ENVIRONMENTAL CRITERIA FOR RECREATIONALLY ORIENTED HIGHWAY PLANNING

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Recreational land use activities are rapidly increasing and are tending toward multiple-use, year-round complexes. This trend is placing a severe strain on highway location, design, and subsequent improvements. Environmental criteria affecting the developmental capacity near inland lakes and rivers have become more refined and are of increasing concern to both public and governmental bodies. Therefore, it is necessary to explore economical techniques of evaluations of these terrain parameters, which provide reliable information to engineers, planners, and the public. The methodologies employed are a function of the areal extent of the study, the geological complexities, the controlling governmental agency, the extent of existing and projected development, and the involvement of the public. Three case studies are described, each employing the same basic air-photo technique but varying in the functions listed above, the specific factors analyzed, and the modes of data compilation and presentation required. Numerical developmental constraints, specific land use capabilities, and particular problem areas are each discussed in their relations to highway engineering planning.

•THE rapid changes in recreational land use patterns and the subsequent effects on the location and design of highways and access roads through these areas have prompted the views expressed in this paper. Having performed consulting and research work in the field of air-photo interpretation and terrain evaluation for the past 8 years, the author has had the opportunity to observe these changes as they have taken place and has recognized the difficulties of predicting the area trends and intensities of recreational developments.

Increased leisure time, combined with a greater public concern over environmental control, has resulted in the addition of a vast number of both physical and social parameters in the planning process, thus creating new concepts of highway planning and design. Consequently, governmental authorities at all levels (municipal, provincial, and federal) have been placed in the difficult position of making rapid adjustments to meet the increased demands of the public. The significant increases in traffic flow, year-round uses of what were originally intended to be summer cottages, and development of high-density multiple-activity resorts have caused rapid increases in land values. As a result applications to government planning agencies have increased for intense developments in areas that were considered to be virgin land only 5 years ago. The situation is particularly difficult in southern Ontario, an estimated 250,000 lakes being contained within the province. Moreover, a large number of such lakes are located within a 150-mile radius of metropolitan Toronto, which has a population of approximately 2.5 million people.

It is the objective of this paper, therefore, to briefly consider the effects of these changes on the physical environment. The terrain considerations involved in improving access roads to highway standards, highway widenings, and highway relocation will be examined in the multiple land use planning concept. The methodologies being employed by various government agencies will be discussed, and three examples from the author's experience will be used to illustrate the effectiveness of these techniques.

REGIONAL CONSIDERATIONS IN HIGHWAY LOCATION AND DESIGN

The ideal highway route location is considered to be over relatively level terrain, consisting of deep, coarse soils, well drained internally. In the distant past, when it was impossible to foresee the demand on potential recreational areas, highways and access routes that later became highways were located through this type of terrain wherever possible. However, what is physically ideal for highways is also ideal for any type of recreational development. Therefore, the result has been in many cases a strip of development along the highway, primarily of a commercial nature. Where the highway or access route passed in close proximity to inland lakes because of the existence of excellent terrain conditions, these lakes invariably became densely developed, resulting in a network of access roads from the highway along the shoreline. This process eventually led to the development of back lots, thus increasing the traffic volume. Subsequently, the more heavily traveled access routes became secondary highways. The resulting increase in volume on the main highway made necessary the widening of pavements. Because the high-density development within resort areas could not be predicted prior to the location of the original highway, overpass bridges had to be either constructed or widened, level crossings became serious hazards, and drainage structures had to be either enlarged or replaced.

Because the original highway locations were not designed for high-speed heavy-volume traffic, alignments had to be improved and small towns bypassed. Thus, the primary and secondary highway system developed so quickly in areas of rapid recreational growth that the government authorities responsible for highway improvements had no choice but to consistently meet the ever-increasing public demands.

Improved methods of water quality detection, technological advances in the detection of air pollution, and substantially increased traffic congestion at peak periods have caused all concerned government agencies to consider the consequences of widening the existing primary highways and creating secondary highway networks geared to meet the demands of the public. The demands on municipalities, such as snowplowing and local improvements, should also be noted.

