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GEOTECHNICAL DATA ON THE MILLSTREAM POTASH DEPOSIT, LOWER MILLSTREAM, KINGS COUNTY, NEW BRUNSWICK

Compiled by

Webb, T.C., Stewart, H.J., and Allard, S.

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Geotechnical Data on the Millstream Potash Deposit, Lower Millstream, Kings County, New Brunswick

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Compilation Tim C. Webb, Holly J. Stewart, and Serge Allard

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Report prepared by

Minerals, Policy and Planning Division
Department of Natural Resources
Province of New Brunswick

Hon. Wally Stiles
Minister of Natural Resources

May 2009

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ABSTRACT

The Millstream Potash Deposit, discovered by government geologists in 1973, is located 8 km west of Sussex and 80 km northeast of the port of Saint John, New Brunswick. In 1981, BP Resources Canada Ltd. entered into an exploration agreement with the Province of New Brunswick to conduct detailed exploration work on the deposit. This work, carried out over a period of four years, consisted of various ground geophysical surveys and the drilling of eleven exploration wells and one shaft pilot hole. Data gathered from this exploration program assisted in delineating the extent and geologic characteristics of the deposit and served as the foundation for a pre-feasibility study into the establishment of a potash mine and milling facility with a production capacity of 1.2 million tonne per year. In the final analysis, BP Resources chose not proceed with the development of the Millstream property and it was returned to the Province of New Brunswick in 1992.

According to terms of the surrender agreement, BP Resources was required to turn over several binders of geotechnical information on the Millstream property to the Province. Files in digital format have now been prepared from the original printed collection of documents to allow ready access to the public. The compiled data include geological and geophysical investigations, mineral resource estimates and various aspects of the proposed development strategy. Recent trends in global supply and demand for potassium- and magnesium-based products have renewed interest in exploring for these important resources.

RÉSUMÉ

Le gîte de potasse de Millstream, que des géologues du gouvernement ont découvert en 1973, est situé à huit kilomètres à l'ouest de Sussex et à 80 kilomètres au nord-est du port de Saint John, Nouveau-Brunswick. En 1981, la BP Resources Canada a conclu une entente d'exploration avec le gouvernement provincial du Nouveau-Brunswick pour réaliser des travaux d'exploration détaillés du gîte. Ces travaux, exécutés au cours d'une période de quatre ans, ont comporté divers levés géophysiques au sol et le forage de 11 puits d'exploration ainsi que d'un puits vertical d'observation. Les données recueillies au moyen de ce programme d'exploration ont aidé à définir l'étendue et les caractéristiques géologiques du gîte et ont servi de fondement à une étude de préfaisabilité en vue de l'établissement d'une mine de potasse et d'un concentrateur d'une capacité de production de 1,2 million de tonnes par année. En dernière analyse, la BP Resources a décidé de ne pas aller de l'avant avec l'exploitation de la propriété de Millstream et elle a retourné celle-ci au gouvernement provincial du Nouveau-Brunwick en 1992.

Suivant les conditions de l'entente d'abandon, la BP Resources devait retourner plusieurs reliures de données géotechniques sur la propriété de Millstream au gouvernement provincial. On a maintenant préparé des fichiers sous forme numérique à partir de la collection imprimée originale de documents pour faciliter l'accès au public. Les données compilées comprennent des études géologiques et géophysiques, des estimations des ressources minérales et divers aspects de la mise en valeur envisagée. Les tendances récentes de l'offre et de la demande mondiale de produits à base de potassium et de magnésium ont renouvelé l'intérêt à l'égard de l'exploration de ces ressources importantes.

GEOTECHNICAL DATA ON THE MILLSTREAM POTASH DEPOSIT, LOWER MILLSTREAM, KINGS COUNTY, NEW BRUNSWICK

INTRODUCTION

Since 1970, several government agencies and private-sector companies have been involved in the search for potash deposits in New Brunswick. As a result, three major discoveries have been made. Two of these were eventually developed into world-class mining and processing operations, while a third confirmed deposit in the Lower Millstream area has yet to be developed.

The discovery of potash in the Lower Millstream area (NTS 21 H/12) had its beginning nearly 37 years ago with the initiation of a joint federal and provincial government-sponsored exploration program to gather geologic data on salt deposits in parts of the Carboniferous Maritimes Basin in southern New Brunswick. Exploration work in 1970-71, conducted by the New Brunswick Department of Natural Resources, focussed in the Moncton Subbasin in the Sussex area of southern New Brunswick (Fig. 1). Regional gravity surveying and follow-up drilling (Plumweseep #1 and Penobsquis #1 wells) resulted in the discovery of significant potash-bearing evaporites in the area to the northeast of Sussex. A major mine and processing facility was constructed near Penobsquis in 1983 by the Potash Company of America Inc. Since 1993, PotashCorp (Potash Corporation of Saskatchewan) has operated this facility, which has an annual potash production capacity of 785 000 tonnes.

Detailed gravity surveying and a limited drilling program undertaken in 1972-73 by the New Brunswick Department of Natural Resources resulted in the discovery of two more potash-bearing evaporite deposits in the Moncton Subbasin; the Cassidy Lake deposit, located 20 km south of Sussex (Salt Springs #1 discovery well); and the Millstream deposit, located 5 km west of Sussex in the Lower Millstream area (Millstream # 1 discovery well). In 1985, Potash Company of Canada and Denison Mines developed the Cassidy Lake deposit (Fig. 1) into a potash operation with an annual production capacity of 1.3 million tonnes. Mining operations at Cassidy Lake came to an end in 1997 when water flooded the underground workings.

The Millstream #1 well, drilled in 1973 near the center of a 3-milligal gravity low in the Lower Millstream area, cored 925 m of redbeds of the Mabou Group before intersecting evaporites of the Windsor Group (Fig. 1). Technical difficulties restricted the recovery of evaporite core to only a few small fragments containing minor sylvite (Fig. 2) before the hole was abandoned at 937 m. In 1980, following success in attracting interest by the private sector to the Penobsquis and Cassidy Lake deposits, the Province of New Brunswick invited bids to obtain exclusive potash exploration and development rights in the Lower Millstream area. The prospective area for exploration extended over 10 000 hectares from Sussex southwestward to Norton (Fig. 1). Although a potash deposit was suspected at Millstream, it was yet to be confirmed. BP Resources Canada Ltd. was selected over several other interested companies as the successful bidder for the Millstream property. Company officials subsequently signed an exploration agreement with the Province in 1981.

Between 1981 and 1983, BP Resources conducted an extensive exploration program on the eastern half of the Millstream property. Eleven wells, surface seismic and other geophysical surveys confirmed a substantial potash resource (Fig. 3). The deposit, 950

to 1050 m below surface, was found to consist of several potash (sylvinite) zones with apparent thicknesses of up to 38 m with intervening zones of carnallitic-halite up to 76 m thick. Following a comprehensive economic assessment of the deposit, BP Resources obtained a mining lease from the Province of New Brunswick in 1985.

From 1985 to the early 1990's, BP Resources continued to refine its development plan for the Millstream property. This work involved drilling a shaft pilot hole and planning for a subsequent underground exploration program. Several other studies related to mine development and the establishment of surface facilities and infrastructure to accommodate an annual potash production capacity of 1.2 million tonnes were also undertaken. Company officials also pursued partnership arrangements in order to move the Millstream project forward, past the preliminary development stage, but they were not successful in this endeavor. Following corporate restructuring in 1992, BP Resources chose to relinquish all its mining assets concentrating instead on its business interest in the exploration and development of petroleum resources. Consequently, the Millstream property was returned to the Province of New Brunswick along with an extensive collection of geotechnical data, maps, and reports.

The geological information presented below is based largely on documents from BP Resources Pre-Feasibility Study of 1984 submitted to the Department of Natural Resources on surrender of its Millstream Lease in 1992.

