CHILLIWACK INDIAN RESERVES

DYKING OPTIONS

INITIAL ENVIRONMENTAL EVALUATION

M.A. KERR AND S.P. WETMORE

MARCH 1976

ON BEHALF OF THE

CHILLIWACK INDIAN RESERVES
DYKING ASSESSMENT REVIEW COMMITTEE

F305-EI.1

Your file Votre référence

Our file Notre référence

Environment Canada / Environnement Canada

Environmental Management / Gestion de l'environnement

Mr. M. M. Wiggins, Chief,
Water Planning and Management Branch,
Inland Waters Directorate,
404, 1001 West Pender Street,
Vancouver, B. C.

Dear Mr. Wiggins,

We take pleasure in submitting this Initial Environmental Evaluation of Chilliwack Indian Reserves Dyking Options.

The Chilliwack Indian Reserves Dyking Proposal was registered (P-65) under the Environmental Assessment and Review Process with the Pacific Regional Screening and Coordinating Committee (RSCC) 25 September 1975, and the attached initial environmental evaluation (IEE) was prepared.

The Chilliwack Indian Reserves Dyking Assessment Review Committee consisting of Lands Directorate, Inland Waters Directorate, Canadian Wildlife Service, and Fisheries and Marine Service have had an opportunity to review the final draft of this IEE. Revisions suggested by committee members have been taken into account.

As this IEE of a dyking project is the first of its kind known to the authors, certain sections have been expanded beyond the normal scope of an IEE in order that the report might serve as a useful reference document for future environmental evaluations of dyke and bank protection projects.

In the preparation of this report it became clear that there was a paramount need for an assessment of the cumulative effects of dyking projects. Dyke and bank protection projects in the Lower Fraser River each contribute to the reduction of riparian habitat in that system. While each project in itself may result in only a relatively small loss of riparian habitat, the cumulative destruction amounts to many miles of river bank, thus intensifying the loss of ecological, aesthetic and recreational values.

Population estimates project an increase of approximately 6,000 for the Township of Chilliwhack (1971-1986)* and 450,000 for the Greater Vancouver Regional District (1971-1986)**. As the population expands,

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* "Living for Today and Planning for Tomorrow" Chilliwack Progress Supplement, Section A, 1975, p. 7.

** The Greater Vancouver Regional District. The Livable Region 1976-1986. Proposals to Manage the Growth of Greater Vancouver. 1975. p. 4.

increased pressure will be placed on available lands for wildlife and recreational use. Thus, while recognizing the need for additional funding, we recommend the following for future dyking programs:

(1) That a comprehensive dyke and bank protection program be developed to include a multi-purpose planning concept for dyke and bank protection areas in order to preserve and enhance the ecological, recreational and aesthetic values of these areas.

(2) That a vegetation program be established to preserve or plant trees, shrubs and ground cover in dyke rights-of-way, to enhance them for wildlife habitat and recreation as well as aesthetic values. Such a program would require more planning to determine such things as plant suitability, plant availability, costs, engineering criteria for dyke safety, and dyke maintenance problems (real and theoretical). A pilot project in vegetation planting of dyke rights-of-way should be incorporated into the Chilliwack Indian Reserves dyking project.

(3) That wildlife easements be established in areas of dyke rights-of-way which are capable of providing natural habitat for wildlife.

Yours truly,

AK/ja

M. Anne Kerr

Stephen P. Wetmore

on behalf of the
Chilliwack Indian Reserves
Dyking Assessment Review Committee

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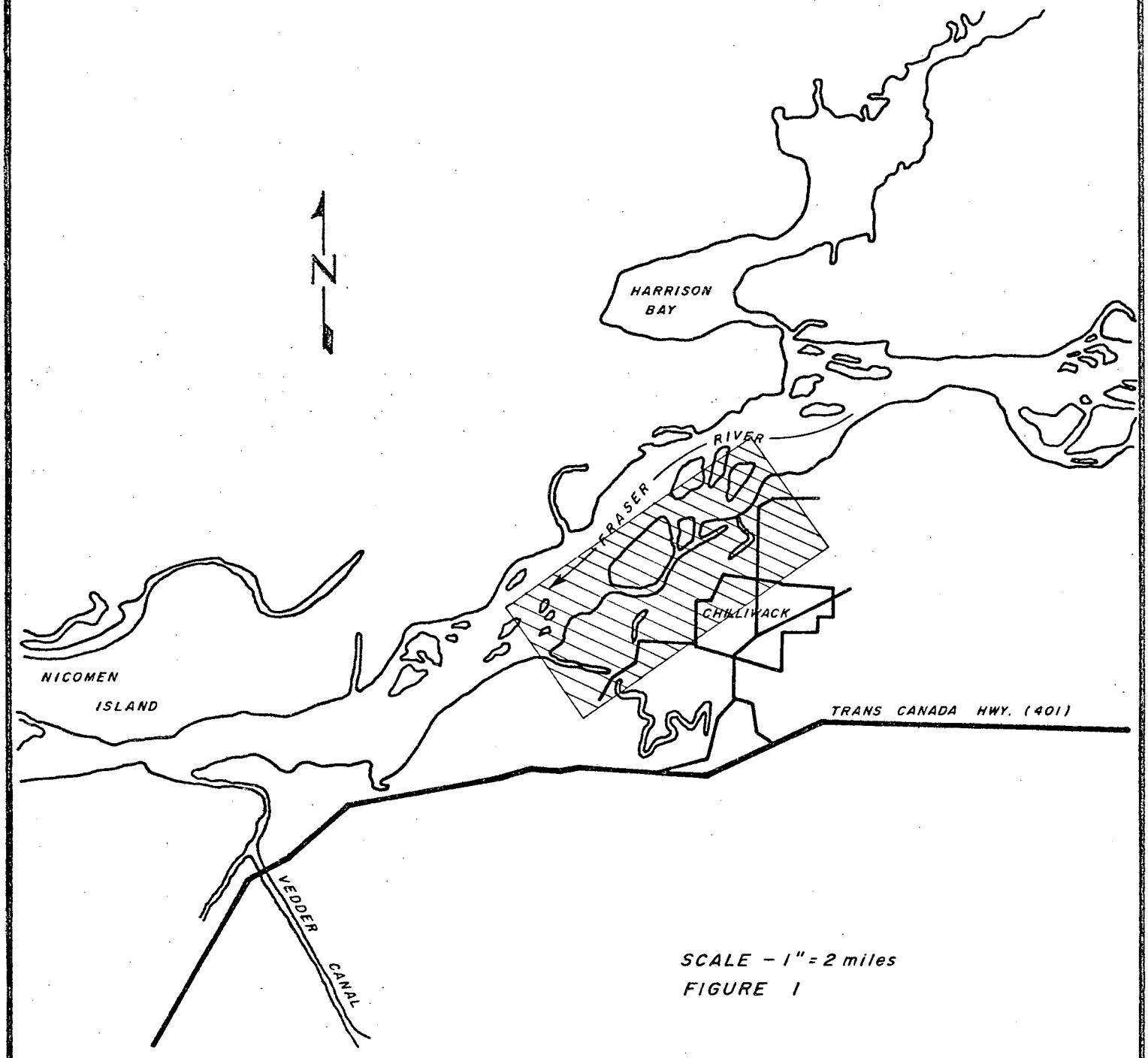
DYKING ASSESSMENT REVIEW COMMITTEE

LOCATION MAP
CHILLIWACK INDIAN RESERVES
DYKING PROPOSALS



SCALE - 1" = 2 miles

FIGURE 1

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GLOSSARY

acre-foot: The volume or quantity of water required to cover one acre to a depth of one foot.

axial flow pump: A pump in which flow is situated around or in the direction of, on or along an axis. The high rotational speed and high pressures under which it operates result in fish kills.

blanket (as in drainage or underseepage blanket): A layer of materials used to reduce or control the intensity of seepage and hydrostatic pressures to the land side of a dyke. Generally an impervious blanket (silty material) is used on the river side to reduce the volume of seepage, and a pervious blanket (free draining material) is used on the land side to allow controlled outflow of seepage without damage to the dyke.

cofferdam: A temporary structure which surrounds or partially surrounds an area which must be dewatered (often by pump) for construction operations.

filter: A layer of pervious material with a controlled gradation of particle sizes, designed to allow free exit of seepage water from the adjacent material without migration of soil particles from either the adjacent material or the filter.

forebay: A small reservoir or area or locally widened canal just upstream of pumping facility from which water is taken to supply the pump.

GSC: Geodetic survey of Canada datum; zero GSC is the same as mean sea level.

headworks (of a relief well): The top portion of the well controlling the outflow; generally that part visible above ground.

redd: The spawning ground or nest of various fish.

relief well: A well whose purpose is to reduce hydrostatic (artesian) pressures above the ground surface that otherwise would cause formation of sand boils and possibly subsurface piping. Relief wells also intercept and provide controlled outlets for seepage that otherwise would emerge uncontrolled landward of the dyke.

relief pits, relief trenches: Similar in function to relief wells i.e. to reduce uplift pressures from seepage forces, but their physical dimensions are different.

revetment: A facing (as of stone or concrete) to sustain an embankment - synonymous with rip-rap.

screw pump: A pump in which flow is forced upwards between spiral blades fixed to a cylinder, by rotation of the cylinder. (An Archimedes screw). It operates under a low rotational speed and atmospheric pressure and thus allows for the safe passage of fish.

slurry: A watery mixture of insoluble matter (as mud).

swale: A very shallow, wide trench (side-slopes often 10:1) to the landward side of a dyke.

three inch (3") minus: Refers to the gradation of the material, i.e. graded from 3 inches in diameter downwards.

turnouts: A space adjacent to a narrow road or dyke in which vehicles may park or pull into to enable others to pass.

I. INTRODUCTION AND ACKNOWLEDGEMENTS

The purpose of this initial environmental evaluation is to analyze the potential effects of two possible dyke alignments for the Chilliwack Indian Reserves (Figure 1 and Appendix A) and to recommend the best option. Dyking in this area is planned under the Canada-British Columbia Fraser River Flood Control 1968 Agreement. The criteria established by the Fraser River Joint Program Committee specifies protection against recurrence of river levels equal to those of the computed 1894 flood profile plus two feet of freeboard to accommodate wave action and errors.

One alignment follows that of the existing dyke which runs south along Young Road from Minto Landing to Hope River, turns west along the south bank of Hope River through Skwah Indian Reserve (I.R.) #4 to Wolfe Road, and along Wolfe Road to Chilliwack Mountain. (Figure 2).

The other alignment joins the existing dyke system at Young Road, follows the Fraser River westerly (north of Clarke Road), crosses the north end of Shefford Slough and runs along the east side of Coco-Oppello Slough at the edge of Skwah I.R. #4 to connect with the existing dyke at Wolfe Road (Figure 2) This dyke will enclose additional Indian lands outside the existing alignment.

The Inland Waters Directorate (IWD), Environment Canada is the federal agency responsible for the project. The project has been registered (25 September 1975) under the Environmental Assessment and Review Process with the Pacific and Yukon Regional Screening and Coordinating Committee. A Chilliwack Indian Reserves Dyking Assessment Review Committee, consisting of Fisheries and Marine Service, Inland Waters Directorate, Lands Directorate and Canadian Wildlife Service was established for this project. All members of the committee have participated in the review of this document and concur with its recommendations.

We acknowledge the assistance of Mr. John Preston for critically reviewing Section III of the report; Dick Boak and Mike Mazalek for the maps and drawings, and Sheila Talley for the final typing. Land use and capability maps were drawn by Lissa Decker of Lands Directorate.

II. METHODS

An environmental evaluation attempts to arrange, present, and evaluate physical, biological and social effects of a proposed project. Currently there are an increasing number of methods for measuring environmental effects. These range from the very general and descriptive to the specific and quantitative. A hierarchy has been suggested as: 1) multidisciplinary teams, 2) checklists, 3) matrices, 4) modelling.1/

Each project has a set of characteristics which dictates the appropriate method, type of data and extent of review and analysis required. Some of these characteristics are: 1) project size, 2) concerns expressed by government agencies, 3) data and funding available, 4) community interest, 5) resource commitments, and 6) the sensitivity of the environment. In light of the preceding we have chosen to use a checklist method of assessment where the significant interactions between the project and environmental components are noted (Table I, p.54). Using existing information these interactions are assessed. This method has shortcomings in that the assessment is more descriptive and less quantitative than are more sophisticated approaches.

Major contributors of information were the: Lands Directorate; Canadian Wildlife Service; Fisheries and Marine Service; Water Quality Branch, I.W.D.; and Water Development Impacts Division, Planning Division, Projects Division and the Senior Hydraulic Engineer of Water Planning and Management Branch, IWD.

Also contacted were: British Columbia Fish and Wildlife Branch; District Agriculturist for Chilliwack area; Chilliwhack Township planners; Fraser-Cheam Regional District Planner; Chilliwack District Dyking Board; and Department of Indian and Northern Affairs (DINA), Fraser Indian District, Real Estate Advisor.

The environmental effects have been evaluated in the context of

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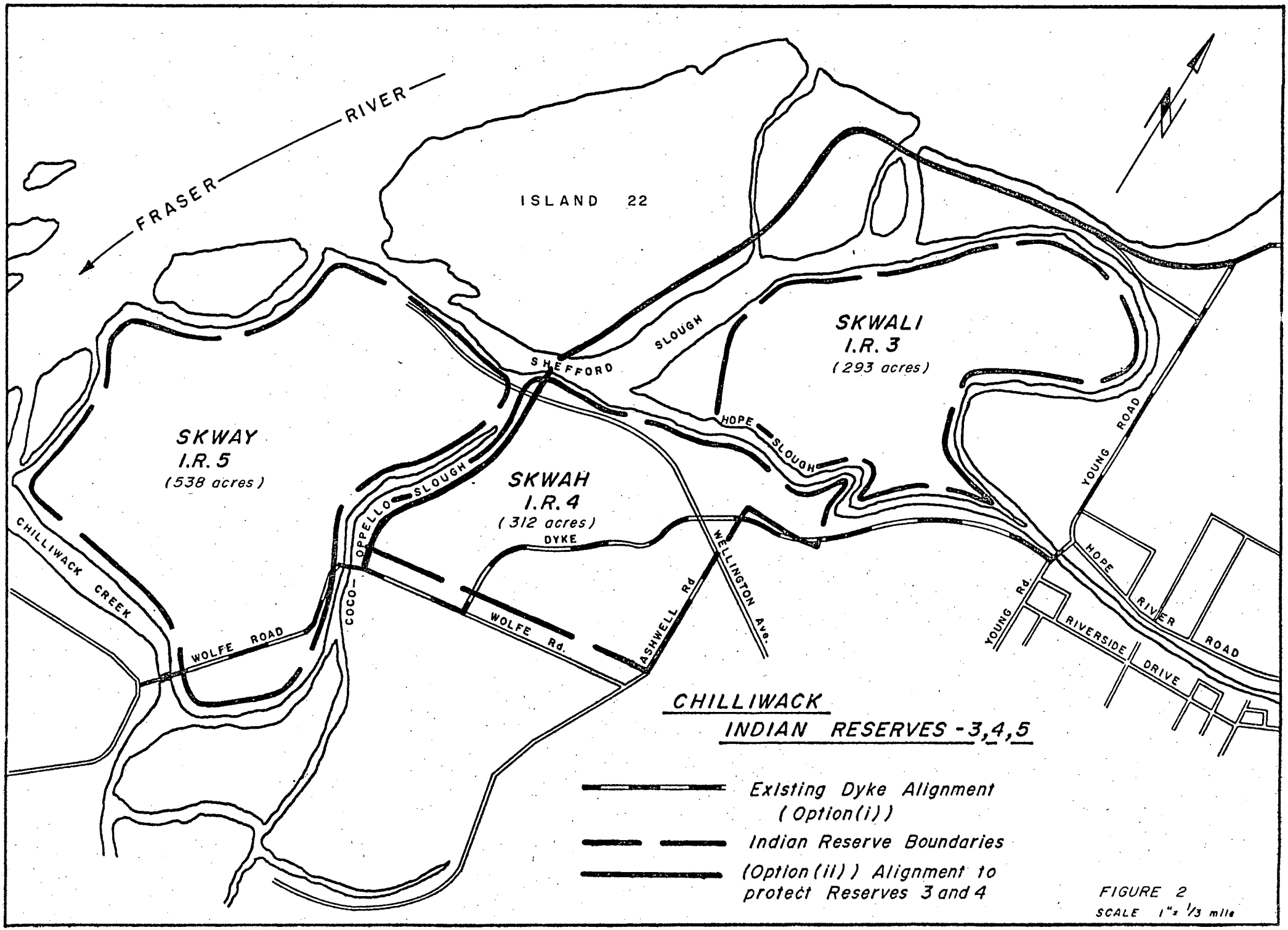
1/ Burchell, R.W. and D. Listokin. The Environmental Impact Handbook. Rutgers, The State University of New Jersey. 1975

existing and proposed social and economic conditions in the area with the view of recommending the best of the two dyking alignments. Unless specifically cited, background information on the proposals is from correspondence on file with Water Planning and Management Branch, Inland Waters Directorate, Vancouver.


FRASER RIVER
ISLAND 22
SHEFFORD SLOUGH
SKWALI
I.R. 3
(293 acres)
HOPE SLOUGH
YOUNG ROAD
SKWAY
I.R. 5
(538 acres)
SKWAH
I.R. 4
(312 acres)
COPPELLO SLOUGH
DYKE
CHILLIWACK CREEK
WOLFE ROAD
COCO-
WOLFE Rd.
ASHWELL Rd
WELLINGTON Ave.
YOUNG Rd.
HOPE RIVER ROAD
RIVERSIDE DRIVE
CHILLIWACK
INDIAN RESERVES - 3,4,5
Existing Dyke Alignment (Option(i))
Indian Reserve Boundaries
(Option (ii)) Alignment to protect Reserves 3 and 4
FIGURE 2
SCALE 1" = 1/3 mile

III. PROJECT DESCRIPTION

A. BACKGROUND INFORMATION

The Canada-British Columbia Fraser River Flood Control 1968 Agreement includes provisions for the reconstruction and replacement of existing dykes and the construction of dykes in areas which are not protected. In 1969 the dyking of Chilliwack Indian Reserves #3, #4, and #5 was included in the Program under the Agreement subject to a review of the economic justification. In providing flood protection it is generally considered that the benefits should at least equal the costs before any project is constructed. The existing dyke alignment protects: none of 293-acre Skwali I.R. #3, approximately 87 of the 312 acres of Skwah I.R. #4, and about 80 of the 538 acres of Skway I.R. #5 (Figure 2).

1. Alternative Alignments Considered

The preliminary concept suggested an alignment which ran from the north end of Young Road, along the western perimeter of Skwali #3, thence along both sides of Hope Slough extending east through the Township and City of Chilliwack, thence along the northern borders of Skwah #4 and Skway #5, thence near the western edge of Skway #5 and thence along Chilliwack Creek to join the existing dyke at Wolfe Road.

Chilliwack Township and City objections to this alignment were: a) right-of-way, construction and maintenance access problems, and b) the adverse effects on many properties in the area. Fisheries objected to the closure of a portion of Hope Slough which drains into Shefford Slough. The Indians were against the quantity of their land being taken up by dyke right-of-way. As a result, between 1969 and 1973 numerous alternative schemes for a dyke alignment from Minto Landing to Chilliwack Mountain were investigated from an engineering and economic point of view.

Scheme 1 (Figure 3) included a structure on Hope Slough which would maintain slough water levels at 25 feet GSC (Geodetic Survey of Canada datum) to store storm runoff. This water would then be diverted via Coco-Oppello Diversion ditch and slough to Chilliwack

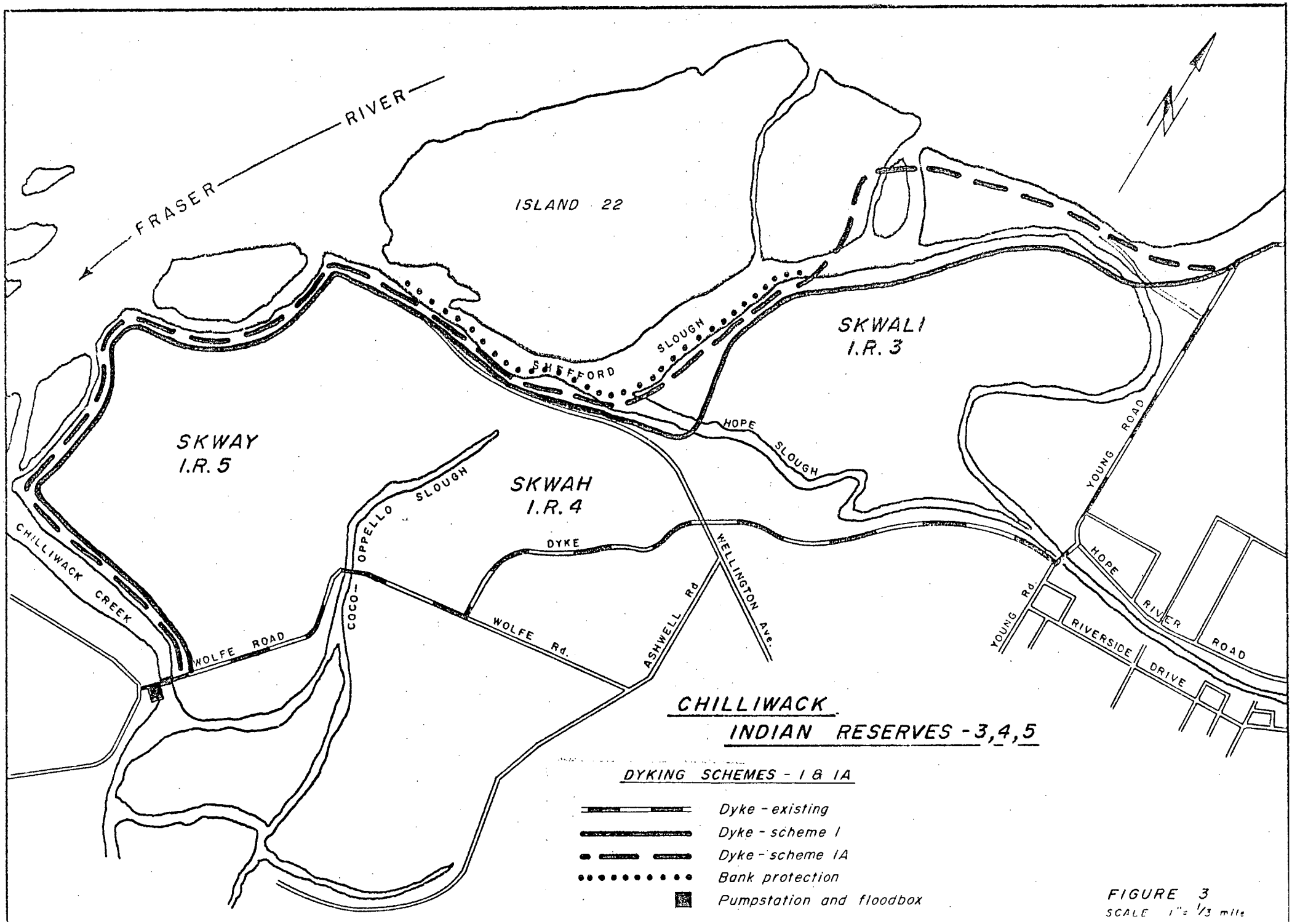


FIGURE 3
SCALE 1" = 1/3 mile

Creek pumping station thereby alleviating the need for a pump station on Hope Slough. Fisheries objected to this scheme on the grounds that redirection of salmon runs through the diversion would result in a high fish mortality unless the diversion was limited to periods when the slough level was over 29 feet GSC. Without the storage capacity the scheme would not save in pumping costs. The Indian Bands rejected the proposal because they did not want a ditch through Skwah #4, and considered that dyke right-of-way would take up too much of their land.

Scheme 2 (Figure 4) protected Island 22 as well as Indian lands. This scheme was favoured by the Township of Chilliwhack because of their plans for the Island as a future recreation area. It was rejected by the Department of Environment on economic grounds.

Scheme 3 (Figure 4) which ran along the western borders of Skwali #3 and Skwah #4 to join the existing dyke at the south end of Coco-Oppello Slough, excluded Indian Reserve #5. The Department of the Environment considered that the cost of building a dyke around this reserve would outweigh any net gain. The Indians were against any of their land being taken up by dyke right-of-way unless all their land was protected.

Because of the difficulty in reaching an agreement on a dyke alignment with the Indian Bands concerned, two alternative alignments that did not cross Indian Reserves #3, #4 and #5 were considered. Implementation of Scheme 4 (Figure 5) required the improvement of two miles of existing dykes and two miles of new dykes plus a pump station and floodbox on Chilliwack Creek. It would have provided the same protection for the Chilliwack area as improvement of existing dykes except portions within Indian Reserves #4 and #5 would not be protected. Scheme 4A (Figure 5) involved the reconstruction of 1.6 miles of existing dykes plus over four miles of new dykes, two pump stations and a diversion channel. It would have left unprotected a large area of land now protected by the existing dykes. These two alternatives were rejected due to higher costs and fewer benefits than improvements to the existing alignment.

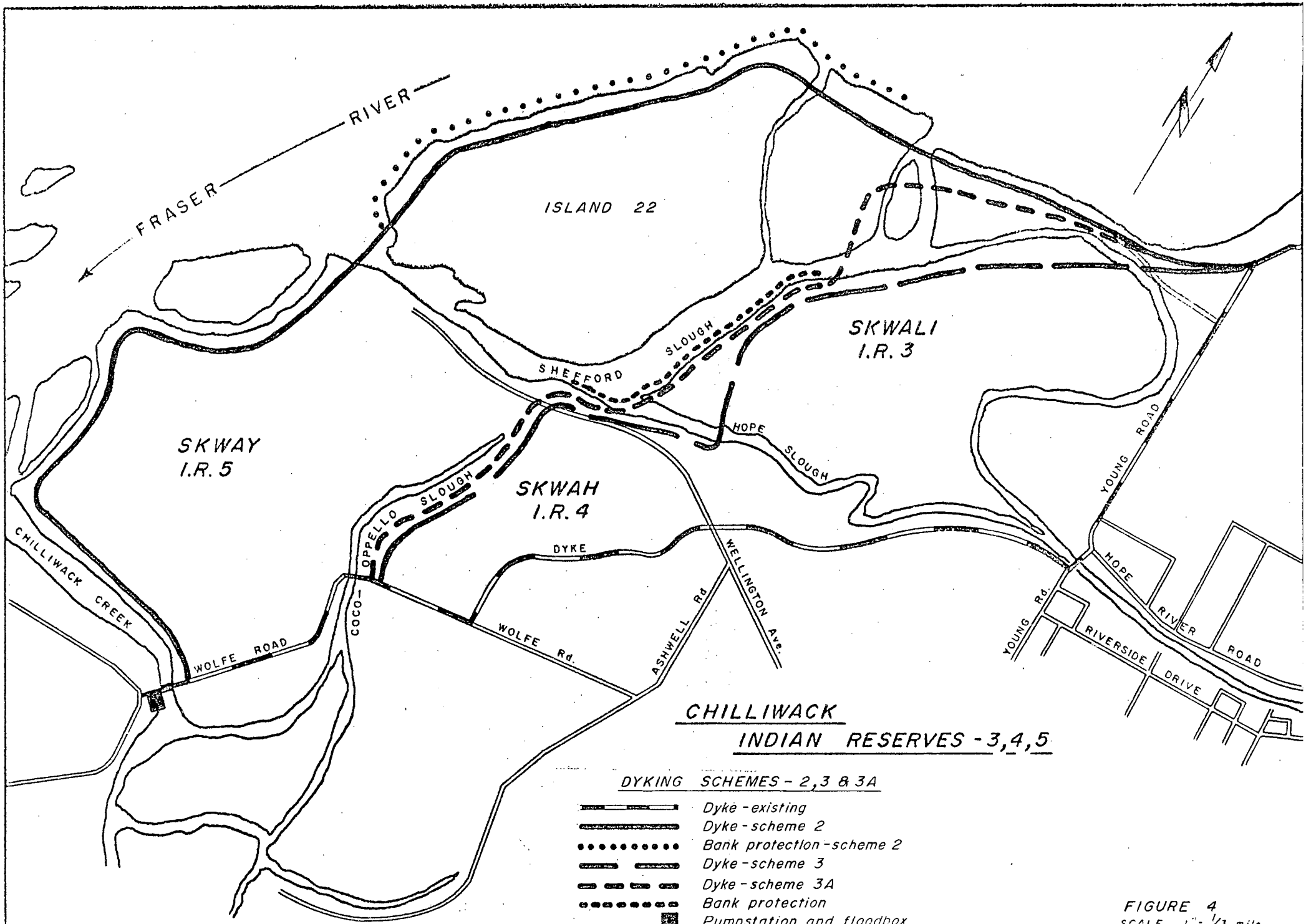


FIGURE 4
SCALE 1" = 1/3 mile

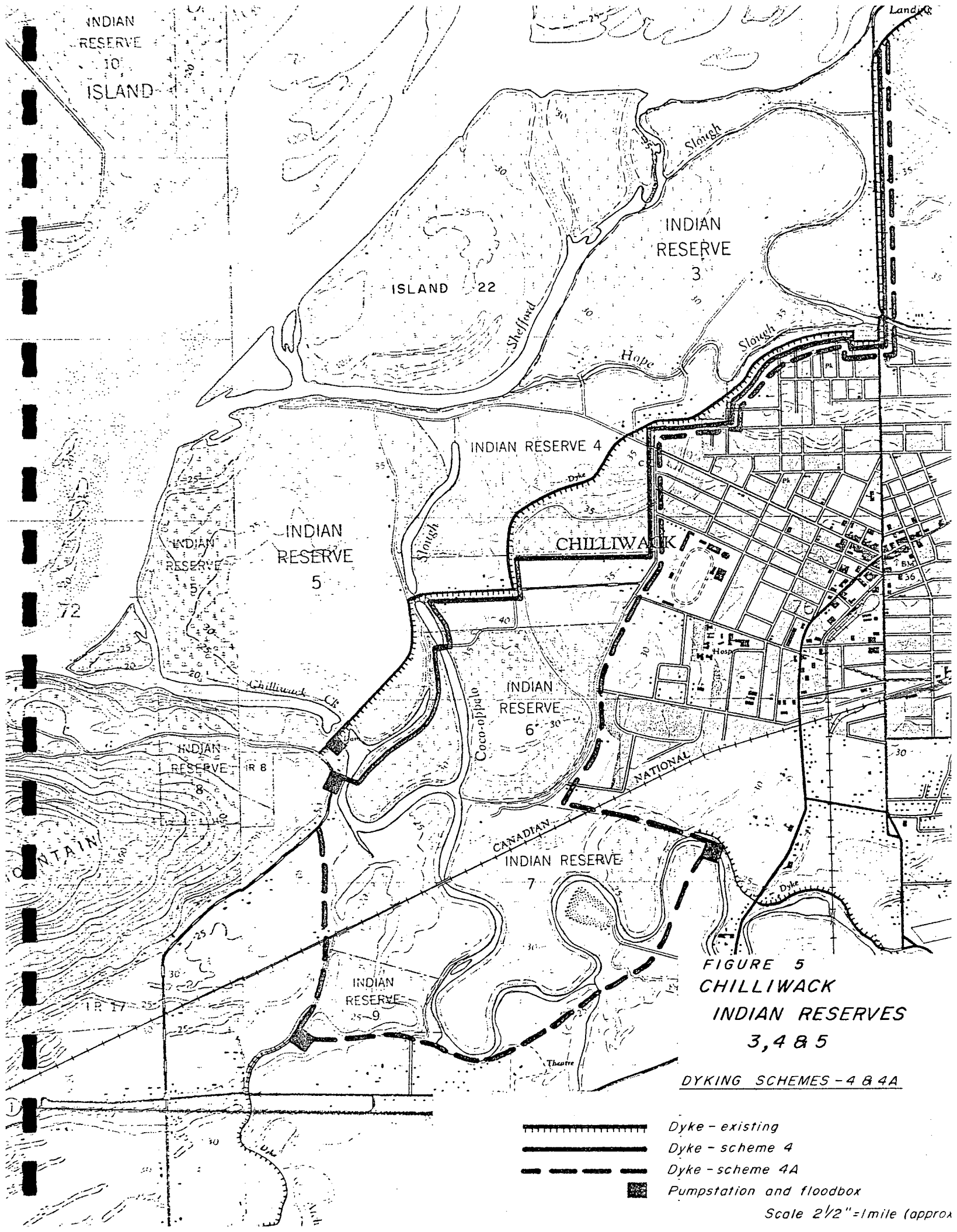


FIGURE 5

CHILLIWACK INDIAN RESERVES 3, 4 & 5

DYKING SCHEMES - 4 & 4A

Dyke - existing

Dyke - scheme 4

Dyke - scheme 4A

Pumpstation and floodbox

Scale 2½" = 1 mile (approx)

In May 1971 as a result of discussions with the Indian Bands, cost estimates for two more schemes were drawn up. Scheme 1A (Figure 3) attempted to keep a greater proportion of the proposed dyke off Indian land and include Skway #5 in the protected area. This required bank protection along Shefford Slough on private land located west of Skwali #3. This scheme was rejected on the grounds of being too costly. The inclusion of Skway #5 behind dyke protection could not be economically justified.

Alignment #3A (Figure 4) was rejected as being too costly from an engineering standpoint. Shefford Slough had to be crossed twice, a pump station and floodbox were required on Hope Slough, storage capacity of Shefford Slough could not be utilized, and bank protection works would be required to protect the private property west of Skwali #3.

2. New Proposed Outside Alignment (Option #2)

Agreement to the general alignment protecting Skwali #3 and Skwah #4 was obtained with the Indian Bands in 1972. In the spring of 1973 a new dyke alignment was designed that would run along the west side of Shefford Slough on Island 22 and the east side of Coco-Oppello Slough, with a pump station on Shefford Slough downstream from its confluence with Hope Slough (Figure 2).

