Los Angeles County Flood Control District

DESIGN MANUAL

DEBRIS DAMS AND BASINS

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CRITERIA FOR DESIGN OF DEBRIS DAMS AND BASINS

The following text and exhibits have been prepared as a guide for design, preparation of plans and specifications, and construction of debris dams and basins constructed by others for transfer to the District for maintenance.

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DESIGN OF
DEBRIS DAMS AND BASINS

SECTION A

DESIGN OF DEBRIS DAMS AND BASINS

A-1 Basin Design

A-1.1 General

The volume of debris to be impounded shall be the amount generated from the watershed upstream of the selected site as indicated on the debris production curves.

Generally, the bottom of the basin shall be established at the average slope of the original stream bed. If extensive excavation below stream bed level is a design requirement, an inlet structure shall be provided at the upper end of the basin to prevent erosion of the stream bed upstream of the basin.

The cut slopes of the excavated basin shall be no steeper than that recommended by the soil engineer in his subsurface investigation report. Extensive cut slopes shall be protected against erosion from surface runoff from the surrounding area above by a "U" shaped protective gutter (Type B) around the perimeter of the cut area. (See Figure 1, page I-6).

The basin design shall include an access ramp to the bottom of the basin from the crest of the dam for debris removal purposes.

The sizing of the basin to contain the volume of debris to be impounded by the dam is accomplished by trial and error. The designer should be aware that certain dams as defined in the "Statutes and Regulations Pertaining to Supervision of Dams and Reservoirs" published by the State Department of Water Resources, Division of Safety of Dams, will fall under the jurisdiction of the State.

A-1.2 Basin Capacity

The required debris capacity for design of the basin shall be determined from the Debris Production Zones and the Debris Production Curves developed by the District and shown on pages I-1 through I-5. Because it is possible to have drainage area conditions which may affect the use of the curves, it is recommended that confirmation as to application of the curves be obtained from the District.

A-1.3 Debris Volume

The calculations for the debris volume shall be based on the assumption that the debris will be deposited in such a manner that the debris slope, sloping upstream from the spillway crest, will be equal to 50 per cent of the average slope of the original stream bed for the total length of the basin site.

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A-2 Earth Dam Design

A-2.1 General

The height of the dam is measured vertically from the spillway crest to the natural bed of the stream or watercourse at the downstream toe of the dam.

The stability of the earth dam under various conditions which may exist following construction is a prime concern in the design of the slopes for the dam's earth embankment. It has been the experience of the District that 3:1 slopes for the upstream and downstream faces of the dam are usually stable even under the most adverse conditions. Steeper slopes may be approved by the District if their stability is demonstrated to be adequate when analyzed in accordance with accepted design criteria for small dams.

An area of approximately 1,200 square feet (30 x 40) should be provided at the top of the dam for a shelter house and parking adjacent thereto.

A-2.2 Foundation and Abutments

Preparatory to construction of the earth dam, the ground shall be stripped of all vegetation and other organic material. In addition, any trash, debris, soft or compressible material or other objectionable material unsuitable for support of the dam, whether disclosed by the subsurface investigation or discovered during stripping shall be excavated as directed by the soil engineer and approved by the responsible agency's inspector.

A-2.3 Percolation Path at Dam Contact Areas

The horizontal length of the path of percolation between embankment and abutments and foundation shall be of such length as to be consistent with limitations for percolation and piping based upon existing local soil conditions and type of embankment material to be used. The District has found that, as a general rule, a minimum path of percolation ratio of 8 to 1 is satisfactory (8 represents the level length of path along the contact and 1 represents the corresponding head differential between the elevation of upstream end of path and the maximum elevation of the basin water surface). This condition should be satisfied for any horizontal plane through the embankment above the contact of the bottom of the basin and upstream slope of embankment.

A-2.4 Crest of Dam

The crest of the dam shall be 20 feet wide (measured parallel to the center line of the spillway) and shall have a minimum rising slope from the spillway walls to the abutment equal to 60 per cent of the average grade of the natural stream bed, unless otherwise approved by the District. (See Figure 2, page I-7). It shall be graded to form a "V" shaped surface 6 inches deep at the center and paved with 3 inches

SECTION A
Continued

of asphaltic concrete. A 4-inch diameter hole shall be provided in the spillway wall for drainage at the low point of the "V" shaped crest of dam.

A-2.5 Protection for Dam Slopes

A-2.5.1 Upstream Face

The upstream face of the earth dam shall be protected with a 6-inch thick (measured normal to slab) reinforced concrete facing slab unless otherwise approved by the District. The reinforcement for the concrete slab shall be No. 5 reinforcing bars at 18-inch centers in both directions placed in the center of the slab. The reinforcement shall be continuous through all construction joints and shall be spliced by lapping 20 bar diameters. Construction joints shall be parallel or at right angles to the center line of spillway and shall be spaced not more than 50 feet nor less than 10 feet apart. The slab shall be extended on the same slope to a depth of 5 feet below the bottom of the basin as well as to to the bottom of the outlet works excavation. The slab shall also be extended into the abutments for a minimum of 2 feet. (See Figure 3, page I-8).

A-2.5.2 Downstream Face

The downstream face of the dam shall be protected from erosion by placing some type of protective covering such as planting or matting.

A-2.5.3 Slope Protection Gutter

"U" shaped gutters (Type B) shall be placed at the re-entrant contact of two planes of fill or the intersection of compacted fill and natural ground. (See Figure 1, page I-6).

A-3 Access to Dam and Basin

A 28-foot wide access road (two 12-foot lanes and 4-foot wide gutter) with adequate wearing surface, cross drains, and gutters shall be provided from the nearest public street into the basin area to permit removal and hauling of storm deposited debris. The access road shall be cross sloped towards the 4-foot wide gutter. The road grade downstream of the crest of dam shall not exceed 10 per cent; however, if such grade for some valid reason is not practicable, a grade of 15 per cent shall not be exceeded. Grades steeper than 10 per cent shall be paved with 3-inch A. C. The access ramp into the basin from the crest of dam shall be 20 feet wide on a grade not to exceed 10 per cent. No paving or gutter will be required for this portion of the access road.

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Continued

A-4 Access Road Gutter

The 4-foot wide drainage gutter for the access road shall be constructed of gunite, concrete, or A. C. The 4-foot wide gutter shall be so shaped as to be maintainable by use of mechanized equipment and be without a sharp drop so as to be safe and drivable for traveling vehicles. Details of an A. C. access road gutter are shown in Figure 1, page I-6.

A-5 Earthwork for Debris Dams and Basins

The earthwork for debris dams and basins shall be in accordance with Section 300-6 of the Standard Specifications for Public Works Construction, 1973 Edition.

A-6 Gage Board Pipe Supports

On the upstream side of dam on the same side as the access road, 2-1/2 inch diameter galvanized standard pipes shall be embedded in the facing slab for future installation of gage boards by the District. The pipes shall be 5 feet 6 inches long and project 4 feet 7 inches above the surface of the facing slab. They shall be placed in a straight line, usually parallel to the center line of the spillway, and so placed as to have a difference of 4 vertical feet between the pipes at the surface of the facing slab. The lowest pipe shall be set at an elevation one foot below the elevation of the bottom of the debris basin and the uppermost pipe at an elevation within 4 feet of the elevation of the crest of dam at the spillway wall. Details of a gage board pipe installation are shown in Figure 4, page I-9.

A-7 Debris Barrier

A-7.1 General

A debris barrier shall be provided upstream of the spillway to prevent large debris from entering and clogging the spillway and/or the conduit downstream of the spillway. This is usually achieved by placing a series of vertical members in the concrete facing slab so as to form a protective screen around the spillway entrance. A typical layout is shown on Figure 2, page I-7.

The debris barrier shall be designed considering the barrier to be 100 per cent plugged and acting as a submerged sharp crested weir. The freeboard between the crest of dam and basin water surface upstream of the debris barrier shall be a minimum of two feet.

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Continued

A-7.2 Location and Spacing of Barrier

The debris barrier shall be placed upstream of the spillway and no closer than six feet from the intersection of the spillway invert slab and the concrete facing slab.

The top of the barrier members shall be placed one foot below the basin water surface elevation required to pass the design Q (burned and bulked) through the spillway.

The barrier members may be spaced up to four feet apart but in no case shall be more than two-thirds of the width of the conduit at the downstream end of the spillway.

A-7.3 Design of Barrier Member

The debris barrier shall be assumed to be 100 per cent plugged and the members designed for an equivalent fluid pressure of 62.5 psf. The loading can be considered as temporary and the allowable stresses increased by one-third.

The barrier member shall be assumed to be restrained laterally by the concrete facing slab and the embedment length shall be determined by use of the following formula developed by E. Czerniak:

$$L = 1.85 \sqrt[3]{\frac{Mo}{R}}$$

where:

L = Length embedment in feet

R = 300 psf/ft. depth (a constant)

$Mo = \frac{M}{d}$

M = Moment applied to barrier in foot pounds

d = Diameter of pipe encasement in feet

SECTION A
Continued

A-7.4 Selection of Barrier Member

The barrier member shall be selected so that the required section modulus is satisfied along the weak axis and may be of a structural steel shape, pipe, or square tubing. If a hollow member is selected, it shall be filled with concrete.

A-8 Right of Way

A-8.1 General

Sufficient right of way shall be provided for the construction and economical maintenance of the dam and basin and shall include sufficient area to provide for an access road from a dedicated public street to the basin.

A-8.2 Right of Way Limits

Right of way for the basin shall include the area encompassed by the contact points of the debris surface contours with the existing ground based on a theoretical debris slope, sloping upstream from the spillway crest, of 75 per cent of the average slope of the original stream bed for the total length of the basin site. In general, the contours of the theoretical debris surface shall be assumed as straight lines at right angles to the center line of the spillway and/or the basin and stream bed, depending on the shape of the basin involved.

The right of way for the access road from a dedicated street shall be wide enough to provide for a 28-foot wide road as described in Section A-3.

A-9 Fencing

Adequate fencing, enclosing the limits of the debris basin, shall be provided to discourage unauthorized persons from entering the area. Said fencing shall conform to District Standard Drawing No. 2-D 178 (see page I-29).

A-10 Debris Disposal Area

A debris disposal area, of sufficient storage capacity subject to District approval, shall be provided within an economical hauling distance from the debris basin.

SECTION B

SUBSURFACE INVESTIGATION REPORT

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SUBSURFACE INVESTIGATION REPORT

B-1 Field Investigation

Prior to District approval of plans and specifications for a proposed debris basin, a subsurface investigation shall be made to obtain and present sufficient information about the soil, ground water, and foundation conditions on the project for the proper design of structures with minimum construction problems and low operation and maintenance costs. The subsurface investigation shall be planned and supervised by a registered civil engineer experienced in soil mechanics.

B-2 Subsurface Report

B-2.1 General

The original and one copy of the subsurface investigation report prepared by the soil engineer in accordance with the following requirements shall be furnished to the District at time of submittal of plans for the debris basin. The report shall contain findings and supporting information regarding the following items:

1. The types of materials to be encountered in the proposed excavations or borrow site.
2. Anticipated excavation problems.
3. Location and extent of required overexcavation.
4. Slope and excavation stability.
5. Bearing capacity and settlement characteristics of subgrade materials.
6. Suitability of excavated materials (including bedrock) for use as fill, backfill, and bedding.
7. Required relative compaction of fill and backfill materials.
8. Compaction characteristics of the predominant soil.
9. Substances in the ground water or in the native soils deleterious to concrete, steel, or other construction materials.

SECTION B
Continued

B-2.2 Detailed Recommendations

Specific, detailed recommendations with supporting data shall be included for such items as, but not limited to, stability of cut slopes; excavation in bedrock; necessary depth of stripping or overexcavation in areas to be covered by fills to minimize settlement; subdrains or toe drains and the gradation requirements for required filter and drain materials; stability of proposed dam embankment under the various conditions that may exist following construction, with due allowance for seismic loading and seepage; inlet structures as needed to prevent unacceptable erosion of stream bed material upstream of the basin; stability of natural slopes; erosion prevention treatments, including plants, drainage devices, or erosion resistant covers for cut and fill slopes, including the downstream face of the dam, and for the crest of the dam.

Field observations of items which can affect the construction operations, such as surface water flow, springs and seeps, bedrock outcroppings, trash dumps, existing wells or tunnels, large concrete blocks, etc., shall be recorded in the report.

All field, laboratory, and office information shall be submitted on 8-1/2" x 11" sheets or on sheets folded to that size.

B-3 Exploratory Borings

B-3.1 Location and Number of Borings

Borings shall be drilled at least at the following locations:

1. Proposed dam foundation.
2. Each dam abutment.
3. Along alignment of outlet pipe.
4. Borrow area.
5. Proposed inlet structure and outlet tower, etc.
6. Proposed cut slopes for access road and basin.

A boring may be located to furnish information for more than one of the areas listed above. On the other hand, it may be necessary to drill borings at locations not listed above but which are necessary to provide complete subsurface information.

SECTION B
Continued

It may be possible to reduce the number of borings needed by the use of supplemental information obtained by seismic or electrical resistivity methods. However, it will not be permissible to replace the drilling of borings entirely with geophysical methods.

B-3.2 Depth of Borings

The minimum boring depth shall be as follows unless firm bedrock is encountered at shallower depths:

1. Borings in the foundation of the proposed dam shall be drilled to firm material, bedrock, or to a minimum depth equal to the height of the dam at the crest. If soft or loose materials are found at this depth, drilling shall be continued until firm material is reached.

2. Borings at the abutments shall extend to firm material suitable for support of the dam.

3. Borings in borrow areas or in proposed cut slope areas shall extend at least five feet below the proposed excavation line.

4. Borings at locations for structures shall extend at least five feet below structure subgrade. If water is encountered, the boring shall be drilled at least ten feet below structure subgrade.

B-3.3 Type of Borings

The word "boring" as used herein shall include borings by drill rigs, holes, pits, or tunnels dug by hand-held equipment or by equipment such as bulldozer, backhoe, or clam bucket.

Borings shall be drilled dry, if possible, by using buckets, augers, or similar tools to facilitate examining, sampling, and logging the materials as encountered. The use of drilling mud should be avoided if casing can be used. Continuous flight helical augers may be used only as the last resort to drilling where other methods have failed.

SECTION B
Continued

B-4 Logs of Borings and Location Map

B-4.1 General

The logs of borings shall include Unified Soil Classification System descriptions and group symbols as shown in District Drawing No. 2-D 413 (see page I-31) and shall include pertinent notes about water elevations, seepage, approximate per cent rock encountered, ease of drilling, type and depth of soil or rock sample, caving, running sands, trash, and any other useful information. Pertinent information as indicated in Column 6 on Drawing No. 2-D 413 shall be included. Descriptions and group symbols shall be consistent with results of laboratory classification tests. The elevation of proposed excavation subgrade, etc., shall be shown graphically on the log. Exploratory borings shall be identified with a numbering sequence increasing upstream.

The boring locations shall be shown on a recent topographic map to a scale not less than 1" = 100'. Boring locations may be referenced in terms of coordinates if such a system is available or by offsets and the stationing along the center line of the basin or spillway. The elevation of the ground surface at each boring location, the date each boring was drilled, and method of drilling shall be included.

B-4.2 Ground Water

The logs of borings shall indicate the depth at which ground water was encountered. Any change in the ground water level during drilling shall be noted. If water was not encountered, a statement to that effect shall be included.

B-5 Samples

Samples representing each type of material encountered shall be obtained in each boring. Both undisturbed and bulk soil samples of each type of material shall be obtained if reasonably possible. In cases where all or most of the soil in a boring is of one type, there shall be <u>no less than</u> two representative undisturbed and bulk soil samples taken from each boring. When very firm soil or a large rock mass (not boulders) is encountered within the proposed excavation for a structure or cut which cannot be penetrated by normal soil boring equipment, core samples shall be obtained.

SECTION B
Continued

Samples of any ground water encountered shall be obtained for chemical analysis. Samples of any surface water flowing at the site shall also be obtained.

Soil and bedrock samples shall not be discarded until after notification to the District's Materials Engineering Division either in writing or by telephone at 226-4285. District personnel may elect to examine the samples and possibly store them on District premises.

B-6 Laboratory Analyses

B-6.1 Required Analyses

Laboratory analyses shall be made on the soil samples as indicated in the following table:

(See next page for table)

LABORATORY ANALYSES

Type	Method	Purpose
Mechanical Analysis (See Note 2)	ASTM D 422	Evaluation of project excavation material for use as fill, backfill or bedding.
Sand Equivalent Determination	ASTM D 2419 or California Test Method No. 217	
Laboratory Maximum Density (See Note 3)	California Test Method No. 216	Establishing the in-place soil density and relative compaction of major soil types. (See Note 4)
Density of Soil in Place	ASTM D 2937, D 2167, D 1556	
Moisture Determination	ASTM D 2216	
Strength Characteristics (See Note 5)	Triaxial Shear Test Direct Shear Test	Evaluation of bearing values; embankment and slope stability; and tunnel loads.
Consolidation Characteristics (See Note 6)	ASTM D 2435	Evaluation of the degree of compression, collapse, or expansion of soils.
Chemical Analysis (See Note 7)	Analysis of a distilled water soil extract, ground water, or surface water in accordance with; ASTM D 516 - Sulfate; ASTM D 1067 - Acidity; ASTM D 512 - Chloride.	Determination of the presence of sulfates, acids and chlorides in ground water or in the native soil (as per cent dry weight of soil) which are deleterious to concrete, steel, or other construction materials.

SECTION B
Continued

B-6.2 Notes Pertaining to Laboratory Analyses

The following shall apply to the performance of the analyses:

1. All necessary laboratory tests shall be performed by a laboratory certified by the City of Los Angeles, Department of Building and Safety, or by the Department of County Engineer, or by a laboratory operated by the public agency having jurisdiction.

2. The mechanical analysis shall be performed on representative portions of bulk samples using sieve sizes 3", 3/4", #3/8, #4, #8, #16, #30, #50, #100, and #200. Other combinations of sieves may be used as allowed by the ASTM procedure. At least one mechanical analysis test shall be made for each major soil type encountered. The analysis of predominant non-plastic soil types shall be repeated in alternate borings. Gradation curves shall be furnished for the soils which contain less than 12 per cent passing the No. 200 sieve.

3. A sufficient number of laboratory maximum density tests shall be performed to be used by the consultant to calculate the relative compaction of each undisturbed soil sample. A laboratory maximum density test result may be used to calculate the relative compaction of similar soils from other nearby borings. However, a laboratory maximum density test result shall not be applied to a density test farther than 500 feet from the boring where the material for the laboratory maximum density was taken.

4. Relative compaction means the ratio of the field dry density to the laboratory maximum density expressed as a percentage.

5. Triaxial shear test values shall be reported in terms of both total and effective stress. Direct shear test values shall be reported in terms of both peak and ultimate shear strength.

6. Sample to be submerged in water during the test.

7. One determination in each boring where ground water was encountered and one determination per alternate boring where ground water was not encountered.

SECTION C

ENGINEERING GEOLOGY
INVESTIGATION REPORT

SECTION C

ENGINEERING GEOLOGY INVESTIGATION REPORT

C-1 Field Investigation

In addition to the subsurface investigation described in Section B, Subsection B-1, sufficient surface and subsurface engineering geological exploration shall be made to permit the District to make an adequate assessment of geological problems which may be encountered during project construction.

C-2 Geologic Report

C-2.1 General

The original and one copy of the engineering geology investigation report prepared or supervised by a registered geologist certified in engineering geology, in accordance with the following requirements, shall be furnished to the District at the same time as the subsurface investigation report described in Section B.

The report shall be accompanied by an independently prepared geological map, prepared on a topographic base map of sufficient scale to show detail, yet not overly limited so as not to show important geologic features in close proximity to the project. A sufficient number of geologic cross sections should be submitted with the map to show correlation of all subsurface data, from test borings and other sources, with surface data.

The location of all subsurface data shall be indicated in the text of the report as well as on all maps and cross sections. In addition, a copy of the geologic logs for each test boring or other sources of subsurface data shall be included in the text, or appended thereto.

Geologic logs of borings shall contain a lithologic description of the geologic character of each stratum, the depths at which changes in the character of materials are observed, the thickness of the strata, and depth to water (where applicable).

The engineering geology report shall, in the text, contain findings and supporting information for, but not limited to, the following:

1. Type and extent of in situ rock and/or unconsolidated surficial deposits to be encountered.

2. Structural features.

SECTION C
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3. Surface water and ground water conditions.

4. Other geologic features of special significance to the project.

5. Excavation problems related to bedrock.

6. Location of fill.

7. Needs for additional subsurface data.

8. Special construction problems.

The scope, length, and organization of reports will be highly dependent upon the physical situation of the project and the following comments are intended to serve as a general guide and check list for those who prepare and use geological reports, rather than a rigid framework of requirements.

C-2.2 Detailed Information

In accordance with the above noted general requirements, the following is a detailed, though not necessarily complete, list of topics that ordinarily should be considered in geologic reports submitted to the District:

1. In Situ Rock and Surficial Deposits

   a. Identification, distribution, and general physical characteristics.

   b. Special physical characteristics or chemical features, distribution of weathered zones, and significant differences between fresh and weathered material.

   c. Response to natural surface and near surface processes (e. g. mass movement, ravelling, gullying, etc.).

2. Structural Features (e. g. faults, shears, folds, joints, foliation, schistosity)

   a. Occurrence, distribution, and effects upon the in situ rock and other earth materials.

   b. Special features of faults (e. g. zones of gouge and breccia, nature of offsets, active or inactive).

   c. Seismicity consideration (e. g. earthquake activity, historical recordings, anticipated forces, etc.).

SECTION C
Continued

3. Surface and Ground Water Conditions

   a. Distribution and occurrence (e.g. streams, ponds, swamps, springs, seeps, subsurface basins).

   b. Relation to topography and geologic features (e.g. pervious strata, faults, fractures).

   c. Effect of water on the properties of in situ materials.

   d. Water rights, existing rights, potential effects of proposed construction on ground water regimen.

4. Geologic Features of Special Significance

   a. Slump and slide masses within the drainage areas in surficial deposits and in situ rock, including distribution, geometric characteristics, correlation with topographic and geologic features, age and rates of movement, etc.

   b. Indications of subsidence or settlement (e.g. scarplets, fissures, crack patterns, topographic bulges, tilted reference features, historic records and measurements).

   c. Features indicative of accelerated erosion (e.g. cliff re-entrants, badlands, advancing gully heads).

5. Excavation Problems

   a. Prediction of what materials and structural features will be encountered.

   b. Prediction of cut slope stability.

   c. Rippability estimates for unusually hard or massive rock (e.g. classification as to rippable, marginally rippable and non-rippable based on average seismic velocity of materials).

   d. Recommendations for reorientation or repositioning of cuts, reduction of cut slopes, development of compound cut slopes, special stripping above daylight lines, buttressing, protection against erosion, handling of seepage water, setbacks for structures above cuts, etc.

   e. Excessive ground water flows.

   f. Problems caused by features or conditions in adjacent properties.

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6. Location of Fill

Recommendations for positioning of fill masses, special preparation of ground to be loaded with fill, provision for underdrainage, buttressing, special protection against erosion, setbacks for structures near edges of fill prisms, etc.

7. Recommendations for Additional Subsurface Testing, Exploration and Inspection

a. Cuts and test holes needed for additional geologic information.

b. Program of subsurface exploration and testing, based upon geologic considerations, that is most likely to provide data needed by the foundation engineer.

c. Geologic inspection needed during construction.

8. Special Construction Problems

a. Areas to be left as natural ground.

b. Removal or buttressing of existing slide masses.

c. Problems of ground water circulation.

d. Position of structures with respect to active faults.

