Public Works Canada

Travaux Publics Canada

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Western Region Région de l'Ouest

FINAL DESIGN SUBMISSION

MACKENZIE HIGHWAY MILE 425.4 TO 448.0

AMENDED NOVEMBER, 1976

000008

Government of Canada / Gouvernement du Canada

MEMORANDUM **NOTE DE SERVICE**

TO / À

Mr. W. R. BINKS
Director, Transportation Program
Design and Construction
Public Works Canada
OTTAWA, Ontario

FROM / DE

Mr. F. E. KIMBALL
Manager
Highways Program
Public Works Canada
EDMONTON, Alberta

SECURITY CLASSIFICATION – DE SÉCURITÉ

OUR FILE – N/RÉFÉRENCE
6220-A3-B

YOUR FILE – V/RÉFÉRENCE

DATE
November 30, 1976

SUBJECT / OBJET

FINAL DESIGN SUBMISSION - MACKENZIE HIGHWAY
MILE 425.4 TO 448.0, NOVEMBER 1976

In accordance with the direction by the Director of Engineering and Architecture Branch, D.I.A.N.D., one set of design plans for contract purposes are enclosed. Thirteen copies of the narrative portion will be forwarded under separate cover.

One set of sepia mylar copies of the design plans for the above-mentioned submission will be forwarded to G. D. Reid for printing and distribution.

Copies of the plans and narrative will be sent to F. Janz, D.I.A.N.D., D.O.E. in Edmonton and Winnipeg and E.M.R. in Calgary.

F. E. KIMBALL
Manager
Highways Program

Encl.

FINAL DESIGN SUBMISSION

MACKENZIE HIGHWAY

MILE 425.4 TO 448.0

Amended: November, 1976

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INTRODUCTION

This Final Design, covering Mile 425.4 to 448.0 is the second submission for this section of the proposed Mackenzie Highway.

The changes from the Detail Design Data covering this section involves one major alignment revision in the vicinity of Wrigley, Mile 433.7 to 439.7 and two minor revisions, Mile 429.2 to 431.8 and Mile 440 to 442; several revisions to the vertical alignment; Special Requirements, Division 1, Section 1; General Requirements, Division 1, Section 2 and Standard Specifications, Division 9, Section 1 to 15.

The client's comments on the Final Design Submissions Mile 390 to 428 and Mile 428 to 470 have been responded to. The E.W.G. comments have been considered in preparation of this submission although detailed responses to individual comments are not included.

The reader should note that this report forms only part of a total design submission, the major portion of which is contained in separate plan form.

CHAPTER I

REFERENCE: Response to Information Omissions Noted in Letter of Direction for Final Design Submission, Mile 348 to 390, d.d. January 15, 1974.

INFORMATION OMISSIONS

The information omissions for the 'Final' Design Submission, Mile 348 to 390 noted in our letter to you dated January 15, 1974, have also been noted in this design submission. You are therefore requested to ensure this information is provided in subsequent submission for this section.

As noted in our letter of May 21, 1974, two sets of plans (one for review purposes and one for contract purposes) will be required in order to provide the requested information.

1. *Orthophoto Mapping*

   As the orthophoto mapping requested was not available at the time the interim final design submission was submitted, you are requested to submit the final design with the orthophoto mapping as soon as it becomes available.

   - Orthophoto mapping has been included on the Mile Sheets of the Final Design Submission, Mile 425.4 to 448.0 amended November, 1976.

   - The plans for contract purposes are not included at this time because of the indefinite deferral of construction in the area.

2. *Ditching*

(a) *The location and nature of all off-take ditches should be plotted on the orthophoto mapping to the detail and accuracy that can be determined from information available.*

- All off-take ditches have been plotted as requested.

(b) *Typical Design Details of other methods of special treatments for ditches that will be employed in addition to the variable spacing of ditch checks are requested.*

- Appendix "A" of this report describes the various methods proposed for special treatment for ditches. Typical details of ditch blocks, ditch checks and ditch linings are illustrated on the plan, "Typical Drawings for Erosion Control" contained in the Final Design Submission, Mile 425.4 to 448.0 amended November, 1976.

(c) *Please provide an explanation of how ditch checks will be protected against crest erosion whenever flow occurs during periods when culverts upstream from ditch checks are frozen solid together with more design information about ditch checks. In particular, details concerning size, shape, method of construction, composition, design lifetime and maintenance requirements are requested.*

- Appendix "A" of this report clarifies the intended meaning of a ditch check and the plan, "Typical Drawings for Erosion Control" contains typical

drawings of ditch blocks and ditch checks.

- Construction of the ditch block is similar to embankment construction. Details concerning size, slope and rip-rap are contained in the typical drawing of ditch blocks.

3. *Cross Sections of Cuts and Fills*

Please ensure that cross sections for all cut and fill sections over 15 feet are provided on all future design submissions. Please note that the letter of direction dated December 10, 1973, requested that the sideslope angles for the design sections, wherever possible, take into account the material type to be used in the cut or fill.

- Cross sections for cut and fill sections over 15 feet are not provided in this Design Submission.

- The cuts and fills will be constructed in accordance with the sections shown on the plan, "Typical Sections". The Field Engineer will if required, adjust the slope angles.

4. *Borrow Areas*

It is noted that all of the information requested by our Letter of Direction dated December 10, 1973, has been provided. All information available to D.P.W. should be submitted on the 1"=200' mapping. The information should continue to be shown on the 1"=1000' mosaics as well.

If at any time subsequent to the submission of a Final Design,

requirements for borrow areas additional to those shown on the design plans are identified, this Department should receive for approval:

(a) *a plan showing areas where new pits are to be developed accompanied by all the information required for borrow areas;*

(b) *a plan indicating those borrow areas that are to be increased in volume by a factor greater than three or in areal extent by a factor greater than three over the anticipated sizes indicated by the Final Design Submission along with all relevant information.*

- All information on borrow areas available to D.P.W. at the time of this Design Submission has been included on the 1"=200' orthomapping and on the 1'=1000' mosaics.

5. *Effects of Construction on Fish and Wildlife*

After consultation with the Canadian Wildlife Service and Fisheries Service you are requested to provide specific recommendations regrading limitations in construction operation, practice and scheduling to protect wildlife and fish.

Construction operation constrictions are specified in the Environmental Protection Schedule Restrictions, Division 1, Section 1 of the Contract Specifications.

6. *Waste Material Disposal Sites*

Information as requested by the letter of direction dated December 10, 1973, on waste material disposal sites other than borrow pits

was not provided with the design submission. It is understood that the only waste material disposal sites contemplated between Miles 348 and 390 are borrow pits. However, in such cases, written confirmation is requested.

Borrow pits have been chosen as disposal sites for waste material, for this section, Mile 425.4 to 448.0

7. *Submission of Final Design Plans*

As noted in the letter of May 21, 1974, two sets of plans (one for review purposes and one for contract purposes) will be required in order to provide the requested information.

The Client instructed that the special E.W.G. package be deferred for Mile 725 to 936. D.P.W. is also providing only one set of plans for the amended Final Design Submission Mile 425.4 to 448.

CHAPTER II

REFERENCE: Letters of Direction for Final Design Submissions, Miles 390 to 428, dated March 14, 1974.

I. *Information Omissions*

The information omissions for the 'Final' Design Submission, Mile 348 to 390 noted in our letter to you dated January 15, 1974, have also been noted in this design submission. You are therefore requested to ensure this information is provided in subsequent submission for this section.

The information requested is provided in Chapter I of this report.

It is noted that in order to provide the information requested two sets of plans may be required; one for review purposes and one for contract purposes. A final decision will be made when a full assessment of advantages and costs has been completed. This will be discussed further at the next meeting of the DRCC.

As for section, Mile 725 to 936, only one set of plans is included in this submission.

