ECOLOGICAL HABITAT MAPPING OF THE AOSERP STUDY AREA (SUPPLEMENT): PHASE 1

by

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for

ALBERTA OIL SANDS ENVIRONMENTAL RESEARCH PROGRAM

PROJECT LS 2.3.1

(formerly VE 2.3)

April 1979

The Hon. John W. (Jack) Cookson
Minister of the Environment
222 Legislative Building
Edmonton, Alberta

and

The Hon. John Fraser
Minister of the Environment
Environment Canada
Ottawa, Ontario

Sir:

Enclosed is the report on "Ecological Habitat Mapping of the AOSERP Study Area (Supplement): Phase I".

This report was prepared for the Alberta Oil Sands Environmental Research Program, through its Land System, under the Alberta-Canada Agreement of 28 February 1975 (amended September 1977).

Respectfully,

W. Solodzuk, P.Eng.
Chairman, Steering Committee, AOSERP
Deputy Minister, Alberta Environment

A.H. Macpherson, Ph.D.
Member, Steering Committee, AOSERP
Regional Director-General
Environment Canada
Western and Northern Region

ECOLOGICAL HABITAT MAPPING OF THE AOSERP STUDY AREA (SUPPLEMENT): PHASE I

DESCRIPTIVE SUMMARY

BACKGROUND AND PERSPECTIVE

This final report has been designed to supplement the Interim Report prepared in 1978 (Thompson et al. 1978), in reporting on the new work carried out in 1978-1979 and in containing additions and modifications to the Interim Report based on the ground surveys and completed mapping of the study area.

The ground surveys confirmed that the vegetation and surficial geology mapping reasonably represented the major plant associations within the study area. Some minor modifications were made to the legends and to the maps previously prepared. Other necessary changes have been made to portions of the Interim Report and are detailed herein.

This program has led to the production of a set of reconnaissance scale vegetation maps of the entire AOSERP study area, with appropriate documentation. These should be valuable for the research being carried on now and in the future within this area.

ASSESSMENT

The final report "Ecological Habitat Mapping of the AOSERP Study Area (Supplement): Phase I" which was prepared by M.D. Thompson, M.C. Wride, and M.E. Kirby of Intera Environmental Consultants Ltd., has been reviewed and accepted by the Alberta Oil Sands Environmental Research Program.

In view of the value of the document AOSERP Management has recommended that the report be published and made available to other AOSERP researchers as soon as possible.

The report supplements the material presented in the Interim Report by confirming that the classification system utilized in the mapping reasonably describes and defined the major vegetation types within the AOSERP study area. It should be emphasized that the features described apply only to the point in time that the aerial photography was flown or the ground verification conducted and that no succession data are assumed or implied.

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ABSTRACT

The purpose of this study was to prepare ecological habitat working maps at a scale of 1:50,000 from false colour infrared photographs of the AOSERP study area obtained in 1977 and 1978, and to evaluate multispectral and multistage remote sensing techniques for application of mapping and monitoring in the study area. This was done in two stages, the first during 1977-1978 was reported in an Interim Report (Thompson et al. 1978), and included the development of a classification system for mapping vegetation and surficial geology, the multispectral and multistage remote sensing evaluation, and automated ecological mapping. The second stage, reported in this document and carried out during 1978-1979, involved ground surveys in the AOSERP study area, and completion of the mapping of the study area.

This final report supplements the material in the Interim Report. First, ground surveys of vegetation and surficial geology are described. These surveys generally confirmed that the classification systems used in the mapping accurately described and defined the ecological habitat features within the AOSERP study area. Based on these surveys and new information from areas mapped in this second phase, a few modifications and additions were made to both the legends. Where necessary, the maps produced during the first stage of the program were altered to ensure consistency in mapping throughout. Next, additions and modifications to the Interim Report are described including revised photo-interpretation keys for vegetation and surficial geology, a comprehensive overview of the surficial geology, further discussion of possibilities of larger scale mapping of surficial geology, and changes in the surficial geology glossary.

Finally, a summary of the material presented is made, and conclusions drawn, showing that the maps produced are accurate within the limits of scale and represent the major vegetation communities and surficial geology features within the AOSERP study area.

ACKNOWLEDGEMENTS

The principal consultants for this project were:

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The co-operation of the Alberta Remote Sensing Center (Edmonton) in allowing the use of their facilities and equipment during the 1977-1978 stage of the mapping program is gratefully acknowledged. The Center also worked with the Canada Centre for Remote Sensing in the planning and co-ordination of the remote sensing data acquisition on behalf of AOSERP. Facilities of the Canada Centre for Remote Sensing (Ottawa) were also made available for data analysis.

This research project LS 2.3.1 (initially VE 2.3) was funded by the Alberta Oil Sands Environmental Research Program, a joint Alberta-Canada research program established to fund, direct, and co-ordinate environmental research in the Athabasca Oil Sands area of northeastern Alberta.

1. INTRODUCTION

The primary objective of this project was the preparation of Phase 1 Ecological Habitat Maps at a scale of 1:50,000 for the Alberta Oil Sands Environmental Research Program (AOSERP) study area (Figure 1) using 1:60,000 scale false colour infrared (FCIR) photographs. A secondary objective was to assess Landsat and the various remote sensors utilized in the 1977-1978 remote sensing data acquisition program for correlations with habitat characteristics. In addition, the use of remote sensing for automated ecological mapping and for ecological monitoring was evaluated.

This program has been carried out in two stages. The first, during 1977-1978, involved the derivation of a classification system for the habitat mapping and the subsequent completion of nine map sheets for the study area. Also during this stage, the Landsat, multispectral, and automated ecological mapping studies were completed. Following completion of this part of the program, an Interim Report (including the nine maps) was published, detailing all of the work to date (Thompson et al. 1978).

The second stage of the program, carried out during 1978-1979, involved ground surveys in the AOSERP study area, and completion of the mapping of the entire study area. This present report thus contains a description of the ground surveys carried out for vegetation and surficial geology (Section 2), and the minor modifications to the mapping which resulted from these surveys (Section 3). Also included in Section 3 are other revisions and additions to the Interim Report, based on the ground survey information and completion of mapping in the rest of study area. In Section 4, a summary of the second stage work is presented and conclusions drawn. Section 5 contains additions to the List of References presented in the Interim Report.

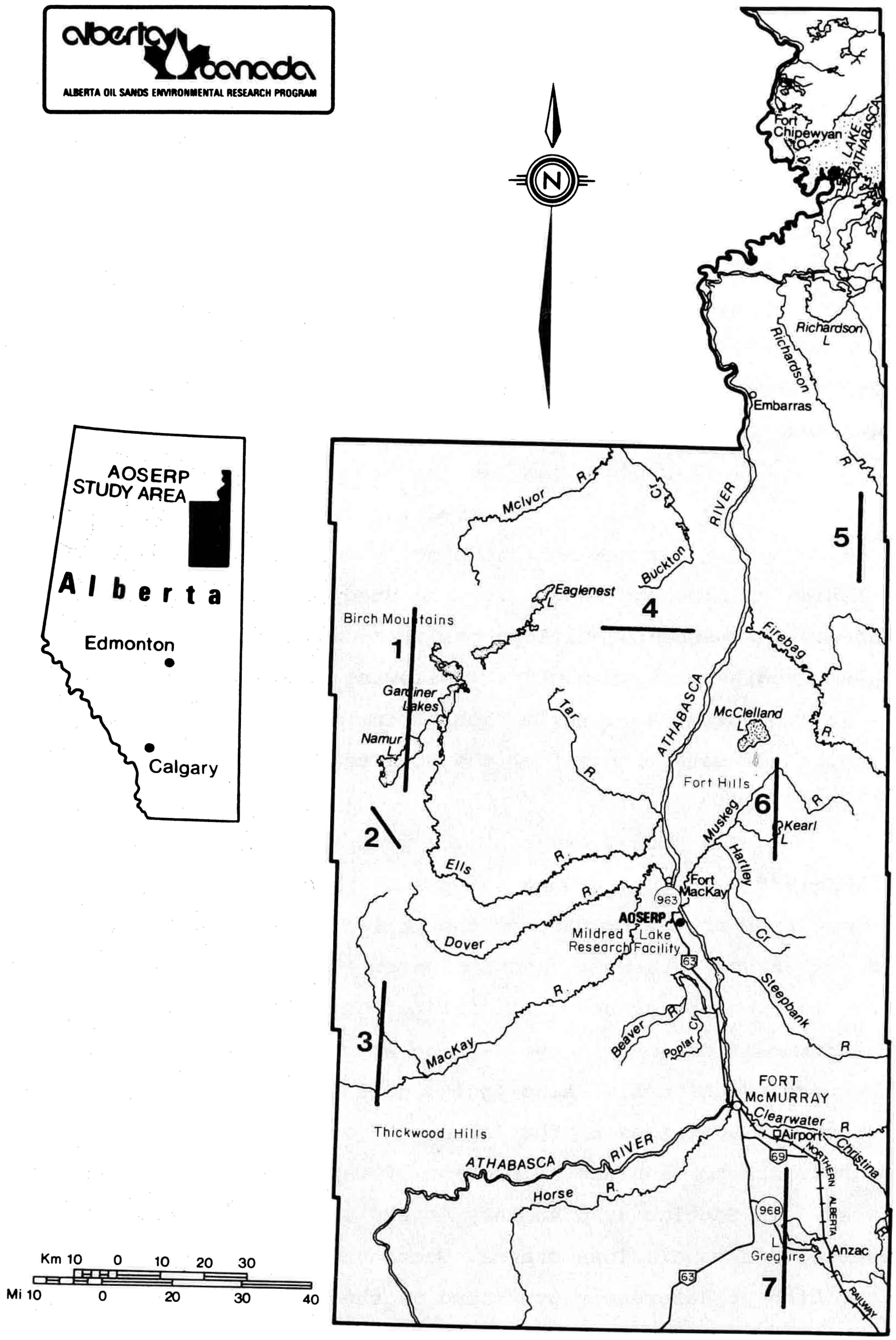


Figure 1. Location of AOSERP study area and transects used for field surveys.