SECTION D

STRUCTURAL DESIGN CRITERIA

SECTION D

STRUCTURAL DESIGN CRITERIA

D-1 General

The minimum and maximum reinforcing bar size for cast-in-place conduits shall be #4 and #9, respectively. The clear distance between parallel bars shall not be less than the nominal bar diameter, 1-1/2 times the maximum size coarse aggregate, or 1 inch. The main stress-carrying steel shall be centered not farther apart than 3 times the member thickness nor more than 18 inches. Where conduit is constructed on curves, steel shall be placed radially from the maximum spacing and special attention shall be given to steel details to insure that the spacing on the inside of curves is not less than the allowable.

Main stress-carrying steel shall comply with A. S. T. M. A-615, Grade 60. Longitudinal steel shall comply with either A. S. T. M. A-615, Grade 40 or Grade 60. Anchorage requirements for reinforcing steel shall be as specified in Section 918 of ACI 318-63. Splices for stress-carrying steel shall be 30 bar diameters minimum and for longitudinal steel 20 bar diameters. Shear stress shall be calculated in accordance with Section 1201 of ACI 318-63.

The 28-day compressive strength of the concrete shall be specified to be 4000 psi for spillway walls and 5000 psi for the invert slab. However, in design, both the spillway walls and the invert slab shall be designed on the basis of 4000 psi concrete. The concrete for structures other than the spillway may have a 28-day compressive strength of 3000 psi. However, the concrete for the "U" shaped gutters for slope protection may have a 28-day compressive strength concrete of 2000 psi.

Design criteria not specifically covered in this manual shall be as specified in the 1963 Edition of the "Building Code Requirements for Reinforced Concrete" (ACI 318-63) published by the American Concrete Institute.

Design of conduits which join the spillway and conveys the flows from the spillway and basin shall be designed in accordance with the District's "Structural Design Manual".

Design of structural steel members shall be in accordance with the current edition of the A. I. S. C. Manual of Steel Construction. Allowable stresses for members subjected to temporary loadings, such as debris barriers, may be increased by one-third.

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D-2 Allowable Stresses

Allowable concrete and reinforcing steel unit stresses shall be as shown below.

Concrete	Maximum Stress	Any Strength Concrete	Stress for f'c equal to 3000 psi	Stress for f'c equal to 4000 psi
Flexure, fc				
Extreme fiber in compression		.45 f'c	1350 psi	1800 psi
Extreme fiber in tension, in plain concrete		$1.62\sqrt{f'c}$	88	102
Extreme fiber in tension, in reinforced concrete		None		
Shear, v				
Beams without web reinforcing		$1.1\sqrt{f'c}$	60	70
Horizontal shear in shear keys		.10 f'c	300	400
Bond, u				
Top bars*	350 psi	$3.4\sqrt{f'c/D}$	186/D	215/D
All others	500	$4.8\sqrt{f'c/D}$	263/D	304/D
Bearing, fc				
On full area			750 psi	1000 psi
On 1/3 area or less			1125 psi	1500 psi

*Top bars are horizontal bars having more than 12 inches of concrete cast in the member below the bar.

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Reinforcing Steel	Unit Stresses
Tension	
Flexural members and web reinforcing	24,000 psi
Compression	
Combined flexure and axial stress	nfc
Compression, flexural members	n times the compression in the surrounding concrete

SECTION E

DESIGN OF

RECTANGULAR SPILLWAY

SECTION E

DESIGN OF RECTANGULAR SPILLWAY

E-1 Hydraulic Design

E-1.1 Spillway Design Q's

The District will provide assistance in the determination and/or confirmation of design Q's upon request provided a suitable drainage map of the area is submitted. It is recommended that confirmation of design Q's be obtained from the District prior to start of design.

E-1.2 Spillway Requirements

The width of spillway and height of spillway walls at the crest shall be determined by use of the broad crested weir formula with the coefficient of discharge C = 2.80. The spillway shall be sized to pass the District's capital flood Q with an allowance made for increased flow due to a burned watershed and the inclusion of bulking of the flow caused by inorganic debris with the appropriate freeboard or the greater of "Creager's Q" (see page I-11) or the probable maximum precipitation (PMP) Q with zero freeboard whichever requires the higher walls. Downstream of the crest, the spillway walls shall contain the above mentioned flows with their respective freeboards as far downstream as the toe of dam embankment. The height of spillway walls shall not be less than 6 feet and the convergence of the walls shall not exceed 5 degrees for each side of the spillway or 10 degrees for total convergence. The floor of the spillway upstream of the crest shall slope down at a 3 per cent grade toward the basin for drainage.

E-1.3 Freeboard

The minimum freeboard at spillway crest shall be 2 feet or equal to 25 per cent of head differential from the spillway crest to the water surface in the basin, whichever is greater.

Downstream of the crest, the minimum freeboard shall be 2 feet for average flow velocities of 35 fps or less and 3 feet for average flow velocities greater than 35 fps.

E-2 Structural Design

E-2.1 Method of Design

Consideration shall be given in each individual project to the conditions of soil, ground water level, slope of adjacent ground surface and live loading, existing or proposed.

SECTION E
Continued

The design of the spillway structure shall consider seismic forces and provide for active earth load pressures as calculated by the Coulomb theory plus additional pressures resulting from application of horizontal and vertical accelerations to the sliding wedge.

Two analyses shall be made of each section, empty and flowing full. The spillway structure shall be considered as a "U" channel and be designed as a rigid frame.

E-2.2 Horizontal Loads

E-2.2.1 Spillway Empty

Spillway walls, regardless of height, shall be designed for a lateral soil force applied on the earth face of the wall equivalent to:

$$P = 1/2 \ wH^2 \ [K + 3/4 \ (a/g)]$$

where:

P = Total lateral force, pounds per lateral foot of spillway wall

w = Soil density, pounds per cubic foot

H = Wall height, feet

K = Coefficient of active earth pressure, abstract number

a = Horizontal ground acceleration, feet per second per second

g = Acceleration due to gravity, feet per second per second

The active soil pressure represented by $1/2 \ KwH^2$ shall be applied at a point 1/3 H above the base and the dynamic force represented by $3/8 \ (a/g) \ wH^2$ shall be applied at a point 2/3H above the base. It is recommended that a value of 1/3 the acceleration due to gravity be used for the horizontal ground acceleration. Curves showing moments and shear for the above loading (earth plus dynamic) are shown on page I-12.

Where existing, the effect of a sloping surcharge on the lateral soil force shall be taken into consideration. It may be advisable to increase the width of berm adjacent to the spillway wall to prevent excessive earth loads due to sloping surcharge.

SECTION E
Continued

E-2.2.2 Spillway Full

Spillway walls, regardless of height, shall be designed for 40 psf equivalent fluid pressure applied on the water side to top of wall. This assumes active resistance from the soil outside the walls, or allows an increase in stresses for short time loading should active pressure not exist. Moment and shear curves for 40 psf equivalent fluid pressure are shown on page I-12.

E-2.2.3 Stability and Sliding

Rigid frame "U" channels with differential lateral loadings shall be checked for stability, soil reaction, and sliding. The factor of safety against sliding shall be 1.5 minimum.

E-2.3 Vertical Loads

The weight of earth shall be assumed at 110 pcf, the weight of water at 62.5 pcf and the weight of concrete at 150 pcf.

E-2.4 Soil Pressure

Soil pressures on "U" channels shall be computed considering the invert slab as a beam on an elastic foundation (see "Beams on Elastic Foundations" by M. Hetenyi, University of Michigan Press, Ann Arbor, Michigan, 1946). Design information and curves showing moments and soil pressures in "U" channels are included herein, pages I-13 through I-28. When the width of channel is less than the minimum values shown on the curves, uniform soil pressure shall be assumed.

E-2.5 Construction Joints

E-2.5.1 General

Construction joint details shall be shown on the project drawings.

E-2.5.2 Transverse Construction Joints

Transverse construction joints shall not be more than 50 feet or less than 10 feet apart and construction joints in the walls and slabs shall be in the same plane. Shear keys shall not be used for transverse construction joints and steel reinforcement shall be continuous through the construction joints and lapped 20 bar diameters.

SECTION E
Continued

Concrete anchors as shown on Figure 2, page I-7, shall be constructed monolithically with the transverse invert slab joints. The anchors shall be placed within the limits of the spillway that lies on the downstream slope of the dam.

E-2.5.3 Longitudinal Construction Joints

Shear keys shall be used in longitudinal wall joints which shall be located at an optional 4 inches to 12 inches above the invert slab.

E-2.6 Thickness of Members

Side walls shall have a minimum thickness of 8 inches. The earth face of walls shall be battered from the required thickness at the base to the minimum thickness at the top.

Invert slabs shall have a minimum thickness of 9 inches. There shall be a minimum projection of the invert slab beyond the walls (i.e. a heel) of 6 inches.

E-2.7 Placement of Steel Reinforcement

E-2.7.1 Steel Clearances

Steel clearances should be shown on the project drawings from the center of the bar to the face of the concrete. Said clearances shall not be less than the following distances:

Side walls, inside and outside - 2 inches

Top of invert slab - 2-1/2 inches for velocities less than 10 feet per sec.

3 inches for velocities of 10 feet per sec. or more but less than 40 feet per sec.

3-1/2 inches for velocities of 40 feet per sec. or more.

Bottom of invert slab - 2-1/2 inches.

Where concrete is subject to the action of harmful ground water, soils, etc., an additional cover of 1/2 inch shall be provided.

SECTION E
Continued

E-2.7.2 Transverse Reinforcement

Transverse reinforcing steel shall be as follows:

1. Minimum size of reinforcing bars shall be #4 and the maximum spacing 18 inches.

2. Earth face wall steel shall be "L" bars bent into the bottom face of the invert slab.

3. Channel face wall steel shall be "L" bars bent into the bottom face of the heel.

4. "U" bars shall not be used.

5. Unduly long bars shall be avoided.

E-2.7.3 Longitudinal Reinforcement

Longitudinal reinforcing steel shall be #5 bars at 12-inch centers in each face of walls and slabs and shall be continuous through the construction joints.

E-3 Subdrains

A subdrainage system shall be provided for the spillway structure and shall be designed to discharge through the spillway walls at a minimum height of 18 inches above the invert slab. The subdrains shall consist of 6-inch perforated pipes laid in trenches filled with drain material. See Figure 5, page I-10, for details.

Not more than three lateral subdrains shall be connected to a longitudinal subdrain which conveys the waters from the laterals and discharges the flow through the spillway wall. The portion of the longitudinal subdrain between its discharge end and the closest lateral connected to it shall be of non-perforated pipe.

SECTION F

OUTLET WORKS

SECTION F

OUTLET WORKS

F-1 General

The outlet works consist of an outlet tower, base, and an encased outlet pipe which extends under the dam from the outlet tower and usually outlets into and is joined to the spillway with a junction structure. Hydraulically, the system shall be designed for non-pressure flow at maximum head with a discharge of 150 cfs. The flow shall be regulated by the size of the opening at the base of the tower. The slope of the outlet pipe shall not be less than 5 per cent in order to maintain the system free of silt deposits, unless otherwise approved by the District.

F-2 Outlet Tower

The tower shall be a reinforced concrete structure which may be constructed by either pouring the concrete in place or by guniting. Unless otherwise approved by the District, the requirements for the tower shall be as follows:

1. The inside diameter shall be 5 feet and the wall thickness shall be 6 inches.

2. The openings in the wall of the tower shall be rectangular in shape, 24 inches long and 4 inches wide on the outside face and tapered to 5 inches wide on the inside face. Eighteen openings shall be equally spaced around the circumference.

3. The height of the tower shall be determined by locating it at the lowest point of the debris basin and constructing it to a height that shall project at least 1 foot above the theoretical debris slope.

4. The tower shall be located so that it is away from the direct line of flow between the inlet to the basin and the spillway.

5. The tower shall have safety collars set 9 feet apart vertically and a removable cover with an access manhole set on top of the tower for maintenance purposes.

6. A smooth transition to the outlet pipe shall be provided in the base of the tower.

Details of the outlet tower and steel reinforcement are shown on Drawing No. 2-D 404, page I-30.

SECTION F
Continued

F-3 Outlet Pipe

The reinforced concrete outlet pipe shall not be less than 36 inches in diameter, encased in concrete, sufficiently reinforced to prevent cracks, and be provided with cutoff collars to prevent piping along the pipe encasement. The length of the encasement shall be from the outlet tower base to the junction with the spillway wall. In cases where the junction with the spillway wall is downstream of the toe of the dam fill, the 36-inch reinforced concrete pipe is not required to be encased between the downstream toe of the dam fill and the junction structure at the spillway wall. Details of the outlet pipe, encasement, and steel reinforcement are shown on Drawing No. 2-D 404, page I-30.

The subgrade for the outlet pipe encasement or outlet pipe shall be over-excavated by 2 feet 6 inches unless the subgrade is on bedrock. In cases where it can be shown to the satisfaction of the District that the subgrade is on bedrock, the subgrade shall be at the bottom of the concrete encasement. The details as shown on Drawing No. 2-D 404 shall be revised accordingly.

SECTION G

SPECIFICATIONS

SECTION G

SPECIFICATIONS

Specifications covering the work to be performed shall either be set forth in the construction plans or submitted separately in typed form.

The specifications shall adequately describe the requirements for clearing, grubbing, stripping, excavating, placing fill and backfill, relative compaction requirements, methods of testing, disposal of excess and removed material, and all other related earthwork operations. Said specifications shall be based upon the information obtained from the subsurface investigation report and the engineering geology investigation report covered under Sections B and C.

The specifications shall also require the submittal of a signed construction report by the geologist and soil engineer covering observations made during the excavation for the dam foundation and abutments as described in Section H, Subsection H-2.

In addition, the specifications shall describe the requirements for materials and construction requirements involving concrete, pipe subdrains, reinforced concrete pipe, gunite, and all other items to be incorporated in the project.

The specifications may incorporate applicable portions of the "Standard Specifications for Public Works Construction", 1973 Edition, including Supplements thereto as well as the District's Additions and Amendments and Additional Provisions thereto (Parts D through M) by means of appropriate reference thereto. In this respect, particular attention is directed to Subsection 300-6 and to Subsection 303-1 of said specifications.

SECTION H

CONSTRUCTION REQUIREMENTS

SECTION H

CONSTRUCTION REQUIREMENTS

H-1 General

The construction of debris dams and basins shall be strictly in accordance with plans and specifications approved by the District. All earthwork construction, including stripping, excavation, overexcavation, backfill, and fill shall be supervised by the same soil engineer who performed the subsurface investigation, unless District approval to the contrary is obtained in advance. The soil engineer shall perform or supervise the necessary soil tests and shall direct the earthwork operations to assure conformance with the approved plans and specifications. Results of all tests shall be submitted to the District. All inspection and testing shall be without cost to the District and the District reserves the right to make its own inspections and tests, and to be compensated for the expense of such inspection and tests by the owner or the contractor.

H-2 Construction Reports

During construction, in the stripping and excavation phase, the soil engineer and the geologist shall observe and compile data on the actual depth of stripping and materials encountered in the excavation for the foundation and abutments of the dam and prepare a construction report on the actual conditions encountered in the field. The report shall also include a geologic map showing the location and various types of material exposed in the dam foundation and abutment areas. The geologic map shall be prepared from a topographic survey made to the same scale as the contract drawings. Both the report and the geologic map shall be signed by the soil engineer and the geologist and submitted to the District within 30 days after completion of the excavation for the dam foundation and abutments.

After completion of construction, the soil engineer shall prepare and sign a brief final construction report and submit it to the District with the "as built" drawings described in Section H-4. The final construction report shall include results of all tests with complete information and identification as to date, location, and elevation. It shall document field observations made of the actual construction of the dam and basin including any changes made to the contract drawings.

H-3 Supplemental Information and Recommendations

If it should prove necessary to make changes in the design or construction which may affect the operation or maintenance of the basin, supplemental information and recommendations shall be submitted. For example, if an unexpected shortage of borrow material should require the use of a new borrow area or pit, the materials in the new source shall be investigated by the soil engineer and approved by the District prior to use.

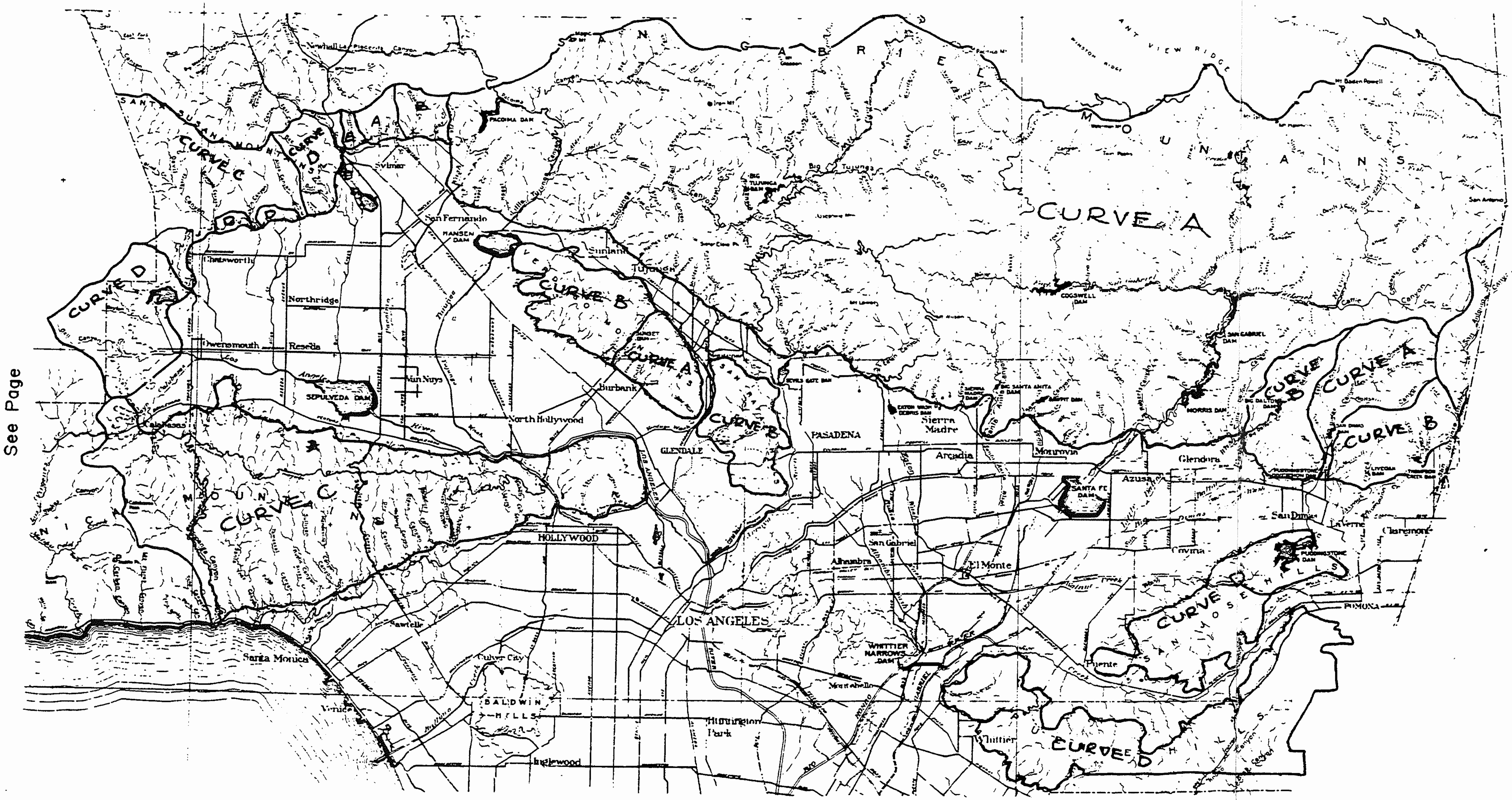
SECTION H
Continued

H-4 "As Built" Drawings

After completion of construction, a set of "as built" drawings showing all changes to the contract drawings which were made during construction shall be submitted to the District. Each sheet of the contract drawings shall have "AS BUILT" noted in the lower right hand corner whether or not that particular sheet had any "as built" changes made on it.