II. *Alignment*

(1) *Horizontal*

The horizontal alignment for Miles 390 to 424 has been previously approved. The section from Mile 424 to 428 falls within the Wrigley area where possible revisions are being

considered. Further alignment approvals in this area cannot be given at this time.

(2) *Vertical*

The vertical alignment in this section appears to be well integrated with the landscape and continuous with the horizontal alignment.

(1) Horizontal

No horizontal alignment revisions have been made between Mile 425.6 and 428.

(2) Vertical

Minor revisions to the vertical alignment have been made.

III. *Drainage*

(1) *Culverts*

(a) *It is requested that the culvert exit velocity at design discharge be provided for the following culverts:*

Mile 411.9
Mile 418.4
Mile 424.3

(b) *Concern is expressed that in some cases the culvert spacing may be extreme for the gradients encountered. The locations identified are:*

Mile 401-402	*Stations 329-364*
Mile 402-403	
Mile 413-414	
Mile 414-415	
Mile 425-426	

(c) A ditch check is required at Mile 399-400, Station 240.

(d) It is requested that the expected tailwater elevations for fish migration discharge be provided for the culverts located at the following mileages: 396.1, 406.2, 412.8, 422.7, 426.5 and 427.5.

(e) The culvert inlet velocity for both design discharge and fish migration discharge should be provided for all large culverts. The exit velocity at fish migration should also be provided for all large culverts.

(f) Significant differences have been noted between the drainage areas recommended for use by your hydrology consultant and those recommended by your environmental consultant for the culverts located at the following mileages: 396.1, 407.5, 418.4 and 419.5. Please request your consultants to verify their information on these culverts.

(g) In addition to the culverts recommended by your environmental consultants for fish migration design, those located at Mile 392.0, 396.1 and 412.8 are also to be designed for fish migration.

(h) It is noted that at a number of locations, your hydrology consultant has recommended baffle installation to allow for fish migration rather than reducing the slope of the culvert. At this time, it is not known if baffle installation will produce satisfactory results. Further

direction will be forthcoming when the MHEWG have fully evaluated their Baffle Study.

(*i*) *When streams are identified as having moderate to high fishery potential, scheduling constraints should be indicated. If scheduling constraints are not considered important at a particular culvert, it should be so indicated. For the design submission Mile 390-428, scheduling constraints have not been indicated for the culverts located at the following mileages: 392.0, 394.7, 406.4, 407.5, 411.6 and 412.0.*

(1) Culverts

(a) This area is outside the limits of this Design Submission.

(b) Culverts have been added for section Mile 425 to 426.

(c) This area is outside the limits of this Design Submission.

(d) Tailwater elevation are shown on the special culvert drawings.

(e) Inlet and outlet velocities for design and fish migration discharge are shown on the special culvert drawings.

(f) This area is outside the limits of this Design Submission.

(g) This area is outside the limits of this Design Submission.

(h) No D.P.W. response required.

(i) This area is outside the limits of this Design Submission.

(2) *Special Treatment of Ditches*

(a) Appropriate special ditch treatment and silt trapping devices should be shown for Mile 426.5, Stations 1654-1659 and Stations 1667-1689.

(b) There appears to be a contradiction between two tables in the Detail Design Data Report. Table on page 49 shows several sections where the average slope exeeds 4% while table C-1, Appendix "A" indicates that gradients should not exceed 4% for any drainage course.

(2) Special Treatment of Ditches

(a) Special treatment for planned ditches has been identified in accordance with Appendix "A" of this Design Submission for the following locations. There are some changes from the previous Design Submission due to change in gradeline.

Mile	Station	Average Slope %	Estimated Discharge in C.F.S.	Ditch Protection or Ditch Creek Spacing
426-427	1655-1658	4.5	1	Coarse Gravel
	1666-1677	3.0	2	Coarse Gravel
427-428	1704-1713	3.2	7	Coarse Gravel
	1719-1726	1.8	4	60'
	1733-1741	4.0	3	Coarse Gravel

(b) Table C-1's reference to maximum gradients of 4% applies to drainage courses of depth up to three feet. Flows of 7 C.F.S. in a 12 foot wide ditch will have depth of flow considerably less than three feet. D.P.W. does not anticipate problems with the ditch design gradients on this section.

IV. Soils

(a) We wish to reiterate our concern that D.P.W. design teams allow for a general greater distribution and generally larger ice contents in fine-grade soils then reported by the consultants.

(b) No geo-technical information has been provided for Mile 393 to 395. The geo-technical information previously collected in this area should be shown on the next design submission for this section.

(c) Geo-technical information has not been collected for Mile 419 to 427 due to its closeness to the Wrigley area. Once the alignment in this area is approved for investigation, appropriate geo-technical information should be collected.

(a) The design in this Design Submission does reflect on the geo-technical information obtained by D.P.W.

(b) This area is outside the limits of this Design Submission.

(c) Geo-technical information has now been obtained for this section.

V. *Borrow Areas*

1. *Location of Pits*

(a) *The proposed borrow pit located at Mile 391 should be located so as not to encroach upon the stream banks and to avoid any disturbance to, or siltation of, the stream.*

2. *Location of Borrow Area Access Roads*

(a) *It is understood that the borrow pit at Mile 406.1 is not being used due to its high moisture content. However, should the pit be used consideration should be given to relocation of the access road as originally proposed on the Final Design for the Training Section Mile 399 to 410.9.*

(b) *The access road to the borrow pit at Mile 399 should be relocated or a culvert installed in the access road to accommodate fish migration.*

1. Location of Pits

(a) This area is outside the limits of this Design Submission.

2. Location of Borrow Area Access Roads

(a) This area is outside the limits of this Design Submission.

(b) This area is outside the limits of this Design Submission.

VI. *Wildlife and Fish Resources*

(a) *As requested by our letter of direction dated January 15, 1974,*

D.P.W. are to consult with the Canadian Wildlife Service and Fisheries Service and provide specific recommendations regarding limitations in construction operation, practice and scheduling to protect fish and wildlife.

(b) It is requested that the detailed information on wildlife and fish resources gathered by your consultants be made available to the Canadian Wildlife Service and Fisheries and Marine Service respectively, to enable these agencies to adequately assess the data provided on the Environmental Data Sheets. Such information should include data regarding beaver and water-fowl concentrations for evaluations of wildlife resources. For evaluation of fish resources, the information should include the number of visits to a site, dates, numbers of fish observed/caught, species and age.

(c) At Mile 395.9 the Right-of-Way crosses a lake outlet near a presently active beaver dam. Disturbance of this dam should be avoided.

(d) The preliminary design submission had identified trap lines extending along the CNT line and proposed highway near the Willowlake River. The final design submission now states "No anticipated trapline conflict. Main trapping area is far to the east of ROW location." Please explain whether there are no anticipated trapline conflicts along this entire section or just at Mile 395 and if there are no anticipated conflicts, why the change from the preliminary design assessment.

(a) Construction operation constrictions based on recommendations from Canadian Wildlife Service and Fisheries Service are specified in the Environmental Protection Schedule Restrictions, Division 1, Section 1 of the Contract Specifications.

(b) Base data compiled by D.P.W.'s Environmental Consultant has been forwarded to interested agencies.

(c) This area is outside the limits of this Design Submission.

(d) The area concerned with is outside the limits of this Design Submission.

VII. *Sensitive Areas*

(a) All disturbances of the ground surface and vegetation mat should be minimized. All travel along the C.N.T. line and the highway R.O.W. prior to construction should be kept to a minimum.

(b) Concern is expressed that flow slides may occur in fine grained soils with high water content. In these areas special precautions or construction techniques may be necessary. The areas identified are:

Mile 413-414	*Stations 955-960*
	Stations 960-970
Mile 414-415	*Station 1017+80*
	Station 1027+00
Mile 427-428	*Stations 1704-1715*

(c) *Future design submissions are to identify sensitive areas which would be particularly vunerable to clearing one year or more in advance of construction.*

(a) Disturbance of the ground surface and vegetation will be minimized.

