A THEORETICAL FRAMEWORK AND ITS PRACTICAL APPLICATION TO FACILITATE THE CHOICE, INVENTORY AND DESCRIPTION OF ENVIRONMENTAL STUDY SITES

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Douglas A. Chekay

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ABSTRACT

Surveys have shown the need for and the desire to have environmental education in Manitoba's school system. An attempt has been made in this practicum to begin the process that will be required to develop an environmental education program in Manitoba. The practicum provides a theoretical administrative structure for the development of environmental education in Manitoba. A community approach to this responsibility has been taken.

Specific attention has been focused on environmental study sites. General requirements for selecting environmental study sites are given along with specific criteria the study sites should fulfill. A process of site selection is postulated which utilizes a concentric ring system for determining the overall value and use of each site.

A framework is provided which describes the type and nature of information that should be and can be gathered from environmental study sites throughout Manitoba. This inventory and analysis framework is then tested by applying it to and gathering information from a regional study area around the City of Winnipeg and from six specific study sites within the Perimeter Highway. Recommendations are made with regard to various agencies responsibilities for establishing environmental education in Manitoba. The resource information in this practicum should be useful to teachers in the Winnipeg school system.

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Chapter 1 - Introduction

1.1 The Problem

Thirty years ago most Canadians lived in non-urban environments. Through an infinite daily association with the natural environment that is an integral part of rural life, man developed an appreciation and understanding of his inter-dependence with the natural environment. Recently, Canadians have become urbanized and have lost this contact with nature. Their awareness that man is dependent upon the natural environment for his survival and that his welfare depends upon proper environmental management is also being lost.

Urban living and the infrastructure that is developed around urban communities present special problems on top of the loss of contact with the natural environment. Many urban communities are troubled by inefficient city planning; air, water and noise pollution, traffic congestion and the lack of proper facilities to deal with environmental problems.

At the same time as the Canadian citizen is losing this contact with the natural environment, he is being asked to make social and economic decisions which ultimately affect his environment. Decisions made on water use, urban development, transportation schemes, air and water pollution control, food production, energy provision and use and land use policies will affect the present and future environment of all Canadians. In order to make informed environmental decisions, the Canadian citizen should understand the environment in which he lives.

He should have the opportunity to observe and learn about the interrelationships which occur between man and his environment and the effects which man's activities have on that environment.

Special efforts will now be required to assist the Canadian citizen in renewing the environmental awareness formerly gained through rural life. As well, owing to the increasing complexity of the world society, our citizens must also have the opportunity of learning about the interrelationship and systematic involvement of the world as a whole. To allow present and future citizens the opportunity of becoming environmentally aware, our educational system must embark on comprehensive environmental education programs spanning both formal and nonformal education.

1-2 Background

Definitions, purposes and objectives of environmental education have been extensively developed and discussed in the pertinent literature. To clarify what environmental education is and what it proposes to accomplish, I will cite some definitions and objectives.

In the words of W. B. Stapp, (1970):

> Environmental education is aimed at producing a citizenry that is knowledgeable concerning the biophysical environment and its associated problems, aware of how to help solve these problems, and motivated to work toward their solution.

The International Union for Conservation of Nature and Natural Resources (1970) recommended this definition of environmental education:

> Environmental education is the process of recognizing values and clarifying concepts in order to develop

> skills and attitudes necessary to understand and appreciate the interrelatedness among man, his culture and his biophysical surroundings. Environmental education also entails practice in decision-making and self-formulation of a code of behavior about issues concerning environmental quality.

Although such definitions are useful as guidelines, inevitably program organizers will tailor such definitions to meet the needs of their own community or school.

To make environmental education an integral part of an educational program, objectives of the environmental education component must be developed. These objectives should explain what knowledge is to be gained upon completion of the environmental education component of the educational program.

W. B. Stapp (1970) develops these environmental education objectives:

> Environmental education should help individuals acquire:
>
> 1. A clear understanding that man is an inseparable part of a system, consisting of man, culture and the biophysical environment, and that man has the ability to alter the interrelationships of this system.
> 2. A broad understanding of the biophysical environment, both natural and man-made, and its role in contemporary society.
> 3. A fundamental understanding of the biophysical environmental problems confronting man, how these problems can be solved, and the responsibility of citizens and government to work toward their solution.
> 4. Attitudes of concern for the quality of the biophysical environment which will motivate citizens to participate in biophysical environmental problem-solving.

The Province of Saskatchewan has recognized the need for environmental education for its citizens and in 1972 a Department of Education Advisory Committee on Environmental Education established these environmental education program goals:

a) To develop in people an understanding of the mechanisms by which the environment functions.
b) To develop in people an awareness and appreciation for the interrelatedness of man to his total environment.
c) To encourage people to transfer this awareness and appreciation into positive action within the community.
d) To assist people in recognizing that in order to arrive at solutions to environmental problems, compromises and sacrifices will be necessary.

Although the Federal Government has no formal control over education in the ten Canadian Provinces, the Canadian Council of Resource and Environment Ministers, an agency created by the Federal and ten Provincial Governments produced this statement about environmental education in their Background Paper on Education, November 1973:

> The aim of environmental education is to foster in the Canadian people an environmental ethic necessary for survival and for human development.
>
> The need for comprehensive environmental education, identified by groups across the country, stems from two basic concerns. First, there is the realization that the management of the environmental problems facing us will require ongoing and broadly based participation, for which education is a necessary prerequisite. Secondly, there is the slightly more elusive sentiment that increased familiarity with, and closeness to, the natural environment will provide people with a kind of satisfaction, and basis for values that are needed in today's society.
>
> The Task Force sees education as a continuing process whereby we prepare ourselves to deal effectively with the reality surrounding us. This education should facilitate the transformation of information into personal knowledge, and lead to action. Environmental education must supply a basis for understanding the imbalances which are consequences of our acts, and therefore, help us achieve a world view in which we are in harmony with the inanimate forces surrounding us.

Many government agencies across Canada have recognized the need for environmental education, and have proposed, or are preparing to propose environmental education policies. Included in these policy statements will be recommendations governing the structure, development and implementation of environmental education programs.

The environmental education programs being planned will encompass both formal and informal education. They will range from formal programs spanning kindergarten through twelfth grade to informal programs for pre-kindergarten, voluntary organizations, business organizations, and government units.

Successful implementation of these environmental education objectives and programs will require local community commitment and citizen participation. Community based organization committees allow the citizens to assist in adding local relevancy to the developing program.

Committees of professionals and community citizens will be established to co-ordinate the preparation and development of program goals and objectives, curriculums, inservice education, administration and financing and program evaluation techniques. These committees will also oversee the process of environmental study site selection and site inventory and analysis.

Under the co-ordination of these committees curriculums and programs will be developed that contain the concepts necessary to offer Canadians the opportunity of becoming environmentally aware citizens.

1-3 Objectives

The major emphasis of this practicum will be on one component of environmental education; the environmental study site. If Manitoba is to implement an environmental education program, environmental study sites will need to be selected and established in our cities, towns and rural areas to facilitate the teaching of environmental education. A theoretical framework for selecting, inventorying and describing environmental study sites will be developed. This framework will give the environmental education committee guidelines to follow in selecting potential environmental study sites in their region. As well it will outline various factors that should be inventoried and analyzed to provide a general information base on the region and each specific study site within that region.

To indicate the type of information that can be compiled by following this framework, it has been applied to a region around the City of Winnipeg and to six specific sites within the Perimeter Highway.

This practicum will also develop a process that can be followed to establish environmental education committees for the purpose of implementing an environmental education program.

Recommendations will be made in regard to the establishment of a network of environmental study sites through the Province of Manitoba.

Therefore the objectives of this practicum are:

1) To suggest a structure for community involvement into a program of environmental education.

2) To propose criteria for the choice, inventory, and description of environmental study sites.

3) To demonstrate how these criteria may be applied in the choice, inventory and description of sites in an urban-rural setting.

4) To recommend a scheme for utilizing this framework in Manitoba.

1-4 Precepts

1) The site selection, inventory and analysis framework was developed so that it may be applied to any area in Manitoba. The testing of the framework was carried out in the Winnipeg area for ease of access.

2) Regional analysis data were collected mainly from existing studies and literature. Specific site data were collected through actual inventory and analysis of the six study sites.

3) This study is concerned primarily with one aspect of environmental education; that of environmental study sites. If environmental education is to be implemented in Manitoba, additional study will be required in regard to teacher qualifications, curriculums, administrative problems and functions, etc. Only then will we have the information necessary to prepare a formal plan to implement environmental education in Manitoba.

1-5 Study Area

The Winnipeg area was chosen for the purpose of testing the site selection and inventory and analysis framework. As one-half of

Manitoba's population resides in Winnipeg and urban development is rapidly deteriorating its few remaining natural sites, it was a prime starting point.

The regional study area consists of that portion of land within a 35-mile radius of Winnipeg. The selection of specific study sites was confined to the area within the Perimeter Highway.

Chapter Two: The Environmental Education Committee

Because the concerns of environmental education touch in some way everyone in the community a broad consensus among community citizens needs to be achieved if a program of environmental education is to succeed. The development and implementation of environmental education programs which will successfully involve all segments of society and take into account the diverse interests of those different segments requires an organizational structure which can reach effectively into all parts of the Province. Individuals responsible for making that organizational structure work must have an intimate understanding of the economic, political, social and cultural life of the environment they serve. That varies in Manitoba from the timber, mining and wilderness areas of the north to the agricultural areas of the south to the man-made environment of the cities and towns.

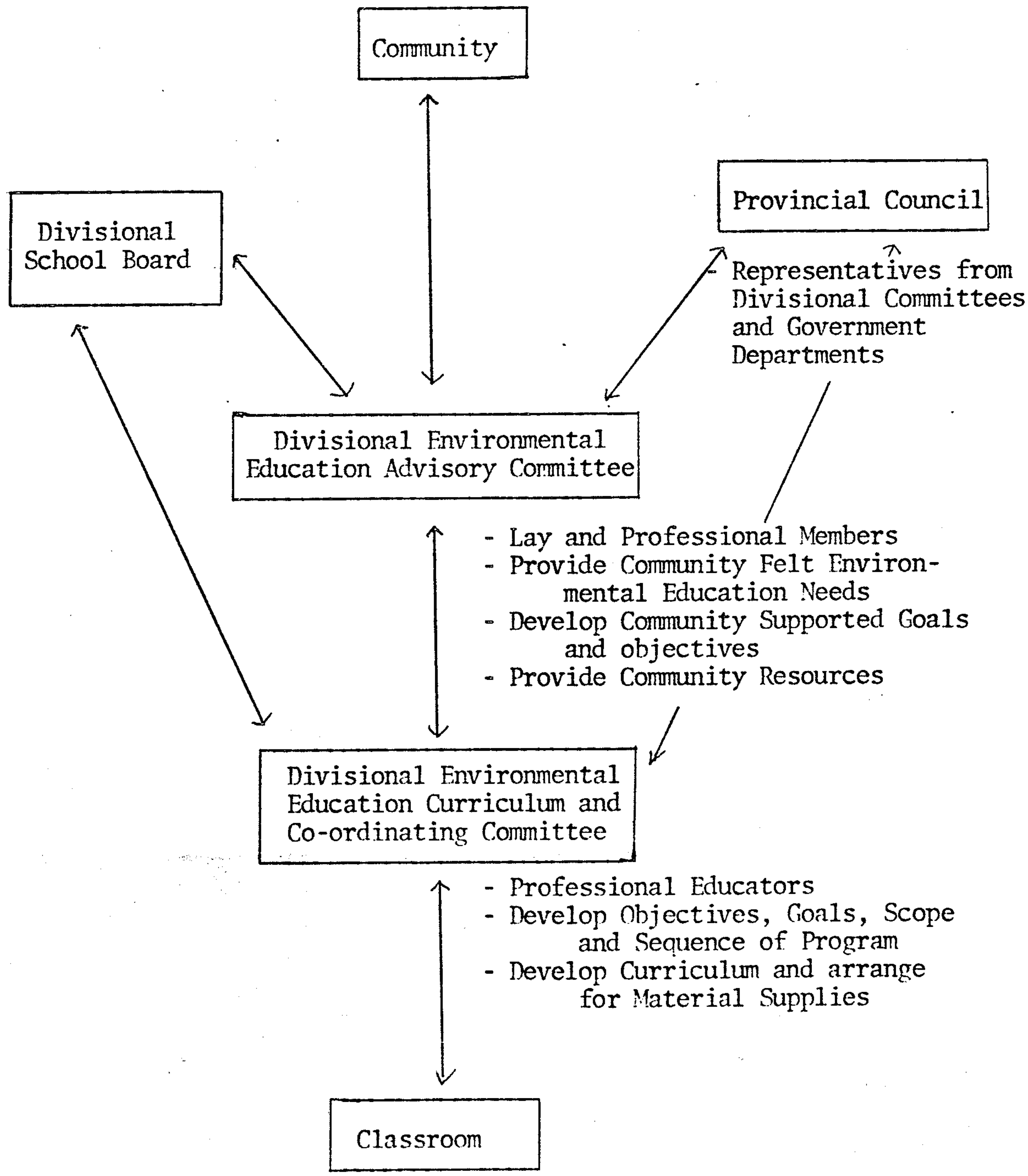
Individuals responsible for planning and initiating environmental education programs in schools and communities throughout Manitoba must have a basic understanding of these differences if they are to be responsive to the needs of those to whom their programs are directed. For only if programs respond to real needs will they be accepted and effective.

2-1 Administrative Framework In Which the Manitoba Environmental Education Committees and Council Will Function.

To be effective the environmental education committees and Council should be closely aligned with the administrative process of education in Manitoba. The role these committees should play is advisory, which should in turn be translated by administrators and teachers into action and policy.

Ultimately, each school division in Manitoba should have one environmental education advisory committee and one environmental education curriculum and co-ordinating committee. There should be one provincial environmental education council to provide support and general direction for all divisional committees.

The following is a representation of a line of authority the hypothetical committees and council could take:



2-2 Members of the Environmental Education Committees and Council

Each divisional environmental education advisory committee should consist of individuals representing the following groups:

- elementary and secondary teachers and students
- post-secondary educational institutions
- education administrators (board member, superintendent, principal)
- voluntary organizations (Manitoba Naturalists Society, Wildlife Foundation of Manitoba)
- business and industry
- community citizens
- governmental units (Department of Education, Agriculture, Mines, Resources and Environmental Management, Parks, etc.)

Such a committee would assure representation of all major segments of the division and would bring together those people involved in and knowledgeable about the diverse environmental education needs and related programs within the division. They would develop the general philosophy of the program and establish general community objectives.

The divisional environmental education curriculum and co-ordinating committee should consist of professional teachers that will be directly responsible for implementing the environmental education program.

The provincial environmental education council should be made up of selected members of the divisional committees and members appointed by the Province of Manitoba. This council should be attached to the Provincial Department of Education.

2-3 Function of the Divisional Environmental Education Committees and the Provincial Environmental Education Council.

Once organized the divisional environmental education committees may be responsible for several functions including the following. The extent of the committee's responsibility for these functions will depend on whether or not an environmental education specialist is available within the division.

2-31 Function of the divisional environmental education advisory committee

1) Identify community needs for an environmental education program;

2) develop community environmental education goals and objectives and establish a community consensus on them at the local level;

3) develop a communications network among the various groups in the division as one means of co-ordinating environmental education effort, and communicating between the divisional committees, provincial council and appropriate provincial departments and agencies;

4) finding and providing access to community resources;

5) assist in acquainting the community with the environmental education program and seeking community participation.

2-32 Function of the divisional environmental education curriculum and co-ordinating committee

1) Translate community environmental education goals and ob-

jectives into a functional curriculum. Determining learning experiences, materials required and community resources needed;

2) define the scope and sequence of the environmental education program;

3) plan and participate in or co-ordinate a comprehensive divisional environmental inventory upon which to base the environmental education program emphasis;

4) assist in or co-ordinate the selection, planning, development and utilization of divisional environmental study sites;

5) co-ordinate the organization and operation of an environmental education resource center for the division or individual schools. Consideration should be shown for factors such as informational materials; equipment and rosters of resource people available for consultation and assistance within the division;

6) assisting schools within the division with the preparation of funding proposals for submission to provincial and federal governments and other funding sources;

7) assist in providing for evaluation of the environmental education program and in the use of the evaluation results.

2-33 Function of the provincial environmental education council

Responsibility of the provincial environmental education council would include:

1) Planning and preparing a provisional provincial environmental education development plan in co-operation with the Provincial Departments

of Education, Mines Resources and Environmental Management, Agriculture and Tourism, Recreation and Cultural Affairs;

2) co-ordinating the activities of the divisional committees in accordance with the provisional provincial environmental education development plan;

3) preparing and submitting proposals for program funding to Provincial and Federal governments and private sources;

4) evaluating programs made in implementation of the provincial plan and making appropriate revisions in it.

Chapter 3: Selection of Environmental Study Sites

An environmental study site can be defined as a place with characteristics that lend themselves to the study of the processes and dynamics of some aspects of man's environment. They are physical sites, both natural and cultural, which can be utilized to apply classroom learning to actual physical situations outside the classroom. Environmental study sites may include garbage dumps, forests, grass-lands, ponds, marshes, bogs, farms, schools, and places exhibiting the processes of government, industry or other aspects of man's culture.

According to the United States Department of the Interior, Office of Environmental Interpretation, a properly developed environmental education program which utilizes environmental study sites can enhance the environmental awareness, and influence the values and behavior of students. Environmental study sites can often be adapted and altered to meet the conditions and needs of existing curricula. As well environmental study sites can support resource protection and environmental management programs.

The ideal environmental study site is not reserved exclusively for environmental education. Multiple uses enrich a site's educational value, since multiple interactions make the environmental processes graphic and observable, with clear applicability to the students day-to-day life. Recreation potential, wildlife management potential, and the ability of the area to act as a buffer-zone or aesthetic green space in urban environments are of great importance to a site's value to the community.

3-1 General Requirements of Environmental Study Sites

When selecting environmental study sites, the individuals responsible, must select sites that exemplify the natural and man impacted features of the local environment. Owing to regional differences in natural vegetation, physiographic features, soil types, climate and human activity, the physical make-up of environmental study sites will vary from region to region. An adequate number of physically different study sites should be selected for each region, so that together the sites represent the major physical biological and human features of that region.

The following are natural and culturally impacted features that might be included in environmental education study sites in Manitoba:

1) a coniferous forest
2) a mixed wood forest
3) a deciduous forest
4) a riverbottom habitat
5) a grassland
6) a water body
7) a river, stream or creek
8) a marsh
9) a swamp
10) an esker
11) a marine shoreline
12) an area of tundra

13) areas impacted by human activity

- mining operations
- deforested areas
- agricultural enterprizes
- urban development
- garbage and sewage disposal areas

14) an historical feature

15) a cultural feature

Many of the features listed above may be found in association on one site. Sites showing multiple features are certainly the most valuable for educational purposes, however, sites showing excellent examples of one or a limited number of features should not be overlooked.

The nature of the environmental study sites selected will depend upon the environmental education program goals and objectives. Care should be taken in recognizing and supporting broader roles or uses of each site which will enable pupils and citizens to participate in a variety of first-hand activities designed to stimulate interest, awareness, understanding, and respect for the natural and man-made environment. Multiple use potential of the site will significantly increase its value to the community.

It has been recommended by many authors that the evaluation of environmental study sites will be assisted by answering a number of pertinent questions with respect to each potential site. The following is a list of questions which may be applied to potential Manitoba environmental study sites.

1) What are the sites major features?

2) What does the site offer the environmental education curriculum?

3) Does the site contain any special natural feature, i.e. a marsh, stream, lake or forest?

4) What kind of flora and fauna are represented on the site?

5) Does the site show any forms of succession?

6) Does the site have an exposure of bedrock which exposes several different formations?

7) Is any of the land characteristic of early Canada or a reflection of the historic growth of Manitoba?

8) Does the site show features of man's direct impact on his environment?

3-2 Specific Criteria For Evaluating Environmental Study Sites

A number of criteria should be applied to each site during the evaluation stage. The individuals responsible for site selection must remember, however, that each area is unique and that criteria are to be used only as guidelines. Sites that fulfill all of the criteria will not necessarily be the best sites for your curriculum, and it goes without saying that all criteria need not be fulfilled by each site.

There are many criteria to consider when evaluating potential environmental study sites. Certain criteria are of primary importance while others may be considered of secondary importance or simply desirable. The following are primary, secondary and desirable criteria that I feel will assist in the selection of the best potential sites.

3-21 Criteria of primary importance

1) The site shows a diversity of habitat (a variety of features);

2) the features of the site are relevant to the curriculum;

3) the site is readily accessible by road;

4) the site is adaptable to and can withstand normal student activity without degradation of its features;

5) the site is free of unnecessary hazards, such as unprotected banks, pits, treacherous water;

6) the site lies within a reasonable distance from the school, in relation to the purposes for which it will be used; for example, daily use, weekly use or use on a more limited scale will partially determine distance limits.

7) the site can be protected from radical alteration for a reasonable time period.

3-22 Criteria of secondary importance

1) The site shows suitability for use by handicapped and partially handicapped individuals;

2) the site has sufficient open spaces for gathering the class together;

3) the site has topography and slope of a nature suitable for student activity;

4) the land on which the site is located is available for purchase or the landowner will allow free access. If the land is saleable, are the finances available within your budget for its purchase?;

5) features of this site cannot be located on public or or crown land.

3-23 <u>Desirable criteria</u>

1) the site contains some form of shelter from the extremes of winter weather;

2) the site is free of sources of potential distraction or discomfort. For example, the presence of factories, airports, city sewage treatment plants or major highways (these can in certain instances be desirable features).

3-3 <u>Concentric Ring System</u>

A concentric ring is suggested as a pattern which should be used in the development of a system of environmental study sites.

The concentric ring system would consist of three concentric rings around a given school site (Fig.#1). A school site and its grounds form a centre nodule, the community immediately surrounding the school makes up the first ring, the district community makes up the second ring and the third ring is that of an intangible area. Because each ring takes the students further away from the school site, use of the distant sites will decrease in proportion to the distance from the school to the site.

By providing experiences and facilities in all of these circles, an integrated program which covers a wide variety of educational opportunities can be provided.

3-31 The school site

While utilizing this concentric ring system the site selection committee should try to choose a limited number of sites that will most adequately exemplify the local and regional environment. They should search for a diversity of site types so that the regions physical and biological features are well represented.

The school site is undoubtedly the most important and accessible study area available to any environmental education program. In Manitoba one half of our school year occurs in winter months. During this period it is difficult to take students out of doors for extended periods and transport them great distances, thus the on-school grounds site increases in importance to the environmental curriculum. The students can get to the study site, take part in the learning activity and be back indoors in a matter of minutes. Thus the on-school site must be analyzed for its potential to provide the opportunity for teaching environmental concepts before attention is focused on any more distant sites. School ground sites have the potential to offer examples of a variety of ecological relationships, including man-impacted areas, multiple resource use, historical events, as well as natural ecological relationships.

Many school grounds in Manitoba were not and are not being planned and designed to facilitate study of the environment. They were and are being developed to facilitate the three R's, with parking lots, tennis courts, playgrounds, and sports fields being included as necessities. A great proportion of the school site's natural landscape has been removed or covered in order to facilitate the laying of cement or asphalt.

However, William Stapp, (1973) feels that "the potential for developing environmental education facilities within a school (ground) is limited only by the boundary of one's imagination, resourcefulness and enthusiasm". Essentially, he is saying that all school grounds have the potential to be used for environmental education. Certainly some will have more area, better natural landscape, and more diverse habitat than others, but those grounds may also show less of man's impact in terms of pollution, effect of asphalt on run-off, heat sink effect, etc., than other school grounds. All school grounds can be managed, altered, and manicured in even simple inexpensive ways to improve or develop their potential to teach about the environment.

3-32 Immediate community sites

Immediate community sites (ring one) (Fig.#1) will be those within one mile or walking distance of the school. They may range from natural areas on private or public land to historic sites, man-impacted sites or business facilities. These sites place the student in the real world where invaluable resources of people, places and processes can be reached and utilized for educational purposes.

3-33 Distant community sites

Distant community sites (ring two) (Fig.#1) are areas containing features that cannot be found on the school site, or in the immediate community and yet are features of substantial importance to the environmental study program to merit establishing a site even at the extended distance. These sites will require latitude in the scheduling of classes and will require detailed preparation of plans for transportation.

In most areas of Manitoba, and certainly around the major urban centers these sites will enclose natural features such as marshes, grasslands, forests, sand dunes and other ecosystem types imperative to the study of man and his environment. They may also be sites showing aspects of the areas economic development processes. Food processing plants, feed lots, and mines fall into this group.

3-34 Extended visitation sites

The ring furthest from the school (ring 3) (Fig. #1) is reserved for sites showing unique features of Manitoba, or areas with facilities which would enable overnight or extended visitation. The unique features will be those important enough to the environmental study program to warrant at least one trip throughout the year. Examples of this might be the shoreline of Glacial Lake Agassiz, the Spruce Woods Provincial forest, Lake Winnipeg, or an archaelogical find. Extended visitation sites would be special centers that the Province of Manitoba should eatablish as provincial and regional facilities to encourage and promote environmental education in Manitoba.

The extended visitation ring has no distance limits, but use of sites within it is controlled by the organizational and financial limitations imposed by the Provincial Government, school divisions, municipalities, school administrators and teachers involved in the environmental education program.

3-35 Value of the Concentric Ring System

The concentric ring system takes into account the importance of transportation facilities and time away from the classroom. It provides an indication of how much preparation will be involved in attending sites within the various rings. Certainly the "school site" and the "immediate community sites" should be utilized the most often. They exist in the student's own community therefore adding relevancy to any learning activities that take place on those sites. As well, administrative problems of taking students away from the school a walking distance is much less than organizing transportation facilities for distant travels. However, the "distant community sites" and the "extended visitation sites" are just as important to the overall program as are sites within walking distance. The value of these more distant sites is in the uniqueness of their physical and biological properties and the importance of their role in the structure and function of the world's ecosystem. Because of practical considerations these "more distant sites" will not be as heavily used as the closer sites, yet they must still play a major role in any environmental education program.

3-4 Processes In The Selection of Environmental Study Sites

By itself enumeration of a set of criteria will not insure nor necessarily even promote selection of the best possible sites for an environmental education program. Only an orderly and planned procedure utilizing trained personnel can accomplish this task.

The site selection committee should be composed of members of the divisional environmental education advisory committee, the divisional environmental education curriculum and co-ordinating committee, teachers who will be utilizing the sites and trained resource management personnel. With this mix of expertise on the committee all aspects of what requirements the sites should fulfill will be known. The resource management personnel will be able to assist in interpreting the natural features of the site.

This committee should then go through the following process to assist them in evaluating the best potential sites.

1) Understand the philosophy of the environmental education program, its goals and objectives;

2) realize the types of sites required to fulfill the demands of the curriculum;

3) realize the primary and secondary criteria environmental study sites should fulfill;

4) understand the strategy of the concentric ring system;

5) understand the regions physical and biological features, research the regions historical and cultural development pattern, realize the economic development and man's impact on the area.

Upon completion of this process, the committee should have the information available to evaluate and select the best potential environmental study sites that will fulfill the site criteria, meet the curriculum requirements, relate to the philosophy of the environmental education program, its goals and objectives and will exemplify the physical, biological and social features of the region.

To assist in the understanding of the local region, resident citizens who are familiar with and understand the various features of the region should be contacted. Regional Provincial and Federal civil servants may also be of assistance on features of the region which relate to their technical expertise. Aerial photographs, topographical maps, and resource oriented maps are invaluable for the ability to place the area in question into perspective.

Evaluation of each potential site is assisted if at the time of first observation a short description is written describing the features of each site, its assets and disadvantages.

The individuals responsible for site selection must keep in mind that the "perfect site" for a specific purpose is not necessarily the desired study site for environmental education. Study sites that possess a diversity of features with natural and man-impacted areas are of much greater value to a program than are sites which show perfect examples of just one or a few features. In addition, the importance of an interpreter with the ability to communicate the significant features of the site to his students cannot be overstressed. Each site is unique and will relate its own value to the program.

Chapter 4 Environmental Study Site Inventory and Analysis Framework

The user of an environmental study site must understand the physical and biological structure of that site. He must be familiar with the sites historial, economic and cultural background and the impact it has had on the surrounding area.

After the potential environmental education study sites have been selected, an inventory and analysis of each site must be carried out.

Site inventory and analysis is an in-depth study of the physical and biological character of a site. It is concerned with all aspects of its surface and sub-surface character. Included are natural and man-made environmental influences relating to ecological, economic, political social, technological, and aesthetic factors. Site inventory and analysis is performed at varying levels of complexity dependent upon user requirements. However, it is felt that the basic inventory and analysis should be carried out in as detailed a manner as can be accomplished given the personnel, money and time you have available. Owing to the constant change in the natural and man-made characteristics of each site, inventory and analysis must be a continuous and on-going process. Data of a complexity and detail that will fulfill all user requirements will be provided as a result. The first inventory and analysis of each site should be conducted by individuals possessing technical competency in the environmental field. These individuals must also understand the basic philosophy of environmental education and realize to what uses the actual site and information base will be put.

The information base produced by the inventory and analysis will provide the teacher with the information necessary for the development of programs and activities based upon use of that site. Teachers should be assisted in gathering this information as they seldom possess the technical expertise and experience necessary to carry out an environmental inventory and analysis. As well, teachers do not have enough time away from their regular teaching duties to gather these data. However, the more the teachers become involved in the site inventory and analysis, the more familiar they will become with the site and the more valuable the site will become to their teaching program.

The information produced will also be a source of reference material and background data for student use. The information should be placed in an environmental study resource library for use by teachers and students.

When teaching about the environment we must keep in mind the interrelatedness of all factors. Each specific site chosen using the "concentric ring system" must be considered as an integral component in the world ecosystem. Because of this, it is important to understand the region as a whole, this then assists your understanding of a specific site or a component of a specific study site. For this reason it is suggested that two inventories and analyses be conducted simultaneously. One of the region, and the other of the specific site. Only by utilizing this technique can both the micro and macro features of the site and the surrounding area be understood. For example, this practicum chose six specific environmental study sites within the perimeter of the City of Winnipeg, then to give regional context to this information examines an area having a thirty-five mile radius around the City of Winnipeg (Fig.2).

The following inventory and analysis parameters are considered imperative to the body of information that should be compiled on the region and specific sites.

The parameters have been listed in similar fashion to the process Ian L. McHarg calls his ecological planning method whereby one looks at a given area in vertical cross-section. This approach allows the systematic separation of all of the interacting factors lying in a vertical cross-section. Thus the cross-section will progress from the underlying geology and groundwater to soils and surface hydrology to natural features such as vegetation and wildlife to climate. The impact of mans activities on this environmental cross-section are then determined.

This is not an exhaustive framework, it is more simply one which should be utilized to develop the first basic body of information. As each site is utilized for teaching about the environment, additional information will be gathered that can be added to this basic body of information. As well, many of the student educational projects will involve information gathering from the actual site and this information should also be applied to the basic information base.

4-1 Regional and Specific Site Inventory and Analysis Framework

1 Regional analysis

1-1 Geographic location

1-2 Size of region

1-3 Natural features

- 1-31 Regional geology
- 1-32 Regional hydrology
- 1-33 Regional soils
- 1-34 Regional topography
- 1-35 Regional resource types and distribution
- 1-36 Regional climatic factors

1-4 Regional historic and cultural factors

1-5 Regional economic factors

1-6 Regional population factors

2 Specific site analysis

2-1 Physical geology

2-2 Hydrology

2-3 Soils

2-4 Topography

2-5 Ecological parameters

- 2-51 Flora
- 2-52 Invertebrates and vertebrates
- 2-53 Habitats

2-54 Successional stages

2-55 Food webs and energy flow regimes

2-6 Climate

2-61 Temperature

2-62 Air movement and quality

2-63 Precipitation

2-7 Historical, existing and proposed resource use

2-8 Environmental impact

4-2 Information to be Gathered While Utilizing the Framework and Sources of Regional and Specific Site Information

1 Regional Analysis

Regional analysis will identify and relate the community and regional setting of the specific site. It will explain broad community and regional influences in terms of the historical development of physical, biological and human factors. Regional cultural, economic and social impacts on the site will also be clarified. For this practicum, the region consists of an area having a 35 mile radius around the centre of the City of Winnipeg.

1-1 Geographic location: using topographic and legal description maps locate and delimit by longitude and latitude, section, township and range the region to be studied.

Information source -

Note: refer to information source Key (pg.41) for code to the information source numbers (III g).

1-2 Size: using a topographic map and the dot grid or planimeter method determine the size of the region to the nearest township, section or acre.

1-3 Natural features:

1-31 Regional geology: develop a written description of the historical occurrence and structure of the geology of the region. Produce maps and diagrams showing the underlying bedrock and geological stratification of the region.
Information source - III c and g, IX f, XIV.

1-32 Regional hydrology: develop a written description of aquifers, aquifer recharge areas, and surface and groundwater movements of the region. Substantiate this with maps, and diagrams showing the position of aquifers, direction of surface and groundwater flow and areas of recharge.
Information source - II, III h.

1-33 Regional soils: develop a written description of the historical occurrence and structure of the soils of the region.

Describe the development and capability of the soil of the region. Produce maps and diagrams showing soil types, soil profiles and soil capability of the region.

Information source - I, IIIb and g, VIII, IXaii and e, XIV.

1-34 Regional topography: develop a written description of the regional topography, physiography, relief and drainage. Produce maps, graphs and diagrams to substantiate the written description.

Information source - III g and h, XIV, XV.

1-35 Regional resource types and distribution: develop a written description of the types and distribution of renewable and non-renewable resources of the region. Include natural vegetation, agriculture, wildlife and minerals. Produce maps showing the resource types and their distribution throughout the region.

Information source - I, II, III, IXe, XIV.

1-36 Regional climatic factors: develop a written description of the climatic factors of the region. Supplement this with maps, graphs and diagrams of temperature, rainfall, snowfall, prevailing winds, and other climatic factors that affect the region throughout the four seasons of the year.

Information source - III h, Va, IXe, XIV, XV and various regional geography and climatology publications.

1-4 Regional historic and cultural factors: develop a written description of the ancient (archaelogical), pioneer and contemporary history and culture of the region. Indicate the chronological progression of settlement patterns and how the patterns were affected by ethnic background, transportation, resource utilization and development. Produce maps showing historic populations, settlement patterns and movements.

Information source - VII, IXb and g, XII, XIII, XIV.

1-5 Regional economic factors: produce a written description of the development of the economic structure of the region. Include in this analogue indications of land and resource use and industrial development.

Information source - II, VI, IX a and d.

1-6 Regional population factors: produce a written description to indicate population trends of the region. Produce demographic maps showing the population changes that have occurred since settlement.

Information source - II, IX e and h, X.

2 Specific Site Analysis

Specific site inventory and analysis must be carried out on each chosen environmental study area. The information gathered will in most cases be unique to each individual site. It will build a body of information specific to the physical and biological features of that site and will help compare and contrast its features to the surrounding region and other specific sites.

Analysis at the specific site level should cover only those parameters that were not covered in enough detail in the regional analysis. For example, if the geology of the specific site does not differ from the regional giology as analyzed in the regional study then further analysis is not necessary. However, for a factor such as climate, the microclimate of each site will vary from the regional climate and therefore should be analyzed for each specific site.

2-1 Physical geology: produce a written description of the chronological formation of the site. Indicate how the underlying geology helped to form the surface geology. Research the possibility of geology core sampling on the site. Produce a cross-sectional diagram of the geology of the site. Map and indicate the depositing of overburden on the site.

Information source -

III c and h, IX f.

2-2 Hydrology: produce a written description of the limnology of any water body(ies) on the site. Take water samples and analyze their chemical properties or have their chemical properties analyzed by the Environmental Health Laboratory, Department of Mines, Resources and Environmental Management. Produce tables showing the chemical analysis. Map the water body(ies) and indicate how they were formed, their age, how they influence run-off, erosion and deposition. Map run-off patterns on the site. Diagram a local hydrologic cycle.

Information source - III a,d,e,h.

2-3 Soils: produce a written description of the soil types found on the site. Analyze the soil profile and produce a soil cover and soil profile map. Take and analyze soil samples of the area to determine the physical and chemical make-up of the soil. Describe the water retention and percolation properties of the soil profile found on the site, relate this information to the water table and surface vegetation. Indicate the capabilities and restrictions of the soil using the Canada Land Inventory System.

Information source - I, III, VIII, IX a.

2-4 Topography: produce a written description of the topography of the site with reference to such features as ridges, eskers, moraines, drainage patterns, slope, glacial striations, shorelines and beaches. Indicate limitations imposed by topography. Indicate major and minor land form structure on the site. Produce maps of the site showing the topographical features in vertical and horizontal planes.

Information source - III g, h, IX e.

2-5 Ecological parameters

2-51 Flora: produce a written description of the common flora (algae, mosses, grasses, weeds, flowers, shrubs, trees) of the site and supplement the description with a vegetation cover map.

Information source - III, IX ai and c, XI. Various keys pertinent to Manitoba flora: Native Manitoba Plants in Bog, Bush and Prairie, 1972, Hector MacDonald, Manitoba Department of Agriculture; Native trees of Canada, 1966, Canada Department of Forestry and Rural Development. Flora of Manitoba, 1957 H. J. Scoggan, National Museum of Canada, Department of Northern Affairs and National Resources. Illustrated Flora of the Northeastern United States and Adjacent Canada, Vol. 3, 1952 Henry A. Gleason, The New York Botanical Garden.

2-52 Invertebrates and Vertebrates: tabulate the various insects (aquatic and terrestial) fish, reptiles, amphibians, birds and mammals found on the site during one or more of the four seasons of the year. This process can be facilitated by live and kill trappings and field sightings.

Information source - III, V b, c and d, IX a and i, XI.

2-54 Successional stages: indicate utilizing maps and a written description the successional stage of the flora found on the site. Map and describe the types, associations, seasonal variations and ecological relationships of the flora and fauna. Determine and indicate various productivity levels that occur during the various successional levels. Indicate the relationship between the stage of development and the fauna population.

Information source - III, IX c and i, XI.

2-55 Food webs and energy flow regimes: indicate by diagram and written description, a portion of the foodwebs, food chains and energy flow regimes found on the site. Indicate the relationships that occur among various inhabitants in respect to mutualism, competition, parasitism, predation, etc.

Information source - III, IX c and i, XI.

2-6 Climate: produce a written and graphic description of the site's climate. Concern should be shown for the microclimate as well as the general site climate. The following parameters should be considered.

2-61 Temperature: graph and describe site temperature for the four seasons of the year. Include such information as first and last average frost, the effect topography and vegetation has on the local temperatures. Map or indicate snow cover accumulation, show its effect on temperature at various strata. Graph and describe soil temperature fluctuation throughout the four seasons of the year.

2-62 Air movement and quality: describe and map general air movement patterns as they are affected by the site's topography, structure and vegetation. Determine and indicate the ambient air quality of the site.

2-63 Precipitation: produce a written description of the types and quantities of precipitation occurring on the site over a one year period. Indicate by map and graph the varying amount of precipitation that occurs on the site during each of the four seasons of the year. Diagram accumulation patterns that are assumed to occur on the site using cross-sectional and surface diagrams.

Information source - III h, V a.

2-7 Historical, existing and proposed resource use: map and produce a written description of the historical, present and proposed resource use of the site. Indicate the changes that have occurred and how they have affected the surrounding environment.

Information source - III b,g,f, IV, X.

2-8 Environmental impact: document the impact man's activity has had on the environment of that specific site. Aspects to consider would be pollution, altered drainage patterns, cutting down of green growth for installation of asphalt, cement or man-made structures, noise and odor, or other deterioration of habitat that once was suitable for harbouring animals.

4-21 Information sources Key

I Manitoba Department of Agriculture

II Manitoba Department of Industry and Commerce

III Manitoba Department of Mines, Resources and Environmental Management.

- a) Environmental Protection Branch
- b) Lands Branch
- c) Mines Branch
- d) Research Branch
- e) Resources Management Division
- f) Resources Planning Division
- g) Surveys Branch
- h) Water Resources Branch

IV Manitoba Department of Municipal Affairs

V Environment Canada

- a) Atmospheric Environment Service
- b) Canadian Forestry Service
- c) Canadian Wildlife Service
- d) Fisheries and Marine Service.

VI Department of Regional Economic Expansion

VII Statistics Canada

VIII Canada-Manitoba Soil Survey

IX University of Manitoba

Departments or Faculties

a) Agriculture

i) Plant Science

ii) Soil Science

b) Anthropology

c) Botany

d) Economics

e) Geography

f) Geology

g) History

h) Sociology

i) Zoology

X City of Winnipeg

XI Museum of Man and Nature

XII Manitoba Archaelogical Society

XIII Manitoba Historical Society

XIV Economic Atlas of Manitoba

XV Ministry of Transport

Chapter 5 Application And Testing Of The Theoretical Framework

The overall theoretical framework as previously described was applied and tested on a study area around the City of Winnipeg and on six specific study sites within the Perimeter Highway. The regional study area was confined to an area with a thirty-five mile radius around the City of Winnipeg. The specific study sites were chosen on the basis of their suitability for studying the environment as determined by the site selection format. Variation in physical and biological structure was an important factor in selection of the sites, as the author wished to test the framework on a wide spectrum of site types, e.g. grassland, marsh, riverbottom, etc.

The information that follows is an example of what can be produced by following the theoretical framework as described. The information was gathered and compiled over a four month period by the author and four graduate assistants. Final writing was carried out by the author over a nine month period. The information is organized in a manner similar to the organization structure as outlined in Chapter 4.

This practical application tested the framework's ability to provide the basis of information required by or for an environmental education program. However, ultimate success of this framework in its ability to produce a valuable body of information for environmental education cannot be finally determined until this information has been utilized in a pilot environmental study program.

5-1 Regional Analysis

5-11 Geographic location

The regional study area has as its centre the City of Winnipeg. The approximate geographic centre of Winnipeg is at the axis of 97^{o} 00'E longitude and 49^{o} 54'N latitude. (Fig.#2).

5-12 Size

The regional study area takes in 3,846 square miles of land.

5-13 Natural features

5-131 Regional geology

According to J. F. Davies et al (1942) the bedrock of the Winnipeg area is made up of mainly Palaeozoic era rocks. The Precambrian surface in the Winnipeg area is covered by sandstone and shale of the Ordovician Winnipeg formation. The main section of Palaeozoic strata above the basal sands is composed of dolomite and limestone, with thin shale and evaporite beds, of Ordovician, Silurian and Devonian ages (Fig.#3). The deposition of these rocks was associated with the development of the Williston sedimentary basin which extended into southwestern Manitoba.

I. Ordovician Age Bedrock

The rocks of Ordovician age have been divided in ascending order into the Winnipeg, Red River, and Stony Mountain formations (Table #1). They form the bedrock surface through a broad arc of flat lake and marsh land along the western edge of the Precambrian Shield and extend west through our regional study area (Fig. #4).

1-1 Winnipeg Formation

The Winnipeg formation is exposed along the eastern edge of the regional study area (Fig. #4). It consists of basal sandstone composed of poorly consolidated well-rounded and frosted quartzose sand, interbedded shale and sandstone.

1-2 Red River Formation

The Red River formation outcrops over a large section of the regional study area (Fig.#4). This formation consists of predominately dolomites and dolomitic limestone varying in thickness from 20 feet to 550 feet.

1-3 Stony Mountain Formation

The Stony Mountain formation is a narrow band of argillaceous limestone, dolomite and calcareous shale running North-South across the middle of the regional study area (Fig. #4). The Stony Mountain formation is well exposed at Stony Mountain and complete 140 ft. sections have been intersected in nearby wells.

II Silurian Age Bedrock

Dolomite of Silurian Age is present as the Interlake group of rocks which make up the major western portion of the regional study area (Fig. #4).

II-1 Interlake Group

The top part of the Interlake group in southern Manitoba has been removed by pre-middle Devonian erosion and the thickness decreases from 400 feet in the southwestern corner of the province to zero at the erosion edge just west of the Stony Mountain formation (Fig.#4).

The Interlake group is characterized by limited variation in lithology, in that it is almost exclusively dolomite.

III Devonian Age Bedrock

The Devonian strata comprise the thickest unit of the Palaeozoic section with over 1,400 feet of Devonian rock present in the southwest corner of Manitoba. However, in out study area, the Devonian strata is restricted to a maximum thickness of 335 feet found in the Winnipegosis formation.

III-1 Elk Point Group

The Elk Point Group is represented as a small intrusion into the extreme western section of our regional study area (Fig.#4).

III-1:a Ashern Formation

The Ashern formation is 10 to 50 feet thick in the sub-surface, and consists of red and green dolomite shale and red and purplish argillaceous dolomite (Fig. #4).

III-1:b Elm Point Formation

Overlying the Ashern formation is the finely granular, yellowish grey, Elm Point limestone (Fig. #4).

III-1:c Winnipegosis Formation

The Winnipegosis formation is composed of reef and inter-reef facies. The reefs consist of hard dense massive dolomite, commonly highly fossiliferous. Inter-reef deposits consist of poorly fossiliferous bedded dolomite containing some thin shaly bands (Fig. #4).

5-132 Regional hydrology

The regional study area lies within the Red-Assiniboine Rivers secondary watershed division of the Saskatchewan River-Nelson River primary watershed division (Weir, 1960). Topographical contours play an important role in surface and groundwater movement in this area. As it is a rather topographically level area minor watersheds tend to be large and difficult to bound (Fig. #5).

Ehrlich et al (1953) in describing surface water movement in the Winnipeg area, notes that this area which was once completely covered by Glacial Lake Agassiz, now contains no lakes of major significance. However, although the total surface area of open water in lakes and ponds is small, there are a number of sections of Bog and Half-Bog in the eastern portion of the regional study area (Fig.#5).

The regional study area is drained almost exclusively by the Red and Assiniboine Rivers and their tributary streams. The flat topography and prevailing clay texture of the surface deposits of this area require man-made drainage channels to drain rainstorm and flood water into natural streams and rivers (Red, Assiniboine, La Salle and Seine Rivers, Sturgeon Creek, etc.) Normally the peak flow in the Red River and its tributaries occurs during the months of April and May and the lowest discharge occurs during the month of February.

Charron (1969) has determined that continental groundwater flow in the Winnipeg area flows from the Monominto, Ostenfeld area south-east of Winnipeg toward the Morden area south-west of Winnipeg. A large discharge zone (man-made flowing wells or natural springs) has been identified by Charron (1969) to occur south-east of Winnipeg and north-west of the highlands of Sandilands Forest Reserve. Another much smaller dishcarge zone is located northwest of Winnipeg. Due to the removal of water from these areas for domestic and commercial purposes a lowering of the piezometric level of the groundwater is occurring and these discharge zones are gradually decreasing in size.

The recharge area for the large discharge zone is situated in the highlands of the Sandilands Forest. The recharge area for the small discharge zone northwest of Winnipeg is believed to occur between Lake Manitoba and Lake Winnipeg.

Ehrlich et al (1953) has determined that in the south-western portion of the regional study area groundwater suitable for domestic use is otten difficult to locate. When an abundant supply of water is located in sand and gravel lenses in the lower portion of surface deposits, or from bedrock, the water is usually quite saline and therefore of limited use. Artesian water occurs in the southwestern portion of the regional study area. This artesian area extends east of the Red River and north to Defresne and Niverville. The source or charge area of this artesian water is again the precipitation which enters the deep sand deposits in the highlands of the Sandilands Forest to the east. This resulting groundwater then flows west and southwest in the direction of the dip of the underlying geological formation. As the water is confined under the impervious clay soil of the lower lying areas, artesian conditions are produced.

5-133 Regional soils

I General description

According to W. A. Ehrlich, et al (1953) glaciation during the pleistocene period covered the entire Winnipeg area with glacial drift. The glacial drift or boulder till deposits range in thickness from less than 20 feet to greater than 200 feet. The location and distribution of the soil zones, and the various soil units can be seen on the soils maps produced in the Reconnaissance Soil Survey of Winnipeg and Morris Map Sheet Areas by Ehrlich et al (1953).

II Soil Classification of the Winnipeg area

I Soils of the Blackearth Zone

a) Red River Association

(i) Red River Clay

(ii) Osborne Clay

(iii) St. Norbert Clay

b) Marquette Association

c) Fort Garry Association

d) Lakeland Association

e) Sperling Association

II Soils of the Grey-Black Zone

a) Pegius Association

III Soils of the Grey Wooded Zone

a) Garson Soil Complex

b) Birds Hill Association

IV Local Soil Areas

a) Organic Soils

(i) Half-Bog Soils

(ii) Bog Soils

III. Soils of the blackearth zone

Typical or zonal Blackearth soils are characterized by a "black" "A" or surface horizon, which is granular in structure, high in organic matter, friable, and generally neutral to slightly alkaline in reaction; and which fades gradually into a lime carbonate accumulation horizon at depths that vary with the parent materials on which the soils are developed. These soils, which occur as the well-drained members on the various soil parent materials in the Blackearth zone, have been developed under tall prairie-grass vegetation, but some tree invasion of prairie has occurred in local sites. The dominant feature of the landscape of the Blackearth zone, in the Winnipeg-Morris map areas, is the broad expanse of prairie which, in general, is broken only by trees and bushes bordering the meandering stream channels. A few small clumps of trees have become established some distance from the streams and, as the Grey-Black transitional soil zone is approached, the tree vegetation becomes more prominent. In some areas the trees have been established long enough to modify the soil profile on which they are supported; this is especially true where mature woods occur as a fringe on the upland adjacent to, and along the margins of the large stream channels.

a) Red River Association

The soils designated as the Red River soil association consist of Blackearth or blackearth-like and associated soils that have developed on the lacustrine fine clay deposits in the central basin of glacial Lake Agassiz. All the soils in this association at one time or another have been under the influence of excessive moisture, and are now passing slowly through various stages of transition from poorly drained to better-drained conditions. Somewhat more than one-half the area occupied by this association has soils that show the effects of hydromorphism (excessive moisture).

The one outstanding characteristic that the Red River soils have in common is the fine texture of the parent clay, but due to differences in drainage or moisture regime, different soil types with varying morphological features have developed on the same parent material. The topography of the clay deposits, in general, is flat and very smooth, and although there is a fall from the western and eastern margins to the Red River channel, and from south to north along the axis of the plain, the grade over much of the area is less than two feet per mile.

Micro-relief features have had a profound effect on the soils of this association. Although the differences in surface level appear slight, the drainage or moisture conditions within the soils located in the different micro-relief positions vary, and hence the soil climate varies with the variation in soil moisture regime. Consequently, the soil-forming processes on the various sites have been affected to the extent that different soil types have been produced.

On the somewhat higher and better-drained sites within this region Blackearth or blackearth-like soils have developed. These soils are characterized by a dark "A" horizon tongued with icicle-like intrusions into a greyish brown clay. The black tongued intrusions are the result of the cracking and shrinkage which is common in these soils during aperiodic dry seasons. The better the drainage, the more distinct is the brown color of the subsoils. The flat and poorly drained sites are occupied by Meadow soils that are characterized by a relatively thin dark "A" horizon, over a subsoil that is dominantly grey when moist and flecked with limonite (iron) concretions which indicate periodic excessively wet conditions. In the intermediate positions, and between these two soil types, are soils that may be classed as Blackearth-Meadow intergrades. These intergrades can be recognized by intermediate depths of dark "A" horizon and a distinctly olive cast in the underlying clay subsoil. Of the soils under the influence of hydromorphism (excessive moisture) both salinized and non-salinized types occur, and in the intermediately drained sites, tough, waxy soil profiles showing alkalinized (or solonetzic) characteristics are widespread.

In the better-drained sites, the soils are approaching equilibrium with the regional climate and, under the regional tall prairie-grass cover, have developed blackearth-like characteristics. However, adjacent to and above the banks of the river channels, where the soil is well drained, an invasion of oak and aspen poplar has formed a fringe of tree growth under which (depending upon the age of the forest) the soils show varying degrees of degradation or modification by leaching, so that degrading Blackearth or Grey Black soils are in the process of development.

Where the well to intermediately drained Blackearth and blackearth soils were dominant, they were delineated and shown on the soil maps as Red River clay. Where the poorly drained Meadow type soils predominate, they are delineated and shown on the soil map as Osborne clay. Where tree growth has invaded the well-drained sites, and degrading Blackearth or Grey-Black soils prevail, the areas were delineated and designated as St. Norbert clay.

(i) Red River Clay

The representative blackearth-like soil of the Red River association is the well to intermediately drained associate. This soil is characterized by a black to very dark grey "A" or surface horizon 8 to 12 inches thick, neutral in reaction, rich in organic matter, and with granular microstructure that tends to from columnar aggregates when dry. The "B" of transition horizon is 4 to 6 inches thick, dark greyish brown in color and slightly alkaline in reaction. This horizon grades into a light greyish brown horizon of clay that effervesces feebly with acid. This type is commonly found on the crests of the low clay ridges or adjacent to stream channels where drainage is better than average.

The intermediately drained soils constitute a considerably larger portion of the Red River clay area than that covered by the better-drained soils. The typical intermediately drained soil has a very dark grey to black "A" or surface horizon 6 to 12 inches thick, neutral in reaction and with finely granular microstructures that sometimes form slightly solonetzic structural aggregates. This horizon may grade through a lime carbonite accumulation or fade directly into greyish brown clay, amorphous to fragmental in structure, that has an olive cast when moist. In local areas the intermediately drained soils have become more or less alkalinized (or solonetzic) in character, in which case they may be designated as Morris clay.

