1301 DEBRIS CONTROL STRUCTURES AND BASINS

1301.1 Introduction

Debris transported by storm water can cause severe problems with flood control structures and other public facilities. Debris-related problems include: clogging of channels and culverts, filling of detention ponds, and burial of or physical damage to roadways and other property. Consequently, the need for debris control is an essential consideration in the design of hydraulic structures, particularly culverts and detention basin outlets.

In order to select an appropriate debris-control measure, the debris within a particular basin should be classified. A classification used by the U.S. Department of Transportation (USDOT, 1971) follows:

1. Light floating debris -- small limbs or sticks, orchard prunings, tules and refuse

2. Medium floating debris -- limbs or large sticks

3. Heavy floating debris -- logs or trees

4. Flowing debris -- heterogeneous fluid mass or clay, silt, sand, gravel, rock, refuse, or sticks

5. Fine detritus -- fairly uniform bedload of silt, sand, gravel more or less devoid of floating debris, tending to deposit upon diminution of velocity

6. Coarse detritus -- coarse gravel or rock fragments carried as channel bedload at flood stage

Debris can be controlled by three methods: (a) interception near the debris source or above a critical hydraulic structure downstream of the source: (b) deflecting the debris for detention near (usually above) a culvert or inlet; or (c) passing the debris through the channel or inlet structure. Commonly used structures for controlling various types of debris are listed in **Table 1301** and described in the following sections.

1301.2 Debris Deflectors

Debris deflectors are used to divert medium and heavy floating debris and large rocks from the culverts (or other inlets) for accumulation in a storage area and subsequent removal after the flood subsides. The storage area must be adequate to retain the anticipated type and quantity of debris during any one storm or between clean-outs. Typical debris deflectors for culvert protection are shown in **Figure 1301**.

1301.3 Debris Racks

Debris racks provide barriers across stream channels to stop debris that is too large to pass through downstream channels or culverts. Debris racks vary greatly in size and in construction material. Height of racks should allow some freeboard above the expected depth of flow in the upstream channel for the design flood. Racks should not be placed in the plane of the culvert entrance, since they induce plugging when thus positioned. Access to the rack is necessary for maintenance.

The rack should be placed well upstream from the culvert or improved channel inlet in those situations where a well-defined upstream channel exists. However, they should not be placed so far upstream that debris enters the channel between the rack and the inlet. Typical debris racks for use with small to medium-sized culverts and on improved channels are shown in **Figure 1302**.

1301.4 Debris Risers

Debris risers generally consist of a vertical culvert pipe and are usually suitable for installations of less than 54-inch diameter. Risers are normally used with detention ponds or debris basins or where a considerable height of embankment is available above a culvert crossing. The riser is particularly effective where debris consists of flowing masses of clay, silt, sand, sticks, or medium floating debris without boulders. Risers are seldom structurally stable under high-velocity flow conditions because of their vulnerability to damage by impact. A typical debris riser is shown in **Figure 1303**.

1301.5 Debris Cribs

Debris cribs are particularly adapted to small-size culverts where a sharp change in stream grade or constriction of the channel causes deposition of detritus at the culvert inlet. The crib is usually placed directly over the culvert inlet and in "log cabin" fashion.

Figure 1304 shows the general dimensional details of a typical debris crib. Spacing between bars should be about 6 inches. A crib may be open or covered with horizontal top members spaced equal to the crib members. Debris can almost envelop a crib without completely blocking the flow and plugging the culvert. When an open crib is used as a riser and an accumulation of detritus is expected, provision can be made for increasing the height.

1301.6 Debris Dams and Basins

On channels carrying heavy sediment and debris loads, it is often economically impracticable to provide culverts large enough to carry surges of debris. If the height of an embankment and storage area are not sufficient for a riser or crib, a debris dam and/or basin placed some distance upstream from the culvert may be feasible. These are sometimes used to trap heavy boulders or coarse gravel that would clog culverts.

A number of detention and/or debris basins have been identified in the CCRFCD Master Plan. The larger basins are generally located at or just below the mouths of mountain canyons at points just above the alluvial fans on the periphery of the valley areas. These canyon areas and the immediately down gradient fans are the source areas for large quantities of suspended sediment and bedload, which are carried in the washes during floods.

Detention basins located in the mountain canyon areas can accumulate large deposits of rocky debris, either over the course of several years or after each extremely large load event. Design of detention ponds (Section 1200) in these areas must include provisions for debris (and suspended sediment) deposits and control of floating debris using debris racks and/or risers.

Much of the rock debris will deposit in the upper reaches of detention ponds where high-velocity flood waters first encounter slack, ponded water. If regularly maintained and cleaned of these deposits, detention ponds can effectively serve multiple purposes of attenuation of flood peaks and entrapment of sediment and debris (see Section 1200 for further discussion of detention pond design).

1301.7 Sizing of Control Structures and Basins

The spacing of bars on trash racks, debris racks, debris deflectors, debris risers and debris cribs is based on the size of the structure to be protected and the anticipated size and gradation of the debris. To minimize the potential for clogging, in no case shall the barrier members be spaced more than two-thirds of the conduit diameter.

The size of debris basins is most dependent on the physical properties of the watershed and the intensity of flood events. Specific sedimentation data have not been developed for the Clark County area, and designs must be based on site specific data from other areas. The U.S. Department of Agriculture reports sedimentation rates for reservoirs nation-wide in a report "Sedimentation Deposition in U. S. Reservoirs: Summary of Data Reported Through 1975" (USDA, 1976). The average annual sedimentation rates reported vary over five orders of magnitude. For this reason, the use of data from other areas is limited.

The major threat to debris basins is from a single rare flood event. The Los Angeles Department of Public Works has published curves for debris production per storm event for the Los Angeles area (LADPW, 1989). These rates vary from approximately 250,000 yd^3/square mile to 4,200 yd^3 /square mile. Again, the soil types and storm patterns vary considerably between Los Angeles and Clark County, but the data developed for Los Angeles does illustrate the problem.