2. GROUND SURVEYS AND MAPPING VERIFICATION

2.1 INTRODUCTION AND METHODOLOGY

In August 1978, following the completion of ecological habitat mapping of nine 1:50,000 scale sheets within the AOSERP study area (Thompson et al. 1978), a field program was undertaken to verify the interpretation of the FCIR photographs and the legend classification system utilized in the mapping. This field program, carried out jointly by INTERA Environmental Consultants Ltd. and Beak Consultants Ltd., was designed to cover representative classes of vegetation and terrain as outlined in the legends, as well as the problem areas identified in the mapping already carried out. This was accomplished using a helicopter flying at various altitudes to check the selected areas, with ground stops made as required to examine some of the areas in greater detail. A few of the areas of interest were also accessible by road, and were thus examined during a period of inclement flying weather using a car.

As described in the Interim Report (Thompson et al. 1978), seven transects had been previously selected by AOSERP as important or representative of the AOSERP study area (Figure 1). In July and August 1977, FCIR photography was flown of these transects at 1:30,000 and 1:15,000 scales, to supplement the 1:60,000 scale coverage. Because of this larger scale coverage and of the value of these transects in representing vegetation and terrain in the AOSERP study area, the ground surveys concentrated mainly on examination of these areas. Each was examined on the large and small scale photography before going into the field, for familiarization.

Areas which had already been mapped for vegetation and surficial geology (this included three of the transects) were also examined on the prepared maps, and these were taken into the field. In the areas where mapping had not been completed (including Lines 1, 2, 3, and 5), 1:50,000 base maps were used in the field; where these were not available, 1:25,000 scale photomosaics (black and white) were used. As mentioned, anomalous or problem areas encountered during the 1977-1978 mapping were also examined.

The following sections describe the field surveys carried out for vegetation and for surficial geology during August 1978.

2.2 VEGETATION FIELD SURVEYS

The vegetation field survey took place during the peak of the growing season, when many plants were in bloom or fruiting, and trees were not yet senescing or defoliated, allowing rapid identification of species. Most observations were limited to distinguishing the dominant cover species and vegetation associations, as mapped from the remote sensing imagery. Ground checks were made to assess species where not identifiable or visible from the air. Observations were noted directly on the maps or photomosaics, and 35 mm colour photographs taken as a record.

The field survey allowed the photo interpreters to identify the specific vegetation classes designated in the legend and to modify the classes and interpretation techniques to more accurately map the vegetation parameters of habitat. Previously mapped vegetation units, such as in the Gregoire Lake area, the Fort Hills, and the Birch Mountains from Eaglesnest Lake east to the Athabasca River, could be correlated to the ground surveys and an estimate of confidence in the mapping made.

Field checking of the transects provided sufficient diversity of vegetation types to allow the interpreters to test the entire legend and to confirm species composition in the communities. Lines 1, 2, and 3, on the western edge of the study area and not yet mapped, had very different vegetation communities than those mapped in the central and southern portions of the study area.

Line 1 traverses an area of good drainage, and the hills were heavily forested with aspen, white spruce, and jack pine. The classes included in the legend under Upland Communities (2) were well suited to the vegetation cover observed in this area and were readily identified. The jack pine sub-class ("2c" in the legend) was present on the better drained sites and usually formed pure, medium density stands (Figure 2). Here, the questionable areas appearing white on the FCIR photographs beneath the ragged crowns of the jack pine were found to be bare sandy soil in some locations, and lichen ground cover (reindeer moss, *Cladina* spp.) in others. The difference between the two cannot be reliably distinguished on the 1:60,00 scale FCIR photographs.

Line 2 crosses large wetlands and a number of small shallow lakes. Fen communities are common about the lakes (Figures 2 and 3) and riparian communities easily delineated. The presence of balsam poplar, aspen, and birch in the Bottomland and Riparian Forest ("la" in the legend) was confirmed. An example of this type is seen in Figure 4. The questionable white speckled areas observed in the FCIR photographs in the wetlands in this area were found to be collapse scars in the Black Spruce Bog Forest ("3b"), resulting from discontinous permafrost.

Line 3 traversed an extensive area of open muskeg ("3d" in the vegetation legend), and the sinuous MacKay and Dunkirk rivers. These rivers provided a wide bed of alluvial material which was heavily vegetated by tall willow and alder. It was confirmed that the Riparian class termed Deciduous Shrub ("lb") is adequately described in the legend and easily identified on the 1:60,000 scale FCIR imagery (an example of this class in seen in Figure 4). The Lightly Forested Tamarack and Open Muskeg community ("3d") was more difficult to delineate. Patches of low density stunted black spruce and tamarack were scattered through wet areas of low shrub and grasslike communities. The "Possible Components" listed in the legend did not adequately describe the open muskegs of the western portions of the study area. It was thus necessary, on the basis of this information, to modify the legend, so that the "3d" subclass now includes low shrubs,

Figure 2. Large sand dune south of Ronald Lake near Line 4. Vegetation cover is jack pine ("2c"), and in the background is seen a fen (Fen Communities, "3a").

Figure 3. This area at the west end of Line 4 shows typical Fen Communities ("3a") without the tamarack as seen in Figure 7. Marsh grasses and floating sedge mats can be seen. In the top left, adjacent to this very wet site, jack pine ("2c"), typical of very dry situations, is found.

Figure 4. Riparian vegetation beside the Athabasca River near Shott Island. Class "lb" (Deciduous Shrub) is found on the sand bars, with white spruce and aspen, while tall white spruce and poplar ("la") are found adjacent to the river. A series of ridged parallel meander scrolls with intervening poorly drained lowlands indicate former channels of the Athabasca River.

sedges, wetland grasses, rushes, and scattered tamarack (see Section 3.1). Sphagnum mosses and black spruce may be present, but do not represent major components.

In the area north of Line 1, extensive sites of recurrent burning were observed (Figure 5). The ground cover was a mosaic of wetland shrub communities (labrador tea, swamp willow, bog birch, and low density stunted black spruce) and fen communities, the patterning arising from the presence of discontinuous permafrost and the vegetation types typical of frequently burned-over land. The vegetation did not readily fall into any of the classes in the legend; however, since the area was dominantly wetland shrub, it was classed as "3(D)". No change on the legend was necessary, as the "3(D)" classification makes use of the Undifferentiated Wetland class, "3", and the deciduous shrub descriptor, "(D)". Areas of more recent burning with charred vegetation (for example, directly west of Michael and Baynard lakes) were classified as Burn ("4").

Line 4 runs from west to east across the eastern slope of the Birch Mountains, over poorly drained areas of Black Spruce Bog Forest ("3b") and Mixed Aspen-White Spruce Forest ("2aM"). Jack pine occupied the better drained upland areas, forming low density cover seldom taller than 20 m. Down the slope toward the Athabasca River, very tall (25-35 m) aspen and white spruce forest was encountered (Figure 6); there was a high incidence of slumping in the narrow creek valleys and the valley sides were unvegetated or sparsely treed with "drunken" white spruce forest (mainly classed as Non-Vegetated, "5"). Several old burns and an abundance of black spruce forest were found at the eastern end of Line 4. As this line had already been mapped, it was possible to check the accuracy of interpretation. Units on the maps based on species classes corresponded well with the field observations but estimates of tree height were sometimes in error.

Line 5, located in the northeast corner of the AOSERP study area, was omitted from the field check due to time and

Figure 5. Area of recurrent burning north of Line 1 (near Alice Creek). Wetlands shrubs (appearing gray-brown here) include bog birch, swamp willow, labrador tea and stunted black spruce, and were mapped as "3(D)".

Figure 6. Large slump on valley wall near Line 1 (Alice Creek). Vegetation cover is mainly Upland Mixed White Spruce-Aspen Forest ("2aM"). There is an extensive area of dense Black Spruce Forest in the poorly drained area adjacent to the well-drained riparian community.

Figure 7. Fen communities near McClelland Lake (Line 6) showing ridges of low density tamarack and tall shrubs perpendicular to the drainage pattern. This fen type is mapped as "3aT".

weather limitations. Vegetation units in the area were large, however, and did not pose any unique interpretation problems.

Line 6 is located east of McClelland Lake and runs south past Kearl Lake, an area of considerable interest due to the frequency of large string bogs and fens. Field investigations led to several changes in the legend. At the southeast end of McClelland Lake, a large string bog had been mapped in 1977-78; in the field survey, it was discovered that the area includes an extensive fen ("3a"), a fen with lightly forested ridges, and lightly forested bog grading to a very dense black spruce bog forest at the margin of the wetland area. The previous mapping has since been reworked to incorporate the various wetland communities rather than designating the entire area as Open Muskeg ("3d"). Field work in this area showed that Fen Communities ("3a") include peat-covered areas with a high water table and a dominant cover of sedges; other components include low shrubs, semi-aquatic forbs, rushes, and feathermosses. This has been added to the legend (Section 3.1).

The netlike pattern in some of the fen communities is created by ridges lightly forested with tamarack and tall shrubs, running perpendicular to the drainage pattern (Figure 7). This type of fen is designated as "3aT". The Black Spruce Bog Forest ("3b") had been readily classified in the mapping due to its easily recognized high density forest cover. The Semi-Open Black Spruce, Tamarack Bog Forest ("3c") class, similar to the black spruce forest, is a lower density forest with open patches and tamarack, and also had been accurately identified (Figure 8).

