VOLUME I

SAND AND GRAVEL RESOURCES OF THE BRANDON REGION

PREPARED FOR

MANITOBA

DEPARTMENT OF MINES, RESOURCES & ENVIRONMENTAL MANAGEMENT

BY

The UMA Group

JUNE 1977

UMA Underwood McLellan & Associates Limited

1479 Buffalo Place, Winnipeg, Manitoba R3T 1L7 Telephone (204) 284-0580

June 30, 1977

Dr. F.J. Elbers,
Director,
Mineral Evaluation and Administration Branch,
Mineral Resources Division,
Department of Mines, Resources
and Environmental Management
993 Century Street
Winnipeg, Manitoba
R3H 0W4

Dear Sir;

We are pleased to submit our report "Sand and Gravel Resources of the Brandon Region".

Supplementary to this report is a technical file which will provide you with more detail on sand and gravel potential than what is presented in the report.

We trust that the findings of this report will provide a useful document to assist in future land use planning and resource management.

We have found this study most challenging and we have appreciated the co-operation extended to us by the Mineral Resources Division.

Yours truly,

UNDERWOOD MCLELLAN & ASSOCIATES LIMITED

R. Hood, P. Eng.
Vice-President and Manager
Manitoba & Northwestern Ontario

C.E. Anderson, P. Eng.
Director
Resource Planning and Development

CEA/smc

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ACKNOWLEDGEMENT

We wish to express our appreciation to the many individuals who co-operated with the study team and without whose assistance and guidance this report would not have been possible.

Special appreciation is due to Ms. Susan Ringrose of the Mineral Resources Division, who acted as study co-ordinator on behalf of the Division.

SUMMARY

The purpose of the study was to compile a quantitative and qualitative inventory of the sand and gravel resources in the Brandon region and assess the demand for these resources to allow for rational land use planning.

The Brandon region comprised an area of some 3,600 square miles (932,000 hectares) around the City of Brandon.

The study components were:

— to forecast sand and gravel resource demand in the region to the year 1996 and extrapolate that forecast to the year 2026.

— to provide an estimate of the quantity and quality of sand and gravel potentially available within the region based on existing data, selective field exploration and laboratory testing.

The expected demands were projected to be:

	CUMULATIVE TO 1996 Millions of		CUMULATIVE TO 2026 Millions of	
	Short Tons	Metric Tonnes	Short Tons	Metric Tonnes
Total Sand and Gravel	24-27	22-24	74-82	67-74
High Quality Sand and Gravel	3.8-4.2	3.5-3.8	12-13	11-12

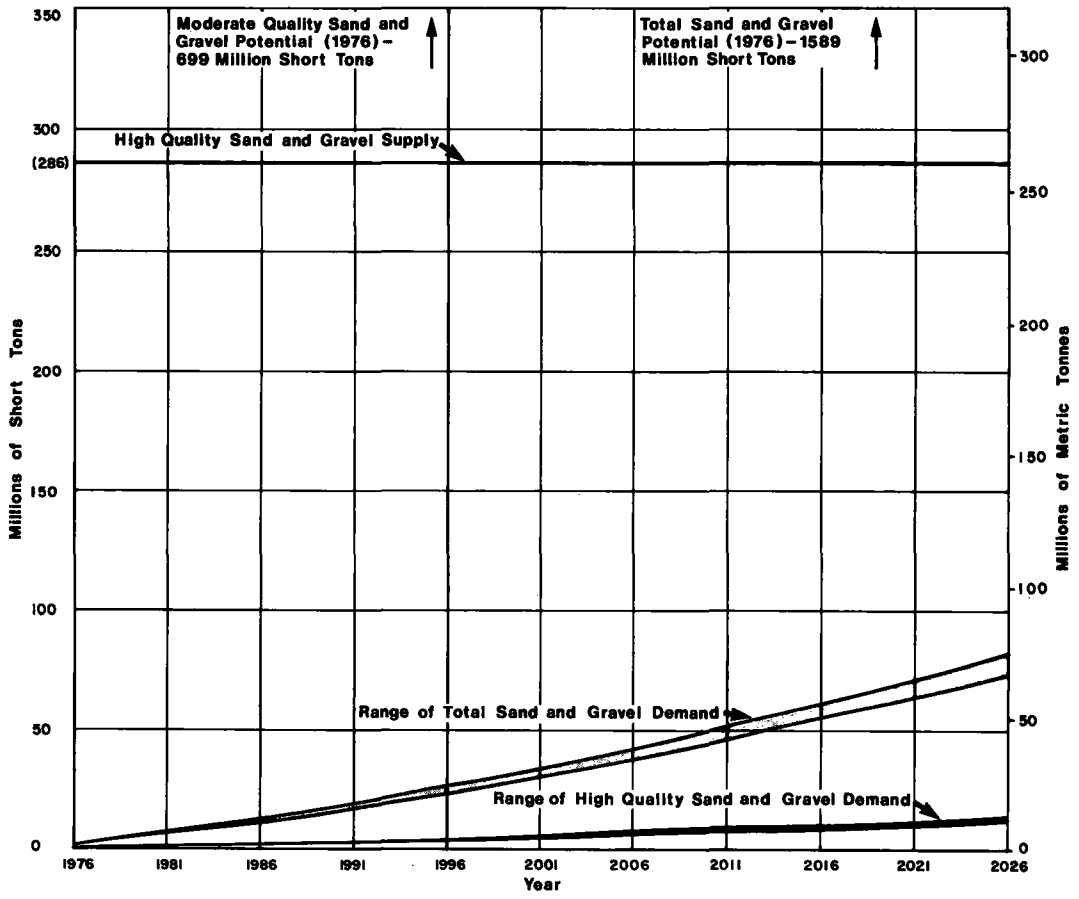
The sand and gravel potential as compared to the projected demand by municipality for the region is summarized as follows:

BRANDON REGION MUNICIPALITY
SAND AND GRAVEL RESERVES
AND 1996 CUMULATIVE DEMAND

Municipality	1976 Reserve Estimate (Millions of Short Tons	1996 Low Estimate Cumulative Demand (Millions of Short Tons)	1996 High Estimate Cumulative Demand (Millions of Short Tons)
Blanshard	3.68	0.68	0.77
Cornwallis	505.95	7.51	8.34
Daly	489.67	0.82	0.91
Elton	5.57	1.66	1.90
Glenwood	3.23	0.94	1.04
Hamiota	2.20	1.37	1.53
Langford	12.94	1.13	1.26
N. Cypress	2.17	1.49	1.65
Oakland	77.30	1.46	1.63
Odanah	0.17	0.97	1.08
Saskatchewan	24.80	0.78	0.87
Sifton	—	0.43	0.48
S. Cypress	7.69	0.54	0.60
Whitehead	136.89	1.06	1.18
Woodworth	253.77	1.19	1.32
Additional Reserves (see Table D-7)	63.26	—	—
Other Engineering*	—	2.20	2.45
Total	1589.29	24.24	26.94

*See Section C 1.7.3

The following graph illustrates the relationship between supply and demand.



The conclusions that were derived based on the scope of this study are:

— there appears to be sufficient high quality sand and gravel within the region to meet the regional demands to well beyond the year 2026.

— if the demand for sand and gravel from a municipality is to be met with supplies found entirely from within that municipality, it appears that the Rural Municipalities of Odanah and Sifton do not have adequate sand and gravel resource potential to meet their estimated 1996 sand and gravel demands.

— if the demand for sand and gravel from a municipality is to be met with supplies found entirely from within that municipality and assuming that projected usage figures are realized, it appears that the Rural Municipalities of Blanshard, Glenwood, Hamiota and North Cypress do not have adequate sand and gravel resource potential to meet their estimated 2026 sand and gravel demands.

It is suggested that in certain areas where transportation costs dictate, alternatives to conventional production of sand and gravel such as the washing of granular tills, may prove feasible.

Primarily, agriculture, recreation, forestry and wildlife management will conflict with sand and gravel extraction operations in the region. A program should be developed to define these conflicts and to minimize them through sequential land use planning and pit rehabilitation processes.

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SECTION A
INTRODUCTION

1. TERMS OF REFERENCE

The terms of reference for the Study were generally outlined in the request for proposals by the Department of Mines, Resources and Environmental Management dated March 19, 1976 and subsequently in the agreement dated September 15, 1976 between the Mineral Resources Division, Department of Mines, Resources and Environmental Management, Province of Manitoba and Underwood McLellan & Associates Limited. These terms of reference are summarized as follows:

1.1 Purpose

The purpose of the study is to compile a quantitative and qualitative inventory of the sand and gravel resources in the Brandon region and assess the demand for these resources to allow for rational land use planning.

1.2 The Brandon Region

The Brandon region was defined as the municipalities of Blanshard, Cornwallis, Daly, Elton, Glenwood, Hamiota, Langford, North Cypress, Oakland, Odanah, Saskatchewan, Sifton, South Cypress, Whitehead and Woodworth. Six square miles in the southern portion of the municipality of Minto were included in the study area. The resultant Brandon region study area comprising 3,600 square miles is defined on Plate A-1.

1.3 Study Components

a. Forecast sand and gravel resource demand in the region to the year 1996 and extrapolate that forecast to the year 2026.

b. Provide an estimate of the quantity and quality of sand and gravel potentially available within the region based on existing data, selective field exploration and laboratory testing.

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Study Area

MANITOBA
DEPARTMENT OF MINES, RESOURCES & ENVIRONMENTAL MANAGEMENT

Sand and Gravel Resources of the Brandon Region

The Brandon Region Study Area

0 2 4 6 10 15 Miles
0 2 5 10 15 25 Kilometres

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Plate A - 1

SECTION B
CLASSIFICATION AND PRODUCTION OF SAND AND GRAVEL

1. INTRODUCTION

Within the Brandon region aggregate is obtained from sand and gravel deposits.

Typical uses for sand and gravel are:

- concrete
- bituminous paving mixtures
- granular road surfacing
- railway ballast and sub-ballast
- concrete blocks
- other masonry products
- backfill
- culvert bedding and backfill
- rip-rap and filters

In order to meet the many specifications demanded by the end use, sand and gravel must be processed and the basic material should consist of sound, tough and durable pebble and rock fragments and sand, with which may be included a quantity of fine particles and which must be free from roots, sod and other deleterious substances.

2. CLASSIFICATION OF SAND AND GRAVEL

Gradation specifications for sand and gravel can be found in the American Society for Testing and Materials and Canadian Standards Association manuals. These specifications are too numerous to identify within the context of this report but some discussion on general specification considerations is warranted.

Sand and gravel is generally classified by silt content (percent by weight less than No. 200 sieve size); sand content (percent by weight greater than No. 200 sieve size but less than No. 4 sieve size); and gravel content (percent by weight greater than No. 4 sieve size); and by the uniformity of gradation of various mixtures of these material sizes. Most specifications call for well-graded granular material to ensure the void ratio of placed material is at a minimum.

The usage of sand and gravel will depend upon required gradations. Sand and gravel with less than 5 percent passing the No. 200 sieve is considered "clean" and one with greater than 15% passing the No. 200 sieve is considered "dirty". The following examples assist in clarifying these definitions:

- for a sand and gravel to be free draining, as in the case of a filter material, the percent passing the No. 200 sieve should be in the range of 0 to 5 percent.
- for a sand and gravel to be relatively well-draining, readily compactable, and of high strength, as in the case of roadway fills or base coarse under pavements, the percent passing the No. 200 sieve should be in the range of 5 to 15 percent.

— if the percent passing the No. 200 sieve is greater than 15 percent, the sand and gravel will be poor draining and may be frost susceptible.

Examples of sand and gravel usage are:

— sand and gravel with 90 to 100 percent passing the No. 4 sieve is required for use in fine concrete, seal coat paving, plaster and masonry mortar.

— specifications for concrete blocks, concrete culverts, railway sub-ballast, roadway base coarse and granular backfill generally call for gravel content in three broad ranges: 40-90 percent, 70-90 percent or 40-70 percent passing the No. 4 sieve.

— sand and gravel with less than 40% passing the No. 4 sieve could be crushed and blended with other aggregates to give required gradations or used for coarse masonry grout, coarse culvert subdrain filter and for coarse concrete sand and gravel.

A poor quality sand and gravel deposit is usually lacking in coarse material, with only 10 to 25 percent being retained on the No. 4 sieve. A high quality material will have 40 to 70 percent retained on the No. 4 sieve. The poor material can be modified to produce a high quality sand and gravel. This is done by screening the pit run material and separating the coarse material from the fine; crushing the coarse material to the desired sieve size; and then blending the coarse with the fine to comply with the required gradation specifications.

3. EXTRACTION METHODS AND PROCESSING

In general, obtaining sand and gravel from naturally occurring sources is described by the term "Surface Mining". In the Brandon region, sand and gravel is obtained by the technique of open pit mining.

Every extraction method and processsing operation and production site is unique in its own operation. Many basic individual production steps are common to all plants and are used in various sequences to ensure the required product.

The following basic steps are common to most sand and gravel aggregate production operations:

Clearing

— involves the removal and disposal of trees, shrubs, and other surface litter.

Stripping

— involves the removal of topsoil and subsoil.

Excavation

— raw material may be removed with many types of equipment.

Stockpiling

— unprocessed and processed materials are stockpiled to ensure a wide variation of production demands.

Processing

— sand and gravel production, in general, involves the use of various types of equipment. The processing steps include screening, crushing and washing. Fill material in general

needs no processing.

Sand and gravel aggregates produced for today's construction needs are more superior than in the past. This is mainly due to new technology in the production field. Crushing techniques have improved, with the present day capability to crush boulders as large as 30 inches in diameter. Portable conveyors and automated equipment can produce sand and gravel aggregates that can be accurately proportioned to produce any type of construction materials needed within the industry.

The flow diagram on Plate B-1 depicts typical sand and gravel aggregate operations, which are common to the Brandon region.

FLOW DIAGRAM FOR SAND AND GRAVEL OPERATION

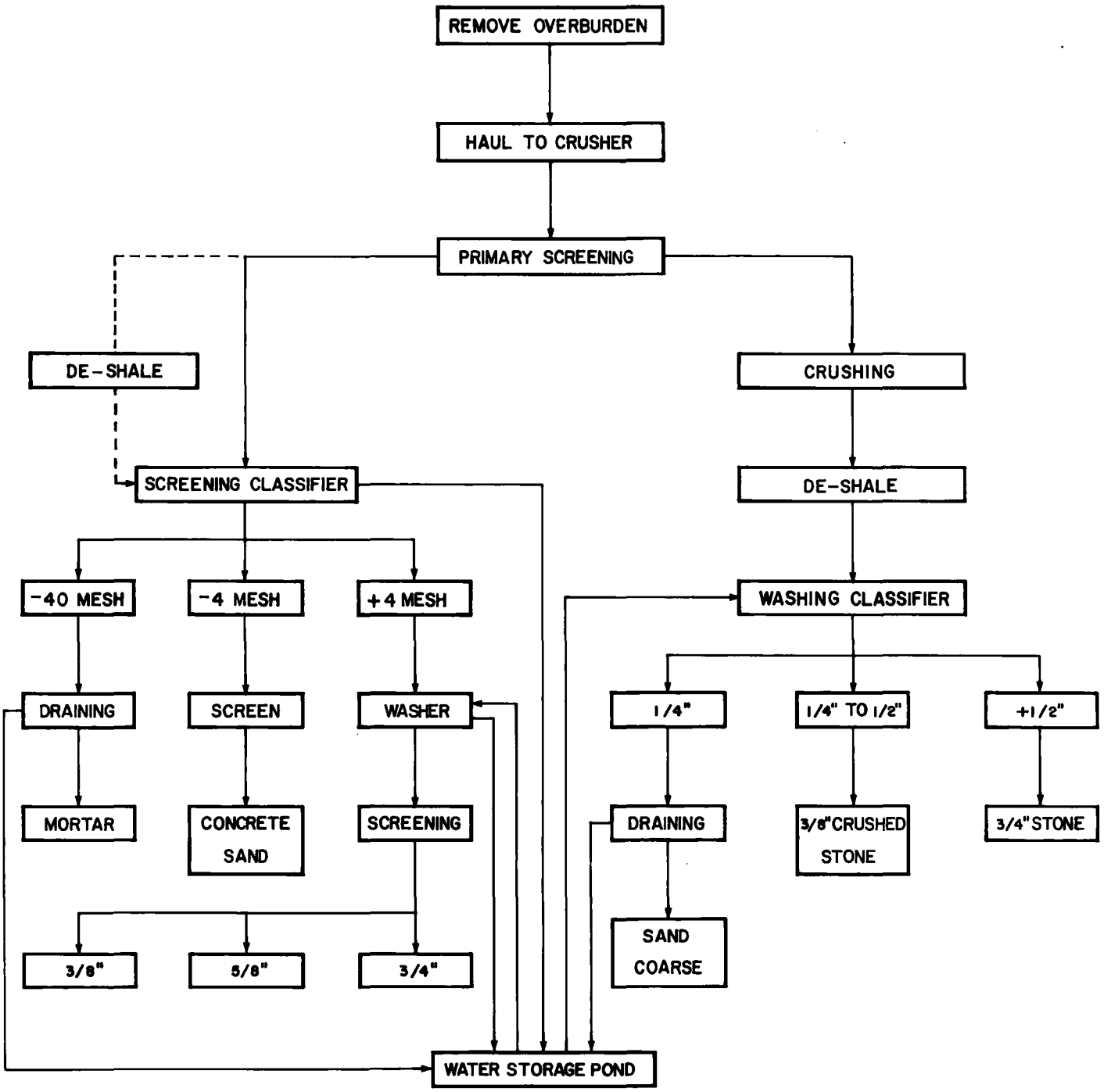

Plate B-1

SECTION C
SAND AND GRAVEL REQUIREMENTS IN THE BRANDON REGION

1. INTRODUCTION

1.1 Abstract

This section of the report contains an analysis and projection of future sand and gravel demand in the Brandon region to 1996 based on anticipated construction activity and derived coefficients of sand and gravel usage in each construction sector, as determined through analysis of historical data for the Province and the Region. The detailed forecast covers a 20-year period from 1976 to 1996. Estimates are provided through to the year 2026 by means of extrapolation of forecast results.

1.2 Study Region

For purposes of the demand analysis contained in this section of the report, the Brandon region is defined as Southwestern Manitoba, comprising the municipalities of Hamiota, Blanshard, Saskatchewan, Odanah, Langford, Woodworth, Daly, Elton, North Cypress, South Cypress, Cornwallis, Oakland, Glenwood, Whitehead and Sifton. The City of Brandon is the largest urban area in the study region, containing slightly over half the region's population.

Because of the relatively small size of the study area it was not broken down into sub-regions as was done for the Winnipeg Region Study. The study area is set out on Plate C-1.

1.3 Study Methodology

The Brandon Study was able to benefit from the recently completed Study for the Winnipeg Area. The basic methodology developed in the Winnipeg Study was employed in the Brandon Study after making a number of minor adjustments to accommodate the particular circumstances and relationships that existed in the Brandon Area.

In simplified form the study methodology was as follows:

- Local producers and users (including various levels of government) were surveyed as to their production and use of sand and gravel.
- This information was supplemented by available published data, especially usage related to residential and non-residential construction activity.
- The results of the survey were combined with the available published data to provide a picture of construction expenditure and sand and gravel usage in the Study Area over the 1970-1974 period.
- By applying the appropriate sand and gravel technical usage coefficients developed for the Province in the Winnipeg Region Study, average construction expenditures by sector share and total construction expenditures by year were determined for the Study Area.

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BLANSHARD
SASKATCHEWAN
ODANAH
LANGFORD
DALY
ELTON
WOODWORTH
NORTH CYPRESS
WHITEHEAD
CORNWALLIS
SIFTON
GLENWOOD
OAKLAND
SOUTH CYPRESS

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Legend

Study Area

MANITOBA
DEPARTMENT OF MINES, RESOURCES & ENVIRONMENTAL MANAGEMENT

Sand and Gravel Resources of the Brandon Region

Municipalities of the Brandon Region

0 2 4 6 10 15 Miles
0 2 5 10 15 25 Kilometres

The UMA Group

Plate C – 1

— These annual totals were applied to historical construction activity data for the Province to determine the Study Area's relative share of Provincial usage.

— The Study Area's relative share was applied to projections based on construction expenditures for the Province which had been developed in the Winnipeg Study to derive forecasts for the Brandon region.

— Average sector shares for the Study Area were applied to these forecast totals to provide forecasts of expenditure by sector.

— The appropriate technical usage coefficients were applied to each sector to derive forecasts of tonnage requirements for each sector.

— By using a combination of projected population growth and past historical data for road construction, these sector forecasts were allocated to each municipality in the Study Area.

1.4 Construction Sectors

The analytical approach adopted utilized a series of projections by construction sector. The construction categories or sectors into which construction activity is categorized are the same as those employed for the Winnipeg Region Study, namely:

a) Residential — single family, multi-family dwellings and apartments.

b) Non-Residential — commercial, institutional and industrial building construction except mine and mine mill buildings.

c) Road Construction — includes roads, highways, bridges, trestles and related structures.

d) Other Engineering — includes sewer and water and related engineering.

e) Residual — includes power stations, power lines, gas wells, mine shafts, parks, pools, tunnels, telegraph lines, signals, street lighting, fences and snowsheds.

The last category (residual) has been identified to separate out construction activities unlikely to occur in the Brandon region, e.g. mine shafts, and to eliminate essentially minor uses of construction aggregate, e.g. pools.

1.5 Sand and Gravel Coefficients

Technical usage coefficients which related sand and gravel usage in the Winnipeg Study area to construction expenditures were developed for the Province in the Winnipeg Region Study. These coefficients, which were tested and proved valid during that study, are as follows:

Residential	0.003588
Non-Residential	0.005734
Road	0.106191
Other Engineering	0.014536

By multiplying available published data on construction expenditures (i.e. — building permit values for residential construction) by the relevant coefficient (in this case

0.003588), a sand and gravel tonnage figure can be calculated. The reverse is true for converting tons in each category to construction dollars.

1.6 Information Sources

Information and statistics were gathered from the various sources and agencies who compile data relevant to the construction industry and the production and consumption of sand and gravel. These sources included the Department of Mines, Resources and Environmental Management, the Department of Highways, Statistics Canada, as well as municipalities and private companies engaged in the production and distribution of sand and gravel in the Study Area.

As most municipalities and private companies do not document or publish their consumption and usage data in a form suitable for this study, a questionnaire was directed to aggregate producers, intermediate users and basic users. These questionnaires were distributed by mail and were followed up by telephone and personal interviews. Private firms and government departments involved in the production and use of sand and gravel in the Brandon region were contacted in this manner to provide information to augment the published statistics.

This direct solicitation was necessary to obtain consumption figures relative to unit measures of construction activity, and to provide a level of detail for analysis which the published statistics did not contain. As well, careful inspection of published data on the sand and gravel industry in Manitoba, and particularly in the Brandon region, revealed the necessity for a more detailed study of the producer-user relationship in an attempt to develop an accurate accounting for the industrial flow of sand and gravel as it progresses from the producer through the direct and indirect channels prior to final consumption.

1.7 Limitations on Published Data

Data problems, similar to those found in the previous Winnipeg Region Study, were encountered in this study. While there are many sources of published data on the construction industry, there were problems in attempting to apply this data within the constraints of the study. Data problems are often encountered in any complex analysis of the type undertaken here because of the many factors to be analyzed, the many sources of data available, and the necessity to perform the analysis at a level of detail beyond that of conventional data sources.

The problems with published data included conflicting information, errors, omissions, failure of respondents to submit information for publication and, of major consequence, the lack of data at the sub-provincial level.

The problems associated with the data, and the provisions introduced to overcome data problems, are discussed below according to major subjects and topics of data research.

1.7.1 Residential and Non-Residential Construction

For residential and non-residential building construction, the only sub-provincial data in regular form is available from Statistics Canada. This is the

value of building permits issued by municipality (Cat. 64-203) where building permit data is broken down into residential, industrial, commercial and institutional government categories. The data provides only a general indication of levels of activity in each municipality or economic region for the following reasons:

- Building permits reflect budgets rather than actual construction values
- Delays in timing of construction after a building permit is issued may lead to data inconsistencies on an annual basis, e.g. housing starts and completions.
- Building permit by-laws in certain municipalities may not require licensing/reporting of all building construction.
- Most important of all, not all municipalities regularly report building permit data to Statistics Canada. For example, in the Brandon region during the period of study (1970-1974), municipalities such as Hamiota, South Cypress, Oakland, and Odanah all failed to report monthly building permits at least once during the year. Owing to limited resources Statistics Canada does not follow up on delinquent municipalities and therefore reports only data received. Such procedures tend to cause the data to overstate the activity in major urban centres such as Brandon relative to the rest of the study area.

1.7.2 Road Construction

Information on sand and gravel used for road construction and maintenance was derived from two sources. The Manitoba Department of Highways supplied data on tonnage used on Provincial Roads in each municipality for select years and this was averaged for a five year period to give a Provincial Highways figure for the study area. This was supplemented with information supplied by each municipality related to its own local usage. These two information sources were combined to provide an accurate estimate of sand and gravel used for road purposes.

1.7.3 Other Engineering Construction

To estimate the amount of sand and gravel used for purposes other than residential, non-residential, and road construction local users were surveyed as to their own needs. The only major users not covered by municipal road work or Department of Highways work were found to be the C.N.R. and C.P.R. Railways.

Originally statistics on local improvement expenditures were considered as being a possible indication of other engineering sand and gravel usage. However, such expenditures are not broken down by category (i.e. roads, sewer and water, etc.). When the results of the municipal surveys were examined it was found that virtually all sand and gravel used in the

municipalities was for road purposes. This had already been covered under the above Road Construction sector and consequently to include a portion of local improvement expenditures as other engineering sand and gravel usage would have led to an over-estimation of sand and gravel used in that period.

1.8 Producer and User Survey

1.8.1 Method

A survey of all producers and users of sand and gravel was carried out to obtain data on the Brandon region.

The survey was concerned with the volume of sand and gravel produced, its disposition or consumption for construction and maintenance purposes, and with the general source areas of sand and gravel. A questionnaire form was used for purposes of gathering this information. Because of the lack of tabulated historical data, many of the respondents were unable to provide information directly from summaries of operating data, and thus faced the laborious and time consuming task of assembling the required information from past records. Consequently, only 1973 information was requested from private producers and users.[1] This resulted in a complete industry profile for 1973, the basic reference year used throughout the study, and provided a direct comparison with the Winnipeg Study.

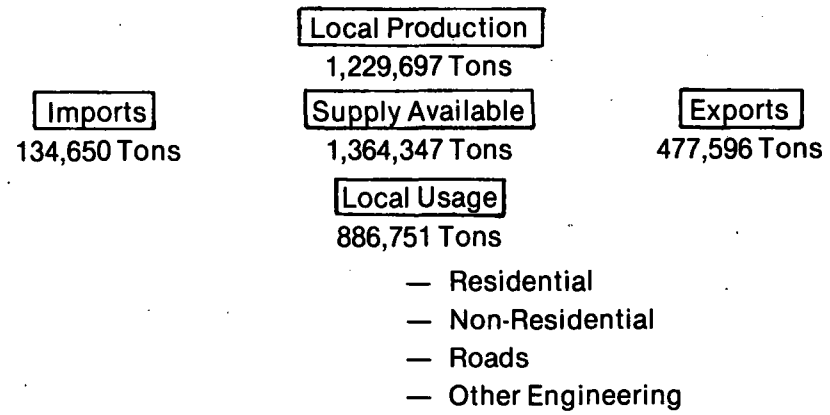
Three types of respondents were surveyed — producers, intermediate users and end users. Producers are companies engaged in extracting and processing sand and gravel. Intermediate users are companies who convert sand and gravel to products used in the construction industry such as ready mix, asphalt and precast concrete products. End users are the companies, government departments and agencies and local municipalities, that use sand and gravel in their construction projects. A list of the respondents is contained in Appendix 1. Appendix 2 contains copies of the questionnaire forms used in the survey.

1.8.2 Survey Results

The results of the survey have been incorporated into the various data summaries and statistical table presented in this report. The survey revealed that the volume of sand and gravel produced in the Brandon region in 1973 was approximately 1.23 million tons.[2] As well, an additional 135,000 tons were imported from outside sources (mainly neighbouring municipalities), establishing a total supply of over 1.35 million tons. Of this amount the

1. Other years' data were requested from certain large users such as the Manitoba Department of Highways and the Municipalities.
2. All tonnages in Section C, unless otherwise specified, refer to Short Tons.

survey revealed that nearly 900,000 tons was used locally with the balance being exported.



It is the general concensus of the companies and agencies surveyed, that future requirements will follow current trends of slow growth and that there are no signs of major new technology that will drastically change industry practices or lead to new types of demand for sand and gravel.

While in the Winnipeg Region Study, it was reported that transportation costs represented 50% of the total cost of sand and gravel, it was found in this study that they ranged up to 75% of the total cost. Although this may largely be a reflection of lower aggregate costs in the Brandon region, any developments which may contribute to increased hauling distances and costs are, nonetheless, of concern to everyone in the industry.

No significant increases in road construction activity are anticipated in the Study Region during the forecast demand period. No major technological breakthrough is anticipated over the next 25 years. The rising costs of transporting sand and gravel, the reduction in the highway standards and a better utilization of existing resources should mitigate any substantial increases in sand and gravel demand for road construction. Manitoba already has an adequate network of road and highways, particularly in the southern half of the Province. The Trans-Canada Highway is almost double-laned to Brandon and the short distance remaining is covered by the tonnage increase in annual sand and gravel requirements that is forecast over the next decade.

1.8.3 Implications of Using Survey Results for Forecasting

As with the Winnipeg Region Study, it was considered essential that these surveys be conducted in the Brandon area to establish usage patterns, to establish production figures, and to establish sand and gravel flows. The published industry statistics were not sufficiently complete (and in many cases were non-existent) to allow a comprehensive analysis.

While the data provides a profile of the commodity flow for five years, the use of this short time span to forecast future requirements has obvious implications on forecast reliability since it reflects only a short term profile of activity. Nevertheless, this five year period was considered to be representative of conditions in the industry and a reliable basis for forecasting. Consequently the forecasts do contain relative growth parameters which are based on historical relationships and trends in the construction industry.

2. SAND AND GRAVEL STATISTICS

Table C-1 presents standard end-use allocation data for sand and gravel as reported in the Winnipeg Region Studv. This data was originally tabulated for 1973 by Statistics Canada and was revised through discussions with major producers in the Winnipeg region.

The net effect of these adjustments resulted in a figure for sand and gravel production which is approximately 5% higher than the figures reported by Statistics Canada. The major increases are in road construction, concrete aggregate and railroad ballast. In contrast, allocations reported under all other categories declined.

Approximately 7% of the revised production figures could not be allocated to any of the nine major categories; in all instances, these discrepancies were due to lack of data for smaller operators.

Table C-1 by itself does not provide sufficient data to identify the proportion of sand and gravel being directed into each construction sector in the Province. These estimates were derived from the major users participating in the Winnipeg Study survey. Survey data concerning the allocation of concrete aggregate made it possible to determine the final end-use allocation for sand and gravel production in 1973. This is shown in Table C-2 by construction sector.

3. CONSTRUCTION EXPENDITURE AND SAND AND GRAVEL USAGE IN THE BRANDON REGION

Estimates of construction expenditures and sand and gravel usage in the study area have been derived from a combination of published data and user surveys.

3.1 Published Data

Building permit data from Statistics Canada Catalogue 64-203 provided residential and non-residential construction information for the municipalities in the study area. This information was collected and analyzed for a five year period from 1970 to 1974. Unfortunately, for reasons outlined previously, such material is not always complete nor is it always a true reflection of the actual cost of construction (permits often reflect proposed budgets rather than actual final costs). In cases where permit data was missing it was either supplied by the municipality upon request or was estimated on the basis of relative growth within the particular municipality. Once the permit data was gathered it was totalled and converted to 1973 dollar amounts.

Table C-3 contains residential construction data for each rural and incorporated urban municipality for the 1970-1974 period. Data was originally recorded in actual dollars and

TABLE C-1
SAND AND GRAVEL ALLOCATION DATA, 1973
(000 Tons)
MANITOBA

Use	Statistics Canada	Revised	Percent Adjustment
Road Construction	6,747	8,669	28.5
Ice Control	79	14	(82.2)
Concrete aggregate	1,843	2,241	21.6
Asphalt aggregate	550	535	(2.7)
Railroad ballast	776	928	19.6
Mortar sand	153	26	(83.0)
Mine fill	67	—	—
Other fill	1,618	1,113	(31.2)
Other uses	13	2	(84.6)
Total allocated	11,846	13,528	14.0
Total production	13,700	14,449	5.5
Percent allocated	86.5	93.6	—

Sources: Statistics Canada Cat. 26-215 and the Producer and User Survey
Reproduced from "Aggregate Resources of the Winnipeg Region".

TABLE C-2
SAND AND GRAVEL
FINAL END USE ALLOCATION, MANITOBA 1973
(000 tons)

	Concrete Aggregate	Other Sand & Gravel	Total	Percent Allocated to Each Sector
Residential	922.9	51.8	974.7	6.7
Non-Residential Building	669.1	294.0	963.1	6.7
Road Construction)			9,218.0	63.8
)	733.8	10,830.9		
Other Engineering)			2,346.7	16.2
Not Allocated	—	946.5	946.5	6.6
Total Production	2,325.8	12,123.2	14,449.0	100.0

Sources: Statistics Canada and the Producer and User Survey
Reproduced from "Aggregate Resources of the Winnipeg Region."

TABLE C-3
BRANDON STUDY AREA
RESIDENTIAL CONSTRUCTION
(1973 Constant Dollars)

	1970	1971	1972	1973	1974	Average
1. Hamiota, R.M.	$ 47,337	$ 45,924	$ 43,716	$ 40,000	$ 34,996)	
					)	$ 104,376
Hamiota, Vl.	47,381	47,391	50,273	122,000	42,870)	
2. Blanshard, R.M.	47,338	45,924	43,716	40,000	34,996	$ 42,395
3. Saskatchewan, R.M.	393,745	83,745	73,745	100,000	87,489)	
					)	$ 119,858
Rapid City, Vl.	1,183	51,665	64,481	269,000	124,234)	
4. Odanah, R.M.	23,669	22,962	21,858	20,000	17,498)	
					)	$ 538,221
Minnedosa, T.	382,249	319,174	786,885	386,000	511,811)	
5. Langford, R.M.	24,775	24,755	16,393	50,000	7,874)	
					)	$ 603,989
Neepawa, T.	168,047	672,790	556,284	906,000	594,051)	
6. Woodworth, R.M.	112,493	112,493	112,494	120,000	104,987	$ 112,493
7. Daly, R.M.	55,000	55,000	55,000	55,000	55,000)	
					)	$ 123,763
Rivers, T.	41,420	11,491	16,393	12,000	262,467)	
8. Elton, R.M.	52,071	303,100	236,065	565,000	352,581	$ 301,763
9. N. Cypress, R.M.	196,850	196,850	196,850	196,850	196,850)	
					)	$ 357,015
Carberry, T.	117,160	104,478	81,967	261,000	236,220)	
10. Whitehead, R.M.	35,543	103,330	14,208	102,000	181,102	$ 87,229
11. Cornwallis, R.M.	408,284	346,728	174,863	168,000	282,589)	
					)	$5,578,643
Brandon, City	1,466,272	5,419,059	7,190,164	7,495,000	4,942,257)	
12. Oakland, R.M.	155,731	155,731	155,731	155,731	155,731)	
					)	$ 164,210
Wawanesa, Vl.	9,468	9,185	8,743	8,000	6,999)	
13. S. Cypress, R.M.	47,337	45,924	113,716	40,000	34,996)	
					)	$ 64,874
Glenboro, Vl.*	9,468	9,185	8,743	8,000	6,999)	
14. Glenwood, R.M.	47,337	45,924	43,716	40,000	34,996)	
					)	$ 245,558
Souris, T.	155,030	120,155	92,896	363,000	284,339)	
15. Sifton, R.M.*	72,655	162,249	196,113	223,519	166,722	$ 163,550
Oak Lake, Vl.*						
	$3,817,843	$8,515,212	$10,355,012	$11,746,100	$8,760,654	

* No statistics were available for Glenboro, Oak Lake, or the R.M. of Sifton. Consequently, aggregate usage figures were estimated on the basis of their population as a proportion of total study area population, taking into consideration other areas of similar size.

Also, in some municipalities, data had not been reported in certain years. Estimates for those missing years were based on averages from other years.

Source: Statistics Canada, Catalogue 64-203, Building Permits.

the appropriate implicit price index was applied to convert that year's data to a 1973 base year. Construction estimates for Glenboro, Oak Lake, and the R.M. of Sifton were based on each area's population as a portion of the total population, giving consideration to construction expenditures in areas of similar size and character.

The subsequent table, Table C-4, contains similar data for non-residential construction by municipality for the same period. In this case there were many more instances where construction was not reported, especially in the rural municipalities. Rather than a failure to report construction this is more likely a reflection of the lack of non-residential type construction in many areas. Therefore, no attempt was made to estimate construction figures for these municipalities.

3.2 Survey Data

Three separate surveys were conducted. The first involved all the municipalities in the study area and they were surveyed as to their sand and gravel usage in recent years. This provided an estimate of how much sand and gravel was being used over time, and for what purposes, by municipalities in the study area. It was found that virtually all sand and gravel usage by the municipalities, except for occasional insignificant amounts, went towards road construction and maintenance. This road sand and gravel usage figure was supplemented with material supplied by the Manitoba Department of Highways related to gravel usage on Provincial Roads. The Highway and Municipal data provided an accurate indication of sand and gravel being used for road purposes.

The results of the Municipal Survey and the data supplied by the Department of Highways are contained in Tables C-5 and C-6 respectively. Most information supplied by municipalities was fairly complete.

Where data was missing it was estimated on the basis of usage in other years or was calculated as a proportion of total regional cosumption.

Department of Highways data was less detailed in that it was supplied for every second year (1970, 1972 and 1974). Also, sand and gravel used by Highways is not constant in that the department engages in periodic major reconstruction and gravelling programs. Consequently sand and gravel usage may appear to be very low in one year and very high in another year. To overcome this problem a three year average was taken of the years reported and it was assumed that this average figure was also applied to 1971 and 1973.

The second survey covered the major sand and gravel producers in the study region and the immediately adjoining vicinity. Producers were asked to indicate their 1973 production, the general source area of their sand and gravel, and their major customers in that year. The survey revealed that some producers obtained sand and gravel from outside the study area in adjacent municipalities. Consequently production figures apply to an area somewhat larger than the defined study area itself. Major producers covered in this survey were the C.N.R. and C.P.R. as well as private firms.

The third survey concentrated on the users of sand and gravel, other than the

TABLE C-4
BRANDON STUDY AREA
NON-RESIDENTIAL CONSTRUCTION
(1973 Constant Dollars)

	1970	1971	1972	1973	1974	1970-1974	Average
1. Hamiota, R.M.*	—	—	—	—	—	—	—
Hamiota, Vl.	—	—	—	—	—	—	—
2. Blanshard, R.M.	—	—	—	—	—	—	—
3. Saskatchewan, R.M.	—	—	—	—	—	—	—
Rapid City, Vl.	$ 37,870	$ 11,481	$ 34,972	$ 9,000	$ 10,499	$ 20,764	$ 20,764
4. Odanah, R.M.	—	—	—	—	—	—	$ 544,953
Minnedosa, T.	2,060,355	10,333	97,268	45,000	511,811	544,953	
5. Langford, R.M.	—	—	38,251	24,000	7,874	14,025	$ 858,577
Neepawa, T.	2,081,656	335,247	778,141	732,000	295,713	844,552	
6. Woodworth, R.M.	—	—	—	—	—	—	—
7. Daly, R.M.	—	—	—	—	—	—	—
Rivers, T.	—	—	—	—	—	—	—
8. Elton, R.M.	—	—	—	—	—	—	
9. N. Cypress, R.M.**	—	—	—	—	43,745	8,749	$2,208,044
Carberry, T.	42,604	345,580	15,301	523,000	59,991	199,295	
10. Whitehead, R.M.	—	—	—	—	—	—	
11. Cornwallis, R.M.	137,278	1,862,227	8,743	53,000	220,472	456,344	$8,093,605
Brandon, C.	11,969,231	9,570,608	6,999,727	7,597,000	2,099,738	7,637,261	
12. Oakland, R.M.	—	—	—	—	—	—	
Wawanesa, Vl.	—	—	—	—	—	—	
13. S. Cypress, R.M.	—	—	—	—	—	—	$ 1,420
Glenboro, Vl.	7,101	—	—	—	—	1,420	
14. Glenwood, R.M.	—	—	—	—	—	—	$ 334,748
Souris, R.M.	92,308	32,147	1,419,672	22,000	107,612	334,748	
15. Sifton, R.M.	—	—	—	—	—	—	
Oak Lake, Vl.	—	—	—	—	—	—	
	$16,428,403	$12,167,623	$9,392,076	$9,005,000	$3,357,455		

* Where no data was reported for a municipality, it was assumed that there was no non-residential construction in that municipality.

** Where the data was only reported for one year out of the five, it was assumed that this was a true reflection of the level of non-residential construction in that municipality. Consequently the one year figure was averaged for the five years to give an annual estimate of non-residential construction activity.

Source: Statistics Canada, Catalogue 64-203, Building Permits.