1301.7.1 Sediment Sources

To size detention/debris basins, amounts of sediment/debris carried by flood events should be estimated. These amounts of sediment are derived from sediment eroded from watersheds. The gross erosion depends on the source of sediments in terms of upland erosion, gully erosion, and local stream bank and bed erosion. Upland erosion generally constitutes the primary source of sediment; other sources of gross erosion, such as mass wasting or bank erosion and gully erosion should be estimated separately by calculating the volume of sediment scoured through lateral migration of the stream and the upstream migration of headcuts. In relatively stable fluvial systems, the analysis of sediment sources and yield focus on upland erosion from rainfall and snowmelt (JULIEN, 1995). For watershed basins having defined channels, potential sediment supply from stream bank and bed erosion can be estimated using a sediment transport equation. The total sediment yield is then the sum of the sediment supply from upland erosion and the sediment supply from stream bank and bed erosion.

1301.7.2 Types of Methods for Predicting Sediment Yield

Numerous mathematical approaches can be used to determine sediment yield from natural or disturbed land surfaces. One category of mathematical models is the “black box,” or lumped parameter model. Another category is based on regression equations as typified by the Universal Soil Loss Equation (USLE), to be discussed later. Both types interpret input-output relations using simplified forms that may or may not have physical significance. Processes related to the movement of water and sediment through the watershed are grouped into coefficients, such as in the rational formula for estimating peak discharge, i.e., $Q = CIA$, where Q is peak discharge, I is rainfall input, A is the drainage area, and C is the runoff coefficient that represents all hydrologic processes. Although lumped parameter and regression methods are often used, the parameters may not accurately represent observable physical characteristics. Another disadvantage is that some methods do not consider the physical environment as dynamic with respect to time and location.

Another approach is through the use of stochastic models. If rainfall events, watershed response, and runoff events are stochastic, i.e., probabilistic in nature, the processes of sediment yield are also stochastic. However, stochastic models are difficult to apply (SHEN and LI, 1976) and do not readily show the response of a watershed undergoing changes as a result of various land use activities. Most hypotheses used in stochastic models have not been tested by field data. Knowledge in applying stochastic models to sediment yield from watersheds is still primitive.

The physical process simulation model is another type of method in which the governing processes controlling sediment yield are formulated and analyzed separately to provide model sensitivity to land management alternatives. These models are used to estimate or predict sediment yields resulting from natural or disturbed watershed lands, taking into account important physical processes such as raindrop splash, overland flow erosion, channel erosion, and movement of different sediment size fractions. However, these models are quite complex and are beyond the scope of this MANUAL.

One important aspect of model development and operation is data. Without adequate data, the testing and verification of models for application to field situations may produce erroneous results unrepresentative of actual conditions. An understanding of model operations and the controlling physical processes aids in the detection of erroneous data. Development or prediction methods, keeping physical processes and data needs in the forefront, can produce realistic, accurate methods for estimating sediment yield from watersheds.

1301.7.3 The Universal Soil Loss Equation

The USLE is the most widely used equation for empirical estimation of gross erosion from upland areas (SMITH and WISCHMEIER, 1957). This equation has been used on cropland and rangeland to estimate long-term (10 years or more) average annual soil losses from sheet and rill erosion with varying degrees of success, depending on the amount of quantitative data available to estimate factor values (WISCHMEIER, 1973). The USLE equation is:

$$A = RKLSCP \qquad (1301)$$

where A is the estimated annual soil loss in tons per acre, R is the rainfall-erosivity factor, K is the soil-erodibility factor, LS is the topographic factor, C is the cropping factor, and P is a supporting conservative practices factor. SMITH and WISCHMEIER (1957), MEYER and MONKE (1965), and WISCHMEIER (1973) provide detailed descriptions of this equation.

The rainfall-erosivity factor R can be calculated for each storm from:

$$R = 0.01\,\Sigma(916 + 331 \log \mathrm{I})\,\mathrm{I} \qquad (1302)$$

where I is the rainfall intensity in inches per hour. The annual rainfall erosion factor in the United States decreases from a value exceeding 500 near the Gulf of Mexico to values under 100 in the northern states and in the Rockies.

Soil erodibility factor K was found by WISCHMEIER, et al. (1971) to be a function of percent of silt, percent of coarse sand, soil structure, permeability of soil, and percent of organic matter. The soil erodibility nomograph is shown in **Figure 1303a**.

The topographic factor LS was defined as the ratio of soil loss from any slope and length to soil loss from a 72.6 foot plot length at a 9 percent slope, with all other conditions the same. This factor can be approximated from the field runoff length X_r in feet and surface slope S_o in feet per feet by:

$$LS = \sqrt{X_r}\,(0.0076 + 0.53\,S_o + 7.6\,S_o^2) \qquad (1303)$$

where the runoff length was defined as the distance from the point of overland flow origin to the point where either slope decreases to the extent that deposition begins or runoff water enters a well-defined channel (SMITH and WISCHMEIER, 1957). The effect of the runoff length on soil loss is primarily a result of increased potential due to greater accumulation of runoff on the longer slopes.

The cropping-management factor C was defined as the ratio of soil loss from land cropped under specific conditions to corresponding loss from tilled, continuously fallow ground. WISCHMEIER (1972) presented a method including graphical aids for determining the cropping-management factor. This factor, ranging from approximately 0 to 1.0, is the product of the effect of canopy cover (C_I), effect of mulch or close-growing vegetation in direct contact with the soil surface (C_{II}), and tillage and residual effect of the land use (C_{III}). That is,

$$C = C_I C_{II} C_{III} \qquad (1304)$$

Figures 1303b, 1303c, and **1303d** show graphical relations to estimate these factors.

The conservation practice factor P accounts for the effect of conservation practices such as contouring, strip cropping and terracing on erosion. Its values can be obtained from **Table 1301A**. This factor has no significance for wildland areas and can be set at 1.0.