The representative alkalinized or solonetzic soil associate has a very dark grey "A" or surface horizon 6 to 10 inches deep, which is tough and compact, and neutral in reaction. This horizon grades into a very dark greyish brown cloddy and somewhat prismatic "B" horizon, 8 to 10 inches deep, which is very stiff and plastic, and dries into extremely hard amorphous clods. Immediately below this horizon, lime carbonate concretions occur in an amorphous dark grey to greyish brown horizon. Some small areas of degrading Solonetz or solidized soils are also found as associates. They are characterized by a greyish, ash-like slightly acid "A_2" horizon, and very hard round topped columns in the upper portion of the "B" horizon.

(ii) Osborne Clay

The Osborne soils are the Meadow type soil associates of the Red River association. These soils have been developed on flat or depressional topography under meadow or swale grass vegetation. The representative soil has a very dark grey "A" horizon 3 to 6 inches thick, which is rich in organic matter, somewhat granular and friable when moist, lumpy and hard when dry, and usually alkaline in reaction. This horizon is tongued deeply into the underlying soil horizons. A lime carbonate accumulation may or may not occur immediately below the "A" horizon. Where it occurs it is light greyish brown to grey in color, granular in structure, very sticky and plastic when wet, and is flecked by iron staining and concretionary lime carbonate. The subsoil is olive grey to grey clay which is massive in structure when moist but may show fragmental micro-aggregation; plastic and sticky when wet but very hard when dry, and is sometimes moderately high in lime and always iron stained.

Several variations of this poorly drained associate occur in the regional study area. These variations include salinized, slightly alkalinized, and peaty meadow variants.

(iii) St. Norbert Clay

This soil is the wooded associate of the Red River association. It occurs chiefly along the river channels where woodland invasion of prairie has developed to the greatest extent. The vegetation on these soils is dominantly oak with some aspen and hazel. The better developed virgin soil has a brown leaf mat or "A_0" horizon; a very dark grey clay "A_1" horizon which is up to two inches thick, granular and neutral in reaction: and a dark grey clay "A_2" horizon which is 1 to 4 inches thick, ash-like and slightly acid in reaction. The "B" horizon is 12 to 20 inches in thickness, cloddy to massive, very hard when dry, plastic when moist, and slightly acid in reaction in the upper portion. Vertical cracking occurs when the soil dries so that it may have a somewhat columnar appearance. The "C_1" horizon is dark brown to dark greyish brown clay which is massive, alkaline in reaction, and contains carbonate concretions.

Many variations in the degree of development of wooded soil profiles exist and all variations between a blackearth soil and the wooded soil profile described above are to be found. Included in the St. Norbert soil area are small areas of well-drained and intermediately drained Red River clay profiles.

b) Marquette Association

The soils of the Marquette association are developed on about 16 to 30 inches of lacustrine clay sediments over till or stratified drift. These soils are located in a transitional position between the soils of the Red River association and soils developed on modified till. Therefore some soils in the Marquette association may resemble soil types of the adjoining associations. Surface textures range from heavy clay loam to clay in texture. The topography of the association is level with some large micro-depressional areas. On the better-drained sites, tall prairie grasses and herbs are normally found but some woodland invasion by aspen has occurred. In many sites, patches of salt-tolerant plant species are found, and in the lower positions, sedges, meadow grasses and willow are the main types of vegetation.

The Marquette association contains three soil associates; namely the blackearth-like, well to intermediately drained associate, the alkalinized soil associate, and the poorly drained or Meadow soil associate.

The dominant, well to intermediately drained associate is blackearth-like. It has a very dark grey "A" or surface horizon, 8 to 10 inches thick, which is granular in structure, very hard when dry and plastic when moist, and neutral to slightly alkaline in reaction. This horizon fades into a dark brownish grey clay to heavy clay loam "B" horizon, which is prismatic to granular, hard when dry, very plastic when moist, and alkaline in reaction. The "C_1" horizon is brownish grey clay to heavy clay loam, which has a massive structure that breaks down into fine granules, and is mottled with lime carbonate and iron concretions. This horizon is often thin and it may be absent where the lacustrine mantle is shallow. Below the lacustrine material, which is usually 16 or more inches thick, a modified calcareous glacial till occurs. Immediately below the junction of the lacustrine clay and the glacial till, this material is usually stratified, but with an increase in depth it grades into unmodified grey mottled till.

c) Fort Garry Association

The soils of the Fort Garry association are developed on a clay and silty clay mantle which lies over strongly calcareous silty and fine sandy clay dolomitic sediments. The clay mantle may be from 6 to 20 inches or more in thickness and it is invariably tongued into the underlying pale yellow material on which it rests. In some areas the calcareous silty material s are confined to low ridges with clay soils of the Red River soil association occupying the intervening positions, whereas other areas are covered completely by the silty deltaic and lacustrine deposits. These deposits, which are up to six or more feet thick, consist of laminated deposits varying in texture from very fine sandy loam to sandy clay and silty clay. Lacustrine clay, generally varved, occurs beneath these silty sediments.

The dominant associate is a blackearth-like soil. In cross section this soil has an "A" or surface horizon which is usually 7 to 10 inches thick but may extend 30 inches downward in large pendulous tongues. The "A" or surface horizon consists of very dark grey clay to silty clay which may show hard prismatic columns in the tongues when dry, and which is plastic and sticky when wet, neutral to slightly alkaline, and grades sharply into a light grey, friable marly horizon that lies over light grey to pale yellow, laminated, and highly calcareous very fine sand to silty clay. A varved clay substrate occurs at depths ranging from 3 to 7 or more feet. In intermediately drained areas well-developed Alkalinized or Solonetz and solidized Solonetz soils occur, but these types make up only a very small part of the acreage of the association. A considerable acreage of poorly drained or Meadow soil associates occurs in this association, and these poorly drained soils are invariably more or less salinized, and highly calcareous.

d) Lakeland Association

The Lakeland soils are weakly developed calcic blackearth-like soils and associates that have been developed on pale yellow calcareous silty or fine sandy lacustrine and flood-plain sediments. These soils are calcic or high in lime because they have been developed on calcareous parent materials, and they may contain ground-water lime, derived from a water table that may appear periodically above the underlying calcareous till substrate.

The terrain occupied by the Lakeland soils has a smooth to very gently sloping topography. Some large areas occur in which the Lakeland soils occupy a depressional position in relationship to the surrounding land. Under such conditions the soils are poorly drained, and in some cases they may have a thin surface deposit of peat. Internal subsoil drainage is impeded in most sites due to an underlying till substrate. However, the better drained soils have sufficient relief to remove excess surface water and in these soils surface drainage is not a serious problem.

This association has been separated into two textural types, i.e., very fine sandy loam, and clay loams to clays. The fine sandy loams occur most extensively in the Woodlands-Stonewall sub-area, and the clay loams to clays occur principally in the northern extremities of the Red River Plain. The finer textured soils are largely intermediately to poorly drained because of the low position they occupy in relation to adjacent soils, and because of the retarding effect of the till substrate on sub-soil drainage. However, where the drainage positions are comparable, the profile characteristics of soils within the two textural types are quite similar except for differences such as texture and porosity.

The blackearth-like or well to intermediately drained soil associate has a very friable "A" or surface horizon, that is 5 to 12 inches in thickness, dark grey to very dark grey in color, fine sandy loam in texture, and moderately alkaline in reaction. In a few locations a very shallow transitional "B" horizon occurs but generally the "A" horizon grades directly into a very light grey or white lime carbonate layer which may be up to 9 inches in thickness. The lime carbonate accumulation horizon grades into a light grey to pale brown (or yellowish) fine sandy loam to silty loam subsoil. The "C_1" horizon may be thin, but in most profiles a considerable thickness of silty parent material occurs which is highly calcareous, moderately iron stained, and generally underlain by calcareous till similar to the parent material on which the Isafold soils are developed. This till substrate is not part of the Lakeland soil profile, but indirectly it does influence the soil insofar as it affects the water regime by retarding drainage and contributing to the soluble salt and lime content through upward movement of these constituents when ground water is present.

e) Sperling Association

The Sperling soil association is composed of Blackearth and associated types that have developed on light grey to light yellowish brown sediments which have been transported by the Boyne Creek from the lower Assiniboine delta. The sediments are levee and overwash deposits along the banks of this intermittent stream where it flows over the clays of the Agassiz basin. The Sperling soils extend from Carman to Sperling in a strip that is no more than three or four miles wide. Meandering dry stream channels that fade out in the eastern portion can be traced through this area. Near the stream channels the levee deposits may be 7 to 10 feet in thickness but these sediments gradually become thinner with increasing distances from the channels. Near the outer boundaries of the Sperling soils the super-imposed materials are thin and may not exceed one or two feet in depth. A buried soil, similar to the Osborne clay in character, can be found below the Sperling parent material. However, fairly typical Blackearth soils have been developed on the levee deposits indicating that the parent materials of the

Sperling soils have been in position for a sufficient length of time to permit the establishment of Blackearth profiles.

The texture of the sediments on which the Sperling soils have been developed varies from west to east and from the stream channels to their margins. The surface soil tends to be fine to very fine sandy loam in the western and central portions of the association, but towards the eastward margin of the Sperling soil association the texture gradually becomes finer and grades through silt loam, and clay loam, to silty clay, which are the predominant surface textures of these soils in the Winnipeg map sheet.

The Sperling soils have developed, under tall prairie grasses and herbs with some associated meadow grasses, on smooth topography and under good surface drainage. The dominant soil has a very dark brown to black "A" or surface horizon, 10 to 16 inches thick, ranging in texture from fine sandy loam to silty clay, finely granular in structure friable, and slightly alkaline in reaction. The "A-B" or transition horizon, if present, is thin and poorly developed. The "A" or "A-B" horizon where present, grades into a light grey lime carbonite horizon which in turn fades into a light grey to light yellowish "C_1" horizon.

II Soils of the Grey - Black Zone

The Grey-Black soils occur as well-drained representative members of a transitional belt of soils between the Blackearth and Grey Wooded soil zones. In addition, Grey - Black soils or degrading Blackearths occur as associated local soils in adjacent soil areas within the

Blackearth and Grey Wooded zone. Grey - Black soils can be considered as a group which represent all transitional stages of profile development between Blackearth soils, developed under grassland vegetation and Grey Wooded soils developed under forest vegetation. These Grey - Black (or degrading Blackearth) soils were originally developed under grassland vegetation and originally had Blackearth characteristics, but forest invasion of grassland has advanced to a point where the soils now show varying degrees of degredation. The "A" or surface horizon of these soils shows varying degrees of transition from black to grey black or grey, (a grey black mottling is quite common), and is nutty in structure, and the aggregates more or less coated with humus that has leached from the "A" horizon. The lime carbonate below the "B" horizon is concretionary and usually well defined, but it occurs at greater depths than in the corresponding adjacent Blackearths.

In the Grey - Black (or degrading Blackearth) transitional soil zone of the Winnipeg-Morris map areas, large areas of intrazonal soils may occur in association with the Grey-Black soils, especially on sites where the topography is nearly level and the internal drainage of the soil is impeded. In the hydromorphic sites of this transitional soil zone, the soil climate is conducive to the formation of Peaty Meadow soils, but Meadow and Meadow Podzol soils occur in minor areas. Little or no salinity is normally encountered in locally humid soils of this transitional zone. The poorly drained soils are usually developed under meadow-grass vegetation whereas trees are the dominant vegetation on the better drained sites.

a) Pegius Association

The Peguis soil association consists of soils in the Grey - Black transitional zone which have been developed,under forest invasion of grassland, on clay that is underlain with calcareous till at depths ranging from 16 to 30 inches. The clay sediments are a part of the clay plain laid down in the waters of glacial Lake Agassiz. The parent material of this association is similar to the parent material of the Marquette association which occurs in the Blackearth zone, but the profile of the well-drained Peguis soil is degrading due to the effects of forest invasion.

The representative degrading Blackearth soil in this association is well to intermediately drained. It has an "A_0" horizon which is a dark brown leaf mat, neutral in reaction, resting on an "A_1" horizon that is very dark brown in color, 1 to 2 inches thick, and neutral to slightly acid in reaction. This grades into an "A_2" eluvial horizon consisting of dark grey clay, 2 to 4 inches in depth, granular in structure, and slightly acid in reaction. The "B" or illuvial horizon is 7 to 8 inches thick, with a somewhat cloddy to columnar macro-structure that breaks into nutty aggregates, very plastic when moist, and neutral in reaction. This horizon fades into a slightly iron-stained greyish brown clay, that is granular in structure, 6 to 18 inches thick and moderately alkaline in reaction. The clay is superimposed over an unrelated substratum, which may consist of either till or modified till.

III Soils of the Grey Wooded Zone

Grey Wooded soils in the eastern portion of the regional study area have been developed under Boreal forest vegetation and, in virgin condition, are characterized by a mat of forest litter and organic residue that is granular to platy in structure, and slightly acid (or neutral) in reaction; and by a brown to greyish brown more or less nutty structured "B" or illuvial horizon that grades into a well-defined accumulation of lime carbonate. Between the leaf mat and the "A_2" horizon, a thin grey black crumbly "A_1" horizon may be present, in which the organic matter from the "A_0" has been mixed with the upper portion of the mineral soil by organisms. In some cases the grey black crumbly "A_1" horizon is absent.

The climate of the Grey Wooded soil zone is cooler and more moist than the Blackearth zone. The higher precipitation effectively favours tree growth, and the tree cover together with the more moist soil climate favours degredation or leaching in the upper part of the soil profiles. In the Grey Wooded zone of the regional study area wooded uplands with either grassy or wooded swamps in the associated hydromorphic sites are characteristic features. Mixed stands of aspen and oak are most common, but areas of mixed woods occur in which white spruce is intermixed with oak, aspen and balsam poplar. In local areas, where the soil climate is dry, due to coarse texture and droughty soil conditions, jack pine and big bluestem are characteristic. Because the topography in this area of Grey Wooded soils is generally irregular, large areas of the poorly drained soils occur. Wet-land grasses and sedges which form and grow over fen peat are common on the poorly drained sites in the southern section, but black spruce and tamarack, along with swamp birch, willow and associated hydrophytic plants are commonly found on the peat deposits and wet sites in the northern section.

a) Garson Soil Complex

The Garson soil complex is a group within the Grey Wooded zone which contains degrading Rendzina soils, developed on reworked calcareous boulder till, and minimal Grey Wooded soils developed on a mantle of sandy and stony erosional residue, up to 15 inches in depth, resting on reworked calcareous boulder till. All degrees of transition between these two soil types occur, but soils with a very thin sandy mantle predominate, and intrazonal soils, common to the Grey Wooded zone, are found in association. The Garson soils are all more or less stony, and in many cases have a cobbly or gravelly lens under the thin sandy mantle. The irregular very gently sloping topography has many depressions in which poorly drained soils occur.

b) Birds Hill Association

The Birds Hill soil association consists of coarse textured Grey Wooded and associated soils that have developed on coarse sandy and gravelly outwash deposits in the form of kames, eskers and beaches. Many surface boulders may occur especially in the Birds Hill area. The topography varies from variable sized ridges to irregular gently sloping hillocks. A gradation in profile character of the well drained soils from blackearth-like to Grey Wooded soils can be found. The cobbly knolls which are usually under grassland vegetation have blackearth-like characteristics, whereas the coarse sandy and fine gravelly soils under forest show distinct Grey Wooded characteristics. Where a large percentage of coarse gravel and cobbles prevail, the horizons have less thickness, and the soil characteristics are weakly expressed. The Birds Hill soils which occur in the easterly locations are more strongly leached than the soils occurring in the vicinty of Birds Hill.

The depth of soil profiles seldom exceeds 12 inches in the representative well-drained Birds Hill soil. The dark colored "A_1" horizon may be absent or up to 3 inches thick. The "A_2" horizon is a light brownish grey sand, 2 to 4 inches thick, and slightly alkaline due to the presence of numerous small partially decomposed limestones. The "B" or illuvial horizon is brown to yellowish brown, light sandy loam in texture, 3 to 5 inches thick, and moderately alkaline in reaction. This horizon may contain some clay although the amount is usually less than ten percent. The "C" horizon consists of pale brown to light yellowish brown stratified sand and gravel.

IV Local Soil Areas

Several local or azonal soil areas are shown on the Winnipeg-Morris map sheets that do not have the zonal soil characteristics common to the zone in which they occur. The characteristics of these local soils are influenced profoundly by parent material, immaturity, or drainage. The local soil areas here referred to include the Organic or Half-Bog and Bog soils.

a) Organic Soils

The soils that have been designated and mapped as Half-Bog and Bog soils are organic deposits, or accumulations of plant remains, that have been formed as peat under hydromorphic (water-logged or excessively wet) and anaerobic (not sufficient air) conditions. The peat deposits vary in appearance and physical condition depending on the type of vegetation from which the peat was derived, and on the degree of decomposition that has taken place.

Peats can be differentiated as (a) sedimentary peat, or fine muck and jelly-like deposits that have settled or precipitated in ponded waters; (b) fen peat, or accumulations of aquatic plants, reeds,sedges and grasses which have filled in areas that were formerly ponds, and may be in either a fibrous or crumbly condition, depending on the degree of decomposition that has taken place; (c) woody peat, or the remains of trees and shrubs that invaded earlier peat formations; (d) moss peat, or the remains of mosses and allied plants and which is generally fibrous or felty; (e) mixed peats, in which the various forms of peat were found superimposed one over the other. Because of the excessively wet conditions that prevail where these various plant remains are deposited, decomposition is either slow or inhibited. Varying degrees of anaerobic and aerobic decomposition however do occur depending on the degree of saturation that prevails, or in the degree of aeration that follows when dry seasons or other factors result in improved drainage. A further factor involved in the formation of peat is the chemical reaction and composition of the swamping waters. Thus the peat and the saturating waters may be acid, neutral, or alkaline in reaction, and hence the reaction as well as the type of peat, affects the plant species that are found growing on the respective sites.

In the regional study area the organic soils or peats are differentiated on the basis of depth, and vegetative cover. Where the peat is 10 to 30 inches in depth is is classified and mapped as Half-Bog soil, where the peat is over 30 inches in depth it is classified and mapped as Bog soils. (Where the peaty surface covering is only a few inches in thickness and a hydromorphic soil profile has developed in the underlying mineral materials, the soil is classified as a Peaty Meadow associate of the soil association in which it is included.)

(i) Half-Bog Soils

Where Half-Bog soils occupy hydromorphic sites in the Blackearth zone they are invariably on the fen peat type. In the Grey - Black soil zone, although the fen type of peat predominates, some of the Half-Bogs have been invaded by tamarack and black spruce. In the northern portion of the Grey Wooded soil zone in the regional study area, black spruce and tamarack with associated growths of leatherleaf and moss are the dominant type of vegetation on mixed fen and woody types of peat. In the southern portion, wet-land grasses, sedges and reeds are intermixed with clumps of black spruce and tamarack, and fen rather than woody peat predominates.

(ii) Bog Soils

The Bog soils or deep peats occur chiefly in the excessively hydromorphic sites within the Grey Wooded, and to a lesser extent in the Grey - Black soil zones. These organic soils tend to be saturated or water-logged almost continuously. Poor stands of black spruce and tamarack are dominant except in the southern portion where sedges, reeds and swale grasses are more prevalent.

5-134 Regional topography

Winnipeg is situated in the heart of the Manitoba lowlands at the junction of the Red and Assiniboine Rivers (J. J. Labella, R. J. Brown and M. D. Hasinoff,(1966). J. H. Ellis, (1938) states that the Winnipeg area lies in the valley floor or the bed of the former Glacial Lake Agassiz. This area varies in elevation from 980 feet above sea level 300 miles south of Winnipeg, to 720 feet above sea level at Lake Winnipeg. It is approximately 15 miles wide at the Canada - U.S. border (49th parallel) and widens to 100 miles around Winnipeg (50th parallel). The Canadian section of the valley is a nearly level plain, characterized to the east of Winnipeg by a slow rise in elevation as it blends into the Canadian Shield. The appearance of much swamp land in this area due to poor drainage is caused by the lack of significant local relief differences of over 25 feet. To the west of Winnipeg, the valley terminates abruptly with the rise of the Manitoba Escarpment. The

Assiniboine River cuts its way through this escarpment and forms a broad rich-soiled valley, extending west and north into Saskatchewan. The Red River Valley to the south of Winnipeg is also poorly drained and as a result low lying swamp lands are numerous (Fig. #6).

The Red River is a wide, undulating water course with a width of 600 feet at Winnipeg and a length that is double the distance from its source to Winnipeg. The Red River's elevation drops at a fairly even rate of 3 inches per mile from Grand Forks to a few miles beyond Winnipeg and thereafter to its mouth at Lake Winnipeg at a rate of 6 inches per mile.

This trenched type of topography (on a large scale) affects wind movement and wind directioning, thus effecting the occurrence of transient weather formations and moisture regimes over Winnipeg. This topography also effects the seasonal and permanent upland and local Winnipeg area drainage patterns and watershed basins. As a result the topography of this area played an integral part in the historic settlement patterns and land use of the Winnipeg area.

5-135 <u>Regional resource types and distribution</u>

According to Bossenmaier and Vogel (1974), the pre-settlement habitat of our regional study area was rich and varied as several major habitat types occurred side by side. There were grasslands, marshes, broadleaf parklands and mixed broadleaf coniferous forests. The two major rivers flowing through the study area supported river bottom habitat and aquatic ecosystems. These water regimes are supplemented by smaller water courses throughout the study area. Included also is Oak Hammock Marsh and a small portion of Netley-Libau Marsh. (Fig.#7).

During the period the regional study area was being inhabited by homesteads and agriculture was becoming a way of life for Manitoba residents, changes were occurring in the area habitat.

The grasslands were being altered extensively by agricultural development as great grassland tracts were converted into cropland by drainage and ploughing. Many of the wet prairie zones were drained and ploughed with Oak Hammock Marsh being the final remnant of the once vast system of semi-permanent and permanent marshes (Fig.#8).

Although many large pre-settlement marshes were drained the regional study area still possesses the Netley-Libau and Oak-Hammock marshes.

The broadleaf parklands and forest habitat types were extensively cleared and broken for agricultural cropland. However, numerous small tracts of these habitat types have been left in their near natural state. Although many of the former animal species that inhabited these communities are gone, many species remain.

A great deal of the mixed forest habitat of the regional study area is little changed from the pre-settlement period, although agriculture, logging and fire have altered some tracts. Evidence points out that the mixed-forest habitat has undergone less change than the other habitat types of the Winnipeg region with the possible exception of some wetlands.

The City of Winnipeg also provides certain types of habitat.

Although a great deal of vegetation has been supplanted by asphalt, concrete and high-rise buildings, many areas do exist in the city where natural habitat can still be found. River corridors, parks, schoolyards, boulevards, all contribute to the habitat of the regional study area.

Agricultural cropland is now the dominant landform of the regional study area. As can be seen from a comparison of Fig. #7 and Fig. #8 almost the entire former wetland area has been converted to cropland.

Agricultural land use in the regional study area reflects the influence of both the local domestic market and the export market. Cereal crop production is by far the dominant land use in this area. However, as Ehrlich, et al (1953) postulated, population growth within the City of Winnipeg will increase the demand for dairy products, poultry products, livestock products and market gardening. These agricultural practices are now occurring on agricultural land within the urban shadow. As well, agricultural diversification and land use modification has expanded agricultural production in this area to now include sugarbeets, corn, sunflower and canning peas.

Bannatyne (1973) describes the mineral resources of the regional study area. Commercial gravel and sand deposits are found in the northern half of township 11, range 2E, extending into township 12. range 2E, and a second deposit is located south of Birds Hill Park.

Clay from various deposits in the Winnipeg area is used in various commercial enterprises, dependent upon the structure of the clay. Glacial Lake Agassiz clays from the Ft. Whyte area are used in the manufacture of Portland cement. Glacial Lake Agassiz clay from the St. Boniface area is used to produce lightweight aggregate for the manufacture of concrete blocks. Surficial clays of both alluvial and Pleistocene deposits were at one time used in the manufacture of common brick. Common brick is no longer produced in Manitoba, and thus the clay is not considered an economic resource.

Silica sand occurs in deposits just north of the City of Winnipeg and in an area south east of Ste. Anne. Major uses of silica sand are in the manufacture of glass, as foundry sand, for sand blasting, and for treatment of waste water.

Deposits of gypsum are located in the regional study area in the Charleswood area and in the area between the Perimeter Highway and Headingley. Gypsum is used in the production of wallboard, plaster and Portland cement.

High-calcium limestone deposits have been located in the regional study area. These deposits have not yet become economically attractive to the cement and lime operations in Winnipeg, owing to the high mining costs.

Dolomite is quarried in the Stonewall-Stony Mountain area and is used for the production of magnesium lime, for concrete aggregate, for railway ballast and as rubble and rip rap.

Tyndall stone occurs at a depth of over 150 feet in the Winnipeg area, however, it is not considered an economic resource as it cannot compete with the readily available Tyndall in the Garson area.

5-136 Regional climatic factors

With its mid Canada location, Winnipeg shows a typical 'Continental' type climate. Temperatures in the Winnipeg area vary greatly throughout the year, the normal temperature curve being at its lowest (-18°C) during mid to late January and at its highest (21°C) during mid to late July (Labelle, Brown and Hasinoff, 1966).

Environment Canada's Annual Meteorological Summary for Winnipeg (1973) reports that an average frost free period (0°C., or less) for Winnipeg would be approximately 118 days,(Fig. #9) running from May 25 (last frost date) to September 21 (first fall frost date). Winnipeg averages 131 days yearly which are free from killing frost of -2°C. Ice break up on the Red River usually occurs in early April and Freeze up occurs in mid November.

The hours of bright sunshine per month are usually longest in July (averaging 310 hours) and shortest in December (81 hours). As Winnipeg is situated on the 50th parellel, the area is affected by the prevailing westerly winds which form a broad belt circling the entire globe 30 to 60 degrees North and South of the equator. These winds are responsible for variations in year to year seasonal as well as single season weather, through changes in their average path of flow. Day to day climatic variations are caused in part by migrating weather systems transported by the predominant winds. As well, it is affected by the differential daily heat and energy exchanges between mid continental land formations and the seas and ocean bodies.

Because of the flat terrain of the Winnipeg area, there is little in the way of major local climate variations. The channeling of wind along the Red River Valley, a slight warming and drying in south-westerly winds, and the influence of the large lakes (Winnipeg and Manitoba) to the North and North-West are some factors that do cause local variations in climate. For example, in late summer and fall when the winds are from the North and North-West, the lakes help to maintain a slightly higher temperature and increased cloudiness than would normally prevail without them.

The Annual Meteorological Summary (1973) indicates that winter snowfall in Winnipeg averages 52 inches. Annual precipitation averages 21.06 inches with the heaviest precipitation occurring during the months of April to October (Fig. #9). Thunderstorm activity reaches its peak in July however hail is infrequent in Winnipeg and the Red River Valley

5-14 Regional historic and cultural factors

As explained by Weir (1960) the first settlements established in Manitoba were associated with the fur trade. However, in 1812 Lord Selkirk associated agriculture with the fur trade by founding an agricultural settlement at the junction of the Red and Assiniboine Rivers to supply provisions to the Hudson's Bay Company's fur brigades. By 1870, the year the Province of Manitoba was created, and the population of the Province numbered 12,288.

For many years communication with the outside world was basically via Hudson Bay. However, in 1850 Red River carts were being used on a trail between Fort Garry and St. Paul, Minnesota. Later in 1859, this route to the United States was supplemented when the first steamboat was placed in operation on the Red River.

The single trading centre in Manitoba in 1870 was Winnipeg. This small village of about 100 inhabitants had begun to take shape in the 1860's about half a mile north of the junction of the Red and the Assiniboine Rivers. Most of the people lived in parishes that extended along the Red and Assiniboine Rivers, though there were a few small outlying settlements. The farms were established in long lots along the rivers producing an elongated form of settlement along the rivers (Fig. #10).

The sectional survey was first started systematically in 1871 and the Dominion Lands Act of 1872 made homesteads available to settlers. These events signalled the end of the fur trade era in the west and began the opening of settlements on an agricultural basis.

Until 1878 immigrants had two ways of coming to Manitoba. They could enter Manitoba via the United States by Red River steamer or by an all Canadian, Dawson route via the Great Lakes that was a combination of trails, steam launches and portages. In 1878 the railway was completed from Emerson to St. Boniface and settlers had an easy link from the United States to Manitoba.

After 1870 the settlers no longer stopped at the flood plains of the rivers but went farther afield into the prairies and park lands. However, settlements were not evenly distributed over the countryside. A considerable number of Ontario settlers, who comprised the greatest single group of immigrants in these years, occupied the park lands beyond the river lots on either side of the lower Red River.

It then became the practise of granting reservations of land to various ethnic groups for their exclusive use. As a result tracts of land were reserved for the Metis and the French-Canadian and also for other ethnic groups from overseas. Most of the Metis and French-Canadian reservations were in lowland Manitoba not far from the Red and Assiniboine Rivers. Between 1874 and 1880 approximately 7,000 Mennonites migrated to Manitoba from Russia. They were granted land south of the French-Canadian settlements on the Seine River, and Steinbach became their main centre. However, by this time, Winnipeg was securely established as the dominant trade centre of our regional study area.

Manitoba farmers usually settled on 160-acre homesteads, thus providing a fairly dense rural population in our regional study area. As technology improved farm settlements, farm operations became more efficient, but at the same time more expensive to operate. Technology thus increased farm size while at the same time it reduced the number of citizens working the land.

In the regional study area people began leaving farming for occupations in Winnipeg and other provinces. Thus the urban centre of Winnipeg grew at the expense of population decreases in the rural sector.

The regional study area comprises a mix of many ethnic backgrounds. British, Europeans and Americans all settled in this area to build new lives in the western frontier.

As can be seen from Table 2, the British have always dominated the ethnic groups in both Winnipeg and Manitoba. Citizens of Ukrainian ancestry have been the second most dominant group since 1931. Residential concentration of ethnic groups has a long history in Winnipeg and its precursor, the Red River settlement. In the 1860's the parishes of St. Norbert, St. Boniface and St. Francois Xavier were comprised of almost entirely French-Canadian and Metis Roman Catholic families. In sharp contrast, the parishes of St. Peter and Upper and Lower St.Andrews were comprised almost entirely of British and half-breed protestant families. Later, when St. Boniface became part of Greater Winnipeg, the early pattern of French Canadian concentration was preserved and even today most are located in St. Boniface.

Similarly was the marked concentration of Polish, Ukrainian, German and Jewish - in what is commonly known as the North End. For, by 1921, sixty per cent of the Germans, eighty-six per cent of the Ukrainians, eighty-four per cent of the Jewish and seventy-six per cent of the Polish in Winnipeg were located in the North End. This pattern has been considerably modified since 1921, in particular there has been movement out of the North End to the Kildonans, Transcona and Brooklands. However, to some degree these groups still reside mainly in north Winnipeg.

The main Group, the British, are found throughout the city, but relatively few of them live in north Winnipeg and the older parts of St. Boniface (T. J. Kuz, 1974).

5-15 Regional economic factors

Commercial activities within the city of Winnipeg allow it to dominate the economic structure of our study region. From its very beginning Winnipeg has been the transportation centre for the prairies. Winnipeg was the focus point for fur traders, steamboat activity, settlers moving west and, finally, the railroad. The positioning of the railroad helped to materialize Winnipeg as the centre of the prairie wheat trade and other commercial activities. T. J. Kuz (1974) points out that Winnipeg reached the height of its power and influence in the west by 1912. Winnipeg controlled grain marketing for the entire prairie region, it wholesaled manufactured goods from the Great Lakes to the Rockies, its financial institutions operated throughout Canada and controlled the prairie region. The manufacturing industry was meeting demands for products in the construction industry. The railroad yards and shops were crucial to the operation of the whole western rail network. Winnipeg was at this time the most dominant city of the prairie region.

From its role as the dominant centre for the prairie regions economic affairs, Winnipeg has matured into an economically stable city which is still the largest metropolitan centre in the prairie region. However, much of its early control over the prairie regions economic activities has been spread to the regions other metropolitan cities.

Today Winnipeg is still the major rail centre of the prairies and is still in control of a high portion of Canadian wheat sales and shipments. Winnipeg is also the prairie city with direct U.S. rail connection.

According to T. J. Kuz (1974) employment in metropolitan Winnipeg in 1951 accounted for 51.8% of the total employed labour force in Manitoba; this increased to 56.7% in 1961 and 58.9% in 1971.

In 1971 Winnipeg had an employed labour force of 229,640 people.

Manufacturing is the most important economic activity in Winnipeg by virtue of its contribution through employment, wages and investment. In 1970 there were 957 firms engaged in manufacturing which employed 39,305 people and produced goods valued at 1.03 billion dollars; the total wage payroll was over 234 million dollars.

The mix of manufacturing industry in Winnipeg is typical of a diversified industrial economy. While processing of primary resources continues, expansion has occured into industries which are not dependent upon proximity to a raw material base. Examples of such industries are clothing, transportation equipment and electrical products and industries.

In 1970 Winnipeg's most important manufacturing industries were food and beverage, clothing, printing and publishing, machinery industries and transportation equipment. The food and beverage industry in terms of employment and value of shipments is the most important manufacturing activity in Winnipeg. In 1970 there were 147 establishments engaged in the industry which employed 8,288 people and produced goods valued at 378 million dollars. The industry is directed at both export and domestic markets. Commodities confined to local markets include processed dairy products, bakery goods, soft drinks and brewery products.

Winnipeg supports the third largest clothing industry in Canada. As an employer of people it is second only to the food and beverage industry. In 1970 the clothing industry employed 5,900 people and produced goods valued at over 84 million dollars.

Included within the metal industry category are the machinery, transportation equipment, electrical products, metal fabricating and primary metals industries. As a group these industries have registered the greatest increases in both employment and value of shipments in Winnipeg during the past decade. In 1970, the metal industry employed 12,837 people and produced goods valued at over 259 million dollars.

Among the most important elements of growth in the Winnipeg economy during the past years have been the service industry. In almost all service activities the rate at which employment increased was in excess of the rate at which the city's population increased.

There are many other industries in Winnipeg that provide a great economic impact on the region under study. For example, the financial and government processes provide a large amount of economic activity to Winnipeg. However, the factors discussed have the most economic impact on this study region.

5-16 <u>Regional population factors</u>

The 1971 Census placed the population of Manitoba at 988,247 as of June 1, 1971 (Statistics Canada, 1971). On June 1, 1973, Statistics Canada estimated the provincial population to be 998,000. Between 1941 and 1973, the provincial population grew by 36.8% for an average annual growth of 1.2% (T. J. Kuz, 1974).

The rate of growth was not steady, experiencing sudden and wide fluctuations, during this period. There was an absolute decline in population between 1941 and 1946, and then an increase of about 9.5% from 1951 to 1956 (a rate of about 1.9% per year). Between 1956 and 1961 the province grew by about 8.4% (1.7% per year) and by 4.5% (0.9% per year) between 1961 and 1966.

Natural increase has been the main source of poputation increase in Manitoba since 1941. One of the striking facts about Manitoba's population growth is that there has been virtually no net migration of people into the province during the last 30 years to contribute to the total increase in population; another is that in many years even a significant part of the natural increase has been lost due to out-migration from the province. Another consideration is the great extent to which the growth of Manitoba has been accounted for by Metropolitan Winnipeg. Winnipeg has been consistently growing at a faster rate than Manitoba as a whole. The growth rate of the rest of the province, when Winnipeg is excluded, is negligible, consistently below 1% per year. This is far less than the rate of natural increase, with substantial absolute losses in 1941-1946 and 1966-1969, indicating a continued out-migration from the rest of the province either into the Metropolitan Winnipeg area or out of Manitoba altogether (D. Lofto, 1971).

As can be seen on (Fig.10) and (Table 3) the largest population density in our study region is found within the city of Winnipeg where persons per square mile varies from 100 to 25,000+. As one proceeds toward the periphery of the study area population density decreases owing to the agricultural based employment opportunities. It is interesting to note the relatively high population density (in rural terms) along the course of the Red River (Rig. 10).

Winnipeg had a population of 241 in 1871 and comprised a small cluster of merchants offices-cum-residences in the vicinity of what became the intersection of Portage Avenue and Main Street. Except for the boom of 1881-84, population growth of the city was steady, but unspectacular until the turn of the century. In particular, Winnipeg's suburbs have increased dramatically from a population of 78,000 in 1941 to 310,000 in 1973, while the central core of the city experienced a slow growth to 1961 and thereafter has declined slightly. Slow but steady growth of the city is expected to continue in the future, and it is anticipated that by 1991 the population of Greater Winnipeg will be about 725,000.

The growth experienced by Winnipeg during the past thirty years has not been matched by the province as a whole. The farm population decreased from 249,599 to 131,202 between 1941 and 1971, and this downward trend seems likely to continue for at least a decade or two. In addition, many towns and villages, especially the smaller ones, have declined in recent years. Taken together, these trends have meant that an increasing proportion of the total population of Manitoba lives in

Winnipeg. Thus, in 1881, only 13 per cent of Manitoba's population lived in Winnipeg, but by 1941, 40 per cent, and by 1971, 55 per cent. In one hundred years then, Manitoba has been transformed from a rural into an urban province; a province, moreover, dominated by one large metropolitan area (T. J. Kuz, 1974).

5-2 Specific Site Analysis

I On-School Grounds Site

The on-school grounds site is located at approximately the axis of 97° 09' 30" E longitude and 49° 49' 30" N latitude (Fig. 11).

II Gravel Pit Site

The gravel pit site is located at approximately the axis of 97° 15' 5" E longitude and 49° 57' 0" N latitude (Fig. 11).

III Grassland Site

The grassland site is located at approximately the axis of 97° 09' 30" E longitude and 49° 58' 15" N latitude (Fig. 11)

IV Marsh Site

The marsh site is located at approximately the axis of 96° 58' 30" E longitude and 49° 54' 00" N latitude (Fig. 11).

V Riverbottom Site

The riverbottom site is located at approximately the axis of 97° 07' 00" E longitude and 49° 49' 30" N latitude (Fig. 11).

VI <u>City Site</u>

The city site is located at appoximately the axis of 97° 09' 00" E longitude and 49° 53' 50" N latitude (Fig. 11).

5-21 <u>Physical geology</u>

About 30,000 years ago great changes occurred in the climate of North America. Temperatures dropped and remained low resulting in no seasonal variation in temperature to melt ever falling snow.

As this snow accumulated, the upper layers compressed lower layers first into brittle ice and finally into plastic ice. The plastic ice began to flow, spreading out in all directions to cover Canada and the northern United States as far south as St. Louis, Missouri. This massive sheet of glacial ice was believed to have been 12,000 to 14,000 feet thick.

About 10,000 years ago, temperatues began to increase and the southern face of the ice sheet began to melt. Floods of meltwater poured southward carving out the great valleys of the Ohio, Mississippi and Missouri Rivers. The front of the ice sheet retreated (moved northward) because the ice at this point melted faster than it flowed southward. The retreating ice front exposed a vast, at first lifeless desert strewn with boulders, gravel, sand and clay (glacial drift) that the ice sheet had rasped and ground from the bedrock surface and deposited within itself as it had moved southward.

The ice front slowly retreated northward until it reached a point about 450 miles south of Winnipeg. Again the climate cooled and the ice front stopped its northward retreat. Although the front halted, the plastic ice kept moving south, thrusting up great 'mountains' of ice and glacial drift at the ice sheet's leading edge. As the leading edge of the ice sheet melted, the glacial drift was deposited to form a terminal moraine.

Once again the climate warmed and produced climatic seasons approximating what we have today and as a result the ice front started its final northward retreat. However, the meltwaters which had formerly drained away to the south were now dammed up by the terminal moraine. As a result, the largest body of inland freshwater that ever existed was formed. It was called Glacial Lake Agassiz.

The ice front, forming the northern shore of Glacial Lake Agassiz, retreated steadily to a point near the north end of present day Lake Winnipeg. At this time the lake stretched from a point just south of the present day boundary between North and South Dakota to the north end of Lake Winnipeg, west to Souris and Brandon and east as far as Kirkland Lake, Ontario. During this time the geological formation of the Winnipeg area was developing.

Along the bottom of the lake, the retreating ice had deposited a fairly uniform layer of a special type of glacial drift, called glacial till. Glacial till is boulders, gravel, sand and silt cemented together by clay. Around the shores of the lake, the shale bedrock was being broken down by frost, wind and running water. The resulting mud was washed into the lake where it settled on top of the glacial till. During the summers, coarse mud was washed in and during the winter very fine clays settled out of the water where it had been suspended by wave action. The result was a formation known as varved or layered clays - similar to the annual growth rings of trees, that is spring growth - summer growth, summer varves and winter varves. These varves can be seen in any excavation in Winnipeg, or in some places along the river banks.

The final stage in the geological formation of the Winnipeg area took place when the ice retreated a relatively short distance further north exposing the channel of the Nelson River. Glacial Lake Agassiz drained away into Hudson's Bay, exposing its muddy bottom as a vast, nearly flat plain which is now dotted by Lakes Winnipeg, Manitoba and Winnipegosis, all remnants of the former lake. On the flat surface, rainwaters collected in low spots near the centre of the plain, forming the Red and Assiniboine Rivers and their tributaries.

a) On-School Grounds Site

This site's surface is typical, flat, Agassiz Plain which marks the present surface of the varved, lake clays. Where shallow diggings occur the organic topsoil is exposed, however the true lake clays would only be exposed in deeper excavations.

b) Gravel Pit Site

In general, the limestone bedrock surface lies at a depth of about seventy feet in downtown Winnipeg. From here the bedrock surface, and its covering of glacial till slopes upward to the west until in St. James it lies at depths of fourteen to eighteen feet. The glacial till is exposed in the banks of the Assiniboine River, just upstream from the St. James Bridge.

The gravel pit site represents an upward roll in the surface of the glacial till. It is surrounded on all sides by Agassiz clays.

c) Grassland Site

While no excavations are present on this site it is obvious that the area is underlain by the typical, Glacial Lake Agassiz clays. While moving eastward through the study area, the limestone bedrock and its mantle of glacial till slopes downward to ever-increasing depths.

d) Marsh Site

While no excavations are present on this site it is obvious that the area is again underlain by the typical, varved Agassiz clays.

e) Riverbottom Site

The first time Lake Agassiz drained away, the rivers cut their first channels into the Agassiz clays. Then the return of a cold climate formed ice on and blocked the Nelson River outlet a second time. What is called Lake Agassiz II formed, once again flooding the plain, but only to shallow depths as compared with the assumed depth of Lake Agassiz I of 600 feet. The river channels were filled with silt which has been found to contain a considerable amount of organic material including tree roots and the bones of some dead animals. Then the lake drained away for the last time and the rivers recarved their channels in the river silt. Thus in areas like Kilkenny Park it is possible to find river silts for a certain distance out from the river to a point where the ground changes to typical lake clays (George Russell, Personal Comm. July 1974).

5-22 Hydrology

Water samples for chemical analysis were taken at the gravel pit site and the marsh site. Chemical analysis were carried out by the Environmental Protection Laboratory, Department of Mines, Resources and Environmental Management. The results as shown in Table 4 are indicative of the chemical differences between a lake type water body and a marsh type water body.

5-23 Soils

I Soil profile analysis

a) On-School Grounds Site

The soils of this site consist of the moderately well drained (Solonetzic) to the poorly drained (Osborne) types, developed on fine textured lacustrine and alluvial deposits (Smith, R.E. per.comm. 1974). The topography is level with a slope of less than one percent and this combined with slow to moderate slow permeability of the soils results in wet conditions.

The soils on the on-school grounds site developed on weakly calcareous lacustrine, fine-textured sediments which were deposited in the basin of Lake Agassiz during the ice-age of the Pleistocene Period. The thickness of the lacustrine deposits overlying the glacial till deposits is variable and may range up to 60 feet or more (Smith, R.E., per. comm. 1974). According to Kerr (1949), the sediments under the glacial till are considered to range in age from the Cretaceous to the Precambrian Periods.

In the latter stages of Lake Agassiz, parts of the basin through which the Red River flows probably remained as broad shallow ponds which received alluvial sediments during periods of flooding. This, in part, accounts for the presence of moderately to strongly calcareous sediments occurring as local pockets or as stratified layers in the surficial soil (Michalyna, W., 1963). See cross section of the surface deposits and underlying material (Fig. 12).

R. E. Smith (per. comm. 1974) and Ehrlich et al (1953) describe the area of the on-school grounds site as consisting of soils belonging to the St. Norbert clay (Solonetzic), the Morris (Solonetzic) Black soil and the Osborne clays.

1) Soil Profile Pit #1, Fig. 13

The soil type of this soil profile pit is representative of the St. Norbert Series, a moderately well-drained Solonetzic dark grey soil. This soil is the wooded associate of the Red River association. The native vegetation is dominantly oak, aspen, herbs and grasses.

HORIZON A: The better developed virgin soil of this profile has a brown leaf mat, a dark grey clay Ahe 0-3 inches thick, neutral in reaction. The surface soil is affected by biological processes. No shine effect. Granular to medium granular (not colloidal size). Friable when moist.

HORIZON B: Integrated between horizons A and C, a grey clay AB 3-18 inches thick, slightly acid in reaction. Moderate fine granular, friable when moist, slightly hard when dry. Coarse to very columnar structure (forms angular blocks). Plastic when moist. Bm showing colouration with organic matter.

HORIZON C: Dark brown to dark greyish - massive clay 18-27 inches thick, flecked by Fe staining, saturated with Ca^{++}. Sub-angular fine-granular structure. Weakly calcareous, firm when moist.

2) Soil Profile Pit #2, Fig. 13

The soil type of this soil profile pit is representative of the Morris Series, a moderately drained Solonetzic Gleyed Black Soil This soil is the open area associate of the Red River association. The vegetation of these soils are dominantly herbs and grasses with a bordering aspen and willow stand.

HORIZON A: The surface layer of the virgin soil of this profile has a black-earth sod mat, 2-3 inches thick. Biological processes are not noticeable. Structure is granular with a progression into a columnar B horizon.

HORIZON B: 3-12 inches thick. (Similar to that of horizon B of Pit #1).

HORIZON C: 12-24 inches thick. Much lighter grey colour than the "B" horizon, flecked with Fe staining with a weak prismatic to massive macrostructure to moderate fine sub-angular blocky microstructure. Fine textured. Firm when moist, hard when dry. Developed on weakly calcareous lacustrine clay.

3) Soil Profile Pit #3, Fig. 13

The soil type of this soil profile pit is representative of the Osborne Series, a poorly drained Rego Humic Gleysol soil. This soil is a meadow-willow associate of the Red River association. A depression in relief characterizes this area.

HORIZON A: The surface consists of a very thin (½ inch) peaty covering forming an organic layer. Below the organic layer is a very dark grey clay 0-6 inches (Ahg 6-8 inches) thick. Slightly acid to neutral in reaction (alkaline). No biological processes due to H_2O saturation. Granular (massive to weak fine granular), friable when moist (mucky), plastic when wet, hard when dry. Grades through a smooth boundary into the C horizon, with tonguing (0-12").

HORIZON B: Absent.

HORIZON C: 8^+ inches, grey, massive, plastic when wet, firm when moist, hard when dry. Granular. Weakly calcareous, fine mottles masked by grey clay.

b) Gravel Pit Site

The soils of the Gravel Pit site have developed on weakly calcareous clay loam to clay underlain by moderately calcareous sediments. The profile pits indicate that it is clay overlying sorted till. R. E. Smith (pers. comm. 1974) suggests that the presence of boulders in the adjacent fields keynote a thin layer of clay over till.

1) Soil Profile Pit #1, Fig. 14

The soil type of this Soil Profile pit is representative of the Myrtle Series, a moderately well-drained Orthic Black Clay soil. This soil is the open grassland associate of the Red River association. The native vegetation is dominantly herbs and grasses. (The soils of this area probably developed under tall grass prairie vegetation).

HORIZON A: The soil of this profile is characterized by a black overburdened Ap 0-3" surface horizon; and a granular (not columnar) well-structured Ah 3" - 8". The Ah layer is tongued with icicle-like intrustions into a greyish-brown clay. The black tongued intrusions are the result of cracking and shrinkage due to aperiodic dry seasons.

HORIZON B: Forms a brown (reddish colour owing to Fe bearing compounds)

Bm 4" - 6" in pockets. This layer of soil is coloured from melonization (darkening). A BC layer is present between the 6" - 8" level.

HORIZON C: Forms an olive-green, massive clay layer of 3, to 5 feet in depth. Granular.

2) Soil Profile Pit #2, Fig. 14

In this soil profile there are no characteristic soil horizons. The surface soil has been disturbed by tracked vehicles. There is now only slight development of an organic layer approximately 2-3 mm. in thickness. Below this thin layer is a 60% Ca CO_3 content clay layer IC about 12 inches in depth. Beneath the clay is what appears to be the former surface soil IIC (lithologic change) heavily over-burdened with Fe compounds giving a mottling effect.

c) Grassland Site

The soils of this site are developed on weakly calcareous clay underlain by moderately calcareous sediments.

1) Soil Profile Pit #1, Fig. 15

The soil type of this soil profile pit is representative of the Dencross Series, a moderately drained Gleyed Rego Black soil.

HORIZON A: The soil is characterized by a very dark grey Ah horizon 0-12" (varies between 7" - 12" thick) with weak fine granular structure. An Ac horizon 2-6 inches thick is also characteristic of this soil series.

HORIZON B: Absent

HORIZON C: A light brownish grey stratified silty clay loam to silty clay C horizon. Surface textures range from fine sandy loam to clay but clay is the dominant soil type. Where the coarser textured mantle is from 12" - 18" thick, a weak prismatic B horizon is characteristic. These coarser deposits were likely formed by wave action as they tend to occur in strips paralleling the topographical contour lines.

2) Soil Profile Pit #2, Fig. 15

The soil type of this soil profile is representative of the Osborne Series (Glenmore), a poorly drained Rego Humic Gleyed Soil. This soil is the Meadow type soil associate of the Red River association. The vegetation is dominantly grass and willow. These soils occur in a depressional area and as a result have a low permeability.

HORIZON A: The profile is characterized with a thin surface organic matter accumulation (moss) and a very dark grey clay Ah kg. Another thin layer Ack bands around a tonguing IC clay layer.

HORIZON B: Absent

HORIZON C: A IC clay layer situated just below the A horizon tongues down to a depth of about 12". The IIC_1K light grey layer is situated between the tonguing IC clay and a IIC_2 yellow brown layer that has a high Ca CO_3 content.

d) Marsh Site

1) Soil Profile Pit #1, Fig. 16

The soil type of this soil profile pit is representative of the Morris Series, a Gleyed Solonetzic Black soil.

HORIZON A: This profile is characterized by a granular remolded sod mat of one to two inches that has been extensively aerated by earthworms. The A horizon tongues into the C horizon.

HORIZON B: Below the sod mat is a Bnjgj layer, 6" - 8" deep, it is a dark soil containing a high percentage of organic matter. The B horizon tongues into the C horizon.

HORIZON C: The C horizon starts at a depth of about 10" and is characterized by its lime to almost lime green coloured clay layer. This layer produces strong effervescence when hydrochloric acid is applied, indicating a high $CaCo_3$ accumulation in the soil.

e) Riverbottom Site

Soil Profile Pit #1, Fig. 17

The soil type of this soil profile is representative of the Gleyed Cumulic Regasol Series. These soils are from very dark grey to dark brownish grey and have been formed as part of a flood plain relic built up by vertical accretions.

HORIZON A: This soil profile has a thin leaf mat covering a granular Ahjgj layer which is 8" - 10" deep. The Ahjgj is a very dark grey to dark brownish grey colour.

HORIZON B: There is no characteristic B horizon in this soil profile, but there is a strata consisting of a relic A layer, it is referred to as Ab.

HORIZON C: The C horizon varies from a dark brownish grey to light brownish grey colour. The occurrence of clay layers between the relic Ab layers is referred to as C1, C2, and C3. Evidence of free lime content is indicated by the effervescence of hydrochloric acid at about the 2.5 foot level.

II Soil chemical analysis

a) Introduction

Soil samples were taken at the five study sites in late July and were analyzed by the Provincial Soil Testing Laboratory at the University of Manitoba. The soils were analyzed for nitrate nitrogen, available phosphorus, available potassium, percent organic matter, pH and conductivity.

1) Nitrate Nitrogen

In agricultural soils the nitrate nitrogen content may range from 0-15 ppm. A content of 15 ppm NO_3 -N is considered high. Usually soils that are left uncropped develop a high nitrogen content, due to the production of nitrogen by the root system of leguminous plants. Nitrogen is water soluble and may move up or down with movement of the water table.

2) Available Phosphorus

The range of phosphorus usually varies from 1 ppm. to 15 ppm. A phosphorus content greater than 18 is considered high. Phosphorus is always higher at the surface for two reasons - 1) accumulation of phosphorus from fertilizer, and 2) accumulation from plants (phosphorus is immobile).

3) Available Potassium

Potassium ranges in the following way:

Sandy Soil	50-100 ppm.
Loam Soil	150-300 ppm.
Clay Loam Soil	300-400 ppm.
Clay Soil	400-800 ppm.

Potassium also is always higher at the surface.

4) Percent Organic Matter

Organic matter is always higher at the surface.