(b) Only the area of concern, Mile 427 to 428, Station 1704-1715, is within the limits of this Design Submission.

The gradeline has been adjusted in this area to reduce the length of cut in the section showing soil with high water content.

(c) No comments required from Department of Public Works.

VIII. *Aesthetics*

Appropriate selective clearing and revegetation procedures will be carried out after roadbed construction, with appropriate field supervision required to supervise the integration of the highway into the surrounding landscape.

Borrow pits on eskers and drumlines should be located on the crest of the land forms or excavation carried out, to the extent possible, in such a manner as to maintain the natural land form shape.

The above recommendations will receive due consideration.

IX. *Sequential Land Use of Construction Camp Sites*

It is noted that the information requested by Recommendations 44 and

45 of our letter of direction dated December 10, 1973, has not been provided.

In this regard, recommended sites for maintenance depots should be developed in conjunction with Mr. John Hamilton. Camp sites identified as a result of discussions with the pipeline consortium for possible use in a pipeline construction program should be indicated on the design plans.

All other sites will be rehabilitated in accordance with directions to be given by field representatives of this Department.

A separate committee was formed by I.A.N.D. to select sites for roadside development. No decisions have been received from the committee.

X. *Willowlake River Crossing, Mile 393-399*

(a) *The horizontal alignment in this area has been previously approved. We are also in agreement that the steep gradients should be reduced if at all possible and the new design submitted for approval.*

(b) *The geo-technical information available for the area Mile 393 to 395 should be shown on the design plans.*

(c) *It is understood that the complete area around Fort Alexander, and hence the revised routing, has been archaeologically*

surveyed and the only archaeological site identified was flagged. We would appreciate reviewing written confirmation of this.

(d) It is noted that in order to reduce the gradients it might be necessary to undertake stream diversions. In order to assess proposed diversions the following information is required:

(i) A contoured location map at an appropriate scale, but in any case not smaller than 1:12,000 and with contours at five or ten foot intervals;

(ii) A map of soils and surficial geology of the diversion route. This map should include a description of the ground ice content of the diversion route, and of potential slope stability problems;

(iii) Hydrological data on the stream to be diverted, and on the stream into which the water will flow;

(iv) Information on the potential of both these streams for fish use, and on the actual use made by fish;

(v) Information on the possible effects of the proposed diversion on wildlife and waterfowl.

(e) Slope stabilization measures should be undertaken immediately after excavation of the cuts is completed. The stabilization techniques should take into account the revegetation study currently in progress.

(f) The borrow pits at Mile 395.1 and Mile 395.4 should be the first pits eliminated should the cuts produce sufficient

quantities of borrow material such that additional material from off the right-of-way is no longer required.

(g) *Consideration should be given to incorporating a runaway lane at Mile 396 to 397, Station 96.*

This area is outside the limits of this Design Submission.

CHAPTER III

REFERENCE: Letter of Direction for Final Design Submission Mile 428 to 470, d.d. June 15, 1974.

I. *Information Omissions*

The information omissions for the 'Final' Design Submission, Mile 345 to 390 noted in our letter to you dated January 15, 1974, have also been noted in this design submission. You are therefore requested to ensure this information is provided in the subsequent submission for this section.

The information requested is provided in Chapter I of this report.

It is requested that two sets of plans be used in the submission of this information, one for review purposes and one for contract purposes.

The Client instructed that the special E.W.G. package be deferred for Mile 725 to 936. D.P.W. is also providing only one set of plans for the amended Final Design Submission Mile 425.4 to 448.

II. *Alignment*

1. *Horizontal*

The horizontal alignment from Mile 445 to 470 has been previously approved. The section from Miles 428 to 445 falls within the Wrigley area where possible alignment revisions are being considered. Further alignment approvals in this

area cannot be given at this time.

The horizontal alignment has been revised to the east of the original alignment between Mile 433.7 to 439.7. The proposed crossing of the Hodgson Creek is approximately 2,800 feet upstream from the old crossing.

Two other crossings of Hodgson Creek in the vicinity of the proposed crossing will be investigated prior to construction.

While other aspects of the alignment alternates shown for Smith Creek remain to be evaluated, alternate 2 is preferable from a recreational and aesthetical point of view.

The horizontal alignment at Smith Creek has been revised to the west of the old slide area on the south bank of the river. Another alignment to the west of the proposed alignment will be investigated prior to construction.

2. *Vertical*

The vertical alignment within the approved section appears to be well integrated with the landscape and continuous with the horizontal alignment.

Some minor changes to the vertical alignment have been made.

3. *Typical Cross Sections*

Typical cross-sections have not been provided for the approach

cuts and fills at a number of stream crossings which require bridges. It is recognized that this is due to the fact that bridge design elevations had not been firmly established when the roadway design was submitted for review. It is requested that these typical cross sections be provided with the amended final design submission or as part of the bridge design submission.

- Typical cross sections for cut and fill sections have not been provided in this Design Submission.

- The cuts and fills will be constructed in accordance with sections shown on the plan, "Typical Sections". The Field Engineer will, if required, adjust the slope angles.

III. Drainage

1. Culverts

(a) It is requested that culvert inlet velocities for design discharge be provided for all large culverts and that inlet velocities and exit velocities be provided at fish migration discharge for those culverts subject to fish migration criteria. Please note that this is a change from an earlier request that culvert inlet velocities be provided at fish migration discharge for all large culverts.

The above request has been included in the special culvert sheets contained in this Design Submission.

(b) It is agreed with your environmental consultants that only

the culverts located at Mile 461.6 and Mile 469.0 require fish migration design. However, the proposed use of baffles may not prove to be satisfactory. As of this date, the final results of the MHEWG sponsored Baffle Study are not available.

This area is outside the limits of this Design Submission.

(c) *Fisheries Service have suggested that a wide span elliptical culvert would be preferred at Mile 461.6. We would appreciate receiving your comments regarding the feasibility of using such a culvert at this location.*

This area is outside the limits of this Design Submission.

(d) *When streams are identified as having moderate to high fishery potential, scheduling constraints should be indicated. If scheduling constraints are not considered important at a particular culvert, it should be so indicated. For the design submission Mile 428 to 470, scheduling constraints have not been indicated for the culverts located at the following mileages: 430.0, 436.5, 454.6, 459.7, 461.6, 469.0.*

Scheduling constraints based on the recommendation from Fisheries Service are specified in the Environmental Protection Schedule Restrictions, Division 1, Section 1 of the Contract Specifications.

2. *Special Treatment of Ditches*

(a) *Appropriate silt trapping devices should be installed to ensure that silt does not enter the stream at Mile 469.0.*

This area is outside the limits of this Design Submission.

(b) *There are a number of locations where large cuts are proposed which will concentrate runoff water into ditches. Concern has been expressed that sufficient protection should be provided at the ditch outlet to achieve dispersion of this flow without undue erosion. Please indicate how this protection will be achieved.*

The use of through grade culverts, ditch blocks and off-take ditches at the upper end of large cuts will minimize run-off water from entering these cut sections. During the preconstruction surveys the field construction engineer will also determine the need for upslope interceptor ditches along the right of way parallel to the cut section, to divert larger quantities of run-off water away from these areas. Where undue erosion is anticipated at ditch outlets, ditch blocks will be provided to reduce water velocities and to disperse the water onto the vegetated ground.

Special treatment for planned ditches has been identified in accordance with Appendix "A" of this report.

Note there are some changes from the previous Design Submission due to vertical and horizontal alignment changes.