The district municipality of Muskoka, a highly developed recreational area lying between 80 and 160 miles north of Toronto, encompasses an area of approximately 2,000 square miles. The municipal government is currently in the process of evaluating the terrain capability for development of this large land area with the objective of preparing an official development plan based on, among other factors, the realities of the available land for future development and the realization that the pattern of development adopted will strongly influence the future transportation system within the municipality.

The treaty Indians of Canada have begun to realize the economic development potential of the federal reserve lands over which they have jurisdiction. The extended highway networks and the increased mobility of the general public have increased the accessibility of these lands, and the demand for recreational property, even with the prospect of a short-term (20-year) lease, has created a new awareness within the native peoples of the value of the reserve lands.

Studies are now being undertaken by, for example, the Ontario Ministry of Transportation and Communications. This Ontario government agency is currently investigating the possibilities of partial relocation of some of the established highway routes through densely populated recreational areas.

Each of the situations previously described involves a different level of government authority. An example will therefore be cited from each case to illustrate the effectiveness of the methodology described in the next section of this paper.

METHODOLOGY FOR REGIONAL AND DETAILED TERRAIN EVALUATIONS

A recent study, carried out by a multidisciplinary team from the Institute of Environmental Sciences and Engineering, University of Toronto, revealed that the most influential physical parameters affecting the capacity of an inland lake for recreational development are the physiographic characteristics of the water and land area within the watershed (1). Therefore, the input to this study by all disciplines concerned resulted in the recognition of the fact that the basic geological terrain conditions represent, to a large extent, the controls on recreational development capacity. Consequently, the physical dimensions of the watershed area, the topographic slopes, the type of soil and depth of overburden, the type of underlying bedrock and fracture structure, the soil moisture conditions and height of water table, and density and type of vegetative cover were considered to be of basic importance.

Because the septic tile bed is a common method of sewage disposal in recreational areas, this facility must be evaluated based on the preceding criteria to permit logical intensities of development. The Ontario Ministry of the Environment is currently investigating the capability of Precambrian soils to absorb septic tile bed effluents. Certain remedial measures can be undertaken to either prevent or substantially delay the return of septic tile bed effluents to a source of surface or groundwater supply.

Sources of potable water supply are dependent on a variety of physiographic and local terrain factors. Potentials of continuing groundwater supplies are partially assessed by the effectiveness of the disposal of septic tile bed effluents and potential contributions of the pollutants from other land uses within the watershed area. Surficial sources of water supply may be evaluated initially by examination of the runoff factors, the proximity of the tile beds to the lake in question, and type and density of encroaching aquatic vegetation around the shoreline.

During the study, the existence of man-made changes in surface runoff characteristics, particularly power lines, access roads, and highways, was considered to be highly significant in determining the capacity of the watershed to sustain recreational development without detrimental effects on the water quality. Therefore, proposed access routes paralleling the shores of an inland lake must now be investigated from the standpoint of environmental changes brought about primarily by the changes in surface and subsurface drainage.

Most recreational development areas pose the types of problems previously outlined. Therefore, any transportation route, be it a railway, waterway, access road, or highway, will have some positive effect on the original terrain conditions. For example, the construction of a highway and the soil compaction involved have a significant effect in certain cases on the direction and volume of groundwater flow. This effect may be beneficial or detrimental depending on the local terrain conditions.

Because of the interacting factors outlined previously, it has become increasingly evident that a regional terrain evaluation is necessary to assess the developmental capability of the area under study, thus aiding in the determination of the economic development potential, prior to any decision regarding the location of a new access route or the improvement of an existing highway. The significant environmental terrain factors must be known within a high degree of certainty in order that the problems of the past may be avoided. The increase in recreational activities has been established, and methodologies of a practically oriented nature should be used to assess the terrain conditions and present these parameters in an easily understood fashion. All existing data from the various provincial government agencies within the study area should also be evaluated with respect to their relevancy to the objectives of the study, and the frequency of investigation and accuracy of determination of the data must also be examined.