In sandy soil 1-3%

Other 2.5 - 6 or 7 up to 10.

b) On-School Grounds Site

1) Nitrate Nitrogen

Soil sample No. 1 was taken in an oak and aspen bluff. The leaf litter is about 15 mm. in depth and a characteristic L-F-H layer is discernible. The 0-6 inch sample contains a NO_3-N content of 5.4 (Table 5). This is higher relative to all the other samples in this area, however, according to Dr. Racz, Department of Soil Science, University of Manitoba (pers. comm. 1974) the differences are minute. However, Dr. Stewart, Department of Botany, University of Manitoba (pers. comm.) stated that the high NO_3-N content may be largely owing to the accumulation and degration of a heavy leaf litter from the oak. The results obtained for organic matter also apply here. For the remainder of the samples (2-5) the values obtained are typical of areas affected by a river system.

2) Phosphorus and Potassium

Phosphorus and potassium both follow the characteristic of being higher at the surface (except for No. 1) than at the 6-24" depth. (Table 5). In sample No. 1 the phosphorus content is high at the 0-6" and 6-24" depths. Sample No. 2 is typical of a grass type plant community and sample No. 5 is typical of a farmland situation. It is possible that the nutrients are returning to the surface from fertilization of crop fields, as 1948 aerial photographs indicate that the area in which soil sample No. 5 was taken, was in agricultural production. However, it is difficult to speculate what may precisely be the factor as phosphorus is known to be immobile. The high 0-6" values are probably due to phosphorus being washed down from the surface leaf mat. The potassium values are typical to the Red River Valley area, however, the 6-24" depth values may be caused by a banding process in the soil in this area.

3) Organic Matter

All the samples characteristically contain a higher amount of organic matter at the surface than at the 6-24" depths. (Table 5). Samples No. 1, 2 and 4 contain high percentages of organic matter in the 0-6" depth. These results are probably due to a heavy leaf mat accumulation at the surface. Samples 3 and 5 were taken where the leaf mat is absent, typically these samples show low organic matter content.

4) pH

In all five sample locations the pH is greater at the 6-24" depth as compared to the 0-6" depth. (Table 5). These are expected values and trends.

5) Conductivity

The salt content conductivity of the on-school grounds site is low at all five sample locations, therefore, the soils of this site are not considered saline (Table 5).

c) Gravel Pit Site

1) Nitrate Nitrogen

Soil sample No. 1 contains a higher than normal nitrogen content (Table 6). This high nitrogen level may be attributed to the dense growth of alfalfa, sweet clover and weeds as they release nitrogen through normal growth and decomposition. The terrain is elevated at sample location No. 1 and the water table may not be high enough to carry away accumulated nitrogen.

Soil sample No. 2, shows a more normal nitrogen level. This difference may be attributable to the fact that the water table at the location is high and may therefore move the nitrogen down into the soil profile with fluctuations in the water table.

2) Phosphorus

Characteristically higher at the 0-6" than at the 6-24" depths (Table 6). Sample No. 1 contains a high amount of phosphorus when compared to agricultural soils.

3) Potassium

The results obtained for potassium at both sample locations are typical of clay type soils (Table 6) (i.e., 700 ppm is not unusual for these soils).

4) Organic Matter

The percent of organic matter is characteristically higher at the surface than at the 6-24" depth (Table 6).

5) pH

The pH values are characteristically higher at the 6-24" as compared to the 0-6" depths (Table 6).

6) Conductivity

Not saline.

d) Grassland Site

1) Nitrate Nitrogen

Soil sample Nos. 1 and 2 are lower in nitrogen content at the 0-6" depth than at the 6-24" depth (Table 7). These two locations have little accumulation of leaf material and the water table probably fluctuates drastically. Sample No. 3 was taken in an aspen-willow bluff. There is a heavy accumulation of leaf material at this location and nitrogen levels are higher than at sample locations 1 and 2 where there is little leaf material accumulation. Thus the results indicate that a heavy accumulation of leaf material results in higher nitrogen levels.

2) Phosphorus

At all three sample locations the phosphorus content is characteristically higher at the 0-6" than at the 6-24" depths (Table 7). However, the phosphorus values are expected to be high on a grassland site.

3) Potassium

The potassium content is higher in the 0-6" samples than in the 6-24" samples at all three sample locations (Table 7). As with phosphorus, the expected potassium values for a grassland soil type are higher than was analyzed at this site.

4) Organic Matter

Organic matter is characteristically higher at the 0-6" than at the 6-24" depths (Table 7). The aspen-willow bluff of this site, as in the oak-aspen bluff of the Fort Richmond Site typically indicates that the accumulation of organic material results in an accumulation of nitrogen.

5) pH

As at the Fort Richmond Site the pH values are lower at the 0-6" than at the 6-24" depths (Table 7).

6) Conductivity

The salt content is low in all sample locations on this site, therefore these soils are non-saline (Table 7). As the salt content in sample 2 is somewhat high (0.9) this may indicate a tendency toward salinity, however, this is not high enough to impede vegetation growth.

e) Marsh Site

1) Nitrate Nitrogen

The nitrate content of the samples taken from these soils are extremely low (Table 8). It is difficult to determine the reasons for the low nitrate accumulations as more detailed analysis would be required. The water table at this site can be expected to fluctuate often, which may effect nitrogen content.

2) Phosphorus

The phosphorus content in the soil at this site is much lower than the normal range for soils of this type.

3) Potassium

Potassium values follow the expected trend, being higher at the surface than at the 6-24" depth (Table 8).

4) Organic Matter

Sample locations No. 2 and 3 which are both located in densely wooded areas, show a higher content of organic matter at the 0-6" than at the 6-24" depths (Table 8).

5) pH

Sample location No. 1 is alkaline (pH = 8.0). Soil analysis for free lime content also shows extremely strong effervescence (Table 8).

Sample Nos. 2 and 3 follow the trend of being higher at the 6-24" than at the 0-6" depths. The soils of sample location Nos. 2 and 3 are of the Osborne Series, whereas that of sample location 1 is of the Morris Series.

6) Conductivity

No saline (Table 8).

f) Riverbottom Site

1) Nitrate Nitrogen

All three sample locations were taken from a forested area (dominantly oak and elm). The results are higher at the 0-6" depths than at the 6-24" depths. This is an indication that the leaf litter results in NO_3 -N build up (Table 9).

2) Phosphorus

The results for phosphorus are characteristically higher at the surface than 6-24" depth (Table 9). At all three sample locations the phosphorus content is high at the surface when compared to agricultural soils.

3) Potassium

Potassium results are characteristically higher at the surface than at the 6-24" depth (Table 9). These values are normal (e.g., 300-400) for the Red River Valley soils.

4) Organic Matter

In sample No. 1 the percentage of organic matter at the surface is less than the percentage at the 6-24" depth (Table 9). This result is normal as the land on the edge of the forest has been disturbed by plowing, which turns the leaf litter underneath and brings up the lower less organically rich soil. Sample Nos. 2 and 3 are characteristic of a vegetated plant community. Sample No. 3 which was taken near the river is high in organic matter. This is not unreasonable, as every spring and after rain a certain amount of the leaf litter is washed down from the upper river bank area.

5) pH

Values are characteristic of those along the Red River where the soils are slightly alkaline (Table 9).

6) Conductivity

Not saline Table 9).

5-24 Topography

Methods - Relative positions were taken from aerial photographs from direct observation and measurement. Elevation was determined by the use of a transit and surveyor's stick. A survey complete enough to justify the use of isolines was not done on any of the sites, but the major relief features were measured. The point of lowest elevation on the site was assigned a value of zero feet and all other measurements are relative to that point. The major features of each site are outlined along with their elevation in feet. The relative elevations can be obtained over the entire site if the transit lines intersect.

a) On-School Grounds Site

Major Features

1) Dalhousie School and immediate vicintiy - Fig. 18.

The Dalhousie Elementary School (1) is located on the north east corner of the study site. The building is surrounded by an area which is elevated artificially to a height of about 3½ feet (relative to the lowest measurement encountered on the site, which was assigned an elevation of 0 feet). This artificial elevation extends east to Dalhousie Drive, south approximately 10 yards, west and south west approximately 15 yards to a parking lot and driveway which extends west into the treed portion of the site. This driveway forms a loop (2) approximately 25 yards in diameter to serve as a turnaround for vehicular traffic. This loop is one of the more obvious features apparent on aerial photographs.

2) To the south of the school is a wooded area (3) approximately 100 yards (N-S) and approximately 65 yards (E-W). It is bordered on the east by Dalhousie Drive and on the south by Killarney Avenue.

This area is traversed by several footpaths and in the SE corner there is a winter skating pond (4) approximately 12 x 12 yards. This area has an elevation of between one and two feet.

3) Pond (5)

Approximately 65 yards west of Dalhousie Drive and 45 yards north of Killarney Avenue there is a man-made pond approximately 35 yards long (N-S) and 20 yards wide (E-W). About 3 yards from the east shore there is a small island (approximately 8 yards in diameter). The pond contains water until about mid-July.

4) Tennis Court (6) and playground.

Approximately 15 yards north of Killarney Avenue and 90 yards west of Dalhousie Drive there is a flat asphalt surface, a tennis court which is 18 yards N.S. by approximately 30 yards E.W. at an elevation of approximately 3 feet. Just north of the tennis court (5 yards) is a band of shrubbery (7) approximately 4 yards wide and 16 yards long (E-W). The centre of this area is at an elevation of approximately 10 inches which is probably close to the natural elevation of this part of the site. North of this shrubbery is a walkway and then approximately 90 yards of playground (8) which slopes gently from 2'4" to 10". From the man-made pond the playfield extends westward several hundred yards with a rectangular built-up area (9) as the major topographical feature. The east side is approximately 110 yards west of the pond. The area is approximately 60 yards (E-W) by 85 yards (N-S) and has a maximum elevation of approximately 4 feet, making it the highest area on the site.

5) Playground and Acadia School.

West of the tennis courts is an area of trees and shrubs and a small open area (10) equipped with playground equipment. West of the wooded area and approximately 140 yards from the tennis courts is the Acadia Junior High School (11). As this corner of the site is not included in any of the resource studies, the relief aspects have not been included.

6) Wooded Area

West of the Dalhousie School and north of the playfield is the remainder of the site. This is generally a wooded area which approximates a rectangle 370 yards long (E-W) and 160-170 yards wide (N-S). The area is penetrated by a number of footpaths and contains 2 small clearings (12) and the previously mentioned traffic loop. Due to the difficulty of finding a clear line of sight through the wooded area the relief data are minimal.

Transit lines I, II and III, Fig. 18 did penetrate the woods and the data tabulated, Fig. 19, suggested the following general description of the area. The lowest area on the site occurs SSW of the traffic loop. The lowest measurements were obtained 180 - 200 yards north of the tennis courts and 80-90 yards west of the Dalhousie School as shown by transit I and II, Fig. 19. The validity of the measurements is borne out by the fact that this area was wet in mid-July. To the SSW of these measurements, approximately 200 yards west of Dalhousie Drive and 175 yards north of Killarney Avenue, on the border between the playfield and the woods is an area which is probably a few inches lower. This was indicated by standing water (13) to a depth of 8 to 10 inches in Mid-July.

This low lying area (14) extends from that point NNE to the edge of the site where run-off is collected in a man-made ditch (15). This low lying trough was probably once part of a drainage system which was blocked when the area was developed. This hypothesis is supported by the abundance of dead and dying trees, especially aspen, in the west area. If we assume that these trees died as a result of excess water it follows that in the past there was better drainage which allowed these trees to germinate and grow.

From this low lying area the wooded terrain rises gradually to the west and borders the Dalhousie School and its artificial elevation on the east.

At the IV transect, approximately 330 yards west of Dalhousie Drive and extending 90 yards north from the southern edge of the woods, the relief drops slightly and gradually (south to north) from 1'11" to 1'1". The remainder of the wooded area (17) is generally flat, sloping gradually to the north and east.

The northern border of the site is approximately 330 yards from Killarney Avenue and consists of a ditch (15) 3-4 yards wide and 2-3 feet deep which until mid-July contained water. Immediately to the north of this ditch is a man-made ridge (16), apparently the precursor of a future street.

b) Gravel Pit Site

Major Features

The major features of the Gravel Pit site (Fig. 20) are man-made water bodies and clay "hills" which are the result of excavation in search of gravel at some time in the past. Clay and till from the pits was piled on the perimeters of the pits. The pits probably penetrated the water table in the area and have subsequently filled with water.

1) The largest water body (I) is 165 yards west of the gravel road (II) and 340 yards north of Highway 221. This man made water body is approximately 465 yards long (E-W) and about 65 yards (N-S) at its widest point. It is much narrower (15 yards) at the east end where the water body terminates in an L-shaped "bay". Water depth was measured at approximately 25 yard intervals on an imaginary line bisecting the water body into northern and southern portions. Water depth varied from 3 Ft. at the east end to a maximum of 21 ft. as shown in Fig. 20. The water body bottom slopes quite sharply; if depth is plotted against the width for each depth measurement and assuming a constant slope at each measurement location, the average slope of the lake bottom is 0.12 feet drop per 1 ft. width.

2) The next largest water body (III) is located 30-35 yards north of (I). Its eastern extremity is 200 yards west of the gravel raod (2), and its south shore is 360-370 yards from highway 221. This water body is roughly oblong in shape with a length of 170-175 yards, and a maximum width of approximately 50 yards. At the east end of the water body is a small semi-detached marsh or pond (IV) which is not included in the measurements but is worthy of mention.

The depth measurements in this water body were taken along the EW centre line at approximately 20 yard intervals and the results are shown on Fig. 20. The average slope of the bottom is calculated to be 0.185 ft. drop per 1 ft. width.

3) Most of the periphery of these two large water bodies consist of the clay hills which were mentioned previously. The highest peak (V) of these hills is 20'2" above the surrounding flat terrain and approximately 23 ft. above the water level in lake (I). The height of all of the peaks (relative to the flat area (VI) south of the peak (V)) are shown on Fig. 20. The tops and slopes of the chain of hills - south of the water body (I) are criss-crossed with trails made by dirt bikes. These trails are bare of vegetation and show up on aerial photographs as white or light lines and patches.

4) There are 3 smaller water bodies on the site which are best defined as ponds. The first of these (VI) is located with its eastern extremity about 200 yards west of gravel road (II) and 175-180 yards north of Highway 221. This pond is approximately in the shape of a right triangle with sides of 50 yards (facing west) and 87 yards and hypotenuse (facing south) of 100 yards. The water depth was not measured but the abundance of vegetation suggests that it is fairly shallow, with a minimum of perhaps 6-7 feet. Just east of this pond is a small low-lying area (VIII) with sandy soil supporting a stand of willow brush. The second pond (IX) is smaller in size with an EW diameter of 38 yards and a NS diameter of 25 yards. The eastern extremity is 105 yards west of the road and 310 yards north of Highway 221. Water depth was not measured but lack of vegetation in the centre of the pond suggests that is is relatively deep; a reasonable estimate might be 10-12 feet. Immediately

to the north west of the pond is a low pile of gravel (X) which rises approximately 3 feet above the surrounding terrain. This also shows white on aerial photographs.

The final pond (XI) has a shape which approximates a right triangle with sides of 75 yards (facing south) and 30 yards (abutting the ditch alongside the road) and a hypotenuse of 80 yards. The south edge of the pond is about 315 yards north of Highway 221 and the east edge is about 12 yards from the road. This pond is almost entirely covered with floating vegetation and the shores are lined with dense willow growth. The depth was measured at the small, vegetation free area near the east-end and was approximately 7 feet which is probably the maximum for the pond.

5) The remainder of the site is generally flat and featureless. The actual non-agricultural area extends in an irregular fashion from road (II) some 665 yards west and has a maximum width (N-S) of 325 yards. The area is traversed by several dirt-like trails and is surrounded by flat agricultural land on three sides, the fourth side being bordered by road (II).

c) Grassland Site

Major Features

The grassland site is by far the most topographically featureless of the sites studied. It has no sudden changes in elevation although measurements show a range of 32 inches. The relief was measured with a transit along four lines as depicted on Fig. 21. The results are shown in the form of line graphs (Fig. 22).

d) Marsh Site

Major Features

The marsh site (Fig. 23) is a large shallow man-made pit in what is otherwise fairly even terrain. To the north of the marsh is a road (I) and ditch (II) and to the south is agricultural land (III). To the west of the marsh is an area (IV) covered with trash and rubble and to the northwest of that is a low-lying wooded area (V) where poplars are dying and willows are flourishing. This area, (V) was probably part of a drainage system which was blocked. To the east of the marsh is another area of rubble and rough ground indicating that the topsoil was removed some years ago, probably when the pit (the present marsh) was dug. Much of the shoreline of the marsh is also strewn with garbage and rubble.

Transit readings were taken along two perpendicular lines of sight and the results are shown on Fig. 24. These results indicate a general rise in elevation from east to west. Using the measurement at (V) as zero for the site, the relief measured on line I varies from 7 inches near the east end to 52 inches near the west end; over a span of some 300 yards. The water level in the marsh was four inches, which is higher than the ground surface at (V) where there was no standing water.

As is suggested by Transect II, Fig. 24, the topography in area (IV) is extremely hilly. This is due to truckloads of backfill and rubble which was dumped in this area some years ago. The highest of these hills is 44 inches above area (V) and the relief varies from 0 to 22 inches in a 10 yard span on the transit line.

Several depth readings were taken and are shown on Fig. 23. The depth of the marsh averages 6-8 feet and has a maximum of 12 feet. The west end is generally the more shallow end and has an area (VI) shallow enough for emergent vegetation to grow.

e) Riverbottom Site

Major Features

The riverbottom site (Fig. 25) is located on a point of land bordered on three sides by a meander of the Red River (I). This peninsula is 270-300 yards across (NE-SW) and 750 yards long (NW-SE).

Our studies were confined mainly to the wooded riverbank, (II) (from the tip of the peninsula northward along the west side for a distance of about 500 yards), to the adjacent agricultural land (III) and to the grassed clearing (IV) near the tip of the peninsula. Relief was studies along two transects; the first from the top of the riverbank (point B) down the bank to the water (point A) and the other from point "B" to the water at the tip of the peninsula, point "C". The results of transect I, on transect A B, are shown in graphical form in Fig. 26. The elevations were measured at 5 yard intervals, the results were plotted relative to the elevation at point "A", which was the water level of the Red River at the time. Point A was assigned the value zero. As can be seen from Fig. 26, the riverbank reaches a maximum height of about 21½ feet (258 inches) above the water level. The steepest slope occurs immediately next to the water's edges where there is an almost vertical earth face which rises about 6 feet and is apparently the result of water erosion at times of high water. Since water level does vary it might be more accurate to describe the relief of the area relative to something more permanent and constant such as the bottom of the river or the top of the eroded vertical bank (V) but the same purpose can be achieved by stating that the point to which we assigned the elevation of zero is a point 76 inches below the elevation of (V) at point "A". The maximum riverbank elevation is then about 15½ feet (above V) at point "A") and this rise occurs over a distance of 55-60 yards which indicates an average slope of about 0.26 feet per yard. The entire riverbank, from the highest point almost to the water's edge is heavily wooded except for a cleared pathway from point "B" to point "A" along which the elevation measurements were taken.

The second transect line was taken in a relatively straight line from point "B", the top of the riverbank at transect I, to point "C" the water's edge at the tip of the peninsula. From point "C" the line first encounters a band of dense undergrowth next to the water, then a band of hardwood trees, breaking into an unwooded area approximately 32 yards from the water. This is the clearing (IV) mentioned earlier which has an irregular shape with maximum dimensions of 145 yards (NS) and 104 yards (EW). Its surface is grassy and the area contains a number of shrubs. The line then extends across recent agriculturally utilized land for about 215 yards to point "B". The result of this transect line is shown in Fig. 26, from which it can be seen that the high point on the site occurs about 230 yards from the water's edge and is a ridge extending across the narrow field.

It can also be seen that there is a dip about 130 yards from the water which is probably the bed of a meltstream. The high point is 316 inches and the meltstream dips to 230 inches above water level. It might also be noted that the water level at point "C" was measured to be four inches below the water level at point "A".

Other features of the site include a large wooded area (VI) and more agricultural land (VII).

The wooded area (VI) is north of the clearing (IV) and extends westward from the river a distance of about 165 yards. The agricultural land takes up most of the remainder of the site except for a band of trees (VIII) which border a small creek about 500 yards north of the peninsula's tip. This band of trees averages 40 yards in width and extends some 200 yards inland from the east shore of the peninsula.

5-25 Ecological parameters

5-251 Flora

Determination of flora composition of the various specific sites was carried out by running transects across each site and identifying the flora within a three foot span on each side of the transects. Transects were chosen so as to include the major flora species found on the site.

a) On-School Grounds Site

N- Native Species D-Disturbed Species (70 species in total)

	Scientific Name	Common Name
	Astragalus goniatus	(Vetch, purple milk)
	Lathyrus venosus var.	
	in tonsus	(Vetching, Wild Pea)
	Trifolium pratense	(Clover Red)
	Trifolium repens	(Clover White)
	Trifolium hybridum	(Clover Alsike)
	Melilotus alba	(Clover Sweet) & occidentalis (yellow)
	Vicia americana	(Vetch)
	Plantago major	(Plantain)
	Thalictrum venulosum	(Meadow Rue)
N.	Zizia aptera	
	Artemissia bieniss	(Wormwood)
	Aralia nudicaulis	(Wild Sarsaparilia)
	Galium septentrionale	(Bedstraw)
	Cirsium arvense	(Canada Thistle)
	Taraxacum officinalis	(Dandelion)
	Cypripedium pubescens	(Ladyslipper Yellow)
	Carex sp.	
	Carex tenera	
	Carex aurea	(Sedge)
	Poa pratensis	(Kentucky Blue Grass)

Scientific Name		Common Name
	Sonchus arvensis	(Sow Thistle)
	Petasites sagittatus	(Sweet Colts Foot)
	Dracocephalum parviflorum	(False dragon head)
	Sisyrinchium montanum	(Blue-eyed Grass)
	Achillea millefolium	(Yarrow)
N.	Juncus balticus var. littoralis	(Rush)
	Eleocharis palustris	(Spike Rush)
	Veronica scutellata	(Speedwell)
	Comandra richardsiana	(Bastard - Toadflax)
N.	Maianthem canadense var. interius	(Lily of the Valley)
	Sanicula marilandica	(Sanicle. Black Snakeroot)
	Ranunculus macounii	(Crowfoot. Buttercup)
	Ranunculus cymbalaria	(Crowfoot. Buttercup)
	Sium sauve	(Water Parsnip)
	Rudbekia	(Black-eyed Susan)
	Beckmannia syzigachne	(Slough-Grass)
	Pyrole sp.	(Wintergreen)
	Potenilla norvegica	(Cinquefoil. Five-finger)
	Alisma triviale	(Water plantain)
N.	Rhus radicans L. var. rydbergii	(Sumac. Poison Ivy)

Scientific Name	Common Name
Polegonium amphabium	(Knotweed. Smartweed)
Rumex	(Dock Sorrel)
Smilacina stellata	(False Solomon's Seal)
Viola adunca	(Violet)
C. leucanthemum	(Daisy)
R. acicularis	(Wild Rose)
Bromus inermis	(Brome Grass)
Koeleria cristata	(June Grass)
D. Achillea millifolium	(Yarrow)
Xanthium strumarium	(Cocklebur)
Aster pansus	(Many-flowered Aster)
Aster Laevis	(Smooth Aster)
Helenium autumnale	(Sneezeweed)
Fragaria virginiana	(Strawberry)
Ribes americanum	(Black currant)
Crataegus	(Hawthorn or Plum)
Equisetum arvense	(Field Horsetail)
Anemone canadensis	(Anemone)
Agropyron repens	(Couch-Grass)
Cardamine pensylvanica	(Bitter Cress)
Salix bebbiana	(Willow)
Viburnum lentago	(Sheepberry, Nannyberry)
Prunus pensylvanica	(Pincherry)

Scientific Name	Common Name
Viburnum rafinesquianum	(Downy Arrow-wood)
Prunus virginiana	(Chokecherry)
Cornus stolonifera	(Red Osier Dogwood)
Conolvulus sepium	(Morning Glory)
Corylus rostrata	(Hazel)
Populus tremuloides	(Trembling Aspen)
Populus balsamifera L.	(Balsam Poplar)
Quercus macrocarpa	(Bur Oak)
Quercus bicolor	(White Swamp Oak)
Spiraea alba	(Meadow Sweet)
Circium flodmanii	(Thistle)
Viburnum lentago	(Nannyberry)
N. Oryzopsis sp.	(Mountain-Rice)
Biddens frondosa	(Beggar Ticks)
Epilobium angustifolium	(Fireweed)

b) Gravel Pit Site

N - Native D-Disturbed (52 Species in total)

Scientific Name	Common Name
Bromus inermis	(Brome Grass)
Poa pratensis	(Kentucky Blue-Grass)

	Scientific Name	Common Name
	Poa palustris	(Fowl-Meadow Grass)
	Melilotus alba	(White Clover)
	Melilotus officinalis	(Yellow Clover)
	Cirsium arvense	(Canada Thistle)
	Sonchus arvensis	(Sow Thistle)
	Rumex crispus	(Dock Sorrel)
	Solidago sp.	(Goldenrod)
	Salix interior	(Sandbar Willow)
	Plantago major	(Plantain)
	Taraxacum officinalis	(Dandelion)
	Ambrosia Trifada	(Ragweed)
N	Polygonum coccineum	(Knotweed. Smartweed)
D	Polygonum convolvulus	
N	Polygonus achoreum	
D	Polygonum aviculare L.	
N	Cornus stolinifera	(Dogwood)
	Hordeum jubatum	(Barley)
	Mentha arvensis	(Mint)
	Stachys palustris	(Hedge-Nettle)
	Typha latifolia	(Cat-tail)
	Lathyrus palustris	(Vetchling. Wild Pea)
	Agropyron trachycaulum	(Wheat Grass)
D	Agropyron repens	(Couch Grass)

	Scientific Name	Common Name
	Lysimachia ciliatum	(Loosestrife)
	Asclepias ovalifola	(Milkweed)
	Medicago lupulina	(Medick)
	Tragopogon dubuis	(Goat's Beard)
	Aster laevis	(Aster)
	Aster pansus	
	Scirpus validus	(Bulrush)
	Artemisia sp.	(Sage)
	Ranunculus macounii	(Buttercup)
	Populus tremuloides	(Trembling Aspen)
	Urtica dioica	(Nettle)
	Astragalus canadensis	(Vetch)
N	*Convolvulus sepium*	(Bindweed or Morning Glory)
	Acer negundo L.	(Man.Maple or Ash-Leaf Maple)
N	*Potentilla norvegica*	(Five finger)
N	*Grindelia squarrosa*	(Sticky Gum Cup)
	Equisetum	(Horsetail. Scouring Rush)
D	*Artemisia absinthium L.*	(Wormwood. Absinthe)
N	*Potamogeton richardsonii*	(Pondweed)
	Lemna	(Duckweed)
N	*Elaeagnus commutata*	(Silverberry or Wolfwillowy)
N	*Crataegus sp.*	(Hawthorn)
N	*Symphoricarpos occidentalis*	(Wolfberry)

	Scientific Name	Common Name
N	Anemone canadensis	(Anemone)
D	Pastinaca sativa L.	(Parsnip)
D	Phleum pratense	(Timothy)
	Potomogetan Pectinatus	(Pondweed)
	Potomogetan richardsonii	(Richardsons Pondweed)

c) Grassland Site

N - Native D-Disturbed (91 Species in total)

	Scientific Name	Common Name
	Cirsium arvense	(Canada Thistle)
	Sonchus arvensis	(Sow Thistle)
	Poa pratensis	(Kentucky Blue Grass)
	Astragalus goniatus	(Vetch, Purple Milk)
	Grindelia squarrosa	(Sticky Gum Cup)
N	Potentilla anserina	(Silver Weed)
N	Aster pansus	(Aster)
N	Symphoricarpos occidentalis	(Wolfberry)
D	Agropyron repens	(Couch-Grass)
D	Melilotus alba	(Sweet Clover - White)
D	Melilotus officinalis	(Sweet Clover - Yellow)
N	Petalostemum purpureum	(Purple Prairie Clover)

	Scientific Name	Common Name
	Bromus inermis	(Brome Grass)
	Achillea millefolium	(Yarrow)
	Rumex crispis	(Dock Sorrel)
	Plantago major	(Water Plantain)
	Solidago	(Goldenrod)
N	Hordeum jubatum	(Squirrel-tail Grass)
N	Mentha arvensis	(Mint)
	Ranunculus macounii	(Buttercup)
N	Equisetum arvense	(Field Horsetail)
N	Poa palustris	(Fowl - Meadow Grass)
N	Eleocharis palustris	(Spike - Rush)
N	Calamagrostis neglecta	(Reed-Bent Grass)
	Triglochin maritima	(Arrow Grass)
	Juncus balticus	(Rush)
N	Zizia aptera	(Fern)
N	Salix petiolaris	(Willow)
N	Artemisia biennis	(Wormwood)
N	Spiraea alba	(Meadow Sweet)
N	Stachys palustris	(Hedge Nettle)
	Hierochloe odorata	(Sweet Grass)
D	Medicago lupulina	(Black Medick)
D	Medicago sativa	(Alfalfa)
N	Lysimachia ciliata	(Loosē strife)

	Scientific Name	Common Name
N	Anemone canadensis	(Anemone)
N	Sisyrinchium montanum	(Blue-eyed Grass)
N	Lobelia spicata	(Lobelia)
	Carex	(Sedge)
N	Ranunculus cymbalaria	(Buttercup)
N	Solidago rigida	(Goldenrod)
	Asclepias verticillata	(Milkweed)
N	Populus tremuloides	(Trembling Aspen)
N	Erigeron	(Fleabane)
N	Galium septentrionale	(Northern Bedstraw)
	Potentilla pensylvanica var. bipinnatifida	(Cinquefoil)
	Phleum pratense	(Timothy)
	Glycyrrhiza lepidota	(Wild Licorice)
	Stipa spartea	(Porcupine-Grass)
N	Convolvulus sepium	(Bindweed)
N	Geum triflorum	(Avens)
	Lactuca pulchella	(Lettuce)
N	Oenothera biennis	(Evening Primrose)
N	Ambrosia psilostachya var. coronopifolia	(Perennial Ragweed)
N	Spartina gracilis	(Cord Grass)
N	Linum lewisii	(Blue-flax)

	Scientific Name	Common Name
N	Campanula rotundifolia	(Bellflower)
N	Anemone canadensis	(Anemone)
N	Petalostemum candidum	(White Prairie Clover)
N	Thalictrum venulosum	(Meadow-Rue)
N	Zigadenus elegans	(White Camass)
N	Panicum virgatum	(Switchgrass)
N	Chenopodium	(Pigweed)
N	Plantago eriopoda	(Plantain)
N	Solidago rigida	(Golden Rod)
N	Liatris ligulistylis	(Blazing Star)
N	Andropogon geradi	(Beardgrass)
N	Agropyron trachycaulum var. novae-angliae	(Wheat Grass)
N	Orthocarpus luteus	
N.	Ratibida columnifera	(Prairie-Coneflower)
N	Fragaria virginiana	(Strawberry)
	Medicago	(Alfalfa)
D	Vicia cracca	(Tufted Vetch. Canada Pea)
D	Trifolium hybridum	(Alsike Clover)
N	Apocynum sibiricum	(Dogbane)
N	Solidago nemoralis var. decemflora	(Goldenrod)
N	Cirsium flodmanii	

	Scientific Name	Common Name
N	Liatris ligulistylis	(Blazing Star)
N	Gentiana andrewssi	(Closed Gentian)
N	Aster ptarmicoides	(Aster)
N	Salicornia rubra	(Samphire)
N	Suaeda depressa	(Sea Blite)
N	Distichlis stricta	(Alkali-Grass)
N	Antennaria parvifolia	
N	Spartina pectinata	(Cord Grass)
N	Helianthus maximiliani	(Sunflower)
N	Gentiana affinis	(Gentian)
N	Allium stellatum	(Wild Onion)

d) Marsh Site

N-Native D-Disturbed (49 Species)

	Scientific Name	Common Name
N	Typha latifolia	(Cattail)
	Scirpus validus	(Bulrush)
	Carex spp.	(Sedge)
	Potamogeton	(Eel Grass)
	Medicago sativa	(Alfalfa)
	Poa pratensis	(Kentucky Blue Grass)

	Scientific Name	Common Name
D	Bromus inermis	(Brome Grass)
	Melilotus alba	(White Clover)
	Melilotus officinalis	(Yellow Clover)
	Cirsium arvense	(Canada Thistle)
	Sonchus arvensis	(Sow Thistle)
	Rumex crispis	(Ragweed)
N	Symphoricarpos occidentalis	(Wolfberry)
	Plantago major	(Common plantain)
	Hordeum jubatum	(Barley)
	Stachys palustris	(Hedge Nettle)
	Grindelia squarrosa	(Sticky Gum Cup)
	Equistem sp.	(Horsetail)
	Artemissia bieniss	(Wormwood)
	Sium sauve	(Water Parsnip)
	Thlaspi arvense	(Frenchweed)
	Vicia americana	(Vetch)
	Mentha arvense	(Mint)
	Alisma trivale	(Water Plantain)
	Potentilla anserina	(Silverweed)
	Chenopodium album	(Pigweed)
	Lycopus asper	(Bugleweed)
	Polygonum achoreum	(Smartweed)
	Chenopodium	(Pigweed)

	Scientific Name	Common Name
	Agropyron repens	(Couch Grass)
	Aster pansis	(Aster)
	Beckmannia syzigachne	(Slough Grass)
	Salix interior	(Sandbar - Willow)
	Vicia americana	(Vetch)
N	Ambrosia psilostachya	(Ragweed)
N	Ambrosia trifida	(Buffalo-weed)
N	Lactuca pulchella	(Lettuce)
N	Glyceria grandis	(Reed-meadow-Grass)
N	Polygonum lapathifolium	(Smartweed)
D	Lythrum salicaria	(Spiked Loosestrife)
N	Bidens frondosa	(Beggar-ticks)
N	Spartina pectinata	(Cord Grass)
N	Oenothera biennis	(Evening Primrose)
N	Zizia aptera	(Fern)
N	Sagittaria cuneata	(Arrowhead)
N	Moldavica parviflora	(Dragon head)

e) Riverbottom Site

N-Native D-Disturbed (48 Species)

	Scientific Name	Common Name
N	Matteuccia struthiopteris var. pensylvanica	(Ostrich-Fern)

	Scientific Name	Common Name
N	Potentilla anserina	(Silverweed)
N	Amorpha fruticos var. angustifolia	(False-Indigo)
N	Smilacina stellata	(False Solomon's Seal)
N	Vitis riparia	(Grape)
N	Tilia americana	(Basswood)
D	Asparagus officinalis	(Garden Asparagus)
N	Smilax herbacea var. lasioneura	(Carrion-Flower)
N	Hordeum jubatum	(Squirrel-Tail-Grass)
N	Prunus virginiana	(Choke-cherry)
N	Ulmus americana	(American or White Elm)
N	Laportea canadensis	(Wood Nettle)
N	Symphoricarpos occidentalis	(Wolfberry)
D	Amaranthus retroflexus	(Pigweed)
N	Ambrosia trifida	(Great Ragweed. Buffalo-weed)
N	Stachys palustris	(Hedge-Nettle)
D	Bromus inermis	(Brome Grass)
D	Thlaspi arvense	(Frenchweed. Stinkweed)
D	Malua rotundifolia	(Mallow)
N	Artemisia biennis	(Wormwood)
	Acer negundo	(Manitoba Maple)
N	Petasites sagittatus	(Sweet Coltsfoot)

	Scientific Name	Common Name
	Cirsium arvense	(Canada Thistle)
	Fragaria virginiana	(Strawberry)
	Sonchus arvensis	(Sow Thistle)
	Urtica procera	(Stinging Nettle)
	Convolvulus sepium	(Morning Glory or Bindweed)
N	Thalictrum venulosum	(Meadow-Rue)
	Populus	(Poplar Species)
	Quercus	(Oak Species)
	Rosa	(Rose)
	Rumex crispis	(Dock Sorrel)
	Plantago major	(Water Plantain)
	Cornus stolonifera	(Red Osier Dogwood)
	Anemone canadensis	(Canada anemone)
	Lathyrus venosus	(Wild Peavine)
D	Chenopodium album	(Pigweed)
N	Elymus virginicus	(Terrell Grass)
D	Agropyron repens	(Couch Grass)
D	Polygonum aviculare	(Smartweed)
N	Polygonum achoreum	(Smartweed)
	Descurainia sophis	(Mustard)
	Aster	(Aster)
D	Sonchus arvensis var. glabrescens	(Sow Thistle)

	Scientific Name	Common Name
D	Lactuca scariola	(Lettuce)
N	Poa pratensis	(Kentucky Blue Grass)
	Solidago canadensis	(Goldenrod)

5-252 Invertebrates and vertebrates

(1) Vertebrates

a) Mammals of the Winnipeg Region.

NOTE: This list includes every mammal whose range, according to available literature, infringes on or includes the 35 mile radius of Winnipeg.

Order Insectivora

Family Soricidae

Sorex cinereus	(Masked Shrew)
Sorex palustris	(Water Shrew)
Sorex arcticus	(Arctic Shrew)
Blarina brevicauda	(Short Tail Shrew)

Family Talpidae

Condylura cristata	(Starnose Mole)

Order Chiroptera

Family Vespertilionidae

Myotis lucifugus	(Little Brown Bat)
Myotis keeni	(Keen Bat)
Lasionycteris noctivagana	(Silverhair Bat)
Eptesicus fuscus	(Big Brown Bat)
Lasiurus borealis	(Red Bat)
Lasiurus cinereus	(Hoary Bat)

Order Carnivora

Suborder Fissipedia

Family Ursidae

Ursus americanus	(Black Bear)

Family Procyonidae

Procyon lotor	(Raccoon)

Family Mustelidae

Mustela erminea	(Ermine, Short Tail Weasel)
Mustela rixosa	(Least Weasel)
Mustela freneta	(Long Tailed Weasel)
Mustela vison	(Mink)
Martes americana	(Marten)
Martes pennanti	(Fisher)
Gulo luscus	(Wolverine)
Taxidea taxus	(Badger)
Mephitis mephitis	(Striped Skunk)
Lutra canadensis	(River Otter)

Family Canidae

Canis latrans	(Coyote)
Canis lupus	(Wolf)
Vulpes fulva	(Colored or Red Fox)

Family Felidae

Felix concolor	(Mountain Lion, Cougar)
Lynx canadensis	(Lynx)
Lynx rufus	(Bobcat)

Order Rodentia

Family Sciuridae

Tamias striatus	(Eastern Chipmunk)
Eutamias minimus	(Least Chipmunk)
Marmota monax	(Woodchuck)
*Citellus richardsoni	(Richardson's Ground Squirrel)
*Citellus franklini	(Franklin's Ground Squirrel)
*Citellus tridecemlineatus	(13-lined Ground Squirrel)
Sciurus carolinensis	(Grey Squirrel)
Tamiasiurus hudsonicus	(Red Squirrel)
Glaucomys sabrinus	(Northern Flying Squirrel)

Family Geomyidae

Thomomys talpoides	(Northern Pocket Gopher)

Family Castoridae

Castor canadensis	(Beaver)

Family Cricetidea

Peromyscus maniculatus	(Deer Mouse)
Clethrionomys gapperi	(Boreal Redback Vole)
Phenacomys intermedius	(Heather Vole)
Microtus pennsylvanicus	(Meadow Vole)
Microtus ochrogaster	(Prairie Vole)
Ondatra zibethica	(Muskrat)
Synaptomys borealis	(Northern Bog Lemming)
Synaptomys cooperi	(Southern Bog Lemming)

Family Muridae

Mus musculus	(House Mouse)
Rattus norvegicus	(House Rat)

Family Zapodidae

Zapus hudsonius	(Meadow Jumping Mouse)
Napeozapus insignis	(Woodland Jumping Mouse)

Family Erithizontidae

Erithizon dorsatum	(Porcupine)

Order Lagomorphe

Family Leporidae

Sylvilagus floridanus	(Eastern Cottontail)
Lepus americanus	(Snowshoe Hare)
Lepus townsendi	(Whitetail Jackrabbit)

Order Artiodactyla

Family Cervidae

Cervus canadensis	(Wapiti, Elk)
Odocoileus hemionus	(Mule Deer)
Odocoileus virginianus	(Whitetail Deer)
Alces alces	(Moose)

* also known by generic name Spermopholis

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Hall, R. E. and Kelson, K.R. 1959. The Mammals of North America Vol.I & II, The Ronald Press Company, New York.

Burt, W. H. 1957. Mammals of the Great Lakes Region. The University of Michigan Press, Ann Arbor, Michigan

Wrigley, R. E. 1973. Animals of Manitoba. Published by Manitoba Museum of Man and Nature, Winnipeg.

Pruitt, W. O. 1974. Personal communication and Course Material for Mammalogy 457. University of Manitoba Zoology Department.

b) Mammals of the specific study sites

Small mammal trapping was carried out on 4 of the 5 study sites to substantiate the regional mammal inventory and identify common site residents. Trapping was carried out using both live and Kill traps. Schuyler traps, and Museum special traps were utilized as Kill traps, metal box traps and cone traps were used as live traps.

Traps were placed on the sites in areas where it was felt certain small mammals would be found. This technique was used rather than a method of random sampling as it was our purpose to verify the presence of certain species, not to carry out a population study. Traps were checked daily and live specimens were released, traps were moved daily - except cone traps and all sites were trapped for three consecutive days.

(1) On-School Grounds Site

a) Trapped or observed

Microtus pennsylvanicus	(Meadow Vole)
Clethrionomys gapperi	(Boreal Redback Vole)
Sciurus carolinensis	(Grey Squirrel)
Sylvilagus floridanus	(Eastern Cottontail)

b) Probably present

Blarina brevicauda	(Short-Tail Shrew)
Sorex cinereus	(Masked Shrew)

Mustela erminea (Short-Tail Weasel)

Tamias striatus (Eastern Chipmunk)

Eutamius minimus (Least Chipmunk)

Citellus richardsoni (Richardson's Ground Squirrel)

Citellus tridecemlineatus (Thirteen-Lined Ground Squirrel)

Tamiasiurus hudsonicus (Red Squirrel)

Peromyscus maniculatus (Deer Mouse)

Mus musculus (House Mouse)

Rattus norvegicus (Norway or House Rat)

Zapus hudsonius (Meadow Jumping Mouse)

Napeozapus insignis (Woodland Jumping Mouse)

Myotis lucifugus (Little Brown Bat)

c) Possible occurrences

Mustela rixosa (Least Weasel)

Mustela freneta (Long-Tailed Weasel)

Mephites mephites (Striped Skunk)

Procyon lotor (Racoon)

Taxidea Taxus (Badger)

(2) Gravel Pit Site

a) Trapped or observed

Microtus pennsylvanicus (Meadow Vole)

Clethrionomys gapperi	(Boreal Redback Vole)
Citellus richardsoni	(Richardson's Ground Squirrel)

b) Probably present

Sorex cinereus	(Masked Shrew)
Blarina brevicauda	(Short-Tail Shrew)
Myotis lucifugus	(Little Brown Bat)
Procyon lotor	(Racoon)
Mustela erminea	(Short-Tailed Weasel)
Mustela rixosa	(Least Weasel)
Mephites mephites	(Striped Skunk)
Taxidea taxus	(Badger)
Canis latrans	(Coyote)
Vulpes fulva	(Red Fox)
Tamias striatus	(Eastern Chipmunk)
Eutamias minimus	(Least Chipmunk)
Marmota monax	(Woodchuck)
Citellus franklini	(Franklin's Ground Squirrel)
Citellus tridecemlineatus	(Thirteen-Lined Ground Squirrel)
Tamiasciuris hudsonicus	(Red Squirrel)
Peromyscus maniculatus	(Deer Mouse)
Ondatra zibethica	(Muskrat)
Zapus hudsonius	(Meadow Jumping Mouse)
Erithzon dorsatum	(Porcupine)

Sylvilagus floridanus	(Eastern Cottontail)
Lepus americanus	(Snowshoe Hare)
Odocoileus virginianus	(White-Tail Deer)

(3) Grassland Site

a) Trapped or observed

Microtus pennsylvanicus	(Meadow Vole)
Citellus richardsoni	(Richardson's Ground Squirrel)
Clethrionomys gapperi	(Boreal Redback Vole)
Citellus tridecemlineatus	(Thirteen-Lined Ground Squirrel)

b) Probably present

Blarina brevicauda	(Short-Tail Shrew)
Sorex cinereus	(Masked Shrew)
Mustela erminea	(Short-Tailed Weasel)
Tamias striatus	(Eastern Chipmunk)
Eutamias minimus	(Least Chipmunk)
Tamiasciurus hudsonicus	(Red Squirrel)
Peromyscus maniculatus	(Deer Mouse)
Zapus hudsonius	(Meadow Jumping Mouse)
Myotis lucifugus	(Little Brown Bat)
Sylvilagus floridanus	(Eastern Cottontail)
Lepus americanus	(Snow Shoe Hare)

c) Possible occurrences

Mustela rixosa	(Least Weasel)
Mustela freneta	(Long-Tailed Weasel)
Mephites mephites	(Striped Skunk)
Procyon lotor	(Racoon)
Taxidea taxus	(Badger)
Erithizon dorsatum	(Porcupine)

(4) Marsh Site

a) Trapped or observed

Microtus pennsylvanicus	(Meadow Vole)
Clethrionomys gapperi	(Boreal Redback Vole)
Citellus tridecemlineatus	(Thirteen-Lined Ground Squirrel)
Citellus richardsoni	(Richardson's Ground Squirrel)
Mustela erminea	(Short-Tailed Weasel)
Ondatra zibethica	(Muskrat)
Blarina brevicauda	(Short-Tail Shrew)

b) Probably present

Sorex cinereus	(Masked Shrew)
Tamias striatus	(Eastern Chipmunk)
Myotis lucifugus	(Little Brown Bat)
Procyon lotor	(Racoon)
Mustela rixosa	(Least Weasel)

Mustela freneta	(Long-Tailed Weasel)
Taxidea taxus	(Badger)
Eutamias minimus	(Least Chipmunk)
Tamiasiuris hudsonicus	(Red Squirrel)
Peromyscus maniculatus	(Deer Mouse)
Zapus hudsonicus	(Meadow Jumping Mouse)
Erithizon dorsatum	(Porcupine)
Sylvilagus floridanus	(Eastern Cottontail)
Lepus americanus	(Snowshoe Hare)

c) Possible occurrences

Vulpes fulva	(Red Fox)

C) Birds of the Winnipeg Region

Order Gaviformes

Family Gaviidae

Gavia immer	(Common Loon)
**Gavia stellata*	(Red-Throated Loon)

Order Podicipediformes

Family Podicipedidae

Aechmophorus occidentalis	(Western Grebe)
Podicepps grisegena	(Red-necked Grebe)

Podiceps auritus	(Horned Grebe)
Podiceps caspicus	(Eared Grebe)
Podilymbus podiceps	(Pied-billed Grebe)

Order Pelecaniformes

Family Pelicanidee

Pelecanus erythrorhynchos	(White Pelican)

Family Phalacrocoracidae

Phalacrocorax auritus	(Double Crested Cormorant)

Order Anseriformes

Family Amatidae

Sub-family Cygninae

*Olar columbianus	(Whistling Swan)

Sub-family Anserinae

Branta canadensis	(Canada Goose)
*Anser albifrons	(White-fronted Goose)
*Chen caerulescens	(Blue Goose)
*Chen hyperborea	(Snow Goose)

Sub-family Anatinae

Anas platyrhynchos	(Mallard)
Anas acuta	(Pintail)
Anas strepera	(Gadwall)
Mareca americana	(American Widgeon)
Spatula clypeata	(Shoveler)

Anas discors	(Blue-Winged Teal)
Anas carolinensis	(Green-Winged Teal)
Aix sponsa	(Wood Duck)
Anas rubripes	(Black Duck)
Sub-family Aythyinae	
Aythya americana	(Red Head)
Aythya valisineria	(Canvasback)
Aythya collaris	(Ring-necked Duck)
*Aythya marila	(Greater Scaup)
Aythya affinis	(Lesser Scaup)
Bucephala clangula	(Common Goldeneye)
Bucephala albeola	(Bufflehead)
Melanitta deglandi	(White-Winged Scoter)
Sub-family Oxyurinae	
Oxyura jamaicensis	(Ruddy Duck)
Sub-family Merginae	
Mergus merganser	(Common Merganser)
Mergus serrator	(Red-breasted Merganser)
Lophodytes cucullatus	(Hooded Merganser)
Order Falconiformes	
Family Cathartidae	
Cathartes aura	(Turkey Vulture)
Family Accipitridae	
‡ Accipiter gentilis	(Goshawk)

Accipiter cooperii	(Cooper's Hawk)
Accipiter striatus	(Sharp-shinned Hawk)
Circus cyaneus	(Marsh Hawk)
* *Buteo lagopus*	(Rough-legged Hawk)
Buteo jamaicensis	(Red-tailed Hawk)
Buteo platypterus	(Broad-Winged Hawk)
Aquila chrysaetos	(Golden Eagle)
Family Pandionidae	
Pandion haliaetus	(Osprey)
Family Falconidae	
Falco rusticolus	(Grey Falcon)
* *Falco peregrinus*	(Peregrine Falcon)
Falco columbarius	(Pigeon Hawk)
Falco sparverius	(Sparrow Hawk)

Order Galliformes

Family Tetraonidae

ǂ *Bonasa umbellus*	(Ruffed Grouse)
ǂ *Pedioecetes phasianellus*	(Sharp-tailed Grouse)
ǂ *Phasianus colchicus*	(Ring-necked Pheasant)
ǂ *Perdix perdix*	(Gray Partridge)

Order Ciconiiformes

Family Ardeidae

Ardea herodias	(Great Blue Herron)

Nycticorax nycticorax	(Black Crowned Night Heron)
Botaurus lentiginosus	(American bittern)

Order Gruiformes

Family Gruidae

*Grus canadensis	(Sandhill Crane)

Family Rallidae

Rallus limicola	(Virginia Rail)
Porzana carolina	(Sora)
Coturnicops noveboracensis	(Yellow Rail)
Fulica americana	(American Coot)

Order Charadriiformes

Family Recurvirostridae

Recurvirostra americana	(American Avocet)

Family Charadriidae

Sub-family Charadriinae

*Pluvialis dominica	(American Golden Plover)
*Squatarola squatarola	(Black Bellied Plover)
Charadrius melodus	(Piping Plover)
Charadrius semipalmatus	(Semipalmated Plover)
Charadrius vociferus	(Killdeer)

Family Scolopacidae

Limosa fedoa	(Marbled Godwit)

* Limosa haemastica	(Hudsonian Godwit)
Bartramia longicauda	(Upland Plover)
Tryngites subruficollis	(Buff-breasted Sandpiper)
Tringa solitaria	(Solitary Sandpiper)
Actitis macularia	(Spotted Sandpiper)
Catoptrophorus semipalmatus	(Willet)
Totanus flavipes	(Lesser Yellowlegs)
* Micropalama himantopus	(Stilt Sandpiper)
* Limnodromus griseus	(Short-Billed Dowitcher)
* Limnodromus scolopaceus	(Long-Billed Dowitcher)
* Arenaria interpres	(Ruddy Turnstone)
* Erolia melanotos	(Pectoral Sandpiper)
* Crocethia alba	(Sanderling)
* Erolia fuscicollis	(White-rumped Sandpiper)
* Erolia bairdii	(Bairds Sandpiper)
* Erolia minutilla	(Least Sandpiper)
* Ereunetes pusillus	(Semipalmated Sandpiper)
* Ereunetes mauri	(Western Sandpiper)
Family Phalaropodidae	
Steganopus tricolor	(Wilson's Phalarope)
* Lobipes lobatus	(Northern Phalarope)
Family Scolopacidae	
Capella gallinago	(Common Snipe

Order Charadriiformes

Family Laridae

Sub-family Larinae

Larus argentatus	(Herring Gull)
Larus delawarensis	(Ring-Billed Gull)
Larus pipixcan	(Franklin's Gull)
Larus philadelphia	(Bonaparte's Gull)

Sub-family Sterninae

Sterna hirundo	(Common Tern)
Sterna forsteri	(Forster's Tern)
* *Hydroprogne caspia*	(Caspian Tern)
Chlidonias niger	(Black Tern)

Order Columbiformes

Family Columbidae

‡ *Columba livia*	(Rock Dove) (Domestic Pigeon)
Zenaidura macroura	(Mourning Dove)

Order Cuculiformes

Family Cuculidae

Coccyzus erythropthalmus	(Black-billed Cuckoo)

Order Strigiformes

Family Strigidae

‡ *Bubo virginianus*	(Great Horned Owl)
Asio otus	(Long-eared Owl)

Asio flammeus	(Short-eared Owl)
Nyctea scandiaca	(Snowy Owl)
ǂ Strix varia	(Barred Owl)
ǂ Aegolius funereus	(Boreal Owl)
ǂ Aegolius acadicus	(Saw-Whet Owl)
ǂ Otus asio	(Screech Owl)

Order Caprimulgiformes

Family Caprimulgidae

Caprimulgus vociferus	(Whip-Poor-Will)
Chordeiles minor	(Common Night Hawk)
Chaetura pelagica	(Chimney Swift)

Order Apodiformes

Family Trochilidae

Archilochus colubris	(Ruby-throated Humming Bird)

Order Coraciiformes

Family Alcedinidae

Megaceryle alcyon	(Belted Kingfisher)