This alignment was preferred because: a) it would protect Indian Reserves #3 and #4 while taking up only five acres of Indian land for new dyke right-of-way, b) it avoided burying valuable agricultural land west of Skwali #3 under dykes, c) the alignment on Island 22 would be set approximately 200 feet back from the edge of the Shefford Slough thus eliminating the need for bank protection, and reducing the amount of underseepage works required, and d) it would allow Shefford Slough to be used for additional storage thereby aiding internal drainage. In summary this alignment appeared an acceptable alignment to the Indians at a reasonable cost. The Federal government considered it desirable to protect Indian lands from flood damage, and therefore

agreed to bear the additional capital costs of this alignment when the B.C. government indicated it was not prepared to contribute to this scheme. British Columbia would pay 50% of what it would cost to reconstruct the existing dykes.

The decision to omit Indian Reserve #5 was agreed to by the Department of the Environment and Department of Indian and Northern Affairs after a study showed that the protection of Indian Reserve #5 was not economic. In June 1973 the Indians indicated their agreement with the proposed alignment although no Band resolution had been made. However, in August 1973 the Skwah Indian Band which controls Skwali #3 and Skwah #4 passed a resolution rescinding previous resolutions regarding dyke proposals. The new resolution stated that dyking must provide flood protection for Skway #5, that no right-of-way would be granted for rail or vehicular use, and that any access would be for maintenance purposes only. The Band is concerned about losing control of the dyked area of the Reserve.

The Band still refuses to accept the new alignment, after assurance that the right-of-way would be used for dyke maintenance purposes only, because it does not protect Skway I.R. #5. To date no indication of the Band's reconsideration of the matter has been received. Therefore the Minister of DINA has been asked to exercise his authority under the Indian Act to provide right-of-way on the existing dyke alignment (Option #1) through Reserves #4 and #5 in order that the dyke to protect the Chilliwack area can be completed.

B. DESCRIPTIONS OF PROPOSED WORKS AND CONSTRUCTION METHODS[2/]

1. Upgrading the Existing Dyke Alignment (Option #1)

The slopes of an upgraded existing alignment will fall within the existing surveyed right-of-way, except where none exists in the 500 feet between Young Street Bridge and Cawley Street (Figure 2).

2/ Unless otherwise referenced, material for this section is from: B.C. Water Resources Service. Canada-British Columbia Fraser River Flood Control 1968 Agreement Project No. 5 - Township of Chilliwhack Contract No. 1, Dyke Reconstruction Tender Documents. 1973.

The sequence of construction procedure is generally as follows:

a) Clearing, grubbing and stripping

Clearing is done within the existing right-of-way boundaries. It includes the complete removal of all trees, stumps, downed timber, snags, brush, vegetation, etc. Also included are the removal of existing fences, gates, concrete, rock, and mowing or burning of grass and other low vegetation throughout the entire length and width of the dyke working area. Clearing should be completed at least 0.5 mile in advance of the reconstruction operation.

Grubbing involves the entire removal and disposal by burning within the right-of-way of all embedded stumps, roots, and logs to a depth of 2 feet below the surface. It should be completed at least 1,000 feet in advance of stripping operations.

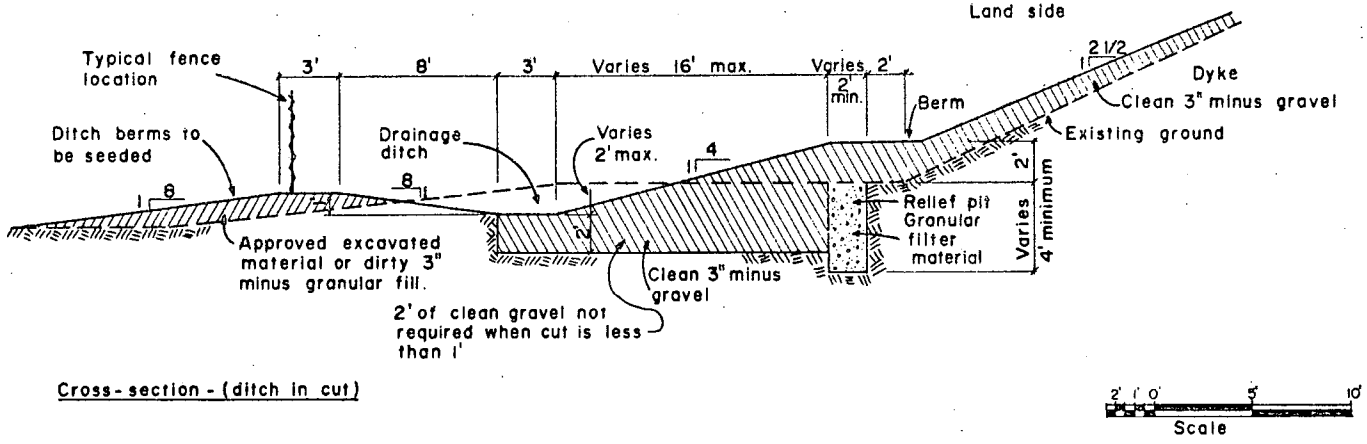
Stripping consists of the removal and stockpiling of the grass and topsoil from the working area to a depth of six inches below the surface. It includes scarifying of these stripped areas. Stripping will be completed at least 1,000 feet in advance of dyke reconstruction work. Stripped material will be stockpiled adjacent to the work for later use as topsoil on the slopes of the new dyke embankment.

b) Excavation and construction of underseepage works

Drainage ditches excavated adjacent to the dyke toe are a minimum of 3 feet wide and have side slopes of 4:1 on the water side and 8:1 on the land side. Drainage off-take ditches are constructed to convey water away from the dyke (Figure 6).

Swales will have a bottom width of not less than 6 feet and side slopes not steeper than 10:1. The top soil excavated from swale areas will be removed, stored, and replaced in a uniform layer after the swale is excavated. Swales may be seeded after construction.

Relief pits will be constructed at the land side toe of the dyke where the height from the design river level to the land side toe



TYPICAL DRAINAGE DITCH

FIGURE 6

Note:
Any topsoil placed on berms or swales shall be to a depth of 16" and shall only be placed where fields are presently cultivated.

of the existing dyke is greater than 4 feet (or as directed by the Engineer). Pits are excavated to a depth equal to the height of the design river level above the existing land side dyke toe or 1 foot below the silt layer, whichever is lesser. The minimum depth is 4 feet. Pits are generally 15 feet long and 2 feet wide. The pits will be backfilled with sand and a 2 foot thick berm of sand and gravel will be placed over the pit. Continuous relief trenches have similar width and depth criteria as relief pits.

A relief well consists of a vertical column (12 inches in diameter) of pea gravel, with a plastic pipe core and well head which is made of perforated concrete pipe with a concrete lid (Figure 7). Relief wells will be located on the land side toe of the dyke at slough crossings, and could be up to 25 feet deep.

Silty gravel blankets will be constructed on the river side slopes of the slough crossings to reduce the amount of seepage. If the land side slough bottom is covered with water then a sandy gravel drainage blanket 2 feet thick will be constructed to extend 100 feet from the land side toe.[3/] (Figure 8) Construction of underseepage works will take place during low river levels. An effective soil sterilant will be applied to those areas to be covered by filters, blankets or drains.

c) Disposal of excavated material

Material excavated from relief pits will be spread, in the form of berms, at the land side toe of the dyke between relief pits. Material from relief trenches, drainage ditches and swales will be used in the construction of berms, or disposed of by wasting either near the dykes in a thin uniform layer or other suitable area, as approved by the Engineer and landowner.

d) Dyke reconstruction and grading of dyke embankments

The natural ground surface and existing dyke surface against which fill is to be placed having been cleared, grubbed and stripped, will

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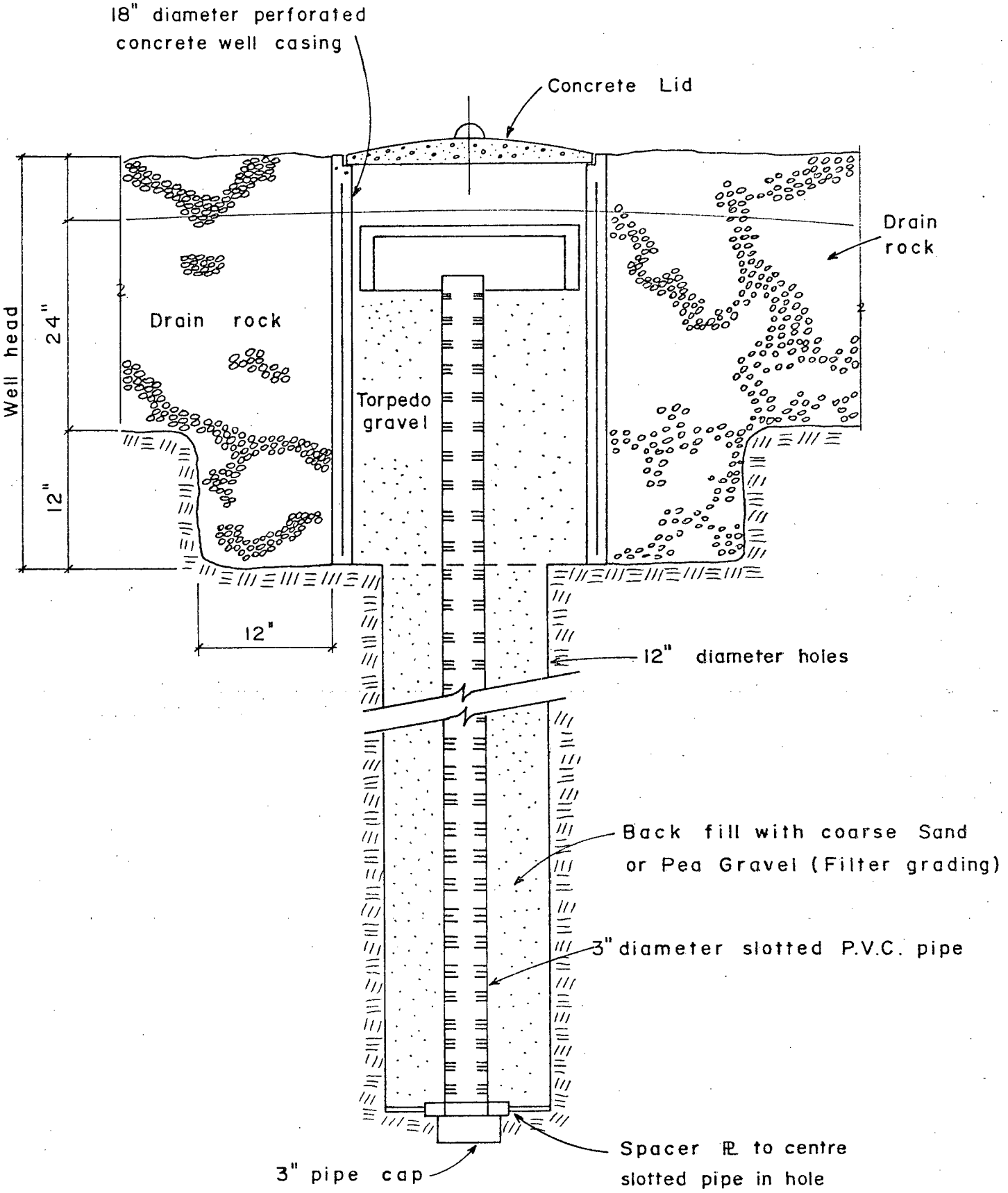
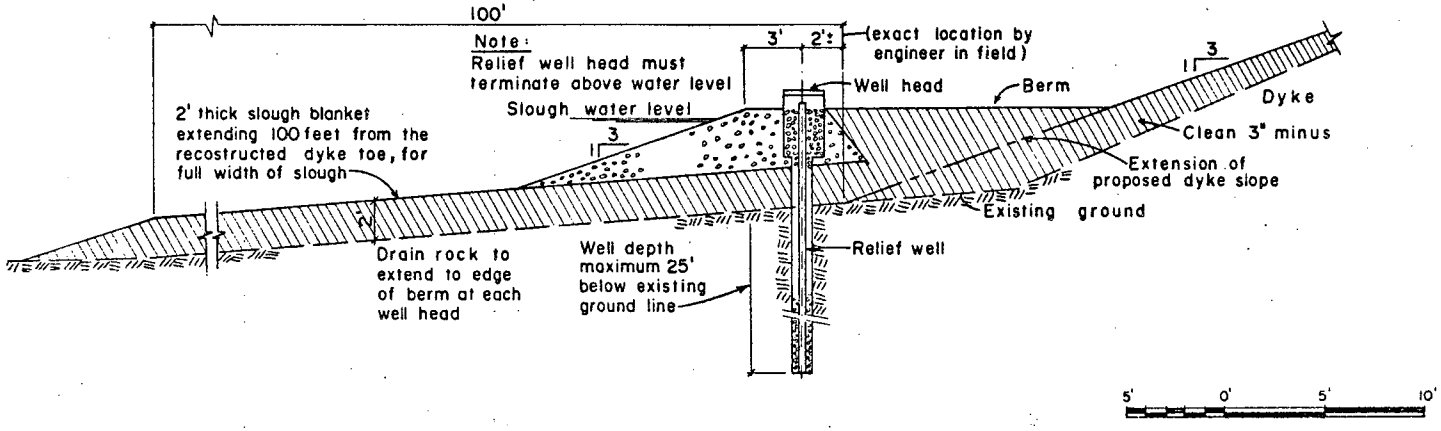
3/ Willis, Cunliffe, Tait & Co. Ltd. Preliminary Design for East Chilliwhack Dyke Reconstruction. For Canada-B.C. Fraser River Flood Control 1968 Agreement Project No. 5, Township of Chilliwhack. December 1970, p. 5.



TYPICAL RELIEF WELL

FIGURE 7



TYPICAL WET SLOUGH CROSSING

FIGURE 8

be trimmed, regraded and compacted in preparation for fill placement.

Granular fill material is used in the construction of land side fills, slough blankets, water side fills, relief pit and drainage ditch berms and to raise the dyke to the required height. Granular fill material will be obtained from borrow pits of the contractor's choosing. In the event that material is obtained from pits or bars in the Fraser River, excavation of same will be governed by the regulations and guidelines for Fraser River borrow pit operations set out in The Fraser River Dredging Guide.[4/]

Stockpiling sites for fill material will be cleared, grubbed, stripped, and drained to the nearest natural outlet (or one designated by the Engineer). The choice of site is up to the contractor with permission of the landowner and approval of the Engineer. After use the site will be restored to the approval of the landowner and all regulatory agencies and statutes.

The crest of all reconstructed portions of the dyke will be 12 feet wide except where the dyke is being used as a roadway in which case the design crest widths will be: [5/]

Location	Width	Surface
Along Young Road	26 feet	18 feet paved, 4 foot shoulders
From Cawley Street to Corbould Street along Hope Slough	16 feet	12 feet paved, 2 foot shoulders
Corbould Street to just south of Wellington Avenue	16 feet	gravel
Along Wolfe Road	24 feet	18 feet paved, 3 foot shoulders

Trimming and grading of all portions of the dyke will conform to the following to ensure that a uniform graded area is achieved: slopes: land side 2.5:1 or flatter, water side 2:1 or flatter;

4/ Boyd, F.C. Fraser River Dredging Guide. Fisheries and Marine Service. Technical Report Series No. PAC/T-75-2. 1975.

5/ Willis, Cunliffe, Tait & Co. Ltd. Preliminary Design for East Chilliwhack Dyke Reconstruction. For Canada-B.C. Fraser River Flood Control 1968 Agreement Project No. 5 - Township of Chilliwhack. December 1970. p. 3.

crest: 12 foot minimum width; turnouts: 1.5:1 or flatter; access approaches: to conform to existing widths and grades.

Trimming of dykes is carried out after the granular fill has been placed and prior to seeding. Work may be suspended during high river levels if the capability of the existing dyke appears to be in jeopardy.

e) Dyke surfacing

Granular surface material consists of 1 inch minus crushed gravel. Bituminous surfacing consists of an asphalt of aggregate and bituminous material. This type of surfacing will be placed on the dykes: along Young Road; between Cawley Street and Corbould Street; and along Wolfe Road.

f) Fences, gates, cattle guards, culverts

New barbed wire fences will be constructed wherever existing fences are removed. Fences will run on one or both sides of the dykes and traverse the dykes in certain locations. Fence posts will be constructed from lodgepole pine treated with pentachlorophenol or chromated copper arsenate Type B. Gates will be placed at points where access may be gained to the dykes from public roads, where the fence traverses the dyke and at points of access to private property.

Cattle guards will consist of galvanized pipe rails with concrete substructures.

Culverts will consist of corrugated metal pipe that is fully asphalt coated. Inlet and outlet ditches will be constructed to the culverts. Culvert trenches will be backfilled with clean gravel.

g) Topsoil and seeding[6/]

Topsoil and seeding will extend along the full length of the dyke (19,500 feet) on both land side and water side slopes from the

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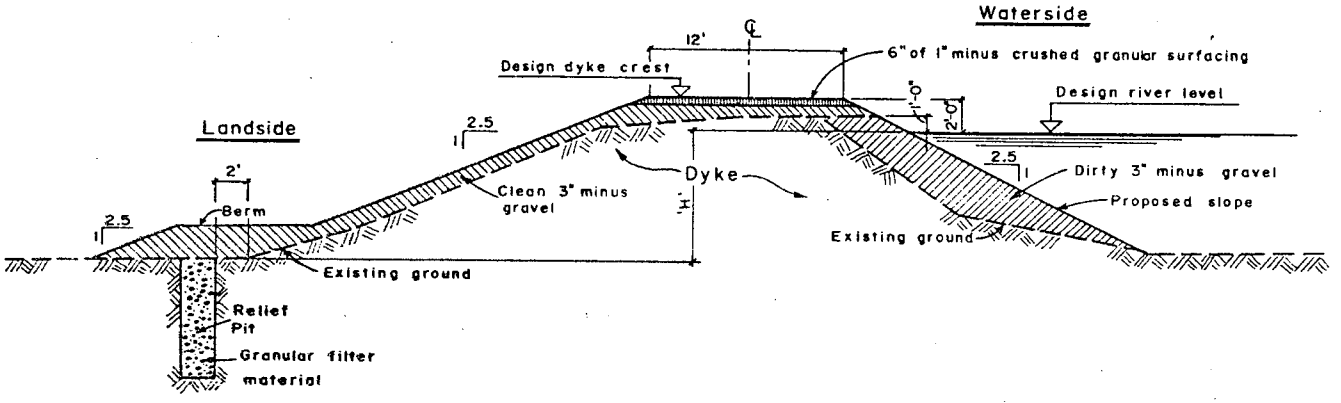
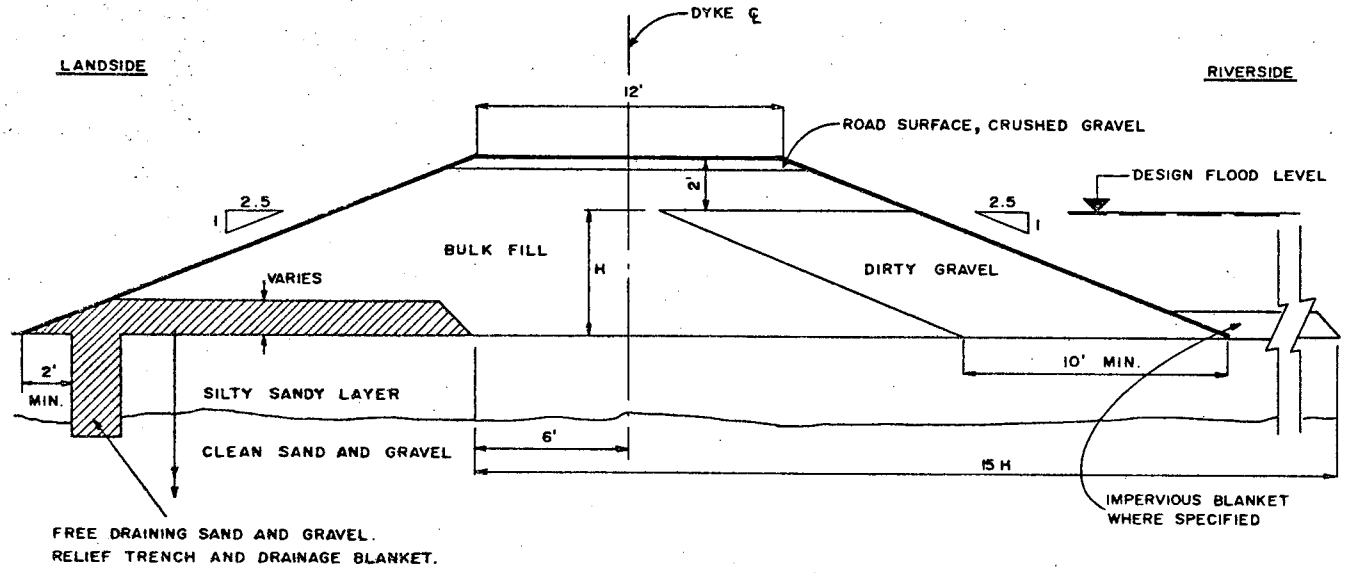
6/ B.C. Water Resources Service. Canada-British Columbia Fraser River Flood Control 1968 Agreement Project No. 6 District of Delta Contract No. 6 Tender Documents. April 1975.

FIGURE 9A

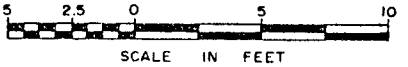


Typical Improved Dyke Cross-Section

FIGURE 9B



Typical New Dyke Cross-Section



dyke crest to the lowest levels of dyke construction work. The dyke crest and slopes blanketed with gravel or rip-rap will not have topsoil nor be seeded. Topsoil will be spread to a thickness of approximately 3 inches. Seeding of dyke slopes is a protection against erosion by heavy rain. The seed mixture, applied at 75 lbs. per acre consists of Creeping Red Fescue (Festuca spp.) 45%, Kentucky Bluegrass (Poa pratensis) 40%, Red Top Fescue (Festuca spp.) 10%, White Dutch Clover (Trifolium repens.) 5%.

The 13-16-10 fertilizer applied at a rate of 300 lbs. per acre will be a type that permits complete suspension of insoluble particles in water for application by a power sprayer.

Additives of either wood fibre mulch and asphalt emulsion, or the chemical Terra-a-tac or equivalent, is combined with fertilizer, seed and water into a slurry. This is applied as soon as areas to be seeded are ready and as soon as possible after the spring freshet recedes. No seeding is to be done before spring freshet nor when the ground is frozen. A typical improved dyke cross-section is shown in Figure 9A.

2. New Proposed Outside Alignment (Option #2)

For the proposed outside alignment (Figure 2) the limit of the right-of-way will be two feet beyond the land side and river side toe of the dyke. The right-of-way width will vary from 40 feet (typical limit of right-of-way) to 120 feet at slough crossings. A 25 foot temporary easement will be required on the land side of the dyke, during construction.

The construction methods and work for a new dyke are basically the same as for reconstructing and upgrading an existing dyke. There will be local differences according to location, ground elevation, slough and river proximity, soil composition and permeability, and ground water tables.

The natural ground surface will be cleared and grubbed to two feet beyond both the land side and water side of the new dyke. All trees and brush will be cut and, along with all stumps and roots and other

organic materials, will be disposed of by burning or other approved means. After all fill materials have been placed, embankment slopes will be trimmed and graded to provide smooth, regular slopes according to the design.

The proposed new alignment runs through a gravel operation west of Minto Landing. Agreement on a suitable dyke design through this operation has been reached. Further west is an emergency dyke erected by the Township of Chilliwhack, which is protected by rip-rap on the river side. The proposed alignment will run along the land side of this emergency dyke.

At slough crossings, dyke slopes will be trimmed to a 3:1 slope. Excavated material may be used to fill the lower dyke slopes but organic material is to be removed. A preliminary engineering report[7/] on the new alignment indicates that approximately 6 relief wells will be required at the Shefford Slough Crossing.

Where feasible, the land side toe of the dyke will be placed at least 200 feet back from the river or slough to permit utilization of any low permeability soils at the surface to increase the seepage path. It has been recommended by soil consultants[8/] that a 150 foot permanent restrictive easement be placed along the entire dyke water side to prevent excavation and disruption and to assure an adequate thickness of relatively impermeable material to reduce underseepage flows.

Approximately 22 acres will be buried by the dyke works, however, about 15 acres of dyke side slopes will be reseeded. Construction of this new dyke, which is approximately 18,175 feet long, is expected to take approximately 9 months. A typical new dyke cross section is shown in Figure 9B.

7/ Associated Engineering Services Ltd. Draft report on Chilliwack Indian Reserves Project. 20 August 1973 p. 3.

8/ Soil Consultants Ripley, Klohn & Leonoff International Ltd. from letter on Water Planning & Management Branch file, 23 June 1973.

3. Bank protection works and construction methods[9/]

River banks are rip-rapped in particular locations to protect flood control works from river current erosion and boat- or wind-generated wave action (Figure 10). If the existing dyke is upgraded bank protection work will not be part of this project. The proposed new alignment will require protection beginning at a point 1000 feet west of Minto Landing and extending to the existing bank protection works, a distance of 1200 feet. The permanent bank protection right-of-way is 15 feet in width from the top of the river bank.

The sequence of construction procedures is generally as follows:

a) Clearing

All trees, stumps, downed timber, snags, brush, vegetation, etc. will be cleared from the overbank and river slope where bank protection is to be improved or constructed. The entire area within the limits of the foundation for the bank to be protected will be grubbed of all stumps, roots, buried logs and other similar material. All holes caused by grubbing operations will be filled to the lower level of adjacent stripping operations.

b) Debris disposal

All logs, brush, slash and other debris from clearing and grubbing operations will be disposed of by burning within the right-of-way.

c) Excavation

Excavation consists of removal of material, including existing rip-rap where necessary, in preparing the foundation and achieving proper alignment of bank protection works.

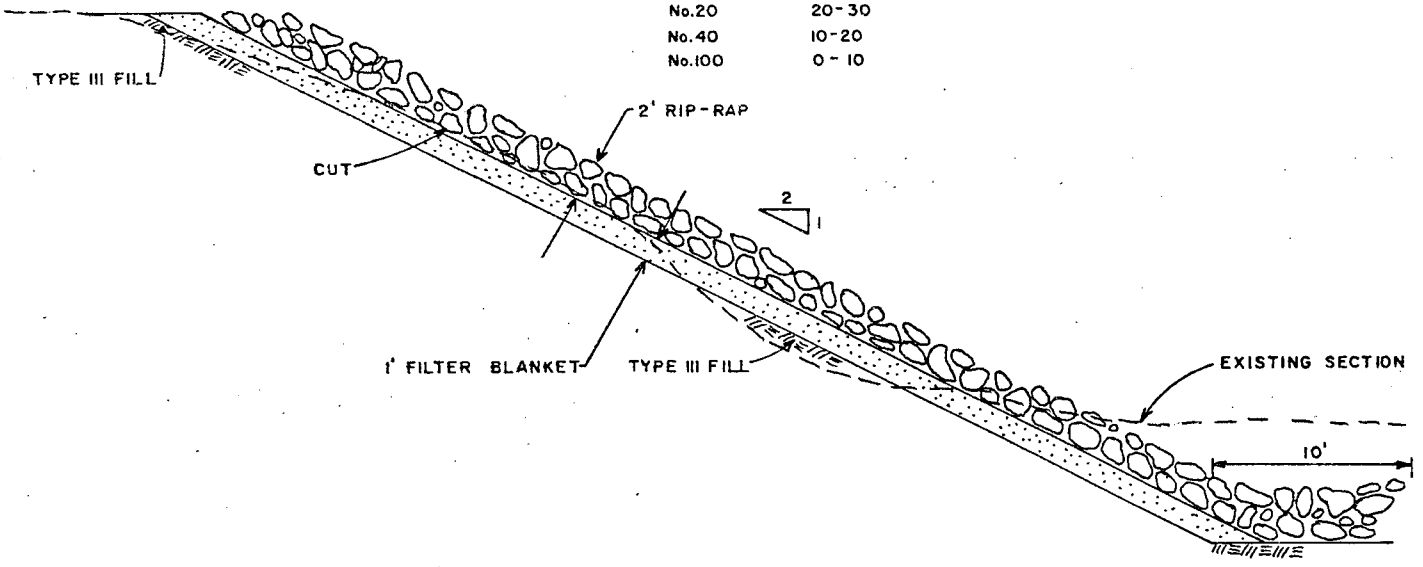
d) Bank fill placement

Excavated materials suitable for bank fill protection or other work will be used. The filter blanket will be 1 foot thick.

9/ B.C. Water Resources Service. Canada-British Columbia Fraser River Flood Control 1968 Agreement Project No. 6 District of Delta Contract No. 6 Tender Documents. April 1975.

GRADING LIMITS

FILTER MATERIAL		RIP-RAP	
SIEVE SIZE	PERCENT PASSING	PARTICLE SIZE (lbs)	% TOTAL WEIGHT LESS THAN
4 Inch	100	650	100
2 1/2	75-95	460	70-80
1	60-75	200	45-55
3/8	50-60	50	20-30
No.4	40-50	10	NOT EXCEEDING 10
No.8	30-40		
No.20	20-30		
No.40	10-20		
No.100	0 - 10		



TYPICAL BANK PROTECTION CROSS - SECTION

FIGURE 10

Placement of the rip-rap will be synchronized with placement of bank fill to prevent damage to and losses of fill.

e) Rip-rap

Rip-rap generally consists of dense, angular material. The size of this material is a function of the river current velocity and the proposed slope of the bank protection works. The finished thickness of the completed rip-rap measured perpendicular to the slope should be 2 feet. Bank protection normally has a slope of 2:1 but this will be decreased to 2.5 to 1 in the vicinity of the gravel operation to provide the optimum alignment in this restricted area.[10/]

C. FLOODBOX AND PUMP STATION WORKS

1. Internal Drainage Characteristics[11/]

a) The average daily runoff during the Fraser River freshet period (May, June, July) for Hope Slough is 110 cfs.

b) Peak flows for Hope Slough:

	Recurrence Interval (Years)	Peak Daily Flow
Winter	25	1200 cfs
	10	1040 cfs
	average 2.33	695 cfs
Summer	25	620 cfs
	10	420 cfs
	average 2.33	220 cfs

c) Approximately 1430 acre-feet of storage are available in Hope Slough and Shefford Slough between water elevations 28.0 feet and 31.0 feet GSC with the proposed outside dyke alignment.

10/ Associated Engineering Services Ltd., op. cit., p. 4.

11/ Willis, Cunliffe, Tait & Co. Ltd. Preliminary Design Township of Chilliwhack Pumping Station Alternatives on Hope Slough and Shefford Slough. March, 1973. Appendix 1, p. 3.

2. Description of Works Construction[12/]

The dyke alignments will require construction of a small dam, pump station and floodbox on either Hope (Option #1) or Shefford (Option #2) Slough to accommodate internal drainage during high water levels when flood gates are closed. The location of the dyke alignment has not been decided upon, therefore no final designs have been approved for the pump station works. However, a generalized sequence of construction is as follows:

a) Dewatering

A cofferdam or other diversion is required to dewater the area to enable construction of the works.

b) Excavation

i) clearing trees from the approach channels,
ii) excavation of the approach and discharge channels,
iii) excavation for construction of pump station works, discharge piping and discharge structures,
iv) excavation and dredging of material from slough and forebay pond.

c) Backfilling

i) placing of granular filter material for lining of the forebay and approach channel,
ii) backfilling clean gravel around pump station and inlet works,
iii) backfilling dirty gravel around discharge structures,
iv) installation of rip-rapping adjacent to the floodbox around discharge structures and over the gravel blanket of the forebay.

d) Construction of pump station and floodbox

i) construction of concrete substructures for the pumphouse,
ii) construction and installation of sheet pile cut off walls for the pump station and floodbox structures,

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12/ B.C. Water Resources Service. Canada-British Columbia Fraser River Flood Control 1968 Agreement Project No. 5 Township of Chilliwhack Contract No. 8 - Construction of Pumping Stations and Floodbox Tender Documents. September 1973.

iii) construction of a concrete floodbox and inlet and outlet structures,

iv) construction of pump intake structures,

v) installation of discharge pipes, fittings and appurtenances for the pump station,

vi) construction of the discharge structures,

vii) completion of the mechanical, electrical and steel works for pump operation.

3. Pumping Alternatives and Fish Diversion Facilities

Hope Slough has significant runs of coho salmon (Oncorhynchus kisutch), and cutthroat trout (Salmo clarki clarki) which spawn in the upper parts of Elk and Dunville Creeks. Therefore, measures to facilitate the safe passage of fish have been considered in the design of pumping facilities for both alignment options. Two alternatives are:

a) The use of axial flow pumps to handle approximately 90% of the flow and a screw pump operating simultaneously to handle 10% of the flow in conjunction with stationary full depth screens to direct the smolts to the screw pump (Figure 11).

b) The use of all screw type pumps to transfer all the flow and smolts over the dyke (Figure 12).

The pumping facility would be in use for 15 to 20 days on an average recurring frequency of every 3 years.

The general design criteria for fish diversion facilities at the proposed pump station has been agreed to by the Department of Fisheries. Full depth stationary screens, with adequate maintenance and operation, would be acceptable. Clear openings for the screens should be 0.10 inches[13/] with the open screen area not less than 50% of the total screen area (2.5 sq. ft. of net screen area per cfs). The approach

13/ Previously 0.15 inches (letter M.J. Holden to R.A. Crouter 20 February 1973) subsequently changed (letter R.A. Crouter to M.M. Wiggins, 14 January 1976 , Appendix B).

velocity ahead of the screens should be 0.4 ft/sec maximum during the operation of all axial pumps. A training wall from the floodbox and screw pumps should be used in containing and diverting the fish into the screw pumps.

