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Influence of Length of Haulage Distances on Potential Development of Granular Resources

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4A Geography
May 10, 2004

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Mr. B. Lumsden, Director
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University of Waterloo
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Dear Sir:

This report, entitled "**Influence of Length of Haulage Distances on Potential Development of Granular Resources**" was prepared as my 4A Work Report for Indian and Northern Affairs Canada's Lands Program. This is my fourth work term report. The purpose of this report is to evaluate the influences of length of haul distances using aspects from the Economic Optimal Haul Distance model.

Indian and Northern Affairs Canada is responsible for development and management for resources and communities.

The Land Program, in which I was employed, is managed by **Bob Gowan** and is primarily involved with management of granular resources for the northern territories.

This report was written entirely by me and has not received any previous academic credit at this or any other institution. I would like to thank Bob Gowan for providing me with valuable advice and resources, including documentation and leads to informative web sites. I would also thank Steve Rozak for assisting me with QuikMap software and digitizing help. I received no other assistance.

Sincerely,

Leo Lau
ID 00129130

Summary

This report discusses the influence of length of haulage distances on potential development of granular resources along the Mackenzie pipeline in the Inuvialuit Settlement Region (ISR). It is important for granular resource managers to understand the decision making process in determining the locations of borrow sites and amounts of granular material extracted. This will allow managers to plan ahead to ensure future developments will have granular resources available. The Economic Optimal Haul Distance (EOHD) model is discussed to evaluate the economics and factors involved in determining the materials available for each portion of the pipeline. Factors such as management, planning, design, site development, extraction, operation, pipeline and post-extraction contribute to the EOHD model.

An evaluation of the optimal distance between two deposits and critical supply areas of the pipeline are studied in depth. These results are displayed in the Appendices in table and map form. There are two critical areas along the pipeline but due to external circumstances, these areas are not seen as problematic. Analysis of the granular deposits and types in the Inuvialuit Settlement Region is provided.

It is recommended that an in depth study of the EOHD model should be conducted and applied to the entire pipeline. A computer application could quicken the data acquisition for analysis and reduce the chance of error.

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1.0 Introduction

Granular materials are vital resources for construction purposes in the Arctic. Management of granular materials is imperative to ensure present reserves are used to its full potential and properly allocated to prevent wasted resources. Short term and long term demand forecasting allow managers to estimate quantity and class of granular material required for future development. Decisions on what resources should be allocated to which projects are more complex. Many factors must be taken into consideration such as location, climate, terrain, materials, competing demands, and cost. Linear projects, such as roads or pipelines, which need large amounts of granular material from many sources, require similar considerations.

This report will attempt to explain the influence of length of haulage distances on potential development of granular resources along the Mackenzie pipeline in the Inuvialuit Settlement Region (ISR). Pipeline proponents will be seeking development approvals for a series of "borrow sites" that they have selected from known resources, based on material quality and development economics. Critical to the economics is the optimization of the balance between the initial costs of "opening" a site for the development, and minimizing the costs of haulage along the pipeline corridor. While it is the responsibility of the proponent to develop a granular materials plan that will optimize haul distance for their project it is also important that resource managers understand the significance of the hauling distances of all the granular resources within the study area.

For each potential source of any given type of granular material one could determine both the length of the pipeline that could be serviced from that source and also the length of an economically viable "haul zone" based on the anticipated costs of pit development.

Granular resource haul "zones" that overlap one another are positive because the segment of the pipeline does not completely rely on one source, minimizing competition for aggregates with other projects that may exist. Haul zones are critical when the pipeline possesses (few or) no overlap. Granular resources managers will focus their attention on potential resource demand conflicts in these critical areas.

1.1 Methodology

Background information of the study area and pipeline will be discussed. The descriptions for each type of granular class are outlined to illustrate the Indian and Northern Affairs classification system for granular materials. A methodological overview explaining the methods taken to plan and develop granular deposits will be established.

Management, planning and design, site development, operation expenses, pipeline and post extraction sections will familiarize the factors that are incorporated to the entire granular pit operation from beginning to end. These factors are later used in the economic optimal distance model. This information is provided from a vast source of engineering reports and personnel from the Indian and Northern Affairs Canada (INAC) Land and Waters Program.

Geographic information systems (GIS) will be employed in this study to evaluate which granular deposits reside within 15 km of the proposed pipeline route where the 15km buffer contains three 5km sections. A detailed GIS methodology of digitizing the required shapefiles and geoprocessing is located in Appendix A. The granular deposits are analyzed by different classes and distance from the pipeline. The total volumes of each deposit will be investigated to determine maximum coverage of pipeline.

A preliminary model will be discussed to attempt to evaluate the Economical Optimal Haul Distance (EOHD). The model will attempt to determine the optimal haul distance between deposits. A formula will be derived to determine the optimal haul distance and the model will be tested using deposits within each of three buffer zones along the pipeline: the 0-5km, 0-10km and 0-15km. All aspects will be discussed with diagrams for easier comprehension.

2.0 Background Information

2.1 Inuvialuit Settlement Region

The Inuvialuit Settlement Region is based primarily on the Mackenzie Delta. The Mackenzie Delta is a flat to hummocky deltaic plain comprising a large number of lakes and channels. It is composed of a mixture of unconsolidated Pleistocene and Recent deposits. The Pleistocene deposits include morainal (till-like) materials, glaciofluvial sand and gravel (outwash and kames) and glaciolacustrine sediments, which overlie pre-glacial deltaic sands. The recent deposits include fine-grained alluvial, organic, marine beach, and lacustrine sediments, however, some tributary channels contain coarse alluvial material (sand and gravel). Flat topography is characterized by small beaded creeks which flow between the lakes; seepage often occurs along ice-wedge trenches which are characteristic of polygonal ground. On gentle slopes drainage tends to occur as seepage along fen-filled valleys with no definite channel. Where definite channels exist the adjacent alluvial terraces often have standing water at the surface.

Although the Mackenzie Delta – Beaufort Sea region has oil discoveries totaling 1.0 to 1.5 billion barrels and gas discoveries of 12 trillion cu. Ft., development has not yet occurred. However, there have been considerable development planning, engineering, regulatory and environmental reviews (North of 60 Engineering Ltd., 1993).

There are six trillion cubic feet of natural gas that has been discovered at these three main sites of the Mackenzie Delta. In 1971, large gas deposits were in the Taglu area of Richards Island by Imperial Oil Ltd., 3.0 trillion cubic feet, and in 1972 in the Parsons Lake area by Gulf Canada Ltd., 1.8 trillion cubic feet (Imperial Oil, APG, ConocoPhillips, Shell Canada, Exxon Mobil 2003). In 1973 Shell Canada Ltd. made several oil and gas discoveries in the Niglintgak, 1.0 trillion cubic ft (North of 60 Engineering Ltd., 1993).

2.2 Mackenzie Gas Pipeline Project

The pipeline Proponents plan to build a buried pipeline, 1420km long, from the three anchor fields, Parsons Lake, Niglintgak, and Taglu, on the Mackenzie Delta to northern Alberta. The pipeline in the Inuvialuit Settlement Region serves as a relay to move natural gas and natural gas liquids from the three natural gas fields to the liquids separation facility near Inuvik (Imperial Oil, et al, 2003). A compressor station will also be stationed near Inuvik to bring the natural gas to the required temperature to enter the main Mackenzie Valley Pipeline south of Inuvik. The Proponents plan to be pumping gas down the Mackenzie Valley by 2008 (Imperial Oil, et al, 2003).

2.3 Required Amount of Granular Material

According to Kaustinen, it would take approximately 5.5 million m³ granular resources for the entire 2120 km stretch of the Mackenzie Gas Pipeline (North of 60

Engineering Ltd. 1993). The chart below illustrates the amount of granular resources needed at a particular segment on the pipeline. These figures are out of date because publications from the Pipeline Proponents have stated that the pipeline will be 1420km in length. However, these figures will be used to determine pipeline fill dimensions, which will be discussed later.

Granular Requirements for a 36" Pipeline
Table # 1

Spread #	Length Km	General Fill m^3	Pipe Protection m^3	Aggregate m^3	Total m^3
1	210	432,840	345,585	948	794,845
2	245	674,806	331,207	1,228	1,054,443
3	250	539,338	321,863	32,780	931,002
4	260	571,607	342,556	62,025	1,020,739
5	275	278,318	318,104	47,956	662,904
6	395	262,217	216,467	44,740	566,105
7	485	237,263	184,610	35,464	495,957
Total	2120	2,996,389	2,060,392	225,141	5,525,995

Source: North of 60 Engineering Ltd. 1993

The amount of granular material required to construct the pipelines and facilities is being studied. Initial estimates indicate that about 5.5 Mm^3 of granular material might be required for use in constructing:

- well-site and production pads
- facility sites
- camp sites
- stockpile and staging sites
- barge landing sites
- airstrips
- access roads
- pipeline backfill in designated areas

Bedding, berm and fill dimensions are needed to calculate the amount of granular material and class type for each meter of pipeline. Approximately, 655280 m^3 of granular material must be extracted to cover the 176km of pipeline in the ISR. These figures are derived from Kaustinen's table above.

794845 m^3 / 210000 m = 3.78 m^2 of granular material per meter of pipeline.

According to the equation, it is determined that 3.78 m^3 of granular material is needed for one meter along the pipeline.

3.0 Granular Resources Availability

3.1 Classification of Granular Resources

In 1983, INAC created a classification system for all borrow material classification to be carried out under the current contract. Materials at prospective borrow sources have been graded into one of the five following classes:

Class 1 – Excellent Quality Material

Excellent quality material consisting of clean, well-graded, structurally-sound sands and gravels suitable for use as high quality surfacing materials, or as high quality asphalt or concrete aggregate, with a minimum of processing.

Class 2- Good Quality Material

Good quality material generally consisting of well-graded sands and gravels with limited quantities of silt. This material will provide good quality base, sub-base and surface course aggregates or structure-supporting fill. Other uses are winter sand backfill for trenches, slabs and pads for structures. Production of concrete aggregate may be possible with extensive processing, except where deleterious materials are present.

Class 3 – Fair Quality Material

Fair quality material consisting generally of poorly graded sands and gravels with or without substantial silt content. This material will provide fair quality general fill for roads, pads for equipment or lay-down yards.

Class 4 – Poor Quality Material

Poor quality material generally consisting of silty, poorly-graded, fine-grained sand with minor gravel. These deposits may also contain weak particles and deleterious materials. These materials are considered suitable for marginal general (non-structural) fill.

Class NG - Non-Granular Material (Bedrock, Felsenmeer and Talus)

Bedrock of fair to good quality, felsenmeer or talus. Potentially excellent sources of construction material, ranging from general fill to concrete aggregate or building stone if quarried and processed. Also includes erosion control materials such as rip-rap or armour stone. Also included in this class are silt and clay material, which is generally unsuitable for construction purposes.

3.2 GIS Analysis of Granular Resources Availability

Granular sources within the study area from a report by Hardy BBT Limited were digitized and analyzed. Geoprocessing determined 90 granular resources resided within the 15 Km pipeline buffer. The 15 Km buffer was used because in a previous similar study conducted at INAC pertaining to the "Developmental Constraints of Granular Resources for the Mackenzie Gas Project within the Gwich'in Settlement Area" by Alex Cicuttini, also used a 15 Km buffer. The number of deposits in each granular type is shown in the table below.

Number of Deposits in Each Granular Class

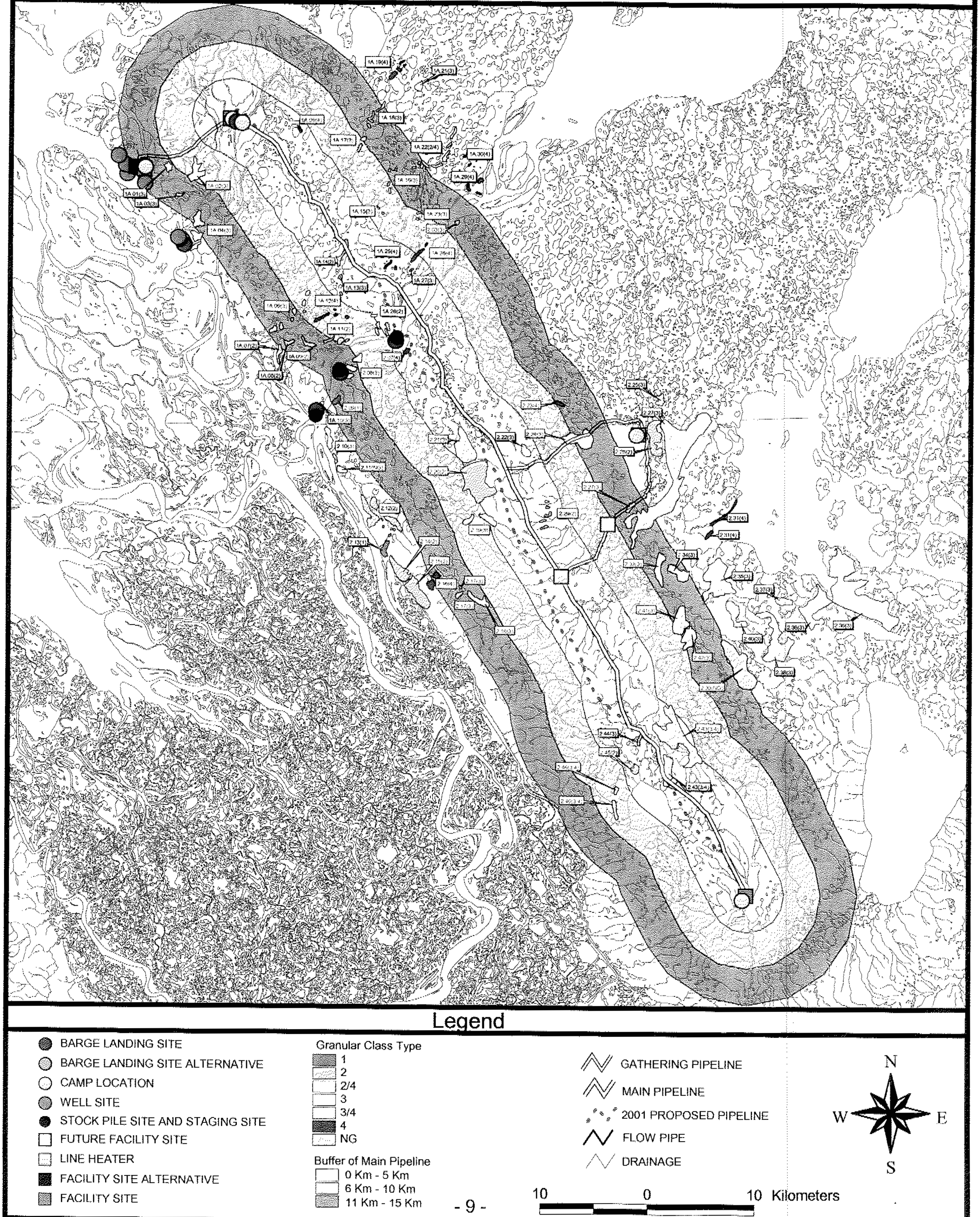
Granular Class	0-5 Km	6-10 Km	11-15 Km	Total 0-15 Km
1	-	-	1	1
2	12	2	4	20
2/4	-	-	4	4
3	7	13	27	47
3/4	2	2	-	4
4	5	5	3	13
NG	-	-	1	1

Table 2

Deposits that were touching the outer 15 km buffer zone are also included in the analysis to allow options to be available. In Appendix B, the each individual source is identified by the buffer zone they are located within and landform type. Figure 1 illustrates all the deposits in the study area. A large version of this map and a detailed overview of each section (northern, mid-section and southern) have been created and are located in Appendix C.

Had further information been available regarding the proposed Mackenzie Valley Pipeline, then further analysis would have been undertaken to determine the extent to which existing sources can satisfy pipeline needs. In the absence of this, all further analysis has considered only the total volume of material available and not material quality. Should better information on pipeline needs for each specific quality classification become available, the following analysis could be refined to take that into consideration.

Figure 1:Mackenzie Pipeline in Inuvialuit Settlement Region with 15 Km Buffer



4.0 Factors Controlling Resource Development

4.1 Management, Planning and Design

The initial phase of granular deposit development is to determine the economic feasibility of the operation. The deposit will not be considered for development if costs of management, planning and design exceed the value for the deposit.

Extraction may be limited to winter operations due to environmental reasons, but this may also be more economically viable than a year round operation. The pipeline construction time period is scheduled for four months, approximately 120 days. Planning the amount of granular material extracted during the construction period allows managers to decide whether more or less equipment and resources will be needed for the operation. If the deposit were near a large facility with large infrastructure that required large amounts of granular material, then a year round operation would be considered feasible. Pipeline operations where granular deposits isolated away from large facilities do not need as much granular material.

4.1.1 Granular Resource Forecasting

Proper management of granular resources ensures long term use of resources by minimizing wasted materials. Short (five-year) and long (twenty year) term forecasting are employed to determine quantity of granular material from deposits and evaluating potential future project demand. Each project is typically assessed by the year, type of project, amount of material and material type (Class 1, 2, 3, etc.). Types of projects can range from airport runways, building development, highway construction and maintenance. Feasibility studies must be conducted for larger projects such as highway construction require considerable amounts of granular resources.

There are discussions whether the construction of a highway from Inuvik to Tuktoyaktuk is feasible. The proposed highway is approximately 143 Km long and requires in total 8,005,000 cubic meters of granular material from the Inuvialuit Settlement Region. There are several deposits planned to be used for the Inuvik-Tuktoyaktuk highway project (Hardy BBT Limited, 1991).

4.2 Site Preparation & Development

Site preparation should be conducted in advance of excavation to prevent contamination of granular materials. This preparation also should preferably be carried out in winter to minimize disturbance to the surrounding terrain. Snow should be cleared from both the area to be excavated and the yard areas and placed so as to minimize subsequent pit infilling by drifting snow. Topsoil consisting of peat and organic soils, while typically scarce, should be stripped where possible and stockpiled or windrowed at the edges of the pit area. Windrows should be placed parallel to slop direction to prevent ponding of surface water during spring, or contamination of granular materials. Inorganic overburden materials should be stripped and placed in separate stockpiles windrows, with similar consideration for drainage considerations. The stripped materials are to be reserved for rehabilitation purposes. Disturbed areas must be kept to a practical minimum (EBA Engineering Consultants Ltd., 1987).

4.2.1 Overburden Thickness

The overburden thickness of a site is an important issue when determining cost of development. If the overburden is too thick, the cost of removal will make borrow site development unprofitable. Overburden is material, usually fine-grained or organic, overlying a granular deposit. Overburden must be removed before the granular material can be extracted. It is usually scraped off and stockpiled on the side of the deposit. It will be used to cover the borrow site after it is depleted. This will help restore the site to pre-development levels (Hardy, 1986).

4.2.2 Initial Capital Expenses

A report conducted by Hewitt in 1984 described the average capital cost of $1,580,000 for equipment such as front end loaders, bulldozers, dump trucks, generators, jaw crushers, conveyors, etc. for a typical Northern operation. It would be a 72.8% change and a cost of $2,730,098 in 2004 by using the inflation calculator from the Bank of Canada to determine the present cost.

Royalties are to be included with the cost of development. Royalties are a fee paid to the land owner based on the amount of material taken. As there are two main land owners, there are two types of royalties, Crown and private. On Crown land, higher royalties are paid for higher quality granular materials. Royalties for granular materials from private (Inuvialuit) lands are generally higher those for Crown lands.

4.3 Extraction

4.3.1 Extraction Methods

Various methods can be employed to extract granular materials. In northern Canada, methods used depend upon the ice content of the material. If ice content is high, blasting or ripping will be required to free the material (EBA, Volume1, 1974). Winter recovery operations will normally consist of the ripping of friable frozen granular material and pushing to temporary windrows or stockpiles for loading. This type of extraction can be conducted with conventional equipment including bulldozers with rippers, loaders, and trucks. Poorly-bonded or friable granular material will usually be located near the surface of deposits that exhibit positive relief. If an insufficient volume of material cannot be obtained through ripping, blasting will be necessary (EBA Engineering Consultants Ltd., 1987). Once free, the material is stockpiled over a summer to thaw it and then it is processed. Since the stockpiled material is not useable until after the summer, transportation is usually done during the winter (EBA Engineering Consultants Ltd., 1987).

If ice content is low, conventional extraction methods are employed. This indicates the application of bulldozers, backhoes, and trucks to extract material and transport it off site. Material that does thaw can be transported as soon as it is processed. For bedrock deposits, blasting, quarrying, and crushing is required before the material is transported. This material type is preferred because there is less cost for extraction and processing, as well as material can be used immediately instead of waiting till the summer for the material to thaw (EBA, Volume1, 1974).

4.3.2 Annual Recoverable

Continuous permafrost extends to a depth of approximately 1,800 feet below ground surface encompasses the Inuvialuit Settlement Region. The active layer is the soil above the permafrost that freezes and thaws with the season. This layer is thicker in the southern areas than in the far north. The organic layer and active layer act as insulation that keeps the underlying permafrost frozen each summer (MacLaren Plansearch 1982).

A factor to take under consideration for granular extraction is annual recoverable amount of material. There are set amounts of thawed aggregates that can be extracted before reaching frozen granular resources. Each summer, the climate thaws a particular depth on the surface of the deposit while the deeper region remains frozen. After stripping the active layer, the frozen region is now exposed from the surface. In the following summer, the frozen region is thawed and now becomes eligible for extraction. This cycle repeats until the deposit is depleted or not possible for any further extraction. Determining the annual recoverable depends on the size and formation of the pit. Also, evaluating ice content may provide an estimate of annual recoverable.

Ice content is an estimate of the likely ice content within the material based upon inference, and where available results of test pitting and drill holes. Data is presented in a semi-quantitative form indicating percentage of visible excess ground ice by volume, as follows: None = 0% visible excess ice or unfrozen

Low = less than 10% visible excess ice

Medium = 10% - 30% visible excess ice

High = greater than 30% visible excess ice

The cycle of operation is largely dependent on the rate of thawing, and the drainage considerations. This method allows potentially greater annual recovery by progressively increasing the amount of thawed material, and it may enhance drainage of the material in stockpiles or windrows (EBA Engineering Consultants Ltd., 1987). However, excessive thawing is problematic due to flooding and pumping water out of the pit would be required and greater operation costs will be incurred.

4.3.3 Loading

In order to move large volumes of material, the 58 tonne trucks must be loaded with minimum delays. It is unlikely that conveyor systems would be used because of their limited flexibility. Trucks would likely be loaded with large rubber tired loaders having lifting capabilities of 18 to 20 tonnes and bucket sizes of $10m^3$. These loaders can fill a 58 ton truck in 3 to 4 passes. Regardless of loading haul distance, this operation would normally take less than 10 minutes (Hewitt, 1984).

4.3.4 Operation Expenses

Equipment upkeep and repairs will be ongoing cost factors. Fuel is an essential expense to power generators for camp facilities and the gravel operation. It is also needed to power machines to extract, process, and transport material.

4.3.5 Post-Extraction

After the operations to fill the pipeline are completed, decisions of whether the gravel operation will be still used in future projects or permanently closed. Easier rehabilitation of a pit can be conducted with proper pit planning and development. Also, the economical and environmental costs would be a lot less than mismanaged pit developments.

If the pit is temporarily abandoned when it still contains usable material, the working face of the pit should be left open for future operators. Restoration steps to be taken for temporary abandonment include clean up, drainage and erosion control. If the pit area is to be abandoned, clean up, drainage and erosion control are also required as well as recontouring, overburden replacement and revegetation.

4.4 Access Roads

Access roads connect the granular deposit (source) to the development project, in this case the pipeline (destination). The short term extraction operation for this portion of pipeline will consist of one season, 120 days so there will not be any construction of permanent access roads. Temporary access roads will be created and these cost substantially less than permanent roads. These roads will be more rugged and less developed to reduce disturbance of the environment. However, the result leads to less productivity from cautious driving.

Ideally, borrow sources would be located along the pipeline route, so as to minimize the length of access roads. In reality the length of access roads is a critical factor in borrow site planning. The cost of haulage represents a major portion of cost of the delivered granular material. Each truckload of material will have an initial cost associated with the length of access.

5.0 Model & Analysis

5.1 Economic Optimal Haul Distance Model

This section will define the properties of the EOHD model to consider factors and influences that affect zone distances. An EOHD is the optimum distance where it is economically feasible to transport a good before the expenses exceed the cost of the good. The diagram below illustrates the EOHD model.

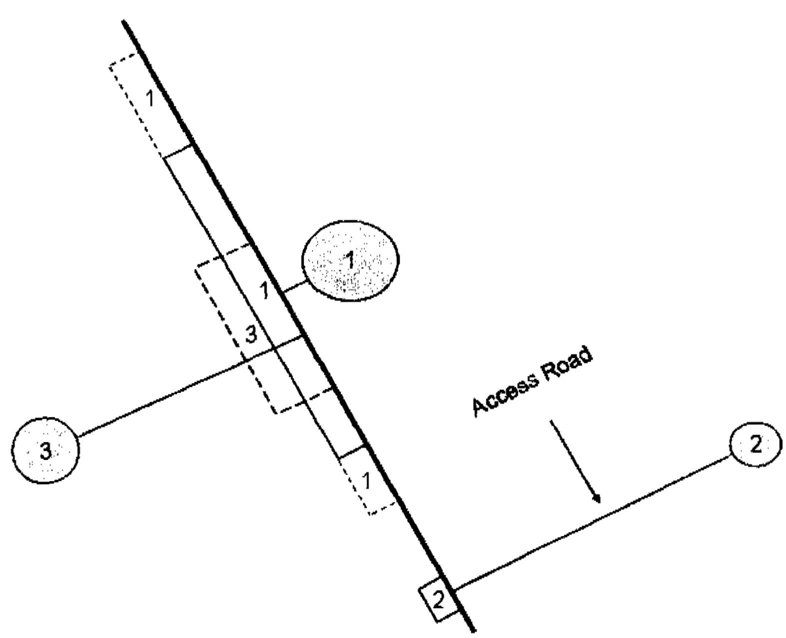


Figure 2: Economic Optimal Distance Model
Note: This figure is for illustrative purposes only and is not to scale

The circles on the figure symbolize granular resource deposits. The deposits on the diagram represent varying proximities from the main pipeline (bold line). Deposit #1 is large and very close to the pipeline and this means the deposit has an abundant supply of granular materials, long term operations, greater pipeline coverage and transport costs are relatively low. As illustrated in the diagram, the haul zone of deposit #1 is larger and closer to the pipeline than deposits #2 & #3. Large borrow pits in close proximity to the construction project would limit disturbances to a localized area and are usually preferred to a series of small developments which effect a disturbance over a wide area (EBA Engineering Consultants Ltd, 1974).

Deposit #2 is small and this suggests a short term operation and the distance to the pipeline is far so transport costs are higher and less pipeline coverage. The haul zone for Deposit #2 covers a small distance on the pipeline. The cost of developing the access road, granular operation, transportation and maintenance are factors that do not make the deposit economically viable to extract.

Deposit #3 is fairly large and it is in close proximity to Deposit #1 but the deposit is further away than Deposit #1. However, the value of the deposit exceeds the development cost and this validates the deposits viability. Deposit #3's haulage zone overlies Deposit #1's haulage zone and this would allow the two haul zone distances to expand. The diagram displays in red the new potential haulage zone when the two deposits overlay each other.

This model is complex to determine because of numerous factors such as deposit properties, size, access road, planning, design, development, maintenance, transport, and post-extraction. Basic assumptions could be made to provide an estimate for the costs. An overview of the EOHD model will be conducted instead of an in depth study because of the complexity and lack of information. Two different approaches to use of the EOHD model will be considered: potential and optimization.