Order Piciformes

Family Picidae

Colaptes auratus	(Yellow-Shafted Flicker)
Melanerpes erythrocephalus	(Red-headed Woodpecker)

Sphyrapicus varius	(Yellow-bellied Sapsucker)
‡ *Dendrocopos villosus*	(Hairy Woodpecker)
‡ *Dendrocopos pubescens*	(Downy Woodpecker)
‡ *Picoides arcticus*	(Black-backed Three-toed Woodpecker)

Order Passiformes

Family Tyrannidae

Tyrannus tyrannus	(Eastern Kingbird)
Tyrannus verticalis	(Western Kingbird)
Myiarchus crinitus	(Great Crested Flycatcher)
Sayornis pheobe	(Eastern Pheobe)
Empidonax flaviventris	(Yellow-Bellied Flycatcher)
Empidonax traillii	(Traill's Flycatcher)
Cantopus virens	(Eastern Wood Pewee)
Nuttallornis borealis	(Olive-sided Flycatcher)

Family Alaudidae

Eremophila alpestris	(Horned Lark)

Family Hirundinidae

Hirundo rustica	(Barn Swallow)
Petrochelidon pyrrhonata	(Cliff Swallow)
Iridoprocne bicolor	(Tree Swallow)
Raparia riparia	(Bank Swallow)
Progne subis	(Purple Martin)
Stelgidopteryx ruficollis	(Rough Winged Swallow)

Family Corvidae	
‡ *Cyanocitta cristata*	(Blue Jay)
‡ *Perisoreus canadensis*	(Gray (Canada) Jay)
Pica pica	(Black-billed Magpie)
‡ *Corvus corax*	(Common Raven)
Corvus brachyrhynchos	(Common Crow)
Family Paridae	
‡ *Parus atricapillus*	(Black-capped Chickadee)
Family Sittidae	
‡ *Sitta carolinensis*	(White-breasted Nuthatch)
Sitta canadensis	(Red-breasted Nuthatch)
Family Certhiidae	
Certhia familiaris	(Brown Creeper)
Family Torglodytidae	
Troglogytes aedon	(House Wren)
Telmatodytes palustris	(Long-billed Marsh Wren)
Cistothorus platensis	(Short-billed Marsh Wren)
Family Mimidae	
Dumetella carolinensis	(Catbird)
Toxostoma rufum	(Brown Thrasher)
Family Turdidae	
Turdis migratorius	(Robin)
Hylocichla guttata	(Hermit Thrush)
Hylocichla ustalata	(Swainson's Thrush)
Hylocichla minima	(Gray-cheeked Thrush)

Hylocichla fuscescens	(Veery)
Sialia sialis	(Eastern Bluebird)
Sialia currucoides	(Mountain Bluebird)
Family Sylviidae	
Regulus satrapa	(Golden-Crowned Kinglet)
Regulus calendula	(Ruby-Crowned Kinglet)
Family Motacillidae	
*_Anthus spinoletta_	(Water Pipit)
Family Bombycillidae	
Bombycilla garrulus	(Bohemian Waxwing)
Bombycilla cedrorum	(Cedar Waxwing)
Family Laniidae	
Lanius excubitor	(Northern Shrike)
Lanius ludovicianus	(Loggerhead Shrike)
Family Sturnidae	
Sturnus vulgaris	(Starling)
Family Vireonidae	
Vireo solitarius	(Solitary Vireo)
Vireo flavifrons	(Yellow-Throated Vireo)
Vireo olivaceus	(Red-eyed Vireo)
Vireo philadelphicus	(Philadelphia Vireo)
Vireo gilvus	(Warbling Vireo)
Family Parulidae	
Mniotilta varia	(Black-and-White Warbler)
Vermivora peregrina	(Tennessee Warbler)

Vermivora celata	(Orange-Crowned Warbler)
Vermivora ruficapilla	(Nashville Warbler)
Dendroica petechia	(Yellow Warbler)
Dendroica magnolia	(Magnolia Warbler)
Dendroica tigrina	(Cape May Warbler)
Dendroica coronata	(Myrtle Warbler)
Dendroica virens	(Black-throated Green Warbler)
Dendroica fusca	(Blackburnian Warbler)
Dendroica pensylvanica	(Chestnut-Sided Warbler)
Dendroica castanea	(Bay-breasted Warbler)
Dendroica striata	(Blackpoll Warbler)
Dendroica pinus	(Pine Warbler)
Dendroica palmarum	(Palm Warbler)
Seiurus aurocapillus	(Oven bird)
Seiurus noveboracensis	(Northern waterthrush)
Geothlypis trichas	(Yellow throat)
Oporornis philadelphia	(Mourning Warbler)
Oporornis agilis	(Connecticut Warbler)
Wilsonia pusilla	(Wilson's Warbler)
Wilsonia canadenisis	(Canada Warbler)
Setophaga ruticilla	(American Redstart)
Family Ploceidae	
‡ Passer domesticus	(House Sparrow)
Family Icteridae	
Dolichonyx oryzivorus	(Bobolink)

Sturnella neglecta	(Western Meadowlark)
Xanthocephalus xanthocephalus	(Yellow-headed Blackbird)
Agelaius phoeniceus	(Red-Winged Blackbird)
Euphagus carolinus	(Rusty Blackbird)
Euphagus cyanocephalus	(Brewer's Blackbrid)
Quiscalus quiscula	(Common Grackle)
Molothrus ater	(Brown-headed Cowbird)
Icterus galbula	(Baltimore Oriole)
Family Thraupidae	
Piranga olivacea	(Scarlet tanager)
Family Fringillidae	
Pheucticus ludovicianus	(Rose-breasted Grosbeak)
‡ _Hesperiphona vespertina_	(Evening Grosbeak)
Carpodacus purpureus	(Purple Finch)
Pinicola enucleator	(Pine Grosbeak)
Acanthis hornemanni	(Hoary Redpoll)
Acanthis flammea	(Common Redpoll)
Spinus pinus	(Pine siskin)
Spinus tristis	(American Goldfinch)
‡ _Loxia curvirostra_	(Red Crossbill)
‡ _Loxia leucoptera_	(White-winged Crossbill)
Passerculus sandwichensis	(Savannah Sparrow)
Ammodramus savannarum	(Grasshopper Sparrow)
Ammodramus bairdii	(Baird's Sparrow)
Passerherbulus caudacutus	(LeConte's Sparrow)

Ammospiza caudacuta	(Sharp-tailed Sparrow)
Pooecetes gramineus	(Vesper Sparrow)
Junco hyemalis	(Slate-colored Junco)
*Spizella arborea	(Tree Sparrow)
Spizella passerina	(Chipping Sparrow)
Spizella pallida	(Cray colored Sparrow)
*Zonotrichia querula	(Harris' Sparrow)
*Zonotrichia leucophrys	(White-crowned Sparrow)
Zonotrichia albicollis	(White-throated Sparrow)
Passerella iliaca	(Fox Sparrow)
Melospiza lincolnii	(Lincoln's Sparrow)
Melospiza georgiana	(Swamp Sparrow)
Melospiza melodia	(Song Sparrow)
Calcarius ornatus	(Chestnut-collared Longspur)
*Calcarius lapponicus	(Lapland Longspur)
Plectrophenax nivalis	(Snow Bunting)
Calcarius pictus	(Smith's Longspur)

This checklist includes all those species of birds whose summer or winter ranges or migratory paths include or infringe upon a 35-mile radius of Winnipeg. Those which migrate through only are indicated by an asterisk (*). Those which are all-year residents are marked (‡). Those with only winter range or summer range are unmarked.

d) Amphibians and Reptiles of the Winnipeg Region

Pseudacris triseriata	(Boreal Chorus Frog)
Rana sylvatica	(Wood Frog)
Hyla crucifer	(Spring Peeper)
Hyla versicolor	(Eastern Tree Frog)
Hyla chrysoscelis	(Western Tree Frog)
Rana pipiens	(Leopard Frog)
Rana clamitans	(Green Frog)
Rana septentrionalis	(Mink Frog)
Scaphiopus bombifrons	(Plains Spadefoot)
Bufo americanus	(American Toad)
Bufo hemiophrys	(Dakota Toad)
Thamnophis sirtalis parietalis	(Red Sided Garter Snake)
Tamnophis radix	(Plains Garter Snake)
Storeria occipitomaculata	(Red Bellied Snake)
Opheodrys vernalis	(Smooth Green Snake)
Heterodon nasicus	(Western Hognose Snake)

(2) Invertebrates

a) Insects

Insect collections were made on each of the six study sites using the beating, hand-picking, and sweep netting methods. Insects collected were sent to the Northern Forest Research Center, Canadian Forest Service, Department of the Environment, 5320-122 Street, Edmonton, Alberta, for identification.

The following is a short list of the insect types most commonly found in the Winnipeg area, as reported by the "Annual Report of the Forest Insect and Disease Survey", 1967 through 1971, published by the Canadian Forest Service, Ottawa.

I Insects of the Winnipeg Region

1) Common Tree Insects

a) Malacosoma disstria
   - Forest Tent Caterpillar (mostly on Poplars)

b) Charistoneura conflictana
   - Large Aspen Tortrix (on Aspen)

c) Linus crypta
   - Poplar Leaf Beetle (on Poplar)

d) Gonioctena americana
   - American Aspen Beetle (on Aspen)

e) Alsophila pometaria
   - Fall and Spring Canker Worm

f) Aphids

g) Phyllocinistis populiella

- Aspen Leaf Miner (on Aspen)

h) Hiriomyza brassicae

- Serpentine leaf miner

i) Psuedexentra oregonana

- Leaf roller

j) Sciaphila dieplex

k) Energia decolor

- Noctuids

l) Corythaca arcuata

- Oak Lacebug

m) Platysamia cecropia

- Cecropia moth (on Maple)

2) Insects Found on Bushes and Shrubs

a) Malacasoma lutescens

- Prairie Tent Caterpillar (on Rose)

b) Spring Elm Caterpillar (on Elm)

c) Sod Web Worms

d) Cut Worms

e) Eriosoma americanum

- Woolly Elm Aphid

f) Eriophyes sp.

- Mites

3) Some Common Gall-forming Insects

a) Aceria froxiniflora

- Ash Flower gall mite (on Green Ash)

b) Contarinia negundifolia

- Boxelder leaf gall midge

c) Ascarpis villosa

- Hairy Oak Gall (on Bur Oak)

d) Andricus sp.

- A Gall Wasp (on Bur Oak)

e) Disholcaspis mamma

- Rough bullet gall (on Bur Oak)

f) Aceria parapopuli

- Poplar bud-gall mite (on Poplar)

g) Asiphum sacculi

- Aspen Leaf Pocket Aphid (on Trembling Aspen)

h) Thecabius affinis

- A Gall Aphid (on Populus balsamifera L)

i) Diplolepis bicolor (on Rose)

- A Gall Wasp

j) Pontania Sp. (on Willow)

- A Gall Sawfly

k) Rhabdophaga strobiloides

- Pine Cone Willow Gall Midge

II Insects Collected from The Study Sites

1) On-School Grounds Site

1) Clastoptera proteus (Dogwood Spittlebug)
2) Hemerobius sp. (Brown Lacewings)
3) Bracon sp. (Parasitic Wasp)
4) Cynipid sp. (Bees,wasps,ants and sawflies)
5) Idiocerus populi
6) Pleuratus ostreatus
7) Rhabdophaga strobiloides (Gall midge)
8) Pontania sp. (Sawfly)
9) Eriophyes emarginata (Mites)
10) Coccinellid sp. (Lady Beetle Eggs)
11) Operophtera brucezta (Bruce Spanworm)
12) Diplolepis sp. (Wasp Gall)
13) Corythucha arcuata (Oak Lacebug)
14) Apanteles sp. (Parasite)
15) Hippodamia tredecimpunctata Tibialis (Lady Beetle)
16) Stictosephala bubalis (Buffalo treehopper)
17) Adelphocoris linealatus (Alfalfa Plant Bug)

2) Gravel Pit Site

1) Melanorhopala clavata

2) Tortricid sp. (Bell Moths (includes Spruce Budworm)

3) Idiocerus populi

4) Bracon sp. (Parasitic Wasp)

5) Phaedon sp. (Leaf Beetle)

6) Diptera sp. (Flies, gnats, midges and mosquitos)

7) Cynipid sp. (Bees, wasps, ants and sawflies)

8) Stictocephala taurina

9) Phymata fasciata (Ambush)

10) Epicauta subglabra (Caragana Blister Beetle)

11) Dissonycha latifrons asteris

12) Chalcoides sp. (Leaf Beetle)

13) Calligrapha atui (Leaf Beetle)

3) Grassland Site

1) Pieris rapae (Cabbage Worm)

2) Colias philodice (Clouded Sulphur Butterfly)

3) Minois alope nephala (Wood Nymphs)

4) Phaedon sp. (Leaf Beetle)

5) Calligrapha alni (Leaf Beetle)

6) Tortricid sp. (Bell Moth)

7) Gryllus sp. (Field Cricket)

8) Idiocerus populi

9) Idiocerus lachrymalis

10) Melanorhopala clavata

11) Hemerobius sp. (Brown Lacewing)

12) Cynipid sp. (Bees, wasps, ants and sawflies)

13) Biblio sp. (March Fly)

14) Lepyrus palustris

15) Tetralopha aplastella (Webworm)

16) Malacosoma disstria (Forest Tent Caterpillar)

17) Melanagromyza sp. (Miner)

18) Cecidomyid sp. (Midge)

19) Pyralid sp. (Small Snouth Moths)

20) Tortricid sp. (Bell Moth)

21) Mirid sp. (Leaf Bug)

22) Phaedon sp. (Leaf Beetle)

23) Melanorhopata clavata (Spider)

4) Riverbottom Site

1) Braconid sp. (Parasitic Wasp)

2) Chalcoides sp. (Leaf Beetle)

3) Psylla sp. (Jumping Plant Lice) (pear psylla)

4) Eriophyes sp. (Mites)

5)	*Cecidomyid sp.*	(Midge)
6)	*Corythucha arevata*	(Oak Lace Bug)
7)	*Alsophila pometaria*	(Cankerworm)
8)	*Psilocoris quercicella*	
9)	*Hypoprepia fucosa*	(Adult Moth)
10)	*Depressaria groteella*	(Webworm)
11)	*Gracillaria sp.*	(Leafminer)
12)	*Coccinellid sp.*	(Lady Beetle)
13)	*Anatis malia*	(Lady Beetle)
14)	*Banasa dimidiata*	
15)	*Collops vittatus*	(Soft Winged Flower Beetle)

5-253 SUCCESSIONAL STAGES

a. On-School Grounds Site

Aerial photographs taken in 1948 show that the area on which the present on-school grounds site is located was at one time poorly drained agricultural land. The overall Fort Richmond area was predominantly oak (Quercus macrocarpa), and aspen (Populus Tremuloides) bush except for the river corridors where elm (Ulmus americana) was the dominant species. The on-school grounds site is predominantly parkland type vegetation, with aspen being the most predominant species. An aspen-oak association has prevailed on this site with aspen as the dominant species in the medium to poorly drained areas, and oak associated with the drier sites (Fig. 27, Area 1). Along the stretches of alluvial soils where drainage is impaired, white elm, basswood (Tilia americana), green ash (Fraxinus pennsylvanica), or Manitoba maple (Acer Negundo) could have at one time been present.

Natural drainage on this site has been impeded by construction of the Dalhousie Elementary School. Backfill that has been placed in an area adjacent to the south-west corner of the school had sufficiently blocked natural drainage to cause a marsh type area to form as a result of a build-up of standing water (Fig. 27, Area 2). During the mid-summer of 1974, this area held water to a depth of 12-14 inches. Owing to this semi-permanent water, the dominant aspen is beginning to die out (Fig. 27, Area 2 and 3). The dominant plant species in this area are the sedges (Carex sp.), with water plantain (Alisma triviale) being common. Red osier dogwood (Cornus stolonifera), nannyberry shrubs (Viburnum lentago), and willow (Salix sp.) are invading this area from adjacent stands. Although aspen is still the dominant species of this marsh type area, reverse succession is occurring where water tolerant species will eventually prevail.

Further north of the zone of dead aspen, the terrain rises and plant species change from aspen, sedges and water plantain to rushes (Juncus sp.) at the first level, then into willow, and finally to the open drier conditions where the grasses predominate.

In the north-west area of the site, aspen is again the dominant species (Fig. 27, Area 4). Little understory is present, except on south and south-west facing openings where sufficient sunlight is able to penetrate the canopy.

On the most westerly portion of this site, where the elevation is the highest, aspen communities give way to the drier habitat preferences of the oak community (Fig. 27, Area 5).

In terms of classification, this overall site could be appropriately referred to as a pioneer succession site (Personal communication J. M. Stewart, Department of Botany, University of Manitoba, 1974).

b. Gravel Pit Site

This site is indicative of an area that has been greatly impacted and altered by man's activity. The dredged clay mounds that are surrounding the water bodies are just now beginning to be inhabited by vegetation and may be considered to be in their pioneer stage of succession (Fig. 28, Area 1). The area is developing rapidly into a perennial herb and weed stage, that will proceed into a shrub and finally into a climax tree stage. The plant species presently inhabiting this site are largely those of a disturbed (exotic) plant community. Examples are Canada Thistle (*Circium arvense*), Couch grass (*Agropyron repens*), and the Sages (*Artemisia spp.*). On the less disturbed fringe areas of this site, a great variety of native Manitoba species are established (Fig. 28, Area 2).

Sages and thistles being inherently tolerant of severe climatic conditions are the dominant plant species of the higher, drier areas of this site (Fig. 28, Area 2). The sages and the thistle are largely self-sustaining plants, in that they are capable of undergoing long periods of adverse climatic conditions by becoming almost dormant. However, they are very quickly able to take advantage of good climatic conditions for growth and reproduction. This ability has allowed the sages and thistles to invade the bare, harsh clay mounds, where moisture is overabundant during periods of rainfall, and almost absent during dry periods.

c. Grassland Site

Aerial photographs show that in 1948 this area was being maintained for either forage production or pasture purposes. In 1948 only four stands of trees (Aspen) were present on the site. Today, the complete northern edge of the site is inhabited by shrubs, and aspen (Fig. 34). As well, a number of stands of aspen having a wolfberry (Symphoricarpus oxidentalis) understory have developed in the interior sections. This major alteration toward colonization by shrub-tree species indicates that around the 1948 period tree growth was being hindered by either heavy foraging or continuous mowing practices. Now that this area is not being heavily utilized for forage production or pasture, the shrub-tree stage is succeeding the herb stage.

The flora of this site is composed of mainly native species and there is an obvious patch distribution pattern of plant species on the site. In other words, certain species are situated in clumps or patches that follow a north-westerly-south-easterly pattern. This is caused by the influence of the prevailing winds on plant seed dispersal. Examples of plants forming these patch-like communities are: blazing star (Liatrus ligulistylis), Flodman's thistle (Circium flodmanii), wild onion (Allium stellatum), big bluestem (Adropogon gerardi), and wolf berry (Symphoricarpus oxidentalis).

The several islands or clumps of tree communities present on the site now are expanding their outward perimeters and it appears that in time will join together to form a complete treed site. This seral stage of aspen and willow habitation will form suitable conditions for oak trees to become established as the site moves towards its climax stage.

This site is presently in the process of reverse succession. In the future this site should follow a normal successional pattern where it will move from a herb stage to a tree stage of aspen to the climax oak inhabitation. Currently this site is in a seral grass-perennial stage.

d. Marsh Site

This site was probably formed as the result of the removal of overburden for housing development requirements, the blocking of natural drainage patterns by both the drainage ditch system and the Winnipeg Floodway (Fig. 35).

Succession has proceeded in this water body from an early stage of fairly sterile conditions when there was little vegetation or fauna growth in the water, through successive stages of increased production of both flora and fauna to the marsh condition it now represents. Nutrients have increasingly built up in the water body by being washed in from the surrounding watershed, and from the remains of dead organisms the water body at one time supported. This build-up of material will continue, until eventually the marsh will dry up completely as terrestrial plants and animals invade the site of the former marsh. Bushes, trees, and herbaceous plants which are tolerant of soggy ground will add their remains to the soil, until conditions become sufficiently mesic to tolerate a purely terrestrial community.

Zonation of aquatic communities is present in this marsh site. According to Benton and Werner (1958) this zonation illustrates the process of succession in lakes. Floating aquatics will occupy the deep water, and various kinds of rooted vegetation will follow in regular sequence up to the beach. Thus we can observe how this water body will become more shallow by the action of various communities and how the changing depth of water affects the composition of the communities.

a) Small Floating Aquatics and Rooted Floating Aquatics.

The areas of a water body involved in zonation include the littoral zone and the psammolittoral zone. The deeper water (littoral zone) has a surface cover of the small floating plants commonly known as duckweeds, (Lemma sp.). Also found colonizing this area are Potamogeton richardsonii and P. pectinatus.

b) Emergents

In the shallow water of this site, a zone occurs that possesses a community dominated by emergent plants. These species have their roots and lower stems in water, but most of the plant projects into the air. The plant species composition of this zone are cattails (Typhia sp.) bulrushes (Scirpus spp.), and water plantains (Alisma trivale). At this site the cattails and bulrushes are colonizing the area from the saturated soil region to a water depth of about three feet.

c. Saturated Soil Region

Next to the shoreline where the soil is saturated with water, the community of plants is dominated by sedges (Carex sp.).

d) Shore Communities

As the shoreline elevation rises abruptly the shrub community is dominated by an aspen stand.

e) Riverbottom site

This site is located on a flood plain of the Red River and is characteristic of flood plain, oxbow type habitat (Fig. 36).

The riverbank stand of mature forest found here is reaching its climax stage. Tree species found on the riverbank are black ash (Fraxinus nigra), oak (Quercus macrocarpa), Manitoba maple (Acer Negundo), basswood (Tilia americana), and elm (Ulmus americana). The oak and elm are the dominant species of this community.

The understory of this community is dominated by younger specimens of the mature tree species plus ostrich fern (Matteuccia struthiopteris), poison ivy (Rhus radicans), and wild sarsaparilla (Aralia Nadicaulis). This riverbank type vegetation is influenced by the extended periods of warm temperatures caused by the temperature retention capacity of the surrounding water. The heat retention capacity of the water allows the vegetation on the riverbank a slightly longer than normal growing season in the late fall.

The north-west facing bank of this site contains a very sparsely populated understory. What understory is present is largely that of ostrich ferns, wild sarsaparilla and poison ivy. The reason for the growth and maintenance of these species only is that this area is inundated almost annually or bi-annually with flood water. As a result it is very difficult for other vegetation such as shrubs and trees to become permanently established.

The south-east facing bank of this site contains a heavy understory of shrubs, chokecherry (Prunis virginiana), Saskatoon (Amelanchier alnifolia), hazel (Corylus rostrata), pincherry (Prunus pennsylvanica) and young aspen. This occurrence is partially due to the flow of the river during flooding. As this area is in the backwash of the river flow coming around the land point, no erosive action occurs here.

Also, this is a south-facing slope and receives more direct sunlight than does the north-west facing slope.

5-26 CLIMATE

Climatic data for the specific study sites will be discussed with reference to six climatological data collection centres located in close proximity to the actual chosen environmental study sites. This discussion will then be substantiaged by a description of the microclimate of the specific study sites.

The six locations for which data are available are 1) North-End Sewage Treatment Plant, 2) Glenlea Research Station, 3) Selkirk Weather Station, 4) Winnipeg International Airport, 5) St. Norbert and 6) St. Boniface.

I. Climate of the City of Winnipeg

a) Air Temperature

According to Labelle, Brown and Hasinoff (1966), frost has often been reported in the city on nights when the screen temperature remained about $0^{o}C$. It has long been realized that there are wide temperature variations over the urban area, especially on clear, calm nights. To determine the magnitude of the variations, a series of observations under these conditions was made in 1952.

The results revealed the presence of heat islands in the populated sections of the city. With the city centre having temperatures $3.5^{o}C$

higher than the airport. Temperatures lower than the airport temperature occur to the north-west, south-west and east. It was noted that the average variation across the city could be as much as six degrees Celsius on any one night.

In the data for the year July 1972 to June 1973 (Fig. 29) it can be seen that there was a difference of 1.5°C in mean maximum temperatures between Glenlea and Selkirk (July 1972); there was a difference of as much as 2°C in mean daily temperatures between Selkirk and St. Norbert (February 1973); and a difference of as much as 3.5°C in mean minimum temperatures between Glenlea and St. Norbert (February 1973).

The variation in maximum and minimum temperatures can easily be seen on Fig. 30. This variation in maximum temperature (5°C), occurred on August, 1972 at Glenlea and the International Airport. The greatest variation in minimum temperature was in October 1972 at Selkirk (STP) and Glenlea where a variation of 3.5°C was reported.

b) Soil Temperature and Solar Input

Variations are also noticeable in the soil temperatures that were recorded for the Glenlea (South Winnipeg) area and the Winnipeg International Airport (North Winnipeg) area (Table 10). The greatest variation between mean temperatures occurred during July 1972 when a difference of 4°C was reported between the two sites. Temperature changes between morning and evening readings and month-to-month readings are expected and show clearly. At the International Airport a warming trend from A.M. to P.M. of anywhere up to $3^{o}C$ appears to be the rule. At the Glenlea Station, from data available, a slightly lesser warming trend from A.M. to P.M. is seen. The amount of warming A.M. to P.M. and the degree of mean soil temperature reached at the International Airport coincides to a great extent with the duration of sunshine (Table 11). Table 11 showed that July 1972 and July 1973 sunshine duration to be the greatest. Coincidingly, the mean temperatures and diurnal increases are also greatest at this time of the year. This results in part from the solar heating mechanisms discussed earlier. Measurements for the two sites are not identical because of the variation in other factors, such as humidity, exposure, soil types, and permeability.

Looking at the soil temperature and sunshine records on a monthly basis (Table 10 and 11), it is seen that during the summer months there is a maximum solar input, maximum surface soil temperatures, and maximum daily warming for the year. The soil temperatures decrease from surface to lower depths because of the high solar intensity at the surface and slow conduction downward. However, from July to November there is a complete reverse, where the lower soils are warmer than the surface soil. This is due to the lack of intense solar influence (Table 11), and the continual loss of heat from the earth's surface combined to create a net efflux of heat from the soil.

This is shown in comparing the air temperatures with the soil temperatures for the month of July, 1972 to January 1973. In July 1972 the P.M. soil reading showed a higher temperature than the air temperature because the solar input is lost and the soil retains the heat better than the air. The soil A.M. readings are cooler than the air, and the solar input is again high and the air is warming faster than the soil surface. Again deeper soils warm more slowly and are relatively cool throughout July in relation to air temperatures and surface soil. The lower soils, which change temperature less readily because of less exposure, evaporation, and wind, are however warmer than the air in winter (January 1973, Table 10, Fig. 30). Even the soil surfaces are warmer than the air in winter, and in spite of the cold air above them, the temperature increases A.M. to P.M. because of solar input. The inflating albedo effect of the snow cover adds to the ground temperature in winter, and causes an even greater difference between soil and air temperatures (Glenlea and International Airport, January 1973, Table 10, Fig. 30). In this case the lower soils are warmer than the surface soils (November 1972 through April 1973, Glenlea and International Airport) (Table 10).

In comparing the International Airport and Glenlea sites for sunshine records, the maximum differences for the year July 1972 to July 1973 were: for sunshine duration, 19 hours difference in July 1973; for maximum sunshine in one day, a difference of 1.0 hours in March 1973, and for number of hours of no sunshine, maximum differences were recorded in March 1973. November to December 1972 showed the maximum number of hours without sunshine (Table 11), this corresponds with the decline of air temperature and a rise in solar temperature relative to that of the air.

c) Precipitation

In the regional analysis it was determined that Winnipeg had annual average precipitation values of 20.35 inches. Figure 31 shows the recordings for a months precipitation and for the International Airport variations from normal are indicated. The greatest difference in total precipitation in any one month was in August 1972 when the International Airport showed 2.12 inches of precipitation lower than Glenlea. The greatest variation in snowfall occurred in October when North Kildonan showed 9.1 inches less than St. Norbert. The inequality of snowfall may have been caused in part by the topographical characteristics of each area. As precipitation levels were higher than usual for December 1972, the snow cover would certainly influence the microclimate of the various areas. With the variation in amounts of snowfall, there would subsequently be greater variation in the effects on the microclimate.

d) Dew

The mean monthly dew points vary with the different seasons of the year. This pattern can be readily identified in Table 12. A comparison of the International Airport and the Glenlea Research Station indicates this variation in dew points, with the greatest differences occurring in April, May and June.

e) Wind Speed and Direction

A comparison of the wind speed and direction shows that on the average in 1972-1973 the Glenlea station experienced a slightly higher wind velocity (Table 13). The predominant winds were north-west, south and north-east at Glenlea, whereas the International Airport showed greater predominance of south, west and north-west winds. Winds can have a significant effect on the microclimate depending on location and exposure. The wind-breaking effect of vegetation also plays an important role in microclimate. These factors work against each other and control the water that is lost from the land surface and the surrounding air.

Though the areas discussed above are not the actual sites the study is concerned with, the data from them indicate the type of variations seen across the city.

II. Microclimate of the Specific Study Sites

a) On-School Grounds Site

As the on-school grounds site is in the extreme south section of the city of Winnipeg it would likely have climatic conditions similar to those found in St. Norbert. There are four representative area types on this site with unique conditions that would in some way effect the microclimate of that area.

Area A (Fig. 32) consists of a central low lying area which collects and holds water well into the summer period. (See discussion of surface hydrology of this site). The south-western section of this area is higher ground covered with short grass. The north and north-eastern part of the area contains tall marsh grasses and is inhabited by a number of water birds. The space outside and north of this area is tall bush. The effects of the tall bush to the north would be to break the cooling effect of the predominant north wind and also hold moisture from evaporating. The presence of water would also help in collecting and holding heat for longer periods of time throughout the day. These factors tend to raise and stabilize the temperature of the area. This may in part account for the relatively unique occurrence of wildlife and their subsistence habitat on this site. With the water and short grassed part of Area A being open to the south, there would be a longer period of exposure to the sun resulting in a greater penetration of heat into the subsurface from spring to fall. As the south winds are usually warmer than north winds this south facing opening would also increase the relative temperatures of Area A. As the area is water soaked, contains open surface water, and is partially covered by dense vegetation, the humidity of the area would also be slightly greater than the surrounding area. Due to evaporation, the air temperature over the water body would be slightly lower in relation to surrounding air temperatures during hours of sunshine. In the winter, the heavy collection of snow in this grass to bush border area would create higher ground temperatures and much insulation for small animals and plants.

Area B on this site consists of the same type and density of vegetation cover as the north part of Area A and would therefore resemble it in part. Area B would receive less solar input and therefore be cooler than open surrounding areas (such as Area D) during sunshine hours. But the windbreaking effect of the bush would prohibit cooling and evaporation of water and therefore cause some warming effect. During periods of little sunshine this area would show a slight warming trend compared to open surrounding areas as the heat would be held in this moister, quiet area. The ground temperatures of Area B as compared to Area A would be generally cooler due to a lack of direct solar input. However, the heat would be held in the soil more effectively in Area B. During the winter, bush in Area B would collect a large amount of snow, however, possibly not as much as in Area A because of Area B's central location in the dense bush. Area A would experience more of a piling effect than Area B. The snow cover in Area B would however give more insulating cover to the ground and small mammals than Area C which would be windswept.

Area C lies in an opening in the bush, is slightly raised and is covered with low grass and an occasional shrub. The wind breaking effect of the surrounding bush stops any cooling effect the wind has, and the openness of the area allows for direct solar heating. The air temperature in this area during the sunshine hours is therefore higher than in Area B. Increased ground penetration by the sun due to the lack of heavy vegetation cover results in higher soil temperatures in Area C than Area B. The humidity is lower in Area C than in Area B and Area A due to Area C's raised open aspect, but humidity is constantly being fed into the area by surrounding bush and nearby water bodies. At night the carbon dioxide yielding properties of the dense vegetation surrounding the area would raise the carbon dioxide level significantly creating an adiatherminous condition which would help to trap rising long wave energy and maintain it in lower ground areas as sensible heat, thus increasing the lower air level temperatures.

During the winter season a great amount of snow would accumulate on Area C. This snow cover would provide excellent ground insulation and would maintain a relatively stable ground temperature. Area D, in contrast to the other 3 areas is artificially raised 10 inches and has little or no wind break around it. Manicured grass is the only vegetation covering the area thus allowing for more extremes in the heating and cooling effect of diurnal solar cycles. This lack of impeding vegetation would allow substantial heating during sunshine hours when there is nothing to interfere with the long wave radiation penetration of ground and air. Similarly, there would be greater cooling at night because of the lack of water, vegetation or other heat retention factors. This area is also subject to a greater loss of water causing sporadic cooling by intense evaporation and much ground air movement, principally eddy diffusion and lower air mixing winds. The humidity of the soil and air as compared to the other areas would be low due to the lack of water retention mechanisms, and as caused by the packing effect on the soils through use of the grounds as play areas.

During the winter season Area D would have some snow cover, but most of it would be blown to lower lying vegetated areas such as Area A. This lack of insulation causes extreme cooling of the ground and ground air layers rendering it unfit for a winter habitat for most animals. Indeed the openness of the area in summer also renders it unfit as habitat for many animals.

b) Gravel Pits Site

The gravel pits are in the extreme north end of the city, approximately 3 miles north of the International Airport and would most closely simulate the climate of the airport. There are three basic representative types of areas on this site and are demarked as are those for the on-school grounds site.

Area A (Fig. 33) consists of a hill approximately 18 feet high with a basal area of approximately 30 square feet. There is light bush and grass vegetation at the base of the hill and progressively thinning grasses as the hill rises. The top of the hill is worn by foot paths and sections of the hill are bare. The northern side of the hill base is bordered by the water of the gravel pit. The west to south section of the hill base is lightly covered by short grass vegetation and to the south and east the hill is covered by tall grassy vegetation. The area surrounding the hill is flat with little in the way of vegetation.

The exposure of the top and sides of the hill to any and all wind tends to have a cooling effect on the surrounding and lower strata (ground) air temperatures. But the raised aspect and direct exposure of the hill through lack of dense vegetation makes for greater warming trends during sunshine hours and, conversely, greater cooling trends during an absence of sunlight. With the surrounding terrain being flat and almost free from vegetation Area A is subject to extreme influences of the large scale weather masses. The north side of the hill, bordering on a body of water would experience greater humidity (especially at the base of the hill) than the south side. The temperature stabilizing effect of the water body would help, to a certain extent, to stabilize the air temperature at the base of the hill. This effect would be lost during windy periods because of the area's open exposure. The south side of the hill could have a generally warmer lower-air temperature because of the wind breaking effect of the hill.

The soil temperatures in summer may be warmer than in vegetated areas because of sun penetration and lack of moisture near the top of the hill. In winter this area would be colder than in vegetated areas because of a lack of snow cover, wind breaking vegetation and topography. The bare top of the hill would, of course, show the most extreme effects of changing weather systems.

Area C is slightly depressed and contains residual run off water in scattered pockets well into the summer. The area contains an abundance of tall grasses, willows and other forbes. There are hills on the east and west as well as bushes to the north to break the wind and generally protect the area. Area C also opens out into the gravel pit and is effected by it to a greater extent than was area A.

Humidity in Area C should be much higher than in Area A as Area C is influenced by the presence of water and vegetation. The air and soil temperature should be much more stable, there should be far less chance of desication than on the hill and passing weather systems should have slightly less effect on the area. This area also supports a variety of wild life. In winter Area C would act as a snow trap and have a great deal of insulating snow cover, another way in which it is better suited to a wildlife habitat than Area A.

Area B is similar to Area C except that it is entirely over a water body, and the heat storing capacity of the water would have a greater effect on the low lying air temperatures.

In comparing the on-school grounds site to the gravel pits site we would likely find the gravel pits site relatively cooler on other than sunny days, because of its open aspect, the depth of the water in the gravel pits and the fact that the land around the site is an open cultivated field. The on-school grounds site is more closed in by bushes and buildings and would retain heat better.

c) Grassland Site

The Grassland Site is topographically relatively flat. Grasses and bush vegetation cover two thirds of the site, with poplar stands inhabiting the remaining area. Adjacent land is in agricultural production and is open and cultivated.

Area A (Fig. 34) has a sandy porous soil and is presently supporting only grasses. Due to this area's flat topography and lack of impeding vegetation passing weather systems and diurnal solar heating greatly effect the climate of this area. As a result the surface soil retains little moisture and the area supports only relatively drought tolerant vegetation.

Area B is also flat, vegetated by grasses and dry land plants, contains soil which loses moisture fairly easily, and is protected from the north wind by a poplar stand. It would therefore tend to be slightly warmer on windy days than A, but cooler during hours of intense solar radiation. There is a greater likelihood of Area B being a valuable wildlife habitat because of its proximity to the protection of the poplar bush.

Area C is inside the poplar stand. The ground in this area would therefore receive less heating effect of the sun and the ground air layer would be cooler than Area A or Area B. The humidity would be higher because of a decrease in wind velocity that would normally remove the moisture trapped by the vegetation. The extra moisture, during hours of intense solar radiation, would have a cooling effect in the bush that is lacking in the open field. The microclimate of the bush, Area C, would be far more stable and discernible than the open field, where the air strata would be intermixed by open air circulation.

d) Marsh Site

The marsh site is climatically rather similar to the gravel pit site. The site is open to wind action on all but one small portion of its western edge where a small forb and poplar stand and man-made hills occur (Area A) (Fig. 35).

The water in the marsh is relatively shallow thus becoming very warm in the summer and freezing solid during the winter. This severe climatic alteration from summer to winter determines the communities of flora and fauna that are able to survive this marsh type habitat.

During the warm summer months the relative humidity of Area B would be high relative to areas beyond the marsh habitat. This occurs because of the heating and eventual evaporation of the shallow water in the marsh. The humidity would be maintained at a high level near the shore line of the marsh because of the thick stand of typha and phragmites.

e) River Bottom Site

The river bottom site has a basic slope from west to east with sharp slopes leading down to the river's edge on all sides (Fig. 36). The centre of the site is open cultivated ground with a border of river bottom vegetation along the river's edge. The entire site is a point of land enclosed by the Red River. Area A is on the edge of the cultivated land and has a tall dense stand of trees to the west and north. Trees protect this area from the cooling wind and yet leave the area open to sunshine most of the day. These factors combine to create a warming trend in this area. The black body effect of the cultivated soil and the easy loss of moisture through evaporation and lack of water retaining vegetation also tend to prevent higher soil and ground air temperatures. Being sloped toward the east and therefore the morning sun, the ground surface is directly exposed to intense solar input for a long period each day. Being close to a densely vegetated area there may be some slight moisture and cooling air masses moving into Area A from adjacent areas. This could affect the air temperatures especially during periods of little solar input. Also being close to the bush there may be some effect on temperatures by the adiatherminous properties of carbon dioxide which is released by the vegetation during times when solar radiation input is low or absent. During anything but a south or east wind the microclimate of Area A should be reasonably stable with little to interrupt the air stratification. In winter this area should accumulate heavy snow cover. In this respect Area A of this site is similar to Area A of the on-school grounds site. Area B on this site is quite similar to Area B in the on-school grounds site, both being enclosed by tall vegetation with heavy undergrowth to hold moisture; a good amount of ground moisture and a nearby body of open water. Area B on this site however, is sloped and its surface water runs off into the river whereas Area B on the on-school grounds site retains its surface water long into the summer. This area in the river bottom site then would be slightly less humid.

Area C, on this site is similar to the north side of Area A, of the gravel pits site. Both open on to a large deep body of water and are steeply slanted. The vegetation in Area C, would tend to trap water vapour in the air and therefore have high humidity. The vegetation also shades the air from direct sunshine therefore causing the area to be cooler both in air and ground temperatures. The river bottom site is also more enclosed by vegetation which is a more effective wind breaking mechanism than the hills on the gravel pit site Area A. Thus the vegetation cuts down on water loss and other mechanisms for removing heat from the land surface.

Area D, is similar to Area A, in all but two major aspects. The ground surface is covered by mowed grass in Area D rather than being tilled soil and the area is more sheltered from the south and east winds. The immediate effects of these factors is to stop wind and water evaporation, therefore building up humidity in and above the surface soils; it allows less intense soil heating by solar penetration (grass cover inhibits black body effects of soil) and also less cooling by water evaporation. The microclimate would be maintained to a greater extent here than in Area A because of less air mixing by cross currents of air at lower levels.

In winter, Area D would probably be better suited for a wide range of wildlife habitat because of its good protection from winds and the variety of depths of snow cover it would receive. The centre of the open field probably being shallowly covered while peripheries would probably experience deeper accumulations of snow.

f) <u>City Site</u>

The microclimate of the city site (Fig. 37) is going to be markedly different from any we have seen so far. The total substitution of artificial inanimate structures for the natural biological surroundings of the other sites makes for a very obvious change in microclimate.

The topography, though it has been altered from its natural conditions is virtually flat. That is unless one wishes to consider the established buildings as part of the topographical foundation on which the weather acts and climatological factors interact. The lack of vegetation and permeability of the ground surface to precipitation and the artificial and immediate removal of all lying surface waters produces an unnatural lack of air and soil humidity. The lack of ground water percolation interferes with natural replenishment of ground water tables, and the enormous consumption of water from this area results in an unnatural water table level (see discussions on hydrology). Though there are many tall buildings to act as wind breaks, their linear arrangement creates a wind tunnelling effect, and in most cases supercedes the wind breaking effect they have. This leads to further removal of any moisture near the ground surface, unless the incoming wind is more heavily laden with moisture than the area it penetrates. Where the wind is stopped by buildings, the calm air is trapped between the tall structures on either side of the street and air circulation is stopped. Lack of vegetation leaves the buildings and ground surfaces open to direct and intense solar radiation. For the most part, today's construction materials are designed to reflect rather then absorb solar energy, but use of metals and tars which collect heat cause greater than normal ground temperature levels, therefore lowering the air temperatures.

The high levels of particulate materials and gasses in the air from industry and commonly used heating structures effect the micro-climate. The particulate matter in the air increases normal atmospheric albedo and blocks the incoming solar energy, therefore decreases its heating effect. However, the high level of carbon dioxide in the air from internal combustion engines, traps the solar energy and produces a green house effect that adiatherminous materials such as glass have. Carbon dioxide lets the solar radiation in but only lets long wave-lengths of around 2.5 to 11.3 escape, trapping all other high energy wave lengths. As well, the presence of huge structures with their own integral sources of artificial heat, which themselves emit long wave radiation, all culminate in the "Urban Heat Island Phenomenon". Even in winter when the air temperatures are naturally low and the snow cover should be insulating the ground surfaces from further incoming solar radiation, the practice of snow removal and artificial heating from a number of sources maintains the above mentioned effect. In winter the average sized Canadian city can be up to $6^{O}C$. warmer than surrounding rural areas.

5-27 Historical, Existing and Proposed Resource Use

a) On-School Grounds Site

The historical land or resource use of this site was that of agricultural production. 1948 aerial photographs show that the major part of this area was under cultivation, while the remainder was sown to tame grass.

The area is presently being used as school grounds and as a City Park.

b) Gravel Pit Site

Formerly this area was commercially mined for the sand and gravel deposits it held. Now that the mining operation has been completed the area is not being commercially utilized.

The area receives some utilization by motorcycle enthusiats who utilize the hills as an obstacle course.

The owners of this property are waiting for the urban fringe to approach so they may subdivide the acreage for a housing development.

c) Grassland Site

Historically this area was utilized as natural grazing land for livestock. At present there is no discernable use being made of the site.

d) Marsh Site

This area is presently being utilized as a refuse dump area.

However, the City of Winnipeg is now negotiating with the Municipality of Springfield, to eventually class this area as a nature park.

e) River Bottom Site

This area was utilized as a market garden until the spring of 1974. At that time the City of Winnipeg purchased the land and will be classing it as a nature park.

5-28 Environmental Impact

a) On-School Grounds Site

The major environmental impact on this study site has been the alteration of the areas drainage pattern. When Dalhousie School was being built, large amounts of fill were placed to raise the foundation of the school. This impeded natural drainage of the surrounding site and has caused an alteration in the vegetation regime. The large playing field in the school ground has also been raised by filling and this too has impeded the natural drainage patterns.

Burnt garbage can be located in the edges of the foundation fill, and will degrade surface and groundwater flows as water percolates through the garbage.

There have been several openings cleared in the forested area. These openings have resulted in an alteration of succession and edge effect of the surrounding flora.

The numerous burned areas on the site and the widespread litter reduce the aesthetic value of the natural flora and fauna.

b) Gravel Pit Site

Commercial activity developed this site after it was determined that economically viable sand and gravel deposits were located in the area. A severe environmental impact occurred on this site as the overburden was removed and the sand and gravel deposit mined. The tailing and overburden that were left in piles beside the open pits or spread out over the area were sterile and devoid of resident life for many years.

Now that the overburden and tailings are becoming inhabited by resident flora and fauna the only major environmental impact is that caused by motorcyclists. As the overburden and tailings material is composed of a great deal of clay material, it can become compacted and rendered unsuitable for organism invasion and habitation.

Motorcyclists using the hills as climbing and obstacle devices have impacted the soil and de-vegetated areas of the site.

Littering is also an environmental problem on this site.

c) Grassland Site

To our knowledge, there has been very little environmental impact on this site. There is some evidence to indicate that the area may have been completely cleared of bush at one time. Also some livestock grazing may have occurred which would indicate why the small clumps of bush have not expanded their borders to overtake the site.

d) Marsh Site

The major environmental impact that has occurred on this site was the impeding of the drainage system by the construction of the Red River Floodway. The marsh habitat has developed as a direct result of this impeded drainage.

Refuse dumping by the local residents has degraded the aesthetic value of the site and may be degrading both surface and groundwater.

e) River Bottom Site

The only major environmental impact on this site has been the removal of the deciduous-broadleaf forest from the central portion of the site. This removal was carried out by the previous owner to facilitate a market-gardening operation. Because this site was privately owned the portion that was not utilized for commercial market-gardening was maintained in its natural condition.

5-3 City Site

The information on the city site has been presented in the following manner because of the inate differences between it and the remainder of the specific study sites.

a) Physical Geology

According to Bannatyne (1973) the geology of the Winnipeg area is constituted by a uniform flat plain, known as the Lake Agassiz Plain left from retreating ice sheets 10,000 years ago. A rich organic layer overlies the layered or varved Lake Agassiz clays. In the downtown area these clays extend down to a depth of seventy feet where the "hardpan" or glacial till layer if found. Below the till layer lies the limestone bedrock.

b) Hydrology

According to Render (1971) the Winnipeg area is underlain by an extensive carbonate rock aquifer which currently yields approximately 3 billion gallons of water per year. Groundwater has been extracted from this aquifer for a period of at least 130 years. During this period over 200 commercial and industrial wells and thousands of private wells have been installed. Total pumpage has varied from less than 1 million to ten million gallons per day. This extensive confined aquifer occurs in the fractured and jointed upper 100 feet of the thick paleozoic carbonate rock sequence underlying Metropolitan Winnipeg. The karstic bedrock surface slopes towards the Red River Valley from recharge areas located in uplands along the borders of the Red River basin. The bedrock surface is mantled by 30 to 200 feet of glacial drift. Groundwater withdrawals have created a major drawdown cone in the central industrial area of metro Winnipeg. Pumpage varies from 5 million gallons per day in the winter months to 10 million gallons per day in the summer air conditioning period. The greater summer withdrawals cause temporary declines in piezometric surface of more than 20 ft. in central Winnipeg and approximately one foot along the outer fringes of the urban areas, (Fig. 38).

c) Soils

Ehrlich, et al 1953 states that the Winnipeg area is dominated by the soils of the Red River association. The Red River Soil association consists of black earth, or black earth-like and associated soils that have developed on the lucustrine fine clay deposits in the central basin of glacial Lake Agassiz. All the soils of this association, at one time or another have been under the influence of excessive moisture, and (due to the gradual improvement in drainage) are now passing slowly through various stages of transition from poorly drained to better-drained conditions.

The downtown core was presumably, before construction of the city, part of the Fort Garry association of the Red River clays. The Fort Garry soils were generally developed on a clay and silty clay mantle which lies over strongly calcareous silty and fine sandy clay dolomitic sediments. In cross section this soil has an "A" or surface horizon which is usually 7 to 10" thick but which may extend 30" downward in large pendulous tongues. This "A" or surface horizon consists of very dark grey clay to silty clay which may show hard presmatic columns in the tongues when dry, and which is plastic and sticky when wet, neutral to slightly alkaline, and grades sharply into a light grey horizon that lies over light grey to pale yellow, and highly calcareous fine sand to silty clay.

d) Social Factors

In discussing the city as an environment, it must be said that man is changing his habitat significantly. The environment governed by natural forces is giving way to an unnatural environment, structured almost entirely by man. Ecological forces still operate but not as in a natural setting. The city today is an industrial-technological complex. Gone are the merchantile-trading centers of the 1800's and their associated roles. Much of the stimuli that impinge on urbanites today were unknown before. The scale and rate of growth have introduced qualitative changes in urban living which requires new modes of adaption.

The noise, polluted air and multitude of congestions due to too many people is said, by urban psychologists, to demand too much psychological energy in learning to cope with the multiple and conflicting stimuli. The city's vulnerability to "information overload" has consequences for individual behavior. The specialization of the city and its high density emphasize the common denominators of day-to-day existence, at the cost of long range and more human involvement in living.

According to Ottelson et al 1974, sociologists have identified the evolution of urban norms, like non-involvement, impersonality and aloofness. This can be seen as a response to an overloaded environment. Where the screening of sensory stimuli can lead to blase attitudes, or even to deviant and bizarre behavior. The city is a hiding place where there is more tolerance for deviance, for often people in cities who show neurosis and psychosis bring them with them from small towns or the country.

There is speculation as to whether crowding or density is the main factor in bringing out the city's pathology. Some say that overcrowding is the most significant factor in stress, poor health, sexual frustration and feelings of dissatisfaction. While others say that high-density neighbourhoods invite social interactions or "contagion" that leads to anti-social behavior.

Yet many people like to live in a city. The city as an entity is composed of neighbourhoods, districts and areas which fit into a social mosaic. Often, certain sections provide people with an identity based on territory or a sense of place. The city is also a place to fulfill goals and ambitions. It is an economic center where money can be made to fulfill those goals. Many people view the city as an intellectual and politically enriching experience.

It therefore provides a host of different environments to different people, depending on their needs and desires. The quality of the urban environment is difficult to judge, for physical parameters are not enough. In comparing it to a more natural, less populated area, the city may be far ahead for one individual yet may be totally negative to another. Environmental quality is a subjective perception of what is desirable and necessary and therefore the best common denominator is usually sought.

e) Architectural Value of Vegetation and Space

Traditionally the downtown core of any city has been a major focus of economic and social life. As the city expands, space in the central business district becomes more valuable and the buildings tend to go up rather than spread out. Business and government offices have traditionally been given priority over such trivia as open spaces and green areas. Even architectural design has taken a back seat to economic and functional factors. However, increasing awareness of environmental factors relating to crowding and stress has caused a revolution in architectural design. According to Rutledge (1971) utilization of space and density networks have become important considerations for planners and architects. The need for green areas and aesthetically pleasing environments in the down town area have also become major issues in urban planning and renewal. It is still debatable as to how important the natural environment, or some semblance of it, is to the well-being and peace of mind of an individual but certainly open spaces can give urbanites a psychological rest from their crowded environment. Open spaces may also provide a place for more relaxed communication, leisure activities or just a place to be alone. Landscaping may be added to perform certain architectural functions such as forming spaces or directing circulation. Plants can provide detail, interest and defer wind. Screening can supply shade, buffer odours and suffocate noise. Urban parks can offer these opportunities which are badly needed in a crowded downtown core. Winnipeg has about 10 acres that could be classified as open and green within the built up urban area around Portage and Main. They are not readily discernible from the general downtown setting but more urban parks are on the drawing board. Winnipeg's main streets are also very wide which gives a sense of spaciousness to the downtown core and also facilitates better traffic movement. Generally the central business district in Winnipeg is not unhealthily crowded but the design of urban renewal will have to include open spaces and green areas if Winnipeg is to remain a "nice" place to live.

f) Air Quality

Air quality of a city is affected by many factors; numbers of people, degree of industrialization, type of local activities, climate, topography, presence or absence of vegetation, etc. It is therefore difficult to strictly compare the air quality of any two cities. Different parameters must be taken into account to discover an accurate measurement of ambient air quality.

The purpose of studying ambient air quality is to assess the pollution levels in the air that affects the most people. In choosing air quality standards, the least harmful levels of pollutants must be decided on by reviewing the literature. Strict standards must be set, particularly for the city, because of the high concentrations of people. However, because of political interests, there is always a margin of error or compromise, where air quality standards are lowered somewhat to allow for, perhaps an important industry to locate in order to create employment, etc. In Winnipeg, although no air quality standards have been set by law, four sample stations have been established under the National Air Pollution Serveillance Program; (1) Union Stock Yards - an industrial sample station, (2) Kennedy at York, the central business district; (3) Hartford at Aikens and (4) Portage at Woodlawn which are both residential areas. (Fig. 39). High dustfall levels are experienced in the downtown area (e.g., Smith at King) as a result of car and truck traffic stirring up the larger particulates which settle out under gravitational pressure (Fig. 40). Generally, during the fall and harvest period, high dustfall and particulate levels are experienced because of dry conditions and the wind blowing in the dust off the prairies. (Figs. 40 and 41). High sulphur dioxide levels (Fig. 42) for the downtown site are a result of a local oil-burning source and subsequently the sample site has been moved. Otherwise, at the downtown site, the highest accumulation of pollutants occurs at rush hour throughout the year and particularly in the spring when the sand and particulates melt out of the snow and are stirred up by cars and trucks (Fig.41). A similar effect occurs in St. Boniface where there are still many gravel roads and major truck routes. The air pollution levels in most suburbs are low depending on the proximity of a local industry or the airport.

