095826

PROMITHIAN INC.

HATCH™

22 July 2002

200 – 1550 Alberni St.
Vancouver, BC V6G 1A5
Tel: (604) 689-5767 ◆ Fax: (604) 689-3918 ◆ www.hatch.ca

Table of Contents

Part I

Part II

List of Figures/Maps

List of Appendices

1 Executive Summary

In April 2002 Promithian Inc., the Nacho Nyak Dun Development Corporation, and the Yukon Department of Energy Mines and Resources engaged Hatch Associates Ltd. to carry out a high level evaluation of Promithian's plan for a mining–steel manufacturing operation in northeastern Yukon. The plan involves developing the Crest Iron deposit and the Wind River Coal Field for the purpose of producing high-pressure natural gas line-pipe. Pursuant to this task, Hatch has reviewed materials made available by Promithian, from other relevant sources, and consulted with appropriate resource people from both within and external to Hatch. This report summarizes the results of our investigation and analysis.

The Crest Iron property is one of the largest iron ore deposits in North America. Located approximately 350-km northeast of Elsa (see Figure 1) in a remote area of the Yukon and Northwest Territories. The total resource of the deposit is estimated to be in excess of eighteen billion tons of 43-46% Fe iron ore. Evaluation studies done between 1961 and 1965 indicated that, with a sufficient source of inexpensive energy, the ore could potentially be beneficiated with an 85% iron recovery rate.

Eighty kilometers southwest of the Crest deposit are the Bonnet Plume Coal Deposits. The coalfield was discovered and worked on between 1977 and 1983. Seven deposits, with five seams, contain some six hundred and sixty million tons of in-situ, bituminous C, thermal coal. In 2001 the principals of Promithian Inc. acquired rights to these deposits, which they have designated as the Wind River Coal Field. One of the deposits, Illtyd Creek, was explored in detail in order to prove reserves. In 1981 a Pre-feasibility Mining study was completed for the Illtyd Creek deposit in conjunction with a plan for onsite electric power generation and transmission to the existing Yukon power grid. Two years of environmental baseline studies were carried out between 1981 and 1983 before the project was abandoned due to a lack of demand for the electricity

In recent years there has been much discussion, study, analysis, and consultation surrounding a number of proposals to access and transport to market "locked-in" natural gas in the Mackenzie Delta and on the North Slope of Alaska. An anticipated two to three million tons of large diameter Arctic grade line-pipe could be needed for the first two major pipelines. Smaller feeder lines will proliferate into the numerous sedimentary basins in the region. An emerging regional market for line-pipe is envisioned.

Hatch believes that a minimum size for an economically viable steel mill in this context would be 1.2 million tons per year.

Hatch supports Promithian's view that the proposed steel mill, as well as the pipe and tube operations, should be at the Illtyd Creek coal-mining site. This would allow the sharing of infrastructure, management, technical and maintenance resources, as well as minimize transportation requirements and environmental impact.

Upwards of one million tons of coal per year would be required to support the iron production process directly as well as to provide electrical energy for mining, benefaction, steel production, processing, manufacturing, and infrastructure requirements. Five thousand tons a day of iron concentrate would be delivered via slurry pipeline from a plant at the Crest iron site. Electricity from the main plant will be provided to the Crest Plant via a power transmission line. Personnel could be transported to and from the Crest Plant by air to preclude the necessity of an all weather road between the sites.

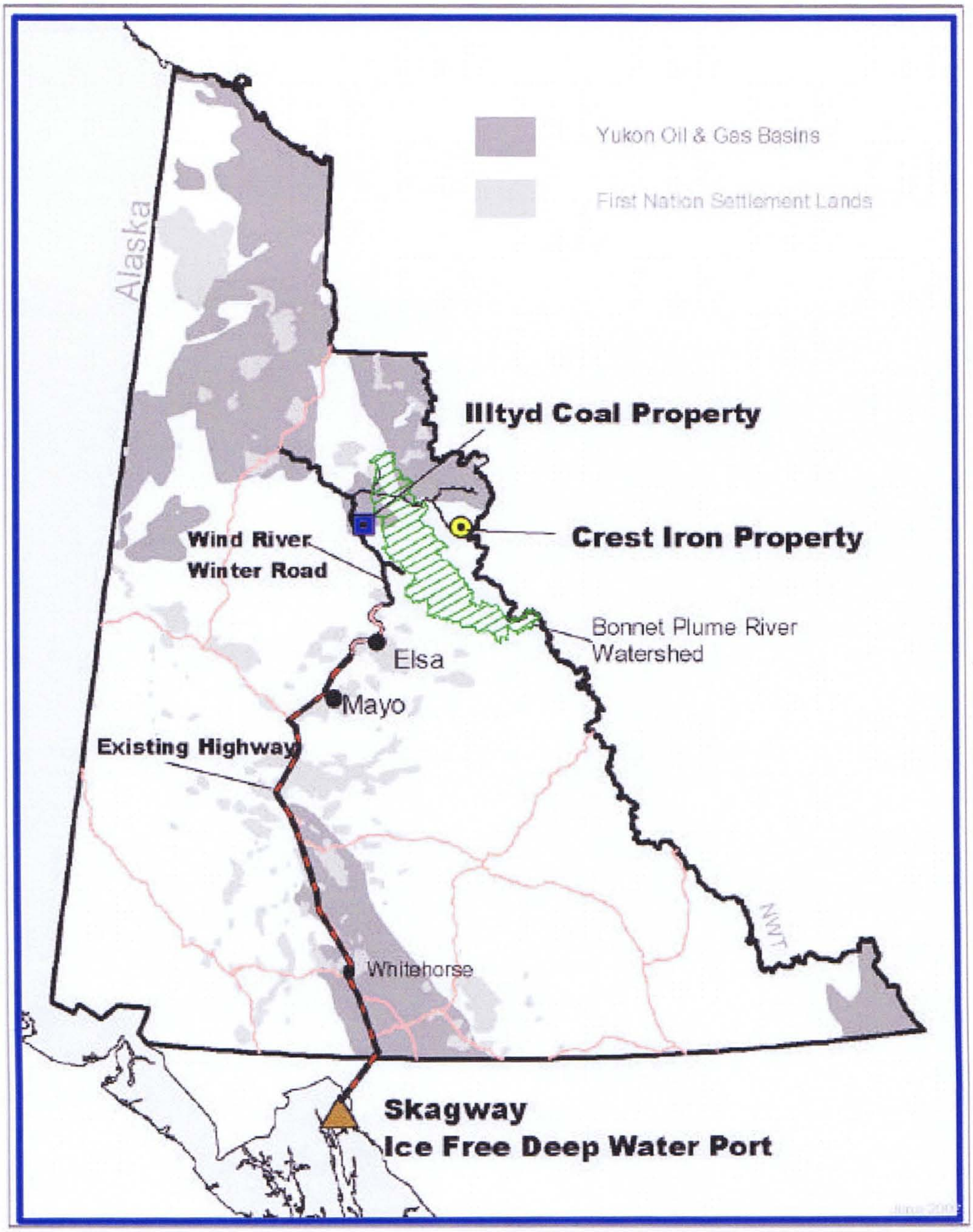
Plant workforce requirements could be considerable. Hatch would contemplate a workforce of some one thousand two hundred people: nine hundred at the main Illtyd Creek plant, one hundred at the attached coal-mining operation and two hundred at the Crest Plant. Hatch believes an operational area of some 245 hectares needs to be available for the considerable plant infrastructure requirements at the Illtyd site.

It is expected that upwards of one hundred, 40-tonne capacity, tractor-trailer units per day would travel the highway to Mayo. The existing Wind River winter road will have to be upgraded to a high quality all-weather highway. All weather access to the Yukon's existing transportation system – and a year round ocean port in Skagway – is of the utmost importance.

Hatch suggests thinking about the project based on a potential cost to full operation in the range of $ 2.5 to $ 3.0 billion dollars. This notional value is based on the costs of comparable projects, tempered for the location, process breadth, infrastructure and transportation requirements contemplated, as well as the length of time needed to achieve product qualification. While in the aggregate, this notional total to execute the project as conceived is large, it is to be remembered that while the steel industry is notoriously capital intensive, individual operations properly configured to serve high value markets can be significantly profitable. As well, the "economic value added" to a region that hosts such a steel making and manufacturing complex can be considerable.

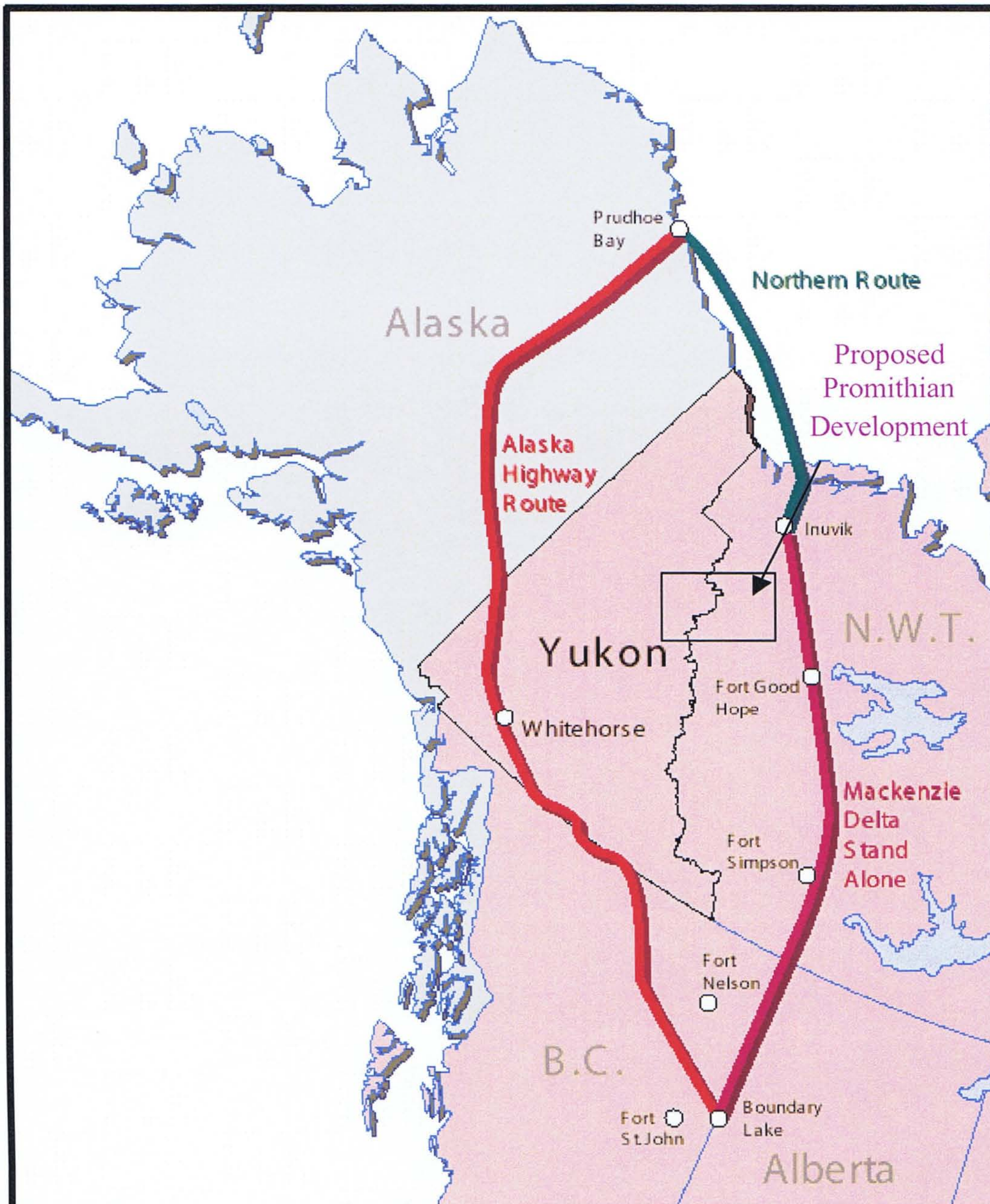
On an operating basis, Hatch would not expect the facilities to have substantial environmental impacts, based on the successful operations of comparable facilities located in environmentally sensitive areas around the world. Particular attention will have to be given to ensuring the compability of any of the corollary impacts of the project with the "Canadian Heritage River" designation given to the Bonnet Plume River.

Hatch is of the opinion that this unique and complex project could be realized, subject to the resolution of the uncertainties and issues raised in this review - many of which are material. These include the permitting and access considerations, the timing and extent of development of the nearby market for line pipe, the beneficiability of the iron ore, the energy and iron unit production routes, and the availability of human resources. Accordingly we recommend to advance this project to the Pre-Feasibility Study stage to more fully assess and define these issues as well as the economical viability of the project.



Map by Promithian Inc.

Figure 1 – Area Map



NORTHERN NATURAL GAS PIPELINE OPTIONS

Map by Promithian Inc.

Figure 2

2 Methodology

Hatch gathered data and formed its opinions using input from a number of sources including:

- discussions with Promithian management
- discussions with members of the steel trading and strategy consulting communities on a "no-names" basis
- recent studies Hatch has participated in or was aware of involving similar projects and/or technological approaches
- staff expertise available from other Hatch Offices
- discussions with external environmental consultants
- existing

3 Historical Perspective

The principals of Promithian had identified opportunities, and established interests in iron ore, coal, and potentially, coal-bed methane resources in the Yukon Territory. Promithian's considerations evolved to adding value to these resources through locally situated conversion to saleable steel products with a focus on the substantial quantities of large diameter, high pressure gas transmission line pipe forecast to be required to access resources currently locked-in in Alaska and the MacKenzie Delta in the future. Promithian has, as well, fostered relationships with Territorial Authorities, First Nations, and with the current holders of the Crest Iron Ore Deposit.

By agreement with Promithian, this review is concerned with, and limited to an assessment of the concepts formulated by Promithian, with appropriate emphasis on:

- the potential viability of such a project given the remote location, the technological requirements, and the market cyclicalities
- the potential environmental, regulatory and community implications
- the justification for further studies

While not specifically included in our mandate, Hatch has nonetheless considered some of the broad economic implications of the project in order to facilitate an appreciation of its potential viability.

The balance of this Summary should be read in conjunction with the Project Outline in Part II and the supporting materials in the balance of the Appendices.

Unless otherwise noted, any dollar amounts are expressed as Canadian dollars.

4 Principal Materials and Energy

In principle, the necessary iron, carbon, and energy units to support a 1.2 million ton per year (an economic minimum size) are available within some 80 kilometres of each other at the site.

Subject to a thorough assessment of the characteristics of the Crest Iron ore and a test-based flow sheet for its beneficiation, Hatch would postulate up to a 10,000 ton per day mining operation, with 5000 ton/day of concentrate delivered to the main operational site at Illtyd Creek by slurry pipeline. The iron ore mining operation would be conventional open pit, with maximal automation and minimal labor requirement, with personnel based in a site camp to avoid all-year all-weather road access. Some 200 people could be required based on our experience.

Significant uncertainties with the Crest ore noted in the reference materials include its high silica and phosphorous contents, and difficulties in elimination of sulfates to permit pelletizing for reduction to electric furnace feed. These can only be resolved through appropriately detailed investigation.

Upwards of 1.0 million tons per year of coal are required to support the iron production process directly and to provide electrical energy for the mining, beneficiation, steel production, processing, and manufacturing operations, as well as for the infrastructural requirements at both sites.

A study will be required to establish the most cost effective mining approach for the Illtyd Creek resource – open pit vs. underground. Decisions as to the degree to which the coal will have to be upgraded will flow from the selection of the iron reduction/energy production process route as discussed at length in the outline. That notwithstanding, Hatch would expect that coal mining operations would engage some 100 people at the Illtyd Creek site.

Based on the materials provided, the coal should be suitable for the processes contemplated.

As well as the principal raw materials, there are several key commodities required to support a steel mill: high purity oxygen, nitrogen, and argon; burnt and dolomitic lime, other fluxes and alloying materials, as well as refractories, electrodes, and other consumables. While the process gases can be produced on-site, the balance must be regularly transported, requiring year-round, high quality road access (as will outbound product shipments) and significant on site warehousing capacity.

5 Plant and Process

Hatch would support Promithian's view that the steel operations should be at the Illtyd Creek Site, inasmuch as there are opportunities to co-generate energy in conjunction with the iron reduction process. Hatch would also suggest that pipe and tube making operations be at the same location, in order to share infrastructure and management/technical/maintenance resources as well as minimize transportation requirements.

As described in the outline attached as Part II of this report, all of the plant and process downstream of the steelmaking furnaces is dictated by the core product requirements, and is known, proven, and in regular operation at numerous locations, including some with harsh winter environments and/or remote locations.

The aspects requiring major study are the energy generation/iron reduction steps. The selection of these technologies is key to establishing the project cost and economics.

Plant infrastructure requirements at the Illtyd Creek site will be considerable. Hatch would contemplate an operational area required of some 245 hectares. A workforce of some 900 people should be contemplated at full operation of all facilities, in addition to the 100 or so involved in the coal mining operation.

The question of whether a "townsite" as contrasted with a "camp" is more appropriate at the Illtyd Creek site will inevitably arise.

6 Marketing

There is little doubt that, given the location, in the absence of an accessible market for high value steel products, the project would not be viable. There is simply too much capacity presently available at too many locations for commodity steel products for a remotely situated new entrant to be successful.

The unique characteristic of the Promithian project is that it could be "drawn up the value scale" by its advantageous proximity to what should be an ongoing market for high value energy related products, enabling it to supply outside markets as well. Hatch would see the large diameter pipe capability supplemented by a smaller diameter capability to enable "full service" to the energy market, minimizing the amount of production directed to the commodity areas.

After process definition and qualification, a core portfolio of some 250,000 tons per year of large diameter transmission pipe from the market identified by Promithian (Appendix A), supplemented by an equivalent amount of smaller diameter ERW gathering, distribution and processing API pipe could provide the basis for a viable order book. The balance of capacity would be of necessity directed to the hot rolled and plate-in-coil markets.

Taking all-weather, year round access as a given, Promithian compares favorably with respect to both on-shore and off-shore competitors for access to end markets as diverse as Anchorage, Fort St. John, the MacKenzie Delta, and so forth. That being said, the range of products contemplated parallels that of IPSCO's Regina operation, an aggressive and capable competitor that would be likely to respond commercially.

As discussed in the outline, a substantial period of time will be involved in establishing the capability to supply the high-end markets. For that period, and going forward, for the product not sold to the accessible high end markets the project will require access to the "international" markets through, most probably, Skagway. Study as to the logistics of such a distribution mechanism is required. As well, arrangements with the distribution and trading community will have to be explored.

Steel trade rules are notoriously volatile. At present, Canadian steel is in general not having difficulty in entering the US – 10 years ago, this was not the case, and there is no certainty with respect to the future, given the rising tide of protectionism around the world. Having noted that, there is also a significant level of interest on the part of offshore producers in establishing operations in North America.

Marketing and distribution are absolutely fundamental to the prospects for the project. Structured discussions with potential customers, distributors, and processors of the target products should commence as a next stage.

7 Environment and Regulatory

In broad terms, the project would involve:

- permitting a 1.5 million ton per year iron ore mine with on site tailings storage and substantial water exports
- permitting a 1.0 million ton per year coal mine
- permitting a slurry pipeline from the Crest site to the Illtyd Creek site
- permitting a power line and access road from Illtyd Creek to Crest
- permitting of a facility having characteristics equivalent to a power station consuming 1.0 million tons per year of coal with respect to air emissions and ash storage
- permitting of a facility having characteristics equivalent to a 1.2 million ton per year electric furnace steel mill with respect to air emissions, water emissions and on-site slag, dust, and waste storage
- permitting an all weather, high capacity, high quality road some 165 kilometres to the vicinity of Elsa (to handle upwards of 100, 40 ton capacity tractor-trailer units per day on a 360 day per year basis)
- permitting residential amenities for upwards of 1200 people between the two sites
- potential permitting of a product marshalling and shipping facility at Skagway
- permitting of airstrips/helipads at both operating sites

On an operating basis, Hatch would not expect the facilities to have substantial environmental impacts, based on the successful operations of comparable facilities located in environmentally sensitive areas around the world. Beyond the basic issue of CO_2 generation resulting from the oxidation of coal, technologies to mitigate all other emissions to generally accepted standards are available. An advantage of the project is that as iron ore and coal resources are withdrawn, space is created for storage of the solid by-products arising from their beneficiation and for those from the iron, steel and energy production processes. As well, many of these latter byproducts are suitable for construction/infrastructural purposes, replacing otherwise virgin aggregates.

Recognition of these requirements by the appropriate regulatory authorities and community groups should be sought as a next stage. Particular attention will have to be given to ensuring the compatibility of any development with the "Canadian Heritage River" designation given to the Bonnet Plume River in 1998 (Appendix H).

8 Management and Human Resources

As noted in the outline, the Project is complex, has highly technical operating and maintenance requirements, and the products require the highest degree of certification. Attracting and retaining appropriately qualified personnel to comparable operations in less "hostile" settings is difficult, this will be an area of significant challenge for Promithian. Of the 1200 or so people identified, specialized skill sets would be required for probably 50 or less; the operations force of some 600 could have basic "mining and milling" qualifications; the 400 person maintenance cohort would require journeyman or technician qualifications comparable to those in the pulp and paper or petrochemical industries, the balance would be clerical and support personnel. A cadre of a dozen or so "veterans" of the business would be required at the senior management and technical positions.

Almost without exception, the successful operations in this segment of the steel industry do not have workforces represented by organized labor. While that is not the sole determinant of success, the need for high performance, versatile, fully committed people to ensure the success of the business generally leads to highly participative work forces with a strong economic interest in the fortunes of the enterprise – a regime that most of the "old-line" industrial unions have considerable difficulty supporting.

Early and on-going involvement of personnel knowledgeable of the industry will be important to credibly assessing and advancing the project.

9 Financial and Economic

In order to assist Promithian in its deliberations, Hatch suggests thinking about the project based on a potential cost to full operation in the range of $2.5 to 3.0 billion dollars. This notional value is based on the costs of comparable projects, tempered for the location, process breadth, infrastructural and transportation requirements contemplated, as well as the length of time needed to achieve product qualification.

Robustly profitable steel operations, albeit in more "benign" locations, generally can be characterized as having total employment costs of 20% or less of their normalized revenue base. In the present case, for some 1200 people at an average cost of say $100,000 per year, a revenue base for the operation of some $500 million per year is implied on a comparable basis. While Promithian is unique in that its personnel cost includes the labor implicit in provision of ore, coal, and energy (which are substantial costs to other operators), all else equal, the impacts of the remote, harsh location, and the high financing costs would offset much of that advantage, and could, in fact, require a materially higher revenue base.

The important point to be made is that in today's market, hot roll coil is selling for over U$300 per ton, freight equalized at point of consumption – up from U$250 or less a year ago prior to the section 201 tariffs in the US; plate-in-coil is of the order of U$400 per ton on a similar basis. Accordingly, for the project to be viable, not only will enough high value product have to be produced and marketed to raise the average net realized revenue to $500 per ton and beyond, the operation will have to be "supported" for the, hopefully, "reasonable" period of time necessary to establish capability, qualification, and credibility as a supplier of the $700 per ton and beyond energy related pipe and tubular products. The large diameter, high quality, line-pipe contemplated to be used by the North Slope producers will sell for approximately $1,000 per ton delivered.

10 Government and Community

Steel mill projects such as that contemplated by Promithian are generally highly sought after by communities given their tremendous economic impact, and relatively small and benign ecological footprint. It is not uncommon in the USA to see substantial state and local incentives provided, as well as sponsored financing in terms of municipal revenue bonds. Offshore, such projects are used as levers to spur development in otherwise disadvantaged regions.

In the present case, not only are there the obvious direct benefits of construction and operation, but also the ancillary employment and value adding in terms of support services, transportation and logistics, and so forth throughout the impacted area. Hatch would suggest that as part of any permitting approach, that a comprehensive economic impact assessment be prepared to attract the interest of the Nacho Nyak Dun First Nation, other First Nations, Yukoners, and the Federal Government, and to strategically mitigate the inevitable anti-development forces.

11 Conclusions and Recommendations

On a conceptual basis, the Promithian Project has strengths including:

- iron ore, coal and energy in close proximity to a potentially large market for high value steel products
- the opportunity to use proven, low cost, mining, steel production and processing technologies
- a community potentially receptive to new investment and development
- an opportunity to engage and provide meaningful employment for local residents

Its conceptual disadvantages include:

- potentially difficult iron ore to beneficiate
- a remote and harsh environment
- potential adverse attention from environmental groups
- high capital costs relative to competitors
- complex technology and stringent product requirements
- long development cycle

The number of uncertainties and issues raised in this review is reflective of the dated and/or otherwise incomplete documentation available to us. Accordingly, Hatch would find it difficult to recommend a Bankable Feasibility Study as a next stage in the advancement of the Project. Rather, we would suggest a "6-month, $350,000 Pre Feasibility Study, managed by an internationally credible Iron and Steel consulting engineering concern, supported by a knowledgeable environmental consultancy with public hearings expertise.

In the course of that study:

- basic layouts and general arrangements for the operating sites, corridors, and transshipment points could be developed, leading to capital cost estimate based on estimating criteria to ±30%
- the access, permitting, and environmental requirements could be established
- the economic impacts and benefits established
- the energy/iron production route established from among the options
- the overall process flowsheet established and a cost model developed
- credible heat and mass balances established permitting determination of cogeneration potential
- marketing strategy determined, with particular emphasis on transition operations from start-up to full qualification
- support services and infrastructure assessed and developed
- financial models and cash flows determined

As well, in the course of this work, potential participants in the project would be identified and, in conjunction with Promithian, approached as to their level of interest. The universe of potential players includes customers, traders/distributors, suppliers, and financial investors as well as other steel producers and governments.

The deliverables from such a pre-feasibility study and related activities would be most helpful in establishing the viability and sustainability of the project, and, in all likelihood, would significantly lower the costs of a Bankable Study if that were the next step to be taken.

Hatch is pleased to have had this opportunity to be of service to Promithian, the Nacho Nyak Dun Development Corporation, and the Yukon Department of Energy Mines and Resources, in the preparation of this review.

Part II

1 Project Outline

Process Flow and Facility Requirements

The following summarizes our view as to the potential approaches and context to realizing on the concepts for development of a steel mill and line-pipe manufacturing complex to be situated in the Yukon Territory. It is intended to be in most respectives reflective of the scope advanced to us by Promithian, and should be read in conjunction with the developmental flowsheets Figures 2A, 2B & 2C (at the end of this Part II).

While there are many uncertainties with respect to the Crest Iron Ore and Wind River Coal properties, which are covered elsewhere in our Report, it is our view that there are no fundamental impediments to the realization of the concepts. Having said that, the processes involved are of high capital cost, of significant technical and operational complexity, and the product specifications and quality assurance levels required are among the most stringent in the universe of steel products. As well, the proposed locations are climatologically severe, environmentally sensitive, infrastructurally spartan, and present significant permitting, construction, operational, and transportation challenges.

While we have considered development of the Ore and Coal properties only to the degree necessary to support a nominal 1.2 million ton per year steel complex, given that the transportation infrastructure to support it should support much higher volumes of shipments, opportunities exist to develop the Ore and Coal properties to significantly higher levels of product and energy output to serve third party customers, assuming that capital and operating costs for extraction and beneficiation are such that returns could be realized independent of the captive market and particular economics provided by the steel mill.

The notion that a substantial proportion of the output of the steel mill will be directed towards the production of Artic grade API X70 (or higher) line pipe at a proximate facility puts significant constraints on the nature of the supplying facilities. While there are several recognized production routes for this product, the most cost effective and flexible is that used by IPSCO at their Regina, Sask. Operations. Essentially, plate-in-coil is uncoiled, leveled, edge prepared, and submerged arc welded along the "long seams" as an endless spiral in a built for purpose mill. While this technique was used for many years in the production of lower service duty pipe products, IPSCO pioneered its successful application to severe service API line pipe.

Subsequent to forming and welding, and cut-off-at-length, the product must be 100% X-Ray and flaw detected, hydrotested, the ends prepared, and the pipe protectively coated. Prior to placement in the field, the pipe must be corrosion protected – this is generally done by a third party such as Shaw Pipe at a proximate plant or at an intermediate location. While straightforward in concept and execution, the spiral pipe process for API line pipe must be extremely tightly controlled; there are many variables involved and a high degree of metallurgical and welding expertise is required. Production is generally supervised by inspectors retained by the customer, notwithstanding which, long term liabilities accrue to the producer as field failures-in-service are neither uncommon nor minimal in consequence. Qualification as a supplier is difficult and time consuming – as well as the demonstrated capability at the pipe making stage (usually based on six-sigma type stasticial process control), similar considerations apply to the quality assurance, consistency and history of the feedstock plate. Full-scale burst tests to demonstrate weld and parent material crack propagation resistance are required.

There are two qualified Canadian producers, and three US based producers who compete for the market. All except Berg Pipe in Panama City, Fla. have captive plate supply, however, because of the "project" nature of the market, it is not uncommon for all except IPSCO to purchase plate, or slabs from which to roll plate, from either each other or, from offshore qualified suppliers. Offshore production of qualified slabs, plate, and pipe is concentrated in Japan, Germany, and Italy. While there have been some exceptions, freight and political considerations have generally seen the bulk of supply for on-shore pipeline projects in North America come from the North American pipe producers.

Given the value of the order of $1000/ton for the product – coated and delivered to field, freight per-se is not as determining a competitive consideration as it is in the case of lower valued intermediates such as plate, plate in coil, and hot rolled coil, which are in the range of $400 to $600/ton. Accordingly, the international market is accessible to those producers who are tidewater situate, generally the Japanese and Europeans. In North America, only Berg and the Napa, Calif. mill of Oregon Steel Mills are considered to be players. Stelco's Welland Tube operation in Welland, Ont., IPSCO in Regina, and the Stelco/Oregon Steel JV in Camrose, Alta are generally considered to be landlocked.

For Promithian to access the export markets for all of its products, year round access to a terminus such as Skagway, Alaska will be required. For advantageous supply to the target Alaska and Mackenzie Valley projects, year round road shipping, or road to a rail interconnection will be required for its pipe.

Given that Promithian will have to start-up, develop, and certify it's production processes and products over a nominal two year period (given an aggressive programme and first class, experienced management) in order to access the high value line pipe markets, it follows that the mill producing the plate, and the units which supply it (potentially back to the iron ore and coal properties) must be configured, and the necessary infrastructure put in place, so that these intermediate units can be put on line and into regular capacity- level operations to generate cash and establish Promithian as a quality capable producer.

As noted above, the decision to have line-pipe as a principal product puts significant constraints on the nature of the supplying facilities – particularly since the feedstock plate must be in the 1/2" or greater thickness range – beyond the capability of any "direct" strip production process. All three of Oregon Steel, IPSCO, and Stelco in Hamilton, Ont. have so-called "Steckel" type combination plate/plate-in-coil/wide hot strip mills. These relatively low cost, flexible mills generally consist of a 4-roll-high reversing mill with coiling furnaces on either side (to preserve heat during the extended rolling cycle). To produce lighter gages of product, the coiling furnaces are used; to produce heavier gage flat products, the furnaces are bypassed. Final product is either coiled in an upcoiler after spray cooling, or if flat, run out to a leveling/shearing facility. These units, like the spiral pipe mills, are robust, proven technologically, and in the appropriate capacity range. While simple in concept and execution, here again, a variety of sophisticated systems are involved in operation, in-depth metallurgical knowledge is required. A physical testing and metallographic laboratory of some sophistication is a necessity.