The other areas of interest visited in the field reconnaissance provided valuable information on use of the legend and confirmation of questionable vegetation patterns and types. One such area was located on the Tar River in the southeast corner of map sheet 84 H/9, where bluish areas of vegetation were questioned. These sites were found to be areas of dense regenerating jack pine. Sites of immature aspen were also located in the vicinity, but jack pine appeared to be the better

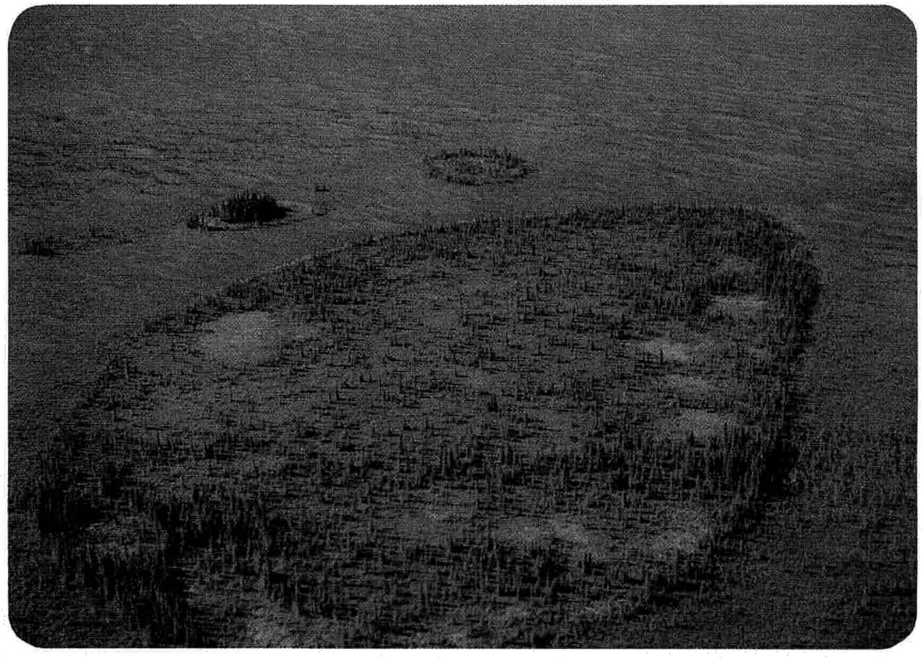


Figure 8. This area near Line 3 shows the typical Open Muskeg class ("3d") with a peat plateau in the foreground classed as Semi-Open Black Spruce, Tamarack Bog Forest ("3c").

Figure 9. Meltwater channel system northwest of Sandy Lake near Line 1. Extensive successive slumps along the valley sides indicate the banks of a pro-glacial drainage channel. Vegetation cover is mainly Mixed White Spruce Aspen Forest ("2aM"), with some Mixed Coniferous Forest ("2aC") in the foreground.

colonizer following fire. On the FCIR photographs, their differing crown shapes and tones allowed the species composition of these young stands to be distinguished.

Helicopter flights parallel to the Athabasca River confirmed the presence of the tall Mixed White Spruce - Aspen Forest ("2aM") as well as stands of pure aspen ("2aA") and mixed conifers ("2aC"). On the floodplain and steep sides of the Dover, Ells and Athabasca rivers, medium to high density forests of white spruce, aspen, and balsam poplar (in excess of 30 m) were verified as mapped (Figure 9).

The Gregoire Lake area (part of Line 7) was visited by automobile. On Stony Mountain, it was found that there was some discrepancy in the mapping of vegetation units; for example, a shrub community was mapped as "2c" (Jack Pine Forest). This was corrected on the map sheet, and in subsequent mapping. Estimates of tree heights from the 1:60,000 photos were also in error in some cases. Tree height in deep valleys was often underestimated, while in wetland areas the height of black spruce was sometimes over-estimated. It was concluded that height is difficult to accurately determine from the photos in some situations.

The ground survey program confirmed that the vegetation legend and the maps produced from 1:60,000 scale FCIR photographs accurately describe the vegetation in the AOSERP study area. Limited modifications to class species composition and use of the classes, based on the field observations, have provided a tool for accurate preparation of reconnaissance level vegetation maps.

2.3 SURFICIAL GEOLOGY SURVEYS

Field time was predominantly spent in the helicopter examining the area from various altitudes. Rather than flying directly from one transect to another, indirect routes were utilized to include as many anomalous areas as possible. For example, after completing Line 4, the area south-southeast of Ronald Lake (Figure 2) was examined prior to investigating the northern portion of Line 6 and the Fort Hills complex. By slowly flying over each transect at various altitudes, the morphology, relief, and spatial distribution of landform features could be examined.

Ground checks were made when and where appropriate; however, the frequency of fens and bogs combined with the dense vegetation cover precluded landing in many areas. The aspen and tall white spruce forest hindered helicopter landings at several good cross-sections which had been exposed by deeply entrenched rivers. Although the helicopter flew as close as possible to such sites, a detailed description of the stratigraphy was impossible.

Additional field time was spent examining areas with adequate road access, in particular the Stony Mountain-Gregoire Lake area. The morphology and distribution of features encountered were compared with the maps of surficial geology already completed for this particular area. The stratigraphy exposed by existing road cuts, gravel pits, landfill sites, landslides, excavation pits, and entrenched stream channels was examined and correlated to the mapped units.

The field survey confirmed that the surficial geology maps produced from 1:60,000 scale FCIR photographs are viable, useful field and research tools. All stratigraphic sections which were checked were consistent with the 1977-1978 surficial geology mapping. The classification system developed for the project facilitated rapid field recognition of the morphologic units, and its flexibility permitted inclusion of additional features encountered during the 1978-79 mapping program.

Several physiographic features were discovered to be more readily identifiable from the 1:60,000 FCIR photo coverage than from the low altitude ground surveys. Subtle vegetation changes reflecting differences in moisture content due to variations in parent material were difficult to observe from the ground, yet the FCIR photographs clearly demarked these variations. For example, long curvilinear ridgelike features characteristic of low relief, proglacial beach ridges were not observed from the helicopter, but were clearly identified on the 1:60,000 FCIR coverage. The varied moisture content and resultant vegetation developed along the beach ridge create subtle tonal variations on the photographs which are not discernable in the field. Likewise, parallel flutings atop portions of the Birch Mountains were easier to discern from the FCIR coverage than on the ground.

Massive slumps characteristic of the Birch Mountain escarpment (e.g., Figure 6) involve such a large volume of material that low altitude flying emphasizes the morphology of successive individual slumps rather than the genesis of the entire eastern face. Sequential slumping along this escarpment probably accompanied deglaciation and the resultant lowering of glacial lake levels. Thawing of the permafrost, more widespread during glacial periods, would result in instability particularly along steep gradients. Many proglacial shorelines would, therefore, have been partially obliterated through downslope movement and subsequential weathering. The high level FCIR coverage de-emphasizes individual slumps, providing the researcher with a better perspective of the entire escarpment.

The field program confirmed the presence of numerous features which were observed on the photographs. In addition, some features not identified on the photographs were noticed. The influence of beaver activity on fluvial deposition is more pronounced than observed on the FCIR 1:60,000 coverage. Variation in the morphology of till on the Birch Mountains was confirmed by ground surveys, as was the presence of a heavily vegetated esker south of Michael Lake, and small meltwater channels within the till. The presence of collapse bogs and beaded drainage in the areas unmapped at the time of the ground surveys indicates more widespread permafrost than had been expected from mapping the eastern portion of the study area.

Entrenched stream channels within the till and along the eastern escarpment were common. The valley sidewalls were predominantly vegetated; however, numerous landslides and slumps (Figure 6) exposed the stratigraphic column and geologic structure. Lakes within the Birch Mountains were discovered to be bordered by narrow, recent lacustrine wash deposits. These deposits varied from well-sorted sands along the south shore of Namur Lake, to gravels. However, the limited extent and discontinuous nature of these deposits precluded their inclusion in the current mapping program.

Numerous bars were observed in the Athabasca River and its tributaries (e.g., Figure 4). Subtle morphological changes in these bars were observed between the topographic maps, aerial photographs, and field observations. The current reconnaissance mapping program does not delineate these modifications or identify the smaller bars; larger scale mapping, however, could include such features.

Exposures within the till on Stony Mountain revealed numerous large granitic erratics, indicating the source area for the till as the Precambrian Canadian Shield. A long, narrow sandy beach ridge paralleling the southern shore of Gregoire Lake was observed in the field. This had not been noted during 1977-1978 mapping, but has subsequently been added to the map. The low altitude coverage was excellent for discerning the extent of sand units, particularly within the Athabasca River valley. Likewise, cross-sections exposed in several areas that were accessible by car indicated the variable depth of the eolian cover. A more intensive study would be required to discern the continuity of the deposit.

It was obvious that the geomorphic units delineated by the 1977-1978 mapping program could be subdivided; however, this would require larger scale photographic coverage and a far more intensive ground survey program. The Fort Hills complex, for example, could be subdivided to delineate the small pockets of till observed in scattered locales. This, however, would necessitate several days in the area and retrieval of core data. Likewise, a more intensive study could utilize a greater number of exposures and sufficient core data to determine the accurate depth of overburden materials and their stratigraphic sequence. The genetic interdependence and transitional nature of many geomorphic features resulted in the delineation of only approximate borders. For example, the boundary distinguishing glaciolacustrine veneer from a blanket must of necessity be estimated. An intensive study would allow a more precise representation of each unit.