The darkening potential of the pollutants in the atmosphere or soiling index is greatest in the downtown area where the concentration of car exhaust is the greatest (Fig. 43). These values however, are also dependent on the local activities at the location of the sample station. Lead concentrations also occur in response to the burning of fuel particularly along truck routes or in the urban core (Fig. 44).

Smog and haze do not occur often in Winnipeg because of the rare occurrence of temperature inversions which do not allow the pollutants to dissipate. Wind has a large effect on air quality in Winnipeg because of its low-lying relief and the presence of agriculture around the city. The absence of a large forest cover around the city gives the wind a clean sweep through Winnipeg, bringing dust at harvest time but also cleaning away much of the air pollution for most of the year.

g) Noise Pollution

Noise pollution may be defined as energy infusion into the environment by sound-wave transmission.

According to Ottelson et al (1974) noise is probably the most common urban stressor. Automobiles, construction work and sirens all contribute to the characteristic din of the downtown core. Recent concern over noise pollution has been directed at establishing standards above which noise can be damaging to health. The effects of noise on an average person may not be readily discernible but when added to the general "stimulus overload" it becomes another input that interferes with efforts to cope with everyday life.

Noise pollution research has just began in Winnipeg. The Environmental Protection Laboratory of the Department of Mines, Resources and Environmental Management is running several studies on noise levels throughout the city. These studies indicate that the most disturbing noise levels occur in residential areas adjacent to truck routes such as Nairn Street and Jubilee Avenue. Heavy and continuous traffic along residential streets may result in certain physiological responses such as loss of sleep, which may be more stressful than a sonic boom, because of the cummulative effect. Noise in the downtown area, which runs at 65 decibels may rise to 80 decibels at peak rush hour times. (e.g., Portage at Kennedy or Portage at Carlton. Figs. 45 and 46). This type of noise, however, is not considered as stressful as the regular, frequent levels mentioned above. Typical residential areas experience noise levels of 45 to 60 decibels, caused primarily by local car traffic, (e.g., Inkster at Aikens, Fig. 41). Readings taken in a suburb adjacent to runway 10, the busiest runway at Winnipeg International Airport sometimes exceed 95 decibels, which is considered harmful. Again, these levels occur at infrequent intervals and although they are annoying, have not proved to be physiologically harmful.

Generally noise levels in Winnipeg are not severe, but in some areas, they may be creating a lot of nuisance or, more seriously, physiological and psychological stress. Tolerance to noise is very subjective and thus, strict standards must be set to ensure a healthy environment.

Chapter 6 Conclusions

The site selection, inventory and analysis framework that has been developed in this practicum and utilized on six sites in the Winnipeg area can be applied to any area in Manitoba. The parameters that have been suggested for inventory and analysis are felt to be those of primary importance to the basic philosophy of environmental education. The framework is meant to be used by individuals who are embarking on an environmental education program and require assistance in selecting and establishing an information base on various types of environmental study sites. It is felt that if this framework were applied to any natural or man-impacted site in Manitoba that the body of information produced would be ample basis upon which to establish an environmental study program for grades one to twelve.

The information that is produced is meant only to provide a basis upon and around which an environmental study program can be developed. It will not provide a ready made curriculum or activities schedule.

As we are always dealing with dynamic factors on the study sites this body of information must be updated and revised as time progresses, however, this revision process is in itself a learning activity and can be incorporated into the actual curriculum.

Chapter 7 - Recommendations

To produce a citizenry knowledgeable about the environment they live in and interact with, Manitoba must develop an environmental education program within its school system. Although education is a lifelong process, the most accessible, impressionable age groups are pre-school, elementary and secondary students. McGary (1974) feels that environmental education must reach pupils at an early age and continue as the pupils progress through school. If society seeks behavioral change (in attitudes toward the environment) then let it begin in schools where the mechanisms for bringing about behavioral change already exist.

Stapp (1973) has pointed out that an appropriate role for school systems to assume in environmental education is to provide the opportunity for youth to explore their environment, sensorially, physically, and intellectually, in order to obtain both the motivating concern and the factual knowledge necessary to become an environmentally literate citizen. Schools have a responsibility to alert and inform youth about merging environmental problems and about appropriate ways for them to act in helping solve and preclude these problems.

Stapp feels that more fundamentally if an important "root cause" of our environmental crisis are peoples life-styles, the schools should become a forum for youth to develop and clarify the beliefs, attitudes, and values that are compatible with each individual living harmoniously with his environment.

(i) To establish an environmental education program in Manitoba the various groups who hold a responsibility for education and the environment must work together to formulate an operational plan. Some environmental education is occurring in Manitoba now, however it is only a piecemeal effort fostered by concerned organizations and school teachers. These environmental education pioneers have shown us that the need for and interest in environmental education is present in Manitoba. However, if environmental education is to advance beyond this nymphal stage, organizational structure and support must be forthcoming at the provincial level;

(ii) a provincial scheme must be formulated to faciliate the orderly development and structure of curriculums, environmentally aware teachers, environmental study sites, infrastructure and finances. This provincial scheme should be fashioned by the Departments of Education; Mines, Resources and Environmental Management; Tourism, Recreation and Cultural Affairs; and Agriculture; the Universities in Manitoba; the Museum of Man and Nature; and representatives from private organizations like the Wildlife Foundation of Manitoba, the Manitoba Naturalists Society, the Manitoba Game and Fish Association, and the Manitoba Association of Outdoor Educators.

All of the above mentioned groups have an interest in education and/or the environment. They should all assist in the preparation of a provincial environmental education scheme by putting forward the philosophy of their department or organization;

(iii) in specific regard to environmental study sites, the Provincial Government through its various departments should co-ordinate their establishment throughout Manitoba. The Land Acquisition Branch through powers vested in it by the Land Acquisition Act can acquire land for those departments concerned. The land classification system should be revised to contain a classification for an "environmental study site". These areas could be multi-disciplinary in nature and provide as well for resource management, public recreation and aesthetic value.

Technological progress has made it easier to produce nearly all products except natural environment. The quantity of that resource is fixed, and our capacity for producing it cannot respond to increases in demand, except perhaps through improved transportation in Manitoba's north. Thus the passage of time not only increases the demand for our fixed natural areas but also simplifies the task of satisfying our other needs in ways that don't require the exploitation of remaining natural areas. These areas must be established now for present and future educational, recreational, aesthetic and resource management use.

The Department of Mines, Resources and Environmental Management, as well as using the Land Acquisition Act can utilize the Wildlife Act to acquire land. The Department of Education can utilize the Education Department Act and the Public Schools Act to enter into agreements and make regulations concerning educational matters. The Tourism and Recreation Act gives the Department of Tourism and Recreation the power to establish interpretive and education sites. Municipalities in Manitoba have the power to acquire land under the Municipal Act, for municipal purposes.

Cities may also acquire land, for example, the City of Winnipeg may establish environmental education study sites through the powers of the City of Winnipeg Act. The Manitoba Museum of Man and Nature has the power to acquire and hold land under the Museum of Man and Nature Act. The Wildlife Foundation of Manitoba, through the Act to incorporate the Wildlife Foundation of Manitoba has the power to receive and hold land, in perpetuity for educational purposes;

(iv) private landowners should also have the opportunity to set aside portions of their land either in perpetuity or for a given period of time to facilitate environmental education. In many cases environmental study sites need not be purchased if local landowners are given the opportunity to realize the value of environmental education and have the assurance that their land will not be harmed. A great majority of environmental study sites needed for Manitoba require no form of infrastructure or capital expenditures to make them valuable for educational purposes. If there are enough sites established in any given area of Manitoba and a proper use plan produced to structure the visitation pattern, site degredation can be avoided;

(v) the Province of Manitoba should begin to establish a number of regional environmental education centres and one provincial environmental education centre. The regional centres should be established in various areas in Manitoba as determined by population and regional school systems. They should be established in a unique or multi-habitat area and provide facilities for extended visitation. They will house curriculum development material, instructional media and field equipment. These centres can function as regional libraries or repositories for information on the local, regional, national and world environment.

The provincial environmental education centre should be established in an area exemplifying a unique environment or an environment of diversified habitats. It would have facilities similar to the regional centres plus the following; it would have extended visitation facilities for large user groups. It should be utilized for environmental education research and curriculum design and be a major centre for in-service teacher education. It would house various curriculum models, research information, specialized equipment and pertinent environmental resource information about the Province of Manitoba. Finally, it would generally function as the overall environmental education coordinating centre for Manitoba;

(vi) the resource inventory and analysis information produced by this practicum should be made available to Winnipeg schools who presently have or are considering developing environmental education programs;

(vii) consideration for establishing the six sites analyzed in this practicum as environmental study sites should be carried out immediately. Some sites will be more valuable than others, however urban development could remove three of them if prompt action is not taken;

(viii) as well, if curriculum development and program implementation (specifically in Winnipeg) is allowed to proceed without the concurrent establishment of new environmental study sites, the few already established sites will become overused and degraded.

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A P P E N D I X   I

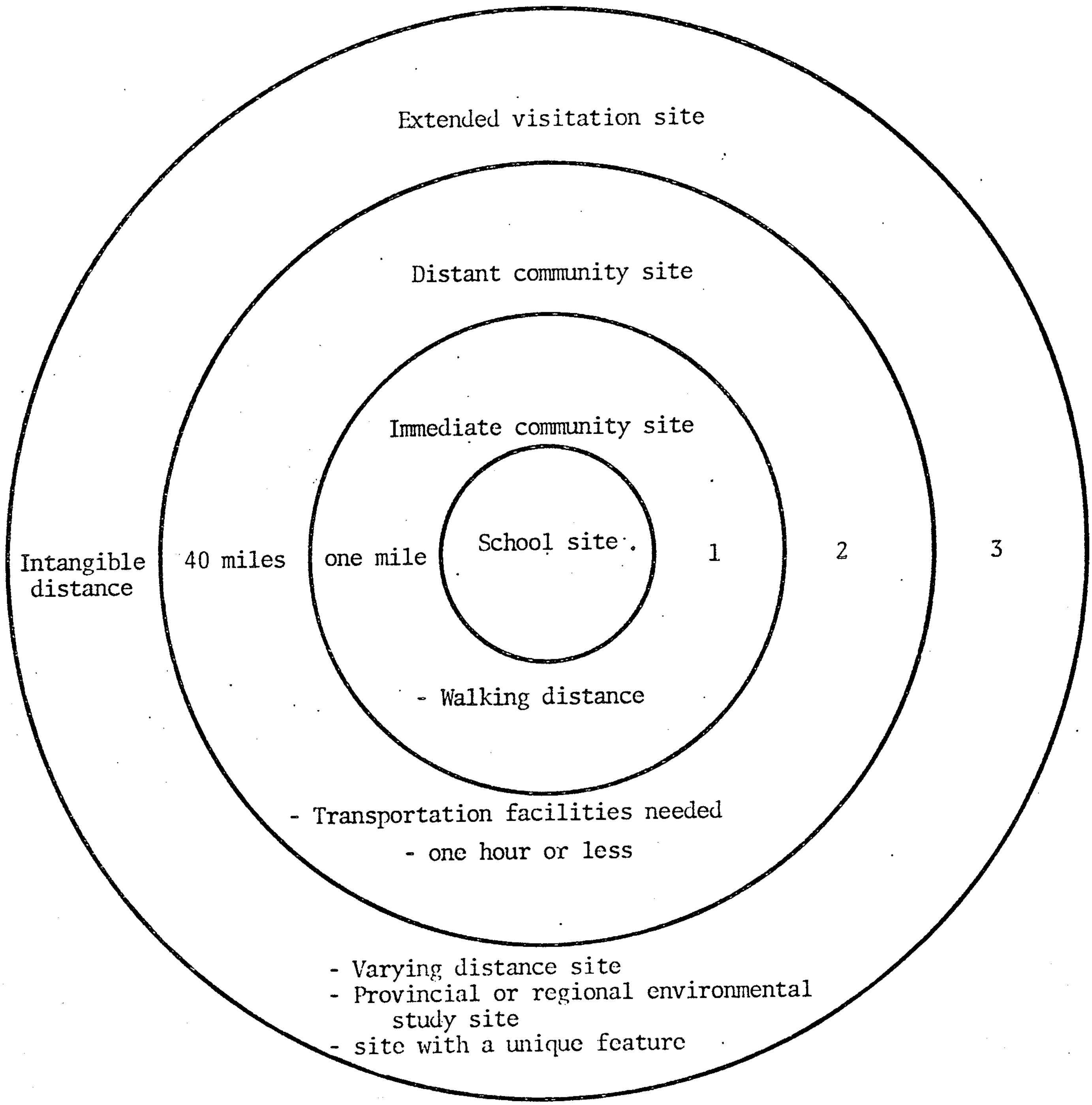


Fig. 1 Concentric Ring System for Site Selection

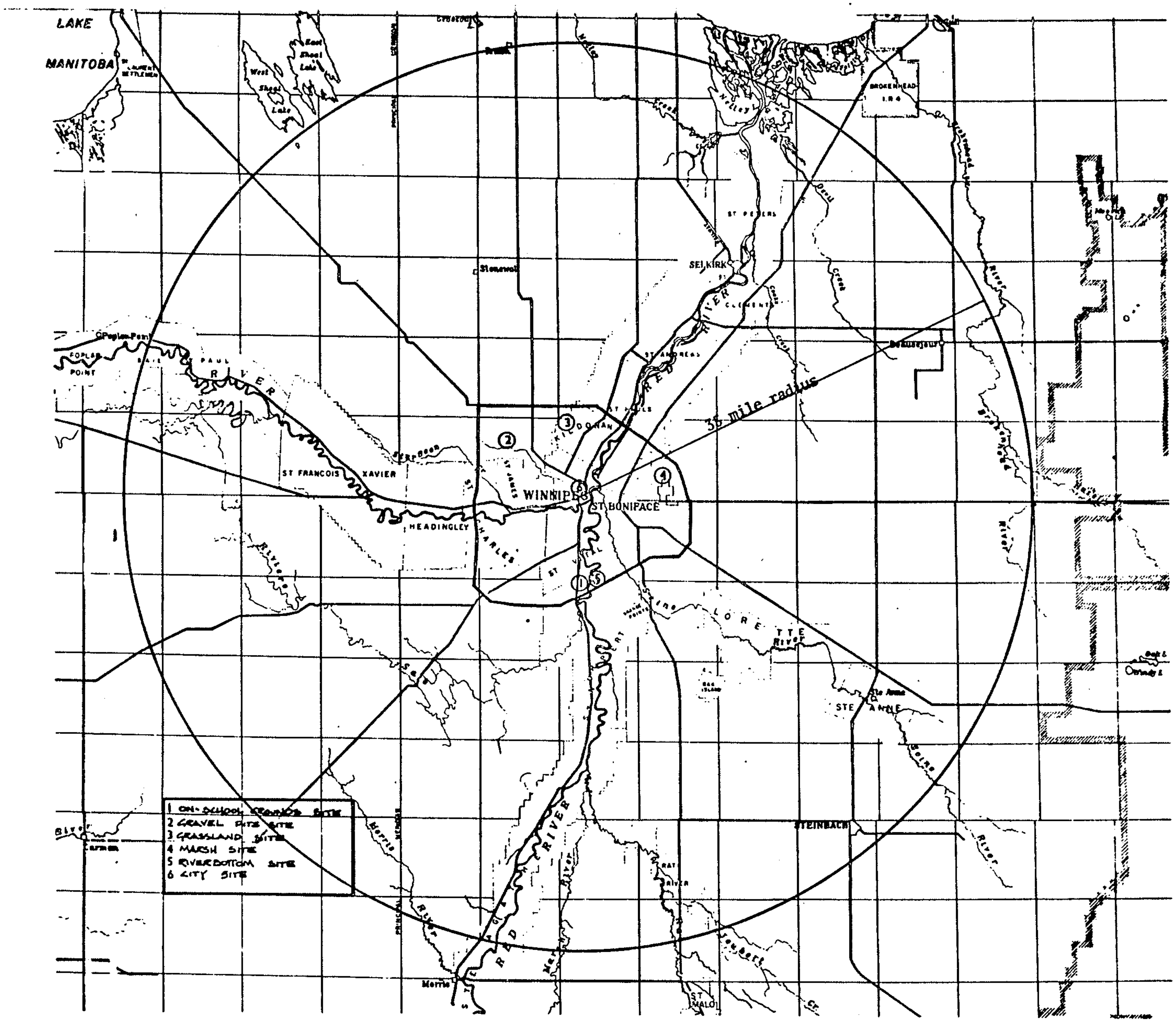


Fig. 2 Regional Study Area and Specific Study Sites

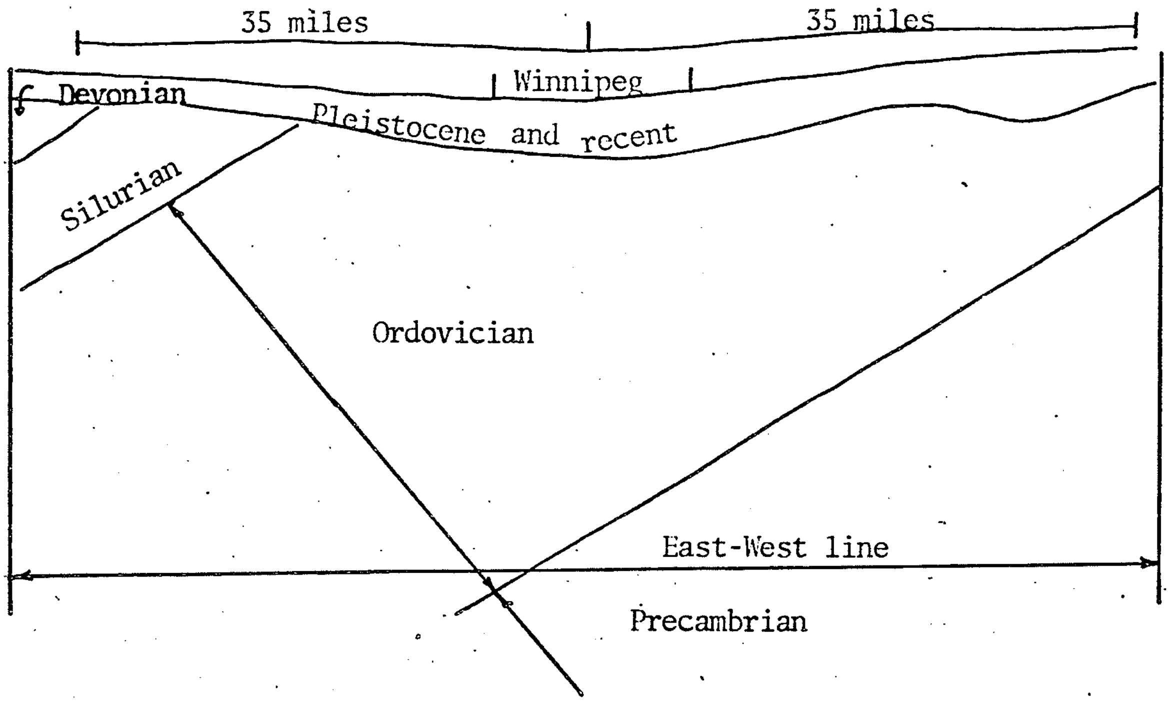


Fig. 3 Generalized Cross-Section of the Geologic Formation through the Winnipeg Area in an East-West Direction.

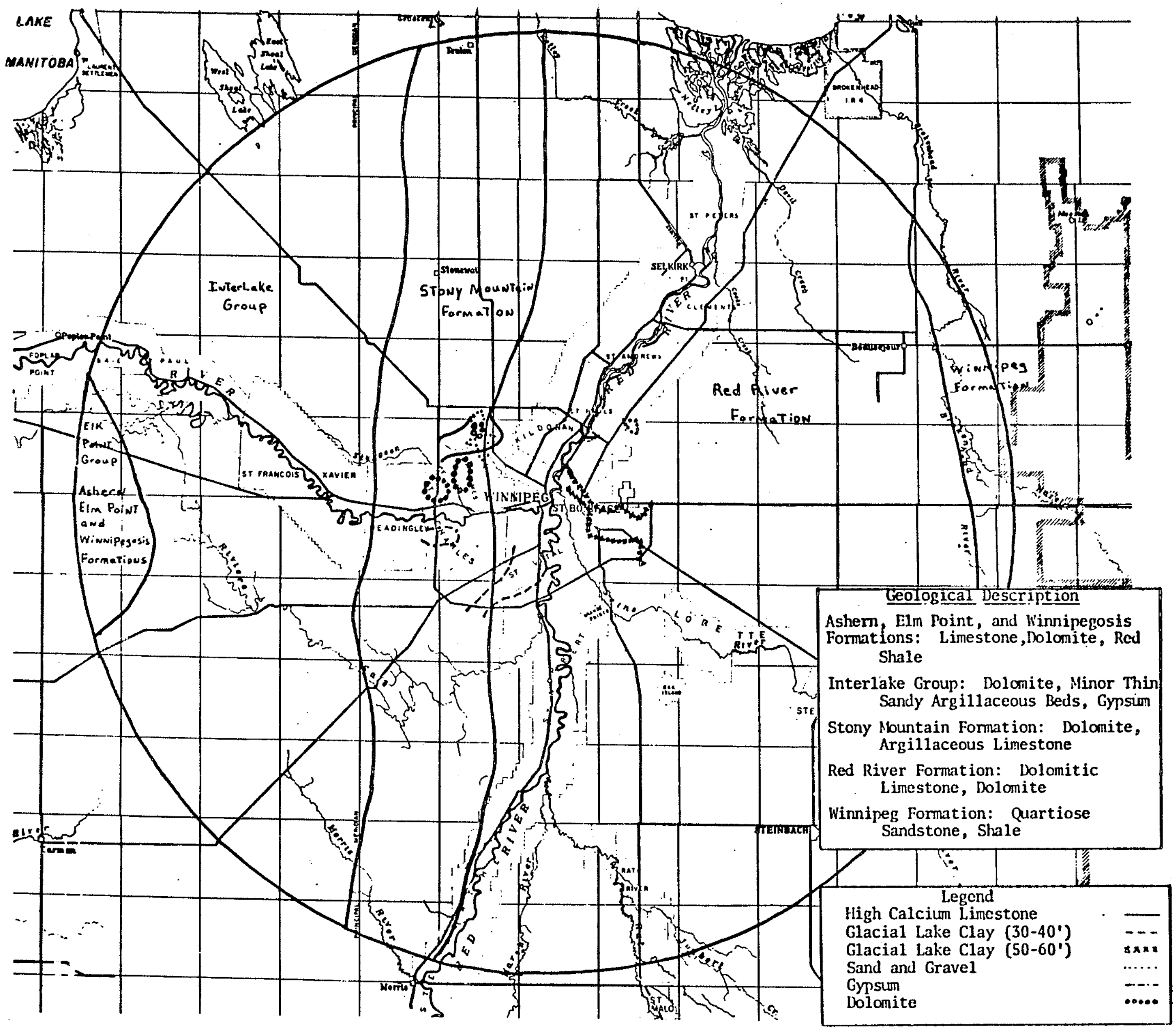


Fig. 4 Minerals and Underlying Geology of The Winnipeg Region

Source: Modified after B. B. Bannatyne 1973 Value of The Mineral Resources, Winnipeg Area. Mines Branch, Department of Mines, Resources and Environmental Management.

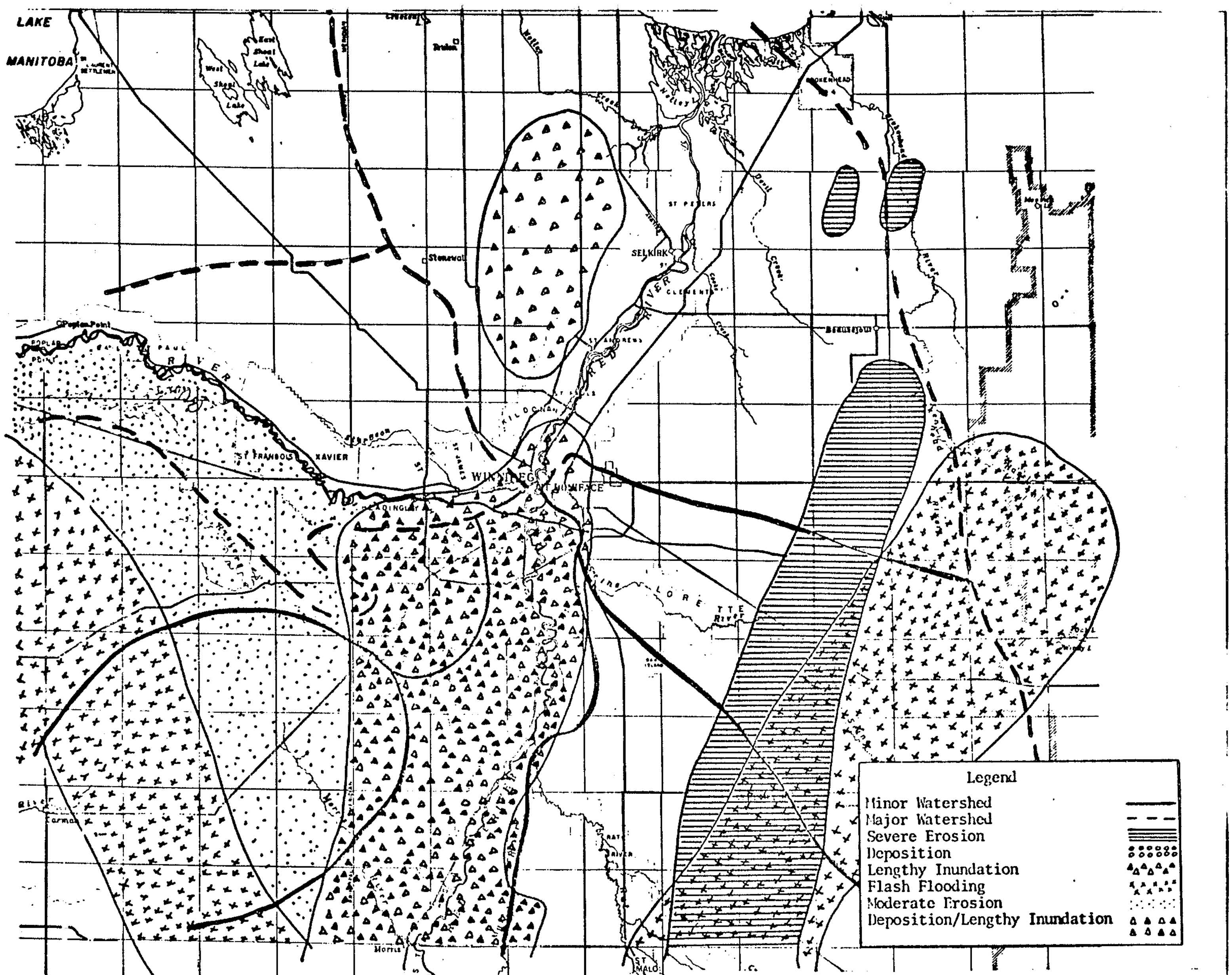


Fig. 5 Regional Hydrology and Watersheds

Source: Modified After Water Control and Hydrology. Regional Analysis Program Southern Manitoba, Regional Development Branch, Department of Industry and Commerce, Province of Manitoba, 1971.

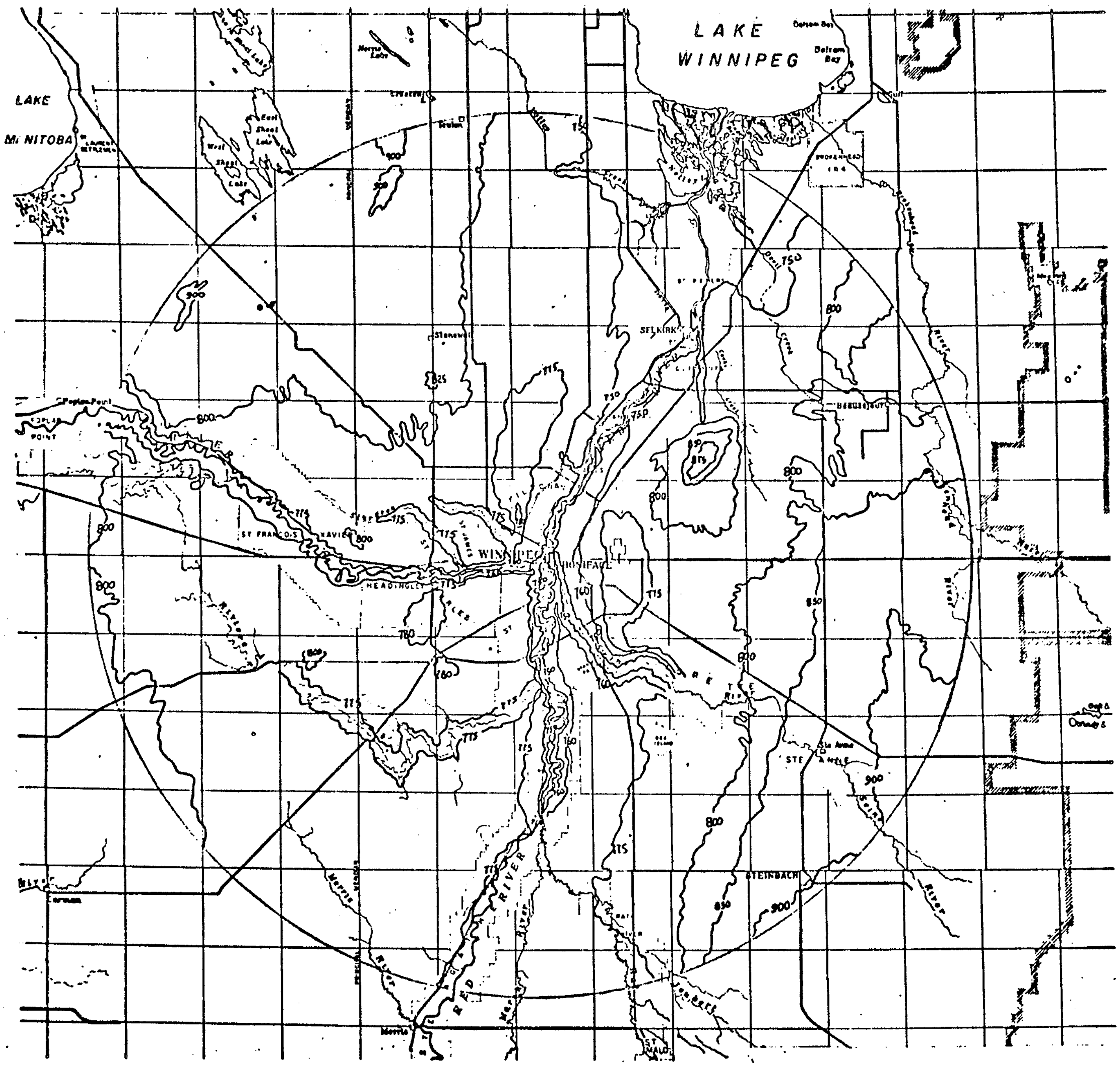


Fig. 6 Regional Topography

Source: Topographic Survey of Canada
Topographic Sectional Maps
73 and 62H

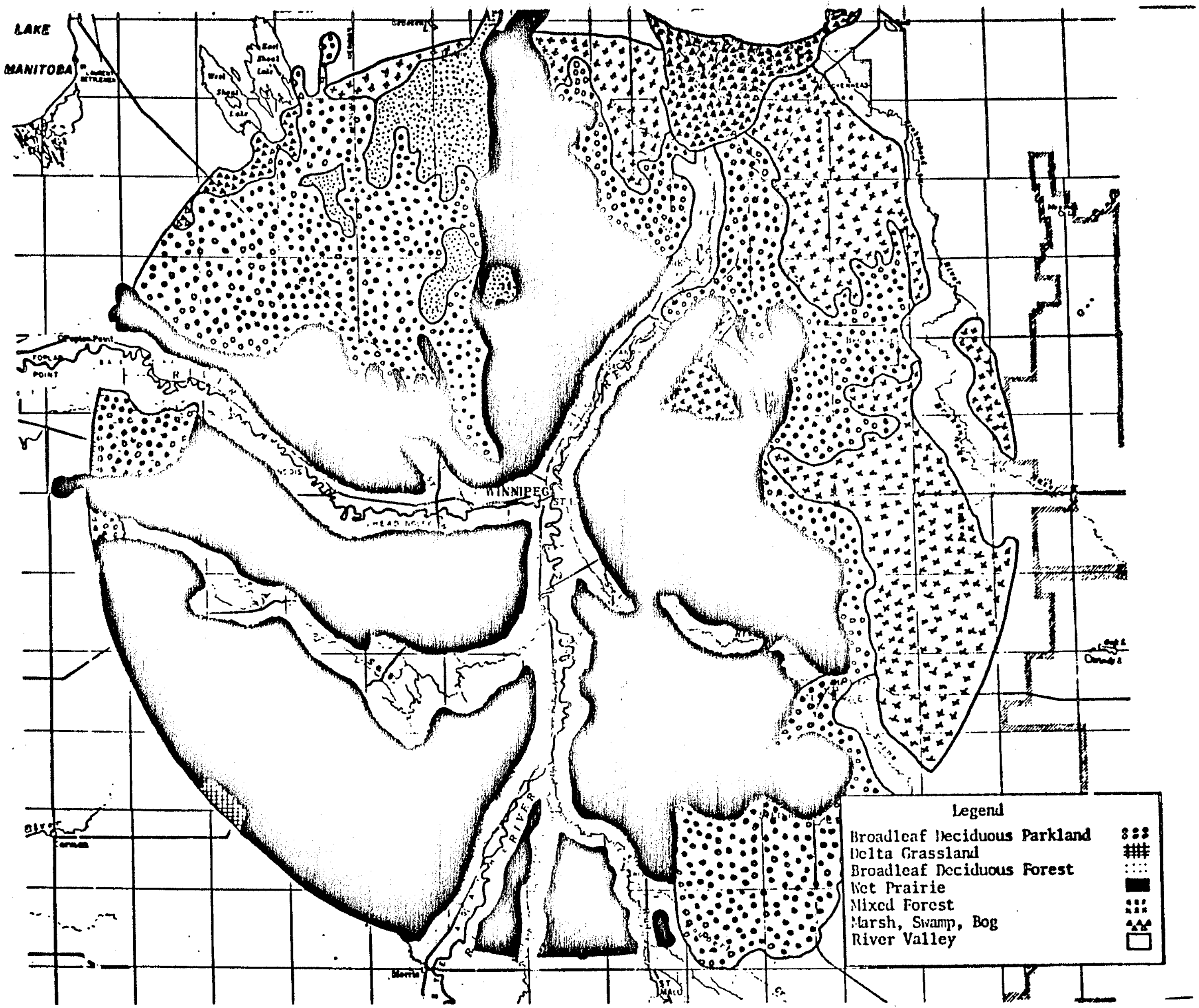


Fig. 7 Historic Resource Types

Source: Modified after E. F. Bossenmaier and C. G. Vogel, 1974 <u>Wildlife and Wildlife Habitat in The Winnipeg Region</u> Planning Division, Manitoba Department of Mines, Resources and Environmental Management.

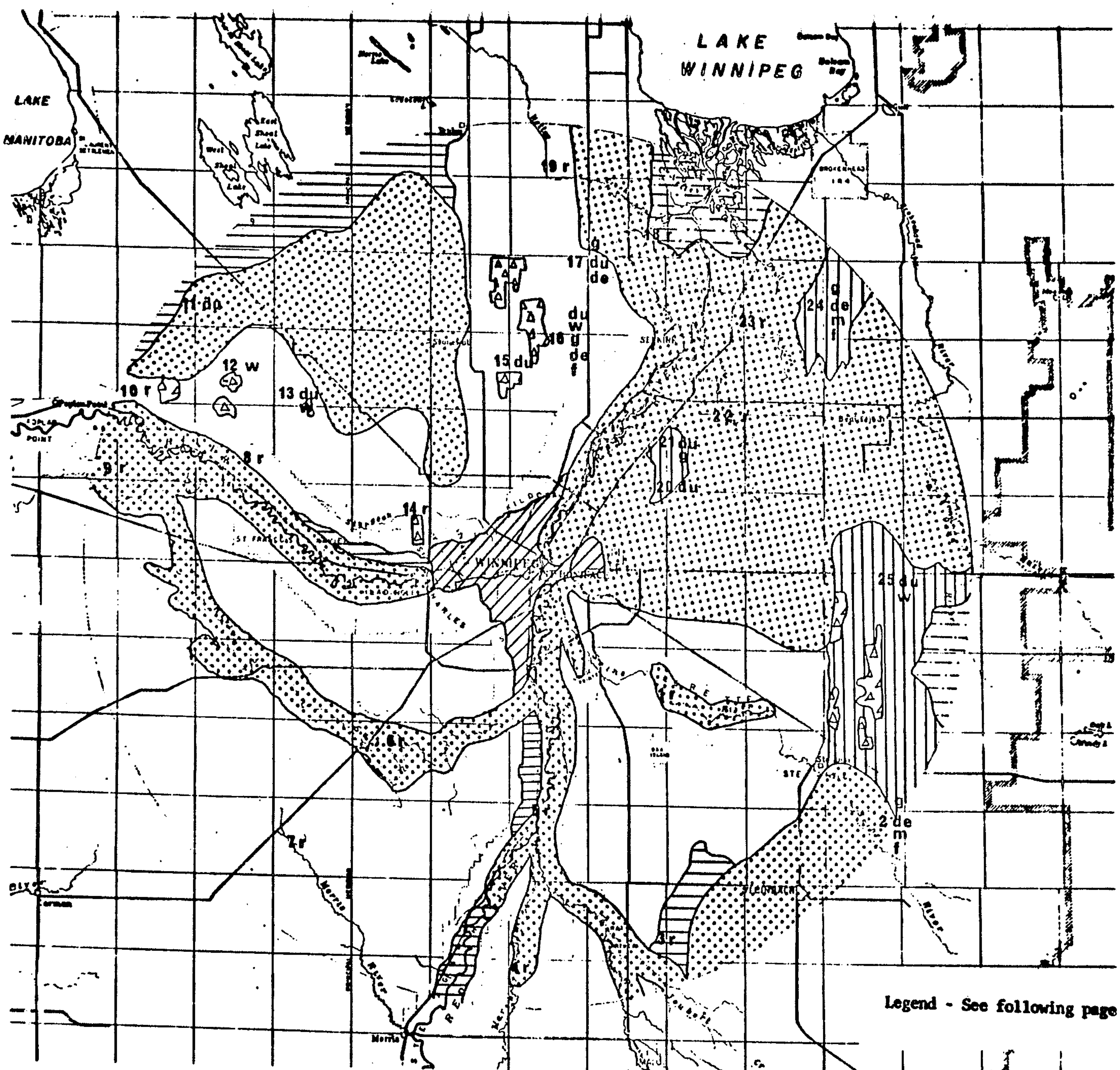


Fig. 8 Present Resource Types

Source: Modified after E. F. Bossenmaier and C. G. Vogel, 1974 Wildlife and Wildlife Habitat in The Winnipeg Region Planning Division, Manitoba Department of Mines, Resources and Environmental Management.

Legend (Fig. 8)

1.	Built-Up Areas	/////	5.	Broadleaf Deciduous Woods	≡
2.	Cropland	White	6.	Mixed Woods	|||||
3.	Wooded Cropland	∴∴	7.	Swamp, Marsh, Bog.	-.-.-
4.	Natural Grassland	ΔΔΔ			

Some Specific Wildlife Habitats of The Winnipeg Region

1) Seine River
2) Richer
3) Joubert Creek
4) Marsh River
5) Red River
6) La Salle River
7) Little Morris River
8) Assiniboine River
9) Mill Creek
10) Long Creek
11) Woodlands - Reaburn-Poplar Pt. Escarpment
12) Rosser - Reaburn Cropland
13) Grant's Lake
14) Sturgeon Creek
15) Stony Mountain
16) Oak Hammock Marsh
17) Clandeboye Pits
18) Netley-Wavey-Medicine-Muckle Creeks
19) Netley Creek
20) Birds Hill Pits
21) Birds Hill Park
22) Cooks Creek
23) Devil Creek
24) Hars Hill
25) Cedar Lake

Habitat Use Code

1. Duck Breeding - Du
2. Canada Goose Breeding- C
3. Waterfowl Staging - W
4. Grouse - G
5. Furbearers - F
6. Deer - De
7. Moose - M
8. Riparian Habitat - R

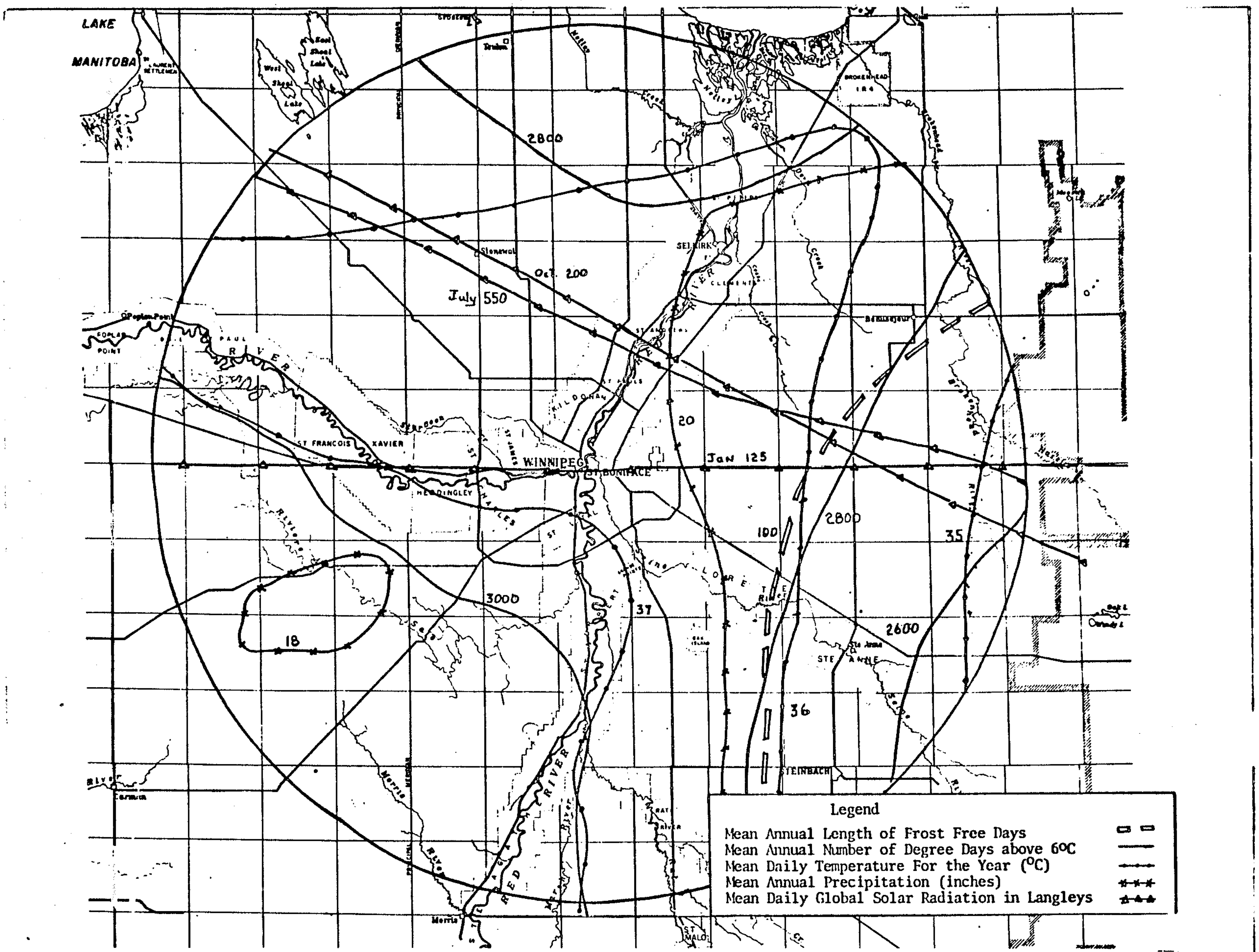


Fig. 9 Regional Climatic Factors

Source: Modified after Canadian Meterological Service Department of Transport, Ottawa.

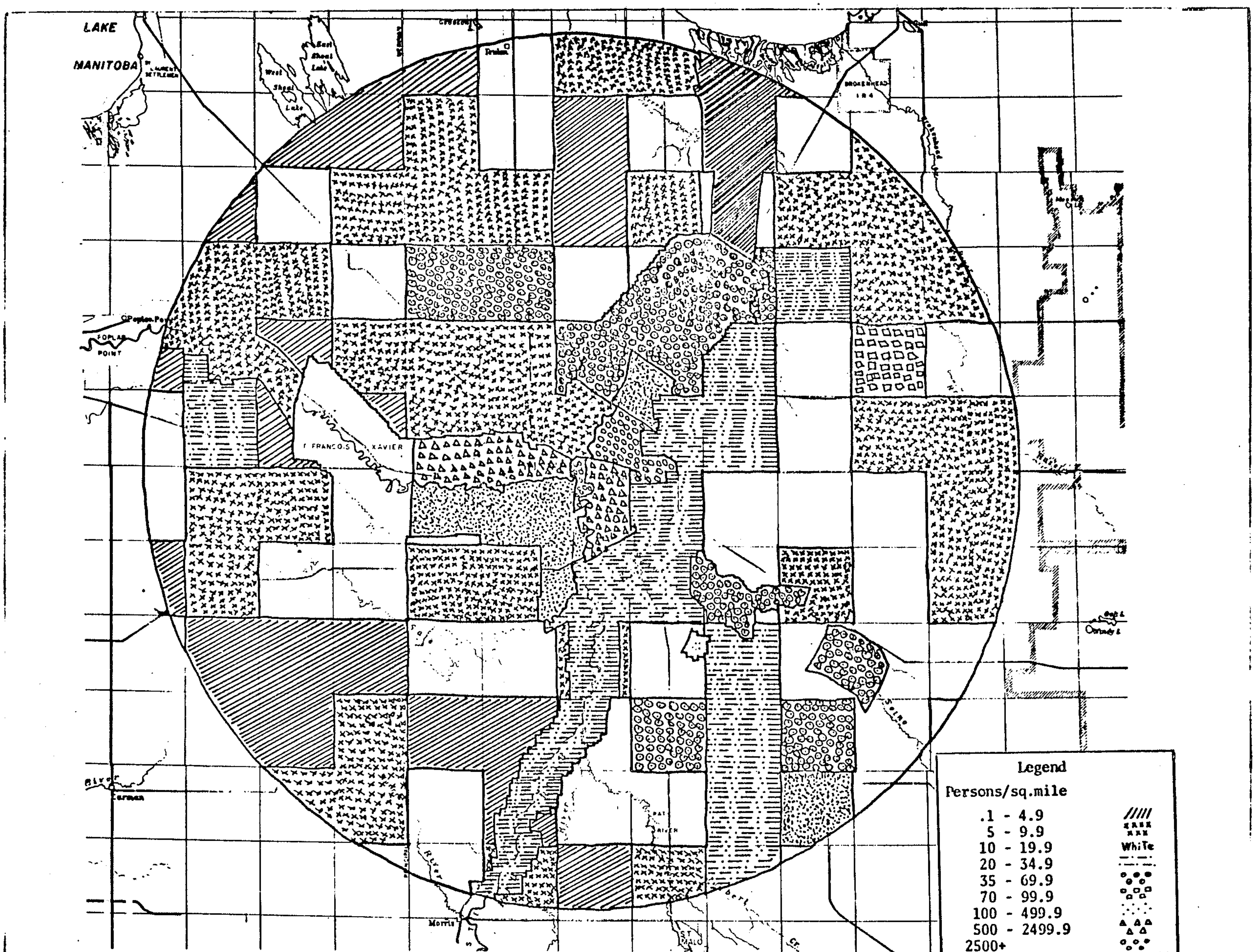


Fig. 10 Regional Population Factors

Statistics from: 1971 Census of Canada
Statistics Canada, Ottawa
Catalogue 92-707, 92-708, 92-711

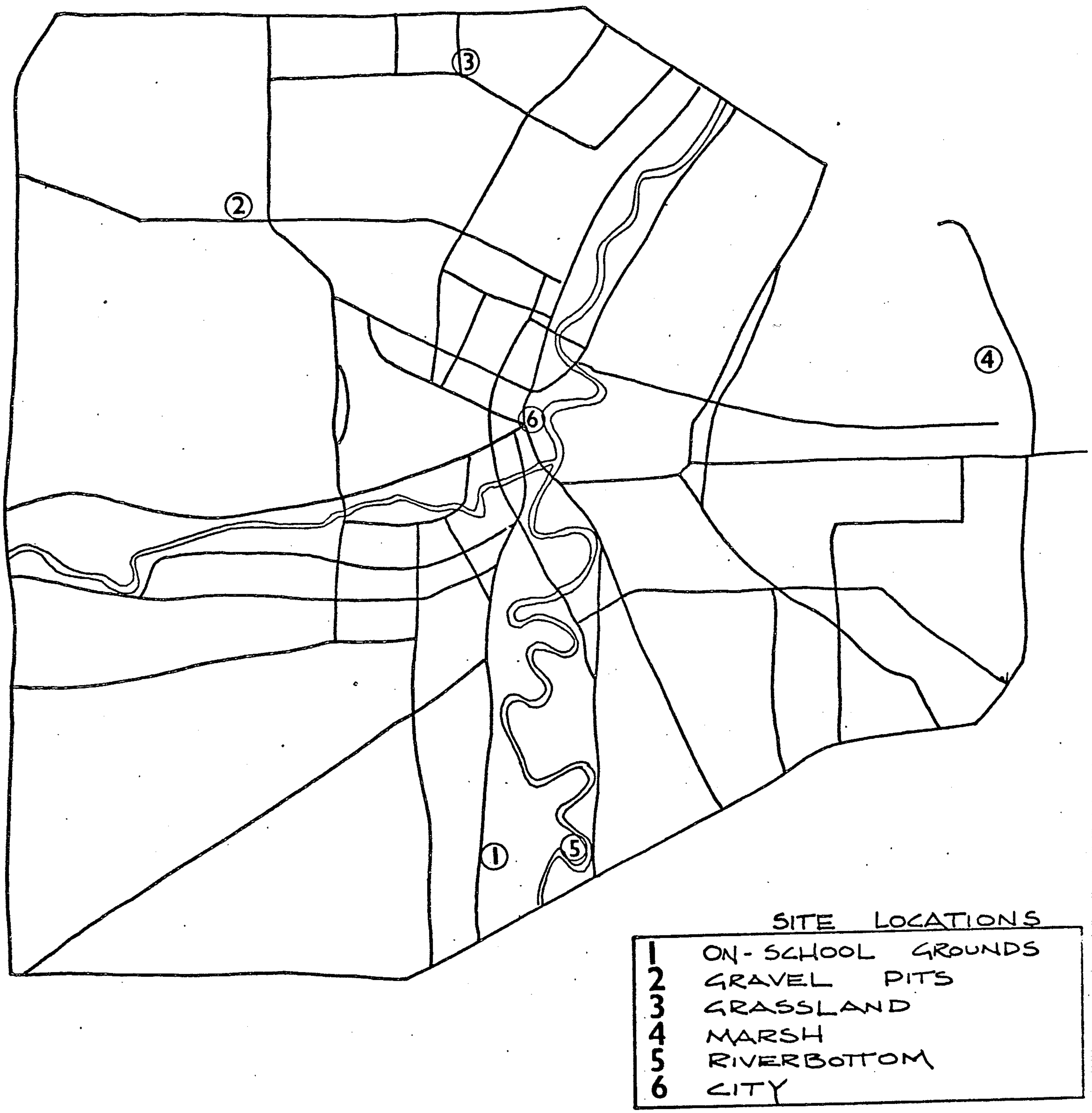


Fig. 11 Location of the Specific Study Sites

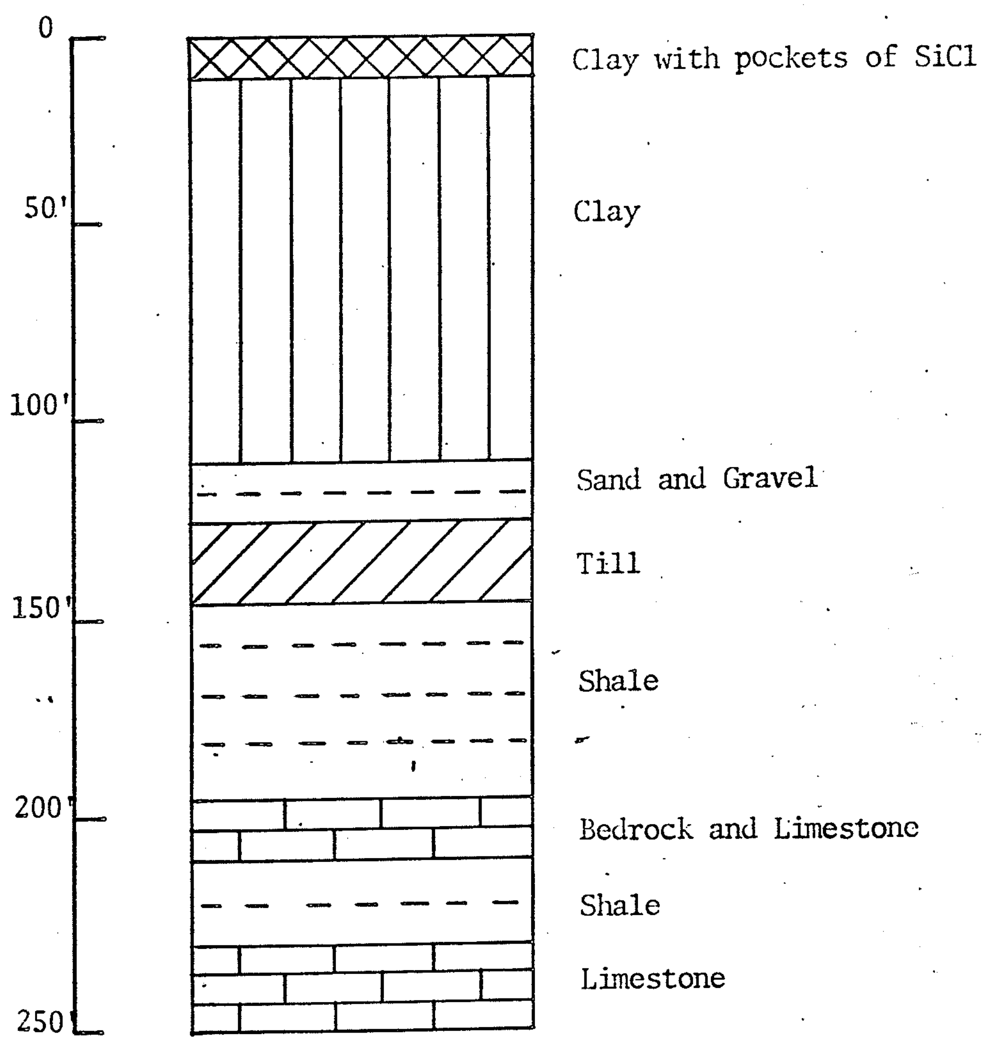


Fig. 12 Cross Section of the Surface Deposits and Underlying Material On-School Site Area.