As well as the Steckel mills operated by the pipe producers, numerous others exist in North America and elsewhere, generally supplied by scrap-fed Electric Arc Furnaces (EAF). Product can be directed to virtually all the conventional market segments for plate, plate-in-coil, and wide hot strip, both domestically and internationally. A significant portion of these markets is of a commodity nature, enabling start-up and developmental product to be sold, albeit at distressed prices, to offset developmental costs and provide cash flow, given that year-round road access to tidewater and/or a railhead can be made available.

Appendix B provides a description of a comparable steel production facility to that suggested for Promithian – IPSCO's new mill at Mobile, Alabama. While this mill is scrap fed, and does not have on-site pipe production or iron reduction/energy generation, it nonetheless is representative of the assets required at the heart of the process.

Steckel mills are generally supplied with continuously cast slabs ranging in thickness from 5 to 10 inches, and in width from 40 to over 100 inches, and lengths from 30 feet upwards. The combination gives rise to the Pounds per Inch of Width (PIW) of the coiled products, and has direct impact on product saleability, and significant corollary impacts on caster productivity, mill productivity, product applicability (due to surface condition and degree of reduction), and slab heating requirements, as well as on capital and operating costs. While an in-depth optimization simulation is required to establish the ideal dimensional set for any given situation, we would expect to see the Promithian caster fall in the 5 to 7 inch thickness range with width of 100 inches maximum, and slab lengths in the 60 foot range. While such slabs would not be ideally tradable, they would suit the Steckel mill product range required and give a saleable PIW. Such continuous slab casters are in regular operation in the trade, are amenable to "sequence casting" of multiple ladles (heats), and can be operated in tandem (linked) with the Steckel Mill, thus avoiding extensive reheating furnace requirements.

A single strand caster as described above, supplied with 120t (net) heats is capable of producing some 1.0 to 1.2 million tons of useable slabs per year. While liquid steel can be produced from a variety of processes, for the product mix and circumstances contemplated, an EAF based process is preferred for reasons of capital cost, operating flexibility, operating cost, and robustness. EAF's have a fundamental advantage over Basic Oxygen Furnace (BOF) based processes in that they can be operated on an "irregular" pattern, heats can be held for extended periods if required, gas collection and cleaning is simple, and a variety of charge materials can be dealt with – BOF's generally require that 70% or more of the metallic charge be in the form of Blast Furnace or equivalent hot metal. Virtually all recently built steelmaking complexes are based on EAF technology.

Subsequent to refining in the EAF, the heats are generally further processed at a "ladle metallurgy facility" (LMF) for desulfurization and final temperature and analysis control before being sent to the caster. These facilities generally consist of low powered EAF in which the roof and electrodes are swung over and lowered into the ladle of steel, which forms the balance of the "furnace." Argon gas is circulated through the steel during treatment, fluxes and alloys are batched and added (or injected) through weight controlled systems. An analytical laboratory is required to serve both the EAF refining operation and the LMF. If hydrogen control is necessary due to product requirements (pipe for sour gas, etc.) a degassing station may also be required.

To this point in the process from shippable pipe back to steelmaking, all of the facilities required are "known, proven, and available off-the shelf." The spiral pipe mill, Steckel Mill, Caster, LMF and EAF and their ancillaries require only final sizing, dimensioning, and respecification for severe/remote location service. Utility and energy requirements are known and readily quantifiable, byproduct and "waste" volumes and characteristics are known as are operating and maintenance manpower and consumable requirements. All metallic scrap and by-products are either recyclable within the facilities (eg. skulls, scrap, crops) or saleable in their own right (eg off-spec pipe).

To now bridge from the iron ore and coal deposits to the feedstock for the EAF becomes considerably more complex, and many more choices for process routes and technologies are involved. This suite of assets not only has to be looked to provide the reductants and energy to convert the iron ore to EAF feed, it should also provide the energy required for melting, rolling, processing and site infrastructure, and be configured to minimize the "dumping" of wastes (dusts, scale, slag, etc) from the steel production processes and as well minimize the volumes of waste water and concomitant treatment costs for the whole complex.

As covered elsewhere, the Crest iron ore deposit, while minimally characterized, is indicated as requiring complex processing in order to beneficiate it to a degree suitable for ironmaking feed, including fine grinding. Given that, and mindful of Promithian's guidance as to the desirability of locating the principal operations at the Illtyd Creek mine site, we believe that the beneficiated fine ore should be transferred the 70-odd km to the coal site by slurry pipeline, and that the water balance at the Crest site should be designed to ensure that virtually all industrial waste water from that site is used as the transport medium for the ore fines. In reverse, we would see that power generated at the coal site be furnished to the Crest site. This configuration would serve to minimize the "environmental footprint" at the Crest site, minimize the need for permanent road haulage, reduce operating and capital costs, and concentrate infrastructural management requirements at the coal site.

Given the fine grinding requirement, the iron ore will have to be agglomerated (pelletized or briquetted) before introduction to any conventional, proven, reduction process unit. We note that while many fine ore based reduction processes for iron ore are in development around the world, none, in our view, is sufficiently demonstrated on a commercial scale to be recommended by us for this project at this time - a number of large-scale operations have in fact been mothballed. A conventional filter plant would be adequate to dewater the iron ore slurry to the level compatible with pelletizing, with the transport water available for site purposes.

We have looked at three process routes of progressive complexity and risk for provision of reduced metallics to the EAF, identified as Options A to C on the referenced flowsheets (Figures 2A, 2B & 2C).

Options A and B both involve the Midrex Shaft Furnace technology for production of Direct Reduced Iron (DRI) to supply all, or a major portion, of the virgin iron units needed to support the EAF. The Midrex technical paper (Appendix C) should be read in conjunction with this discussion. Numerous successful, high productivity, high quality EAF based steelmills around the world use Midrex DRI for up to 100% of their feed. Notable in North America are ISPAT's operations in Quebec, Trinidad, and Mexico, and GSI's at Georgetown SC. All however, have natural gas available to be utilized to produce the reducing gas, and have electric power available from other sources for the steel mill operations.

For A, which involves 100% Midrex DRI feed, in the absence of natural gas at the Illtyd Creek site, and with the prospects for Coal Bed Methane (Appendix G) production as yet uncrystallized, it would seem most reasonable to employ a suitably sized gasifier to produce the required quantities of gas, with consideration given to an overage for supplementing input energy to a high-ash-coal fired generating station - if appropriate to optimize coal mining, preparation, and utilizing. The gasifier-only configuration would be the simplest from an operating standpoint, and produces a product, which can be either used on-site, or sold. Offsetting these advantages, EAF operations on 100% DRI are intensive consumers of electricity, and produce high volumes of slag, with concomitantly lower yields and high flux consumptions. Appendix D addresses some of the gasification technology considerations.

Option B, which has been successfully demonstrated at Saldahna Bay Steel in South Africa, sees the coal gasifier replaced with a "Corex" hot metal (3-4% Carbon) production unit. These units generate substantial quantities of by-product gas, which can be conditioned to be a suitable Midrex shaft furnace feed. While detailed study is required to size the Corex unit to provide the appropriate amount of reducing gas plus supplemental power station feed at the Promithian mill, the Saldahna Bay complex operates with a 0.8:1.0 ratio of hot metal to DRI.

The advantage with this process mix is that a substantial upgrading of the metallic content of the EAF feed is achieved, energy requirements for the EAF are reduced along with flux requirements. Offsetting these advantages are the added costs and complexity of managing the liquid hot metal, slag, etc. as well as the notionally more demanding process control aspects of the Corex melter/gasifier compared to a straight gasifier. Corex hot metal can be granulated, or cast as "pigs" to provide intermediate, readily saleable products.

The iron ore feed for both the Midrex and Corex units would have to be pelletized, normally a relatively straightforward operation, with some degree of induration required to minimize degradation in handling and reduction. Additional gas and or waste heat is required for firing the induration unit, with some offset available by incorporating fine coal in the pellets.

Both the coal gasifier and the Corex melter require considerable tonnages of high purity, high pressure oxygen, as does the EAF refining process. Inasmuch as the principal consumable used in oxygen separation is electricity, and since there are trade-offs available between the unit oxygen and electricity requirements for each of the processes, an optimization simulation is required to establish the relative sizing of each of the units involved.

In summary, we would potentially see the front-end of the Promithian mill as being either an "integrated mini-mill" complex – Option A, or a "Saldahna Bay" complex – Option B as described at pages 11 and 12 respectively of the referenced Midrex paper.

As noted in the Midrex paper, in 1998, only 3% of world DRI production was directly coal based. Midrex has more recently reported that 4.7% and 8.4% of world DRI production was directly coal based in the years 2000 and 2001 respectively. That notwithstanding, we believe there could be significant value in considering a coal based DRI route as an alternative to the Midrex dominated options above. In Option C we reflect the "Red-Smelt," "Iron Dynamics," or Midrex "Fast-Met" rotary hearth processes for primary metallization purposes.

In these processes, ore is pelletized with coal and fluxes, the pellets are introduced into a large rotary hearth furnace (RHF), typically fired with gas or pulverized coal, and discharged after reduction to either a briquetter, or as metallized pellets to a submerged arc furnace (SAF). The logic for further processing a portion of the DRI to liquid hot metal in the SAF is similar to that previously referenced in the Corex/Midrex discussion. In this case, the core technologies have been established – SAF's in many smelting operations, and the RHF's at Inmetco in Detroit, Mich. and in Japan. There is a higher risk of start up and development problems, as commercial scale operation has not been demonstrated on a consistent basis. The installation at Iron Dynamics in Illinois has had successful periods of operation, but is currently under modification. An attractive feature of this process route is that the RHF and SAF off-gases have substantial fuel value. An offsetting disadvantage is that precise control of the incoming materials with respect to their composition and size distribution as well as their proportions is necessary.

It conclusion, it is important that the process route for preparation of the EAF metallic feed, and supply of mill/mines energy requirements be evaluated and finalized in order that the beneficiation requirements for the input coal and iron ore can be established.

While the iron ore requirement is straightforward – the Phosphorous and Silica levels have to be brought down to industry standard to avoid large energy and productivity penalties, the situation with respect to the coal is much more complex. At one extreme, if 100% Midrex DRI were employed, supported by a gasifier complex, then it is possible that minimal beneficiation would be required; at the other, with 100% RHF DRI, ash and impurities in the coal would have to be dealt with in the subsequent hot metal and steelmaking processes, and beneficiation to at least metallurgical coal ash levels would be required.

The principal elements of the process routes discussed above, together with some of the important support systems for each step are summarized in the following Table 1. Elsewhere in the Report we have included capital cost data as available to us from our reference materials to provide guidance as to the potential capital costs of such a project. While in the aggregate, the notional total of $2.5 to 3.0 billion to execute a project as conceived by Promithian are large, it is to be remembered that the steel industry is notoriously capital intensive, but that, properly configured to serve higher value markets, individual operations can be significantly profitable. As well, the "'economic value added" to a region that hosts such a steelmaking and manufacturing complex can be considerable.

Table 1

Facilities Listing

Crest Iron Ore Site – 1.5 million ton/yr shipped

- Camp/Office Complex
- Mobile Shop and Maintenance Facilities
- Trucks, Shovels and Misc. Mobile Equipment
- Water Treatment/Distribution
- Concentrator incl. Control Lab
- Substation
- Product Stocking/Ex-stocking
- Slurry Pumping Station
- Overburden and Tailings disposal
- Airstrip/helipad

Wind River Site

- Camp/Office/Admin.
- Power Station
- Oxygen/Argon Separation plant
- Water Treatment/Distribution/Disposal
- Coal Operation – 1.0 to 1.5 million ton/yr
- Office/Dry
- Surface Mining Equipment or Underground Mining Equipment
- Wash Plant incl. Control/Laboratory Complex
- Product Stocking/Ex-Stocking
- Maintenance Facilities
- Overburden and Tailings Disposal
- Airstrip/Helipad

Primary Metallics Production

Option A

- Gasifier
- Char/Ash Separation, Handling and Disposal
- Slurry Dewatering
- Pelletizing/Aglomeration (ore +plant dusts/scale)
- Midrex Megamod Shaft Furnace
- Gas Cleaning/Conditioning/Recirculation
- Product Stocking/Ex-Stocking
- Water Recirculation/Treatment
- Control/laboratory Complex

Option B

- Slurry Dewatering
- Pelletizing/Agglomeration (ore + plant dusts/scale)
- Corex Gasifier/Melter
- Slag Separation, Handling and Disposal
- Hot Metal Transport Ladles
- Hot Metal Granulation or Pig Casting machine
- Water treatment/Recirculation
- Gas Cleaning/Conditioning
- Midrex Shaft Furnace
- Gas Cleaning/Conditioning/Recirculation
- Product Stocking/Ex-Stocking
- Water Treatment/recirculation
- Control/Laboratory Complex

Option C

- Slurry Dewatering
- Coal Pulverization
- Pelletizing/Agglomeration (ore+coal+plant dusts/scale)
- Rotary Hearth Reduction Furnace
- Gas Cleaning
- Briquetting
- Product Stocking/Ex-Stocking
- Submerged Arc Furnace
- Slag Seperation, Handling and Disposal
- Hot Metal Transport Ladles
- Hot Metal Granulation or Pig Casting Machine
- Gas Cleaning
- Water Treatment/Recirculation
- Control/Laboratory Complex

Steelmaking

Option A

- TwinShell 150ton Electric Arc Furnace Complex
- UHP Transformer/Regulation System
- Batch and Continuous Charging Systems for Metallics
- Batch and Continuous Feeding Systems for Fluxes and Additives
- Gas, Oxygen (low volume), Carbon Injection Systems
- Slag Handling, Processing and Disposal
- Steel Transport Ladles
- Gas/Fume Collection/Handling/Conditioning system
- Water Treatment and Recirculation System
- Maintenance Complex for Furnace Components/Transport Ladles
- Ladle Drying/preheating Stations
- Control/Laboratory Complex

Option B & C

- Hot Metal Desulfurization/Deslagging Station
- Twin Station Conarc Furnace Complex
- UHP Transformer/Regulation System
- Batch Charging Systems for Metallics, Hot Metal
- Batch and Continuous feeding Systems for Fluxes and Additives
- Gas, Oxygen (high volume), Carbon Injection Systems
- Slag Handling, Processing and Disposal
- Gas/Fume Collection/Handling/Conditioning System
- Water Treatment and Recirculation System
- Maintenance Complex for Furnace Components/Transport Ladles
- Ladle Drying/Preheating Stations
- Control/Laboratory Complex

Ladle Metallurgy

- Steel ladle Transfer Cars
- Twin Station Electric Arc Reheating Station
- LP Transformer Regulation System
- Argon Injection
- Cored Alloy Wire Feeding
- Alloy Batching and Addition System
- Gas/Fume Collection/Handling/Conditioning System
- Water Treatment and Recirculation System
- Control/Laboratory Complex

Slab Casting

- Twin Turret for Steel Ladles
- Twin Cars for Tundishes with Preheat
- Weighing Systems for Ladles and Tundishes
- Shroud Handling Systems for Ladles and Tundishes
- Single Strand Fully Segmented Casting Machine
- Top Entry Starter Bar System
- Mold Level Control System
- Fume Collection and Conditioning Systems
- Mold, Machine and Spray Water Control/Recirculation/Treatment
- Slab Measurement/Cut-off/Identification System
- Swarf /Scale Handling System
- Crop Handling System
- Tundish Skulling/Repair/Relining/Drying Stations
- Control Complex

Hot Rolling

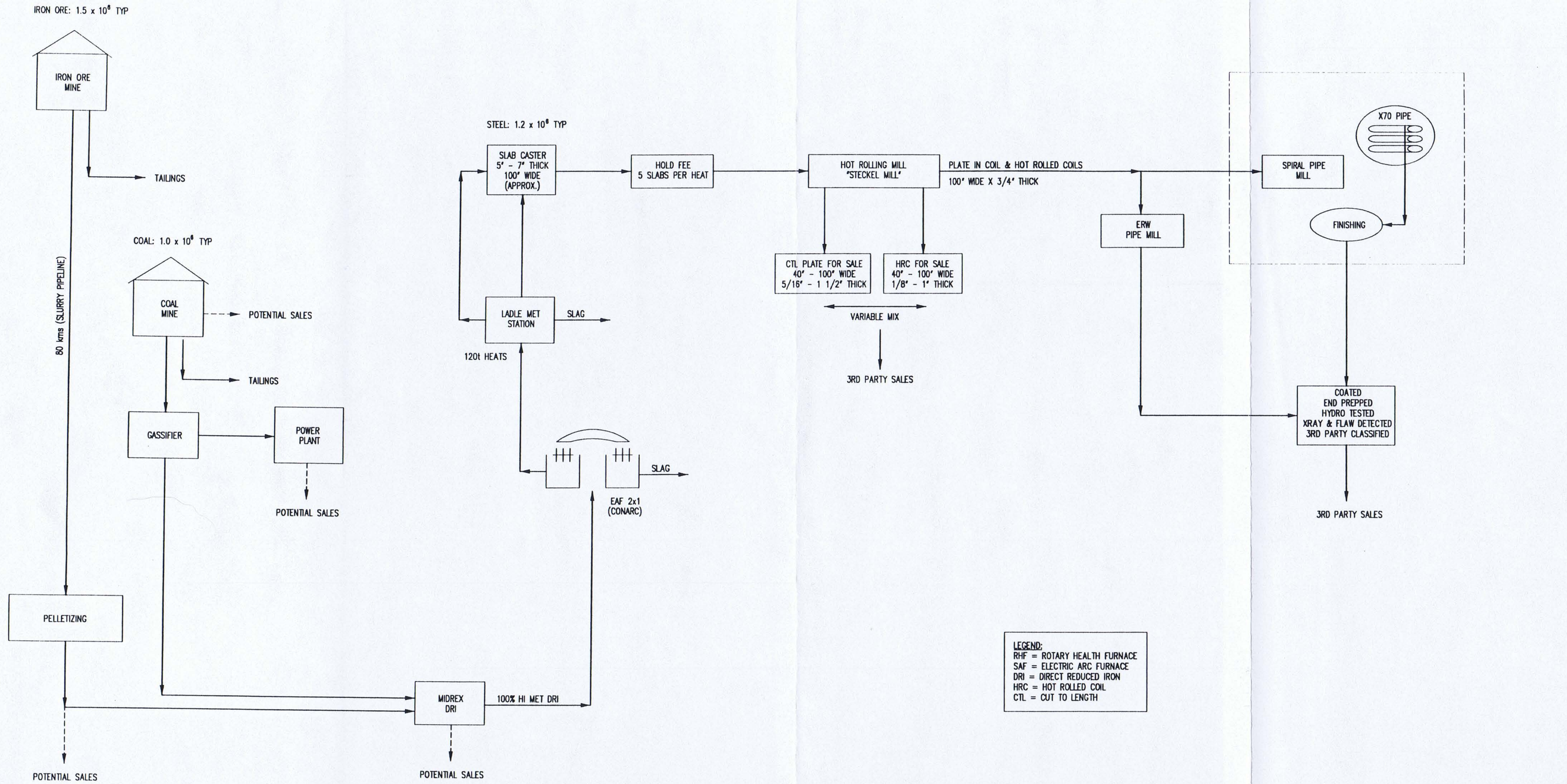
- Slab Equalizing/Reheating Furnace
- High Pressure Descaling System
- Crop Shear with Crop handling System
- Single Stand, 4-Hi Steckel Mill Complex with Edging
- Hydraulic AGC, Roll Bending/ Crown Control
- Coiling Furnaces
- Run-out Table with Laminar Spray Cooling
- Upcoiler with Transfer/Identification System for Coils
- In-Line Leveler for Plate
- Plate Shear and Identification/Handling System
- Scale Handling System
- Water Recirculation and Treatment System

Hot Strip Finishing

- Cooling Yard
- 4- Hi Temper Mill/Rewind Mill
- Cut-to Length Line (Optional)
- Slitter (Optional)
- Packaging and Shipping Complex
- Transfer System to Pipe and Tube Mills

Pipe and Tube Making

- Spiral Mill(s) for 24" + Heavy Wall Pipe incl.
- Uncoiler/Leveller
- Edge Milling
- Strip-to Strip Butt Welding
- High-Speed SA Welding
- NDT
- Pipe Cutoff
- Pipe Handling System
- End Facing
- ND and Hydro-Test
- Coating and Shipping Complex
- Fume Collection and Conditioning
- Water Recirculation and Treatment
- Slag, Scale,Scrap Collection and Handling Systems
- Testing Laboratory
- Control Complex
- Electric Resistance Welding Mill for -32" Pipe and Tube and HSS (Optional) incl.
- Uncoiler/Leveler
- Edge Milling
- ERW Welding
- NDT
- Product Cutoff
- Product Handling System
- End Facing and Coating
- Warehousing and Shipping Complex
- Control Complex



PROGRESS PRINT

JUNE 06, 2002

THIS DRAWING HAS NOT BEEN PUBLISHED BUT RATHER HAS BEEN PREPARED BY HATCH FOR USE BY THE CLIENT NAMED IN THE TITLE BLOCK SOLELY IN RESPECT OF THE CONSTRUCTION, OPERATION AND MAINTENANCE OF THE FACILITY NAMED IN THE TITLE BLOCK AND SHALL NOT BE USED FOR ANY OTHER PURPOSE OR FURNISHED TO ANY OTHER PARTY WITHOUT THE EXPRESS CONSENT OF HATCH

DWG. NO.	REFERENCE DRAWINGS

PROJECT	PROCESS	CIVIL	MECH.	STRUCT.	PIPING	SERVICES	ELECT.	INSTR.	NO	DESCRIPTION	BY	DATE
										ISSUE/REVISIONS		

PROJECT	PROCESS	CIVIL	MECH.	STRUCT.	PIPING	SERVICES	ELECT.	INSTR.	NO	DESCRIPTION	BY	DATE
										ISSUE/REVISIONS		

SECTION:	GENERAL	
SCALE:	NONE	DATE
DESIGN. BY	AM	JUNE/02
DRAWN BY:	DH	JUNE/02
CHECK. BY		
APP. BY:		

PROMITHIAN INC.

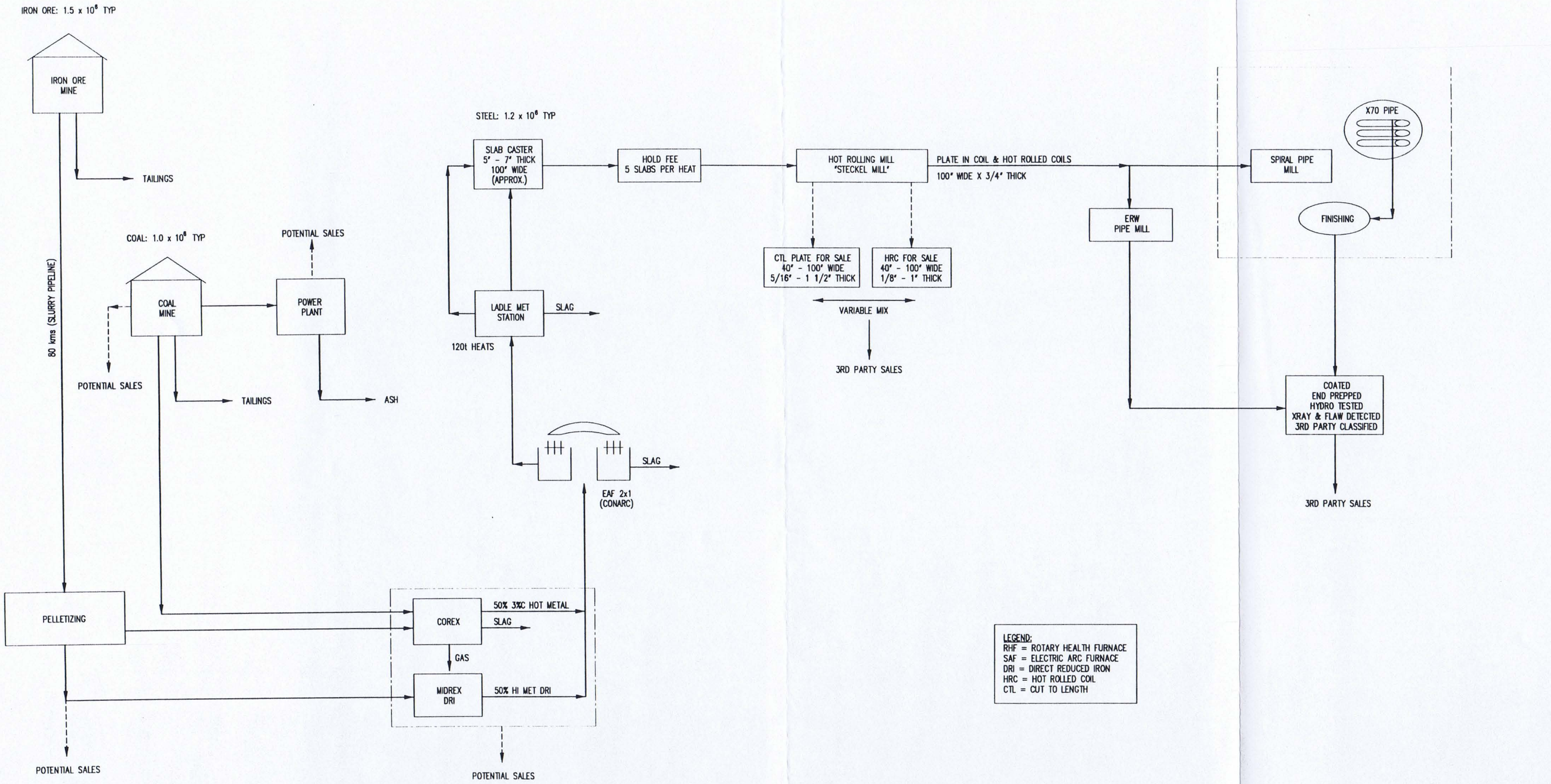
YUKON — ILLTYD CREEK

HATCH

TITLE: PROMITHIAN STEEL COMPLEX

FLOWSHEET OPTION "A"

FILENAME:	PROJECT NUMBER	DRAWING NUMBER	REV
ADF001A.DWG	72291	FIGURE 2A	A



PROGRESS PRINT

JUNE 06, 2002

DWG. NO. | REFERENCE DRAWINGS

PROJECT | PROCESS | CIVIL | MECH. | STRUCT. | PIPING | SERVICES | ELECT. | INSTR. | NO | DESCRIPTION ISSUE/REVISIONS | BY | DATE

PROJECT | PROCESS | CIVIL | MECH. | STRUCT. | PIPING | SERVICES | ELECT. | INSTR. | NO | DESCRIPTION ISSUE/REVISIONS | BY | DATE

SECTION:	GENERAL	
SCALE:	NONE	DATE
DESIGN. BY	AM	JUNE/02
DRAWN BY:	DH	JUNE/02
CHECK. BY		
APP. BY:		

PROMITHIAN INC.

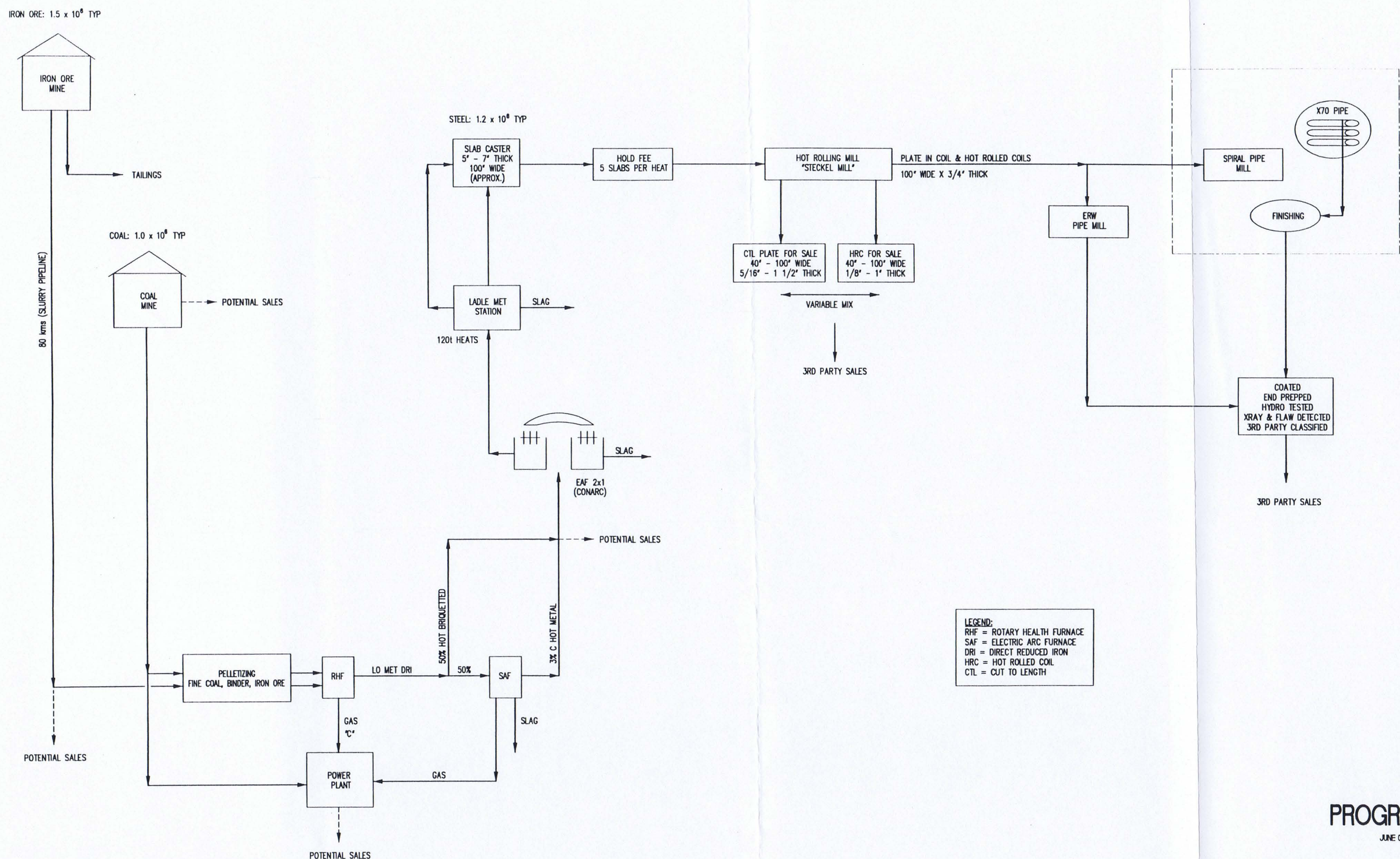
YUKON ILLTYD CREEK

HATCH

TITLE PROMITHIAN STEEL COMPLEX

FLOWSHEET OPTION "B"

FILENAME	PROJECT NUMBER	DRAWING NUMBER	REV.
A0F001B.DWG	72291	FIGURE 2B	A



PROGRESS PRINT
JUNE 06, 2002

DWG. NO.	REFERENCE DRAWINGS

PROJECT	PROCESS	CIVIL	MECH	STRUCT.	PIPING	SERVICES	ELECT.	INSTR.	NO	DESCRIPTION	BY	DATE
										ISSUE/REVISIONS		

PROJECT	PROCESS	CIVIL	MECH	STRUCT.	PIPING	SERVICES	ELECT.	INSTR.	NO	DESCRIPTION	BY	DATE
										ISSUE/REVISIONS		

		DATE
SECTION:	GENERAL	
SCALE:	NONE	
DESIGN. BY	AM	JUNE/02
DRAWN BY:	DH	JUNE/02
CHECK. BY		
APP. BY:		

PROMITHIAN INC.
YUKON ILLTYD CREEK
HATCH

TITLE PROMITHIAN STEEL COMPLEX
FLOWSHEET OPTION "C"

FILENAME:	PROJECT NUMBER	DRAWING NUMBER	REV
ADF001C.DWG	72291	FIGURE 2C	A

3 Project Contacts

Philip Wheelton
President, Promithian Inc.
209-2995 Princess
Coquitlam, B.C.
V3B 7N1
Phone (604) 715-2274
Fax (604) 468-8390
wheelton@direct.ca

Sam Wallingham
President, Nacho Nyak Dun Development Corporation
405 Ogilvia Street
Whitehorse, Yukon
Y1A 2S5
Cell (867) 333-2403
Fax (867) 456-2172
sam.nnddc@northwestel.net

Lori Walton
Senior Mineral Development Advisor
Department of Energy, Mines and Resources
Government of Yukon
Box 2703
Whitehorse, Yukon
Y1A 2C6
Phone (867) 667-5462
Fax (867) 393-6232
lori.walton@gov.yk.ca

Appendix A
Promithian Pipeline Demand Forecast

Option	Prudhoe Bay Pipeline				
1	42 inch diameter 3/4" wall thickness x80 steel (80,000 psi specific min. yield strength)				
	1084 lbs/meter		1084		
				Total weight of steel	
	2816	kilometers		Pounds	Tonnes (metric)
	2816000	meters		3,052,544,000	1,387,520
2	52 inch diameter 1" wall thickness (x100 steel?)				
	estimated weight= interpolation from 30 to 42 to 52 inch = 1356 lbs/meter				
	from 3/4" to 1" = 1.333 x 1356 lbs/meter = 1808 lbs/meter				
			1808		
				Total weight of steel	
	2816	kilometers		Pounds	Tonnes (metric)
	2816000	meters		5,091,328,000	2,314,240
3	**MacKenzie Valley Pipeline**				
	30 inch Diameter Pipeline 3/4" wall thickness				
	769 lbs/meter			Pounds	Tonnes (metric)
	2200	kilometers	769	1,691,800,000	769,000
	2200000	meters			

Total Steel Weight (tonnes)

Low estimate is Option #1 + #3	**2,156,520**
High estimate is Option #2 + #3	**3,083,240**

Pipeline steel is approx. 97% Iron (Fe) by weight

----- Original Message -----
From: Phil Wheelton
To: Klawonn, Rob
Sent: Tuesday, February 05, 2002 9:33 PM
Subject: Promithian - Pipeline scenarios

Rob,

I hope you have received the cd's with the information on the Wind River Coalfield and the Snake River Iron ore deposit by now. They were sent on Monday.