In summary, surficial geology maps produced during the 1977-1978 mapping program were verified by the ground surveys undertaken in August 1978, and minor corrections and additions made where necessary. The legend was verified as a useful tool for accurate representation of the surficial geology and landforms of the AOSERP study area.

3. MODIFICATIONS AND ADDITIONS TO INTERIM REPORT

3.1 VEGETATION MAPPING

3.1.1 Modifications to the Legend.

The vegetation legend modifications have been based on information from the ground surveys and from mapping the rest of the study area. They are limited to revision of the vegetation components present within each class, with the exception of the addition of one new sub-class. The revised legend is presented in Figure 10. Species identified are listed in order of decreasing importance in the community. Use of the vegetation legend and the possible components within each community are clarified in a revised photo interpretation key in Section 3.1.2.

Scrub conifers were added to the Upland Undifferentiated class ("2"). This class had been used in the mapping to identify those areas with complex vegetation communities where it is difficult to delineate individual vegetation types, often a scrubby mix of repeatedly burned vegetation. The White Spruce-Aspen Forest ("2a") should also include the species balsam poplar and balsam fir. Balsam fir was also added to the Upland Mixed Coniferous Forest ("2b"). Aspen poplar is not an important species in the Jack Pine Forest ("2c") and therefore has been deleted. If a significant proportion of aspen are found within a "2c" stand, aspen can be added [e.g. 2c(A)]. The Upland Open class has been reworked to include forbs as well as low herbs.

The extensive wetland areas in the western portion of the study area presented some problems in mapping using the original legend and it was therefore modified as follows: the fen community is defined as a dominantly sedge community with associated rushes, semi-aquatic forbs and rushes, and the shrubs swamp willow, birch, and alder. A new sub-class "3aT" has been added to the legend to denote fen communities with a pattern of ridges sparsely vegetated with tamarack. The Semi-Open Black

VEGETATION LEGEND

		POSSIBLE COMPONENTS VISIBLE ON FALSE COLOUR INFRARED PHOTOGRAPHY
1	BOTTOMLAND & RIPARIAN COMMUNITIES	
	a. BOTTOMLAND & RIPARIAN FOREST	balsam poplar aspen poplar white spruce willow alder paper birch
	b. DECIDUOUS SHRUB	willow alder dwarf birch immature aspen immature paper birch
2.	UPLAND COMMUNITIES UNDIFFERENTIATED (Usually Complex)	deciduous shrub on burned sites scrub conifers aspen poplar willow alder balsam poplar paper birch
	a. WHITE SPRUCE - ASPEN FOREST 2aA aspen 2aM mixed 2aC coniferous	white spruce aspen poplar jack pine balsam poplar balsam fir
	b. MIXED CONIFEROUS	black spruce jack pine white spruce balsam fir
	c. JACK PINE	jack pine black spruce white spruce
	d. UPLAND OPEN	grasses, forbs and shrubs
3.	WETLAND COMMUNITIES UNDIFFERENTIATED (Complex)	
	a. FEN COMMUNITIES	sedges, rushes semiaquatic forbs and mosses swamp birch dwarf willow alder
	aT.	Same as 3a with tamarack on ridges
	b. BLACK SPRUCE BOG FOREST	black spruce, sphagnum mosses
	c. SEMI-OPEN BLACK SPRUCE, TAMARACK BOG FOREST	black spruce, sphagnum mosses tamarack, low shrubs sedges rushes
	d. LIGHTLY FORESTED TAMARACK AND OPEN MUSKEG	sphagnum mosses wetland grasses sedges willow swamp birch tamarack, black spruce
4.	BURN	
5.	NON-VEGETATED	recent slides, slumps with sparse vegetation (unclassified)

Symbols

(Pj)	jack pine
(Sw)	white spruce
(P)	poplar
(A)	aspen
(Sb)	black spruce
(T)	tamarack
(W)	willow
Q	aquatic vegetation undifferentiated
(C)	conifer
(D)	deciduous shrub
(O)	open

Height Class (m)

1	0 - 10
2	11 - 20
3	21 - 30
4	31+

Crown Cover

A	open
B	medium
C	dense

Figure 10. Vegetation legend used for mapping from 1:60,000 scale FCIR photographs.

Spruce, Tamarack Bog Forest ("3c") now includes the species black spruce, sphagnum mosses, tamarack, low shrubs, sedges, and rushes. The Open Muskeg class ("3d") has been modified to include sphagnum mosses, wetland grasses, sedges, swamp birch, and willow, lightly forested with tamarack and black spruce. The three wetland forest types are separated by decreasing density of forest cover and increasing proportions of wetland grasses and grass-like species. Where necessary, these changes have been applied to the nine maps completed in 1977-78, in order to make the mapping consistent throughout.

3.1.2 Photointerpretation Key for 1:60,000 scale FCIR photographs related to the legend for the vegetation maps

Based on information gained through completion of the vegetation mapping of the study areas, the photointerpretation key presented in the Interim Report (Thompson et al. 1978:44) has been modified. The modified key is presented in Table 1.

3.2 SURFICIAL GEOLOGY MAPPING

3.2.1 Modifications to the Legend

The revised legend used for the surficial geology mapping is presented in Figure 11, and shows the addition of several geomorphic symbols and classifiers to the legend described in the Interim Report (Thompson et al. 1978). Since the 1977-78 mapping program concentrated on the Athabasca lowlands and their immediate vicinity, the physiographic diversity encountered within the more remote portions of the study area was not included. Consequently, additional physiographic information has been included on the maps produced in 1978-79; the maps produced in 1977-1978 have been reviewed and updated where necessary to ensure consistency in the mapping.

Table 1. Vegetation legend and photo interpretation key for 1:60,000 scale FCIR.

CLASS	SYMBOL	TYPE	COMPONENTS	SITUATION	PATTERN	TEXTURE	COLOUR	DESCRIPTION	CORRESPONDS TO STRINGER'S VEGETATION TYPE
BOTTOMLAND AND RIPARIAN COMMUNITIES	1a	Bottomland and Riparian forest	balsam poplar aspen poplar white spruce willow	Found on floodplains and sideslopes along drainage courses; bordering lakes, ponds	uniform	coarsely foamy (poplar) medium to fine (white spruce)	pink to red dark magenta	Trees generally tall; white spruce in pure or mixed stands with subordinate species aspen and paper birch. Shrub layer of willow and alder often present, visible at the periphery of the stand.	Bottomland balsam poplar forest
	1b	Deciduous Shrub	willow alder, dwarf birch, immature aspen, immature paper birch	bordering rivers, ponds, lakes; occupying river sandbars, on and along drainage courses	uniform	fine	pink to red	Varies from patches too small to map along stream channels, to extensive willow and alder stands in association with fens. Height up to 6 m. On the photograph this community shows little shape or shadow	Sandbar willow scrub; Tall river alder willow scrub; Tall willow scrub
UPLAND COMMUNITIES	2	Undifferentiated	deciduous shrub on burned sites, scrub conifers, aspen poplar, willow, alder, balsam poplar, paper birch	Moderately to well drained, level or sloping upland sites	broken	very fine	pinkish grey to grey green	Upland communities of mixed species composition within which individual sites are too small to be resolved on the photograph	
	2a	White Spruce-Aspen Forest	white spruce aspen poplar jack pine balsam poplar balsam fir	Moderately to well drained	uniform-broken	fine to coarse	red to pink	Upland forest, subdivided into three forest types dependent upon percentage composition of deciduous and coniferous species: aspen forest with less than 20% coniferous vegetation, mixed forest with 20% - 80% coniferous trees, and a coniferous forest with less than 20% deciduous.	
	2aA	Aspen Forest	aspen poplar paper birch balsam poplar	Most extensive on well to moderately drained upland sites, but can be found in all but the wettest areas	uniform, sometimes broken	fine to very fine	red to pink	Generally extensive stands of aspen poplar 30 m in height. Often forming a very dense canopy. When associated with deciduous shrub, (D) is added to the legend symbol.	
	2aM	Mixed Forest	white spruce aspen jack pine	Moderately to well drained upland sites	stippled, broken	very fine to medium	magenta to red	Extensive stands of mixed upland forest, having significant amounts of deciduous and coniferous vegetation, generally 20 - 30 m in height.	Upland white spruce and aspen forest. Upland mixed wood and deciduous forest.
	2aC	Coniferous Forest	white spruce jack pine balsam fir	Poorly to well drained upland sites	uniform	fine to medium	magenta	Stands of coniferous vegetation generally dominated by white spruce. Height of white spruce occasionally in excess of 35 m.	
	2b	Mixed Coniferous	components black spruce jack pine white spruce balsam fir	Poorly to moderately drained level or sloping upland sites, with inclusions of bog or covered by a thin discontinuous veneer of peat.	fairly uniform	medium coarse	magenta	Relatively tall, very dense, coniferous stands (over 6m), of fire origin, mostly pure black spruce with possible mixture of jack pine and white spruce, depending on site.	Mixed wood and coniferous forest
	2c	Jack Pine	jack pine black spruce white spruce	Well drained sites including aeolian deposits	uniform to stippled	medium coarse	magenta on white background or magenta	Pure stands of jack pine, up to 15 m in height, on dry sandy sites, sometimes mixed with aspen or integrating with black spruce where sandy sites and poorly drained upland sites are mixed. Stand density may vary from very open to very dense. The association with Cladina spp. makes this community very easy to recognize on the photography; the Cladina spp. forms a white background against which the jack pine is contrasted as cyan dots	Jack pine forest

Continued ...

Table 1. Concluded.