4. The Hope Slough Pump Station Proposal[14/]

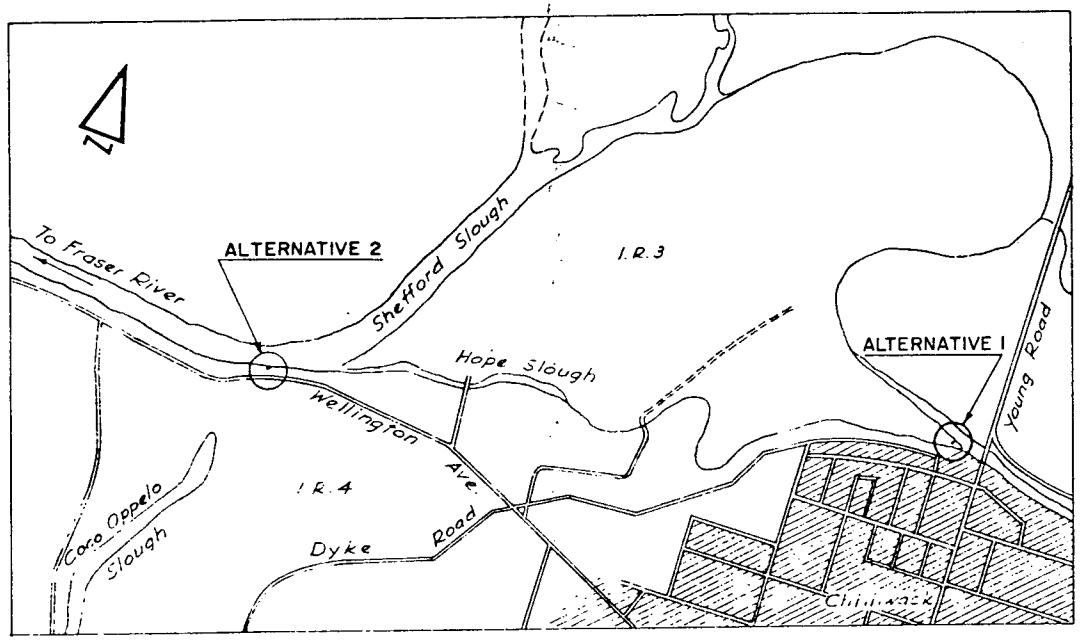
This proposal (a component of dyke Option #1) consists of a 200 cfs capacity pump station on Hope Slough near Young Road, and a floodbox with a capacity of 1200 cfs at a one foot head differential. Winter flows will be drained to the Fraser River by the floodbox which is to be sized for the 1 in 25 year peak daily winter flow (i.e. 1200 cfs).

Summer flows will pass through the floodbox except when the Fraser River rises to a level between 27.0 feet GSC and 29.0 GSC (20 feet GSC at Mission) at the floodgate. The floodgates will be manually closed between these river levels, depending on the anticipated flood conditions. When extreme high river levels are forecast, the floodgates will be closed at 27.0 feet GSC; the pumps will start operating and continue until the internal level is drawn down to 27.0 feet GSC. When the river level is expected to exceed elevation 29.0 feet GSC for only a few days, the floodgates will be closed when the river level rises to 29.0 feet GSC and pumping will begin and continue until the river level drops to this level. The capacity of the pump station is based on maintaining the internal level of Hope Slough below 32.6 feet GSC during a design flood of the Fraser River.

Pump data are as follows:

maximum river level (design flood)	37.7 feet GSC
maximum internal level	32.6 feet GSC
normal internal drawdown level	27.0 feet GSC
minimum internal pumping level	25.0 feet GSC

14/ Willis, Cunliffe, Tait & Co. Ltd. Preliminary Design Township of Chilliwhack Pumping Station Alternatives on Hope and Shefford Slough. March 1973. Appendix 1, pp. 4-6.



Site Plan of General Area

0 1000 2000 Feet

Notes

1. Table of Pump Capacities

Alternative 1	Axial flow pumps	2 × 87.5 c.f.s.
	Screw pump	25.0 c.f.s.
	Total	200.0 c.f.s.
Alternative 2	Axial flow pumps	2 × 145.5 c.f.s.
	Screw pump	34.0 c.f.s.
	Total	325.0 c.f.s.

2. Position of Dyke varies at respective locations

3. Water levels vary at respective locations

From: Willis, Cunliffe, Tait and Co. Ltd., Preliminary Design Township of Chilliwhack Pumping Station Alternatives on Hope and Shefford Slough.

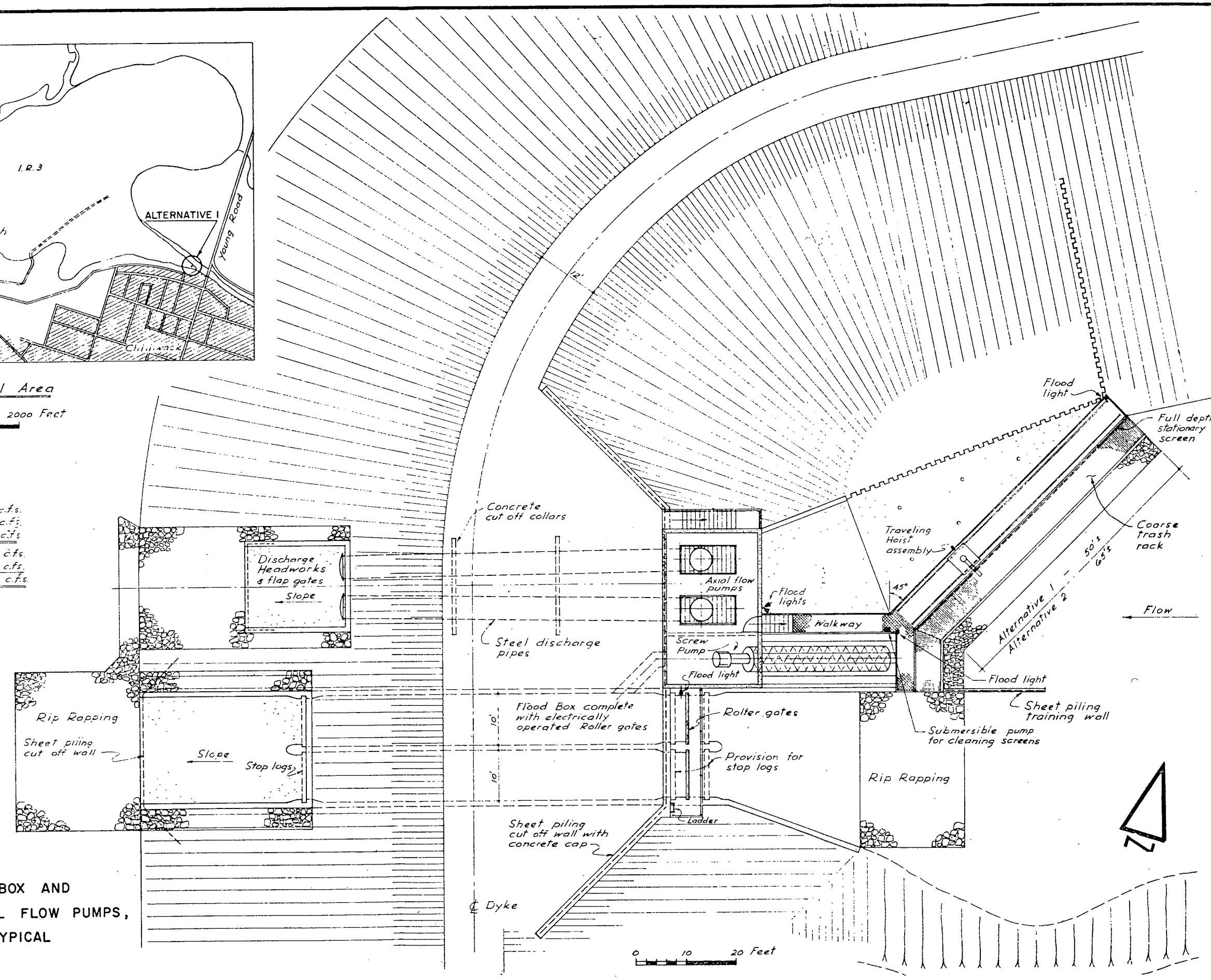


FIGURE 11

GENERAL ARRANGEMENT OF FLOOD BOX AND PUMPING STATION CONTAINING AXIAL FLOW PUMPS, SCREW PUMP AND FISH SCREENS. TYPICAL

Notes

1. Table of Pump Capacities

Alternative 1	Two screw pumps 2 × 100 c.f.s. =	200 c.f.s.
Alternative 2	Three screw pumps 3 × 108 c.f.s. =	324 c.f.s.

2. Position of Dyke varies at respective locations
3. Water levels vary at respective locations

From : Willis, Cunliffe, Tait and Co. Ltd. Preliminary Design Township of Chilliwhack Pumping Station Alternatives on Hope and Shefford Slough – March 1973

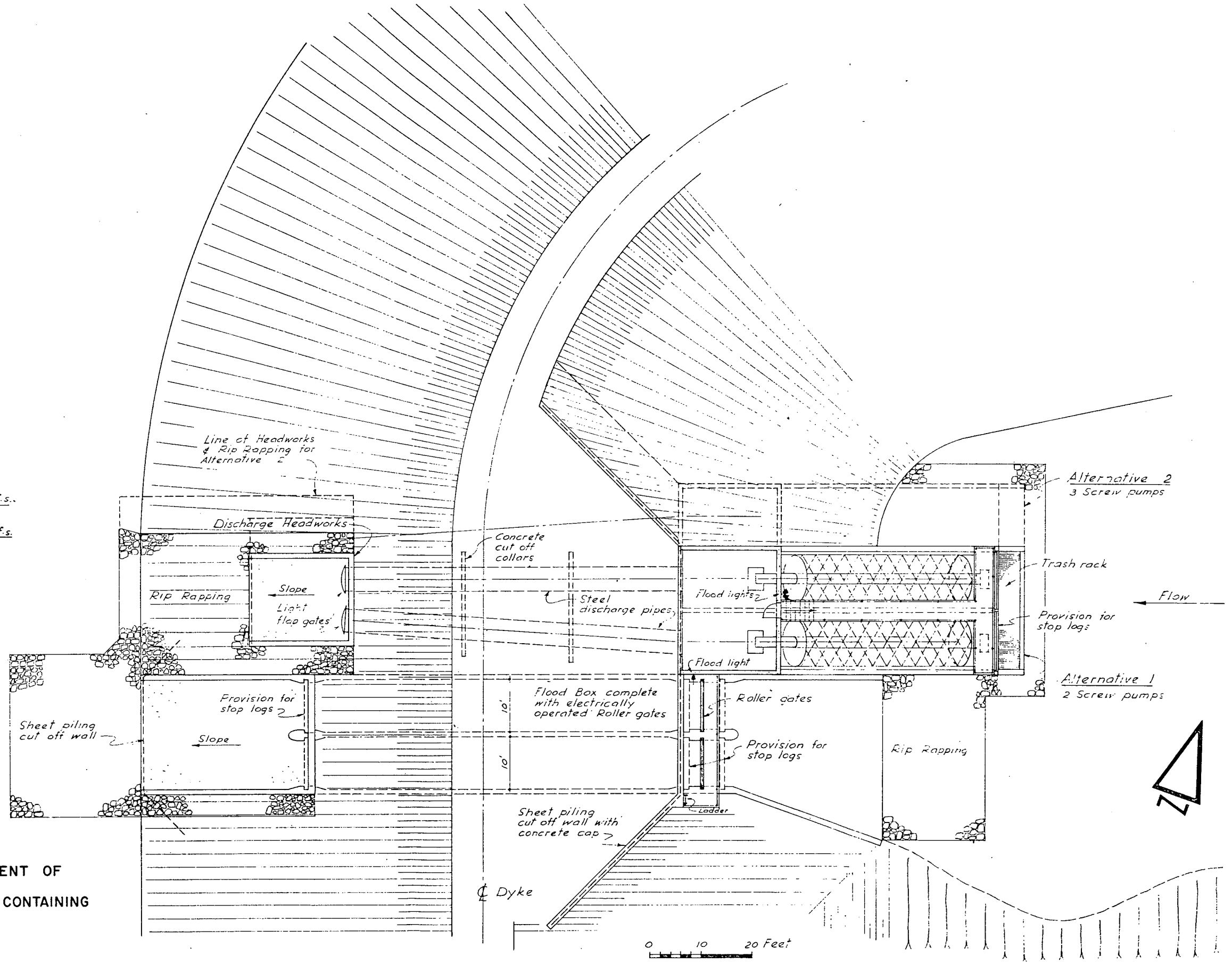


FIGURE 12

PLAN SHOWING GENERAL ARRANGEMENT OF FLOOD BOX AND PUMPING STATION CONTAINING ALL SCREW PUMPS. TYPICAL

5. The Shefford Slough Pump Station Proposal[15/]

This proposal (component of dyke Option #2) consists of a 325 cfs capacity pump station on Shefford Slough about 800 feet west of the confluence of Hope and Shefford Sloughs. The floodbox would have a capacity of 1200 cfs at a one foot head differential.

Winter flows will be drained by the floodbox, which is sized for the 1 in 25 year peak daily winter flow, (i.e. 1200 cfs). Summer flows will pass through the floodbox when the Fraser River level is below 28.0 feet GSC (19.3 feet GSC at Mission). At 28.0 feet GSC the floodgates will be closed manually, and the pumps started. The capacity of the pump station is based on maintaining the internal level of Hope Slough below 31.0 feet GSC during a design flood of the Fraser River.

Pump data are as follows:

maximum river level (design flood)	36.2 feet GSC
maximum internal level	31.0 feet GSC
normal internal drawdown level	28.0 feet GSC
minimum internal drawdown level	25.0 feet GSC

D. DYKE MAINTENANCE AND INSPECTION OPERATIONS[16/]

Vegetation clearing is required in order to facilitate dyke inspection, repair, and emergency flood work. Vegetation, such as bushes and small trees, is removed from the dyke right-of-way by hand clearing methods every 2 years, depending on the location and type of vegetation. Cattle grazing which is allowed on most dyke slopes, keeps the vegetation short. Cultivation, crops and buildings are not permitted in the right-of-way.

In general, routine dyke inspections occur twice a year; once prior to freshet to check for problems, and again during the winter months

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15/ Ibid.

16/ From communications with R. Whitehead, Chilliwack District Dyking Board, November 1975.

when necessary repair work is done. The dyke crest is regraded annually, prior to freshet. Reports, issued two or three times a year, indicate the state of repair of the dykes and the possibility of flood. When the Fraser River level at Mission reaches 18-19 feet GSC, dyke patrols inspect the dykes continuously for weakness and any other problems. The Township of Chilliwhack is responsible for dyke maintenance and inspections in the study area.

IV EXISTING ENVIRONMENTAL CONDITIONS

A. PHYSICAL

1. Geomorphology

The study area is in the Fraser River flood plain. Elevations of this area, whose topography is generally flat with a few depressions and sloughs, range from 20 to 35 feet GSC. Parent materials have accumulated primarily by lateral accretions from the Fraser River; the soils are derived from these flood plain deposits.[17/] Three major soil series are in the area being considered (Figure 13). The Grevell Series is characterized by coarse textures varying from sandy loam to loamy sand; the subsoil consists of sand interstratified with materials of finer texture. Drainage ranges from well drained to rapidly drained. The Monroe Series has general profile textures of silt loam to very fine sandy loam, with minor variations to silty clay loam. The soils in this series are moderately to well drained. The Fairfield Series is of a silt loam and silty clay loam texture (medium to moderately fine textured) and these soils are imperfectly drained.

2. Resource Capability and Use[18/]

a) Agricultural capability

The Canada Land Inventory (CLI) soil capability for agriculture is given (Figure 14). The area is a complex of capabilities ranging from 2-7 on a 7-class scale (Appendix C) with the main limitations being moisture - low water holding capability (M), inundation (I) and stoniness (P). The Fairfield Series and the Monroe Series represent, potentially, the most productive soils for agriculture.

b) Recreational capability

The area is rated moderately high, (class 3) (Appendix C) to moderate (class 4) for outdoor recreation (Figure 15). The dominant

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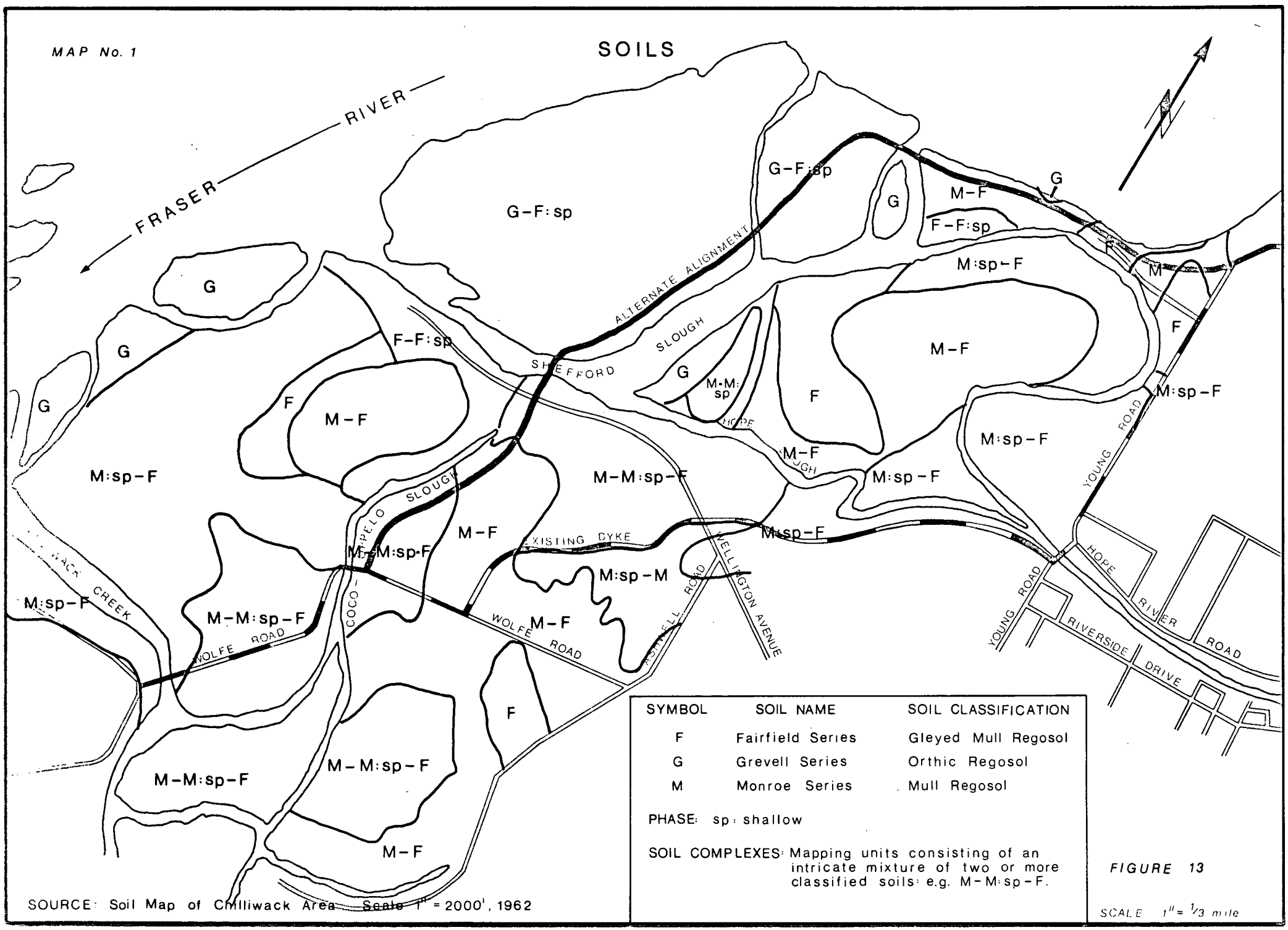
17/ Comar, V.K., P.N. Sprout and C.C. Kelley. Preliminary Report No. 4 of the Lower Fraser Valley Soil Survey. British Columbia Department of Agriculture, Kelowna, B.C. July 1962.

18/ A series of overlays are provided in Appendix C.


MAP No. 1
SOILS
FRASER RIVER
G-F:sp
G
M-F
F-F:sp
M:sp-F
F
M
M-M:sp
M-M:sp-F
M:sp-M
ALTERNATE ALIGNMENT
SLOUGH
SHEFFORD
HOPE
YOUNG ROAD
COCO-PELO SLOUGH
EXISTING DYKE
WELLINGTON AVENUE
ISTWELL ROAD
WOLFE ROAD
HOPE RIVER ROAD
RIVERSIDE DRIVE
SYMBOL | SOIL NAME | SOIL CLASSIFICATION
F | Fairfield Series | Gleyed Mull Regosol
G | Grevell Series | Orthic Regosol
M | Monroe Series | Mull Regosol
PHASE: sp: shallow
SOIL COMPLEXES: Mapping units consisting of an intricate mixture of two or more classified soils: e.g. M-M:sp-F.
SOURCE: Soil Map of Chilliwack Area Scale 1" = 2000', 1962
FIGURE 13
SCALE 1" = 1/3 mile

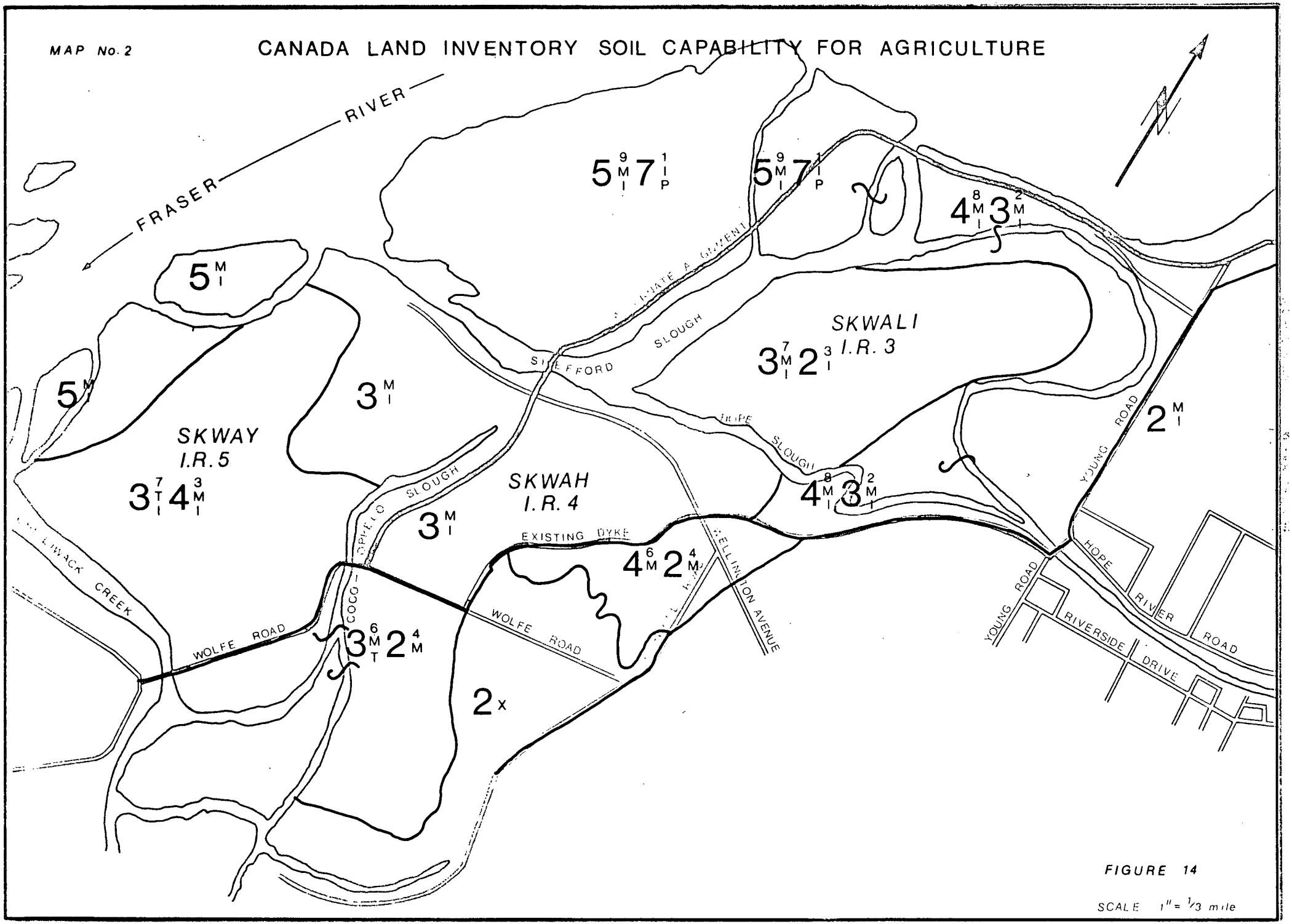
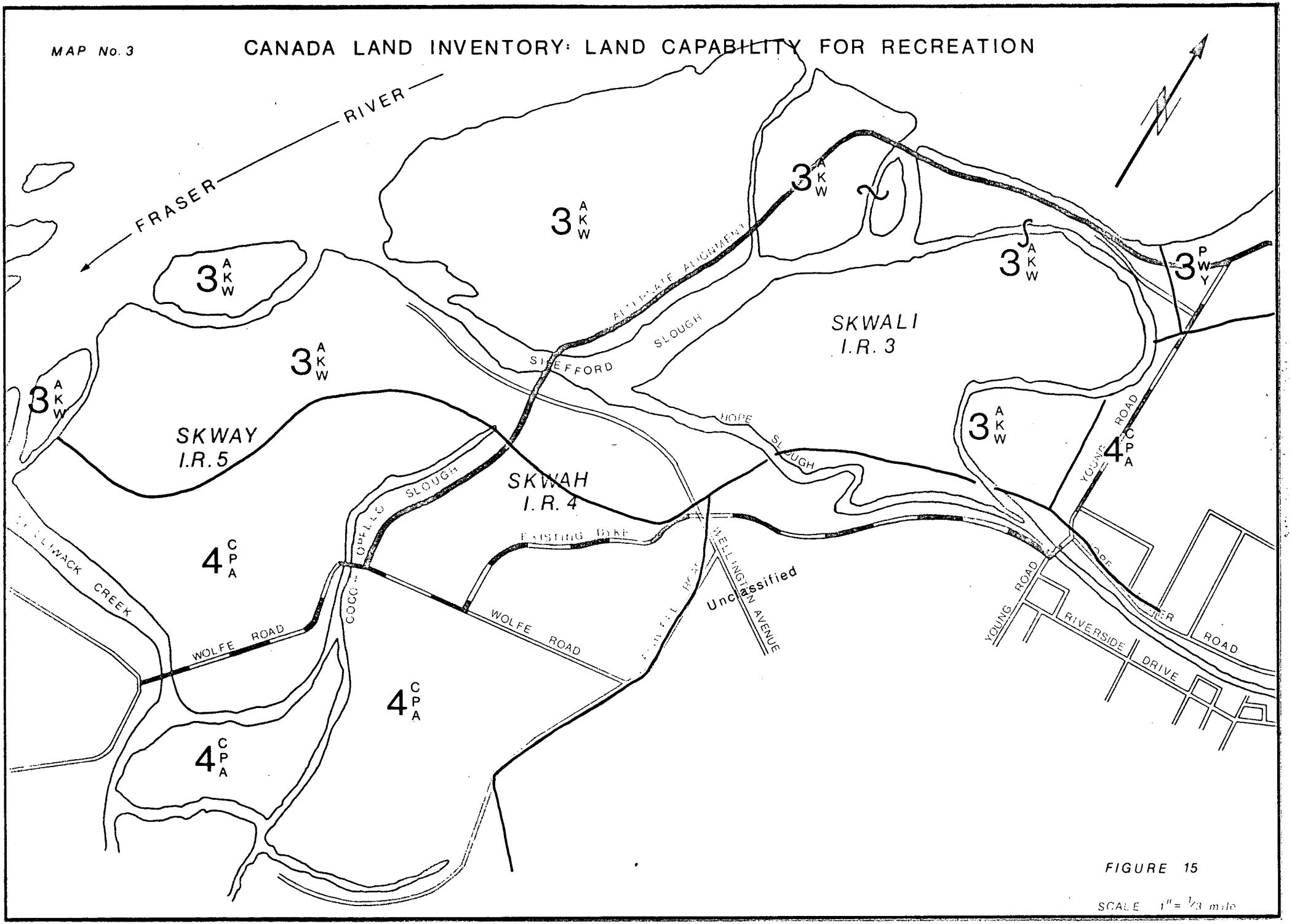


FIGURE 14

SCALE 1" = 1/3 mile


MAP No. 3
CANADA LAND INVENTORY: LAND CAPABILITY FOR RECREATION
FRASER RIVER
3 A K W
3 P W Y
4 C P A
SKWALI I.R. 3
SKWAY I.R. 5
SKWAH I.R. 4
ALTERNATE ALIGNMENT
SLOUGH
SHEFFORD
HOPE
SLOUGH
YOUNG ROAD
CHILLIWACK CREEK
WOLFE ROAD
COQUITLAM
EXISTING DIKE
PROPOSED DIKE
WELLINGTON AVENUE
Unclassified
RIVERSIDE DRIVE
ROAD
FIGURE 15
SCALE 1" = 1/3 mile

feature associated with class 3 lands is outstanding angling opportunities. Canoeing is the dominant feature associated with the class 4 lands.

c) Waterfowl capability

Land capability for the production of waterfowl in this area is low (Figure 16); primarily classes 5 and 7 (Appendix C). The limitations are inundation - excessive fluctuation of water level (I), free flowing water (B), and adverse topography (T). Along Young Road the area is rated class 3 as a migration stop and wintering area.

d) Ungulates capability

The entire area is rated as a complex of classes 3 and 4 in the CLI land capability for wildlife - ungulates (deer). The limiting factor is climate and soil moisture (Appendix C).

e) Forestry capability

The CLI land capability for forestry has not been completed for the area.

f) Present resource use

Most of the original forest has been cleared and the land use outside the existing dyke alignment is now primarily woodland-pasture and agricultural (Figure 17).

The non-Indian land to the north and east of Skwali #3 is zoned for minimum 20- and 5-acre agricultural holdings. Approximately two-thirds of this land consists of improved pasture, vegetable and berry crops, while one-third is in pasture and hay. Skwali #3 is leased for the production of forage crops, corn and cereals. About 40% is in hay and perennial forage and another 30% is improved pasture while 30% remains in the native state. One-half of private land acreage west of Skwali #3 is improved pasture and the remainder is wetland subject to inundation. Island 22 is forest pasture. Skwah #4 is

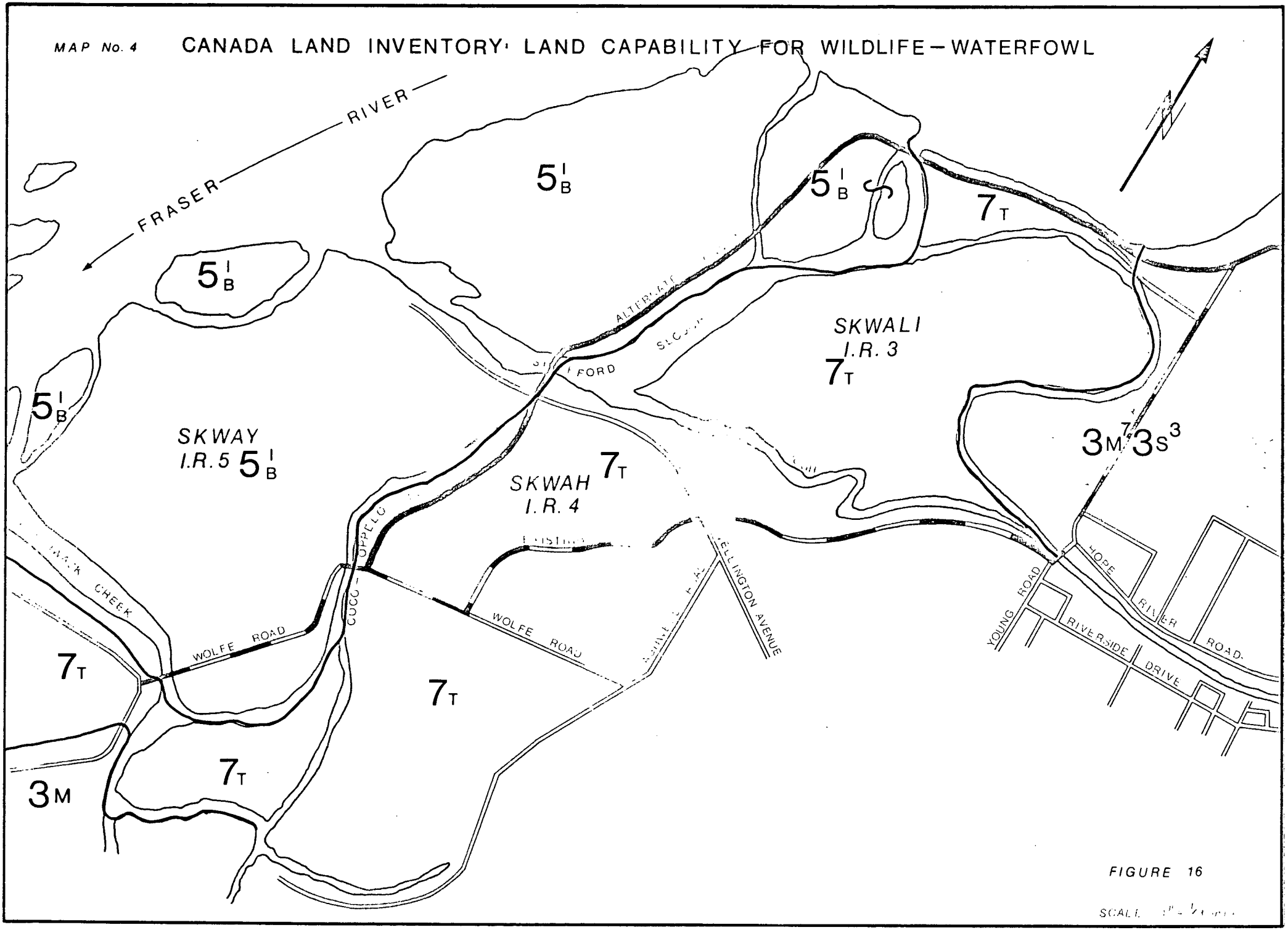


FIGURE 16

SCALE 1" = ½ mile

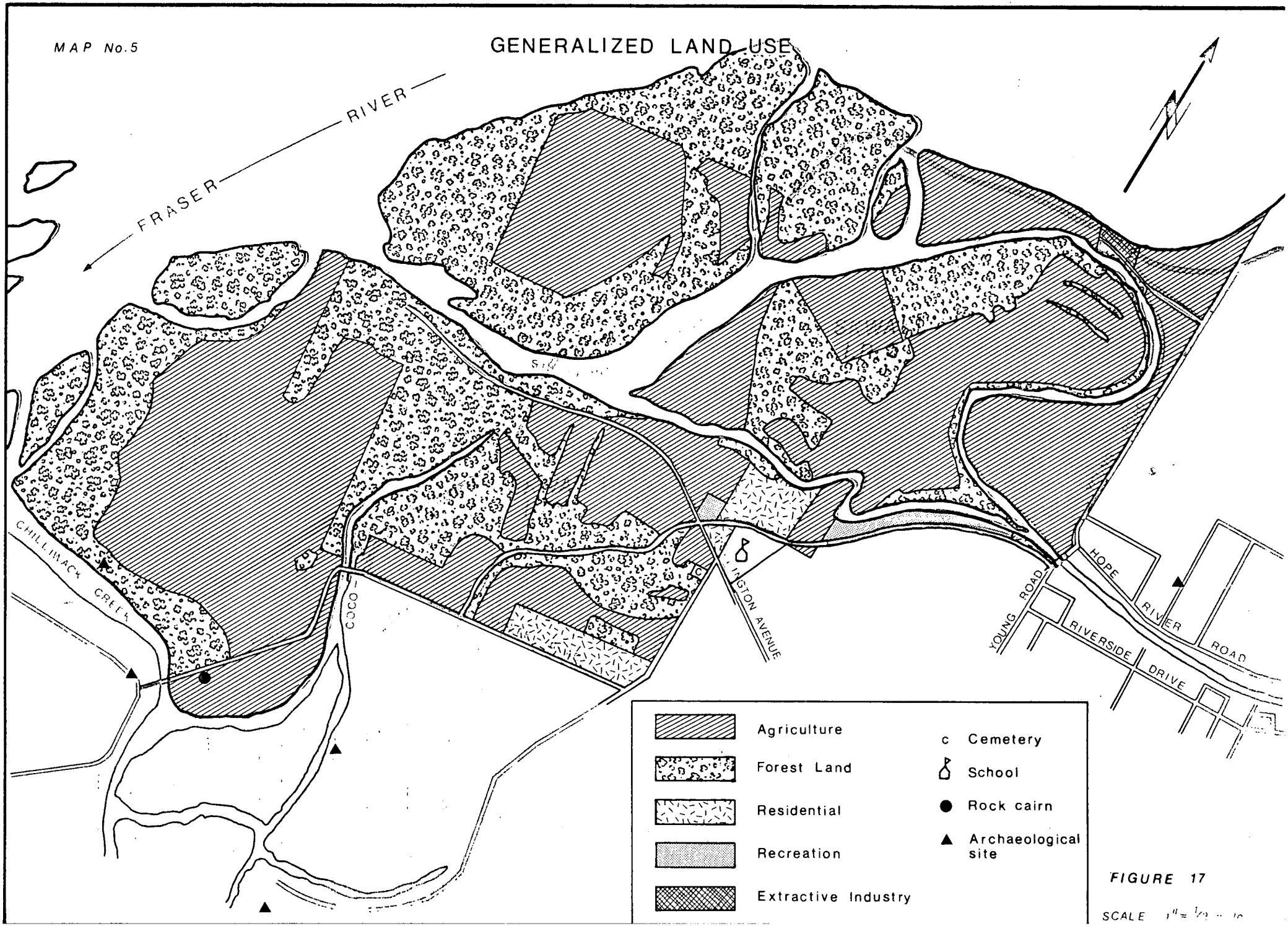


FIGURE 17

SCALE 1" = 1/2 mile

broken up into 7-10 acre agricultural parcels which are used for pasture and some forage production. A strip of non-Indian land north of Wolfe Road is in hay and improved pasture. Skway #5 is currently being leased for the production of vegetable processing crops.