TABLE C-5
BRANDON STUDY AREA
ROAD SAND AND GRAVEL USAGE BY MUNICIPALITY (TONS) — SURVEY RESULTS

	1970	1971	1972	1973	1974	1970-74	Average
1. Hamiota, R.M.	$ 23,262	$ 25,865	$ 24,317	$ 23,135	$ 19,307	$23,177)	
						)	$ 23,252
Hamiota, VI.	75	75	75	75	75	75)	
2. Blanshard, R.M.	35,095	20,129	12,169	13,548	13,330	18,854	$ 18,854
3. Saskatchewan, R.M.*	22,500	22,500	22,500	22,500	22,500	22,500)	
						)	$ 23,375
Rapid City, VI.	0	240	3,195	450	491	875)	
4. Odanah, R.M.**	22,074	21,111	28,118	18,738	20,328	22,074)	
						)	$ 27,085
Minnedosa, T.	5,000	5,000	5,000	5,026	5,026	5,011)	
5. Langford, R.M.	18,750	18,750	18,750	18,750	18,750	18,750)	
						)	$ 23,950
Neepawa, T.	5,200	5,200	5,200	5,200	5,200	5,200)	
6. Woodworth, R.M.	19,712	20,127.8	20,860	21,291.2	15,932	19,585	$ 19,585
7. Daly, R.M.	21,000	19,500	18,000	19,500	22,500	20,100)	
						)	$ 20,265
Rivers, T.	150	150	150	185	185	165)	
8. Elton, R.M.	31,500	31,500	31,500	31,500	31,500	31,500	$ 31,500
9. N. Cypress, R.M.	17,250	17,250	17,250	17,250	17,250	17,250)	
						)	$ 27,073
Carberry, T.	11,223	11,473	12,126	6,582	7,711	9,823)	
10. Whitehead, R.M.	15,293	9,648	11,081	13,604	14,502	12,826	$ 12,826
11. Cornwallis, R.M.	24,116	24,116	24,116	24,116	24,116	24,116)	
						)	$113,448
Brandon, C.	89,332	89,332	89,332	89,332	89,332	89,332)	
12. Oakland, R.M.	22,866	22,866	22,866	22,866	22,866	22,866)	
						)	$ 23,229
Wawanesa, VI.	345	345	345	405	375	363)	
13. S. Cypress, R.M.	5,200	8,800	6,600	5,000	10,000	7,120)	
						)	$ 7,570
Glenboro, VI.	450	450	450	450	450	450)	
14. Glenwood, R.M.	18,750	17,750	18,750	18,750	18,750	18,750)	
						)	$ 22,500
Souris, T.	3,750	3,750	3,750	3,750	3,750	3,750)	
15. Sifton, R.M.***	7,694	7,712	7,665	7,423	7,466	7,592)	
						)	$ 8,192
Oak Lake, VI.	600	600	600	600	600	600)	
	$ 421,187	$ 405,240	$ 402,765	$ 390,026	$ 392,292		
1973 Dollars	$3,966,315	$3,816,143	$3,792,836	$3,672,872	$3,694,164		

* Several municipalities reported their usage as being a constant figure.

** One year's data was missing. That year was assumed to be the average of the following four years.

*** Sifton is an estimate as it was not surveyed.

TABLE C-6
BRANDON STUDY AREA
MANITOBA DEPARTMENT OF HIGHWAYS SAND AND GRAVEL USAGE
(Tons)

	1970	1972	1974	Estimated Annual Average 1970-1974
Hamiota	17,712	—	57,790	25,167
Blanshard	17,712	4,930	—	7,547
Saskatchewan	7,250	4,930	—	4,060
Odanah	—	—	11,415	3,805
Langford*	—	—	—	10,053
Woodworth	—	60,355	6,213	22,189
Daly	0	9,355	6,213	5,189
Elton	63,665	4,750	12,813	27,076
N. Cypress	5,200	4,750	58,415	22,788
Whitehead	57,890	9,335	6,213	24,479
Cornwallis	180,690	59,000	80,465	106,718
Sifton**	—	—	—	5,940
Glenwood	6,715	16,725	643	8,028
Oakland	84,715	—	—	28,238
S. Cypress	5,775	4,750	21,975	10,833
				312,110
1973 Dollars				$2,939,138

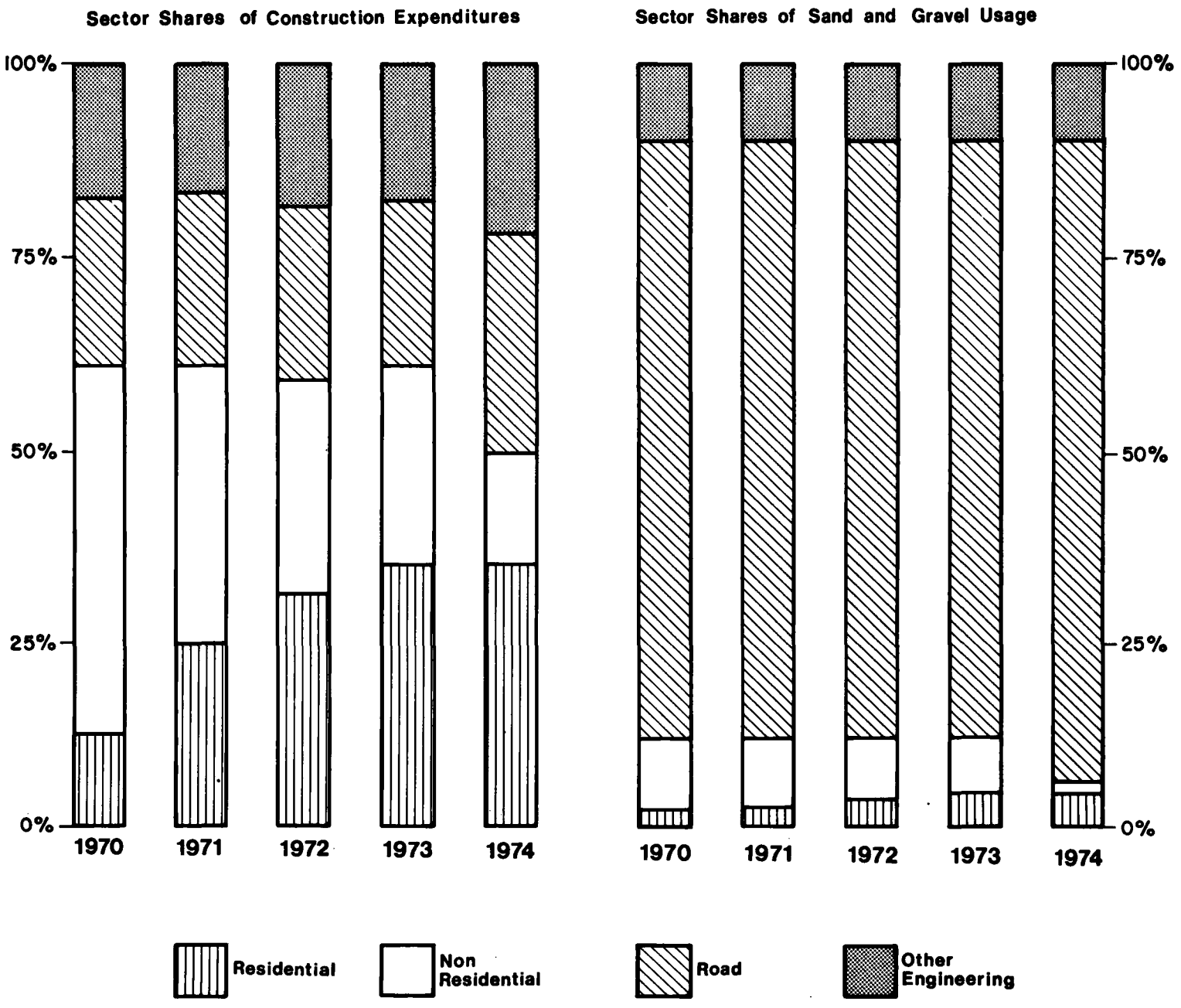
* No Highways work was done in the R.M. of Langford in the three sample years. Data from previous years plus 1975 figures were consequently used.

** R.M. of Sifton figures estimated.

municipalities themselves and the Department of Highways, and was primarily used as a confirmation of other data. Many of the users surveyed were found to be working for the municipalities or Highways and consequently were considered as being only intermediate users.

3.3 Construction Expenditures and Sand and Gravel Usage: 1970-1974

To provide an indication of construction expenditures by sector the appropriate technical usage coefficients from the Winnipeg Study were applied to the tonnage figure. These were then combined with dollar and tonnage figures for residential and non-residential activities as gathered from published data to calculate total annual average construction expenditures and sand and gravel usage in the study area. These are summarized in Tables C-7 and C-8 and depicted graphically on Plate C-2.



MANITOBA
DEPARTMENT OF MINES, RESOURCES & ENVIRONMENTAL MANAGEMENT

Sand and Gravel Resources of the Brandon Region

Sector Shares of Construction Expenditures and Sand and Gravel Usage 1970-1974

The UMA Group

Plate C-2

TABLE C-7
BRANDON STUDY AREA
CONSTRUCTION EXPENDITURES
(000's 1973 Constant Dollars)

	Residential[1]	Non-Residential[2]	Roads			Other Engineering[5]	Total
			Municipal[3]	Provincial[4]	Total		
1970	$ 3,818 (11.7%)	$16,428 (50.3%)	$ 3,966	$ 2,939	$ 6,905 (21.1%)	$ 5,504 (16.9%)	$32,655
1971	$ 8,515 (25.8%)	$12,168 (36.9%)	$ 3,816	$ 2,939	$ 6,755 (20.5%)	$ 5,504 (16.7%)	$32,942
1972	$10,355 (32.2%)	$ 9,392 (29.3%)	$ 3,793	$ 2,939	$ 6,832 (21.3%)	$ 5,504 (17.2%)	$32,083
1973	$11,746 (35.8%)	$ 9,005 (27.4%)	$ 3,673	$ 2,939	$ 6,612 (20.1%)	$ 5,504 (16.7%)	$32,867
1974	$ 8,761 (36.2%)	$ 3,357 (13.8%)	$ 3,694	$ 2,939	$ 6,633 (27.3%)	$ 5,504 (22.7%)	$24,255
Average	$ 8,639 (27.9%)	$10,070 (23.5%)			$ 6,747 (21.8%)	$ 5,504 (17.8%)	$30,960

1. *Source:* Table C-3
2. *Source:* Table C-4
3. *Source:* Table C-5, applying the reverse Road technical usage coefficient
4. *Source:* Table C-6, applying the reverse Road technical usage coefficient
5. *Source:* Based on survey results which indicated a constant tonnage use by the railways; converted to dollars by applying the reverse Other Engineering usage coefficient.

TABLE C-8
BRANDON STUDY AREA
SAND AND GRAVEL USAGE
(Tons)

	Residential[1]	Non-Residential[2]	Roads			Other Engineering[5]	Total
			Municipal[3]	Provincial[4]	Total		
1970	13,698 (1.5%)	94,200 (10.2%)	421,187	312,110	733,297 (79.6%)	80,000 (8.7%)	921,195
1971	30,553 (3.4%)	69,769 (7.8%)	405,240	312,110	717,350 (79.9%)	80,000 (8.9%)	897,672
1972	37,154 (4.2%)	53,854 (6.1%)	402,765	312,110	714,875 (80.7%)	80,000 (9.0%)	885,883
1973	42,145 (4.8%)	51,635 (5.8%)	390,026	312,110	720,136 (80.6%)	80,000 (8.9%)	893,916
1974	31,433 (3.8%)	19,252 (2.3%)	392,292	312,110	704,402 (84.3%)	80,000 (9.6%)	835,087
Average	30,997 (3.5%)	57,742 (6.5%)			718,012 (81.0%)	80,000 (9.0%)	886,751

1. *Source:* Table C-3, applying the Residential technical usage coefficient
2. *Source:* Table C-4, applying the Non-Residential technical usage coefficient
3. *Source:* Table C-5
4. *Source:* Table C-6
5. *Source:* Survey Data

4. PROJECTIONS OF SAND AND GRAVEL REQUIREMENTS INTO THE BRANDON REGION

4.1 Forecasts of Provincial Construction Spending

Forecasts of Provincial construction spending which were developed for the Winnipeg Region Study were used in projecting future construction spending and sand and gravel usage in the Brandon region. Two Provincial forecasts had been developed; the base case forecast utilized Statistics Canada's Population Projection G for the Provinces while the alternate projection was derived from Projection A.[3] These construction estimates are contained in Table C-9.

3 See "Population Projections for Canada and the Provinces" Catalogue 91-514, Statistics Canada, 1974.

TABLE C-9

FORECASTS OF PROVINCIAL CONSTRUCTION EXPENDITURES

(000's Constant 1973 Dollars)

	Base Case Forecast	Alternate Forecast
1976	$ 741,872	$719,370
1981	$ 819,750	$776,667
1986	$ 925,043	$838,785
1991	$ 948,091	$874,041
1996	$1,070,922	$907,445

Source: "Aggregate Resources of the Winnipeg Region".

4.2 Forecasts of Total Brandon Region Construction Spending

In the five year period from 1970 to 1974 the Brandon Study Area's construction expenditures have averaged around 5% of the total Provincial expenditure (see Table C-10). A fairly significant drop occurred in 1974, largely due to a decrease in residential and non-residential construction activity. While this 1974 decrease may signify the beginning of a long term decline in construction in the region, it may also only be an anomaly resulting from a temporary national slump in the residential and non-residential construction sectors of the economy. In order to take these possibilities into consideration, Brandon's share of projected Provincial construction activity has been analyzed as a range varying between 4.5% and 5.0%.

Using these proportions, projected future construction expenditures in the study area have been calculated for the base case forecast and the alternate forecast. As the base case forecast is the preferred forecast, calculations derived from it have been included in the text. Calculations based on the alternate forecast have been included in Appendix 3. Brandon's share of projected construction expenditures are contained in Tables C-11 and A3-1.

4.3 Forecast of Brandon Region Construction Spending by Sector

Sector shares of construction spending in the Brandon region over the 1970-1974 period have been as follows: (from Table C-7)

Residential	27.9%
Non-Residential	32.5%
Roads	21.8%
Other Engineering	17.8%
	100.0%

TABLE C-10
CONSTRUCTION EXPENDITURES IN THE BRANDON STUDY AREA AND IN THE PROVINCE
(000's Constant 1973 Dollars)

	Manitoba Expenditures[1]		Brandon Region[3]	Brandon Region as a % of Province
	Total	Total Less Residual[2]		
1970	$846,662	$629,515	$32,655	5.19%
1971	$774,014	$616,166	$32,942	5.35%
1972	$815,612	$690,189	$32,083	4.65%
1973	$889,247	$688,202	$32,867	4.78%
1974	$859,161	$701,773	$24,255	3.46%

1. *Source:* Statistics Canada, Catalogue 64-201, and 'Aggregate Resources of the Winnipeg Region'.
2. As the Brandon Region statistics did not contain a residual category, Manitoba figures were accordingly adjusted downwards to permit a more accurate comparison.
3. *Source:* Table C-7, Brandon Study Area — Construction Expenditures.

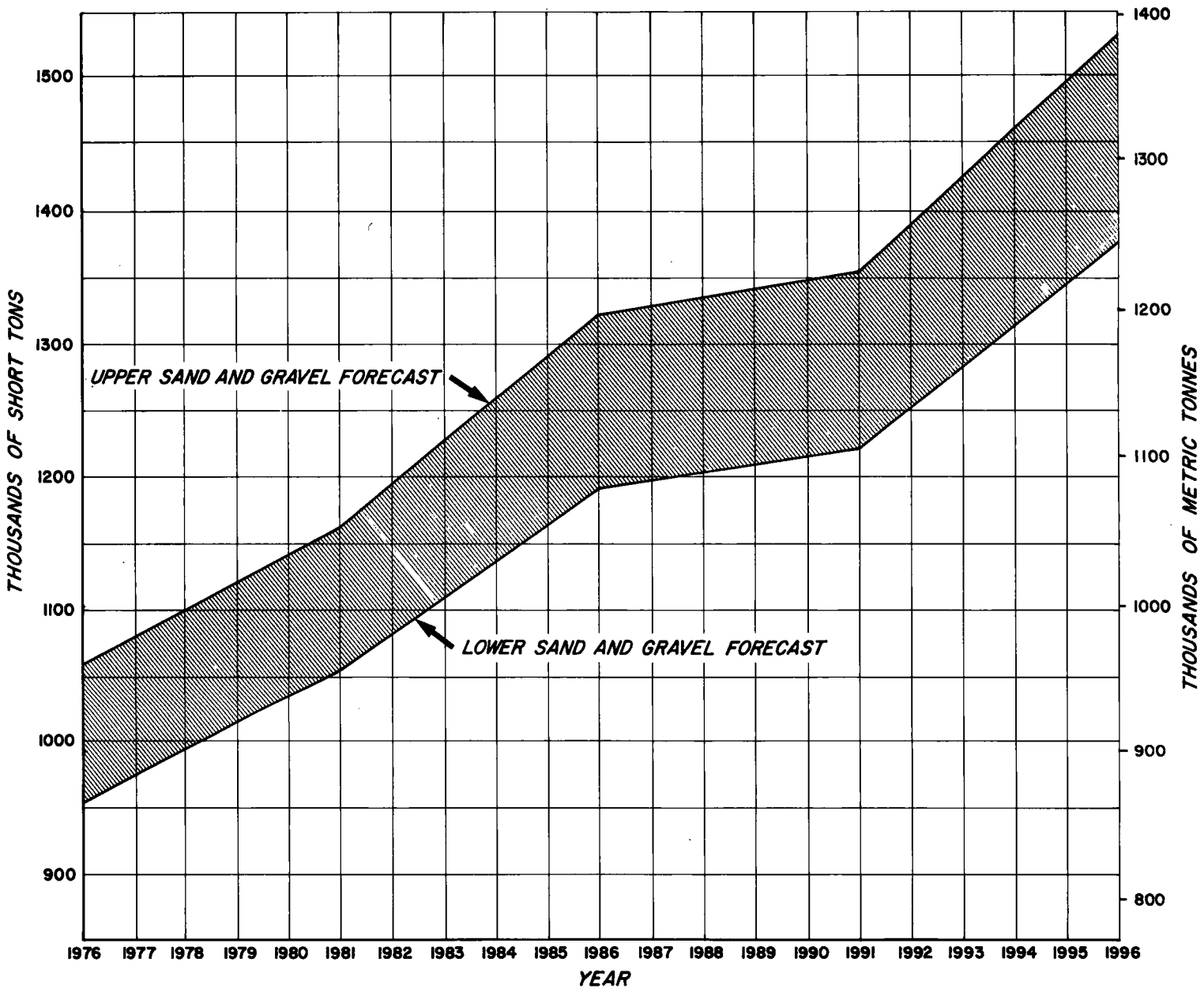
TABLE C-11
BASE CASE FORECAST OF CONSTRUCTION EXPENDITURES IN THE BRANDON STUDY AREA
(000's 1973 Constant Dollars)

	4.5% - 5.0% Share
1976	$33,384 - $37,094
1981	$36,889 - $40,988
1986	$41,627 - $46,252
1991	$42,664 - $47,405
1996	$48,191 - $53,546

It has been assumed that these sector shares will remain relatively constant over time, although there may be minor annual fluctuations. These proportions have been applied to forecast total construction expenditure for the study area to estimate future spending by sectors. (See Tables C-12 and A3-2).

4.4 Forecasts of Sand and Gravel Usage by Sector in the Brandon Region

Once future levels of construction activity had been determined by sector for the study area, the appropriate technical usage coefficients were applied to derive estimates of sand and gravel requirements. These estimates are contained in Tables C-13 and in Appendix Table A3-3. Plate C-3 indicates these forecasted requirements on an annual basis up to 1996.



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Base Case Forecast of Sand and Gravel Requirements in the Brandon Region

Sand and Gravel Resources of the Brandon Region

The UMA Group

Plate C - 3

TABLE C-12

BASE CASE FORECAST OF CONSTRUCTION SPENDING BY SECTOR IN THE BRANDON STUDY AREA (000's 1973 Constant Dollars)

	Residential	Non-Residential	Roads	Other Engineering	Total
1976	$ 9,314 - $10,349	$10,050 - $12,056	$ 7,278 - $ 8,086	$ 5,942 - $ 6,603	$33,384 - $37,094
1981	$10,292 - $11,436	$11,989 - $13,321	$ 8,042 - $ 8,835	$ 6,566 - $ 7,296	$36,889 - $40,988
1986	$11,614 - $12,904	$13,529 - $15,032	$ 9,075 - $10,083	$ 7,410 - $ 8,233	$41,627 - $46,252
1991	$11,903 - $13,226	$13,866 - $15,407	$ 9,301 - $10,334	$ 7,594 - $ 8,438	$42,664 - $47,405
1996	$13,445 - $14,939	$15,662 - $17,402	$10,506 - $11,673	$ 8,578 - $ 9,531	$48,191 - $53,546

TABLE C-13

BASE CASE FORECAST OF SAND AND GRAVEL REQUIREMENTS IN THE BRANDON STUDY AREA (000's Tons)

	Resid.	Non-Resid.	Roads	Other Eng.	Total for the Year	Cumulative from 1976
1976	33-37	62- 69	773- 859	86- 96	954-1061	954- 1061
1981	37-41	69- 76	854- 938	95-106	1055-1161	5923- 6562
1986	42-46	78- 86	964-1071	108-120	1192-1323	11372-12691
1991	43-47	80- 88	988-1097	110-123	1221-1355	17390-19370
1996	48-54	90-100	1116-1240	125-139	1379-1533	23811-26501

4.5 Demand for Sand and Gravel to the Year 2026

Simple extrapolation has been used to forecast sand and gravel demand past the end of the century (Table C-14). The reliability of any forecast diminishes as the time horizon is extended and consequently projected demand figures should be treated as only general indicators of potential sand and gravel usage in that time frame.

5. SAND AND GRAVEL REQUIREMENTS BY MUNICIPALITY

Sand and gravel demand for each municipality was calculated once total future sand and gravel requirements had been determined for the study area. The forecast was done in two ways. First, future sand and gravel requirements for residential and non-residential uses was based on projections of population growth for each municipality. Secondly, sand and gravel requirements for road construction purposes (municipal, and Department of Highways) were calculated by taking the 1970-1974 proportion of total road sand and gravel used by each municipality and applying that proportion to projected road sand and gravel usage figures. The assumption in the latter approach was that relative consumption within each municipality would remain fairly stable over time. This assumption was based on the realization that most

TABLE C-14
FORECAST OF SAND AND GRAVEL DEMAND BETWEEN 1996 AND 2026
(000 Tons)

	Sand and Gravel Demand for the Year	Cumulative From 1976
1996	1,379 - 1,533	23,811 - 26,501
2001	1,465 - 1,628	30,878 - 34,356
2006	1,566 - 1,742	38,407 - 42,724
2011	1,668 - 1,742	46,444 - 51,662
2016	1,770 - 1,969	54,988 - 61,168
2021	1,871 - 2,083	64,040 - 71,241
2026	1,973 - 2,197	73,599 - 81,844

of the study area now contains a fairly complete system of roads and highways and there will not be a great deal of new road construction. Therefore, sand and gravel usage will be directed towards the maintenance and reconstruction of the existing network. Proportions used by municipality should not change drastically.

In both of these calculations, incorporated towns and villages were considered part of the municipality in which they were situated and were consequently added to the municipal figures (i.e. Brandon is included with Cornwallis, Souris with Glenwood, etc.). The towns of Minnedosa and Neepawa, on the periphery of the study area were included with the Rural Municipalities of Odanah and Langford respectively.

5.1 Projected Residential and Non-Residential Sand and Gravel Demand by Municipality

Population projections have been prepared for each municipality and incorporated urban place in the study area and these are presented by municipality in Table C-15. The proportions for each municipality for each projected year have been applied to the base case forecast of residential and non-residential sand and gravel statistics to derive municipal shares. These shares are contained in Table C-16. Alternate forecast results appear in Appendix Table A3-4.

5.2 Projected Road Sand and Gravel Demand by Municipality

Examination of Tables C-5 and C-6 reveals the use of road sand and gravel for each municipality over the 1970-1974 period. By totaling local municipal and Department of Highway sand and gravel usage in each municipality and relating this to total sand and gravel used, a proportionate road aggregate share for each municipality was calculated. The results are contained in Table C-17.

These proportions were then applied to the projected road sand and gravel usage for the study area, providing the results contained in Table C-18 and Appendix Table A3-5.

TABLE C-15
BRANDON STUDY AREA
MUNICIPALITY POPULATION PROJECTIONS

	1976 (%)	1981 (%)	1986 (%)	1991 (%)	1996 (%)
Hamiota	1,562 (2.4)	1,279 (1.9)	1,278 (1.8)	1,147 (1.6)	1,109 (1.5)
Blanshard	915 (1.4)	769 (1.1)	672 (1.0)	582 (0.8)	500 (0.7)
Saskatchewan	1,271 (1.9)	1,049 (1.6)	1,008 (1.4)	905 (1.3)	876 (1.2)
Odanah	3,291 (5.0)	3,393 (5.1)	3,672 (5.3)	3,856 (5.3)	3,965 (5.3)
Langford	4,136 (6.3)	4,455 (6.5)	4,997 (7.1)	5,445 (7.5)	6,015 (8.0)
Woodworth	1,161 (1.8)	979 (1.5)	874 (1.2)	840 (1.2)	751 (1.0)
Daly	3,063 (4.6)	3,012 (4.5)	3,132 (4.5)	3,374 (4.7)	3,511 (4.7)
Elton	1,493 (2.3)	1,530 (2.3)	1,563 (2.2)	1,506 (2.1)	1,600 (2.1)
N. Cypress	3,259 (4.9)	3,287 (4.8)	3,383 (4.8)	3,428 (4.7)	3,659 (4.9)
Whitehead	1,282 (1.9)	1,119 (1.7)	1,143 (1.6)	1,099 (1.5)	1,126 (1.5)
Cornwallis	38,093(57.5)	39,687(59.1)	41,865(59.7)	43,369(60.1)	45,073(60.4)
Sifton	1,259 (1.9)	1,187 (1.8)	1,108 (1.6)	1,027 (1.4)	947 (1.3)
Glenwood	2,504 (3.8)	2,495 (3.7)	2,639 (3.8)	2,777 (3.8)	2,948 (3.9)
Oakland	1,411 (2.1)	1,457 (2.7)	1,421 (1.4)	1,506 (2.1)	1,467 (1.4)
S. Cypress	1,447 (2.2)	1,446 (2.2)	1,433 (2.6)	1,368 (1.9)	1,184 (2.1)
Total	66,152	67,144	70,188	72,227	74,731

TABLE C-16

BRANDON STUDY AREA
BASE CASE FORECAST OF RESIDENTIAL AND NON-RESIDENTIAL SAND AND GRAVEL USAGE BY MUNICIPALITY
(Tons)

	1976		1981		1986		1991		1996	
	Residential	Non-Residential	Residential	Non-Residential	Residential	Non-Residential	Residential	Non-Residential	Residential	Non-Residential
Hamiota	802- 891	1,498- 1,664	702- 780	1,310- 1,456	750- 833	1,401- 1,556	683- 759	1,276- 1,417	724- 804	1,351- 1,501
Blanshard	468- 520	874- 971	406- 451	759- 843	417- 463	778- 865	342- 380	638- 709	337- 375	631- 701
Saskatchewan	635- 706	1,186- 1,317	591- 657	1,103- 1,226	583- 648	1,089- 1,210	555- 617	1,037- 1,152	579- 643	1,081- 1,201
Odanah	1,671- 1,857	3,120- 3,467	1,883- 2,043	3,518- 3,908	2,209- 2,454	4,124- 4,582	2,264- 2,515	4,227- 4,696	2,557- 2,841	4,774- 5,305
Langford	2,105- 2,339	3,930- 4,368	2,400- 2,666	4,482- 4,980	2,959- 3,287	5,525- 6,139	3,203- 3,560	5,981- 6,647	3,889- 4,288	7,206- 8,007
Woodworth	602- 668	1,123- 1,248	554- 615	1,034- 1,149	500- 556	934- 1,037	512- 569	957- 1,063	482- 536	901- 1,001
Daly	1,537- 1,708	2,871- 3,190	1,662- 1,846	3,103- 3,348	1,875- 2,084	3,501- 3,891	2,007- 2,230	3,748- 4,165	2,267- 2,519	4,234- 4,704
Elton	769- 854	1,435- 1,595	849- 944	1,586- 1,762	918- 1,019	1,712- 1,902	897- 997	1,675- 1,861	1,013- 1,126	1,892- 2,102
N. Cypress	1,638- 1,819	3,058- 3,398	1,773- 1,970	3,310- 3,678	2,000- 2,222	3,735- 4,150	2,007- 2,230	3,748- 4,165	2,364- 2,626	4,414- 4,906
Whitehead	635- 706	1,186- 1,317	628- 698	1,172- 1,303	667- 741	1,245- 1,383	641- 712	1,196- 1,329	724- 804	1,351- 1,501
Cornwallis	19,215-21,350	34,881-39,870	21,824-24,259	40,755-45,280	24,877-27,641	46,452-51,616	25,668-28,521	47,929-53,257	29,138-32,376	54,409- 60,456
Sifton	635- 706	1,186- 1,317	665- 739	1,241- 1,379	667- 741	1,245- 3,285	598- 664	1,116- 1,241	627- 697	1,171- 1,301
Glenwood	1,270- 1,411	2,371- 2,635	1,366- 1,518	2,551- 2,835	1,583- 1,759	2,957- 3,285	1,623- 1,803	3,030- 3,367	1,881- 2,090	3,513- 3,904
Oakland	702- 780	1,310- 1,458	997- 1,108	1,862- 2,069	833- 926	1,556- 1,729	897- 997	1,675- 1,861	965- 1,072	1,802- 2,002
S. Cypress	735- 817	1,373- 1,526	812- 903	1,517- 1,686	833- 926	1,556- 1,729	811- 902	1,515- 1,684	772- 858	1,441- 1,601
Total	33,419-37,132	62,403-69,341	36,928-41,032	68,957-76,618	41,671-46,300	77,810-86,457	42,708-47,455	79,748-88,613	90,081-53,601	90,081-100,093

Source: Municipal shares from Table C-15 applied to forecasted sector sand and gravel requirements of Table C-13. Calculations were based on original non-rounded-off data that was used in compiling Table C-13; consequently there may be slight variations between the results contained in Table C-16 and what is produced by using the rounded-off data of Table C-13.

TABLE C-17

HISTORICAL ROAD SAND AND GRAVEL USAGE BY MUNICIPALITY 1970 - 1974

(Tons)

	Municipal Use[1]	Dept. of Highway Use[2]	Total	%
Hamiota	23,252	25,167	48,419	6.8
Blanshard	18,854	7,547	26,401	3.4
Saskatchewan	23,375	4,060	27,435	3.8
Odanah	27,085	3,805	30,890	4.3
Langford	23,950	10,053	34,003	4.9
Woodworth	19,585	22,189	41,774	5.9
Daly	20,265	5,189	25,454	3.6
Elton	31,500	27,076	58,576	8.2
N. Cypress	27,073	22,788	49,861	7.0
Whitehead	12,826	24,479	37,305	5.2
Cornwallis	113,448	106,718	220,166	30.9
Sifton	8,192	5,940	14,132	2.0
Glenwood	22,500	8,028	30,528	4.3
Oakland	23,229	28,238	51,467	7.2
S. Cypress	7,570	10,833	18,403	2.5
Total			714,876	100.0

[1] *Source:* Table C-5

[2] *Source:* Table C-6

TABLE C-18
BASE CAST FORECAST OF ROAD SAND AND GRAVEL USAGE BY MUNICIPALITY
(Tons)

	1976	1981	1986	1991	1996
Hamiota	52,309- 58,122	57,809- 64,223	65,227- 72,477	66,852- 74,282	75,510- 83,901
Blanshard	26,154- 29,061	28,902- 32,112	32,614- 36,239	33,426- 37,141	37,755- 41,950
Saskatchewan	29,231- 32,480	32,302- 35,890	36,450- 40,502	37,358- 41,511	42,197- 46,886
Odanah	33,078- 36,753	36,553- 40,612	41,247- 45,831	42,274- 46,973	47,749- 53,055
Langford	37,693- 41,882	41,653- 46,279	47,002- 52,226	48,173- 53,527	54,412- 60,458
Woodworth	45,386- 50,429	50,153- 55,723	56,594- 62,884	58,004- 64,451	65,516- 72,796
Daly	27,693- 30,770	30,602- 34,001	34,532- 38,370	35,392- 39,326	39,976- 44,418
Elton	63,078- 70,088	69,705- 77,446	78,656- 87,399	80,616- 89,576	91,055- 101,174
N. Cypress	53,847- 59,831	59,504- 66,112	67,145- 74,609	68,818- 76,467	77,731- 86,368
Whitehead	40,001- 44,446	44,203- 49,112	49,880- 55,424	51,122- 56,804	57,743- 64,159
Cornwallis	237,698-264,112	262,668-291,839	296,400- 329,343	303,783- 337,547	343,125- 391,254
Sifton	15,385- 17,095	17,001- 18,889	19,184- 21,317	19,662- 21,848	22,209- 24,677
Glenwood	33,078- 36,753	36,553- 40,612	41,247- 45,831	42,274- 46,973	47,749- 53,055
Oakland	55,386- 61,541	61,204- 68,001	69,064- 76,740	70,784- 78,652	79,952- 88,836
S. Cypress	19,231- 22,223	21,251- 23,612	23,981- 26,646	24,578- 27,310	27,761- 30,846
Total	769,248-854,731	850,059-944,463	959,223-1,065,839	983,116-1,092,387	1,110,439-1,233,833

5.3 Projected Other Engineering Sand and Gravel Demand

The other engineering category in the Brandon region was found to consist solely of sand and gravel used by the C.N.R. and C.P.R. Railways. This usage is largely independent of the municipalities and thus cannot be measured as a potential future municipal demand. Consequently no attempt has been made to relate this category to individual municipalities.

5.4 Total Sand and Gravel Demand by Municipality and Region

Table C-19 contains the total sand and gravel demand forecasts for each of the municipalities as well as projected demand for other engineering category. Similarly figures for the alternate forecast are found in Appendix Table A3-6.

A certain degree of caution should be exercised in dealing with these individual municipal forecasts. At the sub-regional level, the reliability of estimates suffers because of the limited data base and the influence of federal and provincial budgets on the level of economic activity in a small area. Road construction, for example, is directly related to provincial programs and priorities and decisions to upgrade or re-surface a particular roadway in a given municipality can cause enormous fluctuations in sand and gravel usage. Sand and gravel estimates on a wider geographic area will normally compensate for these fluctuations at the municipal level as a major construction and upgrading program in one area will likely be offset by less intensive maintenance programs in others. In terms of long range planning, it is the amount of sand and gravel that is required in a

TABLE C-19
BASE CASE FORECAST OF TOTAL SAND AND GRAVEL USAGE BY MUNICIPALITY IN THE BRANDON STUDY AREA (Tons)

	1976	1981	1986	1991	1996
Hamiota	54,609- 60,677	59,816- 66,459	67,378- 74,866	68,811- 76,458	77,585- 86,706
Blanshard	27,496- 30,552	28,902- 33,406	33,809- 37,567	34,426- 38,230	38,724- 43,026
Saskatchewan	31,052- 34,503	33,996- 37,773	37,122- 42,360	38,950- 43,280	43,857- 48,730
Odanah	37,869- 42,077	41,953- 46,613	47,580- 52,867	48,765- 54,184	55,080- 61,201
Langford	43,728- 48,589	48,535- 53,926	55,486- 61,652	57,357- 63,734	65,477- 72,753
Woodworth	47,111- 52,345	51,741- 57,487	58,028- 64,477	59,473- 66,083	66,899- 74,333
Daly	32,101- 35,668	35,367- 39,295	39,908- 44,345	41,147- 45,721	47,488- 51,641
Elton	65,282- 72,537	72,140- 80,152	81,286- 90,320	83,188- 92,434	93,960- 104,402
N. Cypress	58,543- 65,048	64,589- 71,760	72,880- 80,981	74,573- 82,862	84,509- 93,900
Whitehead	41,822- 46,469	46,003- 51,113	51,792- 57,548	52,959- 58,845	59,818- 66,464
Cornwallis	292,794- 325,332	325,247- 361,378	367,729- 408,600	377,380- 419,325	426,672- 474,086
Sifton	17,206- 19,118	18,907- 21,007	21,096- 23,441	21,376- 23,753	24,007- 26,675
Glenwood	36,719- 40,799	40,470- 44,965	45,787- 50,875	46,927- 52,143	53,143- 59,059
Oakland	57,085- 63,779	64,063- 71,178	71,453- 79,395	73,356- 81,510	82,719- 91,910
S. Cypress	20,778- 23,711	23,580- 26,201	26,370- 29,301	26,623- 29,896	29,974- 33,305
Other Engineering	86,373- 95,967	95,443- 106,055	107,712- 119,675	110,386- 122,655	124,690- 138,543
Total	951,443-1,057,171	1,051,387-1,168,168	1,186,416-1,318,271	1,215,958-1,351,110	1,373,451-1,526,070

Source: Tables C-13, C-16 and C-18.

general area over a given period of time that is significant for long term planning, not individual municipal estimates that can be expected to vary significantly from year to year.

6. REQUIREMENTS FOR HIGH QUALITY SAND AND GRAVEL

In addition to considering the total quantity of sand and gravel, it is important to recognize the particular concern for the quality of the material that will be required in the future. Since the sand and gravel used in concrete and asphalt applications must be of the highest quality, the volume of high quality gravel necessary to support future concrete and asphalt needs in the Brandon region is of special interest.

The Winnipeg Region Study had also determined high quality sand and gravel usage coefficients for the Province. These coefficients are:

Residential	0.003397
Non-Residential	0.003984
Road Construction	0.007165
Other Engineering	0.004228

The above sand and gravel usage coefficients, applied to the construction values in Table C-12, provide long term forecasts of high quality sand and gravel for the Brandon region. These

are contained in Table C-20. Extrapolation has been used to forecast beyond 1996 (Table C-21). The forecasts reflect the base case; an alternate projection is contained in Appendix Table A3-7.

7. SUMMARY AND CONCLUSIONS

This study involved the research and manipulation of significant amounts of data which were obtained from published sources and through direct contact with private firms, provincial and federal government departments and municipal users in the Brandon region. The analysis of this data led to the forecasts of future sand and gravel demand presented in this report.

It was estimated in the Winnipeg Region Study that over the period to 1996, total construction spending in Manitoba (excluding the residual category) would grow from $688 million constant dollars in 1973 to at least $900 million constant dollars in 1996 and perhaps to $1,070 million constant dollars. Barring population and household growth in excess of the rates contemplated, the latter was treated as the "preferred" estimate of total construction spending in Manitoba over the 20 year period to 1996.

Of this total spending, it is projected that approximately 4.5% to 5.0% will occur within the Brandon region.

The study reveals that almost 900,000 tons of sand and gravel were used on the average, in construction activities in the Brandon region in the 1970-1974 period. The forecasts of sand and gravel demand indicate that approximately 24 to 26.5 million tons of construction sand and gravel will be required during the forecast period to 1996 to meet the reasonably foreseeable demands of the construction industry within the Brandon region. Under the alternate (lower) projection assumptions, cumulative requirements to 1996 would be 9% to 11% lower at 21.9 to 24.4 million tons. Extrapolation of forecast results to the year 2026 suggests that consumption from 1996 to 2026 will possibly approach 3 times the 1976-1996 figures.

The requirement for high quality sand and gravel for concrete and asphalt applications to 1996 is estimated at 15% of the total sand and gravel forecast. This is considerably lower than was forecast for the Winnipeg region owing to a greater emphasis on road work and less emphasis on residential and non-residential construction in the Brandon region.

The population projections employed in forecasting future requirements anticipate a Brandon region growth from 64,404 in 1971, to 67,144 in 1981 and 74,731 by 1996.

It should be recognized that the forecasts of sand and gravel requirements presented in this study are based on several key assumptions, the altering of which could lead to significantly different results. Nevertheless, the assumptions employed here are believed to anticipate the future given our present level of information.

TABLE C-20

BASE CASE FORECAST OF HIGH QUALITY SAND AND GRAVEL REQUIREMENTS BRANDON STUDY AREA 1976-1996 (000's Tons)

	Residential	Non-Residential	Roads	Other Engineering	Total for the Year	Cumulative from 1976
1976	32-35	43-48	52-58	25-28	152-169	152- 169
1981	35-39	48-53	58-63	28-31	168-187	944-1,050
1986	39-44	54-60	65-72	31-35	190-211	1,828-2,033
1991	40-45	55-61	67-74	32-36	194-216	2,786-3,098
1996	46-51	62-69	75-84	36-40	219-244	3,806-4,234

TABLE C-21

HIGH QUALITY SAND AND GRAVEL REQUIREMENTS BRANDON STUDY AREA 1996-2026 (000's Tons)

	Sand and Gravel Demand for the Year	Cumulative from 1976
1996	219-244	3,806- 4,234
2001	233-259	4,929- 5,484
2006	249-277	6,126- 6,815
2011	265-305	7,403- 8,256
2016	281-313	8,760- 9,797
2021	297-331	10,197-11,398
2026	313-349	11,714-13,089

SECTION D
SAND AND GRAVEL RESOURCE POTENTIAL

1. INTRODUCTION

This section presents the methodology used to conduct the resources inventory; the general geology including a breakdown of the study area into 4 distinct physiographic regions; the quality of sand and gravel within the study region; a detailed discussion of the surficial geology, emphasizing the sand and gravel deposits, within each physiographic region and, in conclusion, the analyses of the estimated quantity and quality of sand and gravel contained in every deposit identified within the study boundary.

The location of the study area has been previously illustrated on Plate A-1.

2. METHODOLOGY

The inventory of available sand and gravel resources in the Brandon region was conducted in a 3 phase program.

Phase I of the inventory involved the collection of all existing geological information for the Brandon region; in particular, information relative to the occurrence of sand and gravel. The data sources, listed in Appendix 6, were used initially to locate the major granular deposits and existing pits.

Subsequent to the work program outlined in Phase I, a field program was conducted as Phase II of the inventory. The first portion of the program involved a detailed reconnaissance of the study area including approximately 95 percent of all sand and gravel sources. During this stage of the program, representative samples of the granular deposits were collected for laboratory testing. In addition, the surficial geologic units in the study region were identified and mapped on the 1 inch - ½ mile township mosaics with the aid of the available aerial photography.