INDIVIDUAL CASE STUDIES

The specific examples discussed in the following paragraphs have been selected primarily to illustrate the variations in the presentation and significance of environmental terrain conditions as these affect future highway considerations within these areas. The first example discusses a large land area, controlled by a municipal government, wherein the environmental terrain considerations have been coded, based on the most recent technological considerations, to provide a logical basis for future land use planning and route locations. The second example cited involves a relatively small area of federal lands, having a high degree of economic development potential, wherein specific land use capabilities have been designated based on the terrain conditions. The third case study analyzes the cause and effect of a specific development problem on an existing highway and the use of previous aerial photography combined with infrared photography to resolve the situation.

The District Municipality of Muskoka

This district municipality is undergoing considerable pressures for intensive recreational development. In addition, although the final figures have not yet been compiled, this municipality now supports approximately 31,000 year-round residents, an estimated increase of 16 percent during the past 5 years. This area is traversed by more than 200 miles of primary provincial highways and more than 100 miles of supporting secondary highway routes.

The complexities of planning and zoning for development within the municipality, combined with assessments of the existing and proposed highway networks, necessitated an examination of the environmental terrain factors throughout the complete district area.

The legend shown in Figure 1 was selected to define existing terrain conditions and to rate septic tile bed performance and potential sources of water supply. The basic terrain conditions of topography, depth of overburden, type of soil, soil drainage conditions, septic tile bed performance, and potential sources of water supply were assessed for areas having similar terrain conditions and are shown in Figure 1a. It should also be noted that those items shown in the lower portion of the legend were also evaluated and mapped throughout the study area. Encroaching aquatic vegetation indicated the presence of excessive nutrients and stagnant bays and areas subject to flooding or soil failures that are potential hazard zones. In particular, localized heights of land, watershed boundaries, and existing drainage channels are important for the location of transportation routes and subsequent development.

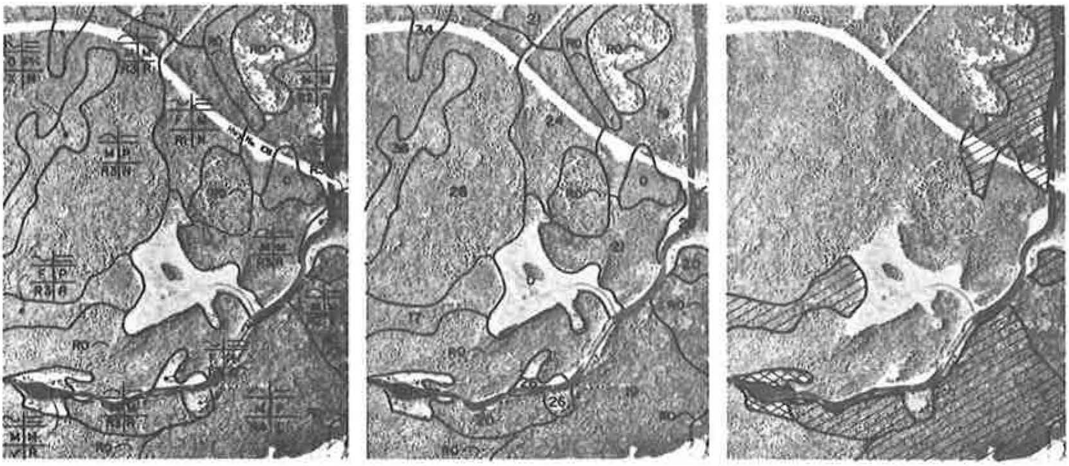
The environmental factors were interpreted from existing panchromatic photographs. Selective field checking was carried out to verify all factors indicated within each terrain evaluation boundary to an accuracy of 90 percent.

The numbers shown for each mapping area (Fig. 1b) represent a weighting system of not only the environmental terrain conditions within each area but also the influence of their immediate surroundings. One example of a consideration external to the immediate mapping area would be the existence of a potential drainage outlet, whereby lowering of the water table could be effected at minimal cost. The numerical designation for each environmental factor is primarily based on the experience of the terrain evaluator, his assessment of available potable water supplies, and the most recent technological advances in methods of sewage disposal. Therefore, these numerical evaluations, although considered to be valid at the time of the study, are subject to modification as further development takes place or as more effective means of sewage treatment become economical. For example, higher land values and more intensive development may justify a piped water system over difficult terrain, or a vacuum sewage removal system to a nearby lagoon site may become practicable.

