Ministry of
Transportation and
Communications
Ontario

REPORT EM- 50

INVESTIGATION OF PERFORMANCE OF GRANULAR BASE AGGREGATES FROM THE DUNDEE & DETROIT RIVER CARBONATE ROCKS IN ESSEX COUNTY

Engineering
Materials
Office

INVESTIGATION

of

PERFORMANCE OF GRANULAR BASE AGGREGATES

from

THE DUNDEE AND DETROIT RIVER CARBONATE ROCKS

in

ESSEX COUNTY

by

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SOILS AND AGGREGATES SECTION
ENGINEERING MATERIALS OFFICE

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TABLE OF CONTENTS

TABLE OF CONTENTS (CON'D)

LIST OF MAPS AND FIGURES

LIST OF TABLES

LIST OF PHOTOGRAPHS

APPENDICIES

1 - Letter and Survey Form MTC Soils and Aggregate Section to Essex County Townships - 1980

2 - Letter from Public Works Canada to Chris Rogers MTC Soils & Aggregate Section - 1979

3 - Notes from Visit to Chemstone Quarry - Ohio 1977

4 - Prices of Aggregate at East Windsor Dock - 1981

5 - Prices of Aggregate at Sombra Dock - 1981

1. INTRODUCTION

Three Essex County quarries, located in the Dundee and Detroit River Formations, have produced granular base aggregates for several decades. These products have been used mainly by local municipalities in Essex County and by the county itself.

The materials have also been used on MTC contracts, but it was found that their fines content (i.e., percent passing 75 µm sieve) has been above the 10 percent allowed in MTC Form 1010, for Granular A and 16 mm crushed type B. Therefore, the quarries are only approved for these uses with the restriction that each stockpile is accepted specifically for each contract.

This restriction often prevents the use of these quarries for MTC contracts because the contractors tendering have to calculate a risk factor into the granular base items which increases the bid price.

The local municipalities, on the other hand, claim that, in spite of the excess fines content, the products they use perform well when used either as a road base or untreated road surface gravel.

The purpose of this investigation was to provide recommendations concerning the acceptability of granular base aggregates currently produced by the three quarries.

2. STUDY APPROACH

In order to establish the recommendations, the following approach was used:

2.1 The geological framework of the area was studied and described from available literature (i.e., reports and maps).

2.2 The producing layers were studied in detail at the quarries during the summer of 1980. The operating faces were described, photographed and sampled. The past history of the quarries, as well as the test results of past samples, were examined and summarized. Also, wherever possible, samples of the granular base products were taken from stockpiles. The samples were tested for grain size distribution, as well as quality, in the laboratory at Downsview.

2.3 The performance of the aggregates on municipal contracts was investigated in the field. The municipalities were requested to fill out a questionnaire indicating their appraisal of the performance of the aggregates. At selected locations, samples were taken and later tested for grain size distribution at the Downsview laboratory.

2.4 The findings of the investigation were summarized and, on the basis of these, recommendations were formulated.

3. SURFICIAL GEOLOGY

A major portion of the study area is covered with a bevelled till plain. In the western part of Sandwich West, the southeast parts of Colchester South, Gosfield and Mersea Townships and along the south shore of Lake St. Clair, the till is overlain by sand plains. These sand plains were formed by the various stages of glacial lakes inundating the area after the retreat of the Wisconsin glacier.

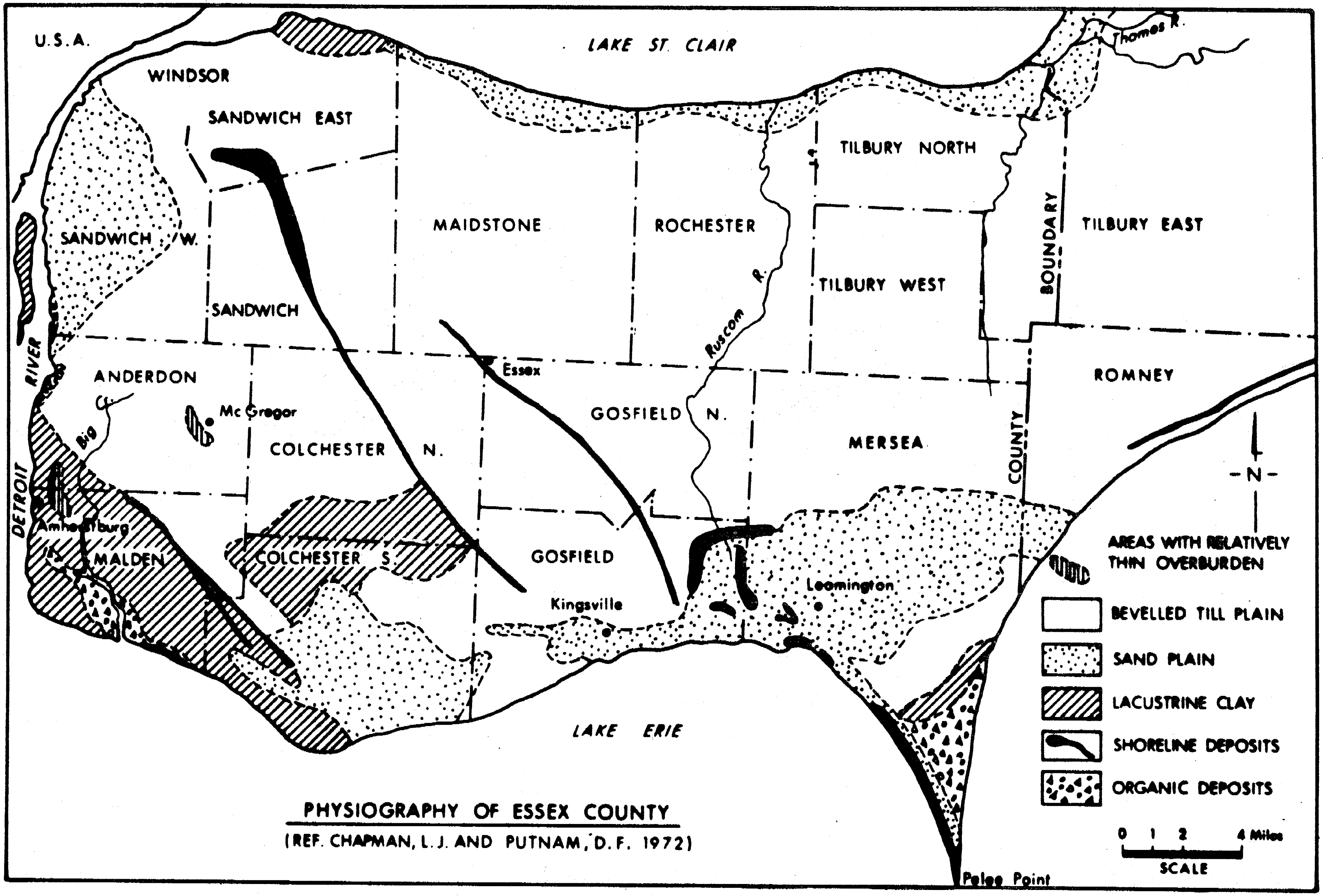
In the southwest part of the area north of Pelee Point and northwest of Windsor, the till is covered with lacustrine clay (refer to Map 1).

The county is an area of low relief which drains at a gentle gradient partly towards Lake St. Clair and partly towards Lake Erie. The only feature to break the continuity of the smooth surface is a small morainic knoll, known as the Leamington moraine, lying 35 to 50 metres above the general landscape between Leamington and Ruthven.

The thickness of the Quaternary deposits over the bedrock varies between 15 and 45 metres with three exceptions:

<u>The Area East of Amherstburg</u>: the bedrock surface at this location is the highest subsurface elevation in the county and is only covered with 4 to 8 metres of clay overburden.

<u>The Area South and West of the Village of McGregor</u>: the bedrock elevation is approximately 6 to 10 metres below the surface.

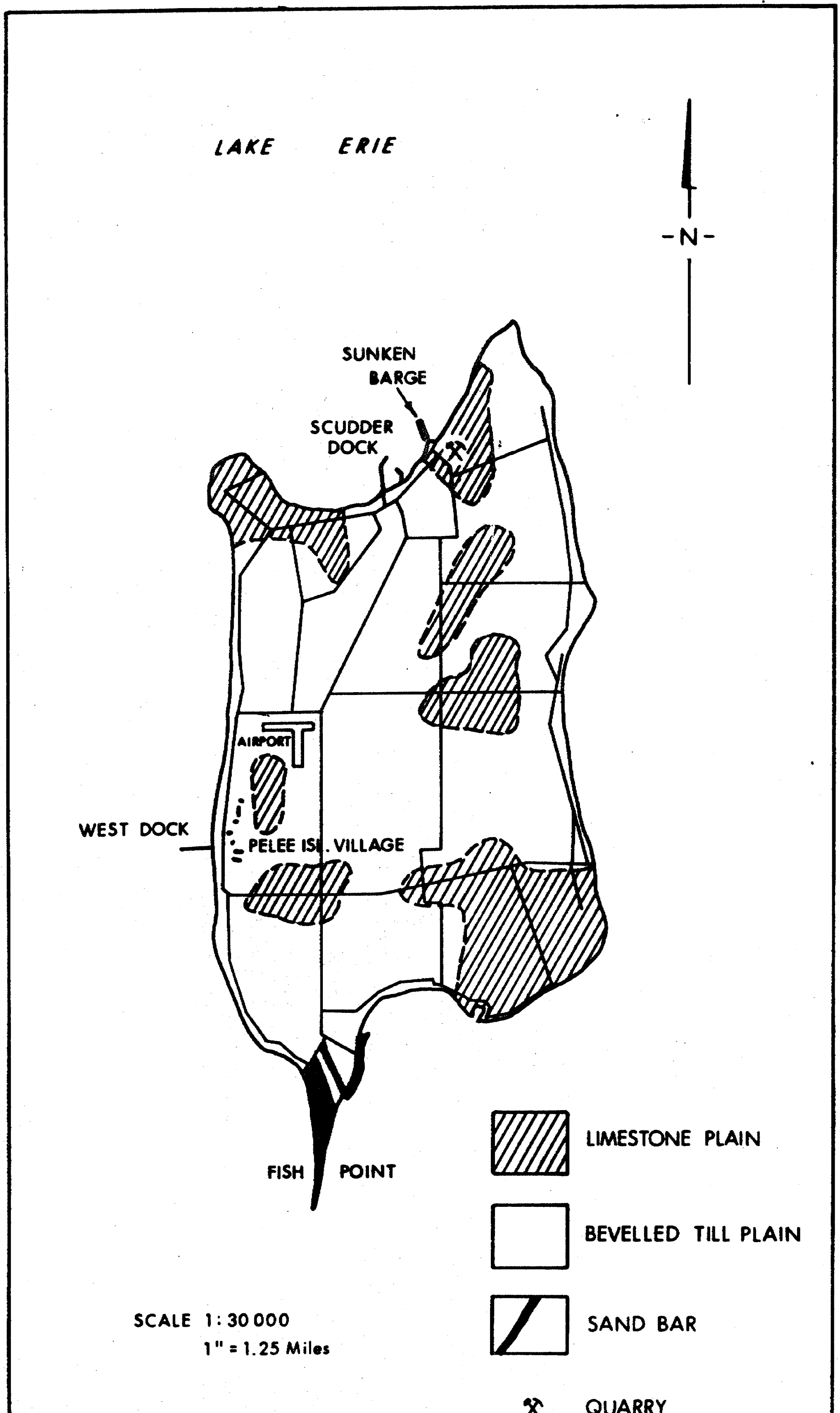


PHYSIOGRAPHY OF ESSEX COUNTY

(REF. CHAPMAN, L.J. AND PUTNAM, D.F. 1972)

MAP 1

Pelee Island: the northern and southern parts of the Island are covered by a relatively thin (0.5 - 2 m) layer of till. In some areas, the bedrock is exposed at the surface. The middle portion of the Island is traversed by a 30 m deep east to west trending subsurface valley which is not filled by glacial till (Map 2).



PHYSIOGRAPHY OF PELEE ISLAND

(REF. CHAPMAN, L.J. AND PUTNAM, D.F. 1972)

MAP 2

4. SAND AND GRAVEL RESOURCES

All gravel pits in Essex county still containing aggregates are located in the shoreline deposits of glacial lakes (refer to Map 1).

The gravel resources are extremely limited. Aside from a few isolated pockets, there are no workable deposits suitable for the production of crushed aggregates. In the past, small quantities of gravel were extracted from the area north of Leamington and at the south point of Pelee Island, but these deposits are now depleted or unavailable due to environmental constraints.

Sands and some sandy fine gravels are found in approximately thirty pits situated in Mersea, South and North Gosfield and Colchester North Townships. The majority of these pits are located at the shoreline fringe of the morainic knoll between Leamington and Ruthven. The sand sources are capable of supplying granular subbase aggregates as well as hot mix asphaltic concrete and mortar sands.

The sand deposits of Pelee Island are generally small and too finely graded for crushed products, and are only suitable for subbase aggregates.

5. GENERAL DESCRIPTION OF DEVONIAN ROCKS OF SOUTHWEST ONTARIO

5.1 STRUCTURAL FEATURES

The Precambrian basement rocks of Southwestern Ontario are overlain by a succession of sedimentary rocks of Paleozoic Age, (including the Devonian) with a maximum thickness of nearly 1,500 m. These sediments in Essex County have been investigated to the Precambrian with drill holes by the petroleum and natural gas industry.

The study area is located at the meeting of several regional structural features (see Map 3):

- the Michigan Basin to the north and the west
- the Appalachian Basin to the southwest and south
- the Chatham Sag immediately to the northeast
- the Findlay Arch to the southwest
- the Algonquin Arch to the northeast.

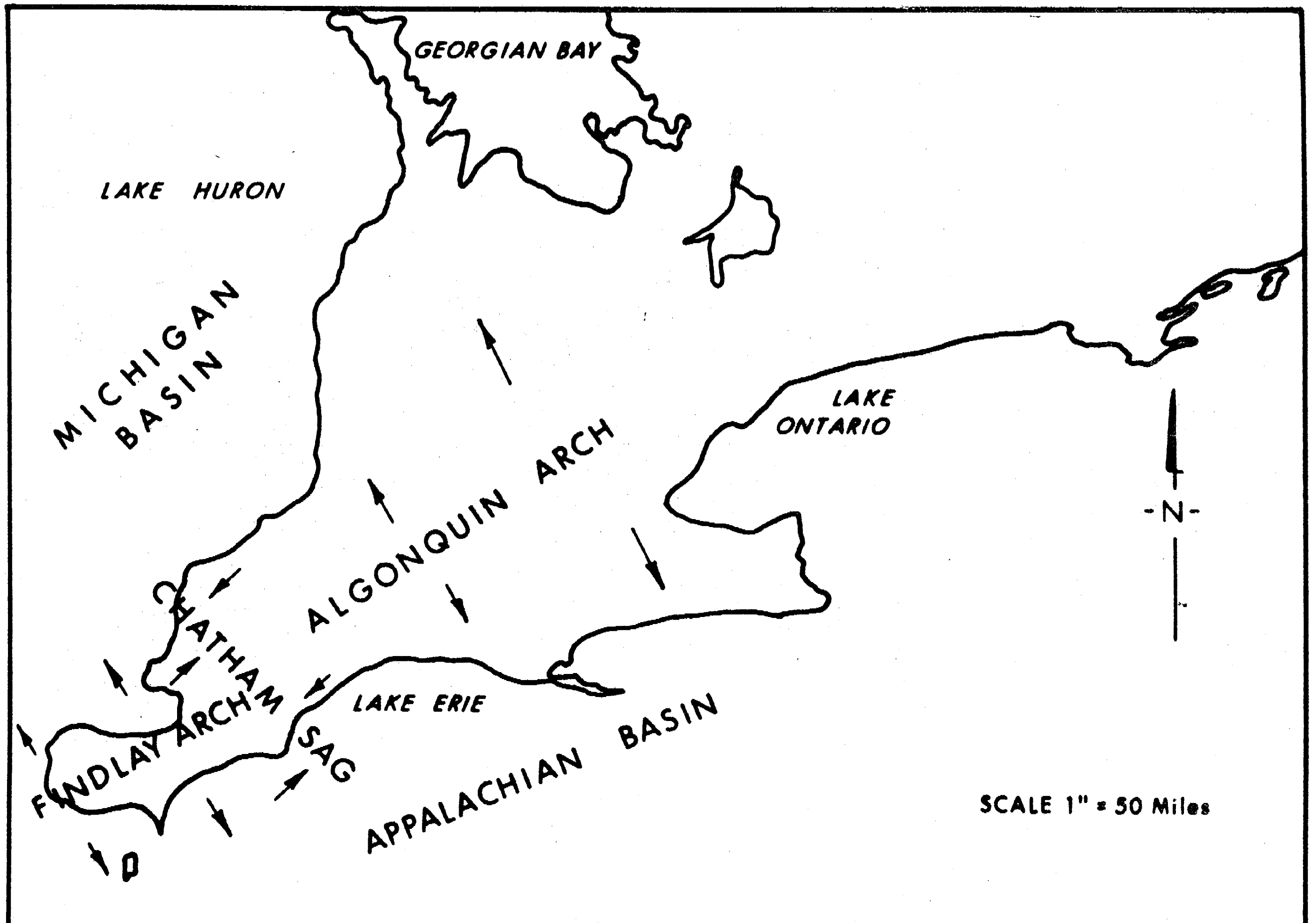
The structural attitude of the study area was affected locally by the following:

- tectonic deformation
- collapse caused by dissolution of underlying salt strata
- draping of sediments over organic reefs.

The Devonian formations of Essex County dip slightly to the southwest at an average of 0.2 m per km (Brigham, 1971).

5.2 STRATIGRAPHY

The rocks of the Devonian System in southern Ontario are located at or near the surface in two areas. One is a



REGIONAL STRUCTURAL FEATURES OF SOUTHWEST ONTARIO

(REF. R.J. BRIGHAM, 1971)

MAP 3

band extending from Fort Erie to Kincardine, the second stretches at the west side of the Chatham depression from Ohio through Pelee Island along the Detroit River to northern Michigan. (see Map 4 and Table 1)

5.2.1 Oriskany Sandstone

The lowest formation of the Devonian System, the Oriskany Sandstone, disconformably overlays the Silurian Bertie-Akron dolostones. The only known exposed deposit of Oriskany Sandstone in Ontario is found in the Town of Haldimand (formerly Oneida and North Cayuga Townships). Its thickness rarely exceeds 5 m (Hewitt, 1966). The sandstone practically disappears towards the west and the limestones of the Bois Blanc overlie the eroded surface of Silurian rocks.