The Resource Potential approach focuses on the volume of granular material available at a deposit and determines how much of the pipeline requirements could be covered by each deposit. There are three aspects that are involved in the potential approaches section, total volume, annual recoverable and volume confidence.

The Resource Optimization approach deals with factors such as access road distance, haul speed and the site development costs. Assembling all these factors and other would create the main frame work of the EOHD model.

5.2 Potential Approach

5.2.1Total Volume

The maximum length of pipeline covered from each deposit was determined by examining the volume of material available at each deposit. Reports from various engineering companies provided "proven", "probable" and/or "prospective" volumes for each deposit. Material volumes were not recorded for several deposits while other deposits only had total volume. For this study, probable volumes were used wherever possible since this provided greatest availability and consistency.

"Probable" resources are granular material whose existence and extent has been inferred on the basis of several different types of direct or indirect evidence including topography, landform characteristics, air photo interpretation, extrapolation of stratigraphy, geophysical data and/or limited sampling. Additional investigation is required to determine a reliable estimate. The volume is estimated by projecting the known parameters over the entire deposit, while adjustments are applied for drainage conditions and the erratic nature of some deposits (Hardy BBT Limited, 1991).

The probable volume of the deposit is divided by the cubic volume of granular material needed per meter (3.78 m^3) of pipeline (see section 2.4) to determine the length of pipeline to be covered. The tables in Appendix D describe each deposits probable volume, total volume, source report, and kilometers of pipeline covered. The volumes from Appendix D were placed to the corresponding deposits in Appendix E4. Appendix E4 is the final table where all ineligible deposits were removed. Figures 2, 3 and 4 display pipeline coverage of deposits from 5 Km, 10 Km, and 15 Km. These values are derived from Appendix E4. Larger maps of the figures can be found in Appendix F.

Coverage zones for each deposit tend be high since most of the values used are probable and total volumes. The majority of the deposits contained enough material to supply the entire pipeline study area. However, there are a few areas along the pipeline where critical zones exist. The critical zones along the pipeline are noted on the following figures and maps in Appendix F. These zones are determined by examining the overlapping pipeline coverage and note areas with few overlaps.

Figure 3: Pipeline Coverage of Deposits within 0-5 Km

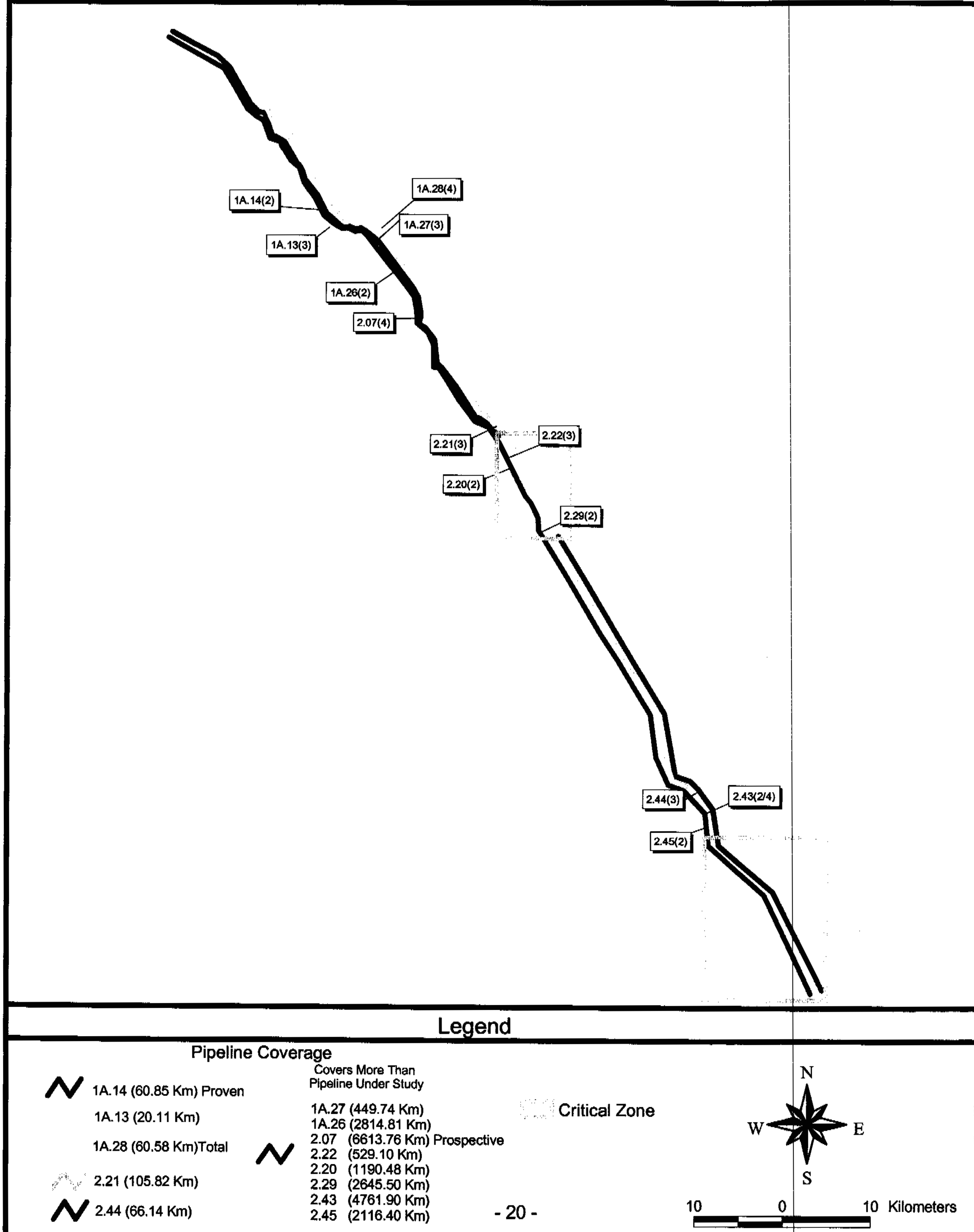
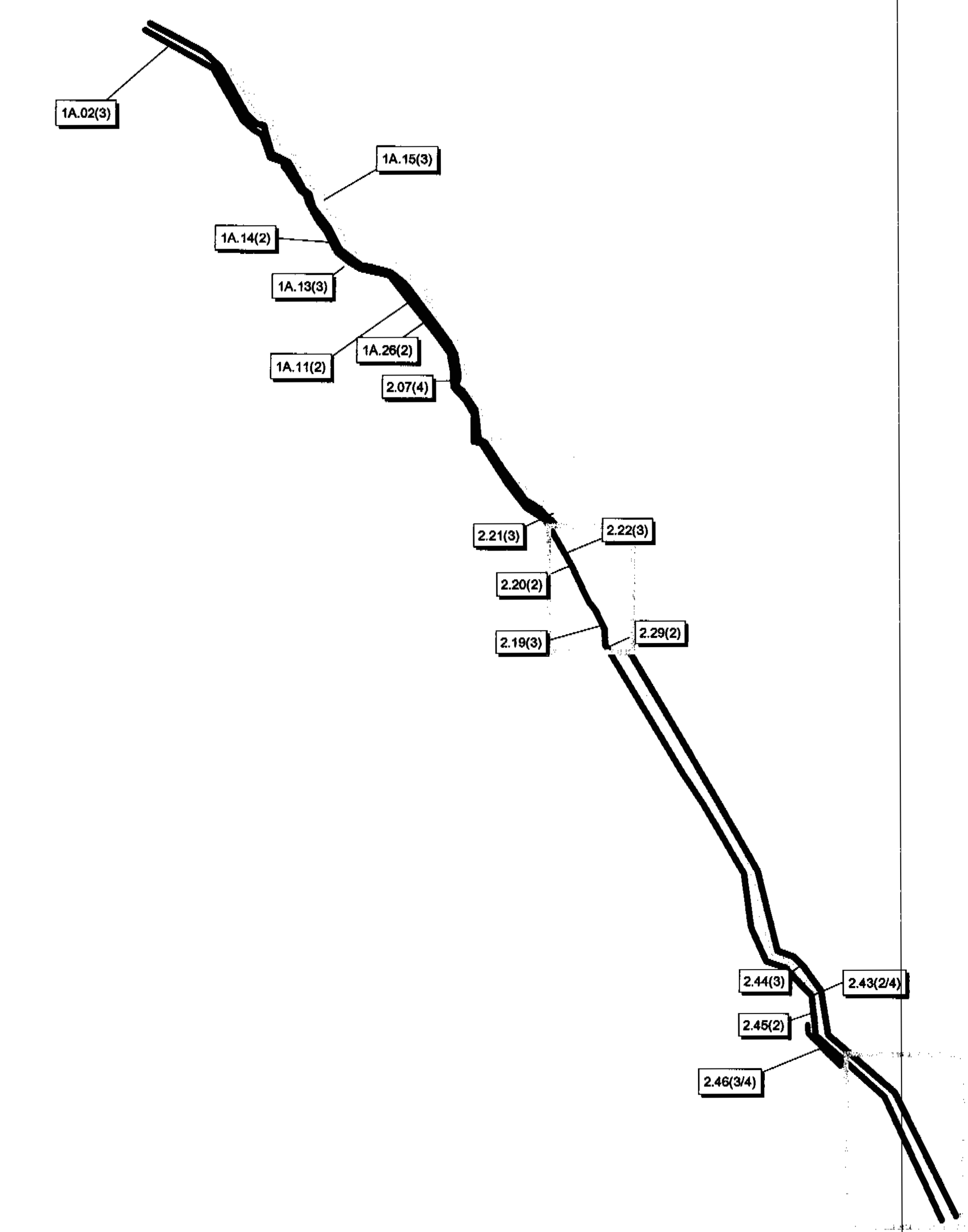


Figure 4: Pipeline Coverage of Deposits within 0-10 Km



Legend

Pipeline Coverage

1A.15 (60.58 Km)Total
1A.14 (60.85 Km) Proven
1A.13 (20.11 Km)
2.21 (105.82 Km)
2.44 (66.14 Km)
2.46 (5.29 Km)

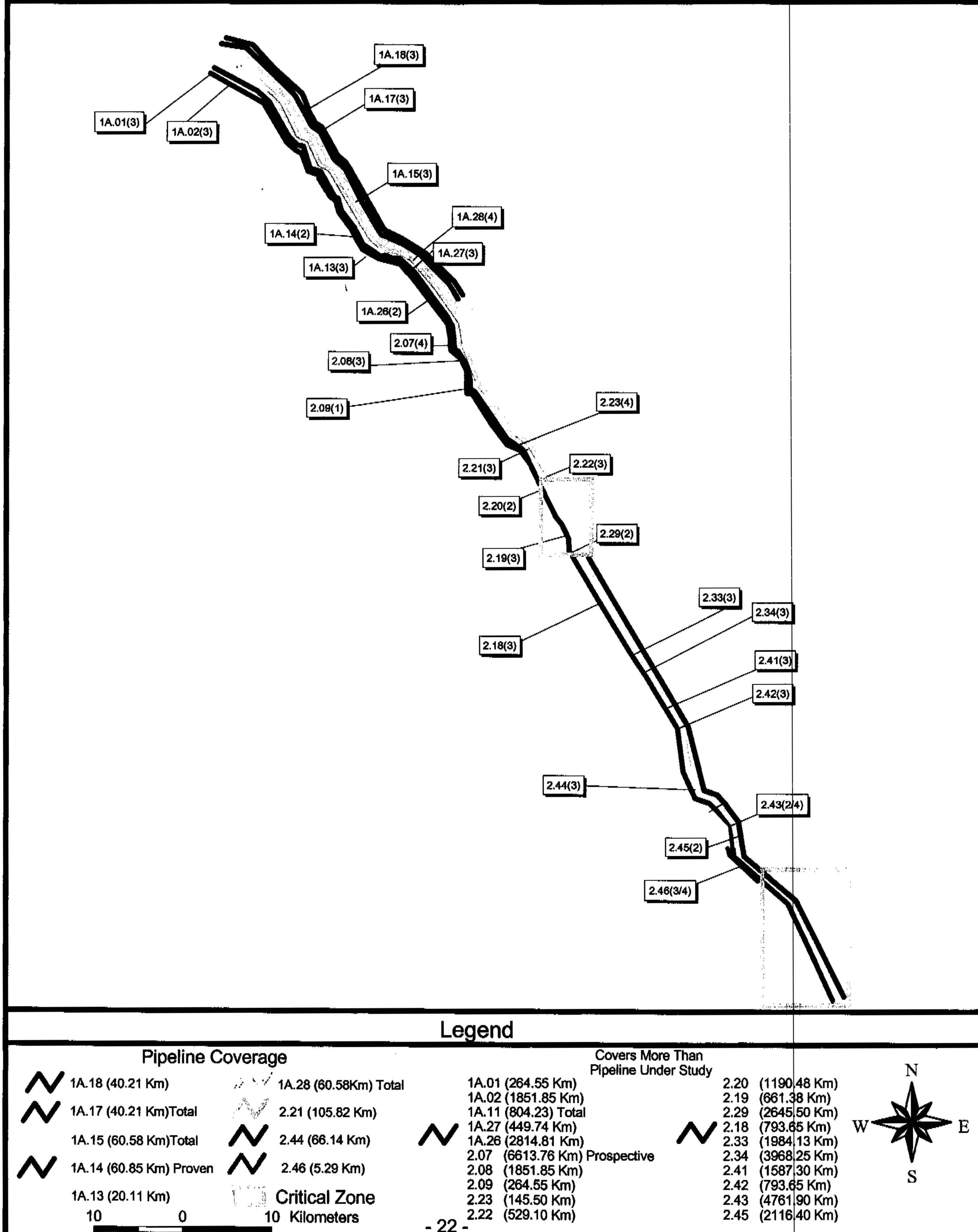
Covers More Than Pipeline Under Study
1A.02 (1851.85 Km)
1A.11 (804.23) Total
1A.26 (2814.81 Km)
2.07 (6613.76 Km) Prospective
2.22 (529.10 Km)
2.20 (1190.48 Km)
2.19 (661.38 Km)
2.29 (2645.50 Km)
2.43 (4761.90 Km)
2.45 (2116.40 Km)

Critical Zone

N
W E
S

10 0 10 Kilometers

Figure 5: Pipeline Coverage of Deposits within 0-15 Km



5.2.1.1 Critical Zone Analysis

There are two critical zones that are illustrated on the figures above. The critical zones encompass nearly the same area in all the maps. As one can observe these zones possess less deposit coverage than the other sections. The first critical zone resides approximately from deposit 2.22 to 2.29 and the second zone is the stretch after deposit 2.45 and 2.46. However, these critical zones may not be a large issue because of additional circumstances pertaining to these zones.

The first zone is approximately 10 km in length near Parsons Lake. According to Bob Gowan, this critical zone may not be a huge issue because of other factors in proximity of the critical zone. East of Parsons Lake there is possible future development of granular deposits due to the Inuvik-Tuktoyaktuk highway. There have been recent surveys east of Parsons Lake and out of the 15km buffer zone to determine the proven volumes for these deposits. Since these deposits have been proven and future possibility of development for the highway, these deposits could supply this critical area. This report studies a 15 km buffer around the main pipeline but the gathering and flow pipelines were not considered. As one can observe, there are sections of the gathering pipeline within the critical zone. Also, there are some deposits in very close proximity to the gathering pipeline. These deposits could potentially supply granular material for the gathering pipeline and facilities near the critical zone.

The second zone is approximately 20 km of the pipeline and ends at the Inuvik facility site. A limitation to this critical zone is this report did not take into consideration the southern deposit sources. There are deposits south of the Inuvik facility site that could be used as a source for granular material.

5.2.2 Annual Recoverable Influence

The amount of annual recoverable resources is an influence on the pipeline coverage. The illustration below depicts two deposits with the assumption that the deposits are identical size in volume, area, access road distance and same development costs. The only difference between these two is the amount of annual thaw depth.

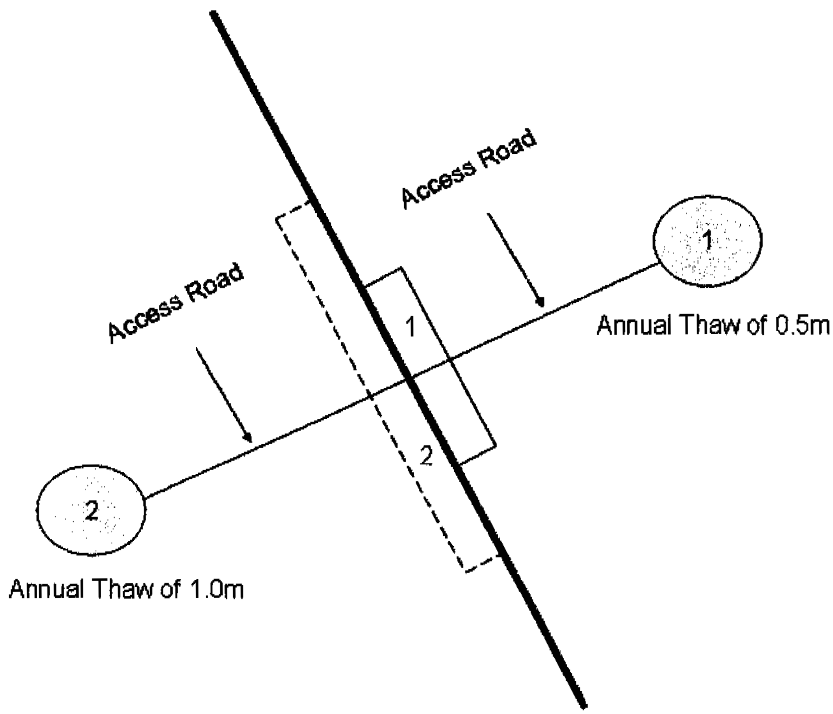


Figure 6: Annual Recoverable Influence on Pipeline Coverage
Note: This figure is for illustrative purposes only and is not to scale

Deposit 1 has an annual thaw depth of 0.5m while Deposit 2 has a depth of 1.0m. Discussed in a previous section, the annual thaw is the recoverable amount of material from a deposit. The diagram demonstrates Deposit 2 has twice the depth of annual thaw and therefore twice the material available to use for the pipeline when compared to Deposit 1.

5.2.3 Volume Confidence: Proven/ Probable/ Prospective

Each deposit has proven, probable and prospective volumes to provide an estimate of existing granular material. Proven values are supported by ground truth information such as geotechnical drilling, test pitting, and/or exposed stratigraphic sections. The volume is calculated assuming an average actual thickness of granular material sampled, extrapolated over an area of approximately 50m radius around a drillhole/test pit. Adjustments are applied by assessing deposit homogeneity, ice content, drainage conditions and topography.

The description of probable values was discussed above in the Maximum Pipeline Coverage section. Prospective values are merely speculated on the basis of limited indirect evidence such as air photo interpretation, and/ or general geological considerations. The volume is estimated for the maximum areal extent of the deposit, which is assessed from the physical features of the deposit and surrounding areas.

The diagram below displays the pipeline coverage of each of the classified volumes for Deposit 2.20. In Appendix D the proven, probable and prospective volumes for Deposit 2.20 are 350,000, 4,500,000 and 10,000,000, respectively.

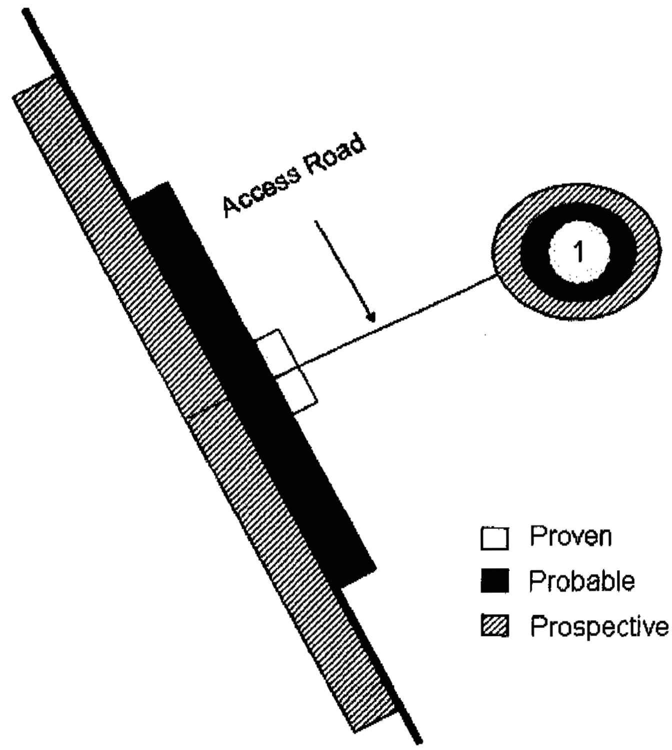


Figure 7: Volume Confidence Pipeline Proportion of Proven, Probable & Prospective
Note: This figure is for illustrative purposes only and is not to scale

The best application which volume to use is obviously the proven volume because these volumes have been surveyed and confirmed. Using probable and prospective volumes should not be used as accurate volumes because this can lead to over estimation of pipeline coverage. The diagram above perfectly describes the situation of using different classified volumes.

5.3 Optimization Approach

5.3.1 Optimal Haul Distance

Optimal haul distance between two deposits can be calculated by determining the distances of access road for each deposit and the distance between them. One can assess the proportion of pipeline each deposit would cover. In the diagram below illustrates the variables needed and explains how optimal haul distance is evaluated.

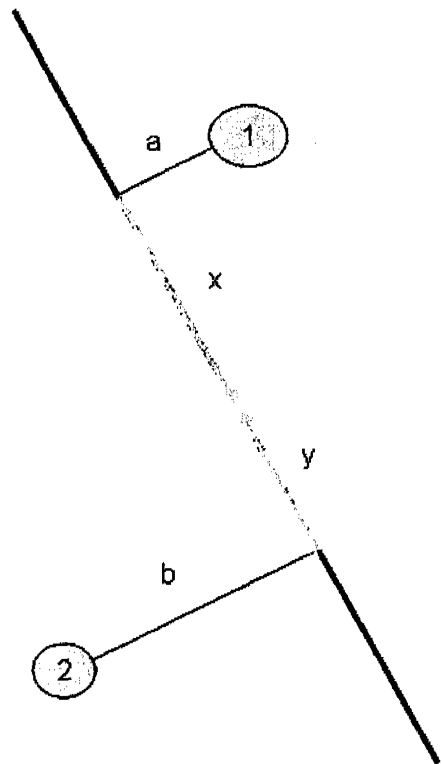


Figure 8: Optimal Haul Distance Model
Note: This figure is for illustrative purposes only and is not to scale

a = the access road distance from Deposit 1
b = the access road distance from Deposit 2
x = the distance from Deposit 1 access road to y. It is the optimal haul distance for Deposit 1
y = the distance from Deposit 2 access road to x. It is the optimal haul distance for Deposit 2

Therefore, $x + y$ = the total distance between Deposit 1 and Deposit 2 access roads. Because the values for a, b and $x + y$ can be measured, it is possible to solve for optimal haul distance between each pair of deposit. An example will provide better understanding of the evaluation process.

Deposit 1A.05
$a = 3.9$ $\quad b = 0.64 \quad x + y = 18.15$
$a + x = b + y$
Solve for x and y
$3.9 + x = 0.64 + y$
$3.26 + x = y$

$x + y = 18.15$
$y = 18.15 - x$
$3.26 + x = 18.15 - x$
$x + x = 18.15 - 3.26$
$2x = 14.89$
$x = 14.89 / 2$
$x = 7.45$
Now that x is now solved, y can be determined
$x + y = 18.15$
$y = 18.15 - 7.45$
$y = 10.7$

Therefore $x = 7.45$ and $y = 10.7$. Therefore, 7.45 km of pipeline from the Deposit 1 access road will be optimal haul distance covered and 10.7 km of pipeline from the Deposit 2 access road will be optimal haul distance covered. These numbers are sensible because the value of b has a shorter access road than a, thereby achieving greater optimal distance.

The example below demonstrates an instance where the value of x or y is a negative value.

Deposit 1A.28
$a = 5.5$ $b = 2.89$ $x + y = 0.78$
$a + x = b + y$
Solve for x and y
$5.5 + x = 2.89 + y$
$2.61 + x = y$
$x + y = 0.78$
$y = 0.78 - x$
$2.61 + x = 0.78 - x$
$x + x = 0.78 - 2.61$
$2x = -1.83$
$x = -1.83/2$
$x = -0.92$
Now that x is now solved, y can be determined
$x + y = 0.78$
$y = 0.78 - (-0.92)$
$y = 1.7$

Therefore x = -0.92 and y = 1.7. This result means that Deposit 1 should not be considered in this segment of the pipeline because it is more feasible to use Deposit 2 to cover the pipeline between the two deposits.

The distances of each deposit to the pipeline and distance from one another was measured using Arcview 3.2 and the measure tool. The distance of error is in the range of +/- one to five hundred meters since this was done manually. Optimal haul distance calculations of each deposit are located in Appendix E1.

Appendix E2 & E3 are identified ineligible deposits within the 15Km buffer. The highlighted rows in Appendix E2 are deposits that did not possess any reported material volumes.

Appendix E3 highlights non-viable deposits due to the optimal distance surplus of adjacent deposits. A spreadsheet formula was created to evaluate the feasibility by examining the possibility of the present deposit supporting the adjacent deposit and vice versa. An example of the formula is = IF ((F19-C19)>F20,TRUE). The formula takes the difference between the previous record's deposits x value and $x + y$ value and checks if the value is greater than the x value from the present deposit. If the present deposit's x is less than the value of $x - (x + y)$ then the present deposit should be excluded from the final revised optimal haul table and the statement "TRUE" will be indicated. A "FALSE" statement is given if the value suggests otherwise.

The example below demonstrates the present deposits, 1A.02, whose optimal distance surplus covers the adjacent deposit's lengths.

Deposit	x	y
1A.02	15.62	-4.97
1A.17	3.37	6.13

As one can observe, the surplus from 1A.02 is able to supply 1A.17 because the surplus of 4.97 km can supply 1A.17's length along the pipeline.

The same applies if it was the reverse:

Deposit	x	y
1A.17	1.51	0.04
1A.04	-2.1	3.63

Deposit 1A.04 has a surplus of 2.1 km and this can be used to supply 1A.17 and this now eliminates 1A.17 from consideration.

In Appendix E3, the highlighted rows with regular black characters are deposits that are removed because of the formula results. The highlighted rows with red characters are special cases of non-viable deposits. Deposit 1A.03 was discarded from 0-15 km pipeline coverage table because the maximum distance covered on the pipeline for this deposit was 3.02 km but according to optimal distance calculations, the deposit would have to cover 4.66 km. There is not enough granular material to cover the stretch of pipeline from the deposit. Deposit 2.03 was discarded from the final table because the optimal haul distance from deposit 1A.02 is able to cover deposit 2.03's coverage zone.

5.3.1.1 Optimal Haul Distance Map Analysis

Figures 9, 10, 11 were created to illustrate the effects of optimal haul distance along the Mackenzie pipeline. These plotted lines are derived from Appendix E4. Large versions of these figures are found in Appendix G.