Figure 1c shows the final stage in the environmental considerations and is normally prepared in the form of a clear plastic overlay that may be placed over white prints of the photoflexes of the mosaics on which the other factors previously discussed have been delineated. It is at this point that particular questions should be considered regarding future development, possible realignment of the existing primary Highway 103, or the provision of access roads to the shaded areas. It is evident from Figure 1 that the original considerations for the location of the highway in this particular area were relatively level topography and between 5 and 10 ft of overburden together with the alignment restrictions and the engineering and economical considerations of normal highway location and design. However, the highway was located and constructed at a time when the demand for recreational facilities on the lakes within this region of Muskoka, let alone the connecting rivers such as the Musquash, was virtually nonexistent.

These regional environmental evaluations, performed at different times and under substantially changed economic demands, permit both the planner and the engineer to evaluate the existing highway location and possible changes using definitive environmental information. For example, should direct highway access be provided to the single shaded area, designated by the number 19 in the lower right portion of the study area to the main highway? Should development within this area be encouraged by any form of service access routes, due to the constraints of shallow overburden, poor soil

Figure 1. Development constraints based on physical terrain evaluation.



(a) (b) (c)

Scale: 1 inch = ½ mile

Physical terrain evaluation boundary

TOPOGRAPHY

- Gently undulating slopes (0-10%)
- Moderately rolling (10-20%)
- Steeply rolling slopes (> 20%)

DEPTH OF OVERBURDEN

- Shallow (< 5')
- Moderate (5'-10')
- Deep (>10')

SOIL TYPE

- C COARSE - Sand and gravel
- M MIXED - Tills or medium grain sizes (e.g. - Fine sands)
- F FINES - Silts and clays
- O ORGANIC - Peat

SOIL DRAINAGE

- W Well drained soils
- M Moderately drained soils
- P Poor drainage conditions
- H High water table

SEPTIC TILE PERFORMANCE

- ✓ No apparent constraints

REMEDIAL MEASURES NECESSARY

- R1 Requires tile bed extension
- R2 Requires individual site location
- R3 Requires fill or lowering of water table
- R4 Requires both R1 and R2
- X Unfeasible

WATER SUPPLY

- G Ground water
- L Lake
- R River
- C Combination of above
- N No water supply

RO	Rock outcrop and topographic slope (See topography legend above for slope symbols)		Height of land
O	Deep organic soils		Gradual slope (0-10%)
Φ	Deep organic soils (with drainage outlet)		Moderate slope (10-20%)
	Windbreak, vegetation		Steep slope (> 20%)
V	Encroaching aquatic vegetation		Watershed boundary
Sb	Stagnant bay		Drainage channels
F	Flooding	X	Completed field check point
C	Existing culvert (and direction of flow)	FC	Field check to be performed
✱	Hilltop	④	Ground photograph (Number and direction)

drainage conditions, and the septic tile bed constraints indicated? Would provision of access to this last mentioned area encourage development in those shaded areas adjacent and to the left, and what would be the ultimate effect on the water quality in the lake downstream along the Musquash River?

The questions raised in the preceding discussion have serious environmental and social implications. The answers must be arrived at primarily through consultations between engineers and planners familiar with the implications of their actions. The answers to these questions could not possibly be contemplated by considering only that small portion of the total study area shown in Figure 1. However, the fundamental environmental considerations, together with their weighted developmental and engineering constraints, are available in a usable format to aid in making logical engineering and planning decisions.