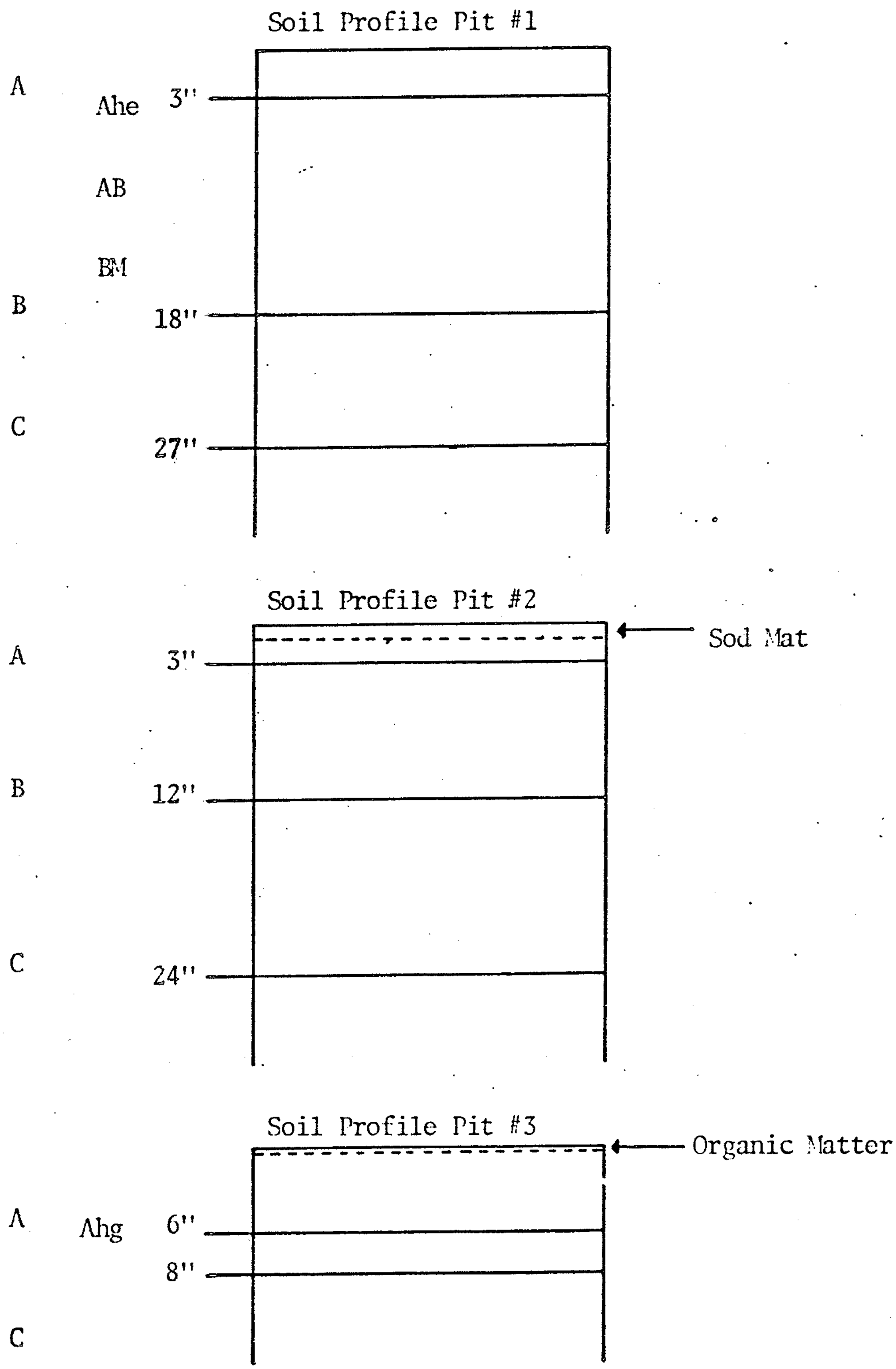
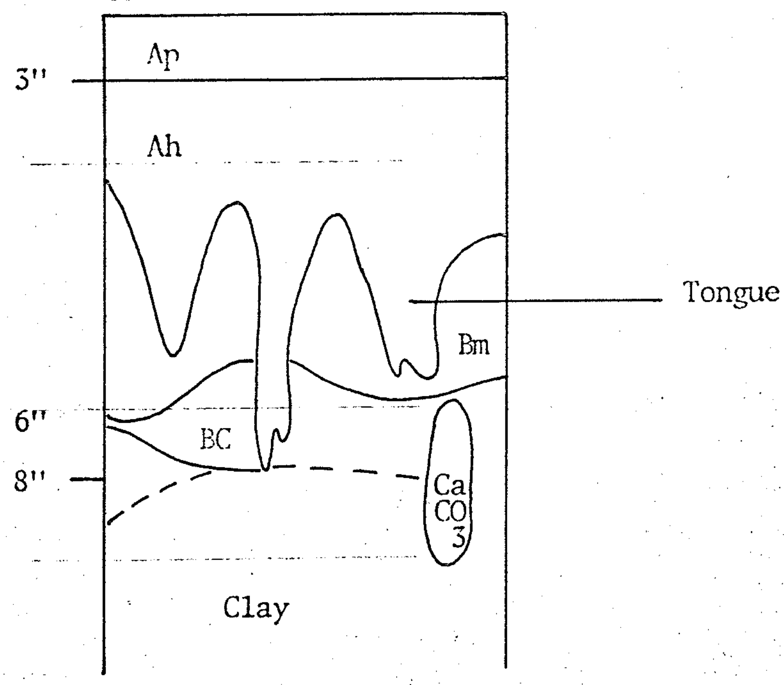
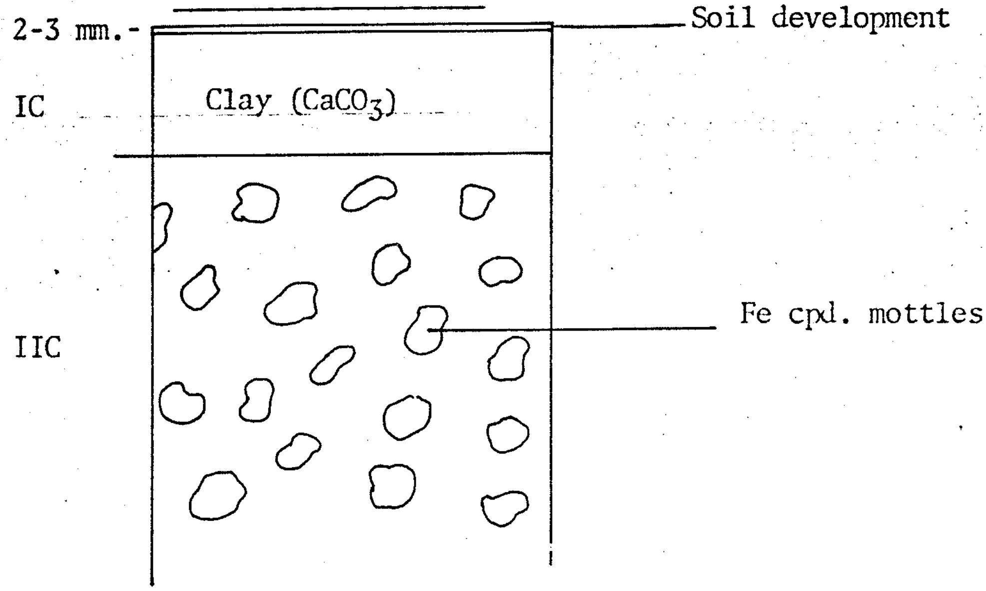


Fig. 13 Soil Profiles - On-School Grounds Site

Soil Profile Pit #1



Soil Profile Pit #2



Clay: 60% $CaCO_3$

Fig. 14 Soil Profiles - Gravel Pit Site

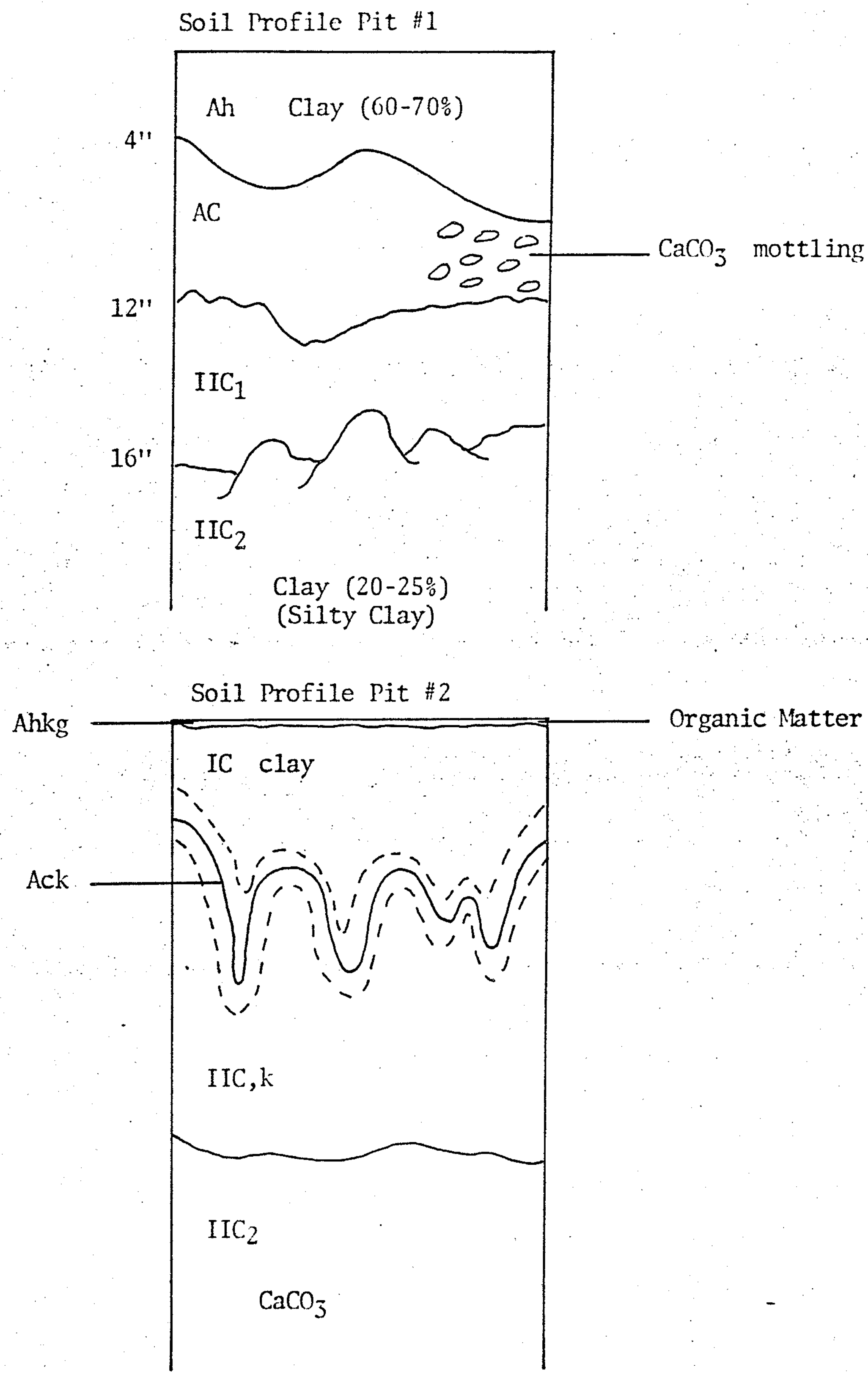


Fig. 15 Soil Profiles - Grassland Site

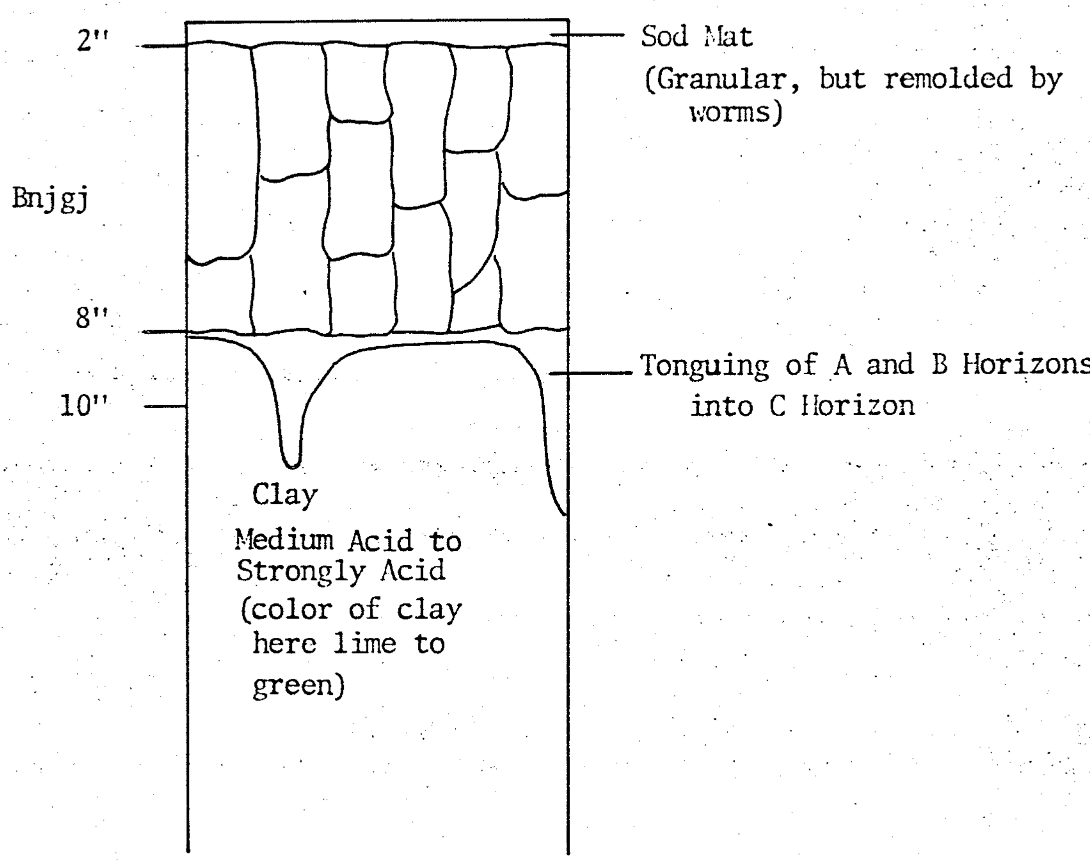
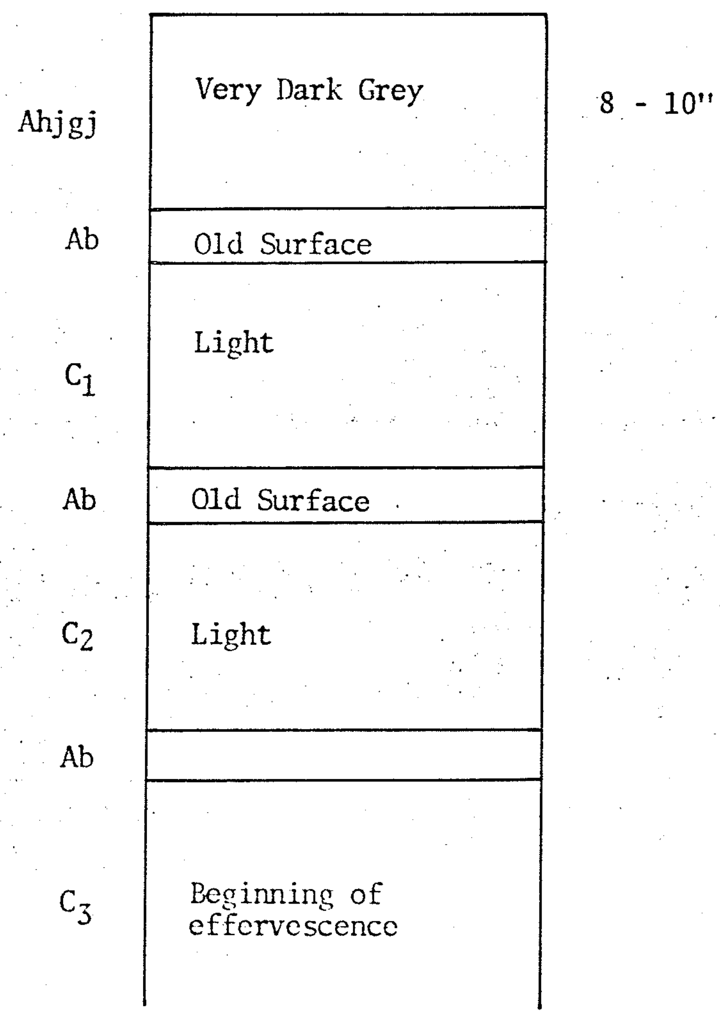


Fig. 16 Soil Profile - Marsh Site



Ab = buried layer

Fig. 17 Soil Profile - Riverbottom Site

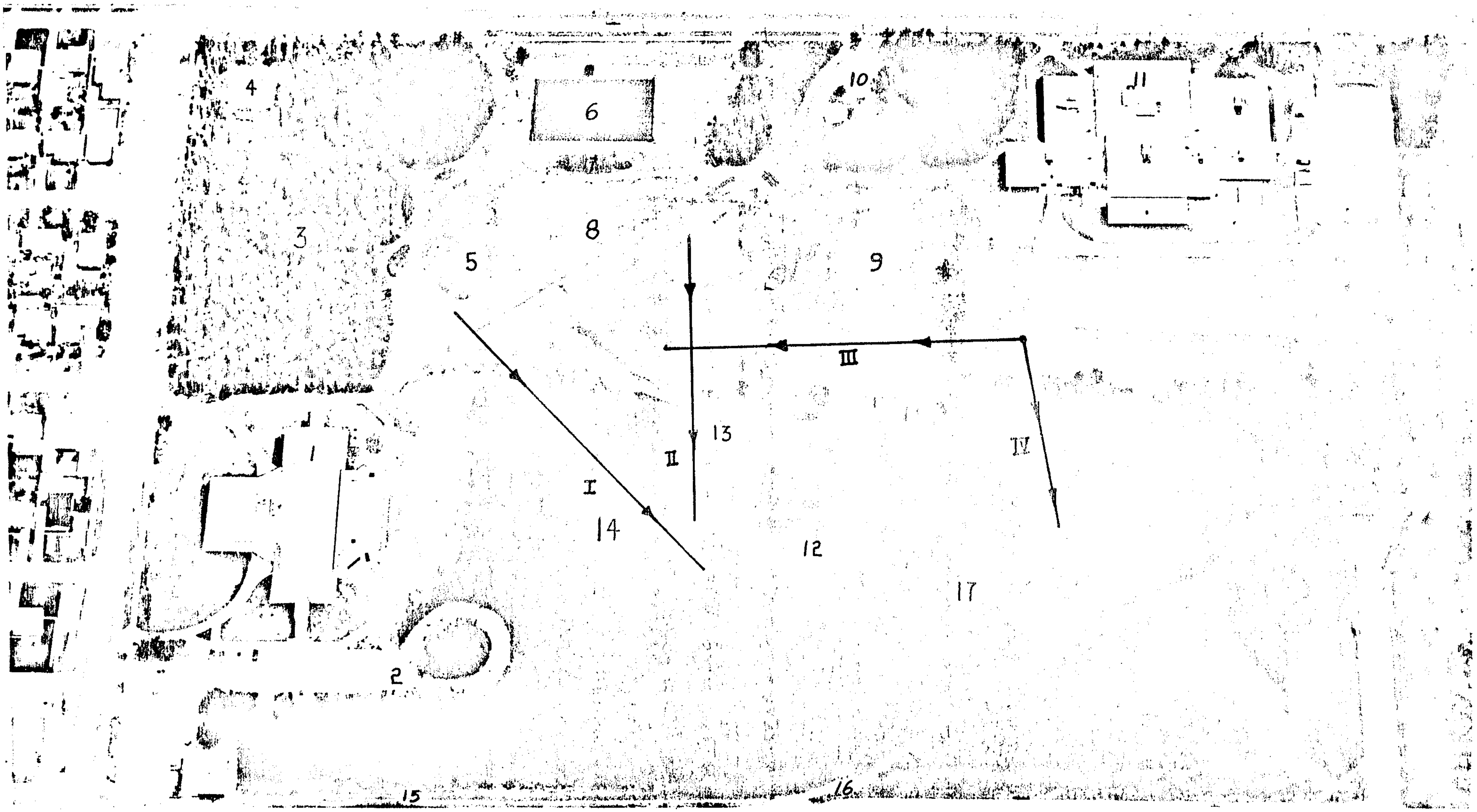


Fig. 13 Topographic Features - On-School Grounds Site

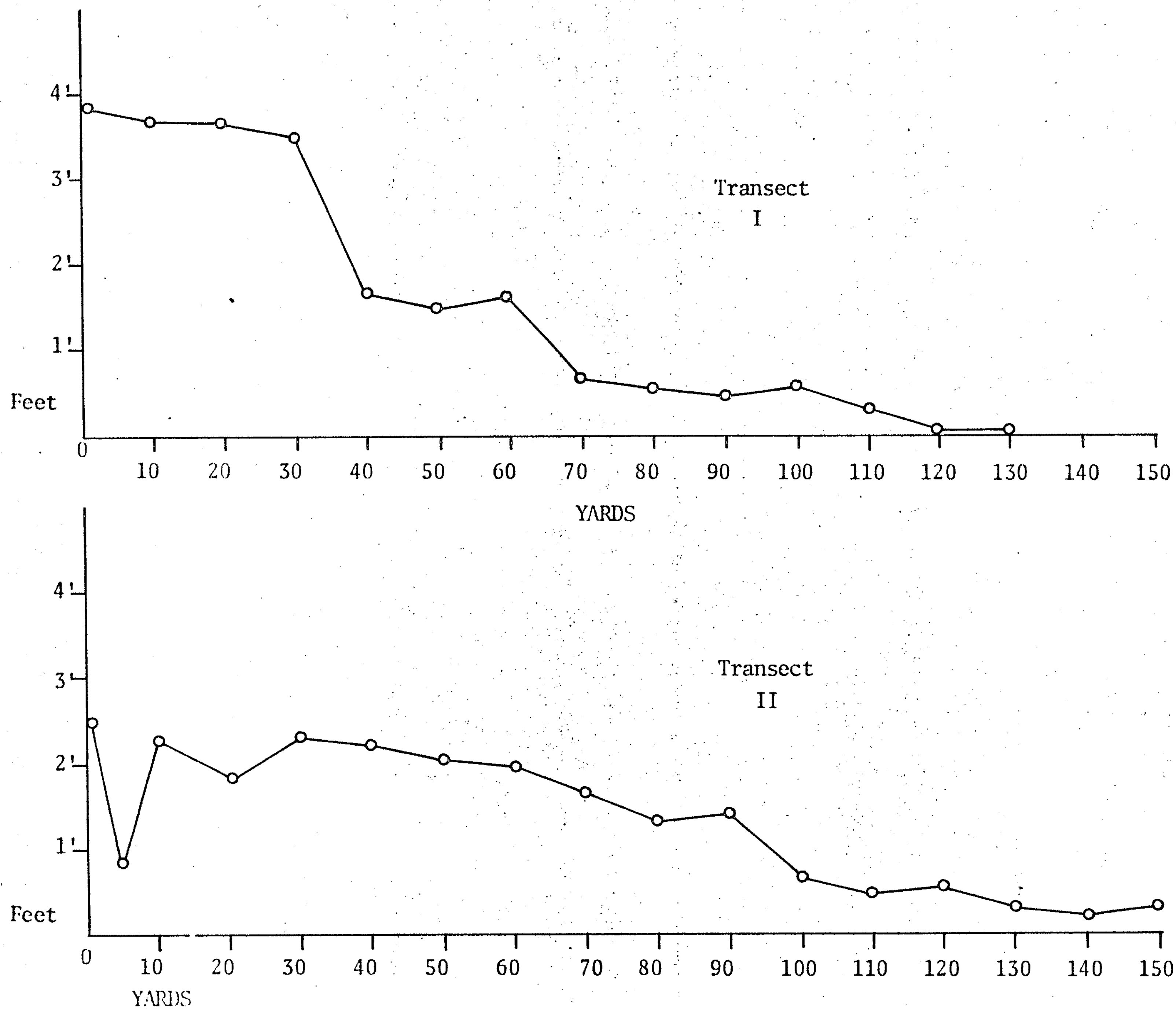


Fig. 19 Topographic Transects - On-School Grounds Site

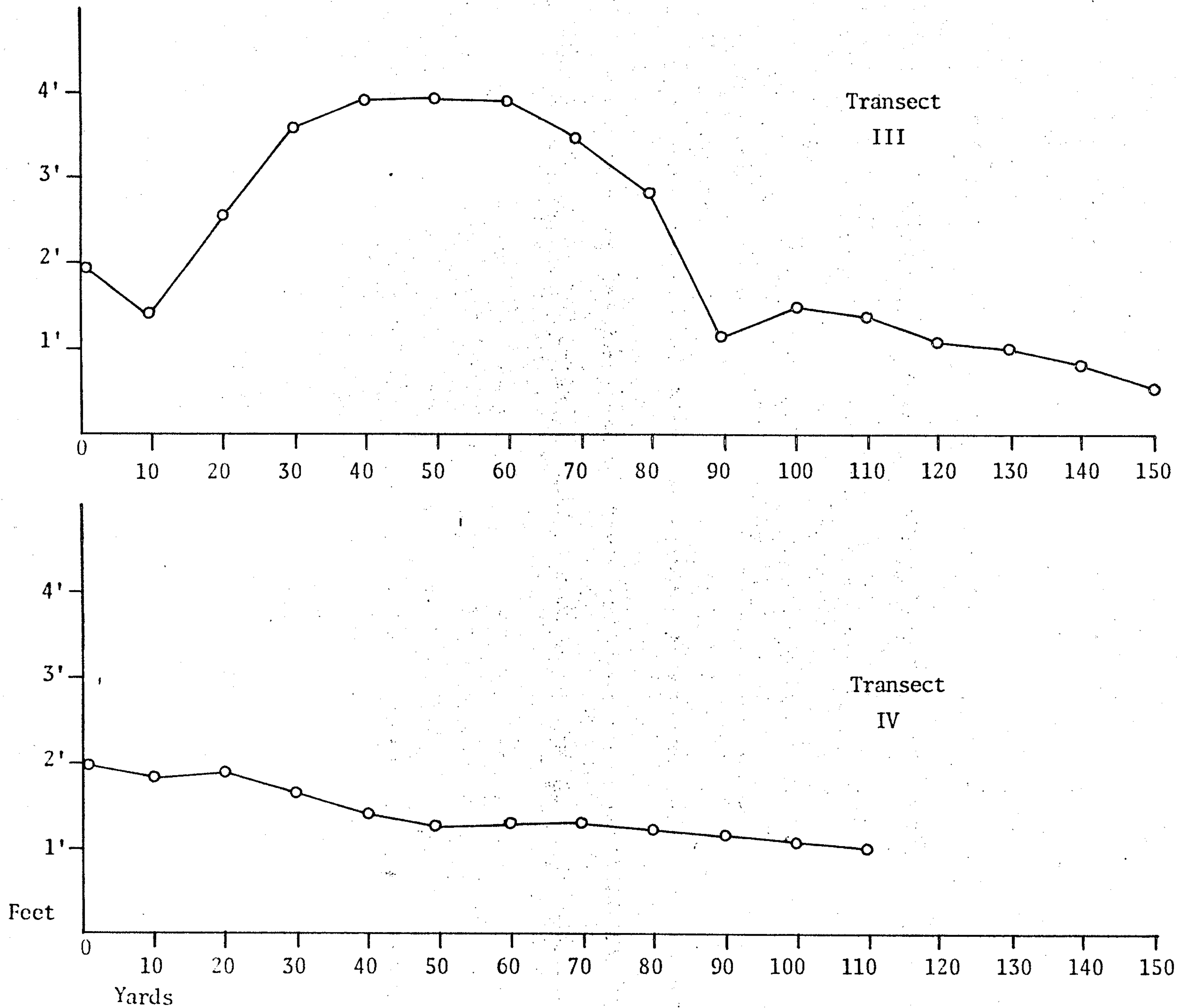


Fig. 19 (continued)

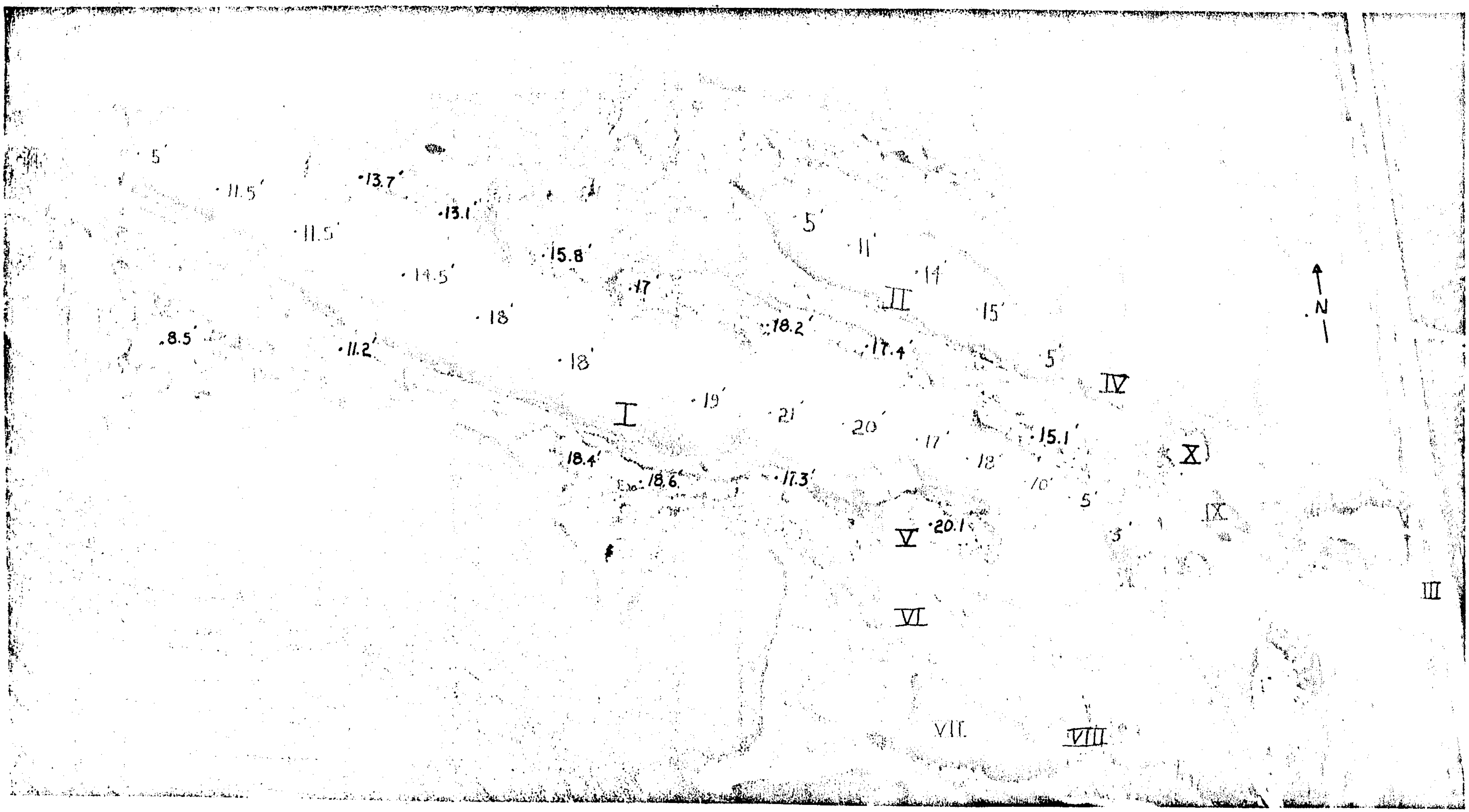


Fig. 20 Topographic Features - Gravel Pits Site

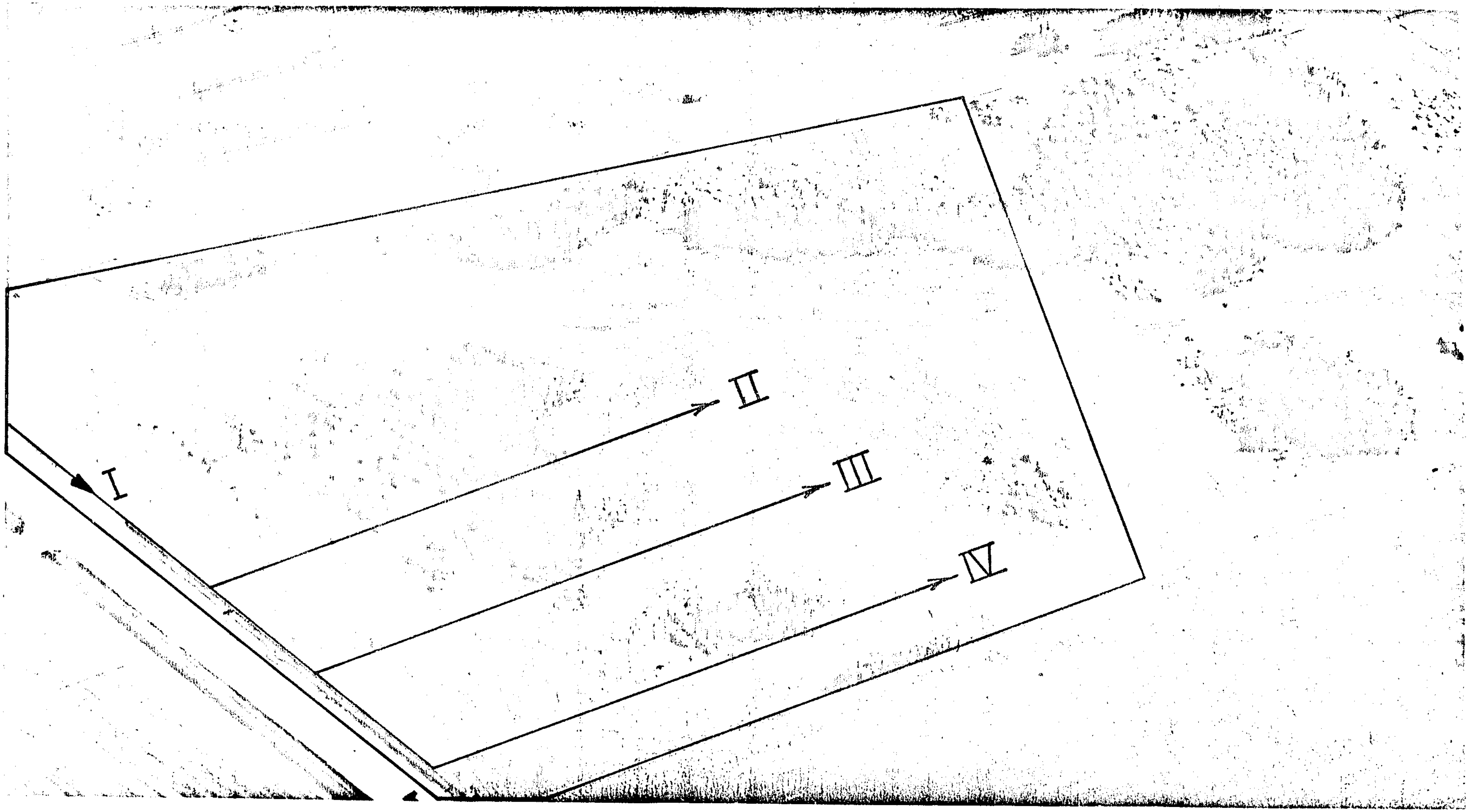


Fig. 21 Topographic Features - Grassland Site

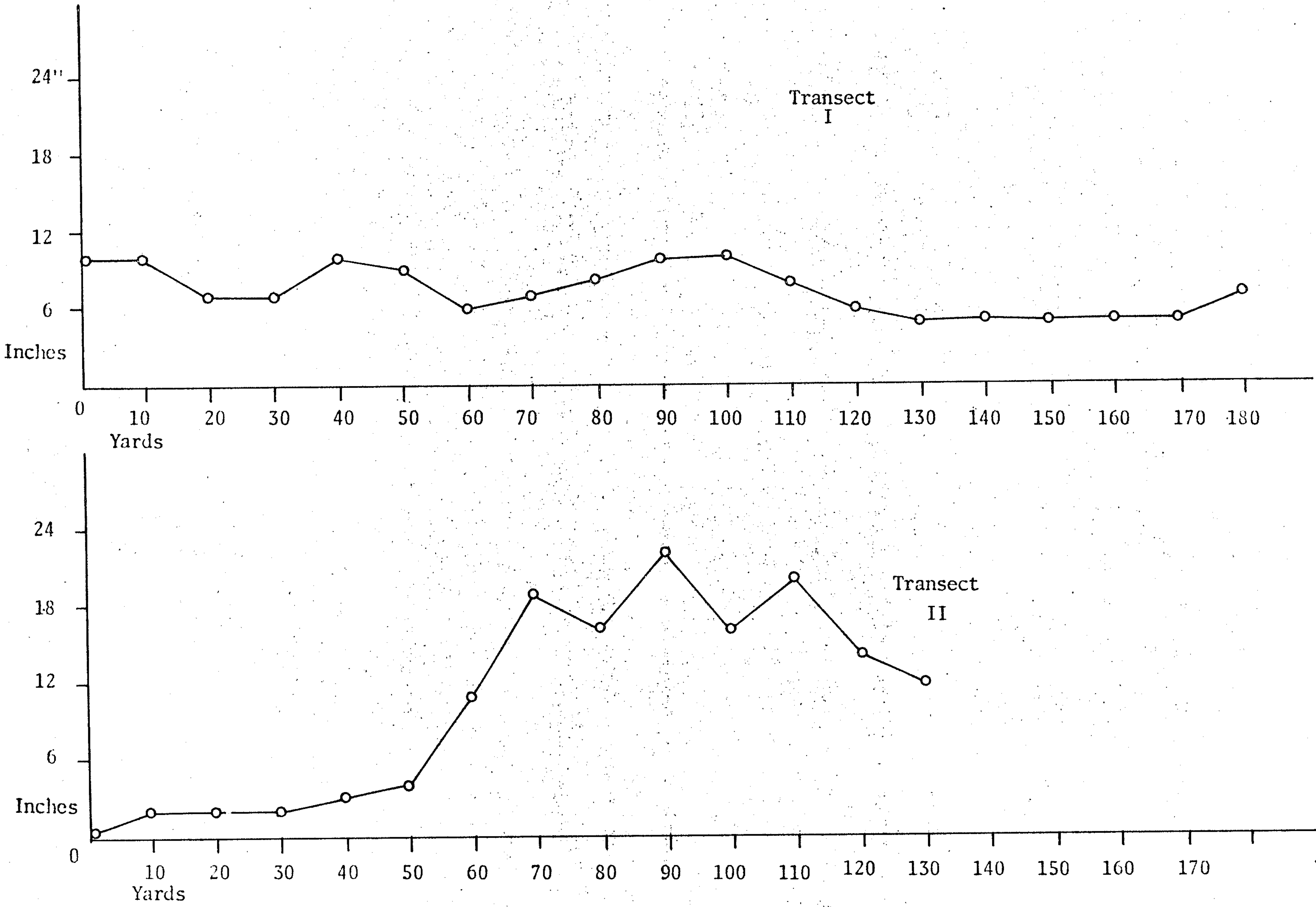
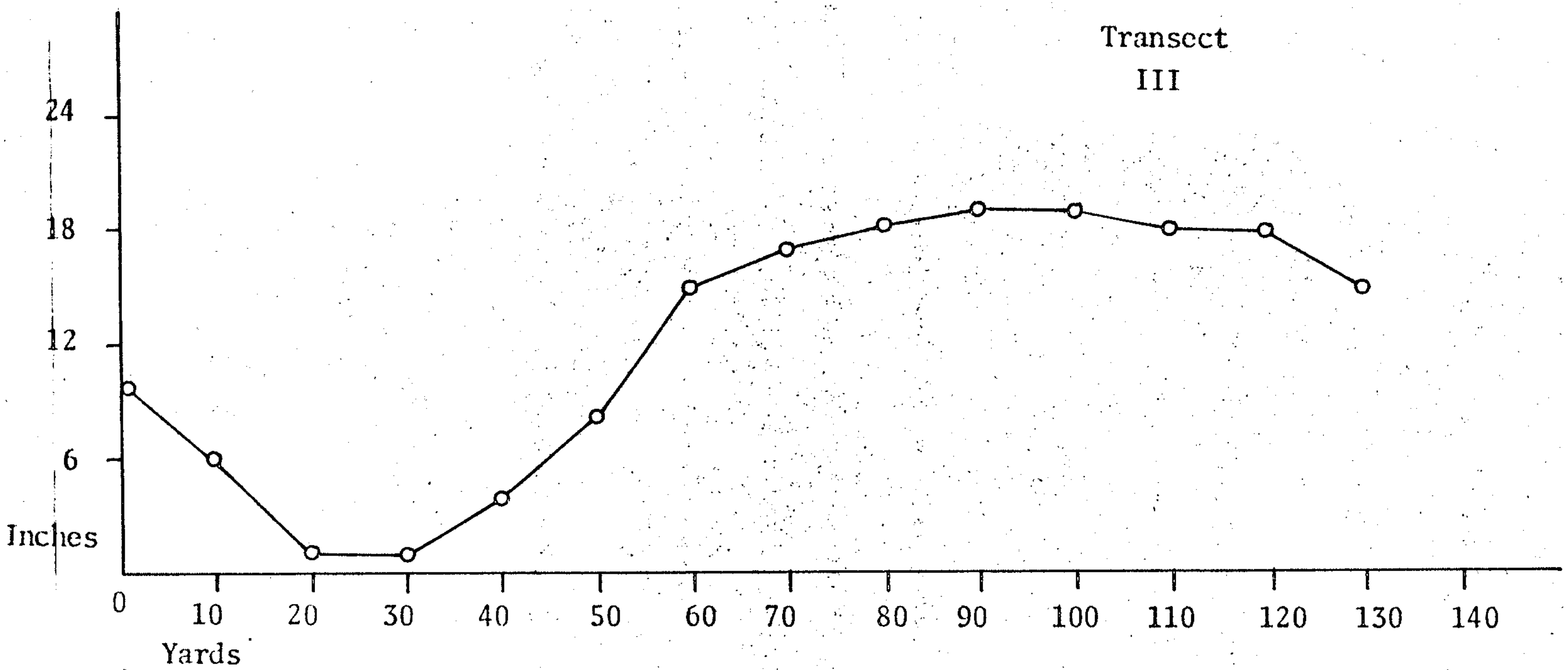
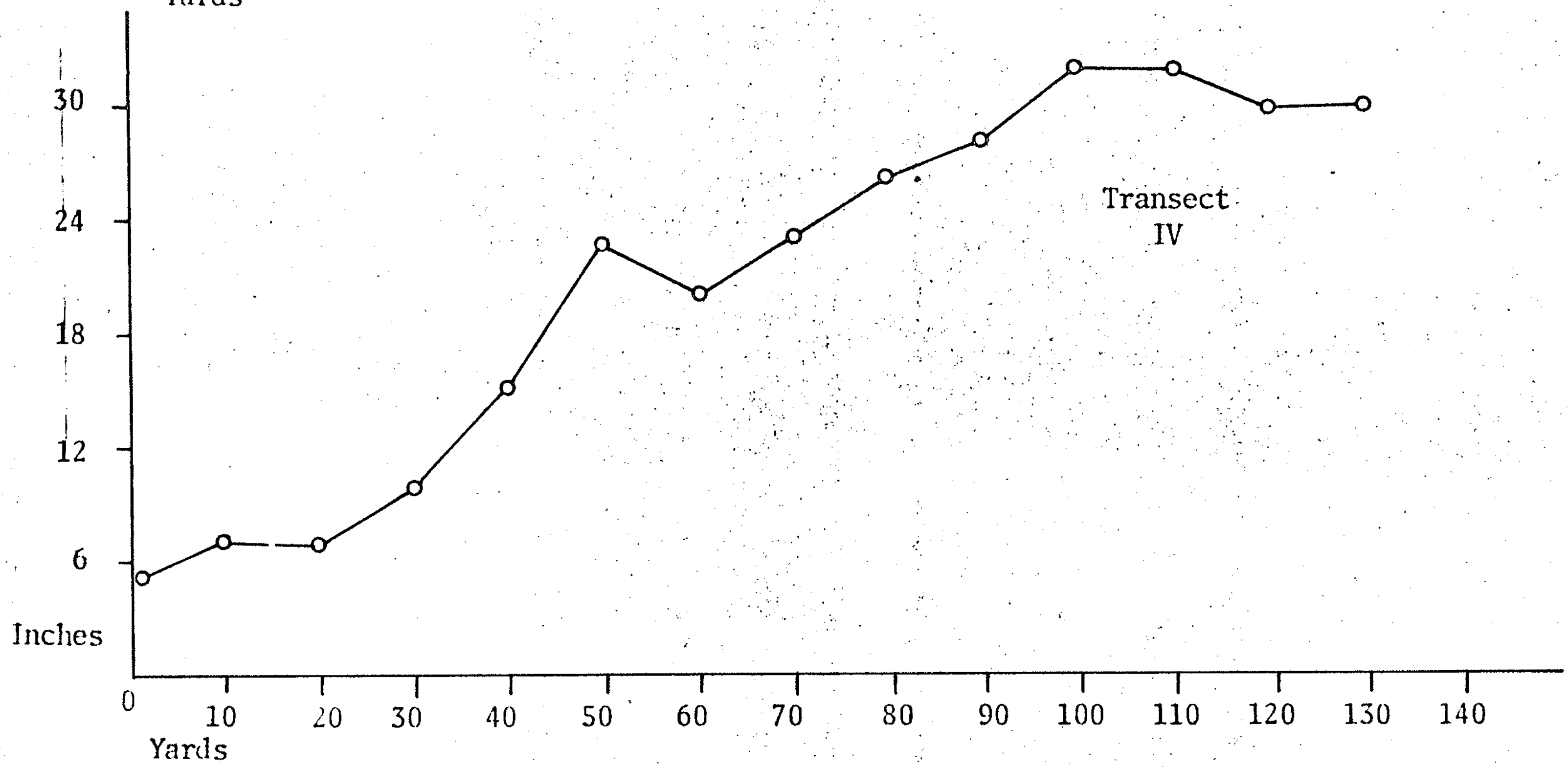


Fig. 22 Topographic Transects - Grassland Site


Transect III
24
18
12
6
Inches
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
Yards


Transect IV
30
24
18
12
6
Inches
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
Yards