The USLE is used with a sediment delivery ratio, S_{DR} to estimate the amount of sediment delivered by channels at a point downstream. This ratio takes into account the storage and deposition of sediment within a watershed, and is found to be highly dependent on the drainage area of the upstream watershed, A_t:

$$S_{DR} = 0.31\, A_t^{-0.3} \tag{1305}$$

The sediment yield can, therefore, be written as:

$$Y_s = A\, S_{DR} \tag{1306}$$

This method was used by the U. S. FOREST SERVICE (1980) and many others, and was compared with other predictive methods by ALLEN (1981). ALLEN indicated that the sediment delivery ratio is oversimplified and unreliable. WISCHMEIER (1971) cautioned that large errors can occur if the R factor is used to predict soil loss on a storm basis.

1301.7.4 The Modified Universal Soil Loss Equation

Because sediment yield in many watersheds is limited by hydraulic conditions, the amount of sediment leaving the watershed is strongly related to flow characteristics and less to rainfall characteristics. Consequently, WILLIAMS and BERNDT (1972) modified the USLE by replacing the rainfall factor R with a runoff factor which is more applicable to short-term, high-intensity storm events. Sediment yield is computed as:

$$Y_s = \alpha\, (VQ_p)^{\beta}\, KLSCP \tag{1307}$$

where Y_s is the storm-event sediment yield in tons, Q_p is the storm-event peak flow in cubic feet per second, V is the storm-event runoff volume in acre-feet, α and β are coefficients, and the other terms are defined above as for the USLE. The coefficients were calibrated as 95 for α and 0.56 for β in watersheds in Texas and Nebraska. These coefficients vary and should be determined in other locations by calibration with watershed data. Application of these coefficients to watersheds in southern California, Arizona, and Nevada also yielded reasonable results.

If the sediment yield from the land surface on an annual basis rather than a single storm event is desired, the MUSLE can also be used. This application is accomplished by determining the soil loss for events of varying return periods. Recommended return periods are 2, 10, 25, 50 and 100 years. The sediment yields are then weighted according to their incremental probability, resulting in a weighted storm average.

To compute the annual water yield, the weighted storm yield is multiplied by the ratio of annual water yield to an incremental probability-weighted water yield. For the return periods recommended, the computation is:

$$A_s = V_A \frac{(0.01Y_{s100} + 0.01Y_{s50} + 0.02Y_{s25} + 0.06Y_{s10} + 0.4Y_{s2})}{0.01V_{100} + 0.01V_{50} + 0.02V_{25} + 0.06V_{10} + 0.4V_2} \quad (1308)$$

where A_s is the annual sediment yield, V_A is the average annual water yield, and the numerical subscripts in the single storm event (Y_s) and water yield (V) refer to the return period of the storm.

When estimating sediment yield using either the MUSLE or other methods, a useful computation is to express the sediment yield in terms of an average concentration (ppm) based on the total water and sediment yields. This value can be compared with measured stream data in the area and results of sediment routing analysis.

1301.7.5 Total Sediment Yield

Total sediment yield is the sum of wash load and bed-material load. Wash load is defined as “that part of the sediment load which is composed of particles smaller than those found in appreciable quantities in the shifting portion of the stream bed” (EINSTEIN, 1950). Quantifying, EINSTEIN suggested the limiting sizes of wash load and bed-material load may be chosen as the grain diameter (D_{10}) of which 10 percent of the bed mixture is finer. SIMONS and SENTURK (1992) give a similar definition. The wash load is usually carried away by the stream without much deposition. In contrast, the transport of bed-material load is controlled by the transport capacity of the channel. The above wash load and bed-material load definitions were applied for this MANUAL.

The USLE and MUSLE methods are generally applicable as predictors of wash load. This section presents an example of applying a sediment transport equation with the MUSLE to determine annual sediment yield. The information required to determine the sediment transport capacity in a channel are the hydraulic characteristics of the channel and the sediment sizes present in the bed. It is assumed that the transporting capacity of material larger than D_{10} controls the transport rate, while the supply controls transport for the smaller sizes. This concept is illustrated in **Figure 1303E.** The transport capacity is determined using a combination of the MEYER-PETER, MULLER bed-load equation and the EINSTEIN integration for suspended load (i.e., **Equation 704**), which is found to provide reasonable estimation of sediment discharges for sandy gravel channels. Individual size fractions are considered. The supply of smaller sediment is determined using the MUSLE.

Table 1301B shows the results of the calculations for individual storms of specified return periods. Assuming the average annual runoff volume for the area is 202 acre-feet and applying **Equation 1308**, the average annual sediment yield is 32,000 tons. This total sediment yield is 50 percent larger than that computed from the MUSLE alone. This illustrates the inaccuracy that can result when the bed-material load in the channels is not considered.

In this example, it was assumed that sizes smaller than 1 millimeter were wash load. The actual division between wash load and bed-material load is difficult to determine and varies depending on the characteristics of the watershed and river system. Often, the division is set at 0.062 millimeter (the largest silt size) for rivers with mild slopes. For steeper watershed streams, the wash load is set at all sizes smaller than a given percent finer, such as D_{10}.

Since for the bed material load the transport rate was assumed equal to the transport capacity, the effect of gullying or bank erosion was indirectly incorporated. The supply of sediment, whether from the channel bed, channel banks, or from gullying, was assumed to be sufficient to allow the channel to transport sediment at its capacity. Therefore, the method used gives a maximum estimate of the combined erosion processes, since a lesser amount of sediment might be supplied to the channel; however, if a greater amount were supplied, the excess would be deposited.

The methodology just described is recommended for the western United States, in most circumstances, rather than a straightforward application of the USLE. The effect of the infrequent, high runoff-producing events is incorporated directly. The substitution of the MUSLE for the USLE provides a methodology that is more applicable to western conditions, especially in arid regions. The inclusion of channel transporting capacity is also important. It is most significant in steep sand-bed channels where the transporting capacity of the bed material sizes can be high.