See Page I-3

See Page

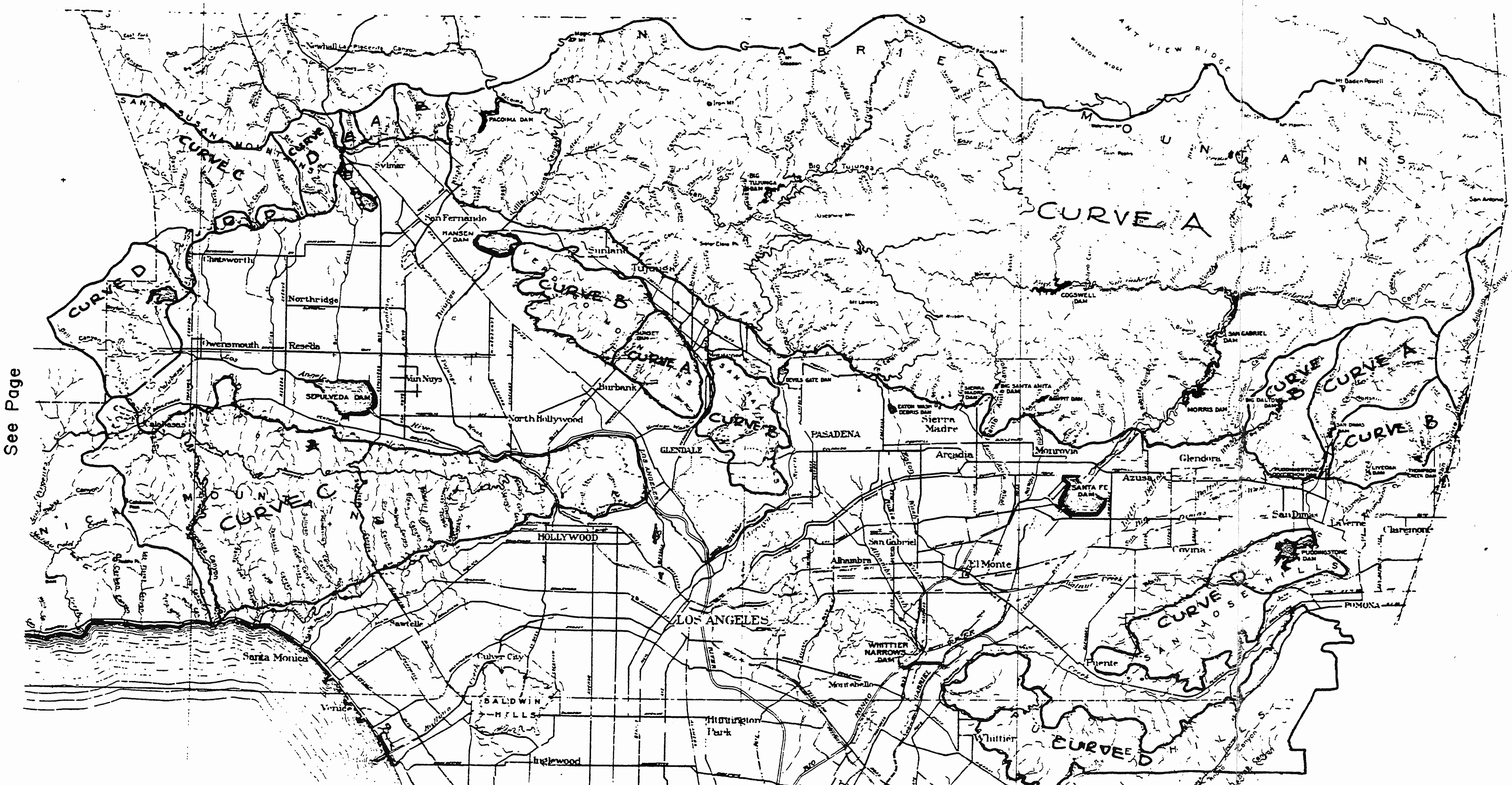


DEBRIS PRODUCTION ZONES

See Page I-4 for Debris Production Curves

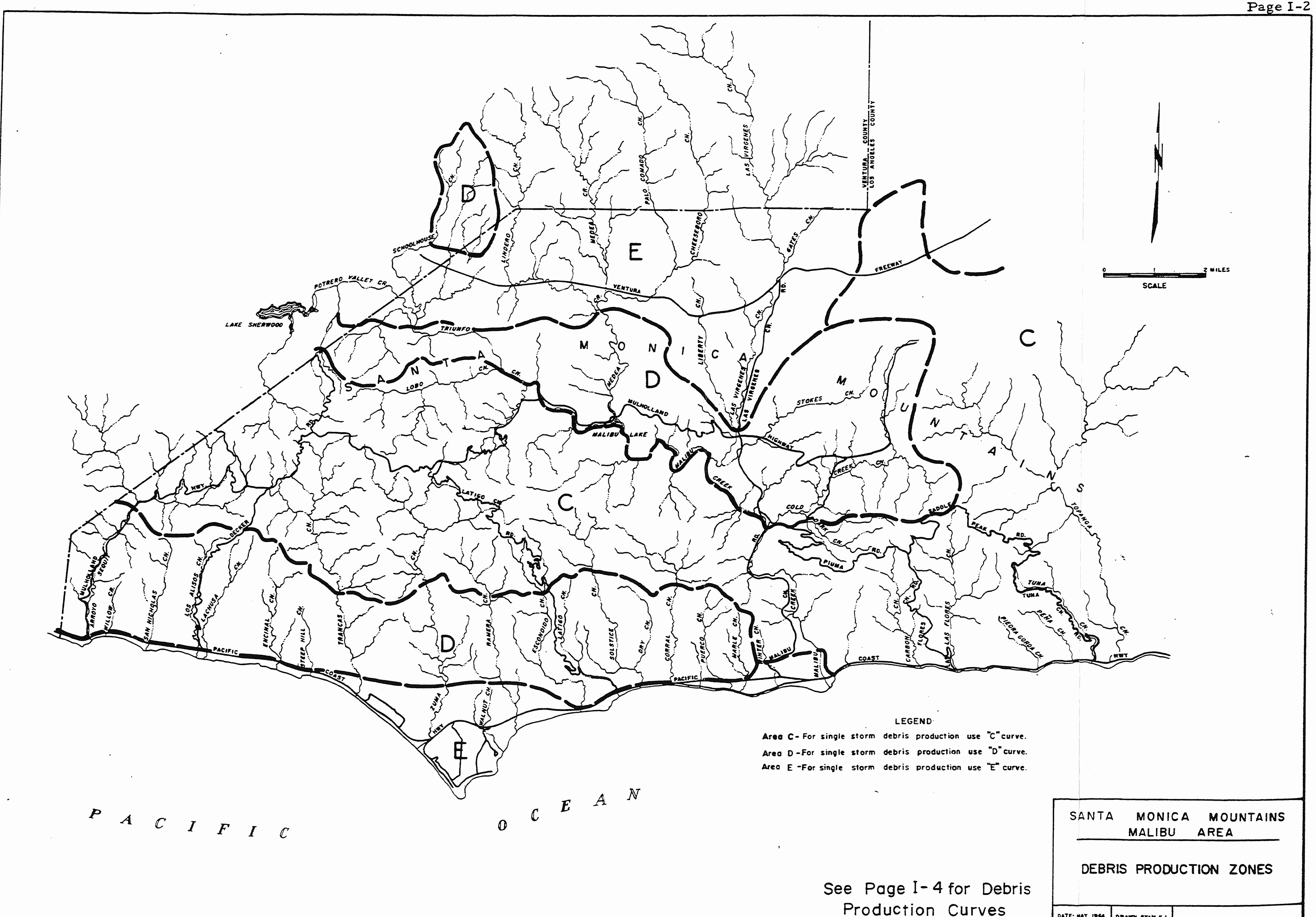
See Page I-3

See Page



DEBRIS PRODUCTION ZONES

See Page I-4 for Debris Production Curves


SANTA MONICA MOUNTAINS
MALIBU AREA
DEBRIS PRODUCTION ZONES
DATE: MAY, 1964
DRAWN BY: M.K.I.
LEGEND
Area C - For single storm debris production use "C" curve.
Area D - For single storm debris production use "D" curve.
Area E - For single storm debris production use "E" curve.
See Page I-4 for Debris Production Curves
SCALE
0
1
2 MILES
N
PACIFIC OCEAN
SANTA MONICA MOUNTAINS
VENTURA COUNTY
LOS ANGELES COUNTY
C
D
E
LAKE SHERWOOD
POTRERO VALLEY CR.
SCHOOLHOUSE
LINDERO
MEDEA
PALO COMADO
CHEESEBORO
LAS VIRGENES
LIBERTY
VENTURA
FREEWAY
TRIUNFO
LOBO
MULHOLLAND
MALIBU LAKE
MALIBU CREEK
STOKES
COLD CREEK
SADDLE PEAK RD.
PIUMA RD.
LATIGO
DECKER
TOPANGA
TUNA
PENA
PIEDRA GORDA
LAS FLORES
CARBON
ARROYO SEQUIT
WILLOW CR.
SAN NICHOLAS
LOS ALISOS CR.
LACHUSA
ENCINAL
STEEP HILL
TRANCAS
RAMERA
ESCONDIDO
SOLSTICE
CORRAL
PUERCO
MARIE
ZUMA
WALNUT
PACIFIC COAST HWY
MALIBU

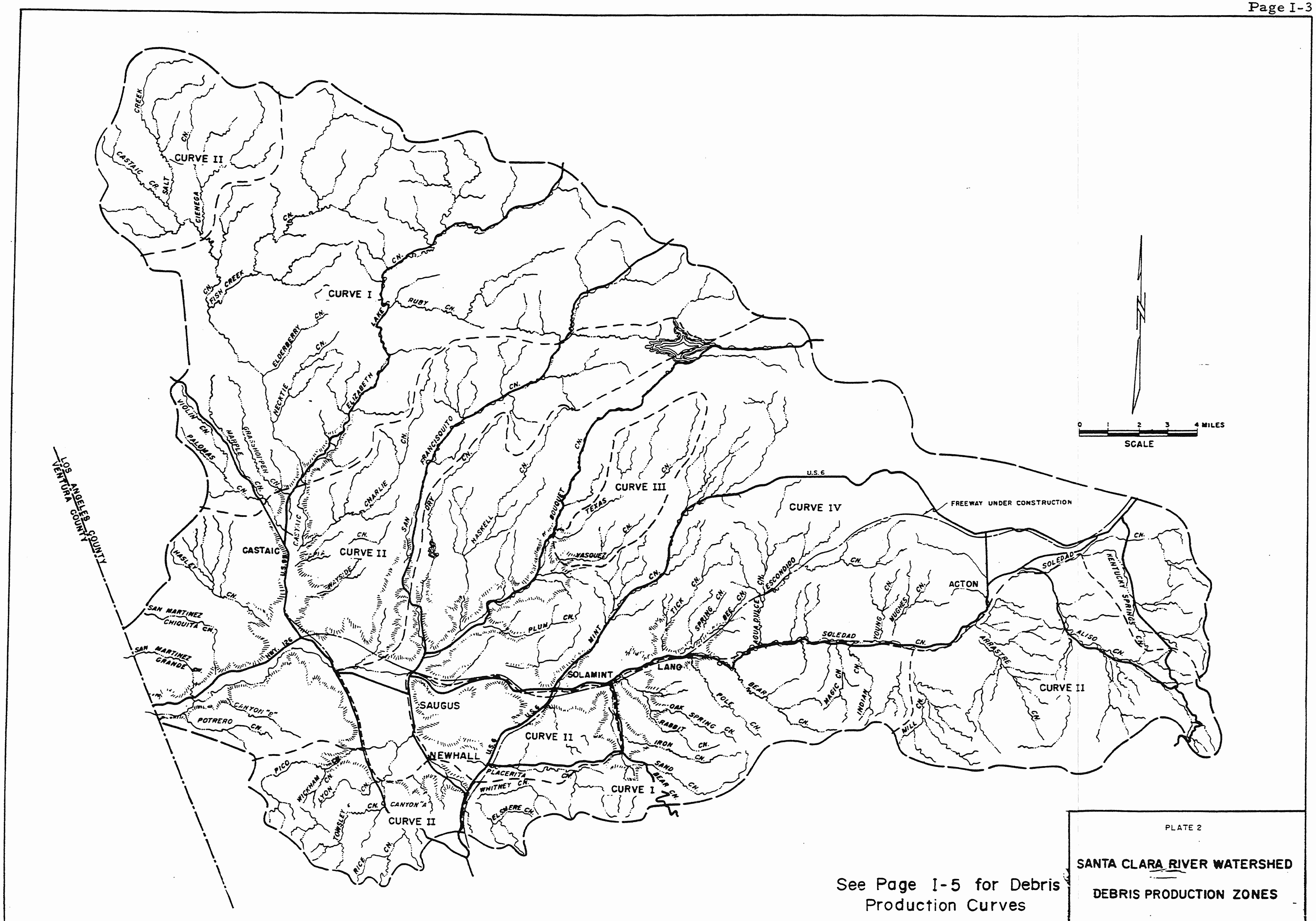
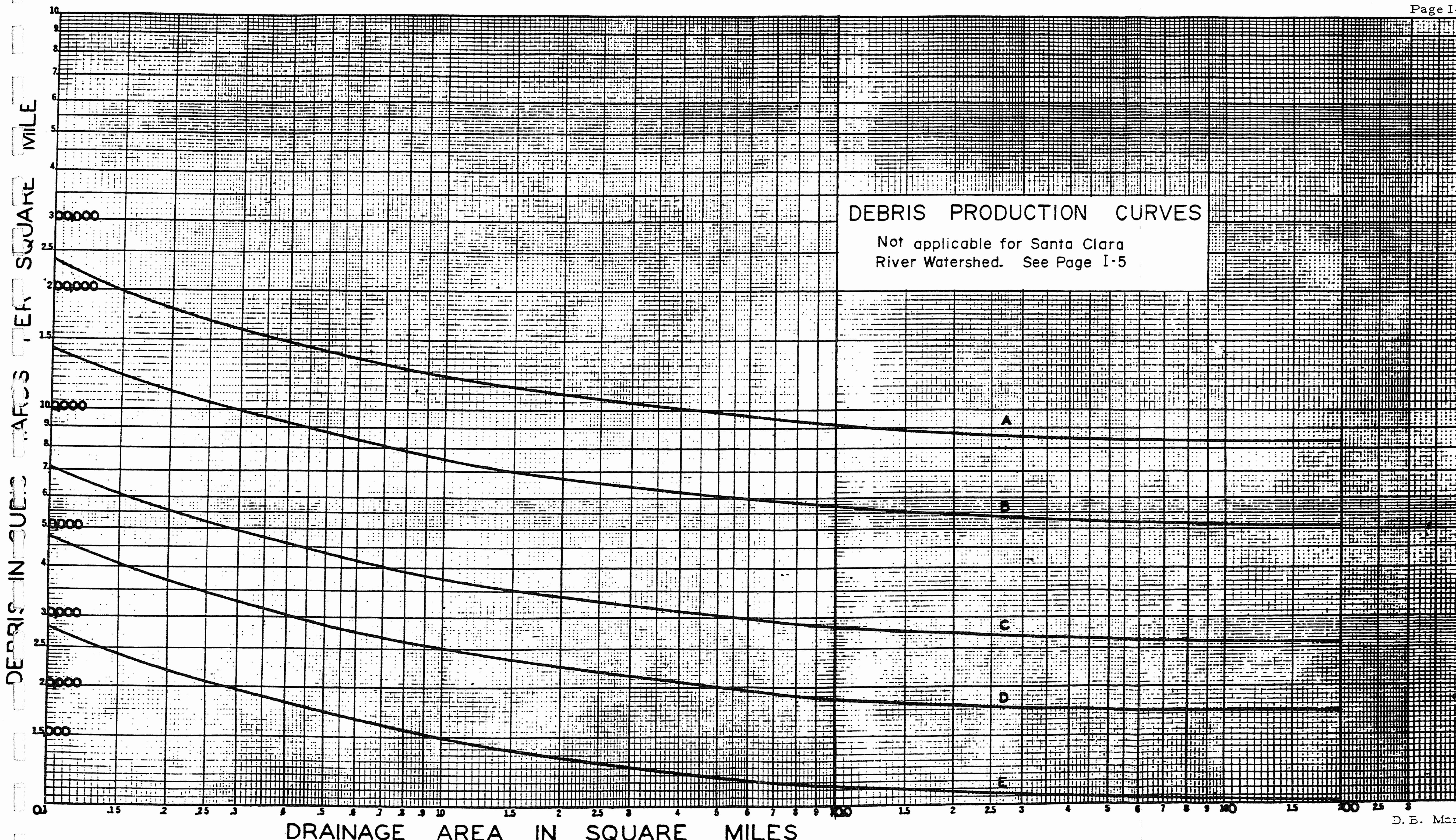


PLATE 2

SANTA CLARA RIVER WATERSHED

DEBRIS PRODUCTION ZONES

See Page I-5 for Debris Production Curves


DEBRIS PRODUCTION CURVES
Not applicable for Santa Clara River Watershed. See Page I-5
A
B
C
D
E
300,000
200,000
100,000
50,000
30,000
20,000
15,000
DRAINAGE AREA IN SQUARE MILES
D. B. Mcn.

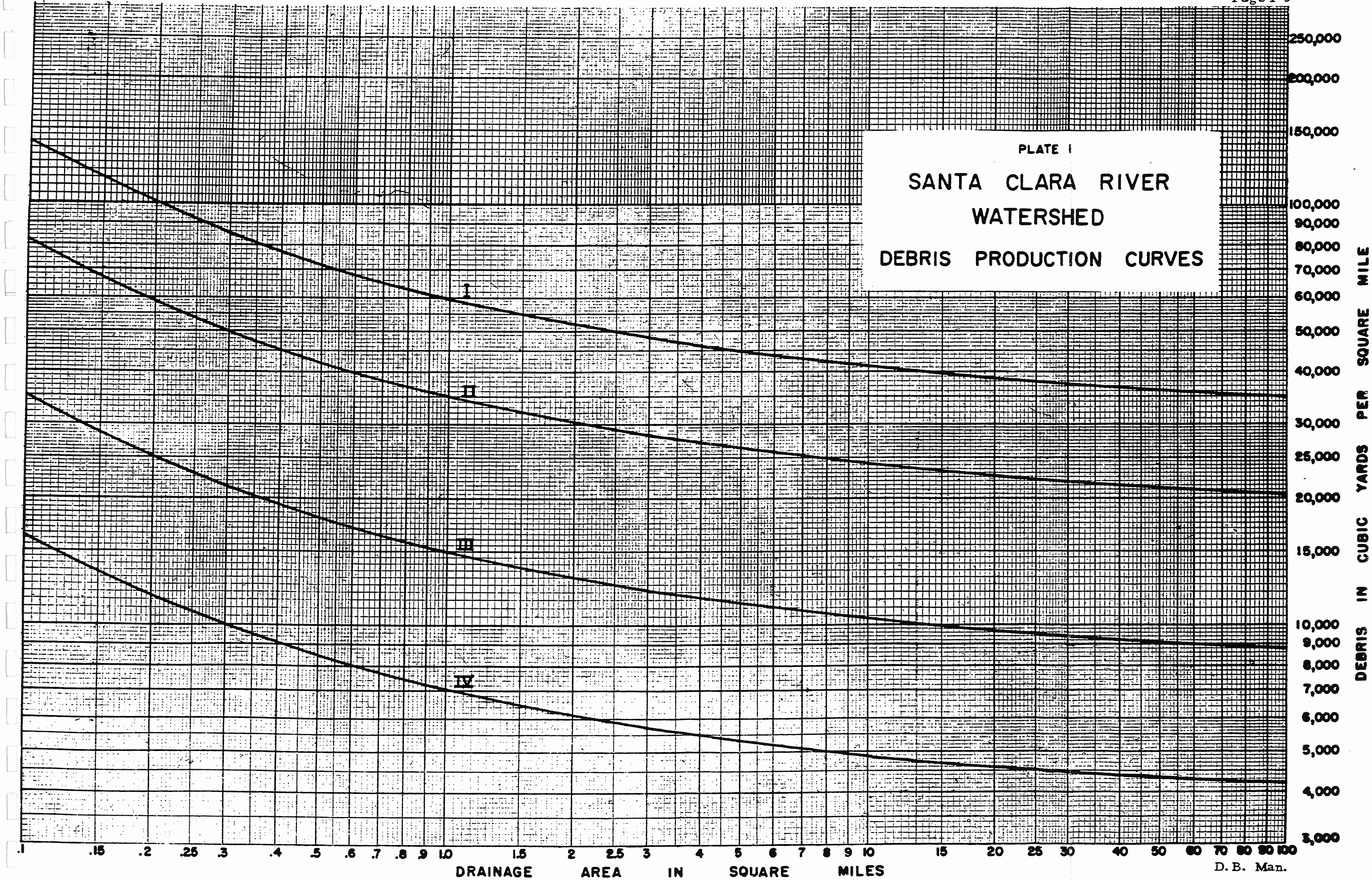
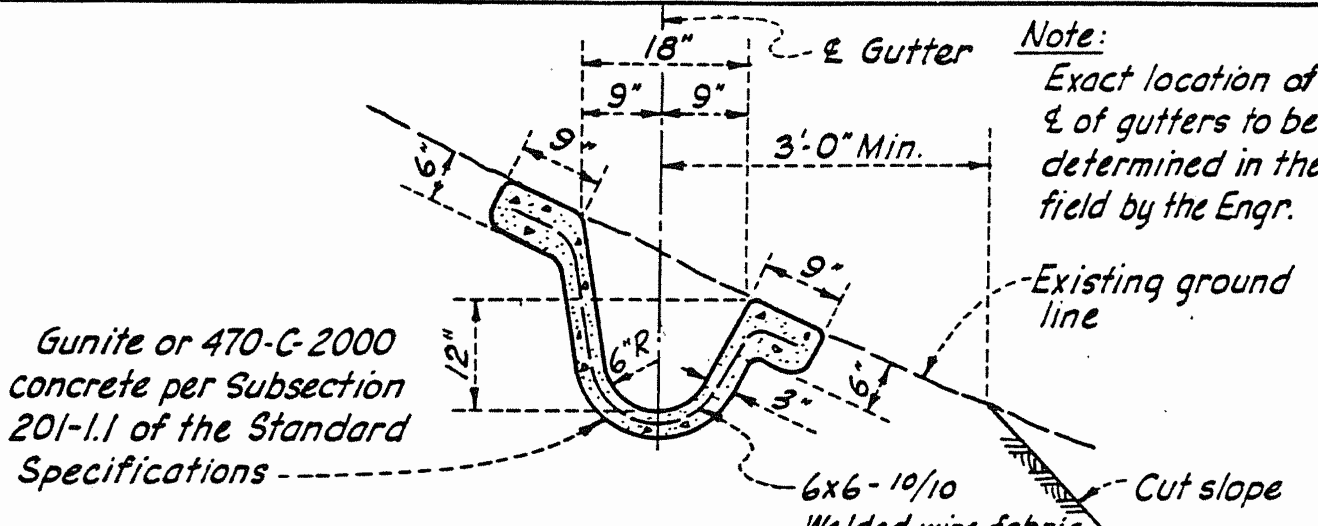
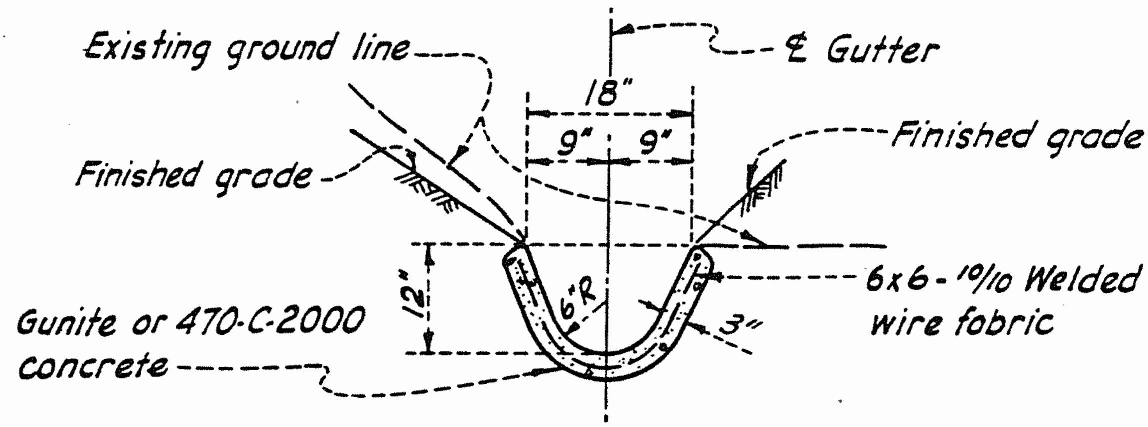


PLATE I
SANTA CLARA RIVER
WATERSHED
DEBRIS PRODUCTION CURVES
I
II
III
IV
250,000
200,000
150,000
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
25,000
20,000
15,000
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
DEBRIS IN CUBIC YARDS PER SQUARE MILE
.1
.15
.2
.25
.3
.4
.5
.6
.7
.8
.9
1.0
1.5
2
2.5
3
4
5
6
7
8
9
10
15
20
25
30
40
50
60
70
80
90
100
DRAINAGE AREA IN SQUARE MILES