GEOLOGY OF THE MILLSTREAM POTASH DEPOSIT

Early Carboniferous evaporites of the Windsor Group are found about midway along the Case Syncline, a small intrabasinal structure in the Lower Millstream area to the west of Sussex near the southwestern limit of the Moncton Subbasin (Fig. 1). The results from regional gravity surveying and geological mapping indicate that the evaporite deposit in the Lower Millstream area extends over 20 km^2. The evaporite deposit consists of a thick sequence of chlorides (sylvinite[1]-carnallitite[2]-halite[3]) of the Cassidy Lake Formation sandwiched between underlying sulphate (anhydrite) of the Upperton Formation, carbonates of the Macumber/Gays River/Parleeville formations and redbeds of the Hillsborough Formation, and overlying redbeds of the Mabou Group (Fig. 4).

Strata of the Mabou Group are typically comprised of fine- to coarse-grained sandstone, siltstone, mudstone, and conglomerate up to several hundred metres in thickness. These rocks are variably jointed, fractured and locally water bearing. Fine-grained sedimentary rocks (siltstone and mudstone and anhydritic-claystone) spatially increase toward the top of the Windsor evaporite sequence. These fine-grained rocks form an important impermeable seal between the soluble chlorides of the Windsor Group and overlying sandstone aquifers in Mabou Group.

The Windsor evaporite sequence in the core of the Case Syncline plunges gently to the northeast (Fig. 4). The top of evaporite sequence occurs at a minimum depth of 700 m on the south limb of the structure and has a maximum depth of 1050 m down-dip near its central axis. The concave-like configuration of the basal evaporites is interrupted by several synchronal, intrabasinal faults. These faults have had a very significant impact on the internal configuration of the evaporite body (i.e. folding, dissolution and erosion; secondary mineralization and facies change). In general, the Millstream evaporite

[1] Sylvite (KCl) in combination with some halite = Sylvinite
[2] Carnallite ($KCl \cdot MgCl_2 \cdot 6H_2O$) in combination with some halite = Carnallitite
[3] Halite (NaCl)

sequence is represented by a maximum apparent thickness of approximately 500 m of halite and sylvinitic- and carnallitic-halite, underlain by 20 m of marl, 150 m of anhydrite, and 10 m of basal carbonate, followed by coarse-grained redbeds (Fig. 5).

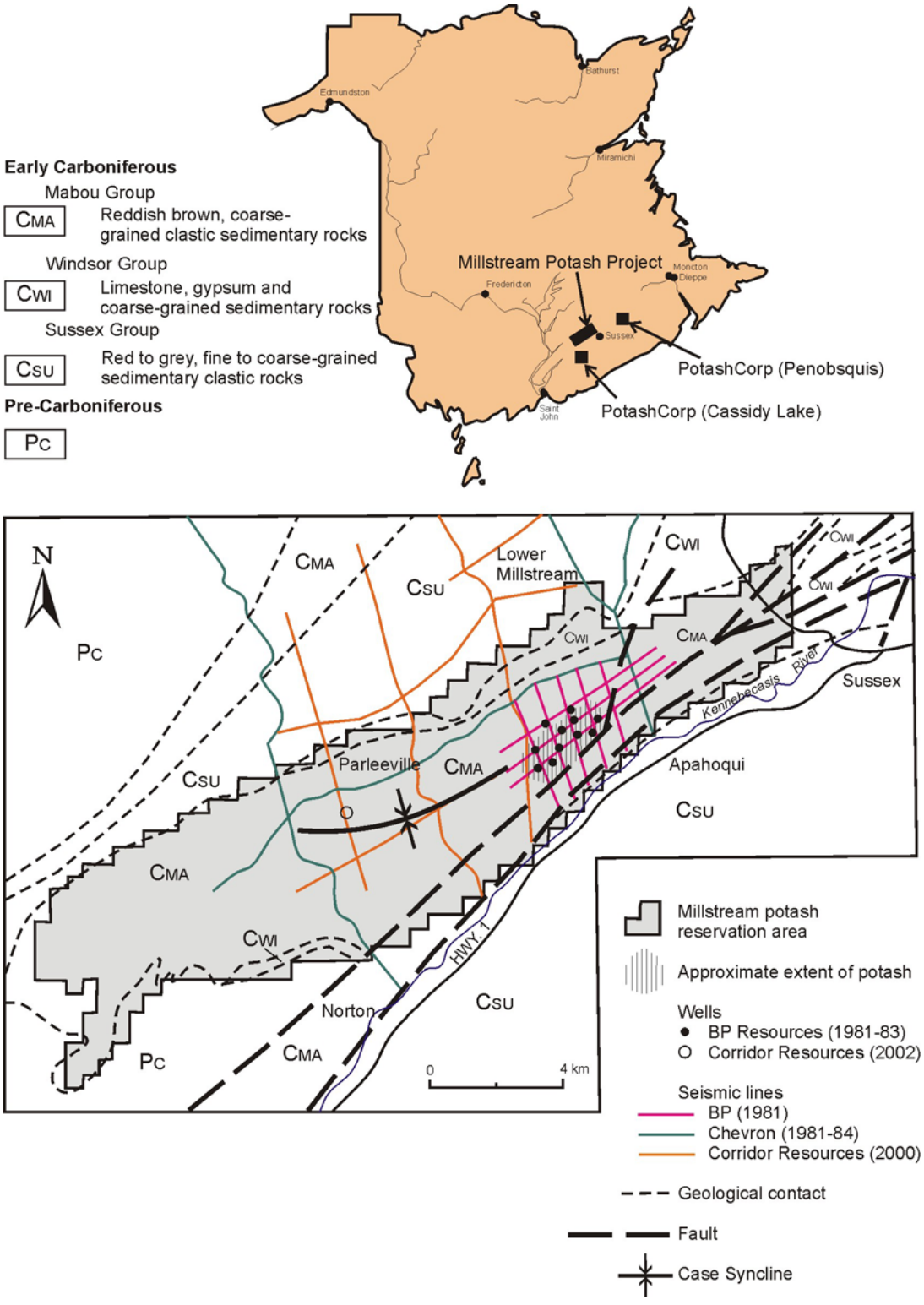

Figure 1. Location and geology of BP Resources Canada Ltd. Lower Millstream reservation

Figure 2. A 4-cm long potash (sylvinite) fragment from the Millstream # 1 discovery well drilled by the New Brunswick Department of Natural Resources in 1973.

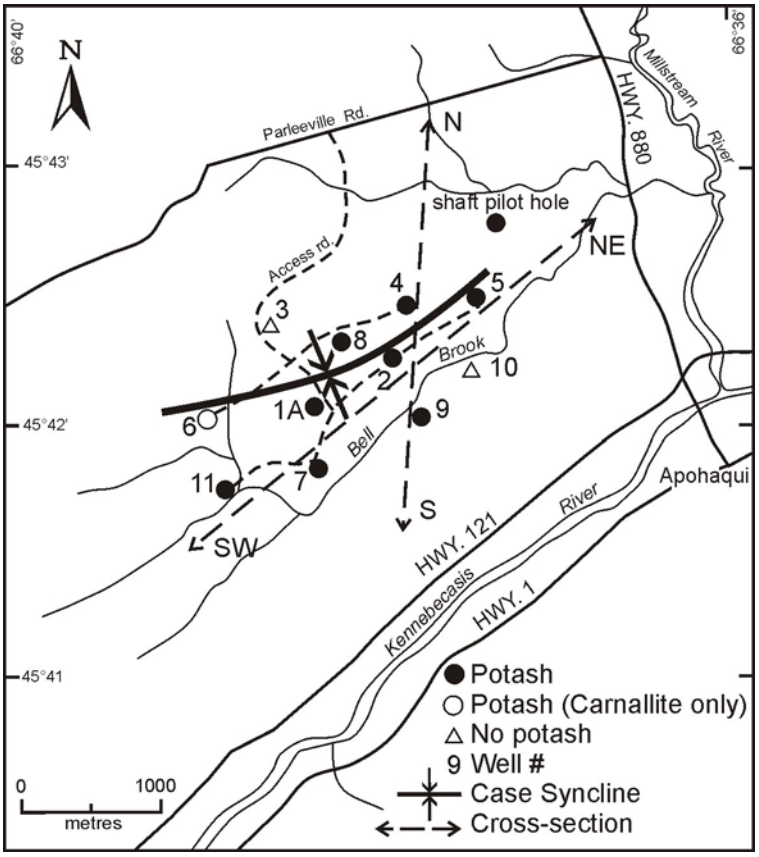

Figure 3. Map showing location of exploration wells and a shaft pilot hole drilled by BP Resources Canada Ltd. between 1981 and 1983 at the Millstream Potash Deposit and locations of N-S and NE-SW cross-sections (see Figure 5).

