GEOLOGY FOR PLANNING

AT

LANGDON, NORTH DAKOTA

BY

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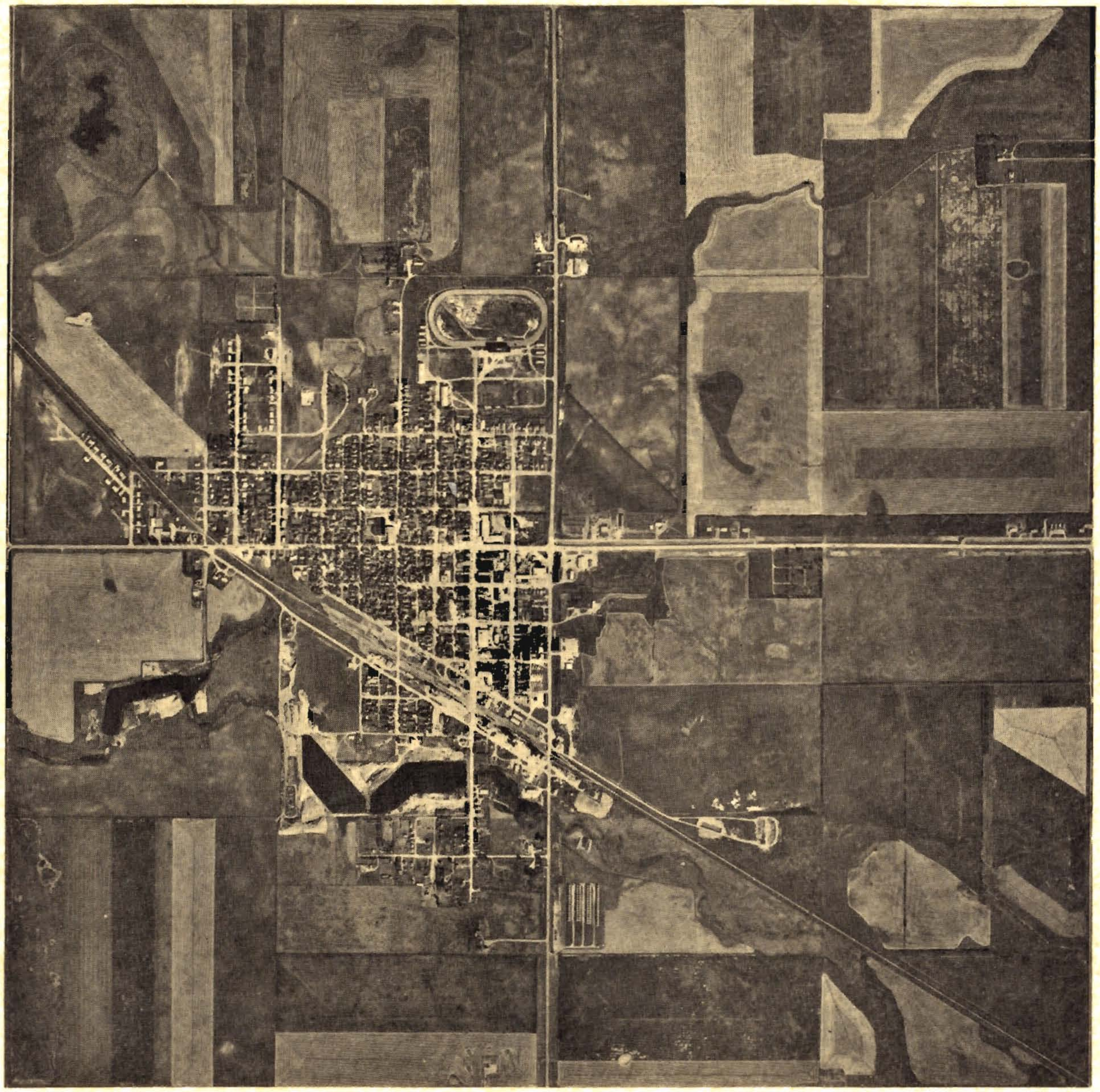

REPORT OF INVESTIGATION NO. 50
NORTH DAKOTA GEOLOGICAL SURVEY
E. A. Noble, State Geologist
1972

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INTRODUCTION

The installation of the Safeguard Ballistic Missile Defense System near Nekoma, North Dakota, has greatly boosted the economy of the area. This economic boost, however, has not been without its problems. The sudden increase in population has resulted in shortages in housing and community services and has strained the capacity of the local schools. The city most severely affected by this construction activity has been Langdon, North Dakota.