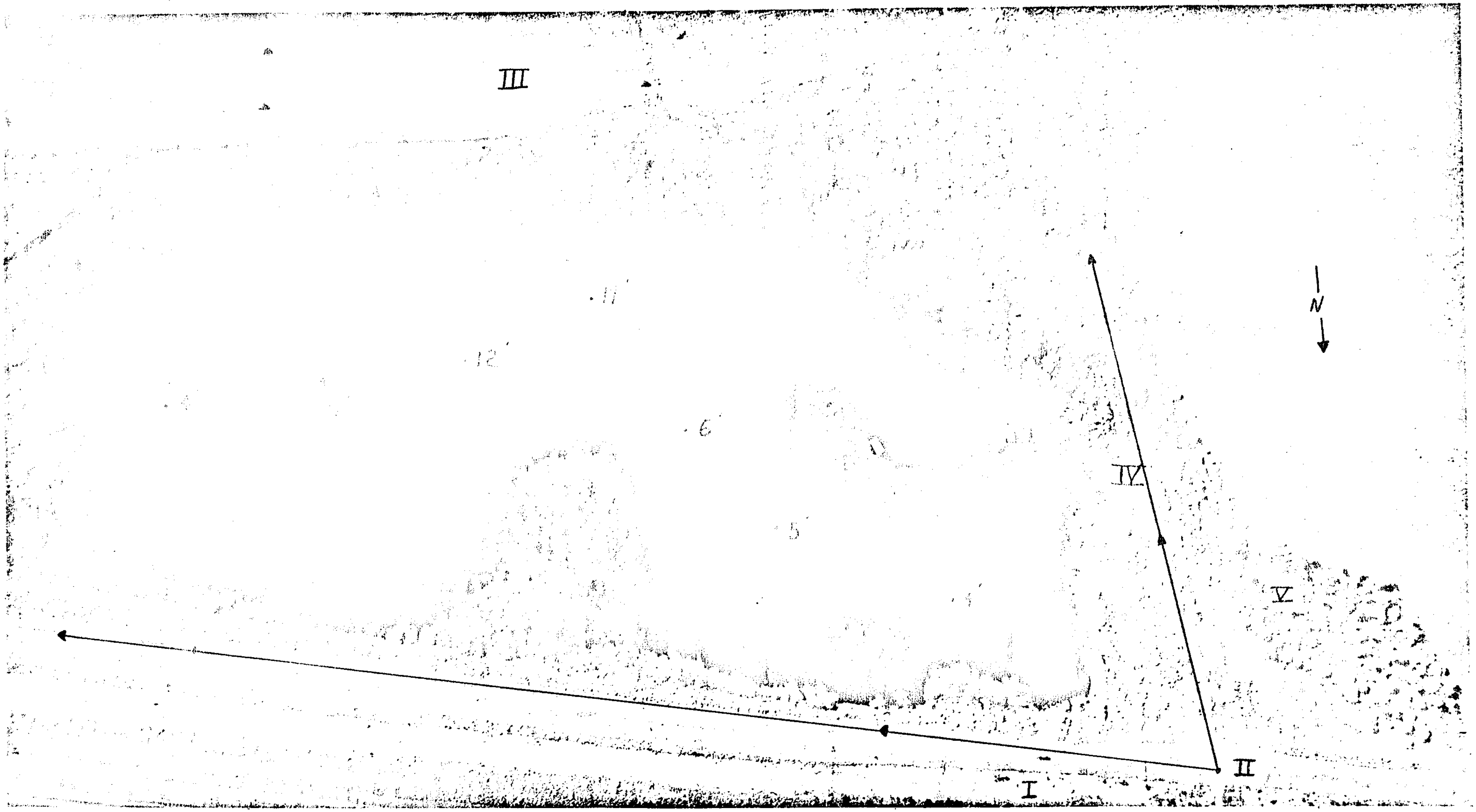


Fig. 23 Topographic Features - Marsh Site

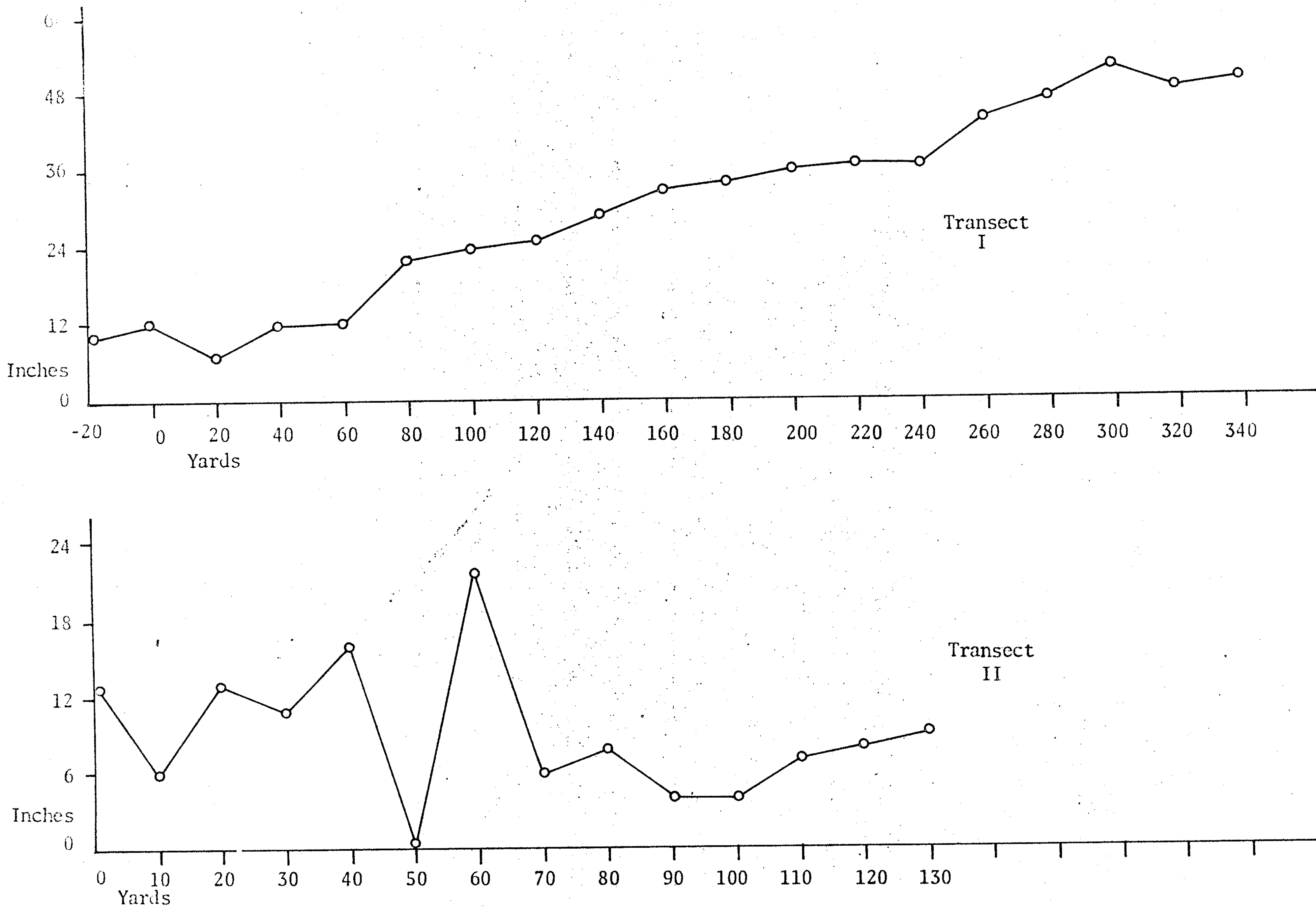


Fig. 24 Topographic Transects - Marsh Site

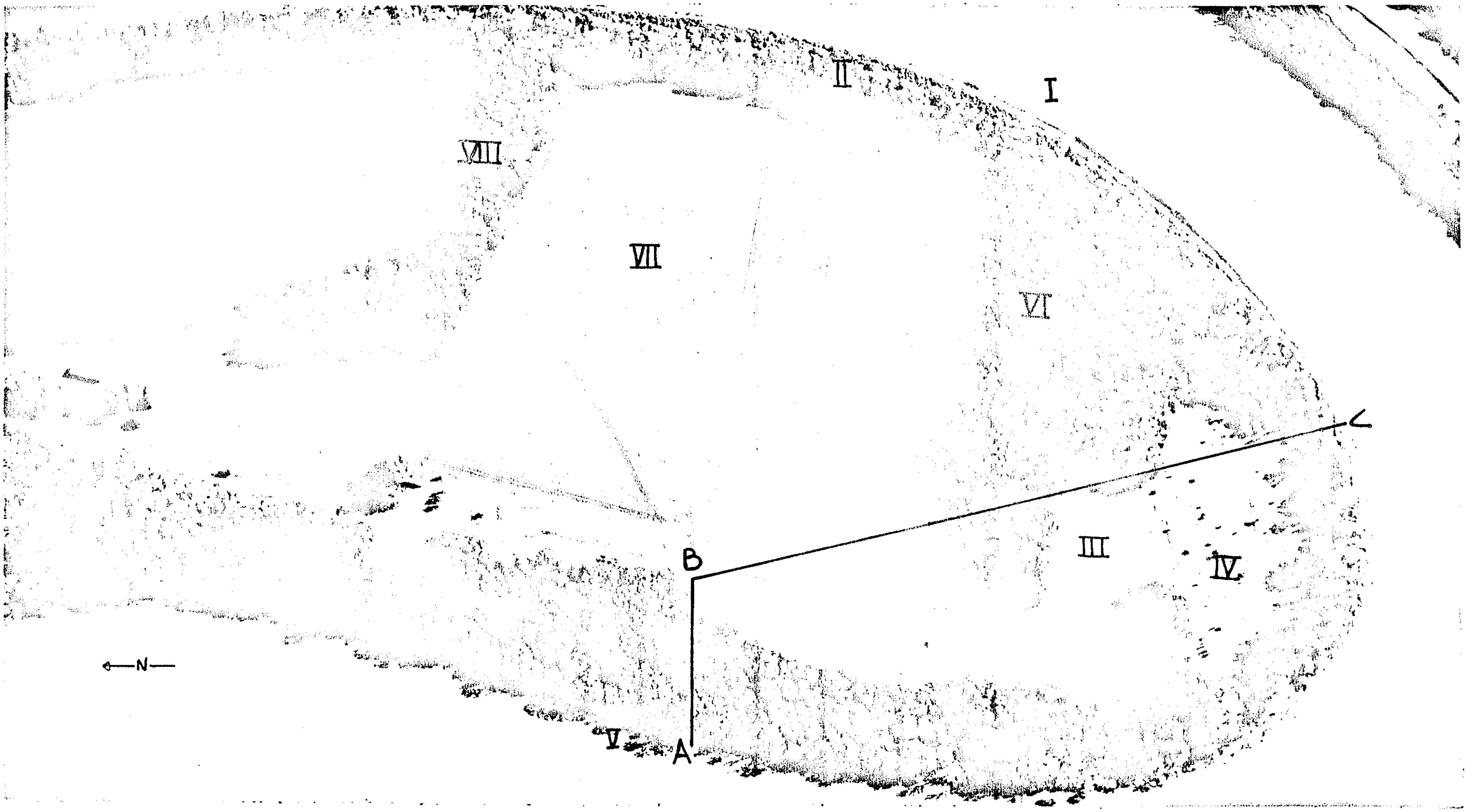


Fig. 25 Topographic Features - Riverbottom Site

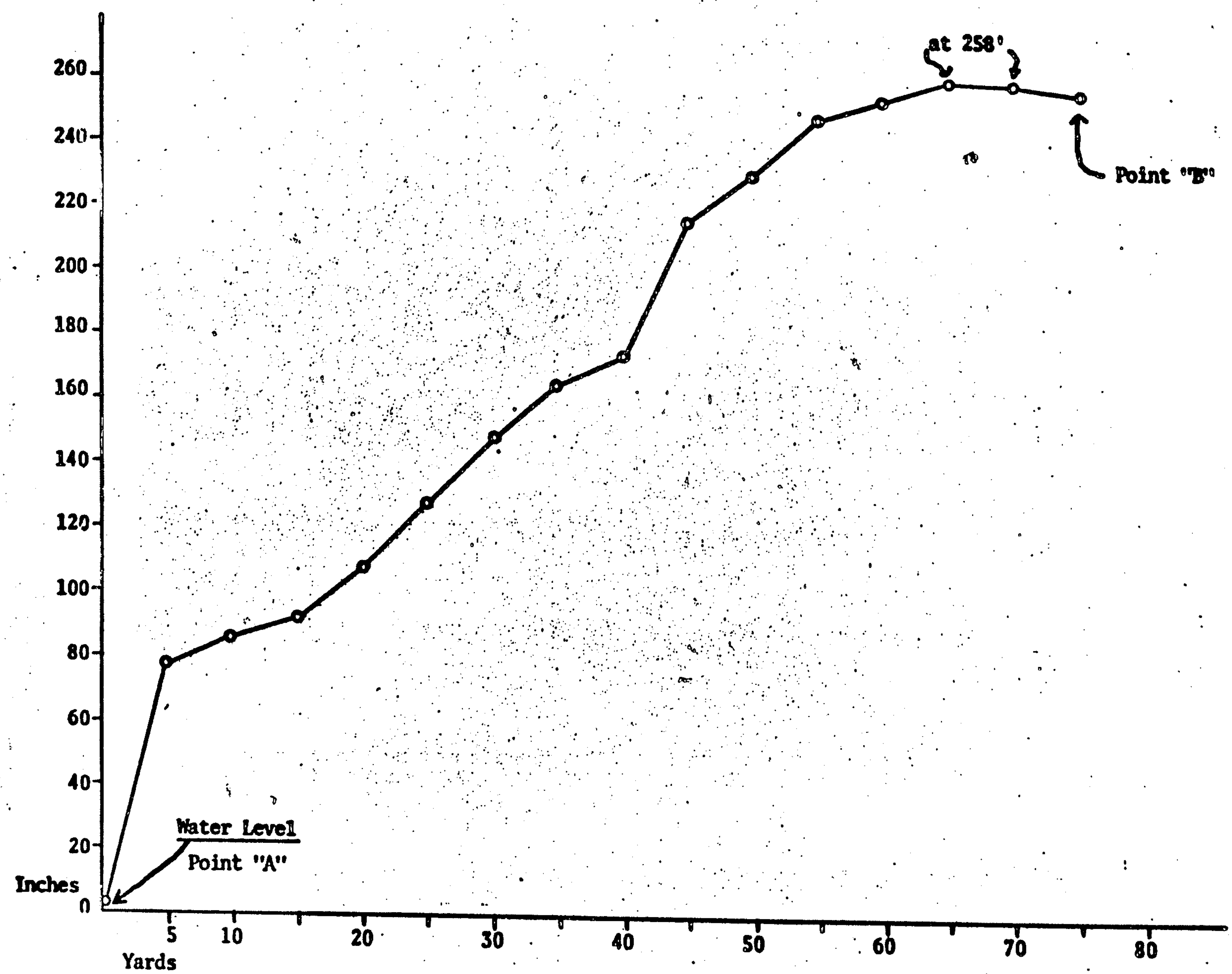


Fig. 26 Topographic Transects - Riverbottom Site

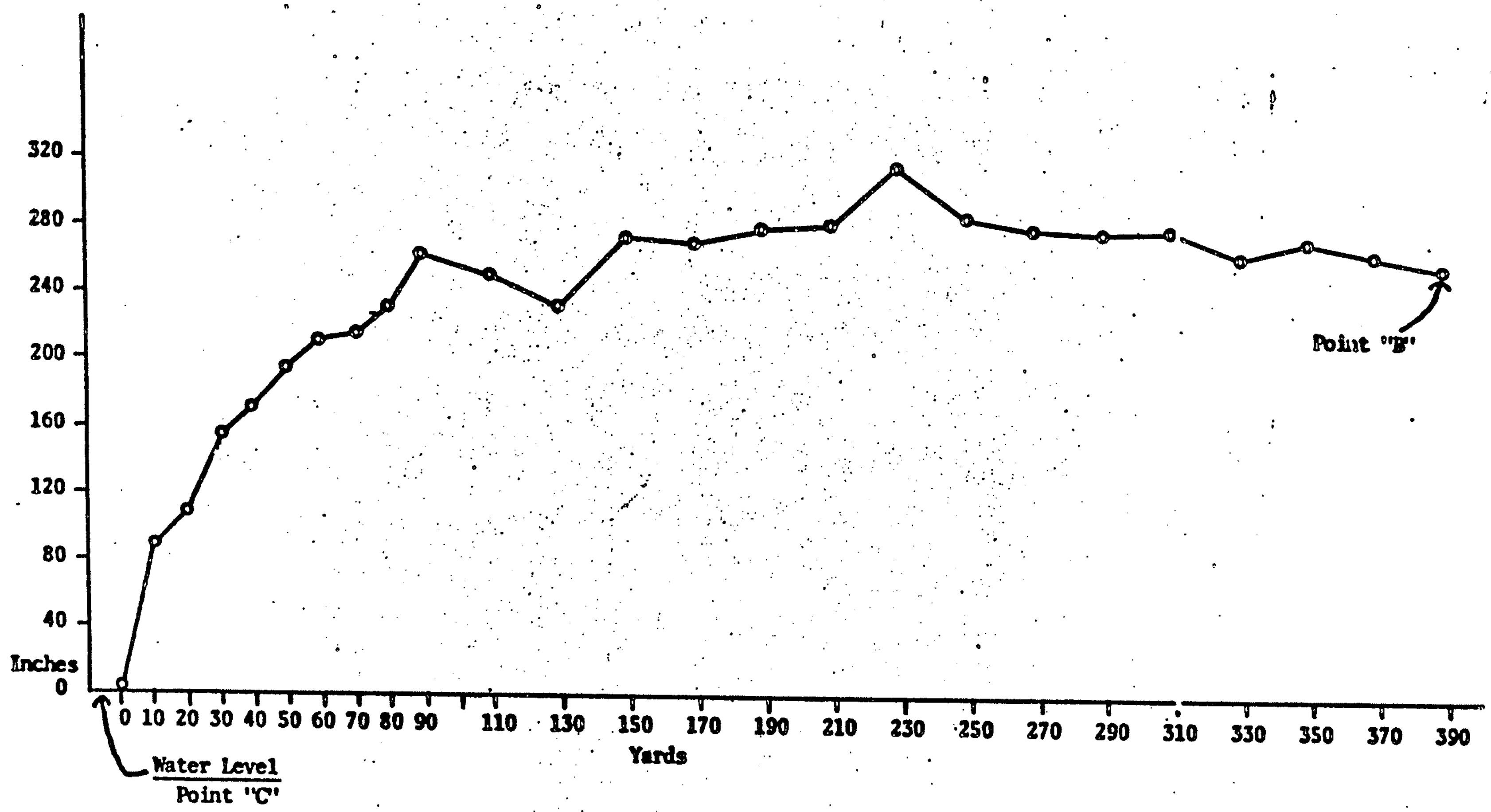


Fig. 26 (Continued)

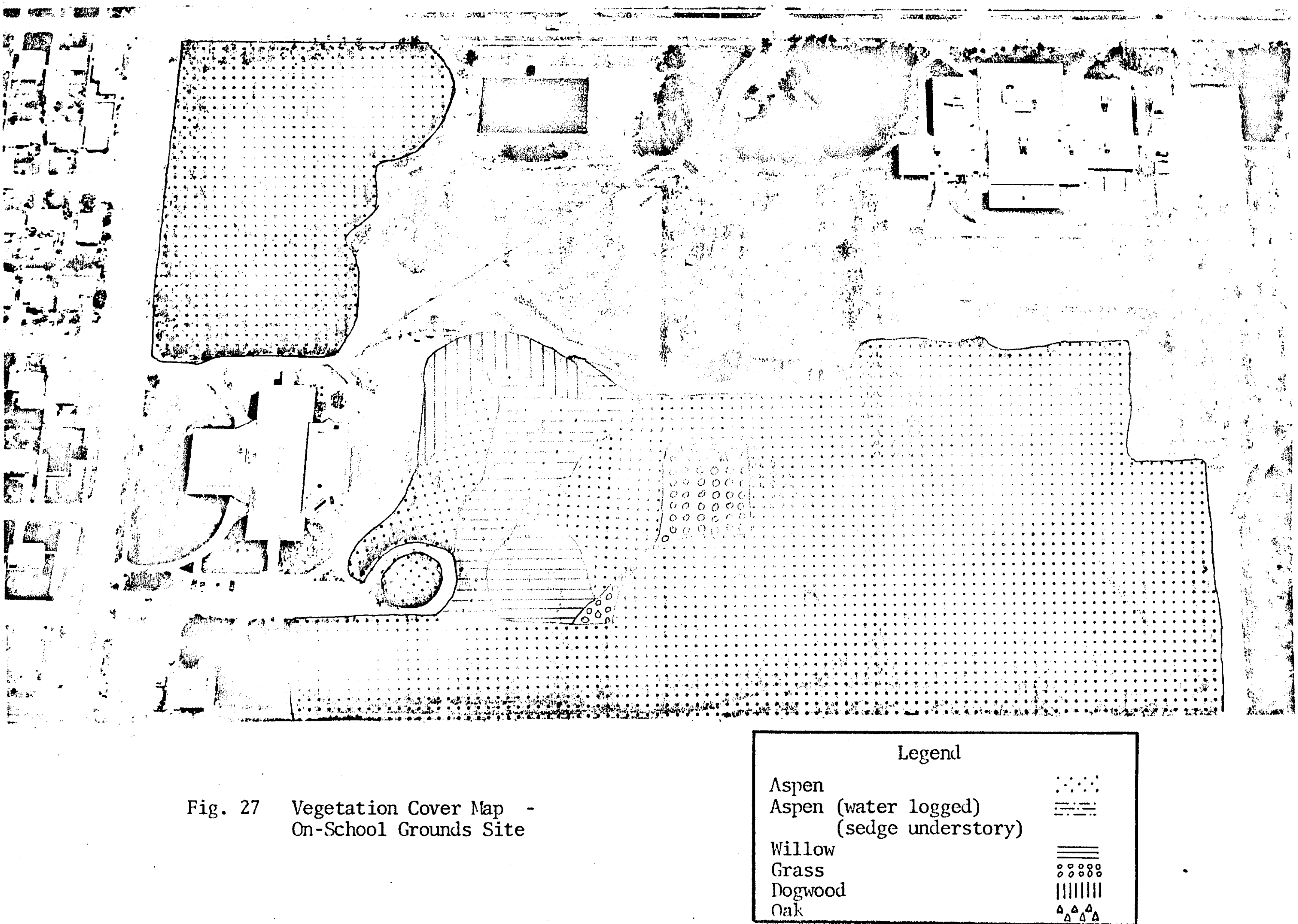


Fig. 27 Vegetation Cover Map - On-School Grounds Site

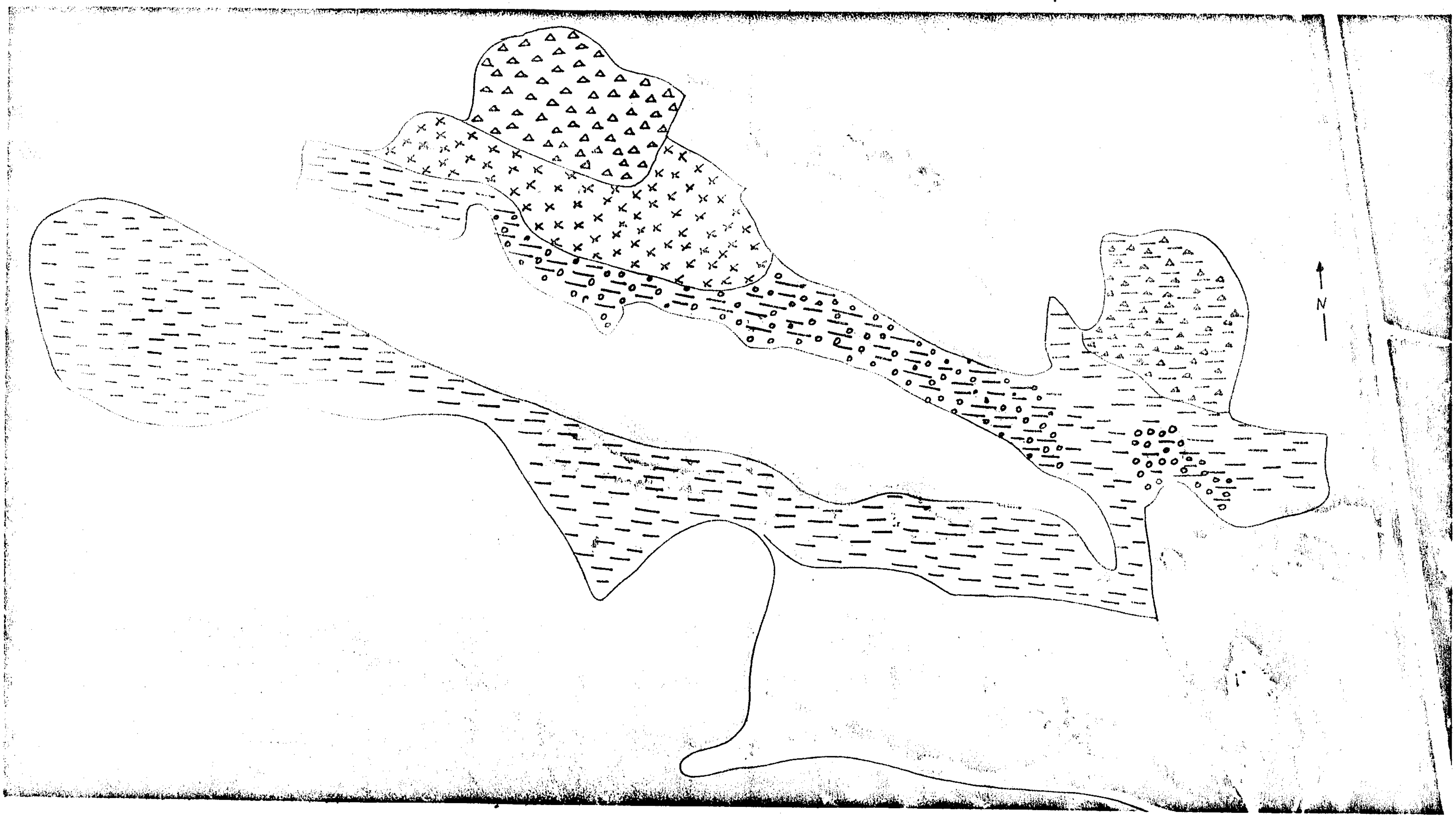


Fig. 28 Vegetation Cover Map - Gravel Pit Site

Legend

Canada Thistle (Cirsium)	═
Sage (Artemsia Spp.)	°o°o°
Ragweed	ΔΔΔ
Aster	xxx

	Glenlea			International Airport			Selkirk			North Kildonan			St. Norbert		
	Max. Temp.	Min. Temp.	Mean Daily Temp.	Max. Temp.	Min. Temp.	Mean Daily Temp.	Max. Temp.	Min. Temp.	Mean Daily Temp.	Max. Temp.	Min. Temp.	Mean Daily Temp.	Max. Temp.	Min. Temp.	Mean Daily Temp.
July 1972	24.5	10.2	17.5	24.1	10.1	17	23	11.3	17.1	24.2	11.4	17.6	23.5	11.5	17.3
August 1972	26.8	11	18.5	26	11.3	18.3	24.5	11.9	18.1	25.9	11.9	18.8	25.3	13	19
September 1972	17	4.3	10.5	16.5	4	10.3	15.9	3.5	9.8	16.4	5	10.6	15.9	5.2	10.6
October 1972	8.5	-2.8	2.8	8.4	-2.8	2.6	7.7	-2.5	2.7	8.4	-1.6	3.5	8	-1.5	3.1
November 1972	-3.5	-11.5	-7	-3.4	-11	-7.2	-3.7	-9.2	-6.8	-3.1	-9.5	-6.5	-3.2	-9.2	-6.9
December 1972	-13.5	-24.3	-19	-14.9	-23.5	-19.1	-14.6	-23.6	-19	-13.8	-22.5	-18	-21.3	-22.2	-17.5
January 1973	-9.5	-20.5	-14.9	-8.9	-19.1	-14	-9.4	-16	-14.5	-9.3	-18.1	-13.5	-9	-18.6	-13.6
February 1973	-7.9	-21.1	-14.5	-8.5	-19.3	-13.8	-8.6	-20.6	-14.6	-8.3	-18.5	-13.5	-7.6	-17.8	-12.3
March 1973	5	-3.5	1	4.9	-3.6	.3		N.A.		4.8	-3	.8	4.8	-3.1	.7
April 1973	9.7	-2.5	3.5	9.1	-4.9	2.6	8.2	-2.8	2.8	8.8	-3.5	2.7	8.7	-2.5	3.1
May 1973	18.4	4.2	11.5	18.4	2.9	10.8	17.1	4.2	10.9	18.2	4.1	11	17.5	5.6	11.4
June 1973	22.4	10	16.4	21.9	10.2	16.3	21.3	10.8	16.1	21.9	11.4	16.8	21.8	11.4	16.6

Fig. 29 Mean Monthly Temperatures in the Winnipeg Region (Celsius)

	Glenlea				International Airport				Selkirk				North Kildonan S.T.P.				St. Norbert			
	Max Temp.	Day Occurr-ed	Min. Temp.	Day Occurr-ed	Max Temp.	Day Occurr-ed	Min. Temp	Day Occurr-ed	Max. Temp.	Day Occurr-ed	Min. Temp.	Day Occurr-ed	Max. Temp.	Day Occurr-ed	Min. Temp.	Day Occurr-ed	Max. Temp.	Day Occurr-ed	Min. Temp.	Day Occurr-ed
July 1972	32.9	29	1.8	3	32.8	29	1.3	3	31.3	29	2.8	3	32.8	29	1.3	3	31.4	29	3.9	5
August 1972	38	29	2.8	3	32.9	29	3.1	3	35.5	29	3.9	3	36.7	29	4.2	3	35	29	3.9	3
September 1972	26.8	3	-2.4	30	26.7	3	-2.5	27	26.7	9	-1.1	23	26.7	9	-2.4	27	25	9	-2.5	27
October 1972	21.1	2	-14.5	31	20.6	2	-13.2	30	18.9	3	-11.2	17	21.1	2	-12.2	18	20.6	2	-12.8	31
November 1972	2.3	5	-23.4	28	2.3	5	-21.4	28	2.3	5	-22.3	28	2.4	23	-22.3	28	2.3	23	-22.3	28
December 1972	-4.3	26	-33.9	6	-3.9	26	-32.8	6	-5.8	21	-32.8	6	-3.9	26	-36	6	-3.9	26	-33.5	6
January 1973	5	24	-37.3	7	5.5	24	-38.8	7	6.1	24	-38.5	7	6.1	24	-36.5	7	5	24	-36.5	7
February 1973	2.3	18	-33.9	16	2.3	18	-33.5	15	1.8	22	-33.9	16	2.3	18	-34.5	15	3.1	22	-32.5	16
March 1973	15	26	-9.5	1	15.3	26	-12.3	1	N.A.				15.3	26	-12.3	1	14.5	26	-10	4
April 1973	21.4	14	-12.2	10	21.2	19	-12.2	9	21.1	19	-9.4	9	21.1	19	-11.8	9	20	14	-9.4	10
May 1973	28.9	17	-7.3	14	27.2	17	-7.4	3	25.7	20	-3.2	14	26.8	17	-6.2	3	27.2	17	-3.8	14
June 1973	32.7	14	1.8	7	29.3	14	2.8	9	29.3	2	.8	7	28.2	15	.8	7	30.6	14	2.8	7

Fig. 30 Variation in Maximum and Minimum Temperatures in the Winnipeg Region (Celsius)

	Glenlea		International Airport		Selkirk		North Kildonan S.T.P		St. Norbert	
	Snow-fall	Total Precip.	Snow-fall	Total Precip.	Snow-fall	Total Precip.	Snow-fall	Total Precip.	Snow-fall	Total Precip.
July 1972	-	1.24	-	2.37	-	2.06	-	1.78	-	1.73
August 1972	-	1.94	-	4.06	-	3.33	-	2.93	-	3.39
September 1972	-	3.56	.3	2.41	-	1.68	-	2.35	-	2.59
October 1972	8.5	2.32	6.0	.97	5.5	.92	3.0	1.20	12.1	1.87
November 1972	5.5	.55	6.7	.41	3.4	.34	10.0	.28	6.5	.70
December 1972	10.7	1.07	10.9	1.0	8.8	.88	12.0	.36	11.7	1.17
January 1973	.6	.16	1.1	.1	.50	.05	3.0	.06	1.1	.11
February 1973	3.5	.35	2.6	.25	2.2	.23	5.0	.23	2.8	2.8
March 1973	2.7	.56	4.0	.54	3.1	.56	5.0	.34	3.6	.44
April 1973	-	.55	.6	.83	.7	1.22	1.0	1.0	.7	.55
May 1973	-	2.30	-	4.06	-	1.79	-	3.13	-	3.13
June 1973	-	2.87	-	3.47	-	5.17	-	2.67	-	4.10
July 1973	-	5.37	-	3.56	-	2.36	-	3.26	-	5.83

Fig. 31 Precipitation in The Winnipeg Region (Inches)

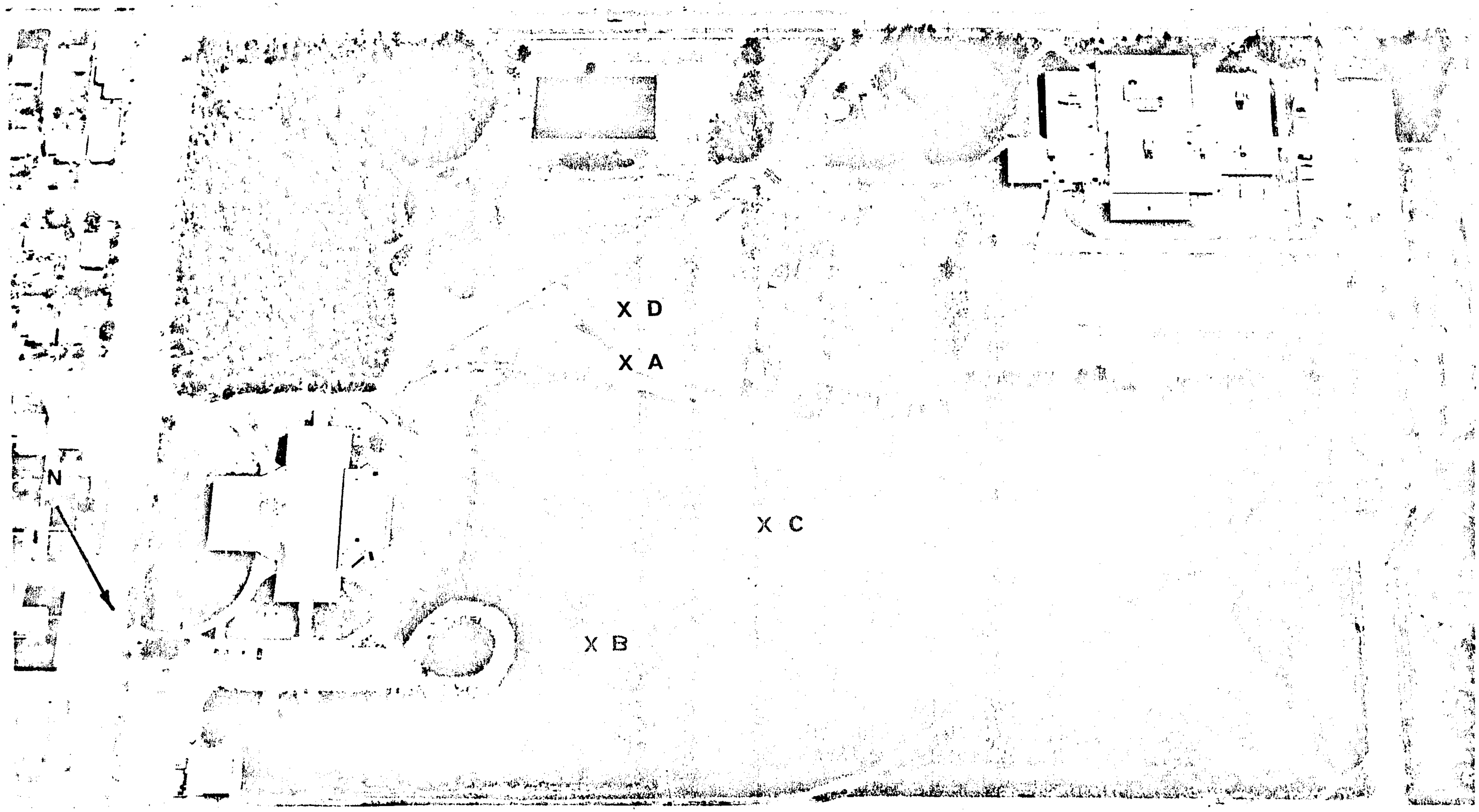


Fig. 32 Microclimate of the On-School Grounds Site

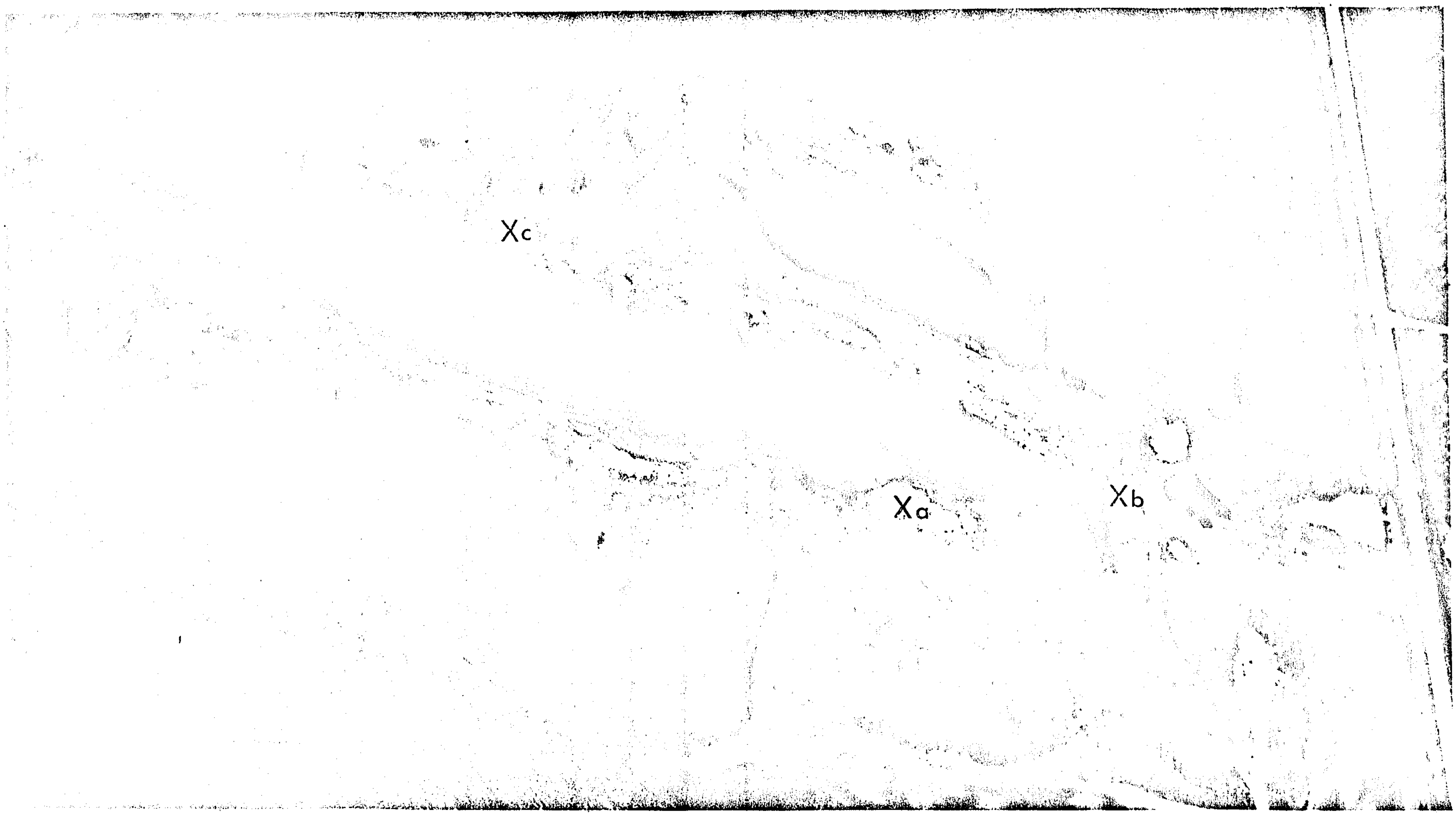


Fig. 33 Microclimate of the Gravel Pit Site

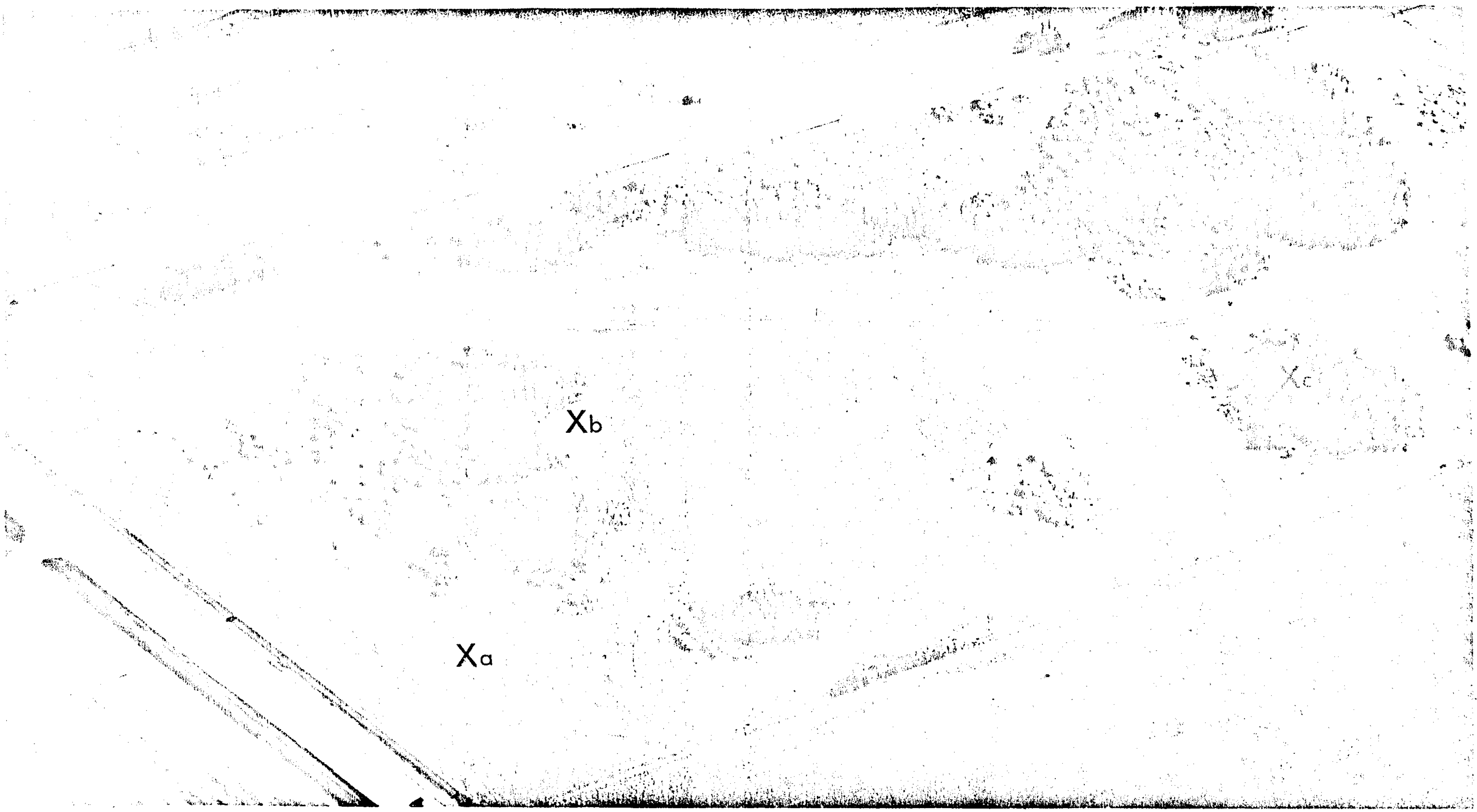


Fig. 34 Microclimate of The Grassland Site

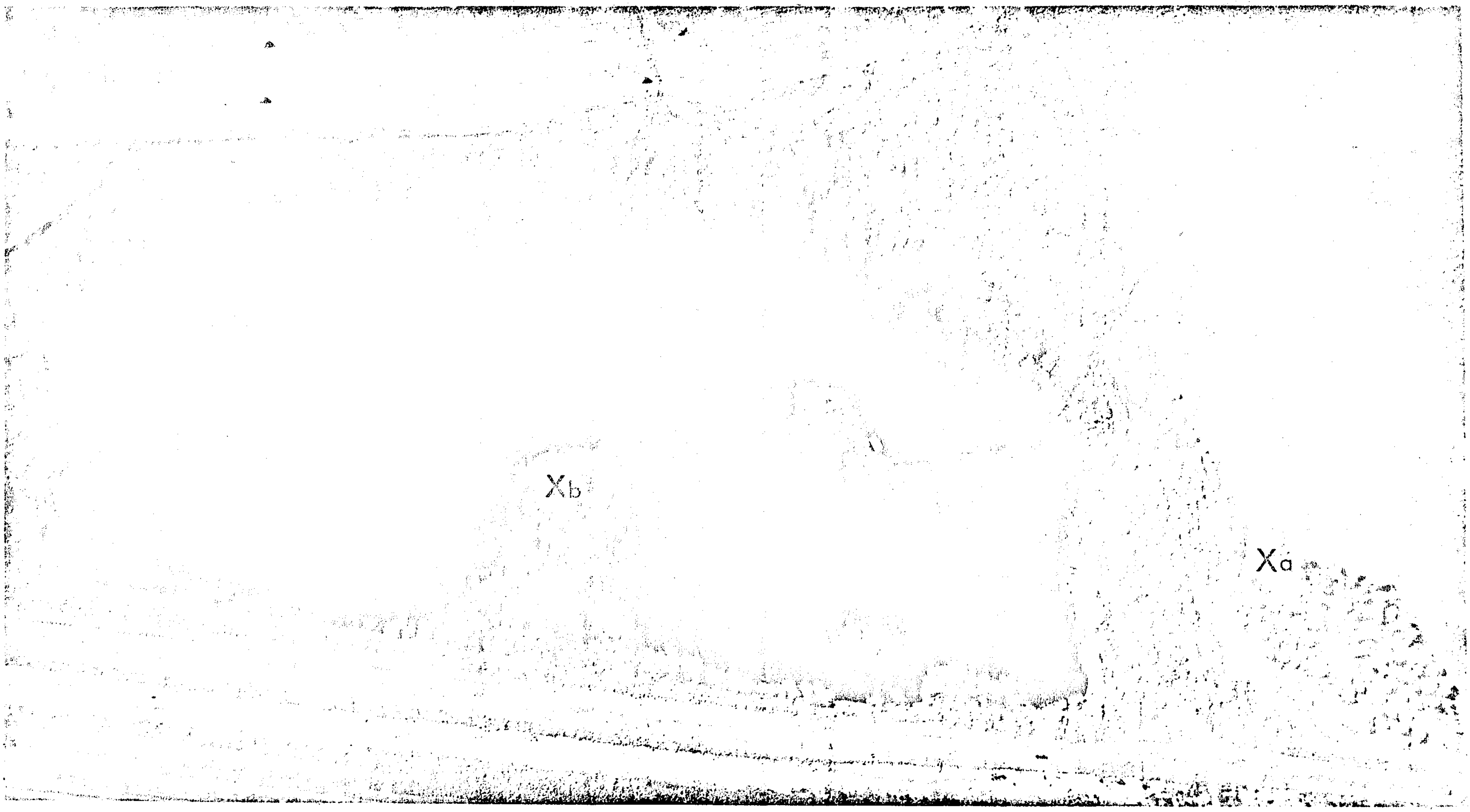


Fig. 35 Microclimate of the Marsh Site

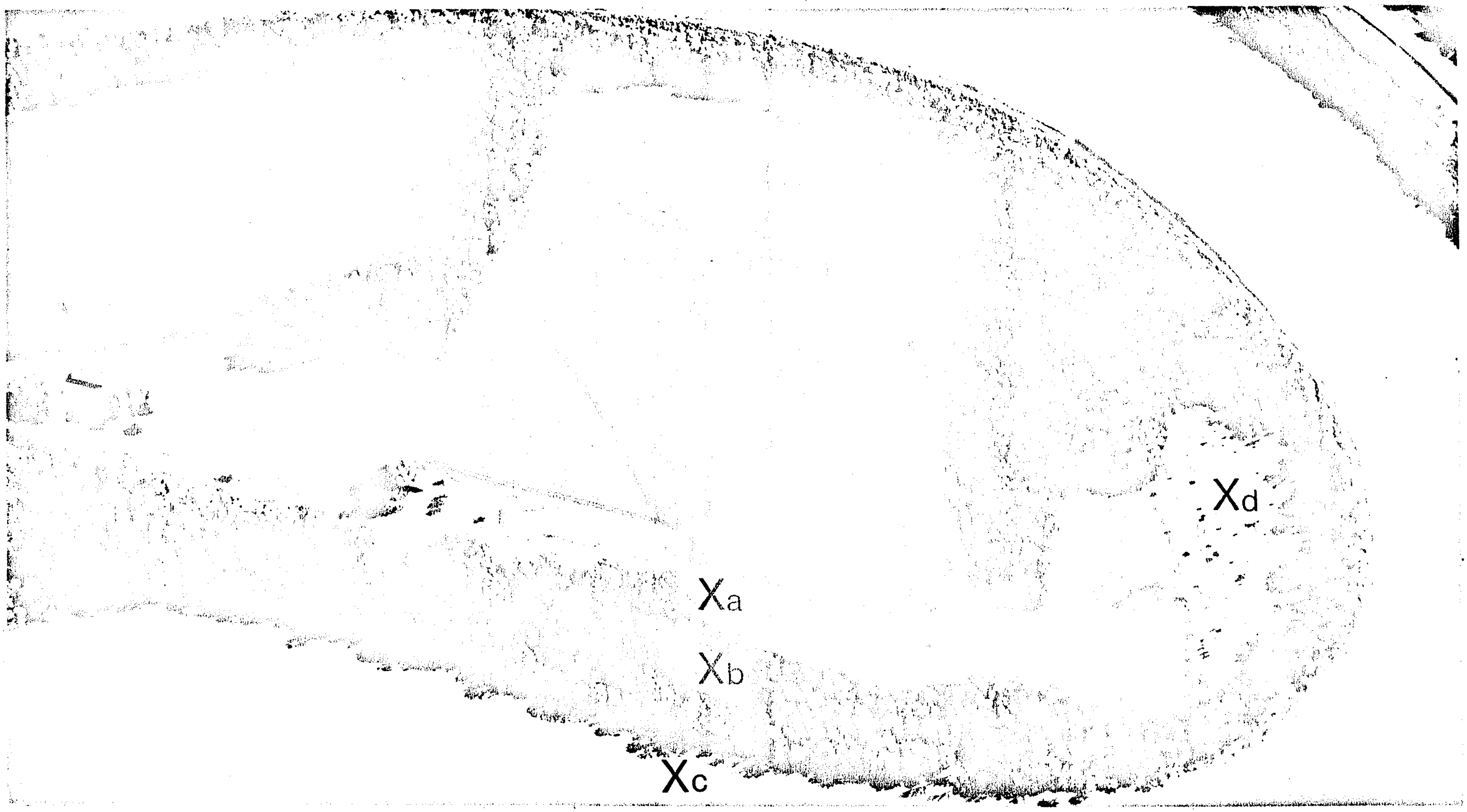


Fig. 36   Microclimate of the Riverbottom Site

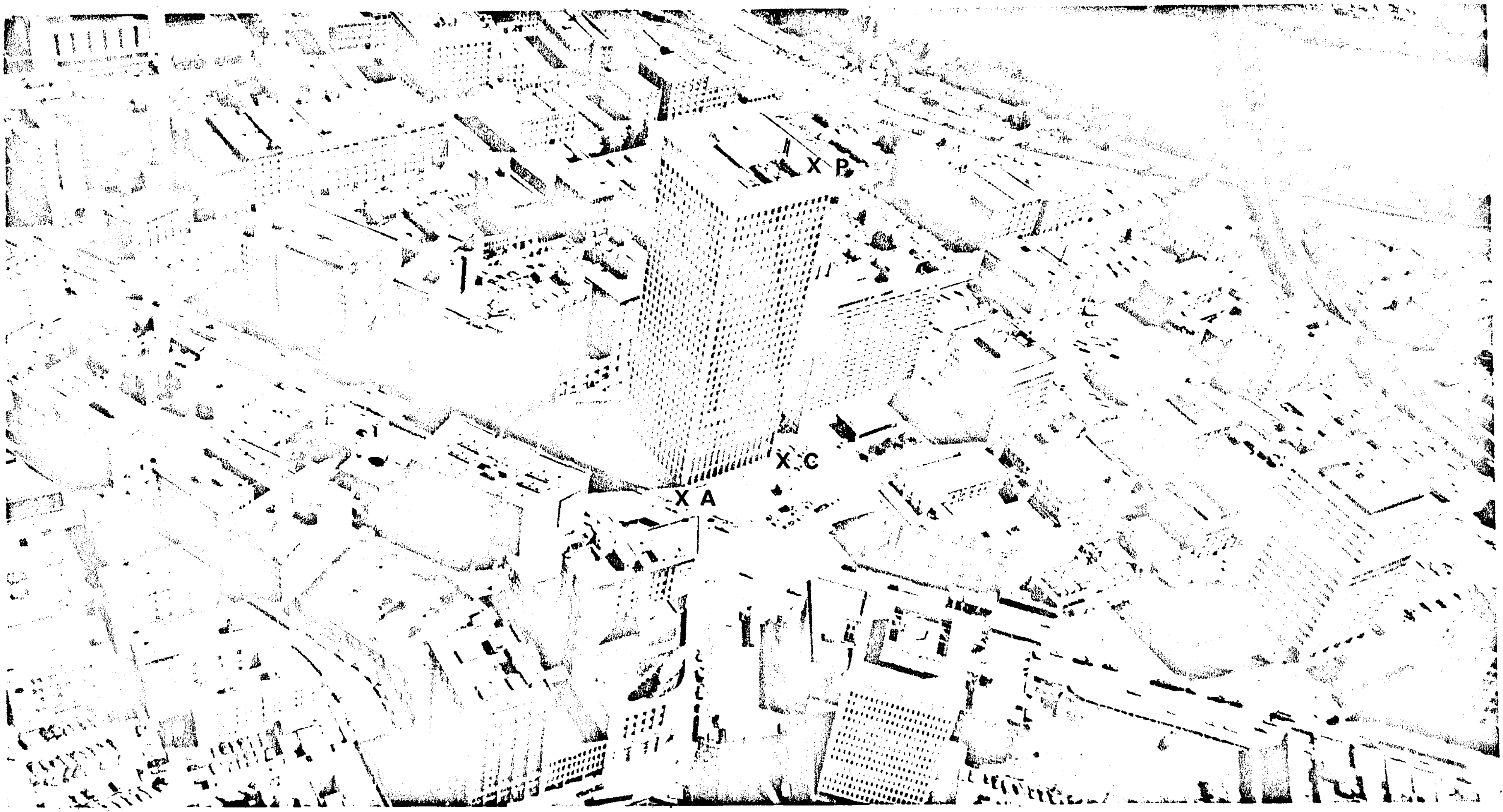


Fig. 37 Microclimate of the City Site

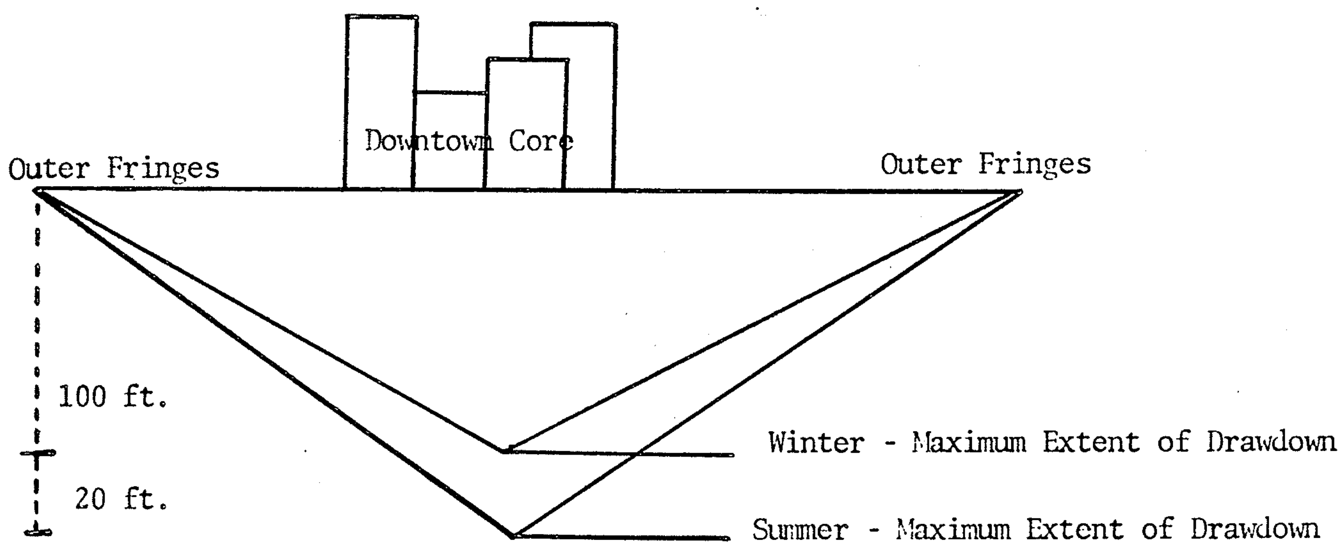


Fig. 38 Drawdown Effect of Commercial and Industrial Water Pumpage in Winnipeg's Core Area.