The thickness and limited areal extent of evaporites in the Lower Millstream area indicates deposition in a sinking, graben-like structural basin. As a result, the evaporite body has been sub-eroded and variably deformed. The main sylvinite-carnallitite units occur in two northeast-trending synclinal folds linked by an anticlinal fold in a north-south configuration (Fig. 4). The major sylvinite beds plunge westward from Apohaqui, to what is considered the thickest part of the evaporite body thereafter rising gently towards the southwestern limits of the basin near the village of Norton (Fig. 1 and Fig. 4).

In plan view, the explored portion of the Millstream Potash Deposit occupies an area of 8 to 10 km^2. Some may consider such a deposit as being relatively small in global terms. However, drilling has confirmed several major potash units, four of which are very thick, exceeding 40 m in places (Fig. 5). The potash-bearing evaporites at Millstream are in the form of sylvinite and carnallitite. Significant sylvinite mineralization is found in five distinct horizons which vary in thickness and depth within the evaporite body. For example, throughout the deposit, the basal sylvinite ore zone, 'SI', ranges in thickness from 6.9 to 38.0 m (Fig. 5). Its base is established at about 830 m below surface in the eastern part of the deposit and near 1 200 m below surface in the central part.

From a qualitative perspective, potash ore is indicated as having average grades of around 22 % K_2O for three sylvinite horizons, 27 % K_2O for one and 16.4 % K_2O for the lowermost and most extensive horizon (SI) (Fig. 5 and Table 1). Based on measurements from various cross-sections constructed from the wells, BP Resources predicted a geological potash resource of 256 000 000 tonnes grading 20.6 % K_2O.

Table 1. Potash grade summary and geological resource estimates for the Millstream Potash Deposit (Source: BP Resources Canada Limited. 1985. Millstream Potash Project, Preliminary Development Plan).

Sylvinite unit	Tonnes 000's	Average Grade % K_2O
SV	17 990	22.6
SIV	30 300	27.5
SIII	16 500	22.5
SII	89 300	22.4
SI	102 100	16.4
Grand Total	**256 100**	**20.6**

The sylvinite horizons are separated by three carnallitite units and several minor intervals of halite. Carnallitite horizons range in apparent thickness from 10.3 to 49.3 m; however, a well at the western limit of the explored area intersected a 65.3 m thick section of carnallitite, which is considered a facies equivalent to the interbedded sylvinite/carnallitite horizons to the east. The paucity of thick halite horizons found in association with the sylvinite and carnallitite horizons is best demonstrated in the Millstream # 1A well (Fig. 4). This well, drilled near the central part of the Case Syncline, provides an excellent representation of all carnallitite, sylvinite, and halite horizons encountered in the Millstream Potash Deposit. A continuous carnallitite-sylvinite-halite section totalling 270 m was intersected in this hole. Halite accounted for only 30% of this section, spread out in three intervals with the thickest reported at 54.4 m.

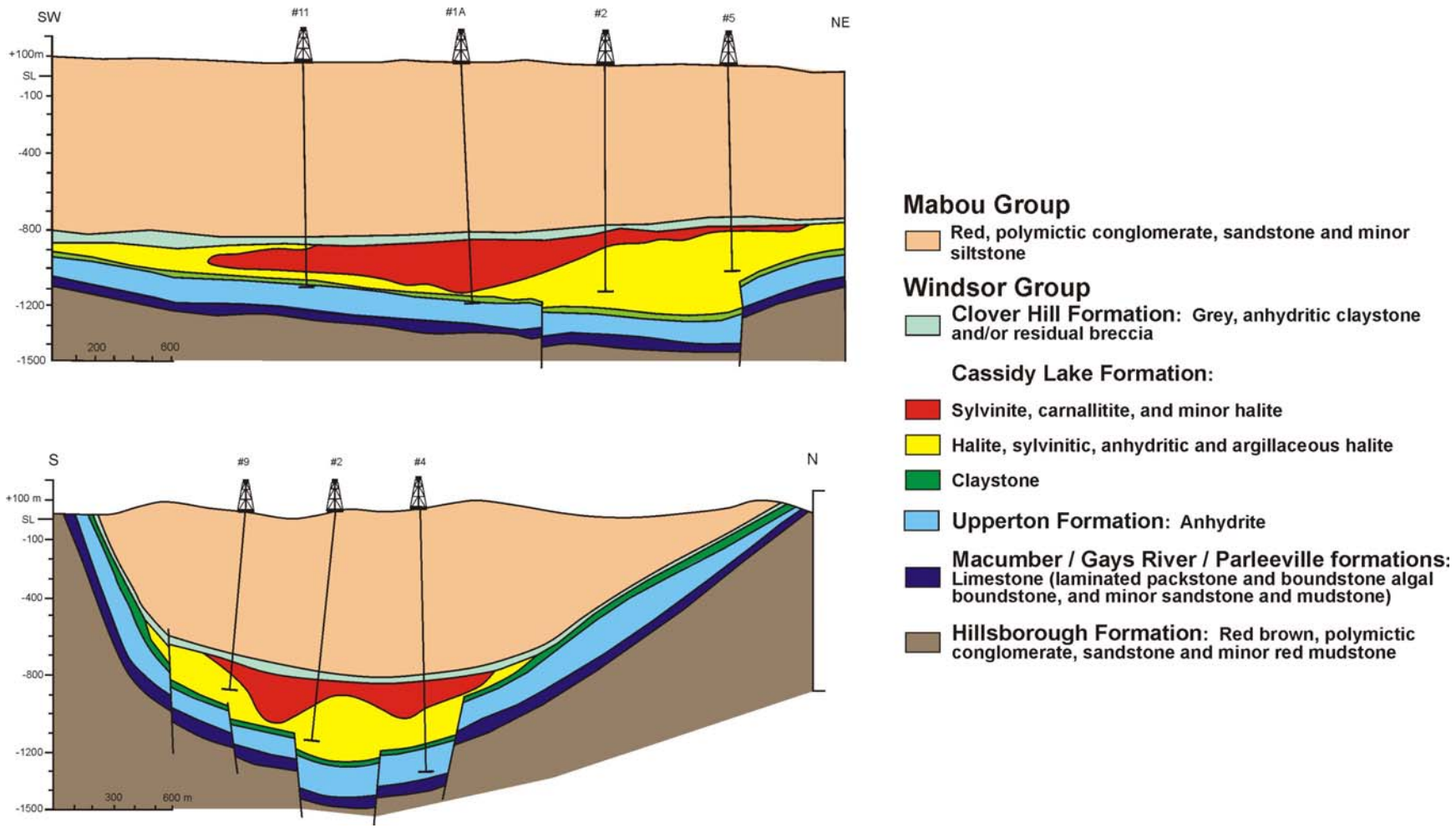

Figure 4. Southwest-northeast and north-south cross-sections of the Millstream Potash Deposit (for cross-section locations see Figure 3).