As I mentioned in my last E-mail I have worked out a number of scenario's to do with possible pipeline steel tonnage demand:

# 1 MacKenzie Valley Pipeline only:	769,000 mt
# 2 MacKenzie Valley Pipeline followed by	769,000
Foothill's Southern Route Prudoe Bay Pipeline	1,387,520
	2,156,520 mt
# 3 MacKenzie Valley Pipeline followed by	769,000
Northern Route Prudoe Bay Pipeline-twin 36"	2,196,990
	2,965,990 mt
# 4 MacKenzie Valley Pipeline followed by	769,000
Prudoe Bay Northern Route single 36" and	1,098,495
Prudoe Bay Northern Route twin 42"	2,569,080
	4,436,575 mt

At this time I would have to say that scenario number 3 is the most likely to occur - with scenario number 2 following it. An affordable, local, supply of pipeline pipe will substantially reduce transportation costs and thus increase the likelyhood that all pipelines will eventually be built - scenario number 4. These numbers exclude any collection systems needed or spur line connections to other sedimentary basins.

As an aside - the Hunt Brothers, from Texas, have just acquired a 450 square kilometre oil and natural gas license in a sedimentary basin just north of our location.

Philip J. Wheelton
Promithian Inc.

The Imperatives of Arctic Natural Gas Development

By
Ronald Oligney, University of Houston
James Longbottom, University of Houston

November 2001

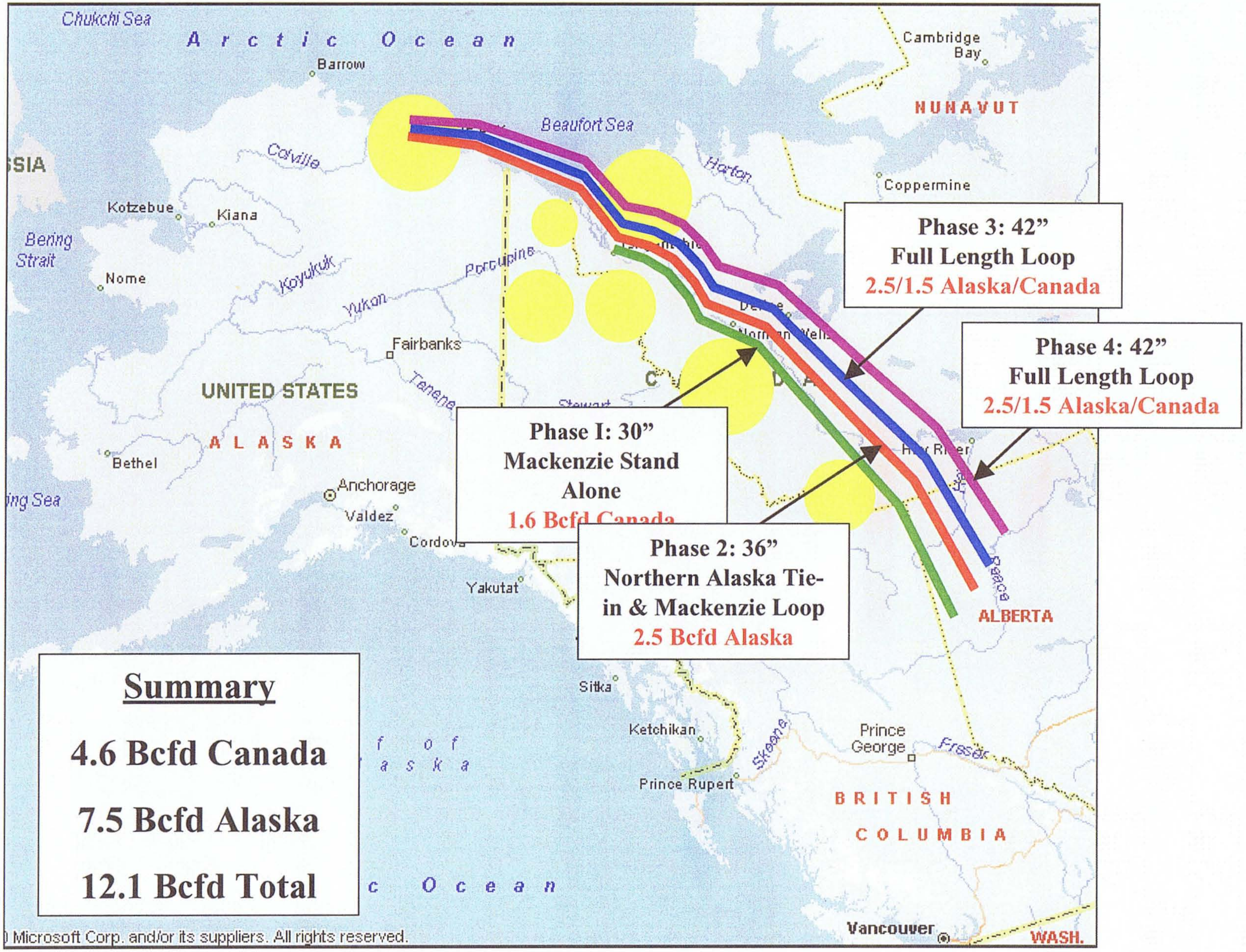
Primary Messages

- The United States must pursue 12 Bcfd of natural gas production from the Arctic, not 4 or 6 Bcfd—America needs the gas!
- Oil or natural gas supply disruptions—whether geopolitical or infrastructure related—quickly destroy 10 million U.S. jobs.
- The $3.00 per Mscf price floor for natural gas necessary to support Arctic pipeline development will emerge in the next 24 months.
- Risk and uncertainty are the greatest roadblocks to Arctic pipeline construction, not the much-debated standard financial variables.
- Staged pipeline construction is the obvious mechanism to materially reduce costs, risk and uncertainty.
- Under almost any political, financial or price scenario, a natural gas pipeline down the Mackenzie corridor will be developed first.

Message to Canadians

- Canada has the lead in Arctic pipeline development—get busy before you lose it!
  - Natural gas in the North, takeaway capacity in the South.
  - No need for international agreement before proceeding.
  - Environmental/regulatory framework in place.
- Mackenzie Valley will develop as pipeline "corridor":
  - Historical and modern imperative of market forces.
  - Construction of first segment reduces risk of corridor route for future expansion and (ult.) connection to Alaska.
- Impact on Canadian employment will be huge:
  - Construction peak employment in 2013 is 23,161 man-years
  - Gas industry job impact by 2020 is 39,694 permanent jobs
- Employ ARC strategy:
  - Best financial parameters.
  - Sensitive to Aboriginal needs.

Multiple Pipeline Stages Used to Access Arctic Gas



Model Results of Recommended Capacity Additions

	Mackenzie Only	Northern Tie-in + Loop	Full Length Loop	Full Length Loop
Capital Cost (Billion USD)	$3.353	$6.128	$8.326	$8.572
Length (miles)	1040	1700	1700	1700
Alaska Capacity (Bcf/d)	0	2.5	2.5	2.5
Canada Capacity (Bcf/d)	1.6	0	1.5	1.5
Size (inches)	30	36	42	42
Tariff Prudhoe to L48 ($/Mcf)	NA	$1.83	$2.22	$2.27
Tariff Mackenzie to L48 ($/Mcf)	$0.96	NA	$1.45	$1.50
Assumed Gas Price ($/Mcf)	$2.63	$2.71	$2.85	$2.93
Netback to Producers ($/Mcf)	$1.07	$0.88	$0.63	$0.66
Recommended On-line Date	2007	2010	2015	2018
Cumulative Capacity (Bcf/d)	1.6	4.1	8.1	12.1

Appendix B
IPSCO Plate Mill

SPECIAL REPORT

Mini-mills
DEC. 20, 2001

Ipsco expands with new Ala. plate mill

By Paul Millbank
Editor, Metal Bulletin Monthly

The deep South of the United States, almost within sight of the Gulf of Mexico might not at first glance seem the obvious location for a new plate mill. But for Ipsco, a company looking to expand its North American presence in discrete and coiled plate and heavy gauge coiled sheet, Mobile County, Alabama, was the place that made most sense.

Just as the company's mid-1990's decision to expand its hot-rolled coil and plate capacity by building a new steelworks at Montpelier, Iowa, was more logical in terms of raw materials sourcing and end-market proximity than expanding its original but remote mill in Regina mid-Canada, so moving south was, for the same reasons, seen as a better bet than adding capacity at Montpelier.

And Mobile does have attractions. It puts Ipsco in easy striking distance of all the southeastern United States, the country's most buoyant steel market, enables the company to compete with plate imports at one of its major points of entry, and allows the mill to address specialized local steel markets such as barge, ship and offshore oil/gas platform building.

But if the location can be explained, what about the timing? When Ipsco announced at the end of 1998 that it was going ahead with the 1.13-million-tonnes-per-year plate mill, the U.S. market was taking a battering from imported steel. The company saw this as a temporary situation and expected that things would be back to normal by the time the new mill commenced shipments in first half 2001. In fact, three years on not much has changed. So why did Ipsco spend $425 million to enter a market as tough as this one?

Senior vice president and chief commercial officer John Tulloch says that with the Regina and Montpelier steelworks Ipsco believed it had developed "a good model for making a good product at a cost-effective rate." The decision to invest at Mobile then stemmed from the company feeling that it had the potential to grow, along with concern that someone else in the industry might recognize the effectiveness of the model they had developed, copy it and beat them to the market.

Big in plate

With its three steelworks, Ipsco will have more plate capacity than any other North American mini-mill group. Montpelier, Iowa, which first melted steel in 1997 but had an extended and acrimonious start-up that went to litigation with the supplier, is of similar size to the new plant, and the company's Regina, Saskatche-wan, steelworks in Canada has a capacity of more than 900,000 tonnes per year bringing group steelmaking capacity close to 3.2 million tonnes per year.

The new mill is working towards achieving full capacity by the end of the first quarter of this year, subject to market conditions, after starting commercial shipments in April 2001. Late November the plant was operating at about 60 percent capacity.

Ipsco Steel (Alabama) is entering the market a little behind, but still broadly in parallel with Nucor's new discrete plate mill (MBM November 2001) and both are having to contend with tonnages of imported steel which the U.S. International Trade Commission (ITC) has already ruled is injurious to domestic mills--though at presstime there was no sign of if and when there will be any protection from this influx.

Built in an area of pine woods and wetland close to the Mobile River and just along Highway 43 from Alabama Power--a factor, along with river access, in the choice of site--the project went from groundbreaking to casting its first slab in 20 months. Except for dealing with a relatively high water table, there were no untoward construction problems, says Paul Wilson, executive vice president at the mill.

For the start-up, a small nucleus of people transferred from Montpelier, but most of the workforce of 310 had to be recruited locally and then trained. Wilson says a slowdown in established local industries like papermaking and chemicals increased the availability of recruits with some industrial experience. Around 100 personnel were trained for up to a year at the Montpelier and Regina steelworks. Subcontracted operations such as scrap management, process water, oxygen supply and mill roll regrinding bring an additional 250 personnel onto the site.

Through the mill

The plant is laid out to provide a more or less straight line process flow from scrap entry at one end of the 600-foot-long building to product dispatch at the other.

Scrap is sourced from all across the Gulf Coast region. Wilson says supply is not a problem as there are several large centers of population, and some of the feed now going into Mobile would otherwise have been exported. He notes that the plant does not have a restrictive scrap mix because its products do not need a low residuals feed. No DRI/HBI (direct reduced iron/hot briquetted iron) is being used, although it could be if appropriate handling facilities were installed.

Around 60 percent of the scrap arrives by barge at a dock some 2 miles from the works, with the balance split between rail and road supplies. Finished product has also been shipped out by barge. As at Montpelier scrap management is outsourced--in this case to IMS.

The melt shop is not in-line but of three-bay configuration, with a charging/furnace bay, hot metal bay (for ladle transfer and secondary metallurgy) and caster turret bay with caster mold and segment maintenance. Wilson points out that keeping the EAF in a separate bay provides more effective fume capture and keeps the operation cleaner. There is space to fit a degassing unit should this be needed to extend the range of grades produced by the mill.

Scrap is charged to a 160-tonne, twin-shell, eccentric bottom tapped AC electric arc furnace rated at 148MVA and equipped with injection lances and oxy-fuel burners. This is operated with a hot heel of 35 to 40 tonnes and is currently achieving tap-to-tap times of below 60 minutes. Melt shop activity has been inhibited by rolling mill commissioning and so far it has only been operating in a single shell mode. Tap-to-tap time is expected to shorten to around 48 minutes as the plant achieves capacity.

Steel is transferred to a twin-station ladle metallurgy unit before casting on the medium-thickness 6-inch slab caster; it is not the intention to vary this thickness, although the slab width can be varied between 60 to 124 inches) "on the fly." Cast slabs either proceed straight to the walking beam reheat furnace for temperature equalization or go to the slab yard. Wilson says the aim is to "hot charge" about 75 percent of slab throughput.

After descaling, reheated slabs transfer to the single stand, 4-high Steckel mill, equipped with automatic gauge control and positive work roll bending, as well as entry and exit furnaces and edger. Slabs require multiple mill passes to reach final gauge, and once the transfer bar reaches the length of the 90-meter mill runout tables (at a thickness of around 25mm thick) it is then coiled after each pass in Steckel furnaces (coil boxes) either side of the mill.

The resulting "mother" plates are sheared and either coiled (by upcoiler) or, in the case of discrete plate, hot leveled prior to the cooling bed. After cooling, plate is cold leveled and cut to length ready for shipment from covered rail and truck loading bays.

Originally the product mix was envisaged as 60 percent plate, 40 percent coil, but so far output has been around 80 percent plate. As Wilson points out, it is the market that will determine the mix.

Apart from shipbuilding and offshore applications for an anticipated 35 to 40 percent of sales, the Mobile mill is targeting the construction, railcar and heavy engineering fabrication sectors, as well as service centers. Discrete plate can be up to 2 inches thick, 120 inches wide, while coiled products go up to 90 inches wide.

"We've ramped up quite well and made the majority of products," comments Wilson. "We have a few of the lighter gauges and wider products still to do." He said the mill should achieve ABS certification for marine steels during December. Total shipments in 2001 were expected to be around 255,000 tonnes (280,000 short tons).

Entering the market

Tulloch explains that regional market growth is not in itself large enough to support the Mobile mill, it can only survive by taking market share from others. Imports are also a target. Competition has eased with the withdrawal of Gulf States Steel, also in Alabama, over a year ago (although there are attempts being made to restart it) and Geneva Steel of Utah's decision last November to temporarily shutdown.

He seems unconcerned about a possible restart of Alabama-based hot coil producer Trico Steel. Because of Trico's restricted coil width, Ipsco is more likely to be a customer than competitor.

"We believe that we can be very competitive. Our approach is to build a facility that is world competitive by any standards," Tulloch states, adding: "time will erode those who are not efficient." Wilson confirms that imports, with their attendant shipping costs, will be a clear target for a mill of this design and with low energy, materials and labor costs. Domestic mills can also gain an advantage over imports by offering a better service to customers.

Ipsco has a string of six steel pipe mills and five cut-to-length facilities, three with temper mills, spread across North America, but Tulloch says the ideal sales strategy for Ipsco Steel (Alabama) would be for none of its output to go to these outlets but to other buyers. The group's downstream plants source coiled steel in the market, and overall the group aims to be a net steel buyer (up to 600,000 tonnes per year in good times); only during weaker market conditions would more of its hot coil go to other Ipsco processing plants.

Clearly Ipsco would like a stronger market in which to launch a new mill, but if nothing else, current conditions do allow a little more time to bring the facility up to capacity. And unlike Nucor, the new mill does have the flexibility to produce either plate or coil. Also, some domestic mills can exploit niches within product sectors--and Ipsco sees its niche in this sector as very high strength as-rolled steel, a speciality that has grown out of many years supplying pipe mills.

Appendix C
Midrex Technical Paper

GASIFICATION AND THE MIDREX®
DIRECT REDUCTION PROCESS

By: Rob Cheeley
Senior Sales Engineer
Midrex

Phone: 704-378-3343
Fax: 704-373-1611
email: robertc@midrex.com

Presented at the

1999 Gasification Technologies Conference
San Francisco, California, USA
October 17-20, 1999

GASIFICATION AND THE MIDREX®
DIRECT REDUCTION PROCESS

By: Rob Cheeley – Senior Sales Engineer, Midrex Direct Reduction Corporation

INTRODUCTION

The production of direct reduced iron (DRI), a basic raw material for making steel, is concentrated in a few countries in the Middle East and Latin America. One primary reason is that natural gas, the main fuel source for most DRI processes, is too costly in many of the steel making regions of the world.

However, coupling a coal or petroleum refining by-products gasification unit with a DRI plant may be economically attractive. This paper will explore the possibilities of combining a gasification unit with the MIDREX Direct Reduction Process, the dominant DRI technology.

I. DRI and MIDREX

Iron Ore Reduction

Iron ore consists primarily of iron oxide (Fe_2O_3), a combination of iron and oxygen. The basic function of all iron ore reduction technologies is to economically remove the oxygen from the iron ore and leave only the iron. Iron is the main component of steel, one of the world's most useful materials. If the iron ore reduction technology operates entirely in the solid state, then the product is called direct reduced iron, or DRI.

To produce DRI, the oxygen in the iron oxide is chemically removed by reacting with carbon monoxide (CO) and/or hydrogen (H_2) at very high temperatures, about 900 C (1650 F) for most technologies.

The chemical formulas for the iron ore reduction reactions are:

$$Fe_2O_3 + 3\,CO \rightarrow 2\,Fe + 3\,CO_2$$

$$Fe_2O_3 + 3\,H_2 \rightarrow 2\,Fe + 3\,H_2O$$

Obviously, a DRI plant needs H_2 and CO. These are called the reducing gases. In all existing DRI plants, these gases are generated from either natural gas or coal. However, over 90% of DRI is produced using natural gas as its fuel source. This can be seen in Table I. In addition, the currently available coal-based DRI technologies have significant limitations in terms of product quality and plant capacities.

TABLE I 1998 World DRI Production by Fuel Type		
Process Fuel	DRI Production (million tons)	% of total
Natural Gas	34.0	92
Coal	3.1	8
Total	37.1	

In Table II, the major DRI producing countries are listed. The table indicates that a disproportionate share of DRI is produced in the relatively low cost natural gas countries of Latin America and the Middle East.

TABLE II 10 Largest DRI Producing Countries (1998)	
Country	DRI Production (million tons)
Mexico	5.7
India	5.2
Venezuela	5.1
Iran	3.7
Saudi Arabia	2.3
U.S.	1.7
Indonesia	1.6
Egypt	1.6
Russia	1.6
Argentina	1.5
World Total	37.1

Steelmaking

Steel is made by refining liquid iron and then cooling and shaping it in a mold. There are two basic methods for making liquid iron: (1) a coal based process consisting of coke ovens, a blast furnace, and a basic oxygen furnace, and (2) a process in which scrap steel and/or DRI is melted by an electric current in an electric arc furnace (EAF). A plant using the electricity based process is called a mini-mill. Almost all DRI is used in mini-mills.

In most parts of the world, the mini-mill steelmaking concept has steadily captured a growing share of the market over the past 20 years. This is because a mini-mill has a much lower capital cost than the coal based iron making route, plus it's more environmentally friendly and is economical at much smaller capacities.

In countries with high cost scrap steel and low cost natural gas, DRI is typically used as the primary iron source for mini-mills. This includes mini-mills making all grades of steel. In the more industrialized countries, DRI is typically only used in mini-mills that make high quality steel. This is because the DRI does not contain the metallic impurities present in scrap steel. This is important because the metallic impurities (Cu, Zn, Sn, Cr, Ni, Mo) can adversely affect the physical and chemical properties of the steel. Thus, as mini-mills take market share away from the coal based iron-making process, the need for DRI will continue to grow.

Table III lists the 10 largest steelmaking countries. You will note that few of those listed in Table III are also listed in Table II as major DRI producers. This is primarily because most liquid iron is generated via the coal based process or made in mini-mills in countries with relatively high-cost natural gas.

TABLE III
10 Largest Steel Producing Countries (1998)

Country	Steel Production (million tons)
China	114
U.S.	98
Japan	94
Germany	44
Russia	44
South Korea	40
Brazil	26
Italy	26
Ukraine	25
India	24
World Total	776

Midrex

Midrex is a technology company based in Charlotte. Our key proprietary technology, the MIDREX Direct Reduction Process, is the dominant technology for making DRI. In 1998, 67% of all DRI was produced using the MIDREX Process. Currently, there are 47 MIDREX™ DR Modules operating in 16 countries, and two more modules are under construction. These operating plants include the four largest DRI plants in the world and six of the seven DRI plants with capacities greater than 1 MMt/y of DRI.

Of the 47 operating MIDREX DR Modules, all but one use a MIDREX™ Reformer to convert natural gas into CO and H_2. The one exception started-up this year and is the world's first (and only) DRI plant to utilize a gasification unit to generate the required reducing gases. This plant built by Saldanha Steel in South Africa, which uses the COREX® Process to generate a synthesis gas, will be discussed in the third section of this paper. Another COREX / MIDREX combination is under construction in South Korea.

A simple schematic of the MIDREX Process is shown in Figure 1.

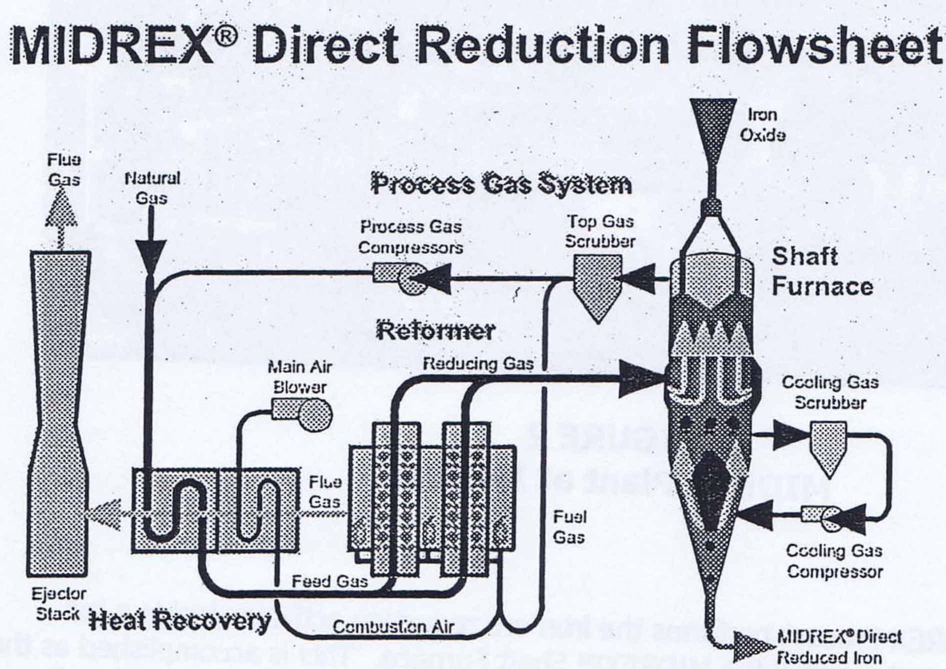


FIGURE 1

The following picture is the MIDREX Plant at the IMEXSA steelworks in Mexico.

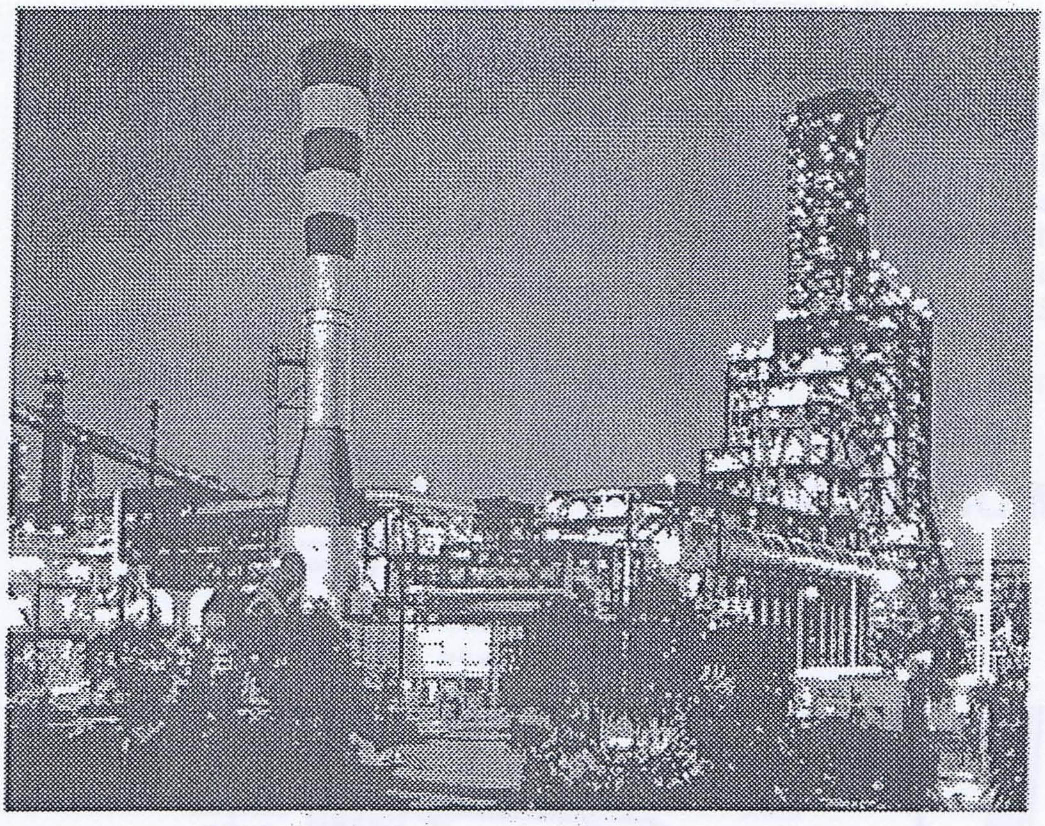


FIGURE 2
MIDREX Plant at IMEXSA

The MIDREX Process performs the iron ore reduction activities inside a tall vertical reactor called the MIDREX™ Shaft Furnace. This is accomplished as the continuously fed iron oxide, which is similar in size and shape to marbles, flows downward through the Shaft Furnace by gravity, countercurrent to the hot reducing gases which are rising up through the Shaft Furnace. The hot reducing gases react with the iron oxide, stripping away the chemically bound oxygen.

II. COUPLING GASIFIERS TO THE MIDREX PROCESS

As mentioned in the first section, almost all DRI is produced using natural gas as its fuel source. However, low-cost natural gas is limited to a few select regions of the world. Unfortunately, this does not include many of the major steel making regions, like East Asia and Western Europe. Thus, the DRI technology providers have searched for an economical method of using coal as an energy source.

Because of the need to utilize coal or petroleum refining by-products as an energy source, Midrex has been working on means of coupling a gasifier with a MIDREX Plant since the first energy crisis began in 1973.

The following schematic describes our current concept for utilizing a gasifier in conjunction with the MIDREX Process.

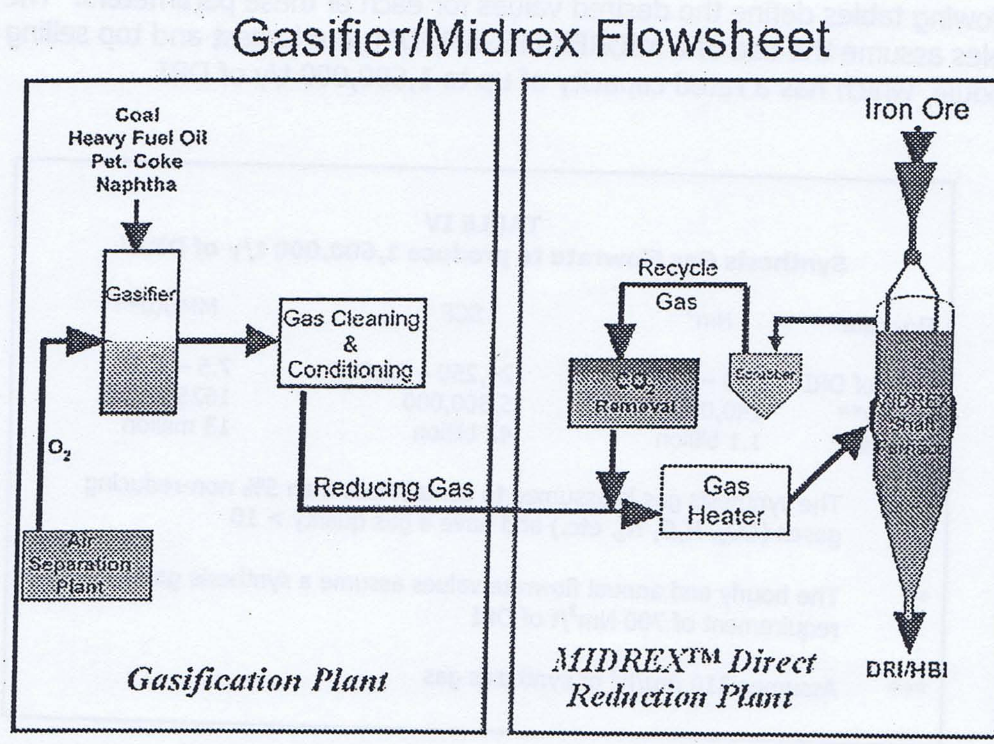


FIGURE 3

The overall concept is broken into two key systems: (1) the Gasification Plant and (2) the MIDREX Plant. Within the Gasification Plant are the gasification unit, the synthesis gas cleaning & conditioning operations, and the air separation plant. Within the MIDREX Plant are the MIDREX Shaft Furnace system, the recycle gas CO_2 removal system, and the reducing gas heating system.