At the height of construction activity, the population is expected to increase by 3,000 people (population of Langdon in 1970 was 2,182). Once the installation is completed, a permanent population increase of several hundred is expected. These increases in population will necessitate careful planning by the city of Langdon in order that it may supply essential services to its residents. The North Dakota Geological Survey was asked by the State Planning Commission for geologic information on the Langdon area to aid in this planning. This planning report, along with other reports by consulting engineers and the Corps of Engineers, is designed to help the city achieve these goals.

This report was critically reviewed by S. R. Moran of the North Dakota Geological Survey and by Lee Clayton of the Geology Department of the University of North Dakota. Their assistance is gratefully acknowledged.

SOURCES OF DATA

This report is based on field mapping done in conjunction with a groundwater study of Cavalier and Pembina Counties. Subsurface information was obtained from test borings by the North Dakota Geological Survey and the State Water Commission. Information based on wells drilled by private contractors was obtained through the courtesy of the U. S. Geological Survey. Test borings completed by Porter and O'Brien (consulting engineers) for the U. S. Air Force were also used. In addition, logs from oil well tests, on file with the North Dakota Geological Survey, were used.

REGIONAL SETTING

Langdon is located in central Cavalier County in northeastern North Dakota. Nearly all of Cavalier County is an area of gently rolling to undulating topography. Elevations in the county range from 1680 feet above sea level south of Langdon to less than 1200 feet at the top of the Pembina Escarpment. Streams are uncommon, and many of these are intermittent, flowing only after storms or during spring runoff. Numerous small ponds and sloughs occur throughout the county. The topographic features in the Langdon area are a result of deposition of materials by the glaciers that traversed the area about 15,000 years ago.

GEOLOGIC SETTING IN THE LANGDON AREA

Two formations are exposed at the surface in the four townships surrounding Langdon. The Coleharbor Formation consists of deposits of glacial origin. The clays and silts of the sloughs and along stream courses that have been deposited since the last glaciation are included in the Walsh Formation (formally defined by Bluemle, in preparation). These formations have been subdivided into units on the basis of morphology and lithology and are shown in Figure 1. The description of these map units is given below.

Map Unit

Walsh Formation	1.	Clay, black, highly organic, plastic. Occurs in undrained depressions and along intermittent streams. Pond, swamp, and slough deposits.
	2.	Clay, locally silty to sandy, sorted. The sediment, which is generally less than two feet thick, overlies pebbly loam. This is a modern stream deposit.
Coleharbor Formation	3.	Pebbly loam, clayey; locally clayey sand and gravel; this unit occurs as small, shallow valleys which were cut by water from the melting glacier. Modern intermittent streams occupy some of these valleys. Glacial till deposited in former meltwater channels.
	4.	Clay and silt, moderately well sorted black to brown layers. Surrounded by a raised rim of pebbly loam. This sediment was deposited in a pro-glacial pond.
	5.	Sand and gravel, stratified, poorly sorted, high shale content. This deposit, which occurs as a linear ridge (esker) or a series of low mounds, may be overlain by several feet of pebbly loam.

Map Unit

6. Pebbly loam; lithologically similar to unit 3. Ridges and trenches are common. Local relief ranges from 20 to 30 feet. Depressions are very abundant, numbering between 20 and 30 per square mile. Drainage is non-integrated to poorly integrated. Glacial till deposited by glaciers.

7. Pebbly loam; chiefly a homogenous mixture of silt, clay, and sand, containing abundant limestone, granite, dolomite, shale, and metamorphic boulders, cobbles, and pebbles. Lignite fragments are present in the sand function. The color of this pebbly loam ranges from yellowish-brown to olive gray. Local relief, which is commonly less than 15 feet, may exceed 40 feet. Ponds and sloughs are few to absent. Drainage is nonintegrated to poorly integrated. Glacial till deposited by glaciers.

A series of linear ridges, which rise 40 to 50 feet above the surrounding area, occurs north of Langdon. The Langdon Country Club is located on such a ridge. These long, linear ridges, or drumlins, are composed of pebbly loam, which may overlie shale at shallow depths. Their southeast trend indicates the direction of ice movement during the last glaciation.