Figure 9: Optimal Distance of Deposits within 0-5 Km

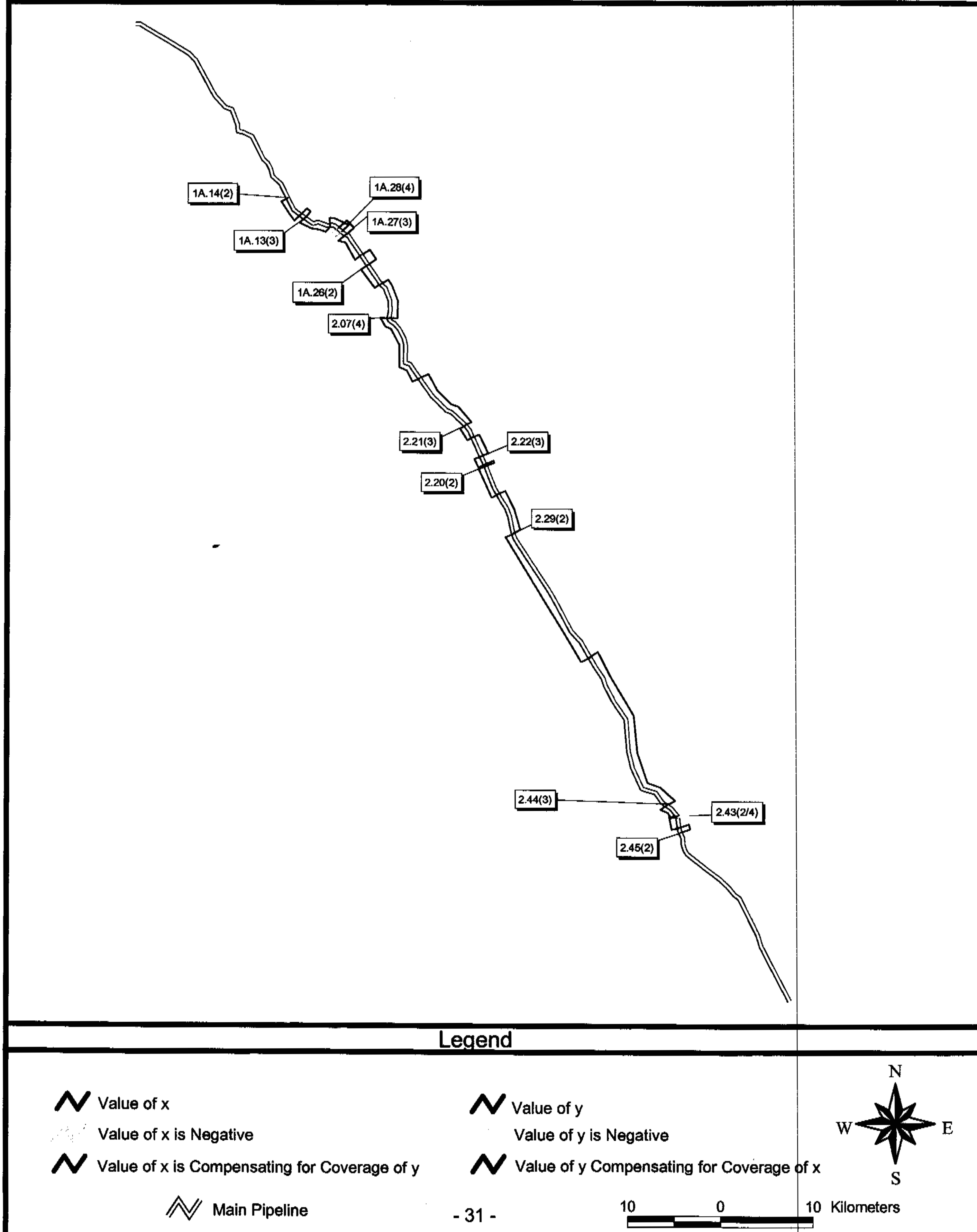
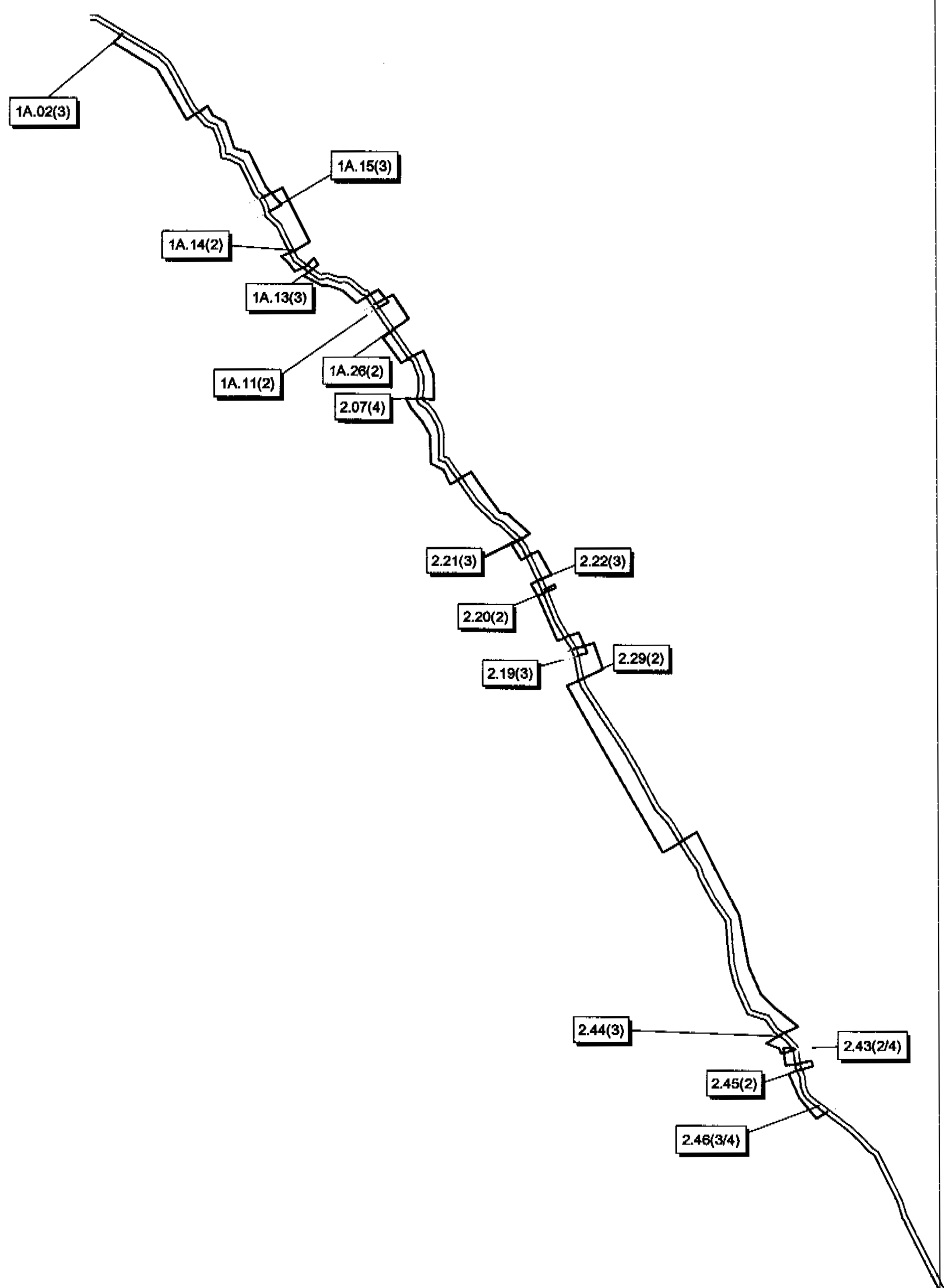


Figure 10: Optimal Distance of Deposits within 0-10 Km



Legend

Value of x

Value of x is Negative

Value of x is Compensating for Coverage of y

Value of y

Value of y is Negative

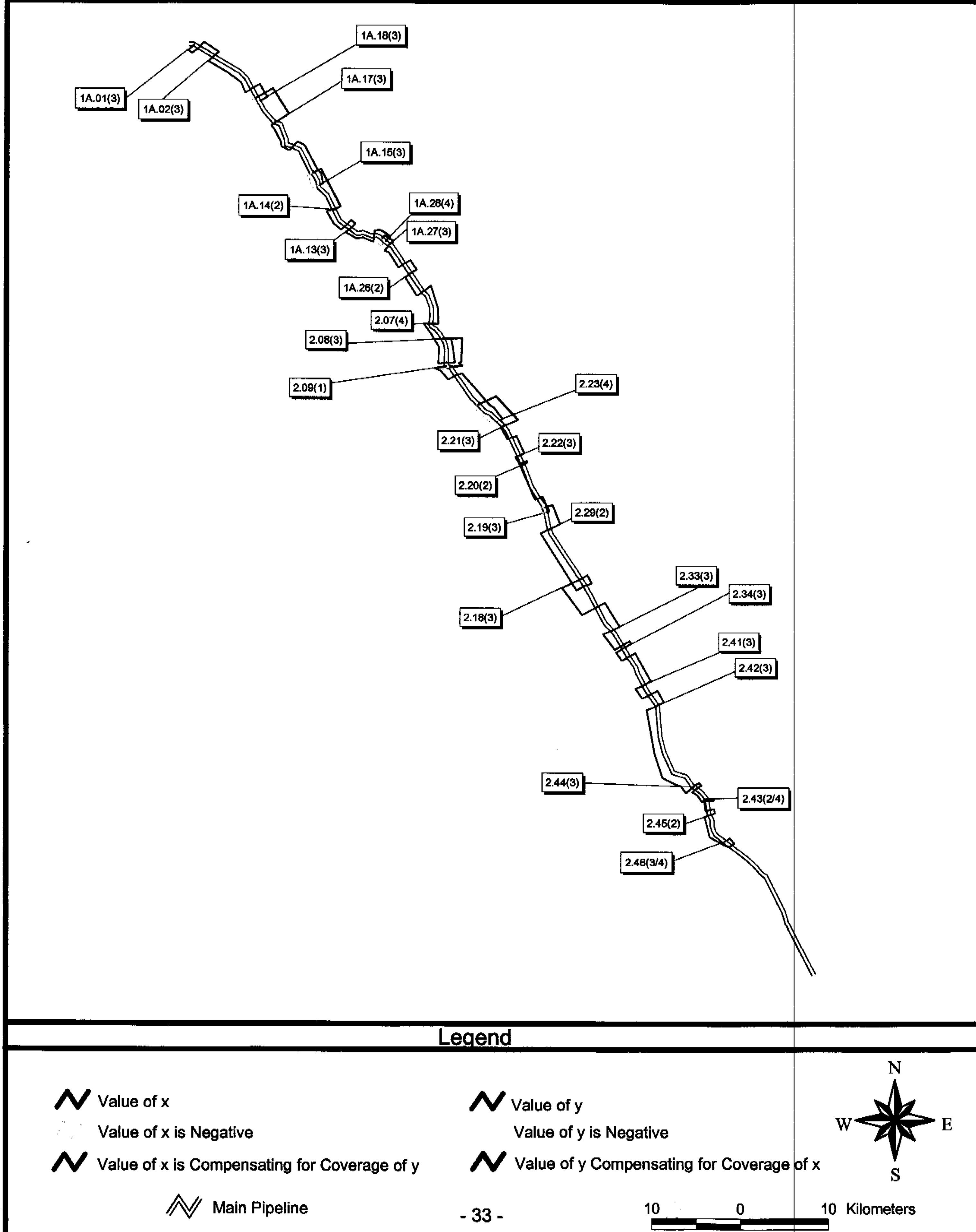
Value of y Compensating for Coverage of x

Main Pipeline

N S W E

10 0 10 Kilometers

Figure 11:Optimal Distance of Deposits within 0-15 Km



All the values on the right side of the pipeline are related x values while the lines on the left are related to y values. The red lines are values of x, the orange lines are negative values of x, and light blue lines are values of x compensating for the negative coverage of y. The green lines are values of y, the dark blue values are values of y compensating for the negative coverage of x, and the pink lines are negative values of y.

As one can observe, in the 0-5 Km table and map, the optimal distances between deposits are relatively equal since these deposits are within the same distance from the pipeline. However, there is more optimal variation between deposits as longer access road deposits are incorporated with short access road deposits. The interaction between short access road deposits and long access road deposits result in higher occurrences of negative x or y values. The maps illustrate this case when comparing 0-5 Km versus 0-15 Km.

A manager can determine from these maps which deposits are to be developed. The manager uses their own judgment from experience and knowledge of the area to determine the utilization or elimination of deposits.

5.3.2 Haul Speed

The length of access roads greatly affects productivity and thereby affecting pipeline coverage. Access roads are under developed roads to connect the deposit to the main pipeline. Since these roads will be used for one season so flattening and leveling areas will not be done. Therefore, these access roads will contain rough terrain and less disturbance of the surrounding area is essential. This would result in longer material transport times to deliver material to the pipeline.

The assumptions for this diagram are both deposits have identical access road length, volume, annual recoverable depth, and site development costs.

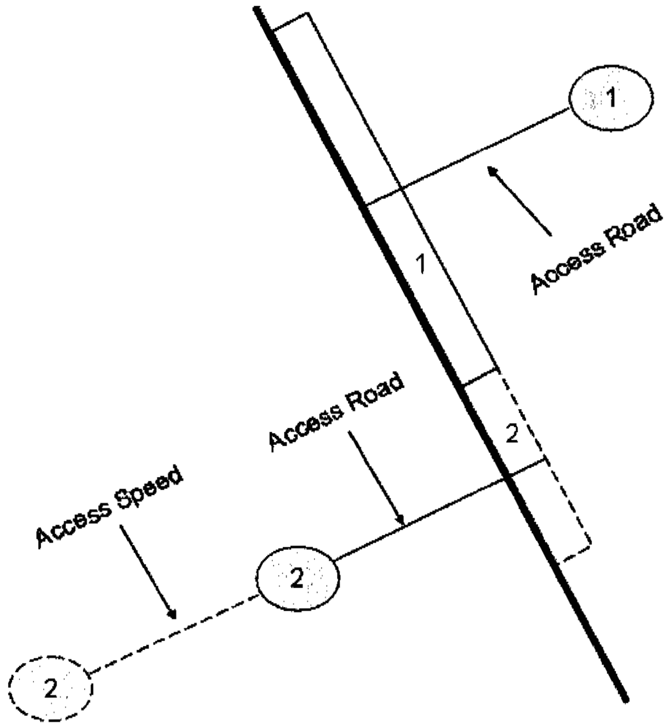


Figure 12: Relationship between Haul Speed and Productivity
Note: This figure is for illustrative purposes only and is not to scale

The dashed extension connected to Deposit 2 is meant to represent the influence of reducing the haul speed to travel along the access road. It is assumed that if a truck travels at 30 km/h from Deposit 1 and at only 15 km/h from Deposit 2, due to rugged terrain, it would take twice as long to travel on the access road from Deposit 2. This has the same effect as doubling the length of the access road, as shown in the illustration.

5.3.3 Site Development Cost

Site development costs may differ from each deposit because of each deposit's unique properties. For example, sites differ by the amount of overburden that exists on the deposit. More overburden that exists on the soil translates to more cost associated to remove. Also, the type and amount of royalties is another factor of site development costs.

The assumptions for this model, is the two adjacent deposits have exactly the same access road length, volume, and annual recoverable but the site development costs differ percentage wise. Also, the transport rates are constant for both deposits. The objective of the model is to provide lowest cost for granular material at any given point along the pipeline segment. The chart below provides site development cost scenarios to show the impacts and interaction of changing development costs for each deposit.

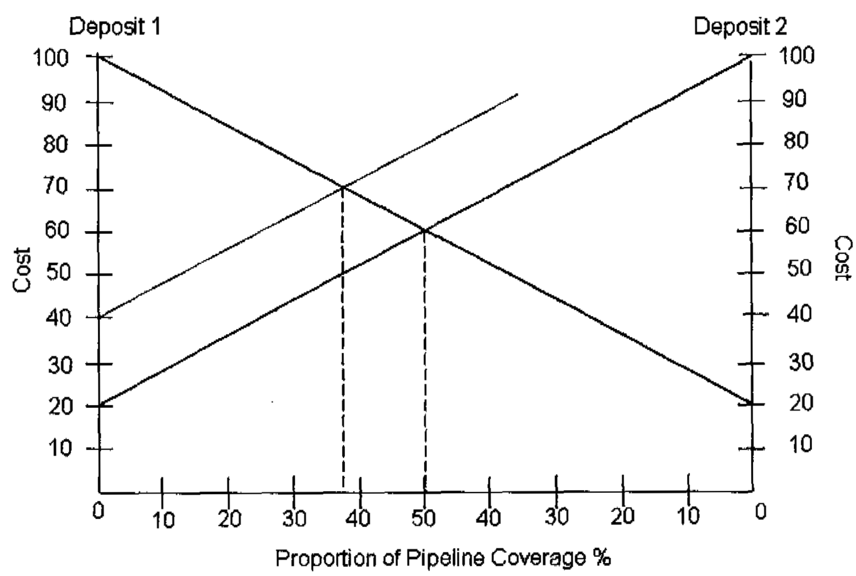


Figure 13: Site Development Chart: Example 1
Note: This figure is for illustrative purposes only and is not to scale

The cost of material at a given point along the pipeline route will be the sum of the development cost plus haulage cost per unit distance. The first scenario is that both deposits have the same site development cost of 20 units. After plotting the respective transportation rates, the intersection is 50, the midpoint between the deposits. This means that the pipeline coverage percentage of each deposit is 50%.

The next scenario on the chart involves doubling the site development units to 40 units for Deposit 1, while Deposit 2's site development cost remain at 20 units. The haulage rate is assumed to remain constant. The red plotted line is from Deposit 1 and it intersects Deposit 2's black 20 line at approximately 38% in Deposit 1's territory. This means that Deposit 2 will occupy 62% percent of the pipeline coverage and Deposit 1 will occupy 38% between the two deposits. The diagram below is based from the chart above to demonstrate the proportion change between the deposits.

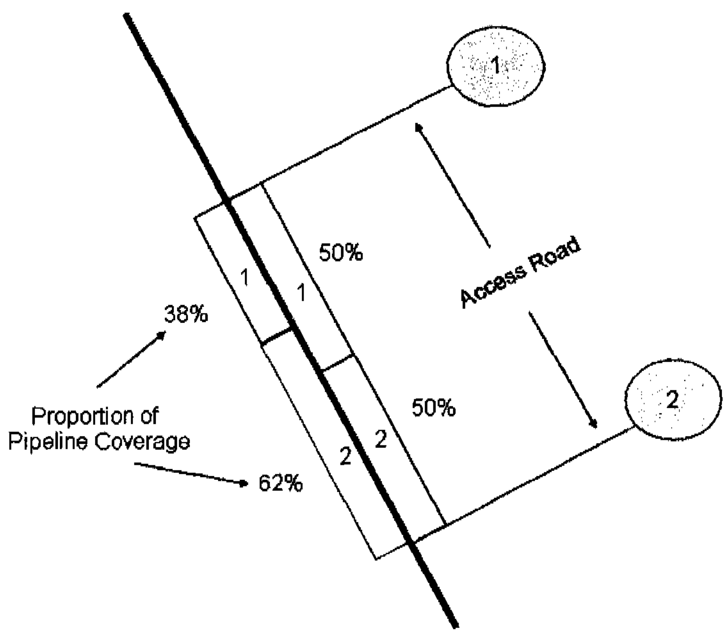


Figure 14: Site Development Proportion of Pipeline Coverage: Example 1
Note: This figure is for illustrative purposes only and is not to scale

Another scenario is provided in the next example. Deposit 1 has development costs of 10 units while for Deposit 2 represent 50 units.

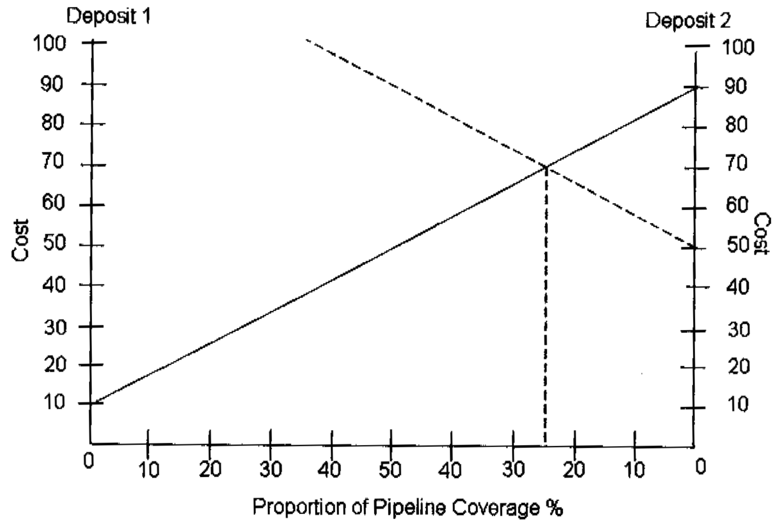


Figure 15: Site Development Chart: Example 2
Note: This figure is for illustrative purposes only and is not to scale

The result is Deposit 1 occupying close to 75% and Deposit 2 only 25% of the pipeline coverage between them. The map below illustrates the chart in spatial form.

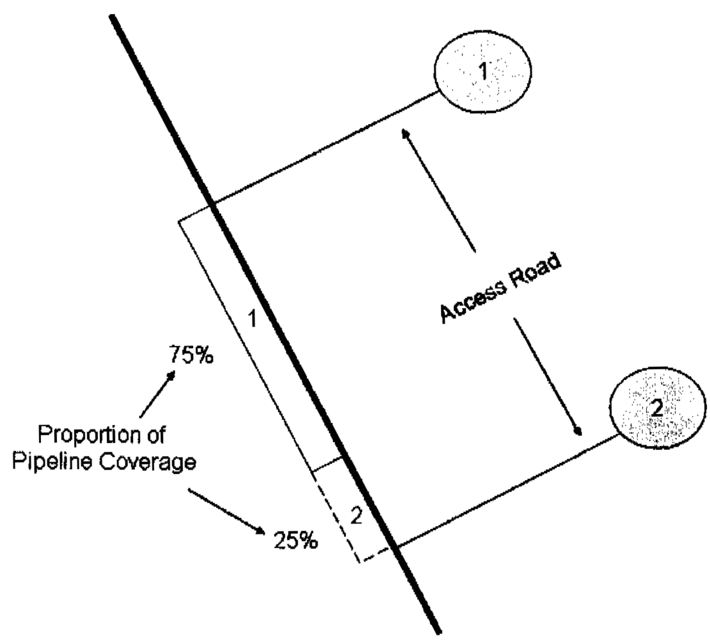


Figure 16: Site Development Proportion of Pipeline Coverage: Example 2
Note: This figure is for illustrative purposes only and is not to scale

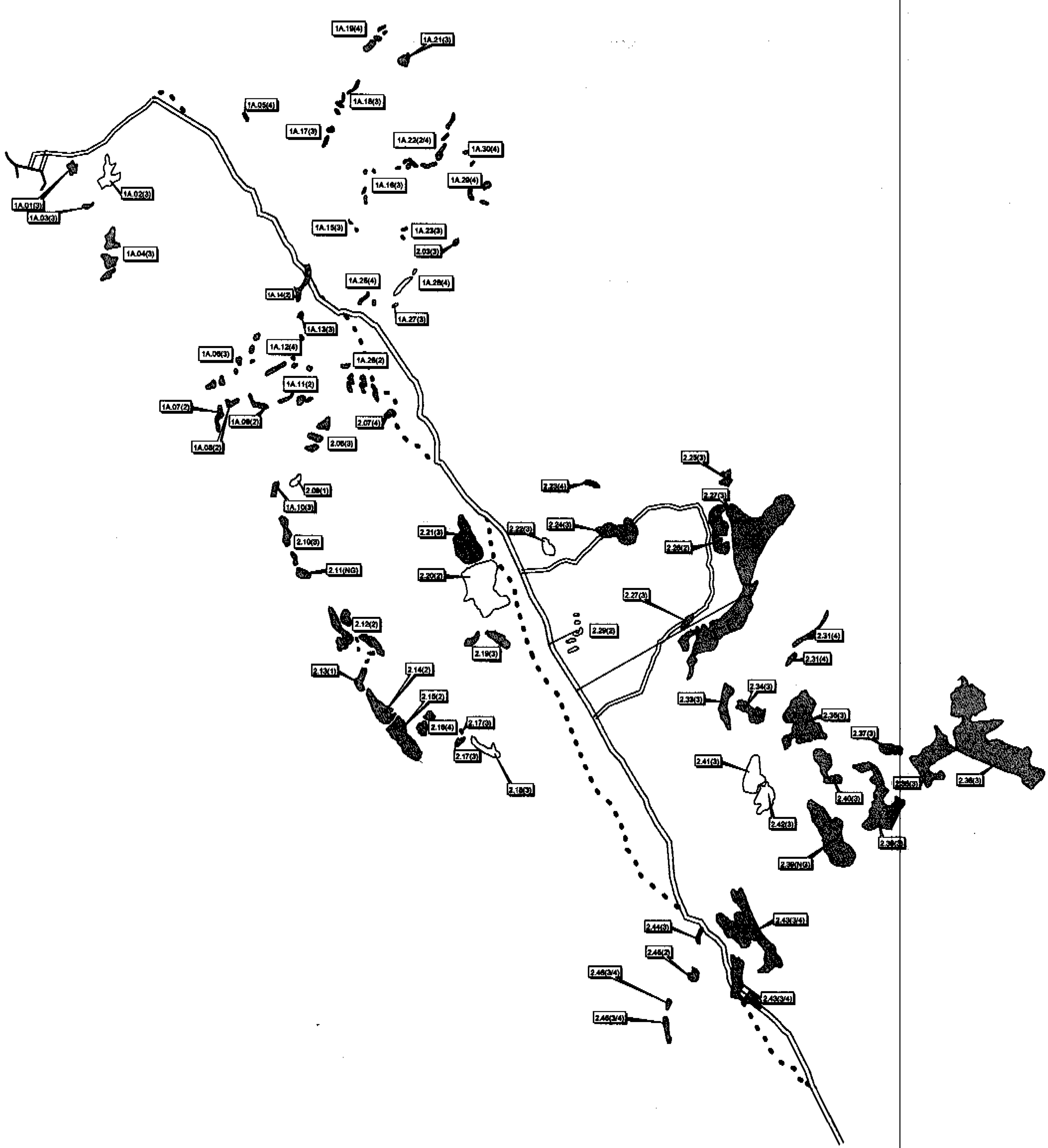
Summary

The potential and optimization approaches have introduced the main components of the EOHD model and demonstrated some other influences affecting haul distance and effected deposit volume. Further study of each of these relationships provides managers with a better understanding of resource utilization pressures.

Figure 17 illustrates an example anticipated resource pressures along the pipeline, based on the optimal haul distance of deposits within 0 – 15 Km, pipeline fill dimensions and probable deposit volumes as derived from Appendix E4. Optimal haul distances of each deposit determine the pressures associated with development. It is evident that smaller deposits located closer to the pipeline route will generally be more depleted. Nonetheless, overall utilization of individual deposits, and the overall resource, is low.

Similar utilization plots for the 5 Km and 10 Km buffers would show higher pressures on same deposits, but the overall pressures for the ISR appear low.

Figure 17: Anticipated Resource Utilization



Legend

Percent of Deposit Used
- 0 % - 0.277%
- 0.277% - 1.488%
- 1.488% - 5.349%
- 5.349% - 11.849%
- 11.849 %- 19.895%

- GATHERING PIPELINE
- MAIN PIPELINE
- 2001 PROPOSED PIPELINE
- FLOW PIPE

N
W E
S

10 0 10 Kilometers

6.0 Conclusion

The Mackenzie Gas Pipeline is a large scale project that requires abundant amounts of granular material. The pipeline and facilities in the Inuvialuit Settlement Region are relatively in close proximity of granular deposits. There are many granular deposits scattered throughout the study area but optimal management of this material is essential to unsure future reserves.

The economic optimal distance model provided insight of the complex and detailed features involved within the model. An analysis of various parts of the model allows a simplistic view for each factor. Further study of this model could be very useful for many applications related to hauling and transportation.

The aspects of granular deposit management, planning, site development, extraction, maintenance and post-extraction were presented. These factors and considerations for preparation of granular deposits, which in affect the pipeline coverage. The lengths of access roads have an adverse effect on the proportion each deposit can cover. This was proven by the optimal distance data and analysis conducted in this report.