It's assumed that the reader is familiar with gasifiers. Therefore, the rest of this section will concentrate on the interface between the gasification plant and the MIDREX Plant and on what occurs internal to the MIDREX Plant.

The basic objective of the gasification plant is to generate desirable reducing gases for the MIDREX Plant. The key parameter for being desirable is the gas quality (or reductants to oxidants ratio).

Gas Quality = (% H_2 + % CO) / (% H_2O + % CO_2)

The MIDREX Process requires a gas quality of at least 10 in order to efficiently produce DRI. Other important parameters include the H_2/CO ratio, the amount of inerts (N_2, etc.), the amount of soot/particulates, and the gas pressure. The following tables define the desired values for each of these parameters. The tables assume the use of a MIDREX MEGAMOD™, our largest and top selling module, which has a rated capacity of up to 1,600,000 t/y of DRI.

TABLE IV
Synthesis Gas Flowrate to produce 1,600,000 t/y of DRI*

Flowrate	Nm^3	SCF	MMBtu***
Per t of DRI	650 – 750	24,250 – 28,000	7.5 – 8.7
Hourly**	140,000	5,300,000	1625
Annual**	1.1 billion	42 billion	13 million

* The synthesis gas is assumed to contain less than 5% non-reducing gases (CO_2, H_2O, N_2, etc.) and have a gas quality > 10

** The hourly and annual flowrate values assume a synthesis gas requirement of 700 Nm^3/t of DRI

*** Assumes 310 Btu/ft^3 of synthesis gas

TABLE V
Other Synthesis Gas Characteristics

	Desired	Acceptable
Temperature	> 1650 F	Ambient – 2700 F
Pressure	45-60 psig	Up to 300 psig
H_2/CO Ratio	0.5 - ∞	0 - ∞
Quality*	> 11	> 2
Nitrogen	< 1 %	< 6 %
Methane	3 – 4 %	0 – 5 %
Sulfur**	< 100 ppm	< 0.3 %
Soot	< 100 mg/Nm^3	< 1000 mg/Nm^3

* Midrex defines quality as the ratio of reductants to oxidants
(% CO + % H_2) / (% CO_2 + % H_2O)

** The sulfur values are economic limitations for the steel mill. The sulfur has a negligible effect on the MIDREX Plant operation.

The values in Table V demonstrate that the MIDREX Process is very flexible and forgiving in terms of all of the above parameters. This is one of the major differences between generating synthesis gas for a DRI Plant versus a Power Plant or Chemical Plant.

The synthesis gas sulfur has a negligible effect on the DRI plant performance. In fact, DRI is a very good sulfur remover. Much of the synthesis gas sulfur will react with the elemental iron in the Shaft Furnace to produce iron pyrite, FeS_2, also called fool's gold. However, some sulfur will pass through the Shaft Furnace and be exhausted to the atmosphere by the CO_2 removal system. In addition, the sulfur in the DRI will have to be removed in the steel mill, which adds cost to steelmaking operation. Therefore, too much sulfur can be an environmental or economic problem.

Typically, DRI contains 1 – 3 % carbon. Thus, the presence of some carbonaceous soot/particulates in the synthesis gas is not a problem. The key issue is whether or not the soot/particulates are hard or if they are soft and sticky. If they are soft and sticky they could plug up the entry port holes into the MIDREX Shaft Furnace.

MIDREX Plants can be readily designed to utilize a reducing gas with H_2/CO ratios ranging from 0 (100% carbon monoxide) up to ∞ (100% hydrogen).

Current operating plants have been designed for H_2/CO ratios ranging from 0.5 to 4.0. The required quantity of synthesis gas tends to be inversely related to the H_2/CO ratio. Since most gasification processes generate a synthesis gas with an H_2/CO ratio of 0.5 – 1.0, the MIDREX Process has the added benefit of not requiring a shift reactor to modify the synthesis gas composition to make it useable.

The MIDREX Process operates at the relatively low pressure of about 1.5 barg (22.5 psig). Therefore, it's advantageous for the synthesis gas to be delivered at a pressure no greater than 4 barg (60 psig). If the gas pressure is higher, then an expander must be added which increases the capital cost of the plant.

MIDREX Plant

Within the MIDREX Plant, the main unit operation is the MIDREX Shaft Furnace. Inside the MIDREX Shaft Furnace, the iron ore is converted to DRI. The spent reducing gases (called recycled process gas) exit the top of the Shaft Furnace where they are cleaned and cooled. The recycled process gas contains a mix of CO_2 and H_2O, unreacted H_2 and CO, and any inerts (N_2, etc.) circulating in the system. To obtain a high enough gas quality for reuse in the Shaft Furnace, most of the CO_2 is removed from the recycled process gas via a vacuum pressure swing absorption (VPSA) unit. After this step, the process gas is mixed with the fresh synthesis gas. At this point, the gas is near ambient temperature. Therefore, the gas must be heated to about 900 C (1650 F) prior to entering the Shaft Furnace, to ensure maximize reduction efficiency.

Economics

Historically, gasifier/DRI plant combinations have not been built because they have been uneconomical relative to alternative methods of producing iron. This is primarily due to the significant capital costs associated with building both a gasification unit and most of a standard DRI Plant. The high capital charge has negated the cost benefits associated with using coal as the primary fuel source.

The following table provides an approximate breakdown of the cost inputs to produce DRI, utilizing a coal gasification unit as the synthesis gas source.

TABLE VI
Expected Gasifier / MIDREX Plant Economics

Basis: MIDREX Plant (1,600,000 t/y of DRI)
Gasifier (coal as fuel source)
U.S. Gulf Coast location

Input	Units	Cost/Unit (US $)	Specific Consumption (per t DRI)	Specific Cost (US$ per t DRI)
Iron Ore	t	40	1.45	58.00
Coal	t	35	0.5	17.50
Electricity	kW-h	0.035	290	10.15
Labor	man-hr	35	0.25	8.75
Limestone	t	30	0.006	0.18
Water	m^3	0.5	1.2	0.60
Maint. & Supplies				5.00
Credits for H.P. steam, slag, and sulfur				(7.00)
Direct Costs				**93.20**
Plant Capital Cost		US $ 300 / t DRI		
Infrastructure Capital Cost		US $ 25 / t DRI		
Capital Charge (@ 10% of capital cost / t)				32.50
General & Administrative				5.00
Indirect Costs				**37.50**
Total Cost				**130.70**

Unfortunately, in the U.S., a total cost of US$ 130 /t is high relative to currently operating natural-gas based DRI Plants, coal based iron-making plants, and high quality scrap steel. A good target total cost is US$ 120/t or less. Thus, cost savings must be found for a gasification based DRI plant to be viable in the U.S.

However, in other parts of the world, the gasification/MIDREX Plant combination can be more cost competitive. This is due to a variety of reasons, including: (1) lower cost iron ore and coal, (2) use of low cost petroleum refining by-products (3) lower cost construction labor, (4) a shortage of existing local steelmaking capacity, and (5) environmental pressures to close existing coal based ironmaking plants. Some or all of the above competitive benefits for the gasifier/DRI Plant combination are found in the major steelmaking regions of China, India, S. Korea, Brazil, South Africa, and Western Europe.

In these countries, the availability of low cost electricity for use in the steel mill is critical. If low cost fuels are available, then the gasification unit could be sized to also make enough synthesis gas for an adjacent power plant to produce the necessary low cost electricity.

The keys to making a gasifier/MIDREX Plant a viable option are:

- Where available, utilize excess synthesis gas production from a separate gasification-based power plant or chemical plant. Depending on local conditions, if an acceptable quality synthesis gas is available "across-the-fence" for less than about US$ 3.00/MMBtu, then a DRI plant may be a viable option.
- Minimize the capital cost of the gasification plant.
  If possible,
  - No desulfurization system
  - No particulate scrubbing system
  - No hydrocarbon removal system
  - No gas expander
- Maximize integration of the gasification and MIDREX unit operations.
- Utilize low-cost petroleum refining by-products where available.
- Build an integrated mini-mill complex, which includes a power plant.

Integrated Mini-Mill Complex

The gasifier/MIDREX Plant combination is ideally used to provide DRI for an integrated mini-mill complex. The integrated mini-mill complex consists of a gasification plant, a MIDREX Plant, an Integrated Gasification Combined Cycle (IGCC) power plant, and a steel mini-mill.

The on-site IGCC would be sized to generate all of the electricity required for the air separation plant, MIDREX Plant, and the mini-mill. The IGCC would take advantage of the low cost gasifier fuel to produce electricity at a competitive price. The low cost electricity is very important in the key steelmaking areas of Western Europe, India, Brazil, and East Asia. If DRI is transported hot at about 700 C (1300 F), directly from the MIDREX Plant via the MIDREX HOTLINK™ system, then it requires about 650 kW-h in the steel mini-mill to produce one ton of semi-finished steel. This power requirement is specific to the mini-mill only and does not include the power requirements for the gasification or DRI plants.

A new world-scale integrated mini-mill complex has a capacity of 2.4 MMt/y of semi-finished steel. This same complex requires about 2.7 MMt/y of DRI. The estimated total power requirement for the entire complex is 360 MW. This includes the electricity for the gasification plant (including the air separation plant), the MIDREX Plant, and the steel mill.

In addition to generating enough synthesis gas to produce 360 MW of power, the gasification unit will also need to produce approximately 9,000,000 SCF/h (2700 MMBtu/h) of synthesis gas for the DRI plant. The annualized value for the DRI plant is 71 billion SCF/year (22 million MMBtu/year).

The integrated mini-mill complex is graphically described in Figure 4.

INTEGRATED MINI-MILL COMPLEX

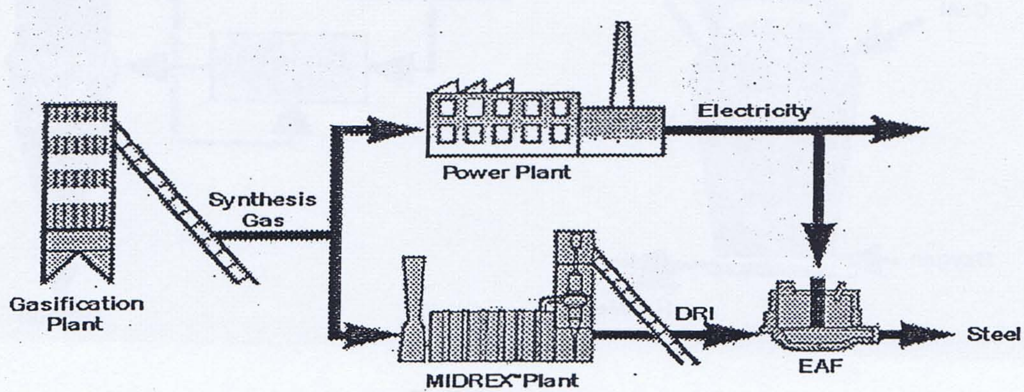


FIGURE 4

III. SALDANHA STEEL

In May 1999, the world's first gasification/DRI plant combination was started-up by Saldanha Steel, near Cape Town, South Africa. The particular gasification technology used is called the COREX Process, developed by VOEST-ALPINE of Austria, a leading steel technology firm. In the COREX Process, a melter-gasifier simultaneously gasifies coal and melts DRI to make liquid iron. The COREX Process was chosen because natural gas is not economically available in the Cape Town region for making DRI.

The COREX-MIDREX flowsheet is graphically shown in FIGURE 5. You will note that the MIDREX Plant portion is similar to the MIDREX Plant flowsheet for the general gasifier/MIDREX combination described in Section 2.

COREX / MIDREX Flowsheet

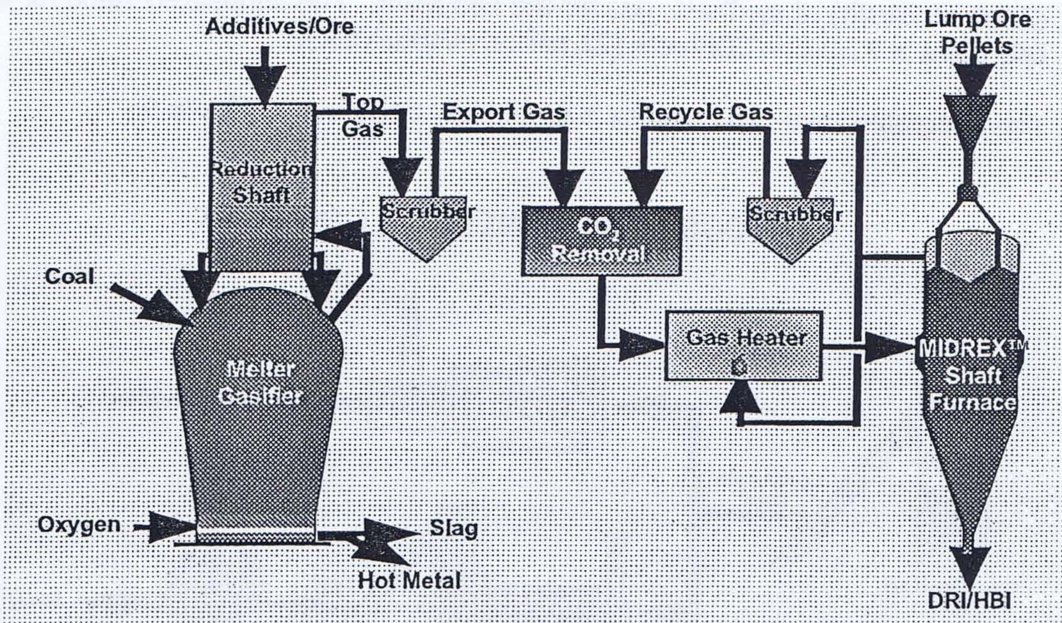


FIGURE 5

The COREX Process consists of 2 key unit operations. In the reduction shaft section, iron ore is reduced to DRI by the off-gases from the melter/gasifier. The DRI then drops by gravity into the melter/gasifier. Inside the melter/gasifier, oxygen and coal are added to create a gasification reaction that generates a synthesis gas and heat. The heat melts the DRI to make liquid iron and the synthesis gas travels upward into the reduction shaft. The spent gases exiting the reduction shaft (called the top gas) are cleaned and cooled in a direct contact water scrubber and then sent to the MIDREX Plant. The cleaned and cooled spent synthesis gas is called the COREX® Export Gas.

The COREX Export Gas has a very low H_2/CO ratio and a very low gas quality. A common VPSA CO_2 removal system is utilized to improve the quality of both the recycled process gas from the MIDREX Shaft Furnace and the synthesis gas from the COREX Plant. The rest of the MIDREX Plant is similar to the one described earlier in section 2. The typical design parameters of the COREX Export Gas, are described in Table VII.

TABLE VII **COREX Export Gas Parameters**	
Item	Typical Design
H_2/CO ratio	0.5
Gas Quality	~ 2
Gas Composition	
CO	35 – 45 %
H_2	15 – 20 %
CO_2	35 %
N_2 , H_2O	1 – 6 %
CH_4	1 %
Temperature	100 – 140 F
Pressure	2 – 25 psig
H_2S	10 – 70 ppm
Particulates content	5 mg / Nm^3
Energy Value	~ 200 Btu / ft^3

The following is a picture of the COREX and MIDREX Plants at Saldanha Steel. The COREX Plant is on the left and the MIDREX Plant is on the right.

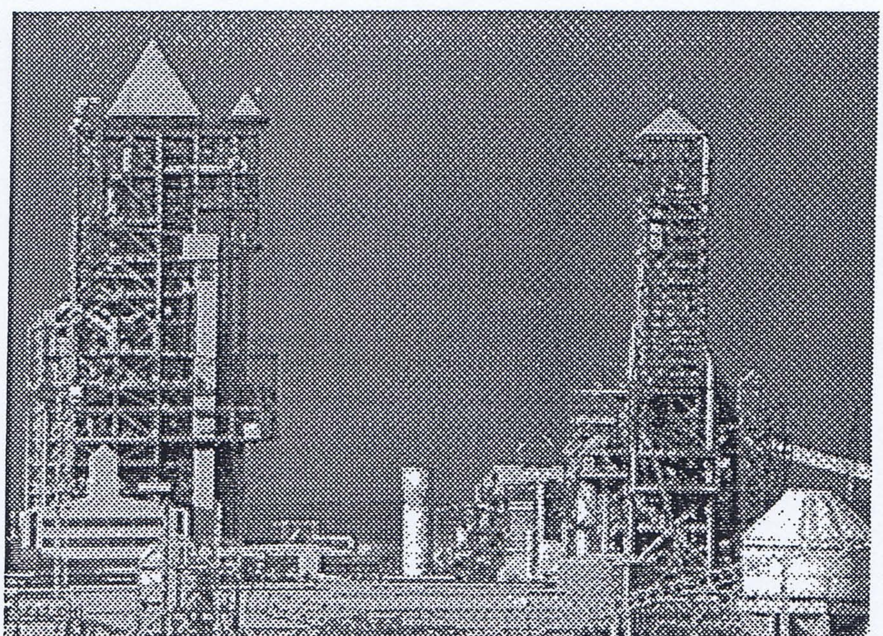


FIGURE 6
SALDANHA STEEL – COREX/MIDREX PLANTS

CONCLUSIONS

Utilizing a gasifier to generate reducing gases can be a technically and commercially viable method for innovative steelmakers to produce DRI in areas where low cost natural gas is not available. Even better economics can be derived when the project is for an entire integrated mini-mill complex, including a steel mill and an IGCC based power plant.

The gasifier/MIDREX concept (especially the integrated mini-mill complex) is best suited for the East Asian countries, where DRI is needed, but natural gas and power costs are high. Other areas with good potential include Western Europe, India, Brazil, South Africa, and the Ukraine. It will be quite challenging to justify a gasifier/MIDREX project in the U.S., unless a very low-cost fuel source can be used to generate synthesis gas at a lower price than from natural gas.

Appendix D
Technical Paper on Gasification

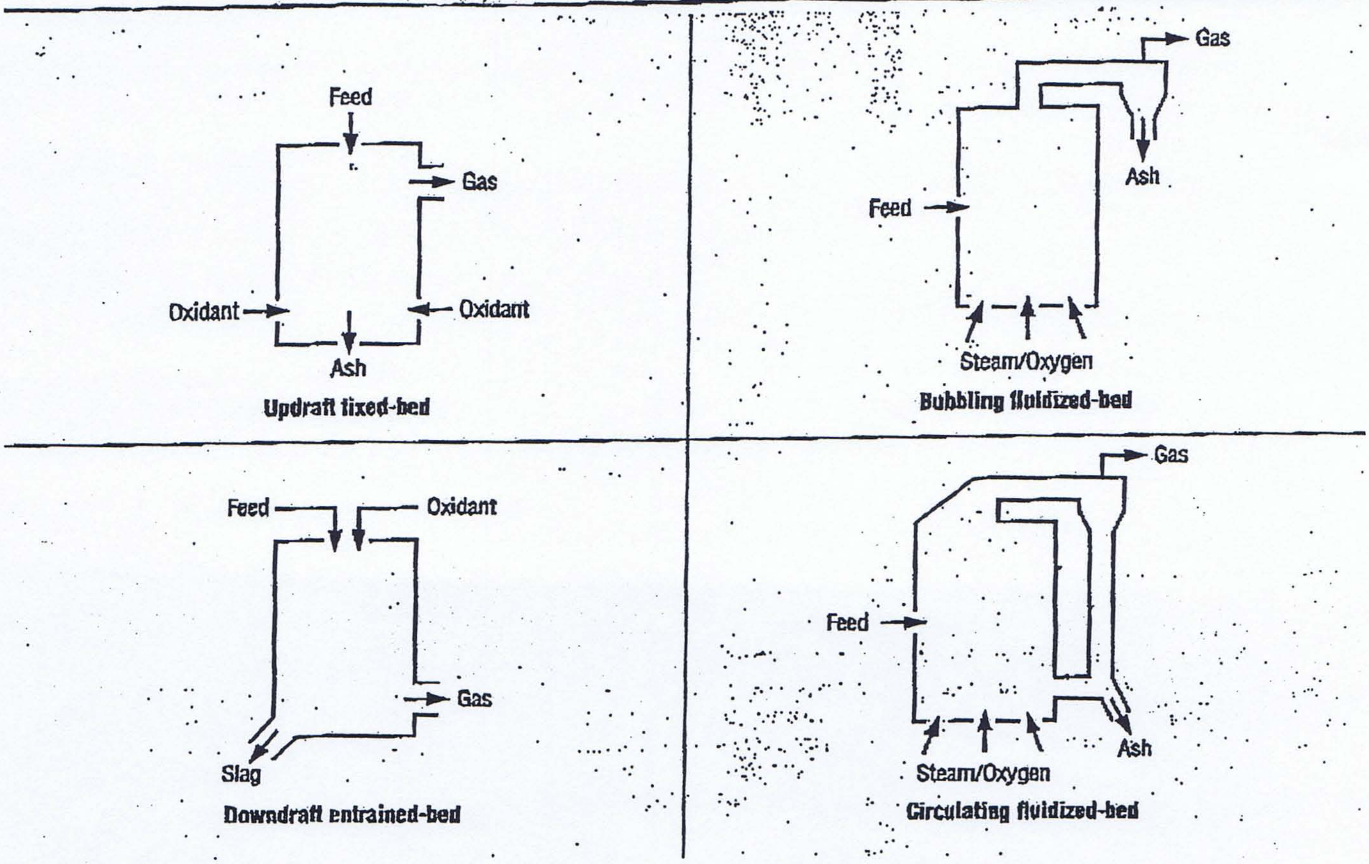


Figure 1 – Directly heated Gasifiers.

Gasification

The benefits of thermochemical conversion over combustion

by Elizabeth Staniewski, B.Sc. (Eng.), M.A.

Definitions

Gasification can be broadly defined as the thermochemical conversion of a usually solid or liquid carbon-based material into a combustible gaseous product. In comparison, "combustion" may be defined as the rapid high-temperature oxidation (burning) of a solid, liquid or gaseous material. Thermochemical conversion and combustion (sometimes called "incineration") are two *different* chemical processes. They share, however, two primary similarities. First, both processes are thermal. Second, combustion (incineration) may or may not occur during thermochemical conversion. Combustion during thermochemical conversion, however, is usually the last phase of the process, and applies to the residue char that was generated during previous stages.

Just as there are differences between chemical reactions which occur during thermochemical conversion and combustion, so also the *chemical products* that are generated are different. The main product of combustion is heat, whereas the main product of gasification is medium energy gas. This gas can be utilized directly as a fuel for power generation in gas turbines, etc. or as a feedstock for the production of chemicals otherwise produced from fossil fuels.

"The third type of directly heated reactors, fluidized-bed gasifiers, seems to be the most appropriate for biomass utilization."

Thermochemical conversion process can be divided into three basic steps:

1. feedstock preparation,
2. pyrolysis,
3. char gasification (combustion).

Feedstock preparation (also known as beneficiation) includes drying and sizing the feedstock to suit the particular gasifier. Pyrolysis can be defined as incomplete thermal degradation of the feed into char, condensable liquids (tars and oils) and non-condensable gases (carbon monoxide, carbon dioxide, water, methane and other light hydrocarbons) in the absence of air, at temperatures above about 200°C. Slow pyrolysis maximizes the production of char (as in charcoal manufacture), whereas fast pyrolysis is used to produce either liquids or gases. Flash pyrolysis (very rapid heating) combined with rapid quenching (cooling) produces high levels of liquid products (called pyrolysis oils). Longer reaction times permit these primary pyrolysis products to further decompose into non-condensable gases and secondary chars.

Effect of temperature

At temperatures in excess of 600°C, the volatile pyrolysis products undergo secondary gas-phase reactions that closely resemble the hydrocarbon cracking reactions used in the petrochemical industry for manufacturing ehtylene and propylene.

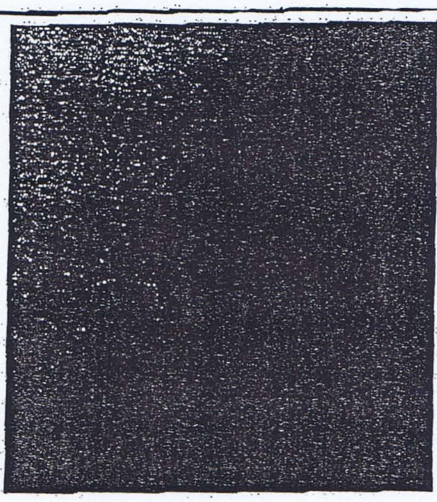
Methanation: $3H_2 + CO \longleftrightarrow CH_4 + H_2O$

Similar cracking (thermal decomposition) and reforming reactions (the opposite of methanation) involving higher hydrocarbons also occur. During this step, condensable pyrolysis products (tars and oils) and primary char decompose further (crack) into non-condensable gases, secondary char and residual tars and oils.

In the final step, the char reacts endothermically with steam (and to lesser extent with carbon dioxide) to produce mainly carbon monoxide and hydrogen. Char reactions require higher temperatures than pyrolysis, and for biomass only proceed rapidly above approximately 700°C. In most gasifiers developed to date, some of the char residue and/or biomass is burned by adding air or oxygen (which generates heat needed for the endothermic pyrolysis and char gasification reactions).

Again, comparing the two processes, combustion and thermochemical conversion, it is relatively easy to observe the differences. During oxidation, components of a material react with oxygen. In turn, during thermochemical conversion different chemical reactions occur. During pyrolysis, a chemical change occurs in the material, caused by heat in the absence of oxygen. During the next step, char, tars and oils generated during pyrolysis undergo further thermal decomposition (again in the absence of oxygen). In the final step, char reacts with steam. At this point air or oxygen may be added to burn char and provide heat for pyrolysis and gasification reactions.

The process can be accomplished in an oxygen-controlled atmosphere (termed partial oxidation), but also in a process that does not require oxygen (termed pyrolytic gasification). The gasification process is endothermal, which means that a certain amount of heat has to be provided for the process to occur. During partial oxidation, oxygen in the process (either pure or from the air) is the source of heat for the reaction. Therefore, the process is called "direct gasification". During



pyrolytic gasification (no oxygen present), a source of heat has to be provided externally, so the process is also called "indirect gasification".

"Gasification systems emit fewer gaseous pollutants than modern incinerators and produce liquid and solid wastes that are non-hazardous."

Air gasification and oxygen gasification are partial oxidation processes. The product of air gasification is a low energy gas (below 200 Btu), which results from nitrogen content in the air. Currently, this gas is only suitable as a fuel (close-coupled to gas/oil boilers) for operation of diesel or spark engines and for crop drying. Oxygen gasification used to be preferred method of gasification in methanol synthesis. The gas product of oxygen gasification is a medium energy gas (300-600 Btu) which requires a minimal cleanup. Synthesis gas (produced from oxygen gasification) can be converted into methanol, used directly for the production of steam in gas-fired boilers, or for peaking turbines in power generation. In turn, indirectly heated processes do not use oxygen as a gasifying medium but steam or hydrogen are employed However, they also generate medium energy gas.

Gasifier types and uses

Directly heated gasification systems have an operational history of dating back over one hundred years. They emerged from coal gasification technologies. The drawback of oxygen-blown gasifiers is that they require high purity oxygen. Oxygen, manufactured on-site or bought from a producer, will significantly increase gasification costs. In addition, oxygen generating plants consume a great amount of electricity.

There are three different types of directly heated gasifiers: fixed bed, entrained-bed and fluidized bed (*see Figure 1*). The fixed bed gasifier is the simplest and was the first to operate successfully on coal and municipal solid waste (MSW). Two types of fixed-bed gasifiers have been built: updraft and downdraft. In an updraft process, the feed is fed from the top and drops to the bottom, while the oxidant and the gases flow upward *counter-current* to the feed. In a downdraft reactor, oxidant and feed are fed from the top, and the gases flow *concurrent* with the feed. The solid residue from the gasifier may be either slag or dry ash. Dry ash gasifiers must keep the temperatures below ash fusion temperatures (1000 – 1300°C). Slagging gasifiers melt the residue into molten slag and require much higher peak temperatures. The feed moves continuously downward, so the fixed gasifier is also known as a "moving bed" gasifier. No fixed-bed gasifiers were ever considered for fuels production, as they produce a large amount of oils and condensable gases that would require cleanup.

Entrained-bed gasifiers are usually oxygen-blown and are characterized by very high temperatures, so that a molten slag residue is formed. The bottom combustion zone can reach 2000°C. The main aim of these gasifiers is to gasify the feed rapidly (i.e. in seconds). This is quite different from some fixed bed gasifiers which have residence times of over one hour (for coal feeds). Oxygen and steam are blown into the gasifier and entrain the feed. Due to the fast reaction times, entrained-bed gasifiers can have high throughput rates at modest reactor sizes, especially when operating at high pressures. Despite many advantages such as complete carbon conversion rates and elimination of tars and oils from the product gas, they have drawbacks that deem them unsuitable for biomass. The most important of them is a need to pulverize feedstock (100-600 microns), which requires large capital and energy inputs. Also, biomass does not require as high temperatures as entrained-bed gasifiers are made for. Recently, however, due to the potential hazards of incinerator ash, slag rather than ash has become the preferable residue from gasification and incineration systems. For this reason, this type of gasifier is often preferred.

The third type of directly heated reactors, fluidized-bed gasifiers, seems to be the most appropriate for biomass utilization. The reason is their ability to accept feeds of different sizes and densities, their low tar/oil input and good solids mixing. Crushed feedstock is fed through the side of the vessel and is mixed and suspended by oxygen or air blown from the bottom. Sand or other inert materials can be used in the bed to carry heat. Typical operating temperatures for fluidized-bed gasifiers are 900-1000°C. (Though these gasifiers look promising for biomass feeds, all the experimental work to date for directly-heated, fluidized-bed biomass wastes gasification use air as the oxidant to produce a low energy gas, which is not suitable for gas turbines or methanol synthesis.)

