,918 | 647,973,945 | 667,413,164 | 687,435,559 | 708,058,625 | 729,300,384 |
| **Calcs: Gen/Admin Expense Escalation** | 23.25 | 23.95 | 24.67 | 25.41 | 26.17 | 26.96 | 27.77 | 28.60 |
| **General and Administrative Expenses [2]** | 49,415,663 | 50,898,133 | 52,425,076 | 53,997,829 | 55,617,764 | 57,286,297 | 59,004,885 | 60,775,032 |
| **Operating Profit before Royalties, Depreciation and Taxes** | **2,831,292,183** | **2,916,230,949** | **3,003,717,877** | **3,093,829,413** | **3,186,644,296** | **3,282,243,625** | **3,380,710,933** | **3,246,003,761** |
| **Crown Royalties** | 111,832,922 | 115,187,910 | 118,643,547 | 122,202,853 | 125,868,939 | 129,645,007 | 133,534,357 | 137,540,388 |
| **Sask. Resource Surcharge** | 134,199,506 | 138,225,492 | 142,372,256 | 146,643,424 | 151,042,727 | 155,574,008 | 160,241,229 | 165,048,466 |
| **Potash Production Tax -- Base Tax** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Potash Production Tax -- Profits Tax** | 298,570,312 | 307,636,412 | 316,978,011 | 326,603,442 | 336,521,292 | 346,740,408 | 357,269,901 | 368,119,159 |
| **Operating Profit before Taxes** | **2,286,689,443** | **2,355,181,135** | **2,425,724,063** | **2,498,379,694** | **2,573,211,338** | **2,650,284,201** | **2,729,665,446** | **2,575,295,748** |
| **Income Tax** | 598,660,668 | 617,153,425 | 636,200,015 | 655,817,036 | 676,021,580 | 696,831,253 | 718,264,189 | 676,584,370 |
| **Net Income *** | **2,232,631,515** | **2,299,077,524** | **2,367,517,862** | **2,438,012,377** | **2,510,622,716** | **2,585,412,372** | **2,662,446,745** | **2,569,419,391** |
| (*) Does not represent 'Net Income' as calculated under Generally Accep | | | | | | | | |
| **Cash Flow** | | | | | | | | |
| **Capital Expenditures** | (69,427,710) | (69,427,710) | (69,427,710) | (69,427,710) | (69,427,710) | (69,427,710) | (69,427,710) | (69,427,710) |
| **Operating Profit Before Tax** | 2,286,689,443 | 2,355,181,135 | 2,425,724,063 | 2,498,379,694 | 2,573,211,338 | 2,650,284,201 | 2,729,665,446 | 2,575,295,748 |
| **Unleveraged free cash flow (before taxes)** | **2,217,261,733** | **2,285,753,425** | **2,356,296,353** | **2,428,951,984** | **2,503,783,628** | **2,580,856,491** | **2,660,237,736** | **2,505,868,038** |
| **Income Taxes** | (598,660,668) | (617,153,425) | (636,200,015) | (655,817,036) | (676,021,580) | (696,831,253) | (718,264,189) | (676,584,370) |
| **Unleveraged free cash flow (after taxes)** | **1,618,601,065** | **1,668,600,000** | **1,720,096,338** | **1,773,134,949** | **1,827,762,048** | **1,884,025,239** | **1,941,973,547** | **1,829,283,668** |

NOTES:

1 : Assumes cost/price increase of 3.0% per annum

2 : Assumes cost/price increase of 3.0% per annum

3 : Assumes cost/price increase of 3.0% per annum

**INTERNAL RATE OF RETURN (IRR)**

IRR before income taxes

IRR after taxes (incl. Royalties)

Discount Factor

**NET PRESENT VALUE (NPV, discounted at 8%)**

NPV (before taxes)

NPV (after taxes)

NPV (after taxes) at 10%

# ENCLOSURE B



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

Magnesium DCF Inputs: Sales escalation 3% Opex escalation 3% brine opex $7.01 BMC for PCC

| | Totals | Project year | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|---|---|
| Brine volume | 100,000 | tonnes | 0 | 0 | 50,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| Brine price | $40 | CAD/tonne | $ 40.00 | $ 41.20 | $ 42.44 | $ 43.71 | $ 45.02 | $ 46.37 | $ 47.76 |
| Hydromag volume | 52,000 | tonnes | 0 | 0 | 0 | 0 | 52,000 | 52,000 | 52,000 |
| Hydromag price | $1,800 | CAD/tonne | $ 1,800.00 | $ 1,854.00 | $ 1,909.62 | $ 1,966.91 | $ 2,025.92 | $ 2,086.69 | $ 2,149.29 |
| MgCO3 volume | 52,000 | tonnes | 0 | 0 | 0 | 0 | 52,000 | 52,000 | 52,000 |
| MgCO3 price | $600 | CAD/tonne | $ 600.00 | $ 618.00 | $ 636.54 | $ 655.64 | $ 675.31 | $ 695.56 | $ 716.43 |
| **Operating revenue** | **$ 21,227,762,690.24** | **CAD** | **$ -** | **$ -** | **$ 2,121,800.00** | **$ 4,370,908.00** | **$ 144,965,534.73** | **$ 149,314,500.77** | **$ 153,793,935.79** |
| | | | | | | | | | |
| Capex | $ 171,164,794.00 | | $ 85,582,397.00 | $ 85,582,397.00 | | | | | |
| Sustaining Capex | $ 269,299,447.84 | | | | $ 1,711,647.94 | $ 1,762,997.38 | $ 1,815,887.30 | $ 1,870,363.92 | $ 1,926,474.84 |
| Opex | $ 5,291,633,405.93 | | $0.00 | $0.00 | $371,845.45 | $766,001.63 | $36,140,132.91 | $37,224,336.90 | $38,341,067.00 |
| Closure provision | $ 17,116,479.40 | | | | | | | | |
| Transport/marketing escalation | only for MgCO3 | | $ 65.00 | $ 66.95 | $ 68.96 | $ 71.03 | $ 73.16 | $ 75.35 | $ 77.61 |
| Transport | $ 556,893,575.62 | | $ - | $ - | $ - | $ - | $ 3,804,219.78 | $ 3,918,346.37 | $ 4,035,896.76 |
| **Operating profit before royalties, depreciation, tax** | **$ 15,092,819,781.45** | | **$ -** | **$ -** | **$ 38,306.61** | **$ 1,841,908.99** | **$ 103,205,294.74** | **$ 106,301,453.58** | **$ 109,490,497.19** |
| Income Tax (27%) | | | $ - | $ - | $ 10,342.78 | $ 497,315.43 | $ 27,865,429.58 | $ 28,701,392.47 | $ 29,562,434.24 |
| **Op. profit before royalties, depreciation** | **$ 11,017,758,440.46** | | **$ -** | **$ -** | **$ 27,963.83** | **$ 1,344,593.57** | **$ 75,339,865.16** | **$ 77,600,061.12** | **$ 79,928,062.95** |
| Crown royalty % | | | 0% | 0% | 5% | 5% | 5% | 5% | 5% |
| Crown royalty $ | $ 1,072,842,772.80 | | $ - | $ - | $ 1,398.19 | $ 67,229.68 | $ 3,766,993.26 | $ 3,880,003.06 | $ 3,996,403.15 |
| **Net Income (Not IFRS)** | **$ 9,944,915,667.66** | | **$ -** | **$ -** | **$ 26,565.63** | **$ 1,277,363.89** | **$ 71,572,871.90** | **$ 73,720,058.06** | **$ 75,931,659.80** |
| | | | | | | | | | |
| *Cash flows* | | | | | | | | | |
| Capex | | | $ (85,582,397.00) | $ (85,582,397.00) | $ - | $ - | $ - | $ - | $ - |
| Op. profit before tax (EBIT) | | | $ - | $ - | $ 38,306.61 | $ 1,841,908.99 | $ 103,205,294.74 | $ 106,301,453.58 | $ 109,490,497.19 |
| **unleveraged FCF before tax** | | | **$ (85,582,397.00)** | **$ (85,582,397.00)** | **$ 38,306.61** | **$ 1,841,908.99** | **$ 103,205,294.74** | **$ 106,301,453.58** | **$ 109,490,497.19** |
| Income taxes | | | $ - | $ - | $ (10,342.78) | $ (497,315.43) | $ (27,865,429.58) | $ (28,701,392.47) | $ (29,562,434.24) |
| **unleveraged FCF after tax** | | | **$ (85,582,397.00)** | **$ (85,582,397.00)** | **$ 27,963.83** | **$ 1,344,593.57** | **$ 75,339,865.16** | **$ 77,600,061.12** | **$ 79,928,062.95** |
| Crown royalties | | | $ - | $ - | $ (1,398.19) | $ (67,229.68) | $ (3,766,993.26) | $ (3,880,003.06) | $ (3,996,403.15) |
| **unleveraged FCF after tax and royalties** | | | **$ (85,582,397.00)** | **$ (85,582,397.00)** | **$ 26,565.63** | **$ 1,277,363.89** | **$ 71,572,871.90** | **$ 73,720,058.06** | **$ 75,931,659.80** |
| | | | | | | | | | |
| Cumulative cash flow | | | $ (85,582,397.00) | $ (171,164,794.00) | $ (171,138,228.37) | $ (169,860,864.48) | $ (98,287,992.58) | $ (24,567,934.51) | $ 51,363,725.29 |

**IRR**

| | |
|---|---|
| IRR before taxes | **32.6%** |
| IRR after taxes | **26.1%** |

**NPV**

| Discount rate | before tax | after tax |
|---|---|---|
| 10% | $835,978,878.52 | $511,897,305.07 |
| 11% | $692,499,338.05 | $417,390,219.09 |
| 12% | $579,156,877.28 | $342,740,261.70 |

**ROI**

| disc rate | before tax | after tax |
|---|---|---|
| 10% | 488% | 299% |
| 11% | 405% | 244% |
| 12% | 338% | 200% |

Magnesium DCF $302.01 BMC for TiO2 $302.01

| | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|
| Brine volume | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| Brine price | $ 49.19 | $ 50.67 | $ 52.19 | $ 53.76 | $ 55.37 | $ 57.03 | $ 58.74 | $ 60.50 | $ 62.32 |
| Hydromag volume | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 |
| Hydromag price | $ 2,213.77 | $ 2,280.19 | $ 2,348.59 | $ 2,419.05 | $ 2,491.62 | $ 2,566.37 | $ 2,643.36 | $ 2,722.66 | $ 2,804.34 |
| MgCO3 volume | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 |
| MgCO3 price | $ 737.92 | $ 760.06 | $ 782.86 | $ 806.35 | $ 830.54 | $ 855.46 | $ 881.12 | $ 907.55 | $ 934.78 |
| **Operating revenue** | **$ 158,407,753.87** | **$ 163,159,986.48** | **$ 168,054,786.08** | **$ 173,096,429.66** | **$ 178,289,322.55** | **$ 183,638,002.23** | **$ 189,147,142.29** | **$ 194,821,556.56** | **$ 200,666,203.26** |
| | | | | | | | | | |
| Capex | | | | | | | | | |
| Sustaining Capex | $ 1,984,269.08 | $ 2,043,797.15 | $ 2,105,111.07 | $ 2,168,264.40 | $ 2,233,312.33 | $ 2,300,311.70 | $ 2,369,321.05 | $ 2,440,400.68 | $ 2,513,612.71 |
| Opex | $39,491,299.01 | $40,676,037.98 | $41,896,319.12 | $43,153,208.70 | $44,447,804.96 | $45,781,239.11 | $47,154,676.28 | $48,569,316.57 | $50,026,396.07 |
| Closure provision | | | | | | | | | |
| Transport/marketing escalation | $ 79.94 | $ 82.34 | $ 84.81 | $ 87.35 | $ 89.98 | $ 92.67 | $ 95.45 | $ 98.32 | $ 101.27 |
| Transport | $ 4,156,973.67 | $ 4,281,682.88 | $ 4,410,133.36 | $ 4,542,437.36 | $ 4,678,710.48 | $ 4,819,071.80 | $ 4,963,643.95 | $ 5,112,553.27 | $ 5,265,929.87 |
| **Operating profit before royalties, depreciation, tax** | **$ 112,775,212.11** | **$ 116,158,468.47** | **$ 119,643,222.52** | **$ 123,232,519.20** | **$ 126,929,494.78** | **$ 130,737,379.62** | **$ 134,659,501.01** | **$ 138,699,286.04** | **$ 142,860,264.62** |
| Income Tax (27%) | $ 30,449,307.27 | $ 31,362,786.49 | $ 32,303,670.08 | $ 33,272,780.18 | $ 34,270,963.59 | $ 35,299,092.50 | $ 36,358,065.27 | $ 37,448,807.23 | $ 38,572,271.45 |
| **Op. profit before royalties, depreciation** | **$ 82,325,904.84** | **$ 84,795,681.98** | **$ 87,339,552.44** | **$ 89,959,739.02** | **$ 92,658,531.19** | **$ 95,438,287.12** | **$ 98,301,435.74** | **$ 101,250,478.81** | **$ 104,287,993.17** |
| Crown royalty % | 5% | 5% | 5% | 10% | 10% | 10% | 10% | 10% | 10% |
| Crown royalty $ | $ 4,116,295.24 | $ 4,239,784.10 | $ 4,366,977.62 | $ 4,497,986.95 | $ 9,265,853.12 | $ 9,543,828.71 | $ 9,830,143.57 | $ 10,125,047.88 | $ 10,428,799.32 |
| **Net Income (Not IFRS)** | **$ 78,209,609.60** | **$ 80,555,897.88** | **$ 82,972,574.82** | **$ 85,461,752.06** | **$ 83,392,678.07** | **$ 85,894,458.41** | **$ 88,471,292.16** | **$ 91,125,430.93** | **$ 93,859,193.85** |
| | | | | | | | | | |
| *Cash flows* | | | | | | | | | |
| Capex | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| Op. profit before tax (EBIT) | $ 112,775,212.11 | $ 116,158,468.47 | $ 119,643,222.52 | $ 123,232,519.20 | $ 126,929,494.78 | $ 130,737,379.62 | $ 134,659,501.01 | $ 138,699,286.04 | $ 142,860,264.62 |
| **unleveraged FCF before tax** | **$ 112,775,212.11** | **$ 116,158,468.47** | **$ 119,643,222.52** | **$ 123,232,519.20** | **$ 126,929,494.78** | **$ 130,737,379.62** | **$ 134,659,501.01** | **$ 138,699,286.04** | **$ 142,860,264.62** |
| Income taxes | $ (30,449,307.27) | $ (31,362,786.49) | $ (32,303,670.08) | $ (33,272,780.18) | $ (34,270,963.59) | $ (35,299,092.50) | $ (36,358,065.27) | $ (37,448,807.23) | $ (38,572,271.45) |
| **unleveraged FCF after tax** | **$ 82,325,904.84** | **$ 84,795,681.98** | **$ 87,339,552.44** | **$ 89,959,739.02** | **$ 92,658,531.19** | **$ 95,438,287.12** | **$ 98,301,435.74** | **$ 101,250,478.81** | **$ 104,287,993.17** |
| Crown royalties | $ (4,116,295.24) | $ (4,239,784.10) | $ (4,366,977.62) | $ (4,497,986.95) | $ (9,265,853.12) | $ (9,543,828.71) | $ (9,830,143.57) | $ (10,125,047.88) | $ (10,428,799.32) |
| **unleveraged FCF after tax and royalties** | **$ 78,209,609.60** | **$ 80,555,897.88** | **$ 82,972,574.82** | **$ 85,461,752.06** | **$ 83,392,678.07** | **$ 85,894,458.41** | **$ 88,471,292.16** | **$ 91,125,430.93** | **$ 93,859,193.85** |
| | | | | | | | | | |
| Cumulative cash flow | $ 129,573,334.88 | $ 210,129,232.77 | $ 293,101,807.59 | $ 378,563,559.65 | $ 461,956,237.72 | $ 547,850,696.13 | $ 636,321,988.29 | $ 727,447,419.22 | $ 821,306,613.07 |