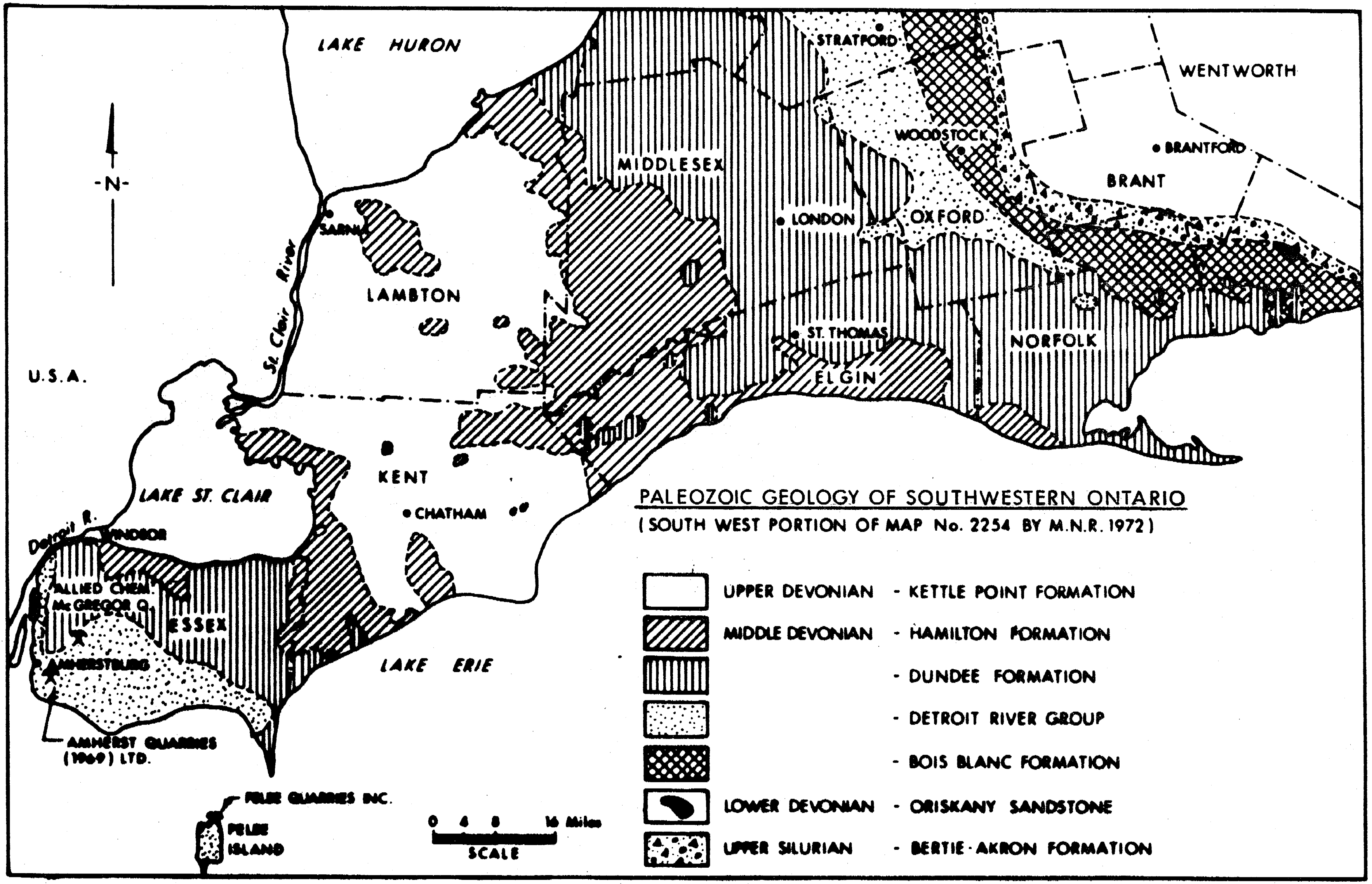
5.2.2 Bois Blanc Formation

The Bois Blanc Formation extends in a band approximately 5 km wide from Fort Erie through Hagersville and Listowell to Port Elgin. It consists of medium bedded cherty limestone. The thickness of the formation varies from 0 to 75 m.

The same formation is also present on the west side of the Chatham depression in the subsurface of most of the Michigan Peninsula, but it thins considerably southward. It is difficult to find in Essex County and it is not located under Pelee Island (B.V. Sanford and W.B. Brady, 1955).

5.2.3 Detroit River Group

Most of the investigated area is underlain by later rocks of Middle Devonian Age known as the Detroit River


LAKE HURON
WENTWORTH
STRATFORD
WOODSTOCK
BRANTFORD
BRANT
MIDDLESEX
LONDON
OXFORD
SARNIA
St. Clair River
LAMBTON
ST. THOMAS
NORFOLK
ELGIN
U.S.A.
-N-
KENT
CHATHAM
LAKE ST. CLAIR
Detroit R.
WINDSOR
ALLIED CHEM.
McGREGOR Q.
ESSEX
AMHERSTBURG
AMHERST QUARRIES (1969) LTD.
LAKE ERIE
PELEE QUARRIES INC.
PELEE ISLAND
0 4 8 16 Miles
SCALE
PALEOZOIC GEOLOGY OF SOUTHWESTERN ONTARIO
(SOUTH WEST PORTION OF MAP No. 2254 BY M.N.R. 1972)
UPPER DEVONIAN - KETTLE POINT FORMATION
MIDDLE DEVONIAN - HAMILTON FORMATION
- DUNDEE FORMATION
- DETROIT RIVER GROUP
- BOIS BLANC FORMATION
LOWER DEVONIAN - ORISKANY SANDSTONE
UPPER SILURIAN - BERTIE-AKRON FORMATION

MAP 4

DEVONIAN ROCKS
IN
CENTRAL AND SOUTHWESTERN ONTARIO

SYSTEM		GROUP	FORMATION	LITHOLOGY
DEVONIAN	UPPER	KETTLE POINT		SHALE
	MIDDLE	HAMILTON		SHALE
		DUNDEE		LIMESTONE
		DETROIT RIVER	LUCAS	LIMESTONE, DOLOSTONE
			AMHERSTBURG	LIMESTONE, DOLOSTONE
			SILVANIA	SANDSTONE
	LOWER	BOIS BLANC		LIMESTONE
		ORISKANY		SANDSTONE
SILURIAN				

TABLE 1

Group, but no natural outcrops are present. The geological information of this formation is based mainly on logs from natural gas and oil drilling.

The Detroit River Group has an outcrop distribution similar to the Bois Blanc Formation. An eastern band stretches from Fort Erie to Kincardine on Lake Huron. The rocks in that band are divided into two facies, the northern composed of limestone, the southern mainly dolomitic with interfingering of the two facies in the St. Marys area.

A second area can be found in the investigated quarries on the west side of the Chatham depression and extends along the Detroit River to northern Michigan. Its thickness in Essex County varies from zero at the southeast end to 300 m in the northwest part. The formation in the western band is represented by interbedded limestones and dolostones. On both sides of the Chatham depression, some of the beds of the Detroit River Group are of high purity calcium carbonate and are used in chemical lime production.

The Detroit River Group is subdivided into the following units:

- Lucas Formation
- Amherstburg Formation
- Sylvania Sandstone

The basal part of the Detroit River Group - Sylvania Sandstone - is not present in the eastern band, but it is found in up to 100 m in thickness in isolated localities in Michigan. In Essex County, it is found only in the subsurface. A 23 m layer is present in the salt mine shafts (at 100 - 130 m depth) south of Windsor. This formation was also encountered in the numerous silica exploration drillings carried out in the area by the glass industry showing the maximum thickness of 38 m.

The Amherstburg Formation consists of buff to brown limestones and dolostones with bituminous partings. This formation is not exposed in the investigated quarries.

The Lucas Formation is found in the Allied Chemical-McGregor Quarry and Amherst Quarries (1969) Inc. quarry. The formation consists of dolostones, dolomitic limestones and limestones in a wide range of colours, hardness and porosity. Some of the limestone, being of high purity calcium carbonate, is used in chemical lime production.

5.2.4 Dundee Formation

The Lucas Formation is overlain by the Dundee Formation. The patches of sandy carbonate or sandstone with occasional light grey chert found on top of the Lucas beds which are classified as the base of Dundee Formation may represent remnants of the Columbus Formation.

The Dundee Formation extends in wide bands on both sides of the Chatham sag parallel to the Detroit River Group. In Essex County, it lies immediately below glacial drift and makes up most of the local bedrock. The formation is exposed in the Amherst Quarries (1969) Ltd. and Pelee Quarries (1969) Inc. properties. It consists of buff, massive bedded, porous, absorptive limestone and dolomitic limestone. Fifteen m of this is exposed at the

Brunner Mond Quarry (presently under water).

The Dundee Formation is quarried extensively in Ohio and in northern Michigan, as well as in Ontario in quarries located on the east arm of the Chatham depression.

5.2.5 Hamilton Formation

The Hamilton, the highest Middle Devonian Formation, is limited in Essex County to the area adjacent to Lake St. Clair and is not found in outcrops. It consists of shale interbedded with limestone. Because of its shaly nature and poor quality, it lies outside the scope of this report.

5.2.6 Kettle Point Formation

The Kettle Point Formation is the only upper Devonian Formation of southern Ontario. It consists of black bituminous shale, and lies outside of investigated area. (in Lambton and Kent Counties).

6. AGGREGATE RESOURCES FROM CARBONATE ROCKS

The main sources of crushed aggregates of Essex county, apart from those imported from the United States, are three open quarries. These are:

- Allied Chemicals of Canada Ltd., McGregor Quarry
- Amherst Quarries (1969) Inc.
- Pelee Quarries Ltd.

The producing carbonate rocks in these quarries are the Lucas Formation and the Dundee Formation.

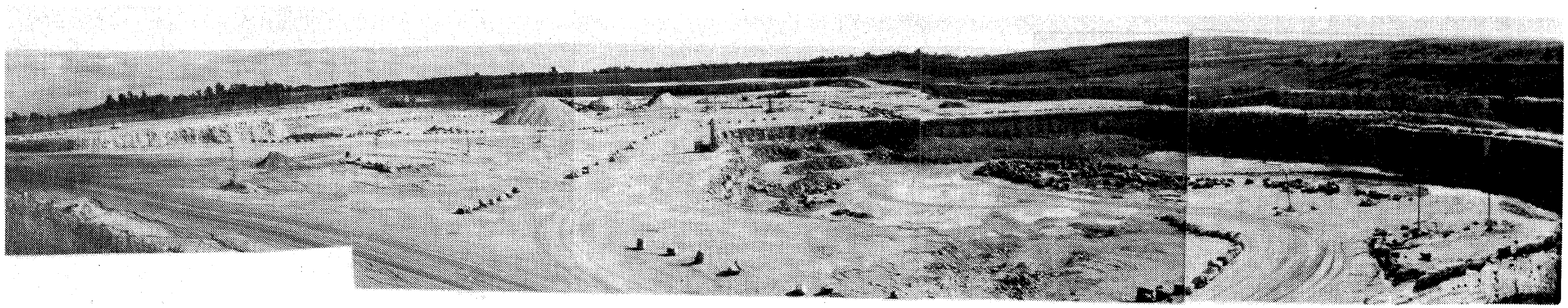
The Lucas Formation is the sole producing formation in the McGregor Quarry. It also appears in the two lower lifts of Amherst Quarries.

The Dundee Formation is the rock found in the top lift of Amherst Quarries. It is the only formation in Pelee Quarries from which aggregate are produced.

The producing layers of these formations are described in the following descriptions of each quarry.

ALLIED CHEMICAL OF CANADA LTD.,

McGREGOR QUARRY



General view from the north

Photo 1

6.1 ALLIED CHEMICAL OF CANADA LTD., MCGREGOR QUARRY

6.1.1 Location

The McGregor Quarry is located on Lot 10, Concession VI and VII of Anderdon Township, about 9 km south of Windsor city limits on the west side of Essex County Road No. 9. A general view of the quarry from the north is presented on Photo 1.

6.1.2 General Information

The owner of the quarry is Allied Chemical of Canada Ltd. The quarry was opened in the mid sixties as a source of high purity limestone for the company's chemical plant in Amherstburg. The opening of this quarry became necessary after the resources of limestone in the Brunner Mond Quarry east of Amherstburg were depleted.

The quarry operation is carried out in two lifts. The rock from the upper lift is used mainly for the production of chemical lime while the lower lift, opened in the early seventies, supplies aggregate materials only.

Upon the request of Allied Chemical of Canada Ltd., the crushed rock from the quarry was tested by MTC Head Office laboratory. In 1972, as a result of those tests, the coarse aggregate from the first lift was approved for H.L. 3, 5 and 6, (hot mix paving) and the quarry was added to the Ministry's Designated Sources List. However, the quarry was taken off the list in 1973 because it was not able to supply the approved products in the required quantities. A list of test results is shown in Table 2.

SUMMARY OF TEST RESULTS 1971 - 1980

ALLIED CHEMICAL OF CANADA - MCGREGOR QUARRY

Laboratory Sample Number	Sample Designation	Petrographic Number		$MgSO_4$ Soundness Loss (%)	Absorption (%)	Los Angeles Abrasion Loss (%)	Fines Pass 75 µm
		Granular Base	H.L. & Concrete				
71-B-14046	Upper lift	-	110	2	0.86	29	-
71-B-20187	Upper lift - HL 5 coarse aggregate	103	104	3	1.10	31	-
71-B-20188	Upper lift - HL 5 coarse aggregate	104	104	4	1.03	28	2.5
71-B-20189	Upper lift - HL 5 coarse aggregate	101	102	4	1.03	28	-
71-B-20016	Upper lift-19 mm stone	101	109	2	1.03	31	-
71-B-20251	Upper lift-19 mm stone	101	107	4	1.13	28	-
71-B-20252	Upper lift-19 mm stone	103	105	3	1.00	-	-
71-B-20253	Upper lift-19 mm stone	100	100	3	1.00	28	-
71-B-20254	Upper lift-19 mm stone	104	114	3	1.20	28	-
72-B-20002	Upper lift-16 mm stone	103	104	1	0.96	25	-
72-B-20003	Upper lift-19 mm stone	104	104	2	1.06	26	-
72-B-20004	Upper lift-19 mm stone	102	102	1	1.0	25	-
72-B-20011	Upper lift-19 mm stone	100	100	7	0.96	28	-
72-B-20012	Upper lift-19 mm stone	100	102	9	1.0	28	-
72-B-20152	Upper lift-19 mm stone	100	105	5	0.98	30	-
73-B-14419	Upper lift	-	101	5	1.03	30	-
73-B-20003	Upper lift-19 mm stone	100	102	3	1.20	27	2.18
74-B-14693	Lower lift-crusher run	129	141	18	3.44	34	-
74-B-20096	Upper lift - HL 6 coarse aggregate	100	100	2	0.90	30	-
75-B-20007	Lower lift - HL 6 coarse aggregate	112	126	17	3.45	32	3.4
75-B-20008	Lower lift - HL 6 coarse aggregate	102	121	19	2.61	31	-
75-B-20048	Upper lift-crusher run	100	100	2	0.90	30	3.3
75-B-20194	Crusher Run	142	146	10	0.86	34	5.6
75-B-20195	Crusher Run	122	127	9	0.88	34	5.6
75-B-20196	Upper lift-crusher run	102	105	4	0.96	30	-
75-B-20433	Upper lift-crusher run	100	100	6	1.03	31	-
80-B-20002	Lower lift - Top 6.1 m	100	124	7	2.07	-	-
80-B-20003	Lower lift - Total 12.2 m	106	116	17	2.85	32	-
80-B-20004	Upper lift - HL 6 coarse aggregate	113	123	12	1.40	-	4.6

TABLE 2

At the present time, Allied Chemical of Canada Ltd. is primarly not interested in the production of aggregates. Nevertheless, the quarry does provide some limited quantities of aggregate as a by-product of their chemical lime production. It also sells shot rock from the lower level.

Depending on demand, the crushed rock is hauled to the Central Crushed Stone Ltd. portable plant for processing. This plant is owned and operated by M.B.L. International Contracting Inc. (Marentette Brothers Ltd.) which crushes, screens, and sells the aggregate. In the fall of 1980, Granular A and H.L. 4 coarse and fine aggregates from this plant were used on the E.C. Row Expressway in Windsor (contract no. 80-43).

6.1.3 Quarry Faces

The chemical rock product is quarried from the 10 m (33 ft.) high upper lift. The rock in this lift is hard, dense to microcrystalline, fossiliferous containing over 50% CaO. It is of excellent quality for aggregates and is suitable for all road building purposes except H.L. 1.

Unfortunately, only the crushed product passing the 25.4 mm (-1") sieve, not used for chemical products, is available for aggregates. At present, this portion of the aggregate is used by local road departments as a Granular A material.

The lower lift of the quarry is represented by a much more variable and poorer quality rock. The 12.2 m (40 ft.) face consists of porous, absorptive, soft limestone, dolomitic limestone and dolostone beds.

The quarry faces are described on Figures 1 and 2.

6.1.4 <u>Investigation</u>

The investigation concentrated on the lower level of the quarry, however, both the upper and lower lifts of the quarry were photographed, measured and described.

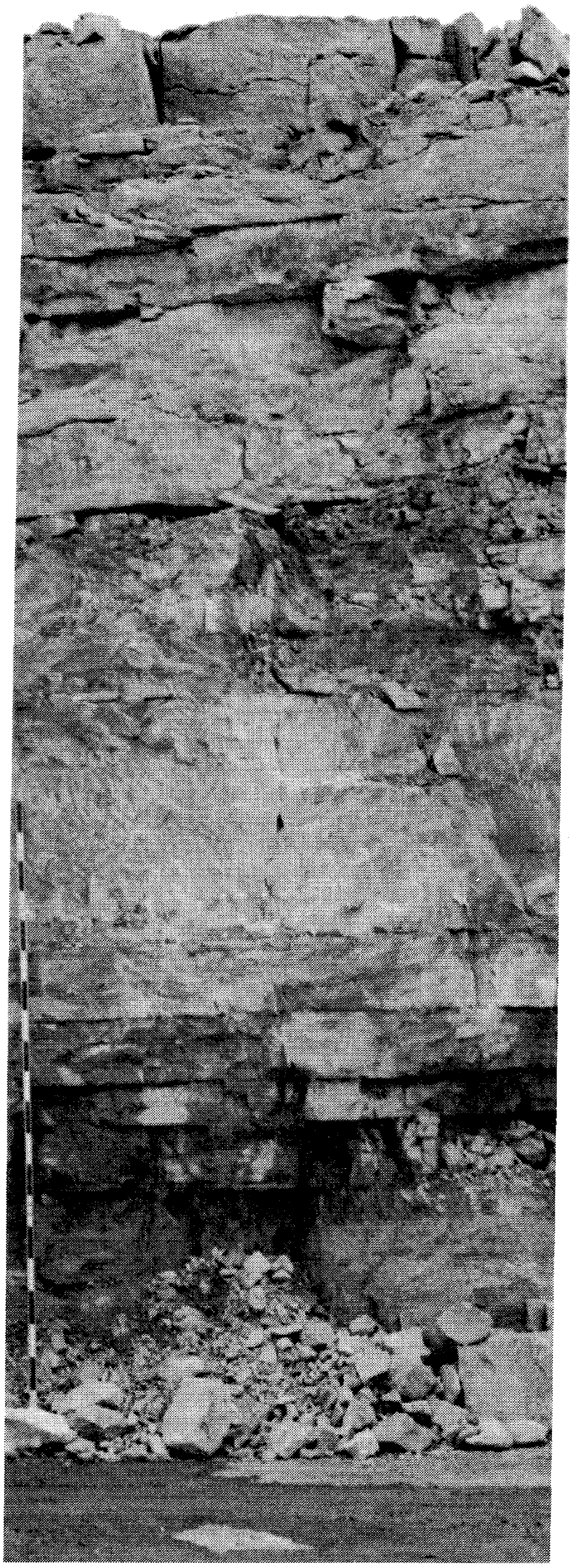
Because of variability in the quality of the lower lift beds, it was decided to take face samples from every vertical 1.5 metre (5 ft.) section of the face. The test results are presented in Table 3. These results show that the upper 6.1 m (20 ft.) of the face is of slightly better quality than the lower beds.

In discussion with the quarry supervisor, it was agreed that, for testing purposes, the top 6.1 m (20 ft.) of lower lift would be blasted and crushed separately. Aggregate produced from this lift, as well as from the full face, was sampled from the conveyor belt and from stockpile, and both of these tested.

A stockpile of crushed product from the upper level was also sampled and tested. The results of these are included in Table 4.

It is important to note that the fines (passing 75 μm) content of the crusher run aggregate from the upper lift is less (approximately 4%) than in the aggregate from the lower lift (approximately 14%). This high fines content puts the lower level crusher run material outside of the maximum 10% permitted for quarried granular base materials as per MTC form 1010.