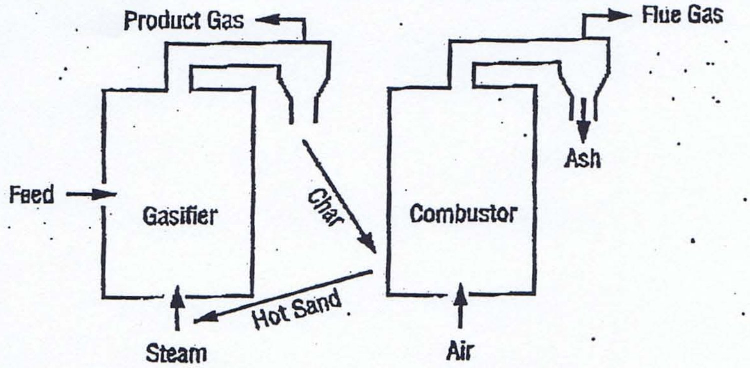
New indirect heat systems for biomass

Indirectly heated gasifiers are heated externally in various ways (*see Figure* 2). The higher reactivity of biomass and biomass wastes compared to coal allows for these new gasification systems to operate at lower temperatures. They are potentially cost effective and efficient, but are in the early stages of commercial development. They usually operate at temperatures 600 – 900°C. Reactor temperatures are lower than ash fusion points, so that clinkering is prevented. The product gas that is formed during the process is usually of medium energy value, avoiding expensive oxygen. These indirectly heated processes have only recently been developed since they are not based on coal gasifier designs; no commercial plants are in operation. Most designs are still in the pilot and demonstration stage.

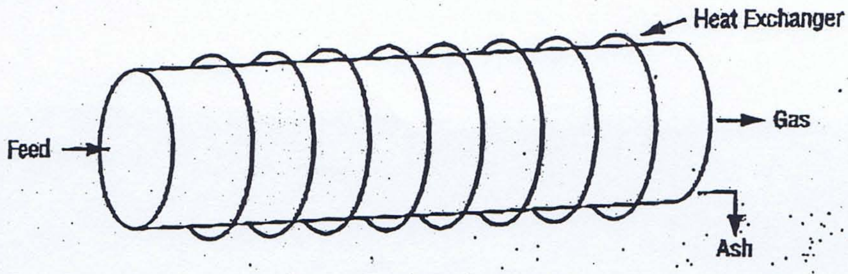
> ***"Several plants based on this design have been built to gasify residues from paper processing operations (mainly black liquor) in India and in North Carolina."***

Two types of indirectly heated gasifiers have been developed in the United States that represent advanced gasification systems able to produce medium energy gas without oxygen. The first one is an atmospheric pressure system that consists of two separate reactors. One reactor is a circulating fluidized-bed gasifier that converts the feed into product gas. The other reactor is an air-blown fluidized bed combustor that burns the residual char to provide the heat necessary to gasify the feed. Sand is circulated between the two reactors to transfer the heat. Steam is injected into the gasification chamber to act as a fluidizing agent. The process is called a fast fluidized process because it has much higher throughputs than typical fluidized-bed gasifiers. Residence times are in the order of one second and operating temperatures are about 800°C. (A 200 tonne/day biomass gasifier/gas turbine is being set up in Vermont.)

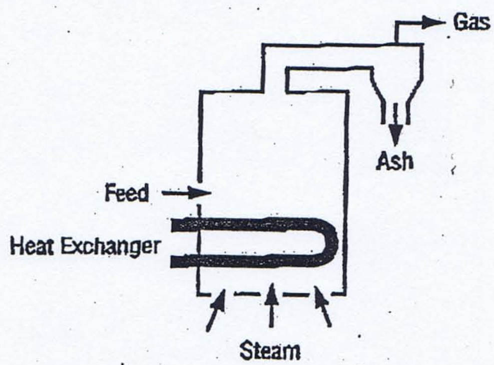
The second design uses a fluidized-bed gasifier with in-bed heat exchanger tubes. A fraction of the product gas is burned with air in a pulse combustor, and the hot combustion products travel through the resonance tubes to provide heat for gasifying the feed. A large amount of steam is injected into the gasifier as the fluidizing medium. The gasifier temperature is quite low (650-800°C). The resident times are much longer than for the first gasification system (in the order of minutes) and the solids are recir-



Fluidized bed gasifier with circulating heating medium (sand)



Rotary kiln with external heat exchangers



Fluidized bed with in-bed heat exchangers

Figure 2 – Schematics of heating methods for indirectly heated gasifiers.

culated to the bed. Several plants based on this design have been built to gasify residues from paper processing operations (mainly black liquor) in India and in North Carolina. Also, another plant has been set up in India that is going to begin commercial operation utilizing sugar mill distillery residues.

Emissions compared to combustion

Emission measurements of gasification systems show that they emit fewer gaseous pollutants than modern incinerators and produce liquid and solid wastes that are nonhazardous. Dioxin and furan emissions are almost nonexistent. Due to lower volumes of gas than combustion, equipment costs for gas cleanup are reduced.

Gasification processes have begun to gain attention throughout the world. Their uses include:

1. production of hydrogen and methanol from carbon-containing materials such as municipal solid wastes, agricultural wastes, forest residues, etc. for use in high-tech fuel cell,
2. gaseous fuel generation, which can be utilized instead of natural gas,
3. power generation (gas turbines, combined cycle).

Currently, methanol and hydrogen are manufactured from natural gas, hydrogen also from water with energy (as in the Canadian Stuart Cell). As emissions-free fuel cell vehicles may replace internal combustion engine vehicles in the near future, the use of gasification to convert waste materials into fuel for fuel cells could literally solve two environmental problems at the same time. ◆

Elizabeth Staniewski, B.Sc. (Eng.), M.A.
Enerquest, Consultant in Kitchener, ON.

Appendix E
Technical Report on Iron Reduction Process

Steelmaking
SPECIAL ISSUE: August 10, 1999

The best hopes for hot metal in steel market recovery

By JOSEPH A. ROONEY
Rooney Associates Inc.

Initially mini-mills were small mills with electric arc furnaces (EAF) created to service local areas with carbon steel merchant products. They were highly competitive because of low investment costs, low man-hours per ton of product, low scrap prices, flexibility in operations and favorable power rates. They multiplied almost rampantly.

The EAF proliferated with changes to increase productivity, reduce operating costs, reduce energy consumption, improve quality, reduce maintenance cost, improve environmental conditions and improve safety. These improvements should continue, but perhaps at slower rates.

The fast growth of EAF shops has exacerbated problems with the scrap supply causing the introduction of alternative metallics along with some integration.

Metallic management has become critical. Metallic consumption represents about 30 percent of the cost of making steel. The scrap that at one time made up 100 percent of the EAF charge now only 83 percent of an average charge, supplemented with alternative metallics such as DRI, HBI, pig iron and iron carbide, and with hot metal overseas.

Global steel demand seems to be recovering, and some are forecasting that the recovery will continue into strong growth. If demand increases, owners will look to increase steelmaking capacity, and they will want to investigate processes that provide hot metal.

Three processes offer the most hopeful prospects to produce hot metal on a justifiable basis. They are a Rotary Hearth Based Smelter Process (RHF/SAF), Corex(r) Technology (Corex) and a blast furnace (BF). The RHF/SAF is an acronym for a process that takes an iron ore (or iron waste) and a coal feed, agglomerates them, reduces them in a rotary hearth furnace (RHF) and finally delivers DRI to a Submerged Arc Furnace (SAF) that produces molten iron.

The RHF process is grounded upon the coal-based rotary hearth investigations by Beggs in the late 1950s and early 1960s. Surface Combustion had a pilot plant process called Heat Fast in the mid-1960s. When the process was transferred to Midrex, Midrex decided to concentrate on gas-based processes.

Commercial RHF/SAF was developed by Inmetco in 1978. Its RHF has been used to reduce iron ores, iron oxide wastes and chromium oxides. Inmetco has successfully produced DRI at 92 percent iron metallization while varying the carbon. Inmetco has been smelting stainless wastes produced as a direct reduced product in an SAF to ingots or pigs.

The RHF/SAF can be visualized as a string of proven sub-processes that do not raise as many process technology as material handling questions. Technically there is a question of the validity of the relation of RHF scale up to productivity. On a continuous basis, raw materials are fed to agglomerators and then to an RHF, which discharges continuously. Next the SAF is basically a batch process, as is the following EAF. The batch sizes between the two vary. Finally a continuous caster drives the whole preceding process. This mixing of batch and continuous processes raises material handling questions that need to be studied for a successful operation.

Steel Dynamics Inc. (SDI) wanted to protect itself from scrap price volatility, to develop a hedge against an uncertain supply of premium quality scrap, and to gain market share in the high-quality, flat-rolled market. After examining several technologies, SDI selected RHF/SAF. Iron Dynamics Inc. (IDI) was formed as a subsidiary of SDI to develop that technology.

For the installation, IDI acted as a general contractor and sub-contracted major portions of the work. Mitsubishi designed the RHF. Mannesmann Demag designed the SAF. The fume collector for the SAF was provided by VAI.

The RHF was commissioned in November 1998. The SAF was commissioned on March 24 and operated until May 1, 1999, when it experienced a breakout and was taken out of service. Since there was no way to feed hot DRI, the RHF was also shut down. The breakout was caused by a rapid erosion of the refractory by the slag. The SAF offgas system was not removing gases as they were generated and so it was decided to upgrade during the shut down. The facility was scheduled to come back on line by the end of July. During the period of full operations, satisfactory results were reported apparently with energy savings, reduced tap to tap time, reduced electrode consumption and reduced residual levels.

There are three suppliers who seem to be closest to building a next-generation commercial scale RHF/SAF installation. They are Iron Dynamics Process International (IDPI), Midrex and Mannesmann Demag. The Process Description is from IDPI but is typical for all suppliers. Variations are in the details. The suppliers provide various costs, but it should be kept in mind that these costs are site specific and few decisions should be made based on them until a legitimate study has been made for a real application. Estimated production costs suggest that product could be competitive with a number of U.S. blast furnaces. Investment costs show too wide a range to comment meaningfully other than to say that site specifics need to be developed. However, the range of capital costs compare favorably to an alternative of a conventional blast furnace. Also the high end of the range is close to Corex.

IDPI is a licensee of IDI and offers the operating technology of the process based on the actual operation at IDI. IDPI was founded by Sumitomo and will have participation by IDI and Mitsubishi. IDI estimates that the capital cost per tonne of capacity is $165 for the first plant, but expects it to be $135 for the second plant. Cash operational costs are estimated to be $130 to $135 per tonne. Additional modules are planned for

SDI, the next one at the new structural mill.

Midrex, Kobelco, National Recovery Systems and EMCI have joined together in a consortium to commercialize RHF/SAF utilizing their process called Fastmelt. Midrex and Kobe Steel built a commercial demonstration scale RHF at Kobe's Kakogawa Works in 1995. In 1998 Midrex commissioned an electric furnace for testing Fastmelt. They are now looking to develop Fastmelt on a full commercial scale. They estimate the cash operational cost to be in the range of $85 to $125 per tonne. The cost of construction is estimated to be about $285 per annual tonne based on a 450,000-tonne plant. They have had inquiries from North American integrated producers and believe that there is serious interest in their process.

REDSMELT is a technology by Mannesmann Demag including features of the Inmetco technology. The company estimates that the cash cost of production for Redsmelt will be between $90 and $130 per tonne. The investment cost is estimated at between $200 and $240 per annual tonne based on a plant size in the range of 300,000 to 1,000,000 tonnes. The company is currently working with Cleveland Cliffs to develop the first large-scale industrial project using Redsmelt at Northshore Mining producing pig iron. Orders for that facility are anticipated within a year.

The RHF portion of the RHF/SAF is receiving attention in applications where one of the major products is DRI. A DRI production unit was installed at Nakornthai Strip Mill by Mannesmann Demag but ran into serious financial problems during start-up and was never completed. AllMet is starting up a waste recovery system for EAF dust at Nucor Corp. Maumee Research & Engineering has installed a waste stream recovery system at Ameristeel and Rouge. Both Midrex and Mannesmann Demag are pursuing waste recycling with variations of their RHF/SAF.

COREX(r), by VAI, is a technology with several successful applications. The Flow Sheet is quite different from the RHF/SAF. Corex uses iron ore pellets, lump ore or a mixture thereof to produce hot metal using non-coking coal. Its first commercial plant was built in 1989 in ISCOR and was a C-1000 Model rated at 440,000 short tons per annum. Since then, it has built nine C-2000 Model units with the most recent starting operations this year at Saldanha.

It is currently developing its C-3000 Model, which will be rated at 1,220,000 short tons per year. It estimates that the capital cost of C-2000 is about $235 per short ton using Chicago-based numbers, not including equipment, to utilize the export gas. The company estimates the cash cost of operating at $105 per short ton, with a credit that assumes that it can sell the gas at $2/MMBTU with an export of 150 MW.

A BF represents the most efficient and cost-effective way of producing iron using lumpy iron carriers and coke and is the most proven technology. The problem has been the capital cost associated with the mega-sized furnaces as well as the normal ancillary equipment such as coke batteries. It has been suggested that a BF in the range of 1 to 2 million tons with purchased coke, fuel injection and pellet feed would provide a competitive source of hot metal. While there apparently are no active projects, it is believed that the cash cost of operating can be $130 per tonne, and that the capital cost could be $200 per tonne.

Meanwhile other processes are being developed to produce molten iron, but are not yet commercial and include Finex, AISI, Dios, CCF, Hismelt, Romelt, Tecnored, Ausmelt and Ifcon.

Joseph A. Rooney is president of Rooney Associates Inc., Exton, Pa.

Appendix F
Coalbed Methane Potential of the Bonnet Plume Basin

COALBED METHANE POTENTIAL OF THE BONNET PLUME BASIN YUKON TERRITORY

Barry Ryan Ph.D. P. Geo

Introduction

The Bonnet Plume Basin is a physiographic and structural depression, located near the eastern margin of the Frontal Belt of the Cordilleran Orogen, in northern Yukon (Figure 1, from Hannigan, 2001). The basin formed in the Late Cretaceous and is filled with late Cretaceous (Albian) and Early Tertiary (Paleocene) sediments of the Bonnet Plume Formation. A major unconformity separates the non-marine Bonnet Plume Formation from underlying Paleozoic rocks (Figure 2, from Hannigan, 2001). The area is bordered by the Richardson Mountains on the east, the Knorr Ranges on the west and the Wernecke Mountains to the south.

The Bonnet Plume Basin is about 240 kilometres northeast of Dawson City. Access to the area is by air or by a 165 kilometres winter road from Elsa, which provides access to the south-western corner of the basin.

The basin is an area of low relief, generally less than 200 metres, with elevations that range from 300 to 600 metres. The terrain is swampy and covered by stunted timber. The basin is traversed by two north flowing rivers, the Bonnet Plume to the east and the Wind River to the west, both of which flow into the Peel River to the north. The Wind River has three major tributaries, which are from south to north, the Little Wind River, Illtyd Creek and Hungary Creek (Figure 3). Most coal outcrops are found along the Wind River and its tributaries; there is little outcrop in the rest of the basin.

The basin covers about 3000 square kilometres (Cameron and Beaton, 2000). The present extent of the basin is defined by the north-trending Knorr Fault to the east and the Deslauriers Fault on the west. Between these faults a number of other north trending faults disrupt the basin. The southern end of the basin is marked by a number of east-west trending north-directed thrusts; the main one being the Wernecke Fault (Figure 4). Norris and Hopkins, (1977) estimate the extent of the basin to be 1800 square kilometres, based on their mapping.

Folds within the basin trend southeast to east and are cut-off by the major north-south trending faults that define the edges of the basin.

Regional Geology

Coal was first reported in the area by the explorer De Sainville in 1893 (referenced in Norris and Hopkins) and the first detailed geological map of the area was made by Stelck (1944) who coined the name Bonnet Plume Basin. Since then the area has been mapped by Norris *et. al.* (1963) and Norris (1975). The geology and coal potential were described by Mountjoy (1967), Norris and Hopkins, (1977) and Long (1983, 1986).

The Bonnet Plume Formation was defined by Mountjoy (1967), who estimated it to be over 1500 metres thick. He measured two sections one over 1500 metres and the other over 1200 metres. However Norris and Hopkins (1977) considered these measurements to represent apparent thicknesses and the true thickness to be considerably less. Norris and Hopkins (1977) describe the formation as deposited in a non-marine alluvial and fluvial environment. They do not provide a thickness but appear to assume it to be about 500-1000 metres thick, based on a section in their paper.

Long (1978) divided the Bonnet Plume Formation into upper and lower members. The lower member is estimated to be over 1000 metres thick (McKinney, 1978) and outcrops mainly in the southern part of the basin. Long (1983) assigned a total thickness of 1960 metres to the formation. This is broken down into 804 metres Maastrictia (lower member), 770 metres Cenomanian to Campanian (lower member) for a total thickness of 1574 metres for the lower member. The lower member is dated by palynology as mid to late Albian (Rouse and Srivastava, 1972) and there therefore appears to be a 35 million year hiatus between the lower and upper member, which is Late Cretaceous to Eocene. Sweet (1979) indicates that the hiatus may be somewhat less than 35 million years. The lower member contains conglomerates, sandstones, siltstones, shales and bituminous-rank coal seams that occur in a number of repeating cycles.

The upper member, which is Late Cretaceous to Eocene (Paleocene, Long, 1978) contains sandstones, shales and lignite. Long (1983) indicates that the upper member accounts for 386 metres of the 1960 metres he assigned to the formation.

Coal Geology

Coal was first described in detail in the area by MacKay (1947) who records seeing lignite along the Peel River and estimates a resource of 1.7 billion tonnes. Lignite was also reported by Mountjoy (1967) and Norris and Hopkins, (1977) who estimated the lignite resource to be 1.4 billion tonnes. This estimate is for the upper member over an area of 90 square kilometres in the northern part of the basin and assumes a cumulative thickness of 12 metres of lignite. The Arial extent of the upper member is much larger than 90 square kilometres.

In 1977 Pan Ocean Oil discovered coal in the lower member of the Bonnet Plume Formation and acquired 24 coal exploration licenses covering an area of 387308 hectares. The company no longer exists and the licenses have changed ownership. However in order to reference the geology discussed in the Pan Ocean Oil reports the licenses with the company numbers are overlain on simplified geology of Norris and Hopkins (1977) (Figure 5). The company conducted a number of exploration programs in the period 1978 to 1980. During that period the company drilled 53 holes for a cumulative length of 10700 metres and mapped the area. A total of seven areas with surface mineable potential were identified that together contain an in-place reserve of 121 million tonnes and a resource in excess of 650 million tonnes (Cullingham *et. al.,* 1981).

There have been a number of more recent estimates of the total amount of coal in the basin. Long (1986) estimates that the lower Cretaceous lower member could contain a coal resource of 1.4 billion tonnes. Cameron (1993) assigns an estimated resource of 200 million tonnes to the whole basin. Cameron and Beaton (2000) describe the basin as having an inferred coal resource of 2.8 billion tonnes. There is obviously a confusion of numbers because of a lack of data. Some authors are estimating resources for the formation and others for one or other of the two members. Also some quoted tonnages include estimates of inferred resources and others do not.

It is useful to consider the coal resource of the basin as three components for the purpose of estimating the CBM resource:

- The ill defined lignite resource in the upper Bonnet Plume Member
- The coal resource in the lower Bonnet Plume Member under part or all of the 1800 square kilometres of subcrop of the upper Bonnet Plume member (Norris and Hopkins, 1977). There are no data on the lower member in the area where it is overlain by the upper member, yet the resource, which would probably be within 1500 metres of surface, could be enormous.
- The better-defined high-volatile B bituminous resources in the lower Bonnet Plume Member where it outcrops in the southern part of the basin.

Norris and Hopkins, (1977) estimate the lignite resource in the upper Bonnet Plume member in the northern part of the basin to be 1.4 billion tonnes based on assuming a cumulative lignite thickness of 12 metres, derived from seams greater than 1.5 metres thick extending over an area of 90 square kilometres (Figure 2 in Norris and Hopkins, 1977). Lignite seams 4-11 metres thick were mapped in the upper member by Long (1978) who also reported seeing coal seams 4.5 to 9 metres thick in the lower member in a small creek between Illtyd Creek and Wind River. The area of the upper member, using the map of Norris and Hopkins, was calculated to be 1832 square kilometres which is in agreement with their quoted value of 1800 square kilometres. If lignite extends into the southern part of this area, then the 1.4 billion tonnes resource estimate could increase substantially. In fact the tonnage could range from the conservative estimate of 1.4 billion tonnes to 28 billion tonnes (1800/90*1.4).

Outcrops of the lower member cover about 630 square kilometres in the southern part of the basin based on Figure 2 in Norris and Hopkins, (1977). Pan Ocean Oil (McKinney, 1978 and 1979, Cullingham *et. al.,* 1981) explored extensively in the southern Bonnet Plume Basin in areas underlain by the lower member and divided the member into three informal units. The lowest unit contains thin coal seams and is about 200 metres thick. The middle unit contains 5 coal zones, that were the focus of Pan Ocean Oil exploration. These coal zones cover the lower 130 metres of the middle unit, which is 220 metres thick. The upper unit, which is at least 300 metres thick, contains rhythmic cycles of coarse to fine sediments capped with carbonaceous shale and occasionally poorly developed coal seams.

It is critically important to determine the thickness of sediments above the 5 coal zones in the middle unit of the lower member because this thickness will determine whether there is any reasonable chance of recovering CBM from most of the basin. This thickness is composed of the upper member , the upper unit of the lower member and 90 metres of the upper part of the middle unit in the lower member. The generalized stratigraphic section (Cullingham, *et al.,* 1981) indicates that the lower member is at least 720 metres thick. Long (1983) estimates the lower member to be at least 1574 metres thick. It is possible that the thickness of the formation is less than 1960 metres and that the thickness of the lower member is greater than 720 metres. Norris and Hopkins (1977) estimated the formation to be less than 1200 metres so it is possible that the lower member is about 800 metres. If this is the case it would be necessary to drill through about 400 metres of the upper member and 600 metres of the lower member to be ensured of testing the 5 coal zones. This means that the coal in the lower member could be accessed by holes less than about 1000 metres deep, which is within prospective depth for CBM and therefore most of the 1800 square kilometres of the Bonnet Plume Basin may be prospective for CBM.

Cullingham, *et al.* (1981) describe the 5 coal zones in 630 square kilometres of the southern part of the basin which were explored by Pan Ocean Oil and they provide average coal quality and thickness data.

The uppermost number 1 coal zone occurs through out the southern end of the basin and contains from 2 to 8 metres of coal. The zone is generally capped by a thick conglomerate sometimes separated from the coal by a shale bed. The average raw ash of the zone is 36.5%.

The Number 2 coal zone is 10 to 40 metres below the number 1 zone and varies in thickness from 2 to a maximum of 10 metres of coal. The roof is usually composed of coarse sediments and the floor is mudstone. The average raw ash of the zone is 24%.

The number 3 coal zone is not well developed and is not recognized in all drill holes. Where developed, it is

10 to 50 metres below the number 2 coal zone. It is often present as two seams with cumulative thickness of about 5 metres. It is less than 3 metres thick when present as a single seam.

The presence of a number 4 coal zone is uncertain and where recognized it has a maximum thickness of 5.45 metres of coal.

The number 5 coal zone is well developed in most areas and ranges in thickness from 2.3 to a maximum of 9 metres of coal. The roof varies from siltstone to conglomerate and the floor is siltstone or sandstone.

The coal quality data presented in Cullingham, *et al.* (1981) are summarized in Table 1 by area and by coal zone (seam). Cumulative coal and the raw and clean coal quality in each zone are presented. Clean coal refers to samples ¼ inch to 28 mesh size floated at 1.9 SG. These samples provide data for estimating rank using volatile matter calculated on a dry ash free basis starting with low ash samples.

CBM Methodology

Cullingham *et. al.* (1981) divide the subcrop of the lower member in the southern part of the Bonnet Plume Basin into seven surface mineable areas, based on minimal outcrop and drill hole data. These areas were enlarged to cover areas where the coal probably occurs at depth and then the coal and CBM resource potential of each area estimated. Cullingham *et. al.* (1981) list average cumulative coal thicknesses for the 5 zones in each of the seven surface mineable areas (Table 1) as well as average coal quality. An empirical equation was developed by the author to estimate mean-maximum vitrinite reflectances (Rmax%) from calculations of volatile matter on a dry ash free basis (VM daf) using clean coal quality and percentage of reactive macerals on a mineral matter free basis. Once Rmax values are established, it is possible to estimate potential CBM content in the coals using the Ryan Equation (Ryan, 1992). When values of VM daf are calculated from samples of varying ash composition and plotted against the ash %, the data do not plot on a horizontal line because of contributions of volatile matter from the ash to the VM daf value. This means that the data have to be projected to a zero ash content to provide the real VM daf value that is used to predict rank.

Ranks of coal in the five zones in each of the seven areas (Table 1) are calculated using VM daf data calculated from the average clean coal quality of the seven mining areas and an assumed reactives content of the coal. The data indicate that the rank of the seams increases with depth but does not appear to vary from area to area. Cullingham *et. al.* (1981) indicate that the average rank of the coal is high-volatile C bituminous. Assuming 100% reactives on an ash free basis the rank for the 5 seams ranges from 0.66% to 0.8% Rmax or if a 90% reactives content is assumed rank varies from 0.59% to 0.72%. The first range covers high-volatile B bituminous and the second high-volatile C bituminous. Late Cretaceous coals are typically rich in vitrinite so there is some indication that the rank might be a little higher than that assumed by Cullingham *et. al.* (1981). For the purposes of this study a 95% reactives content is assumed which provides ranks of seam 1 =0.64% seam 2=0.66% seam 3=0.68%, seam 4=0.70% and seam 5=0.77% (Table 2). These ranks are in the range of high volatile bituminous B and they were then used to predict potential gas contents at varying depths for each seam (Table 3, Figure 6)

The seven surface mineable areas identified by Cullingham *et. al.* (1981) were combined to make four CBM resource areas (Figures 8 and 9). Figures 8 and 9 are located with reference to the regional map (Figure 5) by license numbers, which occur on all Figures. Resource areas are delineated by inward pointing arrows. On Figure 8 the Wernecke+Airstrip area is defined by the 5 zone. The Illtyd west and Spaceship area to the north is also delineated by the 5 zone. It is arbitrarily separated from the Garlic Ring area to the north by an east-west line. The Garlic Ring area is divided into a west portion containing only zones 3, 4 and 5 and an east portion containing zones 1 and 2. On Figure 9 the Wind River area is delineated by the 5 zone. The names of the areas are taken from the report by Cullingham *et. al.* (1981)., The area underlain by each seam was calculated within each resource area. This area multiplied by an average seam thickness to provide an estimate of the tonnage available for the CBM resource calculation. Obviously any folding would increase the surface area of the seam and the estimate of tonnage. In the absence of detailed subsurface geology it was not possible to construct sections illustrating the depth distribution of the tonnages attributed to each seam. Instead an estimate was made of the deepest occurrence of the seam and the tonnage distributed equally in 50 metre depth slices. Gas contents were assigned to each depth slice based on rank, with the exception of the top 25 metre slice that was assigned a zero gas content. The CBM resource of each area was then derived by summing the CBM resources of each slice for all the seams present. The process was made easier with the help of an interactive excel spread sheet that permitted a good deal of trial and error.

A rigorous attempt interpret the geology in each area was not undertaken. In the absence of any CBM data, it was felt that the time involved would not add much to the accuracy of the interpretation. When CBM data are available it should be possible to construct a better interpretation of the geology and a better estimate of the CBM resource.

Coal and Coalbed Methane Potential

The potential CBM resource of the four areas of the lower Bonnet Plume member is 0.43 tcf (Table 4). Tonnages are distributed over depths ranging from surface to 475 metres for the 5 zone and shallower depths for the overlying zones. The resources in the four combined areas are documented in Tables 5 to 8. The CBM resource for combined Wernecke and Airstrip area (Table 5) is 125.8 bcf. The CBM resource for Illtyd west, Illtyd and spaceship areas 40.7 (Table 6). The CBM resource for Garlic Ring area and area north of west Illtyd is 52.5 bcf (Table 7). The CBM resource for Wind River and area to east is 215.4 bcf (Table 8). Based on the tonnage estimate the average gas content is a bit over 100 scf/t, which is probably conservative but takes into account the average raw ash and insitu moisture of the coal. It may be possible to obtain better estimates of the depth distribution of the coal in each area and if depths are increased the CBM resource estimate will also increase.

There is potentially an enormous resource of lignite in the Bonnet Plume upper member. Norris and Hopkins, (1977) estimate a 12 metres thickness of lignite over 90 square kilometres based on the work of Mountjoy (1967) and calculate a lignite resource of 1.4 billion tonnes. The area of the upper member is 1832 square kilometres so that the potential could increase to 28 billion tonnes if the 12 metres cumulative thickness of lignite extends over the whole area. This is a large resource but there may not be enough gas per well spacing to make extraction economic. Adsorbed gas contents in Powder River Basin coals are in the range 25 to 45 scf/t. Production data indicates that there is also a lot of free gas present, which may increase the gas content per tonne of coal to over 100 scf. If an adsorbed plus free gas content of 50 scf/t is assumed for the Bonnet Plume lignite, then a billion tonnes provides a resource of about 0.05 tcf and 10 billion tonnes 0.5 tcf. There is no logic for assuming 10 billion tonnes of lignite other than it increases the 90 square kilometers resource area used by Norris and Hopkins, (1977) to about 1/3 of the area of upper Bonnet Plume member.

The largest CBM resource may exist in the lower Bonnet Plume member where it is overlain by the upper member. This area is up to 1832 square kilometres. It may be considerably less if the upper member overlaps the pre Tertiary basement, which is possible because there is a major hiatus between the upper and lower members. If it is assumed that 1000 square kilometres of the upper member is underlain by the lower member then this is 5 times the area of lower Bonnet Plume member that accounted for a CBM resource of 0.43 tcf. (201 square kilometres, Table 4). Obviously where ever the lower member is overlain by the upper member all the 5 coal zones may be present. A possible stratigraphic section (Figure 7) indicates that one might have to drill from 880 metres to 1010 metres to intersect all five coal zones. If this is the case, then gas contents should be assigned to each zone based on these depths (Table 9). This would indicate a possible resource of 7.6 tcf.

The total estimated potential CBM resource of the basin is 0.43 tcf lower member subcrop, 0.5 tcf upper member and 7.6 tcf lower member where it underlies the under upper member. The total resource is therefore approximately 8.6 tcf. This value is obtained by making some completely unsupported assumptions about the distribution of lignite in the upper member and the extent of coal in the lower member where it is overlain by the upper member. Depending on more conservative or more optimistic assumptions the resource estimate can range from 1 tcf to15.5 tcf. All these estimates are of potential resource. There has been no discussion of feasibility of economic recovery and consequently they are not reserve estimates.

One of the most important parameters for reserve assessment is the concentration of the resource, in this case measured as bcf/section (Table 4) spacing where a section is 1 square mile or 640 acres. CBM drill spacings range from 320 acres per site to 40 acres per site. Closer spacing is required in coals with low permeability but obviously as the drill spacing decreases there is less reserve to pay for drilling the hole. For the areas of the lower member subcrop the resource per drill site (160 acre spacing) ranges from 0.8 to 1.7 bcf/160 acres. Gas prices at the moment range from 3 to 3.5 $US per million BTU. This represents an in-ground value of 7.8 to 9.2 million dollars Canadian based on a 65 cent dollar and it appears that a resource of better than 1 bcf/160 acre or 4 bcf/section has a chance of being economic. In areas where lignite in the upper member overlies areas of the lower member, there is a potential for about 5.5 bcf/160 acre spacing. The high potential value of each 160 acre unit is offset by the fact that one is assuming that CBM can be recovered from all the seams. Also holes will have to be drilled to depths in the range of 1000 metres.

Summary

The Bonnet Plume basin covers over 3000 square kilometres of which 1800 square kilometres is overlain by subcrop of the upper Bonnet Plume member and an additional 600 square kilometres by subcrop of the lower member. There has been a moderate amount of exploration in the 600 square kilometres of the subcrop of the lower member and 200 square kilometres of this area is probably underlain by coal zones. There has been very little exploration aimed at outlining the potential lignite resource in the upper member and there has been no exploration for coal in the lower member, where it is overlain by the upper member.