Mile	Station	Average Slope %	Estimated Discharge in C.F.S.	Ditch Protection or Ditch Check Spacing
429-430	1806-1819	5.4	6	Cobbles
	1841-1845	0.4	2	Coarse Gravel
430-431	1849-1856	5.6	2	Coarse Gravel
	1870-1977	3.7	1	Coarse Gravel
433-434	2042-2052	2.2	7	Coarse Gravel
	2052-2061	1.4	5	80'
436-437	2165-2173	3.1	12	Coarse Gravel
	2199-2206	3.0	8	Coarse Gravel

(c) *Concern is expressed that at Mile 440-441 Station 325 to 347 an additional culvert may be required as the culvert spacing may be extreme for the gradients encountered.*

The horizontal alignment has been revised on this section.

(d) *A significant difference exists between the drainage area determined by your consultant and that determined by the Hydraulic Assessment Sub-Group for the culvert at Mile 448.2. Please request your consultant to verify their information on this culvert.*

This area is outside the limits of this Design Submission.

(e) *At mile 469, Station 1174+25 the plan profile sheets indicate a spring on the east side of the grade. Please indicate how the flow from this spring will be handled.*

This area is outside the limits for this Design Submission

IV. *Soils*

(a) *Additional geotechnical data is required for the revised alignment from Miles 445 to 447 (Revision B19) including deep hole information for the cut at Station 120 to 136 and Miles 460 to 462 (Revision B22). This information should be collected when the additional geotechnical information required for the Wrigley area is collected.*

Additional geotechnical data has been obtained.

(b) *Additional geotechnical information is also required for the deep cuts proposed north of Hodgson Creek at Station 2220 and north of Ochre River at Station 627. Each of these cuts should have at*

least one borehole extending 15 feet below the gradeline.

The horizontal alignment has been changed at Hodgson Creek.

(c) *It is requested that information on the nature of vegetation may be provided for locations where cuts having vertical backslopes are proposed.*

Vertical backslopes are not proposed on the section covered by this Design Submission.

(d) *You are referred to the discussion in the attached report, on the use of vertical backslopes at Mile 453 and Mile 469. In the light of existing geotechnical information, it is felt that the locations selected for the use of vertical backslopes may not achieve the desired results. The use of vertical backslopes should be reconsidered and further drilling undertaken prior to or during construction to confirm the suitability of the design by gathering more information of ground ice at these locations.*

This area is outside the limits of this Design Submission.

(e) *At locations where vertical cuts are proposed, adequate silt traps should be provided to prevent silt from entering adjacent streams.*

Vertical cuts are not proposed on the section covered by this Design Submission.

(f) *D.P.W. have previously indicated that additional geotechnical data was planned for collection at Mile 459, Stations 884 to 890.*

If collected, this information has not been made available to date. If the information is still outstanding, it should be collected with the additional work required in the Wrigley Area.

This area is outside the limits of this Design Submission.

(g) *Please indicate if a quarry site is now proposed within the section Miles 443 to 446. If a site is proposed, please provide what information is available to D.P.W. concerning the site.*

At this time quarry sites are not proposed within the section Miles 443 to 446.

(h) *The borehole information indicates locally high ice content soils at Mile 463, Stations 1084+00 to 1092+00. The cut at this section should be replaced by overlay construction to minimize thermal erosion.*

(i) *Concern has been expressed that locally high ice content soils may exist in the cut area proposed at Mile 461, Stations 984+00 to 997+00. The advisability of a cut at this section will have to be confirmed by the geotech information to be collected on the revision from Miles 460 to 462.*

(j) *Concern has also been expressed that locally high ice content soils may exist in the cut and fill area proposed at Mile 448, Stations 264+00 to 311+00. As it is impractical to completely avoid excavation in this area, please indicate what action could be taken to minimize thermal erosion should ice rich soils be encountered in the cut areas during construction.*

The areas concerned with in paragraph (h), (i) and (j) above are outside the limits of this Design Submission.

V. Borrow Areas

1. Location

(a) *For all borrow areas located near streams or water bodies adequate sediment trapping devices should be installed and maintained. Adequate supervision should also be maintained during borrow pit operation so as to minimize potential erosion and siltation problems.*

Steps will be taken to minimize siltation into water bodies resulting from excavation of borrow areas.

(b) *The borrow area located at Mile 454.2 should be located so as not to encroach upon the stream bank and to avoid any disturbance to, or siltation of, the stream.*

(c) *The borrow area at Mile 469.0 should be relocated to ensure a greater distance from the stream entering the Mackenzie River at this location.*

The areas concerned with in (b) and (c) above are outside the limits of this Design Submission.

2. Location of Borrow Area Access Roads

(a) *The access road for the borrow area proposed at Mile 454.2 should be relocated so as not to closely parallel the stream.*

(b) *The more northerly access road to the borrow area at Mile 463.8 which necessitates crossing a stream, should be eliminated.*

The areas concerned with in (a) and (b) above are outside the limits of this Design Submission.

VII. *Wildlife Resources*

The report Basic Environmental Data, Folio 1, November 1972 by F. F. Slaney indicated a potential impact area at Mile 445 to 446 due to raptor (nesting) throughout the area. The Environmental Data Sheets accompanying the Final Design Miles 428 to 470 make no mention of raptor nesting at this location. Please explain this difference between the preliminary and final designs.

Our Environmental Consultant identified the area Mile 445 to 446 as being a potential nesting area for raptors. However, no raptor nesting has been identified in this area.

VIII. *Aesthetics*

(a) *When clearing areas where vertical backslopes are to be used, please ensure that sufficient treed vegetation is hand cut, with stumps as described in Specification for Hand Clearing, March 1973, to prevent trees from slumping into the ditches.*

(b) *Where possible borrow pit access roads should follow existing man-made openings such as geotech, access roads or seismic lines.*

(c) *Appropriate selective clearing and revegetation procedures will be carried out after road bed construction.*

The above recommendations will receive due consideration.

CHAPTER IV
DESIGN COMMENTS

1. Alignment

(a) Horizontal

The horizontal alignment has been revised at three locations between Mile 425.4 and 448.0. Between Mile 429.2 and 431.8 the alignment has been revised to the west, away from the old slide area on the south bank of Smith Creek. A projected alignment to the west of the now proposed alignment will be investigated further prior to construction. Between Mile 433.7 and 439.7 the alignment has been revised to the east of the original alignment to reduce the impact on the Community of Wrigley. From Mile 440 to Mile 442 the alignment has been shifted to the east, away from two of the lakes in the area.

(b) Vertical

The changes to the vertical alignment do reflect on the additional geotechnical obtained. Sections Mile 443.4 to 443.7 and Mile 446.6 to 446.9 should be investigated prior to construction to determine if R.O.W. cuts are feasible.

Sixty (60) m.p.h. minimum design speed has been used except for where a lower design speed resulted in significant reduction in embankment quantities. Say design speed has been reduced to 55 m.p.h.

2. Drainage

Site specific designs have been provided for all proposed culverts 72" diameter and larger. This in general corresponds to drainage areas greater than 0.7 square miles, although drainage from one larger than the above minimum has been handled by multiple smaller culverts.

Drainage areas have been estimated using 1"=50,000' maps and 1"=3000' aerial photography. Design discharges have been estimated using the curves for 50 year flood and 50 year, 7 day delay discharge shown in Figure 2, of D.O.E.'s report of February 1975, "Mackenzie Highway Project, Tentative Guidelines for Culvert Design".

Drainage areas and design discharges used for design are summarized in Appendix "B" - Hydrology Summary.

Other information including inlet and outlet velocities at design discharge and where applicable at fish migration discharge is shown on the respective culvert drawings.

3. Soils

Some roadway excavations into ice-rich fine-grained are planned to improve the vertical alignment and to minimize construction costs. The subgrade will here be subexcavated to depth determined by the engineer, and the subexcavation backfilled with imported material if required. The ditches and backslopes will be blanketed

with imported material where in the opinion of the engineer this is required.

Applicable geotechnical information collected along and near the centreline and within the proposed borrow areas has been shown on the plans. Where information is lacking, additional investigations are proposed prior to construction.