The amount of pipeline covered from each deposit was graphically represented on maps to display the areas along that pipeline that appeared critical. However, upon further investigation the critical zones along the pipeline do not seem to be a big issue due to their external circumstances. However, one must not be too susceptible to the volumes provided since it is an over estimate of actual volumes.

The results and findings in this report examine the factors of granular resource development, management and planning of granular deposits.

7.0 Recommendations

A study regarding the optimization of haul distance should be conducted for the entire pipeline. There are large amounts of deposits along the whole Mackenzie Gas Pipeline and this would be very time consuming to calculate and map. The computer program, MathCAD is said to be able to solve algebraic functions and formulas. This would enable the program to compile larger data sets and faster calculations than a person manually performing the same task. Visual Basic programming could be utilized to create an application to streamline the entire process. Also, the amount of error would be reduced as well using both methods. The computer application could be created to measure the distances from each deposit to the pipeline, then calculate optimal distance between each deposit and map haul zones to enable an easier data analysis than manually calculating each deposit one by one. This application could further improve by also figuring out the economic haul distance model.

An in depth report of economic haul distance should be conducted to determine all the factors relating to granular deposits. The broad examples used in the potential influence and optimization section provided a dissected theoretical overview of the economic haul distance model. The follow up study should assemble these factors together with confirmed numbers instead of assumptions. This would provide a realistic estimate of the influence of haulage zones of granular deposits. It is recommended if possible to use proven volumes to provide accurate estimates for each deposit. Granular resource managers would understand the decision making process of planners and managers in the private industries.

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Appendix A

GIS Methodology

GIS Methodology

The granular resources from "Report on Evaluation of Granular Resource Potential Mackenzie Delta Region" by Hardy BBT Limited 1991, were digitized from the 1:250000 maps provided in the report. Initially, the granular sources were transferred from the maps to clear transparency, which was later overlaid to NTS 1:250000 107 B & C Topography maps. This was done because the company that conducted the report merged the 107 B & C Topographic maps of the study area. After digitizing the deposits mainly located in the 107 B map, Bob informed me that it was possible to digitize the contractors map sheet without using the transparencies. This can be accomplished by using the grid coordinates from the map sheet as reference points. These grid coordinates exactly correspond to the NTS 1:250000 maps so it was possible to use the map sheets provided from the report.

The conversion from QuikMap dbf file to MapInfo was conducted after the granular deposits were digitized. This would enable analysis to be done with Arc View after converting from MapInfo to Shapefile format. The instructions below are to convert from QuikMap format to Shapefile format. This was complied by previous students, Calvin Simmie, Raymond Baksi and Leo Lau.

Translating Data from QuikMAP to MAPINFO

1. Once you have the database with just the new records you have created, along with polygon areas for each, you are now ready to use the Quik Translator.
2. The Quik Translator is another piece of software offered by QuikMAP Technologies Inc.
3. Open the translator up and select the "MAPINFO" option.
4. After that select "database to MAPINFO format".
5. Then select the database file that you have just created/modified.
6. Make sure the database isn't currently open in some program, cause it won't work.
7. Select where you want the MAPINFO file to go.
8. There is also a place to enter the filter angle.

9. With a filter angle of 0.0 the MAPINFO file will be larger, but data accuracy will be at a maximum.
10. It is highly recommended to use a filter angle of 0.0.
11. When you have everything entered click ok.
12. You should then see the data being translated.
13. If the translation worked, you will only see values for number of records and number of polygons.
14. Also, the number of records should equal the number of polygons (e.g. 329 records and 329 polygons).

Editing Data in MAPINFO

1. The next step involves MAPINFO, so open it up.
2. Once in MAPINFO open a workspace (base map) so that you have something to see the data against.
3. Now you want to import the MAPINFO file you have just created with the translator.
4. Click on table, then import, and select the MAPINFO file you just created.
5. After you click on import the box will change to "import into table".
6. Give the table a name (e.g. cominvgr.tab) and click ok.
7. You can then either go to file, open table, and select the table, or you can go to map, layer control, and go to add to add the table as a layer to the view.
8. If you opened the table using file, open table, then it should already be in layer control.
9. Once in layer control, make sure both the visible and editable boxes are checked.
10. While highlighted on the table/layer click on display.
11. Check the show nodes box and then click ok.
12. The polygons should now be visible in the view with just the nodes as their boundaries.
13. Go back to layer control and make sure the table/layer you are dealing with is at the top.
14. Click on the marquee select icon of the main tool bar, and click and draw a box, which encloses all the polygon data.
15. They should now be highlighted to indicate that they are selected, and make sure that they are the only layer of the view that has been selected/highlighted.
16. Next click on objects, then convert to polylines, and wait for the process to finish.
17. When that is done click on objects, then convert to regions, and wait for that process to finish.
18. You can now unselect the data by going to query, unselect all.
19. Check to make sure that the data are in fact closed polygons now.
20. To do this go to map, layer control, make sure the table/layer you are interested in is highlighted, then click on display.
21. You can then uncheck the show nodes box.
22. Click ok to exit the display box, and ok again to exit the layer control box.
23. Zoom in on some of the polygons to make sure that they are in fact closed polygons.
24. If you want you can go to file, save table to save changes.
25. The next thing you need to do is export the table.
26. Click on table, export, and select the desired table, then click export.
27. Choose the file and file path of the file you want to export the table to.
28. The file you export the table to should have a mif extension (MAPINFO interchange file).

29. You can then click on export.
30. You should now have a new mif and mid file, which are different from the mif and mid files created using the Quik Translator.

Converting Data from MAPINFO to ArcView Format

1. The next thing that needs to be done is to convert the new mif file to an ArcView shape file using ArcView's mifshape utility.
2. The mifshape utility is located in ArcView's Bin32 folder (ArcView 3.2).
3. Open up the mifshape file (not the mifshape executable) and a box will then come up asking for parameters.
4. If you digitized points, lines and polygons in Quikmap, these features are located within the same database file. Therefore there are different parameters to enter in the mifshape utility. These parameters should be entered by the corresponding feature you wish to export (without the "" and ()):

   For polygon: "poly (file path and name of mif) (file path and name of shape file)"

   For line: "line (file path and name of mif) (file path and name of shape file)"

   For point: "point (file path and name of mif) (file path and name of shape file)"

5. When you type it in you don't need brackets, but a single space needs to be kept between the three parameters.
6. Every directory in the path of the filenames should have 8 characters or less.
7. Also, the file name of the shape file can't be the same as the file name of the mif.
8. One last thing to keep in mind is to avoid putting either the mif or shape file at the root directory of a drive.
9. An example of proper parameters when using the mifshape utility would be something like this: poly u:\student\calvin\convert\mack u:\student\calvin\convert\mackgr.
10. If the mifshape conversion works properly then it will say so many polygon features created.
11. The mifshape utility creates three new files and these have extensions of shp, shx, and dbf respectively.
12. You should now be able to add this shape file you just created, as a theme to a view in ArcView.

These converted files are located in U:/STUDENT/LEOLAU/DATA as Sources.shp. All the GIS processing can be located in U:/STUDENT/LEOLAU/main.prj. I edited the data base to remove errors and added new fields such as grade, landform and granular type. The reason is to allow better customization for symbology.Some of the areas and perimeter values are missing from database editing. Finding the topology of the deposits is possible by using Arc Toolbox and converting to a coverage file.

The pipeline was digitized from the "Mackenzie Gas Project: Preliminary Information Package Project Maps". The pipeline section that was digitized only included the Inuvialuit Settlement Region. Point features that were digitized included camp locations, barge landing sites, facility sites, well sites and stockpile sites. A March 2001 proposed pipeline route was also digitized to evaluate the previous proposed line. The maps within the information package that were used in the digitizing were in the scale of 1:250000.

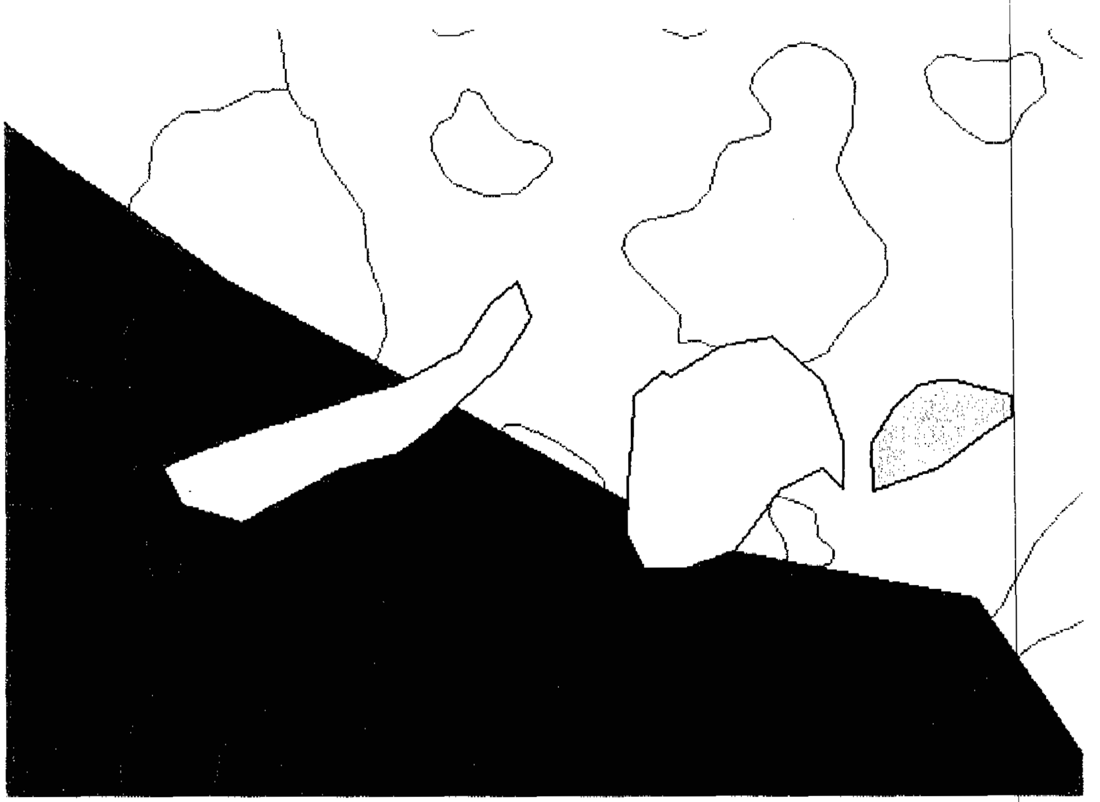
GIS Analysis

The newly created granular resource, pipeline and point site features shapefiles were added along with the water and drainage shapefiles. A buffer of 15 km of increments of three each five km was conducted on the pipeline. This buffer displayed the granular deposits that resided in the buffer.

'Select by theme' was used to select all sources within the 15 km buffer. The selected records within the Sources table were then summarized to count the number of sources in a particular grade. The summarized output files are in dbf format and can be opened and modified for report purposes.

The sources could also be further categorized by the distance from the pipeline. This can be done by selecting the distance buffer that one would like to analyze, for example, selecting the buffer from 11km-15km. Once the desired buffer is selected and highlighted, make the sources layer active and 'select by theme'. Choose 'Intersect' and select the buffer theme that is currently selected. Click on 'New Set' and this will result in all granular deposits from the Sources shapefile within the 11 km – 15 km buffer become selected. One can then summarize the selected files within the Sources shapefile to determine how many sources reside within the buffer and the class. Repeat this process if analysis is needed to be done on the other buffers.

This process is not 100% systematic and requires some user interaction and judgment. There are several granular sources that reside within two buffer areas and when 'select by theme' is used on each of the separate buffers, the granular sources get selected since they touch both buffer zones. This is shown in the figure below.



Therefore, it is for the user to judge which buffer zone the granular resource should reside. For this analysis, I estimated the size of the deposit and selected the polygon that resided > 50% on the one buffer zone. I would then not all the deposits that were selected manually.

Errors

In every instance of transferring information from one medium to another such as digitizing from paper maps to digital form, it is subject to error.

Appendix B

Table: Deposits in Buffer Zone

Appendix B
Deposits in 0-5 Km Buffer Zone

Deposit	Granular Type	Material Class	Landform Type
1A.05(4)	SILT-SAND, TRACE GRAVEL	4	GLACIOFLUVIAL KAME REMNANT
1A.13(3)	SAND-SOME, GRAVEL	3	GLACIOFLUVIAL ESKER
1A.13(3)	SAND-SOME, GRAVEL	3	GLACIOFLUVIAL ESKER
1A.14(2)	SAND-SOME, GRAVEL	2	GLACIOFLUVIAL FLAT-TOPPED RIDGE
1A.25(4)	SILT-SAND	4	GLACIOFLUVIAL KAMES; TERRACES
1A.25(4)	SILT-SAND	4	GLACIOFLUVIAL KAMES; TERRACES
1A.26(2)	SAND & GRAVEL, LITTLE SILT	2	GLACIOFLUVIAL TERRACE REMNANTS
1A.26(2)	SAND & GRAVEL, LITTLE SILT	2	GLACIOFLUVIAL TERRACE REMNANTS
1A.26(2)	SAND & GRAVEL, LITTLE SILT	2	GLACIOFLUVIAL TERRACE REMNANTS
1A.26(2)	SAND & GRAVEL, LITTLE SILT	2	GLACIOFLUVIAL TERRACE REMNANTS
1A.27(3)	SAND-SOME, SILT	3	GLACIOFLUVIAL OUTWASH PLAIN
1A.28(4)	SAND-VARIABLE, SILT, TRACE GRAVEL	4	GLACIOFLUVIAL RIDGE
2.07(4)	SAND	4	GLACIOFLUVIAL OUTWASH PLAIN
2.19(3)	SAND & GRAVEL, TRACE SILT	3	GLACIOFLUVIAL OUTWASH AND ALLUVIAL FAN
2.20(2)	SAND & GRAVEL, TRACE SILT	2	KAME FIELD
2.21(3)	SAND, SOME GRAVEL & SILT	3	KAME FIELD
2.22(3)	SAND, SOME GRAVEL TRACE SILT	3	GLACIOFLUVIAL OUTWASH
2.29(2)	SAND & GRAVEL, TRACE SILT	2	GLACIOFLUVIAL OUTWASH (DISECTED)
2.29(2)	SAND & GRAVEL, TRACE SILT	2	GLACIOFLUVIAL OUTWASH (DISECTED)
2.29(2)	SAND & GRAVEL, TRACE SILT	2	GLACIOFLUVIAL OUTWASH (DISECTED)
2.29(2)	SAND & GRAVEL, TRACE SILT	2	GLACIOFLUVIAL OUTWASH (DISECTED)
2.29(2)	SAND & GRAVEL, TRACE SILT	2	GLACIOFLUVIAL OUTWASH (DISECTED)
2.43(3/4)	SAND & GRAVEL, SOME SILT	3/4	LACUSTRINE VENEERED OUTWASH PLAIN
2.43(3/4)	SAND & GRAVEL, SOME SILT	3/4	LACUSTRINE VENEERED OUTWASH PLAIN
2.44(3)	SAND-SILTY	3	GLACIOFLUVIAL OUTWASH
2.45(2)	SAND & GRAVEL	2	GLACIOFLUVIAL OUTWASH

Appendix B
Deposits in 6-11 Km Buffer Zone

Deposit	Granular Type	Material Class	Landform Type
1A.02(3)	SAND-TRACE, SILT	3	GLACIOFLUVIAL DELTA AND BEACH
1A.06(3)	SAND-SOME, GRAVEL, TRACE SILT	3	GLACIOFLUVIAL KAME
1A.06(3)	SAND-SOME, GRAVEL, TRACE SILT	3	GLACIOFLUVIAL KAME
1A.06(3)	SAND-SOME, GRAVEL, TRACE SILT	3	GLACIOFLUVIAL KAME
1A.11(2)	SAND-GRAVEL	2	GLACIOFLUVIAL LACUSTRINE ESKER-KAME COMPLEX
1A.11(2)	SAND-GRAVEL	2	GLACIOFLUVIAL LACUSTRINE ESKER-KAME COMPLEX
1A.12(4)	SAND-SILT	4	GLACIOFLUVIAL KAME
1A.12(4)	SAND-SILT	4	GLACIOFLUVIAL KAME
1A.12(4)	SAND-SILT	4	GLACIOFLUVIAL KAME
1A.12(4)	SAND-SILT	4	GLACIOFLUVIAL KAME
1A.15(3)	SAND-SILT	3	GLACIOFLUVIAL HILLOCKS
1A.15(3)	SAND-SILT	3	GLACIOFLUVIAL HILLOCKS
1A.16(3)	SAND-SILT AND ICE	3	GLACIAL OUTWASH
1A.16(3)	SAND-SILT AND ICE	3	GLACIAL OUTWASH
1A.17(3)	SAND-TRACE, GRAVEL	3	GLACIOFLUVIAL KAME-ESKER COMPLEX
1A.23(3)	SAND-LITTLE, GRAVEL	3	GLACIOFLUVIAL OUTWASH REMNANT
1A.23(3)	SAND-LITTLE, GRAVEL	3	GLACIOFLUVIAL OUTWASH REMNANT
1A.26(2)	SAND & GRAVEL, LITTLE SILT	2	GLACIOFLUVIAL TERRACE REMNANTS
1A.26(2)	SAND & GRAVEL, LITTLE SILT	2	GLACIOFLUVIAL TERRACE REMNANTS
1A.28(4)	SAND-VARIABLE, SILT, TRACE GRAVEL	4	GLACIOFLUVIAL RIDGE
2.08(3)	SAND AND GRAVEL TRACE OF SILT	3	GLACIOFLUVIAL TERRACES
2.19(3)	SAND & GRAVEL, TRACE SILT	3	GLACIOFLUVIAL OUTWASH AND ALLUVIAL FAN
2.46(3/4)	SAND & GRAVEL, SOME SILT/CLAY	3/4	SMALL KAMES OR CREVASSE FILLINGS
2.46(3/4)	SAND & GRAVEL, SOME SILT/CLAY	3/4	SMALL KAMES OR CREVASSE FILLINGS

Appendix B
Deposits in 11-15 Km Buffer Zone

Deposit	Granular Type	Material Class	Landform Type
1A.01(3)	SAND-TRACE, SILT	3	GLACIOFLUVIAL
1A.03(3)	SAND-TRACE, GRAVEL	3	GLACIOFLUVIAL BEACH & DELTA DEPOSIT
1A.04(3)	SAND-TRACE, GRAVEL, TRACE SILT	3	GLACIOFLUVIAL DELTA PLAIN
1A.04(3)	SAND-TRACE, GRAVEL, TRACE SILT	3	GLACIOFLUVIAL DELTA PLAIN
1A.06(3)	SAND-SOME, GRAVEL, TRACE SILT	3	GLACIOFLUVIAL KAME
1A.06(3)	SAND-SOME, GRAVEL, TRACE SILT	3	GLACIOFLUVIAL KAME
1A.06(3)	SAND-SOME, GRAVEL, TRACE SILT	3	GLACIOFLUVIAL KAME
1A.06(3)	SAND-SOME, GRAVEL, TRACE SILT	3	GLACIOFLUVIAL KAME
1A.07(2)	SAND-GRAVEL	2	GLACIOFLUVIAL LACUSTRINE ESKER-KAME COMPLEX
1A.08(2)	SAND-GRAVEL	2	GLACIOFLUVIAL LACUSTRINE ESKER-KAME COMPLEX
1A.09(2)	SAND-GRAVEL	2	GLACIOFLUVIAL LACUSTRINE ESKER-KAME COMPLEX
1A.11(2)	SAND-GRAVEL	2	GLACIOFLUVIAL LACUSTRINE ESKER-KAME COMPLEX
1A.16(3)	SAND-SILT AND ICE	3	GLACIAL OUTWASH
1A.16(3)	SAND-SILT AND ICE	3	GLACIAL OUTWASH
1A.17(3)	SAND-TRACE, GRAVEL	3	GLACIOFLUVIAL KAME-ESKER COMPLEX
1A.18(3)	SAND-SOME, SILT,TRACE GRAVEL	3	GLACIOFLUVIAL ESKER REMNANT
1A.18(3)	SAND-SOME, SILT,TRACE GRAVEL	3	GLACIOFLUVIAL ESKER REMNANT
1A.18(3)	SAND-SOME, SILT,TRACE GRAVEL	3	GLACIOFLUVIAL ESKER REMNANT
1A.22(2/4)	SAND-SOME, GRAVEL	2/4	GLOCIOFLUVIAL ESKER
1A.22(2/4)	SAND-SOME, GRAVEL	2/4	GLOCIOFLUVIAL ESKER
1A.22(2/4)	SAND-SOME, GRAVEL	2/4	GLOCIOFLUVIAL ESKER
1A.22(2/4)	SAND-SOME, GRAVEL	2/4	GLOCIOFLUVIAL ESKER
2.03(3)	SAND & GRAVEL, TRACE SILT	3	DELTA REMNANT
2.08(3)	SAND AND GRAVEL TRACE OF SILT	3	GLACIOFLUVIAL TERRACES
2.08(3)	SAND AND GRAVEL TRACE OF SILT	3	GLACIOFLUVIAL TERRACES
2.09(1)	GRAVEL AND SAND, SOME SILT	1	GLACIOFLUVIAL TERRACES
2.16(4)	SAND, SOME GRAVEL, SOME SILT	4	GLACIOFLUVIAL TERRACES
2.16(4)	SAND, SOME GRAVEL, SOME SILT	4	GLACIOFLUVIAL TERRACES
2.17(3)	SAND AND GRAVEL, TRACE SILT	3	KAMES WITH SECONDARY OUTWASH AREA
2.17(3)	SAND AND GRAVEL, TRACE SILT	3	KAMES WITH SECONDARY OUTWASH AREA
2.18(3)	SAND & GRAVEL, TRACE SILT	3	GLACIOFLUVIAL OUTWASH
2.23(4)	SAND AND SILT, TRACE GRAVEL	4	KAMES AND ESKER COMPLEX
2.24(3)	SAND & GRAVEL	3	GLACIOFLUVIAL DEPOSITS
2.27(3)	GRAVEL & SAND	3	GLACIOFLUVIAL OUTWASH
2.27(3)	GRAVEL & SAND	3	GLACIOFLUVIAL OUTWASH
2.33(3)	GRAVEL SOME, SAND TRACE, SILT	3	GLACIOFLUVIAL COMPLEX

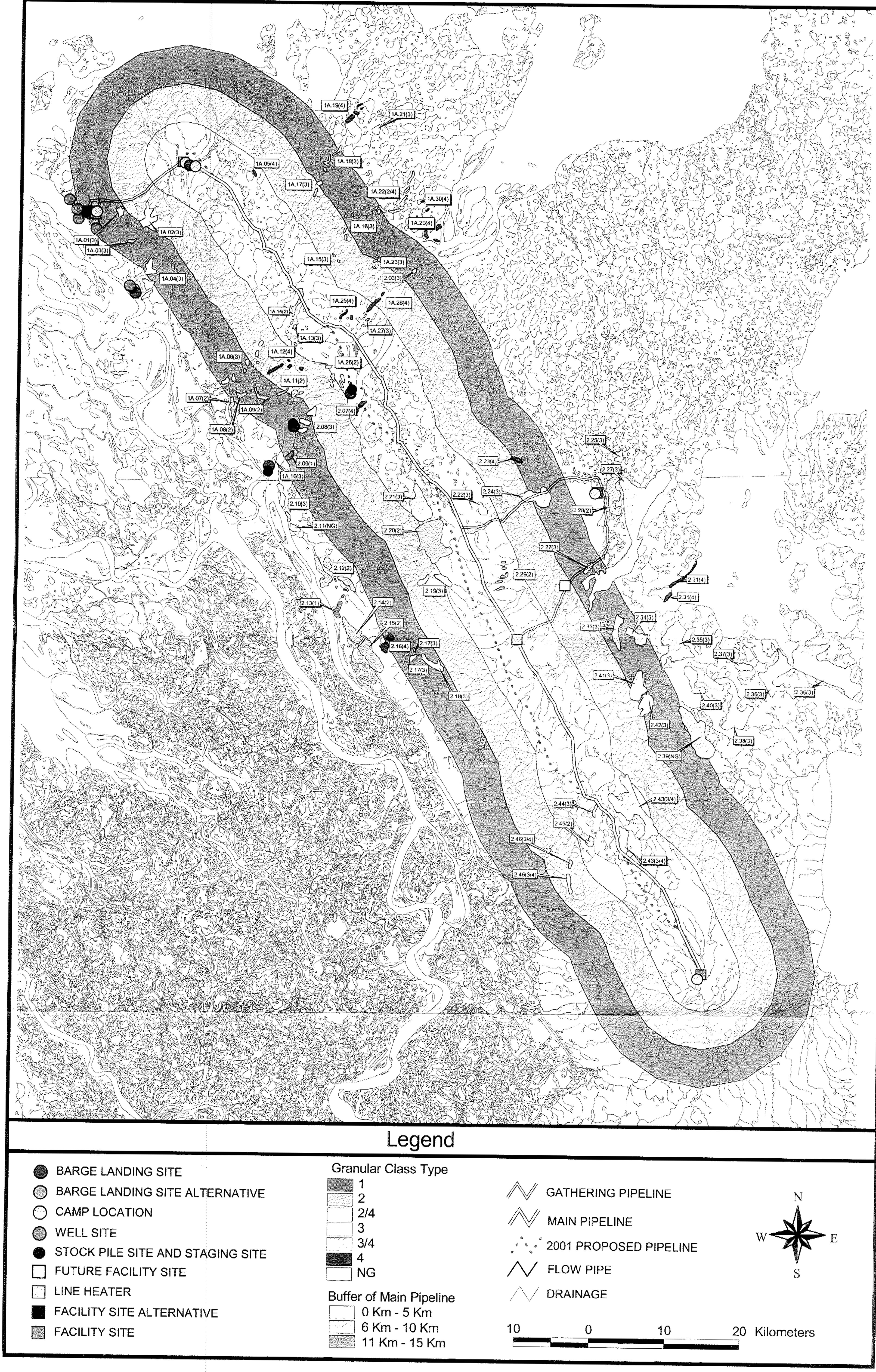
Appendix B
Deposits in 11-15 Km Buffer Zone