There are no CBM desorption data for the Bonnet Plume Basin. All the values discussed in this paper are derived by estimating rank and then using estimated rank values to estimate saturated gas capacity for the coal considering also moisture and ash contents. The Ryan equation used to make gas content estimates was derived by curve fitting to a published database of desorption results (Ryan, 1992). Experience has shown that there is considerable variation in desorption results from coals of similar ranks and sampled at similar depths.

Keeping in mind the limitations discussed above, there appears to be a potential CBM resource in the range of 8.6 tcf in the basin. There is sufficient coal in the section to make possible reasonable resource concentrations expressed as bcf/drill spacing. The potential resource is large but the basin is very isolated and no attempt is made here to discuss development strategies or the cost of infrastructure. Until there is a plausible plan for getting the CBM to market the potential CBM in the Bonnet Plume basin remains a potential resource.

Initial exploration should concentrate on areas which are accessible, and where a drill hole has a good chance of intersecting the maximum amount of coal at a prospective depth. Based on drill hole coal intersection data in the report by Cullingham *et. al.* (1981) (Table 10) hole SC 80-25 in the West Illtyd, Illtyd and Spaceship resource area offers the best compromise.

References

Cameron, A.R. (1993): Sedimentary cover of the Craton in Canada; D.F. Stott and J. Aitkin editors, Geological Survey of Canada, Sub Chapter 6B Coal.

Cameron, A.R. and Beaton, (200): Coal resources of Northern Canada with emphasis on Whitehorse Trough, Bonnet Plume and Brackett Basin; International Journal of Coal Geology, Volume 43, pages 187-210.

Cullingham, O.R., Germscheid, G., Garrison, D., Hargrtave, A. McKinney, J.S. and Hope, D.C. (1981): Coal Exploration on licenses 129, 132 to 154; Pan Ocean Oil; Yukon Territory Assessment Report Number 062055.

Hannigan, P.K. (2001): Petroleum Resource Assessment of the Bonnet Plume Basin, Yukon Territory, Canada, Yukon economic Development.

Long, D.G.F. (1978): Lignite deposits of the Bonnet Plume Formation, Yukon Territory; Current Research, Part A Geological Survey of Canada Paper 1978-1A.

Long, D.G.F. (1986): Coal in the Yukon; *in* Morin J.A. (Ed) Mineral Deposits of Northern Cordillera, Special Volume 37, Canadian Institute of Mining and Metallurgy, pages 311-318.

McKay, B.R. (1947):Coal reserves of Canada; Report of the Royal Commission on Coal, 1946.

McKinney J.S.(1978): Report on exploration Bonnet Plume Basin; Assessment report Yukon by Pan Ocean Oil.

Mountjoy, E.W. (1967):Upper Cretaceous and Tertiary stratigraphy, northern Yukon territory and northwestern district of MacKenzie; Geological Survey of Canada Paper 66-16.

Norris, D.J., Price, R.A. and Mountjoy, E.W. (1963): Geology northern Yukon Territory and northwestern District of Mackenzie; Geological Survey of Canada, Map 10-1963.

Norris, D.K. (1975): Geological Maps of parts of Yukon and Northwest Territories; Geological Survey of Canada, Open File 279.

Norris, D.K. and Hopkins, W.S. (1977): The geology of the Bonnet Plume Basin, Yukon Territory; Geological Survey of Canada, Paper 76-8.

Rouse, G.E. and Srivastava, S.K. (1972): Palynology zonation of Cretaceous and Early Tertiary rocks of the Bonnet Plume Formation, northeastern Yukon, Canada; Canadian Journal of Earth Sciences, volume 9, pages 1163-1179.

Ryan, B.D. (1992): An Equation for Estimation of Maximum Coalbed-Methane Resource Potential; Geological Fieldwork 1991 Paper 1992-1, pages 393-396, B.C. Ministry of Energy, Mines and Petroleum Resources.

Stelck, C.R. (1944): Final geological report on "the Upper Peel River Area" Yukon Territory (Canada); Imperial Oil Limited, Canol Project assignment, Number 23.

Sweet, A.R. (1979): Palynological report on samples from the Bonnet Plume Basin Yukon Territory; Geological Survey of Canada Interim report 1-AS-1979.

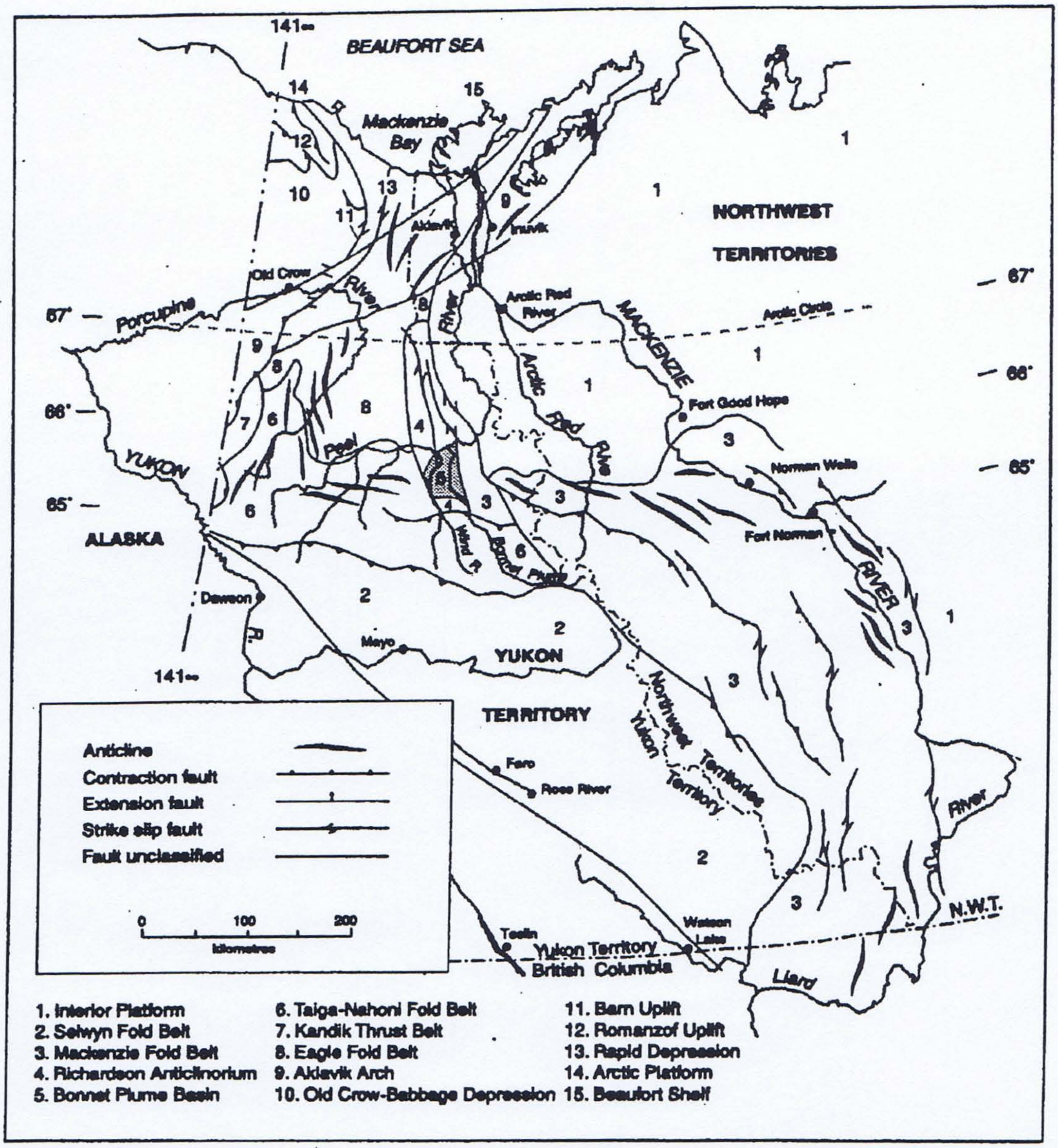


Figure 1: Location of the Bonnet Plume Basin with reference to the tectonic units of northern Canada after Hannagan (2001).

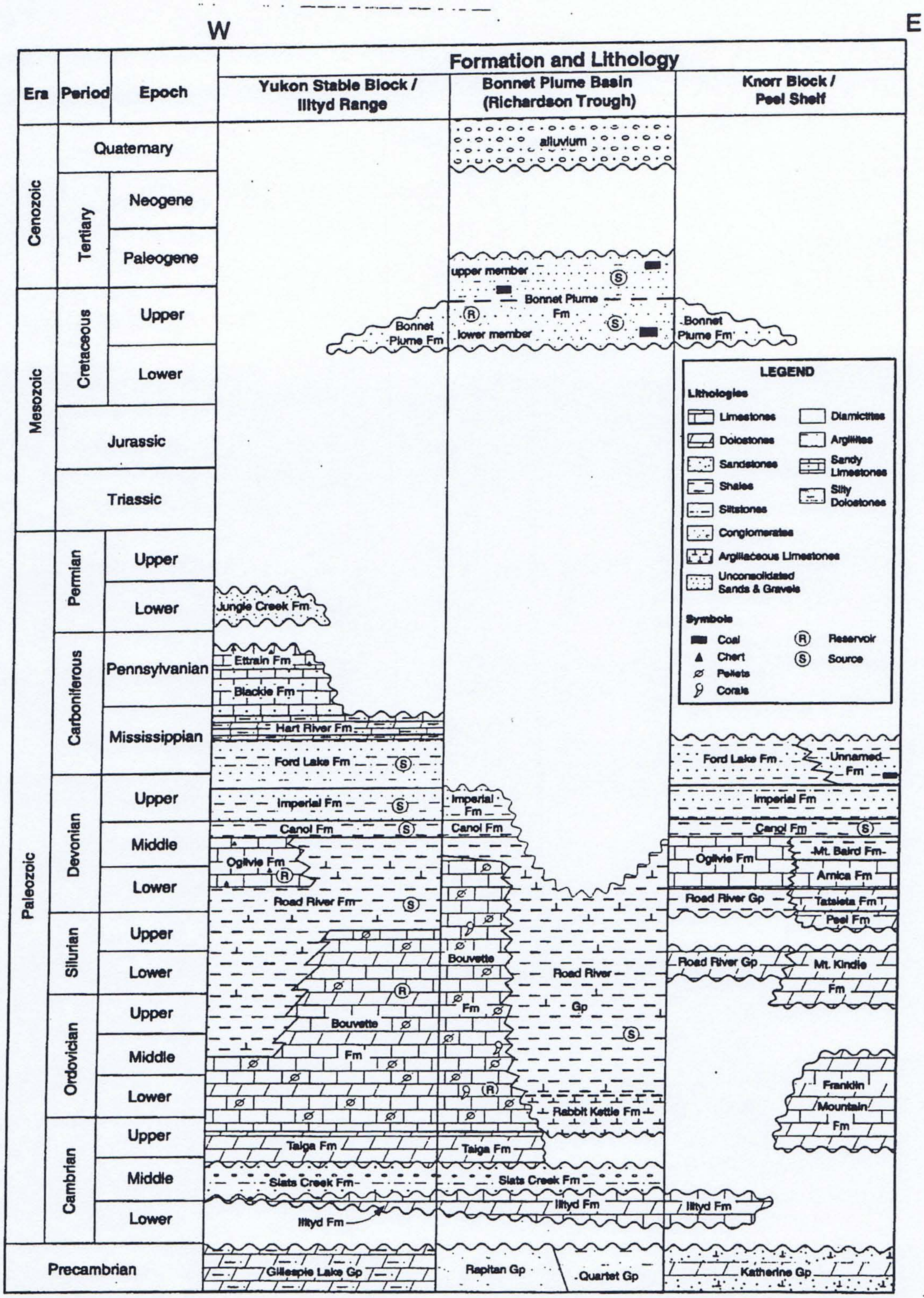


Figure 2: Stratigraphic setting of the Bonnet Plume Basin after Hannigan (2001).

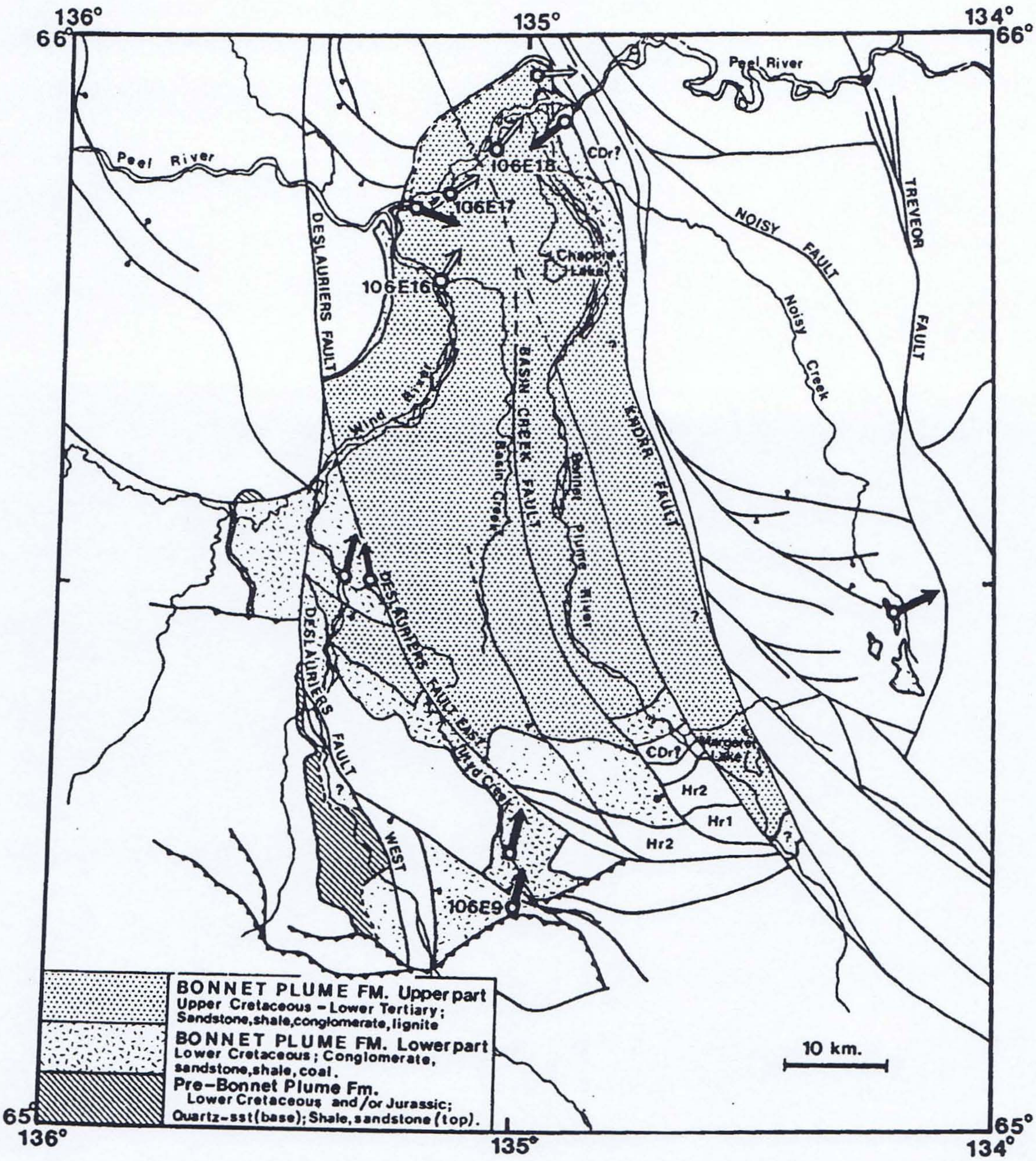


Figure 3: Major rivers and faults in the Bonnet Plume basin (after Long, 1978).

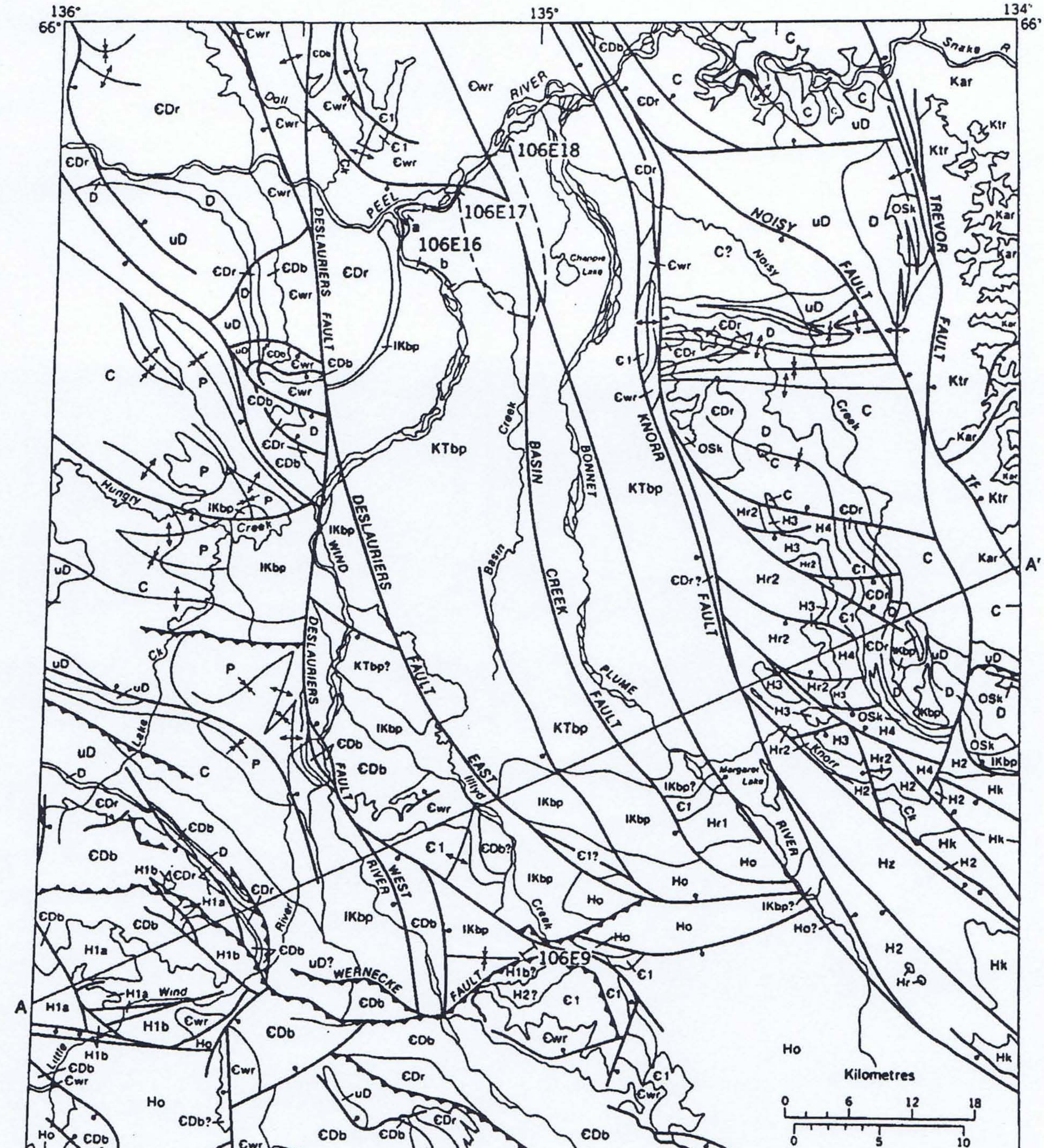


Figure 4: Major faults within and bounding the Bonnet Plume Basin (after Norris and Hopkins, 1977).

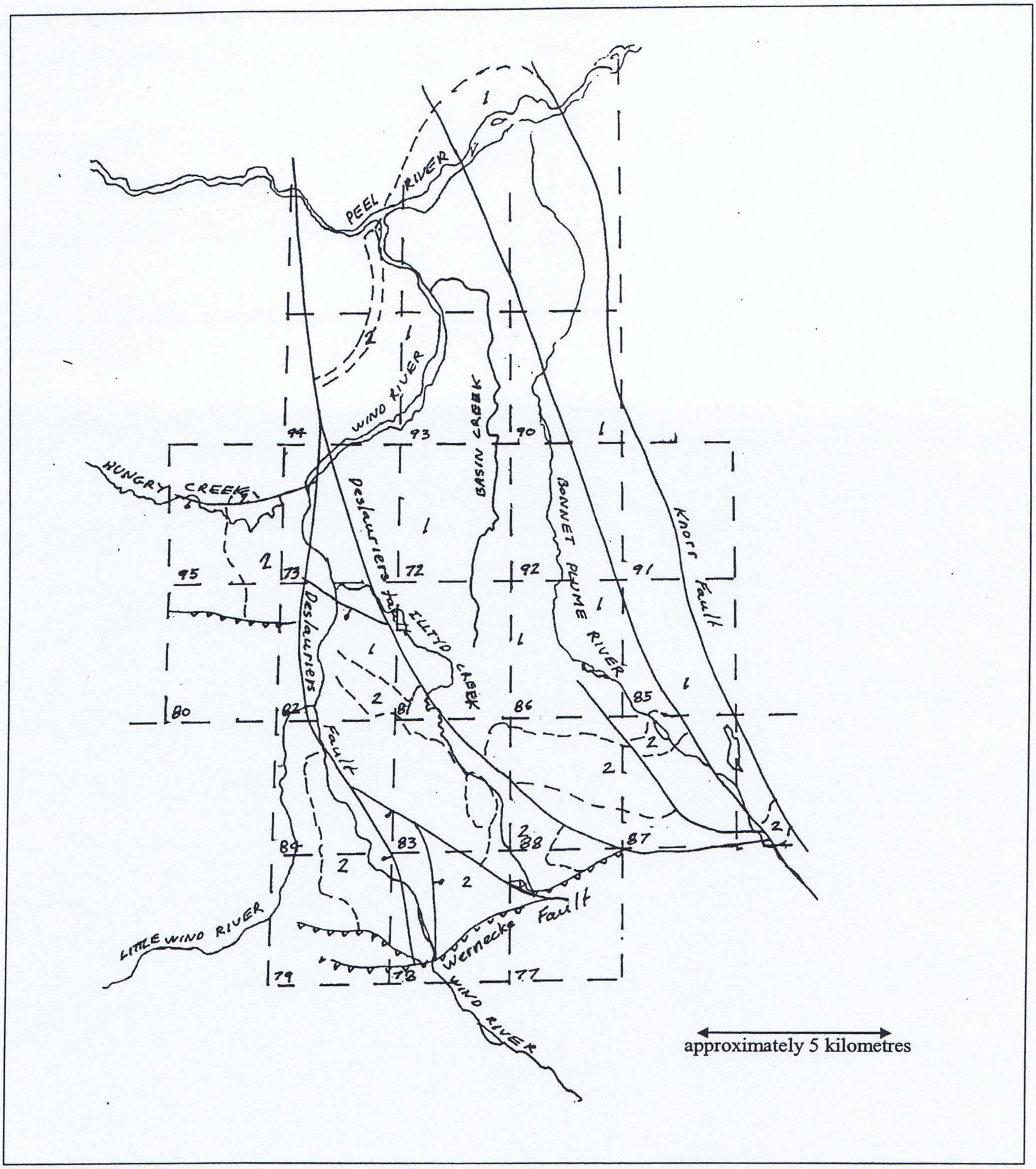


Figure 5: Simplified geology from Norris and Hopkins (1977) with Pan Ocean licenses for reference. Unit 1 is upper Bonnet Member and Unit 2 is lower Bonnet Plume Member.

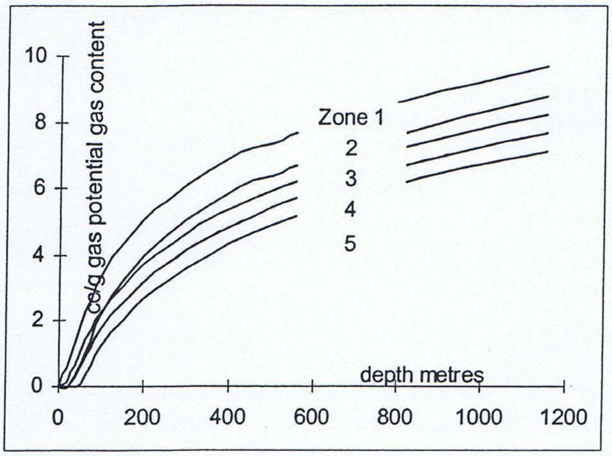


Figure 6: potential gas contents of each seam based on calculated Rmax% values.

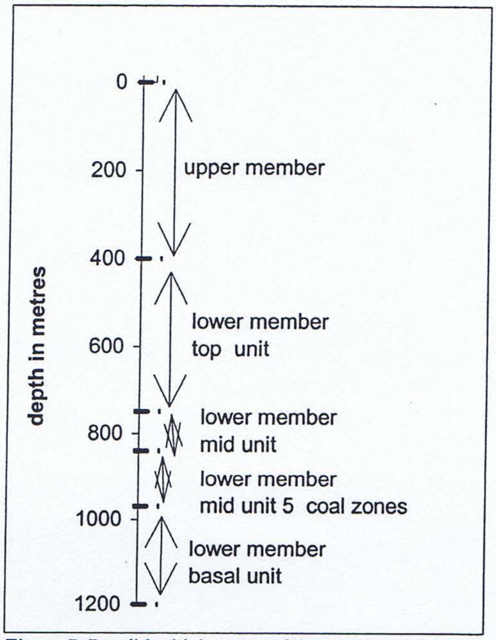


Figure 7: Possible thicknesses of the upper and lower members of the Bonnet Plume Fm and location of the 5 coal zones.

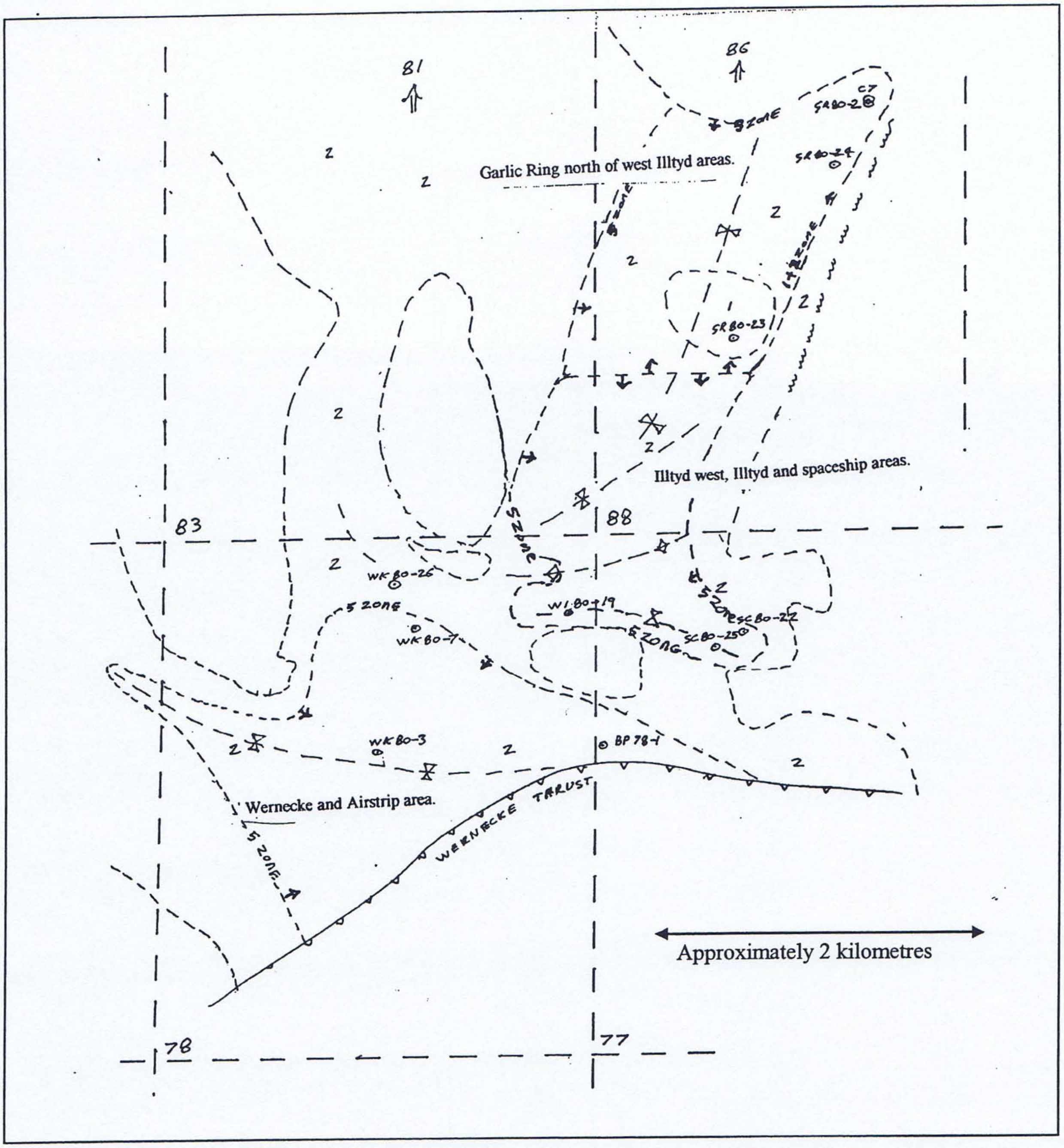


Figure 8: Simplified geology for the Wernecke plus Airstrip; Illtyd west plus Illtyd plus Spaceship and Garlic Ring plus Illtyd north CBM resource areas.