Major recreational land uses located outside the existing dyke are: a municipal park located between the dyke and Hope Slough, and a playground on Skwah #4 adjacent to Wellington Road. There is excellent bar fishing in the Fraser River off Island 22. Recreational fishing occurs in the Shefford Slough area near its outlet into the Fraser River.

The only industrial activity within the study area is a gravel operation located on Clarke Road.

3. Hydrology and Hydraulics

Water in Shefford Slough and Hope Slough is normally clear throughout the year except during spring freshet when muddy flood waters of the Fraser River mix with it. Siltation associated with the back flooding occurs in Shefford and Hope Sloughs. Both Shefford and Hope Sloughs are free flowing water bodies with low velocities. For peak flow data of Hope Slough see Section III.

At present, there is a dam at the north end of Shefford Slough which prevents Fraser River flood waters from entering the Slough. However, this dam washed out in 1964 and would likely be vulnerable again in the event of very high flood waters.[19/]

Flow paths for high flood conditions are shown (Figure 18). Internal slough and groundwater levels are high during flood peaks owing to extensive underground seepage from the Fraser River. This poor drainage affects large tracts of land adjacent to the river.

Rip-rapping has been placed west of Clarke Road on a 2000 foot stretch along the south bank of the Fraser River. A substandard dyke extends west from Clarke Road to the northern part of Island 22.

19/ P.S. Ross and Partners. Potential for Development and Impact of Proposed Flood Protection Skwali No. 3, Skwah No. 4 and Skway No. 5 Indian Reserves Chilliwack B.C. January 1971. p. FE-1.

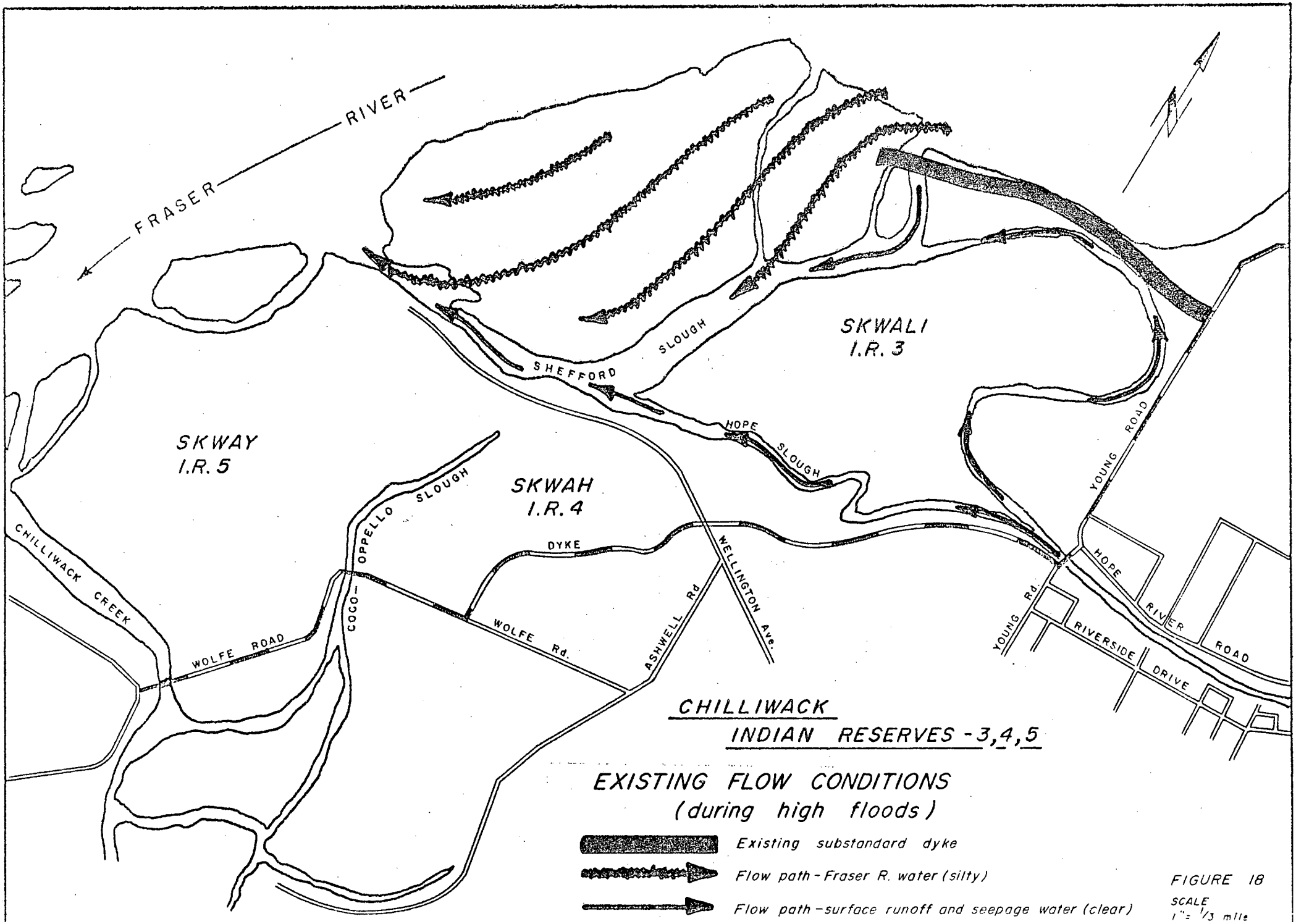


FIGURE 18

SCALE
1" = 1/3 mile

The banks of the Island along this latter section are exposed to slight river erosion. Some patches of rip-rap exist along the west bank of Skway #5 but erosion in this area is slight.

4. Water Quality

Flows in Hope and Shefford Slough exhibit seasonal fluctuations in turbidity. Turbidity from upstream sources is greatest during winter when precipitation is highest. Turbid water from Fraser River back flooding mixes with clear water in Shefford and Hope Sloughs during the spring freshet.

Agricultural runoff (e.g. from livestock wastes and fertilizer applications) contributes to nutrient loadings in Hope and Shefford Sloughs. Some pesticides, applied to nearby crop producing fields, could be entering the waters of the sloughs.

The municipal storm drainage system, part of which discharges into Hope Slough upstream of Young Street Bridge, may be contributing such things as heavy metals to the aquatic environment. Also, not all the houses in the vicinity of Hope Slough are connected to the Chilliwack municipal sewerage system (which discharges directly into the Fraser River) thus septic tanks could be expected to contribute nutrients to Hope Slough. To properly assess the state of the water quality of the streams and sloughs in the Chilliwack area water quality monitoring would have to be conducted.

5. Water Use

The water supply for the Township of Chilliwhack is drawn from Elk Creek by a private waterworks system. Elk Creek, which flows into Hope Slough is heavily licensed for water extraction. Hope Slough, upstream of Young Street Bridge, is used as a receiving water for part of the discharge from the municipal storm drainage system. In addition, septic tank wastes from those houses in the vicinity of Hope Slough not connected to the municipal sewerage system, drain into Hope Slough. All houses on Chilliwack Indian Reserves #3 and #4 have septic tanks; seepage from most of these drains into Hope Slough. Chilliwack's sewage treatment plant is located on Wolfe Road and discharges into the Fraser River from a sewer pipeline on Skway Indian Reserve #5 upstream of the mouth of Chilliwack Creek.

There are no known pumping operations for irrigation purposes in this area.

B. BIOLOGICAL

1. Fish

Shefford Slough, and Hope Slough and its tributaries Elk and Dunville Creeks and other small streams support coho salmon (1970 historic high of approximately 1200), sea run (approximately 200) and resident (approximately 1000) cutthroat trout, rainbow trout (Salmo gairdneri), carp (Cyprinus carpio), squawfish (Ptychocheilus oregonensis), and suckers (Catostomus spp.). Coho hold in Hope and Shefford Sloughs in September and October and spawn up river in November, December and January. Juvenile coho emerge from the redds in April-May and rear in Shefford and Hope Sloughs and tributaries until early in the following summer when smoltification occurs. The system contains both age classes of juveniles during April-July. A large population of chum salmon (Oncorhynchus keta) and pink salmon (Oncorhynchus gorbuscha) which spawn in the main stem Fraser River and Chilliwack Creek adjacent to the project site, occasionally stray upstream in Hope and Shefford Sloughs.

Cutthroat trout begin migrating to spawning areas in October and continue to move up river until May. Spawning begins as early as January and extends into May. The fry emerge from the gravel in June-July. Spawned cutthroat move downstream after spawning; less than 10% of these spawners return to spawn again. Resident cutthroat will remain in the system throughout the year. Rainbow trout resident in Hope Slough move to the upper portions of the drainage to spawn in April, May and June.

Sloughs in the Chilliwack area support a children's fishery of carp, suckers and squawfish. Carp spawning which is distributed throughout the sloughs usually occurs in April and May. Carp return to the Fraser River after spawning. Areas of Hope and Shefford Sloughs are used for recreational sport fishing.

2. Wildlife

Species of mammals which may be found in the Chilliwack dyke area include: muskrat (Ondatra zibethicus), mink (Mustela vison), river otter (Lontra canadensis), raccoon (Procyon lotor), opossum (Didelphis virginiana), beaver (Castor canadensis), red fox (Vulpes vulpes), coyotes (Canis latrans), deer (Odocoileus hemionus), mice, voles and shrews.

The area is used by migrating and wintering waterfowl including: mallard (Anas platyrhynchos), common goldeneye (Bucephala clangula), bufflehead (Bucephala albeola), wood duck (Aix sponsa), teal (Anas spp.). The large area of pasture offers good grazing for widgeon (Mareca americana) and Canada geese (Branta canadensis). This area does not have high waterfowl production values.

Ring-necked pheasants (Phasianus colchicus) and ruffed grouse (Bonasa umbellus) are present and numerous passerine species may be expected during migration and nesting season. Great blue heron (Ardea herodias), American bittern (Botaurus lentiginosus), bald eagle (Haliaeetus leucocephalus), marsh hawk (Circus cyaneus), red-tailed hawk (Buteo jamaicensis), barn owl (Tyto alba), and short-eared owl (Asio flammeus) could be expected in the area.

A limited amount of marsh and pothole habitat is present, however good upland cover is available. No particular population is dependent on the area for its survival. Hunting, practiced by Indian Band members, is of light intensity.

3. Vegetation

The Chilliwack area is within the Coastal Douglas-fir (Pseudotsuga menziesii) biogeoclimatic zone.[20/] On the flood plain vegetation types are controlled primarily by flooding and drainage. Flood frequency and

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20/ Krajina, V.G. "Biogeoclimatic Zones and Classification of British Columbia". Ecology of Western North America, Vol. 1, February 1965, pp 1-34.

duration is related to land elevation while drainage is dependent on soil and water table characteristics.

The majority of the area is infrequently flooded. The forested land in the better drained Grevell Soil Series (see Geomorphology) contains a Symphoricarpos type of association with typical species being northern black cottonwood (Populus trichocarpa), western red cedar (Thuja plicata), red alder (Alnus rubra) and waxberry (Symphoricarpos albus).

In the Monroe and Fairfield Series, with moderate to poor drainage, Lonicera-Rubus type associations might be found. Typical species in these areas are northern black cottonwood, red alder, black twinberry (Lonicera involucrata), and salmonberry (Rubus spectabilis). Along frequently flooded sloughs, creeks and river channels horsetail (Equisetum) and willow (Salix) associations are present.

In areas where plant communities are re-establishing after disturbance by man's activities (e.g. agricultural fence lines and pasture) evergreem blackberry (Rubus laciniatus), waxberry and wild rose (Rosa spp.) are common. Various grasses are growing on dyke side slopes along most of the existing alignment. (See photographs, Appendix A).

C. ECOLOGICAL SYSTEMS

The shore regions of streamways are dynamic zones of continuous biological chemical and physical interactions between land and water bodies. These shore ecosystems are comprised of a variety of both terrestrial and aquatic flora and fauna.

Two components of the Fraser River ecosystem of particular interest in the Chilliwack area are the terrestrial communities of the flood plain and the aquatic community which supports anadromous fish. The types of plants and therefore animals which inhabit the flood plain are dependent upon the periodic flooding and sedimentation of the Fraser River freshet. Changes in this regime either naturally (e.g. via river meander) or by man's activities (e.g. dyking) will result in significant changes in this community.

The aquatic community supports anadromous fish which rely upon passing from the main stem Fraser River into tributaries to spawn. Young fish also pass out of the tributaries and back into the main river. Structures obstructing these movements alter the aquatic system.

Of interest also are the sloughs which are productive areas used by young and adult biota. Here again direct or indirect alterations of the hydrologic regime alter the land-water interaction which dictates the type of ecological system which can function.

D. SOCIAL

1. Flood Plain Zoning

The entire Chilliwack area is situated in the provincially designated Fraser River flood plain zone. The Lower Mainland Regional Plan has designated all land within this zone as agricultural with the exception of urban areas which were established prior to the introduction of the Plan. Any change in zoning from that laid down in the Regional Plan must have the approval of the B.C. Minister of Municipal Affairs. Recommended flood control requirements in flood plain zones are that no building shall be constructed: a) within 100 feet of the natural boundary of any other natural water course, and b) on ground surface less than two feet above the two hundred year flood level where it can be determined. The Township also adheres to flood plain regulations under the National Building Code.

All land outside the existing dyke alignment, including Indian Reserve land, has been zoned for agricultural use under the Regional Plan and has been included within the provincial Agricultural Land Reserve (Figure 19). However, zoning by a municipal, regional or provincial authority does not apply to Indian Reserves. It appears that the flood plain zoning of Indian Reserves can only be enacted under Section 81 of the Indian Act which states that the council of a Band may make by-laws for the purpose of dividing the reserve into zones and prohibiting or regulating the construction of buildings in any such zones.

The Federal government is in the process of developing a national Flood Damage Reduction Program in cooperation with individual provinces. Program principles include the defining and mapping of flood risk zones. Within high flood risk zones there will be no construction of federal

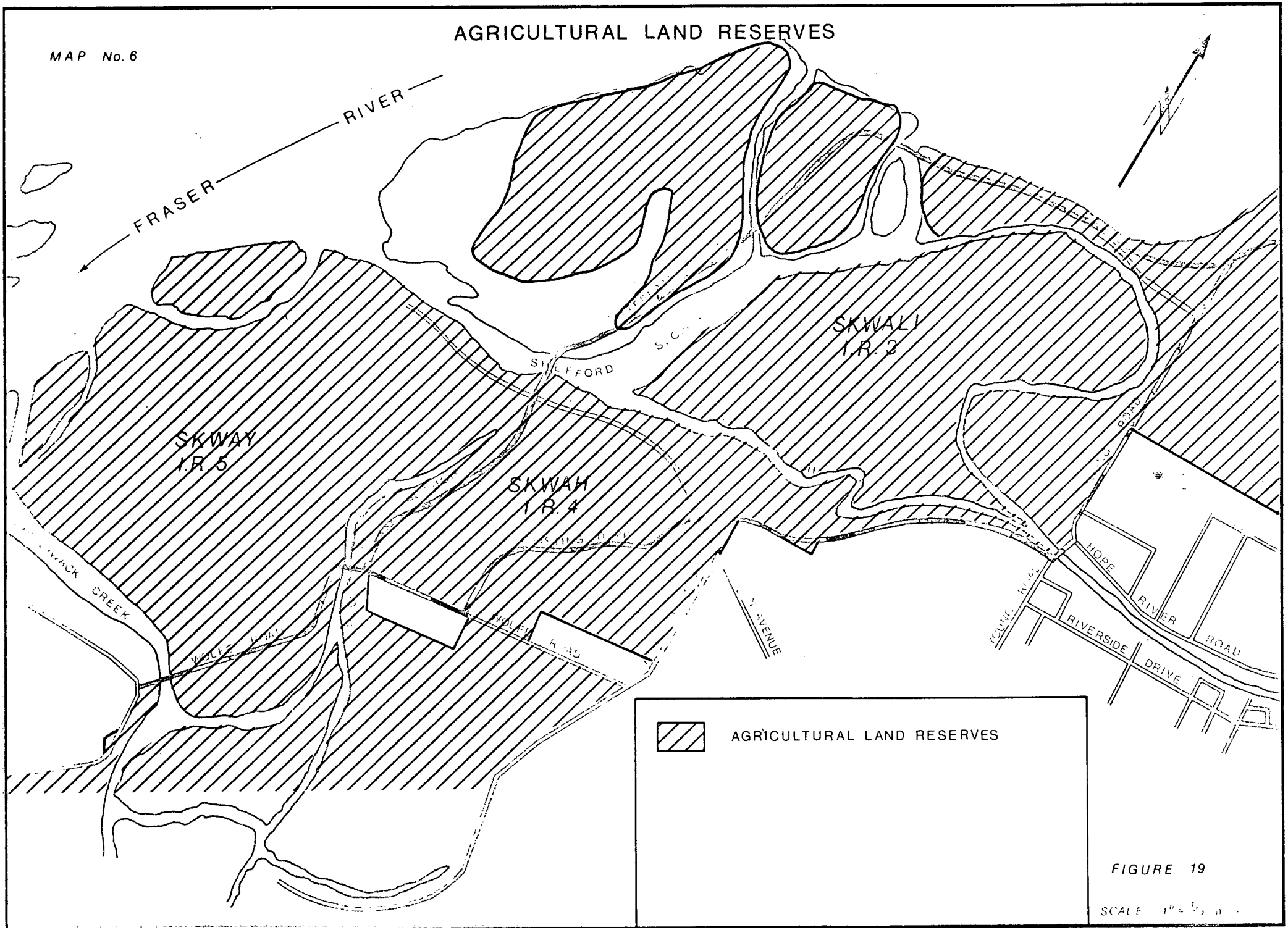

FIGURE 19

SCALE 1" = 1/2 mi.

facilities, nor utilization of federal funds for construction unless adequate flood damage reduction measures are incorporated. Disaster assistance will be curtailed in designated areas, and provinces and municipalities will be encouraged to place appropriate restrictions on land use. Flood hazard information will be communicated to the public, industry and municipalities. Program concepts, proposed accords, and flood risk mapping agreements are currently (December 1975) being discussed by Federal and British Columbia provincial authorities.

2. Land Ownership and Status

A portion of Island 22 and the adjacent island to the northeast is leased from the Province for grazing. A Map Reserve of approximately 45 acres has been established for the use, recreation and enjoyment of the public on the southern portion of Island 22 bordering Shefford Slough (Figure 20). The Provincial Parks Branch has indicated that this area has potential for fishing, swimming and picnicking. The remainder of Island 22 is held privately. A city park extends along the south shore of Hope Slough from Young Road to Marshall Avenue.

There are approximately 45 dwelling units located outside the existing dyke alignment in the area of concern. These are primarily in the easterly portion of Skwah #4 between Wellington Avenue and Hope Slough (which is being developed for low density, single family Indian housing), and along the west side of Young Road. Although a survey of the existing dyke alignment through Indian Reserves #4 and #5 has been registered with the Federal Department of Energy, Mines and Resources, it appears that the right-of-way itself has not been properly registered with the British Columbia Land Registry Office. Also, neither a dyke nor a dyke right-of-way exists in front of the 5 houses which are located in the 500 feet along Hope Slough between Young Road and Cawley Street.

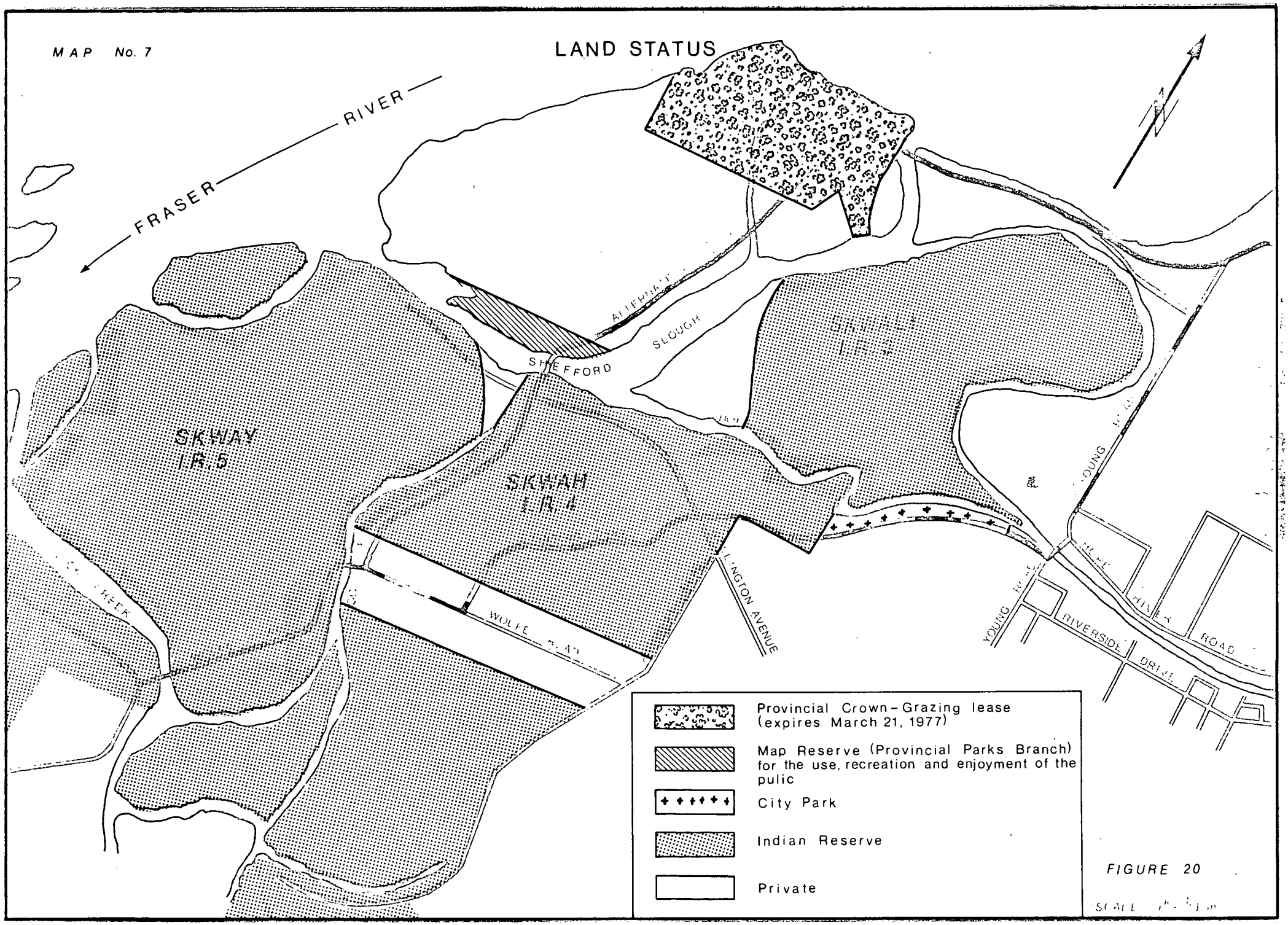
MAP No. 7
LAND STATUS
FRASER RIVER
SHEFFORD SLOUGH
SKWAY IR 5
SKWAH IR 4
WOLFE ROAD
YOUNG ROAD
RIVERSIDE DRIVE
Provincial Crown-Grazing lease (expires March 21, 1977)
Map Reserve (Provincial Parks Branch) for the use, recreation and enjoyment of the pulic
City Park
Indian Reserve
Private

FIGURE 20

3. Projected Land Use and Status of Regional Plans

It is expected that, in the future, the remaining wooded area of Skwali I.R. #3 will be cleared and utilized for forage and crop production.21/ The policy of the Department of Indian and Northern Affairs is to discourage residential development in this reserve. A subdivision plan has been drawn up for the eastern portion of Skwah #4 and houses are being built despite a present, and possible future lack of dyke protection (Figure 21). It is possible that in the future the subdivision will be expanded to the eastern boundary of the reserve and to the west into the agricultural area north and west of Wellington Avenue. The area behind the dyke between Ashwell and Wolfe Road offers potential for residential development. The remaining portion of Skwah #4 that is cleared and outside the dyke will likely remain in pasture and forage crops.

The thrust of development in the Township is being concentrated to the south of the existing City of Chilliwack where services (sewers, etc.) are or will be available. 22/ The future population of this developing area is projected to be 90,000. No further urban expansion of Fairfield Island in the north is planned although land is being sought for use as a park. The Township would like to develop all or portions of Island 22 for a recreation area, including a marina. However, land acquisition costs may be prohibitive. They would also like to have riverside parks along all river banks.

Plans are to have the strip of land adjacent to Wolfe Road removed from the Agricultural Land Reserve and zoned for low density, low rise apartments of approximately 18 units per acre valued at about $30,000 each. Given the proposed new dyke alignment and Indian willingness, the possibility exists that future development of a

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21/ From communications with E. Backman, Real Estate Advisor, Department of Indian and Northern Affairs, Vancouver, November 1975.

22/ From communications with D.J. Wilson, Assistant Planner, Township of Chilliwhack, 30 October 1975.

MAP No. 8

PLANS: INDIAN BANDS AND DISTRICT MUNICIPALITY

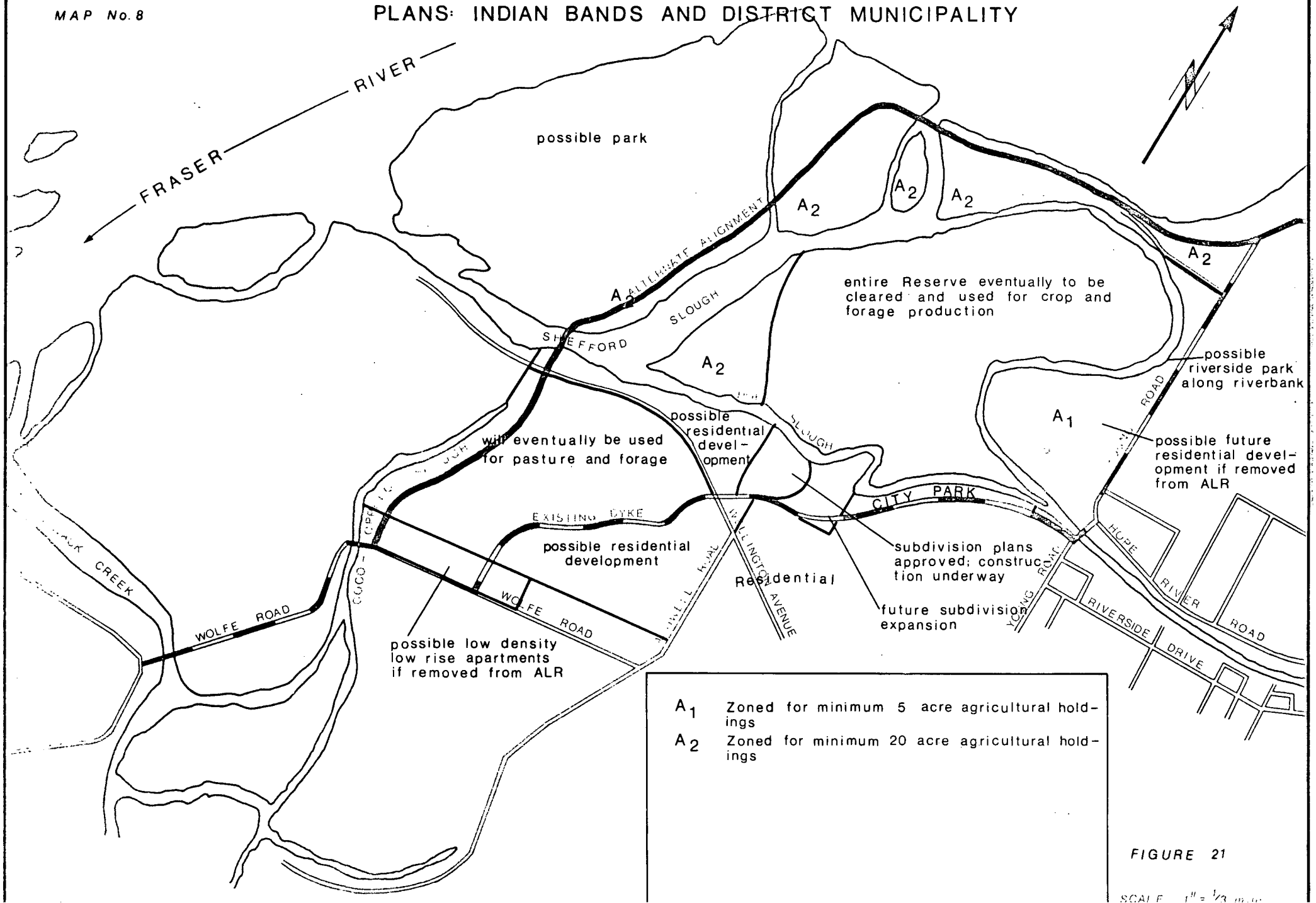

FIGURE 21

SCALE 1" = 1/3 mile

commercial, industrial, or residential nature could occur on Indian lands adjacent to development along Wolfe Road. However, development would not extend to the edge of Coco-Oppello Slough. Also, with an upgraded alignment and willingness on the part of the Indian Band, the area of Skwah I.R. #4, located behind the existing dyke could be developed for residential use.

It should be noted that the above schemes, except for the plans for the land adjacent to Wolfe Road, are only speculatory with no such development proposals foreseen in the near future. Although the Township would like improved flood protection, the alignment of the dykes will not alter substantially, if at all, their future development plans.

4. Archaeological and Historical Resources

The Provincial Archaeological Sites Advisory Board indicates that the general area is quite rich archaeologically; five sites of importance have been identified but none will be affected by dyking operations. 23/ (Figure 17) Each site has been identified on the basis of surface finds and no excavations have taken place.

The only indication of any site of historical importance is the Royal Canadian Engineers rock cairn located on the south side of Wolfe Road near Chilliwack Creek (Figure 17). This cairn indicates that a structure which used to house surveyors during the international border survey of 1858-1863, was located near this site.