1301.8 Siting of Control Structures and Basins

Debris control structures which protect other hydraulic structures (e.g., culverts, bridges, channel) are placed based on structure cost, debris production potential and the importance of the structure. Minor culverts whose failure would have a limited impact on downstream structures would require less debris protection than a major lined channel. Generally speaking, debris control structures should be placed at the source of debris.

1302 CONTROL OF EROSION FROM CONSTRUCTION ACTIVITIES

1302.1 Introduction

The cleaning, stripping, and grading of land may cause severe localized erosion with subsequent sediment deposition and damage to downstream streets, channels, culverts, and other property. Erosion during and immediately following construction may be particularly sever in the following cases:

1. Sites having slopes greater than 4-5 percent
2. Sites where large areas of loose dirt and/or graded earth are left unprotected during the potential rainy season (summer in the Clark County area)
3. Areas of concentrated storm flows in unprotected channels or outlets from storm drains

Studies have shown the construction activities can easily increase the annual soil erosion rates from a parcel by 10 to 100 times those experienced under undisturbed conditions. High erosion from constructed areas normally subside after 2 to 3 years, but can persist indefinitely if gullies, slope failures, and other erosion features are not repaired and controlled.

The purpose of an erosion and sediment control plan is to reduce erosion to an acceptable level, but without undue economic burden to the property, owner, developer, or contractor. To this extent, the local entities rely on the property owner to control erosion from their sites and generally do not require an erosion and sediment control plan. However, when the local entity believes there is a potential erosion and/or sedimentation problem which would affect public or private facilities, the local entity may require the submittal of an erosion and sediment control plan in accordance with Section 1302.

1302.2 References

The following references are suggested for use in preparing an erosion and sediment control plan:

1. GOLDMAN, 1986 - Erosion and Sediment Control Handbook by S. J. Goldman, K. Jackson, T. A. Bursztyusky, McGraw-Hill, 1986 (particularly see Chapter 9, " Preparing and Evaluating an Erosion and Sediment Control Plan").
2. USEPA, 1972 - Guidelines for Erosion and Sediment Control Planning and Implementations, U. S. Environmental Protection Agency Pub. EPA-R2-72-015.
3. DRCOG, 1980 - "Managing Erosion and Sedimentation from Construction Activities", Denver Regional Council of Governments, 2480 East 26th Avenue, Suite 200-B, Denver, Colorado 80211, April 1980.

1302.3 Erosion, Sediment, and Debris Control Plans

All subdivision plats, commercial developments, or other major construction projects requiring a drainage plan shall address erosion and sedimentation control. In cases where there is significant potential for erosion-related problems, the local entity may require an erosion and sediment control plan be prepared which identifies specific measures and structures to mitigate potential damage.

In general, the development of an erosion and sediment control plan involves five steps:

1. Collect and review information on site topography, soils, vegetation, and important adjacent (off-site) features such as open channels and storm drains.

2. Evaluate the information relative to the potential for erosion/sedimentation problems caused by construction.

3. Devise and/or modify construction activities (e.g., schedule) to minimize erosion problems.

4. Develop an erosion and sediment control plan with specific measures tailored to the construction and terrain conditions.

5. Follow and monitor the plan and revise as necessary.

Typically, if the local entity requires an erosion and sediment control plan, only Item I below will need to be addressed. The decision as to the need for a special construction schedule and/or a formal erosion and sediment control plan (Items II and III) will be based on project size, amount of earth disturbance, soil type, slope, and proximity to adjacent property or facilities likely to be damaged by erosion or sediment deposits.

Items to be discussed and/or prepared as part of an erosion and sediment control plan (when required) include the following:

I. <u>Erosion and Sediment Control Narrative</u>

   a. Project description: Nature and purpose of the land-disturbing activity, and the estimated amount of grading involved.

   b. Existing site conditions: Existing topography, vegetation, drainage, and soils (including erodibility and particle size).

c. Adjacent areas: Neighboring areas, such as channels, residential areas, and roads that might be affected by the land disturbance.

d. Critical areas: Areas within the developed site that have potential for serious erosion or sediment problems.

e. Erosion and sediment control measures: Construction schedule and methods that will be used to control erosion and sediment on the site.

f. Permanent stabilization: Description of how the site will be stabilized after construction is completed.

g. Schedule: Schedule of construction activities and regular inspections and repairs of erosion and sediment control structures.

II. Formal Erosion and Sediment Control Plan (When Required)

a. Existing contours: Existing elevation contours of the site at an interval sufficient to determine drainage pattern.

b. Preliminary and final grades: Proposed changes in the existing elevation grades for each stage of grading (e.g. rough grading and final grading).

c. Soils: Boundaries of the different soil types within the proposed development.

d. Existing and final drainage patterns: Map showing the dividing lines and the direction of flow for the different drainage areas before and after development.

e. Limits of clearing and grading: Finished contours and/or boundaries showing the area to be disturbed.

f. Erosion and sediment control facilities: Locations, names, and dimensions of the proposed temporary and permanent erosion and sediment control facilities.

g. Storm water management system: Location and size of permanent storm drain inlets, pipes, outlets, and other permanent drainage facilities (swales, waterways, etc.).

h. Detailed drawings: Dimensioned drawings of key features such as sediment basin risers, energy dissipators, and waterway cross-sections.

i. General seeding and mulching information: Seeding dates, seeding, fertilizing, and mulching rates in pounds per acre and application procedures.

j. Maintenance program: Inspection schedule, spare materials needs, stockpile locations, and instructions for sediment removal and disposal and for repair of damaged structures.

III. Detailed Calculations (When Required)

a. Calculations and Assumptions: Data for design storm, including frequency and intensity, used to size pipes, channels, sediment basins, and traps; design particle size for sediment traps and basins; estimated trap efficiencies, basin discharge rates; size and strength characteristics for filter fabric, wire mesh, fence posts, etc. and other calculations necessary to support drainage, erosion, and sediment control systems.