**IRR**
IRR before taxes
IRR after taxes

**NPV**
Discount rate
10%
11%
12%

**ROI**
disc rate
10%
11%
12%

Magnesium DCF

| | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|
| Brine volume | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| Brine price | $ 64.19 | $ 66.11 | $ 68.10 | $ 70.14 | $ 72.24 | $ 74.41 | $ 76.64 | $ 78.94 | $ 81.31 |
| Hydromag volume | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 |
| Hydromag price | $ 2,888.47 | $ 2,975.13 | $ 3,064.38 | $ 3,156.31 | $ 3,251.00 | $ 3,348.53 | $ 3,448.99 | $ 3,552.46 | $ 3,659.03 |
| MgCO3 volume | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 |
| MgCO3 price | $ 962.82 | $ 991.71 | $ 1,021.46 | $ 1,052.10 | $ 1,083.67 | $ 1,116.18 | $ 1,149.66 | $ 1,184.15 | $ 1,219.68 |
| **Operating revenue** | **$ 206,686,189.36** | **$ 212,886,775.04** | **$ 219,273,378.29** | **$ 225,851,579.64** | **$ 232,627,127.03** | **$ 239,605,940.84** | **$ 246,794,119.06** | **$ 254,197,942.63** | **$ 261,823,880.91** |
| Capex | | | | | | | | | |
| Sustaining Capex | $ 2,589,021.09 | $ 2,666,691.72 | $ 2,746,692.47 | $ 2,829,093.24 | $ 2,913,966.04 | $ 3,001,385.02 | $ 3,091,426.57 | $ 3,184,169.37 | $ 3,279,694.45 |
| Opex | $51,527,187.95 | $53,073,003.59 | $54,665,193.69 | $56,305,149.50 | $57,994,303.99 | $59,734,133.11 | $61,526,157.10 | $63,371,941.82 | $65,273,100.07 |
| Closure provision | | | | | | | | | |
| Transport/marketing escalation | $ 104.31 | $ 107.44 | $ 110.66 | $ 113.98 | $ 117.40 | $ 120.92 | $ 124.55 | $ 128.28 | $ 132.13 |
| Transport | $ 5,423,907.76 | $ 5,586,625.00 | $ 5,754,223.75 | $ 5,926,850.46 | $ 6,104,655.97 | $ 6,287,795.65 | $ 6,476,429.52 | $ 6,670,722.41 | $ 6,870,844.08 |
| **Operating profit before royalties, depreciation, tax** | **$ 147,146,072.56** | **$ 151,560,454.73** | **$ 156,107,268.38** | **$ 160,790,486.43** | **$ 165,614,201.02** | **$ 170,582,627.05** | **$ 175,700,105.86** | **$ 180,971,109.04** | **$ 186,400,242.31** |
| Income Tax (27%) | $ 39,729,439.59 | $ 40,921,322.78 | $ 42,148,962.46 | $ 43,413,431.34 | $ 44,715,834.28 | $ 46,057,309.30 | $ 47,439,028.58 | $ 48,862,199.44 | $ 50,328,065.42 |
| **Op. profit before royalties, depreciation** | **$ 107,416,632.97** | **$ 110,639,131.96** | **$ 113,958,305.91** | **$ 117,377,055.09** | **$ 120,898,366.74** | **$ 124,525,317.75** | **$ 128,261,077.28** | **$ 132,108,909.60** | **$ 136,072,176.89** |
| Crown royalty % | 10% | 10% | 10% | 10% | 10% | 10% | 10% | 10% | 10% |
| Crown royalty $ | $ 10,741,663.30 | $ 11,063,913.20 | $ 11,395,830.59 | $ 11,737,705.51 | $ 12,089,836.67 | $ 12,452,531.77 | $ 12,826,107.73 | $ 13,210,890.96 | $ 13,607,217.69 |
| **Net Income (Not IFRS)** | **$ 96,674,969.67** | **$ 99,575,218.76** | **$ 102,562,475.32** | **$ 105,639,349.58** | **$ 108,808,530.07** | **$ 112,072,785.97** | **$ 115,434,969.55** | **$ 118,898,018.64** | **$ 122,464,959.20** |
| *Cash flows* | | | | | | | | | |
| Capex | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| Op. profit before tax (EBIT) | $ 147,146,072.56 | $ 151,560,454.73 | $ 156,107,268.38 | $ 160,790,486.43 | $ 165,614,201.02 | $ 170,582,627.05 | $ 175,700,105.86 | $ 180,971,109.04 | $ 186,400,242.31 |
| **unleveraged FCF before tax** | **$ 147,146,072.56** | **$ 151,560,454.73** | **$ 156,107,268.38** | **$ 160,790,486.43** | **$ 165,614,201.02** | **$ 170,582,627.05** | **$ 175,700,105.86** | **$ 180,971,109.04** | **$ 186,400,242.31** |
| Income taxes | $ (39,729,439.59) | $ (40,921,322.78) | $ (42,148,962.46) | $ (43,413,431.34) | $ (44,715,834.28) | $ (46,057,309.30) | $ (47,439,028.58) | $ (48,862,199.44) | $ (50,328,065.42) |
| **unleveraged FCF after tax** | **$ 107,416,632.97** | **$ 110,639,131.96** | **$ 113,958,305.91** | **$ 117,377,055.09** | **$ 120,898,366.74** | **$ 124,525,317.75** | **$ 128,261,077.28** | **$ 132,108,909.60** | **$ 136,072,176.89** |
| Crown royalties | $ (10,741,663.30) | $ (11,063,913.20) | $ (11,395,830.59) | $ (11,737,705.51) | $ (12,089,836.67) | $ (12,452,531.77) | $ (12,826,107.73) | $ (13,210,890.96) | $ (13,607,217.69) |
| **unleveraged FCF after tax and royalties** | **$ 96,674,969.67** | **$ 99,575,218.76** | **$ 102,562,475.32** | **$ 105,639,349.58** | **$ 108,808,530.07** | **$ 112,072,785.97** | **$ 115,434,969.55** | **$ 118,898,018.64** | **$ 122,464,959.20** |
| Cumulative cash flow | $ 917,981,582.74 | $ 1,017,556,801.50 | $ 1,120,119,276.83 | $ 1,225,758,626.41 | $ 1,334,567,156.48 | $ 1,446,639,942.45 | $ 1,562,074,912.00 | $ 1,680,972,930.64 | $ 1,803,437,889.84 |

**IRR**
IRR before taxes
IRR after taxes

**NPV**
Discount rate

| | |
|---|---|
| 10% | |
| 11% | |
| 12% | |

**ROI**
disc rate

| | |
|---|---|
| 10% | |
| 11% | |
| 12% | |

Magnesium DCF

| | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 |
|---|---|---|---|---|---|---|---|---|---|
| Brine volume | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| Brine price | $ 83.75 | $ 86.26 | $ 88.85 | $ 91.52 | $ 94.26 | $ 97.09 | $ 100.00 | $ 103.00 | $ 106.09 |
| Hydromag volume | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 |
| Hydromag price | $ 3,768.80 | $ 3,881.86 | $ 3,998.32 | $ 4,118.27 | $ 4,241.82 | $ 4,369.07 | $ 4,500.14 | $ 4,635.15 | $ 4,774.20 |
| MgCO3 volume | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 |
| MgCO3 price | $ 1,256.27 | $ 1,293.95 | $ 1,332.77 | $ 1,372.76 | $ 1,413.94 | $ 1,456.36 | $ 1,500.05 | $ 1,545.05 | $ 1,591.40 |
| **Operating revenue** | **$ 269,678,597.34** | **$ 277,768,955.26** | **$ 286,102,023.92** | **$ 294,685,084.63** | **$ 303,525,637.17** | **$ 312,631,406.29** | **$ 322,010,348.48** | **$ 331,670,658.93** | **$ 341,620,778.70** |
| | | | | | | | | | |
| Capex | | | | | | | | | |
| Sustaining Capex | $ 3,378,085.29 | $ 3,479,427.84 | $ 3,583,810.68 | $ 3,691,325.00 | $ 3,802,064.75 | $ 3,916,126.69 | $ 4,033,610.49 | $ 4,154,618.81 | $ 4,279,257.37 |
| Opex | $67,231,293.07 | $69,248,231.86 | $71,325,678.82 | $73,465,449.19 | $75,669,412.66 | $77,939,495.04 | $80,277,679.89 | $82,686,010.29 | $85,166,590.60 |
| Closure provision | | | | | | | | | |
| Transport/marketing escalation | $ 136.10 | $ 140.18 | $ 144.38 | $ 148.72 | $ 153.18 | $ 157.77 | $ 162.51 | $ 167.38 | $ 172.40 |
| Transport | $ 7,076,969.40 | $ 7,289,278.48 | $ 7,507,956.84 | $ 7,733,195.54 | $ 7,965,191.41 | $ 8,204,147.15 | $ 8,450,271.57 | $ 8,703,779.71 | $ 8,964,893.11 |
| **Operating profit before royalties, depreciation, tax** | **$ 191,992,249.58** | **$ 197,752,017.07** | **$ 203,684,577.58** | **$ 209,795,114.91** | **$ 216,088,968.35** | **$ 222,571,637.40** | **$ 229,248,786.53** | **$ 236,126,250.12** | **$ 243,210,037.62** |
| Income Tax (27%) | $ 51,837,907.39 | $ 53,393,044.61 | $ 54,994,835.95 | $ 56,644,681.02 | $ 58,344,021.46 | $ 60,094,342.10 | $ 61,897,172.36 | $ 63,754,087.53 | $ 65,666,710.16 |
| **Op. profit before royalties, depreciation** | **$ 140,154,342.19** | **$ 144,358,972.46** | **$ 148,689,741.63** | **$ 153,150,433.88** | **$ 157,744,946.90** | **$ 162,477,295.30** | **$ 167,351,614.16** | **$ 172,372,162.59** | **$ 177,543,327.47** |
| Crown royalty % | 10% | 10% | 10% | 10% | 10% | 10% | 10% | 10% | 10% |
| Crown royalty $ | $ 14,015,434.22 | $ 14,435,897.25 | $ 14,868,974.16 | $ 15,315,043.39 | $ 15,774,494.69 | $ 16,247,729.53 | $ 16,735,161.42 | $ 17,237,216.26 | $ 17,754,332.75 |
| **Net Income (Not IFRS)** | **$ 126,138,907.97** | **$ 129,923,075.21** | **$ 133,820,767.47** | **$ 137,835,390.49** | **$ 141,970,452.21** | **$ 146,229,565.77** | **$ 150,616,452.75** | **$ 155,134,946.33** | **$ 159,788,994.72** |
| | | | | | | | | | |
| *Cash flows* | | | | | | | | | |
| Capex | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| Op. profit before tax (EBIT) | $ 191,992,249.58 | $ 197,752,017.07 | $ 203,684,577.58 | $ 209,795,114.91 | $ 216,088,968.35 | $ 222,571,637.40 | $ 229,248,786.53 | $ 236,126,250.12 | $ 243,210,037.62 |
| **unleveraged FCF before tax** | **$ 191,992,249.58** | **$ 197,752,017.07** | **$ 203,684,577.58** | **$ 209,795,114.91** | **$ 216,088,968.35** | **$ 222,571,637.40** | **$ 229,248,786.53** | **$ 236,126,250.12** | **$ 243,210,037.62** |
| Income taxes | $ (51,837,907.39) | $ (53,393,044.61) | $ (54,994,835.95) | $ (56,644,681.02) | $ (58,344,021.46) | $ (60,094,342.10) | $ (61,897,172.36) | $ (63,754,087.53) | $ (65,666,710.16) |
| **unleveraged FCF after tax** | **$ 140,154,342.19** | **$ 144,358,972.46** | **$ 148,689,741.63** | **$ 153,150,433.88** | **$ 157,744,946.90** | **$ 162,477,295.30** | **$ 167,351,614.16** | **$ 172,372,162.59** | **$ 177,543,327.47** |
| Crown royalties | $ (14,015,434.22) | $ (14,435,897.25) | $ (14,868,974.16) | $ (15,315,043.39) | $ (15,774,494.69) | $ (16,247,729.53) | $ (16,735,161.42) | $ (17,237,216.26) | $ (17,754,332.75) |
| **unleveraged FCF after tax and royalties** | **$ 126,138,907.97** | **$ 129,923,075.21** | **$ 133,820,767.47** | **$ 137,835,390.49** | **$ 141,970,452.21** | **$ 146,229,565.77** | **$ 150,616,452.75** | **$ 155,134,946.33** | **$ 159,788,994.72** |
| | | | | | | | | | |
| Cumulative cash flow | $ 1,929,576,797.81 | $ 2,059,499,873.02 | $ 2,193,320,640.49 | $ 2,331,156,030.99 | $ 2,473,126,483.19 | $ 2,619,356,048.97 | $ 2,769,972,501.72 | $ 2,925,107,448.04 | $ 3,084,896,442.76 |

**IRR**
IRR before taxes
IRR after taxes

**NPV**
Discount rate

| |
|---|
| 10% |
| 11% |
| 12% |

**ROI**
disc rate

| |
|---|
| 10% |
| 11% |
| 12% |

Magnesium DCF

| | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 |
|---|---|---|---|---|---|---|---|---|---|
| Brine volume | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| Brine price | $ 109.28 | $ 112.55 | $ 115.93 | $ 119.41 | $ 122.99 | $ 126.68 | $ 130.48 | $ 134.40 | $ 138.43 |
| Hydromag volume | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 |
| Hydromag price | $ 4,917.43 | $ 5,064.95 | $ 5,216.90 | $ 5,373.41 | $ 5,534.61 | $ 5,700.65 | $ 5,871.67 | $ 6,047.82 | $ 6,229.25 |
| MgCO3 volume | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 |
| MgCO3 price | $ 1,639.14 | $ 1,688.32 | $ 1,738.97 | $ 1,791.14 | $ 1,844.87 | $ 1,900.22 | $ 1,957.22 | $ 2,015.94 | $ 2,076.42 |
| **Operating revenue** | **$ 351,869,402.06** | **$ 362,425,484.12** | **$ 373,298,248.65** | **$ 384,497,196.11** | **$ 396,032,111.99** | **$ 407,913,075.35** | **$ 420,150,467.61** | **$ 432,754,981.64** | **$ 445,737,631.09** |
| | | | | | | | | | |
| Capex | | | | | | | | | |
| Sustaining Capex | $ 4,407,635.09 | $ 4,539,864.15 | $ 4,676,060.07 | $ 4,816,341.87 | $ 4,960,832.13 | $ 5,109,657.09 | $ 5,262,946.81 | $ 5,420,835.21 | $ 5,583,460.27 |
| Opex | $87,721,588.31 | $90,353,235.96 | $93,063,833.04 | $95,855,748.03 | $98,731,420.48 | $101,693,363.09 | $104,744,163.98 | $107,886,488.90 | $111,123,083.57 |
| Closure provision | | | | | | | | | |
| Transport/marketing escalation | $ 177.57 | $ 182.90 | $ 188.39 | $ 194.04 | $ 199.86 | $ 205.86 | $ 212.03 | $ 218.39 | $ 224.95 |
| Transport | $ 9,233,839.90 | $ 9,510,855.10 | $ 9,796,180.75 | $ 10,090,066.17 | $ 10,392,768.16 | $ 10,704,551.20 | $ 11,025,687.74 | $ 11,356,458.37 | $ 11,697,152.12 |
| **Operating profit before royalties, depreciation, tax** | **$ 250,506,338.75** | **$ 258,021,528.92** | **$ 265,762,174.78** | **$ 273,735,040.03** | **$ 281,947,091.23** | **$ 290,405,503.96** | **$ 299,117,669.08** | **$ 308,091,199.16** | **$ 317,333,935.13** |
| Income Tax (27%) | $ 67,636,711.46 | $ 69,665,812.81 | $ 71,755,787.19 | $ 73,908,460.81 | $ 76,125,714.63 | $ 78,409,486.07 | $ 80,761,770.65 | $ 83,184,623.77 | $ 85,680,162.49 |
| **Op. profit before royalties, depreciation** | **$ 182,869,627.29** | **$ 188,355,716.11** | **$ 194,006,387.59** | **$ 199,826,579.22** | **$ 205,821,376.60** | **$ 211,996,017.89** | **$ 218,355,898.43** | **$ 224,906,575.38** | **$ 231,653,772.65** |
| Crown royalty % | 10% | 10% | 10% | 10% | 10% | 10% | 10% | 10% | 10% |
| Crown royalty $ | $ 18,286,962.73 | $ 18,835,571.61 | $ 19,400,638.76 | $ 19,982,657.92 | $ 20,582,137.66 | $ 21,199,601.79 | $ 21,835,589.84 | $ 22,490,657.54 | $ 23,165,377.26 |
| **Net Income (Not IFRS)** | **$ 164,582,664.56** | **$ 169,520,144.50** | **$ 174,605,748.83** | **$ 179,843,921.30** | **$ 185,239,238.94** | **$ 190,796,416.10** | **$ 196,520,308.59** | **$ 202,415,917.85** | **$ 208,488,395.38** |
| | | | | | | | | | |
| *Cash flows* | | | | | | | | | |
| Capex | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| Op. profit before tax (EBIT) | $ 250,506,338.75 | $ 258,021,528.92 | $ 265,762,174.78 | $ 273,735,040.03 | $ 281,947,091.23 | $ 290,405,503.96 | $ 299,117,669.08 | $ 308,091,199.16 | $ 317,333,935.13 |
| **unleveraged FCF before tax** | **$ 250,506,338.75** | **$ 258,021,528.92** | **$ 265,762,174.78** | **$ 273,735,040.03** | **$ 281,947,091.23** | **$ 290,405,503.96** | **$ 299,117,669.08** | **$ 308,091,199.16** | **$ 317,333,935.13** |
| Income taxes | $ (67,636,711.46) | $ (69,665,812.81) | $ (71,755,787.19) | $ (73,908,460.81) | $ (76,125,714.63) | $ (78,409,486.07) | $ (80,761,770.65) | $ (83,184,623.77) | $ (85,680,162.49) |
| **unleveraged FCF after tax** | **$ 182,869,627.29** | **$ 188,355,716.11** | **$ 194,006,387.59** | **$ 199,826,579.22** | **$ 205,821,376.60** | **$ 211,996,017.89** | **$ 218,355,898.43** | **$ 224,906,575.38** | **$ 231,653,772.65** |
| Crown royalties | $ (18,286,962.73) | $ (18,835,571.61) | $ (19,400,638.76) | $ (19,982,657.92) | $ (20,582,137.66) | $ (21,199,601.79) | $ (21,835,589.84) | $ (22,490,657.54) | $ (23,165,377.26) |
| **unleveraged FCF after tax and royalties** | **$ 164,582,664.56** | **$ 169,520,144.50** | **$ 174,605,748.83** | **$ 179,843,921.30** | **$ 185,239,238.94** | **$ 190,796,416.10** | **$ 196,520,308.59** | **$ 202,415,917.85** | **$ 208,488,395.38** |
| | | | | | | | | | |
| Cumulative cash flow | $ 3,249,479,107.33 | $ 3,418,999,251.82 | $ 3,593,605,000.66 | $ 3,773,448,921.95 | $ 3,958,688,160.89 | $ 4,149,484,576.99 | $ 4,346,004,885.58 | $ 4,548,420,803.43 | $ 4,756,909,198.81 |