5. Summary of a Benefit Analysis of the Proposed Dyking Alignment

In 1971 a benefit study 24/was done for three Chilliwack Indian Reserve alternative dyking proposals. Scheme #3 (Figure 4) of that study is similar in alignment to the new proposed outside alignment

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23/ From communications with C. Rafferty, Provincial Archaeological Sites Advisory Board, Victoria, November 1975.

24/ Planning Division, Water Planning and Operations Branch. Canada Department of Energy, Mines and Resources. Chilliwack Indian Reserves Alternative Dyking Proposals Benefit Study. April 1971.

in that it would protect Indian Reserves #3 and #4. However, the new alignment protects an additional 82 acres of agricultural land, 52 acres bush land, and 40 acres of Shefford Slough, plus releases 17 acres on Skwali #3, and 2 acres on Skwah #4 from dyke right-of-way usage.

1975 estimates of benefits for dyking the Reserves differ from those reported in 1971 for the following reasons:[25/]

a) Estimated agricultural losses are higher than recorded in 1971 owing to more refined estimates of crop losses, and rising crop prices between 1971 and 1975.

b) Residential damage estimates are different owing to refined methods for estimating damages, higher repair costs, and the addition of new housing between the proposed and existing alignments.

c) The 1975 method for assessing benefits of developing the reserves residentially is different from that used in 1971:

   i) it appears that although the proposed dykes will be protecting new houses, the building of these is not dependent on the new alignment;

   ii) Indian Band plans show no indication that Reserve land will be leased for residential development;

   iii) presently unprotected non-Indian land, for which development was assumed given dyke protection, is now within the provincially designated Agricultural Land Reserve and is limited to 5 acre parcel minimums.

d) Costs of the proposed alignment have been assessed at about twice those of Scheme #3 considered in the 1971 report.

e) Flooding of presently unprotected land is less frequent and less severe than the 1971 report indicated. The 1971 design river levels

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25/ Information supplied by Planning Division, Water Planning and Management Branch, Inland Waters Directorate. November 1975.

were based on river elevations occurring under natural conditions. However, river levels are regulated by the Nechako and Bridge River dams and thus the frequency of design level flooding is reduced.

Conclusions resulting from the recent consideration of the new alignment indicate that the 1975 flood damage prevention benefits are less than $100,000. Therefore the new proposed outside alignment, whose 1975 estimated cost is $1.0 million[26/] over and above that of an upgraded existing alignment, is unecomonic.

26/ 1975 updated costs of dyking projects for Chilliwack Indian Reserves supplied by Projects Division, Water Planning and Management Branch, Inland Waters Directorate.

TABLE I: SIGNIFICANT ENVIRONMENTAL INTERACTION CHECKLIST — PART 1 - UPGRADED EXISTING ALIGNMENT

ENVIRONMENTAL COMPONENT / PROPOSED ACTION	CONSTRUCTION											OPERATION & MAINTENANCE							INDUCED ACTIVITIES					
	VEGETATION REMOVAL	DITCHING	DIVERSIONS	ROADS	BORROW SITES	BURNING	FUEL STORAGE	NOISE	TIMING	LAND BURYING	OTHERS	ROADS	DYKE FACE	DYKE MATERIAL	DYKE INSPECTION	PUMP STATION	WATER LEVELS	OTHERS	RECREATION	INDUSTRY	RESIDENTIAL	RESOURCE EXPLOITATION	RESIDUAL IMPACTS	OTHERS
GEOMORPHOLOGY																								
Surficial Geology																								
Land Forms																								
Soils																								
Others																								
RESOURCE CAPABILITY & USE																								
Agriculture				X						X			X											
Recreation											X	X	X											
Forestry																								
Others																								
HYDROLOGY & HYDRAULICS																								
River Profiles																	X							
Erosion			X																					
Sedimentation																								
Surface Runoff																	X							
Groundwater																	X					X		
Others																								
WATER QUALITY																								
Oxygen																								
Turbidity		X	X	X					X							X								
Nutrients		X																						
B.O.D.																								
Trace Metals																								
Others																								
WATER USE																								
Domestic																								
Waste Disposal																X								
Agricultural																								
Others																								
FISHERY																								
Species Diversity & Abundance																X								
Distribution																								
Migration			X						X							X								
Life Cycle Areas					X																			
Domestic																								
Commercial																								
Sport																								
Direct Mortality		X		X					X							X								
Others																								
WILDLIFE																								
Species Diversity & Abundance																								
Distribution																								
Migration																								
Food & Cover		X								X			X		X									
Life Cycle Areas																								
Exploitation Rate																								
Others																								
VEGETATION																								
Associations																	X							
Others		X	X		X		X			X			X		X									
ECOLOGICAL SYSTEMS																								
Important Components																								
Critical Components																								
Others																								
SOCIAL																								
Land Ownership and Use		X								X	X						X	X						
Projected Land Use																								
Archaeological																								
Historical																								
Economic											X									X	X			
Aesthetics		X		X		X		X	X				X			X								
Others																								

TABLE I: SIGNIFICANT ENVIRONMENTAL INTERACTION CHECKLIST — PART 2 - NEW PROPOSED OUTSIDE ALIGNMENT

ENVIRONMENTAL COMPONENT / PROPOSED ACTION	CONSTRUCTION											OPERATION & MAINTENANCE							INDUCED ACTIVITIES						
	VEGETATION REMOVAL	DITCHING	DIVERSIONS	ROADS	BORROW SITES	BURNING	FUEL STORAGE	NOISE	TIMING	LAND BURYING	OTHERS	ROADS	DYKE FACE	DYKE MATERIAL	DYKE INSPECTION	PUMP STATION	WATER LEVELS	OTHERS	RECREATION	INDUSTRY	RESIDENTIAL	RESOURCE EXPLOITATION	RESIDUAL IMPACTS	OTHERS
GEOMORPHOLOGY																								
Surficial Geology																								
Land Forms																								
Soils																							X	
Others																								
RESOURCE CAPABILITY & USE																								
Agriculture										X		X	X				X			X	X	X		
Recreation												X								X	X	X		
Forestry																				X	X	X	X	
Others																								
HYDROLOGY & HYDRAULICS																								
River Profiles																X	X							
Erosion	X	X	X											X										
Sedimentation																							X	
Surface Runoff		X															X				X	X		
Groundwater																	X							
Others																								
WATER QUALITY																								
Oxygen																								
Turbidity	X	X	X						X							X								
Nutrients	X	X																			X	X		
B.O.D.																								
Trace Metals																					X			
Others																						X		
WATER USE																								
Domestic																					X			
Waste Disposal																X								
Agricultural																								
Others																								
FISHERY																								
Species Diversity & Abundance																X			X	X		X		
Distribution																								
Migration			X						X							X								
Life Cycle Areas					X																			
Domestic																								
Commercial																								
Sport												X										X		
Direct Mortality	X		X						X							X								
Others																								
WILDLIFE																								
Species Diversity & Abundance																					X	X	X	
Distribution																	X							
Migration																								
Food & Cover	X								X				X		X									
Life Cycle Areas																								
Exploitation Rate												X												
Others																								
VEGETATION																								
Associations																							X	
Others	X	X		X		X				X			X		X									
ECOLOGICAL SYSTEMS																								
Important Components																							X	
Critical Components																								
Others																								
SOCIAL																								
Land Ownership and Use	X									X			X											
Projected Land Use																	X							
Archaeological																								
Historical																								
Economic											X										X	X		
Aesthetics											X								X					
Others																								

V. SIGNIFICANT ENVIRONMENTAL INTERACTIONS AND POSSIBLE MITIGATION MEASURES

A. PHYSICAL

1. Geomorphology

a) Option #1 (Upgraded Existing Alignment). No significant environmental interactions are anticipated.

b) Option #2 (New Proposed Outside Alignment). The presence of a new outside alignment will cause a change in the hydrologic regime (See Section V.A.3) in the previously undyked area behind the new alignment. The resultant drier conditions could affect the physical, chemical and biological characteristics of the soil in this area (See Section V.C. for ramifications).

2. Resource Capability and Use

a) Option #1

During construction there will be a temporary loss of pasture land in the 25 foot temporary working easement on the land side of the dyke. Expansion of the dyke cross-section will reduce the amount of land available for grazing in the right-of-way. However, this expansion will increase the dyke surface area and thus the grass-seeded area which may be available for grazing use in some areas.

Access to the municipal park which extends along Hope Slough from near Young Road to Marshall Avenue, will be impeded during the 9 month dyke reconstruction period. Vegetation removal in the park for dyke reconstruction could affect its recreational use.

Dyke crest roads could be built to incorporate bicycle paths and turnouts for parking spaces and picnic areas. This would have the effect of inducing recreational use of the dykes and areas accessed by the dykes. Owing to a commitment made by the Township of Chilliwhack, public access to dykes on Indian Reserves will be restricted.

b) Option #2

The new proposed outside alignment will protect approximately 840 acres more than the existing alignment as follows: Skwah I.R. #4 - 200 acres, Skwali I.R. #3 - 327 acres, Island 22 - 57 acres, private property north-east of Skwali #3 - 131 acres, private property west of Skwali #3 - 47 acres, private property south of Skwah #4 - 24 acres, municipal park plus private property east of Skwah #4 - 14 acres, and slough area - 40 acres. Approximately 22 acres will be covered over by the proposed alignment thus eliminating land for existing and potential agricultural use. However, grass-seeded dyke slopes and rights-of-way which may be available for grazing in some areas will compensate for this loss to some degree. A permanent restrictive easement which will limit the type of land use, will likely be placed on a 150 foot wide strip extending from the dyke toe along the entire water side of the dyke.

The protection from high water levels afforded to areas behind the new alignment will allow these acreages to be more intensively and extensively utilized for agricultural production (See Section V.D.). A change in the hydrologic regime in the area behind the proposed dyke could produce subsequent changes in the soil characteristics and vegetation succession.

The dyke crest road on the new alignment could give better access to woodland and grazing areas on Island 22 and result in greater agricultural use of the area.

That section of the dyke extending west from Clarke Road could be an access route to, and increase the use of, recreational areas on Island 22, without intruding upon Indian lands. However, there is a possibility that a conflict could develop between increased recreational traffic on Clarke Road and existing truck traffic from gravel operations located on this road.

The proposed dyke would pass through the recreational map reserve on Island 22 (Figure 20), thereby reducing some of the recreational value of this area.

Residential and industrial development which could result from flood protection would reduce the capability and use for forestry, agriculture and recreation in this area.

3. Hydrology and Hydraulics

a) Option #1

As the basic dyke structure and associated facilities such as ditches are already in place, reconstruction of the existing alignment (with the exception of the pump station) will have little effect on the hydrologic characteristics of the area. However, groundwater levels in the immediate vicinity of the dyke could be lowered slightly owing to improved drainage ditches on the land side of the dykes.

During pump station construction, temporary diversions will cause some erosion in the immediate vicinity. This will be repaired. Hope Slough profile will be the same as at present during normal water levels. During high flood levels, Hope Slough will be closed between 27 and 29 feet GSC, depending upon anticipated flood conditions, and pumps will begin operating (See Section III.C.). Surface and groundwater runoff will improve on lands behind the existing dykes during flood peaks with pump operation. This could improve agricultural production. Flows in Hope Slough are of low velocity and do not carry a significant sediment load. Therefore, no sediment build-up is anticipated behind the proposed Hope Slough pump station. During closures of Hope Slough back-flooding of the Fraser River into slough areas behind the pump station will be eliminated, thus reducing the influx of sediments from the Fraser.

b) Option #2

Vegetation removal and ditching for dyke construction will cause increased surface runoff and erosion in the immediate vicinity of the dyke, however the sequence of construction procedures should reduce the possibility of significant erosion problems. Construction

diversions will inevitably cause some erosion in the immediate vicinity of the proposed Shefford Slough pump station site. This will be repaired.

The existing substandard dyke at the north end of Shefford Slough could be overtopped and significantly damaged during very high floods, thus allowing Fraser River flows to enter Shefford Slough. However, a new, raised dyke along the proposed outside alignment would be capable of handling higher floods and would therefore eliminate the possibility of the Fraser River developing a major channel through Shefford Slough. This would preclude adjacent property losses from river erosion. The slight river erosion on the north bank of Island 22 is expected to continue with the new alignment. The dykes in the vicinity of Minto Landing will be protected from river current erosion and wave action by rip-rapping.

The effect of the new alignment on the Fraser River profile will be insignificant. 27/ The main river channel in this area is about 4000 feet wide and there will be considerable overbank areas remaining on both sides of the river. The 840 acres taken out of the flood plain carry only a small proportion of the river flow at design flood levels. Upstream dyke elevations were not designed in anticipation of a new outside dyke alignment, however, as noted above, any resultant river level changes in the area will not be significant. Neither the profile of Hope nor Shefford Slough will be altered during normal water levels. Improvements to the sub-standard dykes at the north end of Shefford Slough will slightly reduce seepage from the Fraser River and thus reduce flow in the Slough itself.

Flow paths, after the new dyke construction, for high flood conditions are shown in Figure 22. The Shefford Slough flood gates will close when water levels reach 28 feet GSC and the pumps will

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27/ Information supplied by Projects Division, Water Planning and Management Branch, Inland Waters Directorate.

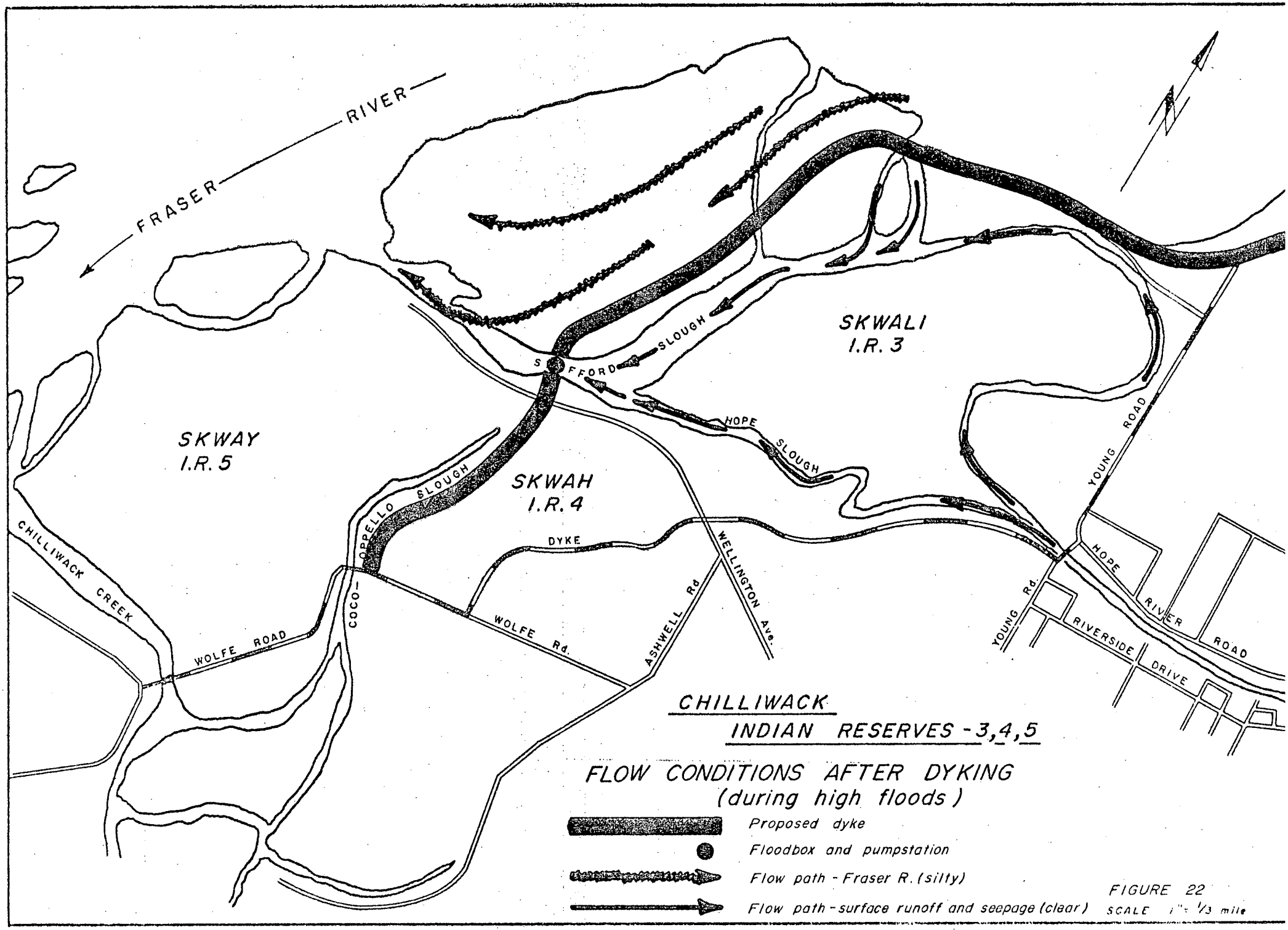


FIGURE 22
SCALE 1" = 1/3 mile

then operate to maintain internal slough levels between 25 and 31 feet GSC (i.e. lower than they would be under natural flooding conditions). Under these pumping conditions surface runoff will improve during flood peaks and groundwater levels could be slightly lower than would naturally occur. Although land drainage will improve due to pumping, internal slough and groundwater levels will still be relatively high during flood peaks owing to extensive underground seepage from the Fraser River. Underground seepage will continue to affect large areas of land adjacent to the River. Given a design flood of 36.2 feet GSC and maximum allowable internal water level 31.0 feet GSC, the land area that would be inundated behind the proposed dyke alignment would be roughly similar to that flooded in 1972.

Deposition of sediment might be anticipated at the mouth of Shefford Slough due to the configuration of the Fraser River at this point, and to reduced overland flows into the Slough (Figure 22). No sediment build-up from Hope or Shefford Slough flows is anticipated behind the proposed Shefford Slough pump station due to low sediment loads. The pump station will eliminate back flooding of the Fraser River into Shefford Slough for the duration of flood gate closure and thus will reduce the sediment influx from the Fraser.

Induced residential development, should it occur, will increase surface run-off during rainstorms. This is not considered significant because the heaviest rains occur during the winter months when the flood gates will be open.

4. Water Quality

a) Option #1

During dyke reconstruction, vegetation removal, ditching, excavating and filling will increase the turbidity of surface runoff in sloughs and streams. Winter construction activities could increase

the turbidity in Hope Slough at a time when it is normally clear. During the process of vegetation removal, top soil stockpiling, burning, and fertilizer application to reseeded dyke slopes, increased amounts of nutrients will be leached from the soil and carried by surface runoff into drainage ditches, sloughs and eventually into the Fraser River. To reduce the turbidity and nutrient loading resulting from construction activities, placement of stripped soil and other debris, and temporary roads should be restricted to the land side of the dyke. In areas where the alignment runs next to waterways, the area on the water side of the dyke toe should be left undisturbed.[28/]

The temporary diversion of Hope Slough for pump station construction will increase erosion and thus turbidity in the adjacent waters. Federal Fisheries and Marine Service suggests that pump station construction take place in January, February and August subject to a review of the specific design of the works. Closure of Hope Slough during flood peaks, will prevent the turbid flood waters of the Fraser River from mixing with clear Hope Slough flows upstream of the proposed pump station. Consequently a water quality gradient between Fraser River and Hope Slough flows will be created at the pump station. Effects of such a gradient are not known.

b) Option #2

As with Option #1 vegetation removal, ditching and diversions will increase the turbidity and nutrient loading of surface runoff into sloughs and streams. This is especially the case along this new alignment where there will be greater physical disturbance than along the existing alignment. Measures to reduce the effects of construction activities on water quality are outlined in a) above.

28/ Fisheries and Marine Service requests a joint on-site inspection by their staff and the project engineer to determine more specific criteria for soil stripping (letter R.A. Crouter to M.M. Wiggins 14 January 1976).

Turbidity levels in the Fraser River are lowest in winter. Therefore, winter dyke construction, as well as increasing turbidity in Shefford Slough, may also create a measurable local increase in turbidity in the Fraser River adjacent to the proposed alignment during this period. Closure of Shefford Slough during flood peaks will create a water quality gradient between Shefford Slough and the Fraser River flows similar to that described for Hope Slough.

If increased agricultural activities such as soil cultivation, fertilizer application and animal husbandry occur, this will increase the amount of nutrients entering the sloughs and Fraser River. Increased agriculture could also result in increased use of organophosphate pesticides. These substances may be leached via ground and surface runoff into adjacent sloughs and streams and assimilated into the biota.

An increase in residential development behind the new dyke alignment would result in increased loadings of nutrients, trace metals and polychlorinated biphenyls, etc. to receiving waters from septic tanks and storm drainage systems servicing the area.

5. Water Use

a) Option #1

Flows in Hope Slough, at times of floodbox closure, would be less than normally would occur during the recession stages of the Fraser River owing to the limitations of pump capacity. This may reduce the flushing rate for dispersion of wastes downstream of the pump station for a short period. However, pumping during flood peaks would increase the rate of waste dispersion at the upstream side of the pump station than would otherwise occur under natural flood conditions. In natural flood conditions, waters of the Fraser River cause flows in Hope Slough to back up.

The present dyke alignment will not affect the use of Elk Creek for Chilliwack's domestic water supply.

b) Option #2

Waste dispersion characteristics under this alternative would be similar to that described for Option #1.

Inundation of lands during spring freshet, either by direct flooding or flood-induced high water tables, prohibits planting of vegetable crops which yield higher returns than cereals which can be planted later in the season. Dyke protection and control of internal water levels by pumping during flood peaks would assist in improving agricultural production.

The proposed dyke alignment will not directly affect water used for domestic purposes. However, any residential growth induced as a result of protection offered by a new dyke alignment could put pressure on the existing capacity of the Elk Creek waterworks system. Also increased residential development could put pressure on the assimilative capacity of the receiving waters of the sloughs if the new houses are on septic tanks. If new houses are connected to the City's sewerage system, this addition would increase the loads to the Fraser River to which the sewage system discharges directly.

B. BIOLOGICAL

1. Fishery

a) Option #1 and Option #2

Any type of construction activity such as vegetation removal, diversions, and ditching, which results in increased siltation in Hope Slough could result in direct fish mortality by covering up food organisms and by smothering eggs. Timing of construction is critical in order to avoid creating: 1) increased turbidity at a time when fish are migrating up the sloughs and 2) increased siltation during incubatory periods (See Section V.B.4.). Borrow pits in the Fraser River, depending on their location, could create a disturbance of egg-laying substrate. Guidelines to lessen any

adverse effects are outlined in the Fraser River Dredging Guide.[29/]

Flood control facilities such as pump station and floodbox works could virtually eliminate runs of various fish to Hope Slough and its tributaries. Closure and resultant delays to fish during their migration to spawning grounds could cause high pre-spawning mortality, and reduce spawning success for those surviving the delay. Thus the design of the pump station and associated works and timing of its operation is critical.[30/] The pumps will be in operation for 15 to 20 days on an average recurring frequency of every three years (See Section III.C.). Those peak flows which require flood gate closure historically occur in June. No major upstream migration of any fish species occurs at this time. Juvenile salmon and spawned adults (e.g. cutthroat trout) proceeding downstream would also be affected by closure of the channel. Screw pumps incorporated into the preliminary design of the pump station, appear capable of handling downstream movement of juveniles, but direct adult mortality could result depending upon the pitch of the screw pump. Delays in the downstream movement of spawned fish are not so critical as during spawning migration. Criteria for water intake fish protection facilities are given in Appendix B. A water quality gradient created at the pump stations during floodgate closure may affect migrating fish.

Accessibility to Fraser River and Shefford Slough fishing areas off Island 22 may be increased with the new alignment via the dyke crest road. This could increase the exploitation rate of the fishery resource.

2. Wildlife

a) Option #1

Vegetation removal and additional land buried during the

29/ Boyd, F.C. op. cit.

30/ Fisheries and Marine Service requests that subsequent pump station designs be submitted for review (letter R.A. Crouter to M.M. Wiggins 14 January 1976).

reconstruction of the existing alignment will reduce the abundance of food and cover for wildlife. Clearing of trees and shrubs should be selective. Fish and Wildlife authorities should work with on-site engineers to determine specific requirements. Planting dyke slopes with species of vegetation which will enhance wildlife habitat would mitigate construction damage (See Section V.B.3.).

Dyke vegetation burning and mowing carried out to facilitate inspection will also reduce food and nesting cover available for wildlife and may cause some direct mortality, particularly to nesting birds. Therefore dyke maintenance work should be restricted to the fall, no burning should be done after March 1st, and no mowing should be done from mid-March through July.

b) Option #2

Vegetation removal and land taken up by the proposed outside alignment will reduce the amount of food and cover available to wildlife to an even greater extent along this alignment. The planting and inspection mitigation measures suggested in a) above apply to this option as well. Where the dyke passes through areas capable of providing natural habitat for wildlife, easements could be established in dyke rights-of-way which prohibit domestic grazing or other agricultural uses.

The land in the area east of the north arm of Hope Slough near Young Road, is an important migration or wintering area for waterfowl. This capability may be reduced when water levels in the area are lowered as a result of the new dyke, thus possibly causing changes in the distribution of migrating birds. The new dyke, by restricting flooding and seepage will alter the hydrologic regime of potholes and depressions which are used by wildlife. Access to recreational areas on and near Island 22 via Clarke Road and the new dyke crest road, will increase the possibility of greater exploitation rates by hunting.

Increased residential and agricultural activities which could

result from the new alignment will, by reducing the amount of food and cover available, affect the abundance and diversity of wildlife species in the area.

A residual impact arising from this new alignment is that change in water levels between the two alignments could affect vegetation species and their succession which in turn would affect the composition of wildlife species which will use the area (See Section V.C.).

3) Vegetation

a) Option #1

Activities such as vegetation removal, ditching, road construction, burning and land burying undertaken during the course of dyke reconstruction will obviously affect vegetation in the dyke right-of-way and in the 25 foot temporary working easement to the land side of the dyke. Some ornamental bushes, trees, and flower gardens in the front yards of residences adjacent to the dyke will be removed. At the north end of Young Road some fruit trees, alder and maple (Acer spp.) trees will have to be removed unless other arrangements can be made. Towards the Young Street Bridge several cottonwoods as well as ornamental bushes, pine (Pinus spp.) and maple trees in front yards adjacent to the dyke will be affected. Eight large shade trees near the banks of Hope Slough may have to be removed in the area between Young Road and Cawley Street where no dyke presently exists. Small conifer trees situated on the slough side of the dyke in the municipal park are likely to be affected by dyke reconstruction. Some large shade trees and riparian vegetation in the park are also near the toe of the dyke. On the land side of this section, numerous areas located within the right-of-way presently used as gardens will be buried, at least partially, by an upgraded dyke. South of Wellington Avenue where the existing dyke crosses Skwah I.R. #4, maple, cottonwood and some alder trees

as well as blackberry and other bushes located at the toe of the dyke immediately behind the dyke fence may have to be removed. The vegetation in several front yards and a group of cedar trees along Wolfe Road may also have to be taken out for dyke reconstruction. Vegetation in the vicinity of the proposed Hope Slough pump station site, north and east of the Young Street Bridge will be removed prior to construction.

A provision in the tender document ensures that vegetation removal will not exceed that necessary for execution of the contract. In order to facilitate this provision, and alleviate any other adverse impact associated with vegetation removal, it is suggested that the following measures be considered:

1) that contractors contact residents whose yards and fences might be affected by construction even though these may be within the legal right-of-way;
2) that parks, fish and wildlife authorities be consulted to advise on specific vegetation removal requirements.

Given an average dyke height of 8 feet and 2.5:1 side slopes, approximately 16.5 acres of dyke slope will be reseeded with grasses and clover after reconstruction of the existing dyke. Retention or replanting of native trees and shrubs as well as ground cover in the right-of-way would further enhance the ecological values of the dyke area. However, to ensure that the safety of the dyke is not placed in jeopardy, root balls of the vegetation must not penetrate the dyke foundation nor its theoretical extension (Figure 23). To facilitate this requirement might necessitate the placement of additional soil on the basic dyke structure, and the planting of only those vegetation types whose root characteristics are flat, spreading and medium shallow. Appendix D gives examples of vegetation native to the Lower Mainland which have these characteristics. Shrubs, artificially interspaced with herbaceous plants should allow relative ease in dyke inspections. This spacing would likely remain for decades. Most shrubs in the Chilliwack area would require about 8-10 inches of topsoil, and for most herbaceous plants, which have shallow roots, 4 inches of topsoil should be adequate.[31/]

31/ From communications with Dr. V.C. Brink, Agronomist, Department of Plant Sciences, University of British Columbia, Vancouver, December 1975.

b) Option #2

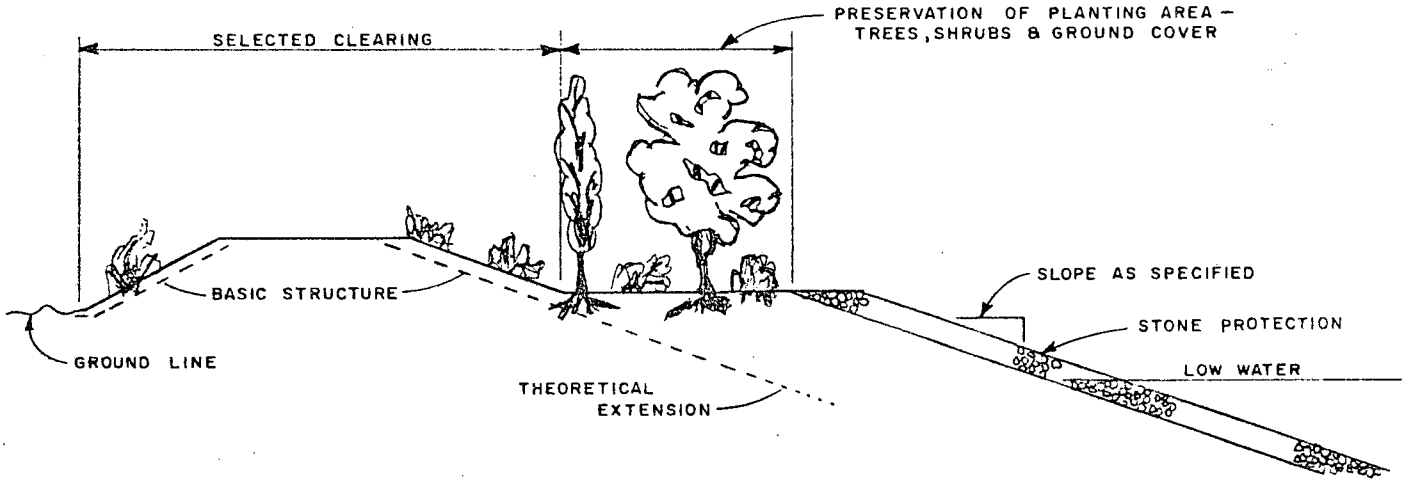
Construction activities including vegetation removal, ditching, road construction, burning, and land burying will reduce the vegetation along the new alignment, in the dyke right-of-way and temporary easement. This disturbance will be most severe along the new right-of-way where there has been no previous construction work, e.g. through Island 22 and east of Coco-Oppello Slough.

Currently, only certain types of grasses and forbs are tolerated and all other vegetation is cut or burned in the right-of-way during dyke maintenance and inspection operations. If a greater diversity of vegetative species that would be acceptable to engineering criteria were planted (See (a) Option #1) this would enhance the value of the dyke areas.

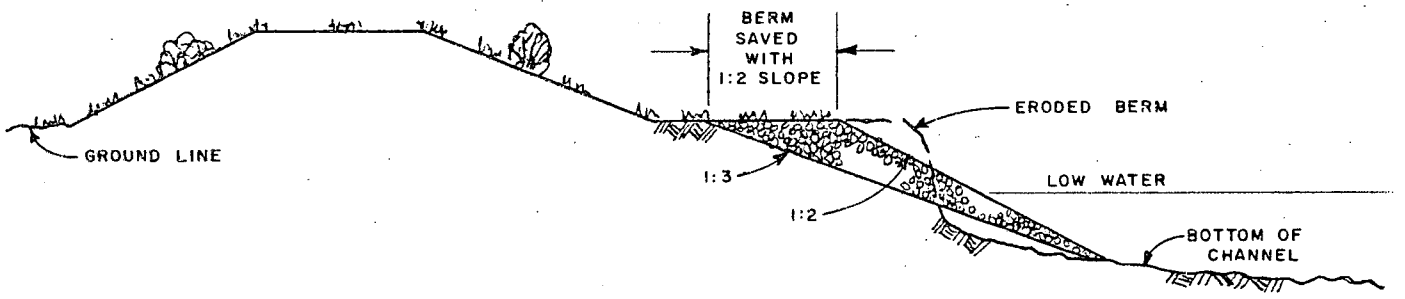
A change in the hydrologic regime behind the new dyke alignment could result in a corresponding change in vegetation associations and succession in the area behind this alignment (See Section V.C.).

The proposed outside alignment will require protection from Fraser River currents beginning approximately 1000 feet west of Minto Landing and extending to existing bank protection works just west of the gravel operation on Clarke Road. During construction of bank protection works, all vegetation on the bank and berm is removed and maintenance operations do not permit re-establishment of natural vegetation. Rivers and natural and semi-natural riparian areas provide highly productive habitat for a variety of fish and wildlife as well as being aesthetically attractive. However, ecological, aesthetic and recreational values have been sacrificed for engineering efficiency. A brief review of the literature indicates that alternatives exist that would allow for preservation of some ecological values in some bank protection areas.