Drainage studies and plans for rough grading to be done early and long-term construction projects shall address the narrative items (Item I) if required by the local entity. If a formal erosion and sediment control plan is deemed necessary, all of the listed drawing features, details, and calculations will be required and shall be submitted either with the drainage plan or as a separate document.

1302.4 Performance Standards

The general standards and criteria for developing an erosion and sediment control plan include the following:

1. Fit the development to the terrain-minimize radical changes in terrain features.

2. Time grading and construction to minimize soil exposure during rainy season (summer).

3. Retain existing vegetation whenever possible.

4. Vegetate, mulch, and/or otherwise protect denuded areas.

5. Direct runoff away from denuded or erosion-prone areas.

6. Minimize length and steepness of slopes.

7. Keep runoff velocities low.

8. Design drainage ways and outlets to withstand concentrated or increased runoff.

9. Trap sediment on-site using such facilities as sediment basins, berms, straw bale dikes, and silt fences during construction.

10. Inspect and maintain erosion control measures and facilities.

DEBRIS STRUCTURE PERFORMANCE

Type of Structure / Debris Classification	Debris Deflector	Debris Rack	Debris Riser	Debris Crib	Debris Basin and Dam
Light Floating Debris		X		X	
Medium Floating Debris	X	X			
Heavy Floating Debris	X				
Flowing Debris			X		X
Fine Detritus			X		X
Coarse Detritus			X	X	X
Boulders	X				

Revision	Date

REFERENCE:
USDOT, FHWA, HEC NO. 9, 1971

TABLE 1301

CONSERVATION PRACTICE FACTOR P FOR CONTOURING, STRIP CROPPING AND TERRACING

Land Slope (%)	Farming on Contour	Contour Strip Crop	Terracing	
			(a)	(b)
2-7	0.50	0.25	0.50	0.10
8-12	0.60	0.30	0.60	0.12
13-18	0.80	0.40	0.80	0.16
19-24	0.90	0.45	0.90	0.18

- For erosion-control planning on farmland.
- For prediction of contribution to off-field sediment load.

Source: After WISCHMEIER (1972).

Revision	Date

REFERENCE: Estimating the Cover and Management Factor for Undisturbed Areas, 1972

TABLE 1301a

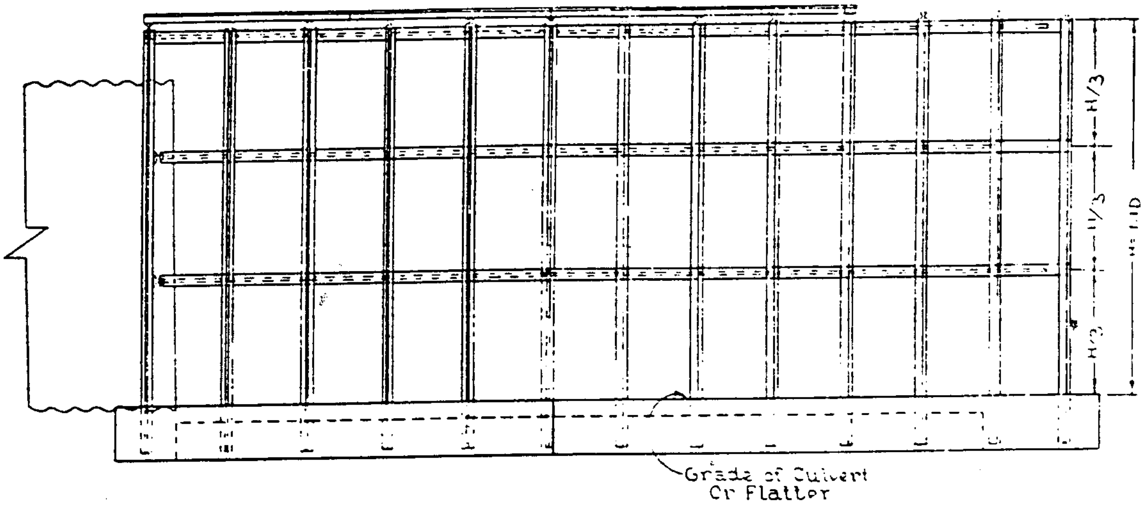
AN EXAMPLE OF TOTAL SEDIMENT YIELD COMPUTATION

Return Period (yrs)	Runoff Volume (ac-ft)	Runoff Peak (cfs)	Wash Load* (tons)	Bed-Material Load** (tons)	Total Sediment Yield (tons)
2	121	336	11,000	9,000	20,000
10	593	1,646	64,000	27,000	91,000
25	917	2,544	100,000	35,000	135,000
50	1,233	3,329	140,000	49,000	189,000
100	1,510	4,190	180,000	62,000	242,000
Incremental Probability Weighted	130	—	13,000	7,030	20,470
Annual Yield	202	—	21,000	11,000	32,000