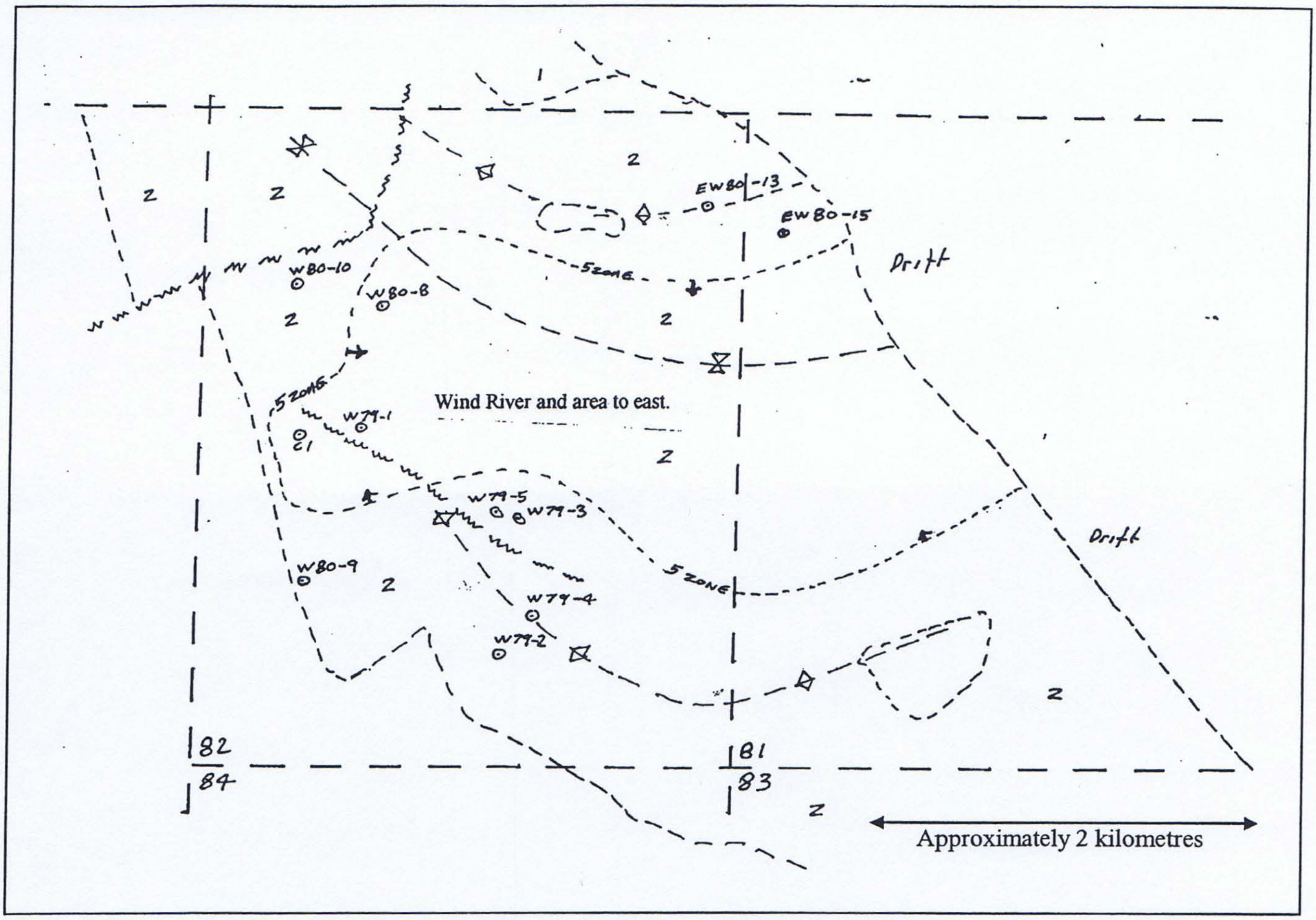


Figure 9: Simplified geology for the Wind River and area to east CBM resource area.

Table 1

Coal thicknesses and coal quality for the 7 surface mineable areas

area name	seam No	thick metres	RAW RM %	RAW ash %	RAW VM %	CLEAN ad %	CLEAN ash ad %	CLEAN VM ad %	CLEAN FC	CLEAN VM daf %	CLEAN VM daf adjust	Rmax %
Spaceship	1	6.42	7	27.8	29.8	4.5	14.9	34.4	46.2	42.7	38.2	0.65
A	2	8.99	7.4	20.9	32	5.2	12.4	34.5	48.2	41.9	38.1	0.68
	3	7.12	7.9	19.3	31.6	4.7	13.3	33.3	48.7	40.6	36.6	0.71
	4	5.45	7.3	16.3	32.5	4.7	12.6	32.8	49.6	39.7	35.9	0.74
	5	1.93	7.5	15.8	30.6	4.9	11.8	30.5	52.8	36.6	33.1	0.84
West Illtyd	1											
B	2											
	3	3.91	7.6	13.1	33.1	6.4	10.5	33	50.2	39.7	36.6	0.74
	4	2.76	7.6	14.1	32.6	6.4	10.3	33.2	50.1	39.9	36.8	0.74
	5	4.1	5.7	34.8	25.4	5.9	16.2	30.2	47.7	38.8	33.9	0.77
Illtyd	1	6.85	6.1	40.2	25.9	5	20.4	32.6	41.9	43.7	37.6	0.62
C	2	3.66	7.1	33.9	31	5.3	13.9	34.3	46.2	42.5	38.3	0.66
	3	2.4	5.1	40.7	25.9	4.9	19.7	32.5	42.7	43.1	37.2	0.64
	4	3.25	7.9	13.6	33.6	4.2	11.2	35.6	48.5	42.1	38.7	0.67
	5	2.28										
Wernecke	1	3.21	4.1	34.3	30.5	5.3	13.5	35.3	46	43.5	39.4	0.63
D	2	8.52	5.4	25.4	32.2	6	13	34.5	46.5	42.6	38.7	0.66
	3	3.43	6.2	25.9	30.1	6.7	16.2	32.2	45.1	41.8	36.9	0.68
	4	2.92	7.3	12.3	34.3	7.3	9.6	33.9	49.3	40.8	37.9	0.71
	5	2.72	6.4	25.6	27	6.5	16.5	29.5	48.5	38.3	33.4	0.78
Airstrip	1											
E	2											
	3	3.04	7.6	20.5	31.3	4.6	14.3	33.5	47.4	41.3	37.0	0.69
	4	4.89	5.7	32.6	25.9	5.1	18.8	30.1	45.6	39.6	33.9	0.75
	5											
Wind River	1											
F	2											
	3	8	6.1	39	25.7	4.4	18.1	31	45.6	40.0	34.6	0.73
	4	4.75	6	30.8	27.5	4.7	14.3	32.6	48.3	40.2	36.0	0.72
	5	9.19	5.1	29.6	26.8	4.5	11.6	31.9	51.9	38.0	34.5	0.79
Garlic Ring	1	2.56	6.3	27.8	28.8	4.3	20.2	31.2	44.2	41.3	35.3	0.69
G	2	3.28	5.6	36.7	27.2	4.4	27.3	28.3	40.2	41.4	33.2	0.69
	3											
	4											
	5											

Combination of areas for CBM evaluation

A+B+C	thickness A	thickness B	thickness C	thickness average	ash A	ash B	ash C	ash average	RM A	RM B	RM C	RM average
1	6.42		6.85	6.65	27.8		40.2	34.5	7		6.1	6.5
2	8.99		3.66	6.12	20.9		33.9	27.9	7.4		7.1	7.2
3	7.12	3.91	2.4	4.50	19.3	13.1	40.7	28.6	7.9	7.6	5.1	6.5
4	5.45	2.76	3.25	4.08	16.3	14.1	13.6	14.8	7.3	7.6	7.9	7.6
5	1.93	4.1	2.28	2.36	15.8	34.8		20.2	7.5	5.7		7.1
tonnes	157.95	47.56	183.64									
total tonnes A+B+C	389.15											

D+E	thickness metres D	thickness metres E	thickness metres average	ash% D	ash% E	ash% average	moisture% D	moisture% E	moisture% average
1	3.21		3.21	34.3		34.3	4.1		4.1
2	8.52		8.52	25.4		25.4	5.4		5.4
3	3.43	3.04	3.34	25.9	20.5	24.65	6.2	7.6	6.52
4	2.92	4.89	3.38	12.3	32.6	17.00	7.3	5.7	6.93
5	2.72		2.72	25.6		25.6	6.4		6.4
tonnes	157.95	47.56							
total tonnes D+E	205.51								

Note mean maximum reflectance (Rmax%) is estimated from volatile matter on a dry-ash-free basis VM daf

VM daf is calculated from volatile matter with an additional correction

ie VM daf at zero ash= VM daf -0.3* ash%

Rmax% is calculated from VM daf zero ash and reactives percent mineral matter free

Table 2

Calculation of average rank for each seam assuming 95% reactives and correcting VM daf for ash effect

Rmax=-1.2124*ln(Vmdaf)+0.0073*R%+4.4851 Rmax% = -1.2124Ln(VMdaf-0.3*ash) + 5.2045 95

seam 1			seam 2			seam 3			seam 4			seam 5		
	ash	VM daf		ash	VM daf		ash	VM daf		ash	VM daf		ash	VM daf
A	14.9	42.7	A	12.4	41.87	A	13.3	40.61	A	12.6	39.66	A	11.8	36.61
C	20.4	43.7	C	13.9	42.45	B	10.5	39.71	B	10.3	39.86	B	16.2	38.77
D	13.5	43.5	D	13	42.59	C	19.7	43.1	C	11.2	42.08	D	16.5	38.31
G	20.2	41.6	G	27.3	41.43	D	16.2	41.76	D	9.6	40.79			
						E	14.3	41.31	E	18.8	39.55			
						F	18.1	40	F	14.3	40.25			
averages		Rmax			Rmax			Rmax			Rmax			Rmax
18.0	**42.9**	**0.636**	**18.07**	**42.16**	**0.658**	**17.08**	**41.54**	**0.675**	**13.48**	**40.67**	**0.70**	**16.5**	**38.31**	**0.77**

rank does not seem to vary within one seam but increases down section from about 0.65% to about 8.0% over about 220 metres

Table 3

Predicted gas contents for the 5 seams at various depths.

seam 1		seam 2		seam 3		seam 4		seam 5	
Rmax%	0.6	Rmax%	0.7	Rmax%	0.68	Rmax%	0.70	Rmax%	0.77
ash	18.0	ash	18.1	ash	17.1	ash	13.5	ash	16.5
metres	cc/gm	metres	cc/gm	metres	cc/gm	metres	cc/gm	metres	cc/gm
0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
25	0.0	25	0.0	25	0.3	25	0.0	25	0.7
50	0.1	50	0.6	50	1.1	50	0.7	50	1.9
75	0.7	75	1.2	75	1.7	75	1.6	75	2.7
100	1.2	100	1.8	100	2.2	100	2.2	100	3.4
125	1.7	125	2.2	125	2.7	125	2.8	125	3.9
150	2.0	150	2.6	150	3.1	150	3.2	150	4.4
175	2.4	175	2.9	175	3.4	175	3.6	175	4.7
200	2.7	200	3.2	200	3.7	200	4.0	200	5.1
225	2.9	225	3.5	225	4.0	225	4.3	225	5.4
250	3.2	250	3.7	250	4.2	250	4.6	250	5.7
275	3.4	275	3.9	275	4.5	275	4.9	275	5.9
300	3.6	300	4.2	300	4.7	300	5.1	300	6.1
325	3.8	325	4.4	325	4.9	325	5.3	325	6.4
350	4.0	350	4.5	350	5.1	350	5.5	350	6.6
375	4.2	375	4.7	375	5.2	375	5.7	375	6.7
400	4.3	400	4.9	400	5.4	400	5.9	400	6.9
425	4.5	425	5.0	425	5.6	425	6.1	425	7.1
450	4.6	450	5.2	450	5.7	450	6.2	450	7.2
500	4.9	500	5.4	500	6.0	475	6.4	475	7.4
550	5.2	550	5.7	550	6.2	525	6.7	525	7.7
650	5.6	650	6.1	650	6.7	575	6.9	575	7.9
750	6.0	750	6.5	750	7.1	675	7.4	675	8.4
850	6.3	830	6.8	830	7.3	775	7.8	775	8.7
950	6.3	860	6.9	860	7.4	855	8.1	855	9.0
1050	6.4	890	7.0	890	7.5	885	8.2	885	9.1
1150	6.5	920	7.0	920	7.6	915	8.3	915	9.2
		950	7.1	950	7.7	945	8.4	945	9.3
						975	8.5	975	9.4
						1005	8.6	1005	9.5
						1035	8.6	1035	9.6
						1075	8.8	1075	9.7

Table 4

Coal and CBM resources of Lower Bonnet Plume subcrop area

COAL RESOURCES SURFACE MINEABLE COAL

	measured	indicated	inferred	total
A Spaceship			157.95	157.95
B West Illtyd		0	47.56	47.56
C Illtyd	120.93	29.21	33.5	183.64
D wernecke		104.65	28.93	133.58
E Airstrip			18.4	18.4
F Wind		60.83	43.8	104.63
G Garlic Ring		8.6	5.55	14.15
			TOTAL	454.4

COAL RESOURCES FOR CBM — 1 acre =4840 sq ft=450 m^2 . 1 section = 640 acres

		area Km^2	coal bt	CBM bcf	bcf/section
Wernecke+Airstrip (D+E)	area 1	58.30	1464	126	5.59
Illtyd west, Illtyd and Spaceship (A+B+C)	area 2	19.70	481	41	5.35
Garlic Ring north and part of west Illtyd (G+B)	area 3	42.44	535	53	3.21
Wind River and area to east (F)	area 4	80.61	1523	215	6.92
Totals lower member outcrop area		201	4003	434	
Average bcf/section lower member outcrop area					5.60
average coal thickness metres lower member outcrop area					17

Total Upper member scf/t=	50	600	10000	500	2.16
Total where lower member under upper member 1000 Km^2 (Table 9)		1000	32.10	7642.0	19.79
Total Bonnet Plume Formation as tcf				8.6	

bt billion tonnes bcf billion cubic feet tcf trillion cubic feet

Table 5

CBM resource for combined Wernecke and Airstrip area

1km^2 on planimetre = 0.0238 seam separatior 0.118125

Sm	plan	Km^2	av thick	ash	RM	SG	mt	maxdpth
1	0.915	38.45	3.21	34.3	4.1	1.6145	199.245	230
2	1.033	43.41	8.52	25.4	5.4	1.481	547.735	275
3	1.151	48.37	3.339745	24.65	6.524	1.469755	237.438	305
4	1.269	53.34	3.375906	16.998	6.93	1.354969	243.968	410
5	1.3875	58.30	2.72	25.6	6.4	1.484	235.32	450
cumthick			**21.17**		**total**		**1463.71**	

SG=1.1+.015*ash

const	slope
1.1	0.015

estimated CBM cc/g — **cc/g to scf** **32.037**

Sm	depth 0	50	100	150	200	250	300	350	400	450
1	0	0.1	1.2	2.0	2.7	3.2	3.6	4.0	4.3	4.6
2	0	0.6	1.8	2.6	3.2	3.7	4.2	4.5	4.9	5.2
3	0	1.1	2.2	3.1	3.7	4.2	4.7	5.1	5.4	5.7
4	0	0.7	2.2	3.2	4.0	4.6	5.1	5.5	5.9	6.2
5	0	1.9	3.4	4.4	5.1	5.7	6.1	6.6	6.9	7.2

	S1			S2			S3			S4			S5		
	thick	3.21	gas	thick	8.52	gas	thick	3.34	gas	thick	3.38	gas	thick	2.72	
depth	area	cc/g	mmcf	area	cc/g	mmcf	area	cc/g	mmcf	area	cc/g	mmcf	area	cc/g	gas
0-25	7.69	0.00	0.0	7.23	0.00	0.0	6.91	0.00	0	5.93	0.00	0	5.83	0.00	0
25-75	7.69	0.07	92.9	7.23	0.60	1761.5	6.91	1.08	1174.3	5.93	0.71	612.45	5.83	1.90	1434
75-125	7.69	1.22	1563.4	7.23	1.75	5126.1	6.91	2.25	2439.7	5.93	2.24	1941.8	5.83	3.38	2548
125-175	7.69	2.04	2606.7	7.23	2.57	7513.3	6.91	3.07	3337.5	5.93	3.24	2817.5	5.83	4.35	3281.8
175-225	7.69	2.68	3415.9	7.23	3.20	9365.0	6.91	3.71	4034	5.93	4.00	3471.5	5.83	5.08	3829.9
225-275				7.23	3.72	10877.9	6.91	4.24	4603	5.93	4.60	3993.8	5.83	5.66	4267.5
275-325							6.91	4.68	5084.1	5.93	5.10	4428.5	5.83	6.14	4631.8
325-375										5.93	5.53	4800.9	5.83	6.56	4943.9
375-425										5.93	5.90	5126.6	5.83	6.92	5216.9
seam													5.83	7.24	5459.4
totals	**mmcf**		**7678.88**			**34643.68**			**20672**			**27193**			**35613**
total bcf		**125.801**													

Table 6

CBM resource for Illtyd West, Illtyd and Spaceship areas

1km² on planimetre = 0.365 seam separation 0.8888 tonnes

	planimetre km2		av thick	av ash	av RM	SG	10^6	maxdpth		
seam 1	3.635	9.96	6.7	34.0	6.6	1.61	106.64	230	SG=1.15+.015*ash	
2	4.524	12.39	6.1	27.4	7.3	1.51	114.70	275	const	slope
3	5.413	14.83	4.5	24.4	6.9	1.47	97.80	305	1.1	0.015
4	6.301	17.26	4.1	14.7	7.6	1.32	93.05	410		
seam 5	7.190	19.70	2.4	25.3	6.6	1.48	68.79	450		
	cumthick		23.72			total mt	480.97			

estimated CBM cc/g   cc/g to scf 32.037

seam	depth 0	50	100	150	200	250	300	350	400	450
1	0	0.1	1.2	2.0	2.7	3.2	3.6	4.0	4.3	4.6
2	0	0.6	1.8	2.6	3.2	3.7	4.2	4.5	4.9	5.2
3	0	1.1	2.2	3.1	3.7	4.2	4.7	5.1	5.4	5.7
4	0	0.7	2.2	3.2	4.0	4.6	5.1	5.5	5.9	6.2
5	0	1.9	3.4	4.4	5.1	5.7	6.1	6.6	6.9	7.2

	S1			S2			S3			S4			S5		
	thick	6.7	gas	thick	6.1	gas	thick	4.5	gas	thick	4.1	gas	thick	2.4	
depth	area	cc/g	mmcf	area	cc/g	mmcf	area	cc/g	mmcf	area	cc/g	mmcf	area	cc/g	gas
0-25	1.99	0.00	0	2.07	0.00	0	2.12	0.00	0	1.92	0.00	0	1.97	0.00	0
25-75	1.99	0.07	50	2.07	0.60	369	2.12	1.08	484	1.92	0.71	234	1.97	1.90	419
75-125	1.99	1.22	837	2.07	1.75	1073	2.12	2.25	1005	1.92	2.24	741	1.97	3.38	745
125-175	1.99	2.04	1395	2.07	2.57	1573	2.12	3.07	1375	1.92	3.24	1075	1.97	4.35	959
175-225	1.99	2.68	1828	2.07	3.20	1961	2.12	3.71	1662	1.92	4.00	1324	1.97	5.08	1120
225-275				2.07	3.72	2278	2.12	4.24	1896	1.92	4.60	1523	1.97	5.66	1248
275-325							2.12	4.68	2094	1.92	5.10	1689	1.97	6.14	1354
325-375										1.92	5.53	1831	1.97	6.56	1445
375-425										1.92	5.90	1955	1.97	6.92	1525
425-475													1.97	7.24	1596
seam total	9.96	mmcf	4110	12.39	mmcf	7254	14.83	mmcf	8515	17.26	mmcf	10371	19.70	mmcf	10411
total bcf			40.7												

Table 7

CBM resource for Garlic Ring North of West Illtyd areas

NOTES planimeter 1 and 2 seams on east side of syncline to axis

and seams 3,4,5 from west from west north projection of west Illtyd to syncline axis

1km2 on planimetre 0.02427 seam separation 0.025

	seam	plan	areaKm2	av thick	ash	RM	SG	mt	maxdpth		
garlic	1	0.465	19.16	2.56	27.8	6.3	1.517	74.412	230	SG=1.15+.015*ash	
Garlic	2	0.465	19.16	3.28	36.7	5.6	1.6505	103.73	275	const	slope
W Il	3	0.565	23.28	3.91	13.1	7.6	1.2965	118.02	305	1.1	0.015
W Il	4	0.565	23.28	2.76	14.1	7.6	1.3115	84.274	410		
W Il	5	0.565	23.28	4.1	34.8	5.7	1.622	154.83	450		
		cum coal		16.61			total	535.27			

estimated CBM cc/g   cc/g to scf 32.037

seam	depth 0	50	100	150	200	250	300	350	400	450
1	0	0.1	1.2	2.0	2.7	3.2	3.6	4.0	4.3	4.6
2	0	0.6	1.8	2.6	3.2	3.7	4.2	4.5	4.9	5.2
3	0	1.1	2.2	3.1	3.7	4.2	4.7	5.1	5.4	5.7
4	0	0.7	2.2	3.2	4.0	4.6	5.1	5.5	5.9	6.2
5	0	1.9	3.4	4.4	5.1	5.7	6.1	6.6	6.9	7.2

	seam1	thick	2.56	seam2	thick	3.28	seam3	thick	3.91	seam4	thick	2.76	seam5	thick	4.1
depth	area	cc/g	gas	area	cc/g	gas	area	cc/g	gas	area	cc/g	gas	area	cc/g	gas
0-25	3.8322	0	0	3.193506	0	0	3.326	0	0	2.5869	0	0	2.3282	0	0
25-75	3.8322	0.072756	34.6893	3.193506	0.6023	333.59	3.326	1.0806	583.6967	2.5869	0.7052	211.56	2.3282	1.9021	943.51
75-125	3.8322	1.22459	583.871	3.193506	1.7527	970.78	3.326	2.2451	1212.693	2.5869	2.236	670.77	2.3282	3.3798	1676.5
125-175	3.8322	2.04183	973.522	3.193506	2.569	1422.9	3.326	3.0713	1658.973	2.5869	3.2443	973.24	2.3282	4.3532	2159.3
175-225	3.8322	2.67573	1275.76	3.193506	3.2021	1773.5	3.326	3.7122	2005.135	2.5869	3.9974	1199.2	2.3282	5.0801	2519.9
225-275				3.193506	3.7194	2060.1	3.326	4.2358	2287.97	2.5869	4.5987	1379.6	2.3282	5.6606	2807.8
275-325							3.326	4.6785	2527.103	2.5869	5.0993	1529.7	2.3282	6.1439	3047.5
325-375										2.5869	5.5282	1658.4	2.3282	6.5578	3252.8
375-425										2.5869	5.9032	1770.9	2.3282	6.9199	3432.4
425-475													2.3282	7.2416	3592
seam totals		mmcf	2867.84			6560.9		mmcf	10275.57		mmcf	9393.3		mmcf	23432
total bcf			52.5292												

Table 8

CBM resource for Wind River and area to east

NOTES planimeter 5 and 4 seams

1km^2 on planimeter 0.024252 seam separation 0.4888

	seam	plan	areaKm2	av thick	ash	RM	SG	mt	maxdpth		
Wind	1	0	0.00	0			1.1	0	230	SG=1.15+.015*ash	
River	2	0	0.00	0			1.1	0	275	const	slope
	3	0	0.00	8	39	6.1	1.685	0	305	1.1	0.015
	4	1.240	51.13	4.75	30.8	6	1.562	379.36	410		
	5	1.955	80.61	9.19	29.6	5.1	1.544	1143.8	450		
	cum coal			**21.94**		total mt		**1523.2**			

estimated CBM cc/g **cc/g to scf** **32.037**

seam	depth 0	50	100	150	200	250	300	350	400	450
1	0	0.1	1.2	2.0	2.7	3.2	3.6	4.0	4.3	4.6
2	0	0.6	1.8	2.6	3.2	3.7	4.2	4.5	4.9	5.2
3	0	1.1	2.2	3.1	3.7	4.2	4.7	5.1	5.4	5.7
4	0	0.7	2.2	3.2	4.0	4.6	5.1	5.5	5.9	6.2
5	0	1.9	3.4	4.4	5.1	5.7	6.1	6.6	6.9	7.2

	seam1	thick	0	seam2	thick	0	seam3	thick	8	seam4	thick	4.75	seam5	thick	9.19
depth	area	cc/g	gas	area	cc/g	gas	area	cc/g	gas	area	cc/g	gas	area	cc/g	gas
0-25	0	0	0	0	0	0	0	0	0	5.6811	0	0	8.0612	0	0
25-75	0	0.072756	0	0	0.6023	0	0	1.0806	0	5.6811	0.7052	952.32	8.0612	1.9021	6970.401
75-125	0	1.22459	0	0	1.7527	0	0	2.2451	0	5.6811	2.236	3019.5	8.0612	3.3798	12385.37
125-175	0	2.04183	0	0	2.569	0	0	3.0713	0	5.6811	3.2443	4381.1	8.0612	4.3532	15952.11
175-225	0	2.67573	0	0	3.2021	0	0	3.7122	0	5.6811	3.9974	5398	8.0612	5.0801	18616.15
225-275				0	3.7194	0	0	4.2358	0	5.6811	4.5987	6210.1	8.0612	5.6606	20743.34
275-325							0	4.6785	0	5.6811	5.0993	6886.1	8.0612	6.1439	22514.19
325-375										5.6811	5.5282	7465.2	8.0612	6.5578	24031.11
375-425										5.6811	5.9032	7971.7	8.0612	6.9199	25357.9
425-475													8.0612	7.2416	26536.93
seam totals		**mmcf**	**0**			**0**		mmcf	**0**		mmcf	**42284**		mmcf	**173107.5**
total bcf			**215.391**												

Table 9: CBM in lower member where overlain by upper member

assumed area overlain by upper member 1000 km

seam	depth	thick	coal bt	gas cc/g	area Km^2	ash	SG	bcf
1	880	6.65	9.11	6.3	1000	18	1.37	1838.8
2	910	6.12	8.39	7	1000	18.1	1.37	1882.336
3	940	4.5	6.10	7.7	1000	17.1	1.36	1505.826
4	970	4.08	5.31	8.5	1000	13.5	1.30	1447.134
5	1000	2.36	3.18	9.5	1000	16.5	1.35	967.8682
totals		**23.71**	**32.10**				**tcf**	**7.6**

Table 10: Coal thicknesses intersected in drillholes (Cullingham et. al. 1981)

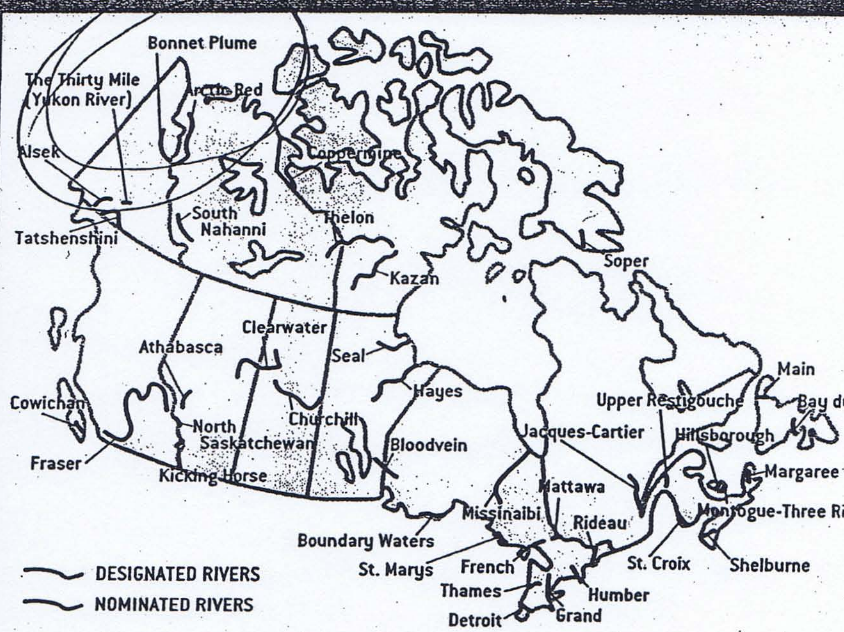
	seam 1		seam 2		seam 3		seam 4		seam 5		total coal
hole	depth	thick	depth	thick	depth	thick	depth	thick	depth	thick	by hole
BP-78-1	63.97	5.65	103.68	3.3							13.69
			108.45	4.74							
W-79-1					11.4	8	61.29	4.53			12.53
W-79-6/6A							7.12	5.28	87.48	8.84	16.22
							22.06	2.1			
W-79-3											
W-79-5							69.42	3.15			3.15
W-79-23					28.7	3.11	92	4.89			8
WK-80-1	27.13	1.38	63.49	3.95	149.01	1.29	241.82	2.15			15.51
			70.19	3.54	151.95	2.15	266.57	1.05			
WK-80-7	66.25	0.57	100.3	4.08	167..86	3.41	245.67	2.12	325.4	2.72	20.01
	68.27	2.88	105.07	4.23							
W-80-8							8.72	4.69	83.2	9.6	14.29
WI-80-16							40.35	2.12	128.05	2.38	5.32
							57.4	0.82			
WI-80-19					43.2	1.51	107.46	3.04	153.4	3.8	12.89
					48.2	2			172	2.54	
GR-80-27											
GR-80-26	156.05	2.4	196.22	2.57							4.97
SC-80-22			39.76	6.07	97.35	4.81	193.83	7.37	255.42	3.17	29.88
			47.77	5.56	107.17	1.63					
					129.81	1.27					
SC-80-25	153.1	6.42	196.11	4.13	233.5	3.38	321.87	3.83	374.15	2.99	26.6
			203.88	2.62	243.67	1.68					
					262.56	1.55					
TOTALS		19.3		44.79		35.79		47.14		36.04	183.06

Appendix G
The Bonnet Plume – A Canadian Heritage River

CANADA'S HERITAGE RIVERS

Canada's historical fabric is bound by a thread of ancient rivers. Drawing on the spirit of Pierre Trudeau and his affection for our natural and cultural heritage, the Canadian Heritage River System (CHRS) was established in 1984 to ensure the long-term management and conservation of our historic waterways. Currently there are 39 in the system, protecting over 9,000 kilometres of rivers in all provinces and territories.

There are two steps in the CHRS appointment process: nomination and designation. A river is nominated when a federal, provincial or territorial government body lends its endorsement based on public support and the river's natural and cultural significance. The first nominated river was the French, a historic voyageur route linking Lake Nipissing with Georgian Bay on Lake Huron. CHRS designation takes place after a conservation and management plan—based on public consultation and consensus—has been tabled with the CHRS governing board. The most recent designation was the Missinaibi River in northeastern Ontario in February. The Thelon River was designated in July 1990.



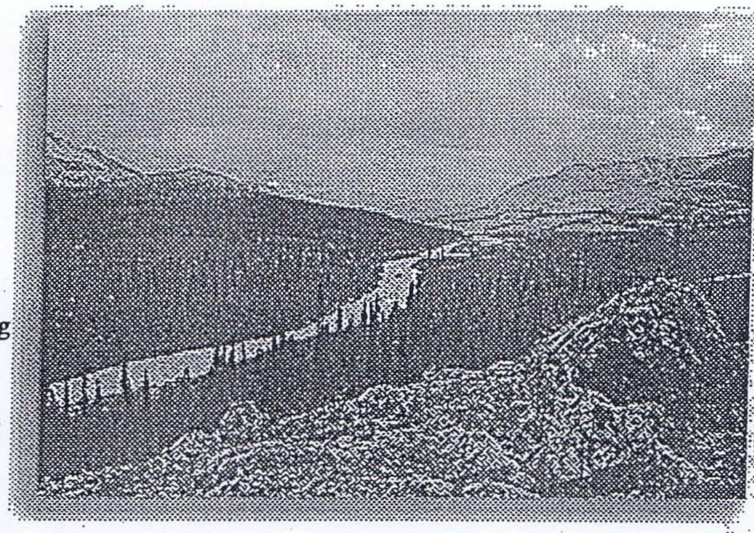
For more information or to get involved, contact the Canadian Heritage Rivers Secretaria at 819-997-4930, or on the Web at **chrs.ca**.

board member. Or e-mail us at donald_gibson@pch.gc.ca.