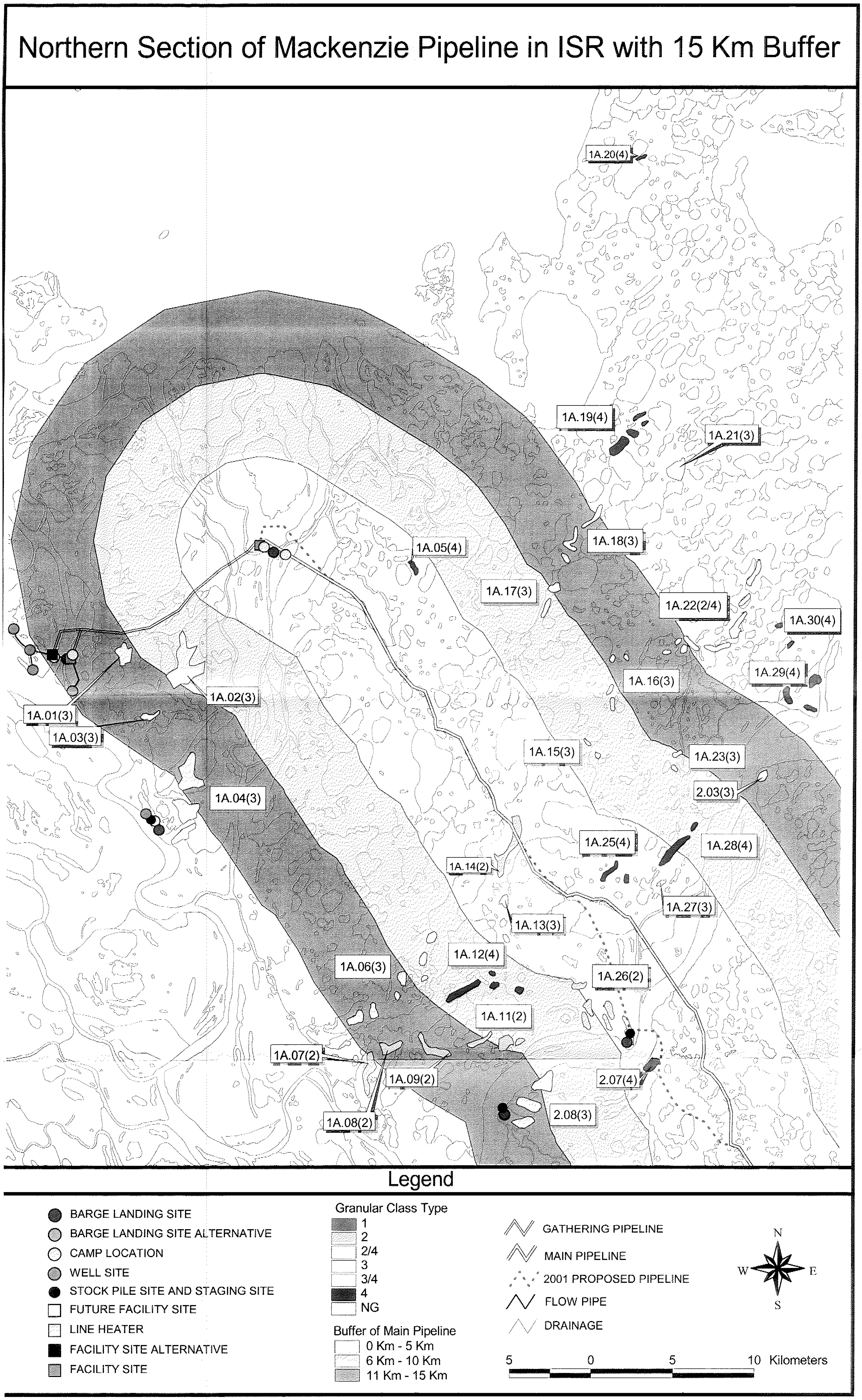
2.34(3)	SAND & GRAVEL	3	GLACIOFLUVIAL DEPOSIT
2.39(NG)	SILT, TRACE SAND & CLAY	NG	GLACIOFLUVIAL DEPOSIT
2.41(3)	GRAVEL & SAND, TRACE SILT	3	GLACIOFLUVIAL TERRACE
2.42(3)	SAND & GRAVEL	3	FLUVIAL TERRACES

Appendix C

Map: Mackenzie Pipeline in Inuvialuit Settlement Region within 15 Km Buffer

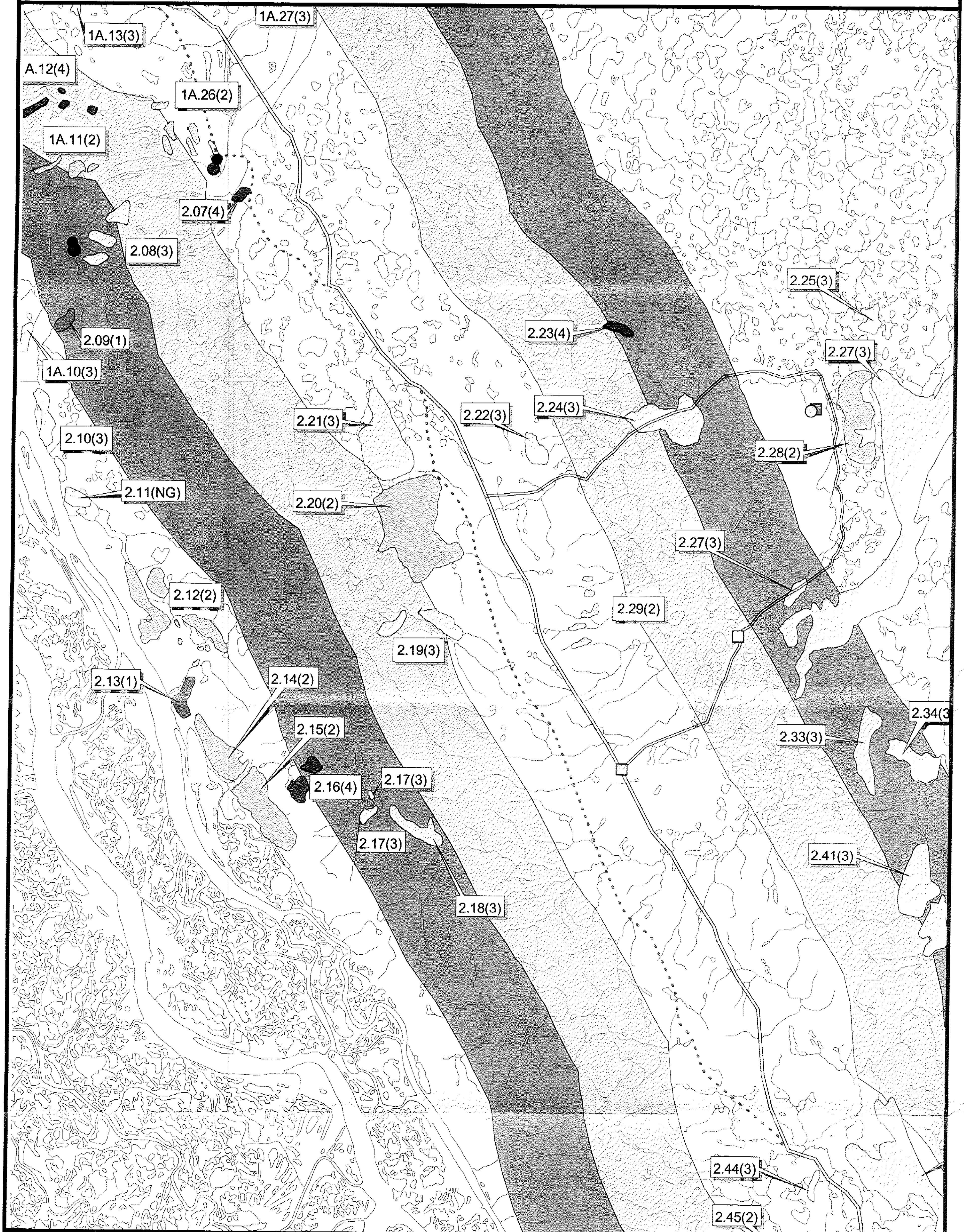
Mackenzie Pipeline in Inuvialuit Settlement Region with 15 Km Buffer





Northern Section of Mackenzie Pipeline in ISR with 15 Km Buffer
1A.20(4)
1A.19(4)
1A.21(3)
1A.18(3)
1A.05(4)
1A.17(3)
1A.22(2/4)
1A.30(4)
1A.29(4)
1A.16(3)
1A.02(3)
1A.01(3)
1A.03(3)
1A.15(3)
1A.23(3)
2.03(3)
1A.04(3)
1A.25(4)
1A.28(4)
1A.14(2)
1A.27(3)
1A.13(3)
1A.12(4)
1A.06(3)
1A.26(2)
1A.11(2)
1A.07(2)
1A.09(2)
2.07(4)
2.08(3)
1A.08(2)
Legend
BARGE LANDING SITE
BARGE LANDING SITE ALTERNATIVE
CAMP LOCATION
WELL SITE
STOCK PILE SITE AND STAGING SITE
FUTURE FACILITY SITE
LINE HEATER
FACILITY SITE ALTERNATIVE
FACILITY SITE
Granular Class Type
1
2
2/4
3
3/4
4
NG
Buffer of Main Pipeline
0 Km - 5 Km
6 Km - 10 Km
11 Km - 15 Km
GATHERING PIPELINE
MAIN PIPELINE
2001 PROPOSED PIPELINE
FLOW PIPE
DRAINAGE
5
0
5
10 Kilometers
N
W
E
S

Mid-Section of Mackenzie Pipeline in ISR with 15 Km Buffer



Legend

BARGE LANDING SITE
BARGE LANDING SITE ALTERNATIVE
CAMP LOCATION
WELL SITE
STOCK PILE SITE AND STAGING SITE
FUTURE FACILITY SITE
LINE HEATER
FACILITY SITE ALTERNATIVE
FACILITY SITE

Granular Class Type
1
2
2/4
3
3/4
4
NG

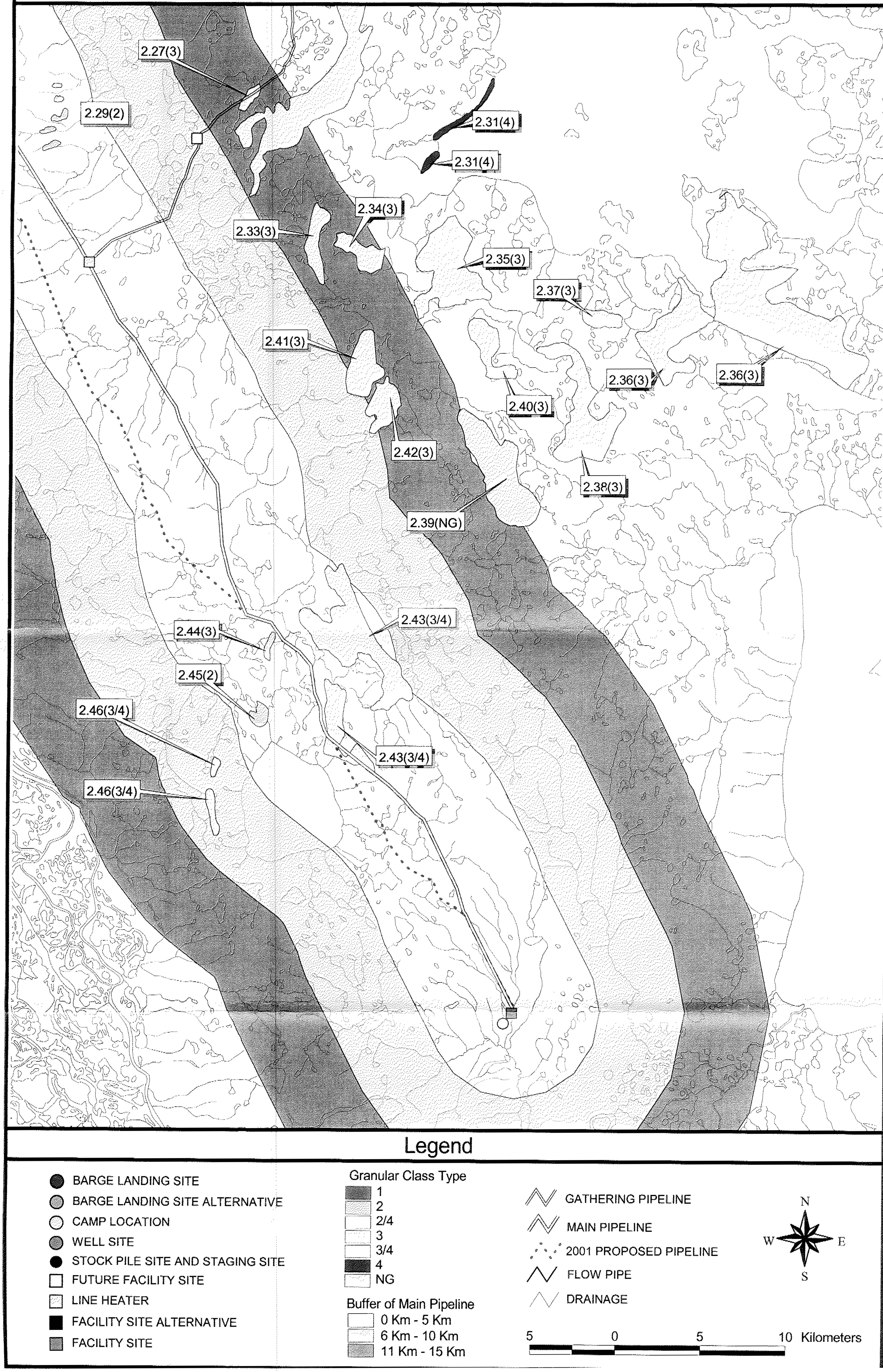
Buffer of Main Pipeline
0 Km - 5 Km
6 Km - 10 Km
11 Km - 15 Km

GATHERING PIPELINE
MAIN PIPELINE
2001 PROPOSED PIPELINE
FLOW PIPE
DRAINAGE

N
W E
S

5 0 5 10 Kilometers

Southern Section of Mackenzie Pipeline in ISR with 15 Km Buffer



Appendix D

Table: Deposit Volumes

Appendix D
Deposit Volumes

Deposit	Report	Proven	Probable	Prospective	Total	Source ID	Pipeline Coverage m³	KM	Comment
1A.01(3)	*		1,000,000	1,000,000			264,550	265	
1A.02(3)	*		7,000,000	7,000,000			1,851,852	1,852	
1A.03(3)			11,400	11,400			3,016	3	
1A.05(4)	/	0	0	0	0	205A	0	0	
1A.18(3)			152,000	152,000			40,212	40	
1A.04(3)			38,000	38,000			10,053	10	
1A.17(3)			152,000	152,000			40,212	40	
1A.16(3)	?					218N	0	0	
1A.22(2/4)		136,000	494,000				130,688	131	
1A.15(3)	/				229,000		60,582	61	Total
1A.14(2)		230,000					60,847	61	Proven
1A.23(3)			190,000	190,000			50,265	50	
1A.06(3)			304,000	304,000			80,423	80	
1A.13(3)			76,000	76,000			20,106	20	
1A.08(2)					6,004,000		1,588,360	1,588	Total
1A.07(2)	/				306,000		80,952	81	Total
1A.12(4)	/	0	0	0		221A	0	0	
1A.25(4)	*	0	0	0		217E	0	0	
2.03(3)		5,000	25,000	35,000			6,614	7	
1A.09(2)					4,180,000		1,105,820	1,106	Total
1A.28(4)	/				229,000		60,582	61	Total
1A.27(3)	*	13,000	1,700,000	1,700,000			449,735	450	
1A.11(2)					3,040,000		804,233	804	Total
1A.26(2)		10,640,000	10,640,000				2,814,815	2,815	
2.07(4)				25,000,000			6,613,757	6,614	Prospective
2.08(3)		4,500,000	7,000,000	10,000,000			1,851,852	1,852	
2.09(1)		400,000	1,000,000	1,000,000			264,550	265	
2.23(4)		55,000	550,000	5,500,000			145,503	146	
2.21(3)		80,000	400,000	1,200,000			105,820	106	
2.22(3)		200,000	2,000,000	3,700,000			529,101	529	
2.24(3)		400,000	4,000,000	12,000,000			1,058,201	1,058	
2.20(2)		350,000	4,500,000	10,000,000			1,190,476	1,190	
2.19(3)		250,000	2,500,000	5,500,000			661,376	661	
2.29(2)		3,000,000	10,000,000	10,000,000			2,645,503	2,646	
2.16(4)		350,000	2,000,000	7,500,000			529,101	529	
2.17(3)		450,000	1,500,000	3,000,000			396,825	397	

Appendix D
Deposit Volumes

Deposit	Report	Proven	Probable	Prospective	Total	Source ID	Pipeline Coverage m³	KM	Comment
2.27(3)		7,500,000	75,000,000	350,000,000			19,841,270	19,841	
2.18(3)		650,000	3,000,000	10,000,000			793,651	794	
2.33(3)		350,000	7,500,000	15,000,000			1,984,127	1,984	
2.34(3)		1,500,000	15,000,000	55,000,000			3,968,254	3,968	
2.41(3)		600,000	6,000,000	25,000,000			1,587,302	1,587	
2.42(3)		30,000	3,000,000	30,000,000			793,651	794	
2.39(NG)							0	0	
2.44(3)		25,000	250,000	1,000,000			66,138	66	
2.43(3/4)		1,800,000	18,000,000	180,000,000			4,761,905	4,762	
2.45(2)		800,000	8,000,000	25,000,000			2,116,402	2,116	
2.46(3/4)		10,000	20,000	25,000			5,291	5	

*	EBA Tuk	
/	Ripley, Klohn & Leonoff	
	Hardy BBT Ltd.	

Appendix E

Table: Deposit Values
E1: Optimal Haul Calculations
E2: Initial Table – Deposits with no volume
E3: Revised Table – Deposits that are not optimal
E4: Final Revised Table

Appendix E1
Optimal Haul Calculations

0-5 Km

1A.05 (4)

A = 3.9 + x
B = 0.64 + y
$x + y = 18.15$
$3.9 + x = 0.64 + y$
$3.26 + x = y$
$x + y = 18.15$
$y = 18.15 - x$
$3.26 + x = 18.15 - x$
$2x = 18.15 - 3.26$
$x = 14.89/2$
$x = 7.45$
$7.45 + y = 18.15$
$y = 18.15 - 7.45$
$y = 10.47$
Therefore $x = 7.45$
$y = 10.47$

1A.14 (2)

A = 0.64+ x
B = 3.4 + y
$x + y = 3.4$
$0.64 + x = 3.4 + y$
$x = 2.76 + y$
$x + y = 3.4$
$x = 3.4 - y$
$2.76 + y = 3.4 - y$
$2y = 3.4 - 2.76$
$y = 0.64/2$
$y = 0.32$
$x + 0.32 = 3.4$
$x = 3.4 - 0.32$
$x = 3.08$
Therefore $x = 0.32$
$y = 3.08$

1A.13 (3)

A = 3.4 + x
B = 1.93 + y
$x + y = 4.95$
$3.4 + x = 1.93 + y$
$1.47 + x = y$
$x + y = 4.95$
$y = 4.95 - x$
$1.47 + x = 3.48 - x$
$2x = 3.48 - 1.47$
$x = 3.48/2$
$x = 1.74$
$1.74 + y = 4.95$
$y = 4.95 - 1.74$
$y = 3.21$
Therefore $x = 1.74$
$y = 3.21$

1A.25 (4)

A = 1.93+ x
B = 5.5 + y
$x + y = 1.55$
$1.93 + x = 5.5 + y$
$x = 3.57 + y$
$x + y = 1.55$
$x = 1.55 - y$
$3.57 + y = 1.55 - y$
$2y = 3.57 - 1.55$
$y = 2.02/2$
$y = 1.01$
$x + 1.01 = 1.55$
$x = 1.55 - 1.01$
$x = 0.54$
Therefore $x = 0.54$
$y = 1.01$

1A.28 (4)

A = 5.5 + x
B = 2.89 + y
$x + y = 0.78$
$5.5 + x = 2.89 + y$
$2.61 + x = y$
$x + y = 0.78$
$y = 0.78 - x$
$2.61 + x = 0.78 - x$
$-2x = 2.61 - 0.78$
$-x = 1.83/2$
$x = -0.91$
$-0.91 + y = 0.78$
$y = 0.78 - (-0.91)$
$y = 1.69$
Therefore $x = -0.91$
$y = 1.69$

1A.27(3)

A = 2.89 + x
B = 4.59 + y
$x + y = 5.22$
$2.89 + x = 4.59 + y$
$x = 1.70 + y$
$x + y = 5.22$
$x = 5.22 - y$
$3.57 + y = 1.55 - y$
$2y = 3.57 - 1.55$
$y = 3.52/2$
$y = 1.76$
$x + 1.76 = 5.22$
$x = 5.22 - 1.76$
$x = 3.46$
Therefore $x = 3.46$
$y = 1.76$

1A.26 (2)

A = 4.59 + x
B = 3.18 + y
$x + y = 5.95$
$4.59 + x = 3.18 + y$
$x = 1.41 + y$
$x + y = 5.95$
$x = 5.95 - y$
$1.41 + y = 5.95 - y$
$2y = 5.95 - 1.41$
$y = 4.54/2$
$y = 2.27$
$x + 2.27 = 5.95$
$x = 5.95 - 2.27$
$x = 3.68$
Therefore $x = 3.68$
$y = 2.27$

2.07(4)

A = 3.18 + x
B = 3.73+ y
$x + y = 14.3$
$3.18 + x = 3.73 + y$
$x = 0.55 + y$
$x + y = 14.3$
$x = 14.3 - y$
$0.55 + y = 14.3 - y$
$2y = 14.3 - 0.55$
$y = 13.75/2$
$y = 6.88$
$x + 6.88 = 14.3$
$x = 14.3 - 6.88$
$x = 7.42$
Therefore $x = 7.42$
$y = 6.88$

2.21 (3)

A = 3.73 + x
B = 3.41 + y
$x + y = 4$
$3.73 + x = 3.41 + y$
$0.32 + x = y$
$x + y = 4$
$y = 4 - x$
$0.32 + x = 4 - x$
$2x = 4 - 0.32$
$x = 3.68/2$
$x = 1.84$
$1.84 + y = 4$
$y = 4 - 1.84$
$y = 2.16$
Therefore $x = 1.84$
$y = 2.16$

Appendix E1
Optimal Haul Calculations

2.22(3)
$A = 3.41 + x$
$B = 4.18 + y$
$x + y = 1.12$
$3.41 + x = 4.18 + y$
$x = 0.77 + y$
$x + y = 1.12$
$x = 1.12 - y$
$0.77 + y = 1.12 - y$
$2y = 1.12 - 0.77$
$y = 0.35/2$
$y = 0.18$
$x + 0.18 = 1.12$
$x = 1.12 - 0.18$
$x = 0.94$
Therefore $x = 0.94$
$y = 0.18$

2.20 (2)
$A = 4.18 + x$
$B = 2.95 + y$
$x + y = 6.8$
$4.18 + x = 2.95 + y$
$1.23 + x = y$
$x + y = 6.8$
$y = 6.8 - x$
$1.23 + x = 6.8 - x$
$2x = 6.8 - 1.23$
$x = 5.57/2$
$x = 2.79$
$2.79 + y = 6.8$
$y = 6.8 - 2.79$
$y = 4.01$
Therefore $x = 2.79$
$y = 4.01$

2.29(2)
$A = 2.95 + x$
$B = 0.86 + y$
$x + y = 33.85$
$2.95 + x = 0.86 + y$
$x = 2.26 + y$
$x + y = 33.85$
$x = 33.85 - y$
$2.26 + y = 33.85 - y$
$2y = 33.85 - 2.26$
$y = 31.76/2$
$y = 15.88$
$x + 15.88 = 33.85$
$x = 33.85 - 15.88$
$x = 17.97$
Therefore $x = 15.88$
$y = 17.97$

2.44 (3)
$A = 0.86 + x$
$B = 3.12 + y$
$x + y = 1.95$
$0.86 + x = 3.12 + y$
$x = 2.26 + y$
$x + y = 1.95$
$x = 1.95 - y$
$2.26 + y = 1.95 - y$
$-2y = 2.26 - 1.95$
$-y = 0.31/2$
$y = -0.16$
$x + (-0.16) = 1.95$
$x = 1.95 - (-0.16)$
$x = 2.11$
Therefore $x = 2.11$
$y = -0.16$

2.43(3/4)
$A = 3.12 + x$
$B = 3.54 + y$
$x + y = 1.93$
$3.12 + x = 3.54 + y$
$x = 0.42 + y$
$x + y = 1.93$
$x = 1.93 - y$
$0.42 + y = 1.93 - y$
$2y = 1.93 - 0.42$
$y = 1.51/2$
$y = 0.76$
$x + 0.76 = 1.93$
$x = 1.93 - 0.76$
$x = 1.17$
Therefore $x = 1.17$
$y = 0.76$

0-10 Km
1A.02(3)
$A = 16.01 + x$
$B = 7 + y$
$x + y = 8.79$
$16.01 + x = 7 + y$
$9.01 + x = y$
$x + y = 8.79$
$y = 8.79 - x$
$9.01 + x = 8.79 - x$
$-2x = 9.01 - 8.79$
$-x = 0.22/2$
$x = -0.11$
$-0.11 + y = 8.9$
$y = 8.79 - (-0.11)$
$y = 8.9$
Therefore $x = -0.11$
$y = 8.9$

1A.02(3)
$A = 9.39 + x$
$B = 3.9 + y$
$x + y = 7.77$
$9.39 + x = 3.9 + y$
$5.49 + x = y$
$x + y = 7.77$
$y = 7.77 - x$
$5.49 + x = 7.77 - x$
$-2x = 7.77 - 5.49$
$-x = 2.28/2$
$x = 1.14$
$1.14 + y = 7.77$
$y = 7.77 - 1.14$
$y = 6.63$
Therefore $x = 1.14$
$y = 6.63$

1A.05(4)
$A = 3.9 + x$
$B = 9.5 + y$
$x + y = 7$
$3.9 + x = 9.5 + y$
$x = 5.6 + y$
$x + y = 7$
$x = 7 - y$
$5.6 + y = 7 - y$
$2y = 7 - 5.6$
$y = 1.4/2$
$y = 0.7$
$x + 0.7 = 7$
$x = 7 - 0.7$
$x = 6.3$
Therefore $x = 6.3$
$y = 0.7$

1A.17 (3)
$A = 9.5 + x$
$B = 6.74 + y$
$x + y = 9.5$
$9.5 + x = 6.74 + y$
$2.76 + x = y$
$x + y = 9.5$
$y = 9.5 - x$
$2.76 + x = 9.5 - x$
$2x = 9.5 - 2.76$
$x = 6.74/2$
$x = 3.37$
$3.37 + y = 9.5$
$y = 9.5 - 3.37$
$y = 6.13$
Therefore $x = 3.37$
$y = 6.13$

Appendix E1
Optimal Haul Calculations

1A.15 (3)
A = 6.74 + x
B = 0.64 + y
$x + y = 3.24$
$6.74 + x = 0.64 + y$
$y = 6.1 + x$
$x + y = 3.24$
$y = 3.24 - x$
$6.1 + x = 3.24 - x$
$-2x = 6.1 - 3.24$
$-x = 2.86/2$
$x = -1.43$
$-1.43 + y = 3.24$
$y = 8.79 - (-1.43)$
$y = 4.67$
Therefore $x = -1.43$
$y = 4.67$

1A.14(2)
A = 0.64+ x
B = 10.74 + y
$x + y = 1.26$
$0.64 + x = 10.74 + y$
$x = 10.1 + y$
$x + y = 1.26$
$x = 1.26 - y$
$10.1 + y = 1.26 - y$
$-2y = 10.1 - 1.26$
$-y = 8.84/2$
$y = -4.42$
$x + -4.42 = 1.95$
$x = 1.95 - (-4.42)$
$x = 5.68$
Therefore $x = 5.68$
$y = -4.42$

1A.23 (3)
A = 10.74 + x
B = 3.4 + y
$x + y = 2.16$
$10.74 + x = 3.4 + y$
$y = 7.34 + x$
$x + y = 2.16$
$y = 2.16 - x$
$7.34 + x = 2.16 - x$
$-2x = 7.34 - 2.16$
$-x = 5.18/2$
$x = -2.59$
$-2.59 + y = 2.16$
$y = 2.16 - (-2.59)$
$y = 4.75$
Therefore $x = -2.59$
$y = 4.75$

1A.13(3)
A = 3.4 + x
B = 8.27 + y
$x + y = 1.73$
$3.4 + x = 8.27 + y$
$x = 4.87 + y$
$x + y = 1.73$
$x = 1.73 - y$
$4.87 + y = 1.73 - y$
$-2y = 4.87 - 1.73$
$-y = 3.14/2$
$y = -1.57$
$x + -1.57 = 1.73$
$x = 1.73 - (-1.57)$
$x = 3.3$
Therefore $x = 3.3$
$y = -1.57$