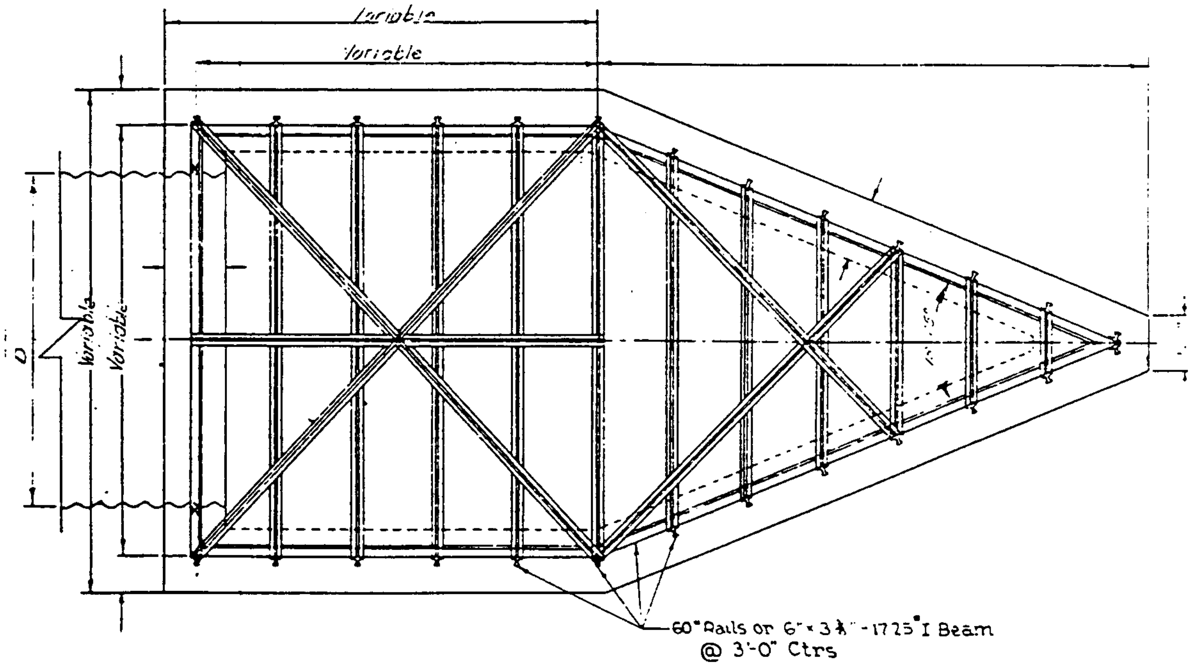
Revision	Date

REFERENCE:

DEBRIS DEFLECTOR
(TYPICAL)