**IRR**
IRR before taxes
IRR after taxes

**NPV**
Discount rate
10%
11%
12%

**ROI**
disc rate
10%
11%
12%

Magnesium DCF

| | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 |
|---|---|---|---|---|---|---|---|---|---|
| Brine volume | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| Brine price | $ 142.58 | $ 146.86 | $ 151.26 | $ 155.80 | $ 160.48 | $ 165.29 | $ 170.25 | $ 175.36 | $ 180.62 |
| Hydromag volume | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 |
| Hydromag price | $ 6,416.13 | $ 6,608.61 | $ 6,806.87 | $ 7,011.08 | $ 7,221.41 | $ 7,438.05 | $ 7,661.19 | $ 7,891.03 | $ 8,127.76 |
| MgCO3 volume | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 |
| MgCO3 price | $ 2,138.71 | $ 2,202.87 | $ 2,268.96 | $ 2,337.03 | $ 2,407.14 | $ 2,479.35 | $ 2,553.73 | $ 2,630.34 | $ 2,709.25 |
| **Operating revenue** | **$ 459,109,760.02** | **$ 472,883,052.82** | **$ 487,069,544.40** | **$ 501,681,630.74** | **$ 516,732,079.66** | **$ 532,234,042.05** | **$ 548,201,063.31** | **$ 564,647,095.21** | **$ 581,586,508.07** |
| | | | | | | | | | |
| Capex | | | | | | | | | |
| Sustaining Capex | $ 5,750,964.07 | $ 5,923,493.00 | $ 6,101,197.79 | $ 6,284,233.72 | $ 6,472,760.73 | $ 6,666,943.55 | $ 6,866,951.86 | $ 7,072,960.42 | $ 7,285,149.23 |
| Opex | $114,456,776.08 | $117,890,479.36 | $121,427,193.74 | $125,070,009.55 | $128,822,109.84 | $132,686,773.13 | $136,667,376.33 | $140,767,397.62 | $144,990,419.55 |
| Closure provision | | | | | | | | | |
| Transport/marketing escalation | $ 231.69 | $ 238.64 | $ 245.80 | $ 253.18 | $ 260.77 | $ 268.60 | $ 276.65 | $ 284.95 | $ 293.50 |
| Transport | $ 12,048,066.68 | $ 12,409,508.68 | $ 12,781,793.94 | $ 13,165,247.76 | $ 13,560,205.20 | $ 13,967,011.35 | $ 14,386,021.69 | $ 14,817,602.34 | $ 15,262,130.41 |
| **Operating profit before royalties, depreciation, tax** | **$ 326,853,953.18** | **$ 336,659,571.78** | **$ 346,759,358.93** | **$ 357,162,139.70** | **$ 367,877,003.89** | **$ 378,913,314.01** | **$ 390,280,713.43** | **$ 401,989,134.83** | **$ 414,048,808.88** |
| Income Tax (27%) | $ 88,250,567.36 | $ 90,898,084.38 | $ 93,625,026.91 | $ 96,433,777.72 | $ 99,326,791.05 | $ 102,306,594.78 | $ 105,375,792.63 | $ 108,537,066.40 | $ 111,793,178.40 |
| **Op. profit before royalties, depreciation** | **$ 238,603,385.82** | **$ 245,761,487.40** | **$ 253,134,332.02** | **$ 260,728,361.98** | **$ 268,550,212.84** | **$ 276,606,719.23** | **$ 284,904,920.80** | **$ 293,452,068.43** | **$ 302,255,630.48** |
| Crown royalty % | 10% | 10% | 10% | 10% | 10% | 10% | 10% | 10% | 10% |
| Crown royalty $ | $ 23,860,338.58 | $ 24,576,148.74 | $ 25,313,433.20 | $ 26,072,836.20 | $ 26,855,021.28 | $ 27,660,671.92 | $ 28,490,492.08 | $ 29,345,206.84 | $ 30,225,563.05 |
| **Net Income (Not IFRS)** | **$ 214,743,047.24** | **$ 221,185,338.66** | **$ 227,820,898.82** | **$ 234,655,525.78** | **$ 241,695,191.56** | **$ 248,946,047.30** | **$ 256,414,428.72** | **$ 264,106,861.59** | **$ 272,030,067.43** |
| | | | | | | | | | |
| *Cash flows* | | | | | | | | | |
| Capex | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| Op. profit before tax (EBIT) | $ 326,853,953.18 | $ 336,659,571.78 | $ 346,759,358.93 | $ 357,162,139.70 | $ 367,877,003.89 | $ 378,913,314.01 | $ 390,280,713.43 | $ 401,989,134.83 | $ 414,048,808.88 |
| **unleveraged FCF before tax** | **$ 326,853,953.18** | **$ 336,659,571.78** | **$ 346,759,358.93** | **$ 357,162,139.70** | **$ 367,877,003.89** | **$ 378,913,314.01** | **$ 390,280,713.43** | **$ 401,989,134.83** | **$ 414,048,808.88** |
| Income taxes | $ (88,250,567.36) | $ (90,898,084.38) | $ (93,625,026.91) | $ (96,433,777.72) | $ (99,326,791.05) | $ (102,306,594.78) | $ (105,375,792.63) | $ (108,537,066.40) | $ (111,793,178.40) |
| **unleveraged FCF after tax** | **$ 238,603,385.82** | **$ 245,761,487.40** | **$ 253,134,332.02** | **$ 260,728,361.98** | **$ 268,550,212.84** | **$ 276,606,719.23** | **$ 284,904,920.80** | **$ 293,452,068.43** | **$ 302,255,630.48** |
| Crown royalties | $ (23,860,338.58) | $ (24,576,148.74) | $ (25,313,433.20) | $ (26,072,836.20) | $ (26,855,021.28) | $ (27,660,671.92) | $ (28,490,492.08) | $ (29,345,206.84) | $ (30,225,563.05) |
| **unleveraged FCF after tax and royalties** | **$ 214,743,047.24** | **$ 221,185,338.66** | **$ 227,820,898.82** | **$ 234,655,525.78** | **$ 241,695,191.56** | **$ 248,946,047.30** | **$ 256,414,428.72** | **$ 264,106,861.59** | **$ 272,030,067.43** |
| | | | | | | | | | |
| Cumulative cash flow | $ 4,971,652,246.05 | $ 5,192,837,584.71 | $ 5,420,658,483.53 | $ 5,655,314,009.31 | $ 5,897,009,200.87 | $ 6,145,955,248.18 | $ 6,402,369,676.90 | $ 6,666,476,538.48 | $ 6,938,506,605.92 |

**IRR**
IRR before taxes
IRR after taxes

**NPV**
Discount rate
10%
11%
12%

**ROI**
disc rate
10%
11%
12%

Magnesium DCF

| | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 |
|---|---|---|---|---|---|---|---|---|---|
| Brine volume | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| Brine price | $ 186.04 | $ 191.62 | $ 197.36 | $ 203.29 | $ 209.38 | $ 215.67 | $ 222.14 | $ 228.80 | $ 235.66 |
| Hydromag volume | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 |
| Hydromag price | $ 8,371.59 | $ 8,622.74 | $ 8,881.42 | $ 9,147.87 | $ 9,422.30 | $ 9,704.97 | $ 9,996.12 | $ 10,296.01 | $ 10,604.89 |
| MgCO3 volume | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 | 52,000 |
| MgCO3 price | $ 2,790.53 | $ 2,874.25 | $ 2,960.47 | $ 3,049.29 | $ 3,140.77 | $ 3,234.99 | $ 3,332.04 | $ 3,432.00 | $ 3,534.96 |
| **Operating revenue** | **$ 599,034,103.31** | **$ 617,005,126.41** | **$ 635,515,280.20** | **$ 654,580,738.61** | **$ 674,218,160.76** | **$ 694,444,705.59** | **$ 715,278,046.75** | **$ 736,736,388.16** | **$ 758,838,479.80** |
| | | | | | | | | | |
| Capex | | | | | | | | | |
| Sustaining Capex | $ 7,503,703.71 | $ 7,728,814.82 | $ 7,960,679.26 | $ 8,199,499.64 | $ 8,445,484.63 | $ 8,698,849.17 | $ 8,959,814.64 | $ 9,228,609.08 | $ 9,505,467.35 |
| Opex | $149,340,132.13 | $153,820,336.10 | $158,434,946.18 | $163,187,994.56 | $168,083,634.40 | $173,126,143.43 | $178,319,927.74 | $183,669,525.57 | $189,179,611.34 |
| Closure provision | | | | | | | | | 17116479.4 |
| Transport/marketing escalation | $ 302.31 | $ 311.38 | $ 320.72 | $ 330.34 | $ 340.25 | $ 350.46 | $ 360.97 | $ 371.80 | $ 382.95 |
| Transport | $ 15,719,994.33 | $ 16,191,594.16 | $ 16,677,341.98 | $ 17,177,662.24 | $ 17,692,992.11 | $ 18,223,781.87 | $ 18,770,495.33 | $ 19,333,610.19 | $ 19,913,618.49 |
| **Operating profit before royalties, depreciation, tax** | **$ 426,470,273.14** | **$ 439,264,381.34** | **$ 452,442,312.78** | **$ 466,015,582.16** | **$ 479,996,049.63** | **$ 494,395,931.12** | **$ 509,227,809.05** | **$ 524,504,643.32** | **$ 523,123,303.22** |
| Income Tax (27%) | $ 115,146,973.75 | $ 118,601,382.96 | $ 122,159,424.45 | $ 125,824,207.18 | $ 129,598,933.40 | $ 133,486,901.40 | $ 137,491,508.44 | $ 141,616,253.70 | $ 141,243,291.87 |
| **Op. profit before royalties, depreciation** | **$ 311,323,299.40** | **$ 320,662,998.38** | **$ 330,282,888.33** | **$ 340,191,374.98** | **$ 350,397,116.23** | **$ 360,909,029.71** | **$ 371,736,300.61** | **$ 382,888,389.62** | **$ 381,880,011.35** |
| Crown royalty % | 10% | 10% | 10% | 10% | 10% | 10% | 10% | 10% | 10% |
| Crown royalty $ | $ 31,132,329.94 | $ 32,066,299.84 | $ 33,028,288.83 | $ 34,019,137.50 | $ 35,039,711.62 | $ 36,090,902.97 | $ 37,173,630.06 | $ 38,288,838.96 | $ 38,188,001.14 |
| **Net Income (Not IFRS)** | **$ 280,190,969.46** | **$ 288,596,698.54** | **$ 297,254,599.50** | **$ 306,172,237.48** | **$ 315,357,404.60** | **$ 324,818,126.74** | **$ 334,562,670.55** | **$ 344,599,550.66** | **$ 343,692,010.22** |
| | | | | | | | | | |
| *Cash flows* | | | | | | | | | |
| Capex | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| Op. profit before tax (EBIT) | $ 426,470,273.14 | $ 439,264,381.34 | $ 452,442,312.78 | $ 466,015,582.16 | $ 479,996,049.63 | $ 494,395,931.12 | $ 509,227,809.05 | $ 524,504,643.32 | $ 523,123,303.22 |
| **unleveraged FCF before tax** | **$ 426,470,273.14** | **$ 439,264,381.34** | **$ 452,442,312.78** | **$ 466,015,582.16** | **$ 479,996,049.63** | **$ 494,395,931.12** | **$ 509,227,809.05** | **$ 524,504,643.32** | **$ 523,123,303.22** |
| Income taxes | $ (115,146,973.75) | $ (118,601,382.96) | $ (122,159,424.45) | $ (125,824,207.18) | $ (129,598,933.40) | $ (133,486,901.40) | $ (137,491,508.44) | $ (141,616,253.70) | $ (141,243,291.87) |
| **unleveraged FCF after tax** | **$ 311,323,299.40** | **$ 320,662,998.38** | **$ 330,282,888.33** | **$ 340,191,374.98** | **$ 350,397,116.23** | **$ 360,909,029.71** | **$ 371,736,300.61** | **$ 382,888,389.62** | **$ 381,880,011.35** |
| Crown royalties | $ (31,132,329.94) | $ (32,066,299.84) | $ (33,028,288.83) | $ (34,019,137.50) | $ (35,039,711.62) | $ (36,090,902.97) | $ (37,173,630.06) | $ (38,288,838.96) | $ (38,188,001.14) |
| **unleveraged FCF after tax and royalties** | **$ 280,190,969.46** | **$ 288,596,698.54** | **$ 297,254,599.50** | **$ 306,172,237.48** | **$ 315,357,404.60** | **$ 324,818,126.74** | **$ 334,562,670.55** | **$ 344,599,550.66** | **$ 343,692,010.22** |
| | | | | | | | | | |
| Cumulative cash flow | $ 7,218,697,575.37 | $ 7,507,294,273.91 | $ 7,804,548,873.41 | $ 8,110,721,110.89 | $ 8,426,078,515.49 | $ 8,750,896,642.23 | $ 9,085,459,312.78 | $ 9,430,058,863.44 | $ 9,773,750,873.66 |

**IRR**
IRR before taxes
IRR after taxes

**NPV**
Discount rate

| |
|---|
| 10% |
| 11% |
| 12% |

**ROI**
disc rate

| |
|---|
| 10% |
| 11% |
| 12% |

# APPENDIX 1



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

Ministry of
Energy and
Resources

Lease No. KLSA 010

# SUBSURFACE MINERAL LEASE

**Lease by Special Agreement under**
**Section 4(b) of *The Crown Minerals Act***

THIS LEASE made as of this 14th day of February, 2011.

BETWEEN:

**HER MAJESTY THE QUEEN IN RIGHT OF SASKATCHEWAN**
as represented by the Minister of Energy and Resources,
hereinafter called the "Minister",

and

**KARNALYTE RESOURCES INC.**
hereinafter called the "Lessee".

IN CONSIDERATION of the mutual covenants herein contained, the parties hereto agree as follows:

THAT, subject to *The Crown Minerals Act* (hereinafter referred to as the "Act") as that Act may be amended, revised or substituted from time to time and subject to any applicable regulations made or continued under the Act, as those regulations or any of them may be amended, revised or substituted from time to time, and the covenants, terms and conditions hereinafter set forth, the Minister hereby grants, demises and leases to the Lessee for the term stated in this lease, the subsurface minerals within the meaning of *The Subsurface Mineral Regulations, 1960*, as the same may be amended, revised or substituted from time to time (hereinafter referred to as "The Regulations") under the lands described in Schedule "A" hereto, insofar as the Minister has the right to grant, demise and lease the same, excepting and reserving the royalties payable pursuant to the Regulations, with full and exclusive power and right, to the Lessee, subject to any applicable laws in force in the Province of Saskatchewan, to search for, dig, work, mine, extract, recover, process and carry away the said subsurface minerals. The Minister and the Lessee further agree as follows:

1. The term of this lease shall be for a period of twenty-one years commencing on September 8, 2010 and expiring on September 7, 2031, both dates inclusive, and shall be renewable at the option of the Lessee for successive terms of twenty-one years each upon the written application of the Lessee submitted to the Minister at least 90 days prior to the expiration of each period of twenty-one years, provided that the Lessee has complied fully with the conditions of the lease or renewal thereof and with the Act and the Regulations.

2. (1) The Lessee shall make or cause to be made all payments and returns in the manner and at the time required by the Regulations or any other applicable laws.

(2) For the purposes of subclause (1), "payments" includes, without restricting the generality of the word, rentals, royalties, fees, rates, taxes and assessments that may be charged or be payable in respect of the subsurface minerals included in this lease or in respect of the operations of the Lessee under this Lease.

(3) Nothing in subclause (1) prejudices the exercise of any right the Lessee may have to appeal or contest any rates, taxes or assessments as provided by law.



Acid-free Paper

3. This lease does not convey to the Lessee any interest in or any right or privilege with respect to the surface of the lease area.

4. The Lessee agrees to keep harmless and indemnify the Minister from and against all actions, suits, claims and demands arising out of or in connection with the operations carried on by the Lessee, its employees, agents, licensees and contractors, deriving from this lease.

5. The Lessee agrees to pay all accounts of every kind for wages, supplies, workers' compensation, assessments and all other accounts and indebtedness incurred by it relating to its operations under this lease as those payments become payable so that no claim or lien can arise on the subsurface minerals, and that the lessee will discharge immediately any liens or other encumbrances which may arise in respect of any work done pursuant to this lease.

6. The Lessee shall carry on all operations under this lease in a skillful and proper manner and in compliance with acceptable practices in the mining industry and shall take all reasonable and necessary steps to prevent injury and damage to life or property.

7 (1) The Lessee shall properly keep all books, records, returns and reports of the kind and in the form mentioned in the Act or the Regulations.

(2) The Minister or his authorized agent may at any time and from time to time enter into any premises or place where the business of the Lessee is carried on, any property is kept, or anything is done in connection with such a business, or any books, records, or reports are or should be kept for the purposes of inspection and examination of such books, records and reports and of the plans, works and operations of the Lessee in connection with this lease and may, without restricting the generality of the foregoing, take samples of minerals and other substances encountered during the operations and carry out tests and examinations.

(3) The Minister or his authorized agent may at any time and from time to time require the production for examination of any property or documents described in subclause (2) and may make and remove copies or extracts therefrom.

(4) The Lessee agrees to give or cause to be given all assistance that the Minister or his authorized agent may require for carrying out the acts mentioned in this clause.

8. The Lessee shall comply with all laws and orders in force in Saskatchewan from time to time applicable to its operations under this lease and in particular, without restricting the generality of the foregoing, shall comply with the Act, the Regulations, *The Oil and Gas Conservation Act* and Regulations, *The Mineral Resources Act, 1985* and Regulations, and with all legislation, regulations and orders in force in the Province of Saskatchewan applicable to its operations under this lease and relating to occupational health and safety, environmental and public protection and safety, resource conservation, management and development and surface rights.

9. No waiver by or on behalf of the Minister of a breach on the part of the Lessee of any covenant, obligation, condition, restriction or stipulation contained in this lease shall take effect and be binding on the Minister unless it is in writing and such a waiver shall extend only to the particular breach waived and shall not limit or restrict the rights of the Minister with respect to any other breach.

10. This lease may be cancelled by the Minister if there has been a breach by the Lessee of any of the provisions of this lease or any of the provisions of the Act or of the Regulations relating to this lease. Unless the Regulations provide for the automatic lapse of this lease, the Minister shall not cancel this lease unless he has given written notice to the Lessee that this lease may be cancelled and the Lessee has not remedied or commenced to remedy the default to the satisfaction of the Minister within 60 days after the receipt of the notice.

11. (1) On the termination of this lease by cancellation, surrender or expiration of term, the Lessee shall comply with all directions or orders of the Minister or any other official of the Province of Saskatchewan respecting the cleanup and restoration of the subsurface mineral lease area.

(2) In the event that the Lessee fails to comply with the directions or orders referred to in subclause (1), the Minister may take whatever action he deems necessary including, without limiting the generality of the foregoing, taking possession of or disposing of any property remaining in the subsurface mineral lease area. Upon such taking of possession or disposition, the Lessee shall be deemed to have forfeited any right, title, or interest it may have had in, or to, such property and any right to claim consideration or compensation therefor and such property shall thereupon become the property of Her Majesty the Queen in right of the Province of Saskatchewan.

(3) Unless otherwise ordered by the Minister to be removed pursuant to subclause (1), upon such termination, any installations in the subsurface mineral lease area necessary for the preservation of the mine or other development work such as underground timbering, supports, shaft linings and well casings shall be left intact and undisturbed by the Lessee and any right, title, or interest which the Lessee may have had in such installations or development work shall be deemed to have been forfeited to and become the property of Her Majesty the Queen in right of the Province of Saskatchewan and the Lessee shall not be entitled to consideration or compensation for them.

(4) Any costs incurred by the Minister as a result of the Lessee's failure to comply with any direction or order mentioned in subclause (1) shall constitute a debt due by the Lessee to Her Majesty and may be recovered by Her Majesty as provided for by law.

(5) The rights and remedies mentioned in this clause shall be in addition to any other rights and remedies which the Minister may have pursuant to this lease or by law.

12. If the Lessee shall become bankrupt or take the benefit of any Act in force for bankrupt or insolvent debtors or file any proposal or make any assignment for the benefit of creditors, the Minister, in addition to any other rights or remedies he may have, pursuant to this lease or by law, shall have the right to terminate this lease by written notice to the Lessee. For greater certainty, if any of the events mentioned in this clause shall occur, the Minister may apply or rely upon any of the provisions of this lease dealing with a default on the part of the Lessee or with the termination of this lease.

13. Any right of action of the Minister against the Lessee in respect of any default of the Lessee in complying with the terms and conditions of this lease shall not be prejudiced by the termination of this lease by cancellation, surrender or expiration of term, and the Minister shall have the same remedies for the recovery of royalties, payments, or damages due or accruing due at the time of termination as if this lease remained in full force and effect.