4. Borrows

Approximate borrow pit outlines and access roads are shown on the Environmental Data Sheets and borehole logs are shown on the 1"=1000' mosaics.

Alternate areas, outlined in the D.P.W. Report "Geotechnical Investigation Mile 347 to Mile 690 Mackenzie Highway" may be investigation prior to construction. In particular sources of borrow on the section between Mile 440 and 446 will be investigated further.

Borrow requirements and approximate pit sizes are shown below. Quantities shown include allowances for stripping. R.O.W. borrow is not shown.

Mile	Quantity	Depth	Cleared Area (Acres)
426.5	145,000	30	6.1
429.3	65,000	18	4.5
434.8	79,000	19	5.0
435.9	52,000	20	3.9
438.8	58,000	20	4.1

Mile	Quantity	Depth	Cleared Area (Acres)
439.9	204,000	30	8.0
442.4	304,000	29	11.0
447.0	221,000	30	8.6

APPENDIX "A"

SPECIAL DITCH TREATMENT

AMENDED: June, 1974

SPECIAL TREATMENT FOR DITCHES

Roadway and offtake ditches are often necessary elements in highway design and construction. These ditches require the removal of the vegetative cover from their respective areas, thus increasing the potential for scour erosion. This scour erosion in highway ditches is dependent upon numerous factors including discharge, channel gradient, sediment in water, soil characteristics such as grain size, density, organic binder, cementation and ice content. Some methods used in highway construction to control or prevent scour erosion are: blanketing the ditch floors with stable, free-draining granular materials, reducing the effective ditch gradient by constructing a series properly spaced ditch checks on the ditch floor and by diverting run-off water out of the ditch onto natural vegetation by using ditch blocks.

Design equations exist for open channel flow, which relate flow velocity to the gradient and cross-sectional configuration of the channel. The Manning formula, is such an equation and is commonly employed for open channel flow calculations. The formula is as follows:

$$V=(1.486/n) \quad R^{2/3} \quad S^{1/2} \quad (1)$$

where V=velocity of water, in feet per second

R=hydraulic radius (water area divided by wetted perimeter)

S=slope of channel gradient, in feet per foot.

n=Coefficient of Roughness (Manning's "n")

One of the principles followed in designing the Mackenzie Highway was to avoid excavation in permafrost wherever and whenever possible. Therefore, the use of standard engineering texts for use in non-permafrost areas was considered applicable for deriving ditch lining and ditch check spacing charts for the Mackenzie Highway.

When cuts through ice-rich permafrost areas are unavoidable it is intended to sub cut and back fill with a sufficient depth of ice-free material, which would provide soil conditions similar to non permafrost areas.

The Handbook of Steel Drainage and Highway Construction Products, second Edition, 1971, lists limiting velocities for non erosion of channels. The following tabulated Manning's "n" and limiting velocities for the general soil types found on the Mackenzie Highway right-of-way are excerpts from this Handbook.

TABLE 1

Material	Manning "n"	Velocity ft./sec. For Clear Water
Fine sand	.020	1.50
Silty sand	.020	1.75
Fine gravel	.020	2.50
Stiff clay	.025	3.75
Coarse gravel Well graded gravel	.025	4.00
Cobbles	.035	5.00
Shale, hard pan	.025	6.00

Using the limiting velocities as tabulated above and Manning's formula, discharge versus gradient curves were calculated for a twelve foot wide "B" type road ditch. (See figure 2).

Ditch Lining

For a given soil type a curve in Figure 2 indicates the limiting discharge for a given gradient above which scour erosion may occur. Therefore, theoretically, by lining the ditch with an adequate depth of material selected higher in the graph scour erosion should be arrested or minimized.

Ditch Checks

As an alternate to ditch lining ditch checks, within their limits, would be adequate and possibly more economical in some areas for scour prevention.

See Figure 7 of this report for a schematic explanation of ditch check theory.

Figures 3 to 6 inclusive of this report are recommended ditch check spacing charts calculated for discharges up to 20 c.f.s. over various soil types. The derivation of these ditch check spacing charts was based on the effective gradient required for non-erosion of a soil type at a given discharge.

Due to the physical limitations of the highway ditch depth the ditch check crest is one foot above the ditch floor. A forty-foot minimum spacing of ditch checks was considered to be reasonable for construction, maintenance and effectiveness.

Discharge Determination

The Rational formula developed in 1889 by sewage engineers is probably the most widely used formula for estimating discharges. The formula is:

$$Q = CiA. \qquad (2)$$

where Q = discharge in c.f.s.

C = the run-off coefficient

i = the intensity of rainfall in inches per hour.

A = the drainage area in acres.

This approach with the following modifications was considered to be an acceptable one for small drainage areas up to about one square mile.

Bolter, Parish, Trimble, consulting engineers, have in their publication, Hydrology Study and Design of Culverts, Mile 297 to Mile 345, Mackenzie Highway, November, 1972, developed a modified Rational formula for large drainage areas in the following form: $Q_i = 26.7\ ARr\ (100 - L)\ M$ (3)

where Q_i = maximum instantaneous discharge - c.f.s.

A = drainage area - square mile

R = rainfall in 24 hours

r = rainfall reduction factor

L = percent water loss

M = conversion factor mean daily discharge to maximum instantaneous.

Rationalizing the variables in the above formula as they are effected in the Mackenzie Valley small drainage areas the following empirical formula was developed for estimating small drainage area discharges:

$Q = .584\ CA$ (4)

where Q = maximum instantaneous discharge in c.f.s.

C = run-off coefficient

A = drainage area in acres.

(a) - ".584" is the resultant of 26.7, R, r, M and the conversion of square miles to acres $(\frac{1}{640})$

"R" - 4 inches per 24 hours was considered a conservative estimate.

"r" - 1.0 was used since no appreciable reduction can be expected in small drainage areas.

"M" - a value of 3.5 was considered conservative for small drainage areas.

(b) - "C" - run-off coefficient is similar to (100-L). Bolter, Parish, Trimble arrived at an "L" value of 75% for large drainage areas (550 acres and greater). The accepted run-off coefficient for concrete and pavement is 0.8 suggesting a water loss of 20%. It was considered conservative to use this 20% water loss for drainage areas of 45 acres and less. Joining these limits with a porabolic curve, expected water losses for intermediate drainage areas were interpolated and converted to the following run-off coefficients:

TABLE 2

Expected run-off coefficients for small drainage areas in the Mackenzie Highway

Acres		"C"
Up to 45	-	0.80
Up to 98	-	0.65
Up to 222	-	0.50
Up to 550	-	0.25

The selection of a particular type of ditch treatment or whether it is required will ultimately rest on the experience of the resident engineer.