D. B. Man.

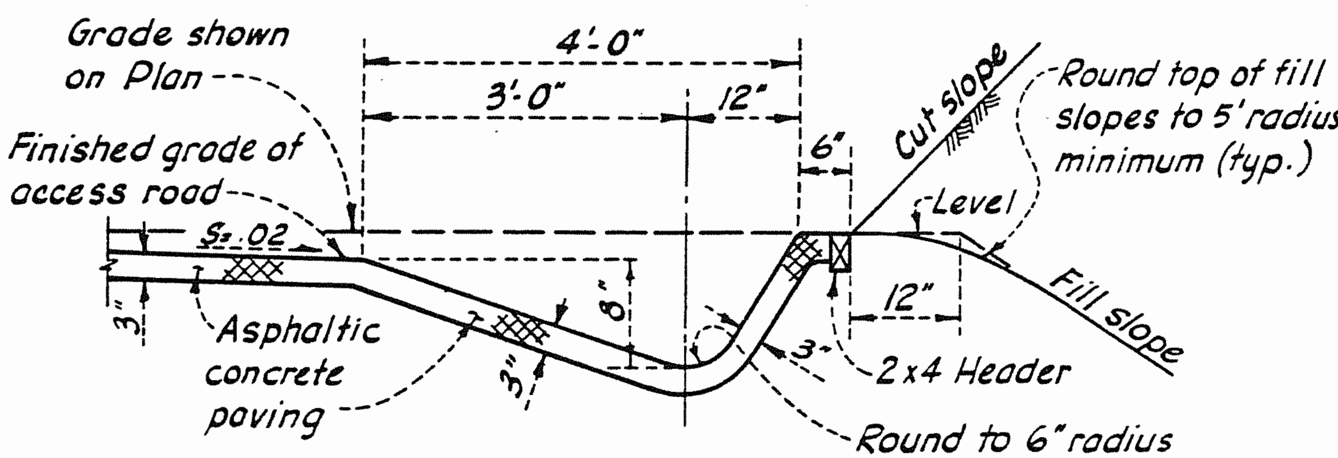


TYPE A



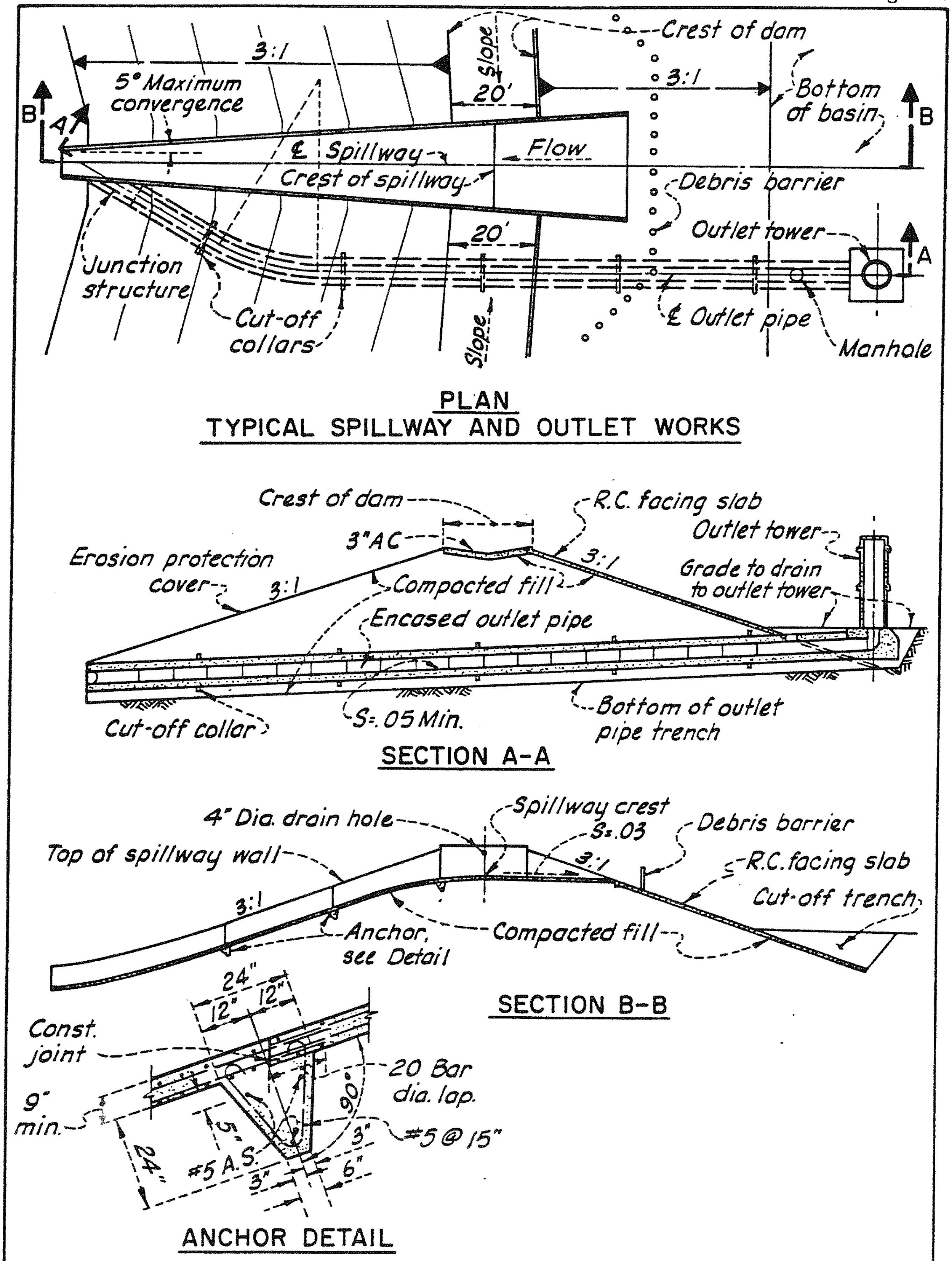
TYPE B

SLOPE PROTECTION GUTTERS



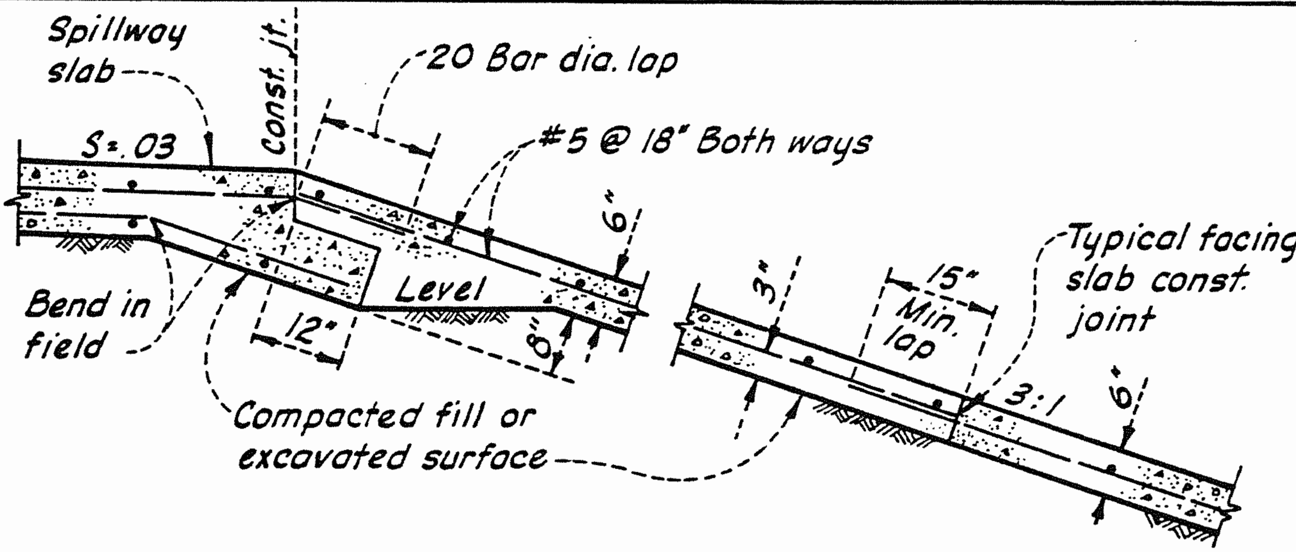
ACCESS ROAD GUTTER

Fig. I

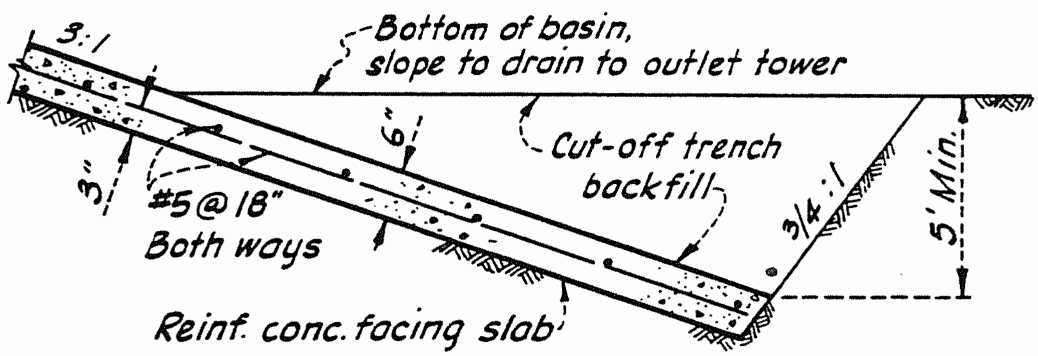


Crest of dam
3:1
Slope
20'
3:1
Bottom of basin
5° Maximum convergence
B
A
B
℄ Spillway
Flow
Crest of spillway
Debris barrier
20'
Outlet tower
A
Junction structure
Cut-off collars
Slope
℄ Outlet pipe
Manhole
PLAN
TYPICAL SPILLWAY AND OUTLET WORKS
Crest of dam
R.C. facing slab
3"AC
Outlet tower
Erosion protection cover
3:1
Compacted fill
3:1
Grade to drain to outlet tower
Encased outlet pipe
Cut-off collar
S=.05 Min.
Bottom of outlet pipe trench
SECTION A-A
Spillway crest
4" Dia. drain hole
S=.03
Debris barrier
Top of spillway wall
3:1
R.C. facing slab
3:1
Cut-off trench
Anchor, see Detail
Compacted fill
SECTION B-B
24"
12"
12"
Const. joint
20 Bar dia. lap.
9" min.
90°
5"
24"
#5 A.S.
3"
#5 @ 15"
3"
6"
ANCHOR DETAIL