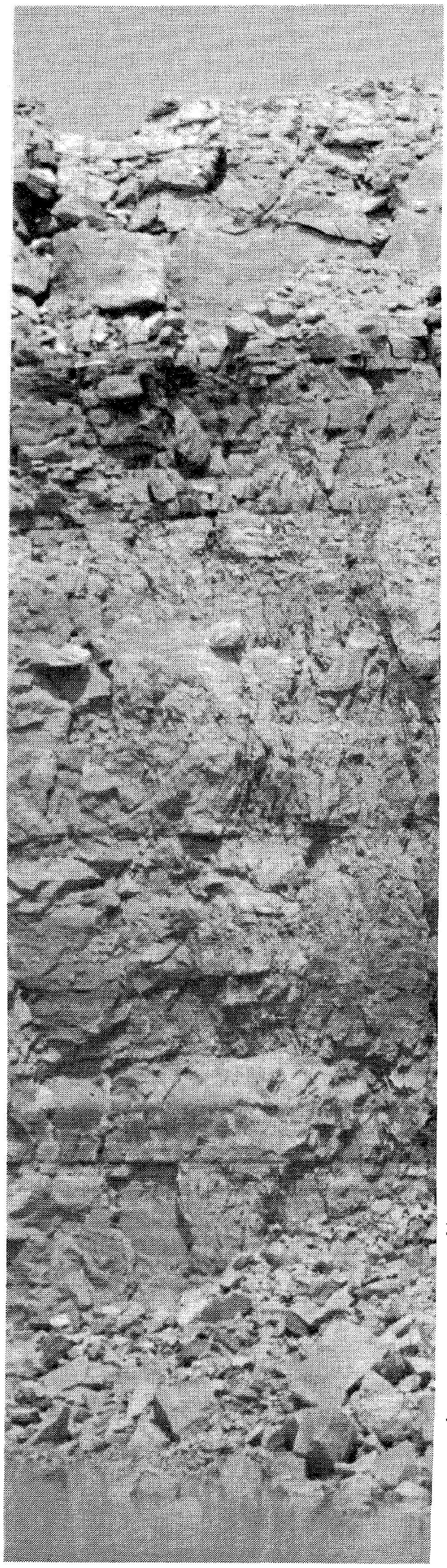
ALLIED CHEMICAL OF CANADA MCGREGOR QUARRY
UPPER LIFT, EAST FACE



ft.	m	
0	0	Limestone, buff to grey, slightly mottled, very fine texture, very hard, massive bedding.
14	4.3	
15	4.6	Limestone, buff to dark greyish brown with slight greenish tint, lithographic, very hard.
18	5.5	Limestone, buff, texture-fine to lithographic, very hard. Massive bedded. Some styloytes.
		Limestone, buff, fine texture, very hard. Massive bedding.
23	7.0	
25	7.6	Limestone, buff, lithographic, very hard.
26	7.9	Limestone, dark grey to brown, lithographic very hard, spotty greenish tint. Medium bedding
		Limestone, buff to yellowish, fine texture, very hard. Slightly banded. Medium bedding.
33	10.1	

Figure 1

ALLIED CHEMICAL OF CANADA MCGREGOR QUARRY
LOWER LIFT, EAST FACE



feet/ metres	
0/0	Limestone, very light grey, fine textured, medium hard, sandy, porous.
5/1.5	Limestone, very light grey, fine textured, medium hard, sandy, porous. Dolomitic limestone, brownish grey, fine textured, very hard. Calcite filled vugs.
10/3	Limestone, very light grey, fine textured, medium hard to soft, porous. Limestone, light brownish-grey, fine textured, medium hard. Some organic matter and very thin shale seams.
15/4.6	Limestone, buff to light grey, fine textured, hard to soft, Dolomitic limestone, grey, slightly mottled, fine textured, very hard.
20/6.1	Limestone, light grey to buffy, very fine textured, medium hard to soft, porous. Stylolytes present. Limestone brownish-grey, fine texture, fossiliferous, hard to soft, porous. Sandstone, buff, fine grained, hard porous.
25/7.6	Dolomitic limestone, buff to light brown, fine textured, hard to very hard, mottled, stylolytic. Limestone, buff, fine textured, medium hard to hard.
30/9.1	Limestone, buff, fine textured, medium hard to hard, slightly fossiliferous. Limestone, mottled (cemented) hard to soft. Limestone, light grey, with thin shale seams and some fossils & stylolytes. Limestone, brown, fine textured very hard.
35/10.7	Limestone, light grey to buff, fine textured, medium hard to soft, porous, small calcite crystals throughout. Dolomitic limestone, brown, fine textured, very hard.
40/12.2	

Figure 2

ALLIED CHEMICAL OF CANADA-MCGREGOR QUARRY

LOWER LIFT, EAST FACE

LABORATORY TEST RESULTS

ft/m	Sample Lab Number	Petrographic Number: Granular Base	Petrographic Number: H.L. & Concrete	$MgSO_4$ Soundness Loss (%)	Absorp. (%)
0/0 – 5/1.5	80-B-9002	114	285	12	2.97
5/1.5 – 10/3	80-B-9003	102	104	2	1.60
10/3 – 15/4.6	80-B-9003	100	100	1	2.51
15/4.6 – 20/6.1	80-B-9005	103	119	4	3.15
20/6.1 – 25/7.6	80-B-9006	124	179	26	3.81
25/7.6 – 30/9.1	80-B-9007	100	112	1	2.67
30/9.1 – 35/10.7	80-B-9008	102	117	6	2.67
35/10.7 – 40/12.2	80-B-9009	103	138	21	5.32

Average of Test Results	Granular Base	H.L. & Concrete	$MgSO_4$ Sound. Loss (%)	Absorp. (%)
0 - 6.1 m	105	152	5	2.56
6.1 m - 12.2 m	107	137	13	3.62

Table 3

SUMMARY OF TEST RESULTS
ALLIED CHEMICAL OF CANADA LTD. - MCGREGOR QUARRY
LOWER LIFT

Laboratory Sample Number	Date Sampled	Sample Location	Petrographic Number		$MgSO_4$ Soundness Loss (%)	Absorption Loss (%)	L.A. Abrasion Loss (%)	Fines Pass 75 µm
			Granular Base	H.L. & Concrete				
80-B-9016	Apr. 16	6.1 m face - belt	101	112	8	2.44	36	10.6
80-B-9017	Apr. 16	6.1 m face - stockpile	108	132	15	2.68	39	11.2
80-B-9018	Apr. 16	6.1 m face - belt	110	131	11	2.67	38	10.2
80-B-9019	Apr. 16	6.1 m face - stockpile	112	139	5	2.27	37	7.3
Average		6.1 m face	108	129	10	2.52	38	9.9
80-B-9010	Apr. 15	12.2 m face-belt	110	139	15	3.65	38	12.6
80-B-9011	Apr. 15	12.2 m face - stockpile	106	132	19	3.56	-	14.4
80-B-9012	Apr. 15	12.2 m face-belt	109	127	12	3.08	37	13.9
80-B-9013	Apr. 15	12.2 m face - stockpile	101	115	17	3.29	37	11.3
80-B-9014	Apr. 15	12.2 m face-belt	100	109	14	3.06	37	16.0
80-B-9015	Apr. 15	12.2 m face - stockpile	117	136	17	2.93	36	14.5
Average		12.2 m face	107	126	16	3.26	37	13.8

TABLE 4

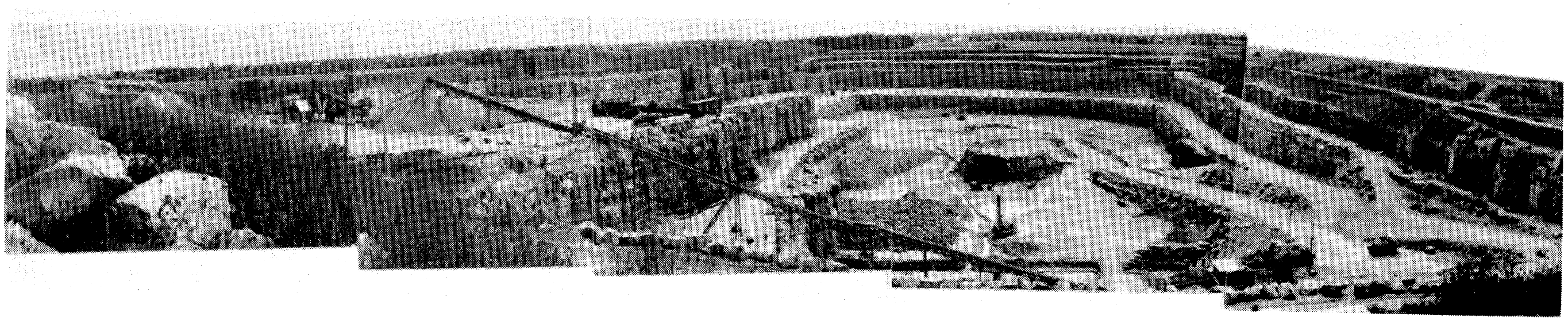
6.1.5 Summary

A) The upper lift of the quarry contains high quality rock capable of producing acceptable aggregates for all highway construction uses. Only the passing 25.4 mm (1") fraction of this is available for aggregate uses. The fines content of crusher run material is well within MTC requirements for granular base uses.

B) The lower lift of the quarry contains variable and, on the whole, poorer quality rock. This is indicated by the higher petrographic numbers, absorption, soundness and abrasion losses. Fines content of crusher run material produced from the total lower level was found to be outside MTC specifications by approximately 3.8 percent.

C) The upper 6.1 m of the lower lift is of better quality than the lower 6.1 m. It is also of better quality than the total face. The fines content of crusher run aggregate from the upper 6 m is just within the MTC specification limit of 10 percent for Granular Base uses.

AMHERST QUARRIES (1969) LTD.



General view from the north

Photo 2

6.2 AMHERST QUARRIES (1969) LTD.

6.2.1 Location

Amherst Quarry is located in Malden Township on Lot 22, Concession III, about 1.5 km (1 mile) east of Amherstburg on the south side of Pike Road. A general view of the quarry from the north is shown in Photo 2.

6.2.2 General Information

The present owner of the quarry is Mr. Murray Smith. It was first opened in the mid thirties under the management of the Industrial Construction Co. Ltd. with offices in Windsor.

Quarrying was done by jackhammers and the entire output was crushed for use as concrete and road aggregate. In 1938, the quarry working face measured 3 m (10 ft.).

It could be assumed that, for some years, the operation was abandoned because when the quarry was opened again in 1959 this time under the name Amherst Quarries Ltd., the depth of working face was still 3 m (Hewitt, 1960).

In June 1959, Mr. H. Marentette, at that time General Manager of Amherst Quarry, applied to the then Department of Highways for approved commercial source status. On the basis of test results, this quarry was not approved for any hot mix asphalt paving and concrete uses, but was approved for use as Granular Base and Subbase materials. (Table 5)

SUMMARY OF TEST RESULTS 1959 - 1977

AMHERST QUARRIES (1969) LTD.

Laboratory Sample Number	Sample Designation	Petrographic Number*		$MgSO_4$ Soundness Loss (%)	Absorption (%)	Los Angeles Abrasion Loss (%)	Fines Pass 75 µm
		Granular Base	H.L. & Concrete				
59-S-20175	Granular A	134		-	2.04	25	6.4
59-S-20174	Granular A	107		5	-	26	6.4
59-S-20250	19 mm stone	105		4	-	27	2.9
59-S-20252	Granular A	118		5	1.77	29	9.1
59-S-20399	37.5 - 22.4 mm stone	108		-	1.77	29	2.8
59-S-20400	Granular A	112		5	1.57	28	6.2
59-S-20401	HL 3 coarse aggregate	110		-	1.90	31	-
59-S-20407	19 mm stone	109		-	1.34	-	-
59-S-20408	Granular A	110		-	1.84	26	4.7
59-S-20452	Granular A	103		-	1.74	29	6.9
59-S-20453	22.4 - 13.2 mm stone	108		-	2.20	29	-
59-S-20454	9.5 mm - crusher run	113		-	2.00	30	3.6
60-S-20279	13.2 - 9.5 mm stone	267		1	1.14	40	4.1
60-S-20280	22.4 - 13.2 mm stone	283		1	-	29	-
60-S-20281	37.5 - 22.4 mm stone	249		1	5.19	34	-
60-S-20282	16 mm - crusher run	200		1	4.82	38	10.1
60-S-20283	Granular A	306		1	5.57	40	11.3
60-S-14047	Granular A	259		27	-	40	-
60-S-1467	Granular A	268		24	-	40	-
60-S-1484	Granular A	208		5	1.94	30	-
60-S-14193	Granular A	106		5	1.57	28	-
60-S-20485	19 mm - crusher run	150		4	-	41	9.8
60-S-20483	16 mm - crusher run	145		3	4.89	35	2.7
61-S-20016	16 - 6.7 mm stone	195		11	4.44	34	3.4
61-S-20017	22.4 - 13.2 mm stone	192		26	4.41	38	-
61-S-20018	34.2 - 22.4 mm stone	185		18	4.41	36	-
61-S-20793	34.2 - 22.4 mm stone	135		22	0.90	37	-
61-S-20794	22.4 - 13.2 mm stone	114		12	3.15	33	-
61-S-20795	9.5 - 6.7 mm stone	131		-	0.77	-	-
61-S-20797	Granular A	122		11	3.56	35	7.7
62-B-20356	Granular A	114		2	3.11	35	-
62-B-20357	9.5 - 6.7 mm stone	136		8	3.91	36	4.1
62-B-20359	Granular A	167		3	2.83	34	13.1
63-B-20102	Granular A	206		8	6.00	39	12.1
63-B-20927	16 mm - crusher stone	164	225	17	4.53	38	12.3
63-B-20928	19 mm - crusher stone	194	281	19	-	40	11.8
64-B-20103	Granular A	237	339	40	8.93	44	10.1
64-B-20104	Granular A	353	426	31	8.66	-	10.8
65-B-20110	Granular A	362	462	45	6.94	43	12.0
77-A-10124	Granular A	132	227	-	-	-	14.9
77-A-10126	Granular A	135	223	-	-	-	5.3
77-A-10148	Granular A	108	200	-	-	-	13.7
77-A-10145	Granular A	115	222	-	-	-	12.9

* till 1963, only combined Petrographic Numbers were calculated.

TABLE 5

At the beginning of the sixties, the quarry was deepened and in 1964, it reached the depth of 16.7 m (55 ft.). At that time, operations were carried out in two lifts; the upper from 9 - 12 m (30 - 40 ft.), the lower 4.5 m (15 ft.).

In 1972, the total depth of the quarry was 24.4 m (80 ft.); the upper lift measuring 15.2 m (50 ft.), the lower 9.1 m (30 ft.) (Hewitt & Vos, 1972).

6.2.3 Quarry Faces

At the present time, the quarry depth measured on the west face is 34.7 m (114 ft.). The operation is carried out in three lifts:

- Upper Lift - 5.8 m (19.2 ft.) - (Figure 3)
- Middle Lift - 15.2 m (50 ft.) - (Figure 4)
- Lower Lift - 13.7 m (45 ft.) - (Figure 5)

According to information from the owner, the quarry operation on the upper lift will terminate in the very near future, due to limited resources.

The first lift is represented by fine to medium textured, buff, porous and heavy bedded limestones, which belong to the Dundee Formation. The bottom of the Dundee Formation is a sandy limestone with some chert nodules exposed in the upper part of the second lift.

The remaining section of the second lift and the total of the third lift are classified as the Lucas Formation. It consists of interbedded magnesium and calcium limestone strata. The detailed descriptions and photographs of quarry lifts are shown on Figures 3, 4 and 5.

Characteristic features of the quarry are wide variations in colour, hardness, texture and porosity of the rock.

- colour: from light buff through yellow to grey and brown
- hardness: from very soft (easy to crumble in fingers) to very hard
- texture: fine, medium to coarse crystalline
- porosity: very absorptive to very dense.

6.2.4 Investigation

The field investigation carried out in the summer of 1980 included detailed logging of the quarry face, sampling and testing of the products.

Study of the faces was conducted on the west side of the quarry as the full profile of exposed rocks was easiest to approach and the investigation did not hamper the quarry operation.

The faces of all three lifts were photographed, measured and described with the aid of "manlift" equipment; hand samples were also taken. Samples of the crushed products produced from each separate lift were taken. The test results are summarized on Table 6 .

During normal operation of the quarry, the rock is blasted on two lifts simultaneously (either upper and middle or middle and lower together). The shot rock from both levels is crushed and screened together. For testing purposes, the owner changed the quarry operation procedure. Rock from each lift was crushed and stockpiled separately. Two samples were taken from the crushed product of each lift; one at noon and another at the end of the working day.

6.2.5 Summary

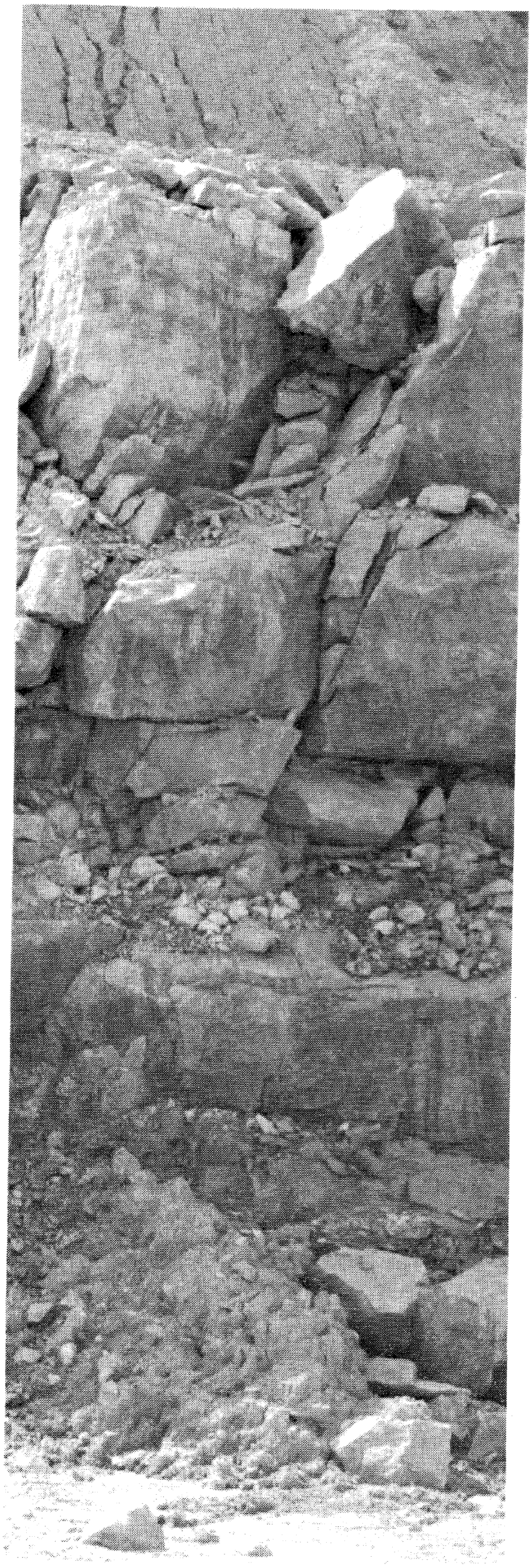
A) The quality of crusher run aggregates produced from the quarry are variable; however, they all meet MTC requirements for Granular A and 16 mm crushed type B uses.

B) Fines content of samples taken between 1962 and 1977 did not meet MTC requirements for these uses.

C) Fines content of 1980 samples meets MTC requirements for these uses.

D) The quality of the lower (bottom) level is the best.