14. The Lessee shall not assign, transfer or sublet this lease or any of the rights, privileges or obligations thereunder without the prior written consent of the Minister.

15. This lease shall be governed by and interpreted in accordance with the laws of the Province of Saskatchewan and the applicable laws of Canada.

16. Time shall be of the essence of this lease and of every part of it and no extension or variation of this agreement shall operate as a waiver of this provision unless specifically stated, in writing, to so operate.

17. The Lessee acknowledges and agrees that its rights, interests, duties and obligations under this lease shall be and shall be deemed to be amended or varied, in whole or in part, in accordance with any amendments to or substitutions of, the provisions of *The Crown Minerals Act* or *The Subsurface Mineral Regulations, 1960* including, without limiting the generality of the foregoing, amendments or substitutions made to the Act or the

Regulations after the execution or issuance of this lease or any renewal or substitution thereof.

18. Any notice to the Lessee under this lease shall be sufficiently served if posted by registered mail in an envelope with postage prepaid to the following address:

Karnalyte Resources Inc.
104 – 26 Crystalridge Drive
Okotoks, AB T1S 2C3

Any notice to the Minister under this lease shall be sufficiently served if posted by registered mail in an envelope with postage prepaid to the following address:

Director, Mines Branch
Saskatchewan Energy and Resources
2101 Scarth Street
Regina, SK S4P 2H9

19. The parties agree that this lease and everything contained herein shall enure to the benefit of and be binding upon their respective successors and permitted assigns.

20. (1) The Lessee shall, within 12 months of the commencement of the lease term, provide the Minister with a technical report that addresses how subsidence associated with activities under the lease, and the impact of subsidence, is to be managed or avoided and, if applicable, establishes safety buffers between adjacent mines and along provincial borders. The technical report shall:

(a) span the next five years of operation, based on the existing mining plan;

(b) identify sensitive structures including but not limited to communities, pipelines, dams, rail lines, airports, towers, gas caverns, lakes, rivers, ground water and adjoining mines;

(c) consider the impact of subsidence under and around sensitive areas;

(d) establish base line data and define how the subsidence will be monitored;

(e) explain and justify the actions intended to minimize subsidence or the impacts of subsidence; and

(f) be prepared and approved by a Professional Engineer.

(2) A new technical report shall be submitted to the Minister every five years, or after each major deviation from the mining plan considered in the previous report, or at any time at the request of the Minister. Each subsequent report, in addition to meeting the requirements of subclause (1), shall review the previous technical report and:

(a) compare the subsidence experienced with the subsidence anticipated;

(b) compare the damages experienced with the damages anticipated; and

(c) confirm the suitability of hypotheses used in the previous technical report.

(3) The Minister may, in his discretion, waive the requirement for a subsequent technical report for non-producing leases.

21. Except as otherwise set out in clause 22:

(a) this lease and all rights and obligations of the Lessee hereunder shall be governed by *The Subsurface Mineral Regulations, 1960,* as those regulations may be amended, revised or substituted from time to time; and

(b) in the event of any conflict between the provisions of this lease and the provisions of the Act or Regulations, the provisions of the Act or Regulations shall govern.

22. Sections 19, 25a and 25b of *The Subsurface Mineral Regulations, 1960* do not apply to this lease.

IN WITNESS WHEREOF this lease has been executed by a designated officer on behalf of the Minister and the Lessee has caused its corporate seal to be affixed hereto, attested by its proper officers in that behalf as of the date first above written.

SIGNED, SEALED AND DELIVERED
in the presence of:

**HER MAJESTY THE QUEEN IN RIGHT OF SASKATCHEWAN,**
as represented by the Minister of Energy and Resources

(Signature)

MIKE DETHARET
(Name in full - print)

DIRECTOR - MINES BRANCH
(Title)

**KARNALYTE RESOURCES INC.**

(Signature)

Robin Phinney
(Name in full - print)

CEO
(Title)

# SCHEDULE "A"

**Attach to the Subsurface Mineral Lease KLSA 010**

**Between**

**HER MAJESTY, THE QUEEN**

**and**

**Karnalyte Resources Inc. 100%**

| | | | | | | Crown Land (Acres) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Sectional | Road Allowances | | |
| Sec | Portion | Description | Twp | Rge | Mer | Area | South | West | Int |
| 28 | ALL | | 31 | 16 | 2 | 640.05 | 8.00 | 8.00 | 0.10 |
| 29 | ALL | | 31 | 16 | 2 | 640.63 | 8.00 | 8.00 | 0.10 |
| 30 | N | | 31 | 16 | 2 | 320.00 | 0.00 | 4.00 | 0.00 |
| 30 | SE | | 31 | 16 | 2 | 160.06 | 4.00 | 0.00 | 0.00 |
| 31 | NW | | 31 | 16 | 2 | 159.98 | 0.00 | 4.00 | 0.00 |
| 31 | S | | 31 | 16 | 2 | 320.00 | 0.00 | 4.00 | 0.00 |
| 32 | ALL | | 31 | 16 | 2 | 640.60 | 0.00 | 8.00 | 0.00 |
| 33 | ALL | | 31 | 16 | 2 | 640.49 | 0.00 | 8.00 | 0.00 |
| | | | | Sub Totals = | | 3,521.81 | 20.00 | 44.00 | 0.20 |
| 04 | ALL | | 32 | 16 | 2 | 639.25 | 8.00 | 8.00 | 0.10 |
| 05 | N | An undivided one-half interest. | 32 | 16 | 2 | 160.35 | 0.00 | 4.00 | 0.00 |
| 05 | S | Road Allowance Only | 32 | 16 | 2 | 0.00 | 8.00 | 4.00 | 0.10 |
| 06 | ALL | | 32 | 16 | 2 | 639.06 | 8.00 | 8.00 | 0.10 |
| 07 | SE | | 32 | 16 | 2 | 159.89 | 0.00 | 0.00 | 0.00 |
| 08 | ALL | | 32 | 16 | 2 | 640.71 | 0.00 | 8.00 | 0.00 |
| 09 | ALL | | 32 | 16 | 2 | 638.03 | 0.00 | 8.00 | 0.00 |
| 10 | ALL | | 32 | 16 | 2 | 638.93 | 0.00 | 8.00 | 0.00 |
| 11 | ALL | | 32 | 16 | 2 | 639.14 | 0.00 | 8.00 | 0.00 |
| 14 | ALL | | 32 | 16 | 2 | 638.15 | 8.00 | 8.00 | 0.10 |
| 15 | ALL | Portion Freehold of 2.00 acres. | 32 | 16 | 2 | 637.48 | 8.00 | 8.00 | 0.10 |
| 16 | ALL | | 32 | 16 | 2 | 639.55 | 8.00 | 8.00 | 0.10 |
| 17 | ALL | | 32 | 16 | 2 | 640.65 | 8.00 | 8.00 | 0.10 |
| 18 | ALL | | 32 | 16 | 2 | 639.05 | 8.00 | 8.00 | 0.10 |
| 19 | ALL | | 32 | 16 | 2 | 639.24 | 0.00 | 8.00 | 0.00 |
| 20 | ALL | | 32 | 16 | 2 | 638.82 | 0.00 | 8.00 | 0.00 |
| 21 | 10 | | 32 | 16 | 2 | 39.99 | 0.00 | 0.00 | 0.00 |
| 21 | NW | | 32 | 16 | 2 | 159.98 | 0.00 | 4.00 | 0.00 |
| 21 | SE | | 32 | 16 | 2 | 159.70 | 0.00 | 0.00 | 0.00 |
| 21 | SW | An undivided one-half interest. | 32 | 16 | 2 | 79.93 | 0.00 | 4.00 | 0.00 |
| 22 | 04 | | 32 | 16 | 2 | 39.90 | 0.00 | 2.00 | 0.00 |
| 28 | SW | | 32 | 16 | 2 | 162.76 | 4.00 | 4.00 | 0.10 |
| 29 | S | | 32 | 16 | 2 | 322.74 | 8.00 | 4.00 | 0.10 |
| 30 | S | | 32 | 16 | 2 | 319.53 | 8.00 | 4.00 | 0.10 |
| | | | | Sub Totals = | | 9,912.83 | 84.00 | 134.00 | 1.10 |

| Sec | Portion | Description | Twp | Rge | Mer | Crown Land (Acres) Sectional Area | Road Allowances South | Road Allowances West | Road Allowances Int |
|---|---|---|---|---|---|---|---|---|---|
| 13 | 04 | | 32 | 17 | 2 | 39.98 | 2.00 | 2.00 | 0.10 |
| 13 | 05 | | 32 | 17 | 2 | 39.98 | 0.00 | 2.00 | 0.00 |
| 13 | NW | | 32 | 17 | 2 | 160.02 | 0.00 | 4.00 | 0.00 |
| 14 | ALL | | 32 | 17 | 2 | 639.20 | 8.00 | 8.00 | 0.10 |
| 15 | ALL | | 32 | 17 | 2 | 640.23 | 8.00 | 8.00 | 0.10 |
| 16 | 09 | | 32 | 17 | 2 | 39.97 | 0.00 | 0.00 | 0.00 |
| 16 | 10 | | 32 | 17 | 2 | 39.97 | 0.00 | 0.00 | 0.00 |
| 16 | 11 | | 32 | 17 | 2 | 39.95 | 0.00 | 0.00 | 0.00 |
| 16 | 12 | | 32 | 17 | 2 | 39.95 | 0.00 | 2.00 | 0.00 |
| 16 | 16 | | 32 | 17 | 2 | 39.97 | 0.00 | 0.00 | 0.00 |
| 16 | S | | 32 | 17 | 2 | 319.92 | 8.00 | 4.00 | 0.10 |
| 22 | 09 | | 32 | 17 | 2 | 39.97 | 0.00 | 0.00 | 0.00 |
| 22 | S | | 32 | 17 | 2 | 319.95 | 0.00 | 4.00 | 0.00 |
| 24 | ALL | | 32 | 17 | 2 | 639.43 | 0.00 | 8.00 | 0.00 |
| | | | | | Sub Totals = | 3,038.49 | 26.00 | 42.00 | 0.40 |
| | | | | | Total Lease Area = | 16,473.13 | 130.00 | 220.00 | 1.70 |

Aggregating 16,824.83 acres, more or less, all in the province of Saskatchewan.

Dated: Feb 14th 2011

Mike Detharet
Director, Mineral Tenure Branch

# APPENDIX 2



ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: www.ercosplan.com

Government of Saskatchewan

# SUBSURFACE MINERAL LEASE

**Lease No. KL 246**

Converted from: KP 360A

THIS LEASE made as of this 27 day of June, 2016

BETWEEN:

**HER MAJESTY THE QUEEN IN RIGHT OF SASKATCHEWAN,**
represented herein by the Minister of Energy and Resources, hereinafter called the "Minister"

AND

**KARNALYE RESOURCES INC.**
hereinafter called the "Lessee".

IN CONSIDERATION of the mutual covenants herein contained, the parties hereto agree as follows:

THAT, subject to *The Crown Minerals Act* as that Act may be amended, revised or substituted from time to time (hereinafter referred to as the "Act") and subject to any applicable regulations made or continued under the Act (hereinafter referred to as the "Regulations"), as those regulations or any of them may be amended, revised or substituted from time to time, and the covenants, terms and conditions hereinafter set forth, the Minister hereby grants, demises and leases to the Lessee for the term stated in this lease, the subsurface minerals within the meaning of *The Subsurface Mineral Tenure Regulations,* under the lands described in Schedule "A" hereto, insofar as the Minister has the right to grant, demise and lease the same, excepting and reserving the royalties payable pursuant to the Regulations, with full and exclusive power and right, to the Lessee, subject to any applicable laws in force in the Province of Saskatchewan, to explore for, mine, work, recover, procure, remove, carry away and dispose of the said subsurface minerals. The Minister and the Lessee further agree as follows:

1. The term of this lease shall be for a period of twenty-one years from 03/13/16, renewable in accordance with the Regulations.

2. (1) The Lessee shall make or cause to be made all payments and returns in the manner and at the time required by the Regulations or any other applicable laws.

   (2) For the purposes of subclause (1), "payments" includes, without restricting the generality of the word, rentals, royalties, fees, rates, taxes and assessments that may be charged or be payable in respect of the subsurface minerals included in this lease or in respect of the operations of the Lessee under this lease.

   (3) Nothing in subclause (1) prejudices the exercise of any right the Lessee may have to appeal or contest any rates, taxes or assessments as provided by law.

3. The Lessee agrees to keep harmless and indemnify the Government of Saskatchewan, its Ministers, officials, agents or employees, past, present and future, from and against all

actions, suits, claims and demands arising out of or in connection with the operations carried on by the Lessee, its employees, agents, licensees and contractors, deriving from this lease.

4. The Lessee shall carry on all operations under this lease in a skillful and proper manner and in compliance with acceptable practices in the mining industry and shall take all reasonable and necessary steps to prevent injury and damage to life or property.

5. The Lessee shall comply with all laws and orders in force in Saskatchewan from time to time applicable to its operations under this lease and in particular, without restricting the generality of the foregoing, shall comply with the Act and the Regulations, *The Oil and Gas Conservation Act* and regulations thereunder, *The Mineral Resources Act, 1985* and regulations thereunder, and with all legislation, regulations and orders in force in the Province of Saskatchewan applicable to its operations under this lease relating to occupational health and safety, environmental and public protection and safety, resource conservation, management and development, and surface rights.

6. No waiver by or on behalf of the Minister of a breach on the part of the Lessee of any covenant, obligation, condition, restriction or stipulation contained in this lease shall take effect and be binding on the Minister unless it is in writing and such a waiver shall extend only to the particular breach waived and shall not limit or restrict the rights of the Minister with respect to any other breach.

7. (1) On the termination of this lease by cancellation, surrender, or expiration, the Lessee shall comply with all directions or orders of the Minister or any other official of the Province of Saskatchewan respecting the preservation, clean up, and restoration of the leased area and facilities in the leased area with respect to operations conducted by or on behalf of the Lessee.

   (2) In the event that the Lessee fails to comply with any direction or order referred to in subclause (1), the Minister may take whatever action he deems necessary, including, without limiting the generality of the foregoing, taking possession of or disposing of any property remaining in the subsurface mineral lease area. Upon such taking of possession or disposition, the Lessee shall be deemed to have forfeited any right, title, or interest it may have had in, or to, such property and any right to claim consideration or compensation therefor, and such property shall thereupon become the property of Her Majesty the Queen in Right of Saskatchewan.

   (3) Unless otherwise ordered by the Minister to be removed pursuant to subclause (1), upon such termination, any installations in the subsurface mineral lease area necessary for the preservation of the mine or other development work such as underground timbering, supports, shaft linings, well casings, ventilation equipment and hoisting installations shall be left intact and undisturbed by the Lessee and any right, title, or interest which the Lessee may have had in such installations or development work shall be deemed to have been forfeited to and become the property of Her Majesty the Queen in Right of Saskatchewan, and the Lessee shall not be entitled to consideration or compensation for them.

   (4) Any costs incurred by the Minister as a result of the Lessee's failure to comply with any direction or order mentioned in subclause (1), which failure shall be communicated to the Lessee, shall be a debt due by the Lessee to the Minister and may be recovered by the Minister as provided for by law.

   (5) The rights and remedies mentioned in this clause shall be in addition to any other rights and remedies which the Minister may have pursuant to this lease or by law.

8. Any right of action of the Minister against the Lessee in respect of any default of the Lessee in complying with the terms and conditions of this lease shall not be prejudiced by the termination of this lease by cancellation, surrender or expiration of term, and the Minister shall have the same remedies for the recovery of royalties, payments, or damages due or accruing due at the time of termination as if this lease remained in full force and effect.

9. This lease shall be governed by and interpreted in accordance with the laws of the Province of Saskatchewan and the applicable laws of Canada.

10. Time shall be of the essence of this lease and of every part of it and no extension or variation of this agreement shall operate as a waiver of this provision unless specifically stated, in writing, to so operate.

11. The Lessee acknowledges and agrees that its rights, interests, duties and obligations under this lease shall be and shall be deemed to be amended or varied, in whole or in part, in accordance with any amendments to or substitutions of, the provisions of the Act and the Regulations including, without limiting the generality of the foregoing, amendments or substitutions made to the Act or the Regulations after the execution or issuance of this lease or any renewal or substitution thereof.

12. In the event of any conflict between the provisions of this lease and the provisions of the Act or the Regulations, the provisions of the Act or the Regulations shall govern.

13. Any notice to the Lessee under this lease shall be sufficiently served if sent to the address for service or email address for service for the Lessee submitted to the Minister in accordance with the Regulations.

14. Any notice to the Minister under this lease shall be sufficiently served if delivered to the address for service or email address for service for the Director, Tenure Services of the Ministry of the Economy as published on the Saskatchewan Government Directory available on the Government of Saskatchewan's website at the time of sending the notice.

15. The parties agree that this lease and everything contained herein shall enure to the benefit of and be binding upon their respective successors and permitted assigns.

IN WITNESS WHEREOF this lease has been executed by a designated officer on behalf of the Minister and the Lessee has caused its corporate seal to be affixed hereto, attested by its proper officers in that behalf as of the date first above written.

[This space intentionally left blank. Signature page to follow.]

SIGNED, SEALED AND DELIVERED by

**HER MAJESTY THE QUEEN IN RIGHT OF SASKATCHEWAN**
as represented by the Minister of Energy and Resources

MINISTRY OF THE ECONOMY SASKATCHEWAN

(Signature)

Carl Anderson
(Name in full)

Acting Director, Tenure Services
(Title)

**KARNALYTE RESOURCES INC.**

(Witness Signature)

(Signature)

Robin Phinney
(Name in full - print)

President, Director
(Title)

[If not sealed, please use "Witness Signature" and following "Affidavit of Execution" page.]

**AFFIDAVIT OF EXECUTION**
(To be completed by witness)

I, Ronald Olchowski (Name) of the

city (Hamlet, Village, Town, City), of Saskatoon (Name of the Hamlet, Town, City) in the

Province of Saskatchewan, engineer (Occupation).

**MAKE OATH AND SAY:**

1. That I was personally present and did see the within instrument duly signed and executed by Robin Phinney (Transferor Name) one of the parties thereto.

2. That the said instrument was executed in the city (Hamlet, Village, Town, City) of Saskatoon (Name of the Hamlet, Village, Town, City) in the Province of Saskatchewan and that I am subscribing witness thereto.

---

**Commissioner for Oaths/Notary Public**

SWORN before me at the city )
of Saskatoon in the Province of )
Saskatchewan this )
23 day of June )
A.D., 2016.

R. Olchowski
Witness signature as shown on previous page

Signature of Commissioner for Oaths/Notary Public

QUENTIN PLESTER Notary Public SASKATCHEWAN

A Solicitor in and for

the Province of Saskatchewan.