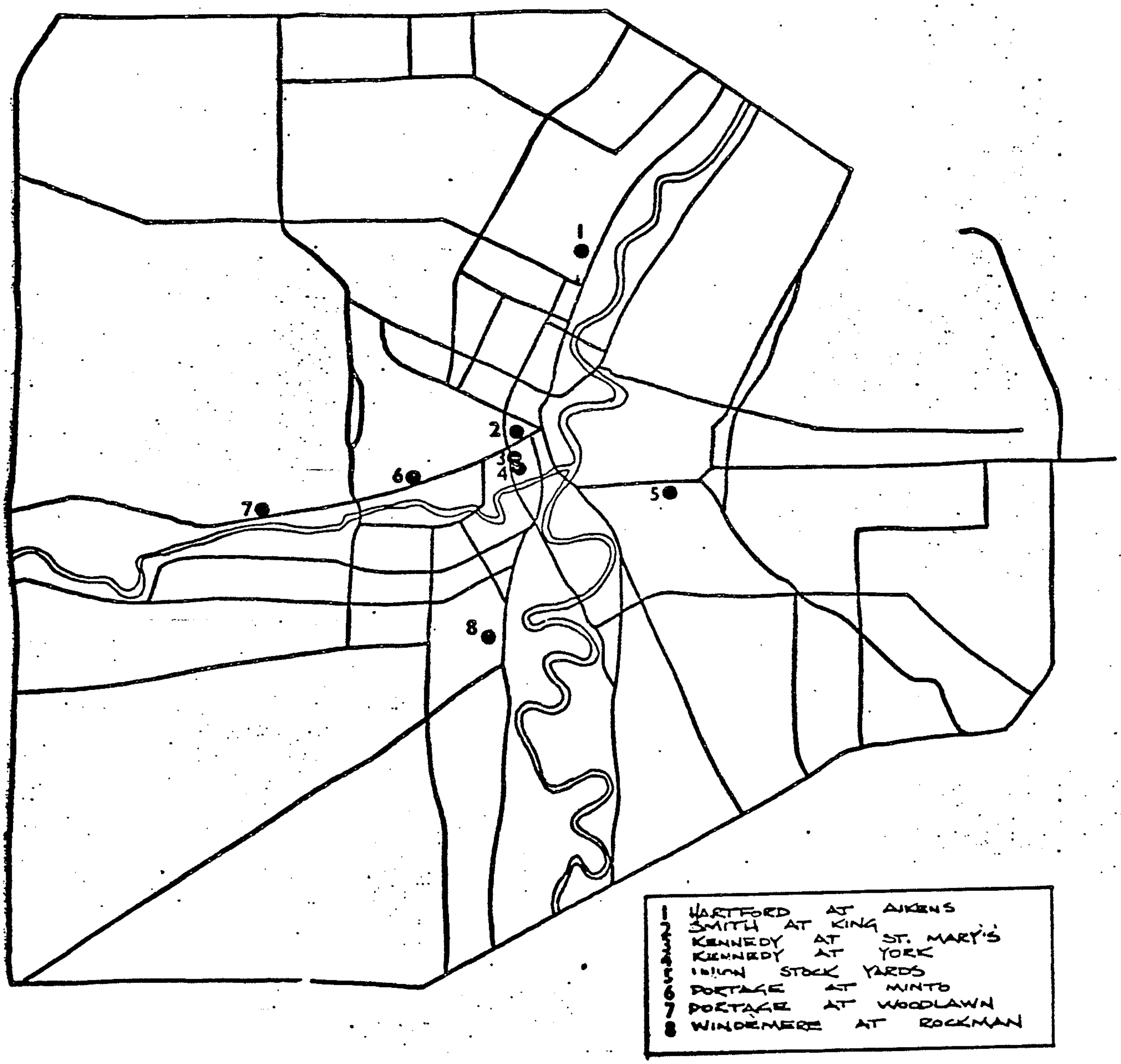


Fig. 39 National Air Pollution Surveillance Program Sample Stations

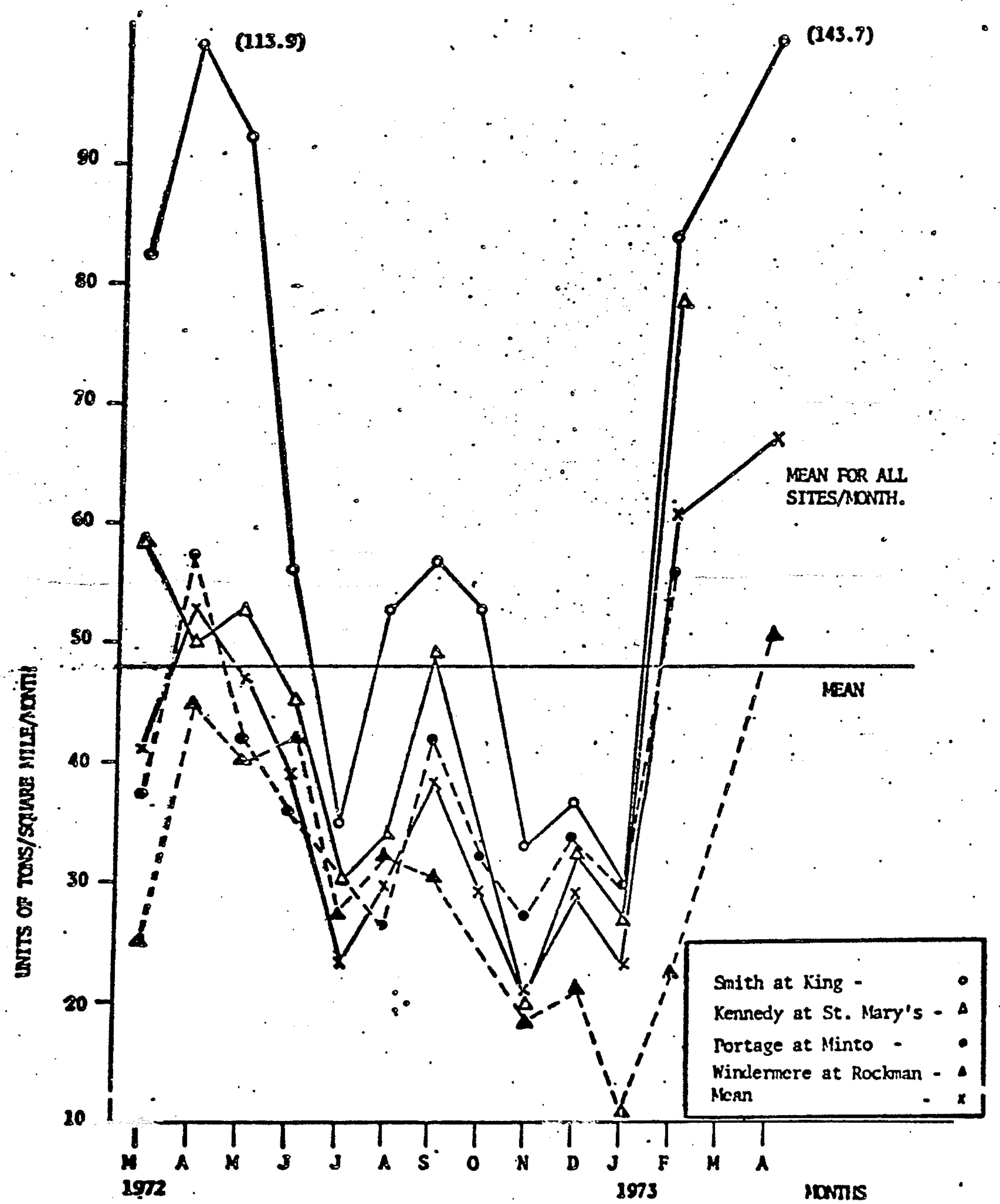


Fig. 40 Dustfall Levels

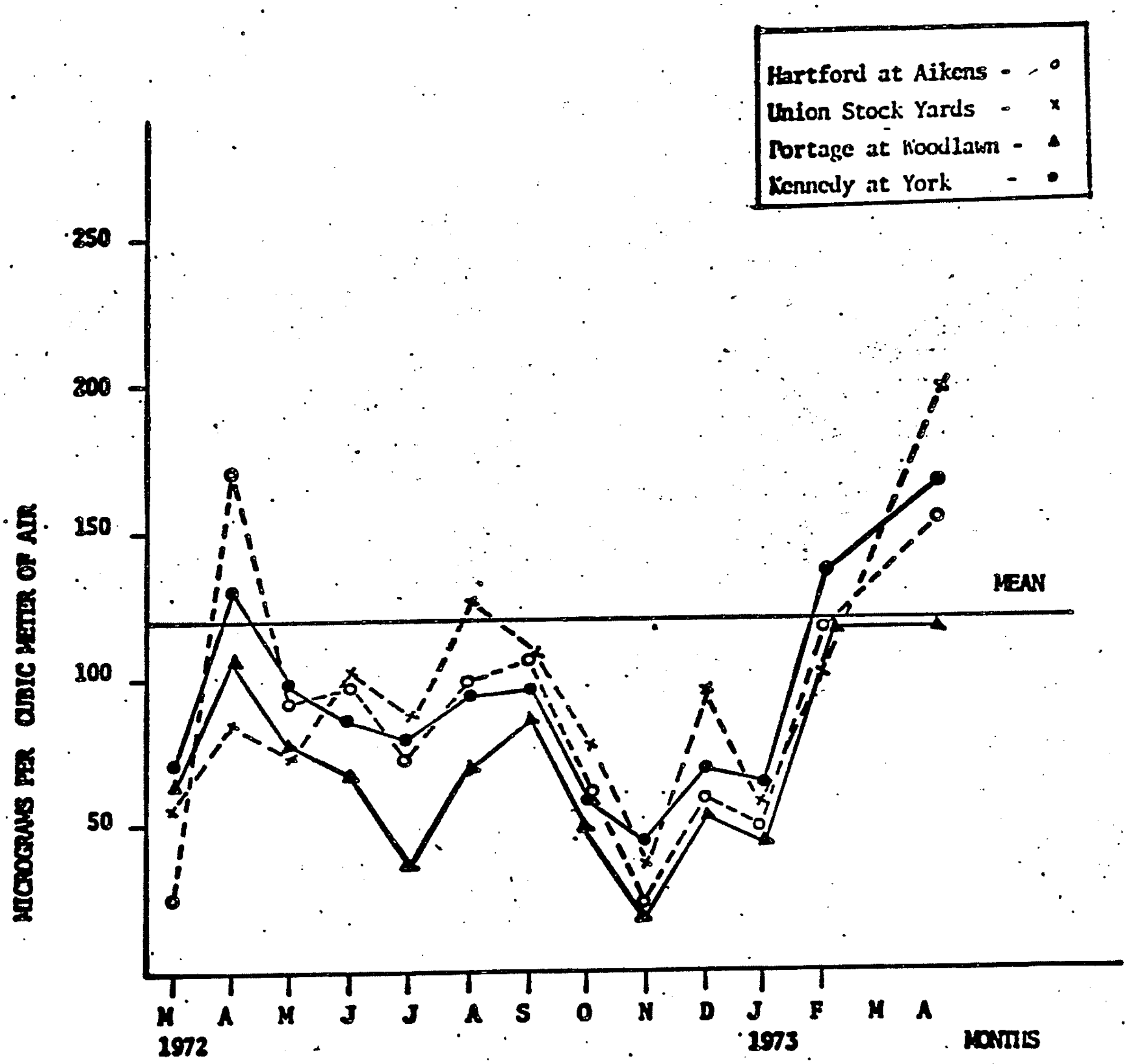


Fig. 41 Suspended Particulate Levels

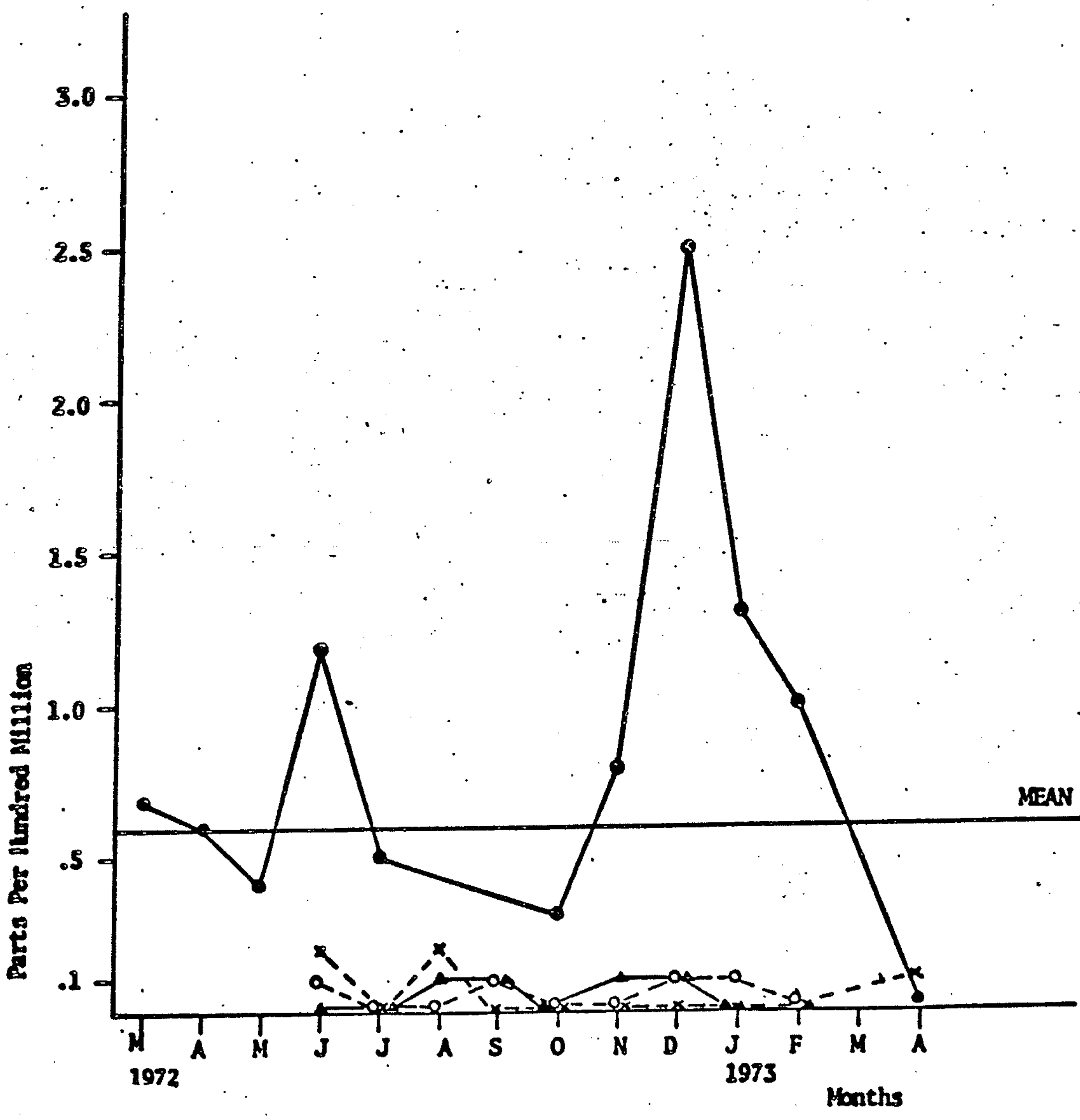


Fig. 42 Sulphur Dioxide Levels

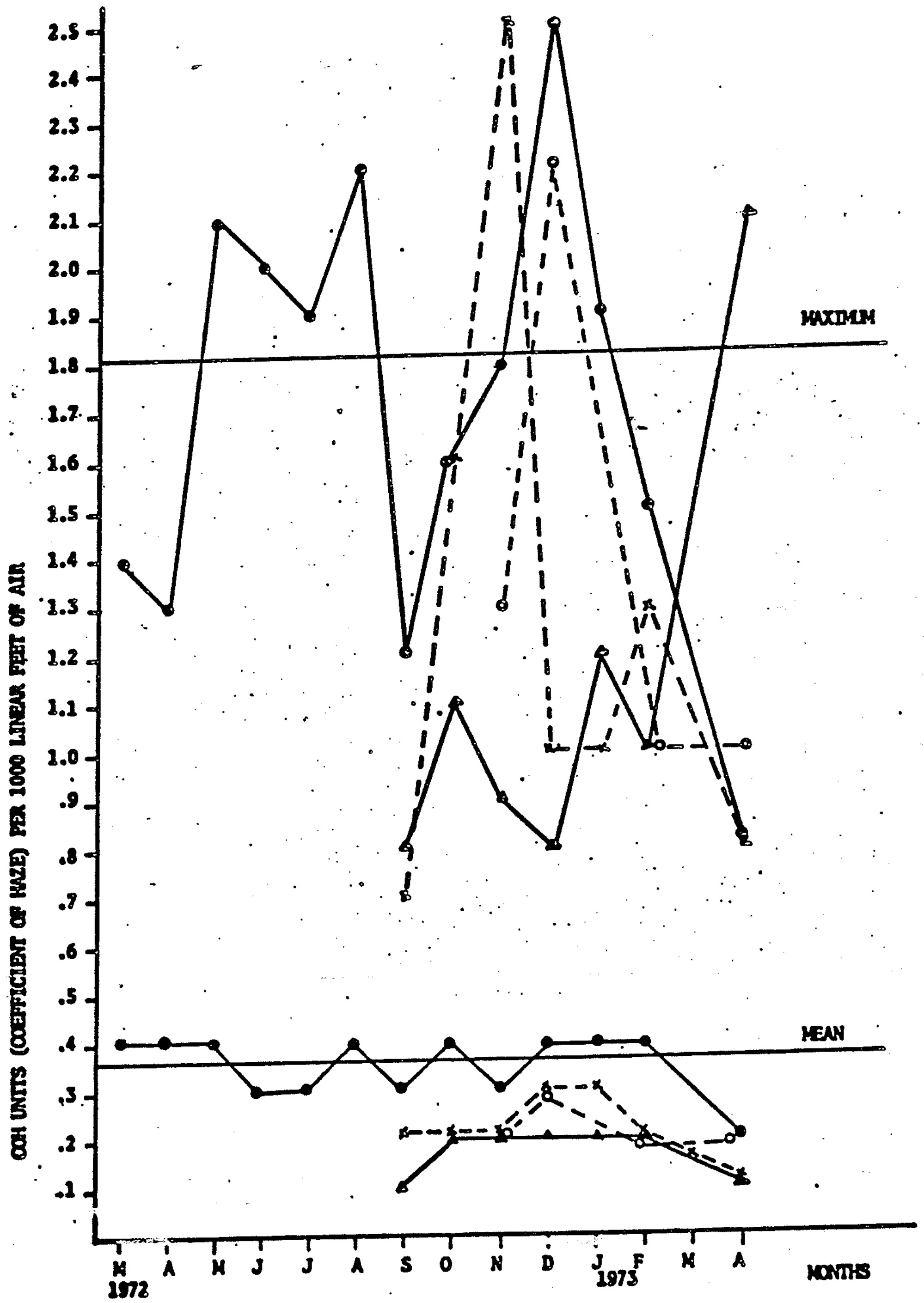


Fig. 43 Soiling Index

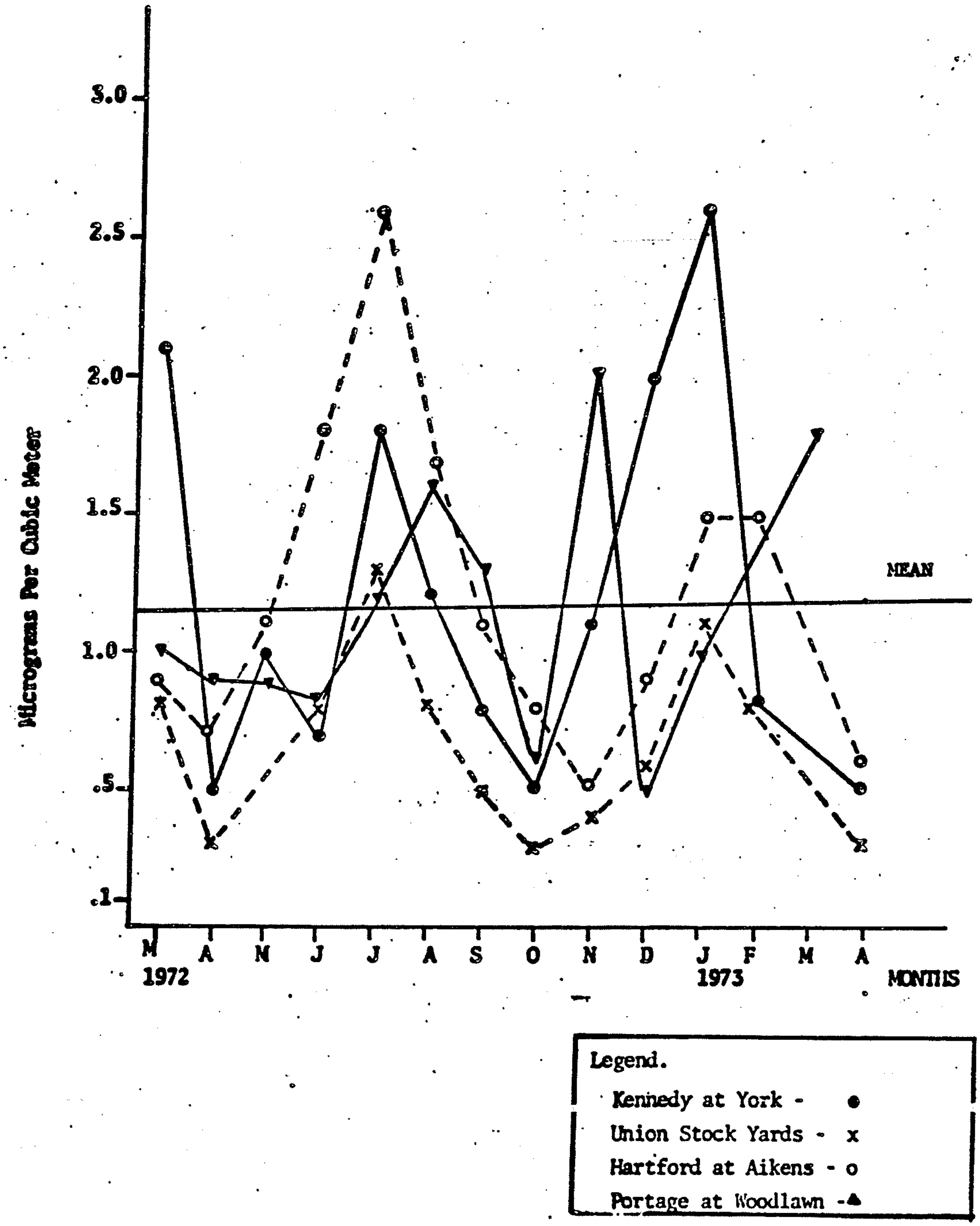


Fig. 44 Lead Levels

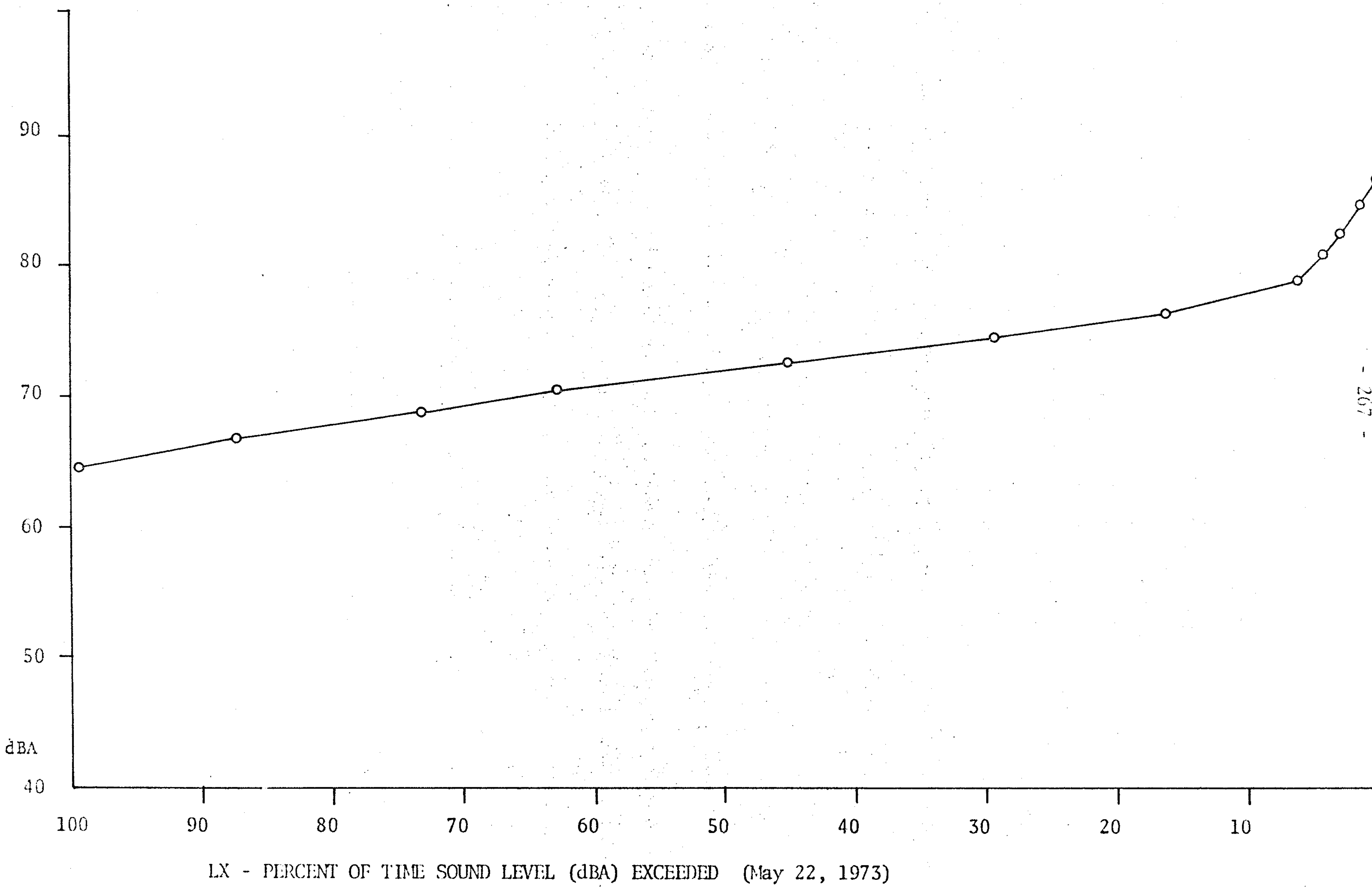


Fig. 45 Noise Levels - Portage at Kennedy

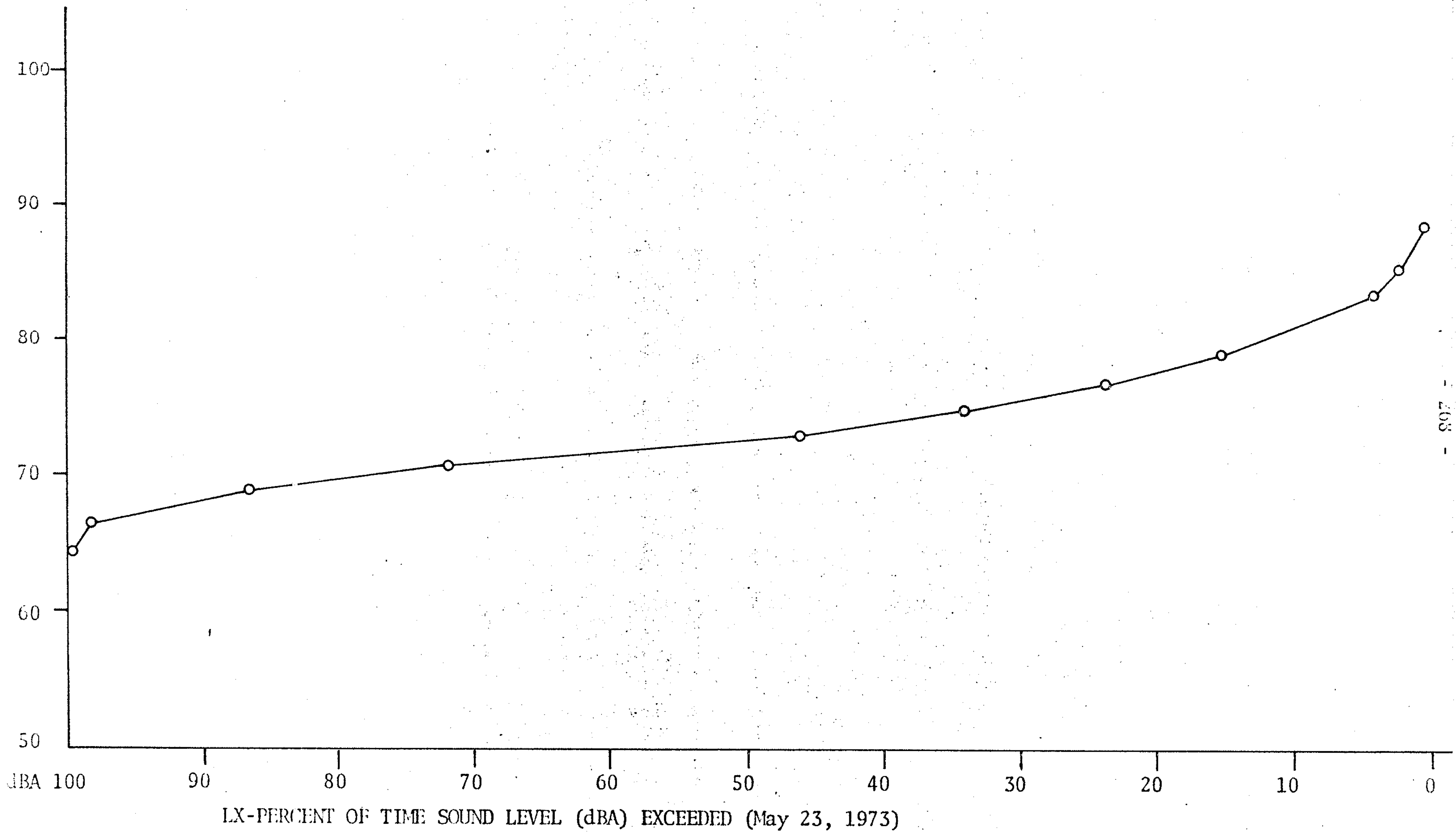


Fig. 46 Noise Levels - Portage at Carlton

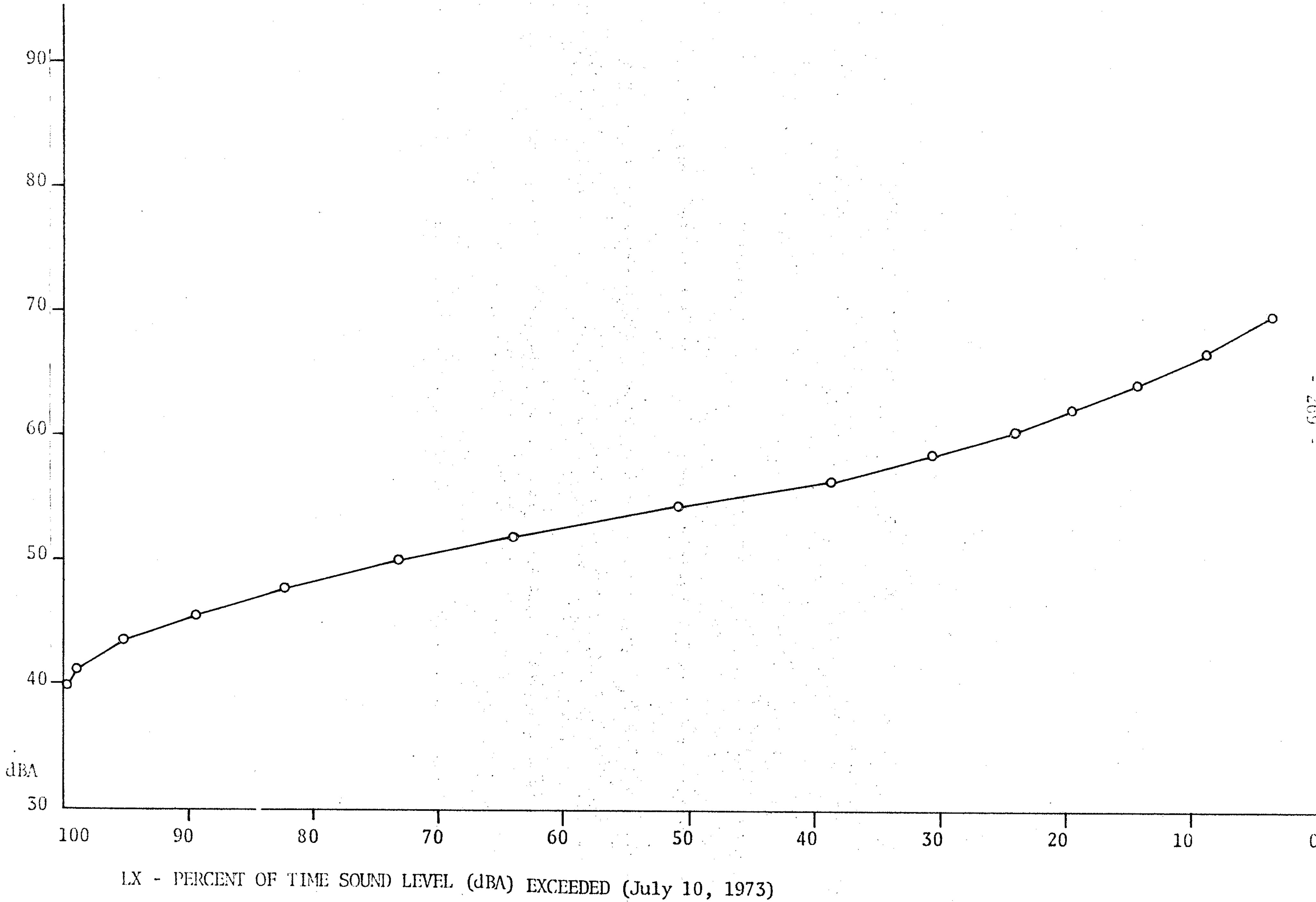


Fig. 47 Noise Levels - Inkster at Aikens

APPENDIX II

Table 1: Geologic Formation of the Winnipeg Area

Era	Period	Group	Formation	Maximum Thickness	Basic Lithology
Palaeozoic	Devonian 265 - 320 10^6 yrs.	Elk Point	Winnipegosis	335 ft.	Dolomite, reef and inter-reef
			Elm Point	50	High calcium limestone
			Ashern	50	Dolomite and Shale, brick red
	Silurian 320 - 360 10^6 yrs.	Interlake		400	Dolomite
	Ordovician 360 - 440 10^6 yrs.		Stony Mountain	180	Dolomite, Argillaceous dolomite fossiliferous calcium. Shale.
			Red River	550	Dolomite, Dolomitic limestone
			Winnipeg	225	Quartzose sand, sandstone, shale.

Modified from J.F. Davies, B.B. Bannatyne, G.S. Barry, and H.R. McCabe, 1962.

TABLE #2 ETHNIC GROUPS 1881-1971: Winnipeg and Manitoba

Group	1881		1911		1931		1951		1971	
	% by Group									
	Wpg.	Man.	Wpg.	Man.	Wpg.	Man.	Wpg.	Man.	Wpg.	Man.
British	70.0	59.7	61.0	59.9	62.0	52.6	52.0	46.7	42.9	41.9
Ukrainian	-	-	2.5	6.7	7.3	10.5	11.2	12.7	11.9	14.6
German	2.0	5.7	6.3	7.6	5.1	5.4	7.7	7.0	11.5	12.4
French	14.0	15.6	4.3	6.8	5.0	6.7	9.3	8.5	8.5	8.7
Polish	-	-	3.3	2.7	5.0	5.6	5.0	4.9	4.8	4.3
Scandinavian	4.0	1.5	3.5	3.8	3.8	4.5	3.2	4.2	3.3	3.6
Jewish	.5	.6	6.2	2.4	6.0	2.7	4.6	2.4	3.6	2.0
Other	9.5	16.9	12.9	10.1	5.8	12.0	7.0	13.6	13.5	12.5
Total Population (000's)	8	62	156	461	293	700	354	777	540	988

TABLE 3

POPULATION DATA BY RANGE AND TOWNSHIP, PARISHES AND CITY COMMUNITIES OF THE REGIONAL STUDY AREA (Note Fig. 13)

Range	Township	Area (Sq.miles)	Population	Density (Persons per square mile)
4W	13	30.2	183	6.06
4W	12	22	95	4.32
4W	11	36	594	16.5
4W	10	36	382	10.6
4W	9	36	158	4.39
4W	8	36	492	13.7
3W	14	36	64	1.78
3W	13	33.1	175	5.28
3W	12	14.9	381	25.6
3W	11	36	901	25.0
3W	10	36	352	9.7
3W	9	36	261	7.25
3W	8	36	142	3.94
3W	7	36	100	2.78
2W	15	36	49	1.36
2W	14	36	408	11.3
2W	13	36	224	6.2
2W	12	17.8	71	3.99
2W	11	15	15	1.00
2W	10	34.8	179	5.14
2W	9	36	501	13.9
2W	8	36	94	2.61
2W	7	36	112	3.11
2W	6	36	225	6.25
1W	16	36	63	1.75
1W	15	36	12	0.33
1W	14	36	263	7.3
1W	13	36	646	17.9

TABLE 3 (cont.)

Range	Township	Area (Sq.miles)	Population	Density (Persons per square mile)
1W	12	33.1	174	5.26
1W	11	7.0	25	3.57
1W	10	11.5	154	13.4
1W	9	36	359	9.97
1W	8	36	147	4.08
1W	7	36	247	6.86
1W	6	36	224	6.22
1W	5	36	502	13.94
1E	16	36	114	3.16
1E	15	36	248	6.89
1E	14	36	353	9.81
1E	13	36	2027	56.3
1E	12	36	304	8.44
1E	11	20.7	157	7.58
1E	10	2	30	15.0
1E	9	36	252	7.0
1E	8	36	406	11.28
1E	7	36	155	4.31
1E	6	36	428	11.89
1E	5	29.3	559	19.1
2E	16	36	375	10.4
2E	15	36	642	17.8
2E	14	36	344	9.56
2E	13	36	2066	57.39
2E	12	36	323	8.97
2E	11	15.2	120	7.89
2E	10	4	99	24.8
2E	9	27.5	242	8.8
2E	8	34.2	401	11.7

TABLE 3 (cont.)

Range	Township	Area (Sq. miles)	Population	Density (Persons per square mile)
2E	7	29.8	99	3.32
2E	6	15.2	65	4.28
2E	5	18	146	8.1
3E	16	36	200	5.56
3E	15	36	133	3.69
3E	14	36	60	1.67
3E	13	34.4	229	6.66
3E	12	W. St. Paul's		
3E	11	Winnipeg		
3E	10	Winnipeg		
3E	9	Winnipeg & St. Norbert		
3E	8	6.2	56	9.03
3E	7	15.4	165	10.71
3E	6	33.2	342	10.3
3E	5	36	147	4.08
5E	16	36	-	
5E	15	29.1	21	.72
5E	14	8.0	82	10.3
5E	13	10.9	392	35.9
5E	12	32.6	691	21.2
5E	11	36	867	24.1
5E	10	36	542	15.1
5E	9	17.2	220	12.8
5E	8	33.2	780	23.5
5E	7	36	721	20.0
5E	6	36	945	26.25
5E	5	36	1057	29.4
6E	16	36	53	1.47
6E	15	36	411	11.4
6E	14	36	270	7.5

TABLE 3 (cont.)

Range	Township	Area (Sq. miles)	Population	Density (Persons per square mile)
6E	13	36	868	24.1
6E	12	36	477	13.25
6E	11	36	458	12.7
6E	10	36	413	11.5
6E	9	34.3	250	7.3
6E	8	23.6	465	19.7
6E	7	36	1285	35.7
6E	6	36	6290	174.7
6E	5	36	415	11.5
7E	15	36	230	6.39
7E	14	36	227	6.3
7E	13	36	322	8.94
7E	12	36	2676	74.3
7E	11	36	317	8.81
7E	10	36	380	10.5
7E	9	36	393	10.92
7E	8	24.2	287	11.9
7E	7	35.6	570	16.0
7E	6	36	636	17.7
8E	14	36	278	7.72
8E	13	36	332	9.22
8E	12	36	385	10.7
8E	11	36	274	7.6
8E	10	36	188	5.2
8E	9	36	227	6.3
8E	8	36	553	15.4
8E	7	36	164	4.56
4E	16	36	257	7.14
4E	15	36	710	19.7

TABLE 3 (cont.)

Range	Township	Area (Sq. miles)	Population	Density (Persons per square mile)
4E	14	34.0	296	8.7
4E	13	5.0	74	14.8
4E	12	6.0	212	35.3
4E	11	20.4	558	27.4
4E	10	28.3	578	20.4
4E	9	30.	838	27.9
4E	8	36	640	17.8
4E	7	36	1464	40.6
4E	6	36	624	17.3
4E	5	36	326	9.06

PARISHES

	Area (Sq. miles)	Population	Density (Persons per square mile)
Lorette	29.3	1,222	41.7
St. Agathe	99.4	2,209	22.2
St. Anne	23.2	1,382	59.6
St. Norbert	63.4	1,340	21.1
St. Andrews	61.4	3,910	63.6
St. Clements	32.2	1,305	40.9
St. Peters	32.3	892	27.6
Baie St. Paul	54.8	514	9.0
St. Francois Xavier	89.8	1,133	12.3

TABLE 3 (cont.)

METROPOLITAN WINNIPEG

	Area	Population	Density
East St. Pauls	19.3	2,616	135.5
West St. Pauls	37.8	2,429	64.8
St. Boniface & St. Vital	41.4	79,685	1,924.8
Assiniboine Park and Fort Garry	71.2	60,965	852.7
St. James-Assiniboia	41.8	71,475	1,709
Winnipeg, Fort Rouge, Midland, Centennial	15.0	143,865	9,591
West Kildonan, Lord Selkirk,Part of St. John's	23.3	89,995	3,862
East Kildonan, Transcona, Part of St. Johns	23.2	89,035	3,837.7

Source: 1871 Census of Canada, Statistics Canada, Ottawa, KIA OT6
Catalogue 92-707, 92-708, 92-711.

Table 4: Chemical Analysis of Water Samples from the Gravel Pit Site and the Marsh Site

	Gravel Pit Site	Marsh Site
True color - relative units	10.	45.
Specific conductivity - UMHO/CM	669.	613.
Total turbidity - turbidity units	1.5	0.7
Bicarbonate - HCO_3 - Mg/L	146.	298.
Dissolved carbonate - CO_3 - Mg/L	34.	0.
Total nitrogen - N - Mg/L	0.6	1.
Dissolved nitrate and nitrate - N-Mg/L	.01	.01
Total ammonia - N - Mg/L	0.05	0.03
Biochemical oxygen demand - O_2 - Mg/L	1.4	2.3
Hydroxide - OH - Mg/L	0.	0.
Total alkalinity - $CaCo_3$ - Mg/L	176.	244.
pH - pH units	8.5	8.2
Nonfiltrable residue - Mg/L	5.	5.
Filtrable residue - Mg/L	36.	390.
Total hardness - $CaCo_3$ - Mg/L	260.	290.
Dissolved sodium - Na - Mg/L	50.	40.
Dissolved magnesium - Mg - Mg/L	34.	42.
Dissolved sulphate - SO_4 - Mg/L	62.5	55.
Dissolved chloride - CL - Mg/L	53.	19.5
Dissolved potassium - K - Mg/L	6.5	6.8
Total manganese - MN - Mg/L	.02	.02

Table 5: Soil Analysis - On-School Grounds Site

Sample No.	Depth	pH	Cond. mmhos	NO_3 -N ppm	Avail. P ppm	Avail. K ppm	% O M
1	0 - 6	7.7	0.5	5.4	19.8	700+	10.91
	6 -24	8.5	0.3	1.6	22.0	455	1.85
2	0 - 6	7.2	0.4	1.6	7.6	548	8.76
	6 -24	7.7	0.4	1.4	3.2	372	3.04
3	0 - 6	7.6	0.5	1.6	2.4	527	5.30
	6 -24	8.4	0.5	1.6	0.6	265	1.91
4	0 - 6	6.4	0.3	0.8	24.0	700+	10.37
	6 -24	6.7	0.3	0.8	3.4	630	2.15
5	0 - 6	8.0	0.6	1.6	58.4+	700+	6.38
	6 -24	8.6	0.5	1.6	2.0	172	1.91

Sample No.	Depth	pH	Cond. mmhos	NO_3 -N ppm	Avail. P ppm	Avail. K ppm	% O M
1	0 - 6	7.4	0.4	16.4	19.4	700+	9.85
	6 -24	7.9	0.6	2.2	8.0	450	3.08
2	0 - 6	7.8	0.4	1.2	3.0	570	6.28
	6 -12	8.0	0.4	0.8	0.8	321	3.98
	12 -24	8.1	0.3	1.6	0.6	335	3.93

Table 6: Soil Analysis - Gravel Pit Site

Table 7: Soil Analysis - Grassland Site

Sample	Depth	pH	Cond. mmhos	NO_3 -N ppm	Avail. P ppm	Avail. K ppm	% O M
1	0 - 6	8.2	0.5	0.8	1.4	415	6.52
	6 -24	8.5	0.3	1.2	0.6	208	1.63
2	0 - 6	7.8	0.3	0.8	2.6	537	6.52
	6 -24	8.4	0.9	1.4	0.4	224	1.93
3	0 - 6	7.4	0.3	1.8	1.8	368	8.99
	6 -24	8.2	0.4	1.8	0.8	224	1.51

Table 8: Soil Analysis - Marsh Site

Sample No.	Depth	pH	Cond. mmhos	NO_3 -N ppm	Avail. P ppm	Avail. K ppm	% O M
1	0 - 6	8.0	0.8	0.4	2.2	315	1.70
	6 -24	7.7	2.1	0.6	2.8	317	1.45
2	0 - 6	6.6	0.5	1.2	7.0	547	9.24
	6 -24	7.8	0.6	0.8	2.0	370	2.59
3	0 - 6	7.4	0.3	0.8	4.4	572	7.43
	6 -24	8.4	0.5	1.2	1.0	295	2.54

Table 9: Soil Analysis - Riverbottom Site

Sample No.	Depth	pH	Cond. mmhos	NO_3 -N ppm	Avail. P ppm	Avail. K ppm	% O M
1	0 - 6	7.9	0.4	3.6	24.2	315	2.29
	6 -24	7.9	0.4	3.4	22.0	300	2.54
2	0 - 6	7.5	0.3	1.4	13.0	330	4.05
	6 -24	7.8	0.2	0.6	2.4	210	2.11
3	0 - 6	7.5	0.2	3.0	37.2	409	6.46
	6 -24	7.6	0.2	1.6	9.6	280	3.20

TABLE 10 : Soil Temperatures (mean degrees Celsius)

GLENLEA

Depth (cm.) Date		005	010	020	050	100	150	300	Snow Cover
July/72	a.m.	15	14	16	14	11	8	5	0
	p.m.	17	15	16					
Aug./72	a.m.	16	15	17	15	13	10	6	0
	p.m.	18	16	17					
Sept/72					I/D				
Oct./72					I/D				
Nov./72	a.m.	1	1	2	4	5	7	8	1.9
	p.m.								
Dec./72	a.m.	-5	-5	-3	1	2	4	7	3.12
	p.m.								
Jan./73	a.m.	-6	-5	-4	-2	-1	2	5	6.13
	p.m.								
Feb./73	a.m.	-6	-5	-5	-3	-1	1	4	4.21
	p.m.								
Mar./73	a.m.	-1	-1	-1	-1	-1	0	3	.13
	p.m.								
Apr./73	a.m.	1	0	0	0	-1	0	2	0
	p.m.								
May/73	a.m.	7	7	7	5	2	2	2	0
	p.m.	10	8	8					
June/73	a.m.	14	14	15	12	8	5	3	0
	p.m.	16	14	14					
July/73	a.m.	17	17	17	15	12	8	5	0
	p.m.	20	17	17					

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Depth (cm.) Date		005	010	020	050	100	150	300	Snow Cover
July/72	a.m.	16	16	16	14	10	7	4	0
	p.m.	21	18	16					
Aug./72	a.m.				I/D				
	p.m.								
Sept/72					I/D				
Oct./72					I/D				
Nov./72	a.m.	1	2	2	4	6	7	8	4.16
	p.m.	1	2	2					
Dec./72	a.m.	-2	-1	-1	1	3	4	7	4.06
	p.m.	-2	-1	-1					
Jan./73	a.m.	-3	-2	-2	-1	1	2	6	7.29
	p.m.	-3	-2	-2					
Feb./73	a.m.	-3	-2	-2	-1	0	2	5	18.78
	p.m.	-3	-2	-2					
Mar./73	a.m.	-1	0	0	-1	0	1	4	7.03
	p.m.	0	0	0					
Apr./73	a.m.	1	2	2	1	0	1	4	0
	p.m.	5	3	2					
May/73	a.m.	8	8	8	6	4	3	3	0
	p.m.	13	10	8					
June/73	a.m.	14	14	14	12	9	8	4	0
	p.m.	16	17	14					
July/73	a.m.	16	17	17	16	13	11	5	0
	p.m.	21	19	17					

Table 11: Duration of Sunshine

GLENLEA

Month	Duration in Hours	% of Possible Duration	Maximum Sunshine in one day		Number of Hours with no Sunshine (Cloud Cover)
			Hours	Date	
July/72	312	64	15.5	3	1
Aug/72	298	67	13.3	23	0
Sept/72	154	41	12.5	4	2
Oct/72	156	47	9.5	22	3
Nov/72	61	23	7.6	24	13
Dec/72	104	41	7.9	9	10
Jan/73	125	47	8.3	27	6
Feb/73	129	46	9.7	19	8
Mar/73	144	39	10.1	30	3
April/73	-	-	13.5	27	-
May/73	285	60	15.5	28	2
June/73	247	51	15.1	12	2
July/73	295	60	15.3	8	1

INTERNATIONAL AIRPORT

Month	Duration in Hours	% of Possible Duration	Maximum Sunshine in one day		Number of Hours with no Sunshine (Cloud Cover)
			Hours	Date	
July/72	301	62	15.7	17	0
Aug/72	285	64	13.5	22	1
Sept/72	158	42	12.3	4	1
Oct/72	168	51	9.8	16	4
Nov/72	52	19	7.4	13	14
Dec/72	121	48	7.9	3	10
Jan/73	141	53	8.3	27	2
Feb/73	140	50	9.8	19	6
Mar/73	150	41	11.1	17	8
April/73	221	54	13.9	26	2
May/73	293	62	15.3	28	2
June/73	254	52	15.8	12	2
July/73	314	64	15.6	8	1

Table 12: Mean Monthly Dew Point (°C)

Month	Glenlea	International Airport
July/72	12	10
August/72	11	11
September/72	5	3
October/72	-2	-3
November/72	-9	-9
December/72	-24	-23
January/73	-18	-18
Feburary/73	-19	-18
March/73	-4	-4
April/73	-4	-6
May/73	4	2
June/73	12	10
July/73	12	12

Table 13: Wind Speed and Direction

Glenlea

Month	July/72	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July/73	Mean
Speed 13-38	15	19	24	24	16	23	26	20	21	25	20	23	19	21.11
1-12	16	12	6	7	14	8	5	8	10	5	11	7	12	.930
Days Calm	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wind Direction														
N	2	5	2	0	1	1	2	2	2	2	5	5	3	3
NE	4	12	3	5	6	3	0	6	4	11	10	1	6	5.46
E	0	0	1	0	0	0	0	0	0	0	0	0	1	0.15
SE	4	1	1	0	2	1	3	1	6	4	5	2	3	2.53
S	2	3	8	6	9	9	12	10	11	2	0	4	5	6.23
SW	9	5	2	7	2	8	2	2	1	1	4	8	3	4.15
W	2	0	3	0	0	1	0	1	2	1	1	1	3	1.15
NW	8	5	11	9	6	8	12	6	4	9	6	9	7	7.6

International Airport

Month	July/72	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July/73	Mean
Speed 13-38	2	6	8	10	7	9	12	6	3	7	8	7	7	7.46
1-12	22	21	20	19	20	21	18	22	19	22	21	21	18	20.3
Days Calm	7	4	2	2	3	1	1	0	4	1	2	2	6	2.69
Wind Direction														
N	1	6	4	5	5	3	1	10	4	6	7	2	3	4.38
NE	1	1	0	1	0	1	1	0	1	6	5	1	1	1.46
E	0	2	4	1	1	0	1	0	5	3	6	3	3	2.23
SE	4	2	1	1	5	1	5	4	3	2	0	5	2	3.076
S	4	9	8	7	6	9	9	8	4	3	1	4	3	5.769
SW	4	1	3	3	0	3	2	0	0	1	2	3	3	1.92
W	5	3	6	4	3	6	5	5	2	3	4	4	8	4.61
NW	5	3	2	7	7	7	6	1	3	5	4	6	2	4.46