Federal Lands: Sucker Creek Indian Reserve

The Sucker Creek Indian Reserve is located approximately 4 miles south of Little Current, Ontario, near the northernmost point of Manitoulin Island. This area has 8,000 ft of frontage on the north channel of Lake Huron (Fig. 2). The land area contained within the reserve boundaries consists of approximately 1,600 acres, the southerly portion of which is traversed by Highway 540, a secondary provincial highway having undergone improvements in alignment and servicing because of gradually increasing traffic counts. The cause of this increase is primarily improved primary road access and realization of the recreational development potential of this large freshwater island containing a number of inland lakes. Consequently, this area has been selected for discussion because of its accessibility to the north end of the island and the significant number of economic development potentials, from a terrain capability standpoint, within a relatively small land area.

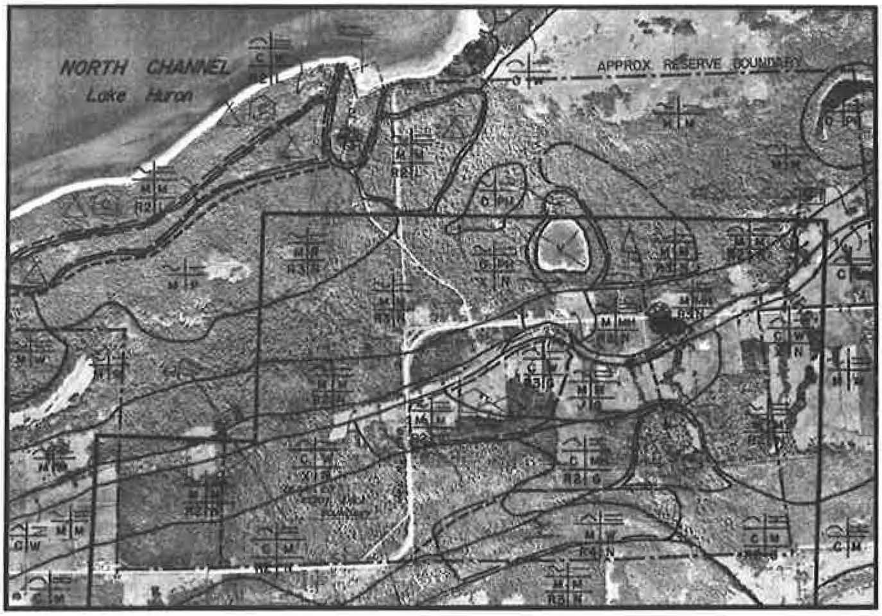
The legend shown in Figure 2 gives a symbology for potential land use and route location areas. (Fig. 1 legend shows physical terrain evaluation symbols.)

This study essentially involves a regional physical terrain evaluation for the entire reserve area, with specific reference to those land uses symbolized. Initially, topography, depth of overburden, type of soil, and soil drainage conditions were evaluated, and, in areas having terrain capability for the potential land uses shown, septic tile bed performance and water supply were also indicated. The portion of the reserve designated as "detailed study area" in Figure 2 was examined specifically with regard to suitable locations for townsite expansion and potential new townsite development in addition to economic development potentials. The study requirements were initiated by the Indian Band Council, sponsored by the Federal Department of Indian Affairs and Northern Development, and a 1-day field investigation was carried out to verify the airphoto evaluation.

The potential for intense cottage development along 8,000 ft of highly desirable shoreline, the associated potential of an excellent marina site, and the topographic suitability for ski slopes along the southerly boundary of the reserve combine to form a significant year-round potential recreational complex in an area previously not used extensively for this purpose. Even when evaluating an area for specific potential land uses, multiple land use capabilities are indicated, such as potential cottage and campsite development along the shoreline of the North Channel. Two potential townsite developments are indicated in order of preference as designated by number. The establishment of these communities in combination with the collective services, such as water supply, currently being installed would substantially improve the living conditions on the reserve for the native people. This factor, combined with the economic development potential, will, at the discretion of the Indian people, lead to staged recreational development of this highly desirable area.