After completion of the reconnaissance, resistivity surveys were carried out across representative sections of the various types of granular deposits. The surveys proved to be an economical method of verifying the width of deposits as mapped during the reconnaissance and providing information on the depth of deposits.

Two non-contacting resistivity units, an EM31 and an EM34, were used for the surveys. These instruments, acquired from Geonics Limited in Toronto, were prototype units. They allow for rapid surveying, but are limited in their ability to determine layer thicknesses. Both instruments proved to be temperature sensitive creating a number of problems with data reduction and interpretation. The presentation of the resistivity profiles and interpreted cross-sections uses only the EM31 resistivities as these were the most consistent with time and with the available ground control. The temperature sensitivity of the EM31 resulted in a wandering of the zero (0) on the instrument dial producing some very high indicated resistivities in granular areas. Data interpretations where the thickness of the granular section was known indicated that a resistivity of 1000 ohm-metres was common for gravels in the

region. In view of the questionable reliability of resistivity values greater than 1000 ohm-metres, it was decided to limit the resistivity readings to a maximum of 1000 ohm-metres and base the interpretation on these values.

The final field program consisted of selective back-hoe test pitting in undeveloped deposits and in deposits thought to extend deeper than current pit depths. This work enabled the classification of material types in undeveloped deposits and an estimation of the depth of the deeper deposits.

Plates D-1 and D-2 indicate the location and distribution of the various sources of field data.

To determine the quality of sand and gravel within the study area, samples collected during the reconnaissance were tested to determine gradational and compositional characteristics. The quality of the Brandon region sand and gravel is discussed in section D-4.

The final phase of the study presents the quantity and quality of the sand and gravel resources of the Brandon region in two volumes. Volume 1 contains the text with the results of the inventory. Volume 2 is the series of 1:50,000 surficial geology maps which emphasize the sand and gravel source areas, depict the gradational quality of the material encountered at each reconnaissance station and identify the deposit numbers referred to in the tabulation of gravel reserves.

3. GENERAL GEOLOGY OF THE BRANDON REGION

3.1 Bedrock Geology

The bedrock of the study area includes rocks entirely from the Cretaceous Period. The majority of the study area is underlain by shales from the following formations:

- Riding Mounting Formation
- Vermillion River Formation
- Favel Formation
- Ashville Formation.

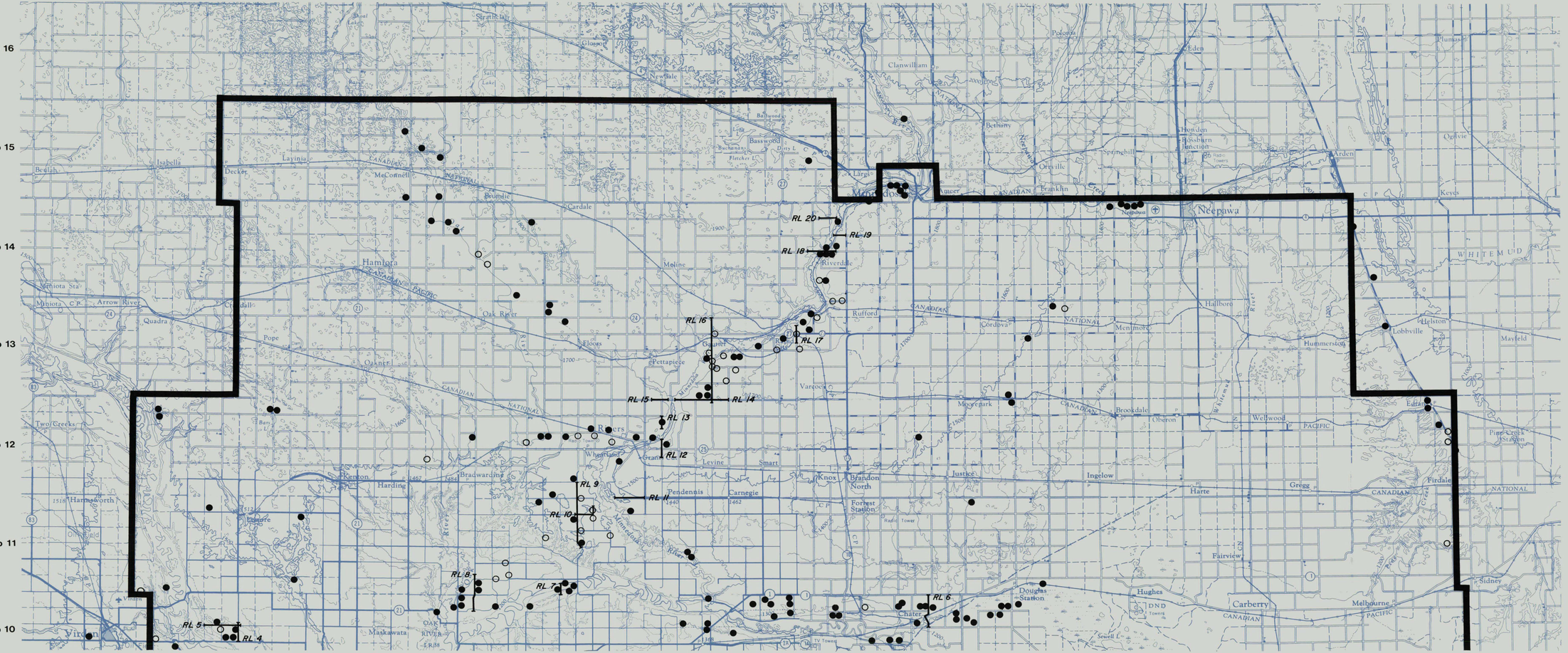
A small area of sandstone bedrock from the Swan River Formation subcrops in the extreme eastern portions of the study area. The bedrock for the most part is buried beneath a varying thickness of primarily unconsolidated Quaternary sediments.

3.2 Quarternary Geology

3.2.1 Quarternary History

Several episodes of continental glaciation and associated interglacial periods are believed to have influenced the Brandon region during the Pleistocene Epoch. The number of times that continental ice sheets invaded the region is not known, as much of the older geologic record has been eroded away by younger glaciations.

In the Brandon region, most of the glacial deposits belong to the latest Wisconsin glacial period although deposits related to older glacials are known to exist in the deep bedrock valleys along the front of the Manitoba



Legend

- Existing Pits ●
- Other Test Locations ○
- Resistivity Lines RL 8
- Study Boundary

MANITOBA
DEPARTMENT OF MINES, RESOURCES & ENVIRONMENTAL MANAGEMENT

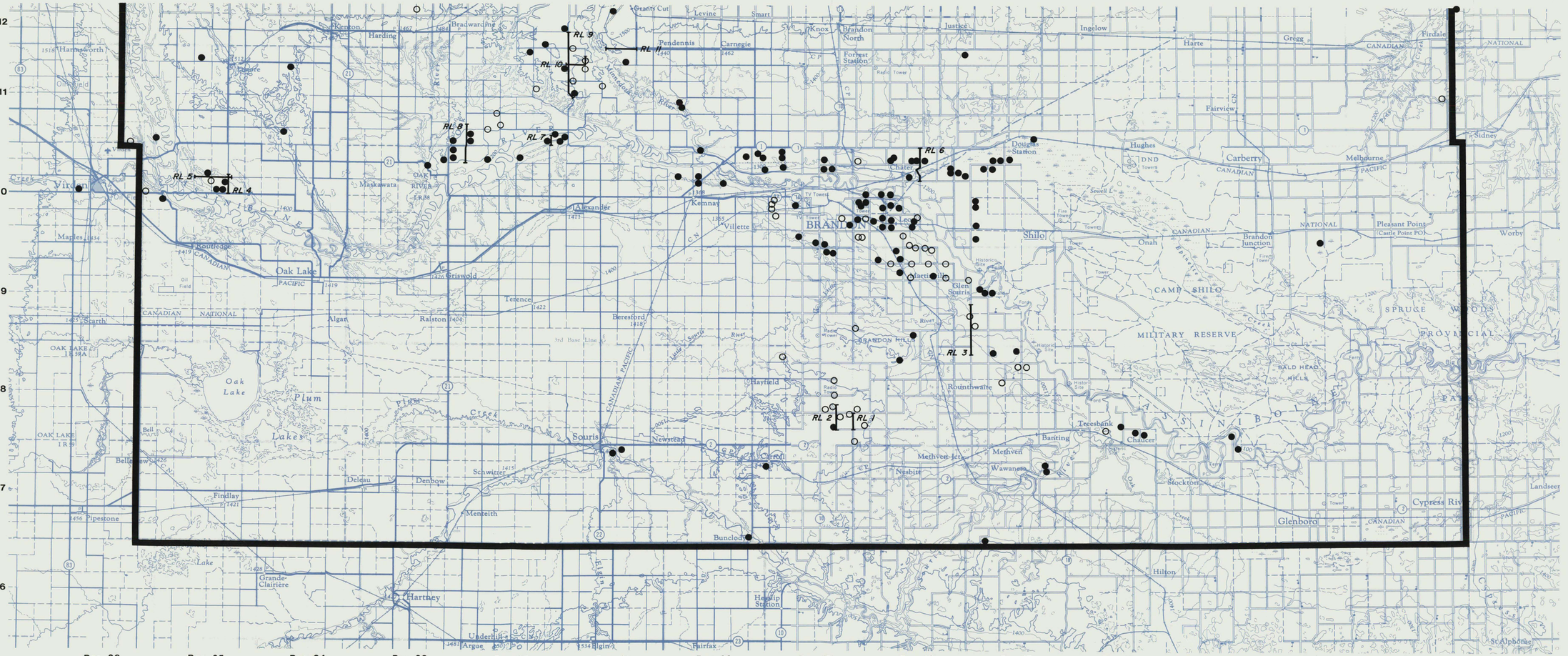
Sand and Gravel Resources of the Brandon Region

Locations of Field Data

0 1 2 3 5 8 Miles
0 1 2 4 8 13 Kilometres

The UMA Group

Plate D-1



Legend

- Existing Pits
- Other Test Locations
- Resistivity Lines — RL 8
- Study Boundary

MANITOBA
DEPARTMENT OF MINES, RESOURCES & ENVIRONMENTAL MANAGEMENT

Sand and Gravel Resources of the Brandon Region

Locations of Field Data

0 1 2 3 5 8 Miles
0 1 2 4 8 13 Kilometres

The UMA Group

Plate D-2

Escarpment. The chronology of these older glacial sediments is unresolved because of their relatively limited extent and the absence of datable material.

The last major Wisconsinan glaciation covering southern Manitoba occurred about 22,000 years ago. Ice which had accumulated in several dispersal centres in northern Canada, coalesced and moved across southern Manitoba. The effects of this ice sheet were felt in southern Manitoba before the ice actually invaded the area. Ice blocking the northward flowing regional drainage caused water to backup creating a large reservoir which preceeded the advancing ice sheet. Sediments being supplied to this proglacial lake caused clay, silt and sand to be deposited in the water-filled lowlands. Much of this sediment, along with sand and gravel deposited directly by meltwater from the glacier, was eroded away as the thick ice sheet moved southward.

Ice may have covered Manitoba continuously from 22,000 years ago until about 13,000 years ago, but beginning about 14,000 years ago the southern margin of the continental ice sheet began to retreat. By this time, most of the till that directly overlies the Mesozoic bedrock in the Brandon region had been deposited.

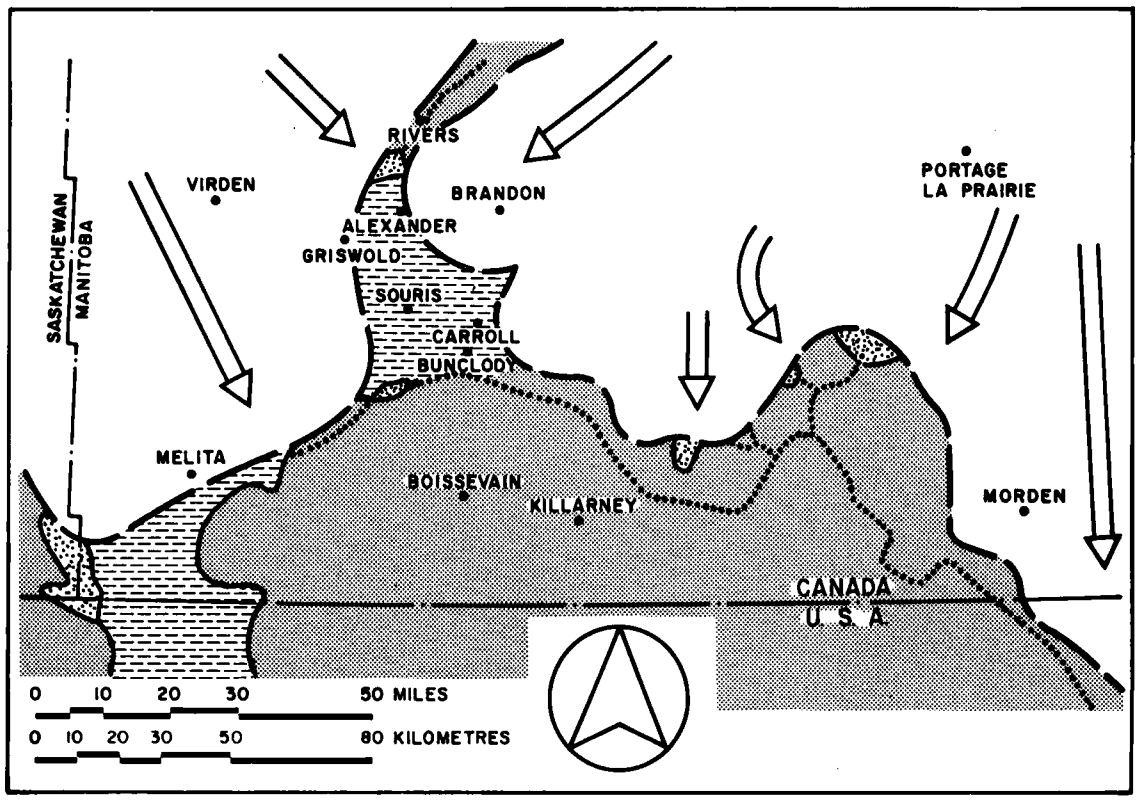
3.2.2 Late Pleistocene Depositional History

The majority of sediments visible on the surface of the Brandon region were deposited during the Late Pleistocene Epoch. Therefore a detailed description of the Late Pleistocene depositional history, based on work done by J.A. Elson (1955), is warranted.

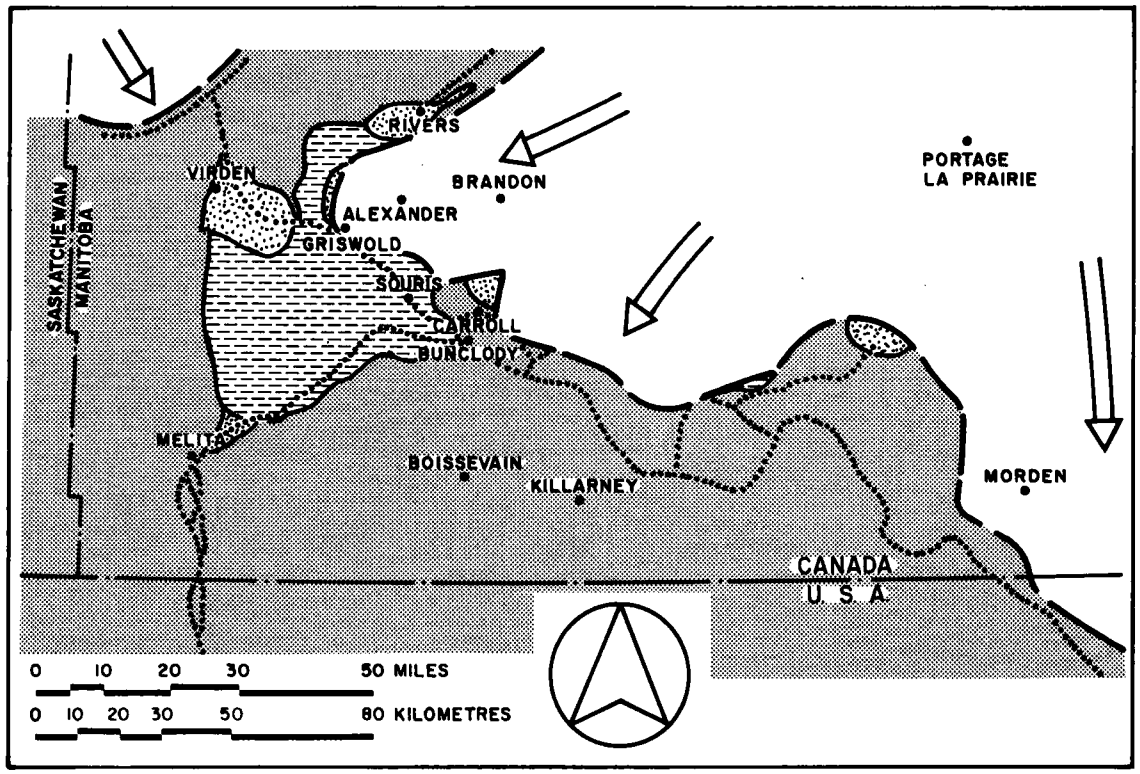
During the late stages of Wisconsinan glaciation, the advance and retreat of two ice lobes controlled most sediment deposition over the Brandon study region. A boundary separating the two ice lobes ran approximately from Boissevain to Brandon and along the Minnedosa River valley thus forming west and east ice lobes. The west lobe flow direction was to the southeast, while the east lobe flow direction was to the southwest. As both lobes retreated northward a series of proglacial lakes were formed and subsequently drained.

The first significant phase of sand and gravel deposition in the Brandon region occurred during the Dand Channel Phase. (See Plate D-3). It was during this time that the two ice lobes were physically separated by the Minnedosa River and glacial Lake Carroll. Glacial outwash from both the east and west lobes was deposited in glacial Lake Carroll near the present day site of Rivers. All meltwater eventually drained southward through the Pembina Trench.

The next major phase of sand and gravel deposition occurred during the



Dand Channel Phase



Lake Hind Phase

Legend

GLACIER MARGIN

DIRECTION OF GLACIER FLOW

ICE FREE REGIONS

SPILLWAY OR CHANNEL

GLACIAL LAKE

DELTA, OUTWASH

Abbreviated Late Pleistocene History of Southwest Manitoba*

*(Adapted from Elson, 1955)

Plate D-3

glacial Lake Hind Phase. (See Plate D-3). Glacial Lake Hind formed as the west ice lobe retreated to the northwest. Glacial outwash deposits that formed in the Brandon study region during this phase were deposited near the towns of Rivers, Griswold and Carroll. A large delta was formed at this time as sediment-rich meltwater from the west ice lobe entered Lake Hind near the present day site of Virden.

Extensive sand and gravel deposition occurred during the rise of Lake Agassiz I (see Plate D-4). Both glacial Lakes Hind and Brandon had vanished by this phase. Lake Hind had drained southward, while Lake Brandon had coalesced with Lake Agassiz. Deposition of outwash along the Minnedosa River valley had ceased prior to the rise of Lake Agassiz. Meltwater flowing through the Assiniboine River valley deposited sand and gravel on a stagnant ice remnant which was left by the retreating east ice lobe, northwest of Alexander. Extensive recession of the east ice lobe occurred during the formation of Lake Agassiz, enabling glacial outwash to be deposited along the southern edge of the east ice lobe, east of Brandon. These outwash deposits formed the core of the complex deltaic feature known as the Assiniboine Delta.

The largest sand and gravel deposit in the Brandon region was formed during the Assiniboine Delta Phase of Lake Agassiz I (see Plate D-4). By this time all ice had retreated well beyond the study region.

Massive volumes of water flowing through the Assiniboine River valley resulted in increased erosion along the valley walls and as a result destroyed most of the Virden-Lake Hind Delta deposit. The large load of the Assiniboine River was deposited in Lake Agassiz into what is known as the Assiniboine Delta. Much of the earlier glacial outwash deposits formed east of Brandon were masked by this deltaic deposition creating a delta with a core of outwash sand and gravel. Sand and gravel beach ridges such as the Campbell strandline were also deposited at this time.

3.2.3 Physiographic Regions

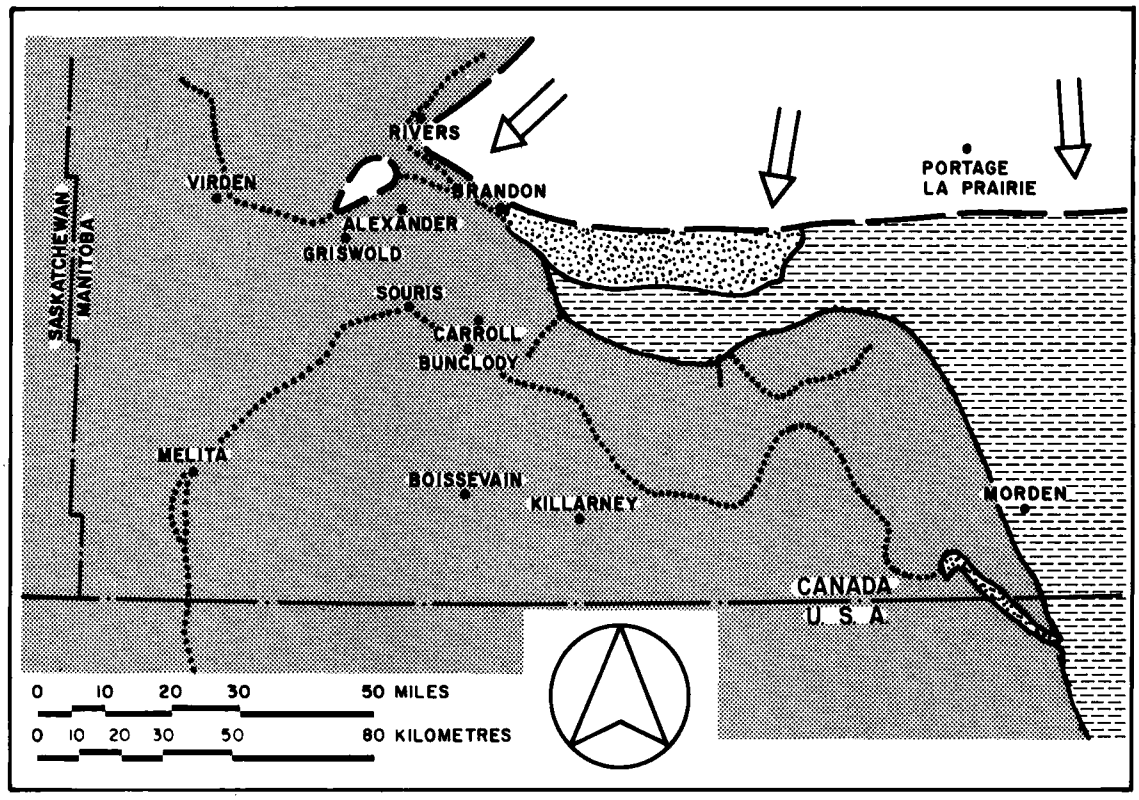
The diverse depositional history of the Brandon region produced four physiographic regions which are presented on Plate D-5.

The **Tiger Hills Upland** is a hilly region formed by terminal moraines.

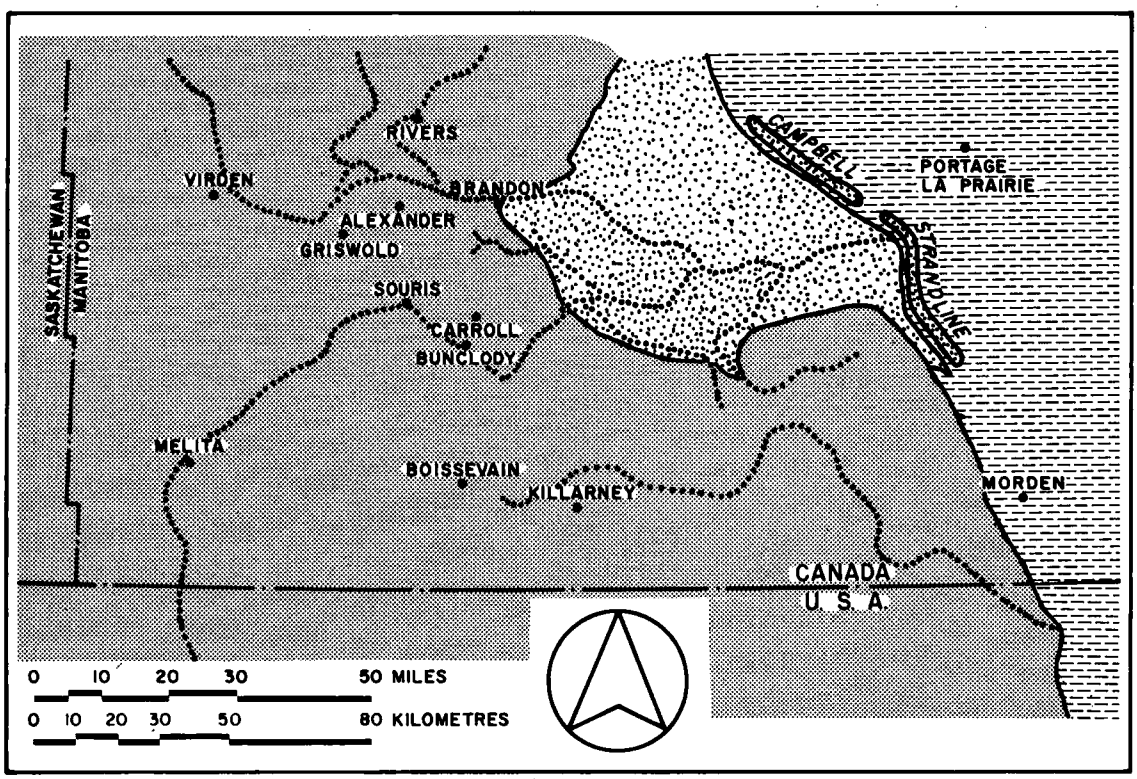
The **Assiniboine Delta** is a gradually sloping area of sand and gravel deposited by the Assiniboine River in Lake Agassiz.

The **Minnedosa Till Plain** is a dead-ice moraine with the characteristic knob and kettle topography.

The **Souris Basin** is a low flat area, largely comprised of lacustrine sediments.



Rise of Lake Agassiz I



Lake Agassiz I, Assiniboine Delta

Legend

GLACIER MARGIN

DIRECTION OF GLACIER FLOW

ICE FREE REGIONS

SPILLWAY OR CHANNEL

GLACIAL LAKE

DELTA, OUTWASH

Abbreviated Late Pleistocene History of Southwest Manitoba*

*(Adapted from Elson, 1955)

Tp 17
Tp 16
Tp 15
Tp 14
Tp 13
Tp 12
Tp 11
Tp 10
Tp 9
Tp 8
Tp 7
Tp 6
Tp 5

Rge 27 Rge 26 Rge 25 Rge 24 Rge 23 Rge 22 Rge 21 Rge 20 Rge 19 Rge 18 Rge 17 Rge 16 Rge 15 Rge 14 Rge 13 Rge 12

MINNEDOSA TILL PLAIN

SOURIS BASIN

ASSINIBOINE DELTA

TIGER HILLS UPLAND

A A' B B' C C' D D'

Legend

Study Area

Regional Cross Section

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DEPARTMENT OF MINES, RESOURCES & ENVIRONMENTAL MANAGEMENT

Sand and Gravel Resources of the Brandon Region

Physiographic Divisions of the Brandon Region

0 2 4 6 10 15 Miles
0 2 5 10 15 25 Kilometres

The UMA Group

Plate D-5

3.2.4 Quaternary Stratigraphy

Four regional cross-sections have been illustrated on Plates D-6, D-7, D-8 and D-9 to present a broad overview of the Brandon region Quaternary stratigraphy. The cross-section locations are plotted on Plate D-5.

Cross-section A-A' (Plate D-6) depicts three physiographic regions, the Tiger Hills Upland, the Souris Basin and the Assiniboine Delta. The Brandon Hills are formed by glacial tills overlying a previously existing bedrock high. The Souris Basin, which is depicted between kilometres 13 and 18 on Plate D-6, is a low area of surficial lacustrine deposits bordering the Brandon Hills. Assiniboine Delta sand and gravel is found on cross-section A-A' between Kilometres 18 and 23. An extensive inter-till sand deposit exists throughout the length of the cross-section.

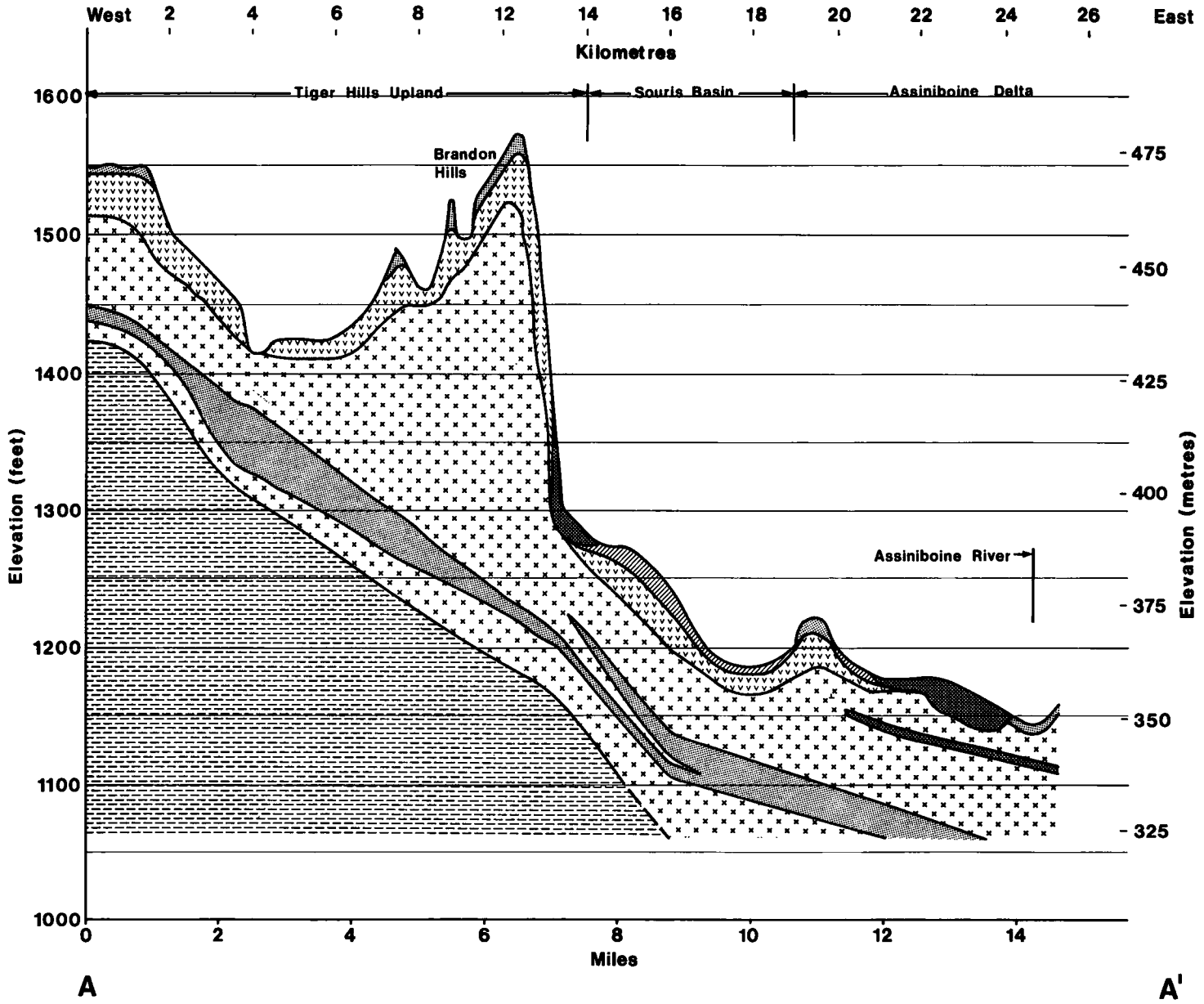
Cross-section B-B' (Plate D-7) illustrates the regional stratigraphy of the outwash-delta formed from glacial meltwater entering the Souris Basin from the Minnedosa River spillway channel. Portions of the Minnedosa Till Plain and the Souris Basin physiographic regions are also included in the section. The outwash-delta sand and gravel deposit between kilometre 5 and kilometre 14 is an important source of granular material for the Brandon region.

Cross-section C-C' (Plate D-8) lies entirely within the Minnedosa Till Plain and illustrates the nature of sand and gravel deposition in the upper portion of the Minnedosa River valley.

Cross-section D-D' (Plate D-9) is located in the Souris Basin and depicts a portion of the Assiniboine River valley near Virden. Some of the granular deposits found in the bedrock valley may predate late Wisconsinan glacial events.

3.2.5 Surficial Geology

The surficial geology of the Brandon region, mapped at a scale of 1:50,000, is presented on twenty-nine (29) maps enclosed in Volume 2 of the report. The fifteen (15) surficial geology units recognized during the Underwood McLellan & Associates Limited (UMA) reconnaissance field inspections are presented by age and genesis in the legend, Table D-1.



Legend:

- Sand and Gravel
- Sand
- Clay
- Brown Till
- Dark Grey Till
- Shale

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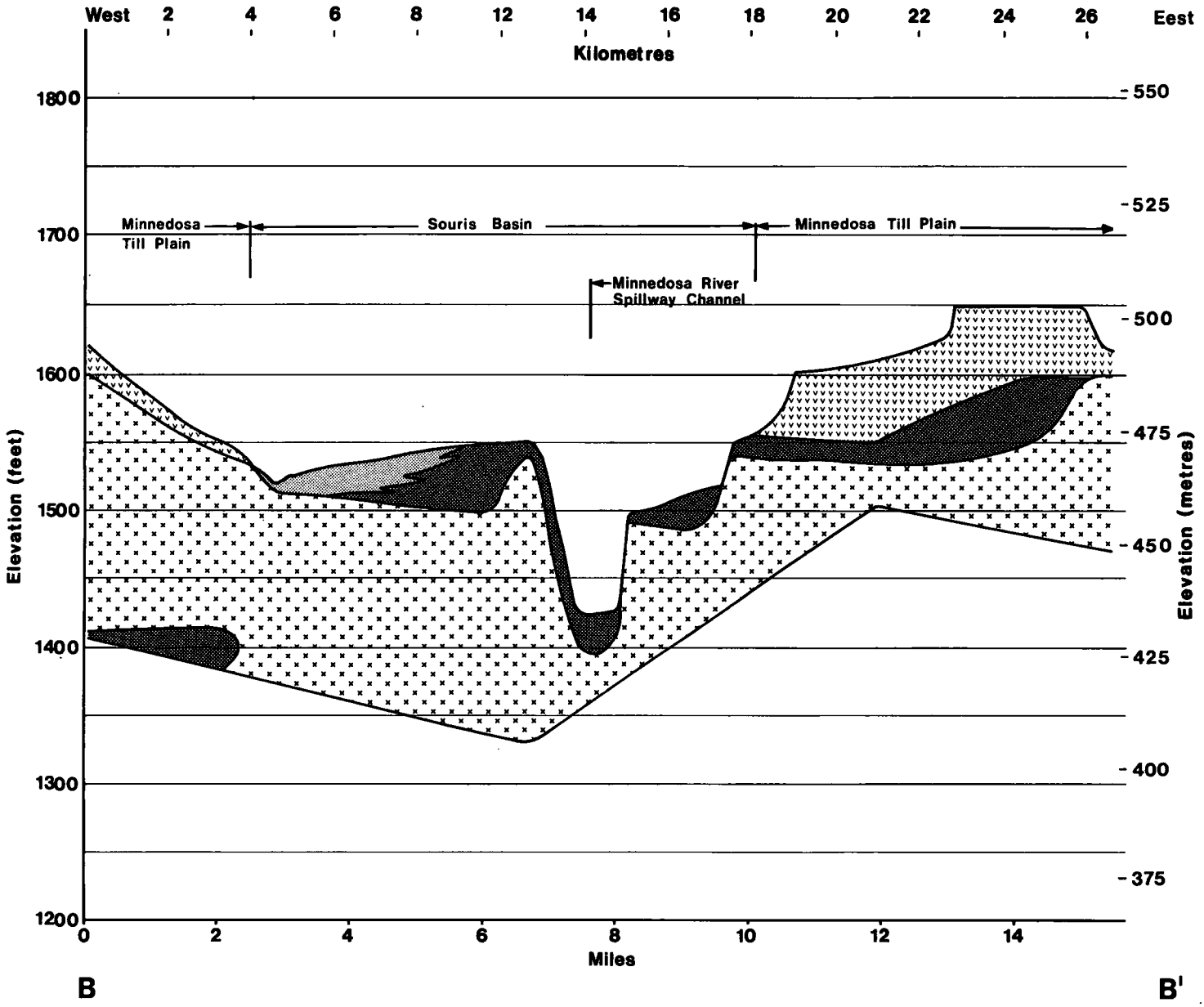
Sand and Gravel Resources of the Brandon Region

Regional Cross Section A-A'

The UMA Group

Plate D-6



Legend:

- Sand and Gravel
- Sand
- Clay
- Brown Till
- Dark Grey Till
- Shale

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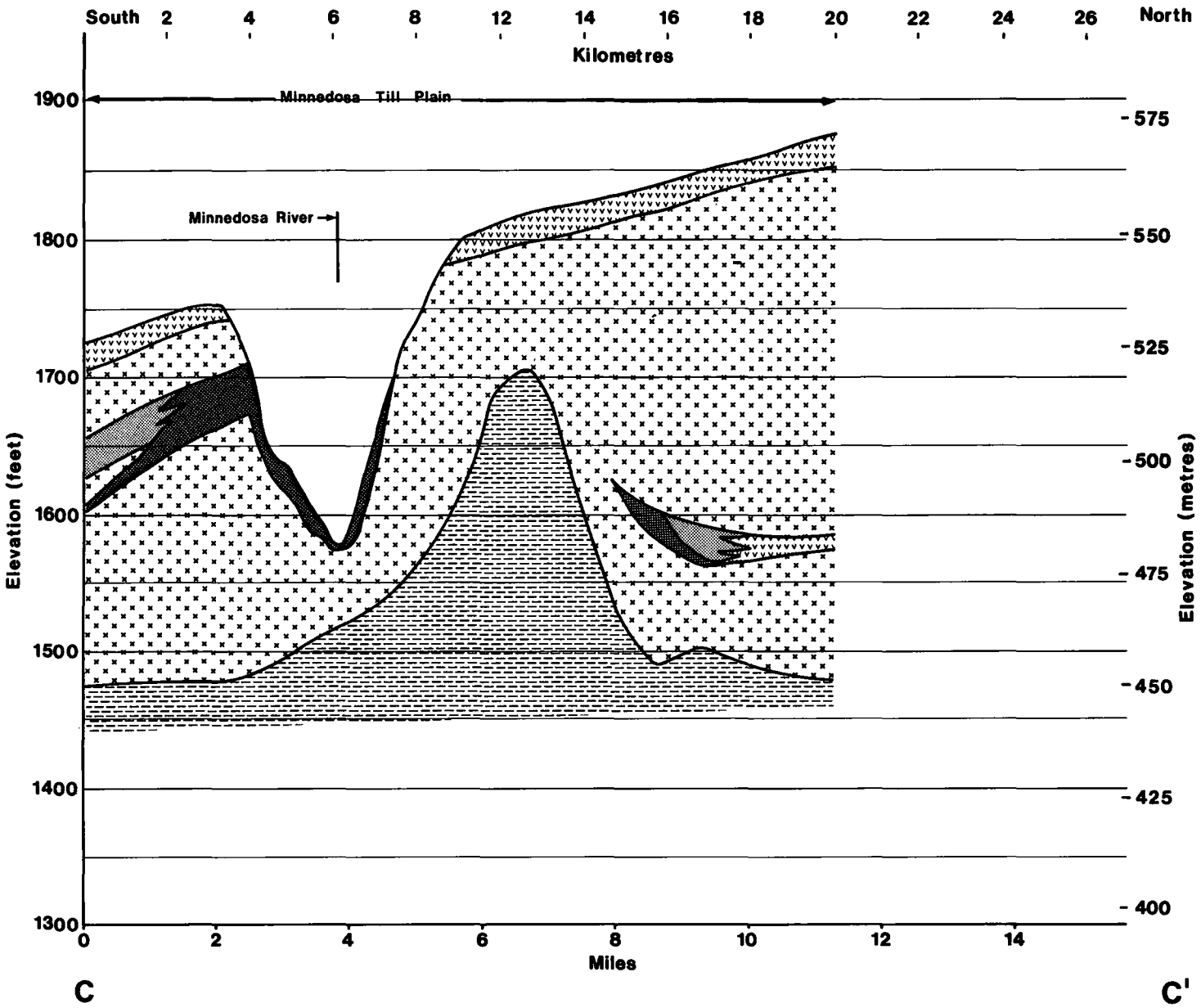
Sand and Gravel Resources of the Brandon Region

Regional Cross Section B-B'

The UMA Group

Plate D-7



Legend:

- Sand and Gravel
- Sand
- Clay
- Brown Till
- Dark Grey Till
- Shale

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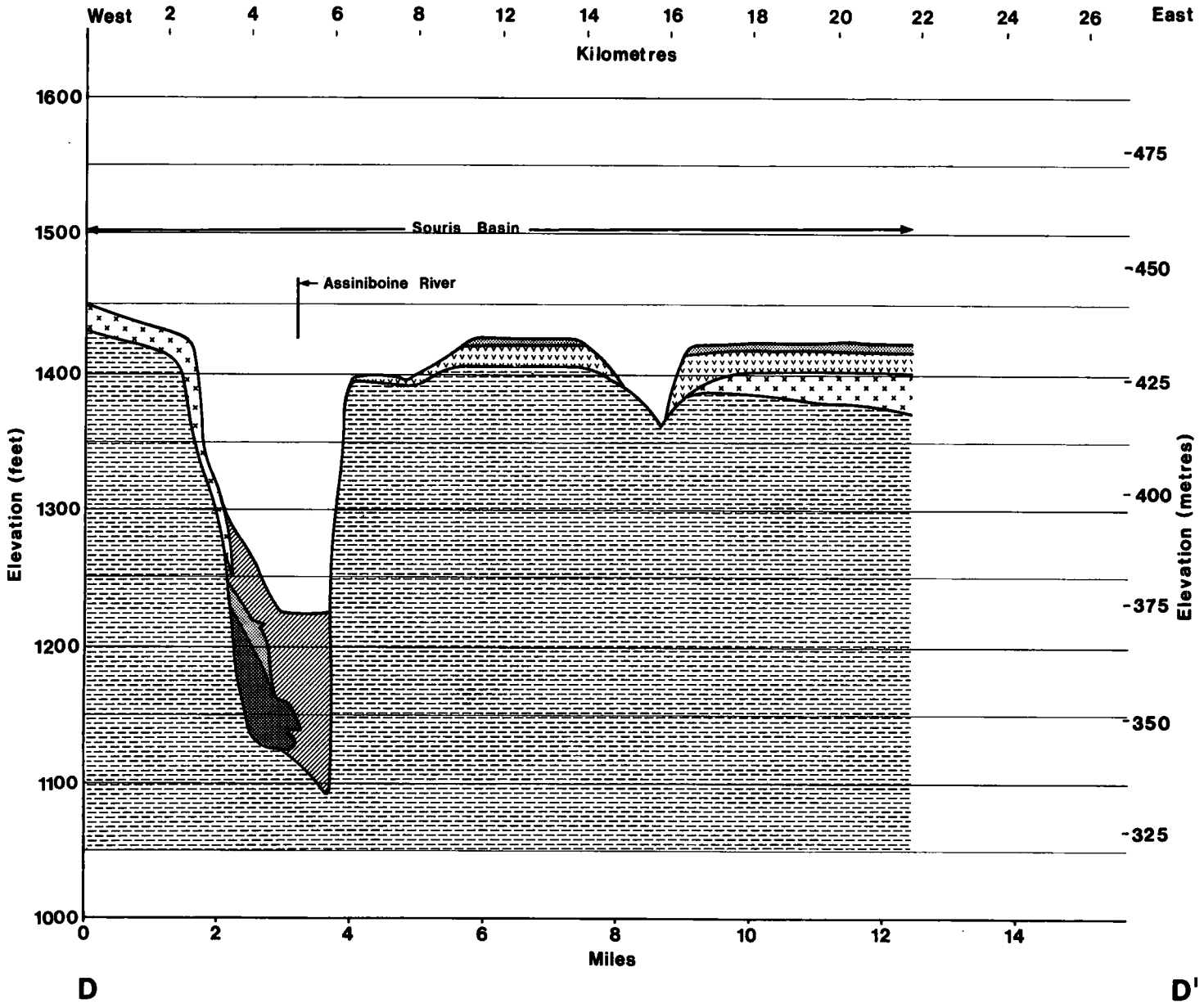
Sand and Gravel Resources of the Brandon Region

Regional Cross Section C-C'

The UMA Group

Plate D-8



Legend:

- Sand and Gravel
- Sand
- Clay
- Brown Till
- Dark Grey Till
- Shale

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Sand and Gravel Resources of the Brandon Region

Regional Cross Section D-D'

The UMA Group

Plate D-9

TABLE D-1

LEGEND

QUATERNARY

HOLOCENE (RECENT)

7D. Eroded Channels and Steep Slopes: includes colluvium and landslide material

7C. Shallow Swamp Deposits: muck and peat

7B. Eolian Deposits: fine sand, derived from lacustrine sediments

7A. Alluvium: flood plains and alluvial fans; poorly sorted sand, silt and clay

PLEISTOCENE

GLACIOLACUSTRINE DEPOSITS

6E. Beach Ridges and Littoral Sand: sand and gravel, sand

6B. Lagoonal Deposits: fine sand, silt

6C. Deep Water Deposits: clay, silt

6D. Deltaic — Fine Offshore Deposits: fine sand, silt; in some cases interbedded with clay

6A. Deltaic — Coarse Apex Deposits: sand and gravel, sand; in some cases interbedded with silt.