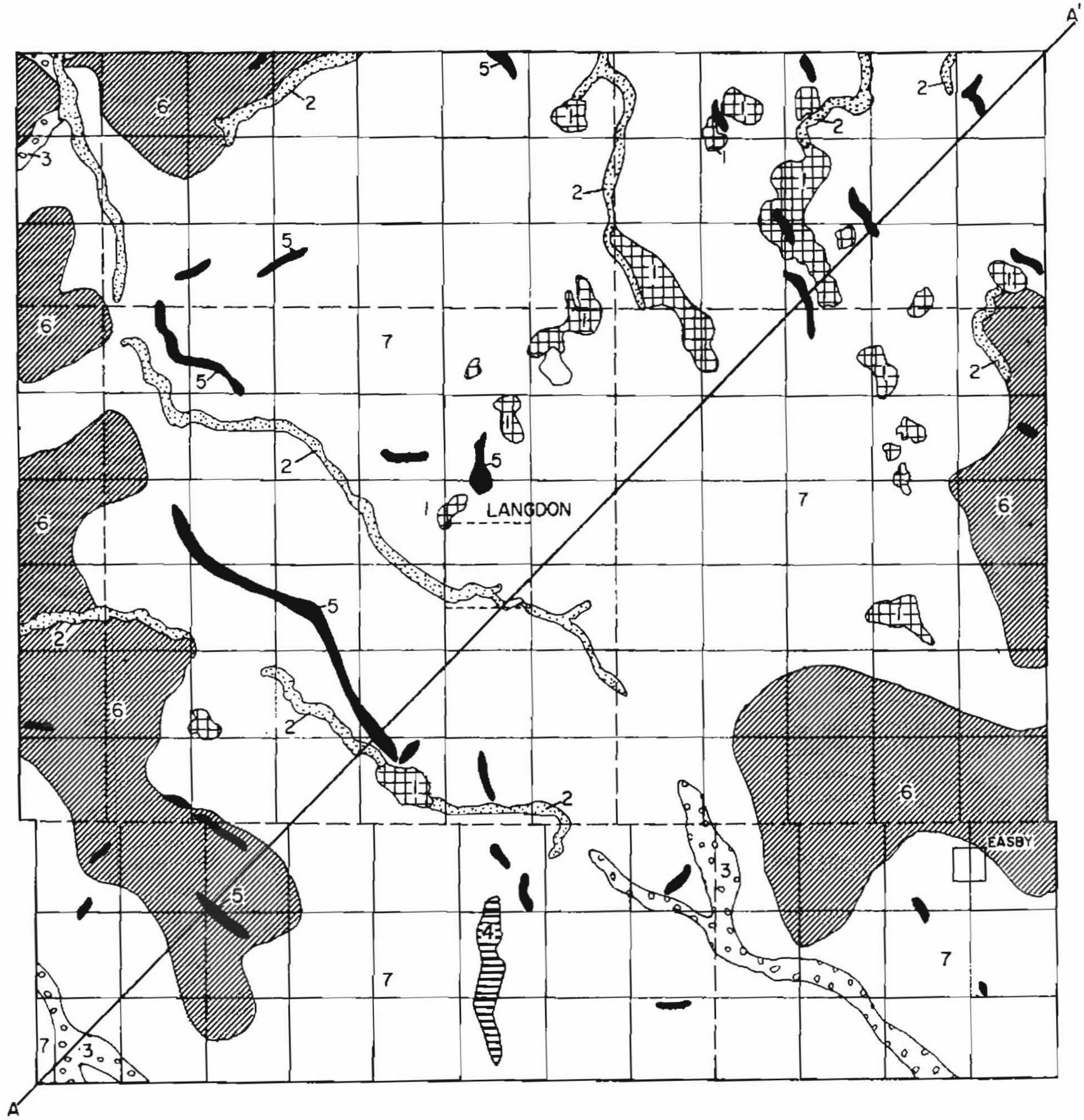

Fig. 1. Surficial geology of the Langdon area.

Age (Millions of years ago)	Era	Period	Formation	Thickness (Feet)	Rock Type
	Cenozoic	Quaternary	Walsh	<10	Sand, silt, clay and gravel
60 my			Coleharbor	10-100	Sand, silt, clay and gravel
	Mesozoic	Cretaceous	Pierre	200-300	Shale
135 my			*	540-870	Shale & Sandstone
		Jurassic		116-380	Sandstone, limestone and shale
350 my	Paleozoic	Mississippian		24-77	Limestone
400 my		Devonian		32-202	Limestone and dolomite
		Silurian		144	Dolomite
500 my		Ordovician		1251	Dolomite and limestone
		Pre-Cambrian			Granite and metamorphic rocks

*Formations below the Pierre Shale have not been differentiated for this report

Fig. 2. Generalized geologic column of rocks underlying the Langdon area.