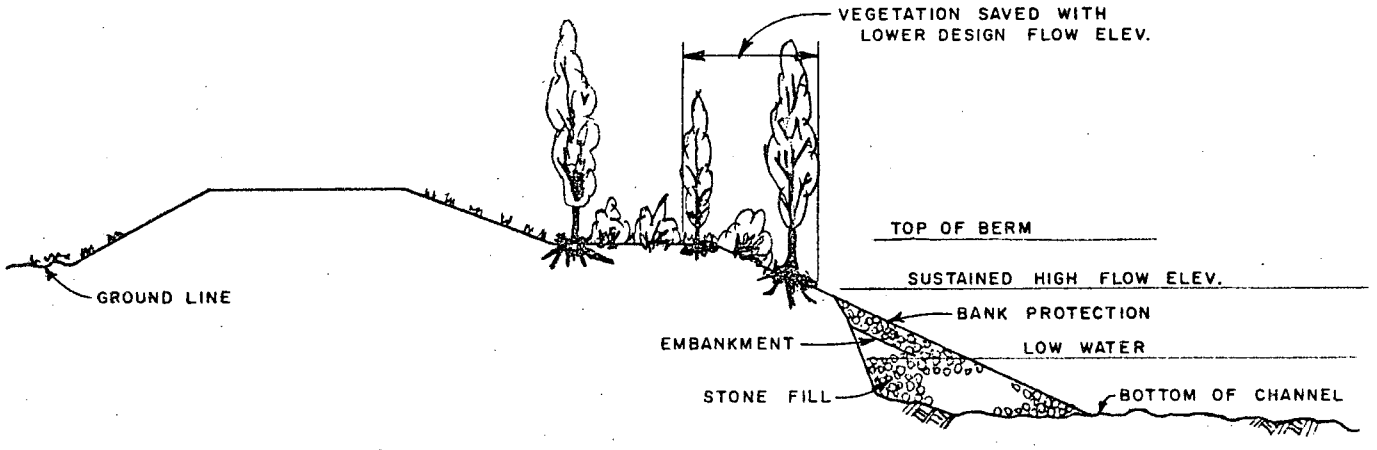
DYKE AND BANK PROTECTION DESIGNS INCORPORATING ENVIRONMENTAL MEASURES



DYKE AND BERM DESIGN INCORPORATING ENVIRONMENTAL MEASURES – FIGURE 23



BERM PROTECTION (1:2 versus 1:3 SLOPES) FIGURE 24



BERM PROTECTION TO HIGH SUSTAINED FLOW ELEVATION FIGURE 25

NOTE – TAKEN FROM MIFKOVIC, C.S & M.S. PETERSON "ENVIRONMENTAL ASPECTS – SACRAMENTO BANK PROTECTION" JOURNAL OF THE HYDRAULICS DIVISION, PROCEEDINGS OF THE A.S.C.E., VOLUME 101, NUMBER HY5, MAY 1975 – P.551.

A few suggestions[32/] are: Construction and maintenance of bank protection works could be carried out from the water side by barge or river dredge so as to disturb as little vegetation as possible outside the construction area. A steep bank protection slope (e.g. 2:1) would allow for an expanded berm, between the rip-rap and the dyke, on which vegetation could be planted (Figure 24). However such a slope would require larger rock material to protect it, and would make access to the water more difficult. Another alternative is the use of a more shallow bank protection slope (e.g. 3:1). Though this would decrease berm width and thus the amount of vegetation which could be grown, the smaller rock material used would allow riparian vegetation to become established more readily, and allow for greater ease of access to the water.

Combining different methods of bank protection provides greater opportunities for preserving or re-establishing riparian vegetation. Revetment such as rock rip-rap could be used on bank slopes up to a sustained high flow elevation leaving the uppermost slope area to be planted with vegetation (Figure 25). Another option is to place quarry stone (or similar material) on the lower portions of the river bank which are subject to more severe and more frequent river current velocities but use cellular cement blocks, which permit vegetation growth in the cells, on the upper portion of the bank. Tests of cellular concrete structures have been made[33/] but a pilot project to determine their suitability in Fraser River flows may be required.

The land adjacent to the planned bank protection works between Clarke and Young Roads is a potential residential area. Incorporation of some of the measures outlined above would increase the value of this river view property and would be more acceptable aesthetically to prospective residents, and to recreationists in general.

32/ Mifkovic, C.S., and M.S. Petersen. "Environmental Aspects-Sacramento Bank Protection". Journal of the Hydraulics Division, Proceedings of the the A.S.C.E., Vol. 101, No. HY5, May 1975, pp. 543-555.

33/ Parsons, D.A., and R.P. Apmann. "Cellular Concrete Block Revetment". Journal of the Waterways and Harbours Division. Proceedings of the A.S.C.E. Vol. 91, No. WW2, May 1965, pp. 27-37.

C. ECOLOGICAL SYSTEMS

1. Option #1

No significant disruptions to existing ecological systems are anticipated.

2. Option #2

The new proposed outside alignment may result in residual impacts which could affect significantly the terrestrial and aquatic ecosystems of the area.

If the terrestrial ecosystem is no longer influenced by flooding but significant groundwater seepage is present, the vegetation communities will remain rich in deciduous and shrub growth. If no seepage is present then, in time, vegetation succession will progress to a type dominated by conifers (e.g. Douglas-fir). This will lead to podzalization of the soils. The resulting natural system will be less diverse and less productive.

A new outside dyke alignment could induce changes in land use which could lead to repercussions for the aquatic ecosystem. Increased agricultural activity will increase nutrient and pesticide loadings to surface and ground waters. Increased residential development could increase nutrient loadings to the system through septic tank seepage, and increase storm drainage discharge which may contain concentrations of trace metals and polychlorinated biphenyls. These loadings could affect the aquatic biota in the system. The significance of these changes is unknown.

D. SOCIAL

1. Option #1

The reconstructed dyke will be confined within the existing right-of-way. Some private use has been made of this right-of-way,

and thus the front yards of approximately thirteen houses situated along the west side of Young Road and eleven along the east may have vegetation and fences removed during dyke reconstruction (See Section V.B.3.). No dyke nor right-of-way exists between the Young Street Bridge and Cawley Street along the south side of Hope Slough. Five of the six houses situated in this stretch are likely to suffer extensive property and associated vegetation losses if this land is expropriated for a typical dyke right-of-way. The 18 residences situated immediately adjacent to the dyke between Cawley and Corbould Streets, plus 2 near Marshall Avenue and 2 near Wellington Avenue will also have fence lines and gardens removed for the dyke reconstruction. Yards most affected along the entire right-of-way will be those to the land side of the dyke where there will be a 25 foot temporary working easement. Vegetation removal in the dyke right-of-way and at stockpile sites will likely be aesthetically displeasing until vegetation on the dyke slopes is re-established. In order to mitigate the effects of vegetation removal, clearing in and near dyke rights-of-way should be selective, and width of temporary working areas through residential areas and parks should be reduced.

Both the raised dykes and the pump station may be objectionable because they obstruct nearby residents' view. Persons residing in the vicinity of the existing alignment, especially those from Young Road to Corbould Street, and near Wellington Avenue, will experience temporary disturbances and inconveniences from construction noise, truck traffic and burning. Construction activities could cause significant disturbance if they are not limited to daylight hours. The tender documents ensure that public disturbance is minimal. For example, all necessary precautions must be taken to prevent damage to property at or adjacent to the site, and a dust palliative must be put down where a dust nuisance may be created.

Traffic is relatively constant over Young Street Bridge. During floodbox and pump station construction, restriction of traffic

movement could cause congestion problems. However, tender documents call for arrangements to be made in advance of construction, for closures of any roads and provision of suitable detours to ensure the least interference with pedestrian and vehicular traffic. Of particular concern are construction activities, especially truck traffic, along the section of the alignment next to a school yard, where the safety of school children could be endangered. Upgrading the existing alignment will involve improvements to public roads, e.g. Young and Wolfe Roads.

Construction of the existing alignment whose 1975 estimated cost was $1,600,000, will provide temporary employment and related economic benefits to the Chilliwack area for the duration of the project. Of this amount, approximately 50% will go towards labour costs.

The alignment of the dykes will not significantly alter Chilliwhack Township's projected future development plans. Residents of Chilliwhack feel secure behind the present dykes (as do most residents behind dykes in the Lower Mainland)[34/] Therefore, upgrading the alignment will not necessarily stimulate private development activity behind the existing dykes.

If the existing dykes were upgraded, the non-Indian agricultural and residential development potential on lands outside the dykes may be reduced because of the flood hazard and marketing problems arising from a lack of, and no prospect of dyke protection. Financial and management assistance that the Indians may require in developing their lands themselves, may be difficult to obtain due to the flood risk involved in the development.

34/ Information supplied by Planning Division, Water Planning & Management Branch, Inland Waters Directorate.

2. Option #2

A survey of the right-of-way for the new proposed outside alignment has been made but the actual right-of-way has not been obtained. Therefore all landowners whose property may have to be bought or expropriated along this alignment will be affected by construction activities such as vegetation removal and land burying. In addition, those persons residing or using land to the land side of the dyke will be subjected to disturbances in the 25 foot temporary working area.

Construction activities in general will be aesthetically displeasing to residents near the east end of the alignment and users of recreational areas. However, much fewer residents will be affected here than along an upgraded existing alignment. If Island 22 and adjacent areas are opened up for recreational use due to the greater ease of access with the new dyke crest roads, the resultant increase in traffic and people may be disruptive to the rural lifestyle of residents in the Clarke Road-north Young Road area.

The proposed outside alignment will provide flood protection for an additional 800 acres of land. Flood damage prevention benefits will accrue from a reduction of: a) physical damage to existing buildings and their contents, bridges and roads, and costs of replacement and repair of affected property; b) agricultural crop losses and livestock losses; c) loss of income due to interruption of business; d) cost of flood fighting, evacuation, and care and rehabilitation of flood victims. In addition, land behind the proposed dyke alignment, particularly land under 30 feet GSC, will not be subject to flooding or substantial crop losses by flood-induced high water tables as frequently. Thus, long term income-producing potential such as an increase in agricultural production, and a change to crops which yield higher returns, can be realized. For example, hay-pasture land may be converted to produce cash crops behind dykes. Prospective buyers, lessees, and

developers may be more inclined to invest in residential development in the area if there is less likelihood of flood hazard owing to dyke protection.

Construction of the new alignment will provide temporary employment and related economic benefits to the Chilliwack area for the duration of the project. Approximately 50% of the estimated $2,700,000 costs (1975) of this alignment will go towards labour costs.

The economic impact of taking 22 acres of agricultural and bush land out of production for the new dyke right-of-way is insignificant.

Even considering the benefits noted above, project costs still outweigh the net benefits and thus the new dyke alignment is an uneconomic proposition (See Section IV.D.5.).

The significance of the social values of a new outside alignment appears questionable in light of the less than enthusiastic response of the prime benefactors, the Indian Bands of Skwali I.R. #3 and Skwah I.R. #4, towards a Federal government offer of virtually a "free" dyke (See Section III.A.).

VI CONCLUSIONS AND RECOMMENDATIONS

From an environmental point of view there do not appear to be any unacceptable impacts which would necessitate the elimination or radical modification of either alignment proposal. However, the upgrading of the existing alignment is the least detrimental. It is recommended therefore that this alignment be followed, taking into account pertinent recommendations below. It is acknowledged that some of these recommendations may be currently practiced.

1. In and near dyke rights-of-way, clearing of trees and shrubs should be minimized in order to preserve the ecological and aesthetic value of dyke areas.

2. Adjacent to waterways, the area to the water side of the dyke should be left undisturbed.

3. Placement of stripped soil and other debris, and construction of temporary work roads should be restricted to the land side of the dyke where possible. If it should become essential to conduct such activity on the water side of the dyke, all precautionary steps should be taken to prevent entry of materials into the streamway.

4. Precautions should be taken in upgrading the existing alignment to ensure that an historical cairn located on Wolfe Road near Chilliwack Creek is preserved.

5. Dyke maintenance operations including mowing should be conducted in the fall and early winter months. No burning should be done after the first of March until the fall.

6. The preliminary designs and operating schedules of the pump station for either option (as outlined in this report) are

acceptable to Fisheries and Marine Service. However, Fisheries personnel should be consulted during the final design phase of the pump station for review and comment of plans and proposals.

7. Pump station construction periods should be discussed with the Fisheries and Marine Service (Appendix B contains correspondence relating to this topic).

8. Fish screen specifications for the pump station works should be discussed with the Fisheries and Marine Service (Appendix B contains correspondence relating to this topic).

9. No pumping operation of any kind shall be permitted to handle winter flows. The floodbox gates should be manually operated and should remain open from August to April of the following year.

10. The Township of Chilliwhack should be made fully aware of and strictly enforce these aforementioned pump station specifications and operation schedules.

11. In order that water level specifications can be strictly observed and enforced, manual water level gauges should be installed on the upstream and downstream sides of the pump station.

12. Bank protection slopes should be steepened (e.g. 2:1) if practicable to preserve and increase the width of the existing berm between the rip-rapped bank and the dyke, and thus allow for vegetation growth. At sites where the difference in berm width between different slopes (e.g. 2:1 and 3:1) is not a critical factor, a flatter slope with smaller sized riprap material would be desirable to allow vegetation to become established more easily within the bank protection works.

13. Vegetation regrowth should be encouraged in the entire berm area between the riprapped bank and the dyke toe. In emergencies, if repairs to the riprap cannot be done from the river, trucks could drive over the vegetation to reach the bank protection works.

It is recommended that the following improvements which would be beneficial for wildlife, recreation and aesthetics be undertaken, provided additional funds can be obtained:

14. Trees, shrubs and ground cover which are unavoidably lost during dyke (re)construction, should be replaced in order to preserve and enhance the ecological and aesthetic values of dyking areas.

15. Lowering of the top of the rock revetment from its present level at the top of the river bank, to a sustained high-flow elevation so that riparian vegetation can be promoted on the upper slopes of the bank, should be investigated.

16. The possibility of incorporating cellular cement blocks, in which vegetation can be planted, into the upper portions of the bank protection works should be investigated. This, or a similar method, should be used if vegetation growth alone would not provide sufficient protection from river currents in certain areas.

17. In order to enhance dykes for recreational use, turnouts, bicycle paths and boat launching ramps (the latter for Option 2 only) should be incorporated into sections of the alignment in the final design. Locations and specifications of these facilities should be drawn up in consultation with provincial parks, fisheries, wildlife and municipal authorities.

18. For bank protection areas to be more aesthetically pleasing and provide some value for recreational use as well as wildlife habitat, measures to promote ecological values are required. To accomplish this, both construction and maintenance operations for bank protection works should be conducted from barges or river dredges wherever feasible, to ensure as little vegetation as possible is damaged.

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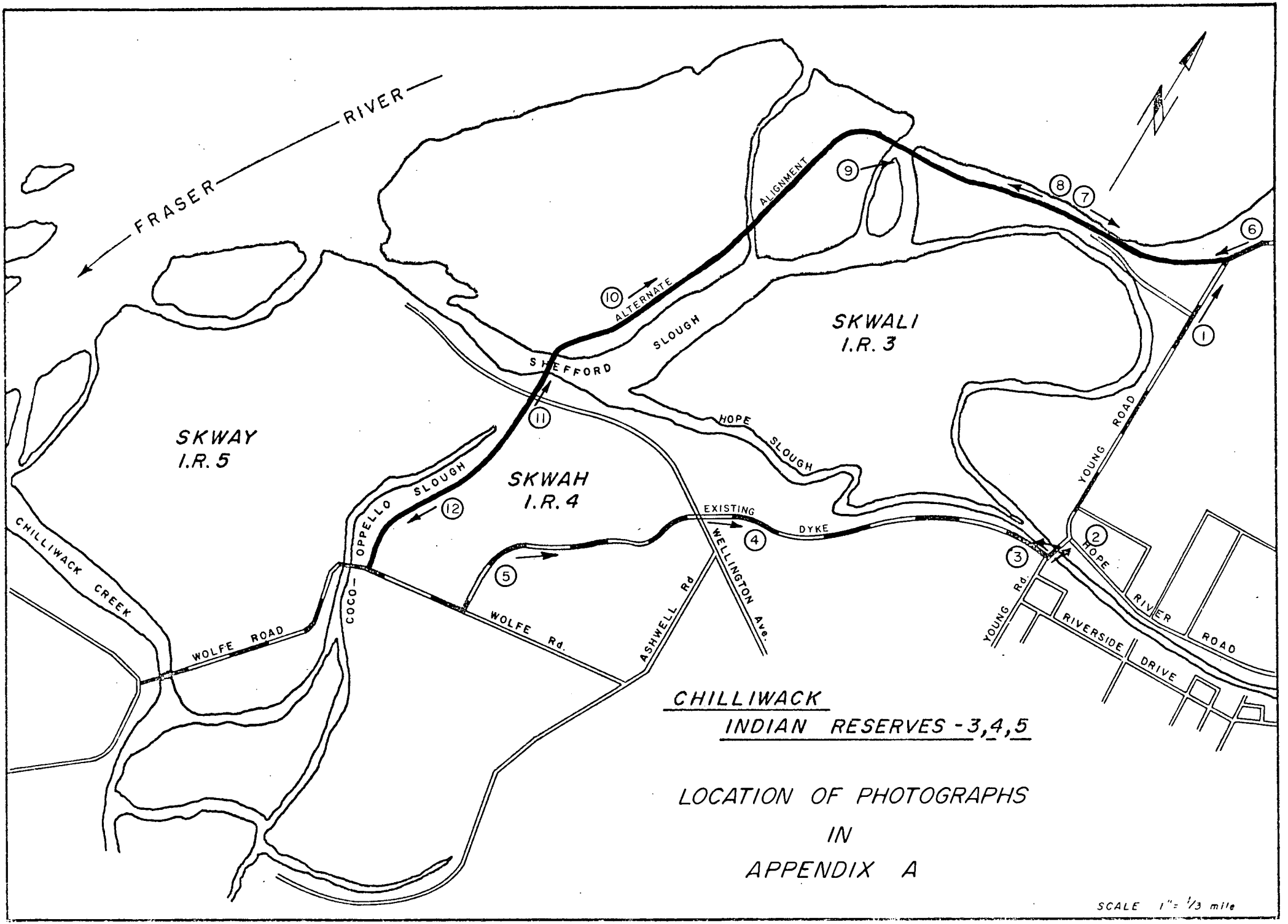
APPENDICES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YOUNG ROAD
SKWAY
I.R. 5
SKWAH
I.R. 4
OPPELLO SLOUGH
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EXISTING
DYKE
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2
HOPE
RIVER
ROAD
3
CHILLIWACK CREEK
5
COCO-
WOLFE ROAD
WOLFE Rd.
ASHWELL Rd
WELLINGTON Ave.
YOUNG Rd.
RIVERSIDE
DRIVE
CHILLIWACK
INDIAN RESERVES - 3,4,5
LOCATION OF PHOTOGRAPHS
IN
APPENDIX A
SCALE 1" = 1/3 mile

APPENDIX A

Photographs of the existing (Option #1) and proposed (Option #2) dyke alignments

1

Existing Alignment
23 Dec. 1975
From Clarke Road looking north on Young Road, Chilliwack.

2

Potential site of Hope Slough pump station upstream of Young Street bridge.

3

Hope Slough, looking downstream from Young Street bridge - no dyke exists in this area.

4 Existing dyke through Skwah Indian Reserve #4, near Wellington Avenue looking east.

5 Existing dyke through Skwah Indian Reserve #4, north of Wolfe Road looking northeast.

6

Looking southwest from Young Road along the proposed dyke alignment.

7

Looking east at bank protection works and gravel operation along the Fraser River, near Clarke Road.

8

Bank protection works which extend to top of the emergency dyke, looking west along the Fraser River. (Proposed alignment would run along inside of emergency dyke).

9

Looking northeast across the north end of Shefford Slough along proposed alignment.

10

Looking north along proposed alignment on Island 22.

11

Looking north across Shefford Slough to Island 22 near proposed Shefford Slough pump station site.

12

Looking southeast along proposed alignment near Coco-Oppello Slough.

Upstream view of typical floodbox and pump station works.

Downstream view of typical floodbox outlet structure.

Environment Canada | Environnement Canada
Fisheries and Marine | Pêches et Sciences de la mer

APPENDIX B

January 14, 1976

Mr. M. M. Wiggins, Chief
Inland Waters Directorate
Water Planning & Management Branch
1001 West Pender Street
Vancouver, B. C.

Your file / Votre référence

Our file / Notre référence
1165-36-F35

Attention: Mr. Steve Wetmore
Ms. Anne Ker

Dear Sir:

Re: Fraser River Flood Control Programme
Chilliwack Indian Reserve - Dyking, Pump Station and Floodbox Proposal - RSCC P-65

Reference is made to the letters dated September 25th, 1975 and October 6, 1975, from the Inland Waters Directorate, Pacific and Yukon Region, to the RSCC and to F. C. Boyd, Fisheries and Marine Service, respectively, and to the subsequent meeting regarding the subject matter held at 1001 West Pender Street, Vancouver, on October 16th, 1975, attended by the following:

M. M. Wiggins, P. Eng.	Inland Waters Directorate
K. Redpath, P. Eng.	Lands Directorate
E. Taylor, Biologist	Canadian Wildlife Service
J. McNally, P. Eng.	Fisheries & Marine Service
S. Wetmore, P. Eng.	Inland Waters Directorate

and the subsequent on-site inspection of November 10th, 1975, undertaken by the following:

M. Noble, Biologist	Canadian Wildlife Service
B. Cox, Biologist	Fish and Wildlife Branch
B. Usher, Technician	Fish and Wildlife Branch
B. Tutty, Biologist	Fisheries & Marine Service
L. Dutta, P. Eng.	Fisheries and Marine Service

The following are the comments on the proposed dyke alignments as detailed on the drawing attached to the September 25th, 1975 letter and the Report, Preliminary Design, Pumping Station Alternatives on Hope and Shefford Slough, Chilliwhack Township, March, 1973.

.....2

Fisheries - Pacific Region
1090 West Pender Street
Vancouver, B.C.
V6E 2P1

Pêches - Région du Pacifique
1090 rue West Pender
Vancouver (C.-B.)
V6E 2P1

The Fraser River Flood Control Programme, Chilliwack Indian Reserve Dyking, Pump Station and Floodbox project, may potentially affect the migration of a stock of coho salmon that have had a recent (1970) historic high of 1200±. This population actively spawn in small areas in the upper reaches of Elk and Dunville Creeks which flow into Hope Slough, thence into Shefford Slough. The adult migration to these streams commences in November, peaks in early December and ends in January. Hope Slough is utilized by the coho as a holding area during maturation in the late fall prior to spawning. Juvenile coho emerge from the redds during April and May and rear in Hope Slough and its tributaries until the following year when smoltification occurs during the early summer months coinciding with the Fraser River freshet. This system supports both age class populations of juvenile coho during April-July of any given year.

Fisheries and Marine Service prefers the alternative (rehabilitation of existing dykes and new Hope Slough pump station near Young Road) shown on Figure 1, rather than Alternative 3 (new dyke alignment, pump station at foot of Wellington Road), shown on Figure 3, on the following grounds:

a. Streambanks of the Shefford Slough will be left undisturbed.

b. Nutrient flow from the upland areas will not be intercepted by dyke.

c. Present salmonid life cycles will remain undisturbed.

d. Large areas of the Hope Slough and Shefford Slough will be left in its present natural state and the present use of the areas for recreational sport fishery will continue unaffected.

However, if other considerations make the adoption of an alternate dyke alignment more desireable, this Service will not object to the adoption of Alternative 3.

It is our understanding that for both alternatives, viz., Alternatives 1 and 3, winter flows will be drained to the Fraser River by a floodbox capable of handling 1 in 25-year peak daily winter flows and that no pumping operation of any kind will be involved in handling winter flows. It is also understood that the floodbox gate will be manually operated, and that this gate will remain open from August to April of the following year, during the entire life of the project.

Field data to substantiate the fact that no pumping will be required

.....3

to handle internal drainage during the late spring and early winter months appears scanty. We would appreciate receiving your comments on this aspect of the operation of the pump station in view of Fisheries' concerns, should high Fraser River discharge necessitate pumping concomitant to adult migration. Please refer to Page 1 of amendments to Hope Slough pumping alternatives, first seventeen lines. (A photo-copy of this page is enclosed for easy reference).

It is our understanding that the operation and maintenance of the facilities after being built will be the responsibility of the District of Chilliwack. We request you ensure that the Municipality of Chilliwhack becomes fully aware and undertakes to strictly enforce these specifications and operation schedules. We would appreciate receiving a copy of the document verifying this fact for our records.

Pumps

Please refer to pages 5 and 6 (memorandum from Cameron to Marr, December 4th, 1972).

The breakdown of handling of discharges of 25 c.f.s. by screw pumps and 175 c.f.s. by screened axial flow pumps is acceptable. However, up to this time, we have no experience in the use of screw pumps for transporting fish. I have instructed my staff to carry out literature search and investigations in this regard. In the interim, your design may proceed on the basis of your proposal with certain flexibility to slight modification in the light of our findings.

Screen specifications for axial flow pump for fish diversion: (Please refer to a letter from Mr. M. J. Holden to Mr. R. A. Crouter dated February 20th, 1973, Page 2 of Appendix 2). The clear openings for the screens of 0.15 inch was specified to divert coho smolts only. Due to the large population of chum and pink salmon which spawn in the mainstem Fraser River and Chilliwack Creek adjacent to the project site, it is our recommendation that the screen opening size should be such as to exclude these fry from the intake should they stray upstream of the pump facility prior to floodbox closure and commencement of pumping. The opening for this purpose shall be 0.10 inch and a copy of screening specifications is enclosed for your reference.

Construction of the Dyke through the Indian Reserve, Alternative 3

The following restrictions shall apply:

I Extent of stripping of topsoil for dyke - construction shall be determined at site. I suggest that an on-site

inspection be undertaken jointly by your project engineer and a member of my staff, prior to the preparation of final drawings and tender documents to settle this issue.

II Stripped soil and other debris shall be deposited on the island above the dyke alignment, away from the stream.

III Temporary roads for movement of equipment and hauling materials shall be built on higher ground, away from the stream.

IV Streambank between the toe of the proposed dyke and the floodway shall be left undisturbed, in its natural state.

V No timing restrictions for dyke construction shall be imposed by this Service as long as the aforementioned conditions are strictly adhered to during construction.

Construction of the Earth-filled Dam and Pump Station across the Shefford Slough (Alternatives 1 and 3)

a. Timing of construction will be of concern to us. For the purpose of planning only, the months of January, February and August may be considered as allowable time period. These are, however, subject to change upon review of your proposed construction methods and construction drawings, for example, use of cellular cofferdams, method of segmenting the stream cross-section, use of land-based equipment, equipment on barges, etc.

b. This phase of the construction shall be planned in consultation with my technical staff. We also request you to forward the preliminary plans and proposals to this office for review and comment.

Please note that L. K. Dutta, P. Eng. (666-3285) and B. Tutty, Biologist (666-3304) of my staff will be available for discussion on any aspect of this project.

.....5

Your courtesy in referring this matter for our review and comments is sincerely appreciated.

Yours very truly,

R. A. Crouter, Manager
Southern Operations Branch
Pacific Region

LKD/cz
BT
Encl.

cc. A. C. Cooper, Director
International Pacific Salmon
Fisheries Commission

G. A. West, Regional Director
Fish and Wildlife Branch, Burnaby

M. Noble
Canadian Wildlife Service

I. S. Todd, Chief
Fraser River-Johnstone Strait-
Juan de Fuca Division, Fisheries
and Marine Service

L. S. Freeman, District Supervisor
New Westminster, Fisheries and Marine Service

J. Hipp, Fishery Officer
Chilliwack

0281550 - B-17

January 4, 1973

Chilliwack Internal Drainage

Amendments to Hope Slough Pumping Alternatives

1. Alternative 1 - Page 4

a) amend "Summer Operation" to read as follows:

Summer flows will pass through the floodgates except when the Fraser River rises to a level between 27.0 feet G.S.C. and 29.0 feet G.S.C. at the floodgates. The floodgates will be manually closed between these river levels, depending on the anticipated flood conditions. A river level of 29.0 feet G.S.C. at the floodgates is equivalent to a river level of 20.0 feet G.S.C. at Mission.

When extreme high river levels are forecast, the floodgates will be closed at 27.0 feet G.S.C. The pumps shall start pumping when the internal water level of the slough rises to 27.5 feet G.S.C. and shall cut out when the internal level is drawn down to 27.0 feet G.S.C.

When the river level is expected to exceed elevation 29.0 feet G.S.C. for only a few days, the floodgates will be closed when the river level rises to 29.0 feet G.S.C. and pumping shall be started.

During any freshet which the floodgates are closed, the pumps shall be stopped and the floodgates opened when the river level falls to 29.0 feet G.S.C., provided it is apparent that peak conditions have passed and the river level continues to drop.

The capacity of the pump station is based on maintaining the internal level of Hope Slough below 32.6 feet G.S.C. during a design flood of the Fraser River. The average summer runoff flow has been combined with the underseepage rates as given in section A-6. The river levels during the design flood are based on the Fraser River Board design flood hydrograph.

b) amend "Pump Data" to read as follows:

maximum river level (design flood)	37.7 feet G.S.C.
maximum internal level (design flood)	32.6 feet G.S.C.
normal internal drawdown level	27.0 feet G.S.C.
minimum internal drawdown level	25.0 feet G.S.C.

screw pump: 25 cfs capacity with a maximum lift of 15.0 feet

axial flow pumps: 175 cfs total design discharge capacity at a design static head of 9.0 feet.

Department of the Environment
Fisheries and Marine Service

WATER INTAKE FISH PROTECTION FACILITIES

PROVISIONS OF THE FISHERIES ACT - SECTION 28

In the Provinces of British Columbia, Manitoba, Saskatchewan and Alberta, the Northwest Territories and the Yukon Territory, every ditch, channel or canal constructed or adapted for conducting water from any lake, river or stream for irrigating, manufacturing, domestic or other purposes, shall if the Minister deems it necessary in the public interest, be provided at its entrance or intake with a fish guard or a metal or wire grating, covering or netting, so fixed as to prevent the passage of fish from any lake, river or stream into such ditch, channel or canal.

Such fish guards shall have meshes or holes of such dimensions as the Minister may prescribe, and shall be built and maintained by the owner or occupier of such ditch, channel or canal, subject to the approval of the Minister or of such officer as he may appoint to examine it.

The owner or occupier of such ditch, channel or canal shall maintain such fish guard in a good and efficient state of repair, and shall not permit its removal except for renewal or repair and during the time such renewal or repair is being effected the sluice or gate at the intake or entrance shall be closed, and the passage of fish into the ditch, channel or canal prevented.

SPECIFICATIONS FOR INTAKE STRUCTURES WITH STATIONARY SCREENS

1. Screen Material: The screen material shall be either aluminum, stainless steel, brass or bronze.

2. Screen Mesh Size: Clear openings of the screen (the space between strands) shall not exceed 0.10 inch*. The open screen area shall not be less than 50% of total screen area. The recommended screen is 8 strands per lineal inch, square-mesh wire cloth with .028 or .025 inch diameter wire.

3. Screen Area: A minimum unobstructed screen area of 10 square feet shall be provided for each cubic foot per second** entering the intake. The required screen area shall be installed below minimum water level. (Screen area lost by framing shall not be included as part of the unobstructed screen area.)

4. Screen Support: The screen shall be adequately supported with stiffeners or "back-up" material to prevent excessive sagging.

5. Screen Protection: The intake structure shall, where necessary, be equipped with a trash rack or similar device to prevent damage to the screen from floating debris, ice, etc.

* 0.10 inch = 3/32" (approximately)
** One cubic foot per second = 450 U.S. gallons per minute
= 375 Imperial gallons per minute

6. Screen Accessibility: The screen shall be readily accessible for cleaning and inspection. (Screen panels or screen assemblies which cannot be removed for cleaning, inspection and repairs should be avoided.)

7. Allowable Openings: The portion of the intake structure which is submerged at maximum water level shall be designed and assembled such that no openings exceed 0.10 inch in width.

8. Design and Location: The design and location of the intake structure shall be such that a uniform flow distribution is maintained through the total screen area.

PROCEDURES FOR INSPECTION AND APPROVAL OF INTAKE STRUCTURES

Diversions less than one cubic foot per second: The intake structure shall be constructed in accordance with the foregoing specifications. Upon completion of construction prior to operation, the owner shall contact a local representative of the Fisheries & Marine Service, Department of the Environment, to arrange for on site inspection and approval of the installation. (Permanently submerged screens must be inspected prior to installation.)

Diversions greater than one cubic foot per second: The owner shall submit to the Regional Director of Fisheries, Department of the Environment, 1090 West Pender Street, Vancouver 1, B.C., detailed plans of the proposed installation for review and approval prior to fabrication. The plans shall contain the following information: intake structure location and dimensions, maximum capacity of diversion (expressed either in cubic feet per second, U.S. or Imperial gallons per minute), screen dimensions, screen material, mesh size, fabrication details and minimum water level at the intake site.

The intake structure shall then be constructed in accordance with the approved plans. Upon completion of construction and prior to operation, the owner shall contact the local representative of Fisheries & Marine Service to arrange for on site inspection and approval of the installation. (Permanently submerged screens must be inspected prior to installation.)

ALTERNATE FISH PROTECTION FACILITIES

Self-cleaning type screens or infiltration-type intakes are sometimes used when diversions present major maintenance and cleaning problems. Enquiries concerning the Department's requirements for these types of structures should be directed to the Fisheries & Marine Service, 1090 West Pender Street, Vancouver 1, B.C.

Revised February 23, 1972.

APPENDIX C

Series of Land Use and Capability Overlays, with Capability Descriptions

WILDLIFE-WATERFOWL

DESCRIPTIVE LEGEND

In general, the needs of all waterfowl are much alike; each individual and species must be provided with a sufficient quality and quantity of food, protective cover, and space to meet its needs for survival, growth, and reproduction. The ability of the land to meet these needs is determined by the individual requirements of the species or group under consideration, the physical characteristics of the land, and those factors that influence the plant and animal communities.

On this map the land is divided into units on the basis of physiographic characteristics important to waterfowl populations. The degree of limitation associated with each unit determines its capability class. The subclass denotes the primary factor that causes the limitation.

This classification system is based on two important considerations.

• Capability ratings are established on the basis of the optimum vegetational stage (successional stage) that can be maintained when good wildlife management is practiced.

• Capability ratings assigned do not reflect present land use (except in extreme cases such as heavily populated urban areas), ownership, lack of access, distance from cities, or amount of hunting pressure.

* **CLASS 1** — LANDS IN THIS CLASS HAVE NO SIGNIFICANT LIMITATIONS TO THE PRODUCTION OF WATERFOWL.