GLACIOFLUVIAL DEPOSITS

5. Channel fill and Terraces: sand with some gravel, poorly sorted sand, silt and clay

PROGLACIAL DEPOSITS

4B. Glacial Outwash and Stratified Drift: sand and gravel, sand; interbedded with till in stratified drift deposits.

4A. Reworked Till: sand and gravel, sand; includes lag concentrates.

GLACIAL DEPOSITS

3. Till: undifferentiated

TERTIARY (may be Early Pleistocene)

2. Souris Sand and Gravel

CRETACEOUS

1. Shale Bedrock

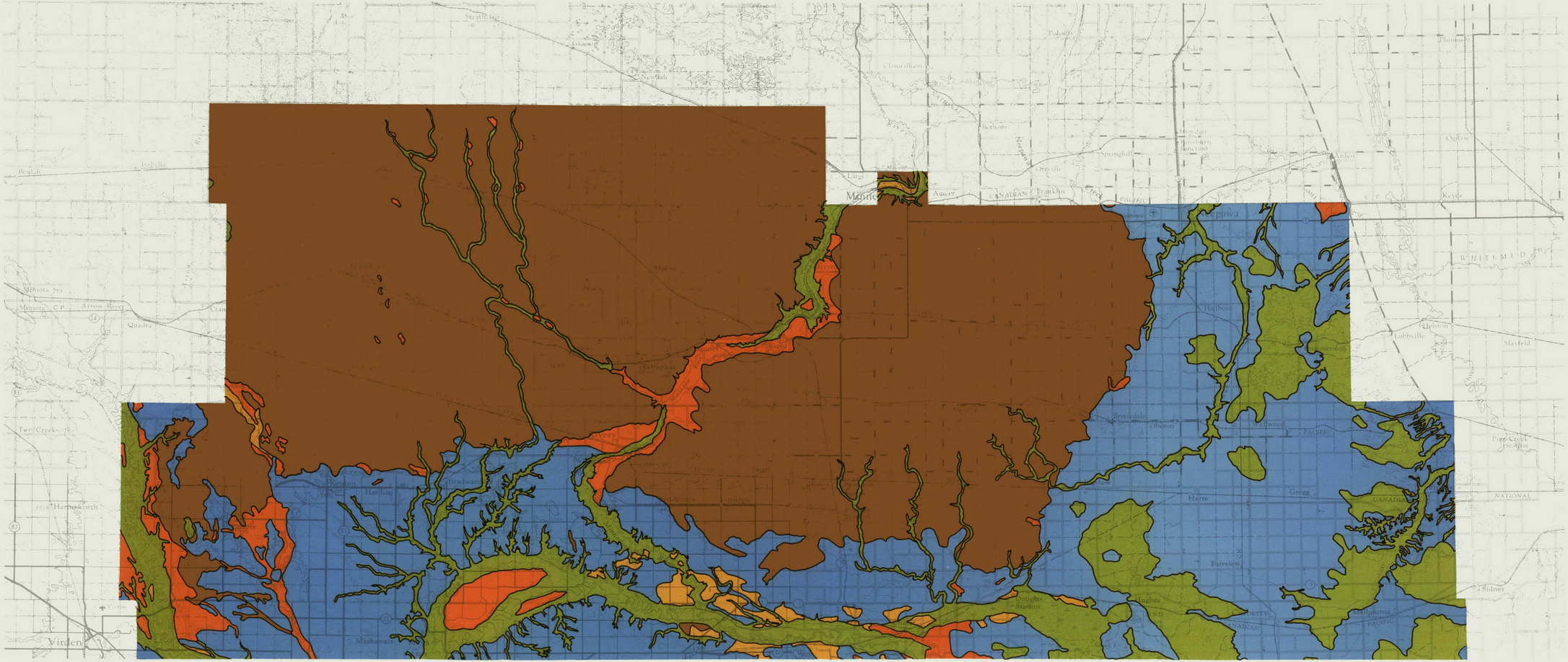
An overview of the surficial geology of the region, scaled at 1:250,000, is illustrated on Plates D-10 and D-11, for which the surficial deposits delineated on the 1:50,000 surficial geology maps have been summarized into the following five broad categories:

- Recent Deposits
- Lacustrine Deposits
- Glaciofluvial Deposits
- Outwash and Reworked Till Deposits
- Undifferentiated Till Deposits.

Additional information presented on the 1:50,000 surficial geology maps includes:

- Location of all gravel pits
- Location of UMA field stations and sample locations
- Location of Dept. of Highway's field stations and sample locations
- Location of UMA resistivity surveys
- Location of UMA backhoe tests
- Location and identification of all sand and gravel deposits
- Sand and gravel deposit quality.

An index for the 1:50,000 surficial geology maps is provided on Plate D-12.



Legend

- Recent Deposits
- Lacustrine Deposits
- Glaciofluvial Deposits
- Outwash and Reworked Till Deposits
- Undifferentiated Till Deposits

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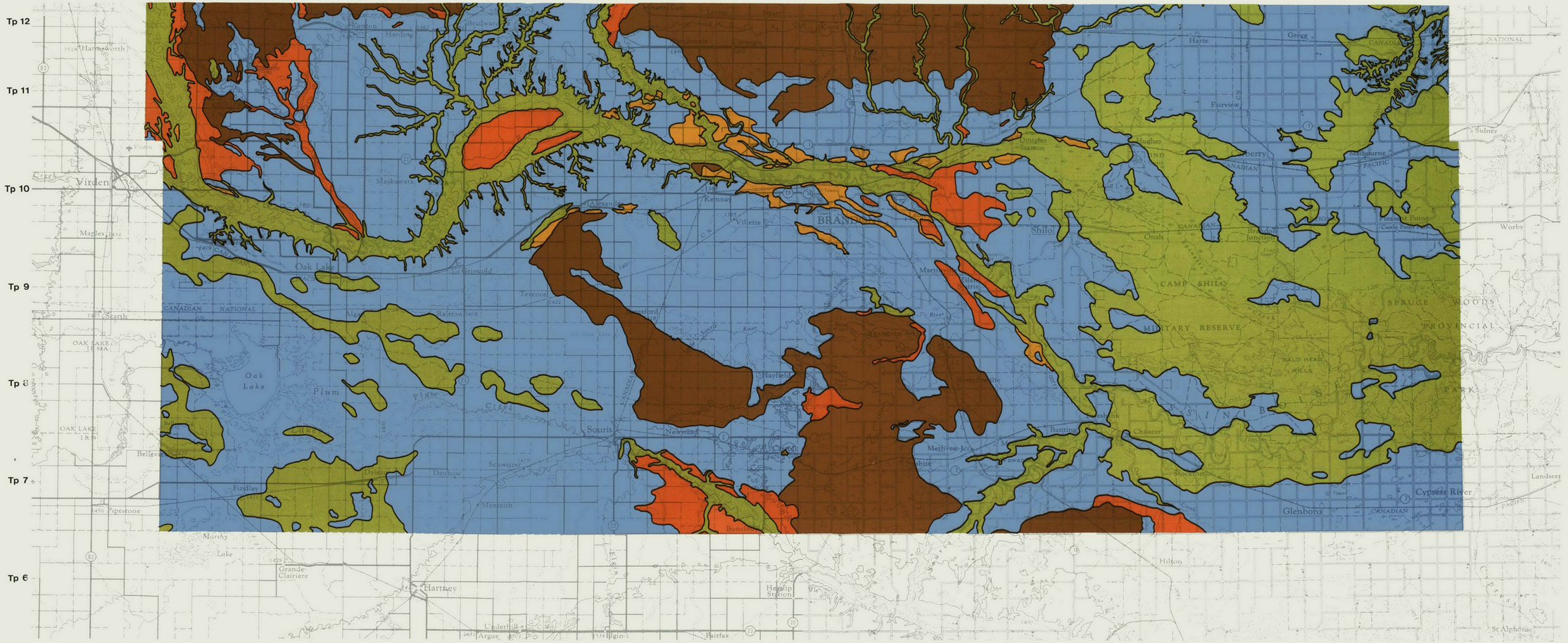
Sand and Gravel Resources of the Brandon Region

Surficial Geology

0 1 2 3 5 8 Miles
0 1 2 4 8 13 Kilometres

The UMA Group

Plate D-10



Legend

- Recent Deposits
- Lacustrine Deposits
- Glaciofluvial Deposits
- Outwash and Reworked Till Deposits
- Undifferentiated Till Deposits

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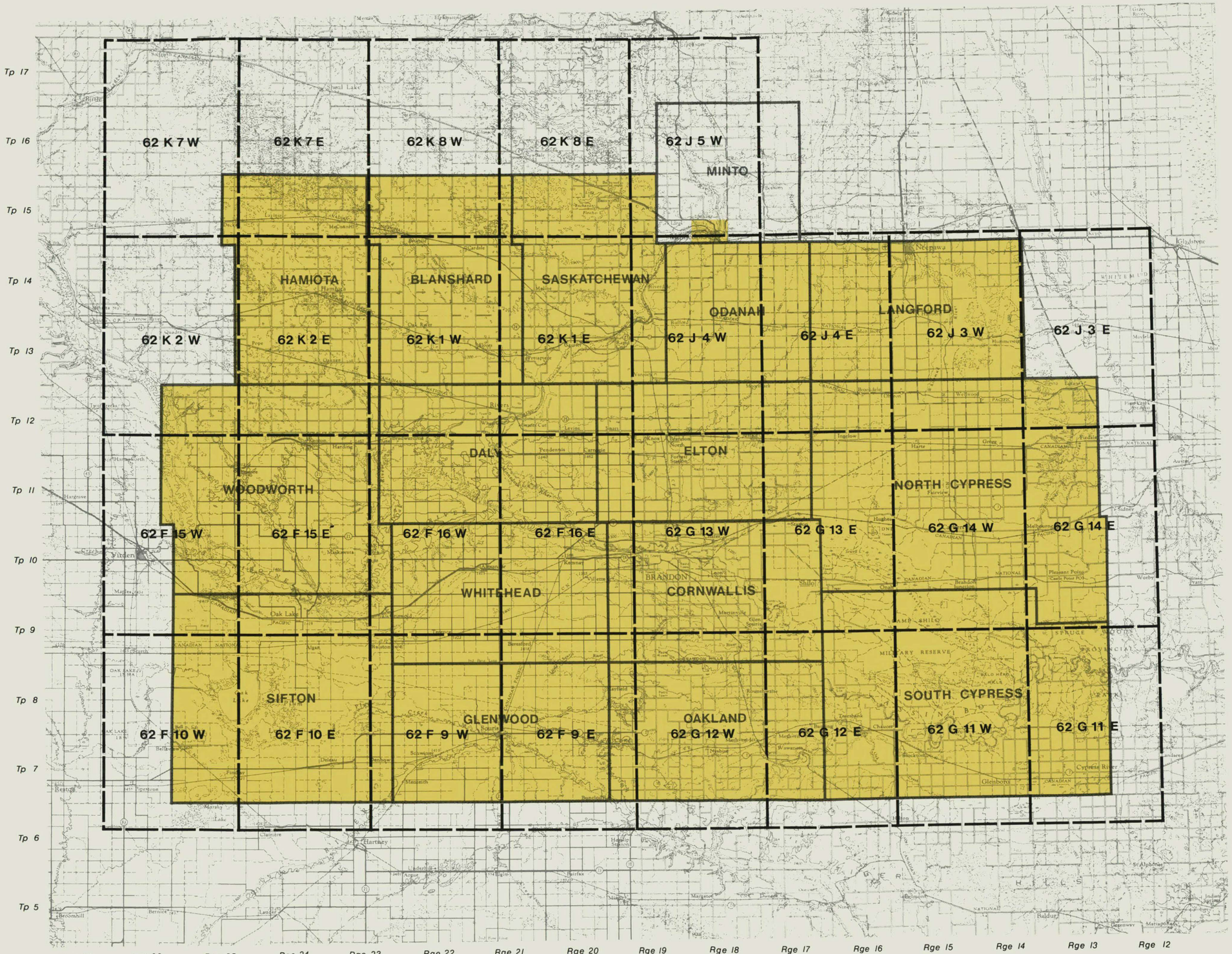
Sand and Gravel Resources of the Brandon Region

Surficial Geology

0 1 2 3 5 8 Miles
0 1 2 4 8 13 Kilometres

The UMA Group

Plate D-11



Legend

Study Area

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Sand and Gravel Resources of the Brandon Region

Index to 1 : 50,000 Surficial Geology Maps

0 2 4 6 10 15 Miles
0 2 5 10 15 25 Kilometres

The UMA Group

Plate D-12

4. SAND AND GRAVEL QUALITY

4.1 Sample Collection and Laboratory Testing

As mentioned in Section D-2 on methodology, representative samples of all sand and gravel deposits visited during the reconnaissance were collected for laboratory testing. The purpose of sample collection and laboratory testing is to determine the gradational and compositional quality as well as the performance characteristics of the sand and gravel within the study area.

The majority of the 139 samples collected were tested for gradation and shale and ironstone content. In addition, selected samples were tested for petrographic composition, soundness and Los Angeles abrasion loss. A summary of all the lab test data is presented in Appendix A4.

4.2 Gradational Quality

A total of 144 UMA gradation analyses and 100 Department of Highway analyses were plotted on overlays to determine if distinctive material gradations of sand and gravel were present in the study area. Seven material size ranges, classified as A to G, were developed and are illustrated on Plates D-13 to D-19.

These ranges have been grouped, as follows, to allow for discussion of quality in other sections of this report.

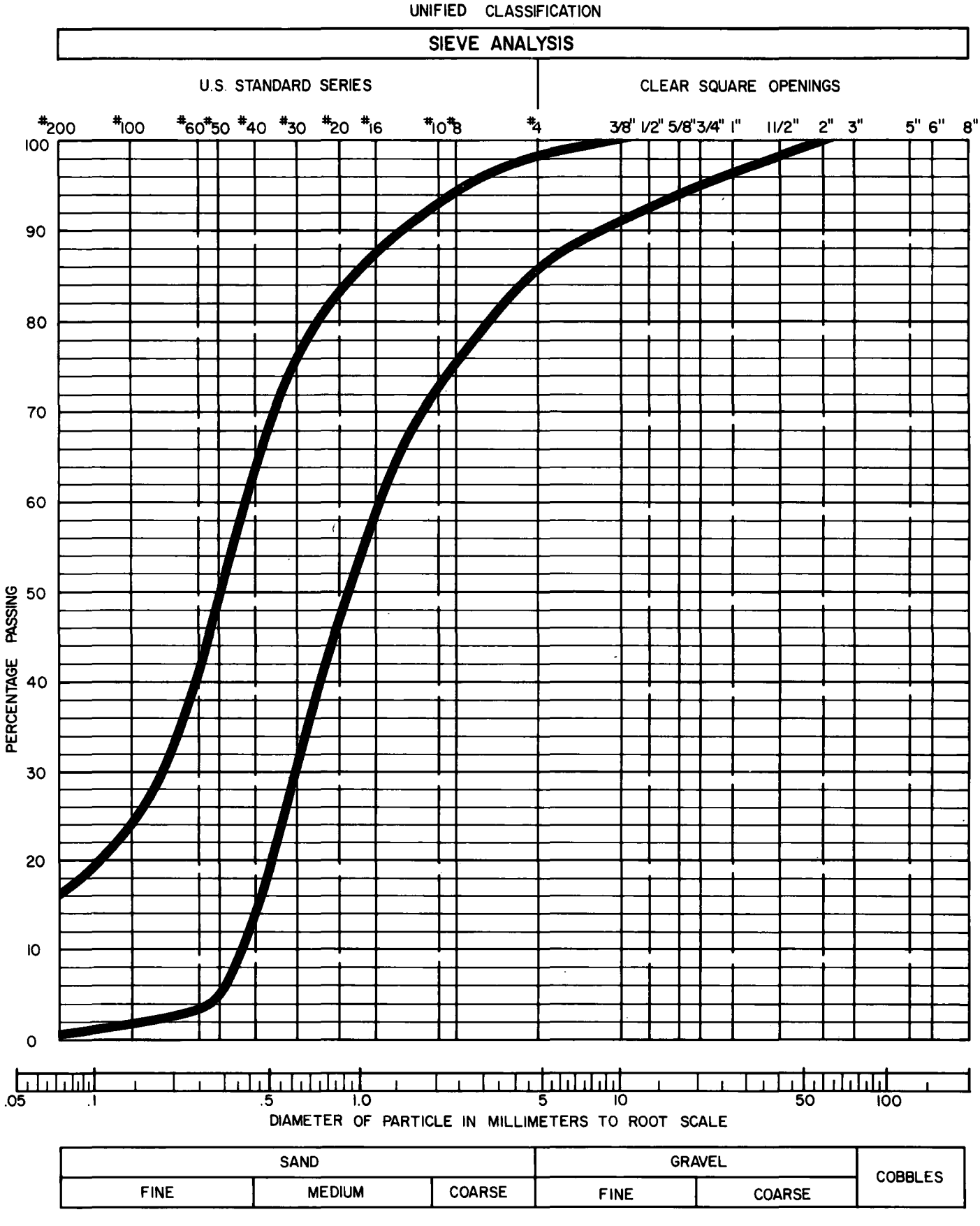
- Ranges E & F — high quality
- Ranges C & D — moderate quality
- Ranges A & B — poor quality
- Range G — granular till.

A comparison of the expected grain size distribution ranges of a particular granular deposit with the specifications for individual uses, should allow an appreciation as to whether the material in that deposit has the potential to meet the specifications.

4.3 Petrographic Composition

Full petrographic examinations were conducted on 34 representative samples from a number of Brandon region sand and gravel deposits. The composition of the material is graphically illustrated in two - 3 component triangular composition plots on Plate D-20. The average non-deleterious component ratio for Brandon region gravel is 59% Carbonates, 29% Igneous and 12% Volcanics. The two illustrated triangular composition ratio diagrams are the Volcanic-Igneous-Carbonates plot and the Shale-Carbonates-Volcanics and Igneous plot.

The composition of six samples continuously falls beyond the average compositional range. Five of these samples (labelled B to F on Plate D-20) have compositions that are relatively close to the average compositional range. One sample, however, differs radically in petrographic composition. UMA station 851 (Souris Sand and Gravel deposit) has a non-deleterious composition ratio of 35% Carbonates, 15% Igenous and 50% Volcanics.



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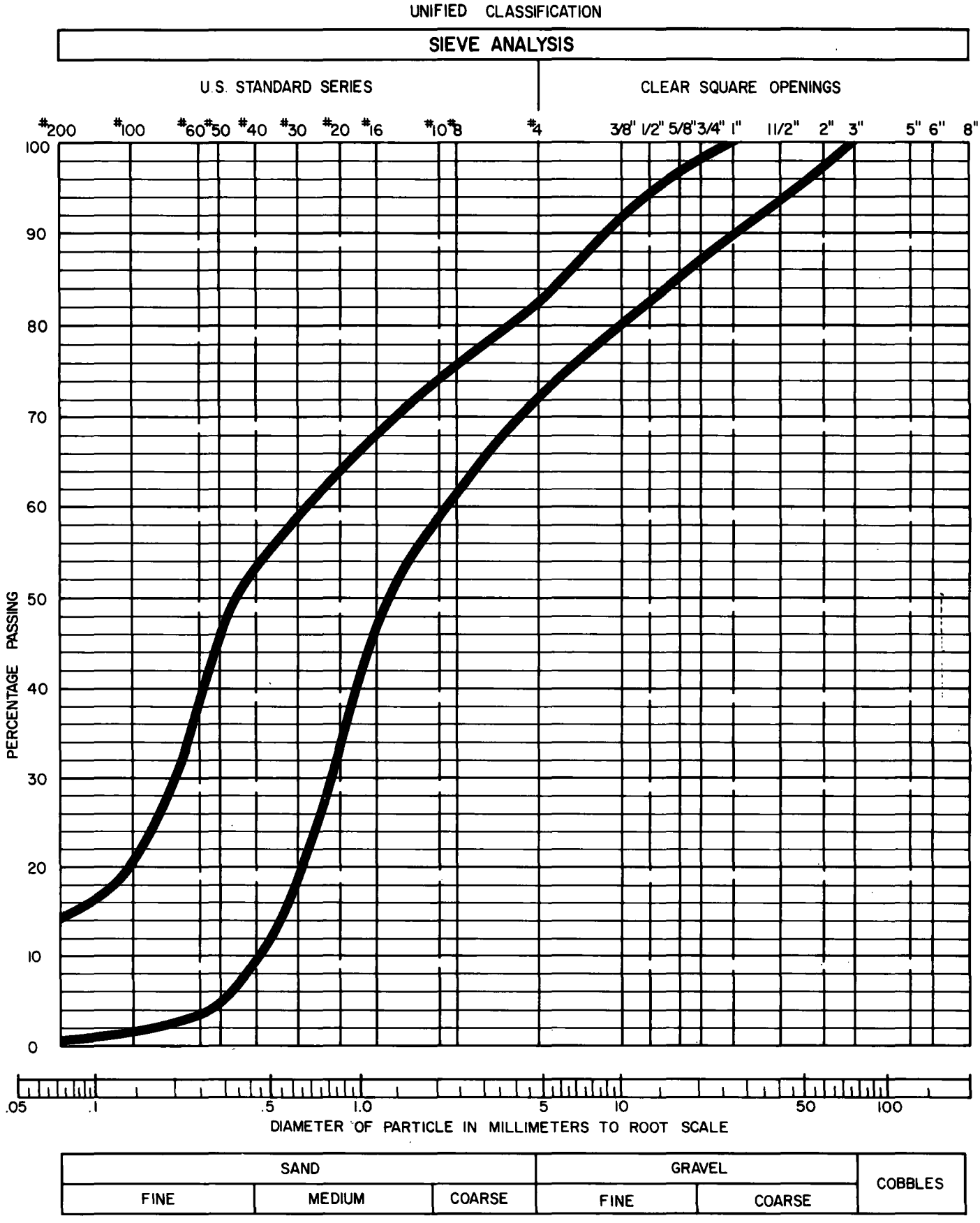
Grain Size Distribution Range A

Sand and Gravel Resources of the Brandon Region

The UMA Group

Plate D-13



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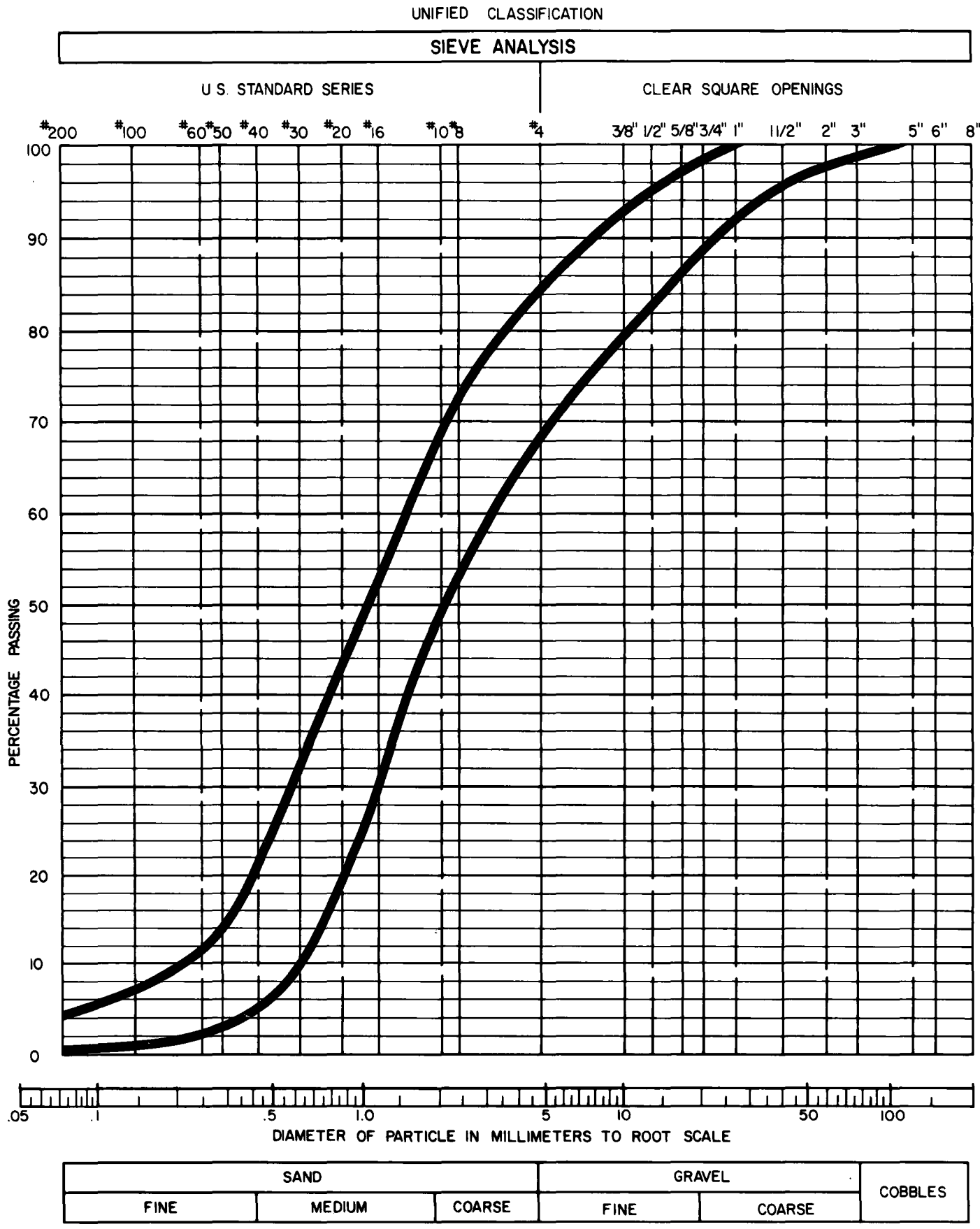
Grain Size Distribution Range B

Sand and Gravel Resources of the Brandon Region

The UMA Group

Plate D-14



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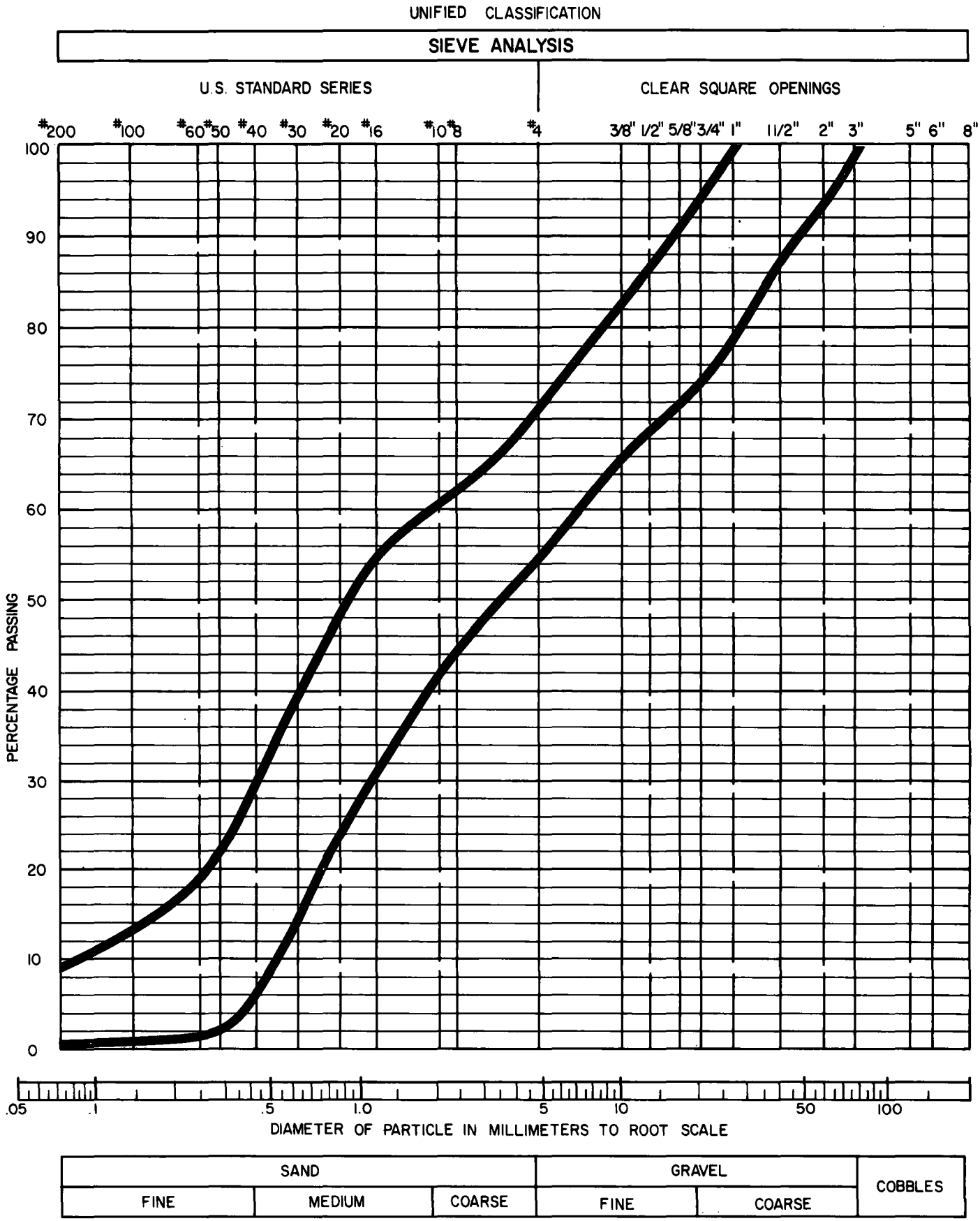
Grain Size Distribution Range C

Sand and Gravel Resources of the Brandon Region

The UMA Group

Plate D - 15



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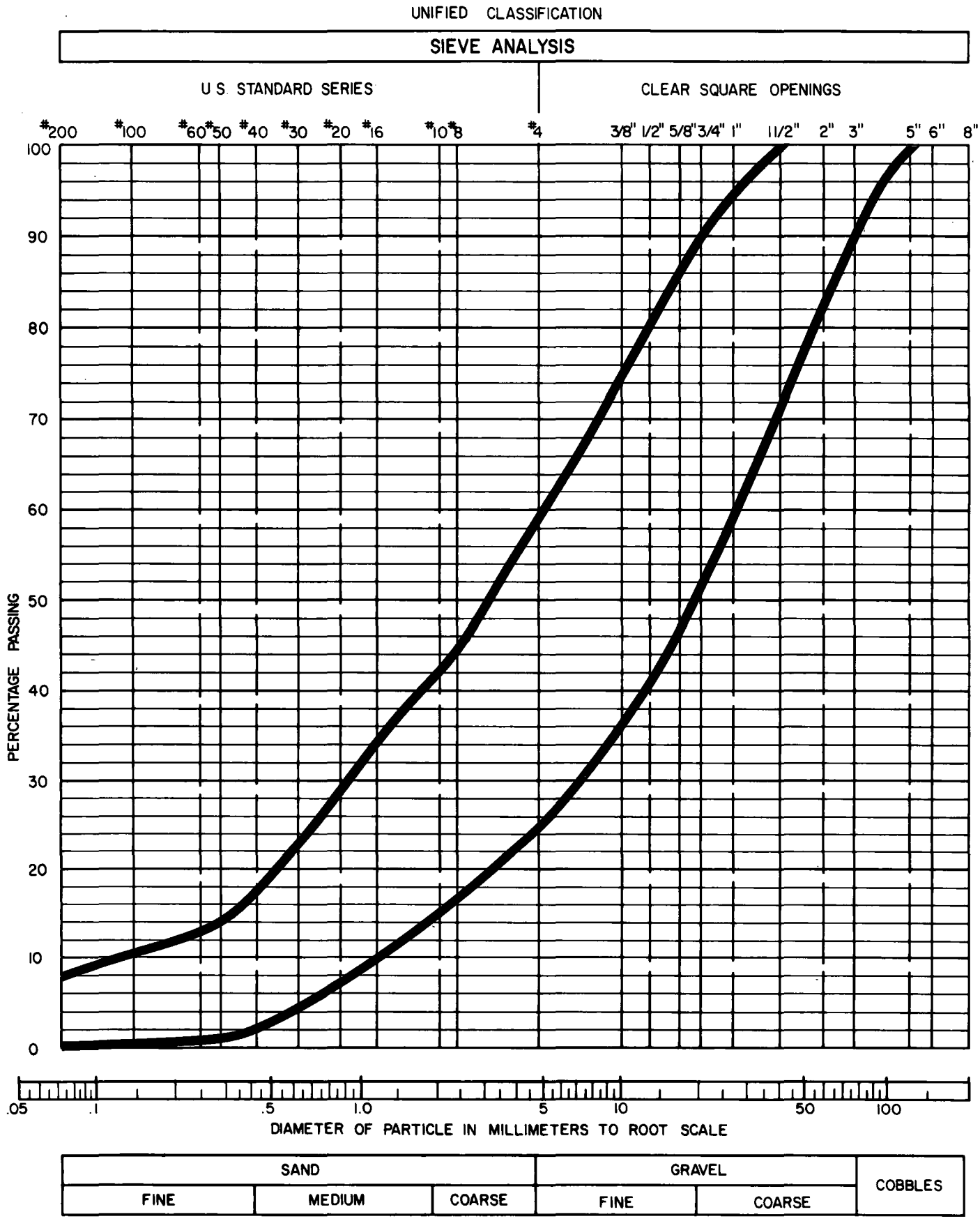
Grain Size Distribution Range D

Sand and Gravel Resources of the Brandon Region

The UMA Group

Plate D-16



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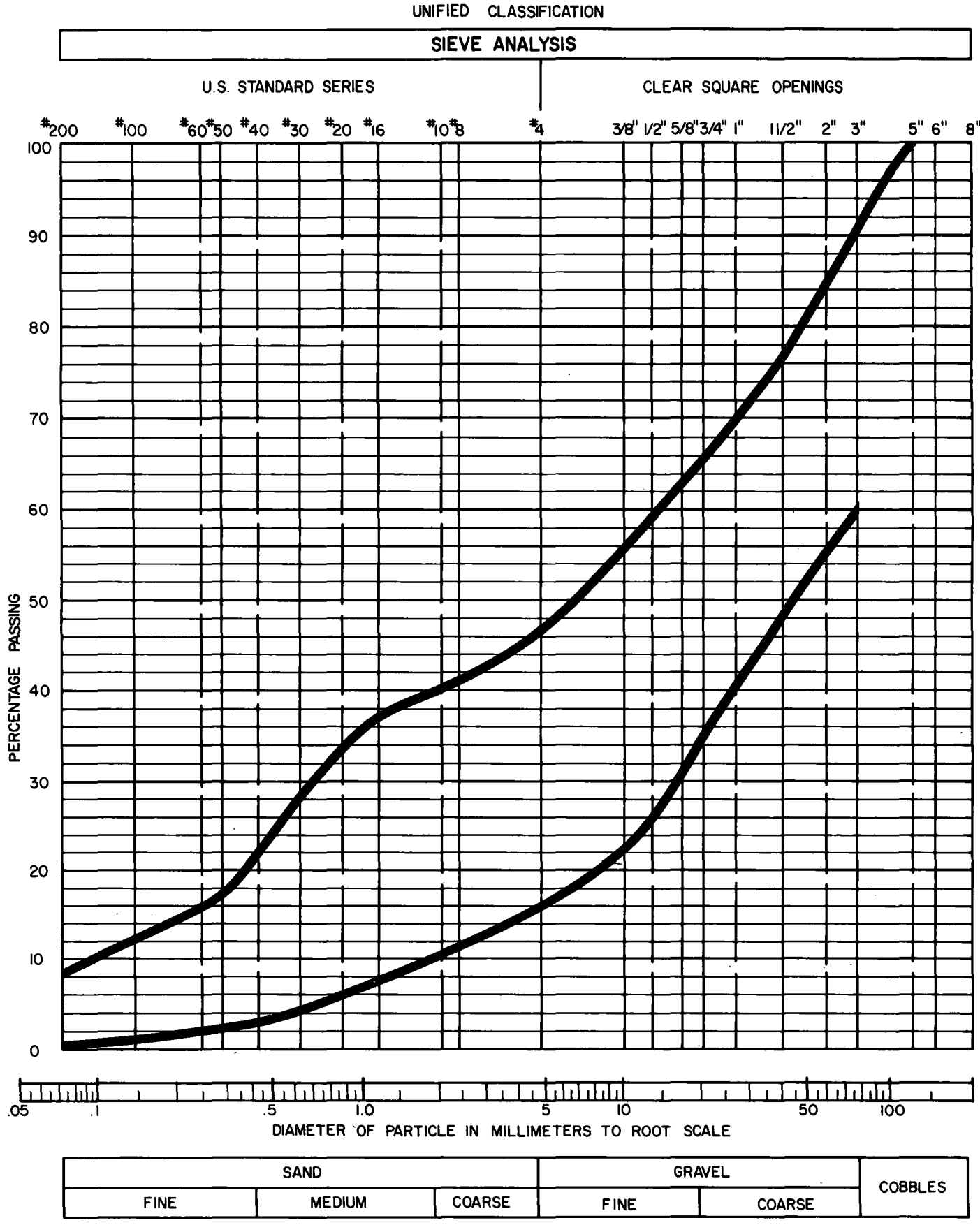
Grain Size Distribution Range E