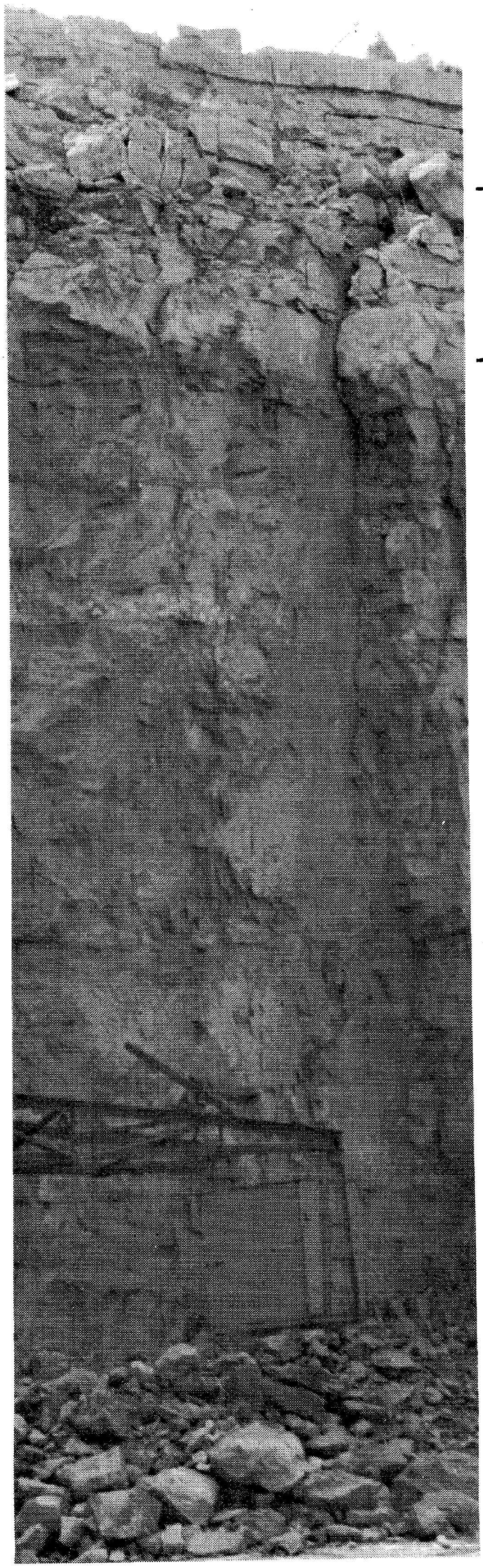
AMHERST QUARRY - UPPER LIFT - WEST FACE



ft.	m	
0	0	
		Limestone, buff banded, fine textured, hard to soft. Very thin seams (uneven) of shale. Some stylolytes present. Massive bedding.
		Limestone, buff to brown, banded, fine textured, hard to medium hard, mottled in sections, fossiliferous.
16	4.9	
		Dolostone, very light grey to brownish grey, banded, fine textured, medium hard to soft, porous. Small vuggs often filled with celestite crystals. Massive bedding.
19	5.8	

Figure 3

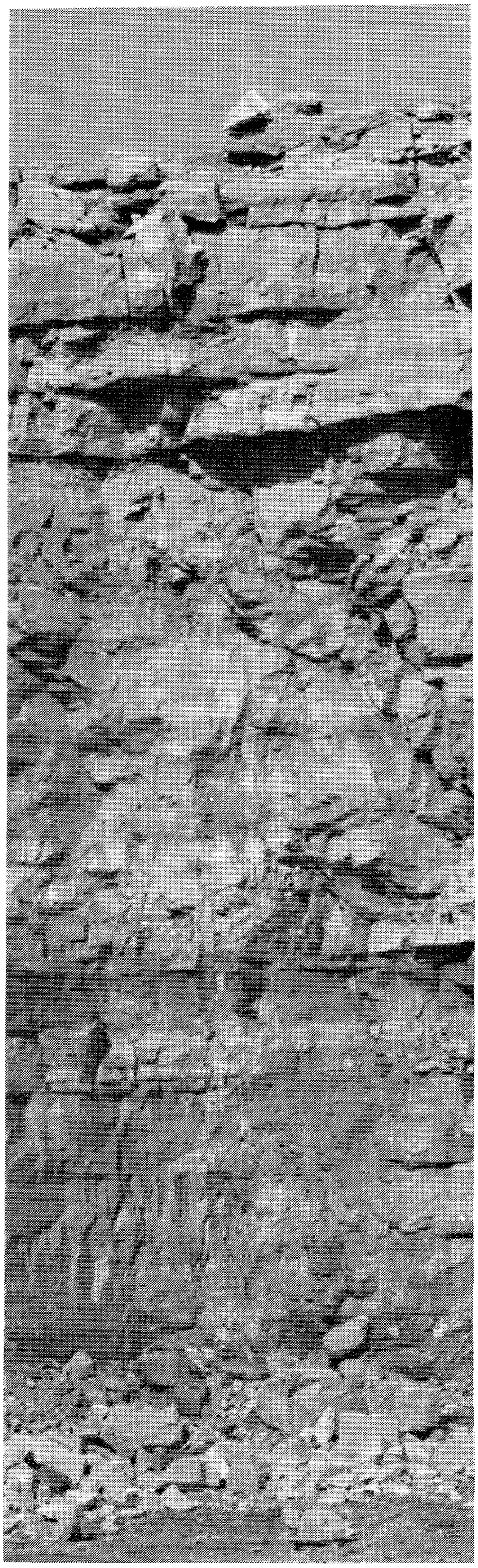
AMHERST QUARRY - MIDDLE LIFT - WEST FACE



ft.	m	
0	0	
6	1.8	Limestone and dolomitic limestone, buff with slight greenish tint, fine textured, medium hard to soft, very porous. On 4' band of nodules and irregular concentrations of white leached chert. Silica cemented sandy sections.
13	4.0	Dolostone, very light buff to cream, soft, very porous. In some sections of face, this bed disintegrates to gritty sugary powder.
33	10.1	Dolostone, buff to grey, banded medium textured, medium hard to soft, absorptive. Celestite and calcite crystals common. Massive bedding.
38	11.6	Dolomitic limestone, buff to grey, banded, medium texture, medium hard to soft, speckled with small calcite & celestite crystals. Massive bedding
43	13.1	Limestone, light grey, fine texture, medium hard to soft, very absorptive Distinctive banding. Clusters of celestite & calcite filling the vugs
50	15.2	Dolomitic limestone, brown to buff, medium texture, medium hard to soft, banded. Small calcite and celestite crystals throughout. Massive bedding.

Figure 4

AMHERST QUARRY - LOWER LIFT - WEST FACE



feet/metres

0/0 Dolomitic limestone, buff to light grey, fine texture, medium hard to hard, banded. Fine calcite veins and crystals.

6/1.8

7/2.1 Dolomitic limestone, banded very hard to soft. Very hard sandy sections

Dolomitic limestone and limestone, buff to grey, irregularly banded, very hard to medium hard. Thin to medium bedded.

12/3.7 Dolomitic limestone, thin bed, white, chalky appearance. Dolostone, grey to greenish grey, banded, fine texture, hard.

Dolostone, white to buff, banded (with light grey), soft. Dolostone buff to grey to brownish grey, banded, medium hard to soft to very soft. Calcite thin veins and crystals present.

Dolostone, grey to greenish grey, banded, fine textured, hard.

27/8.2

Limestone, brown, very hard, (thin bed). Dolostone, greenish-grey, coarse textured, very hard. Dolomitic limestone, buff,

31/9.5 banded, soft. Limestone, light grey, medium textured, hard.

Dolomitic limestone, greyish-brown, medium textured. Medium soft. Banded. Dirty dull appearance. Massive bedding. Calcite and celestite crystals present.

39/11.9

Dolomitic limestone and limestone, light brown to dark brown, fine textured, very hard. Limestone, light buff to brown,

45/13.7 mottled, medium textured, soft, fossiliferous.

Figure 5

SUMMARY OF TEST RESULTS 1980
AMHERST QUARRIES (1969) LTD.

Lab ample umber	Date Sampled	Sample Location	Petrographic Number		MgSO₄ Soudness Loss	Absorption (%)	L.A. Abrasion Loss (%)	(%) Gradation ret						Fines (Pass 75 µm)
			Granular Base	HL & Concrete				19.0	16.0	13.2	9.5	6.7	4.75	
0-B-9030	80 06 24	Top lift	109	152	41	6.53	39	0.4	3.7	9.3	43.1	61.8	72.4	5.3
0-B-9031		Top lift	108	160	36	5.23		0.4	4.4	10.4	43.2	60.8	71.6	5.8
	Average	Top lift	108	156	39	5.88								
0-B-9025	80 06 13	2nd lift	140	231	29	6.26	39	0.8	5.1	14.3	47.7	64.1	73.8	5.8
0-B-9026		2nd lift	123	203	32	6.47		0.5	3.2	8.8	43.8	61.8	72.4	5.4
	Average	2nd lift	131	217	31	6.37								
0-B-9021	80.05.29	Combined 2nd & 3rd lifts	136	171	24	4.81	34							
0-B-9023	80.06.12	3rd lift	129	175	8	4.02	34	1.1	4.9	11.7	46.2	63.3	73.5	3.8
0-B-9094	80 06 12	3rd lift	120	152	10	4.05		0.8	6.0	14.9	47.6	63.7	73.8	3.4
	Average	3rd lift	125	164	9	4.04								

TABLE 6

PELEE QUARRIES INC.

General view from the west

Photo 3

6.3 PELEE QUARRIES INC.

6.3.1 Location

The quarry is located in the northern part of Pelee Island in lots 1 and 2. A general view of the quarry from the west is presented on Photo 3.

6.3.2 General Information

The quarry is owned by Marentette Brothers Ltd. International Contractors Inc. Previously, it was owned by Reiger Brothers Ltd. Originally, the property where the quarry is located belonged to the McCormick family. The surface elevation of most of the Island is only slightly above the water surface of Lake Erie. Numerous dikes, built from local glacial till protect the Island from invasion of water at high lake levels. Shore protection barriers and groynes made from the locally quarried rock protect the shores from erosion.

During the navigation season, the transportation to and from the Island is served by an automobile ferry twice daily. The distance from the Leamington or Kingsville docks to the Scudder dock on the Island is approximately 26 km. During the winter, the main transportation to and from the Island is by aeroplane.

A barge that can act as a break water has been sunk north of the quarry.

6.3.3 Quarry Face

The current quarry face is 6.1 m (20 ft.) deep, consisting of limestone and dolomitic limestone. All of the exposed beds belong to the Dundee Formation and are described in Figure 6.

6.3.4 Investigations

In 1974, the quarry was diamond drilled by Marentette Brothers. The core was sent to the Ministry for logging and laboratory testing. On the basis of the log, the core was sectioned off and each section was tested separately. The quality of each level represented by the core was as follows: (Figure 7)

- top section (1.2 m - 10.5 m): suitable for granular base and subbase uses, unacceptable for HL and concrete uses. The quality of the stone is similar to that of the present working face.
- middle section (10.5 m - 26.5 m): the best quality level. Suitable for granular base and subbase uses. All test results met HL and concrete requirements except absorption.
- bottom section (26.5 m - 27 m): poorest quality level; doubtful if it would be acceptable for granular base or subbase uses; unacceptable for HL and concrete uses.

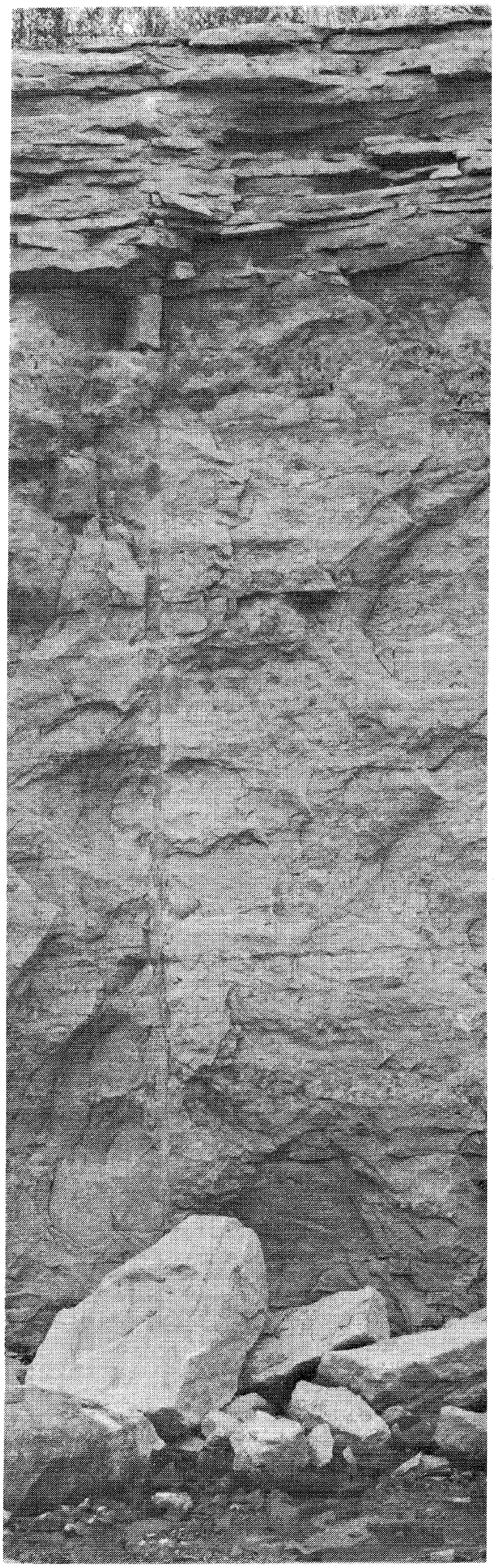
In 1970 and 1974, testing of 37.5 mm and 19 mm crusher run aggregates from the open face gave high petrographic numbers, high Los Angeles abrasion losses and high absorption values. Test results of these samples as well as samples taken in 1957 are summarized on Table 7.

During the current investigation, samples were taken from stockpiles or different size aggregates. The laboratory test results are shown in Table 8. These show that while all of the tested aggregates meet MTC physical requirements for granular base and subbase uses, the improvement in quality due to crushing from the retained 53 mm size was not enough to make that size suitable for hot mix and concrete coarse aggregates.

6.3.5 Summary

The quality of the rock produced from the current face is suitable for granular base and subbase aggregates only.

PELEE QUARRIES LTD - SOUTH FACE



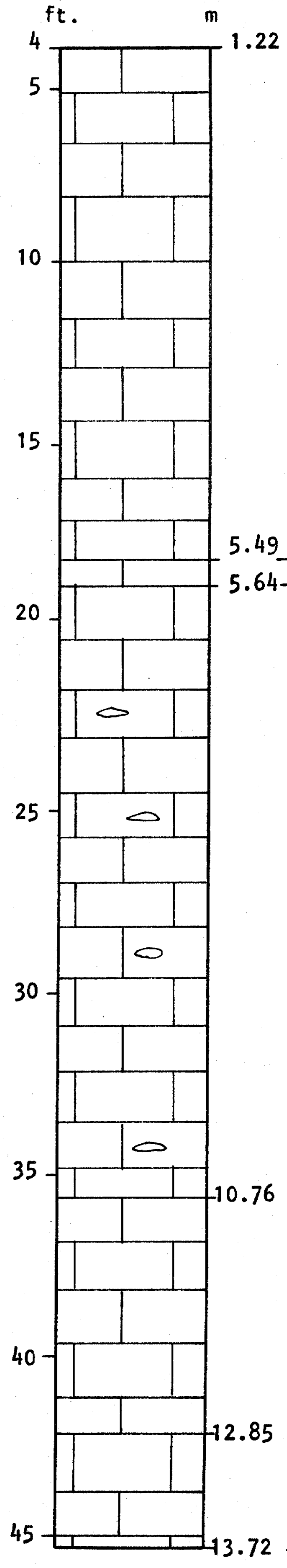
ft.	m	
0	0	
		Limestone, dull, buff to grey. Fine sugary texture, soft, porous. Highly fossiliferous. Thin (2-4") bedded, rubbly.
10.6	3.6	
		Limestone and dolomitic limestone, buff to light grey, fine sugary texture. Soft to medium hard. In places, heavy concentration of organic matter and discolouration of limestone by crude oil. Rocks exude characteristics strong oily smell. Massive bedding. Same light colour chert nodules and sandy pieces found in blasted rock on quarry floor.
20	6.10	

Figure 6

PELEE QUARRIES INC.

DIAMOND DRILL CORE LOG

Logged June 1974



1.22 m – Limestone. Light grey, mottled, medium texture soft, fossiliferous.

5.49 – 5.64 m – Limestone, white to buff, very soft.

Limestone, white to buff, medium texture, occasional chert nodule.

Sample - 74-B-14247

P.N. gran. - 101.5
P.N. hot mix - 206.5
Soundness loss % - 4.8
Los Angeles - 37.0
Absorption - 3.46

10.76 m – Limestone, buff, medium texture, medium hard.

12.85 – 13.72 m – Limestone, buff, medium texture, hard.

Figure 7

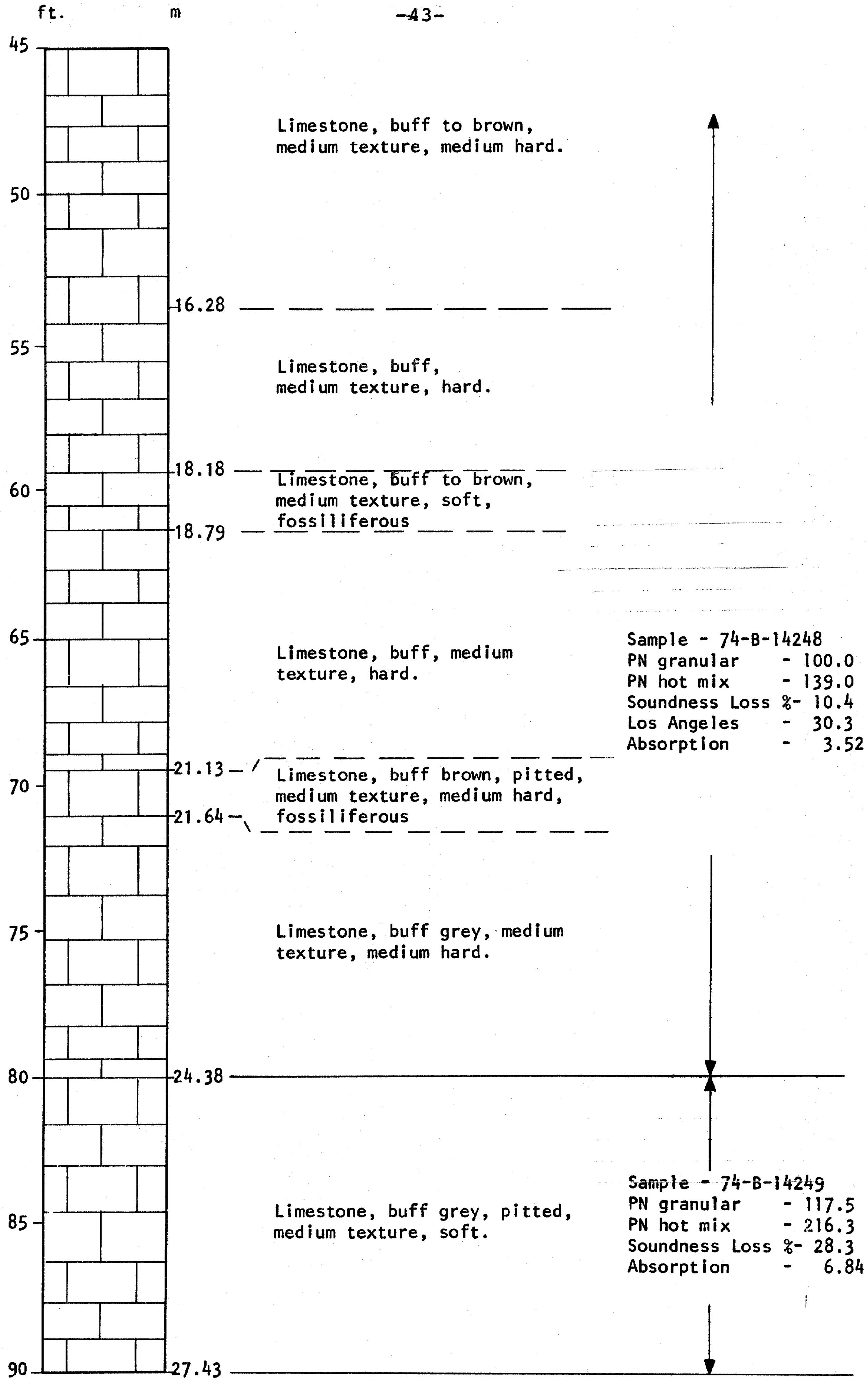


Figure 7 (Cont'd)

SUMMARY OF TEST RESULTS 1957 - 1979

PELEE QUARRIES INC.