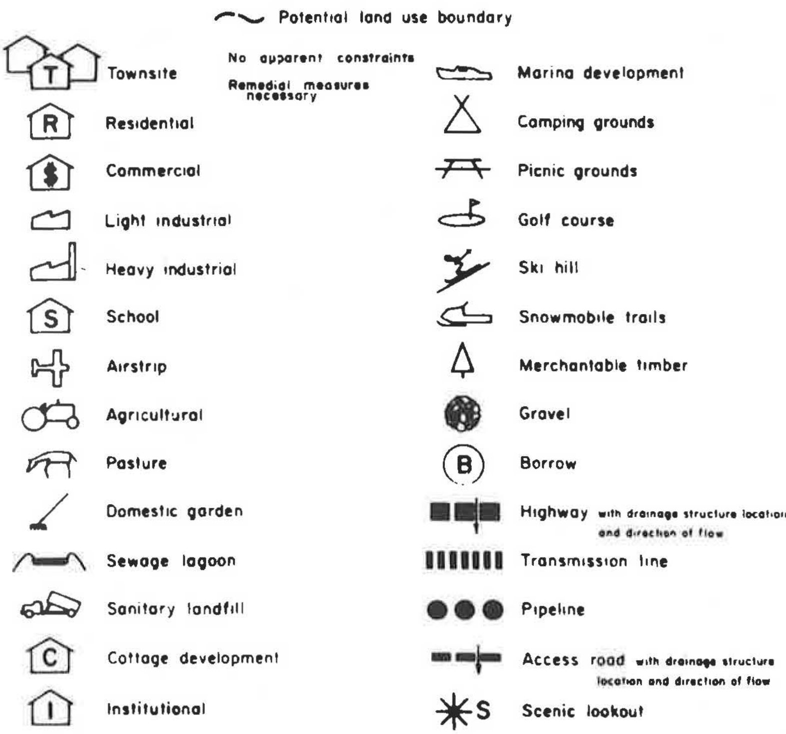
Physical terrain evaluation and subsequent economic development potential assessment provide information that could affect the future development of Highway 540. As in the previous example, the highway has been located through terrain presenting a minimum number of engineering construction problems. However, in consideration of the economic development potential of the area, would relocation of the highway route

Figure 2. Economic land use potential based on physical terrain characteristics.



Scale of reserve area: 1 inch = 2,000

Scale of study area: 1 inch = 800



POTENTIAL LAND USE RATING AND ROUTE LOCATION EVALUATION - Numbers adjacent to or colors within the above symbols indicate relative capabilities.

EXISTING LAND USE AND ROUTE LOCATION - 'E' appearing adjacent to the above symbols indicates existing land use from the central portion of the reserve toward and along the North Channel be economically feasible? Gravel is more available along this route, and what affect would this have on this decision? The existence of a potential marina site and the adjacent gravel deposit would, in all probability, result in lakeshore development of other lands off the reserve area; how would this affect the eventual location of Highway 540?

It may be seen from the preceding observations and questions to be considered that the future of Highway 540 within this particular area is dependent on a thorough knowledge of the physical environmental conditions and the interacting social and economic factors. Consequently, it is evident that prior knowledge of terrain capability within this local area will aid in consultations among the Indian Band Council, the Federal Department of Indian Affairs and Northern Development, and the Ontario Ministry of Transportation and Communications.

Specific Problems: Ski Resort Area

The ski resort shown in Figure 3 occupies the slope and foothills of Blue Mountain in the Delphi Point area south of Highway 26. The area is located in close proximity to the south shores of Nottawasaga Bay, approximately 90 miles north of Toronto in the southern portion of Georgian Bay. The section of Highway 26 shown in Figure 3 has two culverts designated as A and B to channel the flow originating from Blue Mountain into Nottawasaga Bay.

In 1969, the date of the photography shown in Figure 3, the ski resort filed a complaint against the Ontario Ministry of Transportation and Communications alleging that flooding of basements and tennis courts had occurred on its property. The resort owners attributed this to inadequate highway culverts and ditches. Subsequent ground investigations revealed that there was silting occurring in the highway drainage system and that organic pollutants were also present.

Therefore, two immediate problems existed: the cause of siltation of the highway drainage system and the source of the organic pollutants as these would eventually be discharged into Nottawasaga Bay through the highway drainage system.