Sand and Gravel Resources of the Brandon Region

The UMA Group

Plate D-17



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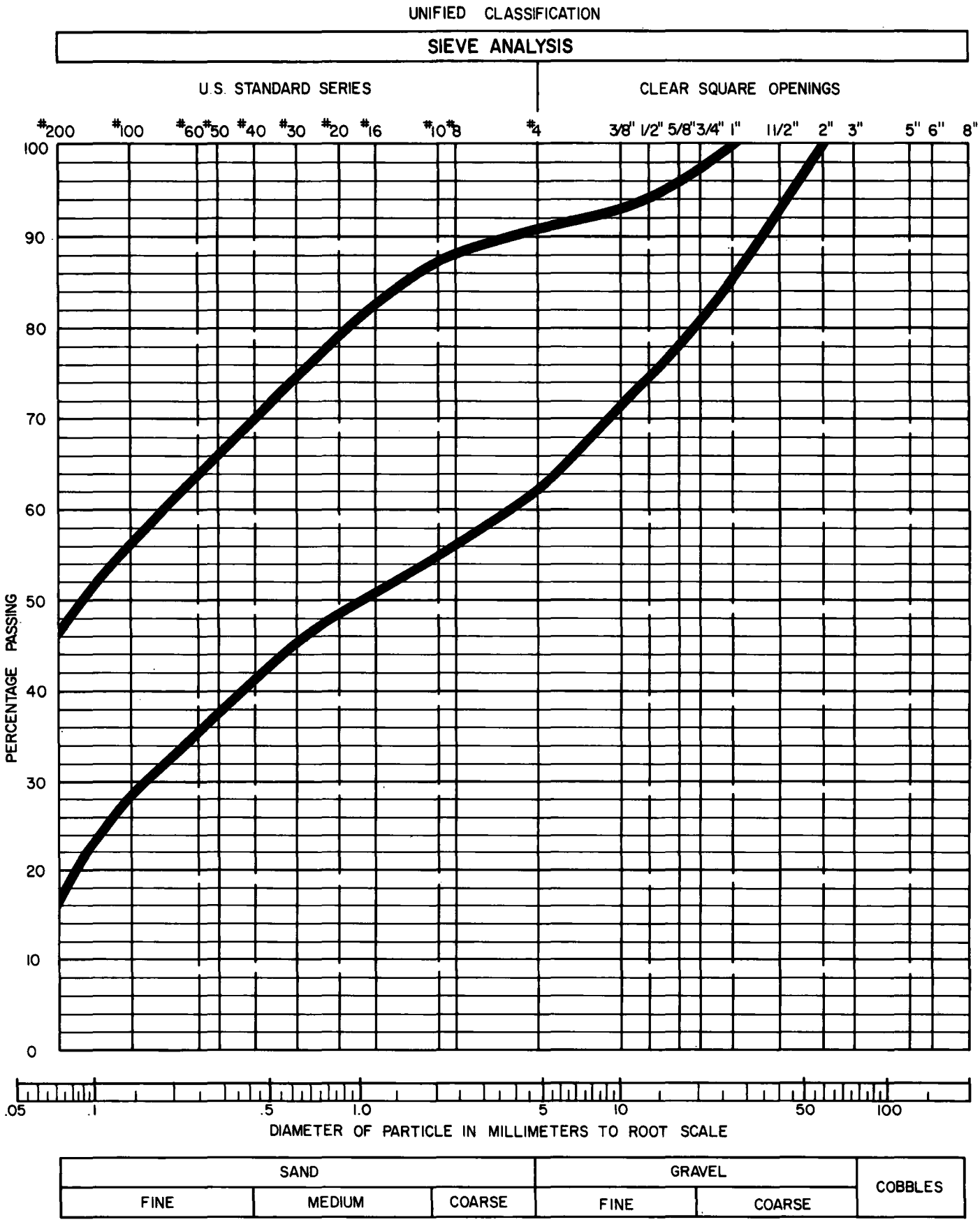
Grain Size Distribution Range F

Sand and Gravel Resources of the Brandon Region

The UMA Group

Plate D-18



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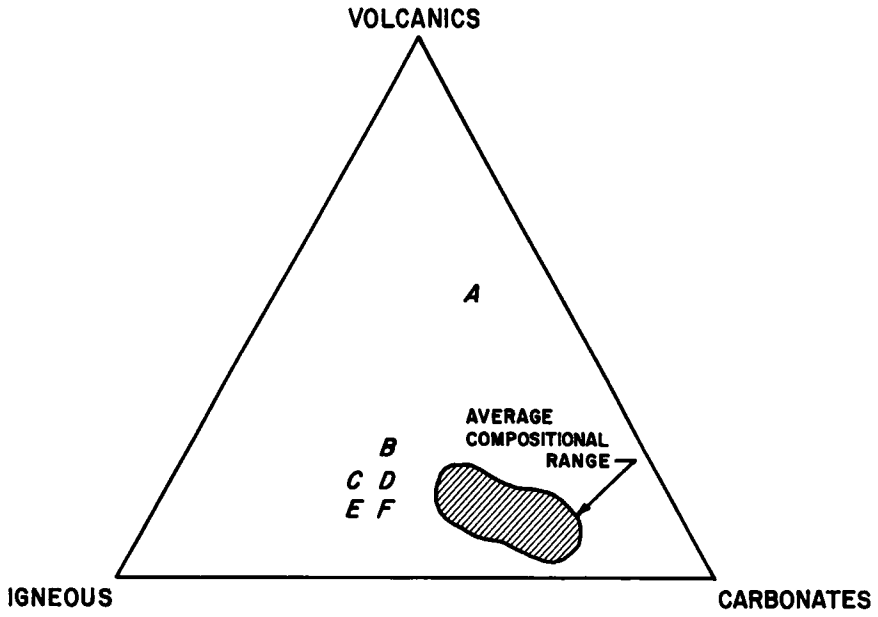
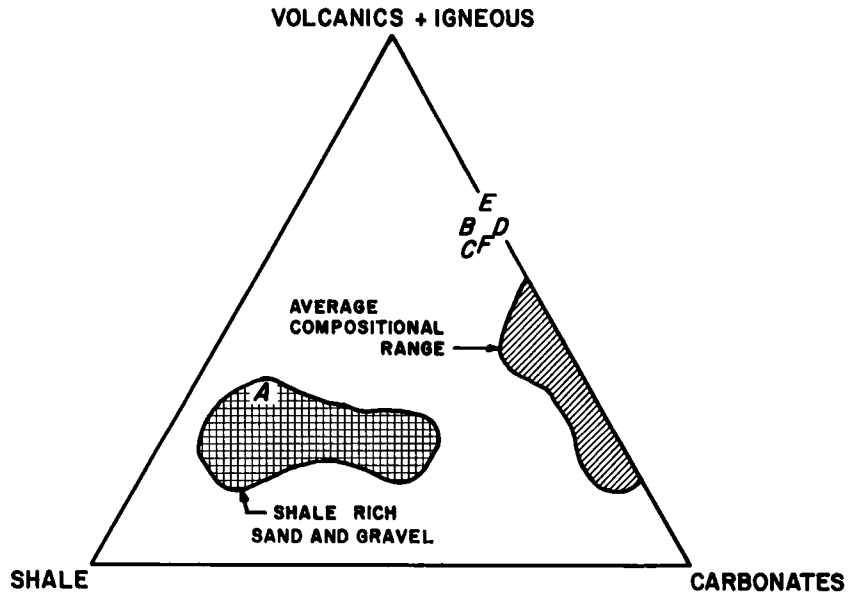
Grain Size Distribution Range G

Sand and Gravel Resources of the Brandon Region

The UMA Group

Plate D-19





LEGEND

A - UMA STATION No. 851 (NE 34 - 7 - 21 WPM)
(SOURIS SAND AND GRAVEL)

B - UMA STATION No. 259 (NW 31 - 10 - 22 WPM)

C - UMA STATION No. 400 (SE 5 - 11 - 25 WPM)

D - UMA STATION No. 153 (SE 20 - 10 - 18 WPM)

E - UMA STATION No. 168 (SE 20 - 9 - 17 WPM)

F - UMA STATION No. 915 (NW 25 - 14 - 19 WPM)

Composition of
Brandon Regional Sand and Gravel

This unusual composition ratio supports the claim that this deposit may be a Tertiary or Early Pleistocene sand and gravel deposit.

4.4 Deleterious Substances

In addition to petrographic analysis, 135 Shale and Ironstone Counts were conducted on Brandon region sand and gravel samples. It should be noted that both shale and ironstone content can vary greatly throughout an individual deposit or individual gravel pit. It is for this reason that the shale or ironstone content of an individual sample may vary dramatically from the average shale or ironstone content of a deposit.

Shale bedrock underlies the majority of the Brandon region and as a result represents the largest deleterious constituent in Brandon region sands and gravels. Table D-2 has been presented in order to show the average shale content of various sand and gravel features in the Brandon region. The proximity of a sand and gravel deposit to shale outcrops governs the shale content of the sand and gravel.

Another problem associated with Brandon region shales is that of heavy shales. Heavy shale is that shale which cannot be washed from a sand and gravel by conventional deshaling operations because of the specific gravity of the shale.

Heavy shale occurs in twelve samples and corresponds to areas underlain by the Cretaceous Odanah Shales. Samples of heavy shale gathered 6 kilometres southeast of Lenore yielded specific gravities of 2.3 to 2.4. Typical specific gravities from shale found in Brandon region sand and gravel are less than 1.9. Areas where heavy shale occurs in sand and gravel deposits are the Lenore area, the Minnedosa area, the Brandon Hills and the Oak River area.

Ironstone is another predominant deleterious substance found in sand and gravel in the Brandon area. Average ironstone content varies from 1 to 3 percent. Table D-3 presents the average ironstone content of sand and gravel features in the Brandon region.

4.5 Los Angeles Abrasion and Soundness Tests

Los Angeles Abrasion tests were conducted on nine (9) representative samples from different deposit areas within the Brandon region. Eight of these samples had a range of values from 24.3 percent to 35.3 percent, with an average abrasion loss of 28.2 percent. One abrasion test conducted on a sample from the Minnedosa River Valley yielded a loss of 50.6 percent. The high loss was attributable to a breakdown of the carbonate fraction during the testing. Visual examination showed that the carbonates in the sample were extremely friable. A detailed listing of the Los Angeles abrasion test values is presented in Appendix D4 of this report.

Three Soundness tests were conducted on samples recovered from the Brandon region. The results of these tests are presented in Table D-4.

TABLE D-2

AVERAGE SHALE CONTENT OF SAND AND GRAVEL FEATURES FROM THE BRANDON REGION

Physiographic Region	Deposit Type	Range of Shale Content (Percent by Weight)	Average Shale Content (Percent by Weight)
Assiniboine Delta (Edrans area)	Beach Ridge	0% to 1%	0.5%
Tiger Hills Upland	Reworked Till & Outwash	0% to 6%	2%
Souris Basin (Alexander area)	Lag	2% to 5%	4%
Minnedosa Till Plain	Reworked Till & Outwash	0.5% to 20%	4%
Assiniboine Delta (Brandon area)	Delta	0.5% to 20%	5%
Souris Basin (Rivers area)	Outwash and Delta	2% to 15%	9%
Minnedosa Till Plain (Neepawa area)	Delta	6% to 15%	10%
Minnedosa Till Plain (Minnedosa River Valley)	Outwash and Stratified Drift	0.5% to 40%	10%
Souris Basin (Virden area)	Delta	1% to 65%	15%

TABLE D-3

AVERAGE IRONSTONE CONTENT* OF SAND AND GRAVEL FEATURES FROM THE BRANDON REGION

*(by weight percent)

Physiographic Region	Deposit Type	Ironstone Content Range	Ave. Ironstone Content
Tiger Hills Uplands	Reworked Till & Outwash	0% to 3%	1%
Souris Basin (Rivers area)	Outwash and Delta	0.5% to 7%	1%
Minnedosa Till Plain (Minnedosa River VAlley)	Outwash and Stratified Drift	0.5% to 4%	2%
Minnedosa Till Plain	Reworked Till & Outwash	0.5% to 4%	2%
Souris Basin (Virden area)	Delta	0% to 7%	2%
Souris Basin (Alexander area)	Lag	2% to 4%	3%
Assiniboine Delta (Brandon area)	Delta	0% to 12%	3%

TABLE D-4
SOUNDNESS TESTING

Physiographic Region	Deposit Type	Soundness	
		Fine	Coarse
Souris Basin (Rivers area)	Outwash and Delta	1.8	1.7
Assiniboine Delta (Brandon area)	Delta	4.0	4.3
Minnedosa Till Plain (Minnedosa River Valley)	Outwash and Stratified Drift	4.1	3.0

5. TIGER HILLS UPLAND

5.1 General Geology

Part of the Tiger Hills Upland occurs in the Brandon study region between the towns of Wawanesa and Souris. This physiographic region is an area of end moraines consisting of irregular hills between which are undrained basins occupied by lakes, sloughs or swamps. Local relief ranges from 15 to 90 metres. The Brandon Hills which are a continuation of the Tiger Hills south of the City of Brandon have elevations of nearly 500 metres above sea level or 120 meters above the Assiniboine River at Brandon.

The most common surficial deposit in the region is till, calcareous and bouldery in nature, with lesser amounts of reworked and unmodified clay tills. Outwash sand and gravel represents less than 1 percent of the surficial deposits in the region.

The general geology of the area is depicted in Volume 1 on Plates D-4 and D-11, with the location of the Uplands region shown on Plate D-3. The detailed surficial geology, at 1:50,000, is illustrated on maps 62G12E, 62G12W and 62F9E in Volume 2 of the report.

5.2 Sand and Gravel Occurrence

Sand and gravel occurrence in the Tiger Hills Upland is limited. Two types of sands and gravels which do occur in this region are reworked tills and outwash.

Large sand and gravel deposits formed from reworked tills are located along the peripheries of the Brandon Hills (see map 62G12W - Volume 2). These deposits are of medium quality.

Outwash sand and gravel, found southwest of the Brandon Hills, ranges in quality from low to medium.

In the future, it may be possible to extract the stone content from bouldery granular tills found south of the Brandon Hills. Stations 306, 307, 308, 309, 310, 311, 312 and 350, shown on map 62G12W, locate specific occurrences of the granular till. An average of 25 to 35 percent of these bouldery granular tills is retained on a #4 sieve.

The overall sand and gravel potential of the entire Tiger Hills Upland is low.

5.3 Resistivity Survey

The locations of all resistivity lines are shown on Plates D-1 and D-2, Volume 1 and also on the 1:50,000 maps in Volume 2. Two resistivity lines were run in the Brandon Hills area of the Tiger Hills Upland physiographic region, RL1 (Plate D-21) and RL2 (Plate D-22). Map 62G12W locates the resistivity lines and illustrates the associated surficial geology. RL1 (Plate D-21) shows a 2 metre reworked till developed over a parent till. RL2 (Plate D-22) indicates a thin 2 metre sand outwash deposited over a till. Both resistivity lines and their interpretation supported field observations made in the Brandon Hills area.

6. THE ASSINIBOINE DELTA

6.1 General Geology

The Assiniboine Delta, located on the western edge of glacial Lake Agassiz, occupies part of a valley eroded through the Manitoba escarpment by the preglacial Missouri River. Topographically the region slopes gradually to the east and is dissected by several gullies and deeply incised by the Assiniboine River.

The Assiniboine Delta can be divided into two parts by the Campbell strandline (Plate D-4). The older, higher part, west of the strandline, forms a primary depositional slope largely composed of sand and some gravel. The lower, younger part, east of the strandline, is comprised of clayey bottomset beds widely overlain by fine sands. Much of the sand in the eastern portions of the delta has been blown into sand dunes ranging from 3 to 15 metres in height.

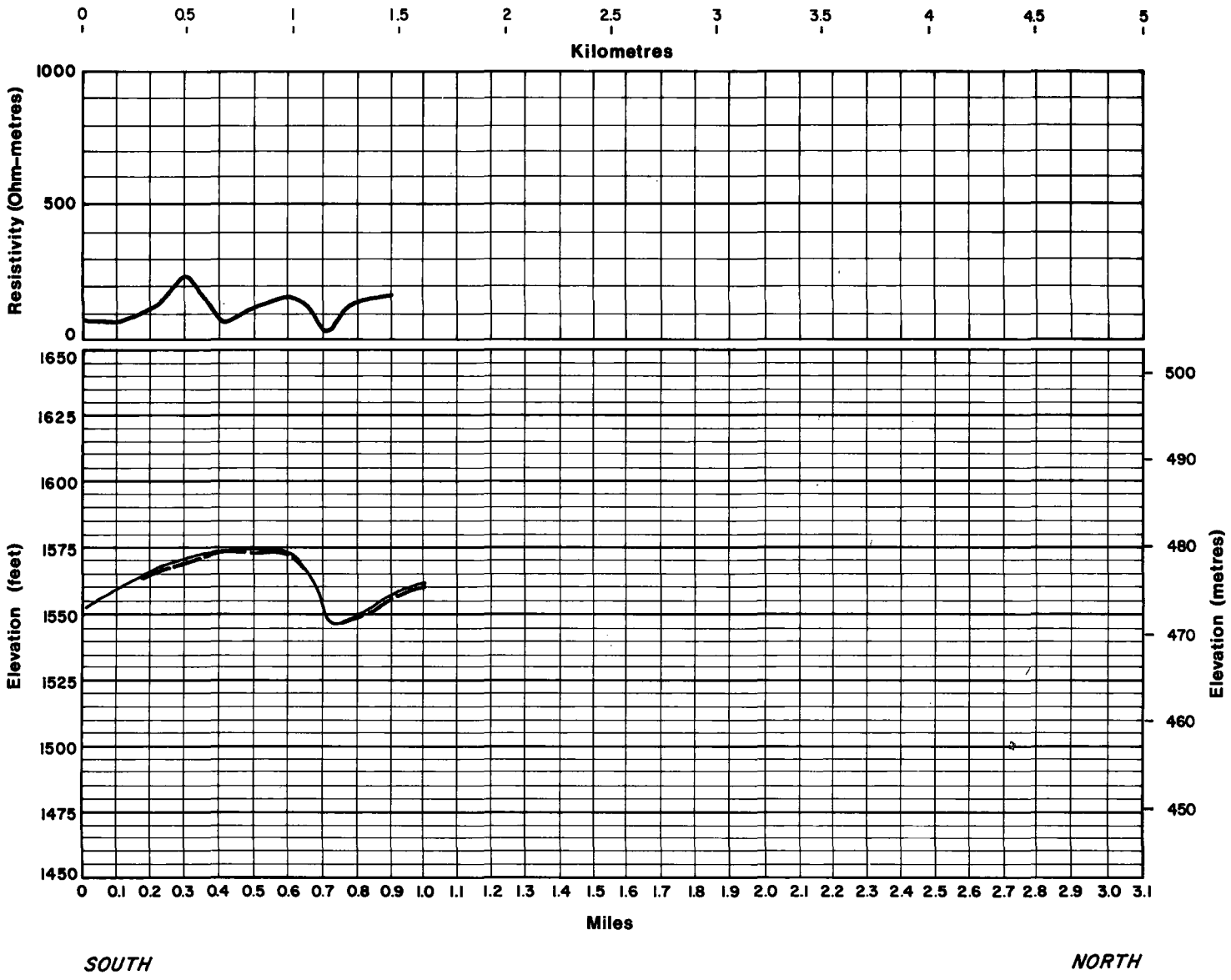
Assiniboine River alluvium parallels the river along its course through the physiographic region. The Assiniboine River valley from Brandon to the confluence of the Souris River is a broad, shallow valley. Downstream from this point, the valley becomes a sinuous trough, averaging 2 kilometres in width and some 30 to 60 metres in depth. Some cut terraces are present along this reach of the Assiniboine.

The general geology of the area is depicted in Volume 1 on Plates D-4, D-10 and D-11 with the location of the physiographic region noted on Plate D-3. The detailed surficial geology is shown on the following 1:50,000 maps in Volume 2; 62G11E, 62G11W, 62G12E, 62G12W, 62F16E, 62G13W, 62G13E, 62G14W, 62G14E, 62J3E, 62J3W and 62J4E.

6.2 Sand and Gravel Occurrence

Large quantities of high, medium and low quality sand and gravel occur in the Assiniboine Delta physiographic region. Sand and gravel, deposited by several modes of deposition, occurs as:

- deltaic sand and gravel
- lag concentrate
- beach ridges
- outwash
- alluvial terrace and fill.



Legend:

Resistivity Profile *

Ground Profile

Bottom of Granular Material (As Interpreted From Resistivity Profile)

* Resistivity Readings Limited to a Maximum 1000 Ohm Metres See Text Section D-2

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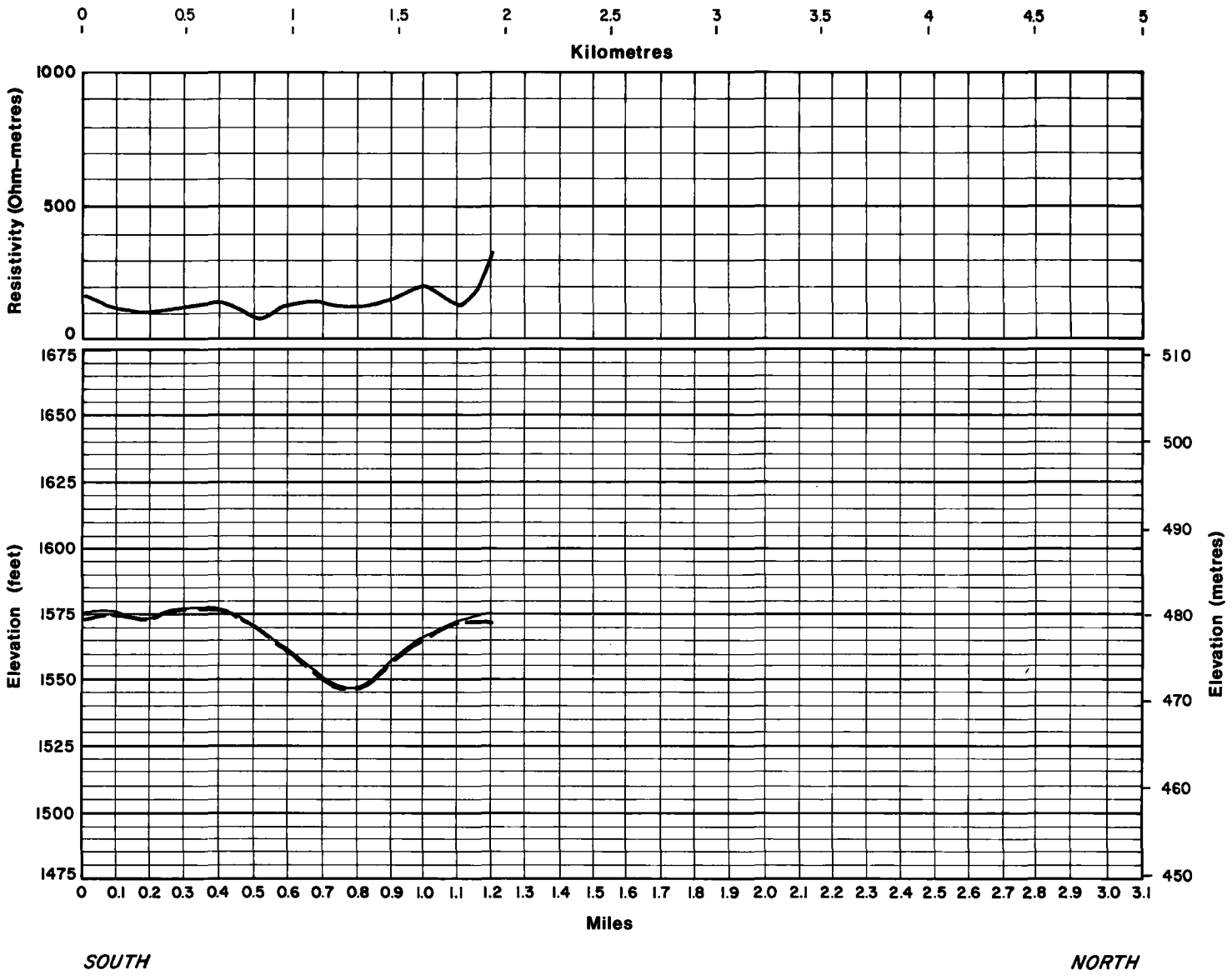
Resistivity Profile

Line 1

Plate D-21



Legend:

Resistivity Profile *

Ground Profile

Bottom of Granular Material (As Interpreted From Resistivity Profile)

*** Resistivity Readings Limited to a Maximum 1000 Ohm Metres See Text Section D-2**

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Resistivity Profile

Line 2

Plate D-22

The largest single sand and gravel feature is the Assiniboine Delta (see map 62G13W - Volume 2). Deltaic, lag and alluvial sand and gravel combine to form this deposit. The quality of sand and gravel in this feature ranges from low to high as a result of the variety of depositional agencies.

Within the area of the Assiniboine Delta physiographic region, alluvial fill and terrace sand and gravel is deposited near the Town of Douglas and along the Assiniboine River from the confluence of the Minnedosa and Assiniboine Rivers to the City of Brandon. Deltaic sand and gravel occurs in abundance in areas east of Brandon (see maps 62G12E, 62G12W, 62G13E and 62G13W - Volume 2). Lag deposits of sand and gravel are located near Leon, Glen Souris and Chater.

Sand and gravel beach ridges, deposited along the shoreline of Lake Agassiz near Arden and the town of Edrans, contain significant quantities of medium quality gravel. Other important sources of medium quality gravel are the deltaic sand and gravel 5 kilometres west of Neepawa and the isolated, coarse alluvium deposits scattered along the Assiniboine River (see maps 62G12E and 62G11W - Volume 2).

The overall sand and gravel potential of the Assiniboine Delta region is high.

6.3 Resistivity Survey

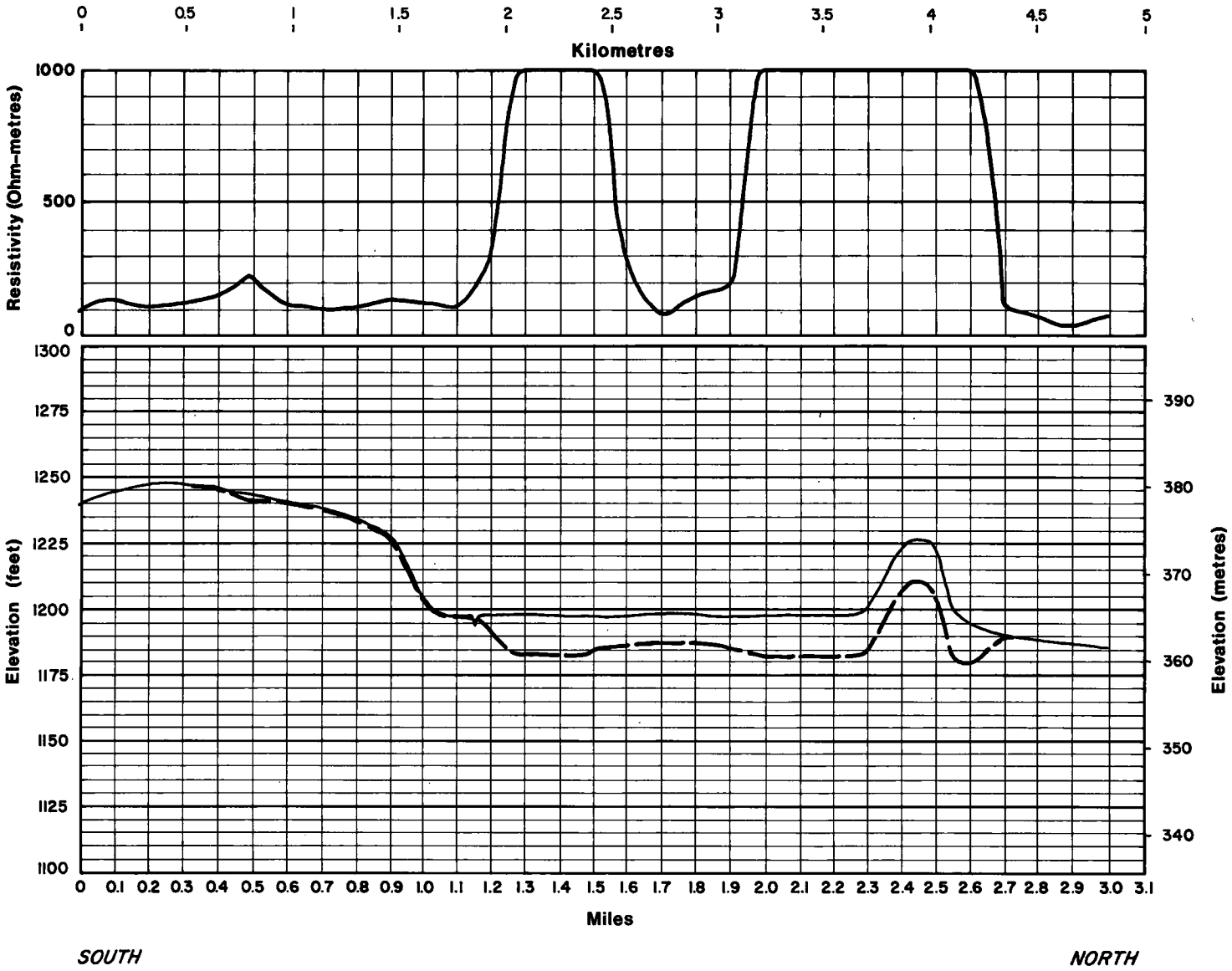
The need for an extensive resistivity survey in the Assiniboine Delta region was minimized by the abundant, available information for this region. Map 62G12W, Volume 2, locates resistivity line RL3 (Plate D-23) and illustrates the associated surficial geology. The difference in resistivity response between clays and tills, south of kilometre 1.8 and sands, north of kilometre 1.8 is clearly visible. A low resistivity zone, between kilometre 2.6 and 3.1 and lying within the area of the Assiniboine Delta sands, is caused by a localized area of saline soil. This saline soil is highly conductive and masks the resistivity response of the underlying sand.

The location of resistivity line RL6 (Plate D-24), as well as the associated surficial geology, is shown on map 62G13W - Volume 2. This resistivity line shows a 3 to 5 metre sand and gravel deposit which is an erosional remnant of the Assiniboine Delta. The resistivity response of the deltaic sand and gravel differs significantly from newer Assiniboine River alluvium. The older deltaic material is far more resistive than the younger alluvium suggesting that the older deltaic material is a coarser granular material.

7. MINNEDOSA TILL PLAIN

7.1 General Geology

The topography of the Minnedosa Till Plain is generally undulating with innumerable undrained depressions varying in size from small potholes and sloughs to larger intermittent and shallow lakes. This topography was formed as dead-ice melted differentially from the till within the region. Surface drainage in the till plain is poorly developed. Runoff in regions close to streams may become excessive while depressions may experience prolonged innundation. Surficial deposits in the till plain are primarily



Legend:

Resistivity Profile *

Ground Profile

Bottom of Granular Material (As Interpreted From Resistivity Profile)

*** Resistivity Readings Limited to a Maximum 1000 Ohm Metres See Text Section D-2**

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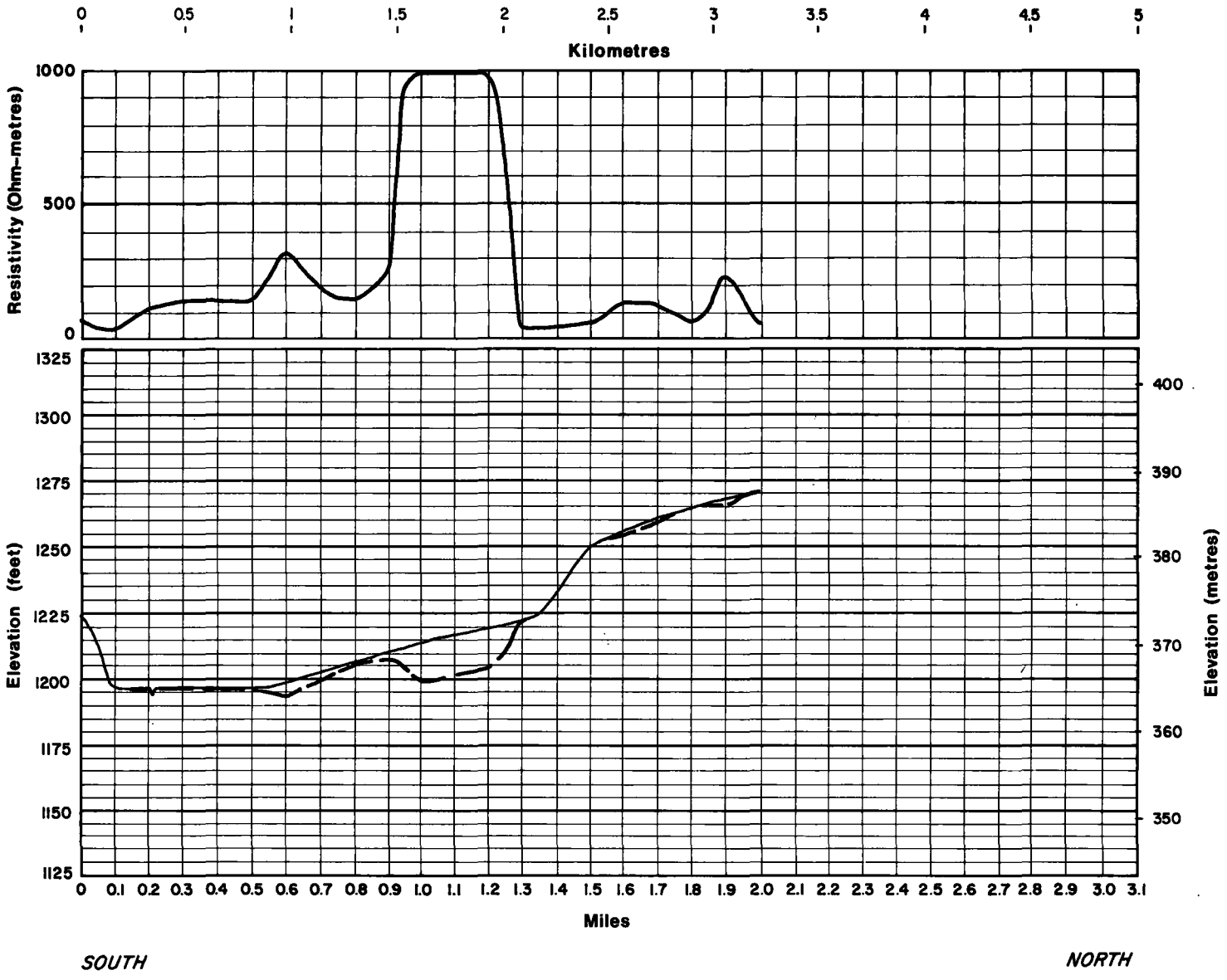
Resistivity Profile

Line 3

Plate D-23



Legend:

Resistivity Profile *

Ground Profile

Bottom of Granular Material (As Interpreted From Resistivity Profile)

* Resistivity Readings Limited to a Maximum 1000 Ohm Metres See Text Section D-2

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Resistivity Profile

Line 6

Plate D-24

clay tills and reworked granular tills.

One area within the physiographic region differing significantly from the till plain is the Minnedosa River valley (see maps 62K1E, 62J4W and 62J5W - Volume 2). Abundant areas of outwash, alluvial terrace and recent alluvium occur within the valley. The prolonged period of time in which the Minnedosa River valley acted as a major glacial meltwater spillway has produced a complex stratigraphy and surficial geology.

The general geology of the area is depicted on Plates D-5, D-6, and D-10 in Volume 1. The areal extent of the Minnedosa Till Plain within the Brandon study region is shown on Plate D-3. Maps 62K7E, 62K8W, 62K8E, 62J5W, 62K2E, 62K1W, 62K1E, 62J4W, 62J4E, 62F15E, 62F16E, 62G13W and 62G13E, in Volume 2 of the report, illustrate the surficial geology at a scale of 1:50,000.

7.2 Sand and Gravel Occurrence

Sand and gravel deposits occur in two distinct groupings in the Minnedosa Till Plain. Sizeable sand and gravel deposits are found in the Minnedosa River valley (see maps 62K1E, 62J4W and 62J5W - Volume 2). These deposits have been formed by the outwashing of sand and gravel into the Minnedosa River glacial spillway, followed by subsequent fluvial modification. The quality of this material ranges from medium to high.

Small, isolated knolls of sand and gravel, which have been formed by the reworking of tills, are found scattered throughout the till plain. These deposits are often found in close proximity to small drainage features such as the Oak River. These deposits are small and range from low to high in quality. The 1:50,000 maps listed previously, which detail the surficial geology of the till plain, can be referred to for the locations of these deposits.

The overall sand and gravel potential of the entire Minnedosa Till Plain is moderate.

7.3 Resistivity Survey

A total of seven resistivity lines were run in the Minnedosa Till Plain physiographic region. All resistivity lines were located near the Minnedosa River and provided information which led to the determination of the areal extent of the sand and gravel deposits near the Minnedosa River.

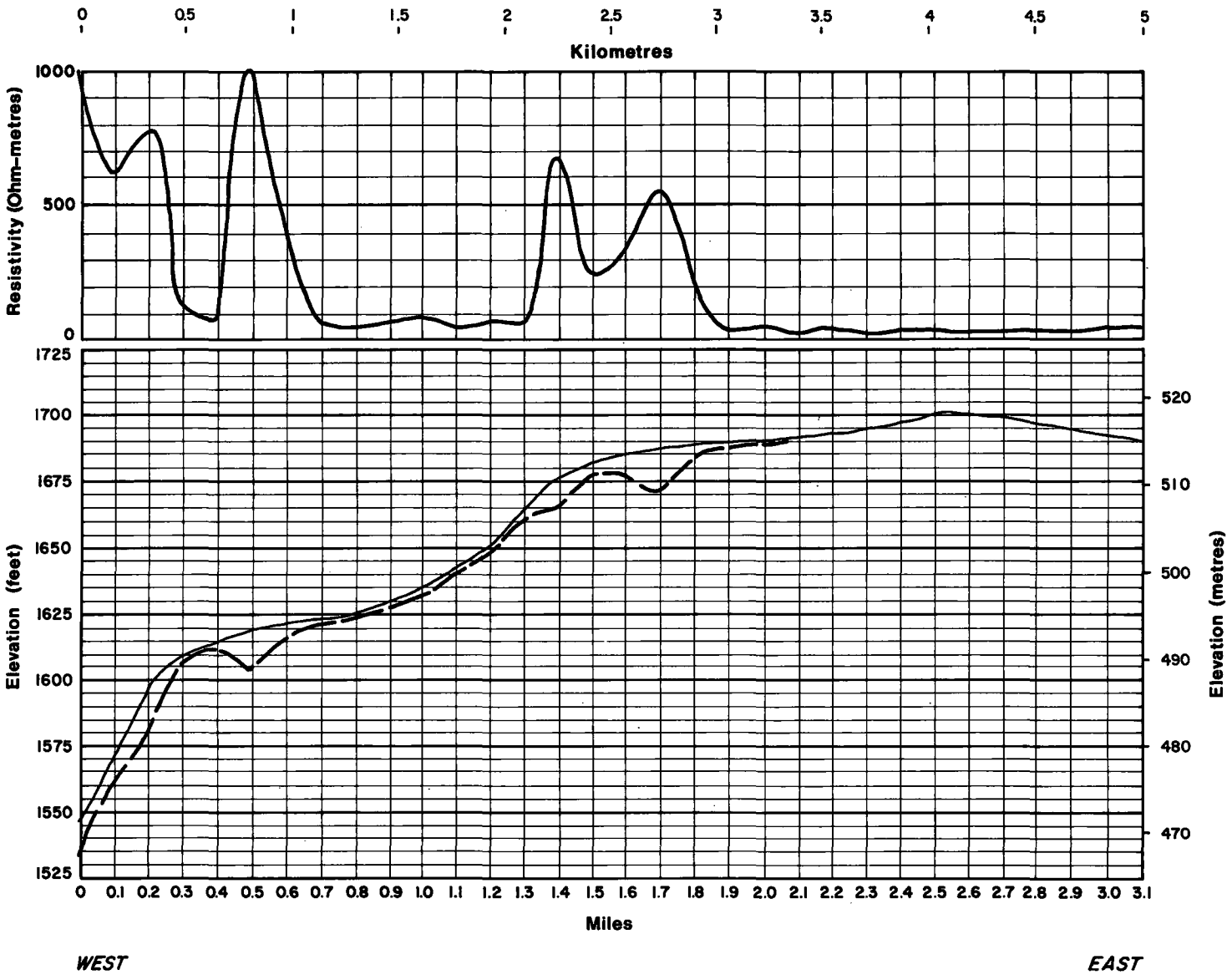
Table D-5 identifies the 1:50,000 map which locates each resistivity line and details the associated surficial geology. In addition, the table summarizes the information obtained from the resistivity work.

From the resistivity data presented in Table D-5 it is apparent that the sand and gravel deposits found along the Minnedosa River are discontinuous in nature.