Laboratory Sample No.	Sample Designation	Petrographic Number		$MgSO_4$ Soundness Loss (%)	Absorption (%)	Los Angeles Abrasion Loss (%)
		Granular Base	H.L. & Concrete			
57-S-14764	Stockpile	217		-	2.54	59
57-S-14765	Stockpile	214		-	2.38	-
57-S-14766	Stockpile	216		-	2.34	59
70-B-14691	Stockpile - 19 mm crusher run	-	-	24	2.98	51
70-B-14692	Stockpile-37.5 mm stone	-	-	18	2.68	46
74-B-14247	Drill Core - 1.2 m - 10.77 m	102	207	5	3.46	37
74-B-14248	Drill Core - 10.77 m - 24.38 m	100	139	10	3.52	30
74-B-14249	Drill Core - 24.38 m - 27.43 m	118	216	28	6.84	-
74-B-20016	Stockpile - 53 mm	112	310	4	2.68	44
74-B-20017	Stockpile - 53 mm	119	305	5	2.48	43
74-B-20018	Stockpile - 22.4 mm	108	321	10	2.71	45
79-B-60436	Stockpile - 13.2 mm - 9.5 mm	106	291	17	2.66	45

TABLE 7

SUMMARY OF TEST RESULTS 1980

PELEE QUARRIES INC.

Laboratory Sample Number	Date Sampled	Sample Location and/or Designation	Petrographic Number		$MgSO_4$ Soundness Loss (%)	L.A. Abrasion Loss (%)	Absorption (%)
			Granular Base	H.L. & Concrete			
80-B-9140	80 09 16	Granular A - Stockpile	114	286	16	43	2.68
80-B-9139	80 09 16	-53 mm Stone - Stockpile	138	308	19	41	2.88
80-B-9138	80 09 16	+53 mm Stone - Stockpile	119	296	19	-	2.85

TEST RESULTS

MARBLEHEAD QUARRY (KELLY'S ISLAND)

80-B-9137	80 09 16	Crushed chips - road side, Pelee Island	110	161	15	31	4.02

TABLE 8

6.4 POTENTIAL UNDEVELOPED SITES

Due to the 15 - 45 metre thick overburden over the bedrock surface in the county, there are only a limited number of sites where quarrying can be considered economically feasible. All of these are located close to existing or depleted quarries (refer to Maps 1 and 2 pages 4 and 6).

6.4.1 Area North of McGregor Quarry

This site is located in Lot 11, Concession VI, Anderdon Township on the north side of the township road adjacent to the quarry. The owner of the property is Amherst Quarries (1969) Ltd. The site was drilled by Canadian Longyear Company 1973, but no detailed information is available on the drill cores. However, the drilling company's logs were made available by the owner. These indicate that the rock belongs to the Lucas Formation and is of similar nature and quality to that of the rocks of the Allied Chemical of Canada Ltd., McGregor Quarry. The thickness of overburden is estimated to vary between 10 and 20 metres. A licence to operate a quarry on this site under the Pits and Quarries Control Act (1971) has recently been applied for.

6.4.2 Area East of Amherstburg

The area east of Amherst Quarries (1969) Ltd. is underlain by the Dundee Formation which is covered by 5 - 10 metres of overburden. The Lucas Formation occurs below the Dundee. Both of these formations could produce granular base aggregates similar to the Amherst Quarries. Part of this area is now built-up and the remainder is located close to built-up areas. Therefore, quarrying in this area is unlikely.

6.4.3 Area 1.5 km South of the Village of McGregor

The thickness of 6 to 7.5 metres overburden over the rock surface appear to be quite favourable for quarry development. The site is underlain by the Lucas Formation of a quality expected to be similar to the rocks of McGregor Quarry.

6.4.4 Pelee Island

Most parts of Pelee Island, except the central area which is covered by thicker overburden, has potential for quarry development. It is likely that the quality of the rock close to the surface is similar to the rock found in Pelee Quarries Inc.

7. PERFORMANCE

7.1 GENERAL INFORMATION

In order to evaluate the acceptability of the Granular 'A' produced from the quarries, a performance survey of municipal roads was carried out. The survey consisted of:

- a questionnaire sent to all municipalities in the County
- a visual investigation of selected township roads (Map 5)
- sampling and testing of granular base materials taken from township roads.

In addition to the survey of the granular base materials, the performance of old concrete produced from Pelee Quarries Inc. and a recent asphalt pavement from the Allied Chemical of Canada, McGregor Quarry were also investigated.

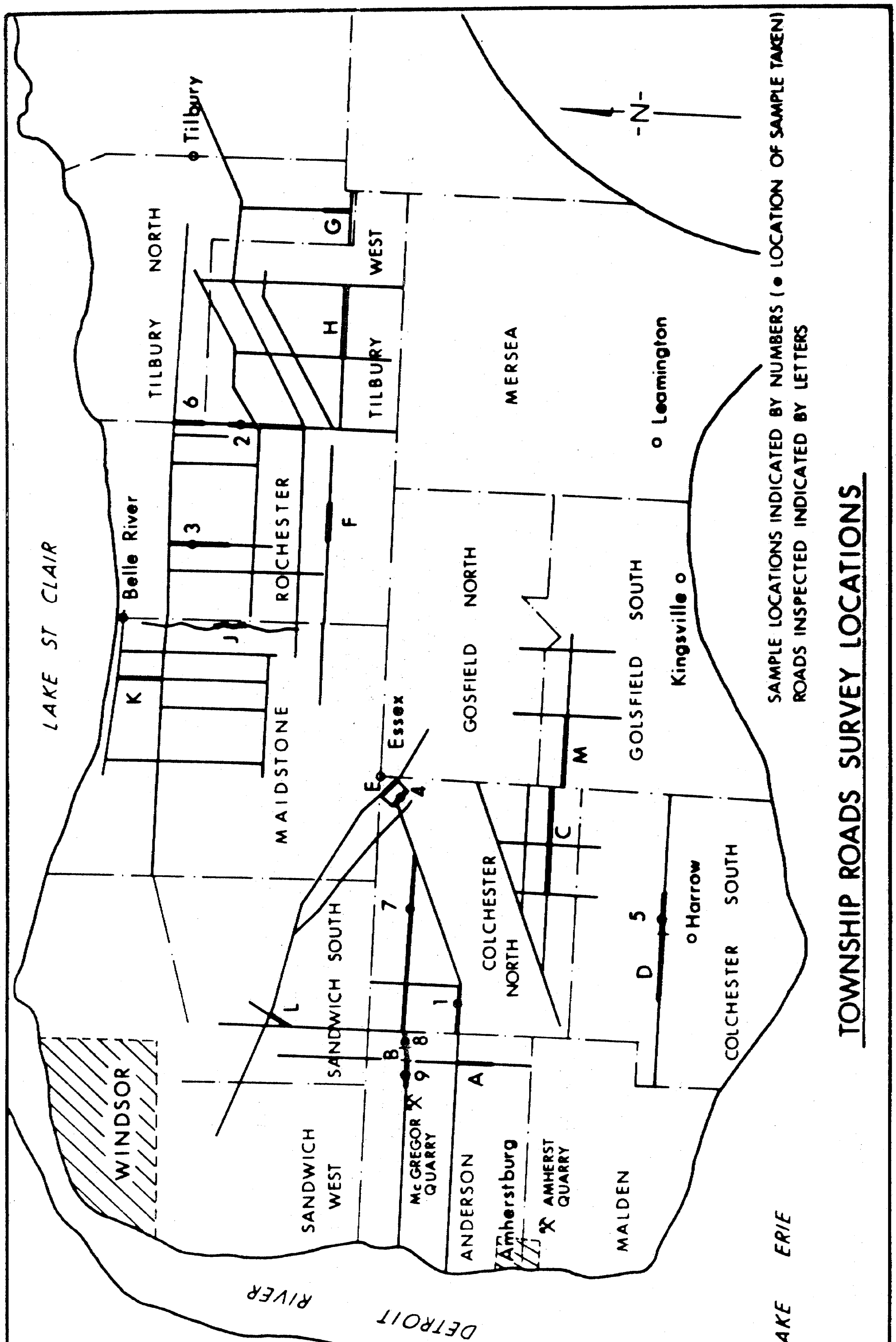
7.2 TOWNSHIP ROADS SURVEY

A questionnaire referring to road construction information was forwarded to each municipality of the county in the summer of 1980 (see Appendix 1). Due to the limited response, it was sent out again last December and was followed up by telephone and personal communication. The summary of the survey is shown in Table 9.

7.3 INVESTIGATION OF TOWNSHIP ROADS BY M.T.C.

Selected sections of township roads were investigated in the fall of 1980 visually for:

- surface roughness
- loose stones on the surface.



TOWNSHIP ROADS SURVEY LOCATIONS

MAP 5

SUMMARY OF ROAD PERFORMANCE

SURVEY QUESTIONNAIRE SENT TO MUNICIPALITIES

MUNICIPALITY	AMHERST QUARRIES INC.				ALLIED CHEMICAL - MCGREGOR Q.			
	NUMBER OF CONTRACTS	SURF. TREATED OR PAVED	UNPAVED	PERFORMANCE RATING	NUMBER OF CONTRACTS	SURF. TREATED OR PAVED	UNPAVED	PERFORMANCE RATING
City of Windsor	No Information Available							
Town of Amherstburg	3	3	-	Satisfactory	-			
Town of Belle River	No Records Kept							
Town of Essex	-	-	-	-	2	2		1 Satisfact. 1 Unsatisfact.
Town of Harrow	Detailed Information Not Available. Roads Where McGregor & Amherst Qs. Were Used Performed Satisfactorily							
Town of Kingsville	-							
Town of Leamington	3	3	-	Satisfactory	-			
Twp. of Anderdon	No Records Kept							
Twp. of Colchester N.	2	2	-	Satisfactory	1	1	-	Satisfactory
Twp. of Colchester S.	7	5	2	Satisfactory	-			
Twp. of Gosfield N.	3	2	1	Satisfactory	-			
Twp. of Gosfield S.	8	-	8	Satisfactory	-			
Twp. of Maidstone	2	2	-	Satisfactory	6	4	2	Satisfactory
Twp. of Malden	6	3	3	Unsatis. 2	-			
Twp. of Mersea	None				None			
Twp. of Pelee	No Information Available							
Twp. of Rochester	7	4	3	Satisfactory	6	6	-	Satisfactory
Twp. of Sandwich S.	12	6	6	Satisfactory	4	3	1	Satisfactory
Twp. of Sandwich W.	8	8	-	Satisfactory	-			
Twp. of Tilbury N.	9	5	4	Satisfactory	3	2	1	Satisfactory
Twp. of Tilbury W.	5	4	1	Satisfactory	-			

1. Cracking and rutting occurred after construction requiring remedial work.
2. Poor internal drainage, soupy conditions.

TABLE 9

The investigated locations are shown on Map 5 and the findings are listed in Table 10.

Granular base material from nine locations was removed from the road and submitted to the laboratory for gradation analysis. The sampled locations are indicated on Map 5. The sieve size analysis of these are shown on Table 11 and gradation curves on Figures 8 and 9.

The performance of some typical unpaved surfaces are illustrated on Photographs 4 to 10.

7.4 BEHAVIOUR OF THE GRANULAR BASE AGGREGATES IN WET AND DRY ENVIRONMENTS

The behaviour of the Granular 'A' products from the mainland quarries in extreme wet environment is undesirable. The material from the lower level of the Allied Chemical Ltd., McGregor Quarry and from the current producing levels of Amherst Quarries (1969) Ltd. becomes soft due to excess fines. This property is accentuated by the poor surface drainage in the county.

Due to the prevailing flat terrain, this condition is especially severe during the spring thaw when the subgrade and earth material underneath the surface are still frozen. Photo 10 of the parking lot of the Malden Township Office illustrates this.

On the other hand, the Granular 'A' from the upper level of the McGregor Quarry behaves differently. Due to the relatively small amount of fines (2.5 - 5.5%) and the better internal drainage, it is less 'soupy' in saturated condition; consequently, it is more stable.

TOWNSHIP ROADS SURVEY
BY
MINISTRY OF TRANSPORTATION AND COMMUNICATIONS

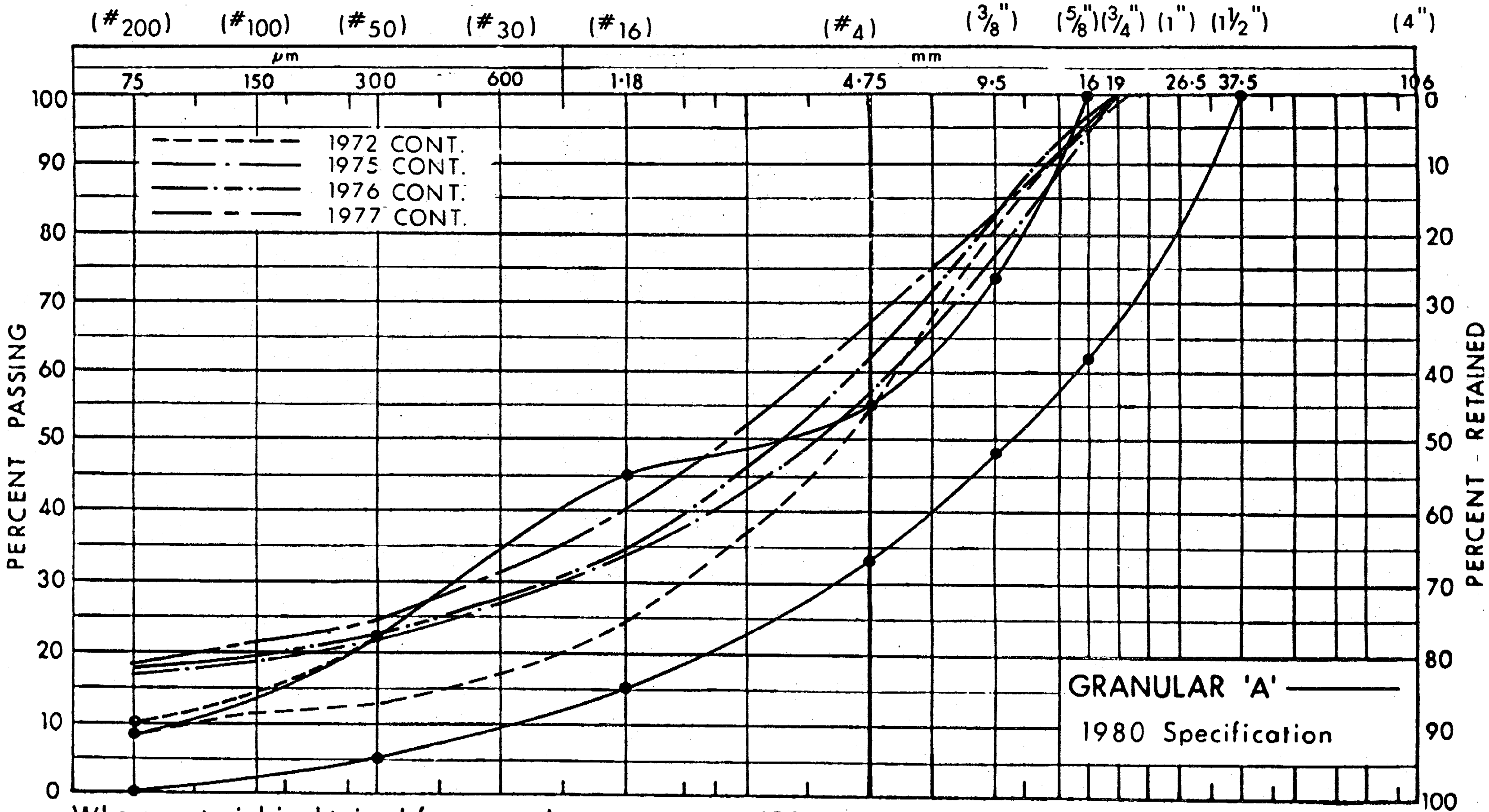
CONTRACT YEAR	TOWNSHIP	MAP REF	SAMPLED OR NOT	SURFACE TYPE	OBSERVATIONS	
					SURFACE ROUGHNESS	LOOSE STONE ON SHOULDERS
	GRANULAR BASE AGGREGATE FROM ALLIED CHEMICAL LTD. - MCGREGOR QUARRY					
1970	Colchester North	1	Yes	Surface Treated	Smooth	Not Applicable
1972	Sandwich South	L	No	Surface Treated	Smooth	Not Applicable
1973	Rochester	3	Yes	Surface Treated	Smooth	Not Applicable
1975	Essex Town	4	Yes	Asphalt Pavement	Smooth	Not Applicable
1975	Maidstone	K	No	Surface Treated	Smooth	Not Applicable
1976	Essex Town	E	No	Asphalt Pavement	Settlement Cracking	Not Applicable
1978	Maidstone	J	No	Surface Treated	Smooth	Not Applicable
1979	Anderdon	A	No	Unpaved	Rough in Sections	Average
1979	Anderdon	B	No	Unpaved	Rough	Average
1980	Anderdon	9	Yes	Unpaved	Undulating	Numerous
	GRANULAR BASE AGGREGATE FROM AMHERST QUARRIES INC.					
1970	Gosfield South	N	No	Surface Treated	Smooth	Not Applicable
1972	Colchester North	C	No	Surface Treated	Smooth	Not Applicable
1972	Tilbury West	2	Yes	Surface Treated	Smooth	Not Applicable
1975	Colchester South	5	Yes	Surface Treated	Smooth	Not Applicable
1976	Colchester South	D	No	Surface Treated	Smooth	Not Applicable
1976	Rochester	6	Yes	Surface Treated	Smooth	Not Applicable
1977	Colchester North	7	Yes	Surface Treated	Smooth	Not Applicable
1978	Tilbury North	G	No	Surface Treated	Smooth	Not Applicable
1978	Tilbury West	H	No	Surface Treated	Smooth	Not Applicable
1979	Anderdon	8	Yes	Sur Unpaved	Smooth	Occasional
1979	Rochester	F	No	Unpaved	Undulating	Numerous

TABLE 10

GRADATION OF SAMPLES
EXTRACTED FROM MUNICIPAL ROADS

Map Ref	Township Sample Location	Type of Road	Cont. Year	CUMULATIVE PERCENT PASSING 19 mm	16 mm	13.2 mm	9.5 mm	6.7 mm	4.75 mm	2.36 mm	1.18 mm	600 µ	300 µ	150 µ	75 µ
	AMHERST QUARRY														
2	Tilbury West	Surface treated	1972	98.6	94.8	91.7	81.3	68.9	54.3	37.2	24.0	17.1	12.8	12.1	8.2
5	Colchester S.	Surface treated	1975	99.3	94.8	88.9	76.4	65.7	56.1	43.5	33.3	26.3	21.8	18.7	16.6
7	Colchester N.	Surface treated	1977	98.7	95.0	91.3	83.3	75.0	66.7	52.4	39.9	31.0	24.8	21.5	18.7
6	Rochester	Surface treated	1976	99.3	96.6	92.5	82.0	71.8	62.2	46.1	34.3	27.2	22.4	19.1	17.1
8	Anderdon	Unpaved	1979	98.1	95.8	93.6	86.8	77.5	66.2	50.1	36.6	28.3	23.0	18.8	16.5
	MCGREGOR QUARRY														
1	Colchester N.	Surface treated	1970	98.7	96.1	92.9	83.8	73.1	62.1	46.9	35.0	27.7	22.6	18.8	16.6
3	Rochester	Surface treated	1973	100.0	99.3	97.5	89.8	77.1	64.1	49.3	34.3	25.1	18.1	14.2	11.7
4	Essex Town	Asphalt covered	1975	98.9	94.0	86.0	70.3	58.6	49.4	39.2	30.6	25.0	20.7	17.5	15.1
9	Anderdon	Unpaved	1980	98.7	95.2	91.6	80.0	68.4	57.1	41.7	29.8	23.2	17.8	14.5	12.2