SUBSURFACE GEOLOGY

Underlying the surface deposits in the vicinity of Langdon is the Pierre Shale of Cretaceous age (fig. 2). The Pierre Shale, which is about 300 feet thick in the Langdon area, is for the most part a hard, gray, siliceous shale. It is highly fractured to depths of as much as 80 feet locally. An abundance of iron-oxide concretions and some thin interbedded bentonite beds occur in this formation.

Figure 3 shows the relationship of the surficial deposits to the underlying shale in the Langdon area.

WATER RESOURCES

An adequate supply of water is essential for the existence and growth of any community. A city in North Dakota may have any of three alternatives in providing an adequate water supply: (1) development of a natural surface supply, such as a lake or river, (2) development and maintenance of man-made reservoirs, (3) development of a ground-water supply.

Langdon is located in an area with no natural lakes. The closest major stream that could supply water to the city is ten miles to the northeast. Consequently, Langdon has developed two artificial reservoirs on the south edge of town. In the past, these two reservoirs have held up to three times the normal demand of the community. The increased demands by an increasing population have necessitated a greater reserve of water. As a result, a pipeline from the proposed Mt. Carmel reservoir, twelve miles to the north, is being planned.

Groundwater supplies in the vicinity of Langdon are limited. The subsurface geology is primarily glacial deposits over shale as shown in the cross section in Figure 3. Neither the glacial deposits nor the shale yields enough water to be used for large-scale development. The shale, however, may supply water to individual wells at a rate generally not more than 10 gallons per minute. This amount is adequate for domestic and general farm use.

WASTE DISPOSAL

Improper waste disposal practices may result in contamination of local groundwater supplies. There are a number of factors involved in selecting a suitable site for waste disposal. These include the nature and type of refuse, the type of contaminants produced as a result of decay, and the possible harmful effects to health as a result of the contaminants produced. These are factors that can be best dealt with by health officials and engineers. There are, however, local geologic and hydrologic factors that may play an important role in selecting suitable waste disposal sites.

A favorable geologic setting for waste disposal is one in which the permeability of the earth materials at the site is low enough to retard the movement of contaminants from that site. The glacial deposits in the Langdon area are relatively impermeable and are generally satisfactory sites for waste disposal. Shale, which underlies the glacial deposits, has a relatively high permeability because of its highly fractured nature. As a result contaminants may move from the disposal site into the groundwater system. The thickness of the glacial deposits over the shale is a factor which should be considered in selecting a disposal site (fig.4).

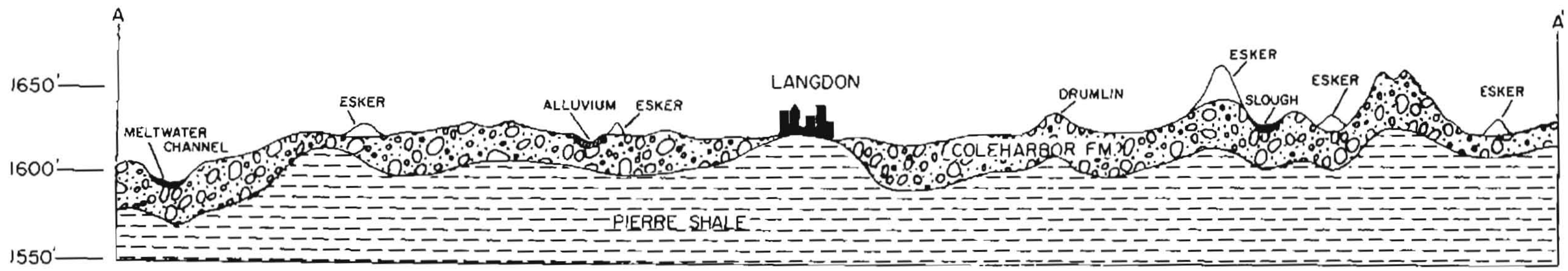

Fig. 3. Generalized northeast-southwest (A-A') cross section showing the Coleharber Formation and the top of the Pierre Shale.