CLASS	SYMBOL	TYPE	COMPONENTS	SITUATION	PATTERN	TEXTURE	COLOUR	DESCRIPTION	CORRESPONDS TO STRINGER'S VEGETATION TYPE
	2d	Upland Open	grasses forbs shrubs	Grassy open areas in White Spruce-Aspen Forest	uniform	very fine	pink	These open areas occur in the upland white spruce-aspen community, generally in the pure aspen stands. Though of small areal extent, they have been typed because of possible habitat significance	
WETLAND COMMUNITIES	3	Undifferentiated (usually complex)		-	mottled	fine to medium	-	Wetlands are generally easy to recognize but differentiation between bogs and fens (Zoltai et al. 1977) is difficult on 1:60,000 photographs. This community has been used where a variety of wetland forms exist that cannot be differentiated or that are too small to type individually. Sometimes it has been complexed with an upland type e.g. 3/2b2C, indicating a wetlnd situation with islands of mixed coniferous vegetation.	
	3a	Fen Communities	sedges, rushes semi-aquatic forbs and mosses, swamp birch, dwarf willow, alder	Poorly drained, generally level to very gently sloped upland sites that are part of a slow moving drainage system; draws and low gradient streams and depressions	uniform	very fine	bright pink	Very wet sites, composed mainly of sedges with a continuous or intermittent low shrub layer, consisting principally of swamp birch. Sometimes larger shrub species such as willow and alder are present which can be observed on 1:60,000 photography and are indicated with 3a(D). Characteristic striping, indicating drainage flow through the plant mass, may be present.	Fen
	3aT	Fen community with ridges	same as 3a, with tamarack	Poorly drained	patterned	fine	bright pink with tan ridges	Very wet fen sites with ridges of tamarack running perpendicular to direction of water flow.	
	3c	Semi-Open Black Spruce Bog	black spruce sphagnum mosses tamarack low shrubs sedges, rushes	Poorly drained, generally level to gently sloped upland sites; wet depressions within well drained sites	uniform	fine	brown to tan	Similar to 3b but stands are more open and tamarack is present. Often a heavy shrub layer of labrador tea, bog laurel, willow, and swamp birch.	Semi-open black spruce tamarack bog forest
	3d	Lightly Forested Tamarack and Open Muskeg	sphagnum mosses wetland grasses sedges willow swamp birch tamarack, black spruce	Poorly drained, generally level to gently sloped upland sites; wet depressions within well drained sites	uniform	very fine	tan to pink	Extensive bog areas as defined by Zoltai et al (1977) with scattered tamarack and black spruce stands of low density. On the photograph it has a uniform pattern, and very fine texture. The height of the trees can barely be discerned.	Lightly forested tamarack and open muskeg
BURN	4	Burn	dead vegetation	May occur anywhere	broken	variable	cyan	Recent burns up to several years old, uniformly coloured blue-green with occasional pink spots, indicating living vegetation.	
NON VEGETATED	5		occasional low herbs & grasses	Recent slides, slumps	uniform to mottled	very fine	cream to grey	No vegetation or possibly very sparse vegetation can be observed on 1:60,000 photographs.	
AQUATIC VEGETATION	Q			Lakes, ponds	of varying density	very fine	red to pink	Red to pink with varying density against a blue or black water background	

SURFICIAL GEOLOGY AND LANDFORMS

Standard: $A\frac{b}{c}$ d, e f

where

A - genetic material
b - qualifying descriptor (not always used)
c - surficial expression
d - specific landform information (not always used)
e - local relief
f - modifying process (not always used)

Composite Area:

- physiographic characteristics indicate a combination of geomorphic processes

GENETIC MATERIAL

C Colluvial
E Eolian
F Fluvial
L Lacustrine
M Morainal
R Bedrock
U Undifferentiated, parent material Indistinguishable due to organic cover (refer to vegetation map)

QUALIFYING DESCRIPTOR

G Glacial

LANDFORM

b fluvial bars, terraces
d drumlin
k kame
t kame terrace
p outwash plain
r outwash bench, outwash terrace outwash bar remnants
c meltwater channel sediments
o active floodplain, oxbows, meander scars
u undifferentiated

SURFACE EXPRESSION

a apron
b blanket
f fan
h hummocky
i inclined
l level
m rolling
r ridged
t terraced
u undulating
v veneer
x extensively eroded by post-depositional processes

LOCAL RELIEF

1 less than 10 meters
2 10 - 50 meters
3 51 - 150 meters
4 over 150 meters

MODIFYING PROCESS

D deflated
R drumlinized (outwash)
E eroded (channelled)
F failing
H kettled
K karst modified
V gullied

SYMBOLS

beaded drainage
collapse bogs and scars
crag and tail
crevasse filling
drumlin
escarpment (indicates downslope direction)
esker
fluting
glacial meltwater channel
kettle
relict shoreline, beach ridges
sand dune or hill
sinkhole
slump
wetlands

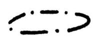
Figure 11. Surficial geology and landforms legend for 1:60,000 scale mapping from FCIR photographs.

Changes or additions to the legend are found in several places. "Drumlin" has been added to the list of "landforms". This was included since drumlins which were not encountered within the area mapped during the 1977-78 mapping program were observed within the complex mantling the Birch Mountains mapped in 1978-79.

The term "abandoned shorelines and beach ridges" has been changed to "relict shorelines and beach ridges" in order to avoid possible confusion between recent abandoned lake shorelines and pro-glacial features. In addition, under the "Modifying Process" category, a new qualifier - drumlinized (outwash) - is now included. This term describes low streamlined hills not necessarily composed of glacial till which formed in response to pressure from readvancing glaciers reworking the pre-existing surficial deposits.

Several symbols for features encountered in the most recent mapping are included in the legend, as follows:

 beaded drainage

 collapse bogs and scars

 crevasse fillings

The limitations inherent in physiographic mapping using FCIR 1:60,000 photography may be restated here. The mapping has been completed at the reconnaissance level only. Although more detailed mapping could be completed using larger scale photography, it is physically impossible to outline small areas on 1:50,000 scale maps without exaggerating their extent. Point bars, for example, identifiable on the larger drainage channels, have been included where practical; however, their limited extent along minor drainage channels precludes their being included on the 1:50,000 maps. In other words, more features can be identified on the photo than can be actually mapped. Secondly, many geomorphic boundaries are transitional and the definition of exact limits must be subjective. An eolian blanket overlying outwash can gradually thicken until no trace of the underlying outwash remains. The exact point at which the outwash can be distinguished from an eolian veneer overlying the outwash and from an eolian blanket is difficult to identify. Obviously, these are transitional boundaries; on the other hand, such features as sand dunes, slumps, and eskers may be more precisely defined.

The physiographic characteristics of numerous regions within the study area reflect a combination of depositional environments. Any attempt to classify such areas as characteristic of a single depositional process would be in error. Low lying hummocky till, for example, can often be partially masked by glaciolacustrine deposits. Whereas the till would dominate the mounds, glaciolacustrine silts and clays dominate the intervening depressions. Delineation of each depression within a moraine would not be possible at a scale of 1:50,000. Consequently such areas have been mapped as a composite: e.g. a glaciolacustrine veneer overlying hummocky moraine with 10 to 50 m local relief, $L_v^G - M_h^G$,2. This technique was utilized whenever more than one depositional process appeared responsible for the physiographic characteristics observed.

3.2.2 Photointerpretation key for the 1:60,000 scale FCIR photographs related to the legend for the surficial geology maps.

Based on the information gained through the field surveys and completion of the surficial geology mapping of the study area, several additions and modifications have been made to the photointerpretation key presented in the Interim Report (Thompson et al. 1978:57-61). These are presented in Table 2.

3.2.3 Glossary

The Interim Report contained a glossary of geomorphological terms in Appendix 11.1 (Thompson et al. 1978: 169-173). Several changes have been made in this glossary, based on the mapping completed for the study area and changes to the legend.

Table 2. Modifications and additions to surficial geology photointerpretation key.

	SYMBOL	TOPOGRAPHY	DRAINAGE	EROSION	VEGETATION	LOCATION	PATTERN	COLOUR	SCALE	EXAMPLE
FLUVIAL:										
Ridged floodplains	$F_r o$	series of gently curved low relief ridges (levees) separated by abandoned meander channels	poorly drained in former drainage channels due to the high silt-clay content, internal on the sandy ridges	minor gully development on ridges	former drainage channel initally boggy and wet; vegetation succession eventually climaxes in riparian forest; willow, aspen, alder and balsam poplar on sandy ridges	bordering either side of downstream, laterally migrating drainage channels	curvilinear strips	buff, pink, to red depending on extent of vegetation cover on ridges; blue to pink in channels	/ / /	New Line 7, # 41
GLACIOFLUVIAL:										
Crevasse filling		relatively straight level narrow ridge; may occur in groups, angular bends possible	internal	minor gully development along edges	usually heavily forested; jack pine, white spruce and aspen common; vegetation contrasts may occur due to opposing slope conditions.	common in hummocky stagnant ice moraine	uniform	red to dark red, slight colour contrast may occur on opposing slopes	/ / /	New Line 9, # 123
GLACIOLACUSTRINE:										
Inclined glacio-lacustrine	L_i^G	gently inclined thick mantle of variable extent completely obsuring underlying topography	dependent on composition: internal if sands and silts dominant; a high clay content impedes drainage resulting in bogs and ponds; collapse scars common	deflation if high sand content; parallel drainage channels common	varied depending on composition of deposit; wetlands common in lower areas, shrubs, and forest cover increasing upslope reflecting increased grain size and better drainage conditions; peat plateaus and collapse bogs common	flanking major upland areas	varies from uniform to mottled depending on stage of development of collapse bogs and peat plateau	varied: pinks, blues buff, and grey	- / /	Line 3, # 102
Relict shoreline, beach ridges (replaces beach ridges and abandoned shorelines)		gently curving ridges of varied length and height frequently following contours; often occur as a series of parallel ridges	internal	eolian activity winnows out finer sands and silts; coarser sands remain as a lag deposit	generally significant variation between vegetation on ridges (often pine) compared to surrounding material (indicative of higher sand content and better drainage on ridges)	frequently occur in series of parallel ridges over glaciolacustrine veneer	speckled	variable dependent on extent and type of vegetation cover (red, dark red, white)	/ / /	Line 11, # 100
MORAINE:										
Drumlin	$M_r d$ 	elliptical ridge of varying width, height and length; occur in groups with long axis paralleling direction of ice movement	internal; occasionally boggy between groups of drumlins	some gullying along edges	heavily forested	till covered upland	uniform	red to dark red	/ / -	Line 7, # 73
COLLUVIAL:										
Colluvial apron	C_a	relatively gently inclined unconsolidated material flanking a steeper slope and extending out onto a plain; materials orginate from steeper, upper slope	dependent on composition of material; parallel gullies common	gullying common	varied depending on composition, slope, and drainage; frequently forested.	normally flanking steeper slopes and extending out over adjacent lowlands	uniform	NA	/ / /	Line 1, # 65
Beaded Drainage:		series of enlarged pools along minor drainage channels	NA	possibly some collapsing along pool peripheries	NA	along minor drainage channels in area underlain by permafrost	resembles beads on a chain	NA	/ / /	Line 1, # 162
Collapse bogs and scars:		circular and near circular depressional fen areas commonly occuring in peat plateaus	high water table; drainage moderately to severaly impeded; form in response to permafrost melting	collapsing banks	fens in circular depression black spruce on peat plateau	variable; frequently encountered in glaciolacustrine blankets and veneers	mottled	white depressed bogs surrounded by grey to black peat plateaus	/ / /	Line 3, # 102