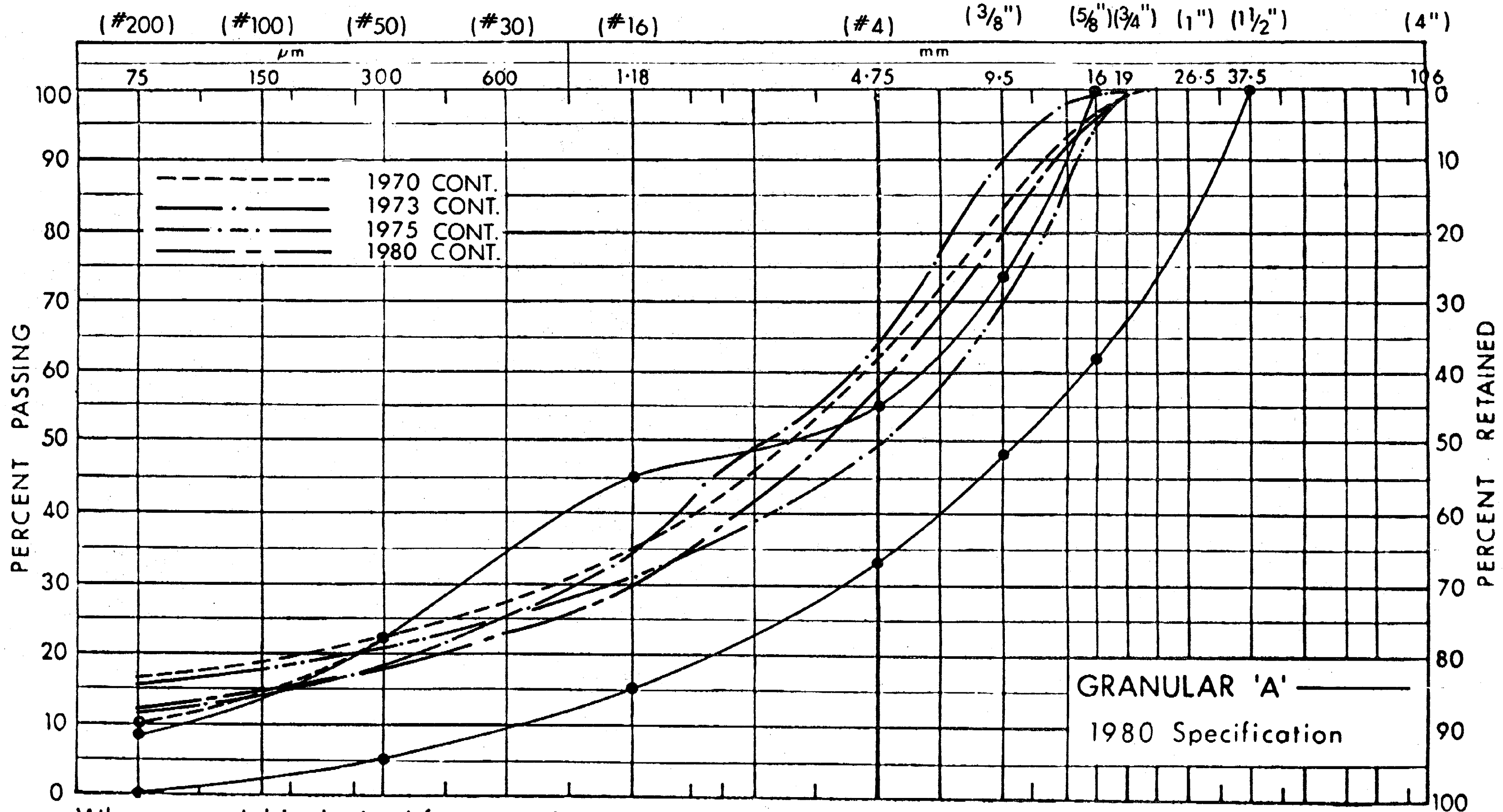
TABLE 11



Where material is obtained from a rock quarry source, 10% passing the 75μm sieve will be permitted.

GRADATION CURVES OF GRANULAR 'A' FROM AMHERST QUARRIES (1969) LTD.
SAMPLED FROM MUNICIPAL ROADS

FIG. 8



Where material is obtained from a rock quarry source, 10% passing the 75μm sieve will be permitted.

GRADATION CURVES OF GRANULAR 'A' FROM ALLIED CHEMICAL OF CANADA - Mc GREGOR QUARRY SAMPLED FROM MUNICIPAL ROADS

FIG. 9

TYPICAL PERFORMANCE OF GRANULAR A

FROM ALLIED CHEMICAL LTD. McGREGOR QUARRY
(upper level)

Unpaved road surface after one year of service.

Note:
The well compacted relatively smooth surface.

Photo 4

Note:
The numerous stones ravelled from the road surface and deposited on the shoulder.

Photo 5

TYPICAL PERFORMANCE OF GRANULAR A

FROM ALLIED CHEMICAL LTD. McGREGOR QUARRY (cont'd)

Close up of road surface. Note the edges of stones also the well compacted nature of the surface.

Photo 6

TYPICAL PERFORMANCE OF GRANULAR A

FROM AMHERST QUARRIES (1969) LTD.

Unpaved road surface after one year of service.

Note:
The well compacted relatively smooth surface.

Photo 7

Note:
The relatively low number of stones ravelled from the surface.

Photo 8

TYPICAL PERFORMANCE OF GRANULAR A

FROM AMHERST QUARRIES (1969) LTD.
(cont'd)

Close up of road surface.
Note:
The rounded edges of stones and well compacted nature of the surface.

Photo 9

Parking lot of Malden Township office.
Note:
"Soupy" over-saturated condition of the granular surface during spring melting.

Photo 10

The behaviour of these same materials under dry conditions is entirely different. The McGregor Quarry lower level and the Amherst Quarries (1969) Ltd. material, after drying out, became extremely hard, well bonded due to the hardened fines. The only problem with this material during dry weather is its proneness to excessive dust under traffic due to high percentage of fines. A large portion of these fines are contained within the original aggregate but some are produced by the traffic abrading the soft stone particles. The dusty condition must be controlled by the application of calcium chloride solution.

The granular material produced from the upper lift of the McGregor Quarry is somewhat less stable and more susceptible to ravelling due to the lesser amount of fines. Consequently, there is a significant loss of stone from the road surface under traffic. The stones end up on the shoulder and, if not graded soon enough, in the ditches. This is well illustrated in Photo No. 5. On the other hand, this material tends to be less "soupy".

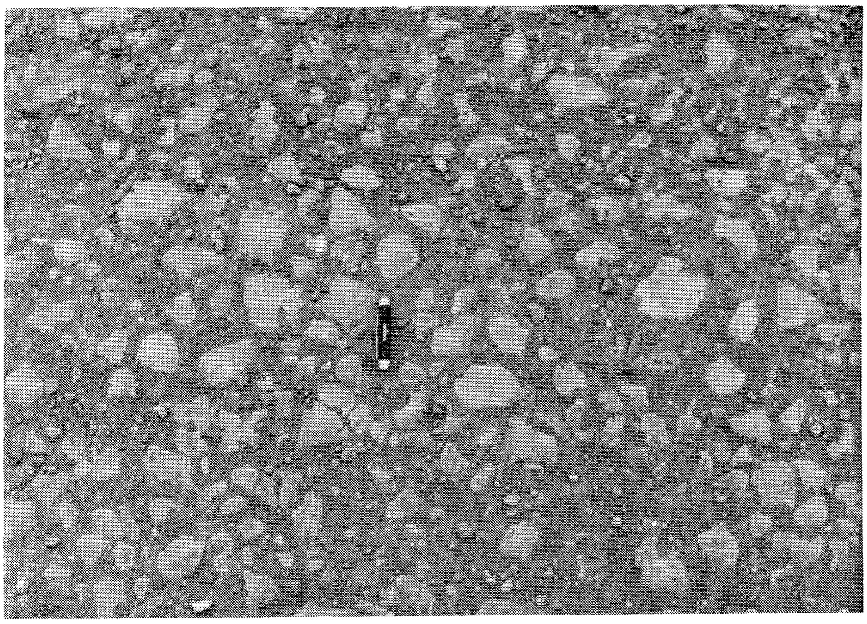
7.5 PERFORMANCE OF ROADS ON PELEE ISLAND

The lack of construction records makes the evaluation of performance very difficult and sketchy.

The granular base material used on the Island was produced from local quarries. By visual inspection, its performance in general on both surface treated and untreated roads was found to be satisfactory. The surface of the untreated roads is well compacted with only a small amount of

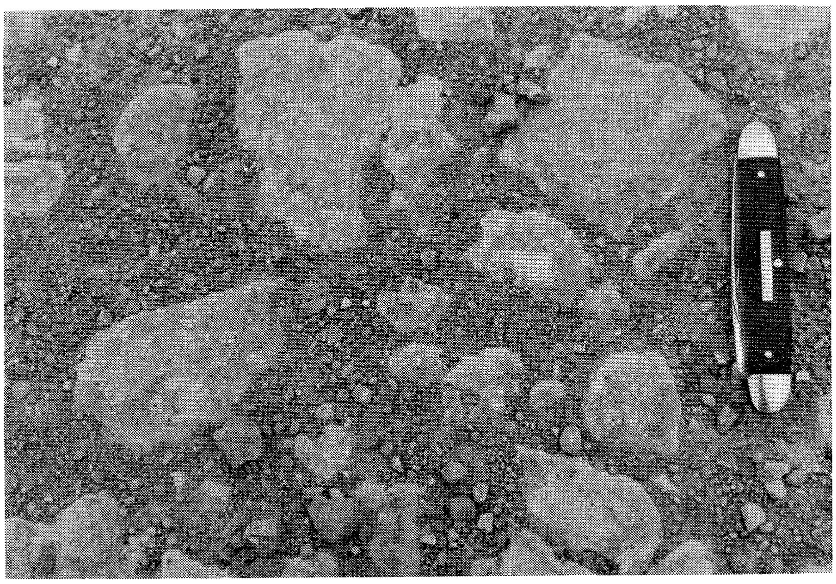
TYPICAL PERFORMANCE OF GRANULAR A

FROM PELEE ISLAND QUARRIES INC.



Location - Pelee Island, main road, north of the village.

Photo 11



as above

- close up

Photo 12

TYPICAL PERFORMANCE OF GRANULAR A

FROM PELEE ISLAND
(cont'd)

Pelee Island surface treated road in front of restuarant at west dock.

Photo 13

loose stone on the shoulder. The stone particles are slightly worn but do not show any deterioration. It should be noted that the performance exhibited was the result of relatively light traffic and a very limited use (if any) of de-icing road salts. The average performance is illustrated on Photos No. 11 to 13.

7.6 INSPECTION OF E.C. ROW EXPRESSWAY

A section of this highway (Contract No. 80-43, from 0.1 miles east of Jefferson Blvd., easterly 2.7 miles) which was constructed during the summer of 1980 was inspected in February 1981.

Aggregate from the lower lift of the McGregor Quarry was used for granular base and H.L. 4 binder course. Although the highway has been open to traffic for only a short time, it is important to note that no visible signs of poor base performance were observed. However, the Granular 'A; in the shoulder exhibited unstable saturated spring condition typical of the material used on municipal roads. It is expected that the shoulder will stabilize when the underlying clear crushed stone is thawed and it is able to drain the internal water from the road base. Additional stabilization is expected when the fines will bind the material after desiccation. Paving of the shoulder will also ensure greater stability by preventing the large scale entry of water into the base of the shoulder.

Because of the softness and high absorption of the coarse aggregate, the condition of the H.L. 4 binder course was also inspected. It was found that the particles were only very slightly affected by the traffic wear. In areas, the pavement shows loss of stones but it was observed to be the result of ravelling caused by excessive speed in paving in order to meet the designated completion date last fall. The pavement condition is shown on Photos No. 14, 15 and 16.

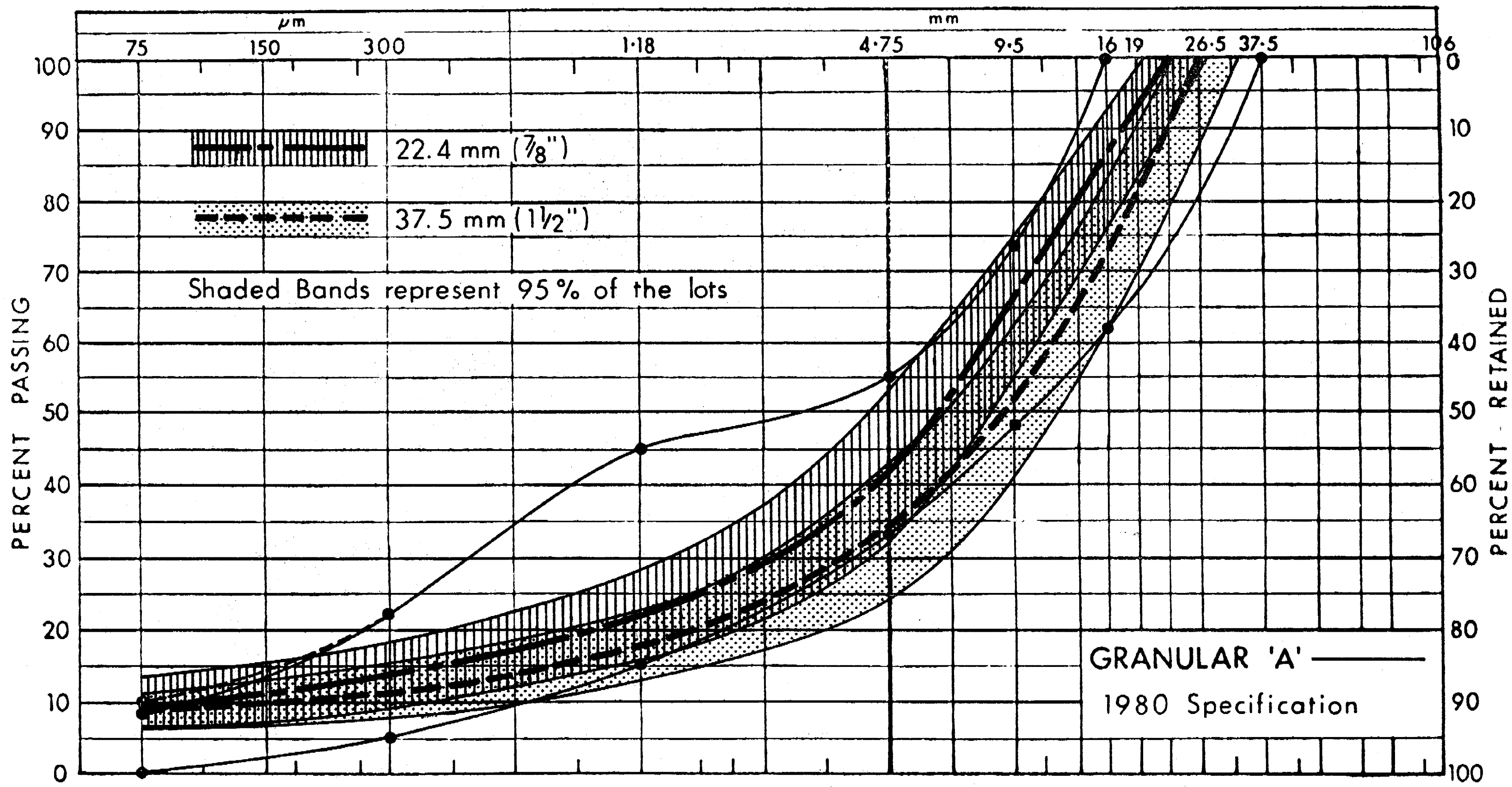
7.7 GRANULAR A MATERIALS FOR E.C. ROW EXPRESSWAY

For Contracts 80-33 and 80-43 in Windsor two different sized Granular A aggregates were used, one with 26.4 mm, the other with 37.5 mm maximum size. In order to compare the gradation of each of these materials test results of 54 lots of the 22.4 mm (7/8") and 27 lots of the 37.5 (1½") were analyzed statistically. Each lot was represented by four individual samples. In the analysis the central tendency ($\overline{X}$), the standard deviation (σ) and ranges (R) on the designated sieves for each of these materials were calculated. These statistical parameters of the lot values are listed on Table 12 and illustrated in Figure 10.

SIEVE SIZE	CUMULATIVE PERCENT PASSING						
	22.4 mm GRANULAR 'A'			37.5 mm GRANULAR 'A'			M.T.C. SPEC. LIMITS
	$\overline{X}$	R	σ	$\overline{X}$	R	σ	
37.5 mm	100.0			100.0			100
16 mm	85.4	74/91	3.7	72.9	61/85	5.0	62 - 100
9.5 mm	65.9	54/73	5.0	51.7	43/65	5.6	48 - 73
4.75 mm	42.2	29/53	5.2	33.4	26/44	4.5	33 - 55
1.18 mm	22.1	13/27	3.2	18.0	14/22	2.4	15 - 45
300 μm	13.9	10/18	2.1	11.7	4/15	2.2	5 - 22
75 μm	9.9	6/14	1.7	8.5	7/11	1.2	0 - 10

TABLE 12

GRADATION OF GRANULAR A, E. C. ROW EXPRESSWAY



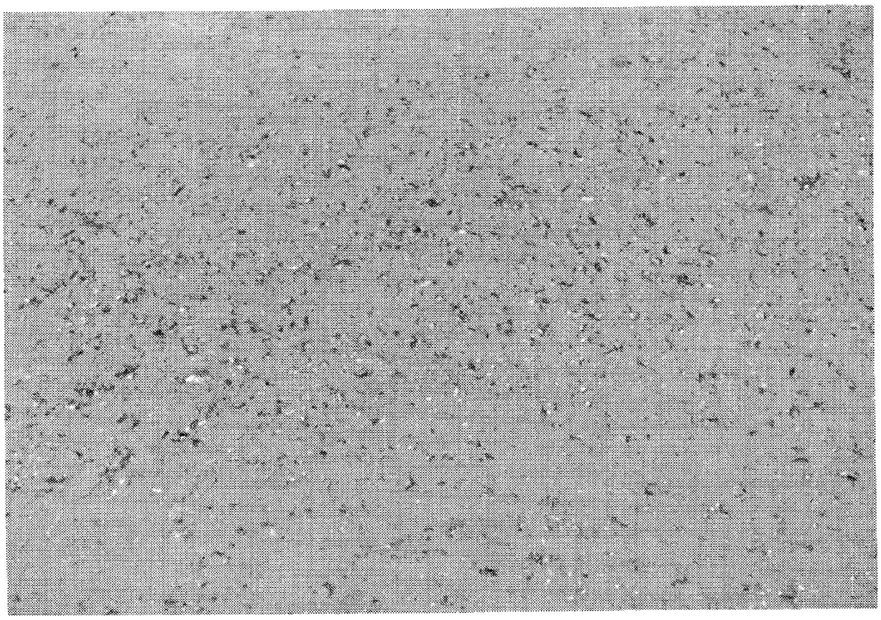
Where material is obtained from a rock quarry source, 10 % passing the 75μm sieve will be permitted.

GRADATION CURVES OF GRANULAR A , E.C. ROW EXPRESSWAY

FIG. 10

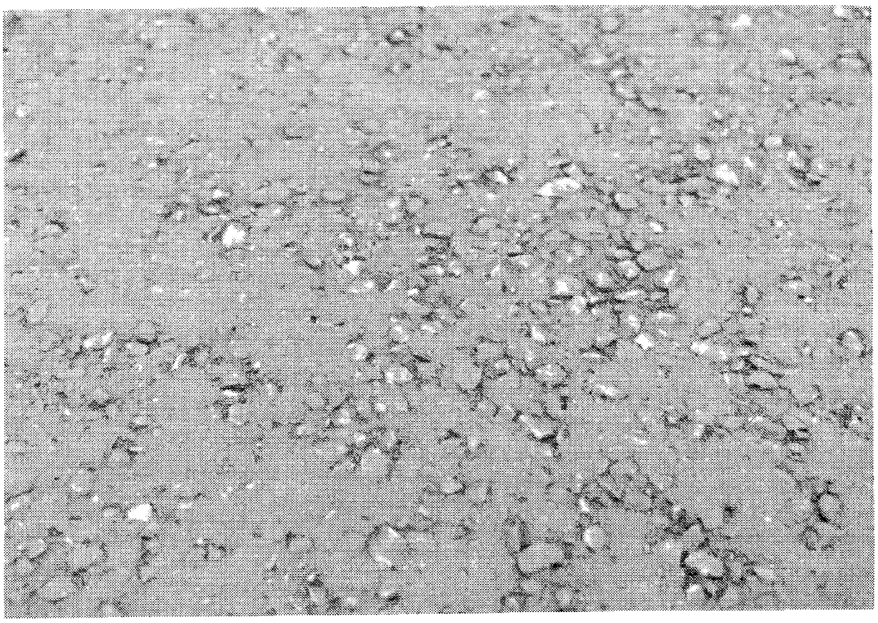
E.C. ROW EXPRESSWAY - WINDSOR

CONTRACT 80-43



Average pavement condition.