My appointment expires n/a.

# SCHEDULE "A"

**Attach to the Subsurface Mineral Lease** **KL 246**

**Between**
**HER MAJESTY, THE QUEEN**
**and**
**Karnalyte Resources Inc. 100%**

| Sec | Portion | Description / Mineral Parcel Number | Twp | Rge | Mer | Crown Land (hectares) Sectional Area | Road Allowances South | Road Allowances West | Road Allowances Int |
|---|---|---|---|---|---|---|---|---|---|
| 13 | NE | 152183000 | 31 | 14 | 2 | 64.932 | 0.000 | 0.000 | 0.000 |
| 13 | NW | 152183011 | 31 | 14 | 2 | 64.956 | 0.000 | 1.619 | 0.000 |
| 13 | SW | Freehold - Road Allowance Only | 31 | 14 | 2 | 0.000 | 0.000 | 0.810 | 0.000 |
| 14 | NE | 161788258 | 31 | 14 | 2 | 64.957 | 0.000 | 0.000 | 0.000 |
| 14 | NW | 152183022 | 31 | 14 | 2 | 64.931 | 0.000 | 1.619 | 0.000 |
| 14 | SE | 131606456 | 31 | 14 | 2 | 32.690 | 0.000 | 0.000 | 0.000 |
| 14 | SW | 161788247 | 31 | 14 | 2 | 32.842 | 0.000 | 0.810 | 0.000 |
| 15 | NE | 151025723 | 31 | 14 | 2 | 64.824 | 0.000 | 0.000 | 0.000 |
| 15 | NW | 151025734 | 31 | 14 | 2 | 64.795 | 0.000 | 1.619 | 0.000 |
| 15 | SE | 151025745 | 31 | 14 | 2 | 32.884 | 0.000 | 0.000 | 0.000 |
| 15 | SW | 151025756 | 31 | 14 | 2 | 32.802 | 0.000 | 0.810 | 0.000 |
| 16 | NE | 131606423 | 31 | 14 | 2 | 64.810 | 0.000 | 0.000 | 0.000 |
| 16 | NW | 152183033 | 31 | 14 | 2 | 64.755 | 0.000 | 1.619 | 0.000 |
| 16 | SE | 131606412 | 31 | 14 | 2 | 32.744 | 0.000 | 0.000 | 0.000 |
| 16 | SW | 152183044 | 31 | 14 | 2 | 32.700 | 0.000 | 0.810 | 0.000 |
| 17 | NE | 131692046 | 31 | 14 | 2 | 64.597 | 0.000 | 0.000 | 0.000 |
| 17 | NW | 131692057 | 31 | 14 | 2 | 64.834 | 0.000 | 1.619 | 0.000 |
| 17 | SE | 131692068 | 31 | 14 | 2 | 32.732 | 0.000 | 0.000 | 0.000 |
| 17 | SW | 131692079 | 31 | 14 | 2 | 32.904 | 0.000 | 0.810 | 0.000 |
| 18 | NE | 161788269 | 31 | 14 | 2 | 65.226 | 0.000 | 0.000 | 0.000 |
| 18 | NW | 152311508 | 31 | 14 | 2 | 64.853 | 0.000 | 1.619 | 0.000 |
| 18 | SE | 152183099 | 31 | 14 | 2 | 33.312 | 0.000 | 0.000 | 0.000 |
| 18 | SW | 152183101 | 31 | 14 | 2 | 33.754 | 0.000 | 0.810 | 0.000 |
| 19 | NE | 149187729 | 31 | 14 | 2 | 65.014 | 0.000 | 0.000 | 0.000 |
| 19 | NW | 149187730 | 31 | 14 | 2 | 64.946 | 0.000 | 1.619 | 0.000 |
| 19 | SE | 149187741 | 31 | 14 | 2 | 65.132 | 0.000 | 0.000 | 0.000 |
| 19 | SW | 149187752 | 31 | 14 | 2 | 65.202 | 0.000 | 1.619 | 0.000 |
| 20 | NE | 152183112 | 31 | 14 | 2 | 64.597 | 0.000 | 0.000 | 0.000 |
| 20 | NW | 152183123 | 31 | 14 | 2 | 64.576 | 0.000 | 1.619 | 0.000 |
| 20 | SE | 152183134 | 31 | 14 | 2 | 64.549 | 0.000 | 0.000 | 0.000 |
| 20 | SW | 149187785 | 31 | 14 | 2 | 64.526 | 0.000 | 1.619 | 0.000 |
| 21 | NE | 152183145 | 31 | 14 | 2 | 64.944 | 0.000 | 0.000 | 0.000 |
| 21 | NW | 152183156 | 31 | 14 | 2 | 64.912 | 0.000 | 1.619 | 0.000 |
| 21 | SE | 152183167 | 31 | 14 | 2 | 64.950 | 0.000 | 0.000 | 0.000 |
| 21 | SW | 152183178 | 31 | 14 | 2 | 64.918 | 0.000 | 1.619 | 0.000 |
| 22 | NE | 152183189 | 31 | 14 | 2 | 64.829 | 0.000 | 0.000 | 0.000 |
| 22 | NW | 152183190 | 31 | 14 | 2 | 64.858 | 0.000 | 1.619 | 0.000 |
| 22 | SE | 131606401 | 31 | 14 | 2 | 64.834 | 0.000 | 0.000 | 0.000 |

| Sec | Portion | Description / Mineral Parcel Number | Twp | Rge | Mer | Crown Land (hectares) Sectional Area | Road Allowances South | Road Allowances West | Road Allowances Int |
|---|---|---|---|---|---|---|---|---|---|
| 22 | SW | 152183202 | 31 | 14 | 2 | 64.864 | 0.000 | 1.619 | 0.000 |
| 23 | NE | 114306230 | 31 | 14 | 2 | 65.104 | 0.000 | 0.000 | 0.000 |
| 23 | NW | 114306241 | 31 | 14 | 2 | 65.019 | 0.000 | 1.619 | 0.000 |
| 23 | SE | 114306252 | 31 | 14 | 2 | 65.093 | 0.000 | 0.000 | 0.000 |
| 23 | SW | 114306263 | 31 | 14 | 2 | 65.009 | 0.000 | 1.619 | 0.000 |
| 24 | NE | 131606399 | 31 | 14 | 2 | 64.993 | 0.000 | 0.000 | 0.000 |
| 24 | NW | 152183213 | 31 | 14 | 2 | 65.020 | 0.000 | 1.619 | 0.000 |
| 24 | SE | 152183224 | 31 | 14 | 2 | 65.033 | 0.000 | 0.000 | 0.000 |
| 24 | SW | 152183235 | 31 | 14 | 2 | 65.061 | 0.000 | 1.619 | 0.000 |
| 25 | NE | 149342980 | 31 | 14 | 2 | 64.858 | 0.000 | 0.000 | 0.000 |
| 25 | NW | 149342991 | 31 | 14 | 2 | 64.808 | 0.000 | 1.619 | 0.000 |
| 25 | SE | 149343004 | 31 | 14 | 2 | 64.842 | 1.619 | 0.000 | 0.000 |
| 25 | SW | 149343015 | 31 | 14 | 2 | 64.805 | 1.619 | 1.619 | 0.040 |
| 26 | NE | 145768528 | 31 | 14 | 2 | 64.880 | 0.000 | 0.000 | 0.000 |
| 26 | NW | 131716032 | 31 | 14 | 2 | 64.913 | 0.000 | 1.619 | 0.000 |
| 26 | SE | 131716043 | 31 | 14 | 2 | 64.914 | 1.619 | 0.000 | 0.000 |
| 26 | SW | 131716054 | 31 | 14 | 2 | 64.947 | 1.619 | 1.619 | 0.040 |
| 27 | NE | 152183246 | 31 | 14 | 2 | 64.831 | 0.000 | 0.000 | 0.000 |
| 27 | NW | 152183257 | 31 | 14 | 2 | 64.844 | 0.000 | 1.619 | 0.000 |
| 27 | SE | 152183268 | 31 | 14 | 2 | 64.821 | 1.619 | 0.000 | 0.000 |
| 27 | SW | 152183279 | 31 | 14 | 2 | 64.834 | 1.619 | 1.619 | 0.040 |
| 28 | NE | 152183280 | 31 | 14 | 2 | 64.893 | 0.000 | 0.000 | 0.000 |
| 28 | NW | 152183291 | 31 | 14 | 2 | 64.883 | 0.000 | 1.619 | 0.000 |
| 28 | SE | 152183303 | 31 | 14 | 2 | 64.909 | 1.619 | 0.000 | 0.000 |
| 28 | SW | 145304760 | 31 | 14 | 2 | 64.898 | 1.619 | 1.619 | 0.040 |
| 29 | NE | 131606377 | 31 | 14 | 2 | 64.690 | 0.000 | 0.000 | 0.000 |
| 29 | NW | 131606388 | 31 | 14 | 2 | 64.665 | 0.000 | 1.619 | 0.000 |
| 29 | SE | 152183314 | 31 | 14 | 2 | 64.649 | 1.619 | 0.000 | 0.000 |
| 29 | SW | 131594687 | 31 | 14 | 2 | 64.623 | 1.619 | 1.619 | 0.040 |
| 30 | NE | 152182997 | 31 | 14 | 2 | 64.931 | 0.000 | 0.000 | 0.000 |
| 30 | NW | 152183325 | 31 | 14 | 2 | 64.894 | 0.000 | 1.619 | 0.000 |
| 30 | SE | 131606366 | 31 | 14 | 2 | 65.002 | 1.619 | 0.000 | 0.000 |
| 30 | SW | 131606355 | 31 | 14 | 2 | 65.009 | 1.619 | 1.619 | 0.040 |
| 31 | NE | 147667090 | 31 | 14 | 2 | 64.755 | 0.000 | 0.000 | 0.000 |
| 31 | NW | 147667102 | 31 | 14 | 2 | 64.654 | 0.000 | 1.619 | 0.000 |
| 31 | SE | 147667113 | 31 | 14 | 2 | 64.858 | 0.000 | 0.000 | 0.000 |
| 31 | SW | 147667124 | 31 | 14 | 2 | 64.829 | 0.000 | 1.619 | 0.000 |
| 32 | NE | 161788270 | 31 | 14 | 2 | 65.136 | 0.000 | 0.000 | 0.000 |
| 32 | NW | 152183358 | 31 | 14 | 2 | 64.878 | 0.000 | 1.619 | 0.000 |
| 32 | SE | 131582493 | 31 | 14 | 2 | 64.735 | 0.000 | 0.000 | 0.000 |
| 32 | SW | 131596241 | 31 | 14 | 2 | 64.700 | 0.000 | 1.619 | 0.000 |
| 33 | NE | 114234544 | 31 | 14 | 2 | 64.976 | 0.000 | 0.000 | 0.000 |
| 33 | NW | 114234555 | 31 | 14 | 2 | 65.191 | 0.000 | 1.619 | 0.000 |
| 33 | SE | 114234566 | 31 | 14 | 2 | 64.879 | 0.000 | 0.000 | 0.000 |
| 33 | SW | 114234577 | 31 | 14 | 2 | 64.869 | 0.000 | 1.619 | 0.000 |
| 34 | NE | 146376838 | 31 | 14 | 2 | 64.850 | 0.000 | 0.000 | 0.000 |
| 34 | NW | 146376849 | 31 | 14 | 2 | 64.865 | 0.000 | 1.619 | 0.000 |
| 34 | SE | 152183369 | 31 | 14 | 2 | 64.839 | 0.000 | 0.000 | 0.000 |

| Sec | Portion | Description / Mineral Parcel Number | Twp | Rge | Mer | Crown Land (hectares) Sectional Area | Road Allowances South | Road Allowances West | Road Allowances Int |
|---|---|---|---|---|---|---|---|---|---|
| 34 | SW | 131594676 | 31 | 14 | 2 | 64.854 | 0.000 | 1.619 | 0.000 |
| 35 | NE | 152183370 | 31 | 14 | 2 | 64.897 | 0.000 | 0.000 | 0.000 |
| 35 | NW | 152183381 | 31 | 14 | 2 | 64.876 | 0.000 | 1.619 | 0.000 |
| 35 | SE | 152183392 | 31 | 14 | 2 | 64.932 | 0.000 | 0.000 | 0.000 |
| 35 | SW | 152183404 | 31 | 14 | 2 | 64.910 | 0.000 | 1.619 | 0.000 |
| 36 | NE | 152183415 | 31 | 14 | 2 | 64.597 | 0.000 | 0.000 | 0.000 |
| 36 | NW | 152183426 | 31 | 14 | 2 | 64.853 | 0.000 | 1.619 | 0.000 |
| 36 | SE | 152183437 | 31 | 14 | 2 | 64.677 | 0.000 | 0.000 | 0.000 |
| 36 | SW | 147244563 | 31 | 14 | 2 | 64.855 | 0.000 | 1.619 | 0.000 |
| | | | Sub Totals = | | | 5,778.625 | 19.428 | 72.858 | 0.240 |
| 01 | NE | 152144041 | 32 | 14 | 2 | 64.685 | 0.000 | 0.000 | 0.000 |
| 01 | NW | 152144052 | 32 | 14 | 2 | 64.699 | 0.000 | 1.619 | 0.000 |
| 01 | SE | 152144063 | 32 | 14 | 2 | 64.685 | 1.619 | 0.000 | 0.000 |
| 01 | SW | 152144074 | 32 | 14 | 2 | 64.738 | 1.619 | 1.619 | 0.040 |
| 02 | NE | 152144085 | 32 | 14 | 2 | 64.676 | 0.000 | 0.000 | 0.000 |
| 02 | NW | 146376850 | 32 | 14 | 2 | 64.687 | 0.000 | 1.619 | 0.000 |
| 02 | SE | 146376861 | 32 | 14 | 2 | 64.702 | 1.619 | 0.000 | 0.000 |
| 02 | SW | 146525609 | 32 | 14 | 2 | 64.714 | 1.619 | 1.619 | 0.040 |
| 03 | NE | 152144096 | 32 | 14 | 2 | 64.741 | 0.000 | 0.000 | 0.000 |
| 03 | NW | 152144108 | 32 | 14 | 2 | 64.757 | 0.000 | 1.619 | 0.000 |
| 03 | SE | Freehold - Road Allowance Only | 32 | 14 | 2 | 0.000 | 1.619 | 0.000 | 0.000 |
| 03 | SW | 152144119 | 32 | 14 | 2 | 64.758 | 1.619 | 1.619 | 0.040 |
| 04 | NE | 150842785 | 32 | 14 | 2 | 64.783 | 0.000 | 0.000 | 0.000 |
| 04 | NW | 152144120 | 32 | 14 | 2 | 64.760 | 0.000 | 1.619 | 0.000 |
| 04 | SE | 146376872 | 32 | 14 | 2 | 64.755 | 1.619 | 0.000 | 0.000 |
| 04 | SW | 145304715 | 32 | 14 | 2 | 64.734 | 1.619 | 1.619 | 0.040 |
| 05 | NE | 152144131 | 32 | 14 | 2 | 64.651 | 0.000 | 0.000 | 0.000 |
| 05 | NW | 152144142 | 32 | 14 | 2 | 64.651 | 0.000 | 1.619 | 0.000 |
| 05 | SE | 152144153 | 32 | 14 | 2 | 64.688 | 1.619 | 0.000 | 0.000 |
| 05 | SW | 146376883 | 32 | 14 | 2 | 64.688 | 1.619 | 1.619 | 0.040 |
| 06 | NE | 131692169 | 32 | 14 | 2 | 64.708 | 0.000 | 0.000 | 0.000 |
| 06 | NW | 131692170 | 32 | 14 | 2 | 64.683 | 0.000 | 1.619 | 0.000 |
| 06 | SE | 146376894 | 32 | 14 | 2 | 64.700 | 1.619 | 0.000 | 0.000 |
| 06 | SW | 146376906 | 32 | 14 | 2 | 64.676 | 1.619 | 1.619 | 0.040 |
| 07 | NE | 152144164 | 32 | 14 | 2 | 64.725 | 0.000 | 0.000 | 0.000 |
| 07 | NW | 152144175 | 32 | 14 | 2 | 64.701 | 0.000 | 1.619 | 0.000 |
| 07 | SE | 152144186 | 32 | 14 | 2 | 64.717 | 0.000 | 0.000 | 0.000 |
| 07 | SW | 152144197 | 32 | 14 | 2 | 64.692 | 0.000 | 1.619 | 0.000 |
| 08 | NE | 152144209 | 32 | 14 | 2 | 64.577 | 0.000 | 0.000 | 0.000 |
| 08 | NW | 152144210 | 32 | 14 | 2 | 64.577 | 0.000 | 1.619 | 0.000 |
| 08 | SE | 152144221 | 32 | 14 | 2 | 64.615 | 0.000 | 0.000 | 0.000 |
| 08 | SW | 152144232 | 32 | 14 | 2 | 64.615 | 0.000 | 1.619 | 0.000 |
| 09 | NE | 152144243 | 32 | 14 | 2 | 64.870 | 0.000 | 0.000 | 0.000 |
| 09 | NW | 152144254 | 32 | 14 | 2 | 64.827 | 0.000 | 1.619 | 0.000 |
| 09 | SE | 152144265 | 32 | 14 | 2 | 64.763 | 0.000 | 0.000 | 0.000 |
| 09 | SW | 152144276 | 32 | 14 | 2 | 64.772 | 0.000 | 1.619 | 0.000 |
| 10 | NE | 152144287 | 32 | 14 | 2 | 64.755 | 0.000 | 0.000 | 0.000 |