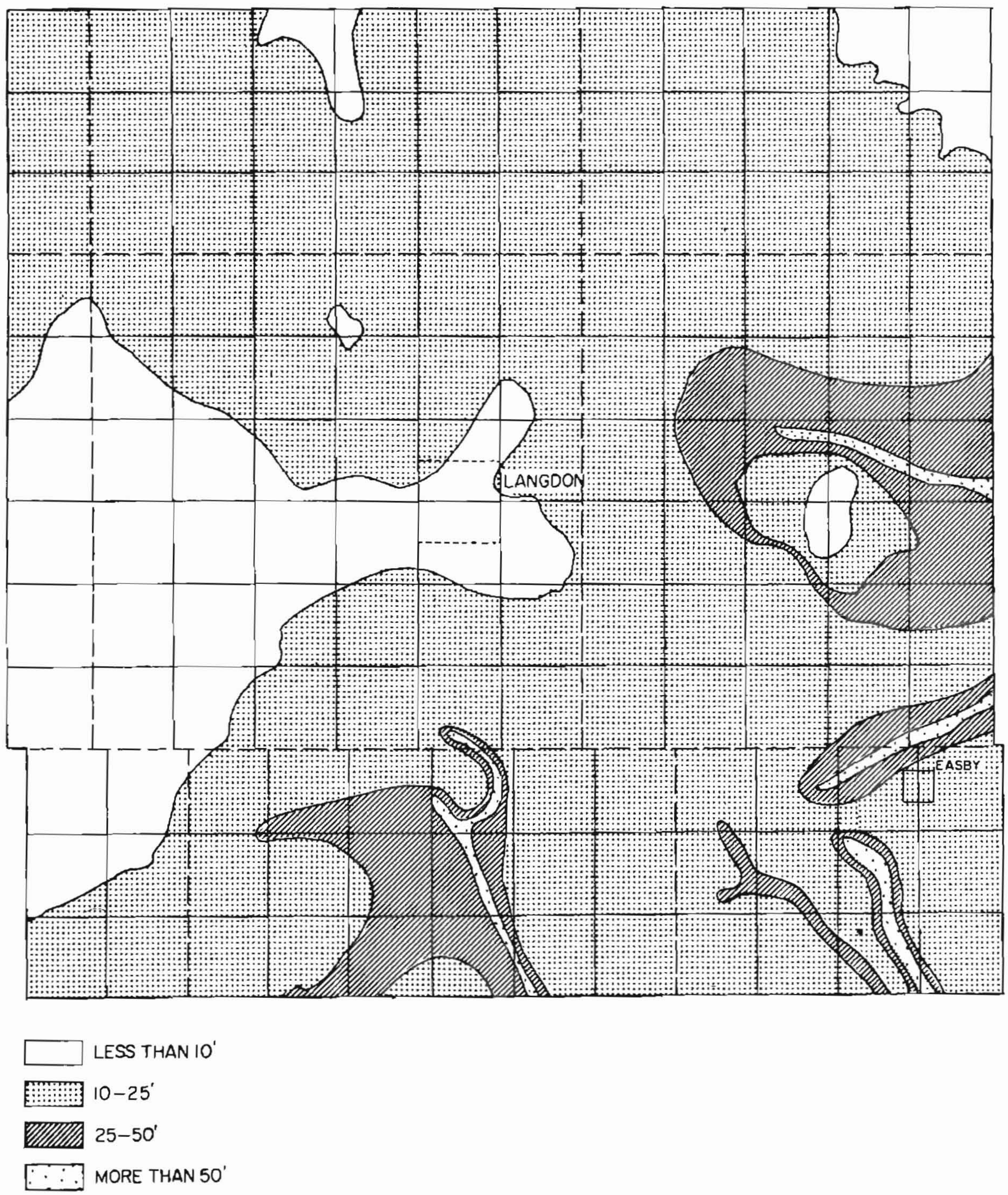

Fig. 4. Thickness of the Coleharbor Formation which overlies the Pierre Shale in the Langdon area.

A hydrologically favorable setting for waste disposal is one in which the groundwater movement is such that fluids from the disposal site do not move into usable surface water or groundwater supplies. This kind of setting is difficult to find in nature, and a more practical approach is to find a site in which contamination is reduced to acceptable levels before reaching potable water supplies.

Reduction of contamination levels generally occurs by natural filtration as fluids move through the earth material. The effectiveness of this filtration is related to the type of material, the rate of movement of the fluid, and the distance traveled prior to entering a water supply system. The rate of movement is dependent on the permeability of the earth materials through which the fluids move and the hydraulic gradient.