Capability on these lands is very high. They provide a wide variety and abundance of important habitat elements; rolling topography is well suited to the formation of wetlands. Predominant water areas on these lands are both shallow and deep permanent marshes, and deep, open water areas with well-developed marsh edges.

* **CLASS 1S** — Lands in this special class are Class 1 areas that also serve as important migration stops.

* **CLASS 2** — LANDS IN THIS CLASS HAVE VERY SLIGHT LIMITATIONS TO THE PRODUCTION OF WATERFOWL.

Capability on these lands is high but less than Class 1. Slight limitations are due to climate, fertility, or permeability of the soils. Topography tends to be more undulating than rolling; a higher proportion of the water areas than in Class 1 are small temporary ponds or deep, open water areas with poorly developed marsh edges.

* **CLASS 2S** — Lands in this special class are Class 2 areas that also serve as important migration stops.

* **CLASS 3** — LANDS IN THIS CLASS HAVE SLIGHT LIMITATIONS TO THE PRODUCTION OF WATERFOWL.

Capability on these lands is moderately high, but productivity may be reduced in some years because of occasional droughts. Slight limitations are due to climate or to characteristics of the land that affect the quality and quantity of habitat. These lands have a high proportion of both temporary and semipermanent shallow marshes poorly interspersed with deep marshes and bodies of open water.

CLASS 3S — Lands in this special class are Class 3 areas that also serve as important migration stops.

CLASS 3M — Lands in this special class may not be useful for waterfowl production, but are important as migration or wintering areas. This class has no subclasses.

* **CLASS 4** — LANDS IN THIS CLASS HAVE MODERATE LIMITATIONS TO THE PRODUCTION OF WATERFOWL.

Capability on these lands is moderate. Limitations are similar to those in Class 3, but the degree is greater. Water areas are predominantly temporary ponds, or deep, open waters with poorly developed marsh edges, or both.

CLASS 5 — LANDS IN THIS CLASS HAVE MODERATELY SEVERE LIMITATIONS TO THE PRODUCTION OF WATERFOWL.

Capability on these lands is moderately low. Limitations are usually a combination of two or more of the following factors: climate, soil moisture, permeability, fertility, topography, salinity, flooding, and poor interspersion of water areas.

* **CLASS 6** — LANDS IN THIS CLASS HAVE SEVERE LIMITATIONS TO THE PRODUCTION OF WATERFOWL.

Capability on these lands is very low. Limitations are easily identified. They may include aridity, salinity, very flat topography, steep-sided lakes, extremely porous soils, and soils containing few available minerals.

CLASS 7 — LANDS IN THIS CLASS HAVE SUCH SEVERE LIMITATIONS THAT ALMOST NO WATERFOWL ARE PRODUCED.

Capability on these lands is negligible or nonexistent. Limitations are so severe that waterfowl production is precluded or nearly precluded.

SUBCLASSES

With the exception of Class 1, and special Class 3M, the classes are divided into subclasses according to the nature of the limitations that determine the class. The following subclasses are used to denote significant limiting factors that may affect either the waterfowl or the ability of the land to produce suitable habitat conditions.

* SUBCLASS A: aridity — The limitation is an arid condition of the land or the susceptibility of the land to periodic droughts, which results in low pond water levels or premature drying of marshes in the breeding season.

SUBCLASS B: free-flowing water — The limitation is usually due to fast or excess water flow, which inhibits development of marsh habitat along the stream edge. It may also be due to a lack of flow through low-lying land, which results in habitat of poor quality.

* SUBCLASS C: climate — A combination of adverse climatic factors may act to reduce favorable habitat and the production and survival of waterfowl.

* SUBCLASS F: fertility — The limitation is insufficient nutrients in the soil and water for optimum plant growth.

* SUBCLASS G: landform — Poor distribution or interspersion of marshes or basins may be a limiting factor of the land and may prevent the development of optimum waterfowl habitat.

SUBCLASS I: inundation — The limiting factor is excessive water level fluctuation or tidal action, which adversely affects the habitat or the nesting success of waterfowl.

* SUBCLASS J: reduced marsh edge — The limitations are topographic features that adversely affect development of optimum marsh conditions along the edge of water areas.

* SUBCLASS M: soil moisture — Poor water-holding capacity of soils, which adversely affects the formation and permanency of water areas.

* SUBCLASS N: adverse soil and water characteristics — Excessive salinity, alkalinity, acidity, lack of essential trace elements, or abundance of toxic elements may limit the development of plant and animal communities essential for waterfowl production.

* SUBCLASS R: soil depth — Restriction of the rooting zone by bedrock or other impervious layers may limit development of suitable plant communities.

SUBCLASS T: adverse topography — Either steepness or flatness of the land may limit the development or permanency of wetlands.

* SUBCLASS Z: water depth — Excessively deep or shallow waters limit the development of optimum waterfowl habitat.

CONVENTIONS

Large arabic numerals denote capability class.

Small arabic numerals placed after class or special class symbols indicate the approximate proportion (in tenths) of the complex represented by that class. The dominant class appears first in the symbol.

Small upper-case letters placed after class or special class symbols denote the subclasses, i.e., limitations.

* Denotes class or subclass not present on this map.

EXAMPLES

An area of Class 5 land with topography and water depth limitations to waterfowl production is shown: 5^{T}_{Z}

A waterfowl production area of which 70% is Class 4 with limitations due to poor water holding capacity of the soils and fertility and 30% Class 3 with limitations due to fertility and poor interspersion of marshes. $4^{7}_{M\,F}3^{3}_{F\,G}$

An important waterfowl production area of which 60% is Class 1 and 40% Class 2 with a slight limitation due to interspersion of wetland types is shown: $1^{6}2^{4}_{G}$

An important migration stop with little or no waterfowl production is shown: 3M

DESCRIPTIVE LEGEND

In this classification the mineral soils are grouped into seven classes on the basis of soil survey information. Soils in classes 1, 2, 3 and 4 are considered capable of sustained use for cultivated field crops, those in classes 5 and 6 only for perennial forage crops and those in class 7 for neither.

Some of the important factors on which the classification is based are:

- The soils will be well managed and cropped, under a largely mechanized system.
- Land requiring improvements, including clearing, that can be made economically by the farmer himself, is classed according to its limitations or hazards in use after the improvements have been made. Land requiring improvements beyond the means of the farmer himself is classed according to its present condition.
- The following are not considered: distances to market, kind of roads, location, size of farms, type of ownership, cultural patterns, skill or resources of individual operators, and hazard of crop damage by storms.

The classification does not include capability of soils for trees, tree fruits, small fruits, ornamental plants, recreation, or wildlife.

The classes are based on intensity, rather than kind, of their limitations for agriculture. Each class includes many kinds of soil, and many of the soils in any class require unlike management and treatment.

* CLASS 1 — SOILS IN THIS CLASS HAVE NO SIGNIFICANT LIMITATIONS IN USE FOR CROPS.

The soils are deep, are well to imperfectly drained, hold moisture well, and in the virgin state were well supplied with plant nutrients. They can be managed and cropped without difficulty. Under good management they are moderately high to high in productivity for a wide range of field crops.

CLASS 2 — SOILS IN THIS CLASS HAVE MODERATE LIMITATIONS THAT RESTRICT THE RANGE OF CROPS OR REQUIRE MODERATE CONSERVATION PRACTICES.

The soils are deep and hold moisture well. The limitations are moderate and the soils can be managed and cropped with little difficulty. Under good management they are moderately high to high in productivity for a fairly wide range of crops.

CLASS 3 — SOILS IN THIS CLASS HAVE MODERATELY SEVERE LIMITATIONS THAT RESTRICT THE RANGE OF CROPS OR REQUIRE SPECIAL CONSERVATION PRACTICES.

The limitations are more severe than for Class 2 soils. They affect one or more of the following practices: timing and ease of tillage; planting and harvesting; choice of crops; and methods of conservation. Under good management they are fair to moderately high in productivity for a fair range of crops.

CLASS 4 — SOILS IN THIS CLASS HAVE SEVERE LIMITATIONS THAT RESTRICT THE RANGE OF CROPS OR REQUIRE SPECIAL CONSERVATION PRACTICES, OR BOTH.

The limitations seriously affect one or more of the following practices: timing and ease of tillage; planting and harvesting; choice of crops; and methods of conservation. The soils are low to fair in productivity for a fair range of crops but may have high productivity for a specially adapted crop.

CLASS 5 — SOILS IN THIS CLASS HAVE VERY SEVERE LIMITATIONS THAT RESTRICT THEIR CAPABILITY TO PRODUCING PERENNIAL FORAGE CROPS, AND IMPROVEMENT PRACTICES ARE FEASIBLE.

The limitations are so severe that the soils are not capable of use for sustained production of annual field crops. The soils are capable of producing native or tame species of perennial forage plants, and may be improved by use of farm machinery. The improvement practices may include clearing of bush, cultivation, seeding, fertilizing, or water control.

* CLASS 6 — SOILS IN THIS CLASS ARE CAPABLE ONLY OF PRODUCING PERENNIAL FORAGE CROPS, AND IMPROVEMENT PRACTICES ARE NOT FEASIBLE.

The soils provide some sustained grazing for farm animals, but the limitations are so severe that improvement by use of farm machinery is impractical. The terrain may be unsuitable for use of farm machinery, or the soils may not respond to improvement, or the grazing season may be very short.

CLASS 7 — SOILS IN THIS CLASS HAVE NO CAPABILITY FOR ARABLE CULTURE OR PERMANENT PASTURE.

This class also includes rockland, other non-soil areas, and bodies of water too small to show on the maps.

* 0 — ORGANIC SOILS (Not placed in capability classes).

SUBCLASSES

Excepting Class 1, the classes are divided into subclasses on the basis of kinds of limitation. The subclasses are as follows:

* SUBCLASS C: adverse climate—The main limitation is low temperature or low or poor distribution of rainfall during the cropping season, or a combination of these.

* SUBCLASS D: undesirable soil structure and/or low permeability—The soils are difficult to till, absorb water slowly or the depth of the rooting zone is restricted.

* SUBCLASS E: erosion damage—Past damage from erosion limits agricultural use of the land.

* SUBCLASS F: fertility—Low natural fertility due to lack of available nutrients, high acidity or alkalinity, low exchange capacity, high levels of calcium carbonate or presence of toxic compounds.

SUBCLASS I: inundation—Flooding by streams or lakes limits agricultural use.

SUBCLASS M: moisture—A low moisture holding capacity, caused by adverse inherent soil characteristics, limits crop growth. (Not to be confused with climatic drought).

* SUBCLASS N: salinity—The soils are adversely affected by soluble salts.

SUBCLASS P: stoniness—Stones interfere with tillage, planting, and harvesting.

* SUBCLASS R: shallowness to solid bedrock—Solid bedrock is less than three feet from the surface.

* SUBCLASS S: soil limitations—A combination of two or more subclasses D, F, M and N.

SUBCLASS T: adverse topography—Either steepness or the pattern of slopes limits agricultural use.

* SUBCLASS W: excess water—Excess water other than from flooding limits use for agriculture. The excess water may be due to poor drainage, a high water table, seepage or runoff from surrounding areas.

SUBCLASS X: minor cumulative limitations—Soils having a moderate limitation due to the cumulative effect of two or more adverse characteristics which individually would not affect the class rating. (This subclass is always used alone and only one class below the best possible in a climatic subregion).

CONVENTIONS

Large arabic numerals denote capability classes.
Small arabic numerals placed after a class numeral give the approximate proportion of the class out of a total of 10. Letters placed after class numerals denote the subclasses, i.e. limitations.

* Denotes class or subclass not present on this map.

EXAMPLES

An area of Class 4 land with topography and stoniness limitations is shown thus: 4^{T}_{P}

An area of Class 2 with topographic limitation, and Class 4 with stoniness limitation, in the proportions of 7:3 is shown thus: $2^{7}_{T}4^{3}_{P}$

RECREATION

DESCRIPTIVE LEGEND

Seven classes of land are differentiated on the basis of the intensity of outdoor recreational use, or the quantity of outdoor recreation, which may be generated and sustained per unit area of land per annum, under perfect market conditions.

"Quantity" may be measured by visitor days, a visitor day being any reasonable portion of a 24 hour period during which an individual person uses a unit of land for recreation.

"Perfect market conditions" implies uniform demand and accessibility for all areas, which means that location relative to population centres and to present access do not affect the classification.

Intensive and dispersed activities are recognized. Intensive activities are those in which relatively large numbers of people may be accommodated per unit area, while dispersed activities are those which normally require a relatively larger area per person.

Some important factors concerning the classification are:

- The purpose of the inventory is to provide a reliable assessment of the quality, quantity and distribution of the natural recreation resources within the settled parts of Canada.
- The inventory is of an essentially reconnaissance nature, based on interpretation of aerial photographs, field checks, and available records, and the maps should be interpreted accordingly.
- The inventory classification is designed in accordance with present popular preferences in non-urban outdoor recreation. Urban areas (generally over 1,000 population with permanent urban character), as well as some non-urban industrial areas, are not classified.
- Land is ranked according to its natural capability under existing conditions, whether in natural or modified state; but no assumptions are made concerning its capability given further major artificial modifications.
- Sound recreation land management and development practices are assumed for all areas in practical relation to the natural capability of each area.
- Water bodies are not directly classified. Their recreational values accrue to the adjoining shoreland or land unit.
- Opportunities for recreation afforded by the presence in an area of wildlife and sport fish are indicated in instances where reliable information was available, but the ranking does not reflect the biological productivity of the area. Wildlife capability is indicated in a companion series of maps.

* **CLASS 1** — LANDS IN THIS CLASS HAVE VERY HIGH CAPABILITY FOR OUTDOOR RECREATION.

Class 1 lands have natural capability to engender and sustain very high total annual use based on one or more recreational activities of an intensive nature.

Class 1 land units should be able to generate and sustain a level of use comparable to that evident at an outstanding and large bathing beach or a nationally known ski slope.

* **CLASS 2** — LANDS IN THIS CLASS HAVE A HIGH CAPABILITY FOR OUTDOOR RECREATION.

Class 2 lands have natural capability to engender and sustain high total annual use based on one or more recreational activities of an intensive nature.

CLASS 3 — LANDS IN THIS CLASS HAVE A MODERATELY HIGH CAPABILITY FOR OUTDOOR RECREATION.

Class 3 lands have natural capability to engender and sustain moderately high total annual use based usually on intensive or moderately intensive activities.

CLASS 4 — LANDS IN THIS CLASS HAVE MODERATE CAPABILITY FOR OUTDOOR RECREATION.

Class 4 lands have natural capability to engender and sustain moderate total annual use based usually on dispersed activities.

* **CLASS 5** — LANDS IN THIS CLASS HAVE MODERATELY LOW CAPABILITY FOR OUTDOOR RECREATION.

Class 5 lands have natural capability to engender and sustain moderately low total annual use based on dispersed activities.

* **CLASS 6** — LANDS IN THIS CLASS HAVE LOW CAPABILITY FOR OUTDOOR RECREATION.

Class 6 lands lack the natural quality and significant features to rate higher, but have the natural capability to engender and sustain low total annual use based on dispersed activities.

* **CLASS 7** — LANDS IN THIS CLASS HAVE VERY LOW CAPABILITY FOR OUTDOOR RECREATION.

Class 7 lands have practically no capability for any popular types of recreation activity, but there may be some capability for very specialized activities with recreation aspects, or they may simply provide open space.

SUBCLASSES

Subclasses indicate the kinds of features which provide opportunity for recreation. They are, therefore, positive aspects of land and do not indicate limitations to use. Features may be omitted from a unit, either because of the imposed three-feature limit, or because their presence was unknown or unconfirmed.

The degree to which these features are judged capable, collectively, of generating and sustaining use for recreation, determines the class. The sequence in which they are listed indicates the order of their significance. Subordinate features may be relatively insignificant and the class of a unit should not be interpreted to indicate the capability of a secondary or tertiary feature.

The subclasses are:

SUBCLASS A—Land providing access to water affording opportunity for angling or viewing of sport fish.

* SUBCLASS B—Shoreland capable of supporting family beach activities. In high class units this will include family bathing. In Classes 4 and 5, the activities may be confined to dry land due to cold water or other limitations.

SUBCLASS C—Land fronting on and providing direct access to waterways with significant capability for canoe tripping.

* SUBCLASS D—Shoreland with deeper inshore water suitable for swimming or boat mooring or launching.

* SUBCLASS E—Land with vegetation possessing recreational value.

* SUBCLASS F—Waterfall or rapids.

* SUBCLASS G—Significant glacier view or experience.

* SUBCLASS H—Historic or pre-historic site.

* SUBCLASS J—Area offering particular opportunities for gathering and collecting items of popular interest.

SUBCLASS K—Shoreland or upland suited to organized camping, usually associated with other features.

* SUBCLASS L—Interesting landform features other than rock formations.

* SUBCLASS M—Frequent small water bodies or continuous streams occurring in upland areas.

* SUBCLASS N—Land (usually shoreland) suited to family or other recreation lodging use.

* SUBCLASS O—Land affording opportunity for viewing of upland wildlife.

SUBCLASS P—Areas exhibiting cultural landscape patterns of agricultural, industrial or social interest.

* SUBCLASS Q—Areas exhibiting variety, in topography or land and water relationships, which enhances opportunities for general outdoor recreation such as hiking and nature study or for aesthetic appreciation of the area.

* SUBCLASS R—Interesting rock formations.

* SUBCLASS S—A combination of slopes, snow conditions and climate providing downhill skiing opportunities.

* SUBCLASS T—Thermal springs.

* SUBCLASS U—Shoreland fronting water accommodating yachting or deep water boat tripping.

* SUBCLASS V—A vantage point or area which offers a superior view relative to the class of the unit(s) which contain it, or a corridor or other area which provides frequent viewing opportunities.

SUBCLASS W—Land affording opportunity for viewing of wetland wildlife.

* SUBCLASS X—Miscellaneous features with recreational capability.

SUBCLASS Y—Shoreland providing access to water suitable for popular forms of family boating.

* SUBCLASS Z—Areas exhibiting major, permanent, non-urban man-made structures of recreational interest.

CONVENTIONS

Large arabic numerals denote capability classes.

Upper case letters denote subclasses.

There may be area distortion due to scale limitations, particularly in the case of corridor-shaped units.

* Denotes class or subclass not present on this map.

EXAMPLES

An area of Class 1 shoreland with very high capability to generate intensive family bathing and beach activities, fronting and providing access to a water body suited to family boating, and with a backshore suited to organized camping is shown thus:

$1^{B}_{K}_{Y}$

A complex unit containing Class 5 upland exhibiting diversity of natural landscape and possibilities for gathering and collecting; Class 3 shorelands with capability for lodging and family boating, and Class 5 upland with viewing possibilities and interesting rock formations; in the proportions of 6:3:1 is shown thus:

$5^{6}_{J}\,3^{3}_{N}_{Y}\,5^{1}_{V}_{R}$

WILDLIFE UNGULATES

DESCRIPTIVE LEGEND

In general, the needs of all ungulates are much alike: each individual and species must have a sufficient quality and quantity of food, protective cover, and space to meet its needs for survival, growth, and reproduction. The ability of the land to meet those needs is determined by the individual requirements of the species or group of species under consideration, the physical characteristics of the land, and those factors, such as climate, that influence the plant and animal communities.

On this map the land is divided into units on the basis of physiographic characteristics important to wild ungulates. The degree of limitation associated with each unit determines its capability class. The subclass denotes the primary factor that causes the limitation.

This classification system is based on two important considerations:

- Capability ratings are established on the basis of the optimum vegetational stage (successional stage) that can be maintained with good wildlife management practices.
- Capability ratings assigned do not reflect present land use (except in extreme cases such as heavily populated urban areas), ownership, lack of access, distance from cities, or amount of hunting pressure.

* **CLASS 1** — LANDS IN THIS CLASS HAVE NO SIGNIFICANT LIMITATIONS TO THE PRODUCTION OF UNGULATES.

Capability on these lands is high. They provide a wide variety and abundance of food plants and other habitat elements.

* **CLASS 1W** — Lands in this special class are Class 1 areas that are winter ranges on which animals from surrounding areas depend.

* **CLASS 2** — LANDS IN THIS CLASS HAVE VERY SLIGHT LIMITATIONS TO THE PRODUCTION OF UNGULATES.

Capability on these lands is high but less than Class 1. Slight limitations are due to climatic or other factors.

* **CLASS 2W** — Lands in this special class are Class 2 areas that are winter ranges on which animals from surrounding areas depend.

CLASS 3 — LANDS IN THIS CLASS HAVE SLIGHT LIMITATIONS TO THE PRODUCTION OF UNGULATES.

Capability on these lands is moderately high, but productivity may be reduced in some years. Slight limitations are due to characteristics of the land that affect the quality and quantity of habitat, or to climatic factors that limit the mobility of ungulates or the availability of food and cover.

* **CLASS 3W** — Lands in this special class are Class 3 areas that are winter ranges on which animals from surrounding areas depend.

CLASS 4 — LANDS IN THIS CLASS HAVE MODERATE LIMITATIONS TO THE PRODUCTION OF UNGULATES.

Capability on these lands is moderate. Limitations are similar to those in Class 3, but the degree is greater.

* **CLASS 5** — LANDS IN THIS CLASS HAVE MODERATELY SEVERE LIMITATIONS TO THE PRODUCTION OF UNGULATES.

Capability on these lands is moderately low. Limitations are usually a combination of two or more of climate, soil moisture, fertility, depth to bedrock or other impervious layer, topography, flooding, exposure, and adverse soil characteristics.

* **CLASS 6** — LANDS IN THIS CLASS HAVE SEVERE LIMITATIONS TO THE PRODUCTION OF UNGULATES.

Capability on these lands is very low. Limitations are so severe that they are easily recognized; for example, soil depth may be negligible or climatic factors so extreme that ungulate populations are severely reduced.

* **CLASS 7** — LANDS IN THIS CLASS HAVE LIMITATIONS SO SEVERE THAT THERE IS NO UNGULATE PRODUCTION.

SUBCLASSES

With the exception of Class 1, the classes are divided into subclasses according to the nature of the limitations, which determine the class. In most cases the limitations do not affect the animals themselves, but rather the ability of the land to produce suitable food and cover plants. For convenience the subclasses are placed in two main groups: those relating to climate and those relating to inherent characteristics of the land.

CLIMATE

The following are used to denote significant climatic factors that may affect either the animals or the ability of the land to produce suitable food and cover.

* SUBCLASS A: aridity — Drought or aridity that adversely affects the habitat.

SUBCLASS C: climate — A combination of climatic factors acting to reduce favorable habitat, and the production and survival of ungulates.

* SUBCLASS Q: snow depth — Excessive snow depth that reduces the mobility of ungulates and availability of food plants.

* SUBCLASS U: exposure or aspect — Special climatic factors, such as exposure to prevailing winter winds, that adversely affect the animals or their habitat.

LAND

The following subclasses are used to denote significant characteristics of land that limit its usefulness for producing suitable food and cover. Some may also have a slight adverse effect on the animals.

* SUBCLASS F: fertility — Lack of nutrients in the soil for optimum plant growth.

* SUBCLASS G: landform — Poor distribution or interspersion of landforms necessary for optimum ungulate habitat.

* SUBCLASS I: inundation — Excessive water level fluctuation or tidal action that adversely affects the habitat or survival of ungulates.

SUBCLASS M: soil moisture — Poor soil moisture, either excessive or deficient.

* SUBCLASS N: adverse soil characteristics — Excessive salinity, lack of essential trace elements, or abundance of toxic elements in the soil.

* SUBCLASS R: soil depth — Restriction of the rooting zone by bedrock or other impervious layers.

* SUBCLASS T: adverse topography — Either steepness or flatness of the land.

UNGULATE INDICATOR SPECIES

Species of ungulates for which capability ratings are assigned are shown by the following symbols:

* *A*. . . . . Antelope
* *C*. . . . . Caribou
D. . . . Deer (white-tailed deer, Columbia black-tailed deer, mule deer)
E. . . . . Elk
* *G*. . . . . Mountain goat
* *M*. . . . . Moose
* *S*. . . . . Mountain sheep

CONVENTIONS

Large arabic numerals denote capability class.

Small arabic numerals placed after class numeral or special class symbols indicate the approximate proportion (in tenths) of the complex that is represented by that class. The dominant class appears first in the symbol.

Small upper case letters placed after class numeral or special class symbols denote the subclasses, i.e., limitations.

Upper case italic letters placed beneath the class numeral denote ungulate species.

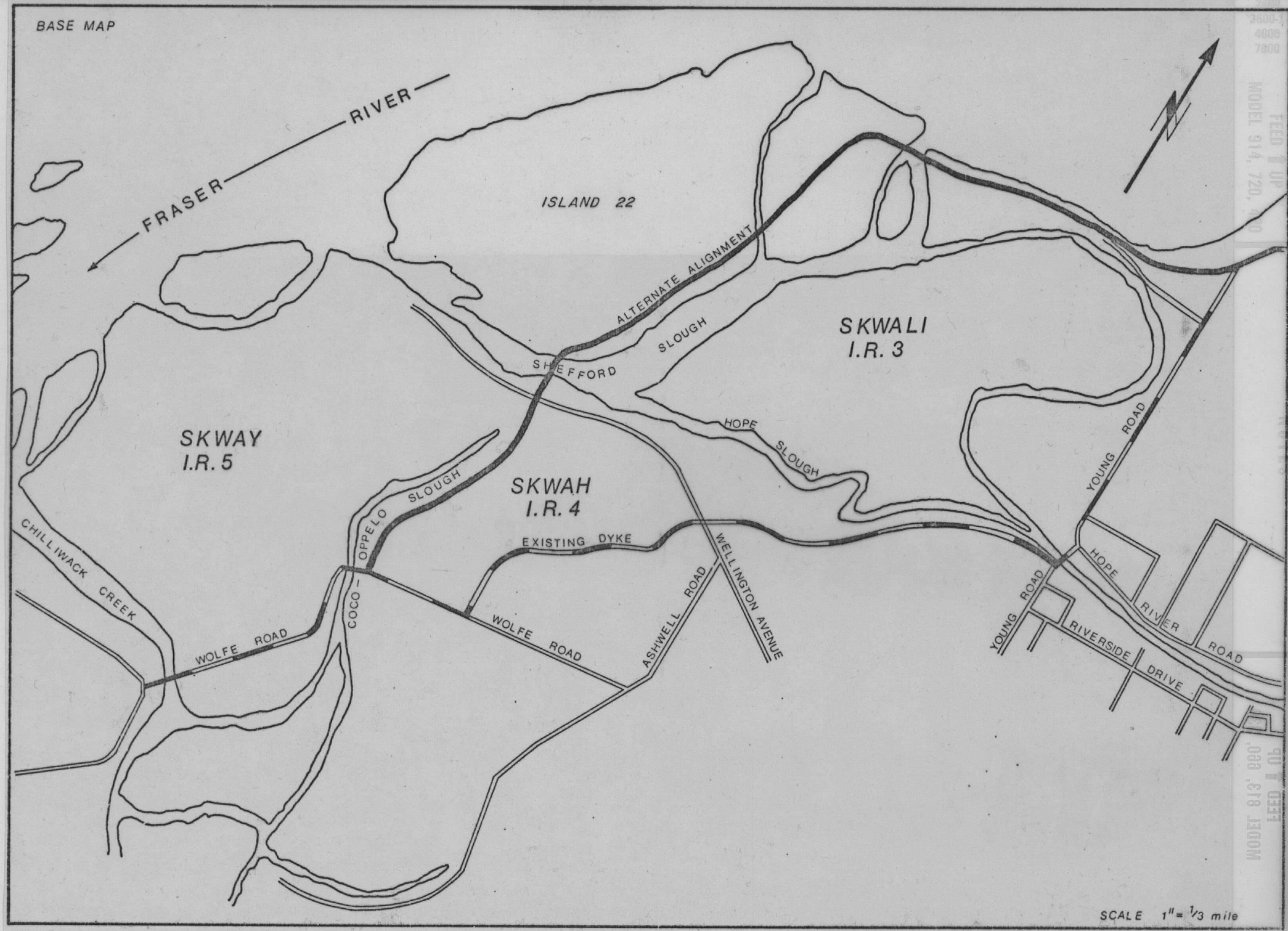
* Denotes class, subclass or ungulate species not present on this map.

EXAMPLES

An area of Class 5 land with topography and soil fertility limitations to deer production is shown: 5^{T}_{F} / *D*

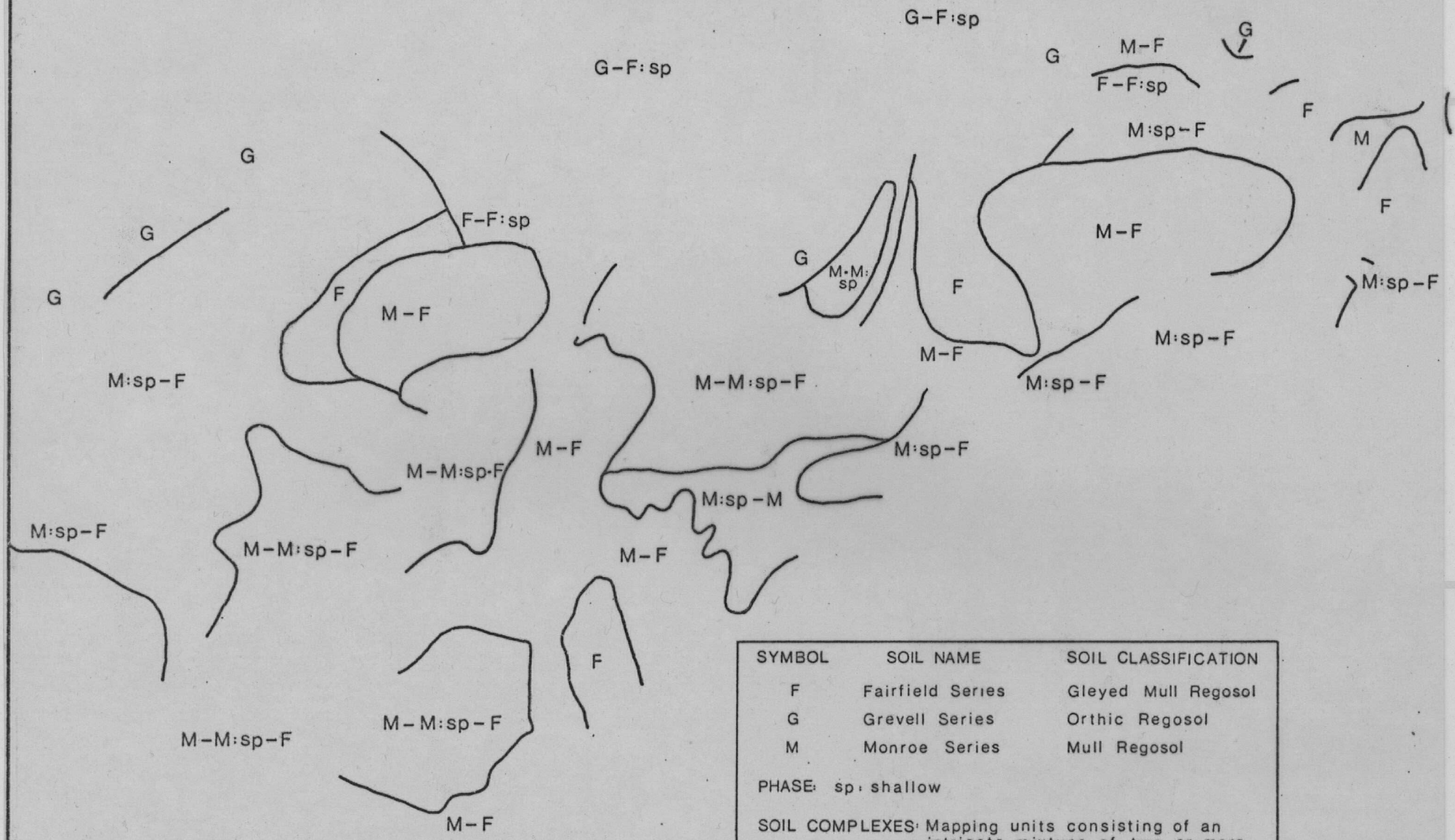
An area of which 70% is Class 4 for deer with limitations due to snow depth and topography and 30% is class 3 wintering area for elk and moose with slight limitations due to snow depth: $4^{7}_{T}3W^{3}_{Q}$ / *D* *EM*

An important wintering area for deer and mountain sheep of which 60% is Class 1 and 40% is Class 2 with slight limitation due to exposed bedrock is shown: $1W^{6}2W^{4}_{R}$ / *DS* *DS*


BASE MAP
FRASER RIVER
ISLAND 22
ALTERNATE ALIGNMENT
SHEFFORD SLOUGH
SKWALI I.R. 3
SKWAY I.R. 5
SKWAH I.R. 4
HOPE SLOUGH
YOUNG ROAD
OPPELO SLOUGH
EXISTING DYKE
CHILLIWACK CREEK
WOLFE ROAD
COCO
ASHWELL ROAD
WELLINGTON AVENUE
HOPE RIVER ROAD
RIVERSIDE DRIVE
SCALE 1" = 1/3 mile

MAP No. 1

SOILS



SYMBOL	SOIL NAME	SOIL CLASSIFICATION
F	Fairfield Series	Gleyed Mull Regosol
G	Grevell Series	Orthic Regosol
M	Monroe Series	Mull Regosol

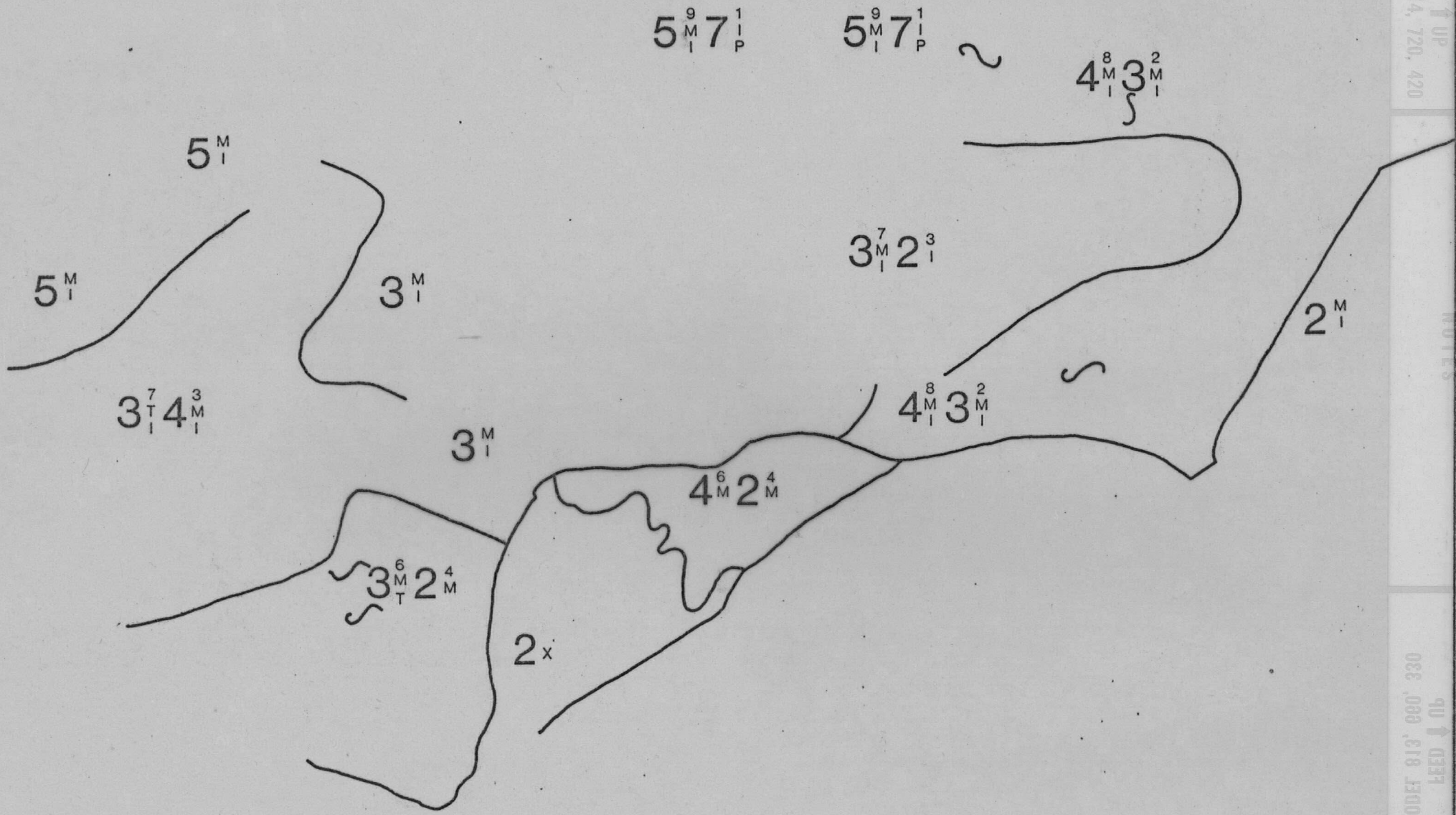
PHASE: sp: shallow

SOIL COMPLEXES: Mapping units consisting of an intricate mixture of two or more classified soils: e.g. M-M:sp-F.