| Sec | Portion | Description / Mineral Parcel Number | Twp | Rge | Mer | Crown Land (hectares) Sectional Area | Road Allowances South | Road Allowances West | Road Allowances Int |
|---|---|---|---|---|---|---|---|---|---|
| 10 | NW | 161795920 | 32 | 14 | 2 | 64.792 | 0.000 | 1.619 | 0.000 |
| 10 | SE | 152144300 | 32 | 14 | 2 | 64.729 | 0.000 | 0.000 | 0.000 |
| 10 | SW | 145476052 | 32 | 14 | 2 | 64.714 | 0.000 | 1.619 | 0.000 |
| 11 | NE | 161795931 | 32 | 14 | 2 | 64.552 | 0.000 | 0.000 | 0.000 |
| 11 | NW | 161795942 | 32 | 14 | 2 | 64.703 | 0.000 | 1.619 | 0.000 |
| 11 | SE | 131606298 | 32 | 14 | 2 | 64.626 | 0.000 | 0.000 | 0.000 |
| 11 | SW | 152144311 | 32 | 14 | 2 | 64.683 | 0.000 | 1.619 | 0.000 |
| 12 | NE | 161795964 | 32 | 14 | 2 | 64.727 | 0.000 | 0.000 | 0.000 |
| 12 | NW | 131606287 | 32 | 14 | 2 | 64.696 | 0.000 | 1.619 | 0.000 |
| 12 | SE | 152144344 | 32 | 14 | 2 | 64.719 | 0.000 | 0.000 | 0.000 |
| 12 | SW | 152144355 | 32 | 14 | 2 | 64.689 | 0.000 | 1.619 | 0.000 |
| 13 | NW | Freehold - Road Allowance Only | 32 | 14 | 2 | 0.000 | 0.000 | 1.619 | 0.000 |
| 13 | SE | Freehold - Road Allowance Only | 32 | 14 | 2 | 0.000 | 1.619 | 0.000 | 0.000 |
| 13 | SW | Freehold - Road Allowance Only | 32 | 14 | 2 | 0.000 | 1.619 | 1.619 | 0.040 |
| 14 | NE | 161795751 | 32 | 14 | 2 | 64.602 | 0.000 | 0.000 | 0.000 |
| 14 | NW | 161795885 | 32 | 14 | 2 | 64.698 | 0.000 | 1.619 | 0.000 |
| 14 | SE | 161795997 | 32 | 14 | 2 | 64.540 | 1.619 | 0.000 | 0.000 |
| 14 | SW | 161795874 | 32 | 14 | 2 | 64.540 | 1.619 | 1.619 | 0.040 |
| 15 | NE | 152144366 | 32 | 14 | 2 | 64.738 | 0.000 | 0.000 | 0.000 |
| 15 | NW | 152144377 | 32 | 14 | 2 | 64.668 | 0.000 | 1.619 | 0.000 |
| 15 | SE | 152144388 | 32 | 14 | 2 | 64.766 | 1.619 | 0.000 | 0.000 |
| 15 | SW | Freehold - Road Allowance Only | 32 | 14 | 2 | 0.000 | 1.619 | 1.619 | 0.040 |
| 16 | NE | 152144399 | 32 | 14 | 2 | 64.730 | 0.000 | 0.000 | 0.000 |
| 16 | NW | 152144423 | 32 | 14 | 2 | 64.754 | 0.000 | 1.619 | 0.000 |
| 16 | SE | 161795908 | 32 | 14 | 2 | 64.764 | 1.619 | 0.000 | 0.000 |
| 16 | SW | 152144434 | 32 | 14 | 2 | 64.786 | 1.619 | 1.619 | 0.040 |
| 17 | NE | 114347808 | 32 | 14 | 2 | 64.592 | 0.000 | 0.000 | 0.000 |
| 17 | NW | 114347819 | 32 | 14 | 2 | 64.592 | 0.000 | 1.619 | 0.000 |
| 17 | SE | 114347820 | 32 | 14 | 2 | 64.569 | 1.619 | 0.000 | 0.000 |
| 17 | SW | 114347831 | 32 | 14 | 2 | 64.569 | 1.619 | 1.619 | 0.040 |
| 18 | NE | 152144445 | 32 | 14 | 2 | 64.709 | 0.000 | 0.000 | 0.000 |
| 18 | NW | 161795986 | 32 | 14 | 2 | 64.666 | 0.000 | 1.619 | 0.000 |
| 18 | SE | 152144467 | 32 | 14 | 2 | 64.781 | 1.619 | 0.000 | 0.000 |
| 18 | SW | 152144478 | 32 | 14 | 2 | 64.879 | 1.619 | 1.619 | 0.040 |
| 19 | NE | 152144489 | 32 | 14 | 2 | 64.757 | 0.000 | 0.000 | 0.000 |
| 19 | NW | 152144490 | 32 | 14 | 2 | 64.734 | 0.000 | 1.619 | 0.000 |
| 19 | SE | 152144502 | 32 | 14 | 2 | 64.733 | 0.000 | 0.000 | 0.000 |
| 19 | SW | 152144513 | 32 | 14 | 2 | 64.709 | 0.000 | 1.619 | 0.000 |
| 20 | NE | 120386651 | 32 | 14 | 2 | 64.557 | 0.000 | 0.000 | 0.000 |
| 20 | NW | 120386640 | 32 | 14 | 2 | 64.557 | 0.000 | 1.619 | 0.000 |
| 20 | SE | 152144524 | 32 | 14 | 2 | 64.589 | 0.000 | 0.000 | 0.000 |
| 20 | SW | 152144535 | 32 | 14 | 2 | 64.589 | 0.000 | 1.619 | 0.000 |
| 21 | NE | 152144546 | 32 | 14 | 2 | 64.720 | 0.000 | 0.000 | 0.000 |
| 21 | NW | 152144557 | 32 | 14 | 2 | 64.707 | 0.000 | 1.619 | 0.000 |
| 21 | SE | 152144568 | 32 | 14 | 2 | 64.782 | 0.000 | 0.000 | 0.000 |
| 21 | SW | 152144579 | 32 | 14 | 2 | 64.750 | 0.000 | 1.619 | 0.000 |
| 22 | NE | 161795784 | 32 | 14 | 2 | 64.617 | 0.000 | 0.000 | 0.000 |
| 22 | NW | 161795773 | 32 | 14 | 2 | 64.673 | 0.000 | 1.619 | 0.000 |

| Sec | Portion | Description / Mineral Parcel Number | Twp | Rge | Mer | Crown Land (hectares) Sectional Area | Road Allowances South | Road Allowances West | Road Allowances Int |
|---|---|---|---|---|---|---|---|---|---|
| 22 | SE | 152144591 | 32 | 14 | 2 | 64.758 | 0.000 | 0.000 | 0.000 |
| 22 | SW | 120820036 | 32 | 14 | 2 | 64.743 | 0.000 | 1.619 | 0.000 |
| 23 | SE | 164617139 | 32 | 14 | 2 | 2.946 | 0.000 | 0.000 | 0.000 |
| 23 | SE | 164617140 | 32 | 14 | 2 | 60.610 | 0.000 | 0.000 | 0.000 |
| 23 | SW | 164617162 | 32 | 14 | 2 | 21.562 | 0.000 | 0.000 | 0.000 |
| 23 | SW | 164617151 | 32 | 14 | 2 | 40.181 | 0.000 | 0.000 | 0.000 |
| 24 | SE | 152144647 | 32 | 14 | 2 | 64.707 | 0.000 | 0.000 | 0.000 |
| 24 | SW | 120991631 | 32 | 14 | 2 | 64.733 | 0.000 | 0.000 | 0.000 |
| | | | | Sub Totals = | | 5,559.812 | 38.856 | 71.236 | 0.480 |
| 13 | NE | 152189680 | 31 | 15 | 2 | 64.673 | 0.000 | 0.000 | 0.000 |
| 13 | NW | 152189691 | 31 | 15 | 2 | 64.803 | 0.000 | 1.619 | 0.000 |
| 13 | SE | 152189703 | 31 | 15 | 2 | 33.939 | 0.000 | 0.000 | 0.000 |
| 13 | SW | 152189714 | 31 | 15 | 2 | 33.670 | 0.000 | 0.810 | 0.000 |
| 14 | NE | 152189725 | 31 | 15 | 2 | 65.002 | 0.000 | 0.000 | 0.000 |
| 14 | NW | 152189736 | 31 | 15 | 2 | 64.755 | 0.000 | 1.619 | 0.000 |
| 14 | SE | 152189758 | 31 | 15 | 2 | 33.529 | 0.000 | 0.000 | 0.000 |
| 14 | SW | 152189747 | 31 | 15 | 2 | 33.356 | 0.000 | 0.810 | 0.000 |
| 15 | NE | 152189769 | 31 | 15 | 2 | 64.779 | 0.000 | 0.000 | 0.000 |
| 15 | NW | 152189770 | 31 | 15 | 2 | 64.624 | 0.000 | 1.619 | 0.000 |
| 15 | SE | 152189781 | 31 | 15 | 2 | 33.483 | 0.000 | 0.000 | 0.000 |
| 15 | SW | 152189792 | 31 | 15 | 2 | 33.422 | 0.000 | 0.810 | 0.000 |
| 16 | NE | 152189804 | 31 | 15 | 2 | 64.891 | 0.000 | 0.000 | 0.000 |
| 16 | NW | 148934649 | 31 | 15 | 2 | 64.916 | 0.000 | 1.619 | 0.000 |
| 16 | SE | 153117626 | 31 | 15 | 2 | 33.456 | 0.000 | 0.000 | 0.000 |
| 16 | SW | 153117648 | 31 | 15 | 2 | 33.424 | 0.000 | 0.810 | 0.000 |
| 17 | NE | 152189815 | 31 | 15 | 2 | 64.522 | 0.000 | 0.000 | 0.000 |
| 17 | NW | 152189826 | 31 | 15 | 2 | 65.424 | 0.000 | 1.619 | 0.000 |
| 17 | SE | 152189837 | 31 | 15 | 2 | 33.216 | 0.000 | 0.000 | 0.000 |
| 17 | SW | 152189848 | 31 | 15 | 2 | 33.662 | 0.000 | 0.810 | 0.000 |
| 18 | NE | 152189859 | 31 | 15 | 2 | 65.373 | 0.000 | 0.000 | 0.000 |
| 18 | NW | 152189860 | 31 | 15 | 2 | 65.049 | 0.000 | 1.619 | 0.000 |
| 18 | SE | 152189871 | 31 | 15 | 2 | 34.326 | 0.000 | 0.000 | 0.000 |
| 18 | SW | 152189882 | 31 | 15 | 2 | 33.799 | 0.000 | 0.810 | 0.000 |
| 19 | NE | 152189893 | 31 | 15 | 2 | 65.050 | 0.000 | 0.000 | 0.000 |
| 19 | NW | 161788180 | 31 | 15 | 2 | 65.013 | 0.000 | 1.619 | 0.000 |
| 19 | SE | 152189949 | 31 | 15 | 2 | 65.139 | 0.000 | 0.000 | 0.000 |
| 19 | SW | 152189950 | 31 | 15 | 2 | 65.102 | 0.000 | 1.619 | 0.000 |
| 20 | NE | 152189961 | 31 | 15 | 2 | 64.892 | 0.000 | 0.000 | 0.000 |
| 20 | NW | 161788191 | 31 | 15 | 2 | 64.918 | 0.000 | 1.619 | 0.000 |
| 20 | SE | 152189972 | 31 | 15 | 2 | 64.903 | 0.000 | 0.000 | 0.000 |
| 20 | SW | 146282799 | 31 | 15 | 2 | 64.940 | 0.000 | 1.619 | 0.000 |
| 21 | NE | 152189983 | 31 | 15 | 2 | 64.936 | 0.000 | 0.000 | 0.000 |
| 21 | NW | 152189994 | 31 | 15 | 2 | 64.961 | 0.000 | 1.619 | 0.000 |
| 21 | SE | 120669116 | 31 | 15 | 2 | 64.910 | 0.000 | 0.000 | 0.000 |
| 21 | SW | 152190008 | 31 | 15 | 2 | 64.915 | 0.000 | 1.619 | 0.000 |
| 22 | NE | 152190019 | 31 | 15 | 2 | 64.580 | 0.000 | 0.000 | 0.000 |
| 22 | NW | 152190020 | 31 | 15 | 2 | 64.604 | 0.000 | 1.619 | 0.000 |

| Sec | Portion | Description / Mineral Parcel Number | Twp | Rge | Mer | Crown Land (hectares) Sectional Area | Road Allowances South | Road Allowances West | Road Allowances Int |
|---|---|---|---|---|---|---|---|---|---|
| 22 | SE | 150953317 | 31 | 15 | 2 | 64.522 | 0.000 | 0.000 | 0.000 |
| 22 | SW | 152190031 | 31 | 15 | 2 | 64.554 | 0.000 | 1.619 | 0.000 |
| 23 | NE | 152190042 | 31 | 15 | 2 | 64.865 | 0.000 | 0.000 | 0.000 |
| 23 | NW | 161788179 | 31 | 15 | 2 | 64.807 | 0.000 | 1.619 | 0.000 |
| 23 | SE | 149649766 | 31 | 15 | 2 | 64.997 | 0.000 | 0.000 | 0.000 |
| 23 | SW | 152190053 | 31 | 15 | 2 | 64.937 | 0.000 | 1.619 | 0.000 |
| 24 | NE | 131584417 | 31 | 15 | 2 | 64.766 | 0.000 | 0.000 | 0.000 |
| 24 | NW | 131584428 | 31 | 15 | 2 | 64.831 | 0.000 | 1.619 | 0.000 |
| 24 | SE | 131584406 | 31 | 15 | 2 | 64.988 | 0.000 | 0.000 | 0.000 |
| 24 | SW | 131584394 | 31 | 15 | 2 | 64.916 | 0.000 | 1.619 | 0.000 |
| 25 | NE | 145768551 | 31 | 15 | 2 | 64.771 | 0.000 | 0.000 | 0.000 |
| 25 | NW | 145768562 | 31 | 15 | 2 | 64.780 | 0.000 | 1.619 | 0.000 |
| 25 | SE | 145768573 | 31 | 15 | 2 | 64.854 | 1.619 | 0.000 | 0.000 |
| 25 | SW | 145768584 | 31 | 15 | 2 | 64.818 | 1.619 | 1.619 | 0.040 |
| 26 | NE | 152190064 | 31 | 15 | 2 | 64.800 | 0.000 | 0.000 | 0.000 |
| 26 | NW | 152190075 | 31 | 15 | 2 | 64.869 | 0.000 | 1.619 | 0.000 |
| 26 | SE | 152190086 | 31 | 15 | 2 | 64.807 | 1.619 | 0.000 | 0.000 |
| 26 | SW | 152190097 | 31 | 15 | 2 | 64.875 | 1.619 | 1.619 | 0.040 |
| 27 | NE | 152190109 | 31 | 15 | 2 | 64.820 | 0.000 | 0.000 | 0.000 |
| 27 | NW | 148934627 | 31 | 15 | 2 | 64.790 | 0.000 | 1.619 | 0.000 |
| 27 | SE | 149649722 | 31 | 15 | 2 | 64.797 | 1.619 | 0.000 | 0.000 |
| 27 | SW | 148934638 | 31 | 15 | 2 | 64.769 | 1.619 | 1.619 | 0.040 |
| 28 | NE | 114234634 | 31 | 15 | 2 | 64.951 | 0.000 | 0.000 | 0.000 |
| 28 | NW | 114234612 | 31 | 15 | 2 | 64.943 | 0.000 | 1.619 | 0.000 |
| 28 | SE | 152190110 | 31 | 15 | 2 | 65.004 | 1.619 | 0.000 | 0.000 |
| 28 | SW | 152190121 | 31 | 15 | 2 | 64.995 | 1.619 | 1.619 | 0.040 |
| 29 | NE | 114234623 | 31 | 15 | 2 | 64.844 | 0.000 | 0.000 | 0.000 |
| 29 | NW | 114234601 | 31 | 15 | 2 | 64.835 | 0.000 | 1.619 | 0.000 |
| 29 | SE | 152190132 | 31 | 15 | 2 | 64.873 | 1.619 | 0.000 | 0.000 |
| 29 | SW | 161788157 | 31 | 15 | 2 | 64.863 | 1.619 | 1.619 | 0.040 |
| 30 | NE | 152190143 | 31 | 15 | 2 | 64.893 | 0.000 | 0.000 | 0.000 |
| 30 | NW | 152190154 | 31 | 15 | 2 | 64.885 | 0.000 | 1.619 | 0.000 |
| 30 | SE | 152190165 | 31 | 15 | 2 | 64.949 | 1.619 | 0.000 | 0.000 |
| 30 | SW | 161788146 | 31 | 15 | 2 | 64.940 | 1.619 | 1.619 | 0.040 |
| 31 | NE | 152190176 | 31 | 15 | 2 | 64.820 | 0.000 | 0.000 | 0.000 |
| 31 | SE | 152190198 | 31 | 15 | 2 | 64.851 | 0.000 | 0.000 | 0.000 |
| 32 | NE | 152190211 | 31 | 15 | 2 | 64.817 | 0.000 | 0.000 | 0.000 |
| 32 | NW | 152190222 | 31 | 15 | 2 | 64.823 | 0.000 | 1.619 | 0.000 |
| 32 | SE | 152190233 | 31 | 15 | 2 | 64.825 | 0.000 | 0.000 | 0.000 |
| 32 | SW | 152190244 | 31 | 15 | 2 | 64.825 | 0.000 | 1.619 | 0.000 |
| 33 | NE | 114234689 | 31 | 15 | 2 | 64.847 | 0.000 | 0.000 | 0.000 |
| 33 | NW | 114234690 | 31 | 15 | 2 | 64.839 | 0.000 | 1.619 | 0.000 |
| 33 | SE | 114234702 | 31 | 15 | 2 | 64.899 | 0.000 | 0.000 | 0.000 |
| 33 | SW | 114234713 | 31 | 15 | 2 | 64.891 | 0.000 | 1.619 | 0.000 |
| 34 | NE | 152190266 | 31 | 15 | 2 | 64.861 | 0.000 | 0.000 | 0.000 |
| 34 | NW | 152190277 | 31 | 15 | 2 | 64.832 | 0.000 | 1.619 | 0.000 |
| 34 | SE | 150486633 | 31 | 15 | 2 | 64.839 | 0.000 | 0.000 | 0.000 |
| 34 | SW | 152190255 | 31 | 15 | 2 | 64.811 | 0.000 | 1.619 | 0.000 |