TABLE D-5

MINNEDOSA TILL PLAIN - RESISTIVITY SURVEYS

RESISTIVITY LINE	MAP	PLATE	REMARKS
RL14	62K1E	D-25	- 3-5 metres of outwash sand and gravel is located in the Minnedosa River Valley - no granular is present on the till plain (East portion of resistivity line)
RL15	62K1E	D-26	- shows trace of reworked till on till plain - no granular in Minnedosa River valley
RL16	62K1E	D-27A D-27B	- shows isolated 5 metre sand and gravel deposit near Minnedosa River valley - note uniform resistivity profile over glacial till in northern portions of the line - note lack of granular near Minnedosa River (verified by backhoe tests)
RL17	62K1E	D-28	- shows poor sand and gravel development - backhoe tests support isolated, 2 metre sand lens interpretation near kilometre 0.0 - note minimal sand and gravel deposition in the Minnedosa River
RL18	62J4W	D-29	- shows 2 metre of sand and gravel in Minnedosa River valley bottom - note possible sand and gravel terrace deposit on east valley wall
RL19	62J4W	D-30	- shows thin 2 metre sand and gravel deposit along Minnedosa River valley bottom
RL20	62J4W	D-31	- good sand and gravel development 5 metre in Minnedosa River valley bottom



Legend:

Resistivity Profile *

Ground Profile

Bottom of Granular Material (As Interpreted From Resistivity Profile)

* Resistivity Readings Limited to a Maximum 1000 Ohm Metres See Text Section D-2

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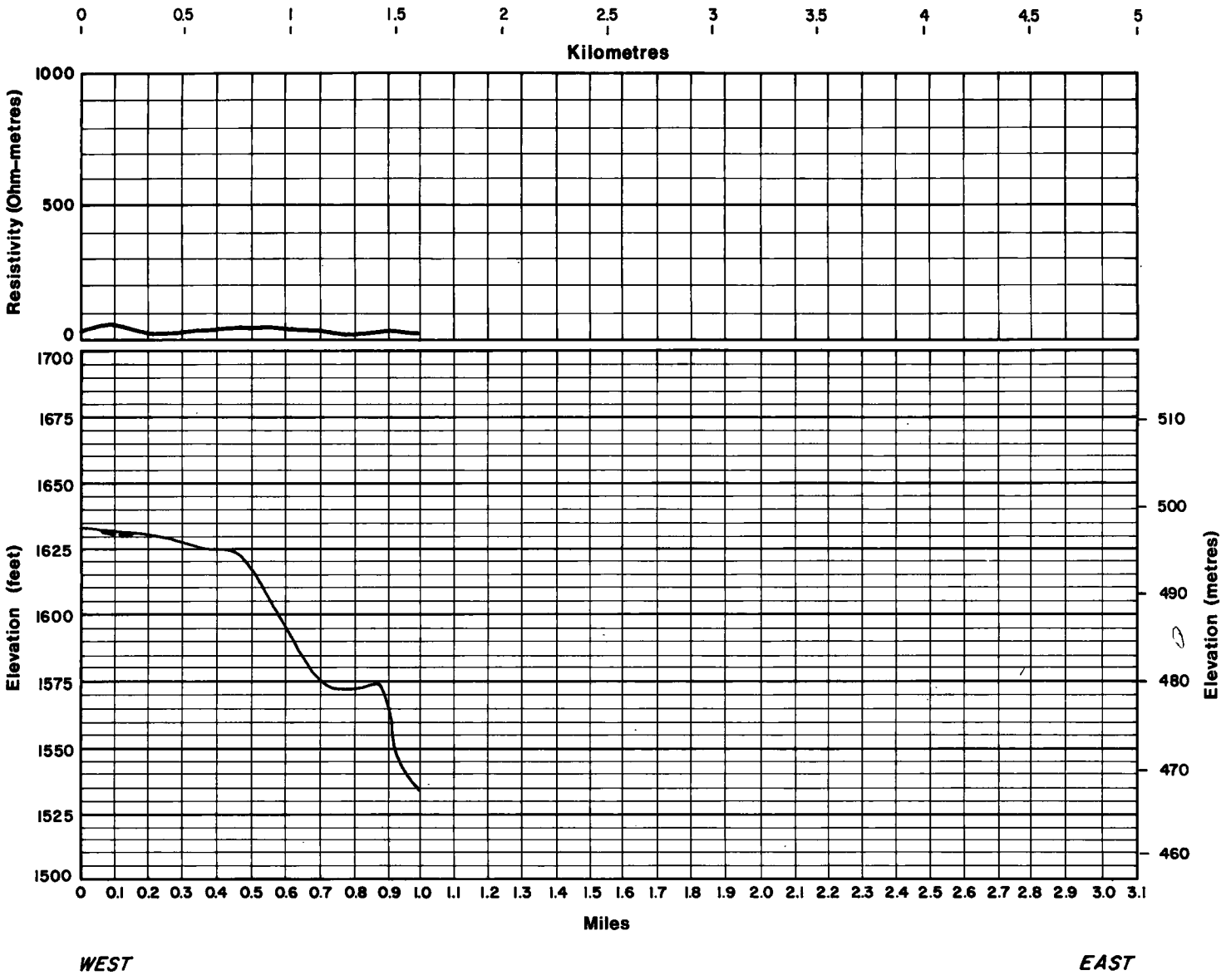
Resistivity Profile

Line 14

Plate D-25



Legend:

Resistivity Profile *

Ground Profile

Bottom of Granular Material (As Interpreted From Resistivity Profile)

* Resistivity Readings Limited to a Maximum 1000 Ohm Metres See Text Section D-2

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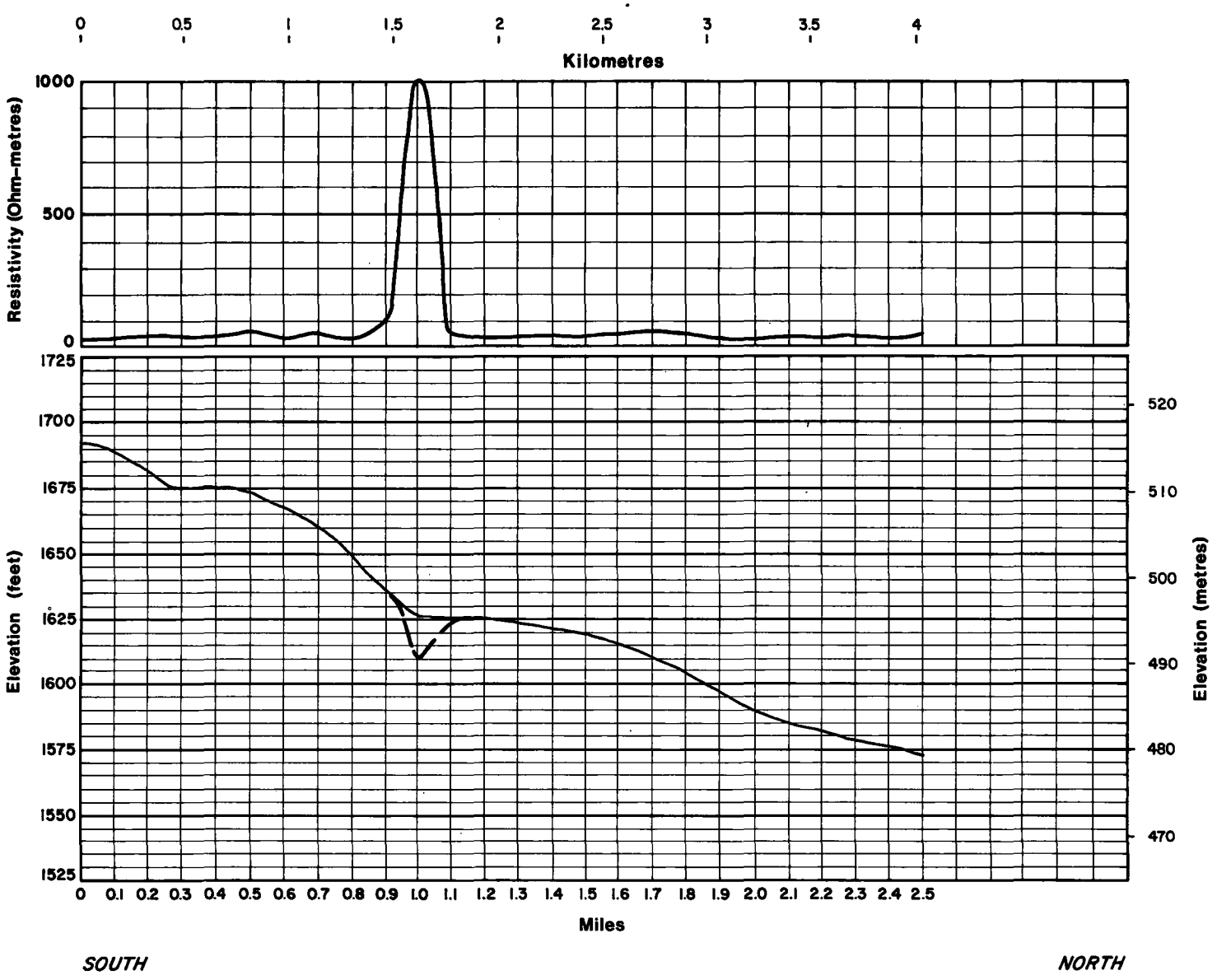
Resistivity Profile

Line 15

Plate D-26



Legend:

Resistivity Profile *

Ground Profile

Bottom of Granular Material (As Interpreted From Resistivity Profile)

* Resistivity Readings Limited to a Maximum 1000 Ohm Metres See Text Section D-2

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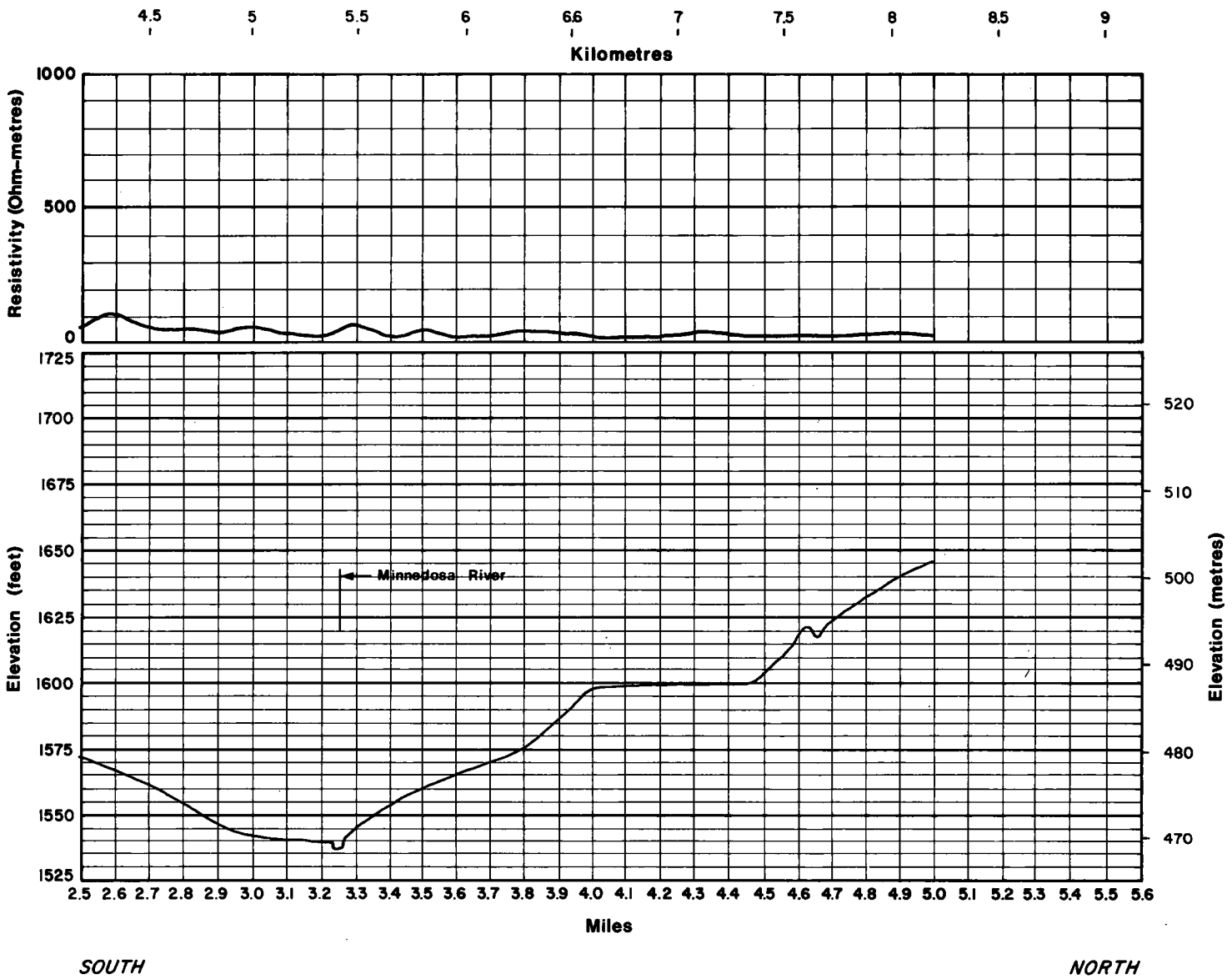
Resistivity Profile

Line 16

Plate D-27a



Legend:

Resistivity Profile *

Ground Profile

Bottom of Granular Material (As Interpreted From Resistivity Profile)

* Resistivity Readings Limited to a Maximum 1000 Ohm Metres See Text Section D-2

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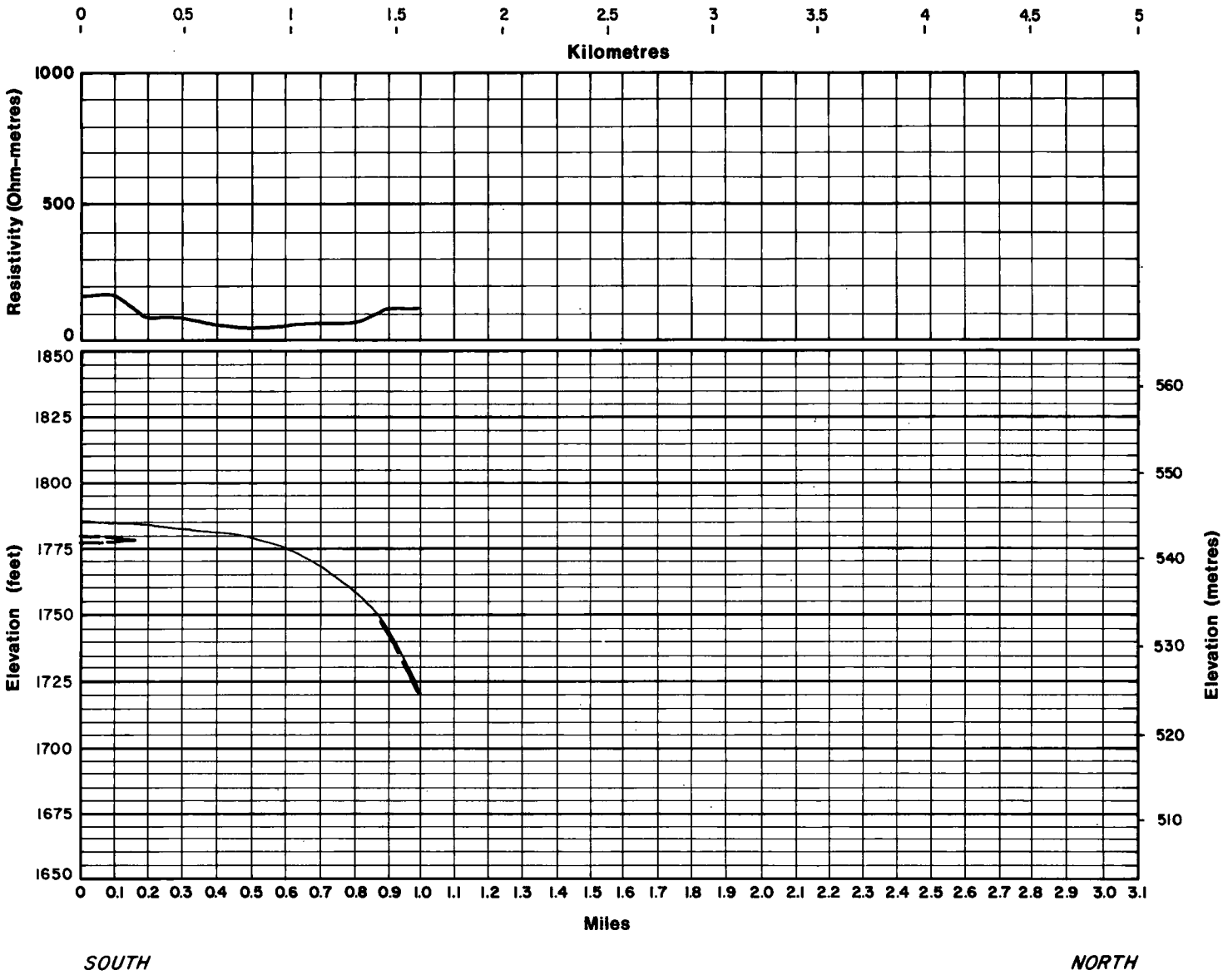
Resistivity Profile

Line 16

Plate D-27b



Legend:

Resistivity Profile *

Ground Profile

Bottom of Granular Material (As Interpreted From Resistivity Profile)

* Resistivity Readings Limited to a Maximum 1000 Ohm Metres See Text Section D-2

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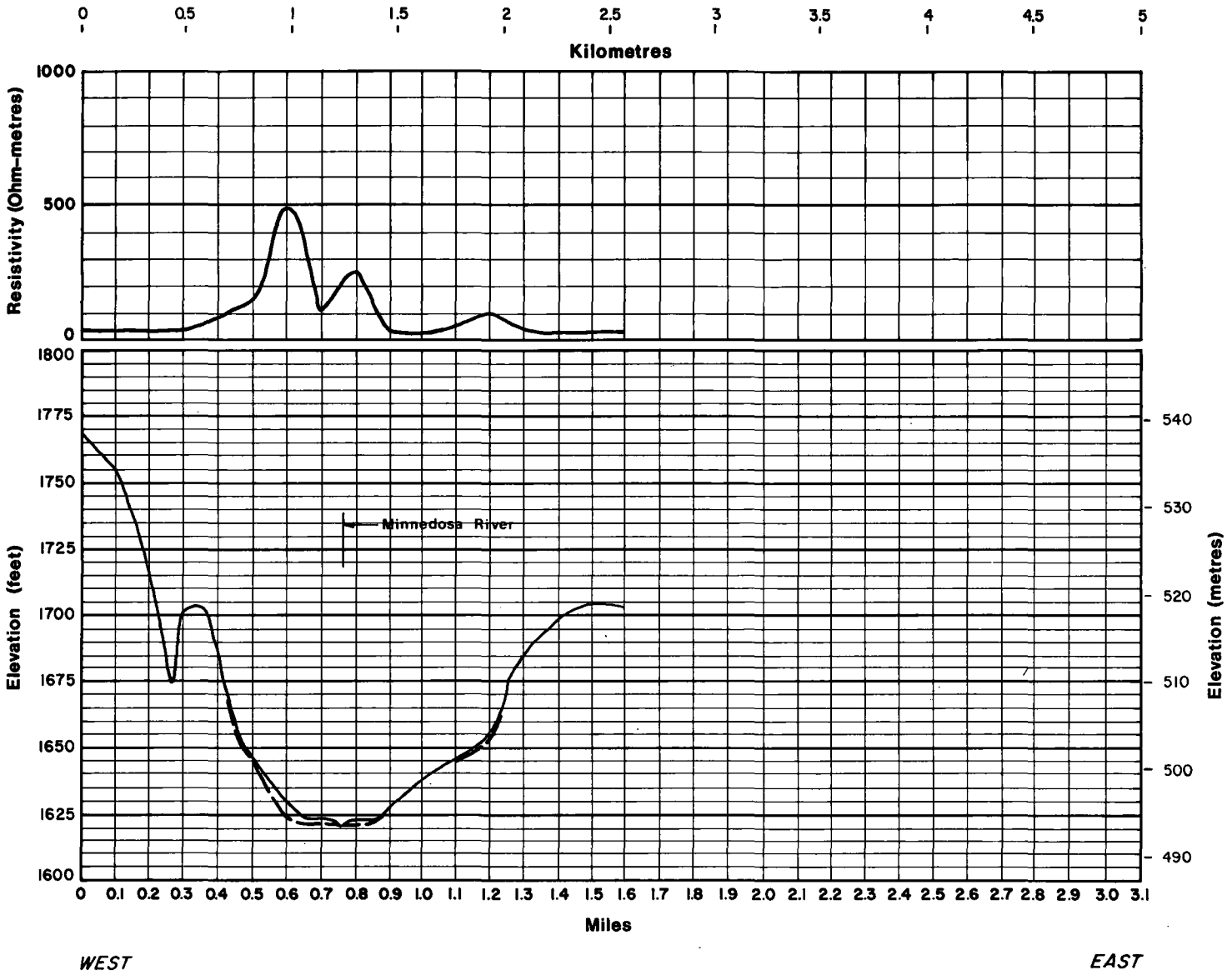
Resistivity Profile

Line 17

Plate D-28



Legend:

Resistivity Profile *

Ground Profile

Bottom of Granular Material (As Interpreted From Resistivity Profile)

* Resistivity Readings Limited to a Maximum 1000 Ohm Metres See Text Section D-2

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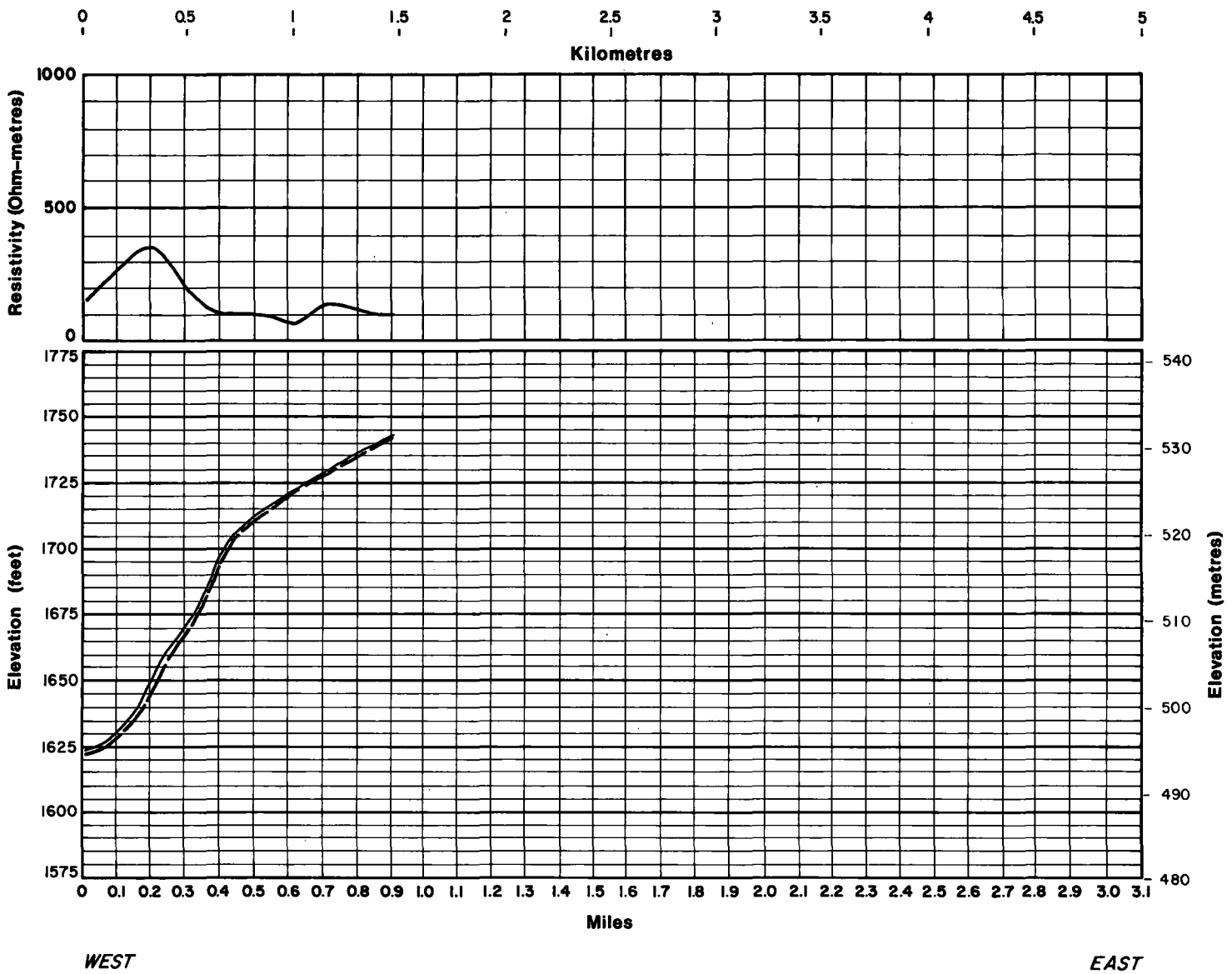
Resistivity Profile

Line 18

Plate D-29



Legend:

Resistivity Profile *

Ground Profile

Bottom of Granular Material (As Interpreted From Resistivity Profile)

*** Resistivity Readings Limited to a Maximum 1000 Ohm Metres See Text Section D-2**

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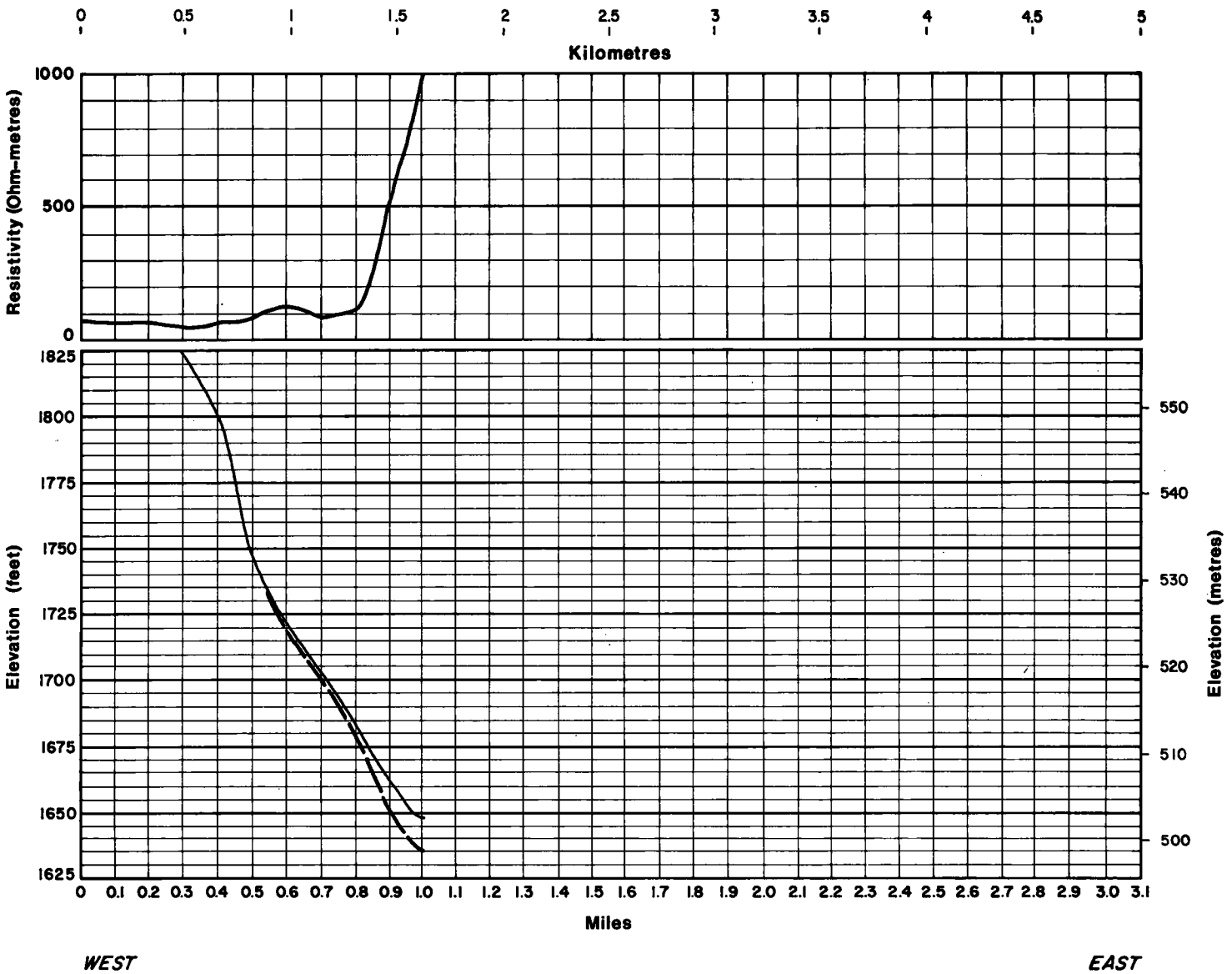
Resistivity Profile

Line 19

Plate D-30



Legend:

Resistivity Profile *

Ground Profile

Bottom of Granular Material (As Interpreted From Resistivity Profile)

* Resistivity Readings Limited to a Maximum 1000 Ohm Metres See Text Section D-2

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Resistivity Profile

Line 20

Plate D-31

8. THE SOURIS BASIN

8.1 General Geology

The Souris Basin is a broad flat expanse which has been deeply incised by the Assiniboine River. The basin forms a broad area of lacustrine sediments underlain and surrounded by glacial till. The lacustrine sediments mark the area covered by glacial lakes Hind and Souris.

Surface drainage within this physiographic region is variable. Silts and clays in the northern part of the basin are generally well drained. Drainage within the area of fine sandy deposits south of the Assiniboine is restricted. The Assiniboine River flows through the region in a broad, steep sided glacial valley with a depth of approximately 60 metres. Several small rivers, streams and creeks join the Assiniboine along its course.

Every surficial unit listed in Table D-1 is present in this physiographic region with lacustrine deposits the most commonly occurring material type. Fine lacustrine sands deposited in the Deleau - Oak Lake districts have been largely sorted and modified by wind action to produce low sand dunes. Lacustrine silt and clay is present in two large areas, north of the Assiniboine and west of Brandon. Till occurs in areas where the erosive power of the Assiniboine River has removed much of the overlying lacustrine sediment cover and in areas along the periphery of the Basin.

Alluvium and terrace deposits are found in abundance along the Assiniboine River valley. Lag concentrates occur along the Assiniboine especially near Alexander. Two outwash-deltaic fans are present within the basin, near the towns of Rivers and Virden.

The general geology of the basin is depicted on Plates D-7, D-10 and D-11 in Volume 1. The location of the basin within the study region is plotted on Plate D-3. Maps 62G12E, 62G12W, 62F9E, 62F9W, 62F10E, 62F10W, 62F15E, 62F15W, 62F16E, 62F16W, 62G13W, 62K1E, 62K1W, 62K2E and 62K2W, in Volume 2 of the report, illustrate the surficial geology at a scale of 1:50,000.

8.2 Sand and Gravel Occurrence

Sand and gravel in the Souris Basin has been deposited by several geologic mechanisms. The types of sand and gravel present in this region are:

- deltaic
- lag concentrate
- outwash
- alluvial fill and terraces.

The largest and most complex sand and gravel occurrence in the Souris Basin is the Minnedosa River outwash - delta. This deposit, shown on maps 62K1E, 62K1W and 62F16W in Volume 2 of the report, extends from northeast of Rivers, Manitoba to the Assiniboine River valley. Drill hole logs show that some portions of this feature exceed 15 metres in thickness. Considerable quantities of coarse deltaic material are overlain by younger, fine sands near Wheatland. Quality of the sand and gravel ranges from high near

the outwash-delta apex to medium and low near the Assiniboine River.

Two large areas of lag concentrate sand and gravel, produced by extensive reworking of dead-ice till, are found in the Assiniboine valley northwest of Alexander (see map 62F16W - Volume 2). The quality of these deposits ranges from high in the western portions of the deposits to low in the eastern portions. Both deposits, although containing significant quantities of high quality sand and gravel, are virtually undeveloped.

Sand and gravel deposits in the Virden-Kenton area (see maps 62F15E, 62F15W, 62K2E and 62K2W - Volume 2) are of low quality and have high shale contents. As a result of the above, the sand and gravel resources of this area are poor. One high quality sand and gravel deposit occurs 6.4 kilometres north of Virden in the Assiniboine River valley. This deposit is a former channel fill and may be pre-Wisconsinan in age.

The most unique sand and gravel deposits found in the study region are the Souris Sand and Gravel deposits. The high volcanic and chert content of this granular supports the hypothesis that this material may be pre-Wisconsinan (possibly Teritary) in age. These deposits are shown on map 62F9E in Volume 2 of the report.

No gravel deposits were found in the Oak Lake Region.

8.3 Resistivity Survey

Nine resistivity lines were run across the major outwash, delta and lag concentrate deposits. A summarization of the data interpreted from these lines follows in Table D-6.

9. SAND AND GRAVEL RESERVE ESTIMATES

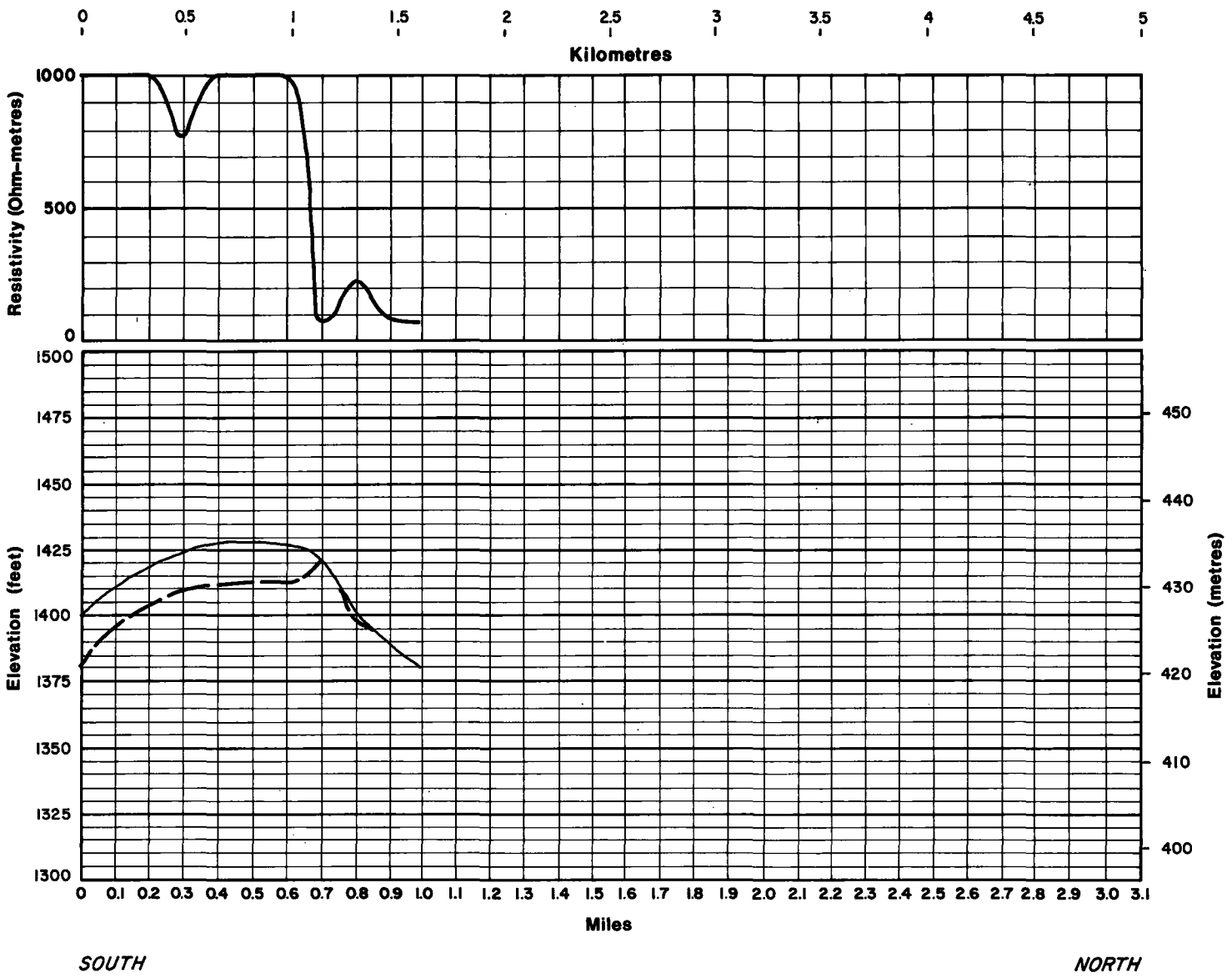
Reserve estimates for 167 sand and gravel deposits were made from a compilation of data from original air photo interpretation, field reconnaissance, resistivity surveys, backhoe test pitting and previously existing Department of Highways data. In addition to reserve estimates, a quality estimate was made for each deposit based on UMA laboratory testing as well as Department of Highways sieve analyses. Table D-7 presents the estimates of individual deposit reserves and deposit quality. Refer to Section D4.2 for a discussion regarding the gradational quality of sand and gravel.

Table D-8 lists the estimated reserve quantity and quality for each municipality in the study area. The location of municipalities comprising the Brandon region is shown on Plate C-1.

TABLE D-6

SOURIS BASIN - RESISTIVITY SURVEY

RESISTIVITY LINE	MAP	PLATE	REMARKS
RL4	62F15W	D-32	- shows 3-5 metres of deltaic sand and gravel developed over a bedrock high. This feature once formed an island in glacial Lake Hinds.
RL5	62F15W	D-33	- shows variable thickness (2-5 metres) of sand and gravel deposited on a bedrock high. This feature once formed an island in glacial Lake Hind.
RL7	62F16W	D-34	- assumed sand and gravel thickness was 5 metres - sand and gravel thickness likely exceeds 5 metres in some locations within this feature - boundaries for deposit determined from resistivity analysis correspond to air photo interpretation.
RL8	62F16W	D-35	- assumed sand and gravel thickness of 5 metres - sand and gravel thickness likely exceeds 5 metres in some locations within this feature - boundaries for deposit determined from resistivity analysis correspond to air photo interpretation.
RL9	62F16W	D-36A D-36B	- shows that the bulk of the Rivers outwash-delta is at least 5 metres thick (probably deeper in spots).
RL10	62F16W	D-37	- shows that the bulk of the Rivers outwash-delta is at least 5 metres thick (probably deeper in spots).
RL11	62F16E	D-38	- shows resistivity response of a till and outwash gravel contact near the Minnedosa River valley - resistivity analysis verified previous air photo interpretation - assumed deposit thickness of 5 metres (likely deeper in spots).
RL12	62K1E	D-39	- shows outwash and lag concentrate sand and gravel deposited on a terrace on the south wall of the Minnedosa River valley - assumed thickness of granular deposit varies from 2 to 5 metres.
RL13	62K1E	D-40	- shows north edge of outwash sand and gravel north of Rivers.