Figure 2

LIMITING CHANNEL GRADES FOR THE DESIGN OF "B" TYPE DITCHES

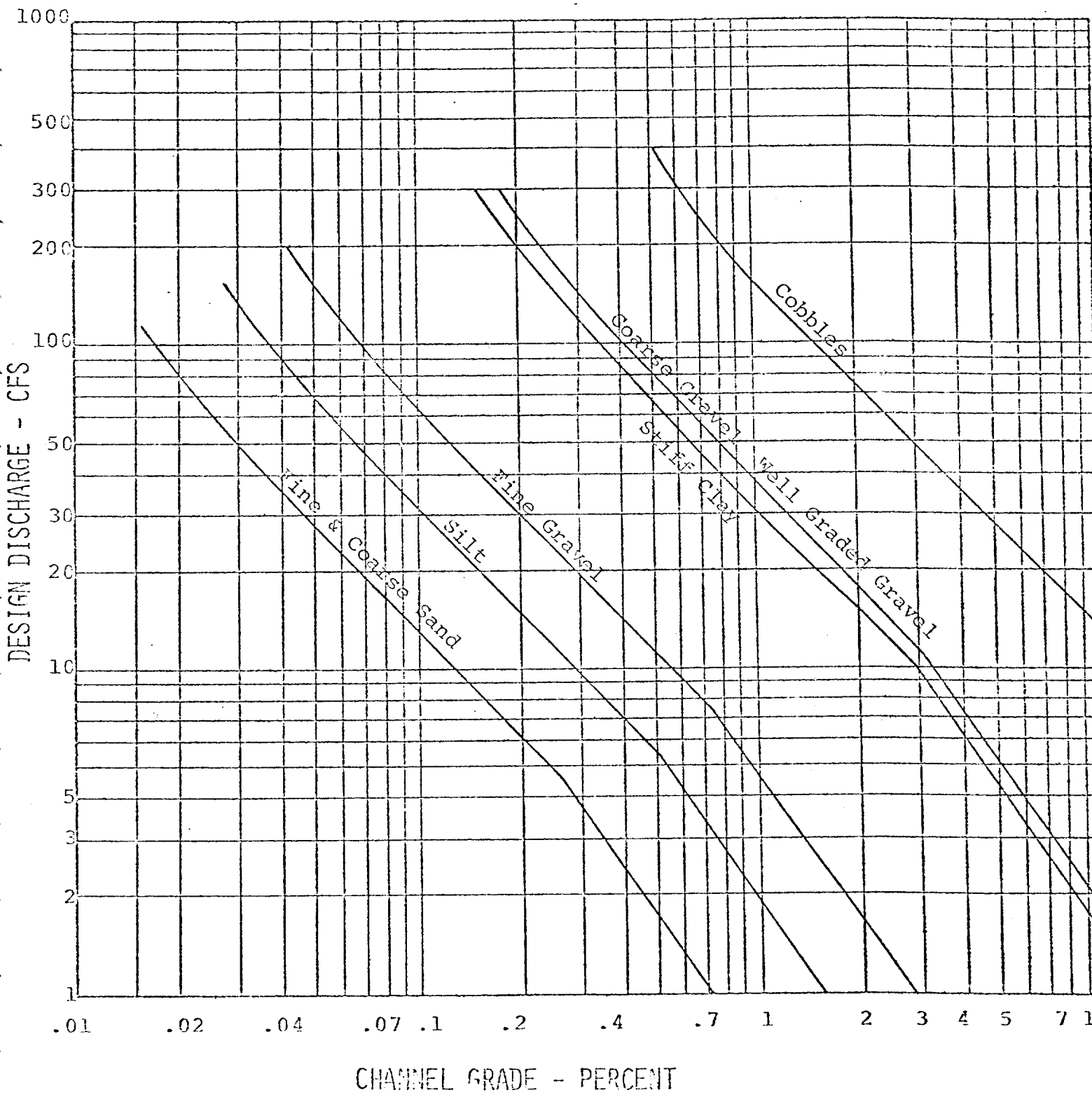


Figure 3

DITCH CHECK SPACING

(DESIGN DISCHARGE - 3 CFS)

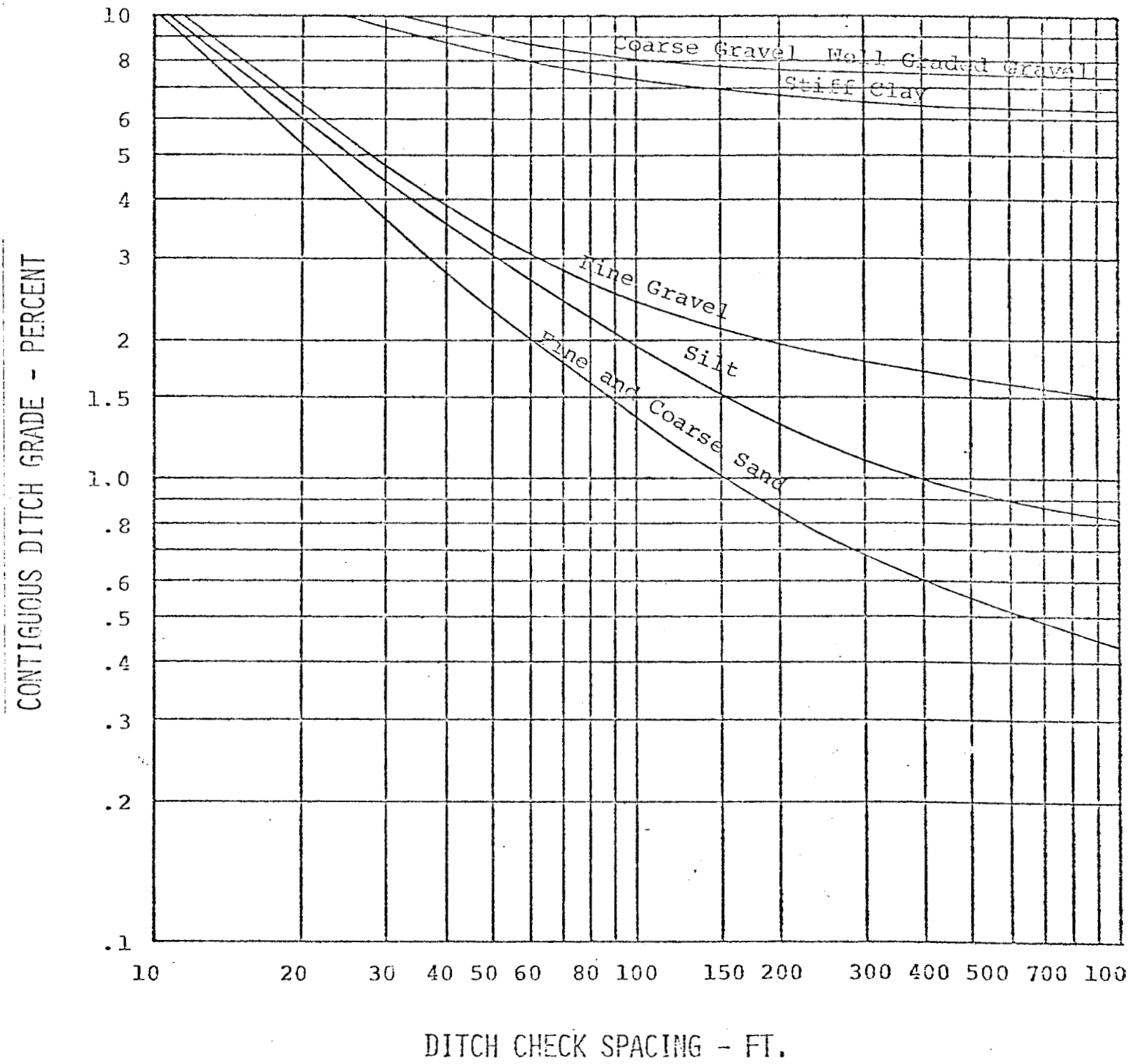


Figure 4

DITCH CHECK SPACING

(DESIGN DISCHARGE - 5 CFS)