| Sec | Portion | Description / Mineral Parcel Number | Twp | Rge | Mer | Crown Land (hectares) Sectional Area | Road Allowances South | Road Allowances West | Road Allowances Int |
|---|---|---|---|---|---|---|---|---|---|
| 35 | NE | 152190299 | 31 | 15 | 2 | 64.814 | 0.000 | 0.000 | 0.000 |
| 35 | NW | 152190301 | 31 | 15 | 2 | 64.865 | 0.000 | 1.619 | 0.000 |
| 35 | SE | 152190312 | 31 | 15 | 2 | 64.822 | 0.000 | 0.000 | 0.000 |
| 35 | SW | 152190323 | 31 | 15 | 2 | 64.871 | 0.000 | 1.619 | 0.000 |
| 36 | NE | 161788168 | 31 | 15 | 2 | 64.642 | 0.000 | 0.000 | 0.000 |
| 36 | NW | 146032343 | 31 | 15 | 2 | 64.743 | 0.000 | 1.619 | 0.000 |
| 36 | SE | 152190334 | 31 | 15 | 2 | 64.764 | 0.000 | 0.000 | 0.000 |
| 36 | SW | 152190288 | 31 | 15 | 2 | 64.793 | 0.000 | 1.619 | 0.000 |
| | | | Sub Totals = | | | 5,721.958 | 19.428 | 69.620 | 0.240 |
| 01 | NE | 146609770 | 32 | 15 | 2 | 64.654 | 0.000 | 0.000 | 0.000 |
| 01 | NW | Freehold - Road Allowance Only | 32 | 15 | 2 | 0.000 | 0.000 | 1.619 | 0.000 |
| 01 | SE | 146609781 | 32 | 15 | 2 | 62.646 | 1.619 | 0.000 | 0.000 |
| 01 | SW | 146609792 | 32 | 15 | 2 | 64.666 | 1.619 | 1.619 | 0.040 |
| 02 | NE | 152391922 | 32 | 15 | 2 | 64.642 | 0.000 | 0.000 | 0.000 |
| 02 | NW | 131939488 | 32 | 15 | 2 | 64.665 | 0.000 | 1.619 | 0.000 |
| 02 | SE | 131939499 | 32 | 15 | 2 | 64.669 | 1.619 | 0.000 | 0.000 |
| 02 | SW | 131939501 | 32 | 15 | 2 | 64.692 | 1.619 | 1.619 | 0.040 |
| 03 | NE | 152391933 | 32 | 15 | 2 | 64.702 | 0.000 | 0.000 | 0.000 |
| 03 | NW | 152391944 | 32 | 15 | 2 | 64.699 | 0.000 | 1.619 | 0.000 |
| 03 | SE | 152391955 | 32 | 15 | 2 | 64.711 | 1.619 | 0.000 | 0.000 |
| 03 | SW | 152391966 | 32 | 15 | 2 | 64.708 | 1.619 | 1.619 | 0.040 |
| 04 | NE | 152391977 | 32 | 15 | 2 | 64.704 | 0.000 | 0.000 | 0.000 |
| 04 | NW | 152391988 | 32 | 15 | 2 | 64.727 | 0.000 | 1.619 | 0.000 |
| 04 | SE | 152391999 | 32 | 15 | 2 | 64.715 | 1.619 | 0.000 | 0.000 |
| 04 | SW | 152392002 | 32 | 15 | 2 | 64.737 | 1.619 | 1.619 | 0.040 |
| 05 | NE | 152392013 | 32 | 15 | 2 | 64.732 | 0.000 | 0.000 | 0.000 |
| 05 | NW | 152392024 | 32 | 15 | 2 | 64.715 | 0.000 | 1.619 | 0.000 |
| 05 | SE | 152392035 | 32 | 15 | 2 | 64.740 | 1.619 | 0.000 | 0.000 |
| 05 | SW | Freehold - Road Allowance Only | 32 | 15 | 2 | 0.000 | 1.619 | 1.619 | 0.040 |
| 06 | NE | 146377053 | 32 | 15 | 2 | 64.699 | 0.000 | 0.000 | 0.000 |
| 06 | SE | 146377075 | 32 | 15 | 2 | 64.708 | 1.619 | 0.000 | 0.000 |
| 07 | NE | 152392046 | 32 | 15 | 2 | 64.671 | 0.000 | 0.000 | 0.000 |
| 07 | SE | 152392068 | 32 | 15 | 2 | 64.685 | 0.000 | 0.000 | 0.000 |
| 08 | NE | 152392080 | 32 | 15 | 2 | 64.420 | 0.000 | 0.000 | 0.000 |
| 08 | NW | 152392091 | 32 | 15 | 2 | 64.953 | 0.000 | 1.619 | 0.000 |
| 08 | SE | 152392103 | 32 | 15 | 2 | 64.605 | 0.000 | 0.000 | 0.000 |
| 08 | SW | 152392114 | 32 | 15 | 2 | 64.785 | 0.000 | 1.619 | 0.000 |
| 09 | NE | 152392125 | 32 | 15 | 2 | 64.675 | 0.000 | 0.000 | 0.000 |
| 09 | NW | 152392136 | 32 | 15 | 2 | 64.678 | 0.000 | 1.619 | 0.000 |
| 09 | SE | 152392147 | 32 | 15 | 2 | 64.685 | 0.000 | 0.000 | 0.000 |
| 09 | SW | 152392158 | 32 | 15 | 2 | 64.688 | 0.000 | 1.619 | 0.000 |
| 10 | NE | 152392169 | 32 | 15 | 2 | 64.688 | 0.000 | 0.000 | 0.000 |
| 10 | NW | 152392170 | 32 | 15 | 2 | 64.684 | 0.000 | 1.619 | 0.000 |
| 10 | SE | 152392181 | 32 | 15 | 2 | 64.695 | 0.000 | 0.000 | 0.000 |
| 10 | SW | 131582505 | 32 | 15 | 2 | 64.691 | 0.000 | 1.619 | 0.000 |
| 11 | NE | 152392192 | 32 | 15 | 2 | 64.590 | 0.000 | 0.000 | 0.000 |
| 11 | NW | 150733672 | 32 | 15 | 2 | 64.612 | 0.000 | 1.619 | 0.000 |

| Sec | Portion | Description / Mineral Parcel Number | Twp | Rge | Mer | Crown Land (hectares) Sectional Area | Road Allowances South | Road Allowances West | Road Allowances Int |
|---|---|---|---|---|---|---|---|---|---|
| 11 | SE | 152392204 | 32 | 15 | 2 | 64.616 | 0.000 | 0.000 | 0.000 |
| 11 | SW | 152392215 | 32 | 15 | 2 | 64.639 | 0.000 | 1.619 | 0.000 |
| 12 | NE | 152392226 | 32 | 15 | 2 | 64.629 | 0.000 | 0.000 | 0.000 |
| 12 | NW | 152392237 | 32 | 15 | 2 | 64.628 | 0.000 | 1.619 | 0.000 |
| 12 | SE | 161792488 | 32 | 15 | 2 | 64.642 | 0.000 | 0.000 | 0.000 |
| 12 | SW | 152392248 | 32 | 15 | 2 | 64.640 | 0.000 | 1.619 | 0.000 |
| 13 | NE | 152392260 | 32 | 15 | 2 | 64.600 | 0.000 | 0.000 | 0.000 |
| 13 | NW | 152392271 | 32 | 15 | 2 | 64.674 | 0.000 | 1.619 | 0.000 |
| 13 | SE | Freehold - Road Allowance Only | 32 | 15 | 2 | 0.000 | 1.619 | 0.000 | 0.000 |
| 13 | SW | 152392282 | 32 | 15 | 2 | 64.744 | 1.619 | 1.619 | 0.040 |
| 14 | NE | 149873967 | 32 | 15 | 2 | 64.585 | 0.000 | 0.000 | 0.000 |
| 14 | NW | 149873978 | 32 | 15 | 2 | 64.560 | 0.000 | 1.619 | 0.000 |
| 14 | SE | 152392293 | 32 | 15 | 2 | 64.618 | 1.619 | 0.000 | 0.000 |
| 14 | SW | 149873989 | 32 | 15 | 2 | 64.593 | 1.619 | 1.619 | 0.040 |
| 15 | NE | 149873990 | 32 | 15 | 2 | 64.660 | 0.000 | 0.000 | 0.000 |
| 15 | NW | 149874003 | 32 | 15 | 2 | 64.662 | 0.000 | 1.619 | 0.000 |
| 15 | SE | 149874014 | 32 | 15 | 2 | 64.669 | 1.619 | 0.000 | 0.000 |
| 15 | SW | 149874025 | 32 | 15 | 2 | 64.672 | 1.619 | 1.619 | 0.040 |
| 16 | NE | 152392305 | 32 | 15 | 2 | 64.652 | 0.000 | 0.000 | 0.000 |
| 16 | NW | 161792387 | 32 | 15 | 2 | 64.656 | 0.000 | 1.619 | 0.000 |
| 16 | SE | 152392316 | 32 | 15 | 2 | 64.666 | 1.619 | 0.000 | 0.000 |
| 16 | SW | 152392327 | 32 | 15 | 2 | 64.667 | 1.619 | 1.619 | 0.040 |
| 17 | NE | 152392338 | 32 | 15 | 2 | 64.583 | 0.000 | 0.000 | 0.000 |
| 17 | NW | 152392349 | 32 | 15 | 2 | 64.768 | 0.000 | 1.619 | 0.000 |
| 17 | SE | 152392350 | 32 | 15 | 2 | 64.414 | 1.619 | 0.000 | 0.000 |
| 17 | SW | 152392361 | 32 | 15 | 2 | 64.939 | 1.619 | 1.619 | 0.040 |
| 18 | NE | 163631224 | 32 | 15 | 2 | 64.653 | 0.000 | 0.000 | 0.000 |
| 18 | SE | 131606197 | 32 | 15 | 2 | 64.655 | 1.619 | 0.000 | 0.000 |
| 19 | NE | 131984310 | 32 | 15 | 2 | 64.661 | 0.000 | 0.000 | 0.000 |
| 19 | SE | 131984321 | 32 | 15 | 2 | 64.582 | 0.000 | 0.000 | 0.000 |
| 20 | NE | 161792545 | 32 | 15 | 2 | 64.684 | 0.000 | 0.000 | 0.000 |
| 20 | NW | 152392484 | 32 | 15 | 2 | 64.707 | 0.000 | 1.619 | 0.000 |
| 20 | SE | 152392495 | 32 | 15 | 2 | 64.626 | 0.000 | 0.000 | 0.000 |
| 20 | SW | 152392507 | 32 | 15 | 2 | 64.614 | 0.000 | 1.619 | 0.000 |
| 21 | NE | 161792534 | 32 | 15 | 2 | 64.684 | 0.000 | 0.000 | 0.000 |
| 21 | NW | 161792556 | 32 | 15 | 2 | 64.664 | 0.000 | 1.619 | 0.000 |
| 21 | SE | 161792523 | 32 | 15 | 2 | 64.639 | 0.000 | 0.000 | 0.000 |
| 21 | SW | 161792602 | 32 | 15 | 2 | 64.627 | 0.000 | 1.619 | 0.000 |
| 22 | NE | 163575670 | 32 | 15 | 2 | 64.603 | 0.000 | 0.000 | 0.000 |
| 22 | NW | 131884498 | 32 | 15 | 2 | 64.662 | 0.000 | 1.619 | 0.000 |
| 22 | SE | 131619315 | 32 | 15 | 2 | 64.650 | 0.000 | 0.000 | 0.000 |
| 22 | SW | 152392563 | 32 | 15 | 2 | 64.650 | 0.000 | 1.619 | 0.000 |
| 23 | NE | 152392574 | 32 | 15 | 2 | 64.465 | 0.000 | 0.000 | 0.000 |
| 23 | NW | 152392585 | 32 | 15 | 2 | 64.429 | 0.000 | 1.619 | 0.000 |
| 23 | SE | 152392596 | 32 | 15 | 2 | 64.551 | 0.000 | 0.000 | 0.000 |
| 23 | SW | 152392608 | 32 | 15 | 2 | 64.525 | 0.000 | 1.619 | 0.000 |
| 24 | NE | 161792567 | 32 | 15 | 2 | 64.681 | 0.000 | 0.000 | 0.000 |
| 24 | NW | 152392619 | 32 | 15 | 2 | 64.708 | 0.000 | 1.619 | 0.000 |

| Sec | Portion | Description / Mineral Parcel Number | Twp | Rge | Mer | Crown Land (hectares) Sectional Area | Road Allowances South | Road Allowances West | Road Allowances Int |
|---|---|---|---|---|---|---|---|---|---|
| 24 | SE | 152392620 | 32 | 15 | 2 | 64.665 | 0.000 | 0.000 | 0.000 |
| 24 | SW | 152392631 | 32 | 15 | 2 | 64.709 | 0.000 | 1.619 | 0.000 |
| | | | | | Sub Totals = | 5,494.006 | 35.618 | 64.760 | 0.400 |
| | | | | | Total Lease Area = | 22,554.401 | 113.330 | 278.474 | 1.360 |

Aggregating 22,947.565 hectares, more or less, all in the province of Saskatchewan.

Dated: June 28 /2016.

(Signature)

Carl Anderson

(Name in full)

Acting Director, Tenure Services

(Title)

**Karnalyte Resources Inc.**

(Signature)

Robin Phinney

(Name in full - print)

President, Director

(Title)

Government of Saskatchewan

# SUBSURFACE MINERAL LEASE

**Lease No. KL 247**

Converted from: KP 360A

THIS LEASE made as of this 23 day of June, 2016

BETWEEN:

**HER MAJESTY THE QUEEN IN RIGHT OF SASKATCHEWAN,**
represented herein by the Minister of Energy and Resources, hereinafter called the "Minister"

AND

**KARNALYE RESOURCES INC.**
hereinafter called the "Lessee".

IN CONSIDERATION of the mutual covenants herein contained, the parties hereto agree as follows:

THAT, subject to *The Crown Minerals Act* as that Act may be amended, revised or substituted from time to time (hereinafter referred to as the "Act") and subject to any applicable regulations made or continued under the Act (hereinafter referred to as the "Regulations"), as those regulations or any of them may be amended, revised or substituted from time to time, and the covenants, terms and conditions hereinafter set forth, the Minister hereby grants, demises and leases to the Lessee for the term stated in this lease, the subsurface minerals within the meaning of *The Subsurface Mineral Tenure Regulations,* under the lands described in Schedule "A" hereto, insofar as the Minister has the right to grant, demise and lease the same, excepting and reserving the royalties payable pursuant to the Regulations, with full and exclusive power and right, to the Lessee, subject to any applicable laws in force in the Province of Saskatchewan, to explore for, mine, work, recover, procure, remove, carry away and dispose of the said subsurface minerals. The Minister and the Lessee further agree as follows:

1. The term of this lease shall be for a period of twenty-one years from 03/13/16, renewable in accordance with the Regulations.

2. (1) The Lessee shall make or cause to be made all payments and returns in the manner and at the time required by the Regulations or any other applicable laws.

   (2) For the purposes of subclause (1), "payments" includes, without restricting the generality of the word, rentals, royalties, fees, rates, taxes and assessments that may be charged or be payable in respect of the subsurface minerals included in this lease or in respect of the operations of the Lessee under this lease.

   (3) Nothing in subclause (1) prejudices the exercise of any right the Lessee may have to appeal or contest any rates, taxes or assessments as provided by law.

3. The Lessee agrees to keep harmless and indemnify the Government of Saskatchewan, its Ministers, officials, agents or employees, past, present and future, from and against all

actions, suits, claims and demands arising out of or in connection with the operations carried on by the Lessee, its employees, agents, licensees and contractors, deriving from this lease.

4. The Lessee shall carry on all operations under this lease in a skillful and proper manner and in compliance with acceptable practices in the mining industry and shall take all reasonable and necessary steps to prevent injury and damage to life or property.

5. The Lessee shall comply with all laws and orders in force in Saskatchewan from time to time applicable to its operations under this lease and in particular, without restricting the generality of the foregoing, shall comply with the Act and the Regulations, *The Oil and Gas Conservation Act* and regulations thereunder, *The Mineral Resources Act, 1985* and regulations thereunder, and with all legislation, regulations and orders in force in the Province of Saskatchewan applicable to its operations under this lease relating to occupational health and safety, environmental and public protection and safety, resource conservation, management and development, and surface rights.

6. No waiver by or on behalf of the Minister of a breach on the part of the Lessee of any covenant, obligation, condition, restriction or stipulation contained in this lease shall take effect and be binding on the Minister unless it is in writing and such a waiver shall extend only to the particular breach waived and shall not limit or restrict the rights of the Minister with respect to any other breach.

7. (1) On the termination of this lease by cancellation, surrender, or expiration, the Lessee shall comply with all directions or orders of the Minister or any other official of the Province of Saskatchewan respecting the preservation, clean up, and restoration of the leased area and facilities in the leased area with respect to operations conducted by or on behalf of the Lessee.

   (2) In the event that the Lessee fails to comply with any direction or order referred to in subclause (1), the Minister may take whatever action he deems necessary, including, without limiting the generality of the foregoing, taking possession of or disposing of any property remaining in the subsurface mineral lease area. Upon such taking of possession or disposition, the Lessee shall be deemed to have forfeited any right, title, or interest it may have had in, or to, such property and any right to claim consideration or compensation therefor, and such property shall thereupon become the property of Her Majesty the Queen in Right of Saskatchewan.

   (3) Unless otherwise ordered by the Minister to be removed pursuant to subclause (1), upon such termination, any installations in the subsurface mineral lease area necessary for the preservation of the mine or other development work such as underground timbering, supports, shaft linings, well casings, ventilation equipment and hoisting installations shall be left intact and undisturbed by the Lessee and any right, title, or interest which the Lessee may have had in such installations or development work shall be deemed to have been forfeited to and become the property of Her Majesty the Queen in Right of Saskatchewan, and the Lessee shall not be entitled to consideration or compensation for them.

   (4) Any costs incurred by the Minister as a result of the Lessee's failure to comply with any direction or order mentioned in subclause (1), which failure shall be communicated to the Lessee, shall be a debt due by the Lessee to the Minister and may be recovered by the Minister as provided for by law.

   (5) The rights and remedies mentioned in this clause shall be in addition to any other rights and remedies which the Minister may have pursuant to this lease or by law.

8. Any right of action of the Minister against the Lessee in respect of any default of the Lessee in complying with the terms and conditions of this lease shall not be prejudiced by the termination of this lease by cancellation, surrender or expiration of term, and the Minister shall have the same remedies for the recovery of royalties, payments, or damages due or accruing due at the time of termination as if this lease remained in full force and effect.

9. This lease shall be governed by and interpreted in accordance with the laws of the Province of Saskatchewan and the applicable laws of Canada.

10. Time shall be of the essence of this lease and of every part of it and no extension or variation of this agreement shall operate as a waiver of this provision unless specifically stated, in writing, to so operate.

11. The Lessee acknowledges and agrees that its rights, interests, duties and obligations under this lease shall be and shall be deemed to be amended or varied, in whole or in part, in accordance with any amendments to or substitutions of, the provisions of the Act and the Regulations including, without limiting the generality of the foregoing, amendments or substitutions made to the Act or the Regulations after the execution or issuance of this lease or any renewal or substitution thereof.

12. In the event of any conflict between the provisions of this lease and the provisions of the Act or the Regulations, the provisions of the Act or the Regulations shall govern.

13. Any notice to the Lessee under this lease shall be sufficiently served if sent to the address for service or email address for service for the Lessee submitted to the Minister in accordance with the Regulations.

14. Any notice to the Minister under this lease shall be sufficiently served if delivered to the address for service or email address for service for the Director, Tenure Services of the Ministry of the Economy as published on the Saskatchewan Government Directory available on the Government of Saskatchewan's website at the time of sending the notice.

15. The parties agree that this lease and everything contained herein shall enure to the benefit of and be binding upon their respective successors and permitted assigns.