Photo 14



Close up of average pavement.

Photo 15

E.C. ROW EXPRESSWAY - WINDSOR

CONTRACT 80-43
(cont'd)

Note:
Loss of
coarse aggregate.

Photo 16

In the examination of test results several significant facts became apparent:

a) The mean of percent passing 75 μm sieve for the 26.5 mm size aggregate is only marginally inside the M.T.C. specification limit of 10% (at 9.9%).

   The same test for the 37.5 mm size aggregate is well within the limit of 8.5%.

b) A much higher percentage of the lots taken from the smaller size aggregate contained excess fines than the larger size aggregate (31.5% and 3.7% respectively).

c) The mean of the percent passing the 4.75 mm sieve on the 37.5 mm size aggregate is only marginally within the specification requirement of 33 - 55% at 33.4%. 44.4% of 27 lots were too coarse on this sieve size.

7.8 ADDITIONAL INFORMATION ON PERFORMANCE IN OTHER USES

Several other limestone quarries on Pelee Island were used locally as well as on the mainland since the beginning of this century.

Numerous blocks of local rock have been placed as breakwater along the shoreline of Lake Erie on the Island as well as at Leamington on the mainland. According to information received from Public Works Canada, Ontario Region, London Office (Appendix 2), some of these have been in place for over 30 years. This shows that this porous, absorptive rock can withstand the stress created by freezing and thawing and is durable after long static exposure. The same source indicates that in 1965, Testing Laboratories of Department of Public Works investigated uses of Pelee Island rock and stated that the Dundee (Delaware) limestone of Pelee Island was used with satisfactory results in the following locations:

- original Welland Canal locks
- the Royal York Hotel in Toronto
- structures on southeast shoal of Pelee Island
- the base of lighthouse on east part of Pelee Island
- various structures and buildings on the Island

M.T.C. investigation of the west dock on Pelee Island in the fall of 1980 found that the 20 year old concrete using coarse aggregate produced from the Pelee Quarries Inc. exhibits satisfactory durability in wetting and drying and freezing and thawing conditions in a salt free environment. This performance is illustrated on Photos No. 17, 18 and 19. The dock was built before the '30s and was reconstructed several times - 1935 and 1959 to 1961.

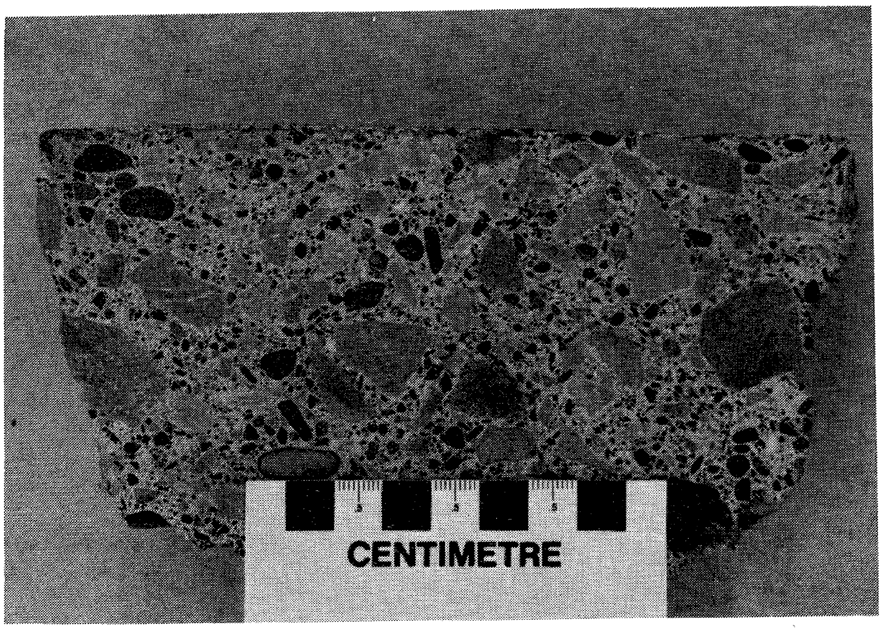
The limestone in Pelee Quarries Inc. is in the same formation as the limestone in the Chemstone Quarry at Marblehead, Ohio. The Dundee Formation is called Columbus in the U.S.A. It also appears to possess similar properties. The coarse aggregate from the Chemstone Quarry has been used for concrete pavement with good performance (see Appendix 3).

There is very little accurate information available on the performance of concrete produced with coarse

WEST DOCK, PELEE ISLAND

Looking west from main road.

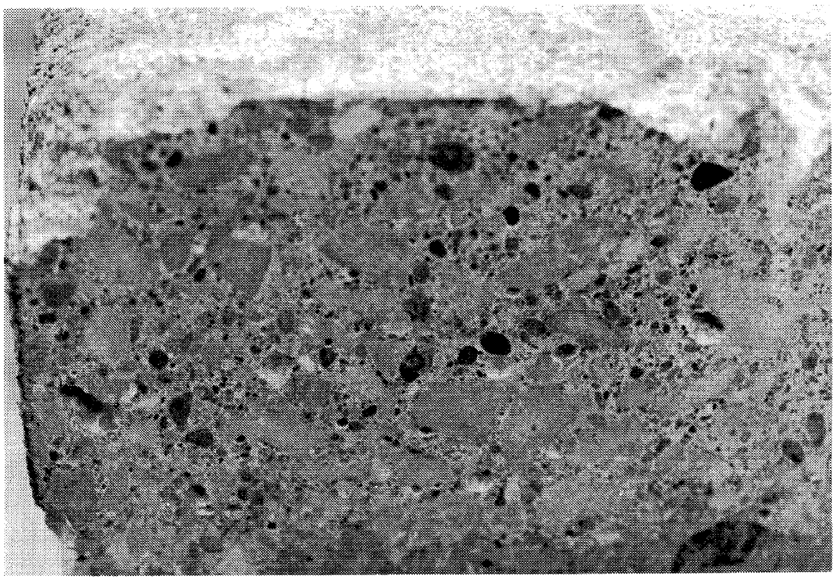
Photo 17



Cut section of concrete from the north wall.
Note:
The sound light coloured limestone particles.

Photo 18

WEST DOCK, PELEE ISLAND
(cont'd)



Cut section of concrete from the north wall.

Note:
The sound light coloured limestone particle

Photo 19

aggregate from quarries on the mainland. Nevertheless, personal communication with Mr. B.K. Glassford, M.T.C. Geologist (now retired) brought to light that concrete produced with limestone from the Amherstburg area was used prior to 1940 in the following roads and buildings:

- Riverside Drive - Windsor
- Malden Road - Colchester Township
- 2nd Concession Road - Anderdon Township
- Hwy. 40 - near Sombra
- Ambassador Bridge (piers) - Windsor
- Detroit Tunnel - Windsor
- Prince Edward Hotel - Windsor (now demolished due to urban redevelopment)
- Norton-Palmer Hotel - Windsor
- Assumption Church - Windsor
- University of Windsor (old buildings)

These sites have not been investigated but since the roads and buildings survived the test of time, it can be assumed that the used concrete coarse aggregate was reasonably sound. At the time of construction only the top level (3 m) of Amherst Quarries was open; therefore, it is certain that coarse aggregates for those roads and buildings were supplied from there.

8. GRADED AGGREGATE SPECIFICATIONS

The current M.T.C. gradation specification for granular A aggregate (M.T.C. Form 1010) restricts the fines content of quarried graded aggregate to 10.0%. The permitted range passing the 4.75 mm (No. 4) sieve is 33 - 55% (refer to Figure 10). These are the two sizes on which quarried aggregates produced in Essex County have a tendency to fail.

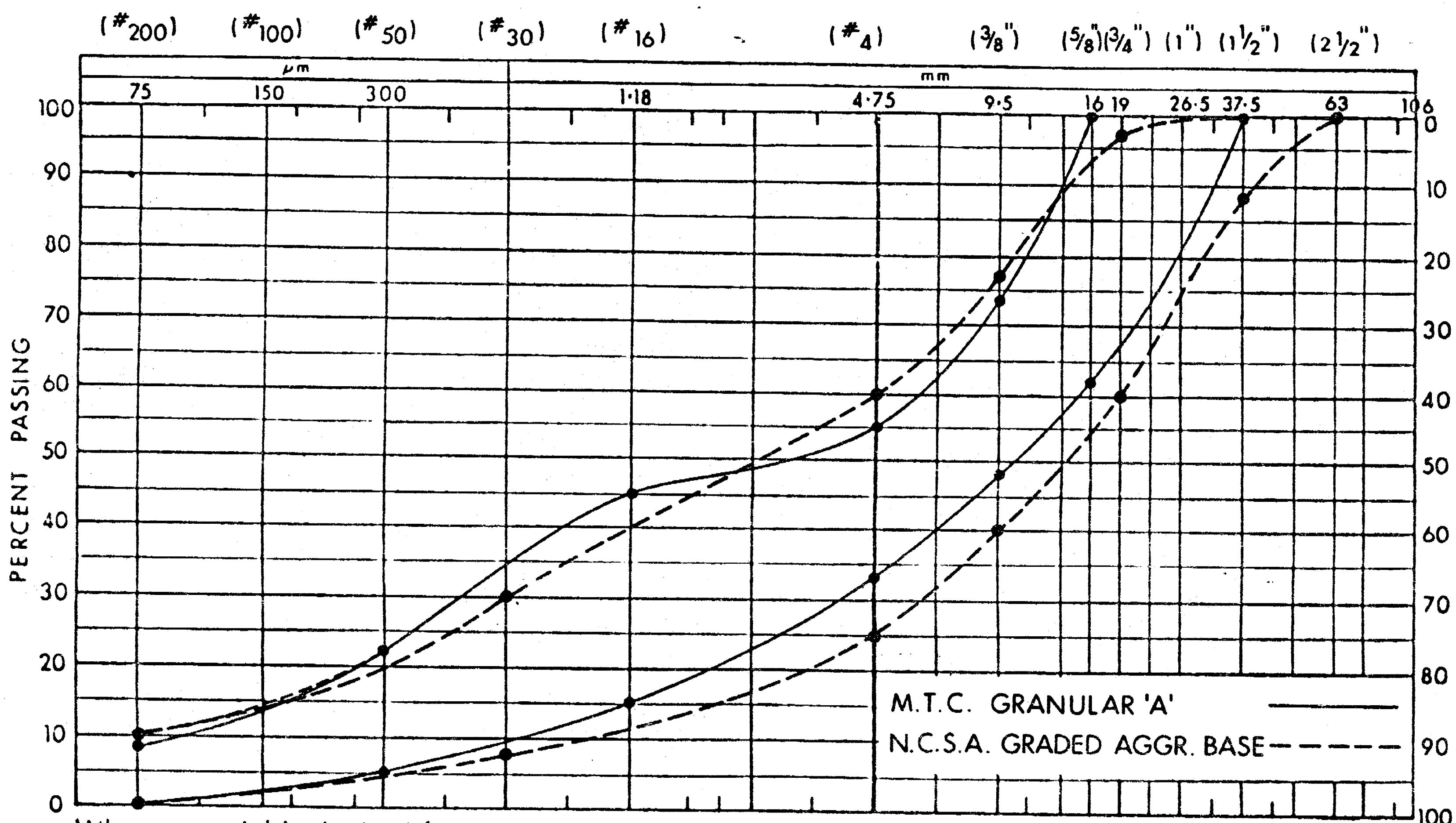
The gradation specification for graded crushed stone bases recommended by the National Crushed Stone Association, (U.S.A.) also restricts the fines content to 10.0%. However, their specification is a great deal more lenient on the coarser sieve sizes (see Table 13 and Figure 11).

TABLE 13

Gradation Limits Recommended by the National Crushed Stone Association for Graded Crushed Stone Base (1976, Guidelines for Serviceable Crushed Stone Bases)

Sieve Size (U.S.A.)	M.T.C. Sieve Equivalents	Master Range Percentage Passing	Job Mix Tolerances
64.0 mm (2½")	63.0 mm	100	
38.1 mm (1½")	37.5 mm	88-100	±5
19.0 mm (3/4")		60-97	±8
9.5 mm (3/8")		40-77	±8
4.8 mm (No.4)	4.75 mm	25-60	±8
595 µm (No.30)	600 µm	7-30	±5
74 µm (No.200)	75 µm	0-10	±3

For granular materials used for untreated surface layers the National Crushed Stone Association recommends fines content up to 12.0% (see Table 14).



Where material is obtained from a rock quarry source, 10 % passing the 75μm sieve will be permitted.

GRADATION ENVELOPE FOR GRADED CRUSHED STONE BASES ACCORDING TO THE NATIONAL CRUSHED STONE ASSOCIATION (U.S.A.)

FIG. 11

TABLE 14

Gradation Limits Recommended by the National Crushed Stone Association for Aggregate Surfacing Materials

Sieve Size	Master Range Percent Passing	Job Mix Tolerances
37.5 mm (1½")	100	
19.0 mm (3/4")	75-100	± 8
4.75 mm (No.4)	35-65	±10
660 μm (No.30)	12-35	± 8
75 μm (No. 200)	4-12	± 3

In order to improve internal drainage of these materials, either a drainage stone layer "daylighted" on both sides of the road or perforated drainage pipes along both sides of the road should be incorporated into the design (Johnson, 1974).

9. FINANCIAL CONSIDERATIONS

In the past, Essex County has been supplied with granular base aggregates from four major sources:

- Quarries at the Cayuga-Hagersville area brought in by rail.
- Gravel pits in the Komoka-London area brought in by truck or by rail.
- Processed aggregate imported from U.S.A. quarries brought in by water.
- Quarries in Essex County brought in by truck.

Due to the current high cost of railway transportation charges, the quarries in the Cayuga-Hagersville area can no longer competitively supply granular base aggregate to the Windsor market. The transportation of gravel from the Komoka-London area has not been competitive; therefore, it has stopped more than two decades ago.

Importing from U.S.A. is a viable alternative and it is still being carried on by several aggregate brokers. (see Appendix 4, 6).

Two of the local quarries discussed in this report, Allied Chemical Ltd., McGregor and Amherst Quarries Ltd. can competitively supply granular base aggregates for all parts of the county.

It should be noted that while gravel is also available at the Pinehurst area eight miles east of Chatham, it is not economical for the Windsor area due to the expensive truck haulage. The available quantity is limited and the owners use their aggregates resources for their own work in the vicinity of Chatham.

The recently published report by consultants Peat-Marwick and Partners and M.M. Dillon Limited list two additional possible sources of aggregates:

- quarries on Manitoulin Island by water.
- gravel pits in the 'Saugeen' (Grey County) area by rail.

While the first alternative is economically feasible, the second one is not, due to the excessive railway transportation cost.

The approximate cost of aggregates at job sites in Windsor from all of these traditional sources has been estimated by the Estimating Office, M.T.C. and are listed on Table 15. The cost of the proposed sources (6 & 7) were obtained from Peat-Marwick & Partners, M.M. Dillon Ltd., 1980, Mineral Transportation Study.

TABLE 15

Cost of Granular Base Aggregates Transported to Windsor F.O.B.

Source of Aggregate	Mode of Transportation	Delivered Price Per Tonne at Windsor (Spring 1981)
1. Quarries at Cayuga-Hagersville Area.	Rail	28.00
2. Gravel pits at the Komoka-London Area.	Rail Truck	21.00 10.00
3. Presque Isle Quarry in USA.	Water & Truck	6.45
4. Allied Chemical of Canada Ltd. Quarry.	Truck	6.70
5. Gravel Pits 8 Mi. East of Chatham.	Truck	10.00
6. Quarries on Manitoulin Island.	Water & Truck	7.65
7. Gravel Pits in Saugeen Area (Grey County).	Rail & Truck	10.25

10. CONCLUSIONS

ON THE BASIS OF THE FINDINGS OF THE INVESTIGATION AS WELL AS ON THE PAST HISTORY OF THE QUARRIES, THE FOLLOWING MAY BE CONCLUDED:

10.1 THE DETROIT RIVER GROUP AND DUNDEE CARBONATE ROCK FORMATIONS, WITH SELECTION, CAN PROVIDE GOOD QUALITY GRANULAR BASE AGGREGATES FOR ESSEX COUNTY.

10.2 QUARRIES IN THESE FORMATIONS CAN PROVIDE THE COUNTY WITH SUFFICIENT QUANTITIES OF GRANULAR BASE AGGREGATES TO MEET M.T.C. AND MUNICIPAL REQUIREMENTS ECONOMICALLY. THEY ALSO PROVIDE HEALTHY COMPETITION TO IMPORTED AGGREGATES FROM THE U.S.A. AND TO AGGREGATES SHIPPED FROM MANITOULIN ISLAND.

10.3 SOME LAYERS IN THESE FORMATIONS ARE SOFTER THAN OTHERS AND AGGREGATES PRODUCED FROM THEM REQUIRE SPECIAL SELECTION FOR GRANULAR BASE AS WELL AS HOT MIX PAVING AND CONCRETE USES.

10.4 THE UPPER LIFT OF THE ALLIED CHEMICAL LTD., McGREGOR QUARRY CONTAINS ROCK OF HIGH QUALITY SUITABLE FOR ALL AGGREGATE USES. THE LACK OF FINES FROM THIS LIFT CAUSES SOME DIFFICULTY IN COMPACTION AS WELL AS LOSS OF STONES WHEN USED ON UNTREATED OR UNPAVED GRANULAR SURFACE ROADS.

THE LOWER LIFT IS OF POORER QUALITY AND IS ONLY ACCEPTABLE FOR GRANULAR BASE, SUBBASE AND H.L. BINDER COURSE PAVING USES. THE ROCK FROM THIS LIFT TENDS TO PRODUCE EXCESSIVE FINES WHEN CRUSHED FOR GRANULAR BASE.

THE BLEND OF GRANULAR BASE AGGREGATES FROM THE UPPER AND LOWER LIFTS WILL LIKELY RESULT IN A SATISFACTORY PRODUCT.

THE UPPER 6.1 m OF THE LOWER LIFT IS OF BETTER QUALITY THAN THE LOWER 6.1 m AND IT WOULD PRODUCE SUITABLE COARSE AGGREGATES FOR H.L. SURFACE COURSE PAVING AND STRUCTURAL CONCRETE.

10.5 AGGREGATE PRODUCED FROM THE THREE COMBINED LIFTS OF AMHERST QUARRIES (1969) LTD. IS ONLY ACCEPTABLE FOR GRANULAR BASE AND SUBBASE USES AND HAS A TENDENCY TO CONTAIN FINES (PASS 75 μm) IN EXCESS OF THE 10.0% PERMITTED BY M.T.C. SPECIFICATIONS. THE FINES CONTENT OF THE GRANULAR BASE AGGREGATE MAY BE IMPROVED BY CRUSHING THE ROCK TO 37.5 mm (1½") MAXIMUM SIZE. THE QUALITY OF THE AGGREGATE MAY ALSO BE IMPROVED BY CRUSHING THE LOWER LIFT (WHICH IS OF THE BEST QUALITY) EXCLUSIVELY FOR THIS PURPOSE.