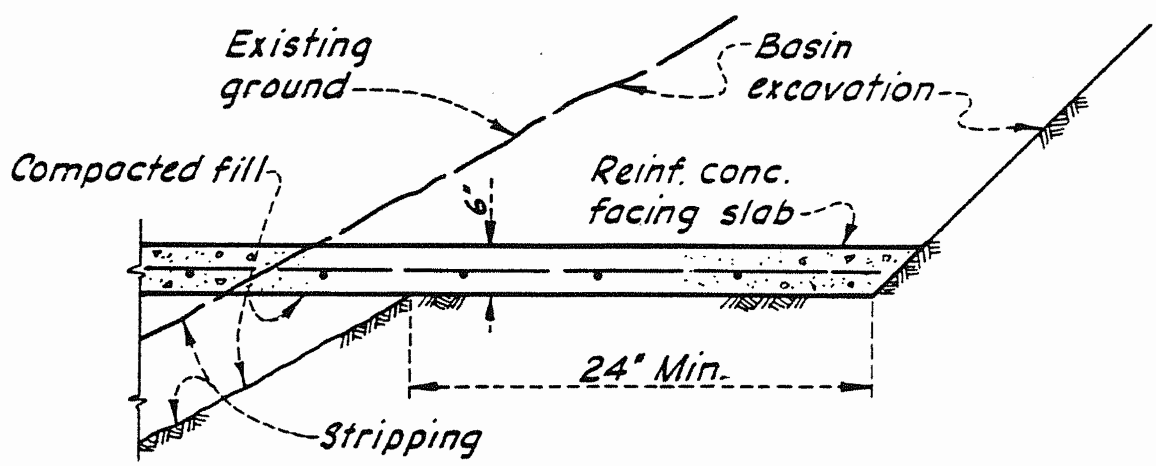
Fig. 2



FACING SLAB DETAIL

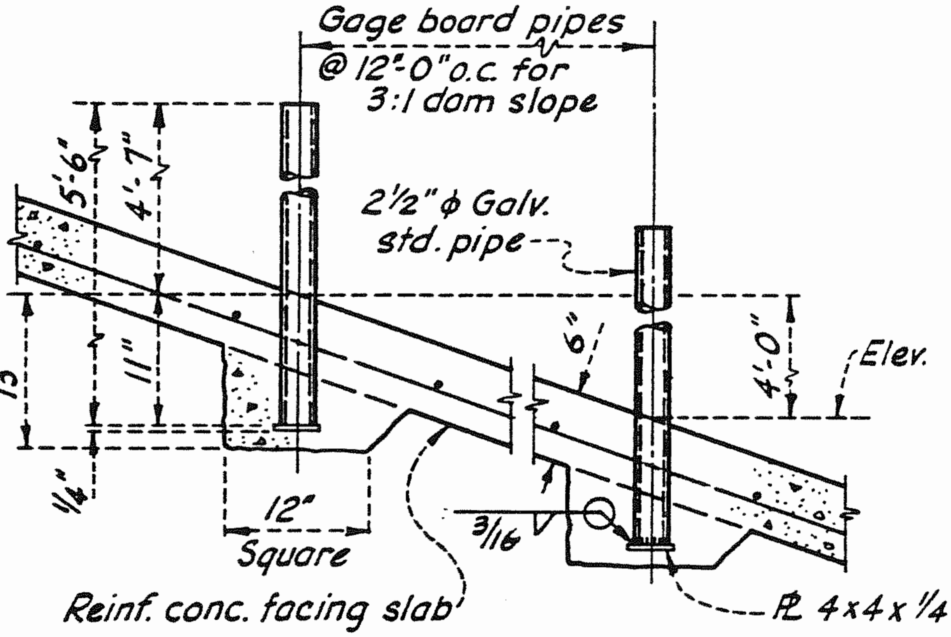


FACING SLAB CUT-OFF DETAIL



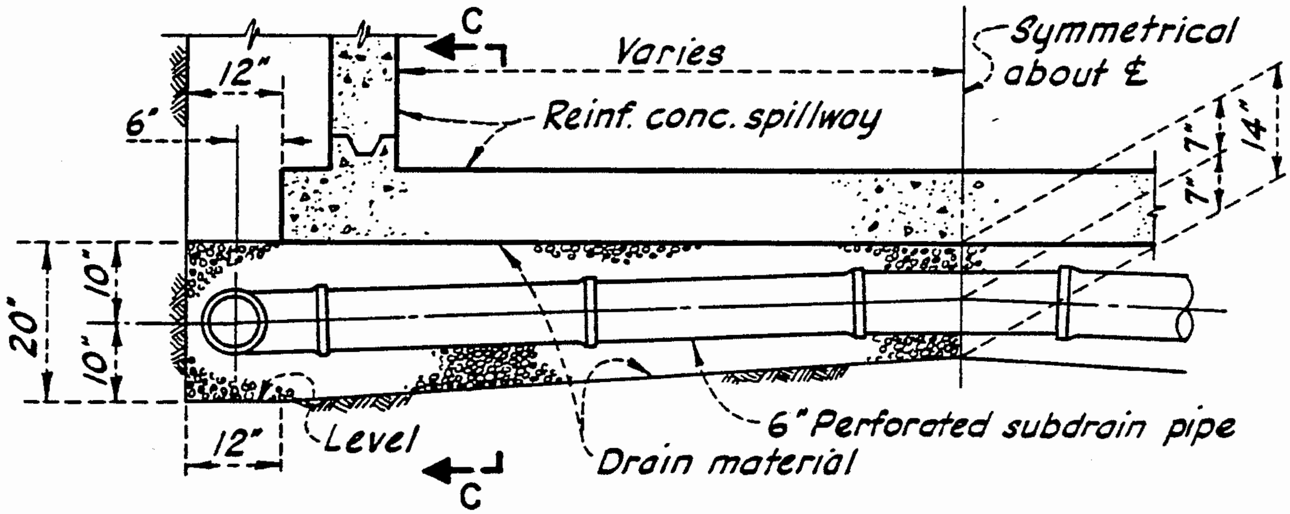
FACING SLAB DETAIL AT ABUTMENTS

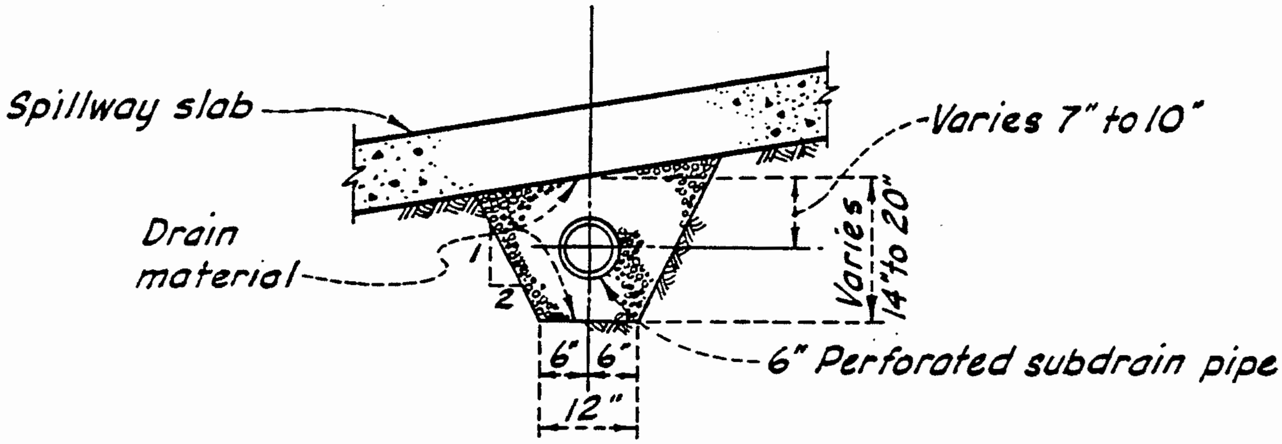
Fig. 3



GAGE BOARD PIPE INSTALLATION

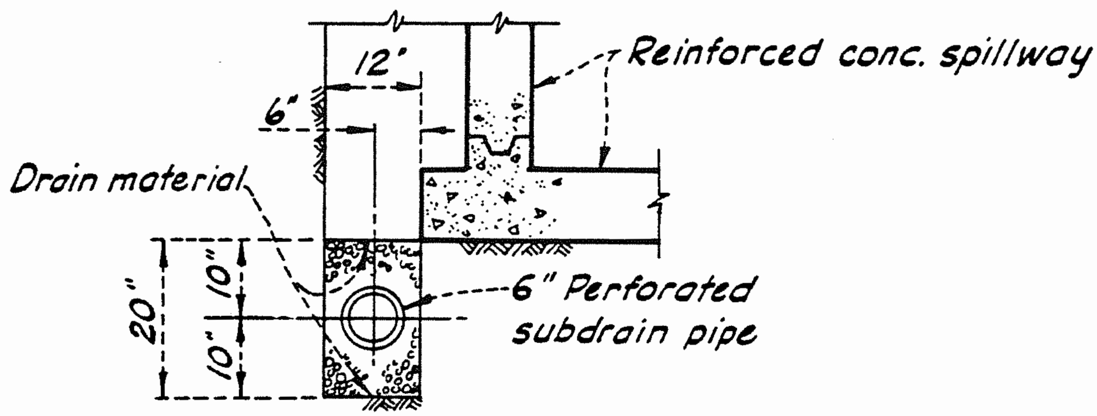
Fig. 4





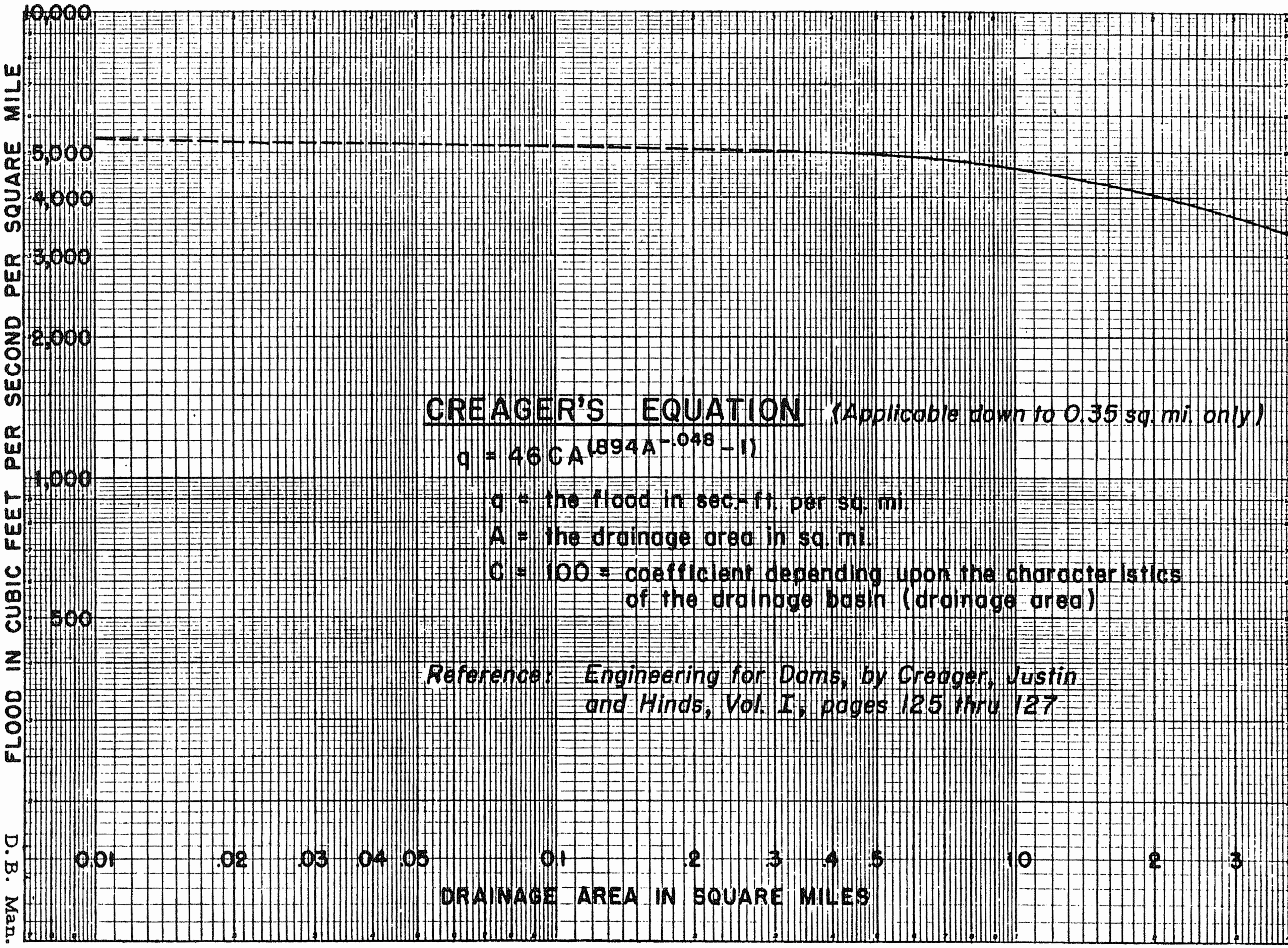
SECTION C-C

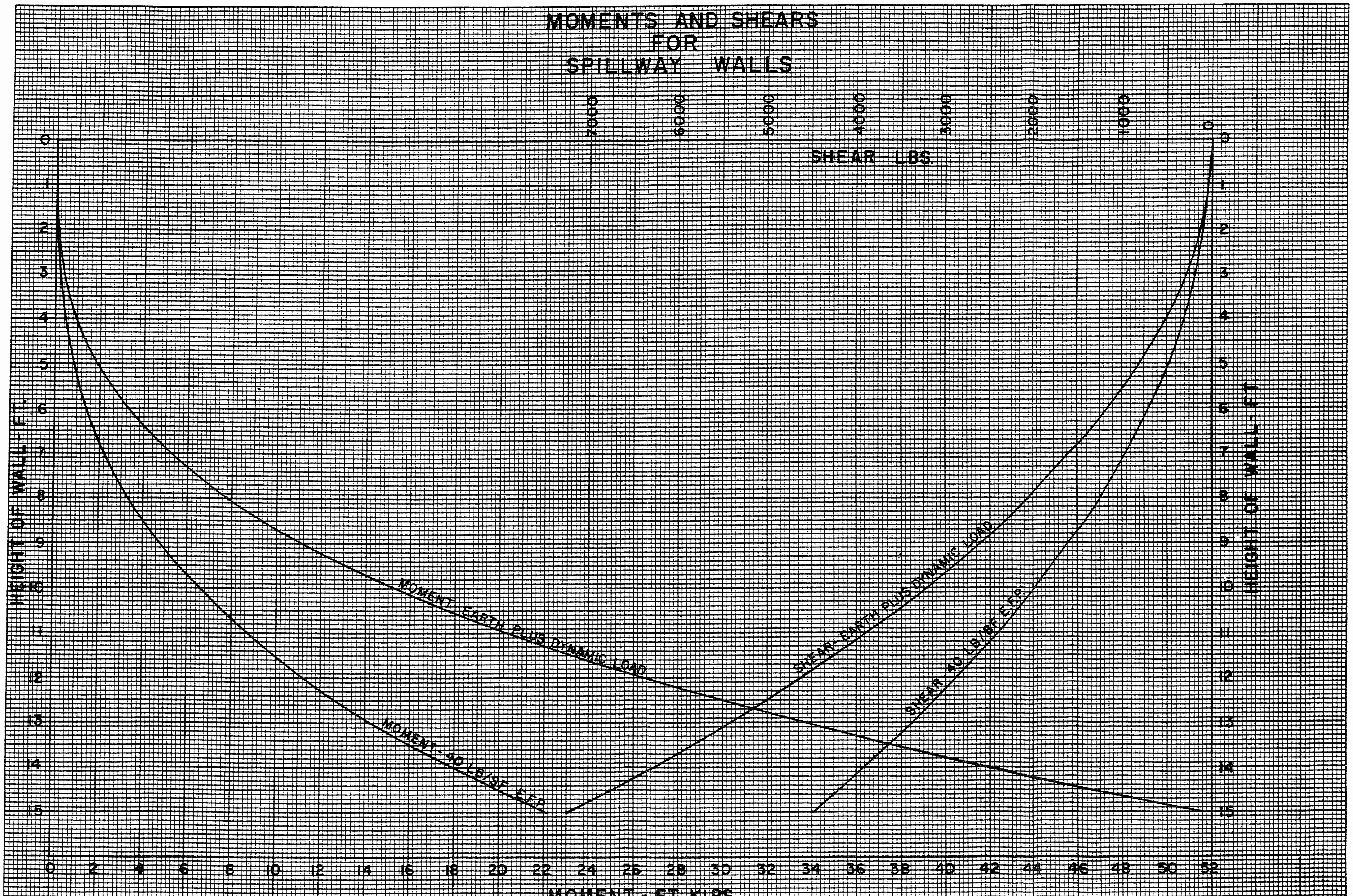
LATERAL SUBDRAIN DETAIL



LONGITUDINAL SUBDRAIN DETAIL BETWEEN CONNECTED LATERALS

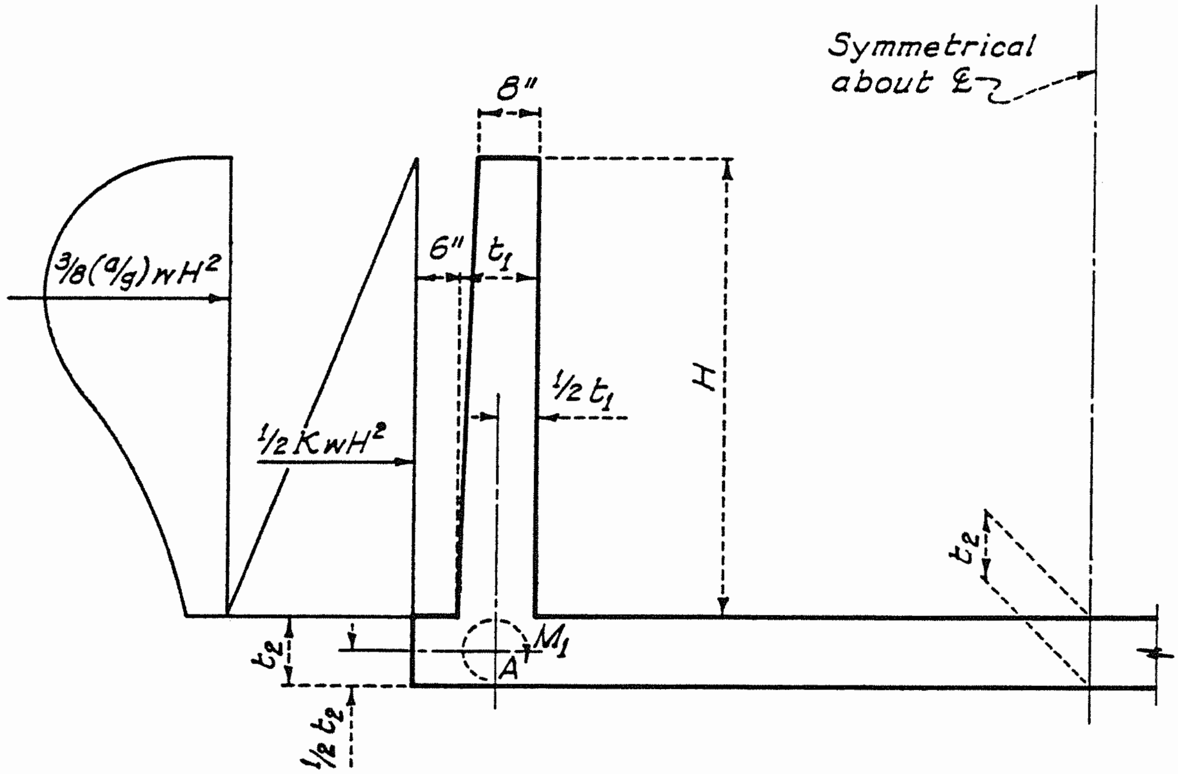
Fig. 5


FLOOD IN CUBIC FEET PER SECOND PER SQUARE MILE
10,000
5,000
4,000
3,000
2,000
1,000
500
0.01
.02
.03
.04
.05
0.1
.2
.3
.4
.5
1.0
2
3
4
DRAINAGE AREA IN SQUARE MILES
CREAGER'S EQUATION (Applicable down to 0.35 sq. mi. only)
q = 46 C A^(.894A^-.048 - 1)
q = the flood in sec-ft. per sq. mi.
A = the drainage area in sq. mi.
C = 100 = coefficient depending upon the characteristics of the drainage basin (drainage area)
Reference: Engineering for Dams, by Creager, Justin and Hinds, Vol. I, pages 125 thru 127



MOMENTS AND SHEARS
FOR
SPILLWAY WALLS
SHEAR - LBS.
7000
6000
5000
4000
3000
2000
1000
0
HEIGHT OF WALL - FT.
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
MOMENT - EARTH PLUS DYNAMIC LOAD
MOMENT - 40 LB/SF E.F.P.
SHEAR - EARTH PLUS DYNAMIC LOAD
SHEAR 40 LB/SF E.F.P.
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52
MOMENT - FT. KIPS

DESIGN OF INVERT SLAB FOR RECTANGULAR SPILLWAYS



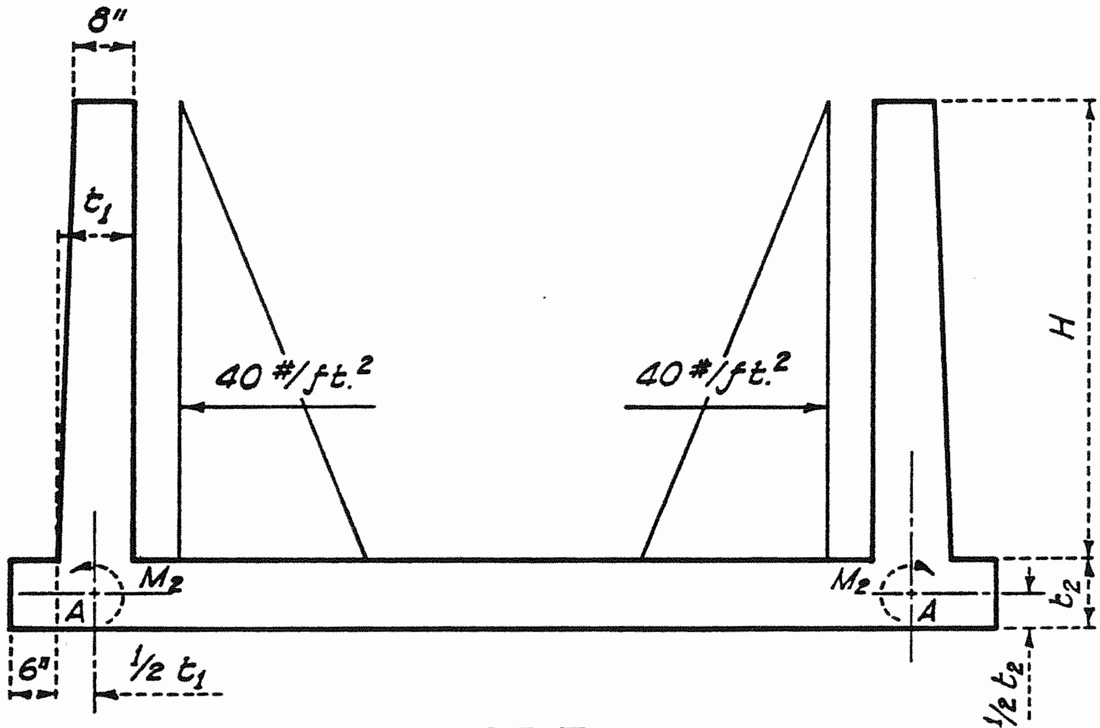
CASE I

Channel Empty

M_1 = Moment at "A" due to external horizontal forces acting on wall.

WALL DIMENSIONS		
H	t_1	t_2
6'	8"	9"
8'	8"	9"
10'	8"	9½"
12'	10"	12"
14'	12"	14½"
16'	14"	17"

DESIGN OF INVERT SLAB FOR RECTANGULAR SPILLWAYS



CASE II

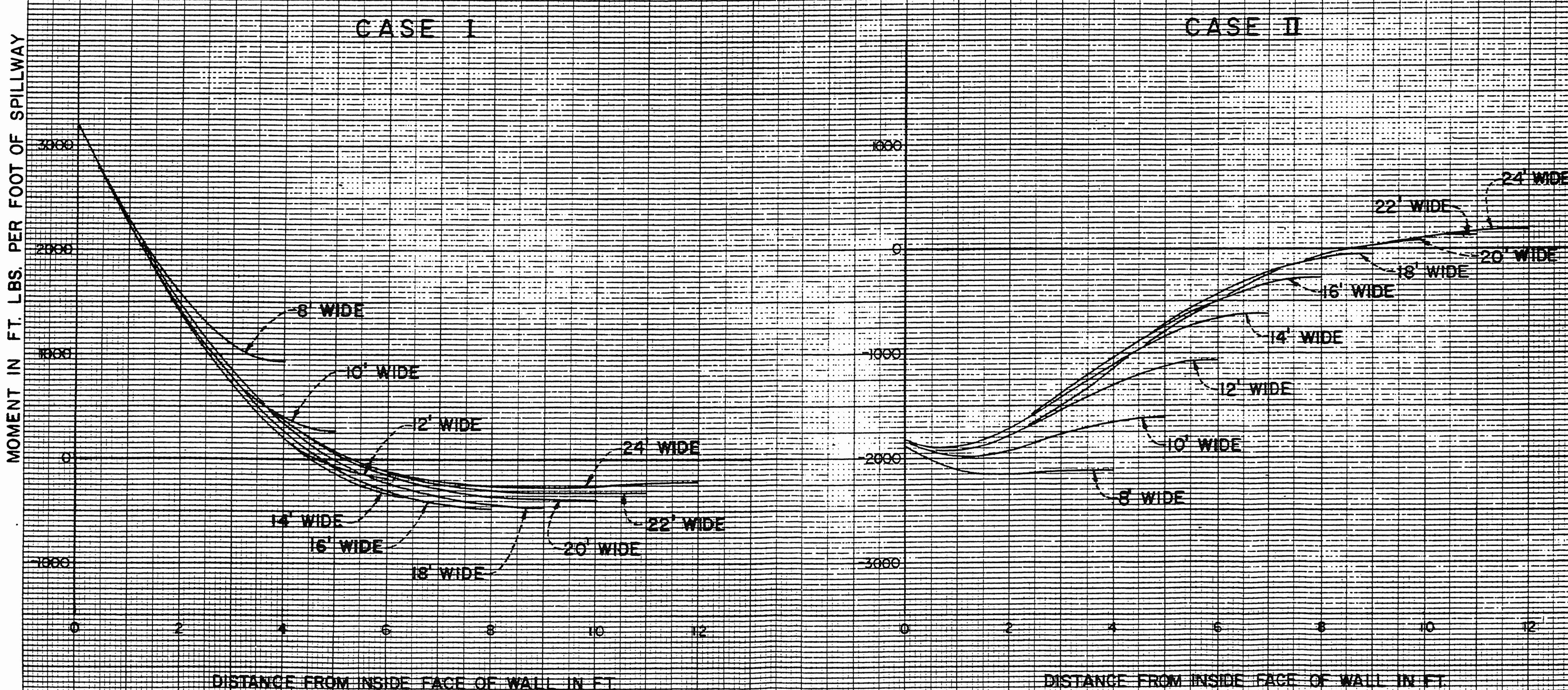
Channel Full

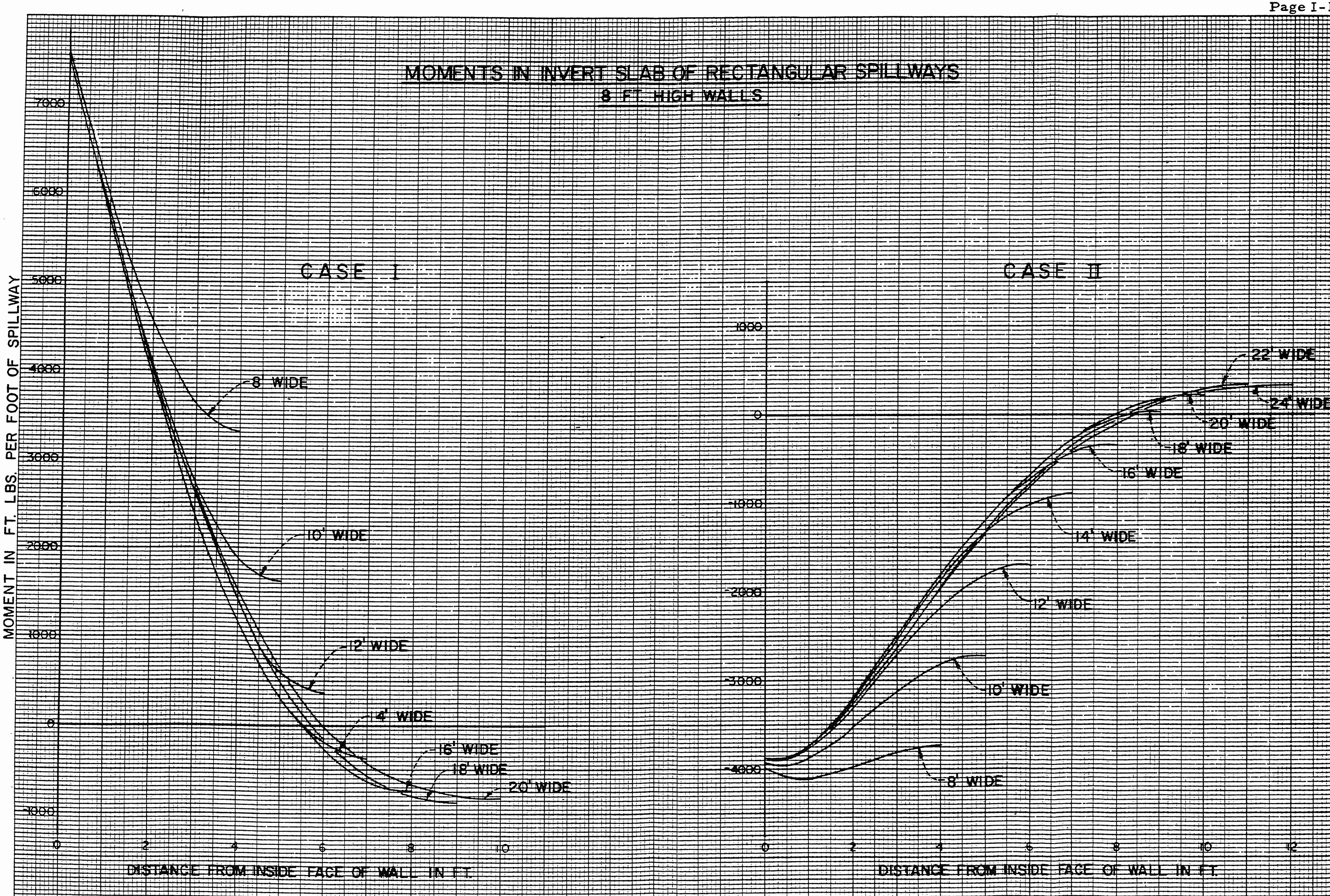
M_2 = Moment at "A" due to equivalent differential hydrostatic pressure.

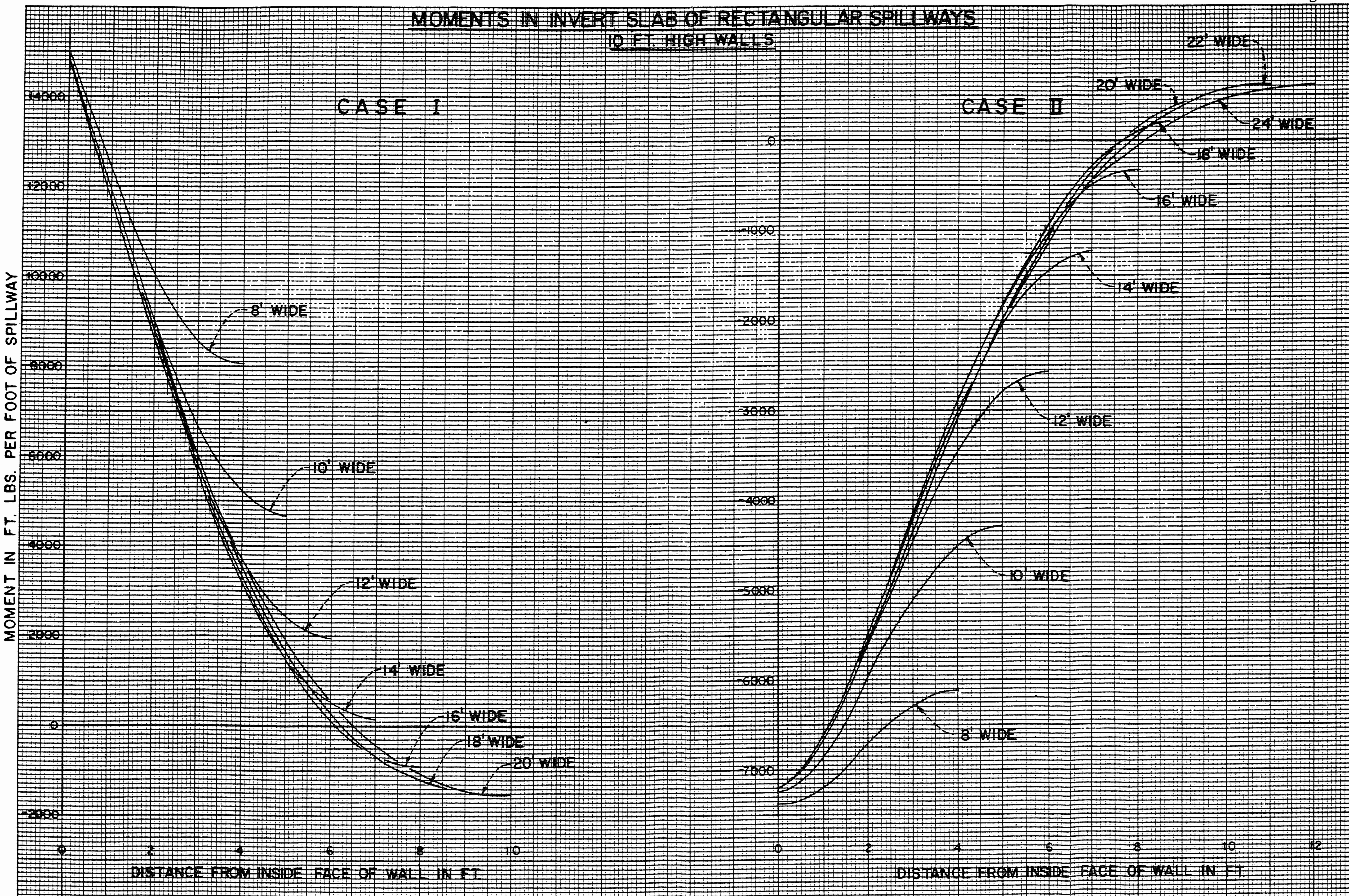
For values of H, t_1 and t_2, see Case I.

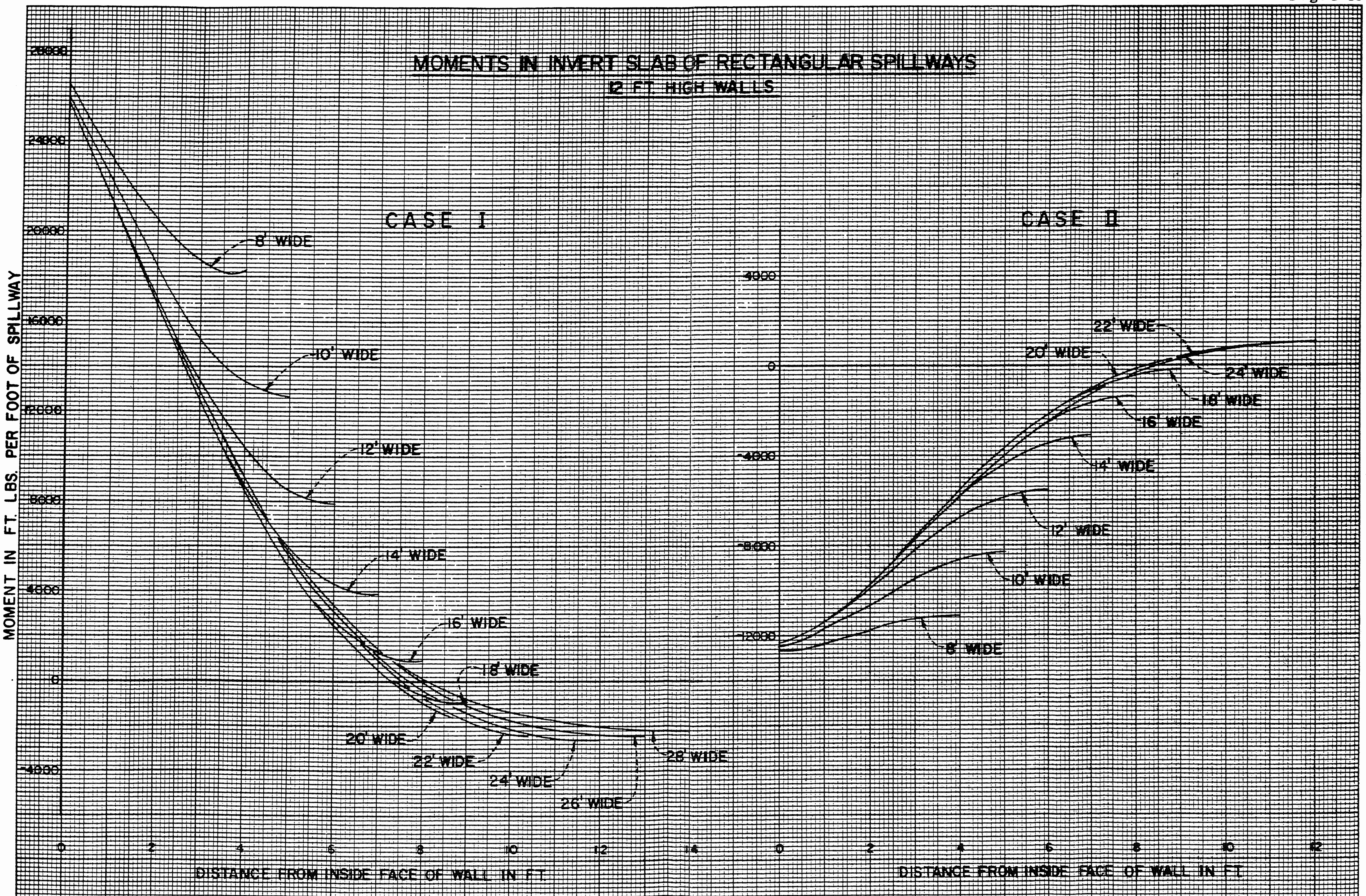
MOMENTS IN INVERT SLAB OF RECTANGULAR SPILLWAYS