Back to Main Menu

Bonnet Plume River

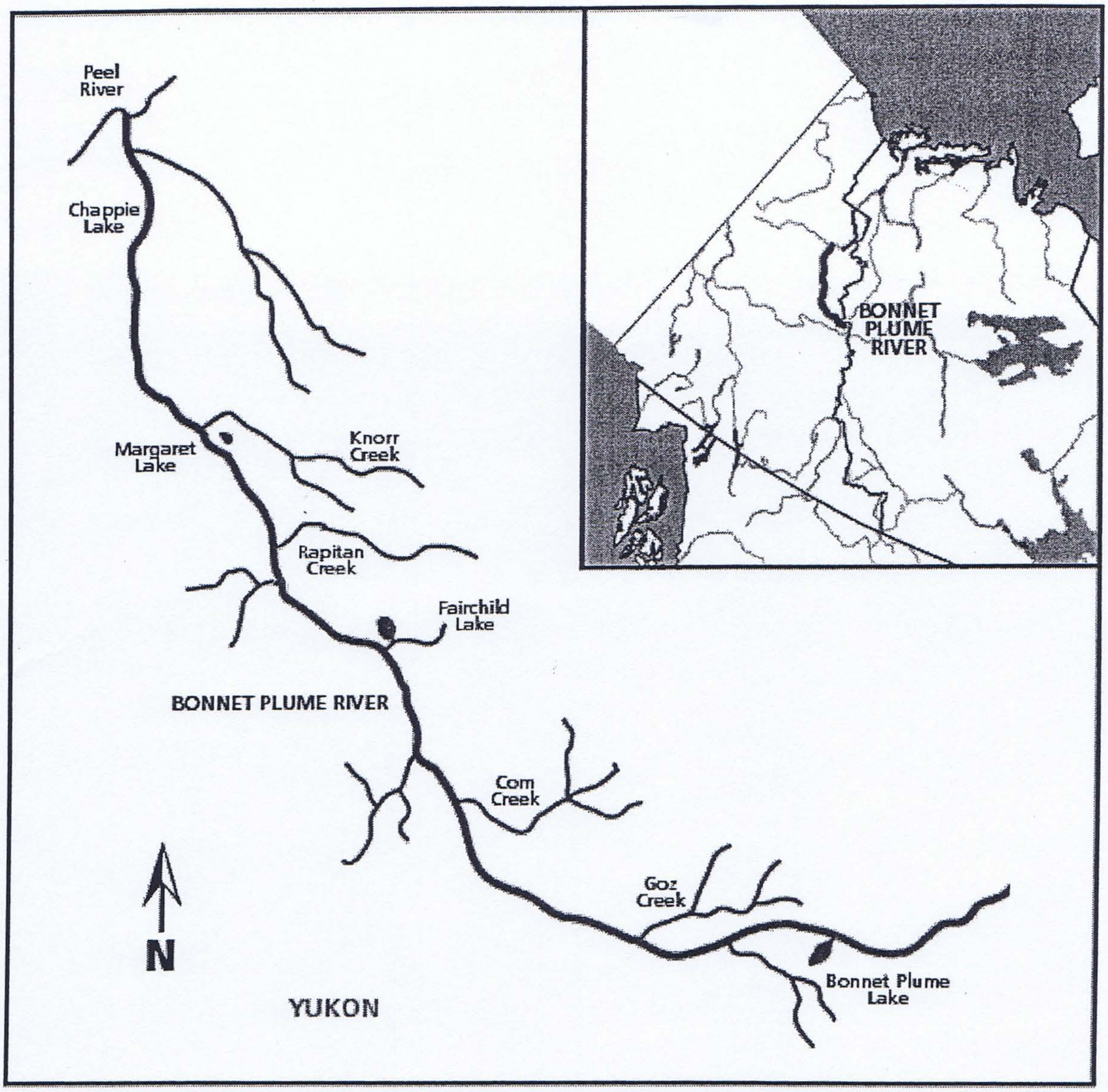
Bonnet Plume River, Yukon
The River of Black Sands
Designated 1998



The Bonnet Plume River rushes through range after range of mountains, cutting across rockslides, sluicing through canyons and sliding for miles through braided gravel flats. Long known as big game hunting country, Dall's sheep, grizzly bear, moose and caribou graze on the alpine meadows and valley bottomlands The river is named in honour of a Gwich'in chief, Alfred Bonnet Plume, who worked with French-Canadian Voyageurs of the Hudson's Bay Company.

Fact Sheet Area Map River Stories

Bonnet Plume River



Scale: 1 cm = 14 km

Back to Bonnet Plume River Main Page

Bonnet Plume River

Back to Bonnet Plume River Main Page

The Bonnet Plume River descends from the rugged Wernecke Mountains carving out a magnificent, wide valley and crossing a lowland plain, heading west and north towards its confluence with the Peel River. A wilderness area rich in natural history, the Bonnet Plume basin features plentiful examples of slip faults, rock glaciers, aretes, cirques and moraines, which reflect a geological history extending back to the Late Pre-Cambrian period. Also significant for its human history, the area has supported the subsistence activities of the Tetlit Gwich'in of the Northwest Territories (NWT) and the Nacho N 'y' ak Dun First Nation of the Yukon for centuries. This traditional use of the valley's resources continues today, alongside the wilderness recreational activity of visitors. The Bonnet Plume is also recognized as a superb recreational river and a significant component of the Canadian Heritage Rivers System (CHRS). The diversity of wildlife, vegetation and scenery of this expansive and beautiful region provides an exceptional opportunity for visitors to appreciate the character of the Yukon wilderness.

Geography

The Bonnet Plume River headwaters in the Mackenzie Mountains, straddle the drainage divide which separates the Yukon and the NWT. The river flows over 350 kms before joining the Peel River, which flows northward across the Yukon/ NWT border to the Mackenzie River delta. Designated in 1998, the Bonnet Plume and its tributary rivers encompass a total area of approximately 12,000 sq kms.

The communities closest to the Bonnet Plume are significantly removed from the river, and access to the basin is only by aircraft. Due to its regular air and road connections with the south, and the presence of air charter operations based there, Whitehorse is the main entry point to the area. Mayo, located on the Stewart River and with access from the Klondike Highway, has a float plane base and air strip but all air service is based in Whitehorse. Fort McPherson, a common destination point for river travelers, offers limited facilities and services. It is accessible both by air, from Inuvik, NWT, and by road, via the Dempster Highway.

▲ Back to top

Natural Heritage

Three mountain systems, the Mackenzies, Werneckes and Richardsons, converge in the Bonnet Plume drainage area. Extensive folding and faulting contributed to the area's complex geologic history. The Bonnet Plume basin contains some of the thickest and most extensive coal deposits in the Yukon, and the entire drainage area has attracted interest in its iron, lead-zinc, copper and uranium deposits. A paleontological find near the mouth of the Bonnet Plume River is of particular significance as it is the only discovery of dinosaur bones in the Yukon. Vertebrae from the back of the tail and a fragment of the fifth finger of the hand from a duck-billed dinosaur were discovered along the south side of the Peel River, between the mouth of the Bonnet Plume and Wind Rivers.

During the earliest Laurentide glacial advance, ice covered all the valleys of the Bonnet Plume area, and was continuous across the divides. Extensive cirque development in the Wernecke Mountains indicates strong alpine glaciation, and other glacial landforms such as aretes, moraines and rock glaciers are common. Continuing erosional forces create hoodoos along the middle sections of the river and fluvial processes result in extensive river braiding. One of the most dramatic physiographic features of the area occurs just below Bonnet Plume Lake, where a large rockslide has transformed the valley, forcing the river to carve a canyon through the massive deposit of rock.

As the river descends from its headwaters in the alpine zone towards its confluence with the Peel, the vegetation changes accordingly. In the upper reaches, the valley lies within the tundra region, and although shrub birch and willow communities occur in protected sites above the treeline, this zone is also characterized by massive scree slopes which are essentially devoid of vegetation. Open stands of black and white spruce occupy the longer slopes and occasionally the well-drained valley bottoms of the river's middle reaches. The dominant ground vegetation includes moss and lichens, usually with heath-like shrubs and sedge tussocks. In the longer reaches of the valley, white spruce is dominant along rivers and streams, in alluvial sites or on dry, upland areas. Black spruce and larch occupy poorly drained sites such as bog forest areas. Other tree species represented are aspen, paper birch and balsam poplar or cottonwood.

The Bonnet Plume area contains three noteworthy vegetation species: a community of tamarack near the mouth of Slats Creek, an occurrence considered unusual at this latitude; a rare vascular plant species, Papaver walpolei, which is threatened in Alaska; and, a species of saxifrage, Boykinia richardsonii, previously thought to be limited to an unglaciated area of the northwestern Yukon.

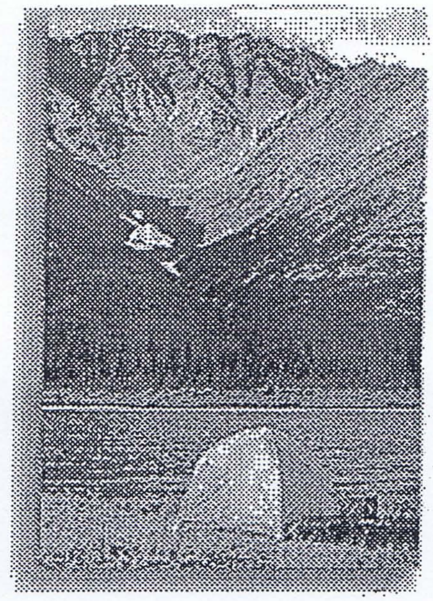
The Bonnet Plume region is noted for its wildlife habitat and supports large populations of sheep, caribou, moose and grizzly bear. The watershed is home to the Bonnet Plume caribou herd, one of the largest sedentary woodland caribou populations in the Yukon. The cottonwood/spruce forests and lichen woodland areas of the valley are considered excellent moose habitat.

A sizable sheep population inhabits the Wernecke Mountains, and relatively high densities of grizzly have been reported in the river area. Bird species include peregrine and gyrfalcon, eagles, ruffed grouse, rock ptarmigan, loons, ducks and swans.

The lower Bonnet Plume River is considered sensitive and valuable fish habitat, and a spawning and nursery area for a number of fish species including Arctic grayling, slimy sculpin, round whitefish and Dolly Varden char. Margaret Lake and Bonnet Plume Lake contain such species as whitefish and lake trout. The Bonnet Plume watershed also contains relic fish populations. Twice during the Pleistocene glaciations, the Peel River was diverted into the headwaters of the Yukon, enabling aquatic organisms to transfer from the Yukon River system to the Bonnet Plume and other parts of the Peel drainage.

▲ Back to top

Human Heritage



The Nacho N 'y' ak Dun of Mayo, Yukon and the Tetlit Gwich'in of Fort McPherson, NWT and their ancestors have used the Bonnet Plume area continuously for thousands of years in traditional subsistence activities of hunting, fishing, trapping and gathering. Other aboriginal groups as well have relied on the resources of the Bonnet Plume area, particularly when the caribou were plentiful. The Wind and Bonnet Plume Rivers have been important traditional travel routes between Fort McPherson and the Mayo and Lansing areas, for travel on foot or with dog packs.

After placer diggings were discovered on the Klondike River in 1896, routes through the Peel River drainage, including up the Bonnet Plume River and westward up Gillespie Creek, were used by many parties travelling to the gold fields. Many of these prospectors were also involved in trapping activities in the Bonnet Plume area.

Early travellers were frequently dependent upon local people for transport, guiding and help in emergencies. It is reported that Andrew Flett Bonnetplume, the river's namesake who lived along the river, was a Gwich'in chief and interpreter for the Hudson Bay Company (HBC). Bonnetplume assisted many travelers, who had been caught by winter on the trail to Dawson, and the river was named after him for this reason.

▲ Back to top

Recreation

As the Bonnet Plume flows from the high alpine area of the Mackenzie Mountains to its junction with the Peel River at an elevation 2,000 m below its source, the river passes through a wide range of environments. This tremendous diversity provides for an extensive variety of recreational activities.

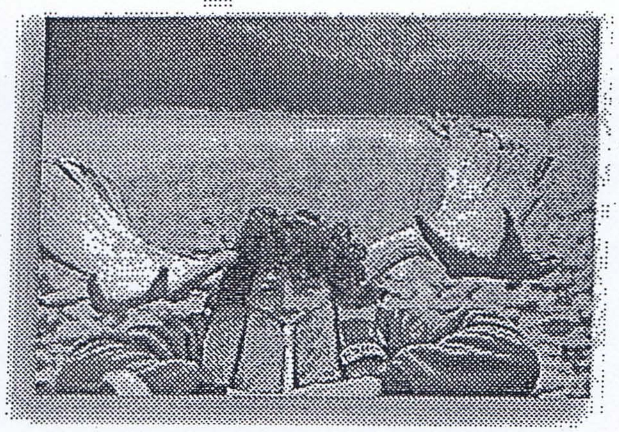
The Bonnet Plume River stands out as one of the premier whitewater wilderness canoe rivers in Canada. It is technically challenging, particularly from just below Bonnet Plume Lake to the junction with Knorr Creek, where Class II and III rapids are frequent with isolated locations of Class IV and V. In fact the river can be considered potentially dangerous, dropping more than three metres per kilometre in the upper reaches. The river trip to Fort McPherson is generally considered only suitable for canoes or kayaks, as potentiel problems with winds and slower current in the longer reaches of the Peel into Fort McPherson, make rafting more difficult. The Bonnet Plume River offers river travellers excellent opportunities for related recreational activities, as excellent camping locations and opportunities for scenic day-hikes, particularly in the alpine areas, are readily accessible from the river.

In the upper reaches of the valley, in the alpine zones and around many of the creeks and small alpine and subalpine lakes, hiking and camping opportunities are superb. Although at lower elevations, in the creek bottoms, hiking is sometimes impeded by thick shrubs or birch and willow growth, ridge hiking and scrambling possibilities in the glaciated summits of the Bonnet Plume headwater area are excellent. As with all wilderness areas of the Yukon, careful attention should be paid to grizzly bear safety when hiking in these areas. Mountain climbing potential is also significant in the area, and peaks such as Mt. McDonald and Mt. Gillespie, in the headwaters along the Yukon/NWT border, present an interesting and rewarding opportunity for climbers.

Opportunities for recreational pursuits focusing on the natural environment, such as wildlife viewing, photography, nature study and scenic appreciation are also significant. Hunting activity has a long history in the Bonnet Plume area, and currently big-game hunting operations attract international clientele. The wilderness qualities of the area emanate from the dramatic scenery of the valley and the special features that create its appeal. Broad, expansive views, a diversity of plants and landforms, interesting landscape formations and extensive wildlife populations provide a remarkable backdrop for wilderness recreational activity.

▲ Back to top

Visitor Information



Access: Access to the headwaters of the Bonnet Plume Basin is by air, either directly from Whitehorse, or through the community of Mayo. Besides returning to these communities, river travellers have the option of proceeding down the Peel River to Fort McPherson, NWT. The typical river trip along the main segment of the Bonnet Plume River itself is suggested to take 7 to 9 days, while the total trip length to Fort McPherson is estimated to be 14 to 18 days. Trip duration is determined by the choice of access points – small lakes adjacent to the river accessible by float plane. Shorter segments are possible but typically do not provide the same range of recreational activity and experience.

Accommodation and Services: Whitehorse (pop. 18,000), is a major centre and capital city of the Yukon, offering a wide range of services. Hotels, restaurants, retail outlets and a full range of outfitting and guiding services, specialty shops and cultural entertainment are all available to the visitor. Whitehorse is easily reached by road or by air from the south, and operates as the base for air charter operations for visitors.

Mayo (pop. < 500), although closer by air to the Bonnet Plume basin, does not offer the visitor the extent of services and facilities available in Whitehorse. Accommodation and basic services such as food, restaurants, camping supplies and fuel, are available. The community has a float plane base and an air strip, but all service is based in Whitehorse.

Fort McPherson is similarly a small community providing only accommodation and basic services to visitors. It is, however, located along the Dempster Highway resulting in road access, as well as regularly scheduled air service from Inuvik, NWT.

Topographic Maps: The Bonnet Plume River is covered by the National Topographic Series 1:250,000 scale maps: 106 B (Bonnet Plume Lake), 106 C (Nadaleen River), 106 D (Nash Creek), 106 F (Snake River), 106 E (Wind River). Maps for the portion of the Peel River from the Bonnet Plume River junction to Fort McPherson are: 106 K (Martin House), 106 L (Trail River), 106 M (Fort McPherson). 1:50,000 maps are not required for river recreation trips.

Maps may be obtained from: Canada Map Office, 615 Booth St., Ottawa, Ont. K1A 0E9 613–952–7000); or Northern Affairs Program, Geological Services, 200 Range Rd., Whitehorse, Yukon Y1A 3V1 (403–667–3100).

▲ Back to top

Further Information

Services, Permits & Regulations: Yukon Visitor Reception Centre, Alaska Highway, Whitehorse, Yukon Tel. 403-667-2915; Yukon Dept. of Renewable Resources, P.O. Box 2703, Whitehorse, Yukon Y1A 2C6 Tel. 403-667-5221; FAX: 403-667-2691.

Tourist Information Accommodation, Air Charters, Outfitters: Tourism Yukon, P.O. Box 2703, Whitehorse, Yukon, Y1A 2C6 Tel. 403–667–5340, FAX 403–667–2634; Tourism Industry Assoc. of the Yukon, 203–208 Main St., Whitehorse, Yukon, Y1A 2A5 Tel. 403–668–3331; FAX: 403–667–7379.

Canadian Heritage Rivers System: Member, CHRS Board, c/o Yukon Renewable Resources (see address above); or, National Manager, Canadian Heritage Rivers System, c/o Parks Canada, Ottawa, Canada K1A 0M5. Tel. 819–994–2913, Fax 819–997–0835. E-mail address: donald_gibson@pch.gc.ca

▲ Back to top

Additional Reading

Brown, Dolores Cline. 1989. Bonnet Plume's Gold. Klein Publishing Company. Mayo, Yukon.

Finkelstein, Max. "Postcards from the Bonnet Plume". Kanawa. Magazine of the Canadian Recreational Canoeing Association. Spring, 1993. Hyde Park, Ont.

Geological Survey of Canada. 1977. Paper 76-8 The Geology of the Bonnet Plume Basin. Yukon Territory. D.K. Norris & W.S. Hopkins Jr.

Madsen, Ken and Graham Wilson. 1989. Rivers of the Yukon: A Paddling Guide. Canada: Primrose Publishing.

Pielou, E.C. 1991. After the Ice Age: The Return of Life to Glaciated North America. Chicago: University of Chicago Press.

Voyages: Canada's Heritage Rivers – Lynn E. Noel, editor. Published by Breakwater Books of Newfoundland and sponsored by QLF/Atlantic Centre for the Environment. Newfoundland orders toll free: 1–800–563–3333, Canadian orders and inquiries outside Newfoundland toll free: 1–800–387–0172, U.S. orders and inquiries toll free: 1–800–805–1083. Discount available from Canadian River Management Society, Tel. 613–824–0410

▲ Back to top

Back to Bonnet Plume River Main Page

YOUR QUESTIONS

Many people wonder what the benefits would be of having "their" river designated to the Canadian Heritage Rivers System (CHRS). Here we try to answer this and other related questions.

What does designation mean?

Designation is the formal proclamation of a river as a "Canadian Heritage River" by the Minister of Canadian Heritage and the equivalent provincial or territorial minister. The river would join an elite group of the most historic and beautiful rivers in Canada, in places ranging from the barrens of the Northwest Territories to the heartland of southern Ontario.

It must be emphasized that designating a river to the Canadian Heritage Rivers System (CHRS) is not an end in itself – it will not automatically bring major benefits to your river or its valley. It is, however, an opportunity to help determine your river's future and to improve the quality of life of people living near it.

With designation comes a commitment by the managing governments to work with "stakeholders" of a river – residents, local governments, landowners, businesses, aboriginal groups and other interested parties – to carry out certain actions contained in a management strategy. The management strategy outlines how the river and its key heritage and recreational features will be managed in the long term.

How could our community benefit financially?

Does designation equal dollars? Not directly. CHR designation does bring recognition and status. The System as a whole is promoted nationally and internationally. Broader recognition of the heritage value of your river valley is an opportunity to market the river. You don't have to, but if you want to showcase your particular river, you can do it better if it is a Canadian Heritage River.

You could also appeal more effectively to future residents as well as to visitors by advertising the particular qualities your river valley might offer as a Canadian Heritage River. These could include it being:

- a clean environment for raising children
- a healthy ecosystem rich in wildlife
- a culturally rich community
- a great place for outdoor recreation
- a prime "ecotouring" area
- a location to set up a business
- a place with a strong sense of community

- a quiet place to retire.

By helping to attract visitors, new residents, money and/or jobs, designation can help to increase employment opportunities in your community's service and retail sectors.

In 1997, it was estimated that the annual economic benefits to Canada attributable to the Canadian Heritage Rivers System totalled some $32 million.

What about non-monetary benefits?

You and your community could benefit from various recreational, cultural and environmental improvements.

Environment: Designation can do a lot to maintain or improve your river's environmental health. Designation requires the managing agency to monitor the river ecosystem and water quality, and to produce after ten years a report that includes information on the state of the river, the integrity of its ecosystem and the status of its natural heritage features. Designation can also provide the impetus to stimulate community involvement in river ecosystem restoration projects.

Recreation: Opportunities for outdoor recreation along a Canadian Heritage River are enhanced, in particular (but not exclusively) water-based types of recreation. The management strategy could encourage facilities for activities that are compatible with the natural environment and scenery.

Heritage Appreciation: As well as protection, education can be an important element of the management strategy. Designation can mean more opportunities for you and your children to learn about your valley's natural and cultural heritage including your own particular traditions and culture.

Preservation of Historic Sites: Publicity surrounding designation could generate the support needed to get your community involved in saving some of the fine old buildings near the river. The management strategy could help ensure that ancient aboriginal sites and key elements of the valley's "cultural landscape" are respected and protected.

Community Development: The process of preparing a management strategy and then implementing it requires that stakeholders along the river are consulted on what should be done. Public involvement allows planners to learn of people's concerns and gives stakeholders a real voice in the future of their river. It also helps to develop a sense of ownership, responsibility and community among those whose lives are affected by the river.

What's in it for the river?

Initially, the river may benefit from monitoring and conservation measures taken by government agencies. This is just a start, however, and the river will benefit more in the long run if local residents and other stakeholders become the "stewards" of the river. Appreciation of the river by its resident community is the best way of ensuring long-term protection.

Co-ordinated River Management: The process of preparing a management strategy focuses on the heritage and recreational values of the river and its valley. It is not a general land-use plan. The strategy serves to draw together all parties interested in the river's heritage and recreation to work together to a common end. These stakeholders include not only local residents, interest groups and river users, but also government agencies having environmental, heritage or recreational responsibilities. Coordinating the planning and management activities of these agencies inevitably results in better co-ordination of existing programs, in reducing conflicts among different river users and in creating more effective new programs for the river.

Greater Environmental Protection: Designation is an opportunity for not only the lead provincial or territorial agency, but also for local governments to adopt policies that will enhance protection of the river. Measures could include green space zoning of river banks or property tax rate adjustments to encourage stewardship of private lands. Local residents might be supported in setting up a "river watchdog network" or hotline. It is also a chance to address specific environmental issues on your river such as vegetation destruction, bank erosion, garbage, floodplain urbanization or fish stock depletion, as well as enforcement measures for resolving these.

Water Quality Improvement: All of the features for which a Canadian Heritage River is nominated must be monitored. The one feature that is probably most closely watched is water quality. Monitoring programs on water quality have been started or upgraded on a number of Canadian Heritage Rivers as a direct result of their designation.

Focus for Government Programs: Many federal and provincial government programs can affect the heritage and recreational features of a river (perhaps too many in the view of some). These include environmental research, water quality monitoring, tourism development, fishery enhancement, reforestation, wildlife studies, and so on. Each government agency needs criteria to select areas for their programs. Government agencies can, and have used the designation of a Canadian Heritage River as a deciding factor in choosing where their programs should be located.

How might I benefit personally?

There are many different ways in which you could personally benefit from CHRS designation. Common improvements to heritage rivers in densely settled parts of Canada include a healthier environment, cleaner water, scenic and aesthetic improvements, more opportunities for recreation and heritage appreciation, better and more sustainable business opportunities, easier resolution and prevention of conflicts over water use. Each of these brings benefits to all individuals in a river valley.

On rivers in remote areas, wilderness values can be preserved for solitude and spiritual renewal, and cultural pride can be promoted, particularly for aboriginal peoples. As well, some business opportunities could be created, most often in outfitting, guiding and local arts and crafts.

Designation will benefit individuals differently according to their occupations, where they live, and what they value most. The range of benefits that could accrue to any one individual or to a community is not easily predicted. Having input on how your river is managed, however, allows you to "tailor" the benefits of CHRS designation to some extent.

But our river is fine as it is!

It may be hard to believe, but your river valley will change within your lifetime. You can be sure that a river, even if it is in a park or other type of protected area, is not immune to external threats. Designation to the Canadian Heritage Rivers System is no guarantee against these threats, but it is often your best opportunity to help secure the future of your river, by minimizing undesirable changes and helping ensure that the changes which do occur are beneficial.

Is there a downside to designation?

People are sometimes concerned that designation will curtail landowner rights and freedoms, or restrict development, or cost taxpayers money, or attract too many people and with them problems like trespassing and vandalism. Here are some responses to those concerns.

Landowner Rights and Freedoms: To date, all protective actions on Canadian Heritage Rivers have depended on enforcement of existing laws and regulations, and on the voluntary actions of stakeholders. Experience has shown that effective management of a designated river can only be achieved with landowners' involvement in decisions and their willing stewardship of their properties. Even non-participating landowners benefit from environmental improvements through higher property values.

Restrictions on Development: The primary goal in managing a Canadian Heritage River is to protect the heritage features for which it was included in the System. This means that timber harvesting, mining and other industrial activities can continue so long as they do not affect these heritage features. Potentially damaging developments within the management area may be restricted by local or other government authorities, while sustainable and complementary developments, such as certain recreational facilities, may be encouraged. Through this type of sustainable development, the community as a whole benefits in the long term.

Costing Taxpayers' Money: Co-ordinated planning is actually a more efficient way of using taxpayers' money. Some up-front expenditures on planning and public involvement reap far larger long-term benefits by ensuring that public funds are not spent on overlapping, conflicting or unpopular programs. In many cases, implementing programs will depend on volunteers, often attracted by the national recognition given to a river by its designation.

Trespassing and Vandalism: There is no evidence that these problems have increased on a Canadian Heritage River. In fact, the status that comes with designation, together with community involvement and civic pride, discourage these types of behaviour. Such problems might occur where tourism increases substantially. But even then, mechanisms established through designation can help, such as controlling public access to the river, directing visitors to specific locations, education programs and promoting codes of personal conduct.

Increased Government Interference: Nominating agencies retain their general legal jurisdiction over lands along designated rivers. As designation is not legislated by the federal government, an additional layer of bureaucracy is not created. In any case, governments in Canada can no longer afford to become directly involved in more land resource management and fewer still can acquire property. That is why many of the benefits described here depend on the voluntary participation of local residents and other stakeholders.

How Does a River Become a Canadian Heritage River?

The objective of the Canadian Heritage Rivers System (CHRS) is to include rivers that represent the best examples of Canada's river heritage, and to ensure that these rivers are managed so that their heritage values are recognized and conserved.

The driving force behind Canadian Heritage Rivers is people. When a community or a group expresses interest in having their river designated as a Canadian Heritage River, they approach their Canadian Heritage River board member(s) armed with information documenting the outstanding values of the river and demonstrating that there is plenty of community support. If the river appears to meet Heritage River criteria, the government with jurisdictiion over the river prepares a background study. As the first step in the process, background studies collect all available information, including field verification, on a river's natural and cultural heritage, its recreational opportunities, and issues that could affect its management as a Canadian Heritage River. If the background study indicates that the river does indeed meet CHRS guidelines, the next step is the preparation of a Nomination Document.

The Nomination Document highlights the outstanding natural, cultural and recreational values of the river and how those values could be protected or enhanced. It is presented to the Canadian Heritage Rivers Board for formal review. The Board then recommends to the Minister of Canadian Heritage and the appropriate provincial or territorial minister, whether or not a river meets CHRS criteria and if it should be considered for inclusion in the System.

Before designation, a management plan, or heritage strategy, must be submitted to the Board that describes the management area and the policies and actions to be put into place to fulfill CHRS objectives. This document is reviewed by the Board to ensure that there is a commitment to manage the river so that its heritage values are not degraded.

Once the plan is accepted by the Board, and the designation approved by Ministers, the next step in the process is the plaque unveiling ceremony to commemorate the formal inclusion of the river in the CHRS. This, however, is not the end of the CHRS process. Yearly status reports must be submitted, on the condition of the river, and every ten years a "State-of-the-River" Report must be submitted to the Board.

If you have any other questions about what CHRS designation can do for your river, call the CHR Board Secretariat (819-994-2913), Parks Canada (819-953-9497) or your local

New Parks North

English
Français

March 2001

Government of Yukon
Canadian Heritage Rivers

Bonnet Plume River

Flowing out of the Wernecke Mountains in the central Yukon, the Bonnet Plume cuts through unglaciated mountain peaks and canyons exposing veins of silver and zinc. This arctic landscape abounds with woodland caribou and grizzly bear dens; its habitat home to a host of rare plants. The valley of the Bonnet Plume was a traditional hunting and travel area for Gwich'in and represents their heritage in its natural state. The remote and little traveled Bonnet Plume, designated in 1998, provides one of the best wilderness adventures to be found in Canada. The Bonnet Plume is the only northern river in the Canadian Heritage Rivers System (CHRS) to date that includes its entire watershed (an area of approximately 12,000 km^2) in its management area. The *Wilderness Tourism Licensing Act 1998* will help preserve the uncrowded and pristine character of the Bonnet Plume.

Trip report data will be used in the long term planning and management of the watershed to ensure sustainable use. In accordance with the CHRS Bonnet Plume River Management Strategy, work on baseline habitat inventories, wildlife population census, fish populations, and classification of vegetation and identification of rare plants is being carried out in the watershed. This work will ensure that data is available to complete the five-year plan review.

New Parks North

Canada
Northwest Territories
Yukon Government
Nunavut
Canadian Parks and Wilderness Society

GOVERNMENT OF YUKON • CANADA

Yukon Government

FOR RELEASE #145
July 17, 1998

BONNET PLUME RIVER OFFICIALLY DEDICATED AS A HERITAGE RIVER

WHITEHORSE – Federal, territorial, municipal and First Nations governments, along with conservation organizations, industrial groups and the Mayo Renewable Resources Council have been invited to Waterfront Park in Mayo this Saturday for the official dedication ceremony to designate the Bonnet Plume watershed as Canada's newest Heritage River.

The Bonnet Plume was nominated for Canadian Heritage River status in 1992 after studies carried out in the 1980s identified a number of unique aspects of the area. This led to the nomination of the entire watershed rather than the main stem of the river.

The watershed covers 12,000 square kilometres and extends almost 350 kilometres from the river's headwaters along the Yukon – Northwest Territories border to where it joins the Peel River. It supports large, healthy populations of grizzly bears, wolves, moose, gyrfalcons and woodland caribou and is largely unaltered by human activity.

The steps to designate the river began with the Nacho N'y'ak Dun First Nation Final Agreement. The Canadian Heritage Rivers Board recommended the designation after accepting a management plan developed for the river. The recommendation was then accepted by the Ministers of Canadian Heritage, the Department of Indian Affairs and Northern Development and the Yukon Department of Renewable Resources.

The plan commits the federal, territorial and First Nation governments to a co-operative management approach and confirms the role of the Mayo Renewable Resources Council as a forum for local input into plan implementation and decision making.

The Bonnet Plume joins the Alsek River and the "Thirty Mile" section of the Yukon River in the Canadian Heritage Rivers System.

The Yukon portion of the Tatshenshini River will be the next river to be designated for heritage river status. Its nomination document was accepted by the Canadian Heritage Rivers Board on June 7 and work is now in progress to develop a management plan.

- 30 -

Dennis Senger
Communications
Renewable Resources
(867) 667-5237