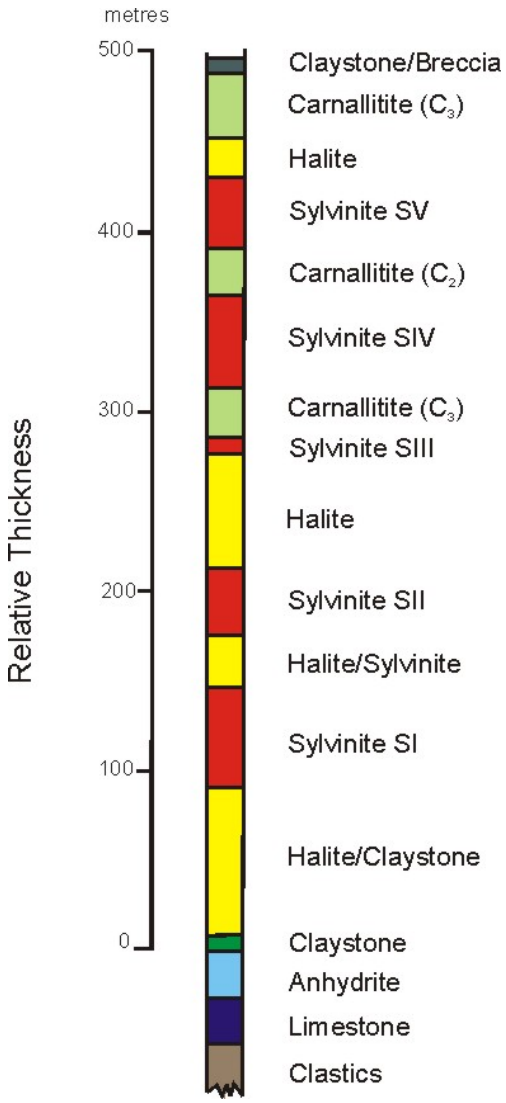

Figure 5. Typical stratigraphic section of the evaporite sequence at the Millstream Potash Deposit.

EXPLORATION DATA

Between 1981 and 1983, BP Resources undertook an extensive exploration program to evaluate the potential for potash deposits on a 10 000 hectare reservation area near Lower Millstream to the west of Sussex (Fig. 1). The work consisted of geophysical surveying and drilling activities.

Seismic Survey

BP Resources commissioned a surface seismic survey to assist in the delineation of the evaporite deposit at Millstream. A total of eight lines were run; five across and three parallel to the general northeast-southwest strike of the deposit. Data interpretation from brute stack seismic profiles by BP Resources indicated a graben-like structure, down-dropped by laterally, coalescing, listric faults (Fig. 4 and Fig. 6).

Gravity Survey

A detailed gravity survey was conducted over the Millstream evaporite deposit by the Geophysics Division, Nova Scotia Research Foundation Corporation. This data was combined with gravity readings from the previous New Brunswick government survey to better define the negative gravity anomaly in support of a proposed BP Resources exploration drill program. Bouguer gravity values were collected and calculated for an additional 350 stations. Due to the rugged nature of the topography and the relatively small amplitude of the Millstream anomaly, terrain corrections were calculated and applied to each gravity value. These were subsequently used to assist in the construction of appropriate computer models for the evaporite deposit.

Wells

Eleven wells and one shaft pilot hole were drilled in the northeastern half of the Millstream property (Fig. 3 and Fig. 6). Nine exploration wells intersected evaporites, encountering five sylvinite and three carnallitite horizons ranging in apparent thickness from 6.1 to 38 m and 11.6 to 29.3 m thick, respectively. The westernmost well, Millstream # 6, intersected 65.5 m of carnallitite and did not encounter any significant potash (sylvinite) mineralization. Two wells, Millstream # 3 and # 10, did not intersect evaporites. Millstream # 3 deviated north of the evaporite body intersecting sulphate, carbonate, and underlying sedimentary rocks. Millstream # 10 intersected a water-bearing fault zone near the southern edge of the evaporite body. This presented difficulties with water control and the hole was subsequently cemented and abandoned. In eight of the eleven holes, potash was encountered in some 22 intersections for a cumulative thickness totalling 408 m.

Down-Hole Geophysical Logs

Two suites of down-hole geophysical profiling were run in each well: one in the redbeds of Mabou Group, and the other in the underlying evaporites of the Windsor Group. In most holes, these profiles consisted of: gamma, density, hole-calliper, sonic, neutron-neutron, temperature, and continuous verticality logs.

Geochemical Analysis

Two types of geological samples were collected from each well for mineral and elemental geochemical analysis. Cuttings of redbeds overlying the evaporites were sampled every 3 m for lithologic analysis. Cored samples from the main evaporite body were oriented and logged geologically before samples were taken, typically at 0.5 to 1.0 m intervals, for mineral and elemental analysis. Samples of water soluble fractions and water insoluble residues (clays) were examined by X-ray diffraction and occasionally X-ray fluorescence. Mineral analysis consisted of % H_2O, KCl, NaCl, and $KCl \bullet MgCl_2 \bullet 6H_2O$ whereas elemental analysis consisted of % K, Mg, Na, and Cl. In addition, halite and sylvinite minerals were analyzed for boron and bromine.

A lithogeochemical correlation based on 72 elements was attempted on the evaporite core from four wells to determine if multiple potash (sylvinite) intersections represented different geologic horizons or the same stratum repeated by internal folding or faulting. Water soluble and insoluble fractions were analyzed using multi-element ICP

instrumentation. Eight elements (Na, K, Mg, Sr, Mn, B, Cl) formed the basis of the water soluble analysis while seventeen elements (Na, K, Mg, Sr, Mn, B, Al, Fe, As, Mo, Co, Cu, Pb, Zn, Ni, Cr) were analyzed from the water insoluble fraction. The geochemical studies confirmed the existence of five separate sylvinite and three intervening carnallitite horizons.

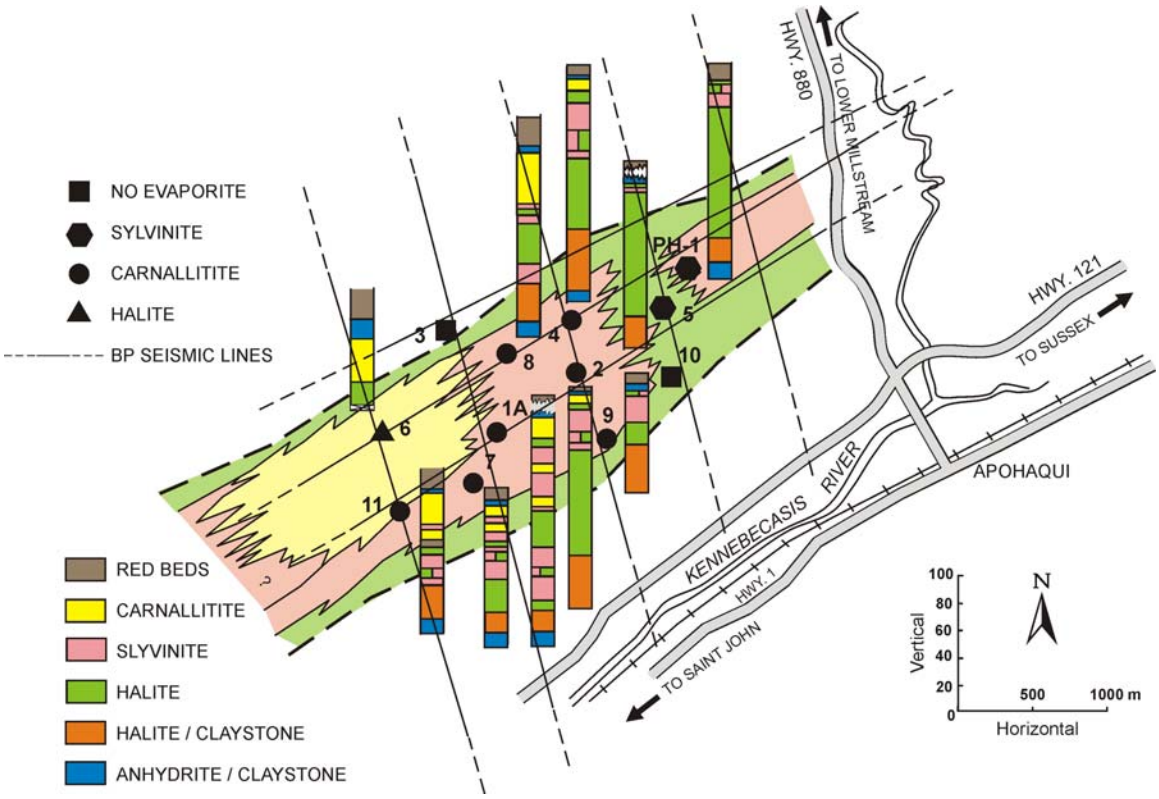

Figure 6. Map showing plan of BP Resources Canada Ltd. exploration wells and location of seismic lines for the Millstream Potash Deposit. An interpretation of main evaporite facies variation is shown in plan view.