1A.12 (4)
A = 8.27+ x
B = 1.93 + y
$x + y = 1.78$
$8.27 + x = 1.93 + y$
$y = 6.34 + x$
$x + y = 1.78$
$y = 1.78 - x$
$6.34 + x = 1.78 - x$
$-2x = 6.34 - 1.78$
$-x = 4.56/2$
$x = -2.28$
$-2.28 + y = 1.78$
$y = 1.78 - (-2.28)$
$y = 4.06$
Therefore $x = -2.28$
$y = 4.06$

1A.25(3)
A = 2.89 + x
B = 8.1 + y
$x + y = 1.82$
$2.89 + x = 8.1 + y$
$x = 5.21 + y$
$x + y = 1.82$
$x = 1.82 - y$
$5.21 + y = 1.82 - y$
$-2y = 5.21 - 1.82$
$-y = 3.39/2$
$y = -1.7$
$x + -1.7 = 1.82$
$x = 1.82 - (-1.7)$
$x = 3.52$
Therefore $x = 3.52$
$y = -1.7$

1A.11 (2)
A = 8.1+ x
B = 4.59 + y
$x + y = 2.22$
$8.1 + x = 4.59 + y$
$y = 3.51 + x$
$x + y = 2.22$
$y = 2.22 - x$
$3.51 + x = 2.22 - x$
$-2x = 3.51 - 2.22$
$-x = 1.29/2$
$x = -0.65$
$-0.65 + y = 2.22$
$y = 2.22 - (-0.65)$
$y = 2.87$
Therefore $x = -0.65$
$y = 2.87$

1A.12 (4)
A = 4.59+ x
B = 3.18 + y
$x + y = 5.95$
$4.59 + x = 5.95 + y$
$1.41 + x = y$
$x + y = 5.95$
$y = 5.95 - x$
$1.41 + x = 5.95 - x$
$2x = 5.95 - 1.41$
$x = 4.54/2$
$x = 2.27$
$3.68 + y = 5.95$
$y = 5.95 - 2.27$
$y = 3.68$
Therefore $x = 2.27$
$y = 3.68$

2.07 (4)
A = 9.5 + x
B = 6.74 + y
$x + y = 9.5$
$9.5 + x = 6.74 + y$
$2.76 + x = y$
$x + y = 9.5$
$y = 9.5 - x$
$2.76 + x = 9.5 - x$
$2x = 9.5 - 2.76$
$x = 6.74/2$
$x = 3.37$
$3.37 + y = 9.5$
$y = 9.5 - 3.37$
$y = 6.13$
Therefore $x = 3.37$
$y = 6.13$

Appendix E1
Optimal Haul Calculations

2.19 (3)

$A = 6.38 + x$
$B = 2.95 + y$
$x + y = 2.03$
$6.38 + x = 2.95 + y$
$y = 3.43 + x$
$x + y = 2.03$
$y = 2.03 - x$
$3.43 + x = 2.03 - x$
$-2x = 3.43 - 2.03$
$-x = 1.4/2$
$x = -0.7$
$-0.7 + y = 2.03$
$y = 2.03 - (-0.7)$
$y = 2.73$
Therefore $x = -0.7$
$y = 2.73$

1A.02(3)

$A = 9.4 + x$
$B = 13.63 + y$
$x + y = 1.4$
$9.4 + x = 13.63 + y$
$x = 4.23 + y$
$x + y = 1.4$
$x = 1.4 - y$
$4.23 + y = 1.4 - y$
$-2y = 4.23 - 1.4$
$-y = 2.83/2$
$y = -1.42$
$x + (-1.42) = 1.4$
$x = 3.73 - (-1.42)$
$x = 2.83$
Therefore $x = 2.83$
$y = -1.42$

1A.18(3)

$A = 13.75 + x$
$B = 15.23 + y$
$x + y = 1.55$
$13.75 + x = 15.23 + y$
$1.48 + x = y$
$x + y = 1.55$
$y = 1.55 - x$
$1.48 + x = 1.55 - x$
$2x = 1.55 - 1.48$
$x = 0.07/2$
$x = 0.04$
$0.04 + y = 1.55$
$y = 1.55 - 0.04$
$y = 1.51$
Therefore $x = 0.04$
$y = 1.51$

Appendix E1
Optimal Haul Calculations

2.19 (3)
$A = 6.38 + x$
$B = 2.95 + y$
$x + y = 2.03$
$6.38 + x = 2.95 + y$
$y = 3.43 + x$
$x + y = 2.03$
$y = 2.03 - x$
$3.43 + x = 2.03 - x$
$-2x = 3.43 - 2.03$
$-x = 1.4/2$
$x = -0.7$
$-0.7 + y = 2.03$
$y = 2.03 - (-0.7)$
$y = 2.73$
Therefore $x = -0.7$
$y = 2.73$

2.45(2)
$A = 3.54 + x$
$B = 8.69 + y$
$x + y = 3.73$
$3.54 + x = 8.69 + y$
$x = 5.15 + y$
$x + y = 3.73$
$x = 3.73 - y$
$5.15 + y = 3.73 - y$
$-2y = 5.15 - 3.73$
$-y = 1.42/2$
$y = -0.71$
$x + (-0.71) = 3.73$
$x = 3.73 - (-0.71)$
$x = 4.44$
Therefore $x = 4.44$
$y = -0.71$

0 - 15 Km
1A.01(3)
$A = 11.12 + x$
$B = 9.4 + y$
$x + y = 2.6$
$11.12 + x = 9.4 + y$
$1.72 + x = y$
$x + y = 2.6$
$y = 2.6 - x$
$1.72 + x = 2.6 - x$
$2x = 2.6 - 1.72$
$x = 0.88/2$
$x = 0.44$
$0.44 + y = 2.6$
$y = 2.6 - 0.44$
$y = 2.16$
Therefore $x = 0.44$
$y = 2.16$

1A.02(3)
$A = 9.4 + x$
$B = 13.63 + y$
$x + y = 1.4$
$9.4 + x = 13.63 + y$
$x = 4.23 + y$
$x + y = 1.4$
$x = 1.4 - y$
$4.23 + y = 1.4 - y$
$-2y = 4.23 - 1.4$
$-y = 2.83/2$
$y = -1.42$
$x + (-1.42) = 1.4$
$x = 3.73 - (-1.42)$
$x = 2.83$
Therefore $x = 2.83$
$y = -1.42$

1A.03(3)
$A = 13.63 + x$
$B = 3.9 + y$
$x + y = 3.9$
$13.63 + x = 3.9 + y$
$9.73 + x = y$
$x + y = 3.9$
$y = 3.9 - x$
$9.73 + x = 3.9 - x$
$2x = 9.73 - 3.9$
$x = 5.83/2$
$x = 2.92$
$2.92 + y = 3.9$
$y = 3.9 - 2.92$
$y = 0.98$
Therefore $x = 2.92$
$y = 0.98$

1A.05(3)
$A = 3.9 + x$
$B = 13.75 + y$
$x + y = 2.27$
$3.9 + x = 13.75 + y$
$x = 9.85 + y$
$x + y = 2.27$
$x = 2.27 - y$
$9.85 + y = 2.27 - y$
$-2y = 9.85 - 2.27$
$-y = 7.58/2$
$y = -7.58$
$x + (-3.79) = 2.27$
$x = 2.27 - (-3.79)$
$x = 6.06$
Therefore $x = 6.06$
$y = -3.79$

1A.18(3)
$A = 13.75 + x$
$B = 15.23 + y$
$x + y = 1.55$
$13.75 + x = 15.23 + y$
$1.48 + x = y$
$x + y = 1.55$
$y = 1.55 - x$
$1.48 + x = 1.55 - x$
$2x = 1.55 - 1.48$
$x = 0.07/2$
$x = 0.04$
$0.04 + y = 1.55$
$y = 1.55 - 0.04$
$y = 1.51$
Therefore $x = 0.04$
$y = 1.51$

1A.04 (3)
$A = 15.23 + x$
$B = 9.5 + y$
$x + y = 1.53$
$15.23 + x = 9.5 + y$
$y = 5.73 + x$
$x + y = 1.53$
$y = 1.53 - x$
$5.73 + x = 1.53 - x$
$-2x = 5.73 - 1.53$
$-x = 4.2/2$
$x = -2.1$
$-2.1 + y = 1.53$
$y = 1.53 - (-2.1)$
$y = 3.63$
Therefore $x = -2.1$
$y = 3.63$

1A.17(3)
$A = 9.5 + x$
$B = 10.43 + y$
$x + y = 6.22$
$9.5 + x = 10.43 + y$
$0.93 + x = y$
$x + y = 6.22$
$x = 6.22 - y$
$0.93 + y = 6.22 - y$
$2y = 6.22 - 0.93$
$y = 5.29/2$
$y = 2.65$
$2.65 + y = 6.22$
$x = 6.22 - 2.65$
$x = 3.57$
Therefore $x = 3.57$
$y = 2.65$

Appendix E1
Optimal Haul Calculations

1A.16(3)
$A = 10.43 + x$
$B = 17.11 + y$
$x + y = 0.61$
$10.43 + x = 17.11 + y$
$x = 6.68 + y$
$x + y = 0.61$
$x = 0.61 - y$
$6.68 + y = 0.61 - y$
$-2y = 6.68 - 0.61$
$-y = 6.07/2$
$y = -3.04$
$x + (-3.04) = 0.61$
$x = 0.61 - (-3.04)$
$x = 3.65$
Therefore $x = 3.65$
$y = -3.04$

1A.14(2)
$A = 0.64 + x$
$B = 10.74 + y$
$x + y = 0.59$
$0.64 + x = 10.74 + y$
$x = 10.1 + y$
$x + y = 0.59$
$x = 0.59 - y$
$10.1 + y = 0.59 - y$
$-2y = 10.1 - 0.59$
$-y = 9.51/2$
$y = -4.76$
$x + (-4.76) = 0.59$
$x = 0.59 - (-4.76)$
$x = 3.14$
Therefore $x = 3.14$
$y = -4.76$

1A.13(3)
$A = 3.4 + x$
$B = 16.87 + y$
$x + y = 1.91$
$3.4 + x = 16.87 + y$
$13.47 + y = x$
$x + y = 1.91$
$y = 1.91 - x$
$13.47 + y = 1.91 - y$
$2y = 13.47 - 1.91$
$-y = 11.56/2$
$y = -5.78$
$x + (-5.78) = 1.91$
$x = 1.91 - (-5.78)$
$x = 7.69$
Therefore $x = 7.69$
$y = -5.78$

1A.22 (2/4)
$A = 17.11 + x$
$B = 6.74 + y$
$x + y = 2.5$
$17.11 + x = 6.74 + y$
$y = 10.37 + x$
$x + y = 2.5$
$y = 2.5 - x$
$10.37 + x = 2.5 - x$
$-2x = 10.37 - 2.5$
$-x = 7.87/2$
$x = -3.94$
$-3.94 + y = 2.5$
$y = 2.5 - (-3.94)$
$y = 6.44$
Therefore $x = -3.94$
$y = 6.44$

1A.23(3)
$A = 10.74 + x$
$B = 15.05 + y$
$x + y = 1.96$
$10.74 + x = 15.05 + y$
$4.31 + y = x$
$x + y = 1.96$
$y = 1.96 - x$
$4.31 + y = 1.96 - y$
$2y = 4.31 - 1.96$
$-y = 2.35/2$
$y = -1.18$
$x + (-1.18) = 1.96$
$x = 1.96 - (-1.18)$
$x = 3.14$
Therefore $x = 3.14$
$y = -1.18$

1A.08(2)
$A = 16.87 + x$
$B = 18.55 + y$
$x + y = 0.5$
$16.87 + x = 18.55 + y$
$1.68 + y = x$
$x + y = 0.5$
$y = 0.5 - x$
$1.68 + y = 0.5 - y$
$2y = 0.5 - 1.68$
$-y = 1.18/2$
$y = -0.59$
$x + (-0.59) = 0.5$
$x = 0.5 - (-0.59)$
$x = 1.09$
Therefore $x = 1.09$
$y = -0.59$

1A.15 (3)
$A = 6.74 + x$
$B = 0.64 + y$
$x + y = 2.43$
$6.74 + x = 0.64 + y$
$y = 6.1 + x$
$x + y = 2.43$
$y = 2.43 - x$
$6.1 + x = 2.43 - x$
$-2x = 6.1 - 2.43$
$-x = 3.67/2$
$x = -1.84$
$-1.84 + y = 2.43$
$y = 2.43 - (-1.84)$
$y = 4.27$
Therefore $x = -1.84$
$y = 4.27$

1A.06 (3)
$A = 15.05 + x$
$B = 3.4 + y$
$x + y = 1.37$
$15.05 + x = 3.4 + y$
$y = 11.65 + x$
$x + y = 1.37$
$y = 1.37 - x$
$11.65 + x = 1.37 - x$
$-2x = 11.65 - 1.37$
$-x = 10.28/2$
$x = -5.14$
$-5.14 + y = 1.37$
$y = 1.37 - (-5.14)$
$y = 6.51$
Therefore $x = -5.14$
$y = 6.51$

1A.07(2)
$A = 18.55 + x$
$B = 8.27 + y$
$x + y = 0.24$
$18.55 + x = 8.27 + y$
$y = 10.28 + x$
$x + y = 0.24$
$y = 0.24 - x$
$10.28 + x = 0.24 - x$
$-2x = 10.28 - 0.24$
$-x = 10.04/2$
$x = -5.02$
$-5.02 + y = 0.24$
$y = 0.24 - (-5.02)$
$y = 5.26$
Therefore $x = -5.02$
$y = 5.26$

Appendix E1
Optimal Haul Calculations

2.08(3)
A = 11.46 + x
B = 14.97 + y
$x + y = 3.07$
$11.46 + x = 14.97 + y$
$3.51 + y = x$
$x + y = 3.07$
$y = 3.07 - x$
$3.51 + y = 3.07 - y$
$2y = 3.07 - 3.51$
$-y = 0.44/2$
$y = -0.22$
$x + (-0.22) = 3.07$
$x = 3.07 - (-0.22)$
$x = 3.29$
Therefore $x = 3.29$
$y = -0.22$

2.22(3)
A = 3.41 + x
B = 10.8 + y
$x + y = 0.74$
$3.41 + x = 10.8 + y$
$7.39 + y = x$
$x + y = 0.74$
$y = 0.74 - x$
$7.39 + y = 0.74 - y$
$-2y = 0.74 - 7.39$
$-y = 6.65/2$
$y = -3.33$
$x + (-3.33) = 0.74$
$x = 0.74 - (-3.33)$
$x = 4.07$
Therefore $x = 4.07$
$y = -3.33$

2.16(4)
A = 15.04 + x
B = 12.82 + y
$x + y = 2.3$
$15.04 + x = 12.82 + y$
$2.22 + x = y$
$x + y = 2.3$
$y = 2.3 - x$
$2.22 + x = 2.3 - x$
$2x = 2.3 - 2.22$
$x = 0.08/2$
$x = 0.04$
$0.04 + y = 2.3$
$y = 2.3 - 0.04$
$y = 2.26$
Therefore $x = 0.04$
$y = 2.26$

2.09(1)
A = 14.97 + x
B = 10.36 + y
$x + y = 8.72$
$14.97 + x = 10.36 + y$
$4.61 + x = y$
$x + y = 8.72$
$y = 8.72 - x$
$4.61 + x = 8.72 - x$
$2x = 8.72 - 4.61$
$x = 4.11/2$
$x = 2.06$
$2.06 + y = 8.72$
$y = 8.72 - 2.06$
$y = 6.66$
Therefore $x = 2.06$
$y = 6.66$

2.24 (4)
A = 10.8 + x
B = 4.18+ y
$x + y = 0.45$
$10.8 + x = 4.18 + y$
$y = 6.62 + x$
$x + y = 0.45$
$y = 0.45 - x$
$6.62 + x = 0.45 - x$
$-2x = 0.45 - 6.62$
$-x = 6.17/2$
$x = -3.09$
$-3.09 + y = 0.45$
$y = 0.45 - (-3.09)$
$y = 3.54$
Therefore $x = -3.09$
$y = 3.54$

2.17(3)
A = 12.82 + x
B = 19.34 + y
$x + y = 0.56$
$12.82 + x = 19.34 + y$
$6.52 + y = x$
$x + y = 0.56$
$y = 0.56 - x$
$6.52 + y = 0.56 - y$
$-2y = 0.56 - 6.52$
$-y = 5.96/2$
$y = -2.98$
$x + (-2.98) = 0.56$
$x = 0.56 - (-2.98)$
$x = 3.54$
Therefore $x = 3.54$
$y = -2.98$

2.23(4)
A = 10.36 + x
B = 3.73 + y
$x + y = 1$
$10.36 + x = 3.73 + y$
$y = 6.63 + x$
$x + y = 1$
$y = 1 - x$
$6.63 + x = 1 - x$
$-2x = 1 - 6.63$
$-x = 5.63/2$
$x = -2.82$
$-2.82 + y = 1$
$y = 1 - (-2.82)$
$y = 3.82$
Therefore $x = -2.82$
$y = 3.82$

***2.20(2)**
A = 2.95 + x
B = 15.04 + y
$x + y = 2.39$
$2.95 + x = 15.04 + y$
$12.09 + y = x$
$x + y = 2.39$
$y = 2.39 - x$
$12.09 + y = 2.39 - y$
$2y = 2.39 - 12.09$
$y = -9.7/2$
$y = -4.85$
$x + (-4.85) = 2.39$
$x = 2.39 + 4.85$
$x = 7.24$
Therefore $x = 7.24$
$y = -4.85$

2.27(3)
A = 19.34 + x
B = 11.45 + y
$x + y = 1.33$
$19.34 + x = 11.45 + y$
$y = 7.89 + x$
$x + y = 1.33$
$y = 1.33 - x$
$7.89 + x = 1.33 - x$
$-2x = 1.33 - 7.89$
$-x = 6.56/2$
$x = -3.28$
$-3.28 + y = 1.33$
$y = 1.33 - (-3.28)$
$y = 4.61$
Therefore $x = -3.28$
$y = 4.61$

Appendix E1
Optimal Haul Calculations

2.18(3)
A = 11.45 + x
B = 11.82 + y
$x + y = 6.93$
$11.45 + x = 11.82 + y$
$0.37 + x = y$
$x + y = 6.93$
$x = 6.93 - y$
$0.37 + y = 6.93 - y$
$2y = 6.93 - 0.37$
$y = 6.56/2$
$y = 3.28$
$x + 3.28 = 6.93$
$x = 6.93 - 3.28$
$x = 3.65$
Therefore $x = 3.65$
$y = 3.28$

2.33(3)
A = 11.82 + x
B = 13.86 + y
$x + y = 2.38$
$11.82 + x = 13.86 + y$
$2.04 + x = y$
$x + y = 2.38$
$x = 2.38 - y$
$2.04 + y = 2.38 - y$
$2y = 2.38 - 2.04$
$y = 0.34/2$
$y = 0.17$
$x + 0.17 = 2.38$
$x = 2.38 - 0.17$
$x = 2.21$
Therefore $x = 0.17$
$y = 2.21$

2.34(3)
A = 13.86 + x
B = 11.19 + y
$x + y = 4.78$
$13.86 + x = 11.19 + y$
$2.67 + x = y$
$x + y = 4.78$
$y = 4.78 - x$
$2.67 + x = 4.78 - x$
$2x = 4.78 - 2.67$
$x = 2.11/2$
$x = 1.06$
$1.06 + y = 4.78$
$y = 4.78 - 1.06$
$y = 3.72$
Therefore $x = 1.06$
$y = 3.72$

2.41(3)
A = 11.19 + x
B = 11.14 + y
$x + y = 2.7$
$11.19 + x = 11.14 + y$
$0.05 + x = y$
$x + y = 2.7$
$y = 2.7 - x$
$0.05 + x = 2.7 - x$
$2x = 2.7 - 0.05$
$x = 2.65/2$
$x = 1.33$
$1.33 + y = 2.7$
$y = 2.7 - 1.33$
$y = 1.37$
Therefore $x = 1.33$
$y = 1.37$

2.42(3)
A = 11.14 + x
B = 17.08 + y
$x + y = 9.25$
$11.14 + x = 17.08 + y$
$5.94 + x = y$
$x + y = 9.25$
$x = 9.25 - y$
$5.94 + y = 9.25 - y$
$2y = 9.25 - 5.94$
$y = 3.31/2$
$y = 1.66$
$x + 1.66 = 9.25$
$x = 9.25 - 1.66$
$x = 7.59$
Therefore $x = 7.59$
$y = 1.66$

2.39(3)
A = 17.08 + x
B = 0.86 + y
$x + y = 1.35$
$17.08 + x = 0.86 + y$
$y = 16.22 + x$
$x + y = 1.35$
$y = 1.35 - x$
$16.22 + x = 1.35 - x$
$-2x = 16.22 - 1.35$
$-x = 14.87/2$
$x = -7.44$
$-7.44 + y = 1.35$
$y = 1.35 - (-7.44)$
$y = 8.79$
Therefore $x = -7.44$
$y = 8.79$

Revised Calculations
0-5 Km
1A.13(3)
A = 3.4 + x
B = 5.5 + y
$x + y = 4.95$
$3.4 + x = 5.5 + y$
$2.1 + x = y$
$x + y = 4.95$
$x = 4.95 - y$
$2.1 + y = 4.95 - y$
$2y = 4.95 - 2.1$
$y = 2.85/2$
$y = 1.43$
$x + 1.43 = 4.95$
$x = 4.95 - 1.43$
$x = 3.52$
Therefore $x = 3.52$
$y = 1.43$

0-10 Km
1A.02(3)
A = 8.79 + x
B = 9.5 + y
$x + y = 10.65$
$8.79 + x = 9.5 + y$
$0.71 + y = x$
$x + y = 10.65$
$y = 10.65 - x$
$0.71 + y = 10.65 - y$
$-2y = 10.65 - 0.71$
$-y = 9.94/2$
$y = -4.97$
$x + (-4.97) = 10.65$
$x = 10.65 - (-4.97)$
$x = 15.62$
Therefore $x = 15.62$
$y = -4.97$

1A.13(3) to 1A.11(2)
A = 3.4 + x
B = 8.1 + y
$x + y = 5.06$
$3.4 + x = 8.1 + y$
$4.7 + x = y$
$x + y = 5.06$
$x = 5.06 - y$
$4.7 + y = 5.06 - y$
$2y = 5.06 - 4.7$
$y = 0.36/2$
$y = 0.18$
$x + 0.18 = 5.06$
$x = 5.06 - 0.18$
$x = 4.88$
Therefore $x = 4.88$
$y = 0.18$

Appendix E1
Optimal Haul Calculations

0-15Km
1A.03(3)
A = 13.63 + x
B = 13.75 + y
$x + y = 6.17$
$13.63 + x = 13.75 + y$
$0.12 + x = y$
$x + y = 6.17$
$x = 6.17 - y$
$0.12 + y = 6.17 - y$
$2y = 6.17 - 0.12$
$y = 6.05/2$
$y = 3.03$
$x + 3.03 = 6.17$
$x = 6.17 - 3.03$
$x = 3.14$
Therefore $x = 3.03$
$y = 3.14$

1A.17(3)
A = 9.5 + x
B = 17.11 + y
$x + y = 6.83$
$9.5 + x = 17.11 + y$
$7.61 + y = x$
$x + y = 6.83$
$y = 6.83 - x$
$7.61 + y = 6.83 - y$
$-2y = 7.61 - 6.83$
$-y = 0.78/2$
$y = -0.39$
$x + (-0.39) = 6.83$
$x = 6.83 - (-0.39)$
$x = 7.22$
Therefore $x = 7.22$
$y = -0.39$

1A.07(2)
A = 18.55 + x
B = 12.2 + y
$x + y = 1.55$
$18.55 + x = 12.2 + y$
$y = 6.35 + x$
$x + y = 1.55$
$y = 1.55 - x$
$6.35 + x = 1.55 - x$
$-2x = 1.55 - 6.35$
$-x = 4.8/2$
$x = -2.4$
$-2.4 + y = 1.55$
$y = 1.55 - (-2.4)$
$y = 3.95$
Therefore $x = -2.4$
$y = 3.95$

2.42(3)
A = 11.14 + x
B = 0.86 + y
$x + y = 10.6$
$11.14 + x = 0.86 + y$
$10.28 + x = y$
$x + y = 10.6$
$x = 10.6 - y$
$10.28 + y = 10.6 - y$
$2y = 10.6 - 10.28$
$y = 0.32/2$
$y = 0.16$
$x + 0.16 = 10.6$
$x = 10.6 - 0.16$
$x = 10.44$
Therefore $x = 10.44$
$y = 0.16$

Highlighted Black Calculations
0-10Km
1A.02(3)
A = 8.79 + x
B = 6.74 + y
$x + y = 20.95$
$8.79 + x = 6.74 + y$
$2.05 + x = y$
$x + y = 20.95$
$y = 20.95 - x$
$2.05 + x = 20.95 - x$
$2x = 20.95 - 2.05$
$x = 18.9/2$
$x = 9.45$
$9.45 + y = 20.95$
$y = 20.95 - 9.45$
$y = 11.50$
Therefore $x = 9.45$
$y = 11.50$

1A.14(2)
A = 0.64 + x
B = 3.4 + y
$x + y = 3.42$
$0.64 + x = 3.4 + y$
$2.46 + x = y$
$x + y = 3.42$
$x = 3.42 - y$
$2.46 + y = 3.42 - y$
$2y = 3.42 - 2.46$
$y = 0.96/2$
$y = 0.48$
$x + 0.48 = 3.42$
$x = 3.42 - 0.48$
$x = 2.94$
Therefore $x = 2.94$
$y = 0.48$

1A.13(3)
A = 3.4 + x
B = 8.1 + y
$x + y = 7.66$
$3.4 + x = 8.1 + y$
$4.7 + x = y$
$x + y = 7.66$
$x = 7.66 - y$
$4.7 + y = 7.66 - y$
$2y = 7.66 - 4.7$
$y = 2.96/2$
$y = 1.48$
$x + 1.48 = 7.66$
$x = 7.66 - 1.48$
$x = 6.18$
Therefore $x = 6.18$
$y = 1.48$

0-15Km
1A.17(3)
A = 9.5 + x
B = 6.74 + y
$x + y = 9.33$
$9.5 + x = 6.74 + y$
$2.76 + x = y$
$x + y = 9.33$
$y = 9.33 - x$
$2.76 + x = 9.33 - x$
$2x = 9.33 - 2.76$
$x = 6.57/2$
$x = 3.29$
$3.29 + y = 9.33$
$y = 9.33 - 3.29$
$y = 6.04$
Therefore $x = 3.29$
$y = 6.04$

2.03(3)
A = 12.2 + x
B = 5.5 + y
$x + y = 0.78$
$12.2 + x = 5.5 + y$
$y = 6.7 + x$
$x + y = 0.78$
$y = 0.78 - x$
$6.7 + x = 0.78 - x$
$-2x = 6.7 - 0.78$
$-x = 5.92/2$
$x = -2.96$
$-2.96 + y = 0.78$
$y = 0.78 - (-2.96)$
$y = 3.74$
Therefore $x = -2.96$
$y = 3.74$

Appendix E1
Optimal Haul Calculations

1A.27(3)
A = 2.89 + x
B = 4.59 + y
$x + y = 4.04$
$2.89 + x = 4.59 + y$
$1.7 + x = y$
$x + y = 4.04$
$x = 4.04 - y$
$2.89 + y = 4.04 - y$
$2y = 4.04 - 2.89$
$y = 2.34/2$
$y = 1.17$
$x + 1.17 = 4.04$
$x = 4.04 - 1.17$
$x = 2.87$
Therefore $x = 2.87$
$y = 1.17$

2.22(3)
A = 3.41 + x
B = 4.18 + y
$x + y = 1.19$
$3.41 + x = 4.18 + y$
$0.77 + x = y$
$x + y = 1.19$
$x = 1.19 - y$
$0.77 + y = 1.19 - y$
$2y = 1.19 - 0.77$
$y = 0.42/2$
$y = 0.21$
$x + 0.21 = 1.19$
$x = 1.19 - 0.21$
$x = 0.98$
Therefore $x = 0.98$
$y = 0.21$

Black & Red Highlighted
2.29(2)
A = 2.95 + x
B = 11.45 + y
$x + y = 6.58$
$2.95 + x = 11.45 + y$
$8.5 + y = x$
$x + y = 6.58$
$y = 6.58 - x$
$8.5 + y = 6.58 - y$
$-2y = 6.58 - 8.5$
$-y = 1.92/2$
$y = -0.96$
$x + (-0.96) = 6.58$
$x = 6.58 - (-0.96)$
$x = 7.54$
Therefore $x = 7.54$
$y = -0.96$

1A.13(3) to 2.03(3)
A = 3.4 + x
B = 12.2 + y
$x + y = 3.56$
$3.4 + x = 12.2 + y$
$8.8 + y = x$
$x + y = 3.56$
$y = 3.56 - x$
$8.8 + y = 3.56 - y$
$-2y = 8.8 - 3.56$
$-y = 5.24/2$
$y = -2.62$
$x + (-2.62) = 3.56$
$x = 3.56 - (-2.62)$
$x = 6.18$
Therefore $x = 6.18$
$y = -2.62$

2.03 would be discarded as well. Refer to 1A.13 to 1A.28 in 0-5Km buffer for values in 0-15Km buffer.