Legend:

Resistivity Profile *

Ground Profile

Bottom of Granular Material (As Interpreted From Resistivity Profile)

* Resistivity Readings Limited to a Maximum 1000 Ohm Metres See Text Section D-2

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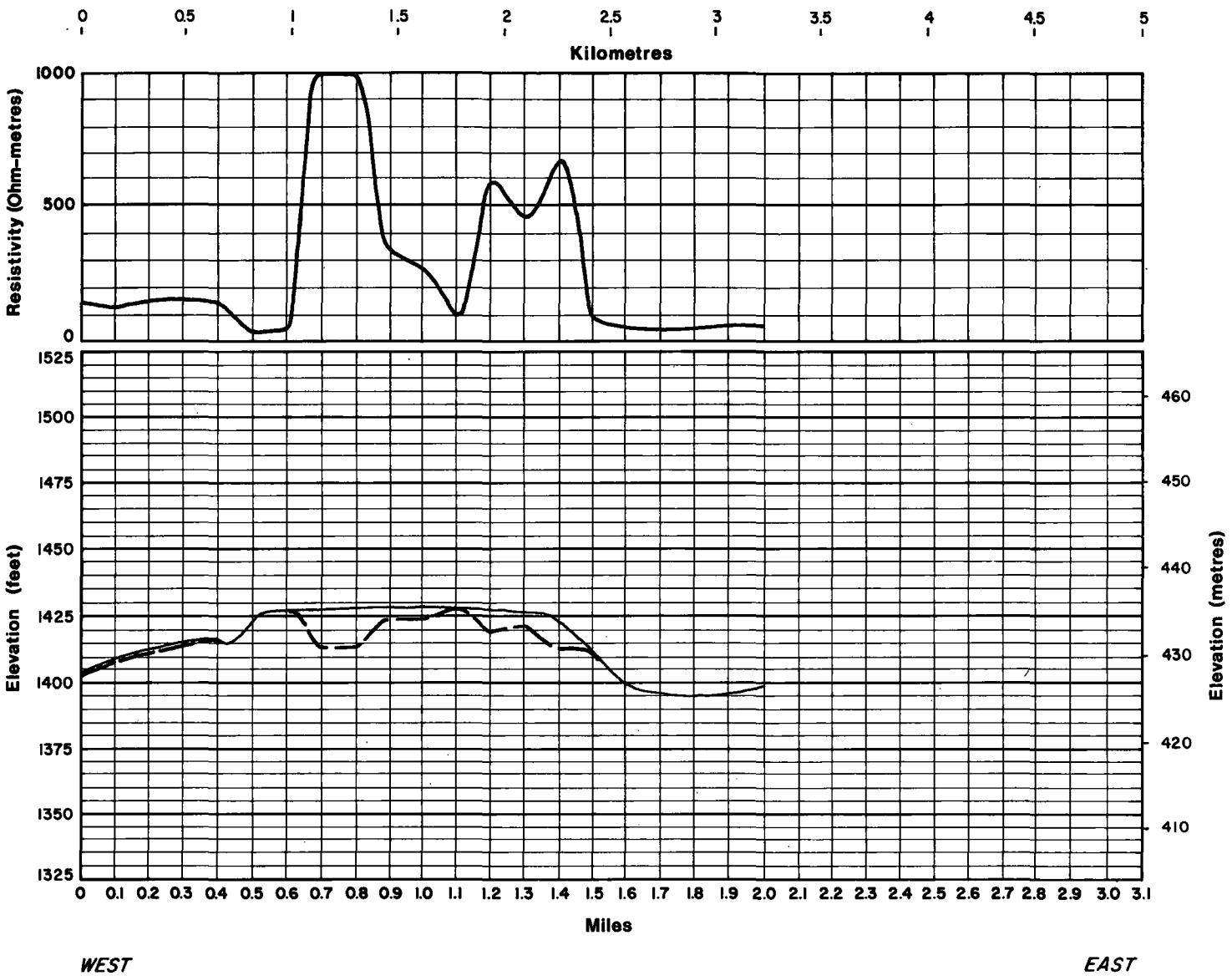
Resistivity Profile

Line 4

Plate D-32



Legend:

Resistivity Profile *

Ground Profile

Bottom of Granular Material (As Interpreted From Resistivity Profile)

* Resistivity Readings Limited to a Maximum 1000 Ohm Metres See Text Section D-2

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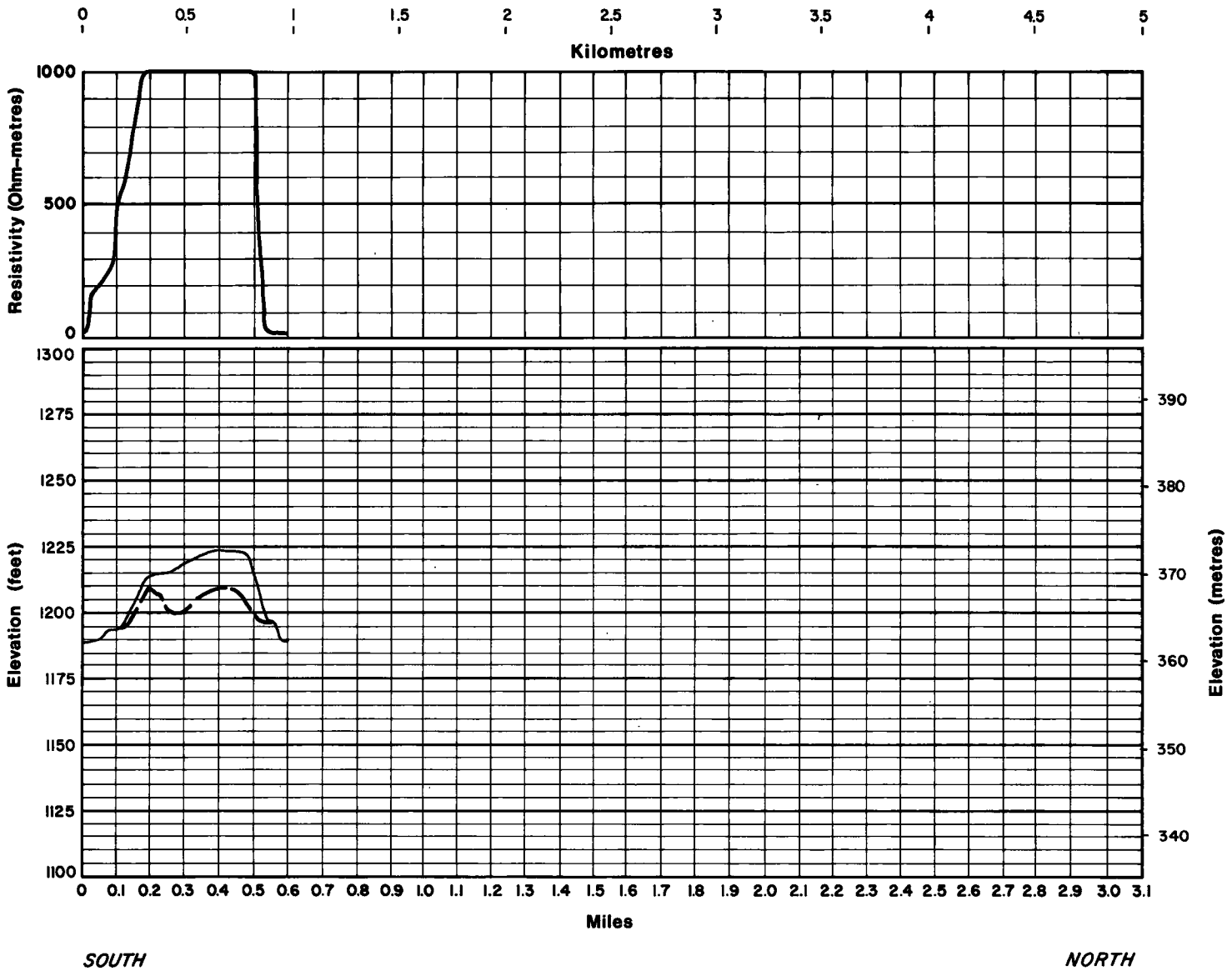
Resistivity Profile

Line 5

Plate D-33



Legend:

Resistivity Profile *

Ground Profile

Bottom of Granular Material (As Interpreted From Resistivity Profile)

* Resistivity Readings Limited to a Maximum 1000 Ohm Metres See Text Section D-2

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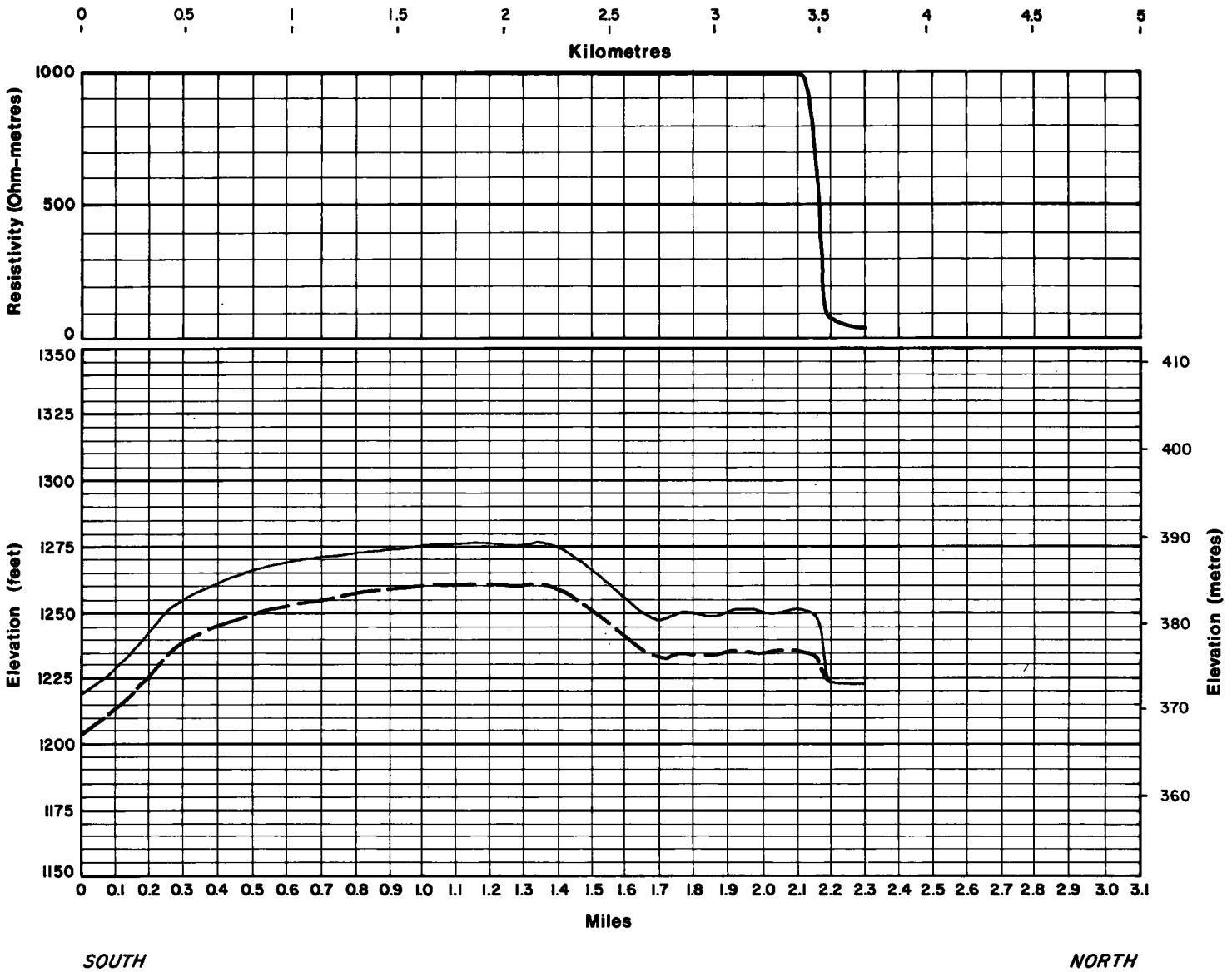
Resistivity Profile

Line 7

Plate D-34



Legend:

Resistivity Profile *

Ground Profile

Bottom of Granular Material (As Interpreted From Resistivity Profile)

* Resistivity Readings Limited to a Maximum 1000 Ohm Metres See Text Section D-2

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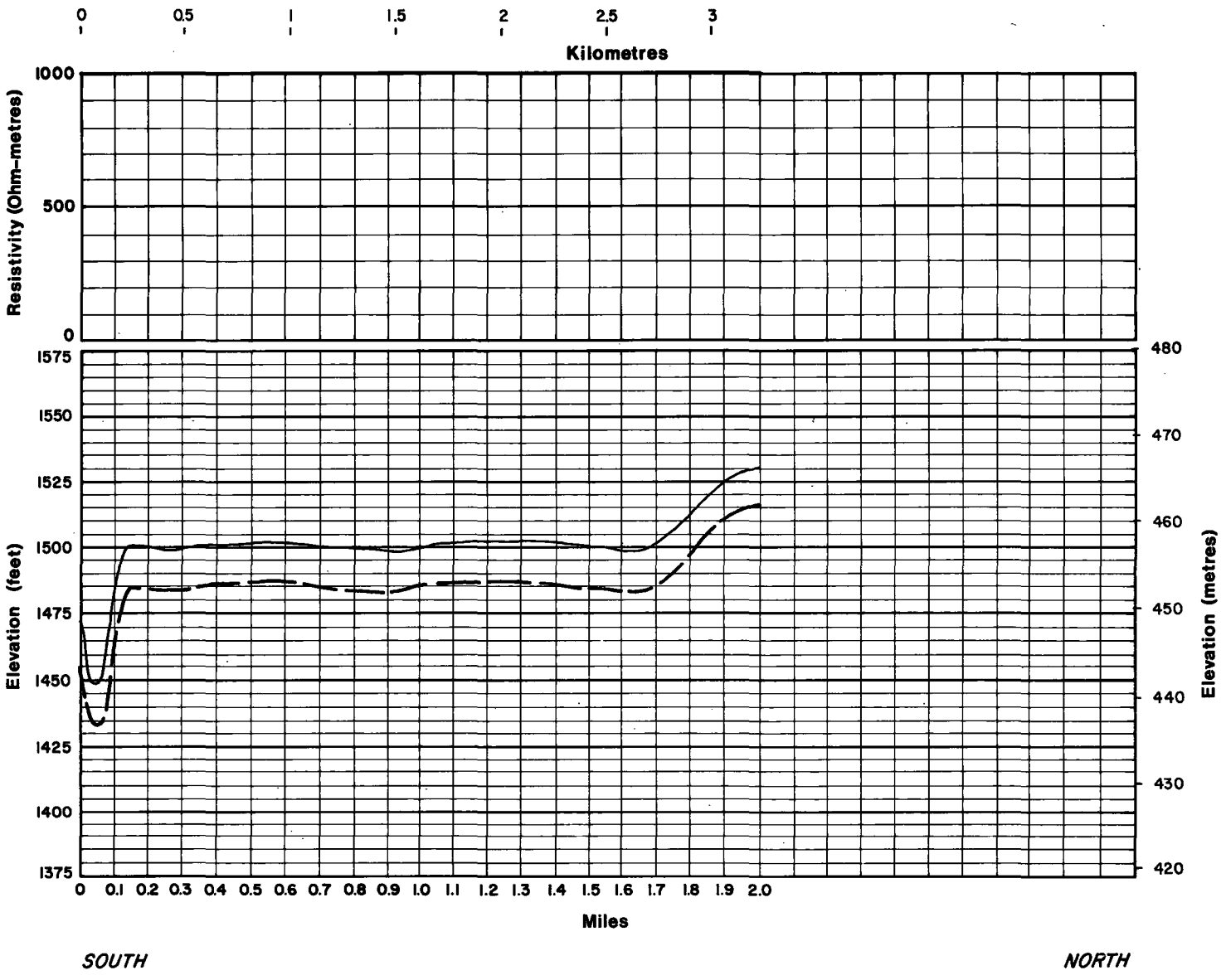
Resistivity Profile

Line 8

Plate D-35



Legend:

Resistivity Profile *

Ground Profile

Bottom of Granular Material (As Interpreted From Resistivity Profile)

*** Resistivity Readings Limited to a Maximum 1000 Ohm Metres See Text Section D-2**

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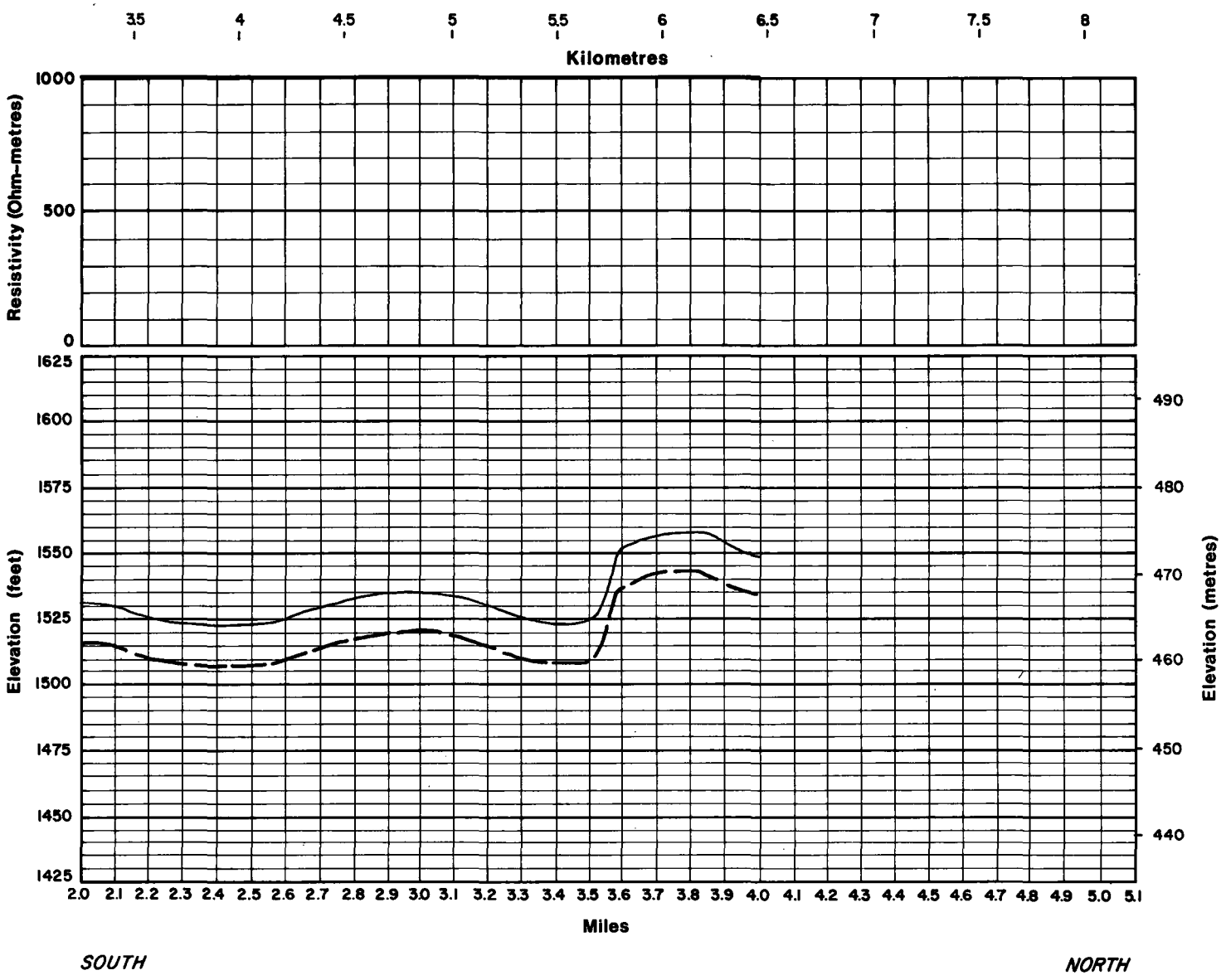
Sand and Gravel Resources of the Brandon Region

Resistivity Profile

Line 9

The UMA Group

Plate D-36a



Legend:

Resistivity Profile *

Ground Profile

Bottom of Granular Material (As Interpreted From Resistivity Profile)

* Resistivity Readings Limited to a Maximum 1000 Ohm Metres See Text Section D-2

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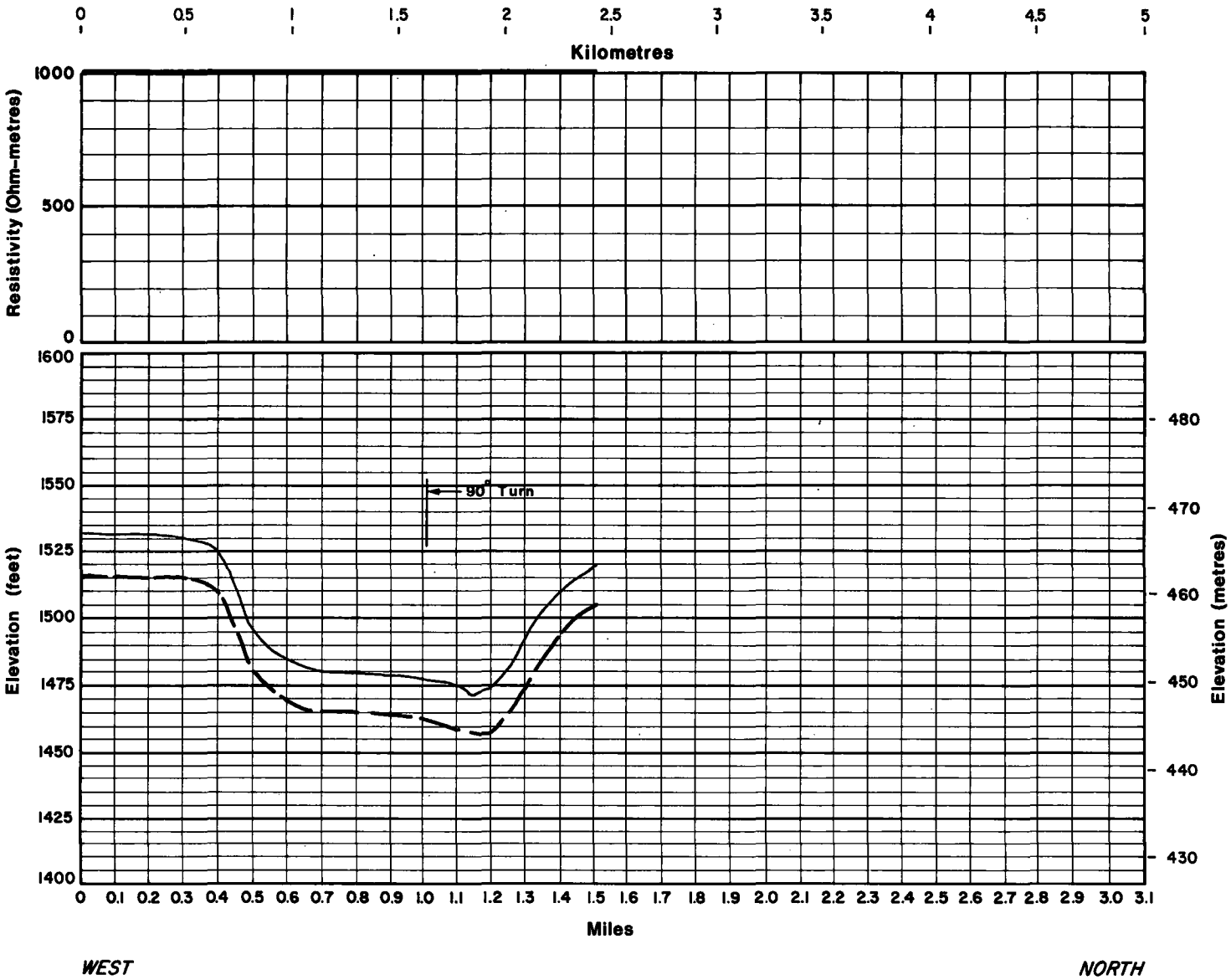
Sand and Gravel Resources of the Brandon Region

The UMA Group

Resistivity Profile

Line 9

Plate D-36b



Legend:

Resistivity Profile *

Ground Profile

Bottom of Granular Material (As Interpreted From Resistivity Profile)

* Resistivity Readings Limited to a Maximum 1000 Ohm Metres See Text Section D-2

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Sand and Gravel Resources of the Brandon Region

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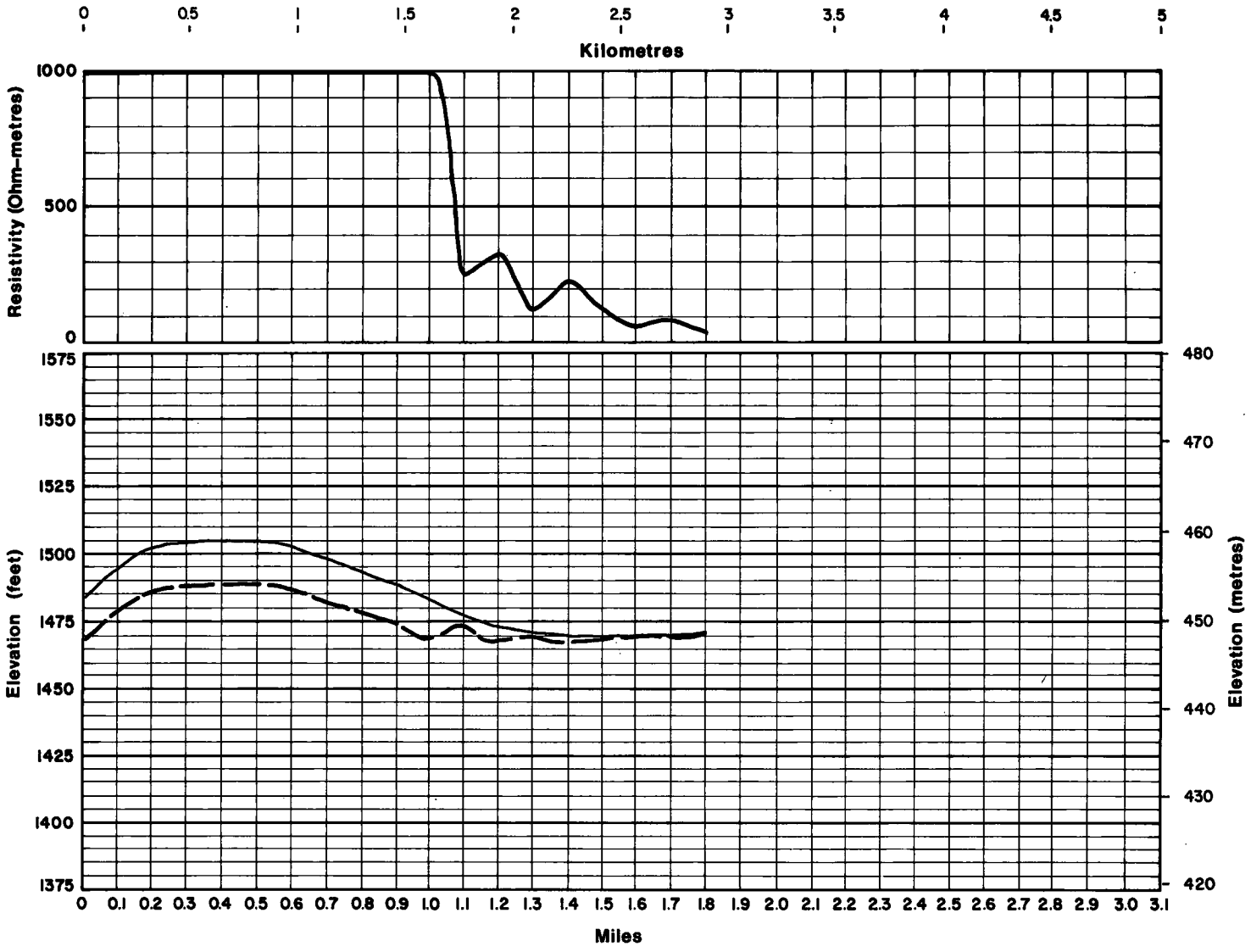
Resistivity Profile

Line 10

Plate D-37



Legend:

Resistivity Profile *

Ground Profile

Bottom of Granular Material (As Interpreted From Resistivity Profile)

* Resistivity Readings Limited to a Maximum 1000 Ohm Metres See Text Section D-2

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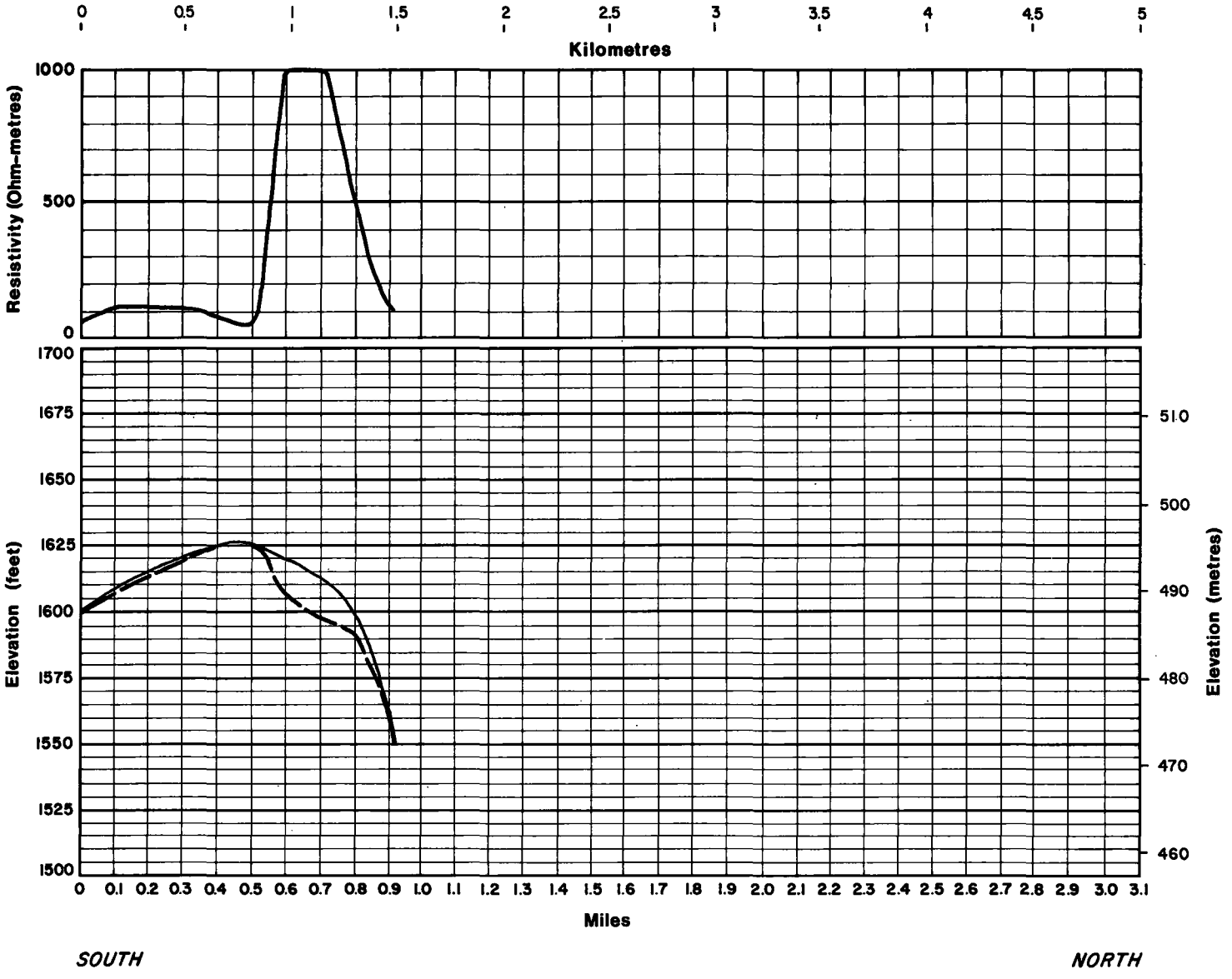
Sand and Gravel Resources of the Brandon Region

Resistivity Profile

Line 11

The UMA Group

Plate D-38



Legend:

Resistivity Profile *

Ground Profile

Bottom of Granular Material (As Interpreted From Resistivity Profile)

*** Resistivity Readings Limited to a Maximum 1000 Ohm Metres See Text Section D-2**

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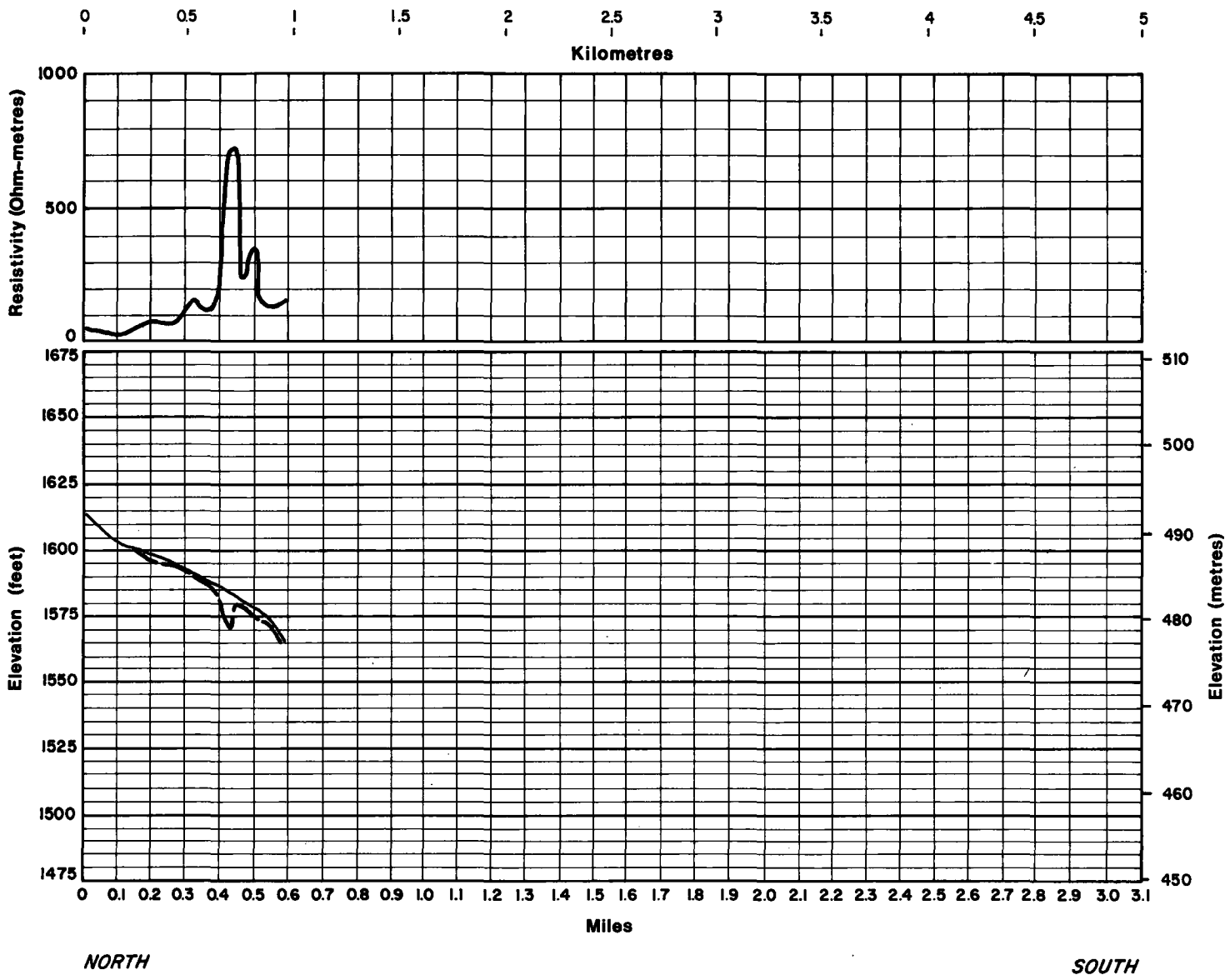
Sand and Gravel Resources of the Brandon Region

The UMA Group

Resistivity Profile

Line 12

Plate D-39



Legend:

Resistivity Profile *

Ground Profile

Bottom of Granular Material (As Interpreted From Resistivity Profile)

* Resistivity Readings Limited to a Maximum 1000 Ohm Metres See Text Section D-2

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Sand and Gravel Resources of the Brandon Region

The UMA Group

Resistivity Profile

Line 13

Plate D-40

TABLE D-7

SAND AND GRAVEL DEPOSIT RESERVE ESTIMATES

Deposit	Map	Estimated Reserves (millions of) Short Tons	Metric Tonnes	Quality Estimation Percent High	Percent Moderate	Percent Low
1	62J3E	.04	.04	—	100	—
2	62J3E	.56	.50	—	100	—
3	62J3E	.31	.28	—	100	—
4	62J3E	.08	.07	—	100	—
5	62J3E	.80	.71	—	100	—
6	62J3E	1.2	1.1	—	100	—
7	62J3E	.21	.19	—	100	—
8	62J3E	1.7	1.5	—	100	—
9	62J3E	.40	.36	—	100	—
10	62J3E	.04	.03	—	100	—
11	62J3E	.49	.45	—	100	—
12	62J3E	2.6	2.4	—	100	—
13	62J3E	.78	.71	—	100	—
14	62J3E	.33	.30	—	100	—
15	62J3E	4.7	4.3	60	40	—
16	62J3E	.31	.28	—	100	—
17	62J3E	.56	.51	—	—	100
18	62J3E	.70	.63	—	—	100
19	62J3E	1.3	1.1	—	100	—
20	62J3E	.37	.34	—	100	—
21	62J3E	.63	.57	—	100	—
22	62J3E	2.2	2.0	—	100	—
23	62J3E	.28	.25	—	100	—
24	62J3E	.19	.17	—	—	100
25	62J3E	.74	.67	—	—	100
26	62J3E	1.0	.93	—	—	100
27	62J3E	2.5	2.3	—	100	—
28	62J3E	.08	.07	—	100	—
29	62J3E	.23	.21	—	100	—
30	62J3E	.31	.28	—	100	—
31	62J3E	.37	.34	—	—	100
32	62J3E	.09	.08	—	—	100
33	62J3E	.70	.63	—	100	—
34	62J3E	1.1	1.0	—	100	—
35	62J3E	.28	.25	—	—	100
36	62G11W	1.3	1.2	—	100	—
37	62G11W	.01	.01	100	—	—
38	62G12E	1.3	1.2	—	—	100
39	62G12E	.36	.33	—	100	—

Deposit	Map	Estimated Reserves (millions of) Short Tons	Metric Tonnes	Quality Estimation Percent High	Percent Moderate	Percent Low
40	62G12E	2.0	1.8	100	—	—
41	62G12E	3.0	2.7	—	100	—
42	62G12E	1.1	1.0	100	—	—
43	62G12E	.28	.25	—	100	—
44	62G12E	8.9	8.0	—	25	75
45	62G12E	1.2	1.1	—	100	—
46	62G12W	6.3	5.7	—	—	100
47	62G13W	171.5	155.5	20	20	60
48	62G13W	167.6	152.0	20	50	30
49	62G13E	16.7	15.2	—	100	—
50	62G13E	4.3	3.9	—	100	—
51	62G13E	.37	.34	—	50	50
52	62J4E	.81	.73	10	50	40
53	62J4E	.09	.08	—	—	100
54	62J4E	.19	.17	100	—	—
55	62J4E	.55	.50	—	100	—
56	62J4E	15.9	14.4	10	90	—
57	62G12W	34.3	31.1	—	10	90
58	62G12W	27.1	24.6	—	100	—
59	62G12W	11.6	10.5	—	80	20
60	62G12W	1.2	1.1	—	100	—
61	62G13W	.31	.28	10	90	—
62	62G13W	11.9	10.8	20	40	40
63	62G13W	9.1	8.3	—	100	—
64	62G13W	.60	.55	—	—	100
65	62F16E	6.0	5.4	—	—	100
66	62G13W	60.0	54.5	50	50	—
67	62G13W	4.4	4.0	—	100	—
68	62G13W	.54	.49	—	100	—
69	62G13W	7.6	6.9	70	30	—
70	62G13W	5.1	4.6	—	50	50
71	62G13W	.77	.70	—	20	80
72	62G13W	1.6	1.4	—	100	—
73	62F16E	11.8	10.7	—	50	50
74	62G13W	4.4	4.0	—	—	100
75	62J4W	.04	.04	100	—	—
76	62J4W	.45	.41	100	—	—
77	62J4W	2.5	2.2	60	30	10
78	62J4W	12.6	11.4	40	40	20
79	62J4W	4.3	3.9	60	40	—
80	62J4W	12.6	11.4	—	100	—
81	62J4W	.23	.21	—	100	—
82	62J5W	20.8	18.9	—	70	30
83	62J5W	.04	.04	—	—	100

Deposit	Map	Estimated Reserves (millions of) Short Tons	Metric Tonnes	Quality Estimation Percent High	Percent Moderate	Percent Low
84	62F9E	.13	.12	—	100	—
85	62F9E	.22	.20	—	100	—
86	62F9E	.95	.87	—	100	—
87	62F9E	1.8	1.6	—	100	—
88	62F9E	.39	.36	—	100	—
89	62F9E	.58	.53	40	60	—
90	62F16E	.73	.66	—	—	100
91	62F16E	.54	.49	—	—	100
92	62F16E	.16	.15	—	—	100
93	62F16E	17.3	15.7	10	50	40
94	62F16E	.24	.22	—	100	—
95	62F16E	11.2	10.1	20	50	30
96	62F16E	6.7	6.1	10	50	40
97	62F16E	.21	.19	—	100	—
98	62F16E	.15	.13	—	100	—
99	62F16E	1.9	1.7	100	—	—
100	62K1E	18.9	17.1	10	70	20
101	62K1E	44.9	40.7	40	50	10
102	62K1E	1.2	1.1	100	—	—
103	62K1E	.42	.38	100	—	—
104	62K1E	.50	.45	—	100	—
105	62K1E	.09	.08	100	—	—
106	62K1E	.33	.30	100	—	—
107	62K1E	.66	.60	—	100	—
108	62K1E	.52	.48	100	—	—
109	62K1E	.31	.28	—	100	—
110	62K1E	.51	.46	50	50	—
111	62K1E	.17	.15	—	100	—
112	62K1E	.14	.13	—	100	—
113	62K1E	.05	.04	—	100	—
114	62K1E	.42	.38	—	100	—
115	62K1E	.14	.13	—	100	—
116	62K1E	.05	.04	—	100	—
117	62K1E	.24	.22	—	100	—
118	62F16W	13.2	12.0	40	40	20
119	62F16W	355.9	322.9	25	50	25
120	62K1W	.38	.34	—	100	—
121	62F16W	1.1	1.0	—	—	100
122	62F16W	119.5	108.4	10	70	20
123	62F16W	3.1	2.8	—	100	—
124	62K1E	45.2	41.0	50	40	10
125	62K1W	10.8	9.8	—	100	—
126	62K1W	3.3	3.0	—	—	100
127	62K1W	.30	.28	—	100	—

Deposit	Map	Estimated Reserves (millions of) Short Tons	Metric Tonnes	Quality Estimation Percent High	Percent Moderate	Percent Low
128	62K1W	.80	.72	40	60	—
129	62K1W	.28	.25	—	100	—
130	62K1W	.36	.33	—	—	100
131	62K1W	.28	.25	—	50	50
132	62K1W	.81	.74	50	50	—
133	62K1W	.49	.45	100	—	—
134	62K1W	.02	.02	—	100	—
135	62K1W	.13	.12	100	—	—
136	62K1W	.09	.08	—	100	—
137	62K1W	.19	.18	—	10	90
138	62K1W	.09	.08	—	70	30
139	62K1W	.55	.50	50	50	—
140	62K1W	.04	.04	—	100	—
141	62K8W	.12	.11	—	50	50
142	62K8W	.05	.04	—	30	70
143	62K8W	.09	.08	—	50	50
144	62K8W	.05	.04	—	50	50
145	62K8W	.05	.04	—	50	50
146	62K8W	.33	.30	—	50	50
147	62K8W	.37	.34	—	50	50
148	62F15E	40.8	37.0	—	30	70
149	62F15E	32.1	29.1	—	—	100
150	62F15E	25.6	23.2	—	—	100
151	62F15E	1.8	1.7	—	—	100
152	62F15E	.46	.42	—	—	100
153	62F15E	33.7	30.6	—	—	100
154	62K2E	1.1	1.0	—	—	100
155	62K2E	11.3	10.3	—	—	100
156	62K2E	.30	.27	—	100	—
157	62K7E	.02	.02	100	—	—
158	62K7E	.01	.01	—	100	—
159	62F15W	5.9	5.3	—	—	100
160	62F15W	4.4	4.0	—	—	100
161	62F15W	2.6	2.4	—	—	100
162	62F15W	9.4	8.5	25	10	65
163	62F15W	1.0	.93	—	—	100
164	62F15W	.61	.56	—	—	100
165	62K2W	9.0	8.1	—	—	100
166	62K2W	54.6	49.6	—	—	100
167	62G13W	.05	.04	—	50	50
Study Area Totals		1589.29	1441.50	18	44	38

TABLE D-8

MUNICIPALITY SAND AND GRAVEL RESERVE ESTIMATES

	Estimated Reserves		Quality Estimations		
	Millions of		Percent	Percent	
Municipality	Short Tons	Metric Tonnes	High	Moderate	Percent Low
Blanshard	3.68	3.35	33	47	20
Cornwallis	505.95	458.85	22	42	36
Daly	489.67	444.14	17	56	27
Elton	5.57	5.05	2	88	10
Glenwood	3.23	2.91	—	100	—
Hamiota	2.20	2.00	5	18	77
Langford	12.94	11.73	14	86	—
Minto	22.92	20.82	—	73	27
North Cypress	2.17	1.95	—	100	—
Oakland	77.30	70.10	—	48	52
Odanah	0.17	0.15	—	48	52
Saskatchewan	24.80	22.40	47	42	11
Sifton	—	—	—	—	—
South Cypress	7.69	6.96	40	60	—
Whitehead	136.89	124.22	36	56	8
Woodworth	253.77	230.31	8	5	87
Study Area Totals	1548.95	1404.94	—	—	—
Reserves Defined Outside Study Area					
Landsdowne	25.39	23.03	11	73	16
Minto	10.71	9.69	—	100	—
North Norfolk	0.26	0.24	—	100	—
Rosedale	3.98	3.60	—	100	—
Total Defined Reserves	1589.29	1441.50	18	44	38

SECTION E
TRANSPORTATION OF SAND AND GRAVEL

An important factor in the production and supply of sand and gravel material is the transportation of that material between the source and the user. The Brandon region has a generally well developed transportation system which provides for the transportation of granular material by both truck and rail modes. Provincial Trunk Highways, Provincial Roads, an extensive system of local section roads, and the main lines and various branch lines of the C.N.R. and C.P.R. make up the transportation system and provide access to the majority of the region.