ELECTRONIC SCANNING OF GEOTECHNICAL DATA

Exploration and development work on the Millstream Potash Deposit by BP Resources generated many reports, maps, cross-sections and charts. Many of these documents were compiled by the Company into an extensive pre-feasibility study in 1984 and submitted to the New Brunswick Department of Natural Resources in 43 separate binders. Documents in 20 of these binders dealing mostly with the geology of the Millstream Potash Deposit have been electronically scanned by the Geological Surveys Branch as a means to digitally archive important technical information on the deposit and to assist its efficient distribution when required. In addition, 18 miscellaneous reports related to the Millstream deposit have been scanned for inclusion in the digital database.

The following is a listing of available reports from the BP Millstream Potash Project, Pre-Feasibility Study of 1984 and from various miscellaneous reports by BP Resources pertaining to the Millstream Potash Deposit. The four 'Appendices' constituting the Pre-Feasibility Study of 1984 pertain to specific subject matter (Geology, Underground

Mining, Surface Plant, and Marketing) and consist of several related 'Books' filed in individual binders. The four appendices and miscellaneous reports are all available in hardcopy and most are available in digital (✓) format except those marked with an (✗) below. All hardcopy data is archived for viewing at the New Brunswick Department of Natural Resources library holdings, located in the Hugh John Flemming Center, Fredericton, New Brunswick.

Appendix I, Geology

BOOK #	TITLE	DIGITAL
1	HAMMOND, G.R. 1984. Evaluation of the Pre-Feasibility Study: Geology Section Lower Millstream Potash Project, New Brunswick, Canada. Seltrust Engineering Ltd., Report No. 29/84. Millstream Potash Project, Pre-Feasibility Report, BP Exploration Canada Ltd., Geology, Appendix I, Book 1, 58 p.	✓
1	HAMMOND, G.R. 1984. Lower Millstream Potash Project, New Brunswick, Canada, Statistical and Graphical Study of Check Assays. Seltrust Engineering Ltd., Report No. 68/84. Millstream Potash Project, Pre-Feasibility Report, BP Exploration Canada Ltd., Geology, Appendix I, Book 1, 17 p.	✓
2	BP EXPLORATION CANADA LIMITED. 1983. Sampling and Testing of Windsor Salt Cores, Millstream Potash Deposit. Millstream Potash Project, Pre-Feasibility Report, Geology, Appendix I, Book 2, 83 p.	✓
3	BP RESOURCES CANADA LIMITED. 1983. Geological and Mining Reserves. Millstream Potash Project, Pre-Feasibility Report, Geology, Appendix I, Book 3, 104 p.	✓
4	CROSBY, K.S. 1983. Stratigraphic and Structural Summary of the Lower Millstream Potash Prospect, Lower Millstream, New Brunswick. (BP Millstream 1A - BP Millstream 11), Millstream Potash Project, Pre-Feasibility Report, BP Exploration Canada Ltd., Geology, Appendix I, Book 4, 157 p.	✓
5	CROSBY, K.S. 1983. Stratigraphic and Structural Summary of the Lower Millstream Potash Prospect, Lower Millstream, New Brunswick. (BP Millstream 1A - BP Millstream 11), Appendices 1-5. Millstream Potash Project, Pre-Feasibility Report, BP Exploration Canada Ltd., Geology, Appendix I, Book 5.	✓
6	CROSBY, K.S. 1983. Stratigraphic and Structural Summary of the Lower Millstream Potash Prospect, Lower Millstream, New Brunswick. (BP Millstream 1A - BP Millstream 11), Appendices 6-7. Millstream Potash Project, Pre-Feasibility Report, BP Exploration Canada Ltd., Geology, Appendix I, Book 6.	✓
7	CROSBY, K.S. 1981. BP Millstream 1A, Well History Report. Millstream Potash Project, Pre-Feasibility Report, BP Exploration Canada Ltd., Geology, Appendix I, Book 7, 149 p.	✓
8	CROSBY, K.S. 1981. BP Millstream 3, Well History Report. Millstream Potash Project, Pre-Feasibility Report, BP Exploration Canada Ltd., Geology, Appendix I, Book 8, 36 p.	✓
9	DRYSDALE, K. 1981. BP Millstream 4, Well History Report. Millstream Potash Project, Pre-Feasibility Report, BP Exploration Canada Ltd., Geology, Appendix I, Book 9, 94 p.	✓
10	CROSBY, K.S. and DRYSDALE, K. 1982. BP Millstream 5, Well History Report. Millstream Potash Project, Pre-Feasibility Report, BP Exploration Canada Ltd., Geology, Appendix I, Book 10, 48 p.	✓
11	CROSBY, K.S. 1982. BP Millstream 6, Well History Report. Millstream Potash Project, Pre-Feasibility Report, BP Exploration Canada Ltd., Geology, Appendix I, Book 11, 59 p.	✓

12	CROSBY, K.S. 1982. BP Millstream 7, Well History Report. Millstream Potash Project, Pre-Feasibility Report, BP Exploration Canada Ltd., Geology, Appendix I, Book 12, 72 p.	✓
13	CROSBY, K.S. 1982. BP Millstream 8, Well History Report. Millstream Potash Project, Pre-Feasibility Report, BP Exploration Canada Ltd., Geology, Appendix I, Book 13, 102 p.	✓
14	CROSBY, K.S. and DRYSDALE, K. 1982. BP Millstream 2, Well History Report. Millstream Potash Project, Pre-Feasibility Report, BP Exploration Canada Ltd., Geology, Appendix I, Book 14, 109 p.	✓
15	CROSBY, K.S. 1982. BP Millstream 9, Well History Report. Millstream Potash Project, Pre-Feasibility Report, BP Exploration Canada Ltd., Geology, Appendix I, Book 15, 68 p.	✓
16	CROSBY, K.S. 1983. BP Millstream 10, Well History Report. Millstream Potash Project, Pre-Feasibility Report, BP Exploration Canada Ltd., Geology, Appendix I, Book 16, 76 p.	✓
17	CROSBY, K.S. 1983. BP Millstream 11, Well History Report. Millstream Potash Project, Pre-Feasibility Report, BP Exploration Canada Ltd., Geology, Appendix I, Book 17, 94 p.	✓
18	Review of Available Data to Assess Hydrogeological Conditions at Proposed Mine Shaft	×
19	HOFFMAN, S.J. 1983. Investigation of the Inductively Coupled Plasma (ICP) Applied to the Analysis of Core Samples from the Millstream Potash Project, NB. Lithogeochemical correlation between Millstream DDH-1A, 2, 4, and 8. BP Minerals Ltd., Report # 83-2. Millstream Potash Project, Pre-Feasibility Report, BP Exploration Canada Ltd., Geology, Appendix I, Book 19, 132 p.	✓
20	Unconfined and Confined Compressive Strength Tests	×
21	Gravity Measurements in the Aulac-Sackville Area	×
22	SILVERSTONE, B. 1982. Geophysical Interpretation of the Millstream Potash Development, Millstream, New Brunswick. Report No. S-1158. Millstream Potash Project, Pre-Feasibility Report, BP Exploration Canada Ltd., Geology, Appendix I, Book 22, 21 p.	✓
23	CROSBY, K.S., KYLE, P.G., and SMITH, A.G. 1985. Bedding and Fracture Azimuth Study of the Hopewell Group within the Pilot Hole Area, Millstream Potash Project, Lower Millstream, New Brunswick. Millstream Potash Project, Pre-Feasibility Report, BP Exploration Canada Ltd., Geology, Appendix I, Book 23, 101 p.	✓
24	Geotech Testing Program & Results: Shaft Pilot Hole	×