The following definitions have been modified:

kame: steep-sided, short, irregular hill or ridge usually composed of stratified sands and gravels formed by meltwater in contact with glacial ice. May be deposited in superglacial, englacial, subglacial, or ice marginal positions.

kame terrace: kettled or nonkettled terracelike body of startified sand and gravel deposited between a valley glacier and the adjacent valley wall, or between two glacial lobes.

lacustrine: (CSSC) sediment generally consisting of either stratified fine sand, silt and clay deposited in lake water and subsequently exposed either by lowering of the water level or elevation of the land; or moderately well sorted and stratified sand and coarser materials transported and deposited by wave action along former shorelines.

meltwater channel: valley (often steep sided) created by the downcutting of a stream whose source of water was the melting of glacial ice and snow.

relict shoreline (replaces abandoned shoreline): residual beach ridge deposited at the former contact between the land and a preexisting water body. These may occur singly or as a series of approximately parallel deposits.

The following definitions have been added:

beaded drainage: a series of enlarged pools along minor drainage channels. The pools form as heat in the flowing surface water thaws the underlying ice masses. The thawing creates enlarged depressions in the drainage channel which subsequently fill with water. Beaded drainage is characteristic of areas underlain by permafrost.

collapse bogs and scars: circular and near-circular depressional fen areas commonly occuring in peat plateaus. An indicator of the former existence of permafrost, they develop as permafrost melts.

crevasse filling: relatively straight and narrow ridge of stratified sand and gravel marking the position of fissures in stagnant ice masses which subsequently melted. Generally, less sinuous, more nearly level, and wider than eskers.

drumlinized: low streamlined hills or ridges not necessarily composed of glacial till. These cigar-shaped ridges were formed in response to glacial pressure reworking pre-existing surficial deposits (for example, outwash).

3.2.4 Possibilities for larger scale mapping.

Based on the 1978-1979 mapping program and other data sources, some additional implications for larger scale mapping have been identified. Larger scale mapping of surficial geology and landforms enables small features to be mapped in greater detail. For example, gully shape can be more accurately determined through detailed larger scale coverage. Gully shape, in turn, provides important clues as to depth and composition of the overburden, an important factor in any geotechnical analysis. Likewise, large scale coverage would more clearly reveal the depth and composition of the bedrock and the nature of the geologic contacts.

In addition to increasing the quantity and quality of geotechnical information which may be derived by larger scale photographs, a wider variety of specific landforms can be identified and mapped. Features such as individual meander scrolls, point bars, oxbow lakes at varying stages of vegetation succession, fluvial terraces, solifluction lobes, and pingos could be mapped. Extension of the legend to include anomalous moisture conditions, textural variability, aspect, and/or slope would clearly differentiate more specific features within each of the mapped units. The variability, distribution, and frequency of various habitats would thus be more precisely outlined by this larger scale mapping.

The AOSERP study area is located within the zone of discontinuous permafrost. Permafrost-related features can be discerned from the 1:60,000 FCIR photographs throughout extensive portions of both the upland and lowland areas. Collapse scars, beaded drainage, and thermokarst related features are identifiable. The extent and depth of the permafrost, however, are difficult to establish at this scale. Similarly solifluction lobes and terraces, possibly occurring along some of the steeper slopes particularly within the Birch Mountains, are not discernible. The consequences of disturbing permafrost are familar to construction crews. Therefore, as development continues geotechnical analysis from large scale photographs should be completed.

3.2.5 Surficial Geology in the Study Area.

As a result of the completion of mapping of the AOSERP study area, a more comprehensive description of the surficial geology in the study area could be prepared. The following replaces Section 4.1 in the Interim Report (Thompson et al. 1978:69-71). The 1:50,000 maps produced in this program provide the first physiographic description of the entire AOSERP study area at this scale. Bayrock (1971), Bayrock and Reimchen (1974), and McPherson and Kathol (1977) mapped portions of the area at scales of 1:250,000, 1:250,000, and 1:125,000 respectively. In addition, several descriptive reports have been prepared in conjunction with mining operations for particular leases. These were included in the Interim Report List of References (Thompson et al. 1978: 158-168).

3.2.5.1 <u>Overview of the Study Area.</u> Surficial deposits throughout the AOSERP study area reflect the impact of Pleistocene ice activity, subsequent deglaciation, and post-glaeial modification of these features. The post-glacial drainage network reflects the variable composition of these deposits. Numerous, shallow lakes characterize the Birch Mountain, Stony Mountain, and Muskeg Mountain uplands. Poorly drained bogs and fens occur throughout the area, dominating the landscape in particular locales. Major drainage channels are characteristically deeply entrenched into the overburden. Successive slumps along these entrenched channels attest to the instablility and textural composition of these valley walls. Poorly sorted to well sorted clay, silt, sand, and gravel alluvium overlie bedrock throughout most of the major river valleys. Stabilized and non-stabilized fluvial bars occur within most of the major river channels. The AOSERP area lies within the zone of discontinuous permafrost. Permafrost-related features such as collapse scars, solifluction lobes and terraces, thermokarst features, and beaded drainage were anticipated. However, only the collapse scars and beaded drainage developed along minor streams were recognizable at this photo scale.

Till, deposited in direct contact with the several thousand metre deep Pleistocene ice advance, dominates the upland areas. This includes ground moraine, recessional moraine, washboard moraine, and hummocky disintegration moraine. The surficial expression of the till is extremely variable and represents a complex sequence of glacial advance and retreat. This nonsorted, nonstratified morainic material varies in depth from 31 m to less than 6 m.

Outwash and meltwater channel features of variable composition formed as the glaciofluvial drainage network carried meltwater and the associated debris from the glacial margins. Generally sorted, these deposits include extensive gravel and coarse sand bars formed within the proglacial drainage system. Stratified outwash deposits normally occur below 305 m above mean sea level (a.m.s.l.). Very well developed meltwater channels occur east of Fort McMurray along the southern bank of the Clearwater River, and along the western bank of the Athabasca River. These channels normally occur below 312 m a.m.s.l., exhibit well defined curving banks, and are frequently eroded into the underlying material, usually outwash. Within the channel banks, fine grained meltwater channel sediments occur. Because these areas are often poorly drained, channel sediments may be covered by organic deposits of sphagnum and sedge peat. Eskers, kames, and kame terraces indicate former glaciofluvial activity within the ice mass. Numerous kettles indicate the former location of buried blocks of ice which melted to form depressions in the landscape.

Wherever the meltwaters were contained, extensive proglacial lakes developed. Their extent increased particularly during the end of the Pleistocene ice advance as deglaciation and the waning ice sheets released massive volumes of water to these proglacial lakes. Shorelines moved further upslope with resultant glaciolacustrine deposits mantling and occasionally obscuring former ice contact features. Relict beach ridges have been mapped along the Thickwood Hills, Stony Mountain, and Muskeg Mountain uplands. Occasionally washover deposits from the beach ridges were observed on the photographs; however, the limited extent of these features has prohibited their inclusion in the mapping. Textural composition of the glaciolacustrine deposits grades from well sorted and partially stratified sandy beach ridges, to silts, and within the deepest portions of the glacial lakes, laminated clays. Localized lacustrine deposits within the upland areas have been indicated on the surficial geology maps. These deposits reflect the shallow supraglacial lakes which occurred upon the ice mass itself and which were subsequently deposited as the ice disintegrated. The uppermost level for the extensive glaciolacustrine veneers varies from 427 to 442 m a.m.s.l. in the Birch Mountains, to 488 m southwest of Fort McMurray. Beach ridges have been identified at elevations from 312 m to 511 m.

Numerous geomorphic complexes have been utilized in the mapping to express the varied genetic processes responsible for the present topographic expression. Glacial progression and regression occurred several times within the study area. These glacial fluctuations resulted in extensive surficial modification. Outwash, for example, could be reworked by subsequent ice advances to morphologically resemble drumlins. Such features, therefore, were not classed as drumlins due to their compositional characteristics, although their genetic derivation would approximate that of drumlins.