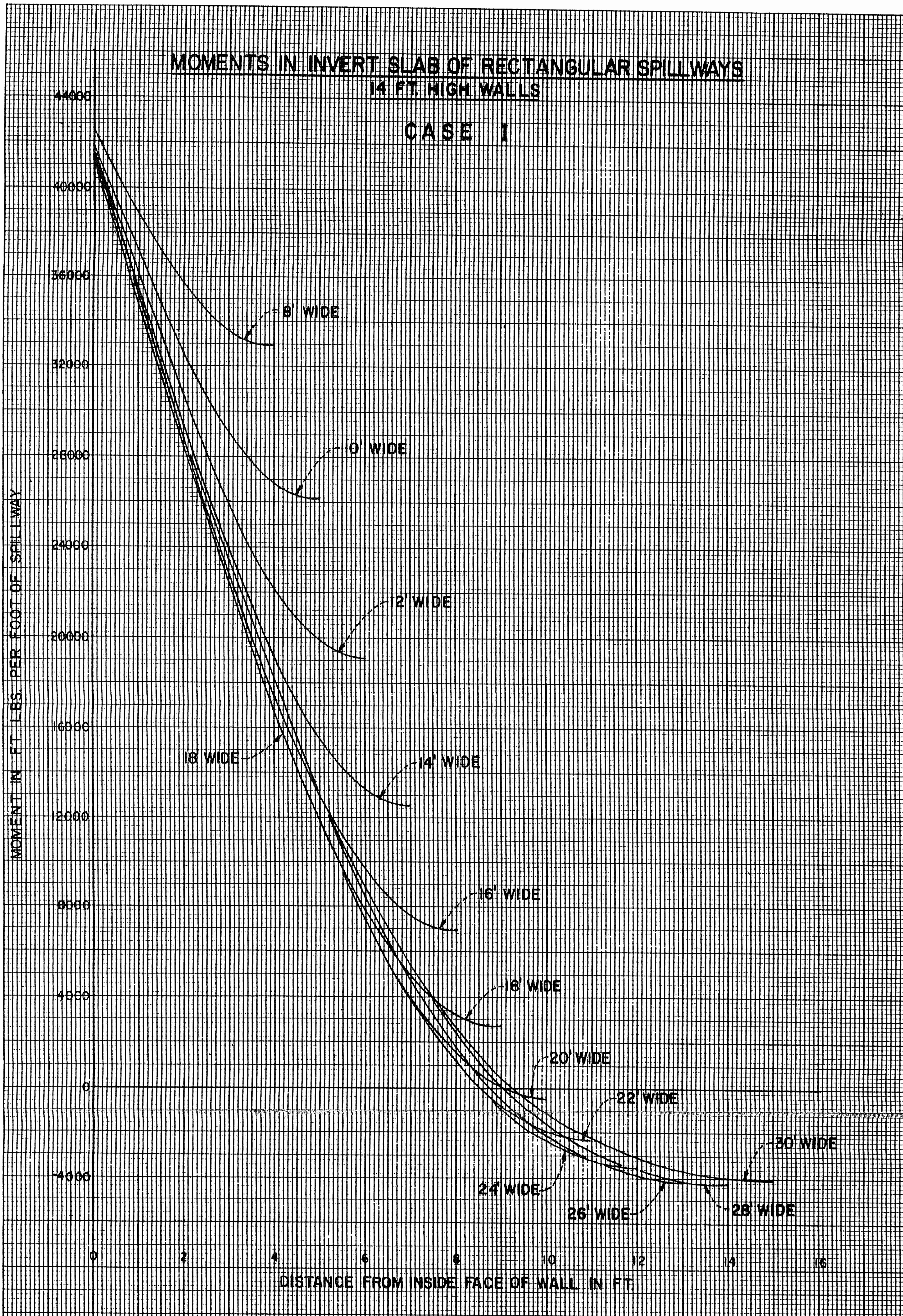
6 FT. HIGH WALLS

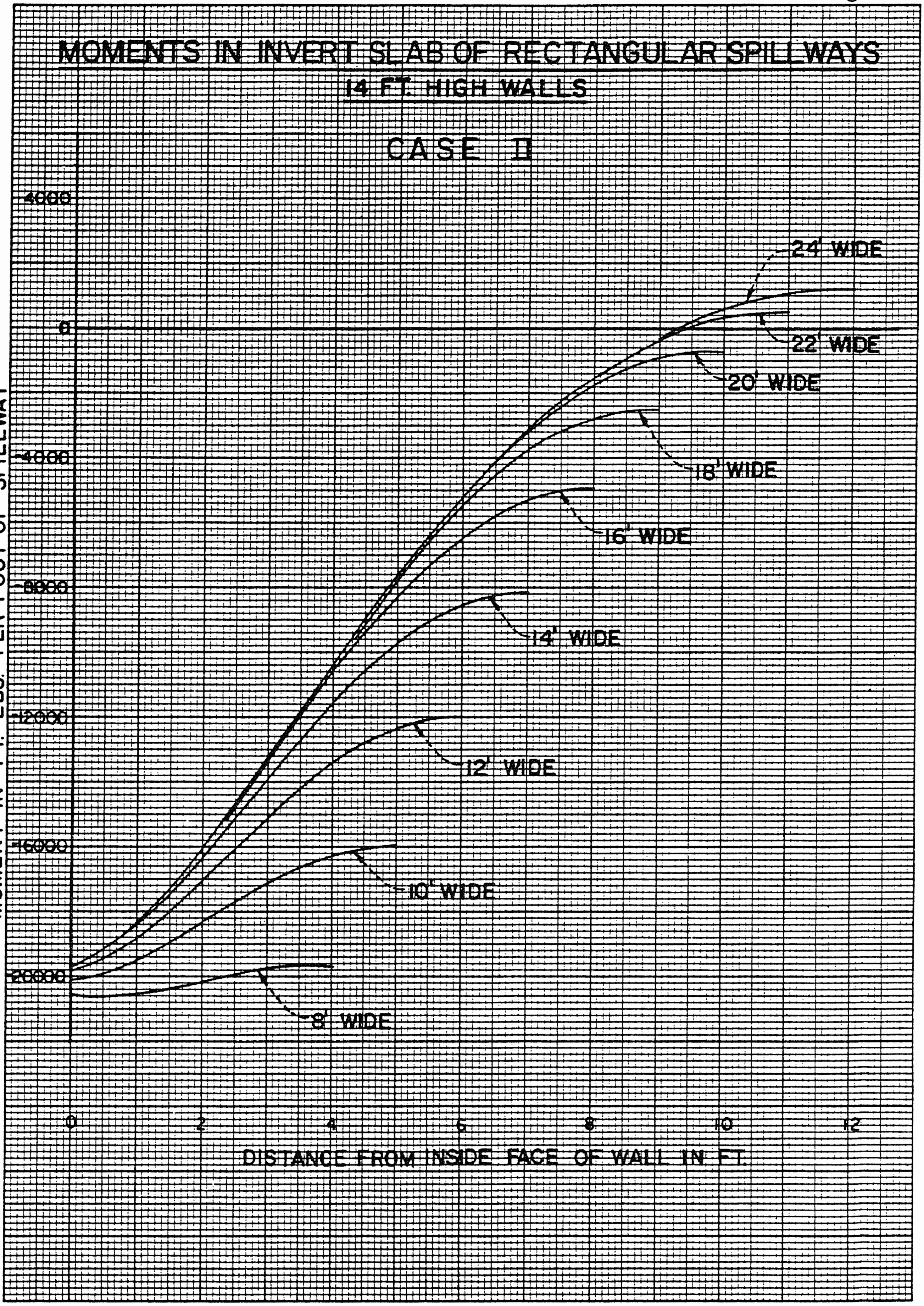


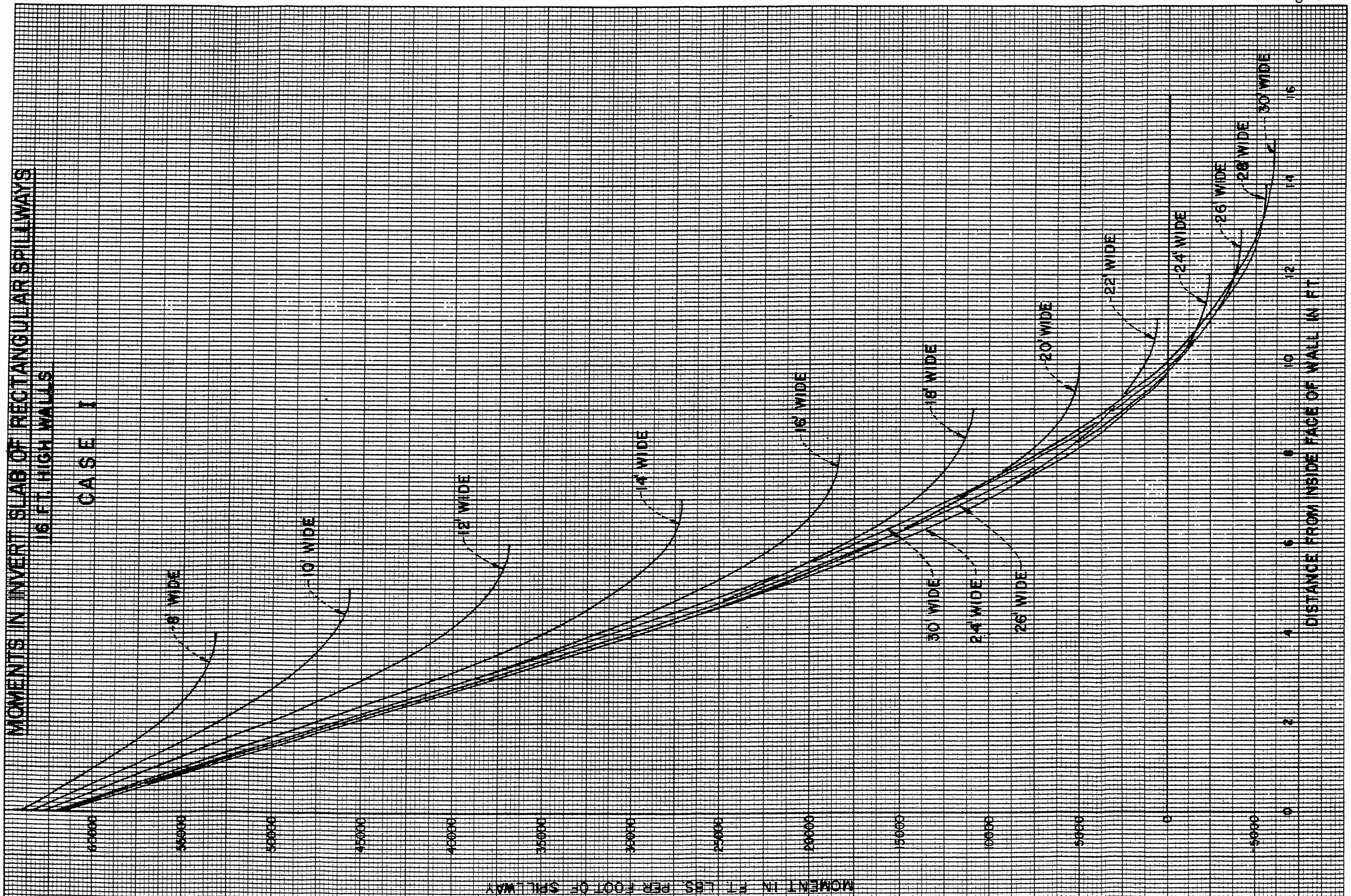

MOMENTS IN INVERT SLAB OF RECTANGULAR SPILLWAYS
8 FT. HIGH WALLS
CASE I
CASE II
MOMENT IN FT. LBS. PER FOOT OF SPILLWAY
7000
6000
5000
4000
3000
2000
1000
0
-1000
-2000
-3000
-4000
8' WIDE
10' WIDE
12' WIDE
14' WIDE
16' WIDE
18' WIDE
20' WIDE
22' WIDE
24' WIDE
0
2
4
6
8
10
12
DISTANCE FROM INSIDE FACE OF WALL IN FT.

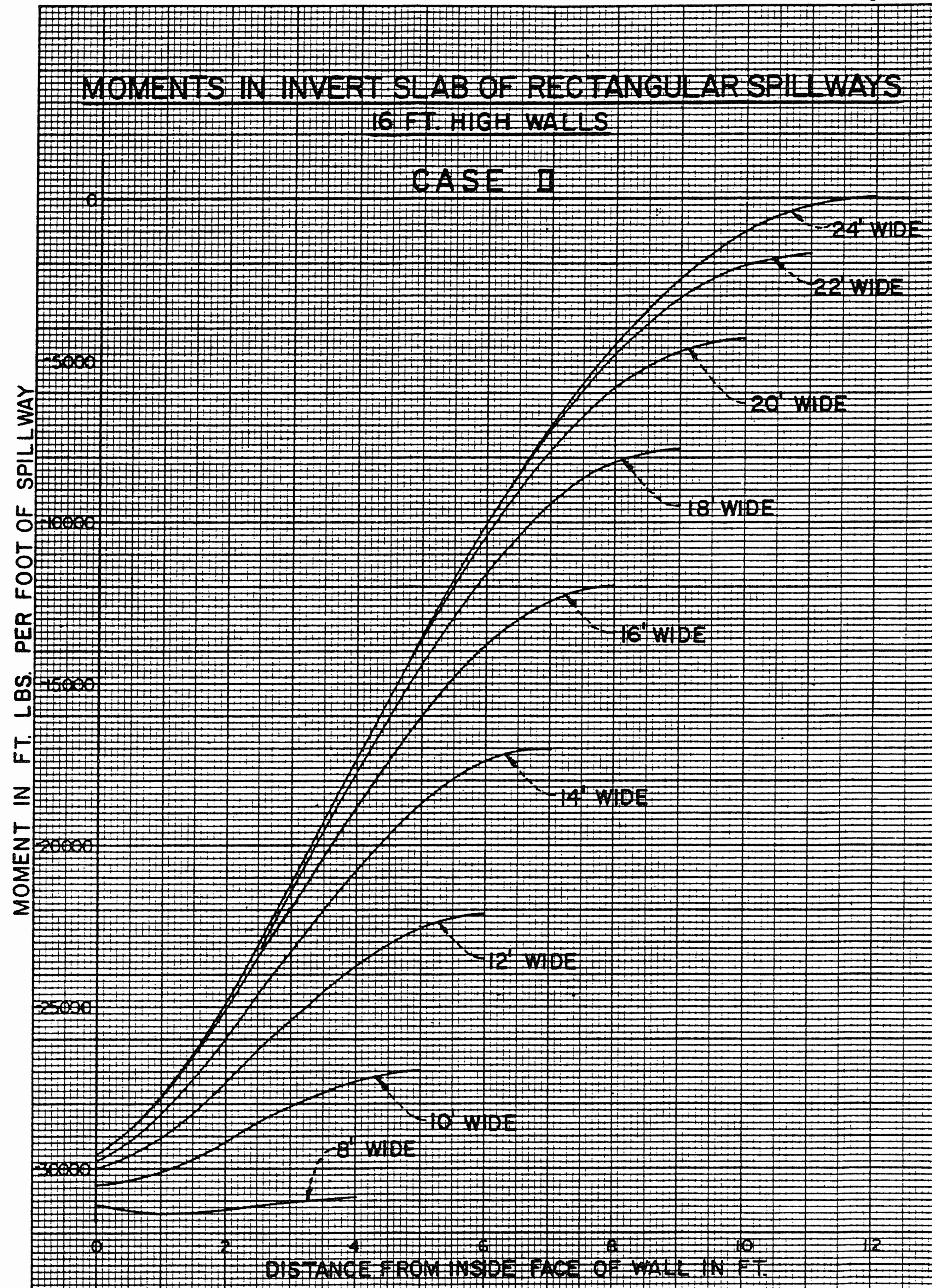

MOMENTS IN INVERT SLAB OF RECTANGULAR SPILLWAYS
10 FT. HIGH WALLS
CASE I
CASE II
MOMENT IN FT. LBS. PER FOOT OF SPILLWAY
14000
12000
10000
8000
6000
4000
2000
0
-2000
-1000
-3000
-4000
-5000
-6000
-7000
8' WIDE
10' WIDE
12' WIDE
14' WIDE
16' WIDE
18' WIDE
20' WIDE
22' WIDE
24' WIDE
0
2
4
6
8
10
12
DISTANCE FROM INSIDE FACE OF WALL IN FT.
DISTANCE FROM INSIDE FACE OF WALL IN FT.


MOMENTS IN INVERT SLAB OF RECTANGULAR SPILLWAYS
12 FT HIGH WALLS
CASE I
CASE II
MOMENT IN FT. LBS. PER FOOT OF SPILLWAY
28000
24000
20000
16000
12000
8000
4000
0
-4000
8' WIDE
10' WIDE
12' WIDE
14' WIDE
16' WIDE
18' WIDE
20' WIDE
22' WIDE
24' WIDE
26' WIDE
28' WIDE
0
2
4
6
8
10
12
14
DISTANCE FROM INSIDE FACE OF WALL IN FT
4000
0
-4000
-8000
-12000
22' WIDE
20' WIDE
24' WIDE
18' WIDE
16' WIDE
14' WIDE
12' WIDE
10' WIDE
8' WIDE
0
2
4
6
8
10
12
DISTANCE FROM INSIDE FACE OF WALL IN FT

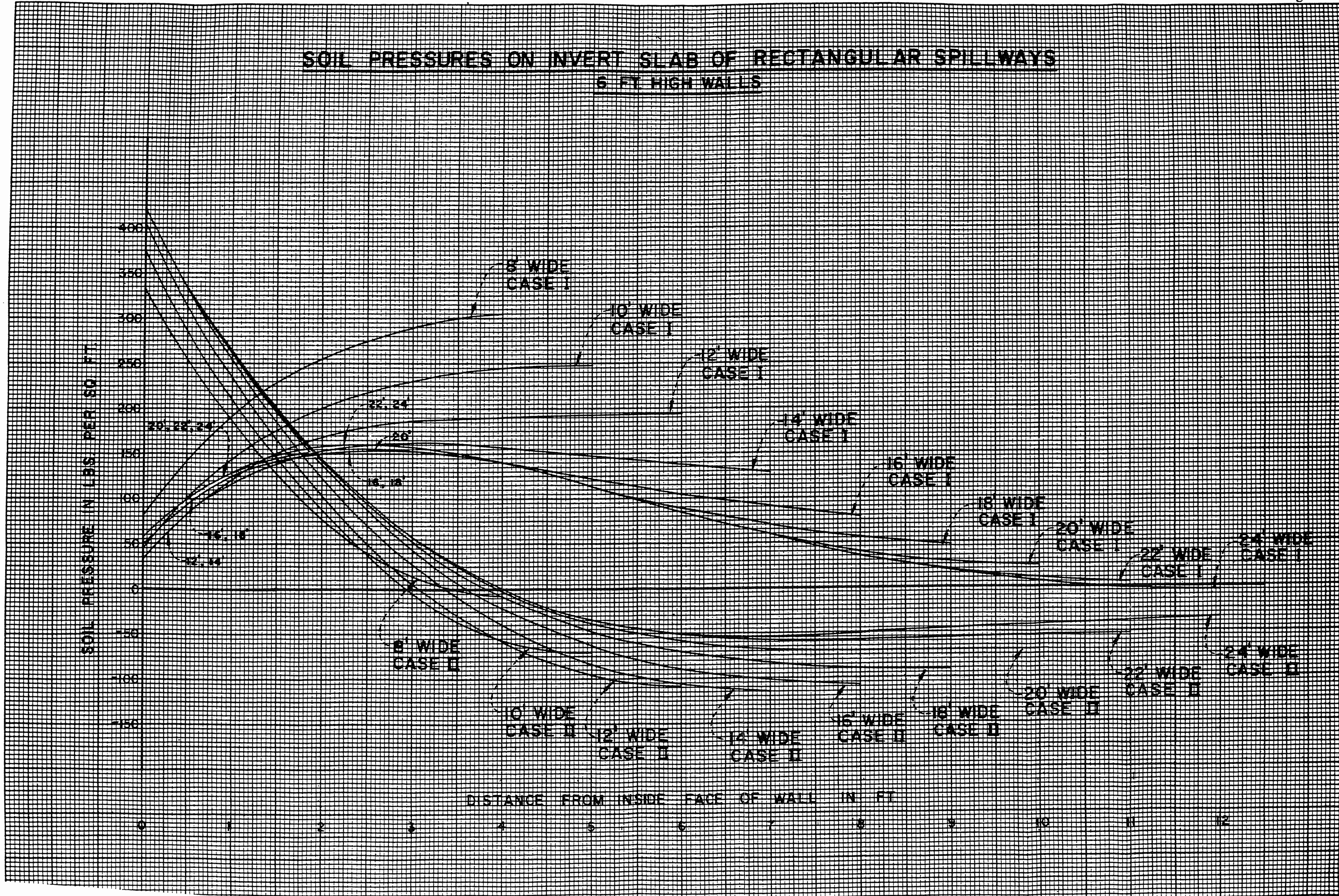

MOMENTS IN INVERT SLAB OF RECTANGULAR SPILLWAYS
14 FT. HIGH WALLS
CASE I
8' WIDE
10' WIDE
12' WIDE
14' WIDE
16' WIDE
18' WIDE
18' WIDE
20' WIDE
22' WIDE
24' WIDE
26' WIDE
28' WIDE
30' WIDE
44000
40000
36000
32000
28000
24000
20000
16000
12000
8000
4000
0
-4000
0
2
4
6
8
10
12
14
16
MOMENT IN FT. LBS. PER FOOT OF SPILLWAY
DISTANCE FROM INSIDE FACE OF WALL IN FT.