A search for historical photo coverage revealed photography taken in the summers of 1954 and 1966. In addition, vertical panchromatic and infrared photography was taken in April 1969, and infrared color obliques were obtained in October 1969.

Drainage boundaries were established for each culvert referred to in Figure 3 for each set of aerial photographs, beginning with the 1954 photography. Preliminary examination revealed that ski runs were located on the side of Blue Mountain between 1954 and 1966, resulting in a significant reduction in vegetation cover.

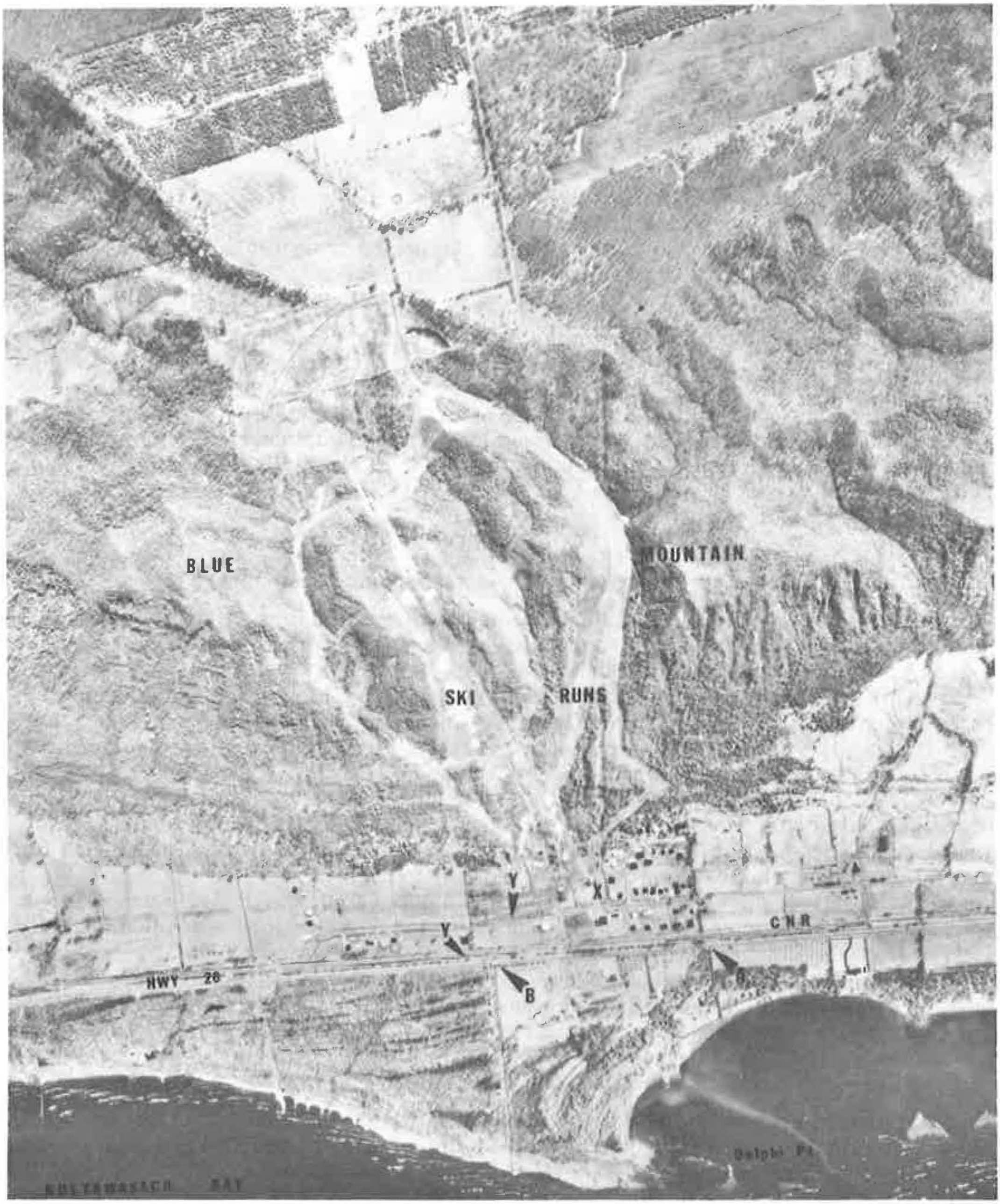
Comparison of the 1954 and 1966 aerial photography revealed the following:

1. Fifteen percent of the bush area had been removed for ski runs;
2. Thirty-five buildings consisting of cottages, chalets, clubhouses, and restaurants had been erected; and
3. The catchment areas of culverts A and B had been reduced by 5 percent and 8 percent respectively as a result of the shifting of the drainage boundaries caused by the location of the ski runs.

Primarily because of clearing of the bush for the ski runs (varying in width from 100 to 300 ft), surface runoff was increased and erosion of the soil accelerated. The majority of the eroded material was carried through natural watercourses within the catchment areas, resulting in the silting up of the culverts and a reduction in their capacity. Improper treatment of the sewage facilities for the 35 buildings previously mentioned, combined with flooding, caused raw sewage to enter the highway drainage system. Therefore, the combined runoff through culverts A and B was substantially increased. Between 1966 and 1969 an additional 15 buildings were constructed, thus increasing the organic pollutant concentration. Ditches, installed within the original catchment of culvert B, indicated substantial overloading (Y, Fig. 3), probably caused by the partial diversion of water at point X as shown in Figure 3.

Although the resort management stated that the slopes had been stabilized by sodding, thus reducing the erosion and partially stabilizing the runoff, oblique infrared color

Figure 3. Blue Mountain ski resort.



Scale: 1 inch = 1,676 feet

photography, taken in 1969, indicated that the roots of the sod had not yet taken, thus negating this theory. Therefore, through the use of historical photography and the oblique infrared color photographs, the following points were established:

1. Bush clearing, slope grading, building construction, and installation of service roads and parking facilities between the summer of 1954 and the spring of 1969 had increased the runoff significantly, thus causing rapid erosion especially on steep slopes because of the nature of the soil (this resulted in the accumulation of silts and clays within the highway drainage system);
2. The catchment areas of the culverts were changed as a result of the construction of new ditches, thus increasing their flow beyond the original design value; and
3. The construction of 50 buildings during the period from 1954 to 1969, located on the resort property, provided the only possible source of organic pollution, which accumulated in the highway ditches and culverts.

The preceding example substantiates the value of historical aerial photography in tracing land use changes to solve a specific highway maintenance problem and also indicates the value of specific types of film such as infrared color in further substantiating the environmental conditions under particular circumstances. As a result of this investigation, the owners of the Blue Mountain resort have taken specific corrective measures to reduce the siltation, thus eliminating the flooding of septic tile beds and reducing the emanation of pollutants.

CONCLUSIONS

Following is a summary of the conclusions supported by this paper:

1. A thorough knowledge of the environmental terrain factors within both a regional and localized band of existing and proposed highway routes is a necessary input for logical engineering and planning decisions;
2. This environmental terrain information can be specifically delineated using airphoto interpretation techniques from existing panchromatic photography (the accuracy of the initial interpretation is more than 80 percent, and this increases to 90 percent when selective field investigation methods are used);
3. Development rating systems using numerical values for environmental characteristics, based on experience and the most recent technological innovations, provide a realistic assessment of developmental capabilities and provide a flexible system for adaptation to technological advances;
4. Specific land uses should be evaluated and delineated, particularly within federally and provincially controlled lands, thus providing more definitive developmental information whereby highway needs may be more accurately predicted; and
5. The use of historical photography and special photographic emulsions, when required, are valuable in tracing land use developments, environmental changes, and existing terrain conditions to solve both regional and local concerns.

ACKNOWLEDGMENTS

The author expresses his appreciation to the following individuals for their assistance in providing factual information and permitting the release of specific material used in this paper: C. Abotossaway, J. Bennett, R. W. Holden, E. Hulsman, T. Phelps, W. H. Potts, G. Power, J. Ross Raymond, and Lawton Tam.

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