As the climate ameliorated at the close of the Pleistocene glacial period, katabatic winds caused extensive reworking of finer grained deposits. Fine silt and clay material was carried from the area and deposited elsewhere as extensive loess fields. Fine and medium grained sand was reworked into extensive migrating dune fields which subsequently stabilized as vegetation succession proceeded. Interdunal areas developed as localized bogs. This is particularly evident in the northern portion of the Clearwater Lowland, and southern portions of the Athabasca Delta Plain, and Athabasca Plain. Coarser sands and gravels remained as lag deposits in the source areas for the eolian material. Not all the reworked sand and silt were deposited as dune fields. Extensive eolian blankets and veneers were deposited directly over the underlying material and subsequently vegetated. Dunes occurring within the study area include classic examples of sief, barchan, and parabolic dunes.

Post-glacial processes included the establishment of a drainage network and subsequent mass movement activity. Extensive slumping occurred along the eastern escarpment of the Birch Mountains, giving it a stair-step-like topography. Numerous small lakes occupy the depressions formed along the backward-rotated edge of the slumps. Similarly along the entrenched drainage channels throughout the study area, numerous slumps attest to the instability of valley walls, particularly within the glaciolacustrine materials. Colluvial materials mantle extensive areas downslope of major escarpments or steep slopes. This material originates higher on the slope and is reworked as it falls and slides downslope.

3.2.5.2 Description of Physiographic Regions in the Study Area. These nine regions are outlined in Figure 2 in the Interim Report. Surficial deposits within the Birch Mountains Upland consist predominantly of undulating and hummocky till of variable depth. The composition and physiographic characteristics vary considerably throughout the upland area. This area includes gently undulating ground moraine with numerous black spruce bogs and wetlands in low-lying depressions, steeper more irregular hummocky disintegration moraine, ridged "washboard" appearing hummocky disintegration moraine with a predominant northeast-southwest trend, some ice contact features including eskers, kames, and the occasional crevasse filling, drumlins, numerous lakes, and an occasional remnant of former meltwater channels within the till.

Drainage varies from the very poorly drained lowlands and depressions to the very well drained eskers and kames. This variability reflects the heterogeneous nature of the till and glaciofluvial features. Localized deflation has occurred in the northern portion of the area, with sand being reworked to form small dunes. Likewise, supraglacial lakes appear more common in the northern portion as evidenced by the subdued undulations, increased silt-clay content, increased areal extent of wetlands, and more frequently encountered collapse scars and bogs.

Drainage channels gradually become more deeply entrenched closer to the northern and eastern escarpments. Bedrock is frequently exposed along valley walls throughout these entrenched channels. Earthflows and successive slumps commonly occur along entrenched channels as the rivers erode deeper into the underlying shales and sandstones.

As with the Birch Mountain Upland, the Stony Mountain Upland consists predominantly of hummocky disintegration moraine and gently undulating ground moraine. Meltwater channel remnants are more recognizable and better preserved in this area. Gently undulating till of low relief occurs in the higher portions of the upland with more irregular disintegration till dominating further downslope. Numerous wetlands and bogs occur in low-lying depressions throughout the area. Kames occur within the disintegration moraine and some have been identified on the 1:50,000 scale maps. The eastern edge of the upland descends to the Methy Portage Plain through intensely dissected colluvial material. This includes reworked till which has moved downslope through mass wasting processes and subsequently undergone fluvial dissection. The northern and western edges of the upland descends more gradually to the Algar Plain. Relict abandoned beach ridges mark the positions of former glacial shorelines along the descending slopes of the upland. Lacustrine material gradually mantles the till, subduing the amount of relief, eventually obscuring all but the most prominent hummocks on the lowland-upland interface. Permafrost-related features are less frequently encountered than in the Birch Mountain Upland.

The Algar Plain includes a variety of genetically diverse surficial features, and abundant evidence of collapse bogs and scars resulting from permafrost thaw. The northern portion of the plain abuts against the Birch Mountain Upland. Features here reflect the gradual thickening of the lacustrine veneer over hummocky till, eventually obscuring the till completely. As the lacustrine silts and clays thicken porosity decreases, drainage is impeded, and wetlands increase. The same progression can be observed from the contact of the Algar Plain and Stony Mountain Upland. Extensive dune fields can be observed on either side of the Athabasca River. Interdunal areas are generally boggy, with jack pine commonly stabilizing the dunes. The lacustrine mantle thins over the Thickwood Hills as underlying till becomes more visible.

The Athabasca River is incised 152.4 m below the surface in this area. Numerous slumps occur along the valley walls with colluvial aprons extending downslope, partially mantling floodplain deposits along the river's edge. Numerous active fluvial bars occur within this portion of the river.

In the southwestern portion of the Algar Plain on either side of the Athabsaca River as the lacustrine mantle thins, "donut-like" till is encountered, the only area within the AOSERP study area that till of this type was identified. Theoretically, "donut-like" till develops as rimmed kettles collapse within hummocky disintegration till. Relief on the semi-circular rims varies from 1 to 3 m with sand being the dominant textural component.

Unlike the Stony Mountain and Birch Mountain Uplands, the portion of the Muskeg Mountain Upland which occurs within the study area is not predominantly till. Although till does occur, much of it is partially mantled by glaciolacustrine materials. Lakes and till mounds are common only in the uppermost portions of the upland area. As with the Stony Mountain Upland, numerous beach lines attest to the fluctuating lake levels which bordered the upland area. Meltwater channel remnants descend the upland slopes with occasional glaciofluvial bars bordering the channels. Drainage is variable within the upland. Low-lying depressions are frequently poorly drained and commonly contain bogs and fens, while till mounds are generally better drained. Evidence of permafrost is infrequent.

The Methy Portage Plain resembles the Algar Plain in its topographic diversity. The southern portion is characterized by hummocky moraine, undulating ground moraine, and recessional moraine partially mantled by glaciolacustrine deposits. Although relatively pure till is recognizable on knolls and hummocks, glaciolacustrine deposits generally occur in low-lying areas. The lacustrine material thickens in the northern portion of the plain. Prominent relict beach ridges are evident north and south of Gregoire Lake. Immediately south of Gregoire Lake several small dunes were identified.

The Firebag Plain includes glaciolacustrine deposits overlying till in the south, with kames, meltwater channel remnants, outwash plains, and an eolian veneer partially masking the northern deposits. Drainage is variable indicating the textural composition of the underlying deposits. Post-depositional fluvial dissection of the kames is readily observable, as is recent slumping along the Firebag River.

The Clearwater Lowland forms the central core of the study area. Both the Athabasca and Clearwater Rivers flow through this area in wide U-shaped preglacial valleys. Stabilized, partially stablized, and nonstablized longitudinal bars occur throughout the river courses. Ridged meander scrolls frequently occur near the confluence of the Athabasca and its principal tributaries in the northern portion of the lowland area, for example the Firebag River. Numerous meltwater channel remnants occur on either side of the Athabasca throughout this portion of its course and wetlands frequently develop in lowlands between the channel bluffs. Gravel and coarse outwash bars occur throughout this area, often separating meltwater channel remnants. Aspen and poplar usually dominate vegetation communities developed on the outwash bars and terraces.

Eolian reworking of sand within the outwash deposits has created several areas of eolian blankets within this lowland area. One such area lies northeast of McClelland Lake where the eolian blanket obliterates most evidence of the former outwash plain. Within this northern area, prominent dunes attest to the volume of sand deposited by the glaciers and subsequently reworked by the wind. Within the Fort Hills complex and north of McClelland Lake on either side of the Athabasca, several sink-holes were identified, indicating subterranean solution of lime-stone within the bedrock. The eastern and western borders of the Clearwater Lowland gradually merge with the glaciolacustrine blanket. The Fort Hills complex contrasts with the dominant topography of the lowland area, as it includes rolling and hummocky hills with interspersed till pockets [identified by Bayrock (1971) and McPherson and Kathol (1977) as a large kame deposit].

The northeasterly section of the Clearwater Lowland and adjacent portions of the Athabasca Delta Plain and Athabasca Plain include an area of intensively dissected and distorted hummocky disintegration moraine. Kames, eskers, and crevasse fillings with extremely steep escarpments occur in this area, as do numerous kettles. Eolian material partially masks the contact of this area with the westerly and southerly outwash plain.

The Athabasca Delta Plain includes meltwater and outwash features along the Athabasca River, as does the Clearwater Lowland. The remainder of the area includes an extensive dune field and thick eolian blanket overlying possible outwash deposits. Classic sief dunes are usually stabilized by jack pine communities. Drainage within the sand areas is excellent and only when the blanket thins and evidence of the underlying outwash appears do many wetland and fen communities occur.

The Athabasca Plain is similar to the Delta Plain, but the depth of the eolian blanket has decreased. Outwash deposits are more visible, as is hummocky and undulating till along the easternmost boundary of the study area. The extensive dune field observed in the Delta Plain continues into this region with wetlands frequently occurring between dunes. As indicated for the Clearwater Lowland, an extensive extremely distorted and dissected hummocky disintegration moraine is located in the southwestern portion of this unit.

3.3 OTHER MODIFICATIONS IN THE 1978-1979 MAPPING PROGRAM

Because of the problems involved with mapping vegetation with October FCIR photography, as described in the

Interim Report, the portions of the study area not covered with summer FCIR photography (as obtained in July and August 1977) were reflown during the summer of 1978. This provided complete coverage of the study area with excellent quality, summer photography (1977 and 1978) at a scale of 1:60,000 and improved the accuracy of the vegetation mapping in those problem areas. When this new photography became available, the areas previously mapped using October photography were checked and modified where necessary. This ensured consistent accuracy as much as possible.