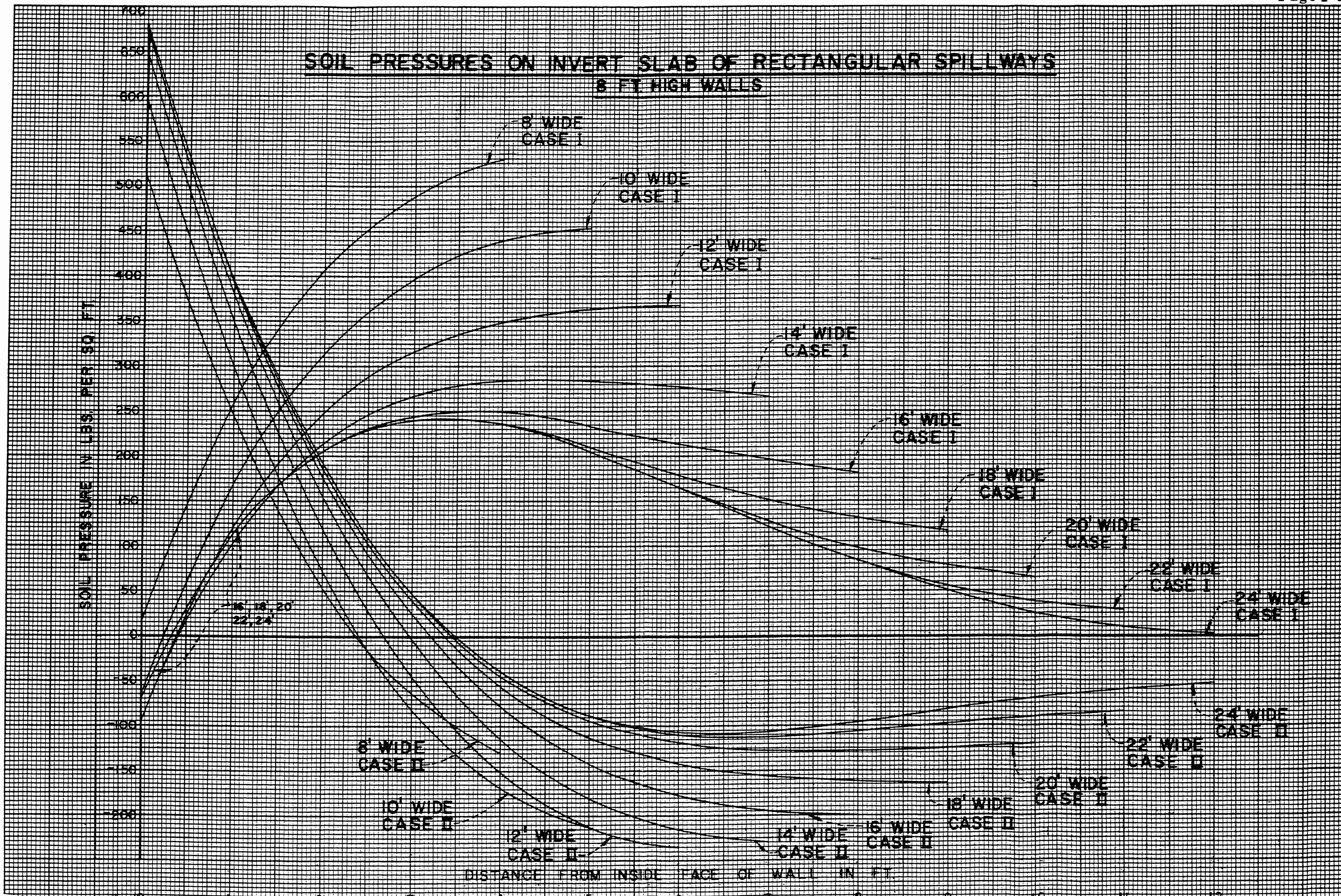

MOMENTS IN INVERT SLAB OF RECTANGULAR SPILLWAYS
14 FT. HIGH WALLS
CASE II
MOMENT IN FT. LBS. PER FOOT OF SPILLWAY
4000
0
-4000
-8000
-12000
-16000
-20000
24' WIDE
22' WIDE
20' WIDE
18' WIDE
16' WIDE
14' WIDE
12' WIDE
10' WIDE
8' WIDE
0
2
4
6
8
10
12
DISTANCE FROM INSIDE FACE OF WALL IN FT.

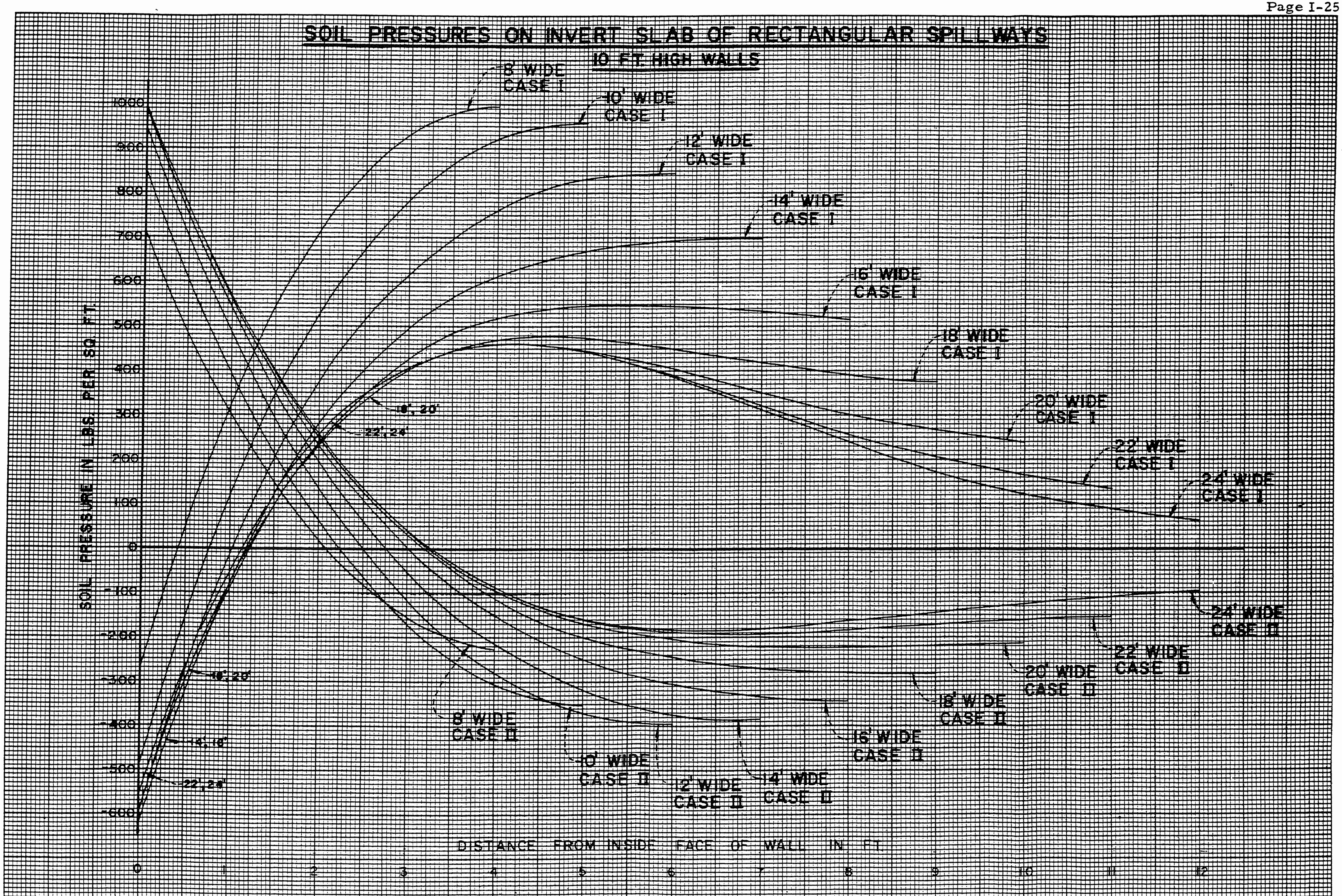

MOMENTS IN INVERT SLAB OF RECTANGULAR SPILLWAYS
16 FT. HIGH WALLS
CASE I
8' WIDE
10' WIDE
12' WIDE
14' WIDE
16' WIDE
18' WIDE
20' WIDE
22' WIDE
24' WIDE
26' WIDE
28' WIDE
30' WIDE
30' WIDE
24' WIDE
26' WIDE
0
2
4
6
8
10
12
14
16
DISTANCE FROM INSIDE FACE OF WALL IN FT.
60000
55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
-5000
MOMENT IN FT. LBS. PER FOOT OF SPILLWAY

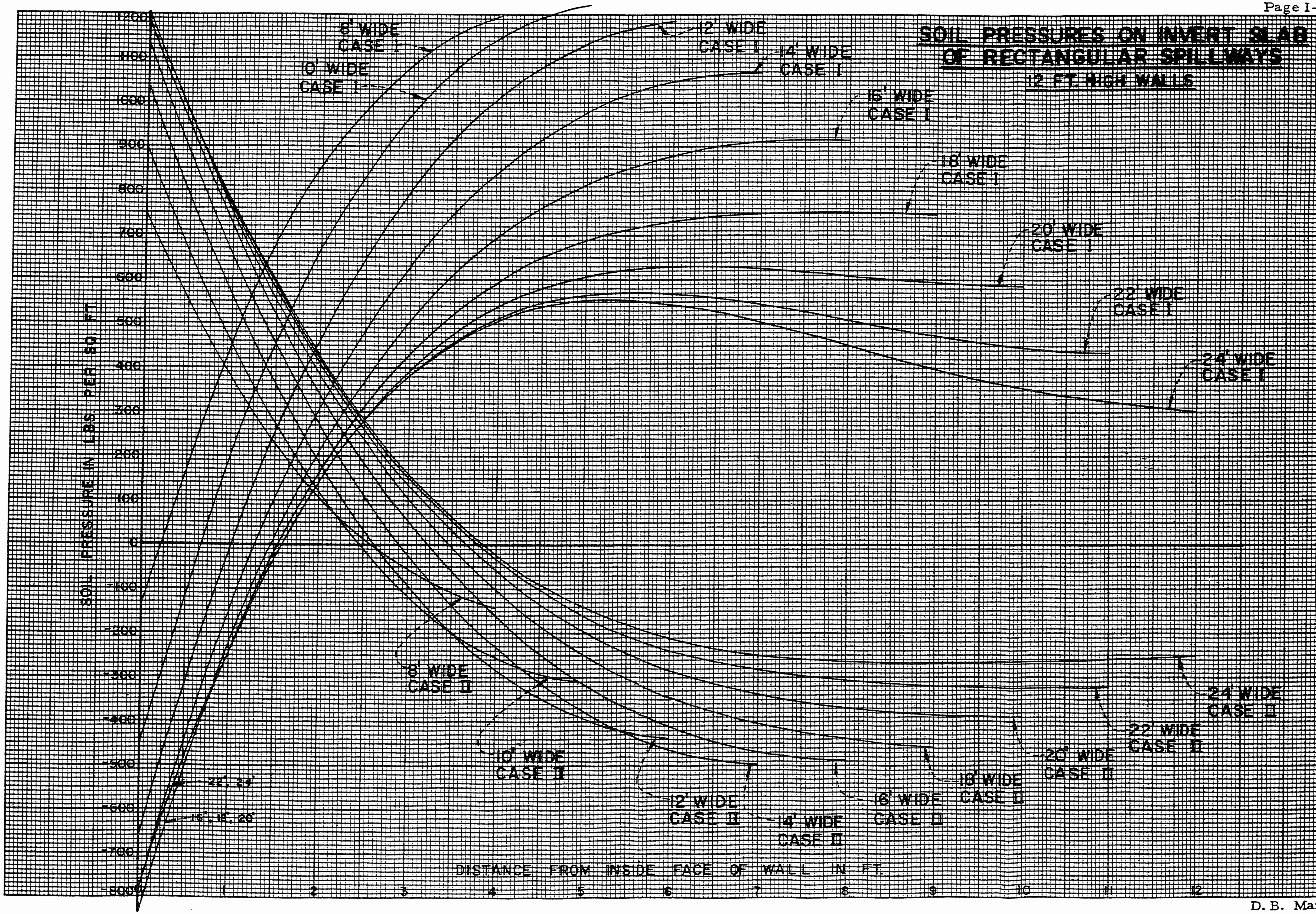


MOMENTS IN INVERT SLAB OF RECTANGULAR SPILLWAYS
16 FT. HIGH WALLS
CASE II
MOMENT IN FT. LBS. PER FOOT OF SPILLWAY
0
-5000
-10000
-15000
-20000
-25000
-30000
24' WIDE
22' WIDE
20' WIDE
18' WIDE
16' WIDE
14' WIDE
12' WIDE
10' WIDE
8' WIDE
0
2
4
6
8
10
12
DISTANCE FROM INSIDE FACE OF WALL IN FT.


SOIL PRESSURES ON INVERT SLAB OF RECTANGULAR SPILLWAYS
6 FT HIGH WALLS
SOIL PRESSURE IN LBS. PER SQ FT
400
350
300
250
200
150
100
50
0
-50
-100
-150
8' WIDE CASE I
10' WIDE CASE I
12' WIDE CASE I
14' WIDE CASE I
16' WIDE CASE I
18' WIDE CASE I
20' WIDE CASE I
22' WIDE CASE I
24' WIDE CASE I
20, 22, 24
22, 24
20'
16, 18
16, 18
12, 14
8' WIDE CASE II
10' WIDE CASE II
12' WIDE CASE II
14' WIDE CASE II
16' WIDE CASE II
18' WIDE CASE II
20' WIDE CASE II
22' WIDE CASE II
24' WIDE CASE II
DISTANCE FROM INSIDE FACE OF WALL IN FT
0
1
2
3
4
5
6
7
8
9
10
11
12

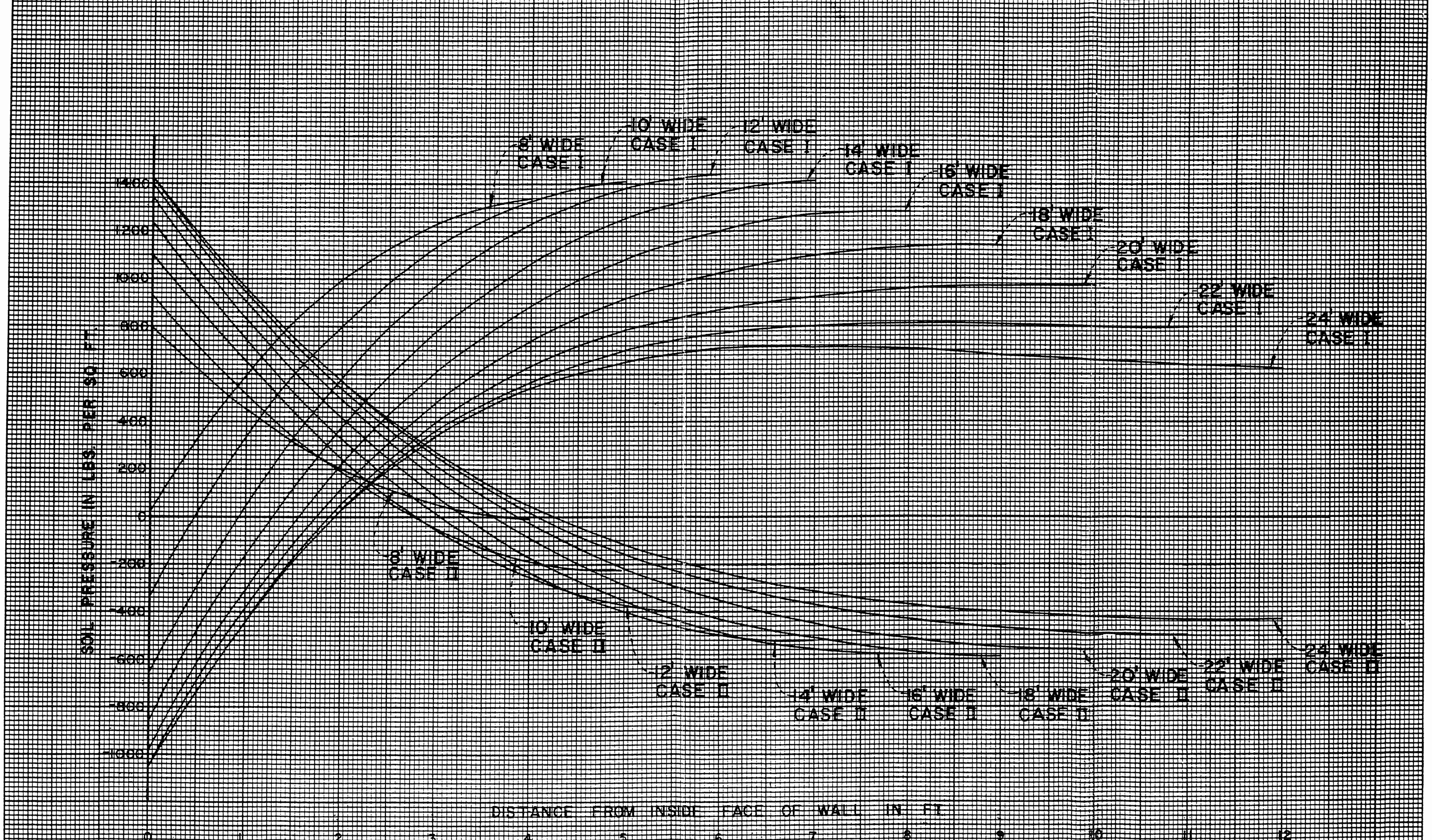

SOIL PRESSURES ON INVERT SLAB OF RECTANGULAR SPILLWAYS
8 FT HIGH WALLS
SOIL PRESSURE IN LBS. PER SQ. FT.
700
650
600
550
500
450
400
350
300
250
200
150
100
50
0
-50
-100
-150
-200
8' WIDE CASE I
10' WIDE CASE I
12' WIDE CASE I
14' WIDE CASE I
16' WIDE CASE I
18' WIDE CASE I
20' WIDE CASE I
22' WIDE CASE I
24' WIDE CASE I
16', 18', 20' 22', 24'
8' WIDE CASE II
10' WIDE CASE II
12' WIDE CASE II
14' WIDE CASE II
16' WIDE CASE II
18' WIDE CASE II
20' WIDE CASE II
22' WIDE CASE II
24' WIDE CASE II
DISTANCE FROM INSIDE FACE OF WALL IN FT.
0
1
2
3
4
5
6
7
8
9
10
11
12

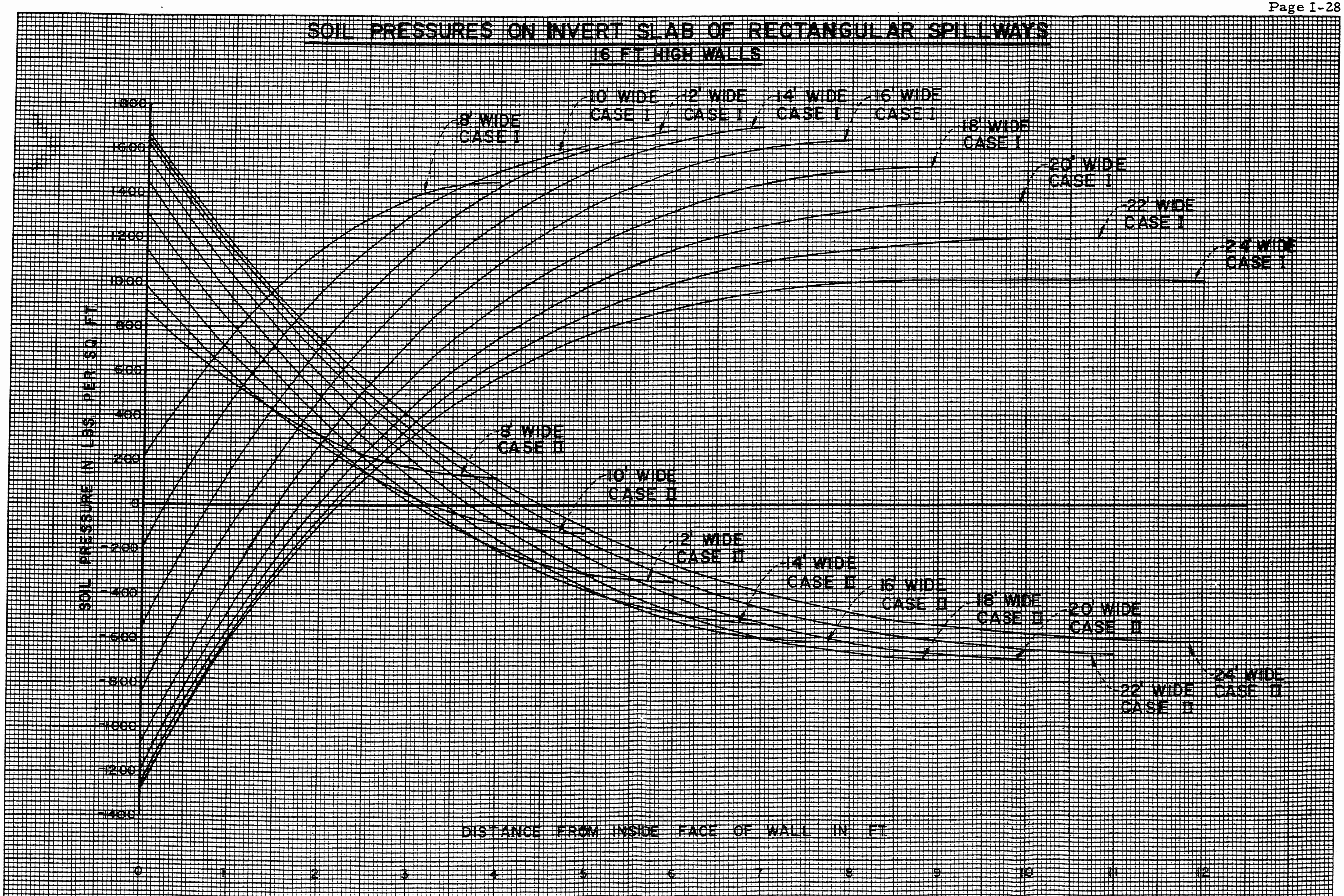

SOIL PRESSURES ON INVERT SLAB OF RECTANGULAR SPILLWAYS
10 FT. HIGH WALLS
8' WIDE CASE I
10' WIDE CASE I
12' WIDE CASE I
14' WIDE CASE I
16' WIDE CASE I
18' WIDE CASE I
20' WIDE CASE I
22' WIDE CASE I
24' WIDE CASE I
18', 20'
22', 24'
18', 20'
14', 16'
22', 24'
8' WIDE CASE II
10' WIDE CASE II
12' WIDE CASE II
14' WIDE CASE II
16' WIDE CASE II
18' WIDE CASE II
20' WIDE CASE II
22' WIDE CASE II
24' WIDE CASE II
SOIL PRESSURE IN LBS. PER SQ. FT.
1000
900
800
700
600
500
400
300
200
100
0
-100
-200
-300
-400
-500
-600
DISTANCE FROM INSIDE FACE OF WALL IN FT.
0
1
2
3
4
5
6
7
8
9
10
11
12

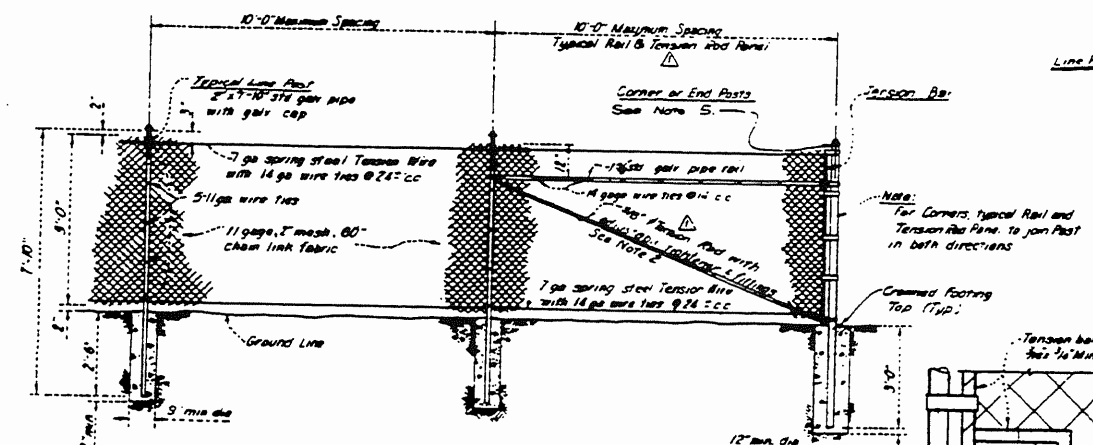

SOIL PRESSURES ON INVERT SLAB
OF RECTANGULAR SPILLWAYS
12 FT. HIGH WALLS
SOIL PRESSURE IN LBS PER SQ FT
DISTANCE FROM INSIDE FACE OF WALL IN FT.
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
-100
-200
-300
-400
-500
-600
-700
-800
1
2
3
4
5
6
7
8
9
10
11
12
8' WIDE CASE I
10' WIDE CASE I
12' WIDE CASE I
14' WIDE CASE I
16' WIDE CASE I
18' WIDE CASE I
20' WIDE CASE I
22' WIDE CASE I
24' WIDE CASE I
8' WIDE CASE II
10' WIDE CASE II
12' WIDE CASE II
14' WIDE CASE II
16' WIDE CASE II
18' WIDE CASE II
20' WIDE CASE II
22' WIDE CASE II
24' WIDE CASE II
22', 24'
16', 18', 20'