The glacial till in the Langdon area has a low permeability and will act as a good natural filter for possible contaminating fluids. The low permeability also causes the rate of movement to be low, and maximum filtration will occur in relatively short distances.

Topography is the only major factor affecting hydraulic gradient in the Langdon area. Where topographic relief is low, the pressure head which causes groundwater to flow is low. In areas of higher topographic relief, rate of groundwater movement will be higher because of the greater hydraulic gradient.

CONSTRUCTION CONDITIONS

Any construction plan should take into account: (1) the local groundwater conditions, (2) the topography, (3) the nature of the foundation materials.

Excavations that intersect the water table may encounter difficulties due to excessive water. In the Langdon area, the water table is generally within ten feet of the surface. However, the permeability of the glacial sediments is so low that problems due to water entering the excavations should be minimal.

Both the glacial till and the underlying Pierre Shale will provide solid foundations for most types of construction in the area. Table 1 is a summary of some of the engineering properties of both the shale and the glacial till. These data are based on engineering tests done by the U. S. Army Corps of Engineers at various depths in several test borings in the Langdon area.

Unit	Dry Weight (lb/ft^3)			Nat.Moist.(%)			Atterburg Limits L.L.			Atterburg Limits P.I.		
	Range	Avg.		Range	Avg.		Range	Avg.		Range	Avg.	
Glacial Till	78-105	88	(38)	19-39	30	(38)	31-56	45	(9)	7-31	15	(8)
Shale	79-100	90	(94)	19-41	30	(94)						

Table I. Summary of engineering data in the Langdon area. Number of samples is given in parentheses.

There are few places in the Langdon area where construction would be inadvisable because of limiting geologic conditions. The areas underlain by clay of the Walsh Formation (unit 1, fig. 1) may not be suitable for construction. Here the deposits of organic silts and clays and the high water table conditions provide inadequate foundation support, and seepage problems would be of constant concern. The clay and silt unit of the Coleharbor Formation (unit 4, fig. 1) may pose problems similar to those of the organic silts and clays of the Walsh Formation. Those areas represented by units 2 and 3 on Figure 1 have limited application because of the intermittent streams that occupy these areas from time to time. The sand and gravel deposits (unit 5, fig. 1) can provide local road surfacing material, and it may be desirable that these should be reserved for such use. From a geologic standpoint, then, most of the land in the Langdon area is suitable for most types of construction.

ECONOMIC RESOURCES

Except for agriculture, there seems to be little in the way of resources in the Langdon area. The sand and gravel deposits throughout the county generally contain too much shale and other impurities to be of much value except for surfacing material for local secondary roads. Some oil exploration wells have been drilled in the county but so far show little promise for oil development in the area. There has been a study made on the use of the Niobrara Formation as a source for cement rock in the southeastern corner of the county. There is also a continuing study on the use of the bentonitic clays of the Pierre Shale for industrial purposes in the vicinity of Walhalla. Neither of these is presently economically feasible.

SUMMARY

In planning for growth, a community should use all available information in determining its needs and available resources. Knowledge of the local geologic conditions can play an important role in helping a community plan its future growth patterns. The geologic conditions in the Langdon area are such that few restrictions need be placed on the city's direction of growth.

There are primarily four categories in which geologic factors need be considered for planning purposes in the Langdon vicinity.

1. Water Supply -- Surface water storage is the only practical means of maintaining adequate water to supply the demand of the community. Groundwater supplies are only adequate to supply individual needs.
2. Waste Disposal -- The till of the Coleharbor Formation has a relatively low permeability and will act to retard the rate of fluids moving through it. Because of the fracture patterns in the Pierre Shale, contamination may not be reduced to acceptable levels prior to reaching a potable water supply. Hydraulic gradients are largely dependent on topographic relief. Low-relief areas with relatively thick

till deposits over Pierre Shale should provide the best sites for waste disposal. Investigation of proposed disposal sites should include detailed study of the subsurface flow system and permeabilities of the earth materials.

3. Construction -- The sediments of the Coleharbor Formation and underlying Pierre Shale should provide adequate foundations for most types of construction. Unstable slopes and unfavorable groundwater conditions are, for most types of construction in the Langdon area, minor factors.

4. Economic Resources -- Present studies show little promise for mineral deposits of any significant economic importance. Studies on cement rock, bentonitic clays, and oil exploration have shown negative results so far. Sand and gravel deposits might be of economic importance, but their generally high content of impurities restricts their use.

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