Another problem with mapping in the AOSERP study area was incomplete NTS coverage of the area with 1:50,000 scale topographic sheets. Although several sheets were made available by the NTS during the course of the 1978-79 mapping program, two full sheets (84 H/15 and 84 H/16) in the northwest corner of the area, and eight half-sheets along the eastern boundary of the area were not available. In order to provide base maps for these areas, several sources were utilized. First, NTS 1:250,000 map sheets for the corresponding areas were photographically enlarged five times to a 1:50,000 scale and redrafted, and the appropriate latitude and longitude detail added. Then additional detail on drainage and cultural features was added from the 1:63,360 scale forestry maps, and from the 1:60,000 scale FCIR photographs. This provided an acceptable substitute base map, until the regular NTS sheets become available in the future.

4. SUMMARY AND CONCLUSIONS

This final report on the AOSERP Ecological Habitat Mapping Project has described the ground surveys carried out in support of the mapping program, and presented the modifications to the Interim Report (Thompson et al. 1978) which resulted from the ground surveys and completion of the mapping of the AOSERP study area.

The field surveys carried out in August 1978 in the AOSERP study area relied mainly on helicopter transport for aerial observations of vegetation communities, surficial geology, and landforms. The areas of investigation mainly included six of the seven transects previously selected by AOSERP personnel as representative of ecological habitat within the study area, and for which large scale photography had been obtained. Also included in the field surveys were areas noted in the mapping already completed as anomalous or questionable in some way. Where necessary and possible, more intensive observations were made on the ground by landing the helicopter or by reaching the location by car.

The vegetation surveys confirmed that the vegetation legend and the maps produced from the 1:60,000 scale FCIR photographs accurately describe the vegetation in the AOSERP study area. A few minor modifications were made to the class composition in the vegetation legend, and one new sub-class was added. It was also noted that in some areas tree heights were sometimes in error.

The surficial geology surveys also confirmed that the legend and the maps produced accurately describe the surficial geology and landforms within the AOSERP study area. As with the vegetation, a few minor modifications to the legend were necessary, and these involved the addition of four landform features (mainly related to the permafrost found in the western part of the study area), one "Modifying Process" qualifier, and one change in terminology. Otherwise, the legend and resultant maps were verified as accurately representing the surficial geology and landforms in the study area.

In Section 3, modifications to the vegetation legend resulting from the ground surveys and completion of the mapping were described in detail, and a revised photointerpretation key for the vegetation mapping presented. Where changes in the mapping procedure were made, the nine maps completed in 1977-1978 were examined and altered where necessary. This was done to ensure consistency in the mapping over the entire study area. Also in Section 3, modifications to the surficial geology legend were detailed, and revisions to the photointerpretation key for surficial geology mapping presented. Also included were modifications and additions to the Glossary contained in the Interim Report. A discussion of further possibilities for larger scale surficial geology mapping, based on the 1978-1979 mapping program and other data sources, was then presented. Finally, a comprehensive description of the surficial geology of the AOSERP study area, both general and related to the nine major physiographic regions, was included.

The 1978-1979 mapping program also involved remapping some areas of vegetation previously mapped from October 1977 photography. This was possible since the areas previously covered only by October photography had been reflown during the summer of 1978; this improved the accuracy and consistency of the vegetation mapping. It was also necessary to create base maps for a portion of the area, using 1:250,000 NTS sheets, forestry maps and the 1:60,000 scale FCIR photographs, since several 1:50,000 NTS sheets were not available during the mapping program.

This program has thus provided reconnaissance maps of vegetation, and surficial geology and landforms at a scale of 1:50,000 for the entire AOSERP study area. Through ground surveys, literature surveys, and examination of several other data sources, these maps have been shown to be accurate within the limits of scale and to represent the major vegetation communities and surficial geology features, as well as to include up-to-date land use and cultural features on the standard NTS base maps. The vegetation and surficial geology legends used, designed not only to be representative of the features of the study area, but also to be "expandable", will allow larger scale mapping of small regions within the study area to be carried out at a later date, expanding on this reconnaissance mapping.

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6. AOSERP RESEARCH REPORTS

1.		AOSERP First Annual Report, 1975
2.	AF 4.1.1	Walleye and Goldeye Fisheries Investigations in the Peace-Athabasca Delta--1975
3.	HE 1.1.1	Structure of a Traditional Baseline Data System
4.	VE 2.2	A Preliminary Vegetation Survey of the Alberta Oil Sands Environmental Research Program Study Area
5.	HY 3.1	The Evaluation of Wastewaters from an Oil Sand Extraction Plant
6.		Housing for the North--The Stackwall System
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12.	ME 1.7	Very High Resolution Meteorological Satellite Study of Oil Sands Weather: "a Feasibility Study"
13.	ME 2.3.1	Plume Dispersion Measurements from an Oil Sands Extraction Plant, March 1976
15.	ME 3.4	A Climatology of Low Level Air Trajectories in the Alberta Oil Sands Area
16.	ME 1.6	The Feasibility of a Weather Radar near Fort McMurray, Alberta
17.	AF 2.1.1	A Survey of Baseline Levels of Contaminants in Aquatic Biota of the AOSERP Study Area
18.	HY 1.1	Interim Compilation of Stream Gauging Data to December 1976 for the Alberta Oil Sands Environmental Research Program
19.	ME 4.1	Calculations of Annual Averaged Sulphur Dioxide Concentrations at Ground Level in the AOSERP Study Area
20.	HY 3.1.1	Characterization of Organic Constituents in Waters and Wastewaters of the Athabasca Oil Sands Mining Area

21.		AOSERP Second Annual Report, 1976-77
22.	HE 2.3	Maximization of Technical Training and Involvement of Area Manpower
23.	AF 1.1.2	Acute Lethality of Mine Depressurization Water on Trout Perch and Rainbow Trout
24.	ME 4.2.1	Air System Winter Field Study in the AOSERP Study Area, February 1977.
25.	ME 3.5.1	Review of Pollutant Transformation Processes Relevant to the Alberta Oil Sands Area
26.	AF 4.5.1	Interim Report on an Intensive Study of the Fish Fauna of the Muskeg River Watershed of Northeastern Alberta
27.	ME 1.5.1	Meteorology and Air Quality Winter Field Study in the AOSERP Study Area, March 1976
28.	VE 2.1	Interim Report on a Soils Inventory in the Athabasca Oil Sands Area
29.	ME 2.2	An Inventory System for Atmospheric Emissions in the AOSERP Study Area
30.	ME 2.1	Ambient Air Quality in the AOSERP Study Area, 1977
31.	VE 2.3	Ecological Habitat Mapping of the AOSERP Study Area: Phase I
32.		AOSERP Third Annual Report, 1977-78
33.	TF 1.2	Relationships Between Habitats, Forages, and Carrying Capacity of Moose Range in northern Alberta. Part I: Moose Preferences for Habitat Strata and Forages.
34.	HY 2.4	Heavy Metals in Bottom Sediments of the Mainstem Athabasca River System in the AOSERP Study Area
35.	AF 4.9.1	The Effects of Sedimentation on the Aquatic Biota
36.	AF 4.8.1	Fall Fisheries Investigations in the Athabasca and Clearwater Rivers Upstream of Fort McMurray: Volume
37.	HE 2.2.2	Community Studies: Fort McMurray, Anzac, Fort MacKay
38.	VE 7.1.1	Techniques for the Control of Small Mammals: A Review
39.	ME 1.0	The Climatology of the Alberta Oil Sands Environmental Research Program Study Area
40.	WS 3.3	Mixing Characteristics of the Athabasca River below Fort McMurray - Winter Conditions
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44.	VE 3.1	Interim Report on Symptomology and Threshold Levels of Air Pollutant Injury to Vegetation, 1975 to 1978
45.	VE 3.3	Interim Report on Physiology and Mechanisms of Air-Borne Pollutant Injury to Vegetation, 1975 to 1978

46.	VE 3.4	Interim Report on Ecological Benchmarking and Biomonitoring for Detection of Air-Borne Pollutant
47.	TF 1.1.1	A Visibility Bias Model for Aerial Surveys of Moose on the AOSERP Study Area
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49.	WS 1.3.3	The Ecology of Macrobenthic Invertebrate Communities in Hartley Creek, Northeastern Alberta
50.	ME 3.6	Literature Review on Pollution Deposition Processes
51.	HY 1.3	Interim Compilation of 1976 Suspended Sediment Data in the AOSERP Study Area
52.	ME 2.3.2	Plume Dispersion Measurements from an Oil Sands Extraction Plant, June 1977
53.	HY 3.1.2	Baseline States of Organic Constituents in the Athabasca River System Upstream of Fort McMurray
54.	WS 2.3	A Preliminary Study of Chemical and Microbial Characteristics of the Athabasca River in the Athabasca Oil Sands Area of Northeastern Alberta.
55.	HY 2.6	Microbial Populations in the Athabasca River
56.	AF 3.2.1	The Acute Toxicity of Saline Groundwater and of Vanadium to Fish and Aquatic Invertebrates
57.	LS 2.3.1	Ecological Habitat Mapping of the AOSERP Study Area (Supplement): Phase I
58.	AF 2.0.2	Interim Report on Ecological Studies on the Lower Trophic Levels of Muskeg Rivers Within the Alberta Oil Sands Environmental Research Program Study Area
59.	TF 3.1	Self-Aquatic Mammals. Annotated Bibliography
60.	WS 1.1.1	Synthesis of Surface Water Hydrology
61.	AF 4.5.2	An Intensive Study of the Fish Fauna of the Steepbank River Watershed of Northeastern Alberta.
62.	TF 5.1	Amphibians and Reptiles in the AOSERP Study Area
63.		An Overview Assessment of _In Situ_ Development in the Athabasca Deposit

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