Highlighted Red Calculations
1A.14(2)
A = 0.64 + x
B = 3.4 + y
$x + y = 3.42$
$0.64 + x = 3.4 + y$
$2.46 + x = y$
$x + y = 3.42$
$x = 3.42 - y$
$2.46 + y = 3.42 - y$
$2y = 3.42 - 2.46$
$y = 0.96/2$
$y = 0.48$
$x + 0.48 = 0.96$
$x = 0.96 - 0.48$
$x = 2.94$
Therefore $x = 2.94$
$y = 0.48$

0-15Km
1A.03(3)
A = 13.63 + x
B = 15.23 + y
$x + y = 7.72$
$13.63 + x = 15.23 + y$
$1.6 + x = y$
$x + y = 7.72$
$x = 7.72 - y$
$1.6 + y = 7.72 - y$
$2y = 7.72 - 1.6$
$y = 6.12/2$
$y = 3.06$
$x + 3.06 = 7.72$
$x = 7.72 - 3.06$
$x = 4.66$
Therefore $x = 4.66$
$y = 3.06$

Appendix E2
Initial Table

Deposits within 0-5 Km

Deposit	From Deposit A to B	x+y	a	b	x	y	Max.Distance of Pipeline Covered
1A.05(4)	1A.05 to 1A.14	18.15	3.9	0.64	7.45	10.7	0
1A.14(2)	1A.14 to 1A.13	3.4	0.64	3.4	2.79	0.615	60.85
1A.13(3)	1A.13 to 1A.25	3.4	3.4	1.93	0.97	2.43	20.11
1A.25(4)	1A.25 ti 1A.28	1.55	1.93	5.5	2.56	-1.01	0
1A.28(4)	1A.28 to 1A.27	0.78	5.5	2.89	-0.92	1.7	60.58
1A.27(3)	1A.27 to 1A.26	5.22	2.89	4.59	3.46	1.76	449.74
1A.26(2)	1A.26 to 2.07	5.95	4.59	3.18	2.27	2.62	2814.81
2.07(4)	2.07 to 2.21	14.13	3.18	3.73	7.42	6.88	6613.76
2.21(3)	2.21 to 2.22	4	3.73	3.41	1.84	2.16	105.82
2.22(3)	2.22 to 2.20	1.12	3.41	4.18	0.94	0.18	529.10
2.20(2)	2.20 to 2.29	6.8	4.18	2.95	2.79	4.01	1190.48
2.29(2)	2.29 to 2.44	33.85	2.95	0.86	15.88	17.97	2645.50
2.44(3)	2.44 to 2.43(3/4)	1.95	0.86	3.12	2.11	-0.16	66.14
2.43(3/4)	2.43(3/4) to 2.45	1.93	3.12	3.54	1.17	0.76	4761.90
2.45(2)			3.54				2116.40
2.19(3)	Located in 10 km buffer		4.98				661.38

Deposits within 0-10 Km

Deposit	From Deposit A to B	x+y	a	b	x	y	Max.Distance of Pipeline Covered
1A.02(3)	1A.02 to **1A.05**	5.28	8.79	3.9	1.14	6.63	1851.85
1A.05(4)	**1A.05** to 1A.17	5.37	**3.9**	9.5	6.3	0.7	0
1A.17(3)	1A.17 to 1A.15	9.5	*9.5*	6.74	3.37	6.13	40.21
1A.15(3)	1A.15 to **1A.14**	3.24	6.74	0.64	-1.43	4.67	60.58
1A.14(2)	**1A.14** to 1A.23	1.26	**0.64**	10.74	5.68	-4.42	60.85
1A.23(3)	1A.23 to **1A.13**	2.16	10.74	3.4	-2.59	4.75	50.26
1A.13(3)	**1A.13** to 1A.12	1.73	**3.4**	8.27	3.3	-1.57	20.11
1A.12(4)	1A.12 to **1A.25**	1.78	8.27	1.93	-2.28	4.06	0
1A.25(4)	**1A.25** to **1A.28**	1.55	**1.93**	5.5	2.56	-1.01	0
1A.28(4)	**1A.28** to **1A.27**	**0.78**	**5.5**	2.89	0.91	-0.13	60.58
1A.27(3)	**1A.27** to_1A.11	1.82	**2.89**	8.1	-1.7	3.52	449.74
1A.11(2)	1A.11 to **1A.26**	2.22	*8.1*	4.59	-0.65	2.87	804.23
1A.26(2)	**1A.26** to **2.07**	5.95	**4.59**	3.18	2.27	3.68	2814.81
2.07(4)	**2.07** to **2.21**	**14.13**	**3.18**	3.73	7.42	6.88	6613.76
2.21(3)	**2.21** to **2.22**	**4**	**3.73**	3.41	1.84	2.16	105.82
2.22(3)	**2.22** to **2.20**	**1.12**	**3.41**	4.18	0.94	0.18	529.10
2.20(2)	**2.20** to 2.19	6.05	**4.18**	6.38	4.12	1.93	1190.48
2.19(3)	2.19 to **2.29**	2.03	6.38	2.95	-0.7	2.73	661.38
2.29(2)	**2.29 to 2.44**	**33.85**	**2.95**	0.86	15.88	17.97	2645.50
2.44(3)	**2.44** to **2.43**	**1.95**	**0.86**	3.12	2.11	-0.16	66.14
2.43(3/4)	**2.43** to **2.45**	**1.93**	**3.12**	3.54	1.17	0.76	4761.90
2.45(2)	**2.45** to 2.46	3.73	**3.54**	8.69	4.44	-0.71	2116.40
2.46(3/4)			8.69				5.29
1A.06(3)	Located in 15 km buffer		7.47				80.42
1A.16(3)	Located in 15 km buffer		9.51				0.00
2.08(3)	**Located in 15 km buffer**		10.28				1851.85

BOLD = Deposits from 0-5 Km Buffer
Italic = Deposits from 6-10 Km

Appendix E2
Initial Table

Deposits within 0-15 Km

Deposit	From Deposit A to B	x+y	a	b	x	y	Max.Distance of Pipeline Covered
1A.01(3)	1A.01 to 1A.02	2.6	11.12	9.4	0.44	2.16	264.55
1A.02(3)	*1A.02* to 1A.03	*1.4*	*9.4*	13.63	2.83	-1.42	1851.85
1A.03(3)	1A.03 to 1A.05	3.9	13.63	3.9	2.92	0.98	3.02
1A.05(4)	1A.05 to 1A.18	2.27	**3.9**	13.75	6.06	-3.79	0
1A.18(3)	1A.18 to 1A.04	1.55	13.75	15.23	1.51	0.04	40.21
1A.04(3)	1A.04 to 1A.17	1.53	15.23	9.5	-2.1	3.63	10.05
1A.17(3)	*1A.17* to 1A.16	6.22	*9.5*	10.43	3.57	2.65	40.21
1A.16(3)	1A.16 to 1A.22	0.61	10.43	17.11	3.65	-3.04	0
1A.22(2/4)	1A.22 to *1A.15*	2.5	17.11	6.74	-3.94	6.44	130.69
1A.15(3)	*1A.15* to **1A.14**	2.43	6.74	0.64	-1.84	4.27	60.58
1A.14(2)	**1A.14** to *1A.23*	0.59	**0.64**	10.74	5.35	-4.76	60.85
1A.23(3)	*1A.23* to *1A.06*	1.96	10.74	15.05	3.14	1.18	50.26
1A.06(3)	*1A.06* to **1A.13**	*1.37*	*15.05*	3.4	-5.14	6.51	80.42
1A.13(3)	**1A.13** to 1A.08	**1.91**	**3.4**	16.87	7.69	5.78	20.11
1A.08(2)	1A.08 to 1A.07	0.3	16.87	18.55	0.99	-0.69	1588.36
1A.07(2)	1A.07 to *1A.12*	0.24	18.55	8.27	-5.02	5.26	80.95
1A.12(4)	*1A.12* to **1A.25**	*0.57*	*8.27*	1.93	-2.89	3.46	0
1A.25(4)	**1A.25** to 2.03	0.54	**1.93**	12.2	5.41	-4.87	0
2.03(3)	2.03 to 1A.09	0.27	12.2	14.68	1.38	-1.11	6.61
1A.09(2)	1A.09 to **1A.28**	0.51	14.68	5.5	-4.34	4.85	1105.82
1A.28(4)	**1A.28** to **1A.27**	0.78	**5.5**	2.89	-0.92	1.7	60.58
1A.27(3)	**1A.27** to *1A.11*	1.82	**2.89**	8.1	3.52	-1.7	449.74
1A.11(2)	*1A.11* to **1A.26**	2.22	*8.1*	4.59	-0.65	2.87	804.23
1A.26(2)	**1A.26** to **2.07**	5.95	**4.59**	3.18	2.27	3.68	2814.81
2.07(4)	**2.07** to 2.08	2.48	**3.18**	11.46	5.38	-2.9	6613.76
2.08(3)	2.08 to 2.09	3.07	11.46	14.97	3.29	-0.22	1,852
2.09(1)	2.09 to 2.23	8.72	14.97	10.36	2.06	6.66	264.55
2.23(4)	2.23 to **2.21**	1	10.36	3.73	-2.82	3.82	145.50
2.21(3)	**2.21** to **2.22**	4	**3.73**	3.41	1.84	3.16	105.82
2.22(3)	**2.22** to 2.24	0.74	**3.41**	10.8	4.07	-3.33	529.10
2.24(3)	2.24 to **2.20**	0.45	10.8	4.18	-3.09	3.54	1058.20
2.20(2)	**2.20** to *2.19*	6.05	**4.18**	6.38	4.12	1.93	1190.48
2.19(3)	*2.19* to **2.29**	2.03	6.38	2.95	-0.7	2.73	661.38
2.29(2)	**2.29** to 2.16	2.39	**2.95**	15.04	7.24	-4.85	2645.50
2.16(4)	2.16 to 2.17	2.3	15.04	12.82	0.04	2.26	529.10
2.17(3)	2.17 to 2.27	0.56	12.82	19.34	3.54	-2.98	396.83
2.27(3)	2.27 to 2.18	1.33	19.34	11.45	-3.28	4.61	19841.27
2.18(3)	2.18 to 2.33	6.93	11.45	11.82	3.65	3.28	793.65
2.33(3)	2.33 to 2.34	2.38	11.82	13.86	2.21	0.17	1984.13
2.34(3)	2.34 to 2.41	4.78	13.86	11.19	1.06	3.72	3968.25
2.41(3)	2.41 to 2.42	2.7	11.19	11.14	1.33	1.37	1587.30
2.42(3)	2.42 to 2.39	9.25	11.14	17.08	7.59	1.66	793.65
2.39(NG)	2.39 to **2.44**	1.35	17.08	0.86	-7.44	8.79	0
2.44(3)	**2.44** to **2.43**	1.95	**0.86**	3.12	2.11	-0.16	66.14
2.43(3/4)	**2.43** to **2.45**	1.93	**3.12**	3.54	1.17	0.76	4761.90
2.45(2)	**2.45** to *2.46*	3.73	**3.54**	8.69	4.44	-0.71	2116.40
2.46(3/4)			8.69				5.29

BOLD = Deposits from 0-5 Km Buffer
Italic = Deposits from 6-10 Km

Appendix E3
Revised Table

Deposits within 0-5 Km

Deposit	From deposit A to B	x + y	a	b	x	y	Max.Distance of Pipeline Covered
	Beginning to 1A.14	25.09					
1A.14(2)	1A.14 to 1A.13	3.4	0.64	3.4	2.79	0.615	60.85
1A.13(3)	1A.13 to 1A.28	4.95	3.4	5.5	3.52	1.43	20.11
1A.28(4)	1A.28 to 1A.27	0.78	5.5	2.89	-0.92	1.7	60.58
1A.27(3)	1A.27 to 1A.26	5.22	2.89	4.59	3.46	1.76	449.74
1A.26(2)	1A.26 to 2.07	5.95	4.59	3.18	2.27	2.62	2814.81
2.07(4)	2.07 to 2.21	14.13	3.18	3.73	7.42	6.88	6613.76
2.21(3)	2.21 to 2.22	4	3.73	3.41	1.84	2.16	105.82
2.22(3)	2.22 to 2.20	1.12	3.41	4.18	0.94	0.18	529.10
2.20(2)	2.20 to 2.29	6.8	4.18	2.95	2.79	4.01	1190.48
2.29(2)	2.29 to 2.44	33.85	2.95	0.86	15.88	17.97	2645.50
2.44(3)	2.44 to 2.43(3/4)	1.95	0.86	3.12	2.11	-0.16	66.14
2.43(3/4)	2.43(3/4) to 2.45	1.93	3.12	3.54	1.17	0.76	4761.90
2.45(2)	2.45 to End	22.27	3.54				2116.40
2.19(3)	Located in 10 km buffer		4.98				661.38

Deposits Within 0-10 Km

Deposit	From Deposit A to B	x + y	a	b	x	y	Max.Distance of Pipeline Covered	Formula
1A.02(3)	From 1A.02 to 1A.17	10.65	8.79	9.5	15.62	-4.97	1851.85	
1A.17(3)	1A.17 to 1A.15	10.3	9.5	6.74	3.37	6.13	40.21	TRUE
1A.15(3)	1A.15 to **1A.14**	3.24	6.74	0.64	-1.43	4.67	60.58	FALSE
1A.14(2)	**1A.14** to 1A.23	1.26	**0.64**	10.74	5.68	-4.42	60.85	FALSE
1A.23(3)	1A.23 to **1A.13**	2.16	10.74	3.4	-2.59	4.75	50.26	TRUE
1A.13(3)	**1A.13** to **1A.28**	5.06	**3.4**	8.1	4.88	1.48	20.11	FALSE
1A.28(4)	**1A.28** to **1A.27**	**0.78**	**5.5**	2.89	0.91	-0.13	60.58	FALSE
1A.27(3)	**1A.27** to 1A.11	1.82	**2.89**	8.1	-1.7	3.52	449.74	TRUE
1A.11(2)	1A.11 to **1A.26**	2.22	8.1	4.59	-0.65	2.87	804.23	FALSE
1A.26(2)	**1A.26** to 2.07	5.95	**4.59**	3.18	2.27	3.68	2814.81	FALSE
2.07(4)	**2.07** to **2.21**	**14.13**	**3.18**	3.73	7.42	6.88	6613.76	FALSE
2.21(3)	**2.21** to **2.22**	**4**	**3.73**	3.41	1.84	2.16	105.82	FALSE
2.22(3)	**2.22** to **2.20**	**1.12**	**3.41**	4.18	0.94	0.18	529.10	FALSE
2.20(2)	**2.20** to 2.19	6.05	**4.18**	6.38	4.12	1.93	1190.48	FALSE
2.19(3)	2.19 to **2.29**	2.03	6.38	2.95	-0.7	2.73	661.38	FALSE
2.29(2)	**2.29 to 2.44**	**33.85**	**2.95**	0.86	15.88	17.97	2645.50	FALSE
2.44(3)	**2.44** to **2.43**	**1.95**	**0.86**	3.12	2.11	-0.16	66.14	FALSE
2.43(3/4)	**2.43** to **2.45**	**1.93**	**3.12**	3.54	1.17	0.76	4761.90	FALSE
2.45(2)	**2.45** to 2.46	3.73	**3.54**	8.69	4.44	-0.71	2116.40	FALSE
2.46(3/4)			8.69				5.29	
1A.06(3)	Located in 15 km buffer		7.47				80.42	
1A.16(3)	Located in 15 km buffer		9.51				0.00	
2.08(3)	**Located in 15 km buffer**		10.28				1851.85	

BOLD = Deposits from 0-5 Km Buffer
Italic = Deposits from 6-10 Km

Appendix E3
Revised Table

Deposits Within 0-15 Km

Deposit	From Deposit A to B	x +y	a	b	x	y	Max.Distance of Pipeline Covered	Formula
1A.01(3)	1A.01 to 1A.02	2.6	11.12	9.4	0.44	2.16	264.55	
1A.02(3)	*1A.02* to 1A.03	*1.4*	*9.4*	13.63	2.83	-1.42	1851.85	FALSE
1A.03(3)	1A.03 to 1A.18	6.17	13.63	13.75	3.14	3.03	3.02	FALSE
1A.18(3)	1A.18 to 1A.04	1.55	13.75	15.23	1.51	0.04	40.21	FALSE
1A.04(3)	1A.04 to 1A.17	1.53	15.23	9.5	-2.1	3.63	10.05	TRUE
1A.17(3)	*1A.17* to 1A.22	6.83	*9.5*	17.11	7.22	-0.39	40.21	FALSE
1A.22(2/4)	1A.22 to *1A.15*	2.5	17.11	6.74	-3.94	6.44	130.69	TRUE
1A.15(3)	*1A.15* to **1A.14**	2.43	*6.74*	0.64	-1.84	4.27	60.58	FALSE
1A.14(2)	**1A.14** to *1A.23*	0.49	**0.64**	10.74	5.35	-4.76	60.85	FALSE
1A.23(3)	*1A.23* to *1A.06*	1.66	10.74	15.05	3.14	1.18	50.26	TRUE
1A.06(3)	*1A.06* to **1A.13**	*1.27*	*15.05*	3.4	-5.14	6.51	80.42	TRUE
1A.13(3)	**1A.13** to 1A.08	**1.92**	**3.4**	16.87	7.69	-5.78	20.11	FALSE
1A.08(2)	1A.08 to 1A.07	0.5	16.87	18.55	1.09	-0.59	1588.36	TRUE
1A.07(2)	1A.07 to 2.03	1.55	18.55	12.2	-2.4	3.95	80.95	TRUE
2.03(3)	2.03 to 1A.09	0.27	12.2	14.68	1.38	-1.11	6.61	FALSE
1A.09(2)	1A.09 to **1A.28**	0.51	14.68	5.5	-4.34	4.85	1105.82	TRUE
1A.28(4)	**1A.28** to **1A.27**	0.78	**5.5**	2.89	-0.92	1.7	60.58	FALSE
1A.27(3)	**1A.27** to *1A.11*	1.82	**2.89**	8.1	3.52	-1.7	449.74	FALSE
1A.11(2)	*1A.11* to **1A.26**	2.22	*8.1*	4.59	-0.65	2.87	804.23	TRUE
1A.26(2)	**1A.26** to **2.07**	5.95	**4.59**	3.18	2.27	3.68	2814.81	FALSE
2.07(4)	**2.07** to 2.08	2.48	**3.18**	11.46	5.38	-2.9	6613.76	FALSE
2.08(3)	2.08 to 2.09	3.07	11.46	14.97	3.29	-0.22	1,852	FALSE
2.09(1)	2.09 to 2.23	8.72	14.97	10.36	2.06	6.66	264.55	FALSE
2.23(4)	2.23 to **2.21**	1	10.36	3.73	-2.82	3.82	145.50	FALSE
2.21(3)	**2.21** to **2.22**	4	**3.73**	3.41	1.84	3.16	105.82	FALSE
2.22(3)	**2.22** to 2.24	0.74	**3.41**	10.8	4.07	-3.33	529.10	FALSE
2.24(3)	2.24 to **2.20**	0.45	10.8	4.18	-3.09	3.54	1058.20	TRUE
2.20(2)	**2.20** to *2.19*	6.05	**4.18**	6.38	4.12	1.93	1190.48	FALSE
2.19(3)	*2.19* to **2.29**	2.03	*6.38*	2.95	-0.7	2.73	661.38	FALSE
2.29(2)	**2.29** to 2.16	2.39	**2.95**	15.04	7.24	-4.85	2645.50	FALSE
2.16(4)	2.16 to 2.17	2.3	15.04	12.82	0.04	2.26	529.10	TRUE
2.17(3)	2.17 to 2.27	0.56	12.82	19.34	3.54	-2.98	396.83	FALSE
2.27(3)	2.27 to 2.18	1.33	19.34	11.45	-3.28	4.61	19841.27	TRUE
2.18(3)	2.18 to 2.33	6.93	11.45	11.82	3.65	3.28	793.65	FALSE
2.33(3)	2.33 to 2.34	2.38	11.82	13.86	2.21	0.17	1984.13	FALSE
2.34(3)	2.34 to 2.41	4.78	13.86	11.19	1.06	3.72	3968.25	FALSE
2.41(3)	2.41 to 2.42	2.7	11.19	11.14	1.33	1.37	1587.30	FALSE
2.42(3)	2.42 to **2.44**	10.6	11.14	0.86	10.44	0.16	793.65	FALSE
2.44(3)	**2.44** to **2.43**	1.95	**0.86**	2.78	2.11	-0.16	66.14	FALSE
2.43(3/4)	**2.43** to **2.45**	1.93	**2.78**	3.54	1.17	0.76	4761.90	FALSE
2.45(2)	**2.45** to *2.46*	3.73	**3.54**	8.69	4.44	-0.71	2116.40	FALSE
2.46(3/4)			8.69				5.29	

BOLD = Deposits from 0-5 Km Buffer
Italic = Deposits from 6-10 Km

Appendix E4
Final Table

Deposits within 0-5 Km

Deposit	From deposit A to B	x + y	a	b	x	y	Max.Distance of Pipeline Covered	Comment	Pipeline Coverage From Each Side	Percent of Deposit Used
	Beginning to 1A.14	25.09								
1A.14(2)	1A.14 to 1A.13	3.4	0.64	3.4	2.79	0.615	60.85	Proven		0.000%
1A.13(3)	1A.13 to 1A.28	4.95	3.4	5.5	3.52	1.43	20.11		4.135	20.566%
1A.28(4)	1A.28 to 1A.27	0.78	5.5	2.89	-0.92	1.7	60.58	Total	0.51	0.842%
1A.27(3)	1A.27 to 1A.26	5.22	2.89	4.59	3.46	1.76	449.74		5.16	1.147%
1A.26(2)	1A.26 to 2.07	5.95	4.59	3.18	2.27	2.62	2814.81		4.03	0.143%
2.07(4)	2.07 to 2.21	14.13	3.18	3.73	7.42	6.88	6613.76	Prospective	10.04	0.152%
2.21(3)	2.21 to 2.22	4	3.73	3.41	1.84	2.16	105.82		8.72	8.240%
2.22(3)	2.22 to 2.20	1.12	3.41	4.18	0.94	0.18	529.10		3.1	0.586%
2.20(2)	2.20 to 2.29	6.8	4.18	2.95	2.79	4.01	1190.48		2.97	0.249%
2.29(2)	2.29 to 2.44	33.85	2.95	0.86	15.88	17.97	2645.50		19.89	0.752%
2.44(3)	2.44 to 2.43(3/4)	1.95	0.86	3.12	2.11	-0.16	66.14		20.08	30.361%
2.43(3/4)	2.43(3/4) to 2.45	1.93	3.12	3.54	1.17	0.76	4761.90		1.01	0.021%
2.45(2)	2.45 to End	22.27	3.54				2116.40		0.76	0.036%
2.19(3)	Located in 10 km buffer		4.98				661.38			0.000%

Deposits Within 0-10 Km

Deposit	From Deposit A to B	x + y	a	b	x	y	Max.Distance of Pipeline Covered	Comment	Total Pipeline Coverage From Each Deposit	Percent of Deposit Used
1A.02(3)	From 1A.02 to 1A.15	20.95	8.79	6.74	9.45	11.5	1851.85			0.000%
1A.15(3)	1A.15 to **1A.14**	3.24	6.74	0.64	-1.43	4.67	60.58	Total	10.07	16.622%
1A.14(2)	**1A.14** to **1A.13**	3.42	**0.64**	3.4	2.94	0.48	60.85	Proven	7.61	12.507%
1A.13(3)	**1A.13** to 1A.11	5.06	**3.4**	8.1	6.18	1.48	20.11		6.66	33.125%
1A.11(2)	1A.11 to **1A.26**	2.22	*8.1*	4.59	-0.65	2.87	804.23	Total	0.83	0.103%
1A.26(2)	**1A.26** to 2.07	5.95	**4.59**	3.18	2.27	3.68	2814.81		5.14	0.183%
2.07(4)	**2.07 to 2.21**	**14.13**	**3.18**	3.73	7.42	6.88	6613.76	Prospective	11.1	0.168%
2.21(3)	**2.21 to 2.22**	**4**	**3.73**	3.41	1.84	2.16	105.82		8.72	8.240%
2.22(3)	**2.22 to 2.20**	**1.12**	**3.41**	4.18	0.94	0.18	529.10		3.1	0.586%
2.20(2)	**2.20** to 2.19	6.05	**4.18**	6.38	4.12	1.93	1190.48		4.3	0.361%
2.19(3)	2.19 to **2.29**	2.03	6.38	2.95	-0.7	2.73	661.38		1.23	0.186%
2.29(2)	**2.29 to 2.44**	**33.85**	**2.95**	0.86	15.88	17.97	2645.50		18.61	0.703%
2.44(3)	**2.44** to **2.43**	**1.95**	**0.86**	3.12	2.11	-0.16	66.14		20.08	30.361%
2.43(3/4)	**2.43 to 2.45**	**1.93**	**3.12**	3.54	1.17	0.76	4761.90		1.01	0.021%
2.45(2)	**2.45** to 2.46	3.73	**3.54**	8.69	4.44	-0.71	2116.40		5.2	0.246%
2.46(3/4)			8.69				5.29			0.000%
1A.06(3)	Located in 15 km buffer		7.47				80.42			0.000%
2.08(3)	**Located in 15 km buffer**		10.28				1851.85			0.000%