SIDE ELEVATION



PLAN

Revision	Date

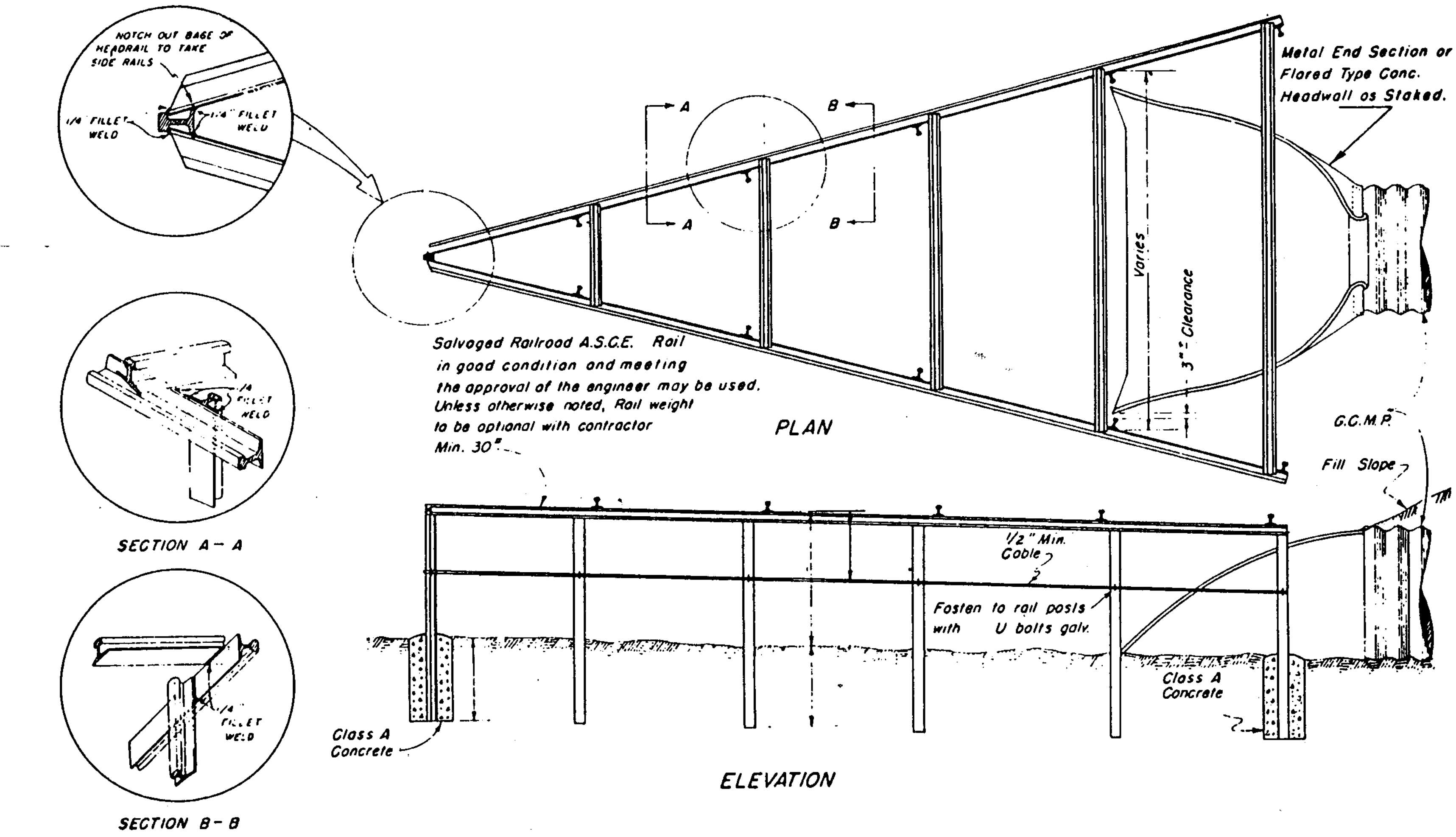
WRC ENGINEERING

REFERENCE:
USDOT, FHWA, HEC NO. 9, 1971

FIGURE 1301
1 OF 2

WRC ENGINEERING

REFERENCE: USDOT, FHWA, HEC NO. 9, 1971

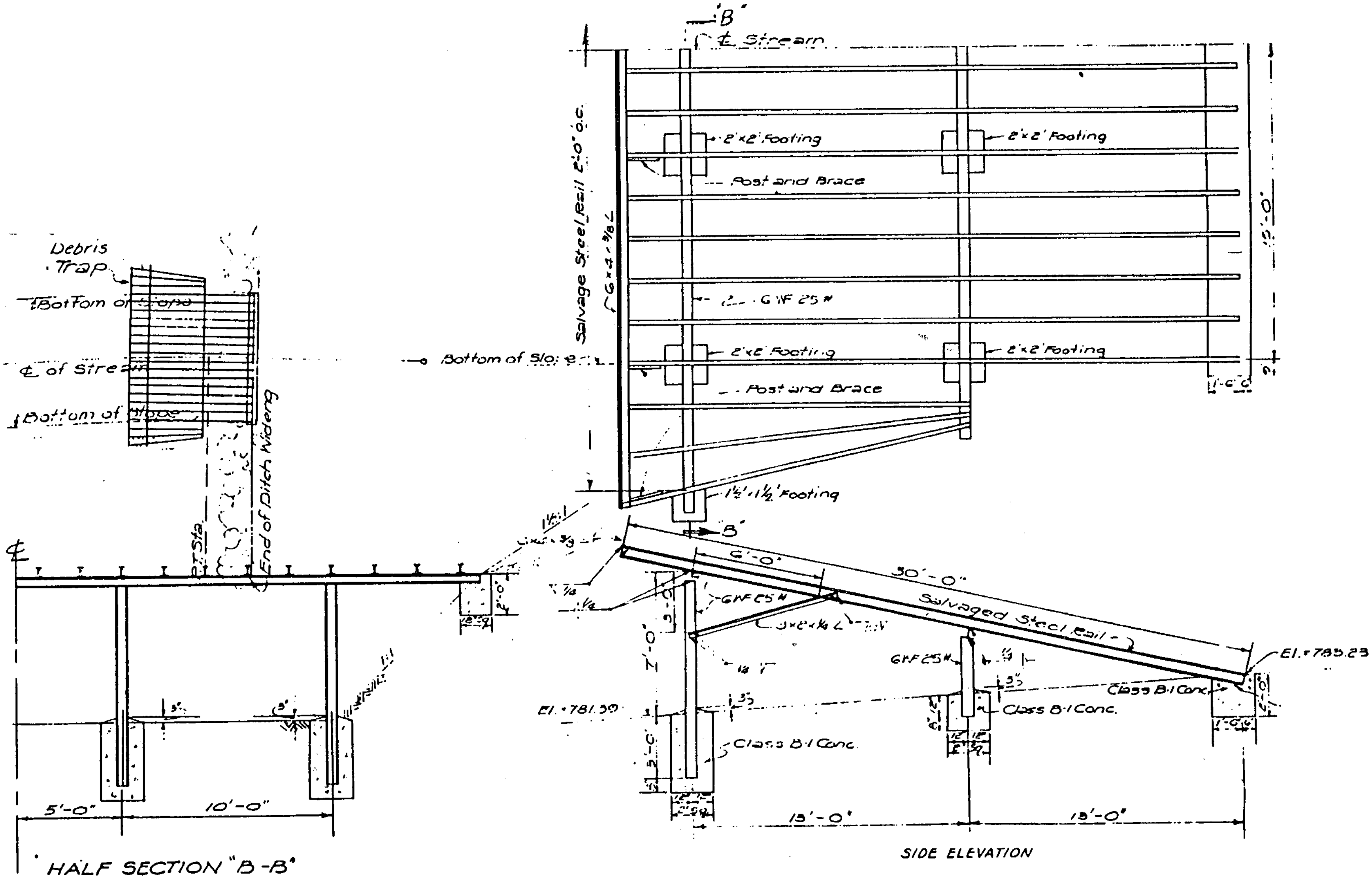


TYPICAL UPPER JOINT DETAILS

DEBRIS DEFLECTOR (TYPICAL)

Revision	Date

FIGURE 1301
2 OF 2



DEBRIS RACK
(TYPICAL)

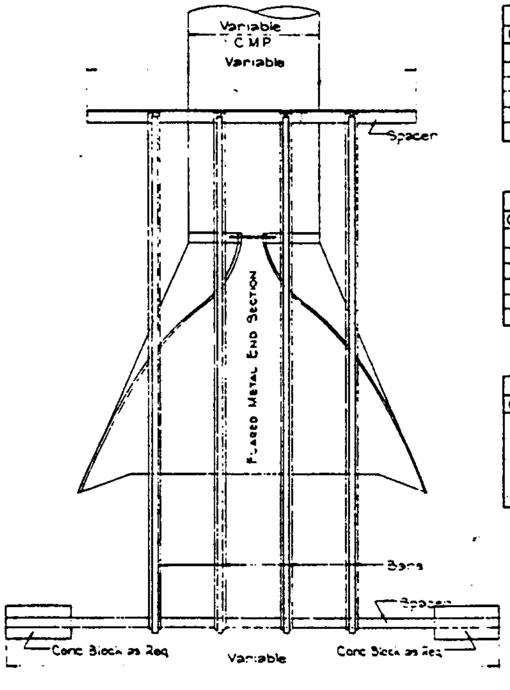
WRC ENGINEERING

REFERENCE: USDOT, FHWA, HEC NO. 9, 1971

Revision	Date

FIGURE 1302
1 OF 2

DEBRIS RACK
(TYPICAL)