SOURCE: Soil Map of Chilliwack Area Scale 1" = 2000', 1962

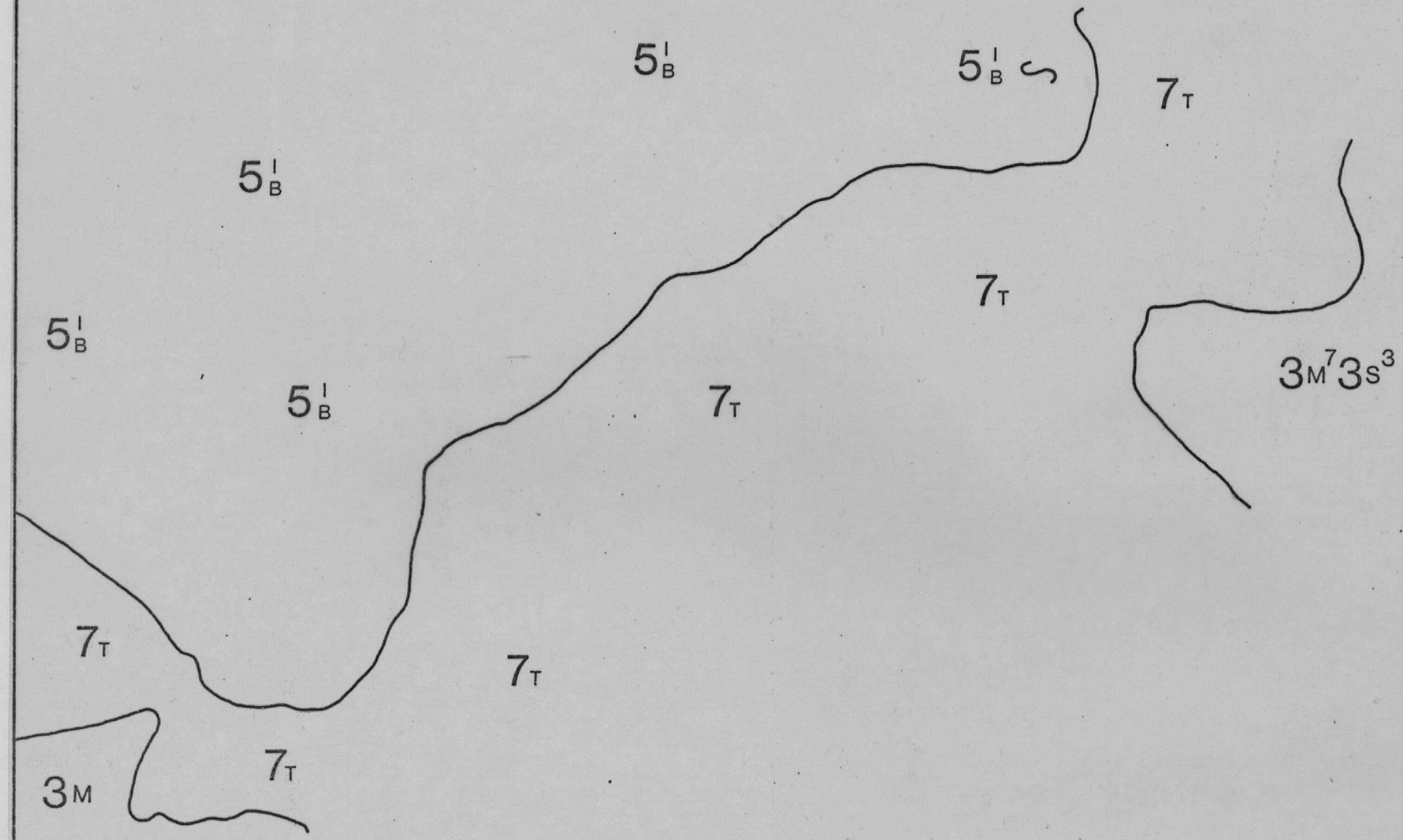
MAP No. 2

CANADA LAND INVENTORY SOIL CAPABILITY FOR AGRICULTURE



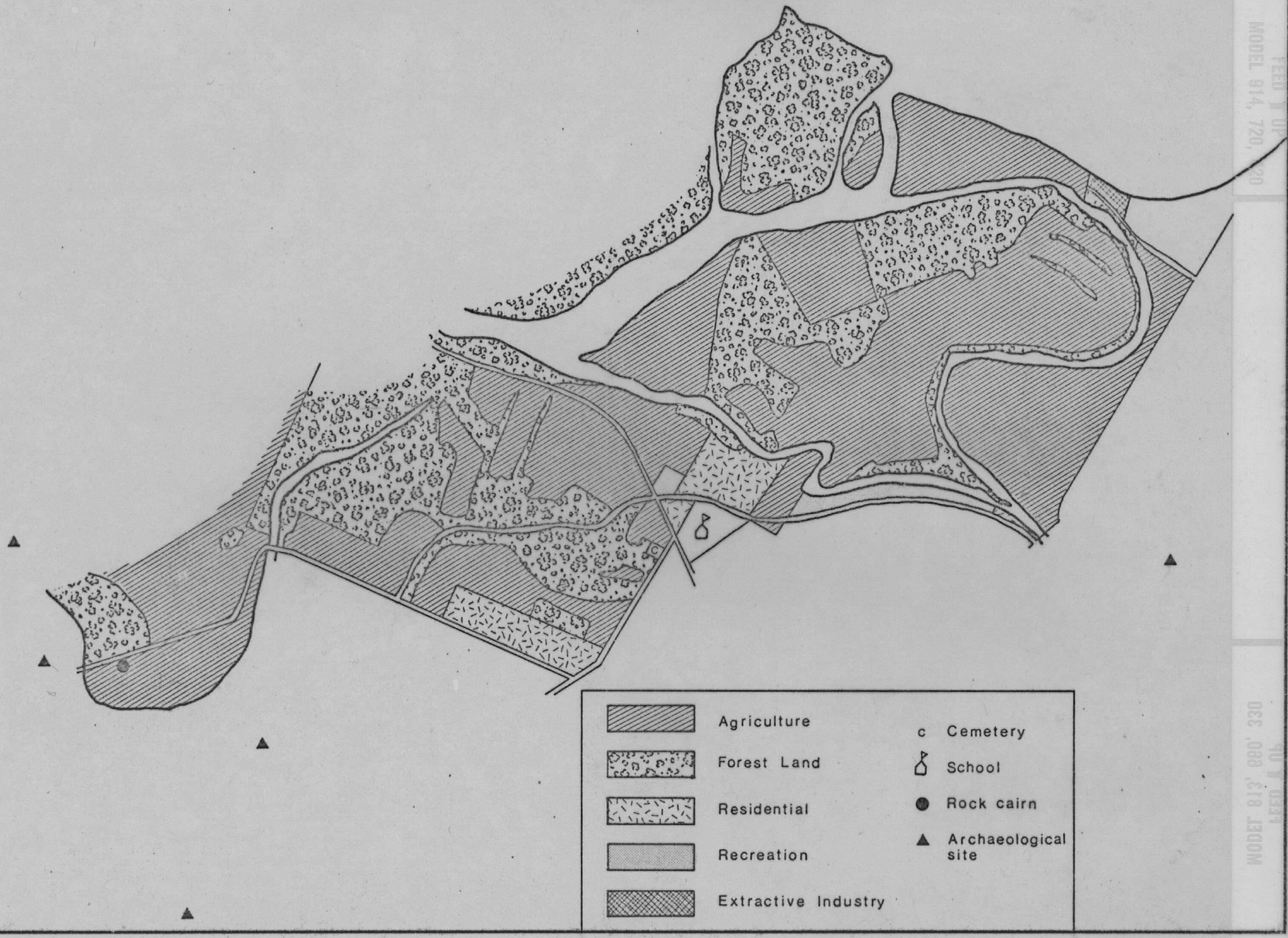
MAP No. 4

CANADA LAND INVENTORY: LAND CAPABILITY FOR WILDLIFE—WATERFOWL



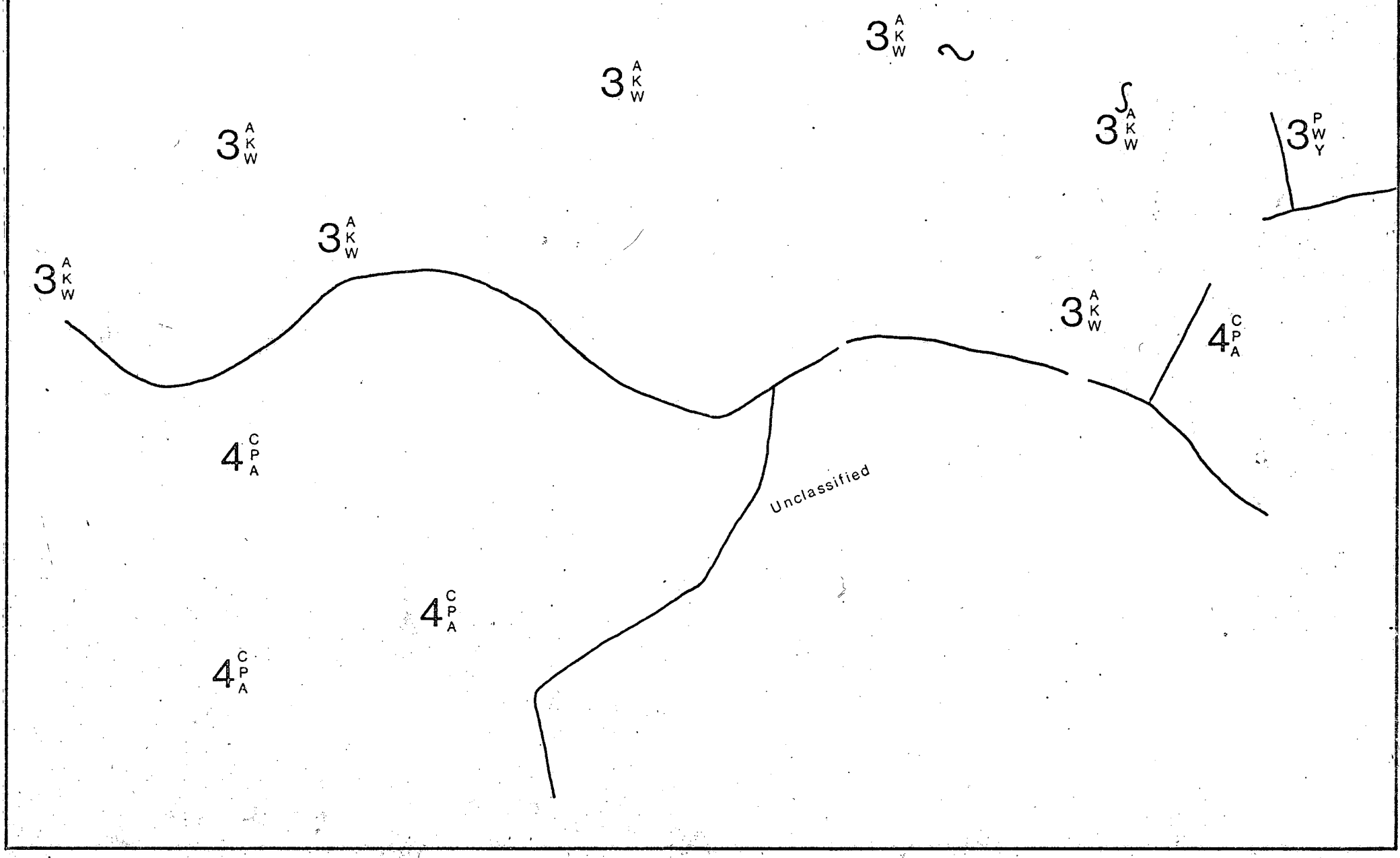
MAP No.5

GENERALIZED LAND USE



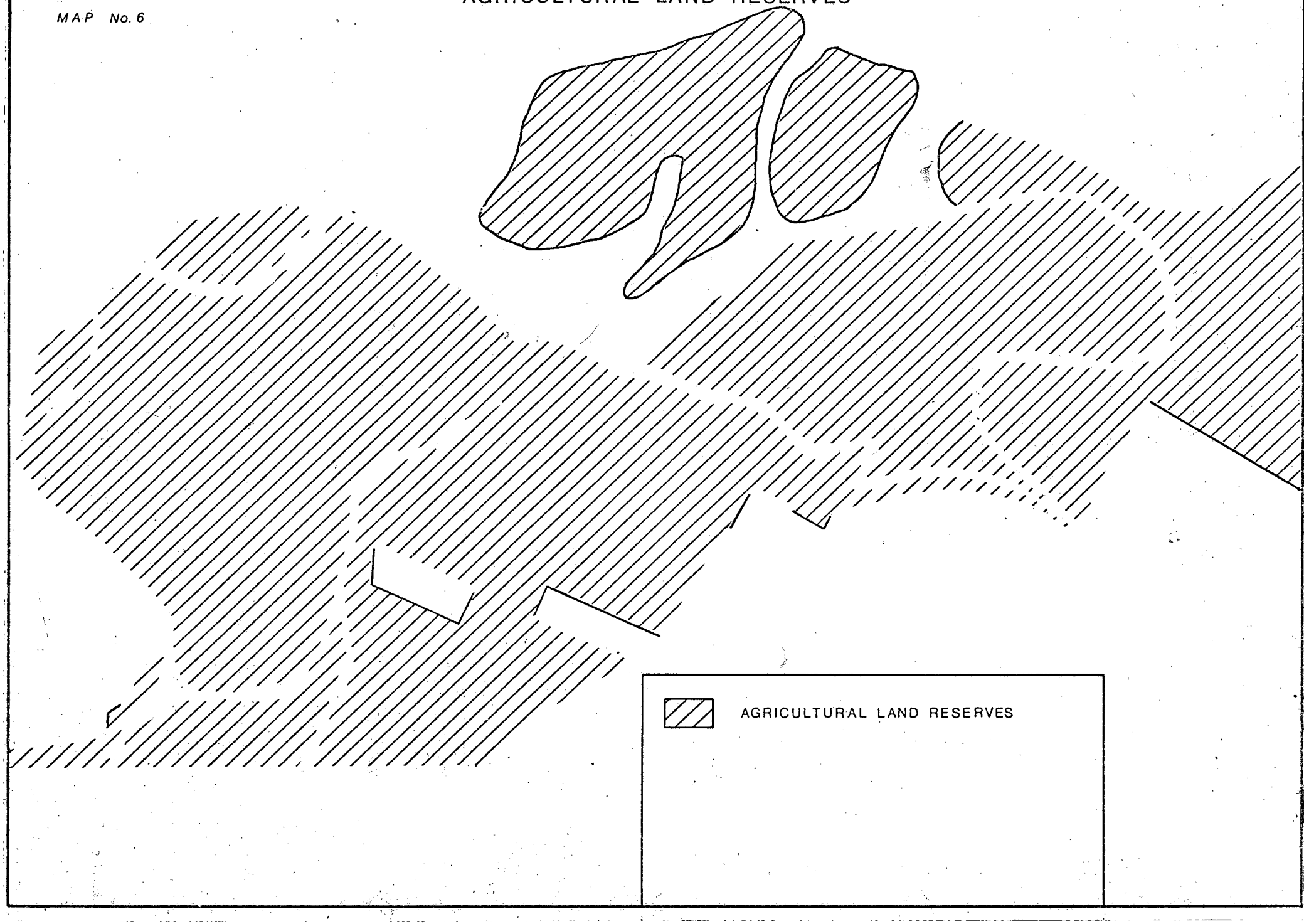
MAP No. 3

CANADA LAND INVENTORY: LAND CAPABILITY FOR RECREATION



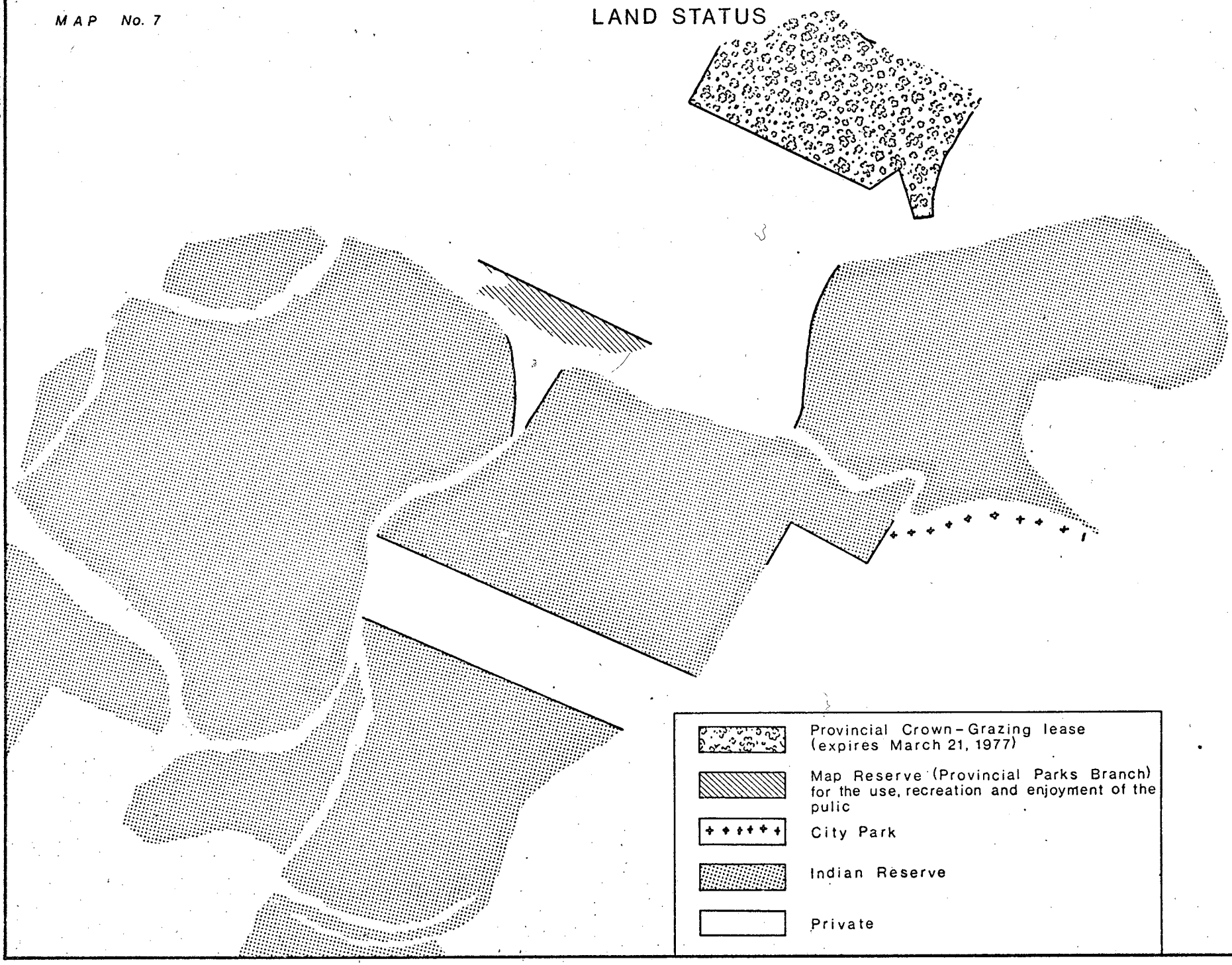
AGRICULTURAL LAND RESERVES

MAP No. 6



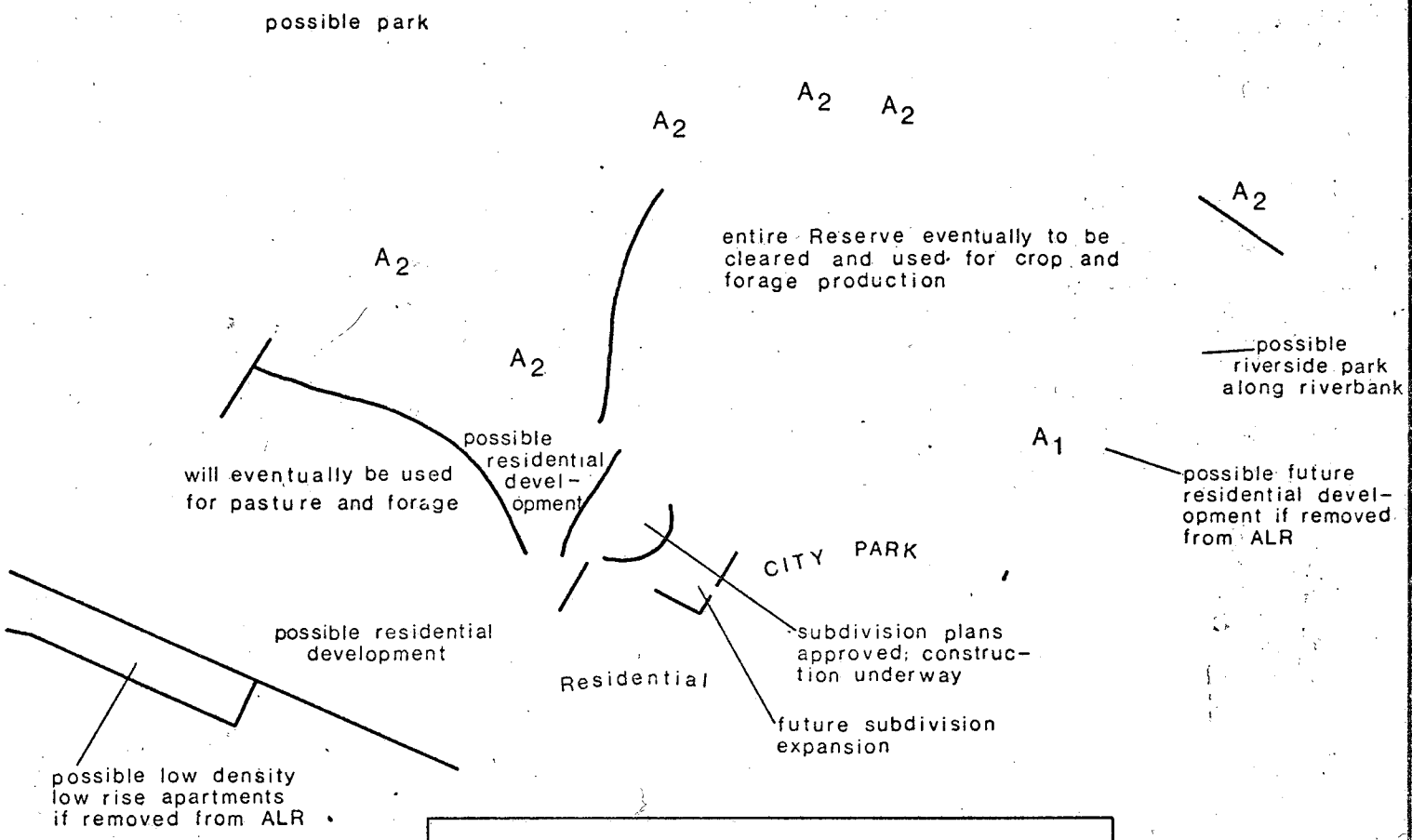
MAP No. 7

LAND STATUS



MAP No. 8

PLANS: INDIAN BANDS AND DISTRICT MUNICIPALITY



APPENDIX D

VEGETATION WHICH MAY BE SUITABLE FOR DYKE AREAS, CHILLIWACK

A. HERBACEOUS PLANTS

For most grasses and forbs, 4 inches of top soil would be adequate in the Chilliwack area. In general, the shorter growing species have shallower root systems.

Common Name	Scientific Name	Preferred Habitat	Comments Re: Suitability For Dyke and Bank Protection Areas
Couch grass	(*Agropyron repens*)	waste places, meadows and pastures	good forage grass, strong creeping rhizomes valuable for holding embankments and sandy soils, 20-40 inches high, troublesome weed in cultivated ground.
Kentucky bluegrass	(*Poa pratensis*)	open woods, meadows and open ground	stems tufted and erect, 12-40 inches tall, valuable for forage, good wildlife habitat if mowed.
Meadow foxtail	(*Alopecurus pratensis*)	wet areas in fields and waste places	erect stems, 12-32 inches tall, occasionally cultivated as meadow grass.
Orchard grass	(*Dactylis glomerata*)	fields, meadows and waste places	stems grow in large, compact tufts 23-47 inches high, commonly cultivated as meadow and pasture grass, good for pheasant habitat.
Perennial ryegrass	(*Lolium perenne*)	meadows and waste places	stems erect or slightly bent at the base, 12-24 inches tall, cultivated in meadows, pastures and lawns.
Reed canary grass	(*Phalaris arundinacea*)	marshes, river banks and other moist places	creeping rhizomes, erect stem 23-59 inches tall, provides wildlife cover.
Red Fescue	(*Festuca rubra*)	meadows, hills, bogs and marshes in cooler areas	stems usually loosely tufted or bent, 16-39 inches high, cultivated for meadows and pastures.
Timothy	(*Phleum pratense*)	along roadsides, and in fields and waste places	stems 20-39 inches tall from a bulb like base forming large clumps.

B. SHRUBS

In this coastal climate shrubs tend to group solidly. However, if shrubs are planted openly and interspaced with herbaceous plants they will maintain their spacing. Most shrubs in the Chilliwack area would require about 8-10 inches of top soil.

Common Name	Scientific Name	Preferred Habitat	Comments Re: Suitability For Dyke and Bank Protection Areas
Black Twinberry	(Lonicera involucrata)	damp ground, sea level to alpine height	3-10 feet high, adapts to sandy-gravelly soils, intermediate.[2]
* Broom	(Cytisus scoparius)	dry slopes, road sides, rocky knolls and waste places, will not tolerate shade from above	good for wildlife, has been used to stabilize bank slopes along roads.
* False Box	(Pachistima myrsinites)	in shade - grows loose and sprawling, in open on rocky slopes - compact form	grows on porous, light soils, low growing (up to 2 feet) possible species for bank protection areas, good.
Goat's Beard	(Aruncus sylvester)	shady forest borders with damp soil, low elevations	3-7 feet high, intermediate.
Gorse	(Ulex europaeus)	rocky knolls, dry slopes, road edges	good in gravelly, coarse material, not very shallow rooted.
Hardhack	(Spirea douglasii)	wet places, margins of ponds and meadows at low elevations, favours open places where there is plenty of light	low shrubs, 3-4 feet high, needs wet, heavy soil, poor if subsoil light.

Common Name	Scientific Name	Preferred Habitat	Comments Re: Suitability For Dyke and Bank Protection Areas
* Hazelnut	(Corylus spp.)	exposed rocky places, open woods	heavy foliage, generally 5-12 feet high, good, adapts well to open environmental and thin subsoil.
* Common Juniper	(Juniperus communis)	dry sites, sometimes below 1000 feet elevation	low growing, possible establishment in bank protection areas.
* Mock Orange	(Philadelphus gordonianus)	shady place with fairly good soils, low elevations, borders of woods near streams and lakes	up to 12 feet high, intermediate to good.
Ocean Spray	(Holodiscus discolor)	dry forest openings or roadsides	shrubs to 15 feet high, possible use in berm areas, intermediate.
Red-berry Elder	(Sambucus racemosa)	coastal forest below 2000 feet elevation	shrubs 6-18 feet high, intermediate adaptability to dyke and bank area type environment.
* Red-osier dogwood	(Cornus stolonifera)	along shady creeks or damp lowlands	shallow rooting, adaptable to gravelly, thin subsoil 5-12 feet high, good.
Red Huckleberry	(Vaccinium parvifolium)	sometimes grows in fairly shady places but more often at edges of forest openings and roadsides, low altitudes	compact shrubs 3 to 6 feet high, poor in a very open environment.
Salal	(Gaultheria shallon)	grows well under cover or in a fog belt, coastal forests to approximately 2500 feet elevation	shrub up to 10 feet high, grows poorly in open environments.
Salmonberry	(Rubus spectabilis)	wet bottom lands or around edges of marshes and creeks, low elevations, good growth in heavy soils.	6 to 8 feet high, can produce a very dense thicket, intermediate.

Common Name	Scientific Name	Preferred Habitat	Comments Re: Suitability For Dyke and Bank Protection Areas
Thimbleberry	(Rubus parviflorus)	damp, shady places along road edges or forest openings	low shrubs 3-6 feet high, intermediate to poor in open, dry environments.
* Waxberry	(Symphoricarpos spp.)	dry open woods, low altitudes	low, bushy shrub 2-3 feet high, good, adaptable to gravelly thin sub soil.
C. TREES			
Red Alder	(Alnus rubra)	moist rich soil along the coast	up to 80 feet high, probable engineering objections: if tree falls, roots will pull up extensive amount of material.
Birch	(Betula papyrifera)	low ground at low elevations	up to 120 feet high, probable engineering objections, may not establish well.
Bitter Cherry	(Prunus emarginata)	low elevations to 3000 feet, low growing shrub on drier sites at higher elevations slender tree in damper environments	up to 60 feet high at the coast, engineering objections probable.
Cascara	(Rhamnus purshiana)	low elevation, wet climates	small tree to 30 feet high, has a water demand, could be suitable at the foot of the dyke.
Black Hawthorn	(Crataegus douglasii)	wet places, edges of streams and meadows, also along roadsides and fields	small, bushy tree to 20 feet high or lower shrub-like growth, good.
Northern Black Cottonwood	(Populus trichocarpa)	low and high altitudes along streams, flood plains, gravel bars or low-lying land	up to 120 feet high, grows well but probable engineering objections owing to size.

Common Name	Scientific Name	Preferred Habitat	Comments Re: Suitability For Dyke and Bank Protection Areas
Douglas Maple	(Acer glabrum)	moist packets on rocky slopes or shores	small tree or shrub up to 25 feet high, a possible species for berm areas, adapts to porous subsoils.
Willow	(Salix spp.)	along stream banks and and near other water sources	shrub or tree seldom more than 30 feet high, good, should be planted on river side of dyke, preferably in berm area.
Western Yew	(Taxus brevifolia)	low altitudes in Coast Forest zone, along river banks and damp canyons, seeks shade of other trees	small, bushy tree 15 to 30 feet high, may be very difficult to establish.

NOTES:

1. * indicates shrubs which would be most suitable for planting in conjunction with dyke and bank protection works.
2. Where applicable, the term good, intermediate and poor refer to a) the adaptability of the species to an open dyke-like environment, b) adaptability to the type of soils generally associated with dykes and bank protection works and c) the root characteristics of the species in terms of engineering criteria (i.e. shallow roots).
3. Sources: Brink, Dr. V.C., Agronomist, Department of Plant Sciences, University of British Columbia, Vancouver, B.C. Personal Communication.

   Garman, E.H. Pocket Guide to the Trees and Shrubs of British Columbia. British Columbia Forest Service, Department of Lands, Forests and Water Resources, Victoria, revised 1963.

   Lyons, C.P. Trees, Shrubs and Flowers to Know in British Columbia. J.M. Dent & Sons (Canada) Ltd. Vancouver, 1974.