Appendix II, Underground Mining

BOOK #	TITLE	DIGITAL
1	Underground Mining	×
2	Pilot Hole # 1 - Core Logging	×
3	Preliminary Geological-Geotechnical Report	×
4	Hydrogeological Assessment for Pilot Shaft	×
5	Pilot Hole # 1 - Drill Stem Tests	×
6	Pilot Hole # 1 - Electronic Tests	×
7	Pilot Hole # 1 - Costs Drill Program	×
8	Exploration - Design Report	×

9	Exploration Shaft - Specification and Bill of Quantities	×
10	Cementation Company Ltd. Proposal to BP Exploration Canada Ltd. for Shaft Pilot Hole Investigation Program, Millstream Project.	×
11	Thysesen Mining Construction of Canada Ltd. BP Canada Resources Ltd. Selco Division, Millstream Project: Proposal for Shaft Design.	×
12	J.S. Redpath Limited. Millstream Project: Comparative Cost Estimates for Four Types of Shaft Lining, Prepared for BP-Canada (Selco Division).	×

Appendix III, Surface Plant

BOOK #	TITLE	DIGITAL
1	Metallurgical Testing of Core Samples	×
2	Surface Facilities	×
3	Pre-Development Environmental Monitoring Program	×
4	Surface Facilities - Side Studies	×
5	Surface Facilities - Side Studies (Continued)	×
6	Tailings Disposal Alternatives	×

Appendix IV, Marketing

TITLE	DIGITAL
Discussion Draft	×

Miscellaneous Reports

TITLE	DIGITAL
A Summary and Assessment Report of the Nova Scotia Research Foundation Gravity Survey of 1984.	×
BELL, J.S. and SILVERSTONE. B. 1981. Millstream Potash Deposit - Gravity Modelling (Part 1). BP Exploration Canada Ltd., Report # 563, 9 p.	✓
BP Canada Inc. (Selco Division), 1985. To Construct an Exploration Mine Shaft, and to Construct and Operate Attendant Surface Facilities and a Storage Area for Temporary Surface Storage of Evaporites Produced during Exploration Mining, an Application for Certificate of Approval, Under Regulation 82-126 of the Clean Environment Act.	×
CROSBY, K.S. 1983. Stratigraphic and Structural Summary of the Lower Millstream Potash Prospect, Lower Millstream, New Brunswick. (BP Millstream 1A - BP Millstream 11), Appendices 1-7. BP Exploration Canada Ltd. Millstream Potash Project, Pre-Feasibility Report. Geology, Appendix I, Books 5 and 6.	✓
BP EXPLORATION CANADA LIMITED. 1985. Millstream Potash Project - Lower Millstream Formation (Evaporite Correlation Sections).	✓
BP EXPLORATION CANADA LIMITED. 1981. Millstream - 1981 (Final Plan), Seismic shot hole location map. Minerals, Policy and Planning Division, New Brunswick Department of Natural Resources, Map Plates 98-61 and 98-68, Scale 1:10 000.	✓
BP EXPLORATION CANADA LIMITED. 1982. Synthetic Seismograms, Millstream-New Brunswick, BP wells 1, 2, 3, 4, 5 and 6, New Brunswick Department of Natural Resources Map Plates 98-62 to -67.	✓
BP EXPLORATION CANADA LIMITED. 1983. Geological Models, Scale 1: 25 000. Millstream Potash Project. BP Exploration Canada Ltd.	✓
BP EXPLORATION CANADA LIMITED. 1983. Mining Reserve Blocks, Scale 1: 5 000. Millstream Potash Project. BP Exploration Canada Ltd.	✓
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BP EXPLORATION CANADA LIMITED. Well Log Summary for BP # 1A, 2, 4, 5, 6, 7, 8, 9, 11. Millstream Potash Project. BP Exploration Canada Ltd.	✓
BP EXPLORATION CANADA LIMITED.1982. Base of salt: Depth-structure map. Contour interval: 50m, Scale 1:5 000.	✓
BP EXPLORATION CANADA LIMITED.1982. Base of salt: Time-structure map. Contour interval: 20m, Scale 1:5 000.	✓
BP EXPLORATION CANADA LIMITED.1982. Salt member thickness: Depth-isopack map. Contour interval: 50m, Scale 1:5 000.	✓
BP EXPLORATION CANADA LIMITED.1982. Top of Windsor Group (salt): Average Velocity map to the top of Windsor Group Contour interval: 50m/s, Scale 1:5 000.	✓
BP EXPLORATION CANADA LIMITED.1982. Top of Windsor Group: Depth-structure map. Contour interval: 20ms, Scale 1:5 000.	✓
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BP EXPLORATION CANADA LIMITED. 1984. Millstream Potash Project, A Background Paper. 48 p.	✓
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CROSBY, K.S. 1982. Distribution of Bromine and Potash Genesis in the Lower Millstream Formation, Lower Millstream, New Brunswick: Preliminary Study. BP Exploration Canada Ltd., 29 p.	✓
CROSBY, K.S. 1984. BP Millstream Potash Project, BP Millstream Pilot Hole No. 1, Geological - Geotechnical Report. BP Exploration Canada Ltd., 358 p.	✓
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CROSBY, K.S. 1984. Stratigraphic Column - Case Syncline. Millstream Potash Project. BP Exploration Canada Ltd.	✓
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CROSBY, K.S., KYLE, P.G, AND SMITH, A.G. 1984. Bromine Investigations (Surface Geology Maps, Geotechnical Maps, and Bromine Profiles). Millstream Potash Project. BP Exploration Canada Ltd.	✓

Kilborn, 1983. Millstream Potash Project: Surface Facilities - Pre-Feasibility Report with Side Studies. For BP Canada.	×
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Kilborn, 1983. Millstream Potash Prospect, Preliminary Proposal for Engineering Services and Supervision of Shaft Design, Development, and Underground Exploration.	×
Kilborn, 1984. Millstream Potash Project: Surface Facilities - Pre-Feasibility Report with Side Studies. For BP Canada.	×
KILBORN. 1983. BP Canada, Millstream Potash Project: Conceptual Flowsheet and Plant Siting Alternatives. 59 p.	✓
KILBORN. 1983. BP Canada, Millstream Potash Project: Preliminary Assessment of the Potential for Solution Mining. 170 p.	✓
KILBORN. 1983. BP Canada, Millstream Potash Project: Surplus Brine Disposal Alternatives. 45 p.	✓
Kilborn. 1983. Geotechnical Investigation and Services Proposed BP Canada Ltd. Millstream Potash Project. Report # 2188-1, 72 p.	×
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Marston & Marston, Inc. 1983. Proposal of Services: Project Management and Engineering to BP Exploration Canada Limited, the Millstream Potash Project, Exploration Shaft.	×
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NEW BRUNSWICK DEPARTMENT OF NATURAL RESOURCES. 1979. Bouguer gravity map of the eastern half of the Case Syncline, NB., (Millstream Potash Prospect). Contour interval: 0.5 milligals, Scale 1:25 000.	✓
NEW BRUNSWICK DEPARTMENT OF NATURAL RESOURCES. Well Log Summary for BP # 1A, 2, 4, 5, 6, 7, 8, 9, 11. Millstream Potash Project. BP Exploration Canada Ltd.	✓
NOVA SCOTIA RESEARCH FOUNDATION CORPORATION. 1981. Gravity Stations: Composite plot map. Scale 1:5 000.	✓
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SILVERSTONE, B. 1982. Seismic Lines 81-115 to -117 and 81-120 to -122, Migrated Stack. Department of Natural Resources Map Plates 98-53a, 98-54b, 98-55b, 98-58, 98-59a, 98-59b, 98-60a, and 98-60b.	✓
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W.H. CRANDALL & ASSOCIATES LIMITED. 1983. Pre-Feasibility Study: Barrack Point Potash Terminal: Development of Third-User (BP) Facilities. Report # 8337-1, 25 p.	✓
Washburn & Gillis, 1985. Hydrologic Investigations for the Millstream River and Bell Brook.	×