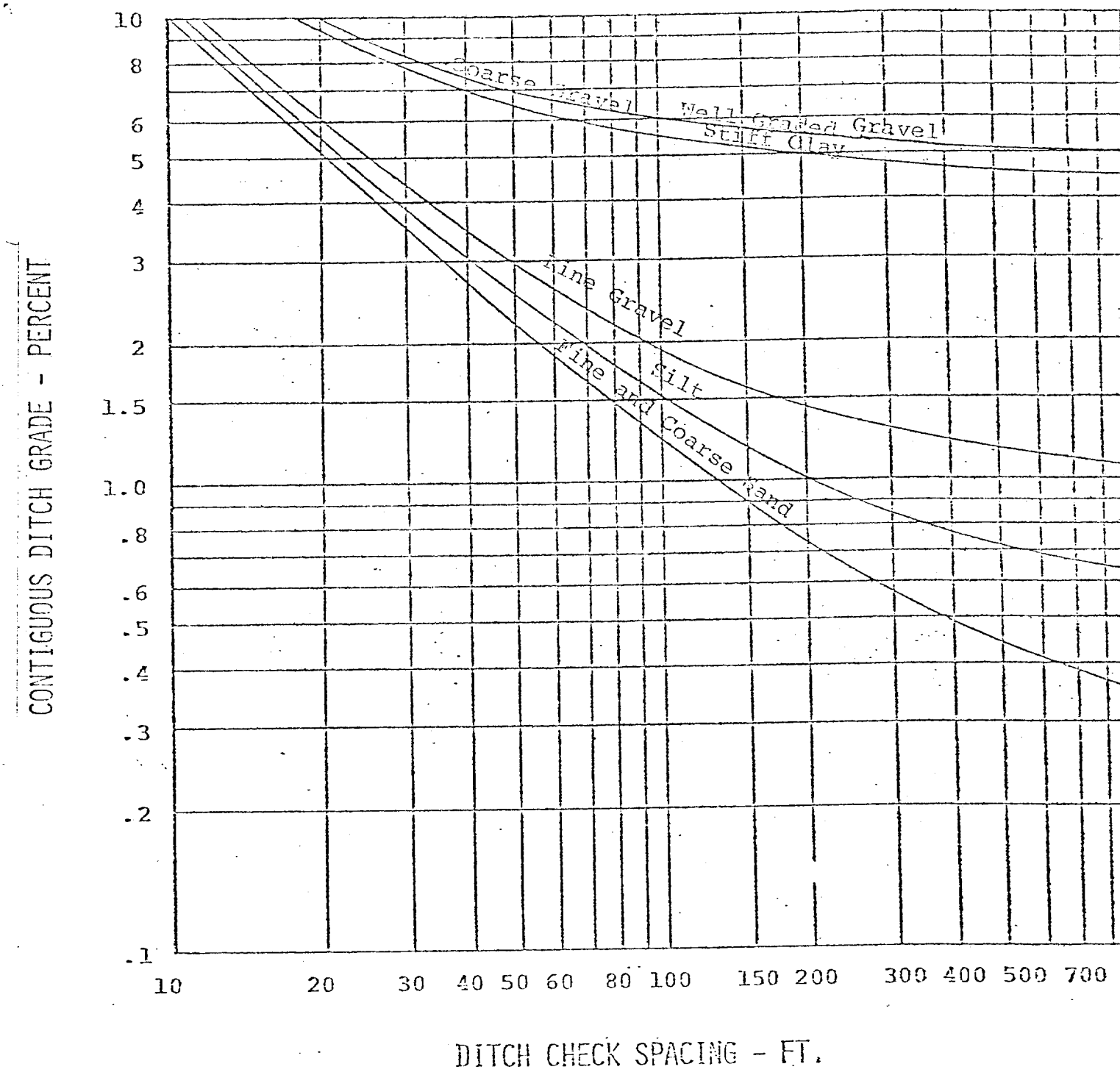


Figure 5

DITCH CHECK SPACING

(DESIGN DISCHARGE - 10 CFS)

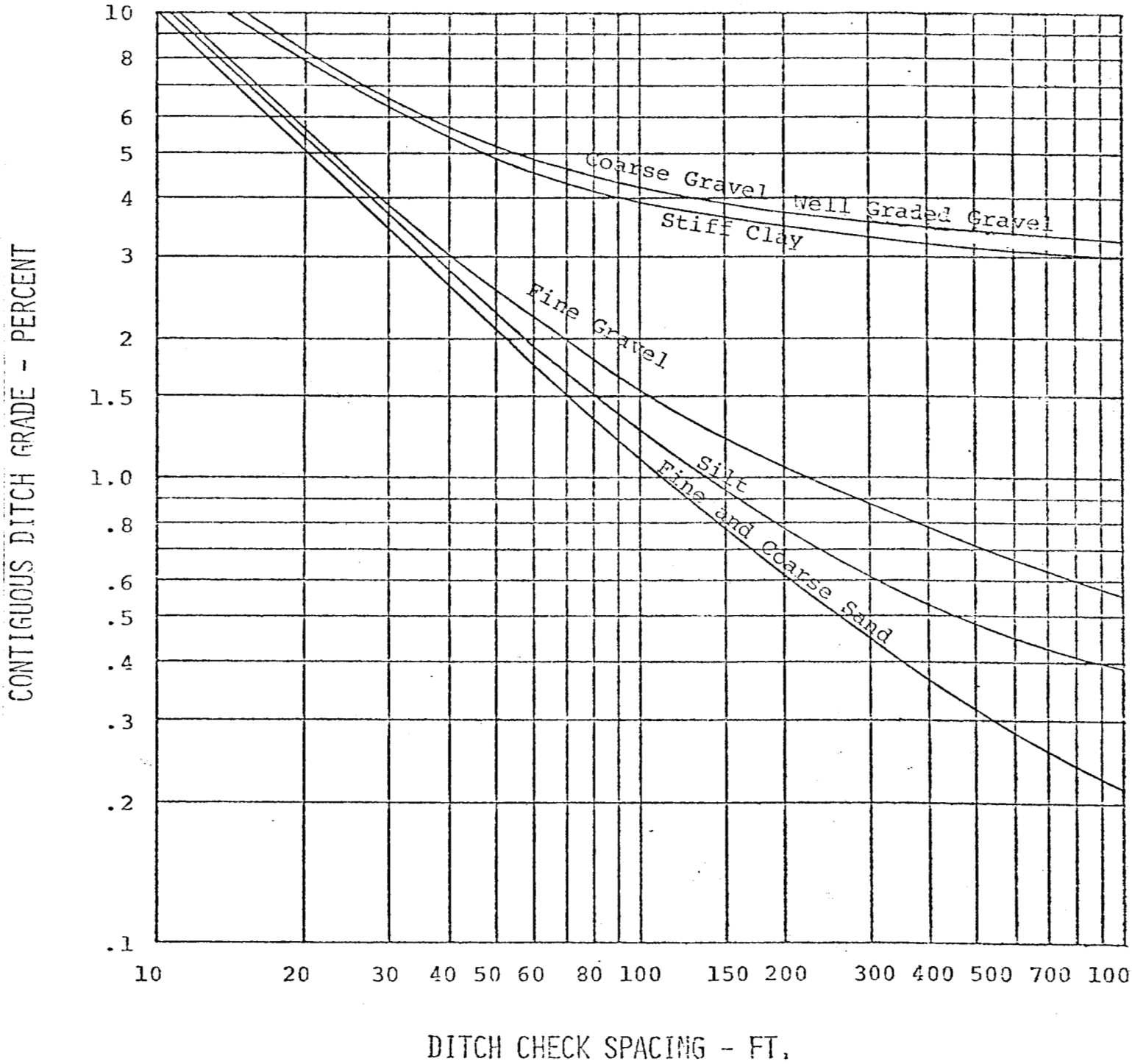


Figure 6

DITCH CHECK SPACING

(DESIGN DISCHARGE - 20 CFS)