IN WITNESS WHEREOF this lease has been executed by a designated officer on behalf of the Minister and the Lessee has caused its corporate seal to be affixed hereto, attested by its proper officers in that behalf as of the date first above written.

[This space intentionally left blank. Signature page to follow.]

SIGNED, SEALED AND DELIVERED by

**HER MAJESTY THE QUEEN IN RIGHT OF SASKATCHEWAN**
as represented by the Minister of Energy and Resources

MINISTRY OF THE ECONOMY SASKATCHEWAN

(Signature)

Carl Anderson
(Name in full)

Acting Director, Tenure Services
(Title)

**KARNALYTE RESOURCES INC.**

(Witness Signature)

(Signature)

Robin Phinney
(Name in full - print)

President, Director
(Title)

[If not sealed, please use "Witness Signature" and following "Affidavit of Execution" page.]

**AFFIDAVIT OF EXECUTION**
(To be completed by witness)

I, Ronald Olchowski of the
(Name)

city, of Saskatoon in the
(Hamlet, Village, Town, City) (Name of the Hamlet, Town, City)

Province of Saskatchewan, engineer.
(Occupation)

**MAKE OATH AND SAY:**

1. That I was personally present and did see the within instrument duly signed and executed by Robin Phinney one of the parties thereto.
(Transferor Name)

2. That the said instrument was executed in the city of
(Hamlet, Village, Town, City)

Saskatoon in the Province of Saskatchewan.
(Name of the Hamlet, Village, Town, City)

and that I am subscribing witness thereto.

---

**Commissioner for Oaths/Notary Public**

SWORN before me at the city )
of Saskatoon in the Province of )
Saskatchewan this )
23 day of June )
A.D., 2016.

Witness signature as shown on previous page

QUENTIN PLESTER Notary Public SASKATCHEWAN

Signature of Commissioner for Oaths/Notary Public

A solicitor in and for

the Province of Saskatchewan.

My appointment expires n/A.

# SCHEDULE "A"

**Attach to the Subsurface Mineral Lease** **KL 247**

**Between**
**HER MAJESTY, THE QUEEN**
**and**
**Karnalyte Resources Inc. 100%**

| Sec | Portion | Description / Mineral Parcel Number | Twp | Rge | Mer | Crown Land (hectares) Sectional Area | Road Allowances South | Road Allowances West | Road Allowances Int |
|---|---|---|---|---|---|---|---|---|---|
| 31 | NW | 152190187 | 31 | 15 | 2 | 64.788 | 0.000 | 1.619 | 0.000 |
| 31 | SW | 152190200 | 31 | 15 | 2 | 64.823 | 0.000 | 1.619 | 0.000 |
| | | Sub Totals = | | | | 129.611 | 0.000 | 3.238 | 0.000 |
| 06 | NW | 146377064 | 32 | 15 | 2 | 64.700 | 0.000 | 1.619 | 0.000 |
| 06 | SW | 146377086 | 32 | 15 | 2 | 64.703 | 1.619 | 1.619 | 0.040 |
| 07 | NW | 152392057 | 32 | 15 | 2 | 64.671 | 0.000 | 1.619 | 0.000 |
| 07 | SW | 152392079 | 32 | 15 | 2 | 64.684 | 0.000 | 1.619 | 0.000 |
| 18 | NW | 152392451 | 32 | 15 | 2 | 64.644 | 0.000 | 1.619 | 0.000 |
| 18 | SW | 152392462 | 32 | 15 | 2 | 64.654 | 1.619 | 1.619 | 0.040 |
| 19 | NW | 152392473 | 32 | 15 | 2 | 64.629 | 0.000 | 1.619 | 0.000 |
| 19 | SW | 131984332 | 32 | 15 | 2 | 64.609 | 0.000 | 1.619 | 0.000 |
| | | Sub Totals = | | | | 517.294 | 3.238 | 12.952 | 0.080 |
| 13 | NE | 150218063 | 31 | 16 | 2 | 64.832 | 0.000 | 0.000 | 0.000 |
| 13 | NW | 150218074 | 31 | 16 | 2 | 64.848 | 0.000 | 1.619 | 0.000 |
| 13 | SE | 131939466 | 31 | 16 | 2 | 33.791 | 0.000 | 0.000 | 0.000 |
| 13 | SW | 131939477 | 31 | 16 | 2 | 33.616 | 0.000 | 0.810 | 0.000 |
| 14 | NE | 152609676 | 31 | 16 | 2 | 64.790 | 0.000 | 0.000 | 0.000 |
| 14 | NW | 152609687 | 31 | 16 | 2 | 64.838 | 0.000 | 1.619 | 0.000 |
| 14 | SE | 152609698 | 31 | 16 | 2 | 33.492 | 0.000 | 0.000 | 0.000 |
| 14 | SW | 152609700 | 31 | 16 | 2 | 33.455 | 0.000 | 0.810 | 0.000 |
| 15 | NE | 152609711 | 31 | 16 | 2 | 64.959 | 0.000 | 0.000 | 0.000 |
| 15 | NW | 163633215 | 31 | 16 | 2 | 64.995 | 0.000 | 1.619 | 0.000 |
| 15 | SE | 152609722 | 31 | 16 | 2 | 33.387 | 0.000 | 0.000 | 0.000 |
| 15 | SW | 152609733 | 31 | 16 | 2 | 33.271 | 0.000 | 0.810 | 0.000 |
| 16 | NE | 152609744 | 31 | 16 | 2 | 64.956 | 0.000 | 0.000 | 0.000 |
| 16 | NW | 152609755 | 31 | 16 | 2 | 64.968 | 0.000 | 1.619 | 0.000 |
| 16 | SE | 114290748 | 31 | 16 | 2 | 33.119 | 0.000 | 0.000 | 0.000 |
| 16 | SW | 114266189 | 31 | 16 | 2 | 32.955 | 0.000 | 0.810 | 0.000 |
| 17 | NE | 152609766 | 31 | 16 | 2 | 64.882 | 0.000 | 0.000 | 0.000 |
| 17 | NW | 163633226 | 31 | 16 | 2 | 64.757 | 0.000 | 1.619 | 0.000 |
| 17 | SW | 152609788 | 31 | 16 | 2 | 33.525 | 0.000 | 0.810 | 0.000 |
| 18 | NE | 163616643 | 31 | 16 | 2 | 64.756 | 0.000 | 0.000 | 0.000 |
| 18 | NW | 150413307 | 31 | 16 | 2 | 64.751 | 0.000 | 0.000 | 0.000 |
| 18 | SE | 163619466 | 31 | 16 | 2 | 33.839 | 0.000 | 0.000 | 0.000 |
| 18 | SW | 150413318 | 31 | 16 | 2 | 41.688 | 0.000 | 0.000 | 0.000 |
| 19 | NE | 152609799 | 31 | 16 | 2 | 64.580 | 0.000 | 0.000 | 0.000 |
| 19 | SE | 152609812 | 31 | 16 | 2 | 64.743 | 0.000 | 0.000 | 0.000 |

| Sec | Portion | Description / Mineral Parcel Number | Twp | Rge | Mer | Crown Land (hectares) Sectional Area | Road Allowances South | Road Allowances West | Road Allowances Int |
|---|---|---|---|---|---|---|---|---|---|
| 19 | SW | 152609823 | 31 | 16 | 2 | 64.767 | 0.000 | 0.000 | 0.000 |
| 20 | NE | 163577885 | 31 | 16 | 2 | 64.905 | 0.000 | 0.000 | 0.000 |
| 20 | NW | 152609845 | 31 | 16 | 2 | 64.779 | 0.000 | 1.619 | 0.000 |
| 20 | SE | 163575119 | 31 | 16 | 2 | 64.872 | 0.000 | 0.000 | 0.000 |
| 20 | SW | 152609856 | 31 | 16 | 2 | 64.746 | 0.000 | 1.619 | 0.000 |
| 21 | NE | 152609867 | 31 | 16 | 2 | 64.900 | 0.000 | 0.000 | 0.000 |
| 21 | NW | 152609890 | 31 | 16 | 2 | 64.934 | 0.000 | 1.619 | 0.000 |
| 21 | SE | 152609902 | 31 | 16 | 2 | 64.927 | 0.000 | 0.000 | 0.000 |
| 21 | SW | 152609913 | 31 | 16 | 2 | 64.948 | 0.000 | 1.619 | 0.000 |
| 22 | NE | 152609924 | 31 | 16 | 2 | 64.998 | 0.000 | 0.000 | 0.000 |
| 22 | NW | 135841956 | 31 | 16 | 2 | 65.029 | 0.000 | 1.619 | 0.000 |
| 22 | SE | 152609935 | 31 | 16 | 2 | 64.985 | 0.000 | 0.000 | 0.000 |
| 22 | SW | 152609946 | 31 | 16 | 2 | 65.019 | 0.000 | 1.619 | 0.000 |
| 23 | NE | 152609957 | 31 | 16 | 2 | 64.723 | 0.000 | 0.000 | 0.000 |
| 23 | NW | 152609979 | 31 | 16 | 2 | 64.771 | 0.000 | 1.619 | 0.000 |
| 23 | SE | 152609980 | 31 | 16 | 2 | 64.759 | 0.000 | 0.000 | 0.000 |
| 23 | SW | 152609991 | 31 | 16 | 2 | 64.804 | 0.000 | 1.619 | 0.000 |
| 24 | NE | 152610005 | 31 | 16 | 2 | 64.951 | 0.000 | 0.000 | 0.000 |
| 24 | NW | 120669105 | 31 | 16 | 2 | 64.961 | 0.000 | 1.619 | 0.000 |
| 24 | SE | 152610016 | 31 | 16 | 2 | 64.892 | 0.000 | 0.000 | 0.000 |
| 24 | SW | 152610027 | 31 | 16 | 2 | 64.905 | 0.000 | 1.619 | 0.000 |
| 25 | NE | 120669093 | 31 | 16 | 2 | 64.927 | 0.000 | 0.000 | 0.000 |
| 25 | NW | 152610038 | 31 | 16 | 2 | 64.936 | 0.000 | 1.619 | 0.000 |
| 25 | SE | 152610050 | 31 | 16 | 2 | 64.972 | 1.619 | 0.000 | 0.000 |
| 25 | SW | 152610049 | 31 | 16 | 2 | 64.982 | 1.619 | 1.619 | 0.040 |
| 26 | NE | 152609968 | 31 | 16 | 2 | 64.729 | 0.000 | 0.000 | 0.000 |
| 26 | NW | 152610061 | 31 | 16 | 2 | 64.708 | 0.000 | 1.619 | 0.000 |
| 26 | SE | 152610072 | 31 | 16 | 2 | 64.702 | 1.619 | 0.000 | 0.000 |
| 26 | SW | 152610083 | 31 | 16 | 2 | 64.680 | 1.619 | 1.619 | 0.040 |
| 27 | NE | 151775084 | 31 | 16 | 2 | 64.822 | 0.000 | 0.000 | 0.000 |
| 27 | NW | 161734776 | 31 | 16 | 2 | 64.837 | 0.000 | 0.000 | 0.000 |
| 27 | SE | 152610094 | 31 | 16 | 2 | 64.830 | 1.619 | 0.000 | 0.000 |
| 27 | SW | 152609878 | 31 | 16 | 2 | 64.798 | 1.619 | 0.000 | 0.000 |
| 34 | NE | 152610207 | 31 | 16 | 2 | 64.803 | 0.000 | 0.000 | 0.000 |
| 34 | NW | 152610218 | 31 | 16 | 2 | 64.823 | 0.000 | 0.000 | 0.000 |
| 34 | SE | 120669071 | 31 | 16 | 2 | 64.804 | 0.000 | 0.000 | 0.000 |
| 34 | SW | 152610229 | 31 | 16 | 2 | 64.815 | 0.000 | 0.000 | 0.000 |
| 35 | NE | 145476816 | 31 | 16 | 2 | 64.821 | 0.000 | 0.000 | 0.000 |
| 35 | NW | 145476827 | 31 | 16 | 2 | 64.793 | 0.000 | 1.619 | 0.000 |
| 35 | SE | 152610230 | 31 | 16 | 2 | 64.755 | 0.000 | 0.000 | 0.000 |
| 35 | SW | 152610241 | 31 | 16 | 2 | 64.741 | 0.000 | 1.619 | 0.000 |
| 36 | NE | 146377097 | 31 | 16 | 2 | 64.800 | 0.000 | 0.000 | 0.000 |
| 36 | NW | 146377109 | 31 | 16 | 2 | 64.874 | 0.000 | 1.619 | 0.000 |
| 36 | SE | 146377110 | 31 | 16 | 2 | 64.834 | 0.000 | 0.000 | 0.000 |
| 36 | SW | 146377121 | 31 | 16 | 2 | 64.875 | 0.000 | 1.619 | 0.000 |
| | | | Sub Totals = | | | 4,202.029 | 9.714 | 41.287 | 0.080 |
| 01 | NW | Freehold - Road Allowance Only | 32 | 16 | 2 | 0.000 | 0.000 | 1.619 | 0.000 |

| Sec | Portion | Description / Mineral Parcel Number | Twp | Rge | Mer | Crown Land (hectares) Sectional Area | Road Allowances South | Road Allowances West | Road Allowances Int |
|---|---|---|---|---|---|---|---|---|---|
| 01 | SE | Freehold - Road Allowance Only | 32 | 16 | 2 | 0.000 | 1.619 | 0.000 | 0.000 |
| 01 | SW | 152301822 | 32 | 16 | 2 | 64.729 | 1.619 | 1.619 | 0.040 |
| 02 | NE | 152301833 | 32 | 16 | 2 | 64.706 | 0.000 | 0.000 | 0.000 |
| 02 | NW | 152301844 | 32 | 16 | 2 | 64.748 | 0.000 | 1.619 | 0.000 |
| 02 | SE | 163629805 | 32 | 16 | 2 | 64.720 | 1.619 | 0.000 | 0.000 |
| 02 | SW | 152301934 | 32 | 16 | 2 | 64.777 | 1.619 | 1.619 | 0.040 |
| 03 | NE | 120669059 | 32 | 16 | 2 | 64.735 | 0.000 | 0.000 | 0.000 |
| 03 | NW | 120669060 | 32 | 16 | 2 | 64.717 | 0.000 | 0.000 | 0.000 |
| 03 | SE | 152301945 | 32 | 16 | 2 | 64.788 | 1.619 | 0.000 | 0.000 |
| 03 | SW | Freehold - Road Allowance Only | 32 | 16 | 2 | 0.000 | 1.619 | 0.000 | 0.000 |
| 12 | NE | 146377143 | 32 | 16 | 2 | 64.689 | 0.000 | 0.000 | 0.000 |
| 12 | NW | 146377154 | 32 | 16 | 2 | 64.690 | 0.000 | 0.000 | 0.000 |
| 12 | SE | 146377165 | 32 | 16 | 2 | 64.703 | 0.000 | 0.000 | 0.000 |
| 12 | SW | 146377132 | 32 | 16 | 2 | 64.705 | 0.000 | 0.000 | 0.000 |
| 13 | NE | 152302306 | 32 | 16 | 2 | 64.625 | 0.000 | 0.000 | 0.000 |
| 13 | NW | 152302317 | 32 | 16 | 2 | 64.599 | 0.000 | 0.000 | 0.000 |
| 13 | SE | 152302328 | 32 | 16 | 2 | 64.646 | 1.619 | 0.000 | 0.000 |
| 13 | SW | 164610154 | 32 | 16 | 2 | 32.298 | 1.619 | 1.619 | 0.040 |
| 13 | SW | 164610143 | 32 | 16 | 2 | 64.646 | 0.000 | 0.000 | 0.000 |
| 21 | NE | 152302744 | 32 | 16 | 2 | 48.556 | 0.000 | 0.000 | 0.000 |
| 22 | SE | 152302777 | 32 | 16 | 2 | 64.652 | 0.000 | 0.000 | 0.000 |
| 22 | SW | 152302788 | 32 | 16 | 2 | 48.427 | 0.000 | 0.000 | 0.000 |
| 23 | NE | 147183262 | 32 | 16 | 2 | 64.508 | 0.000 | 0.000 | 0.000 |
| 23 | SE | 147183273 | 32 | 16 | 2 | 64.649 | 0.000 | 0.000 | 0.000 |
| 23 | SW | 147183284 | 32 | 16 | 2 | 64.680 | 0.000 | 0.000 | 0.000 |
| 24 | NE | 152302812 | 32 | 16 | 2 | 64.563 | 0.000 | 0.000 | 0.000 |
| 24 | NW | 161792017 | 32 | 16 | 2 | 64.527 | 0.000 | 0.000 | 0.000 |
| 24 | SE | 161791982 | 32 | 16 | 2 | 64.604 | 0.000 | 0.000 | 0.000 |
| 24 | SW | 152302845 | 32 | 16 | 2 | 64.601 | 0.000 | 0.000 | 0.000 |
| 25 | NE | 164956056 | 32 | 16 | 2 | 9.602 | 0.000 | 0.000 | 0.000 |
| 25 | NE | 164956045 | 32 | 16 | 2 | 52.520 | 0.000 | 0.000 | 0.000 |
| 25 | NW | 164956102 | 32 | 16 | 2 | 7.783 | 0.000 | 0.000 | 0.000 |
| 25 | NW | 164956090 | 32 | 16 | 2 | 54.344 | 0.000 | 0.000 | 0.000 |
| 25 | SE | 152302913 | 32 | 16 | 2 | 63.755 | 1.619 | 0.000 | 0.000 |
| 25 | SW | 152302878 | 32 | 16 | 2 | 62.157 | 1.619 | 0.000 | 0.000 |
| 26 | NE | 161792107 | 32 | 16 | 2 | 64.690 | 0.000 | 0.000 | 0.000 |
| 26 | NW | 152302935 | 32 | 16 | 2 | 0.274 | 0.000 | 0.000 | 0.000 |
| 26 | SE | 152302980 | 32 | 16 | 2 | 62.244 | 0.000 | 0.000 | 0.000 |
| 28 | NE | 161792040 | 32 | 16 | 2 | 64.601 | 0.000 | 0.000 | 0.000 |
| 28 | SE | 161792129 | 32 | 16 | 2 | 65.157 | 0.000 | 0.000 | 0.000 |
| | | | | | Sub Totals = | 2,188.415 | 16.190 | 8.095 | 0.120 |

| | | | | |
|---|---|---|---|---|
| Total Lease Area = | 7,037.349 | 29.142 | 65.572 | 0.280 |

Aggregating 7,132.343 hectares, more or less, all in the province of Saskatchewan.

Dated: June 28/2016

(Signature)

Carl Anderson

(Name in full)

Acting Director, Tenure Services

(Title)

**Karnalyte Resources Inc.**

(Signature)

Robin Phinney

(Name in full - print)

President, Director

(Title)