WEBB, T.C. 1984. Preliminary Geological Assessment of BP Exploration Canada Limited's Lower Millstream Potash Project, Kings County, New Brunswick. Department of Natural Resources, Mineral Resources Division, 95 p.	✓

The combined information from the BP Resources Pre-Feasibility Study and from the miscellaneous reports is presented on a DVD and categorized into several data folders including: I Geology, II Surface Geophysics, III Geochemistry, and IV Pre-Development Plan.

The Geology folder consists of geological studies dedicated to establishing stratigraphic and structural characteristics of the deposit. Detailed lithologic and down-hole geophysical logs of eleven exploration wells and a shaft pilot hole are included in this folder along with data related to geological and mining potash ore reserves.

The Surface Geophysics folder contains data from various gravity and seismic geophysical surveys that assisted in defining the basic geometry and main structural features of the Millstream Potash Deposit (Table 2).

The Geochemistry folder contains details pertaining to the sampling methods and assay results of evaporite core analysis. Bromine investigations and lithogeochemical studies, which are helpful in establishing stratigraphic correlation between various evaporite units, are also included.

The Pre-Development Plan folder includes documentation summarizing the surface exploration program and details some of the components of a proposed underground exploration program. A summary of a pre-feasibility study that examines the economic viability of a commercial potash operation to provide justification for a subsequent underground exploration program is also included. Other studies provide a conceptual account of a proposed development strategy with attention directed to surface mine/mill facilities, solution mining potential, surplus brine management, and a proposed potash shipping terminal at the Port of Saint John.

Specific details of the information in each digital data folder are listed below.

I. Geology

1. General Geology Reports

1.1 - WEBB, T.C. 1984. Preliminary Geological Assessment of BP Exploration Canada Limited's Lower Millstream Potash Project, Kings County, New Brunswick. Department of Natural Resources, Mineral Resources Division, 95 p.

1.2 - HAMMOND, G.R. 1984. Evaluation of the Pre-Feasibility Study: Geology Section Lower Millstream Potash Project, New Brunswick, Canada. Seltrust Engineering Ltd., Report No. 29/84. Millstream Potash Project, Pre-Feasibility Report, BP Exploration Canada Ltd., Geology, Appendix I, Book 1, 58 p.

Table 2. Summary of geotechnical data available for BP Resources Canada Ltd. exploration wells, Millstream Potash Deposit.

WELL #	WELL SURVEY	WELL HISTORY	DOWN-HOLE GEOPHYSICS							GRAPHIC LITHOLOGIC WELL LOG	
			Gamma	Sonic	Neutron	LS Density	Differential and Absolute Temp	Verticality	Electric	Detailed	Summary
1A	✓	✓	✓	✓	✓	✓	x	x	✓	✓	✓
2	✓	✓	✓	✓	✓	✓	✓	✓	x	✓	✓
3	✓	✓	✓	✓	✓	✓	x	✓	x	✓	✓
4	✓	✓	✓	✓	✓	✓	x	✓	x	✓	✓
5	✓	✓	✓	✓	✓	✓	x	✓	x	✓	✓
6	✓	✓	✓	✓	✓	✓	✓	✓	x	x	✓
7	✓	✓	✓	✓	✓	✓	✓	✓	x	✓	✓
8	✓	✓	✓	✓	✓	✓	x	✓	x	✓	✓
9	✓	✓	x	x	✓	✓	x	x	x	✓	✓
10	✓	✓	x	x	✓	✓	x	x	x	✓	✓
11	✓	✓	✓	✓	✓	✓	✓	x	x	✓	✓

2. Detailed Stratigraphy and Structure

2.1 - CROSBY, K.S. 1983. Stratigraphic and Structural Summary of the Lower Millstream Potash Prospect, Lower Millstream, New Brunswick. (BP Millstream 1A - BP Millstream 11), Millstream Potash Project, Pre-Feasibility Report, BP Exploration Canada Ltd., Geology, Appendix I, Book 4, 157 p.

2.2 - CROSBY, K.S. 1983. Stratigraphic and Structural Summary of the Lower Millstream Potash Prospect, Lower Millstream, New Brunswick. (BP Millstream 1A - BP Millstream 11), Appendices 1-5. Millstream Potash Project, Pre-Feasibility Report, BP Exploration Canada Ltd., Geology, Appendix I, Book 5.

2.2 - CROSBY, K.S. 1983. Stratigraphic and Structural Summary of the Lower Millstream Potash Prospect, Lower Millstream, New Brunswick. (BP Millstream 1A - BP Millstream 11), Appendices 6-7. Millstream Potash Project, Pre-Feasibility Report, BP Exploration Canada Ltd., Geology, Appendix I, Book 6.

2.3 - CROSBY, K.S. 1985. A Lithological, Mineralogical and Nomenclature Summary of the Windsor Group Evaporites at Lower Millstream, New Brunswick. BP Exploration Canada Ltd., 96 p.

2.4 - CROSBY, K.S., KYLE, P.G, AND SMITH, A.G. 1984. Bell Brook Formation (Clastic Data Sections). Millstream Potash Project. BP Exploration Canada Ltd.

2.5 - CROSBY, K.S. (1982-85). Evaporite Correlation Section (Evaporite Stratigraphic Section, 1985; Facies Map of Windsor Group Evaporites, 1983; Evaporite Facies/Erosion Map, 1982). Millstream Potash Project. BP Exploration Canada Ltd.

2.6 - CROSBY, K.S. (1982-85). Geologic Cross-Sections. Millstream Potash Project. BP Exploration Canada Ltd.

2.7 - CROSBY, K.S. 1984. Stratigraphic Column - Case Syncline. Millstream Potash Project. BP Exploration Canada Ltd.

3. Well Data

3.1 - CROSBY, K.S. Well History Reports for BP # 1A, 3, and 4 (1981); BP # 5, 6, 7, 8, and 2 (1982); BP # 9, 10, and 11 (1983). Millstream Potash Project, Pre-Feasibility Report, BP Exploration Canada Ltd., Geology, Appendix I, Books 1-17.

3.2 - BP EXPLORATION CANADA LIMITED. Well Location Map. Millstream Potash Project. BP Exploration Canada Ltd.

3.3 - BP EXPLORATION CANADA LIMITED. Well Log Summary for BP # 1A, 2, 4, 5, 6, 7, 8, 9, 11. Millstream Potash Project. BP Exploration Canada Ltd.

3.4 - NEW BRUNSWICK DEPARTMENT OF NATURAL RESOURCES. Well Log Summary for BP # 1A, 2, 4, 5, 6, 7, 8, 9, 11. Millstream Potash Project. BP Exploration Canada Ltd.