Within the region at the present time, approximately 60 percent of the sand and gravel produced is transported by truck. The remaining 40 percent is transported by rail, and is utilized by C.N. and C.P. Rail within their own system, outside the Brandon region. As a result, all of the material utilized within the region is transported by truck.

The large number of granular sources within the region and the resulting close proximity to the user, allows haul distances to be generally less than ten miles in length at the present time. The only area within the region which requires haul distances appreciably in excess of ten miles is the Rural Municipality of Sifton. This area imports the majority of its sand and gravel requirements from the adjacent Rural Municipality of Pipestone, located outside the study area boundary.

Because the sand and gravel sources and users are spread throughout the region and an extensive transportation network exists, truck haul is the most flexible and economical means of transporting sand and gravel in the Brandon region. Truck transportation, however, is not without its problems. The majority of the transportation network consists of low standard gravel roadways. In times of unfavourable weather conditions, heavy trucks can cause a severe deterioration in the riding quality of these roads. This results in additional costs to the road authority as well as the trucking companies. In addition, weight restrictions placed on a majority of the highway system during the spring season severely restrict the amount of material which can be hauled in that period of the year. This can be circumvented by stockpiling the sand and gravel near the location of demand, but such provisions entail additional costs, which are reflected in the cost of this material. Haul distance, in relation to the number of trips per day which can be made between the source and the user, is another restriction and is reflected in the cost of the sand and gravel.

Depletion of many of the granular sources in the study area by 1996 will lead to the requirement for longer haul distances with a subsequent increase in costs. Larger trucks will likely be utilized, however the increase in fuel costs will likely offset any saving. The use of larger trucks with their heavier loads may also require additional expenditures by the various road authorities to upgrade the roadway system within the region.

SECTION F
CONCLUSIONS ON SUPPLY AND DEMAND

1. DEMAND

Section C of this report has discussed the expected demand for sand and gravel to the year 1996 and has extrapolated these requirements to the year 2026. The expected demand for high quality sand and gravel, such as required for concrete production, has been extracted from the total sand and gravel requirement. Plate F-1 graphically illustrates these expected demands. For year by year and municipality demands, reference can be made to Tables C-13, C-14, C-19, C-20 and C-21.

In summary, the expected demands are:

	CUMULATIVE TO 1996 Millions of		CUMULATIVE TO 2026 Millions of	
	Short Tons	Metric Tonnes	Short Tons	Metric Tonnes
Total Sand and Gravel	24-27	22-24	74-82	67-74
High Quality Sand and Gravel	3.8-4.2	3.5-3.8	12-13	11-12

2. SUPPLY

2.1 Sand and Gravel

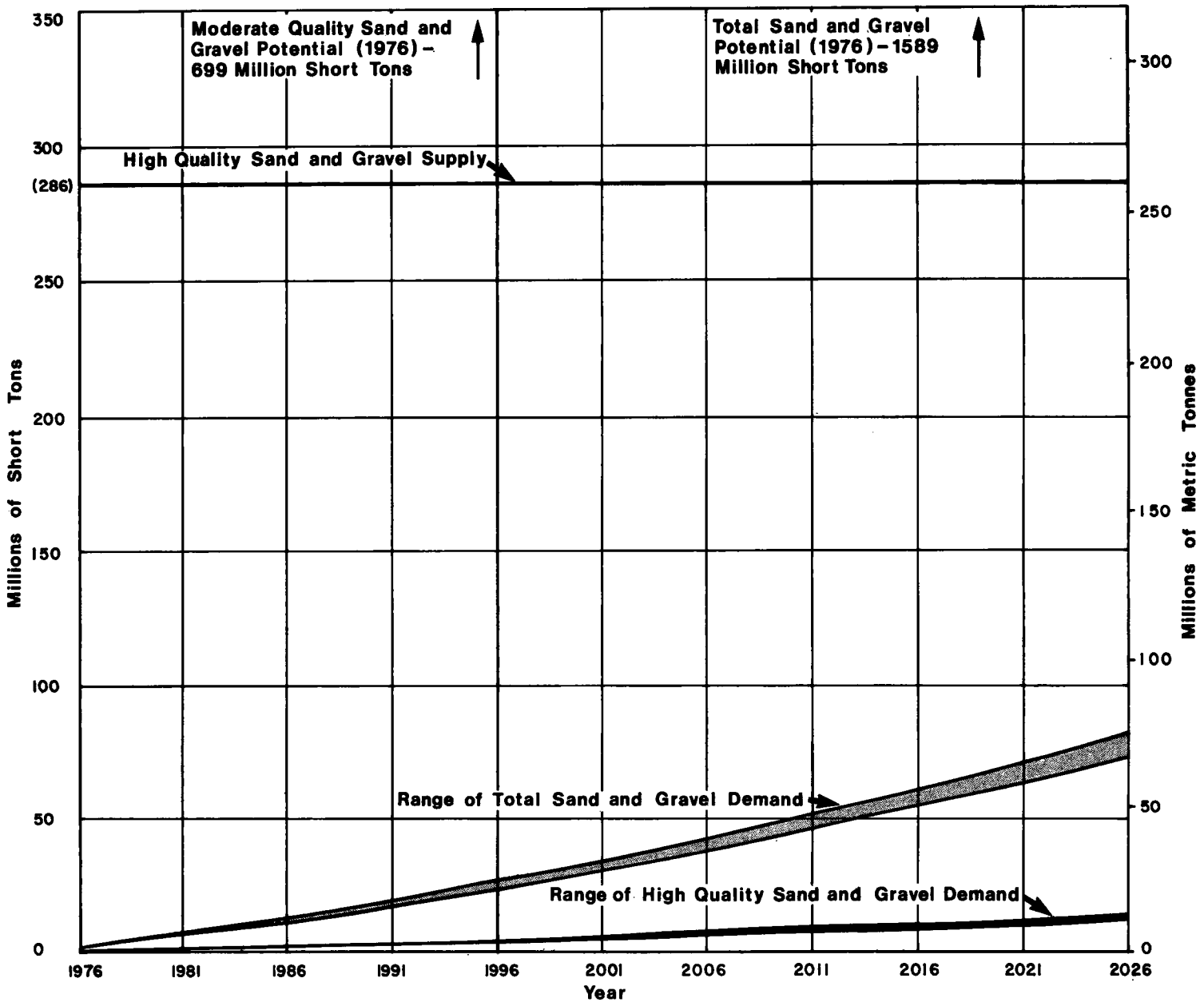
This study has indicated that the estimated reserves of high quality sand and gravel will meet requirements of the region for the next 50 years. This statement can only be made with the qualification that the estimates of available sand and gravel as presented in Section D of this report represent a judgement based upon an understanding of the geological history of the region and limited test data. However, it is considered that they do represent a reasonable assessment that is on the conservative side.

A review of Table F-1 which presents the estimated potential and demand for each municipality and Plate F-1 which presents supply versus demand for the region, leads to the following conclusions.

a. There appears to be sufficient high quality sand and gravel within the region to meet the regional demands to well beyond the year 2026.

b. If the demand for sand and gravel from a municipality is to be met with supplies found entirely from within that municipality, it appears that the Rural Municipalities of Odanah and Sifton do not have adequate sand and gravel resource potential to meet their estimated 1996 sand and gravel demands.

c. If the demand for sand and gravel from a municipality is to be met with supplies found entirely from within that municipality and assuming that projected usage figures are realized, it appears that the Rural Municipalities of Blanshard, Glenwood, Hamiota



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Supply Versus Demand

Sand and Gravel Resources of the Brandon Region

The UMA Group

Plate F-1

and North Cypress do not have adequate sand and gravel resource potential to meet their estimated 2026 sand and gravel demands.

2.2 Alternatives to Sand and Gravel

As haul costs can be expected to increase the costs of sand and gravel substantially in the near future, more thought will have to be given to alternatives to sand and gravel as an aggregate.

Examples of some alternatives requiring further study are:

a. washed granular tills
b. the use of soil cement as road base
c. lightweight aggregates.

TABLE F-1

BRANDON REGION MUNICIPALITY SAND AND GRAVEL RESERVES AND 1996 CUMULATIVE DEMAND

Municipality	1976 Reserve Estimate (Millions of Short Tons)	1996 Low Estimate Cumulative Demand (Millions of Short Tons)	1996 High Estimate Cumulative Demand (Millions of Short Tons)
Blanshard	3.68	0.68	0.77
Cornwallis	505.95	7.51	8.34
Daly	489.67	0.82	0.91
Elton	5.57	1.66	1.90
Glenwood	3.23	0.94	1.04
Hamiota	2.20	1.37	1.53
Langford	12.94	1.13	1.26
N. Cypress	2.17	1.49	1.65
Oakland	77.30	1.46	1.63
Odanah	0.17	0.97	1.08
Saskatchewan	24.80	0.78	0.87
Sifton	—	0.43	0.48
S. Cypress	7.69	0.54	0.60
Whitehead	136.89	1.06	1.18
Woodworth	253.77	1.19	1.32
Additional Reserves (see Table D-7)	63.26	—	—
Other Engineering*	—	2.20	2.45
Total	1589.29	24.24	26.94

*See Section C 1.7.3

SECTION G
LAND USE PLANNING AND ENVIRONMENTAL CONSIDERATIONS

1. LAND USE

Sequential land use planning allows aggregates to be extracted from an area with the alternative to use that land at a later date for such other uses as urban development, recreation, agriculture or forestry. A given deposit area may also be given a non-conflicting use, such as agriculture or forestry, prior to extraction.

Although it is indicated that there is sufficient high quality sand and gravel available to meet regional demand beyond the year 2026, it remains imperative that those areas indicated as having occurrences of significant quantities of moderate to high quality sand and gravel should be reserved primarily for aggregate supply with other land uses being considered secondary. Table F-1 illustrates the quantitative and qualitative potential for sand and gravel for each municipality. Detailed investigations within the municipalities will be necessary to verify the indicated potential and to allow a final judgement on land use planning priorities.

2. ENVIRONMENTAL

A definite end-use should be established for each pit or quarry area prior to aggregate extraction. Rehabilitation costs should become part of the overall cost of the aggregate production from new pits and quarries.

Where rehabilitation costs have not been considered as part of extraction costs in existing pits and quarries, incentives should be established that will encourage the producers to plan for rehabilitation. One such incentive could be a publication of ideas on how pit and quarry areas can be rehabilitated to such end use as urban or recreational, to provide a continuing income from the land after aggregates have been depleted.

An example of a major gravel extraction operation that will require rehabilitative consideration in the near future is the pit being operated by the C.P.R. at Rivers, Manitoba. Rehabilitation planning should be initiated now to minimize the effect of "after-the-fact" planning.

A fallacy which exists is that rehabilitation should return the landscape to as near the original state prior to aggregate extraction as is possible. In many cases, a properly planned and reconstructed topography could enhance either the wildlife or recreational capability of an area.

In areas where agriculture, recreation, forestry or wildlife management are now of prime concern, or where they present a rehabilition alternative, careful consideration will have to be given to extraction and rehabilitation techniques.

APPENDICES

APPENDIX 1
SURVEY RESPONDENTS

ATCHESON CONSTRUCTION LIMITED
ZENITH PAVING LIMITED
BRADLEY SAND AND GRAVEL LIMITED
L.C. BRADLEY CONSTRUCTION LIMITED
W.J. ANDERSON
CUMMING AND DOBBIE LIMITED
OVERLAND CONSTRUCTION
PHIL'S TRUCKING
C.N.R.
CRUSH RITE
MULDER BROTHERS
C & C CONSTRUCTION COMPANY LIMITED
OUTHWAITE REDI-MIX CONCRETE
SLURRY SEAL CONTRACTORS
MIDWESTERN CONCRETE PRODUCTS
WHEAT CITY CONCRETE PRODUCTS LIMITED
EISLER READY MIX
FRED KOZAK AND SONS LIMITED
WESTOBA CONTRACTORS LIMITED
CITY OF BRANDON
TOWN OF MINNEDOSA
R.M. OF CORNWALLIS
TOWN OF CARBERRY
TOWN OF RIVERS
VILLAGE OF WAWANESA
R.M. OF ODANAH
R.M. OF DALY
R.M. OF ELTON
VILLAGE OF HAMIOTA
R.M. OF HAMIOTA
TOWN OF OAK LAKE
R.M. OF BLANSHARD
TOWN OF SOURIS
R.M. OF GLENWOOD
R.M. OF OAKLAND
R.M. OF SASKATCHEWAN
VILLAGE OF RAPID CITY
R.M. OF SOUTH CYPRESS

R.M. OF WOODWORTH
VILLAGE OF GLENBORO
R.M. OF NORTH CYPRESS
R.M. OF WHITEHEAD
DEPARTMENT OF INDIAN AFFAIRS
CANADIAN FORCES BASE - SHILO
PARKS CANADA
PRAIRIE FARM REHABILITATION ACT
OVERLAND CONSTRUCTION LIMITED
C.P.R.
MANITOBA DEPARTMENT OF HIGHWAYS, PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT,
PROVINCE OF MANTIOBA
DEPARTMENT OF MUNICIPAL AFFAIRS, PROVINCE OF MANITOBA
STATISTICS CANADA

APPENDIX 2
SURVEY LETTER AND QUESTIONNAIRES

September, 1976

Dear Sir:

The engineering consulting firm of Underwood, McLellan & Associates Limited, has been commissioned by the Manitoba Department of Mines, Resources & Environmental Management to assess the current market for aggregate in the Brandon region and to forecast future requirements for the next 25 years.

As this information is not available in published form we would appreciate your completing the attached survey, using estimates for the year 1972.

Your assistance and co-operation is greatly appreciated.

Yours truly,

UNDERWOOD McLELLAN & ASSOCIATES LIMITED

BRANDON AGGREGATE STUDY
PRODUCER SURVEY
SURVEY OF 1973 BUSINESS OPERATIONS

1. NAME OF COMPANY _____

2. ADDRESS _____

3. LOCATION OF GRAVEL PIT(S) _____
(Name of Municip. in which pits are located)

OWNERSHIP OF LAND Self_____ Crown Land_____ Other_____

4. PROBABLE FINAL USE OF YOUR PRODUCTION (%):
Concrete Products _____% Other Uses _____%

5. PRODUCTION STATISTICS (1973):
Sand & Gravel _____(tons)* Cost Per Ton ($) _____ Transp. Cost _____
Crushed Limestone _(tons)* Cost Per Ton ($) _____ Transp. Cost _____
Was your 1974 production approximately the same as 1973?
If not, was it higher or lower and by what percentage? _____%

6. MAJOR CUSTOMERS IN 1973:
(Municipalities, Gov't Depts., Contractors, Concrete Product Manufacturers)

	Name	Address	Tons Purchase (Sand and Gravel)	Tons Purchase (Limestone)
a)				
b)				
c)				
d)				
e)				

(same as #5) Totals_____*

7. 1973 PRODUCTION NOT ACCOUNTED FOR IN #6 (above) AND PROBABLE END USE (%):
Residential _____% (Homes & Apt. Blocks)
Roads _____% (Bridges, culverts, sidewalks, roads, parking lots, runways)
Non-Residential_____% Other Engineering_____%

8. COMMENTS, FUTURE TRENDS IN THE INDUSTRY, CURRENT CONDITIONS, ETC.:
(Use back if necessary.)

BRANDON AGGREGATE STUDY
USER SURVEY
SURVEY OF 1973 BUSINESS OPERATIONS

1. NAME OF COMPANY _____

2. ADDRESS _____

3. AGGREGATE PURCHASES IN 1973:

   Sand & Gravel _____(tons) Costs per ton ($) _____

   Crushed Limestone _____(tons) Costs per ton ($) _____

   Were your purchases in 1974 approximately the same as 1973?

   If not, were they higher or lower, and by what percentage _____%

4. MAJOR SUPPLIERS IN 1973:

Company Name	Address	Product

5. DESTINATION OF CRUSHED LIMESTONE:

   _____roadbed _____concrete _____other

6. FINAL DESTINATION OF PRODUCTS IN 1973 (%)

   City of Brandon:_____% Other_____%
   (Town or Municip.)

7. END USE OF PRODUCT IN 1973 (%)

   Residential _____% (Homes & Apt. Blocks)

   Road Construction _____% (Bridges, culverts, sidewalks, Municip. roads, highways, parking lots, runways, etc.)

   Non-Residential _____% (Commercial Bldgs.)

   Other Engineering _____% (Sewer & Water and related engineering)

8. COMMENTS, FUTURE TRENDS IN THE INDUSTRY, CURRENT CONDITIONS, ETC.
   (Use back if necessary.)

_____

_____

_____

BRANDON AGGREGATE STUDY
MUNICIPALITIES

1. Where does the Municipality obtain its supply of aggregate?

Crown Land	Privately owned (Self/Others)	Name	Location

2. Requirements for Road Building and Maintenance (1969-1974)

	Road Building Sand/Gravel (tons)	Maintenance Sand/Gravel (tons)	Cost/ Ton	Cost/ Mile	Transportation Cost
1969					
1970					
1971					
1972					
1973					
1974					

	Road Building Limestone (tons)	Maintenance Limestone (tons)	Cost/ Ton	or	Cost/ Mile	Transportation Cost
1969						
1970						
1971						
1972						
1973						
1974						

3. Major Suppliers
4. Growth Trends in Municipality? (is 1973 a typical year)
5. Transportation Problems — Costs
6. Requirements for Other Purposes?

Ton **or** **Ton** **or**

APPENDIX 3

ALTERNATE FORECASTS OF SAND AND GRAVEL REQUIREMENTS

Appendix 3 contains alternate forecasts of construction expenditure and sand and gravel usage for the study area based on Stastics Canada's Population Projection A. Projection A assumes relatively high fertility and immigration rates but assumes that out-migration levels will also be high. This results in a slightly lower population and household forecast and consequently a lower projection of sand and gravel requirements.

In the Winnipeg region study, the alternate forecasts of total construction activity expenditure were as follows (000's 1973 Constant Dollars).

1976	$719,370
1981	$776,667
1986	$838,785
1991	$874,041
1996	$907,445

For the Brandon study area, therefore, forecasted construction expenditures are:

APPENDIX TABLE A3-1

ALTERNATE FORECAST OF CONSTRUCTION EXPENDITURES IN THE BRANDON STUDY AREA (000's 1973 Constant Dollars)

1976	$32,372 - $35,969
1981	$34,950 - $38,833
1986	$37,745 - $41,939
1991	$39,332 - $43,702
1996	$40,835 - $45,372

APPENDIX TABLE A3-2

ALTERNATE FORECAST OF CONSTRUCTION EXPENDITURE BY SECTOR IN THE BRANDON STUDY AREA (000's 1973 Constant Dollars)

	Residential	Non-Residential	Roads	Other Engineering	Total
1976	$ 9,032-$10,035	$10,521-$11,691	$7,057-$7,841	$5,762-$6,402	$32,372-$35,969
1981	$ 9,751-$10,834	$11,359-$12,621	$7,619-$8,466	$6,221-$6,912	$34,950-$38,833
1986	$10,531-$11,701	$12,268-$13,630	$8,228-$9,142	$6,719-$7,465	$37,745-$41,939
1991	$10,974-$12,193	$12,783-$14,203	$8,574-$9,527	$7,001-$7,779	$39,332-$43,702
1996	$11,393-$12,659	$13,271-$14,746	$8,902-$9,891	$7,269-$8,076	$40,835-$45,372

APPENDIX TABLE A3-3

ALTERNATE FORECAST OF SAND AND GRAVEL USAGE BY SECTOR IN THE BRANDON STUDY AREA (1976-1996)

(000's Short Tons)

	Residential	Non-Residential	Roads	Other Engineering	Total
1976	32-36	61-67	746- 829	84- 93	923-1025
1981	35-39	65-73	805- 895	90-100	996-1107
1986	38-42	71-78	870- 966	98-109	1076-1195
1991	39-44	74-82	906-1007	102-113	1121-1246
1996	41-45	76-85	941-1046	106-117	1164-1293

APPENDIX TABLE A3-4

CUMULATIVE ALTERNATE FORECAST OF TOTAL SAND AND GRAVEL USAGE IN THE BRANDON STUDY AREA (1976-1996)

(000's Short Tons)

	Sand and Gravel Demand	Cumulative Demand
1976	923 - 1,025	923 - 1,025
1981	996 - 1,107	5,684 - 6,314
1986	1,076 - 1,195	10,824 - 12,025
1991	1,121 - 1,246	16,294 - 18,102
1996	1,164 - 1,293	21,985 - 24,426

APPENDIX TABLE A3-5

ALTERNATE FORECAST OF SAND AND GRAVEL USAGE IN THE BRANDON STUDY AREA TO 2026

(000's Short Tons)

	Sand and Gravel Demand	Cumulative Demand
1996	1,168 - 1,297	22,043 - 24,535
2001	1,243 - 1,383	28,393 - 31,192
2006	1,304 - 1,451	34,730 - 38,243
2011	1,365 - 1,519	41,372 - 45,634
2016	1,426 - 1,578	48,319 - 53,365
2021	1,487 - 1,655	55,571 - 61,436
2026	1,548 - 1,723	63,128 - 69,847

APPENDIX TABLE A3-6

ALTERNATE FORECAST OF HIGH QUALITY SAND AND GRAVEL DEMAND BY SECTOR IN THE BRANDON STUDY AREA (000's Short Tons)

	Residential	Non-Residential	Roads	Other Engineering	Total
1976	31-34	42-47	51-56	24-27	148-164
1981	33-37	45-50	54-61	26-29	159-177
1986	36-40	49-54	59-66	28-32	172-192
1991	37-41	51-57	61-68	30-33	179-199
1996	39-43	53-59	64-71	31-34	187-207

APPENDIX TABLE A3-7

ALTERNATE FORECAST OF HIGH QUALITY SAND AND GRAVEL DEMAND IN THE BRANDON STUDY AREA TO 2026 (000's Short Tons)

	Demand for High Quality Sand and Gravel	Cumulative Demand
1976	148 - 164	148 - 164
1981	159 - 177	910 - 1,010
1986	172 - 192	1,731 - 1,925
1991	179 - 199	2,605 - 2,899
1996	187 - 207	3,524 - 3,910
2001	198 - 220	4,481 - 4,971
2006	208 - 231	5,491 - 6,093
2011	218 - 242	6,551 - 7,270
2016	228 - 253	7,661 - 8,502
2021	238 - 264	8,821 - 9,789
2026	247 - 274	10,029 - 11,129

APPENDIX 4

APPENDIX TABLE A4-1

SAND AND GRAVEL SAMPLE TEST RESULTS

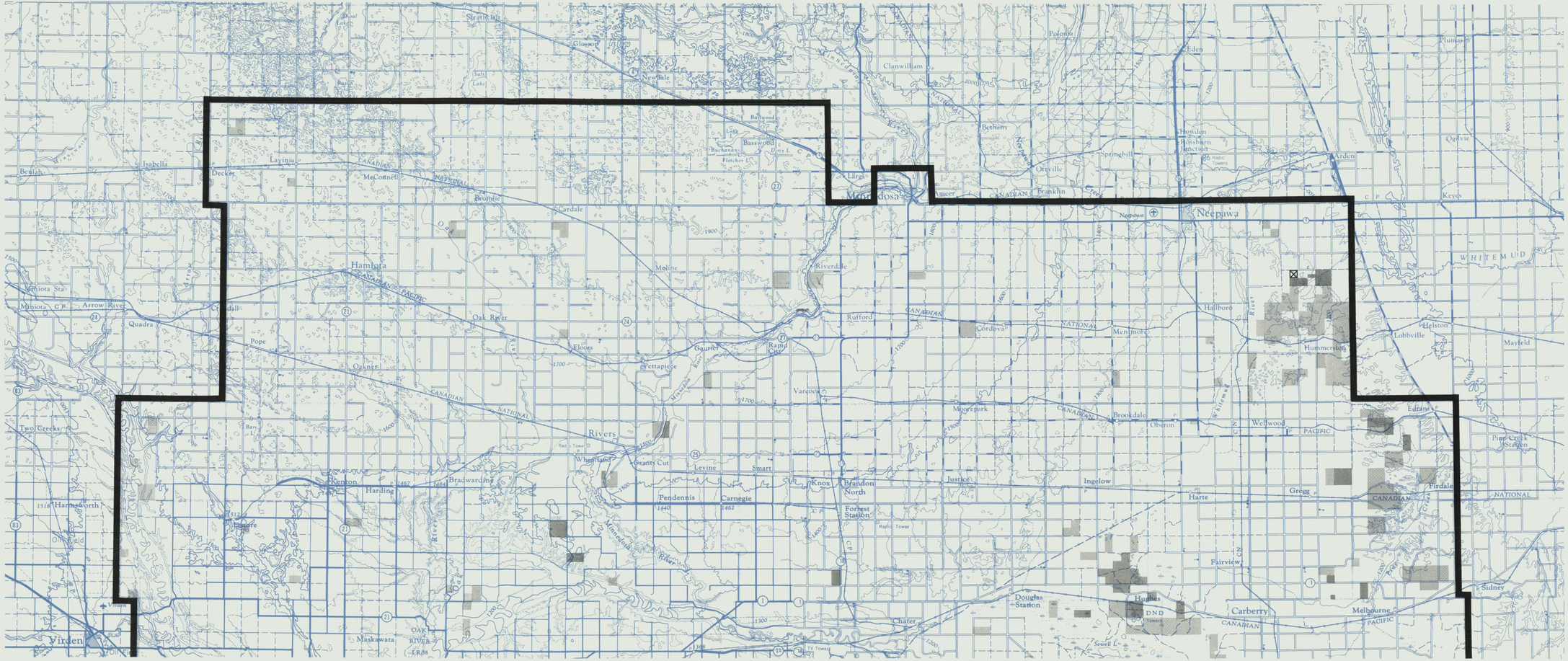
Sample		Petrographic Data (by percentage)					Fineness	Los Angeles	Soundness	
		by weight		by count						
No.	Gradation	Shale	Ironstone	Volcanics	Igneous	Carbonates	Modulus	Abrasion	Fine	Coarse
101	E	0.9	5.7	—	—	—	3.54	—	—	—
103	—	39.2*	0.5*	3.8	12.1	42.6	—	—	—	—
105	C	7.7	1.3	—	—	—	3.09	—	—	—
107	E	1.5	0.9	—	—	—	3.69	—	—	—
108	E	3.1	1.8	16.2	24.9	39.2	3.60	—	—	—
109	E	3.4	4.6	7.2	25.5	51.7	3.29	28.4	4.0	4.3
110	E	3.8	2.2	—	—	—	3.60	—	—	—
111	E	2.3	2.8	—	—	—	3.29	—	—	—
112	D	11.9	0.6	—	—	—	3.49	—	—	—
113	E	2.4	1.5	10.6	17.9	59.8	2.82	—	—	—
114	D	7.8	3.4	—	—	—	3.20	—	—	—
115	E	5.0	2.6	—	—	—	3.45	—	—	—
117	D	41.4	1.1	—	—	—	2.85	—	—	—
119	C	13.2	0	—	—	—	3.35	—	—	—
150	E	—	—	—	—	—	3.65	—	—	—
152	—	1.5	2.9	—	—	—	—	—	—	—
153	E	0.4	1.5	19.0	33.5	28.0	3.97	—	—	—
154	D	—	—	—	—	—	3.23	—	—	—
156	B	0.8	28.8	—	—	—	2.44	—	—	—
157	D	1.2	11.7	—	—	—	3.25	—	—	—
158	E	3.0*	1.9*	13.7	29.7	45.2	3.50	—	—	—
159	C	2.5	10.5	—	—	—	2.83	—	—	—
160	E	6.8	0.8	—	—	—	3.17	24.3	—	—
161	C	5.3	6.7	—	—	—	3.52	—	—	—
162	E	2.8	4.3	—	—	—	3.42	—	—	—
163	D	6.5	1.2	—	—	—	3.42	—	—	—
164	C	—	—	—	—	—	3.58	—	—	—
165	—	7.7*	1.4*	5.0	11.6	72.8	—	—	—	—
167	A	3.6	0	—	—	—	2.88	—	—	—
168	E	0.5	1.6	9.6	46.2	26.9	2.80	24.3	—	—
169	A	8.9	0.5	—	—	—	2.72	—	—	—
170	E	4.7	0.4	5.7	22.2	59.8	3.23	—	—	—
171	C	1.2	0.7	—	—	—	3.53	—	—	—
172	D	1.8	0.5	12.4	20.2	57.5	3.27	—	—	—
173	D	20.1	0.6	—	—	—	2.79	—	—	—
174	—	5.7*	1.3*	14.5	27.6	46.1	—	—	—	—
176	D	8.6	1.6	—	—	—	3.01	—	—	—
178	D	15.9	1.2	—	—	—	3.08	—	—	—
179	A	17.8	0	—	—	—	2.51	—	—	—
180	D	4.4	1.0	—	—	—	3.78	—	—	—
186	E	1.6	2.0	—	—	—	3.45	—	—	—
187	F	4.1	1.4	—	—	—	2.88	—	—	—
188	D	23.4	4.1	—	—	—	3.10	—	—	—
189	C	17.8	1.2	—	—	—	3.34	—	—	—
190	D	10.9	4.3	—	—	—	3.35	—	—	—
200	E	5.7	6.8	11.2	20.8	42.7	3.38	—	—	—
201	E	7.3	0.2	—	—	—	3.89	—	—	—
202	E	2.1	0.8	—	—	—	3.67	28.9	1.8	1.7
205	E	8.2	1.7	—	—	—	3.42	—	—	—
206	E	13.4	0.7	—	—	—	3.38	—	—	—
207	B	—	—	—	—	—	3.09	—	—	—
208	E	8.6	0.7	10.2	27.7	42.5	3.32	—	—	—
209	E	3.1	3.0	—	—	—	3.79	—	—	—

Sample No.	Gradation	Petrographic Data (by percentage) by weight Shale	by weight Ironstone	by count Volcanics	by count Igneous	by count Carbonates	Fineness Modulus	Los Angeles Abrasion	Soundness Fine	Soundness Coarse
212	E	2.5	2.6	—	—	—	2.93	29.3	—	—
213	D	9.8	0.4	—	—	—	3.21	—	—	—
214	E	12.5	1.6	—	—	—	3.67	—	—	—
250	E	6.6	0.6	—	—	—	3.34	—	—	—
251	C	14.5	1.1	—	—	—	3.13	—	—	—
252	A	8.1	0.7	—	—	—	2.60	—	—	—
253	—	4.4*	3.0*	10.8	23.2	52.9	—	—	—	—
254	—	10.8*	3.4*	8.6	26.2	47.7	—	—	—	—
256	A	19.3	0	—	—	—	2.74	—	—	—
257	B	13.3	0.5	—	—	—	3.12	—	—	—
259	(E)	4.8*	3.5*	15.2	29.7	21.4	—	—	—	—
300	—	1.4*	4.7*	5.1	26.7	58.8	—	—	—	—
301	D	2.2	2.4	—	—	—	2.72	—	—	—
302	D	3.2	3.2	—	—	—	3.88	—	—	—
303	D	1.1	0	4.6	12.1	78.2	2.46	—	—	—
304	A	34.8	0.3	—	—	—	2.22	—	—	—
305	A	1.4	1.1	—	—	—	2.33	—	—	—
306	G	1.3	2.2	—	—	—	2.42	—	—	—
307	G	0	0	—	—	—	3.26	—	—	—
308(A)	G	3.3	0.7	—	—	—	2.90	—	—	—
308(B)	E	0	0	—	—	—	3.05	—	—	—
309	G	2.9	0.7	—	—	—	2.39	—	—	—
310	G	3.7	0.8	—	—	—	2.36	—	—	—
311	G	1.3	0.6	—	—	—	2.72	—	—	—
312	G	2.8	0	—	—	—	2.43	—	—	—
350	D	5.9	2.2	8.1	31.9	29.7	2.87	—	—	—
400(A)	F	6.1	6.8	10.5	36.2	22.3	3.34	30.6	—	—
400(B)	A	12.0	1.9	10.3	30.1	21.2	2.76	—	—	—
401	C	11.2	0.3	—	—	—	3.15	—	—	—
402	A	5.9	0	—	—	—	2.41	—	—	—
403	A	0.5	0.8	—	—	—	3.15	—	—	—
404	A	16.9	0.8	4.4	17.9	25.5	2.88	—	—	—
405	G	26.8	4.6	—	—	—	2.27	—	—	—
406	E	8.4	4.8	—	—	—	4.04	—	—	—
407	B	12.4	0.4	5.5	17.1	41.5	3.21	—	—	—
408	A	5.0	1.2	—	—	—	2.69	—	—	—
409	B	49.2	1.4	—	—	—	2.88	—	—	—
410	B	5.5	0.6	—	—	—	2.99	—	—	—
411	A	0.5	0	—	—	—	2.45	—	—	—
412	C	2.4	0.3	12.1	28.0	44.0	3.19	—	—	—
413	A	66.2	0	6	16	8	2.95	—	—	—
500	C	0.3	0	—	—	—	3.67	—	—	—
501	C	tr.	tr.	8.7	21.9	68.0	3.32	—	—	—
502	E	0	0	—	—	—	2.60	—	—	—
550	D	8.6	1.3	7.5	19.5	50.2	2.95	—	—	—
551	D	15.1	0.7	—	—	—	2.80	—	—	—
552	D	8.4	0.3	—	—	—	2.75	—	—	—
553	E	6.3	1.2	—	—	—	2.98	35.3	—	—
700	E	1.2	2.6	—	—	—	3.26	—	—	—
701	F	0.5	3.6	7.8	26.2	55.7	3.14	—	—	—
703	G	5.9	4.4	—	—	—	2.26	—	—	—
704	E	1.0	1.5	—	—	—	3.21	—	—	—
705	E	0.4	0.5	—	—	—	3.14	—	—	—
750	D	2.4	3.7	—	—	—	3.24	—	—	—
751	E	2.4	0.7	—	—	—	3.81	—	—	—
752	C	20.2	0.4	—	—	—	3.31	—	—	—
753	D	43.5	1.3	—	—	—	3.00	—	—	—
754	D	31.8	2.2	—	—	—	3.40	—	—	—
755	B	18.9	0.9	—	—	—	2.96	—	—	—
756	D	6.6	1.2	—	—	—	3.27	—	—	—

Sample No.	Gradation	Petrographic Data (by percentage) by weight Shale	by weight Ironstone	by count Volcanics	by count Igneous	by count Carbonates	Fineness Modulus	Los Angeles Abrasion	Soundness Fine	Soundness Coarse
757	D	17.0	0.7	—	—	—	3.40	—	—	—
758	C	35.7	0.5	4.7	15.6	33.1	3.37	—	—	—
850	B	45.4	0.4	5.8	14.9	19.3	2.08	—	—	—
851	D	13.3	4.0	5.4	2.0	3.7	2.63	24.7	—	—
900	E	5.4	2.2	8.9	27.3	49.2	3.59	—	—	—
901	E	5.5	2.8	—	—	—	3.35	—	—	—
902	D	6.0	1.1	—	—	—	2.80	—	—	—
903	E	2.3	1.9	—	—	—	3.82	—	—	—
904	G	0.3	0.7	—	—	—	2.96	—	—	—
905	D	2.7	1.6	—	—	—	3.22	—	—	—
906	E	3.4	1.0	—	—	—	3.46	—	—	—
907	E	5.9	3.0	8.3	24.9	52.2	3.72	—	—	—
908	E	1.7	3.8	—	—	—	3.23	—	—	—
909	C	11.3	1.5	—	—	—	3.42	—	—	—
910	E	1.4	3.9	—	—	—	3.16	—	—	—
911	E	8.2	2.1	—	—	—	3.20	50.6	4.1	3.0
912	E	1.2	3.1	—	—	—	3.11	—	—	—
914	E	1.1	2.4	—	—	—	3.07	—	—	—
915	D	5.3	1.4	10.8	36.7	26.3	2.87	—	—	—
916	E	6.2	2.1	—	—	—	3.75	—	—	—
917	D	4.5	1.2	—	—	—	2.92	—	—	—
918	A	0.8	0.4	—	—	—	3.38	—	—	—
919	B	2.1	2.5	—	—	—	2.86	—	—	—
950	E	2.7	2.5	—	—	—	3.05	—	—	—
951	B	6.0	1.0	—	—	—	2.40	—	—	—
952	E	3.6	1.7	—	—	—	3.45	—	—	—

NOTE: *under Shale or Ironstone indicates percentage was attained by count rather than by weight.

APPENDIX 5
CROWN LANDS



Legend

Lands with Sand and Gravel Rights retained by Crown.

- Crown Lands
- Leased Crown Lands
- Privately Owned Lands (sold after 1930)

Lands with Sand and Gravel Rights not retained by Crown.

- Crown Lands
- Privately Owned Lands (sold before 1930)
- Study Boundary

MANITOBA
DEPARTMENT OF MINES, RESOURCES & ENVIRONMENTAL MANAGEMENT

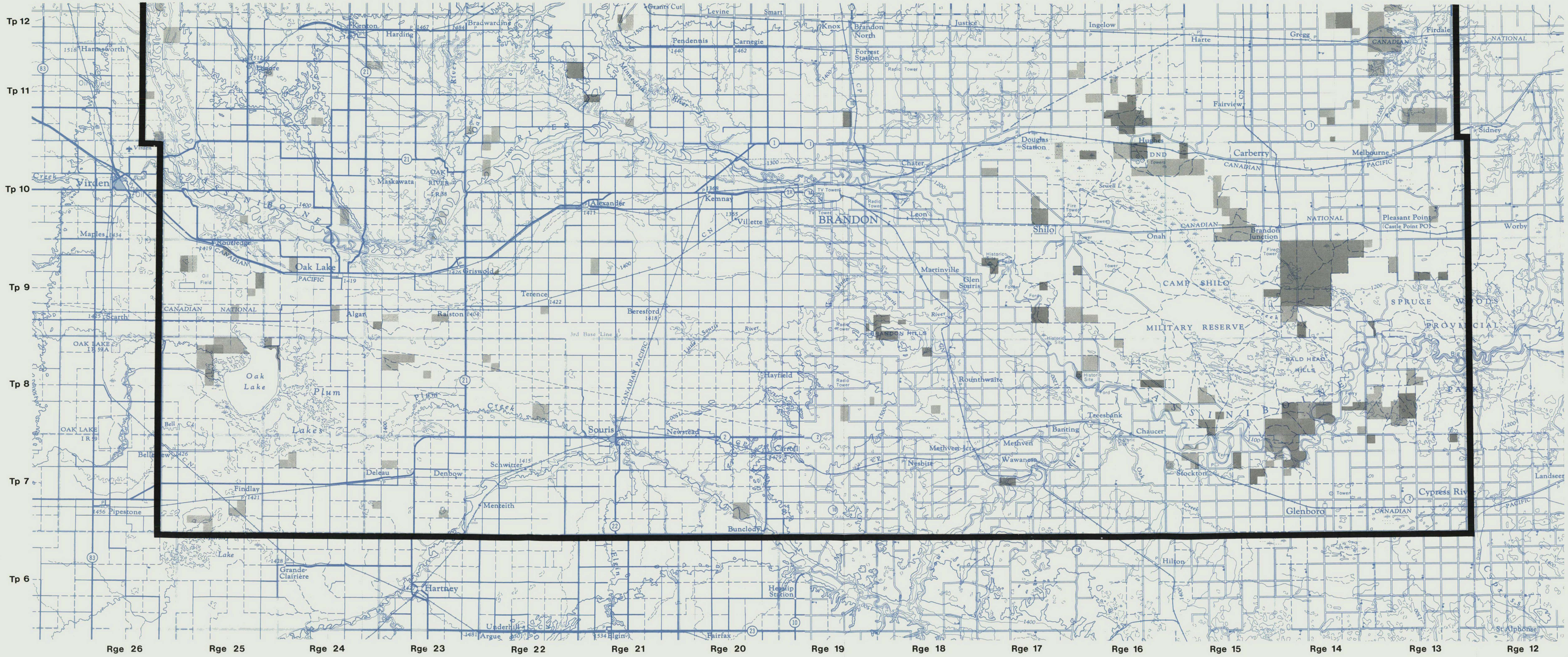
Sand and Gravel Resources of the Brandon Region

Crown Lands

0 1 2 3 5 8 Miles
0 1 2 4 8 13 Kilometres

The UMA Group

Plate A5-1



Legend

Lands with Sand and Gravel Rights retained by Crown.

- Crown Lands
- Leased Crown Lands
- Privately Owned Lands (sold after 1930)

Lands with Sand and Gravel Rights not retained by Crown.

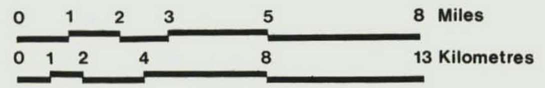
- Crown Lands ⊠
- Privately Owned Lands (sold before 1930)

Study Boundary

MANITOBA
DEPARTMENT OF MINES, RESOURCES & ENVIRONMENTAL MANAGEMENT

Sand and Gravel Resources of the Brandon Region

Crown Lands



The UMA Group

Plate A5-2

APPENDIX 6

SAND AND GRAVEL
RESOURCE POTENTIAL — DATA SOURCES

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