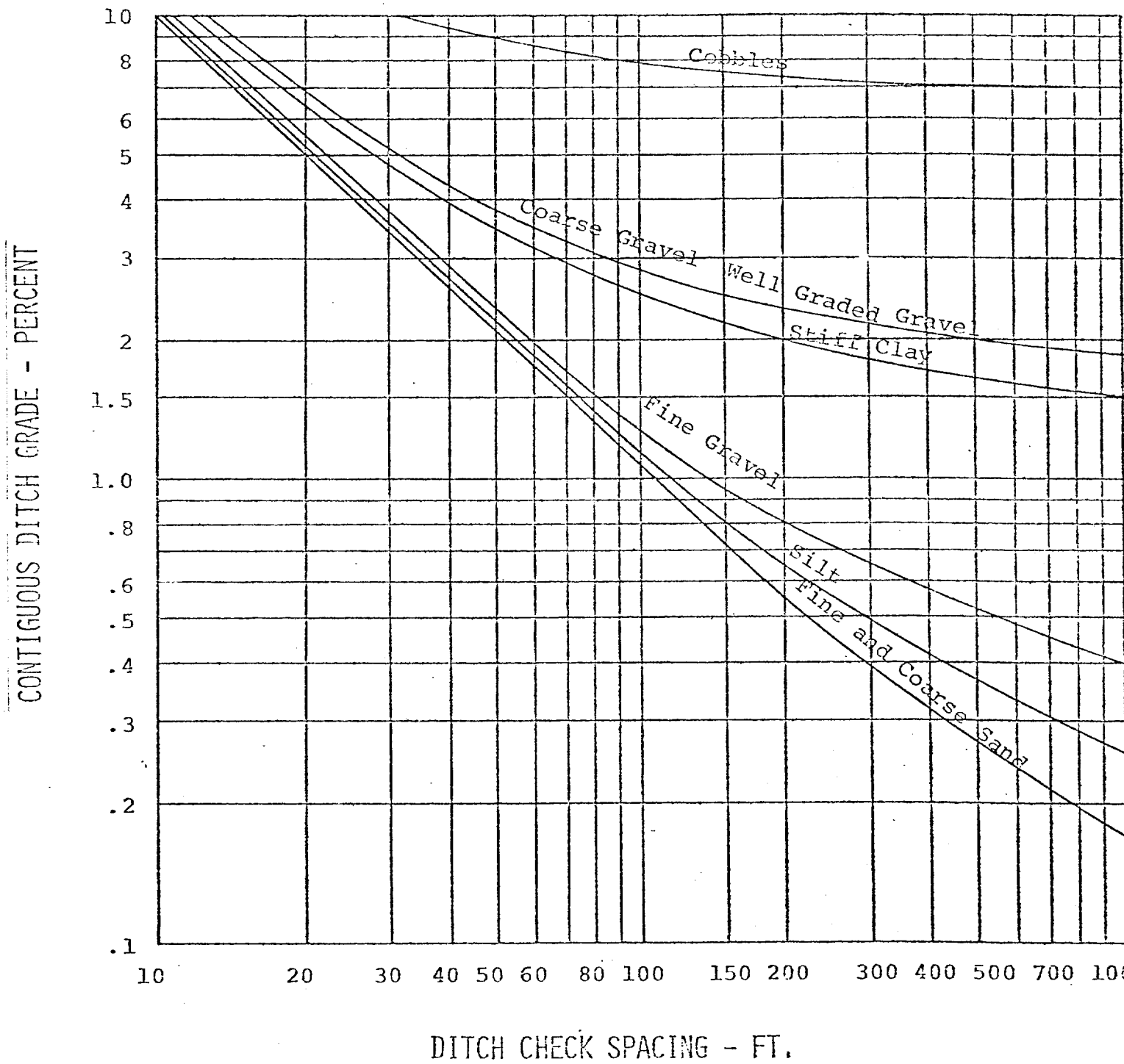
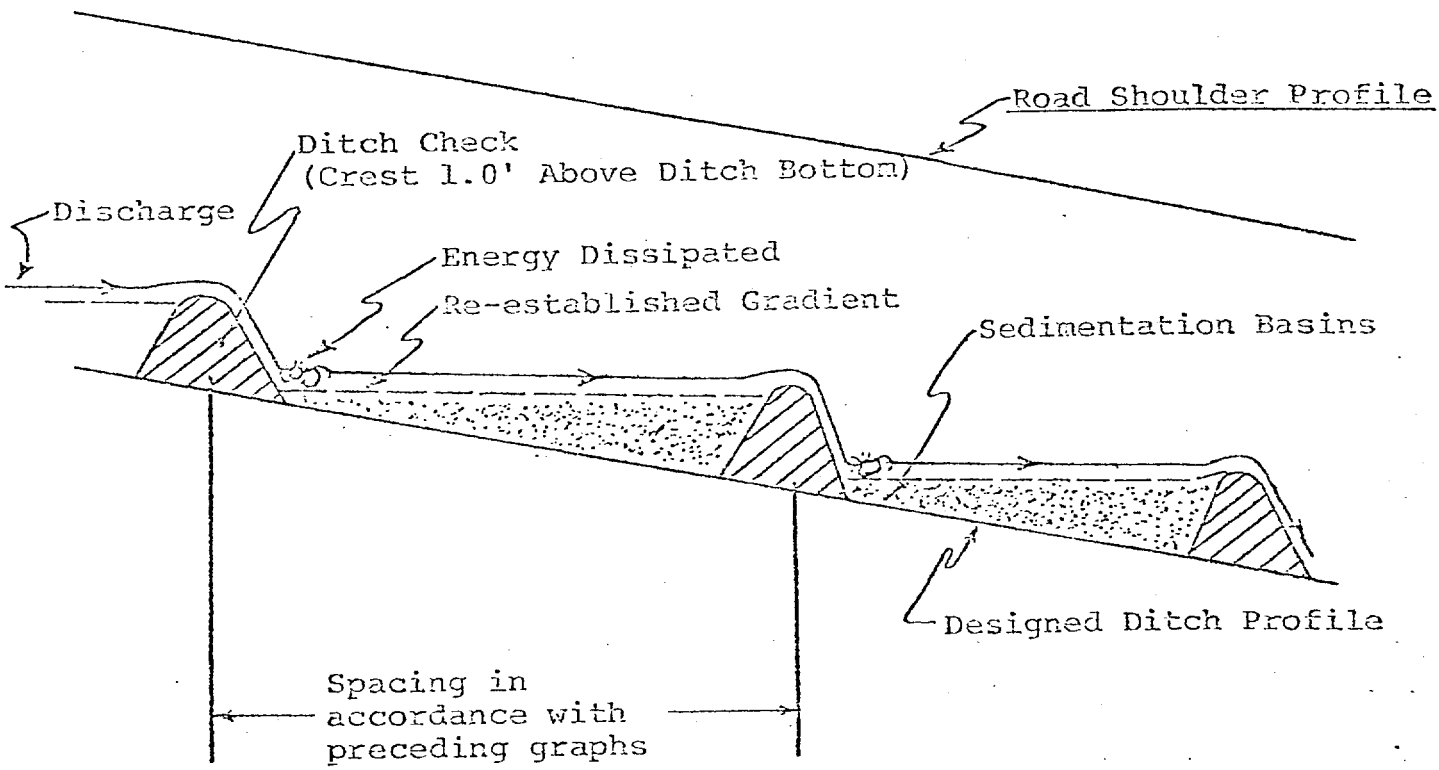


FIGURE 7

DITCH CHECKS



- The ditch checks will be constructed with non-erodible materials.

APPENDIX "B"

HYDROLOGY SUMMARY

HYDROLOGY SUMMARY

MILE 425.4 TO MILE 448

DESIGN DATA					CONSULTANT				COMMENTS
MILE	A	A_E	Q_D	Q_F	MILE	A	Q_D	Q_F	
426.5	5.4	2.8	340	95	426.5	7.5	375	75	Lake Control. Consultant drainage area includes part of adjacen drainage areas.
427.1	0.5	0.4	65						60" C.S.P.P.
427.5	0.8	0.7	105	25	427.5	0.5	120	24	
428.2	1.4	1.1	155		428.2	12	140		
430.0	59.0	54.0	1,350	580	430.0	51.0	4,350		Smith Creek. Previous bridge scheduled.
434.7	1.8	1.8	230						Revised alignments.
435.7	0.8	0.8	120						60" C.S.P.P. plus C.S.I Revised alignment.
436.6	128.3	128.3	2,100		436.5	124	6,200		Hodgson Creek Bridge

A = Total Drainage Area

A_E = Effective Drainage Area

Q_D = 50 Year Design Discharge

Q_F = Fish Migration Discharge