10.6 AGGREGATE FROM THE CURRENT WORKING LEVEL OF PELEE QUARRIES LTD. IS ACCEPTABLE FOR GRANULAR BASE AND SUBBASE USES. THE LOWER LAYERS OF LIMESTONE, BELOW THE QUARRY FLOOR, MAY BE CONSIDERED FOR STRUCTURAL CONCRETE AND HOT MIX BINDER COURSE PAVING COARSE AGGREGATES.

11. RECOMMENDATIONS

11.1 ALL THREE INVESTIGATED QUARRIES SHOULD BE ACCEPTED QUALITATIVELY FOR GRANULAR BASE AND SUBBASE USES.

11.2 FOR GRANULAR A THAT IS TO BE COVERED WITH HOT MIX ASPHALT, CONCRETE PAVEMENT OR SURFACE TREATMENT, THE NOMINAL SIZE OF THE AGGREGATE SHOULD BE NO SMALLER THAN 26.5 mm (1").

11.3 FOR GRANULAR A WITH A NOMINAL SIZE OF 26.5 mm (1"), THE MINIMUM PASSING THE 4.75 mm (#4) SIEVE SHOULD BE CHANGED FROM 33% to 30%.

11.4 FOR GRANULAR A AND 16 mm CRUSHED TYPE B USED FOR UNTREATED SURFACE LAYER OR SURFACE DRESSING, A MAXIMUM MEAN FINES CONTENT OF 12.0% SHOULD BE PERMITTED.

11.5 ALTERNATIVE DESIGNS TO IMPROVE THE INTERNAL DRAINAGE STRUCTURE INCORPORATING 22.4 mm MAXIMUM SIZE GRANULAR A AGGREGATE SHOULD BE INVESTIGATED BY THE PAVEMENT DESIGN AND FOUNDATION SECTION.

11.6 ALL THREE QUARRIES SHOULD BE INVESTIGATED FURTHER TO ESTABLISH THE SUITABILITY OF AGGREGATES FROM SELECTED LEVELS FOR STRUCTURAL CONCRETE AND HOT MIX PAVING COARSE AGGREGATES.

12. REFERENCES

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13. APPENDICIES

APPENDIX 1

Ontario

Ministry of
Transportation and
Communications

Soils and Aggregates Section,
Room 307, Central Building,
1201 Wilson Ave.,
Downsview, Ontario.
M3M 1J8.

Tel. No. 248-3286

Dear

Re: Quarried Aggregates,
Essex County.

Early in the summer of 1980, the Ministry of Transportation and Communications will be carring out an investigation into the suitability of quarried aggregates produced in Essex County.

In regard to the above investigation, we would appreciate receiving information on the use of Granular Base and Hot Mix paving aggregates in contracts awarded by your municipality in the last 10 years. We are particularly interested in crushed aggregates from the following quarries:

Brunner-Mond Canada Ltd.,
Amherst Quarries Ltd.,
Allied Chemicals of Canada - McGregor Quarry,
Pelee Island Quarry.

Attached is a form indicating the information required. Would you please forward this information at your earliest convenience to the undersigned. Should you require any additional information or personal assistance please contact us.

Yours truly,

Z. Koniuszy,
Geologist.

ZK/jc

ROAD CONSTRUCTION INFORMATION

Cont. No.	Year of completion	Road (✓)		Type of Use (✓)			Has the contract been paved over since constr.	Location (Cty.Rd.No.;Twp.Rd.No. Beginning - End)	Source of Aggregate		Name of Construction Company	Remarks (Has the road performed satisfactorily?)
		Paved	Unpaved	Gran. Base	Hot Mix Paving Type	Surface Treat.			Gran. Base	Hot Mix or Surf. Treat. Co.Agg.		

Public Works Canada / Travaux publics Canada

Ontario Region / Région de l'Ontario

APPENDIX 2

457 Richmond St., P.O. Box 668,
LONDON, Ont. N6A 4Y4

25 May 79

Your file / Votre réf. 3162-2-4-1

In reply quote / Réf à rappeler C4242-530

For further information please contact. / Pour de plus amples informations, prière de communiquer avec
T. Greenlees 679-4304 Loc / Poste

Mr. Chris Rogers
Material Laboratory Services Section
Ministry of Transportation&Communication
1201 Wilson Avenue
DOWNSVIEW, Ontario
M3M 1J8

Dear Sir:

Re: Pelee Island, Ont - Aggregate from Pelee Quarry

Your letter of 79-04-11 to Mr. Scantlebury has been referred to me by Mr. T. E. Douglas, Ontario Region Public Works Canada.

I regret that we do not have the construction records which would provide the detailed information that you requested. The north wharf was last reconstructed in 1950 when the approach structure was rebuilt in steel sheet piling. The west wharf approach was partially reconstructed in 1951, and the outer section in 1935, 1959, 1960 and 1961.

We do have some information on the armour stone produced in the quarry for the inner harbour breakwater constructed in 1953, and the offshore breakwater constructed in 1963. The source of the information is a survey of Armour Stone potential prepared by the testing laboratories of the Department in 1965. Please see attached sheets.

The stone has been used in the Leamington breakwater 1957, and at Wheatley in 1978. We consider it to be well suited to breakwater construction and to be durable under long exposure.

I trust this information will be of some use to you. Unfortunately no other records are available.

Yours truly,

W. I. Slywchuk
Engineer-in-Charge
Design & Construction
London

APPENDIX 1

DESCRIPTION OF QUARRIES VISITED

PELEE ISLAND

Only the North and West shores of the island were visited. There rock was found near surface although it is reported that the rock dips belows a considerable cover of overburden in the interior of the island.

The bedrock observed consists of a sandy limestone or dolomite of the Columbus Formation. This formation is relatively resistant to erosion and the island probably owes its existance to this fact.

The stone has been quarried intermittently at a number of locations on the island for more than 100 years although there are no operating quarries now. It has found satisfactory use in:

- the original Welland Canal locks
- the Royal York Hotel in Toronto
- structures on South East Shoal
- the base of a lighthouse east of the island
- various structures and buildings on the island
- the Leamington breakwater
- the Pelee Island (Scudder) breakwaters.

Hand hewen 2'X 4'X 8'rock slabs are found in the old quarry just north of the village of Pelee Island. They are reported to have been part of a shipment for the Royal York Hotel. They are about 75 years old but are still in excellent condition.

The most recent quarry operations were located 1/2 to one mile south east of the Scudder wharf. It actually consist of 2 large quarries which are about 15 feet deep. The quarry section consist of 2 to 3 feet of thin bedded flagstone over a massive 6 foot bed which in turn covers an 8 foot thick bed. It is uneconomical to go deeper because of groundwater conditions. (See Plate 1)

It is reported that during the last quarry operation the stone was quarried exclusively for armour stone for breakwater construction. Vertical holes were drilled on a pattern which was varied according to joint spacings. Dynamite was used. Apparently large sized stone was obtained without difficulty and without excessive handling.

. . . .

'PPENDIX 2

-XAMINATION OF STONE IN USE

PELEE POINT

erosion is known to be a problem on Pelee Point so it was visited to see what materials were in use there.

A 1/2 mile long section of rip rap was found along the west shore near the tip of the peninsula. The rip rap consisted of some limy - dolomite of unknown origin but was mostly granitic boulders.

Rather extensive use of precast sections on both shores (see plates 4 and 5) suggests that armour stone is not readily available there. The lack of protection on the shoreline below most cottages supports this view.

→ PELEE ISLAND

The plan of the North Harbour (Scudder) is shown in figure 1. The two rubble mound breakwaters were constructed in 1963 of stone from the Pelee Island quarry.

The stone fragments are large and blocky and are resisting weathering very well (see plate 6 and 7)

Pelee Island stone has also been used for shore protection along the west coast. This rock is standing up very well. The best proof of successful service is the 75 year old abandoned pier just north of the town of Pelee Island. The rock in this pier is still in excellent condition.

LEAMINGTON

The plan of this structure is shown on figure 2.

The corner on the west side of the pier has been protected by armour stone from the Amherst quarry. The rock is a light buff laminated to massive dolomitic limestone. Some of the pieces of rock have a slabby shape and are splitting along shaly or bituminous partings.

. . . .

Mr. W.R. Bennett,
Head,
Quality Assurance Section,
2nd Floor, West Building.

Mr. B.K. Glassford,
Geologist,
Pav't Design & Management Section.

77 09 02

Visit to Chemstone Quarry - Marblehead, Ohio

This quarry was visited by me on July 5th and 6th, 1977.

The quarry has been developed in a limestone area, where the limestone has a 7% to 12% dolomitic analysis. Locally, the geologic formation is known as the Columbus formation. The quarry covers 22 acres.

There are three lifts or working levels to the quarry, each being distinct from the others.

(a) The first or top lift is a soft, buff coloured limestone, chert free and chemically averaging 7% to 10% dolomite. This top lift was used for a blast-furnace flux rock. At the present time, this top lift has been removed completely from the quarry confines.

(b) The second or middle lift is a soft, buff coloured limestone containing chert nodules. This material is not acceptable for rock as a flux in blast-furnace use, due to the chert content. It is from this second horizon that the Chemstone Corporation would supply GBC 'A' and 5/8" A material to the MTC. The chert content would be approximately 12%.

(c) The third lift is currently being opened and developed for supply of flux for the blast-furnace industry. This horizon is a chert free, soft, buff coloured limestone with a dolomite content averaging 10%. From this working level, Chemstone would supply HL3, 6 and concrete materials if MTC specifications were met.

The quarry operations fall within the MTC definition of a commercial producer. Material is washed and blending facilities are available for any grading specifications required. Operations are on a permanent year-round basis.

Cont'd... /2

Re: Visit to Chemstone Quarry - Marblehead, Ohio

A field opinion of the aggregate materials examined would be as follows:

2nd Lift - This material should fall within MTC specifications for Granular 'A' and 5/8" A, and hence should be suitable for use as such, even though the chert content is approximately 12%. The rock appears soft and the L.A. results should be fairly high. The absorption should also be high. Petrographically, the rock appears to be suitable for Granular 'A' and 5/8" A.

3rd Lift - This material would appear to be borderline for HL3, 6 and concrete aggregates. The rock appears soft and should have a high L.A. loss and also a high absorption loss. Petrographically, the rock from this lift would appear to be borderline for HL3, 6 and concrete.

At the present time the quarry workings are in two lifts which are the original 2nd and 3rd levels. The following lithological descriptions include the present working levels, now designated as 1 and 2 respectively and the section of the drainage sump in the quarry floor.

Standard Slag Company
Marblehead Quarry Division
Vertical Section - West Quarry Face

Unit	Lithological Description	Interval	Thickness
1	Level 1 Limestone: Magnesian; light brownish grey, buff weathering; fine grained; thin bedded; moderately soft to moderately hard; moderately absorptive; occasional thin dark brown bituminous shale seams at the base of beds; thin layer (0.1 ft.) of white chalky chert at 6.0 ft.; upper 2.5 ft. weathered.	0 - 12.0	12.0
2	Level 2 Limestone: Magnesian; light brownish grey buff weathering; fine grained; massive bedded; moderately soft to moderately hard; fossiliferous - mainly brachiopods and solitary corals; absorptive; petroliferous; bituminous shale seam at the base (0.03 ft.).	12.0 - 20.0	8.0

Cont'd.../3

Re: Visit to Chemstone Quarry - Marblehead, Ohio

(Cont'd)

Standard Slag Company
Marblehead Quarry Division
Vertical Section - West Quarry Face

Unit	Lithological Description	Interval	Thickness
3	Limestone: medium grey mottled; medium grained; hard.	20.0 - 23.0	3.0
4	Limestone: medium brownish grey and medium brown to dark brown laminated; fine grained; medium hard; petroliferous; thin bituminous shale seams in the lower 0.05 ft.	23.0 - 24.5	1.5
5	Limestone: medium grey mottled; medium grained; hard.	24.5 - 26.0	1.5
6	Limestone: medium brownish grey mottled; fine grained; medium hardness; petroliferous; rare thin bituminous shale seams.	26.0 - 30.5	4.5
7	Limestone: medium grey; medium grained; hard; thick bituminous stylolitic shale parting at the base.	30.5 - 30.7	0.2
8	Limestone: medium brownish grey and medium brown laminated; fine grained; occasional thin bituminous shale seams; medium hard; petroliferous.	30.7 - 34.2	3.5
9	Limestone: medium grey; medium grained; hard; bituminous shale seam at the base.	34.2 - 35.7	1.5
10	Limestone: medium brownish grey and medium brown laminated; fine grained; moderately hard; petroliferous; thin bituminous shale seam at the base.	35.7 - 37.2	1.5
11	Limestone: medium grey mottled; medium grained; hard.	37.2 - 38.7	1.5

Cont'd... /4

Re: Visit to Chemstone Quarry - Marblehead, Ohio

(Cont'd)

Standard Slag Company
Marblehead Quarry Division
Vertical Section - West Quarry Face

Unit	Lithological Description	Interval	Thickness
12	Limestone: medium brownish grey and medium brown laminated; fine grained; moderately hard; petroliferous; bituminous shale seam at the base.	38.7 - 41.2	2.5
13	Limestone: medium brownish grey and medium brownish grey and medium grey laminated; medium bedded; fine grained; variable hardness - medium to moderately ha hard; petroliferous; bituminous shale seams between beds.	41.2 - 50.2	9.0
	Drainage Sump in Quarry Floor		
14	Limestone: medium brownish grey and medium brown laminated; medium bedded; fine grained; moderately hard; petroliferous; occasional bituminous shale seams between beds.	50.2 - 57.2	7.0
15	Limestone: medium grey; thin bedded; fine grained; dense; very hard.	57.2 - 58.2	1.0
16	Limestone: medium brownish grey; medium bedded; fine grained; medium hardness; thin bituminous shale seams between beds.	58.2 - 60.2	2.0

The following samples of processed aggregates were obtained during this visit.

Sample No.	Size	Wash
77B 20265	1" - 1/2"	Yes
20266	1" - 1/2"	Yes
20267	1" - 1/2"	Yes
20268	1/2" - #4	Yes
20269	1/2" - #4	Yes
20270	Screenings	No

Cont'd.../5

Re: Visit to Chemstone Quarry - Marblehead, Ohio

Test results from the samples listed on page 4 of this memo are as follows:-

Sample No.	PN Granular-HL	Conc.	$MgSO_4$	LA	Abs	Wash 200	SG
20265	100.0	120.0	12.8	30.9	3.48	0.81	2.70
20266	103.8	128.2	18.1	30.9	3.85	0.74	2.69
20267	100.0	116.0	24.4	31.4	4.25	0.94	2.70
20268	106.3	136.0	6.7	31.0	4.70	0.36	2.73
20269	106.1	149.2	11.7	31.2	4.66	0.44	2.71
20270	Screenings		25.7	-	-	24.4 (unwashed)	-

Further testing is being done at Ontario Hydro Laboratories for freeze-thaw determinations on concrete samples made with Marblehead aggregate. Results from this test should be completed by December, 1977.

During this visit an appraisal of the Marblehead Quarry limestone aggregate usage in concrete pavement was made. The highway Ohio No. 2, 4 lanes with a median dividing in the vicinity of Port Clinton, Ohio was constructed with a concrete surface approximately 4-5 years ago. The aggregate used for this concrete came from the Marblehead Quarry.

The present physical condition of the pavement (10 miles) four lanes wide appears to be excellent. The following typical physical concrete pavement failure features were looked for. All transverse joints appeared to be sawn and filled with a neoprene sealant.

1. Loss of base support causing frost heaving and settlement. - none
2. Concrete expansion stresses (blow-ups and failures) - none
3. Spalling of surface - none
4. Spalling caused by steel dowel bars - none
5. Compression spalls - none
6. Longitudinal cracking - none
7. Transverse cracking - few 'hair-line' cracks were noticed from outer edge inwards.
8. Joint stepping - none

Cont'd.../6

Re: Visit to Chemstone Quarry - Marblehead, Ohio

9.	Aggregate 'pop-outs'	- few scattered ones noticed (approx. 0.5%) of entire pavement length.
10.	Aggregate disintegration	- none
11.	Surface polishing	- few small areas up to 6-10 sq. ft.
12.	'D' cracking	- none noticed

The excellent condition of this concrete pavement (up to the present time) does not coincide with the poor physical test results obtained with the aggregate samples from the Marblehead Quarry. The test results would indicate an aggregate of borderline to poor quality.

B.K. Glassford

B.K. Glassford,
Geologist.

BKG/sd

cc:- J.B. Wilkes
A.G. Stermac
T.J. Kovich
J. Roy
Z. Katona
Files

APPENDIX 4

BULK STORAGE (Windsor-Sombra) LTD.

10050 RIVERSIDE DRIVE EAST, WINDSOR, ONTARIO N8P 1A1
TELEPHONE (AREA CODE 519) 735-9822

March 24, 1981

M.T.C.
Estimating Office
1201 Wilson Avenue
DOWNSVIEW, Ontario
M3M 1J8

ATTENTION: MR. SHARMA

Dear Mr. Sharma:

Please find enclosed our prices per net ton for the 1981 season as of April 1, 1981 from our East Windsor (Riverside) dock.

M.T.C. Granular "A"	$5.85
7/8 Modified Granular "A"	$5.10
5/8 Modified Granular "A"	$5.05
3 x 0	$5.05
3/4 Concrete	$7.25
3/4 Clear Sewer Stone	$5.30
3/8 Chips	$7.50
Asphalt Screenings	$6.75

These prices include dockage, weighing, and loading.

All material is sold on consignment and invoiced to you from the dock weigh tickets. Upon receipt of payment in full, ownership and title of the material are transferred to your Company. Weigh scales at the dock site will determine the tonnage loaded on the trucks.

The above prices will increase by 3¢ per net ton on June 1st, August 1st, October 1st, and December 1st due to fuel increases by our boat companies.

All payment cheques will be credited on the oldest invoice. Your Company will be rebated 15¢ per net ton for payments received prior to 15 days from the

con't

date of invoice or a 10¢ per net ton rebate for payments received prior to 30 days from date of invoice. Either rebate will be in the form of a cheque issued to your Company by us. This rebate will not be issued on payments received after 30 days from the invoice date regardless of the date on the payment cheque. A 2% interest charge per month if payment is not received in 30 days from invoice date will apply.

Thank you for the opportunity to quote on your aggregate requirements.

Yours truly,

Jack Frye
Vice President - Sales

JF:dd

BULK STORAGE (Windsor-Sombra) LTD.
1005 RIVERSIDE DRIVE EAST, WINDSOR, ONTARIO N8P 1A1
TELEPHONE (AREA CODE 519) 735 9822

March 25, 1981

M.T.C.
Estimating Office
1201 Wilson Avenue
DOWNSVIEW, Ontario M3M 1J8

ATTENTION: MR. SHARMA

Dear Mr. Sharma:

Please find enclosed our prices per net ton for the 1981 season as of April 1, 1981 from our Sombra Dock.

M.T.C. Granular "A"	$5.99
1 1/2 Modified Granular "A"	$5.15
5/8 Modified Granular "A"	$5.15
3/4 Concrete Stone	$6.95
3/4 Clear Sewer Stone	$5.75
HL4	$6.95
2 x 1	$7.75
Asphalt Screenings (White)	$6.99
Rip Rap	$8.25

These prices include dockage, weighing, and loading.

All material is sold on consignment and invoiced to you from the dock weigh tickets. Upon receipt of payment in full, ownership and title of the material are transferred to your Company. Weigh scales at the dock site will determine the tonnage loaded on the trucks.

The above prices will increase by 3¢ per net ton on June 1st, August 1st, October 1st, and December 1st due to fuel surcharge increases by our boat companies.

All payment cheques will be credited on the oldest invoice. Your Company will be rebated 15¢ per net ton for payments received prior to 15 days from the

con't

date of invoice or a 10¢ per net ton rebate for payments received prior to 30 days from date of invoice. Either rebate will be in the form of a cheque issued to your Company by us. This rebate will not be issued on payments received after 30 days from the invoice date regardless of the date on the payment cheque. A 2% interest charge per month if payment is not received in 30 days from invoice date will apply.

Thank you for the opportunity to quote on your aggregate requirements.

Yours truly,

Jack Frye
Vice President - Sales

JF:dd