4. Potash Reserves

4.1 - BP EXPLORATION CANADA LIMITED. 1983. Geological and Mining Reserves. Millstream Potash Project, Pre-Feasibility Report, Geology, Appendix I, Book 3, 104 p.

4.2 - BP EXPLORATION CANADA LIMITED. 1983. Mining Reserve Blocks, Scale 1: 5 000. Millstream Potash Project. BP Exploration Canada Ltd.

4.3 - BP EXPLORATION CANADA LIMITED. 1983. Geological Models, Scale 1: 25 000. Millstream Potash Project. BP Exploration Canada Ltd.

5. Shaft Pilot Hole

5.1 - CROSBY, K.S. 1984. BP Millstream Potash Project, BP Millstream Pilot Hole No. 1, Geological - Geotechnical Report. BP Exploration Canada Ltd., 358 p.

5.2 - CROSBY, K.S., KYLE, P.G., and SMITH, A.G. 1985. Bedding and Fracture Azimuth Study of the Hopewell Group within the Pilot Hole Area, Millstream Potash Project, Lower Millstream, New Brunswick. Millstream Potash Project, Pre-Feasibility Report, BP Exploration Canada Ltd., Geology, Appendix I, Book 23, 101 p.

5.3 - CROSBY, K.S. 1984. BP Millstream Potash Project, BP Millstream Pilot Hole No. 1, Geotechnical Strip Log.

II. Surface Geophysics

1. Seismic Surveys

1.1 - SILVERSTONE, B. 1982. Geophysical Interpretation of the Millstream Potash Development, Millstream, New Brunswick. Report No. S-1158. Millstream Potash Project, Pre-Feasibility Report, BP Exploration Canada Ltd., Geology, Appendix I, Book 22, 21 p.

1.2 - BP EXPLORATION CANADA LIMITED. 1981. Millstream - 1981 (Final Plan), Seismic shot hole location map. Minerals, Policy and Planning Division, New Brunswick Department of Natural Resources, Map Plates 98-61 and 98-68, Scale 1:10 000.

1.2 - SILVERSTONE, B. 1982. Seismic Lines 81-115 to -117 and 81-120 to -122, Migrated Stack. Department of Natural Resources Map Plates 98-53a, 98-54b, 98-55b, 98-58, 98-59a, 98-59b, 98-60a, and 98-60b.

1.2 - SILVERSTONE, B. 1982. Seismic Lines 81-115 to -122, Unmigrated Stack (interpreted). Department of Natural Resources Map Plates 98-53b, 98-54a, 98-55a, 98-56, 98-57, BP-81-120, BP-81-121, and BP-81-122.

1.3 - BP EXPLORATION CANADA LIMITED. 1982. Synthetic Seismograms, Millstream-New Brunswick, BP wells 1, 2, 3, 4, 5 and 6, New Brunswick Department of Natural Resources Map Plates 98-62 to -67.

1.4 - BP EXPLORATION CANADA LIMITED. 1982. Top of Windsor Group: Time-structure map. Contour interval: 20ms, Scale 1:5 000.

1.4 - BP EXPLORATION CANADA LIMITED.1982. Top of Windsor Group: Depth-structure map. Contour interval: 20ms, Scale 1:5 000.

1.4 - BP EXPLORATION CANADA LIMITED.1982. Base of salt: Time-structure map. Contour interval: 20m, Scale 1:5 000.

1.4 - BP EXPLORATION CANADA LIMITED.1982. Base of salt: Depth-structure map. Contour interval: 50m, Scale 1:5 000.

1.4 - BP EXPLORATION CANADA LIMITED.1982. Salt member thickness: Depth-isopack map. Contour interval: 50m, Scale 1:5 000.

1.4 - BP EXPLORATION CANADA LIMITED.1982. Top of Windsor Group (salt): Average velocity map to the top of Windsor Group Contour interval: 50m/s, Scale 1:5 000.

2. Gravity Surveys

2.1 - NOVA SCOTIA RESEARCH FOUNDATION CORPORATION. 1982. A Gravity Survey over the Millstream Potash Deposit, Kings County, New Brunswick (for BP Exploration Canada Ltd.). Report # 2-82, 17 p.

2.2 - NEW BRUNSWICK DEPARTMENT OF NATURAL RESOURCES. 1979. Bouguer gravity map of the eastern half of the Case Syncline, NB., (Millstream Potash Prospect). Contour interval: 0.5 milligals, Scale 1:25 000.

2.2 - NOVA SCOTIA RESEARCH FOUNDATION CORPORATION. 1981. Gravity Stations: Composite plot map. Scale 1:5 000.

2.2 - NOVA SCOTIA RESEARCH FOUNDATION CORPORATION. 1981. Interpretation of 1981 reduced gravity data. Contour interval: 0.25 milligals, Scale 1:5 000.

2.3 - BELL, J.S. and SILVERSTONE. B. 1981. Millstream Potash Deposit - Gravity Modelling (Part 1). BP Exploration Canada Ltd., Report # 563, 9 p.

III. Geochemistry

1. *CROSBY, K.S. 1982. Distribution of Bromine and Potash Genesis in the Lower Millstream Formation, Lower Millstream, New Brunswick: Preliminary Study. BP Exploration Canada Ltd., 29 p.*

2. *CROSBY, K.S., KYLE, P.G, AND SMITH, A.G. 1984. Bromine Investigations. Millstream Potash Project. BP Exploration Canada Ltd.*

3. *CROSBY, K.S. and SMITH, A.G. (1981-2). Bromine Study, Halite-Potash Description and Bromine Sampling Summary. Millstream Potash Project. BP Exploration Canada Ltd.*

4. *HOFFMAN, S.J. 1983. Investigation of the Inductively Coupled Plasma (ICP) Applied to the Analysis of Core Samples from the Millstream Potash Project, NB. Lithogeochemical correlation between Millstream DDH-1A, 2, 4, and 8. BP Minerals Ltd., Report # 83-2. Millstream Potash Project, Pre-Feasibility Report, BP Exploration Canada Ltd., Geology, Appendix I, Book 19, 132 p.*

5. *BP EXPLORATION CANADA LIMITED. 1983. Sampling and Testing of Windsor Salt Cores, Millstream Potash Deposit. Millstream Potash Project, Pre-Feasibility Report, Geology, Appendix I, Book 2, 83 p.*

6. *HAMMOND, G.R. 1984. Lower Millstream Potash Project, New Brunswick, Canada, Statistical and Graphical Study of Check Assays. Seltrust Engineering Ltd., Report No. 68/84. Millstream Potash Project, Pre-Feasibility Report, BP Exploration Canada Ltd., Geology, Appendix I, Book 1, 17 p.*

IV. Pre-Development Plan

1. Geotechnical Summaries

1.1 - BP RESOURCES CANADA LIMITED. 1984. Millstream Potash Project, A Background Paper. 48 p.

1.2 - BP RESOURCES CANADA LIMITED. 1984. Millstream Potash Project, Exploration Program. 138 p.

1.3 - BP RESOURCES CANADA LIMITED. 1985. Millstream Potash Project, Technical Summary. 94 p.

1.4 - BP RESOURCES CANADA LIMITED. 1985. Millstream Potash Project, Preliminary Development Plan. 43 p.

2. Proposed Mine-Mill and Related Studies

2.1 - KILBORN. 1983. BP Canada, Millstream Potash Project: Conceptual Flowsheet and Plant Siting Alternatives. 59 p.

2.2 - KILBORN. 1983. BP Canada, Millstream Potash Project: Preliminary Assessment of the Potential for Solution Mining. 170 p.

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2.4 - KILBORN. 1983. BP Canada, Millstream Potash Project: Geotechnical Investigation and Services Proposed. Report # 2188-1, 72 p.

2.5 - W.H. CRANDALL & ASSOCIATES LIMITED. 1983. Pre-Feasibility Study: Barrack Point Potash Terminal: Development of Third-User (BP) Facilities. Report # 8337-1, 25 p.

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