BOLD = Deposits from 0-5 Km Buffer
Italic = Deposits from 6-10 Km

Appendix E4
Final Table

Deposits Within 0-15 Km

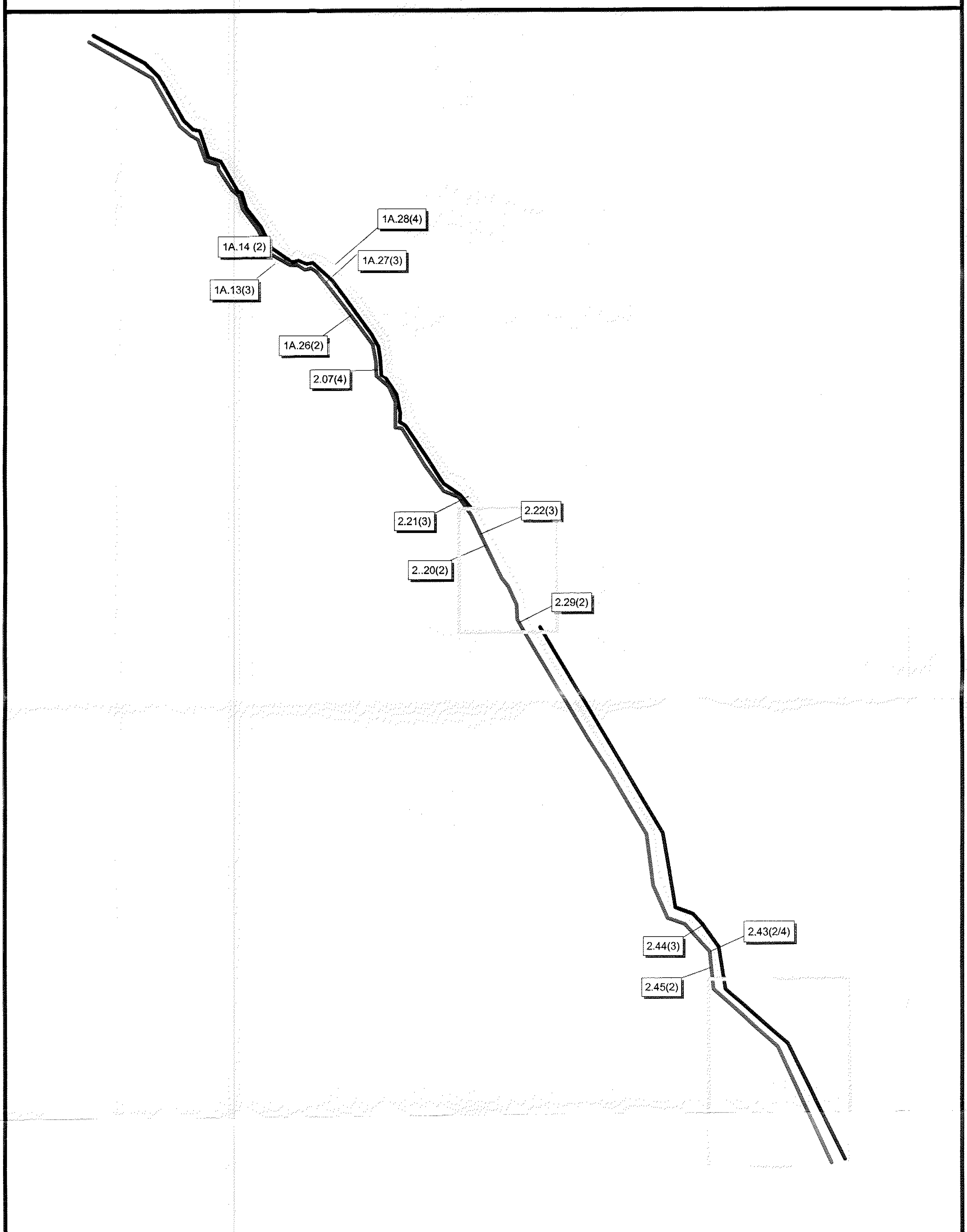
Deposit	From Deposit A to B	x +y	a	b	x	y	Max.Distance of Pipeline Covered	Comment	Pipeline Coverage From Each Side	Percent of Deposit Used
1A.01(3)	1A.01 to 1A.02	2.6	11.12	9.4	0.44	2.16	264.55			0.000%
1A.02(3)	*1A.02* to 1A.18	*7.57*	*9.4*	13.75	5.96	1.61	1851.85		8.12	0.438%
1A.18(3)	1A.18 to 1A.17	3.08	13.75	9.5	-0.59	3.67	40.21		1.02	2.537%
1A.17(3)	*1A.17* to *1A.15*	*9.33*	*9.5*	6.74	3.29	6.04	40.21		6.96	17.308%
1A.15(3)	*1A.15* to **1A.14**	2.43	*6.74*	0.64	-1.84	4.27	60.58	Total	4.2	6.933%
1A.14(2)	**1A.14** to **1A.13**	**3.42**	**0.64**	3.4	2.94	0.48	60.85	Proven	7.21	11.849%
1A.13(3)	**1A.13** to **1A.28**	**4.95**	**3.4**	5.5	3.52	1.43	20.11		4	19.895%
1A.28(4)	**1A.28** to **1A.27**	**0.78**	**5.5**	2.89	-0.92	1.7	60.58	Total	0.51	0.842%
1A.27(3)	**1A.27** to *1A.11*	4.04	**2.89**	4.59	2.87	1.17	449.74		4.57	1.016%
1A.26(2)	**1A.26** to **2.07**	5.95	**4.59**	3.18	2.27	3.68	2814.81		3.44	0.122%
2.07(4)	**2.07** to 2.08	2.48	**3.18**	11.46	5.38	-2.9	6613.76	Prospective	9.06	0.137%
2.08(3)	2.08 to 2.09	3.07	11.46	14.97	3.29	-0.22	1851.85		0.39	0.021%
2.09(1)	2.09 to 2.23	8.72	14.97	10.36	2.06	6.66	264.55		1.84	0.696%
2.23(4)	2.23 to **2.21**	1	10.36	3.73	-2.82	3.82	145.50		3.84	2.639%
2.21(3)	**2.21** to **2.22**	4	**3.73**	3.41	1.84	3.16	105.82		5.66	5.349%
2.22(3)	**2.22** to 2.24	1.19	**3.41**	4.18	0.98	0.21	529.10		4.14	0.782%
2.20(2)	**2.20** to *2.19*	6.05	**4.18**	6.38	4.12	1.93	1190.48		4.33	0.364%
2.19(3)	*2.19* to **2.29**	2.03	*6.38*	2.95	-0.7	2.73	661.38		1.23	0.186%
2.29(2)	**2.29** to 2.18	6.58	**2.95**	11.45	7.54	-0.96	2645.50		10.27	0.388%
2.18(3)	2.18 to 2.33	6.93	11.45	11.82	3.65	3.28	793.65		2.69	0.339%
2.33(3)	2.33 to 2.34	2.38	11.82	13.86	2.21	0.17	1984.13		5.49	0.277%
2.34(3)	2.34 to 2.41	4.78	13.86	11.19	1.06	3.72	3968.25		1.23	0.031%
2.41(3)	2.41 to 2.42	2.7	11.19	11.14	1.33	1.37	1587.30		5.05	0.318%
2.42(3)	2.42 to **2.44**	10.6	11.14	0.86	10.44	0.16	793.65		11.81	1.488%
2.44(3)	**2.44** to **2.43**	**1.95**	**0.86**	2.78	2.11	-0.16	66.14		2.27	3.432%
2.43(3/4)	**2.43** to **2.45**	**1.93**	**2.78**	3.54	1.17	0.76	4761.90		1.01	0.021%
2.45(2)	**2.45** to *2.46*	3.73	**3.54**	8.69	4.44	-0.71	2116.40		5.2	0.246%
2.46(3/4)			8.69				5.29			

BOLD = Deposits from 0-5 Km Buffer
Italic = Deposits from 6-10 Km

Appendix F

Map: Pipeline Coverage

Pipeline Coverage of Deposits within 0-5 Km



Legend

Pipeline Coverage

1A.14 (60.85 Km) Proven
1A.13 (20.11 Km)
1A.28 (60.58 Km)Total
2.21 (105.82 Km)
2.44 (66.14 Km)

Covers More Than
Pipeline Under Study

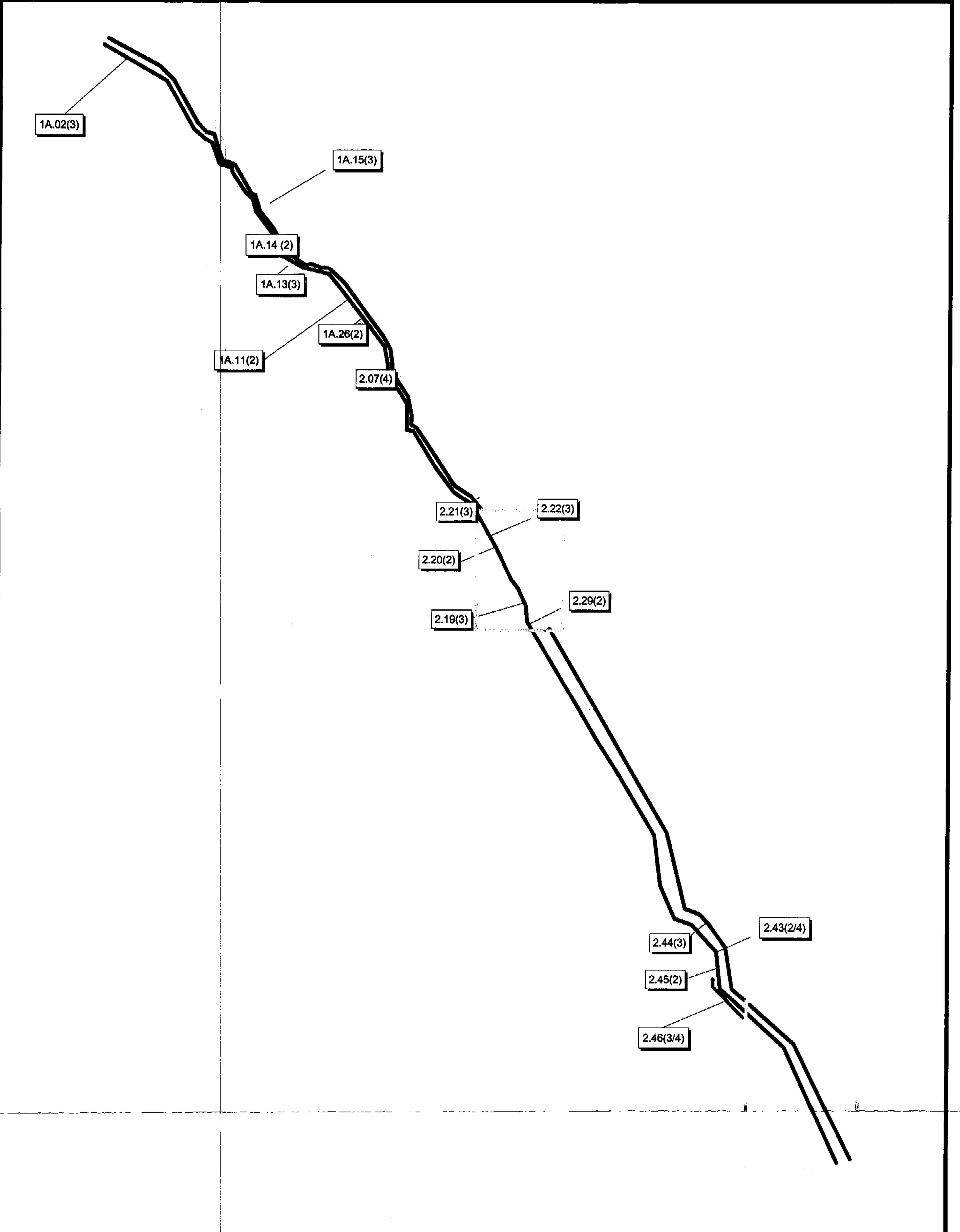
1A.27 (449.74 Km)
1A.26 (2814.81 Km)
2.07 (6613.76 Km) Prospective
2.22 (529.10 Km)
2.20 (1190.48 Km)
2.29 (2645.50 Km)
2.43 (4761.90 Km)
2.45 (2116.40 Km)

Critical Zone

N
W E
S

8 0 8 16 Kilometers

Pipeline Coverage of Deposits within 0-10 Km



Legend

Pipeline Coverage

1A.15 (60.58 Km)Total
1A.14 (60.85 Km) Proven
1A.13 (20.11 Km)
2.21 (105.82 Km)
2.44 (66.14 Km)
2.46 (5.29 Km)

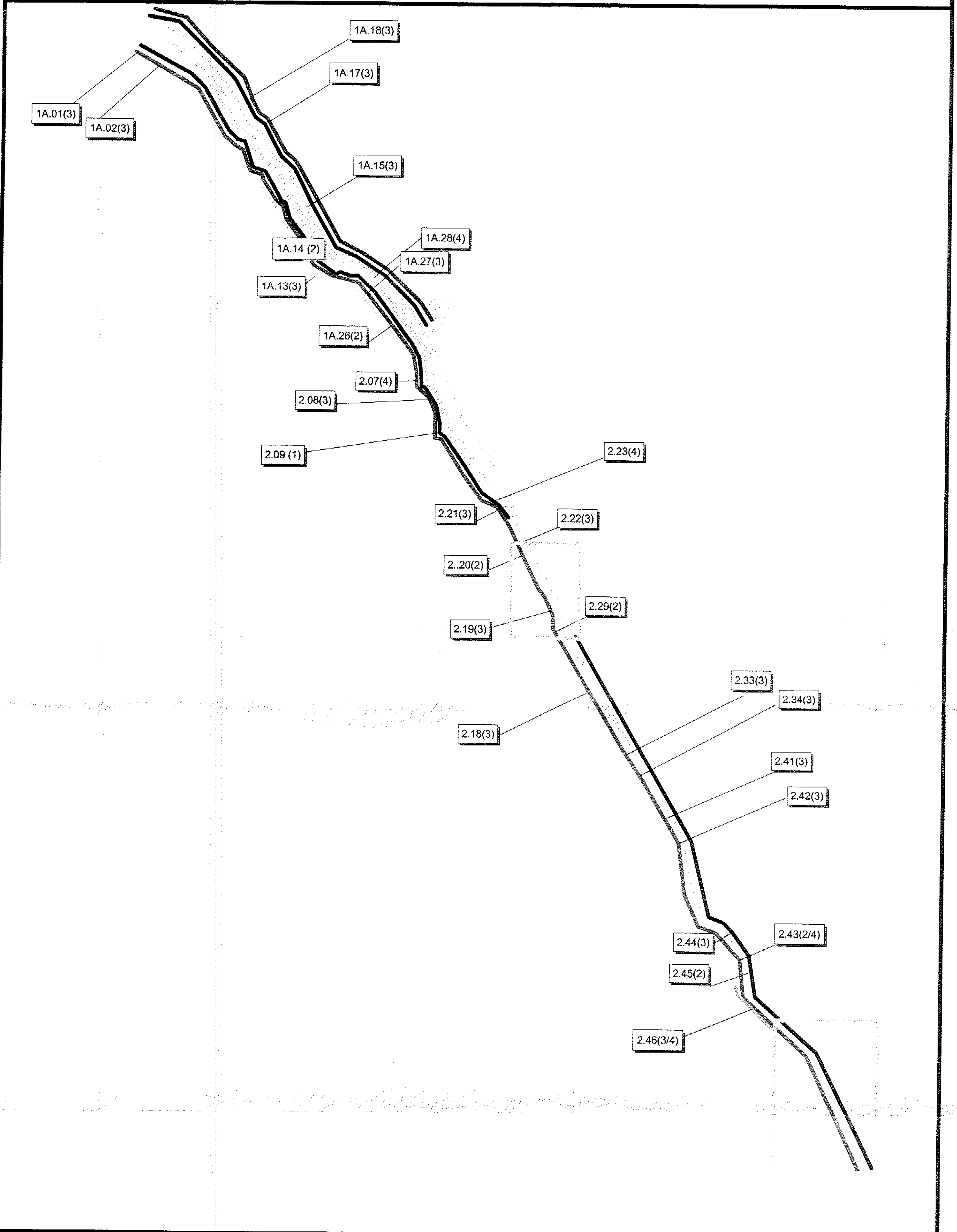
Covers More Than
Pipeline Under Study
1A.02 (1851.85 Km)
1A.11 (804.23) Total
1A.26 (2814.81 Km)
2.07 (6613.76 Km) Prospective
2.22 (529.10 Km)
2.20 (1190.48 Km)
2.19 (661.38 Km)
2.29 (2645.50 Km)
2.43 (4761.90 Km)
2.45 (2116.40 Km)

Critical Zone

N
W E
S

8 0 8 16 Kilometers

Pipeline Coverage of Deposits within 0-15 Km



Legend

Pipeline Coverage

1A.18 (40.21 Km)
1A.17 (40.21 Km)Total
1A.15 (60.58 Km)Total
1A.14 (60.85 Km) Proven
1A.13 (20.11 Km)

1A.28 (60.58Km) Total
2.21 (105.82 Km)
2.44 (66.14 Km)
2.46 (5.29 Km)
Critical Zone

8 0 8 16 Kilometers

Covers More Than
Pipeline Under Study

1A.01 (264.55 Km)
1A.02 (1851.85 Km)
1A.11 (804.23) Total
1A.27 (449.74 Km)
1A.26 (2814.81 Km)
2.07 (6613.76 Km) Prospective
2.08 (1851.85 Km)
2.09 (264.55 Km)
2.23 (145.50 Km)
2.22 (529.10 Km)

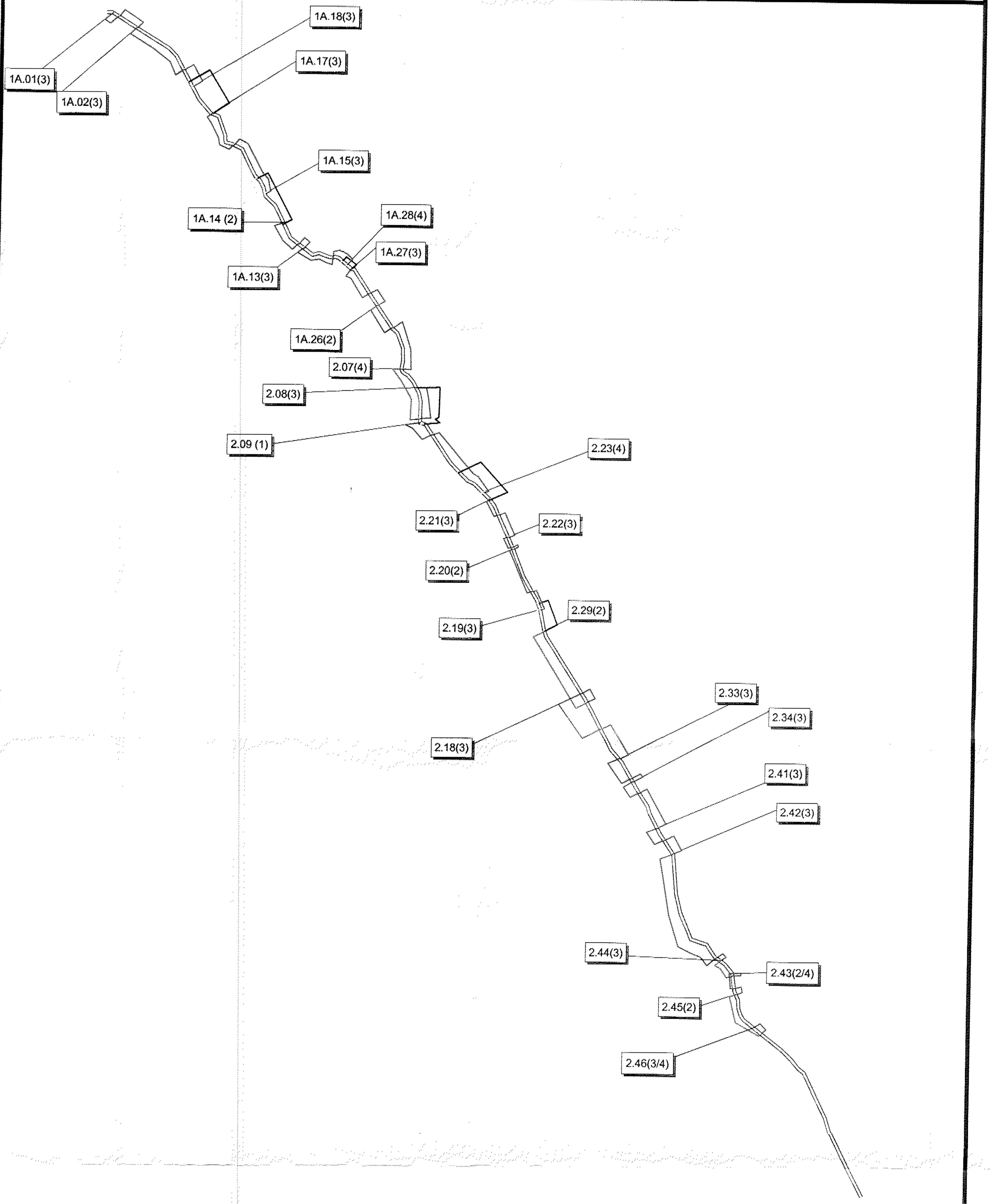
2.20 (1190.48 Km)
2.19 (661.38 Km)
2.29 (2645.50 Km)
2.18 (793.65 Km)
2.33 (1984.13 Km)
2.34 (3968.25 Km)
2.41 (1587.30 Km)
2.42 (793.65 Km)
2.43 (4761.90 Km)
2.45 (2116.40 Km)

N
W E
S

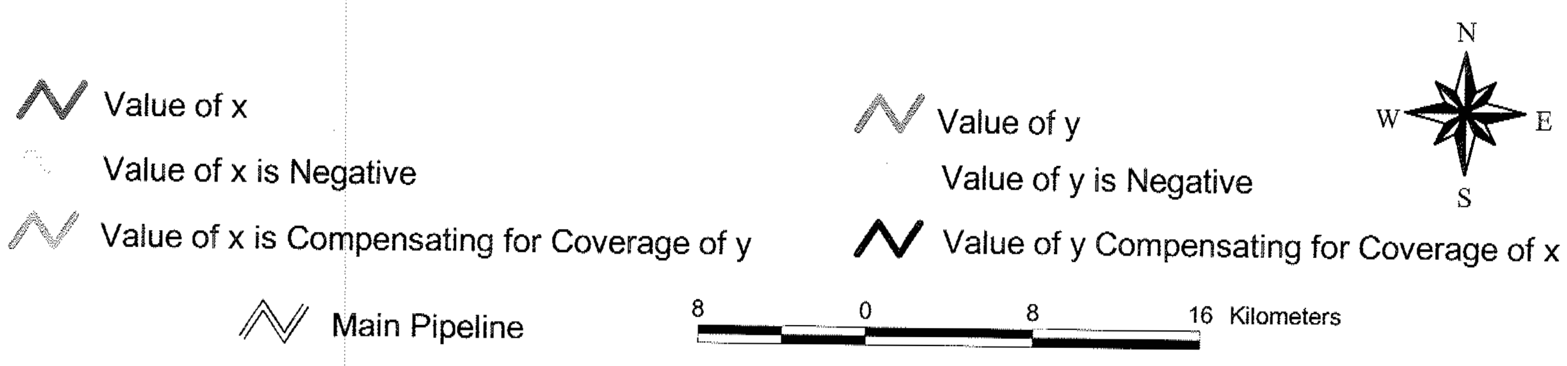
Appendix G

Map: Optimal Distance of Deposits

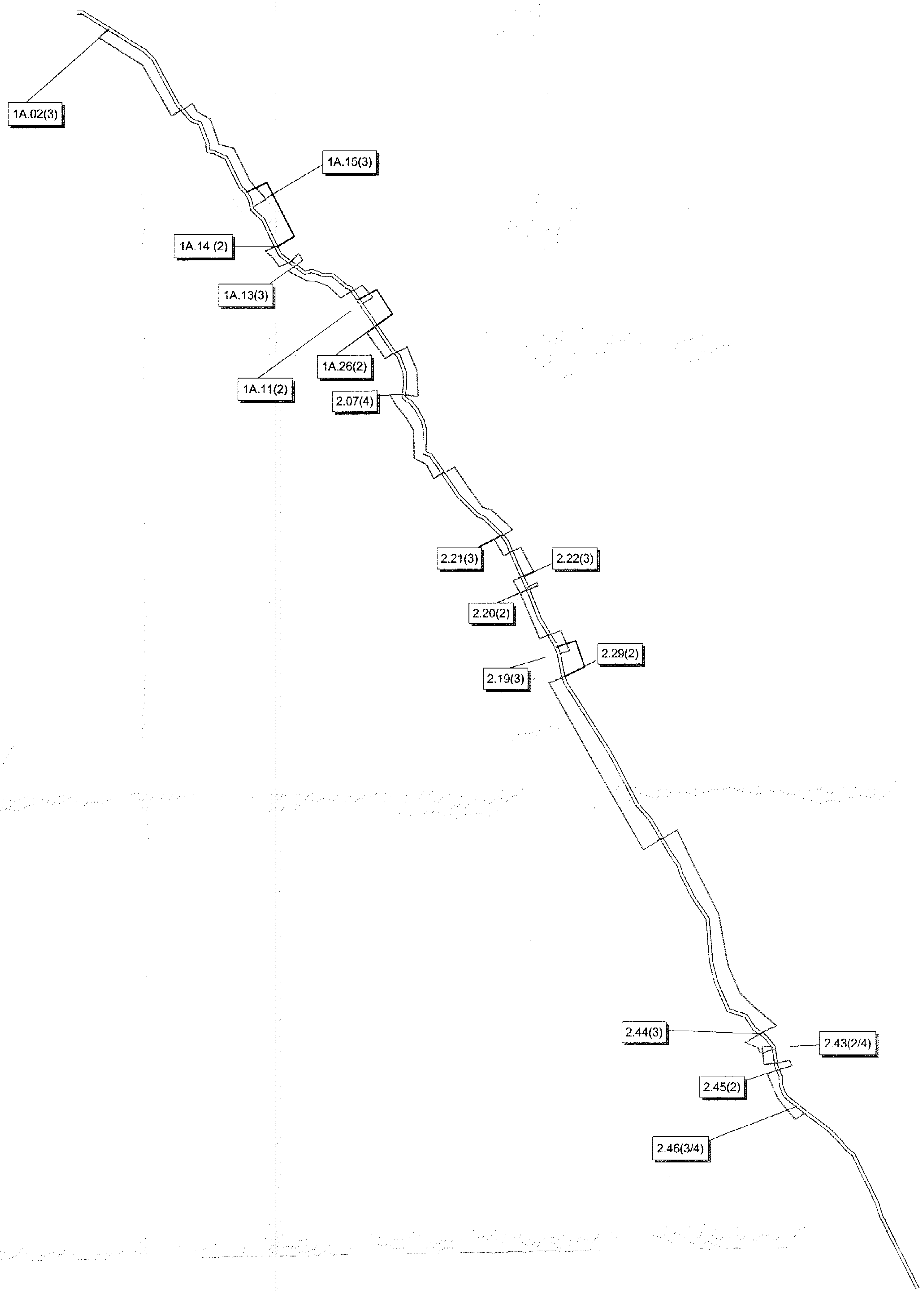
Optimal Distance of Deposits within 0-15 Km



Legend



Optimal Distance of Deposits within 0-10 Km



Legend

Value of x

Value of x is Negative

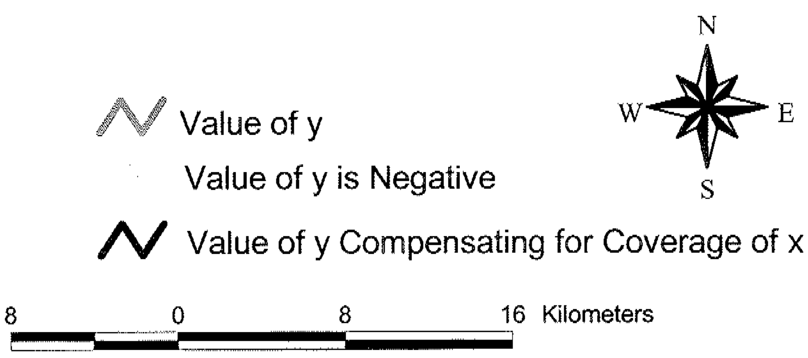
Value of x is Compensating for Coverage of y

Main Pipeline

Value of y

Value of y is Negative

Value of y Compensating for Coverage of x



Optimal Distance of Deposits within 0-5 Km