SOIL PRESSURES ON INVERT SLAB OF RECTANGULAR SPILLWAYS

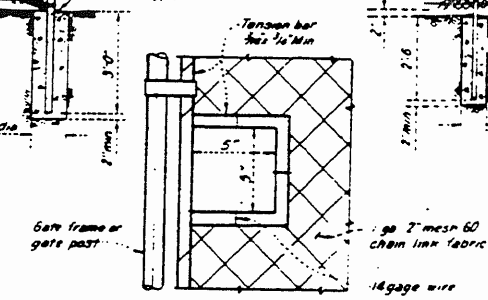
14 FT HIGH WALLS




SOIL PRESSURES ON INVERT SLAB OF RECTANGULAR SPILLWAYS
16 FT. HIGH WALLS
SOIL PRESSURE IN LBS. PER SQ. FT.
1800
1600
1400
1200
1000
800
600
400
200
0
-200
-400
-600
-800
-1000
-1200
-1400
8' WIDE CASE I
10' WIDE CASE I
12' WIDE CASE I
14' WIDE CASE I
16' WIDE CASE I
18' WIDE CASE I
20' WIDE CASE I
22' WIDE CASE I
24' WIDE CASE I
8' WIDE CASE II
10' WIDE CASE II
12' WIDE CASE II
14' WIDE CASE II
16' WIDE CASE II
18' WIDE CASE II
20' WIDE CASE II
22' WIDE CASE II
24' WIDE CASE II
DISTANCE FROM INSIDE FACE OF WALL IN FT.
0
1
2
3
4
5
6
7
8
9
10
11
12

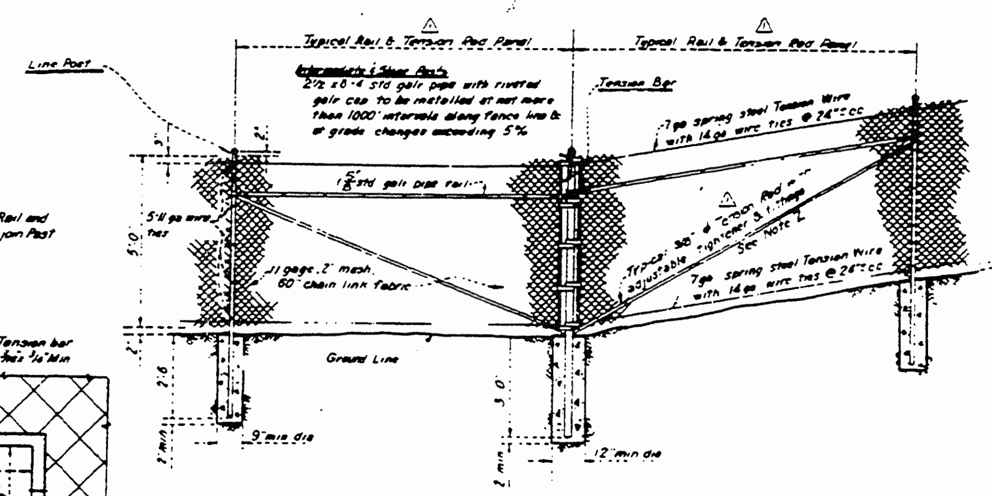


TYPICAL FENCE ELEVATION



DETAIL OF CUTOUT FOR CHAIN AND LOCK

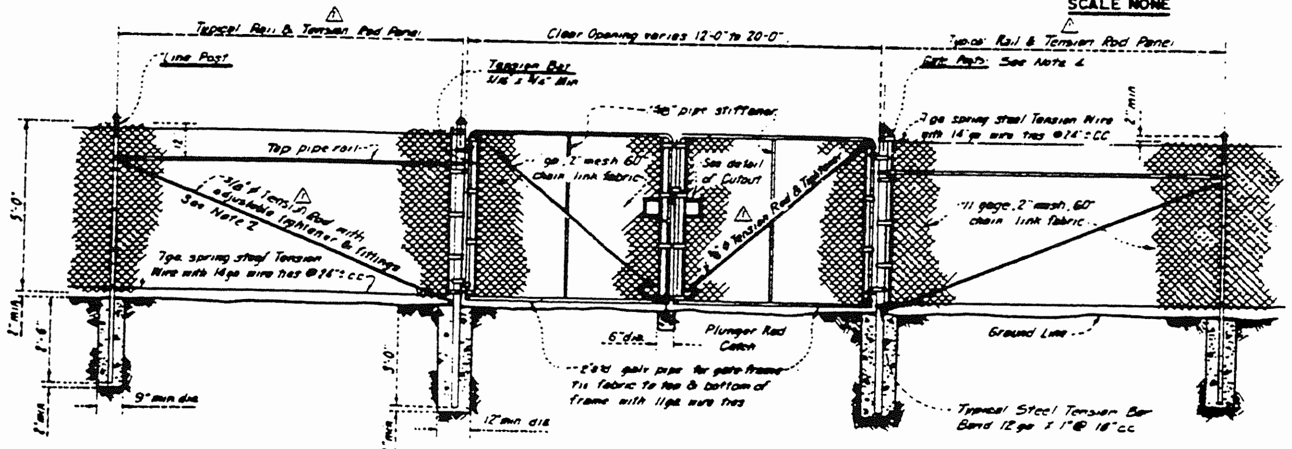
SCALE NONE



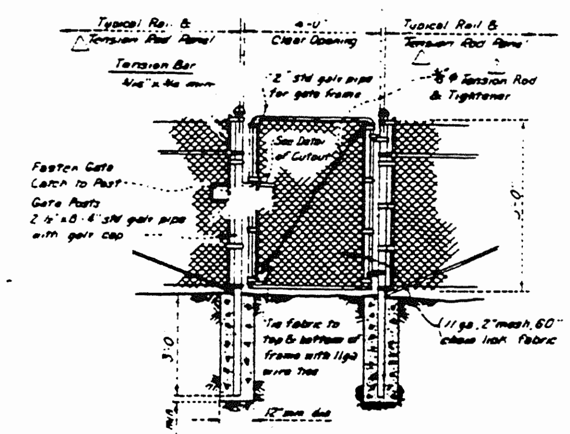
INTERMEDIATE POST DETAIL

GENERAL NOTES

1. All chain link fence materials and fittings shall conform to "Standard Specifications for Public Works Construction" sections 206-6 and 206-7 unless otherwise specified.
2. Adjustable tighteners shall be turnbuckle or equivalent, having 6-inch min. take up.
3. All gate hinges shall be heavy duty, malleable iron or steel, industrial service type 270 degree swing of approved quality and design.
4. △ Gate posts shall be 3" x 8'-4" pipe for 12'-0" opening and 4" x 8'-4" pipe for openings greater than 12'-0".
5. △ Corner or end posts shall be 3 x 8'-4" pipe. Changes in line where the angle of deflection is 30 degrees or more shall be considered a corner.
6. Secure galv. cap to post with 1/4" inch round head rivet.
7. △ Concrete shall be Class 420-C-2000.
8. The fabric shall be placed on the outward facing side of the posts, stretched taut, and securely fastened.
9. Gates shall be provided with a combination spring latch and plunger rod of approved design.
10. △ Dimensions shown for Standard Galvanized Pipe and Posts are nominal outside diameters.



DOUBLE DRIVE GATE DETAIL



TYPICAL WALK GATE

DRAWN BY	REVISIONS		
SYH	MARK	DATE	DESCRIPTION
VM	△ 1	[illegible]	Changed "Truss" to "Tension"
FWR	△ 2	6-14-71	Added Note 10 and changed pipe diameter
C.W.H.	△ 3	4-1-72	Revised Concrete Designation

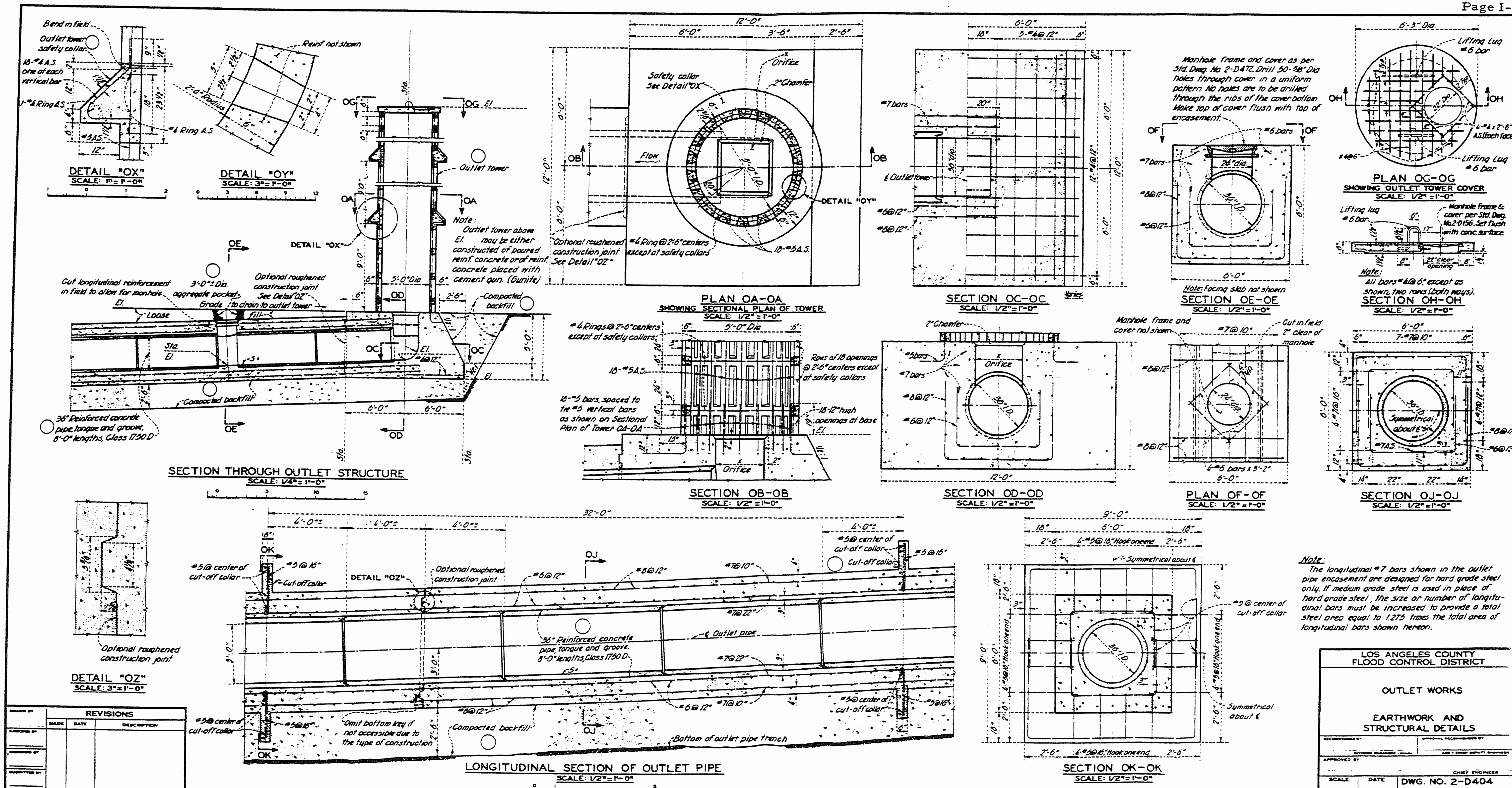
Supersedes Dwg. No. 2-D178 dated Nov. 1952

LOS ANGELES COUNTY
FLOOD CONTROL DISTRICT

TYPICAL FENCE AND GATE DETAILS - FOR CHANNEL RIGHTS-OF-WAY

APPROVED BY 1-6-69

SCALE	DATE	DWG. NO. 2-D178
1/2" = 1'-0"	Dec. '68	SHEET 1 OF 1

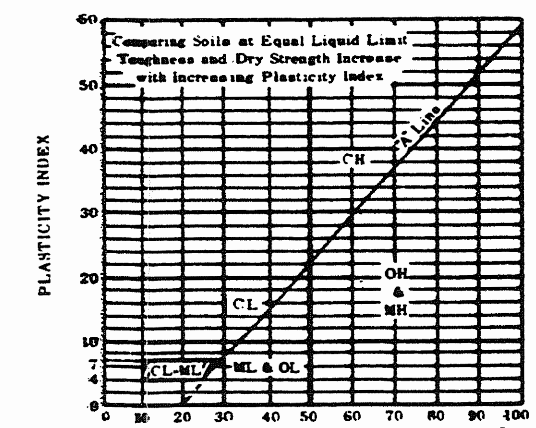

DETAIL "OX"
SCALE: 1½" = 1'-0"
DETAIL "OY"
SCALE: 3" = 1'-0"
SECTION THROUGH OUTLET STRUCTURE
SCALE: 1/4" = 1'-0"
PLAN OA-OA
SHOWING SECTIONAL PLAN OF TOWER
SCALE: 1/2" = 1'-0"
SECTION OB-OB
SCALE: 1/2" = 1'-0"
SECTION OC-OC
SCALE: 1/2" = 1'-0"
SECTION OD-OD
SCALE: 1/2" = 1'-0"
SECTION OE-OE
SCALE: 1/2" = 1'-0"
PLAN OF-OF
SCALE: 1/2" = 1'-0"
PLAN OG-OG
SHOWING OUTLET TOWER COVER
SCALE: 1/2" = 1'-0"
SECTION OH-OH
SCALE: 1/2" = 1'-0"
SECTION OJ-OJ
SCALE: 1/2" = 1'-0"
DETAIL "OZ"
SCALE: 3" = 1'-0"
LONGITUDINAL SECTION OF OUTLET PIPE
SCALE: 1/2" = 1'-0"
SECTION OK-OK
SCALE: 1/2" = 1'-0"
Note: Outlet tower above El. may be either constructed of poured reinf. concrete or of reinf. concrete placed with cement gun. (Gunite)
Manhole frame and cover as per Std. Dwg. No. 2-D472. Drill 50-⅜" Dia. holes through cover in a uniform pattern. No holes are to be drilled through the ribs of the cover bottom. Make top of cover flush with top of encasement.
Note: All bars #4@6" except as shown, two rows (both ways).
Note: The longitudinal #7 bars shown in the outlet pipe encasement are designed for hard grade steel only. If medium grade steel is used in place of hard grade steel, the size or number of longitudinal bars must be increased to provide a total steel area equal to 1.275 times the total area of longitudinal bars shown hereon.
36" Reinforced concrete pipe, tongue and groove, 8'-0" lengths, Class 1750 D.
Compacted backfill
Bottom of outlet pipe trench
Omit bottom key if not accessible due to the type of construction
REVISIONS
MARK
DATE
DESCRIPTION
LOS ANGELES COUNTY
FLOOD CONTROL DISTRICT
OUTLET WORKS
EARTHWORK AND
STRUCTURAL DETAILS
APPROVED BY
CHIEF ENGINEER
SCALE
AS SHOWN
DATE
APRIL 1964
DWG. NO. 2-D404
SHEET
OF

UNIFIED SOIL CLASSIFICATION (INCLUDING IDENTIFICATION AND DESCRIPTION)

Major Divisions (1)	Major Divisions (2)		Group Symbols (3)	Typical Names (4)	Field Identification Procedures (Excluding particles larger than 3 inches and basing fractions on estimated weights) (5)	Information Required for Describing Soils (6)	Laboratory Classification Criteria (7)			Group Symbols (8)
Course-grained Soils More than half of material is larger than No. 200 sieve size.	Gravels More than half of coarse fraction is larger than No. 4 sieve size. (For visual classification, the ¼-in. size may be used as equivalent to the No. 4 sieve size)	Clean Gravels (Little or no fines)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines.	Wide range in grain sizes and substantial amounts of all intermediate particle sizes.	For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions and drainage characteristics.	Use grain size curve in identifying the fractions as given under field identification.	Determine percentages of gravel and sand from grain-size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size) coarse-grained soils are classified as follows: Less than 5%: GW, GP, SW, SP; More than 12%: GM, GC, SM, SC; 5% to 12%: Borderline cases requiring use of dual symbols.	$C_u = \frac{D_{60}}{D_{10}}$ Greater than 4; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between one and 3	GW
			GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines.	Predominately one size or a range of sizes with some intermediate sizes missing.				Not meeting all gradation requirements for GW	GP
		Gravels with Fines (Appreciable amount of fines)	GM	Silty gravels, gravel-sand-silt mixtures.	Nonplastic fines or fines with low plasticity. (for identification procedures see ML below)	Give typical name; indicate approximate percentages of sand and gravel, max. size; angularity, surface condition, and hardness of the coarse grains; local or geologic name and other pertinent descriptive information; and symbol in parentheses.			Atterberg limits below "A" line or PI less than 4 — Above "A" line with PI between 4 and 7 are borderline cases requiring use of dual symbols.	GM
			GC	Clayey gravels, gravel-sand-clay mixtures.	Plastic fines (for identification procedures see CL below)				Atterberg limits above "A" line with PI greater than 7	GC
	Sands More than half of coarse fraction is smaller than No. 4 sieve size.	Clean Sands (Little or no fines)	SW	Well-graded sands, gravelly sands, little or no fines.	Wide range in grain sizes and substantial amounts of all intermediate particle sizes.	Example: Silty sand, gravelly; about 20% hard, angular gravel particles ½-in. max. size; rounded and subangular sand grains coarse to fine; about 15% non-plastic fines with low dry strength; well compacted and moist in place; alluvial sand; (SM).			$C_u = \frac{D_{60}}{D_{10}}$ Greater than 6; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between one and 3	SW
			SP	Poorly-graded sands, gravelly sands, little or no fines.	Predominantly one size or a range of sizes with some intermediate sizes missing.				Not meeting all gradation requirements for SW	SP
		Sands with Fines (Appreciable amount of fines)	SM	Silty sands, sand-silt mixtures.	Nonplastic fines or fines with low plasticity. (for identification procedures see ML below)				Atterberg limits below "A" line or PI less than 4 — Limits plotting in hatched zone with PI between 4 and 7 are borderline cases requiring use of dual symbols.	SM
			SC	Clayey sands, sand-clay mixtures	Plastic fines (for identification procedures see CL below.				Atterberg limits above "A" line with PI greater than 7	SC

The No. 200 sieve size is about the smallest particle visible to the naked eye.

Major Divisions (1)	Major Divisions (2)	Group Symbols (3)	Typical Names (4)	Identification Procedures on Fraction Smaller than No. 40 Sieve Size: Dry Strength (Crushing characteristics)	Dilatancy (Reaction to shaking)	Toughness (Consistency near PL)	Information Required for Describing Soils (6)
Fine-grained Soils More than half of material is smaller than No. 200 sieve size.	Silts and Clays Liquid limit less than 50	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.	None to slight	Quick to slow	None	Give typical name, indicate degree and character of plasticity, amount and max. size of coarse grains, color in wet condition, odor if any, local or geologic name, and other pertinent descriptive information; and symbol in parentheses.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.	Medium to high	None to very slow	Medium	
		OL	Organic silts and organic silty clays of low plasticity.	Slight to medium	Slow	Slight	For undisturbed soils add information on structure, stratification, consistency in undisturbed and remolded states, moisture and drainage conditions.
	Silts and Clays Liquid limit greater than 50	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.	Slight to medium	Slow to none	Slight to medium	
		CH	Inorganic clays of high plasticity, fat clays.	High to very high	None	High	Example: Clayey silt, brown, slightly plastic, small percentage of fine sand, numerous vertical root holes, firm and dry in place, loess, (ML).
		OH	Organic clays of medium to high plasticity, organic silts.	Medium to high	None to very slow	Slight to medium	
Highly Organic Soils		Pt	Peat and other highly organic soils.	Readily identified by color, odor, spongy feel and frequently by fibrous texture.			



PLASTICITY CHART
For laboratory classification of fine-grained soils

(1) Boundary classifications: Soils possessing characteristics of two groups are designated by combinations of group symbols. For example GW-GC, well-graded gravel-sand mixture with clay binder. (2) All sieve sizes on this chart are U. S. standard.

FIELD IDENTIFICATION PROCEDURES FOR FINE-GRADED SOILS OR FRACTIONS

These procedures are to be performed on the minus No. 40 sieve size particles, approximately 1/64 in. For field classification purposes, screening is not intended, simply remove by hand the coarse particles that interfere with the tests.

Dilatancy (Reaction to shaking)

After removing particles larger than No. 40 sieve size, prepare a pat of moist soil with a volume of about one-half cubic inch. Add enough water if necessary to make the soil soft but not sticky. Place the pat in the open palm of one hand and shake horizontally, striking vigorously against the other hand several times. A positive reaction consists of the appearance of water on the surface of the pat which changes to a livery consistency and becomes glossy. When the sample is squeezed between the fingers, the water and gloss disappear from the surface, the pat stiffens and finally it cracks or crumbles. The rapidity of appearance of water during shaking and of its disappearance during squeezing assist in identifying the character of the fines in a soil.

Very fine clean sands give the quickest and most distinct reaction whereas a plastic clay has no reaction. Inorganic silts such as a typical rock flour, show a moderately quick reaction.

Dry Strength (Crushing characteristics)

After removing particles larger than No. 40 sieve size, mold a pat of soil to the consistency of putty, adding water if necessary. Allow the pat to dry completely by oven, sun, or air drying and then test its strength by breaking and crumbling between the fingers. This strength is a measure of the character and quantity of the colloidal fraction contained in the soil. The dry strength increases with increasing plasticity.

High dry strength is characteristic for clays of the CH group. A typical inorganic silt possesses only very slight dry strength. Silty fine sands and silts have about the same slight dry strength, but can be distinguished by the feel when powdering the dried specimen. Fine sand feels gritty whereas a typical silt has the smooth feel of flour.

Toughness (Consistency near plastic limit)

After removing particles larger than the No. 40 sieve size, a specimen of soil about one-half inch cube in size is molded to the consistency of putty. If too dry, water must be added and if sticky, the specimen should be spread out in a thin layer and allowed to loose some of its moisture by evaporation. Then the specimen is rolled out by hand on a smooth surface or between the palms into a thread about one-eighth inch in diameter. The thread is then folded and rerolled repeatedly. During this manipulation the moisture content is gradually reduced and the specimen stiffens, finally loses its plasticity, and crumbles when the plastic limit is reached.

After the thread crumbles, the pieces should be lumped together and a slight kneading action continued until the lump crumbles.

The tougher the thread near the plastic limit and the stiffer the lump when it finally crumbles, the more potent is the colloidal clay fraction in the soil. Weakness of the thread at the plastic limit and quick loss of coherence of the lump below the plastic limit indicate either inorganic clay of low plasticity, or materials such as kaolin-type clays and organic clays which occur below the A-line.

Highly organic clays have a very weak and spongy feel at the plastic limit.

APPROVAL RECOMMENDED BY
G.W. Outland
ASS'T CHIEF DEPUTY ENGINEER
LOS ANGELES COUNTY FLOOD CONTROL DISTRICT

REVISIONS		
MARK	DATE	DESCRIPTION

DRAWN BY JJG — DESIGNED BY —
LOGGED BY — CHECKED BY GLS
SUBMITTED BY [signature] 4/4/65
DIVISION ENGINEER FOUNDATION AND TESTING

LOS ANGELES COUNTY FLOOD CONTROL DISTRICT

UNIFIED SOIL CLASSIFICATION SYSTEM

APPROVED BY [signature] CHIEF ENGINEER

SCALE	DATE	NO. 2-D413
NONE	3-22-65	SHEET 1 OF 1