PLAN

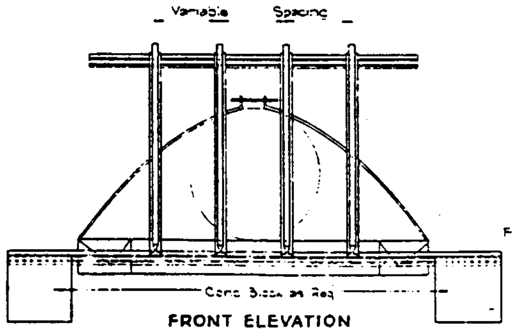
BAR SPACING FOR VARIOUS CULVERTS		
CMP	BARS REQUIRED	BAR SPACING
18"	3	1'-0"
24"	4	1'-2"
30"	4	1'-4"
36"	4	1'-8"
42"	5	1'-8"
48"	5	1'-9"

REQUIRED LENGTH OF BARS			
CMP	SLOPE OF BAR	BAR LENGTH	MATERIAL
18"	3:1	8'-3"	Std. 3" Pipe or 25 to 40 Lb. Rail
24"	3:1	11'-0"	· · · · ·
30"	3:1	12'-0"	· · · · ·
36"	3:1	13'-6"	40 to 60 Rail or Steel I's
42"	3:1	15'-0"	· · · · · · ·
48"	3:1	16'-6"	· · · · · · ·

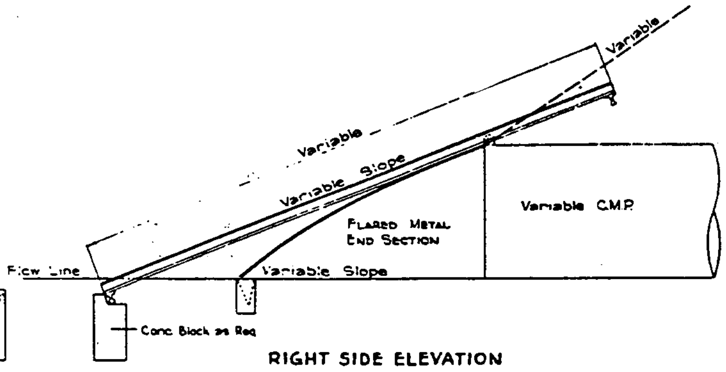
LENGTH OF SPACERS			
CMP	TOP SPACER	BOTTOM SPACER	MATERIAL
18"	6'-0"	8'-0"	4"x4"x3/8" ∠s 40 to 60 Lb Rail or 3" Pipe
24"	7'-0"	10'-0"	
30"	7'-6"	11'-0"	
36"	8'-0"	12'-6"	
42"	9'-0"	13'-9"	
48"	10'-0"	15'-0"	

NOTE

- Special Treatment Required For Pipes Larger Than 48"
- Minimum Bar Spacing 0'-10"
- Maximum Bar Spacing 2'-0"
- Gradients Steeper Than 15% May Require Special Treatment
- Sizes Shown Are Minimums To Be Used.
- Heavier Sections Permitted In All Cases



FRONT ELEVATION



RIGHT SIDE ELEVATION

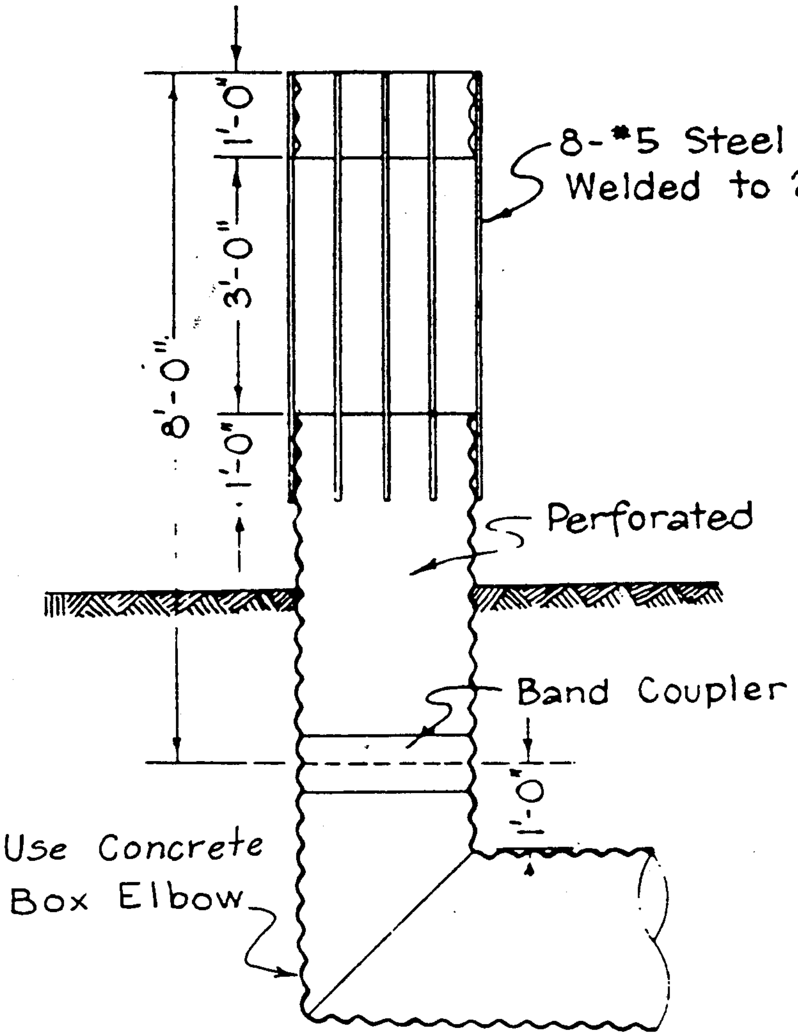
Revision	Date

WRC ENGINEERING

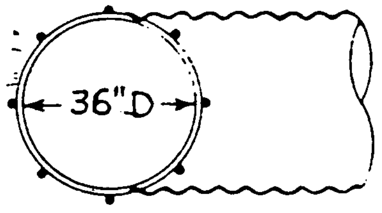
REFERENCE:
USDOT, FHWA, HEC NO. 9, 1971

FIGURE 1302
2 OF 2

DEBRIS RISER
(TYPICAL)



ELEVATION



PLAN

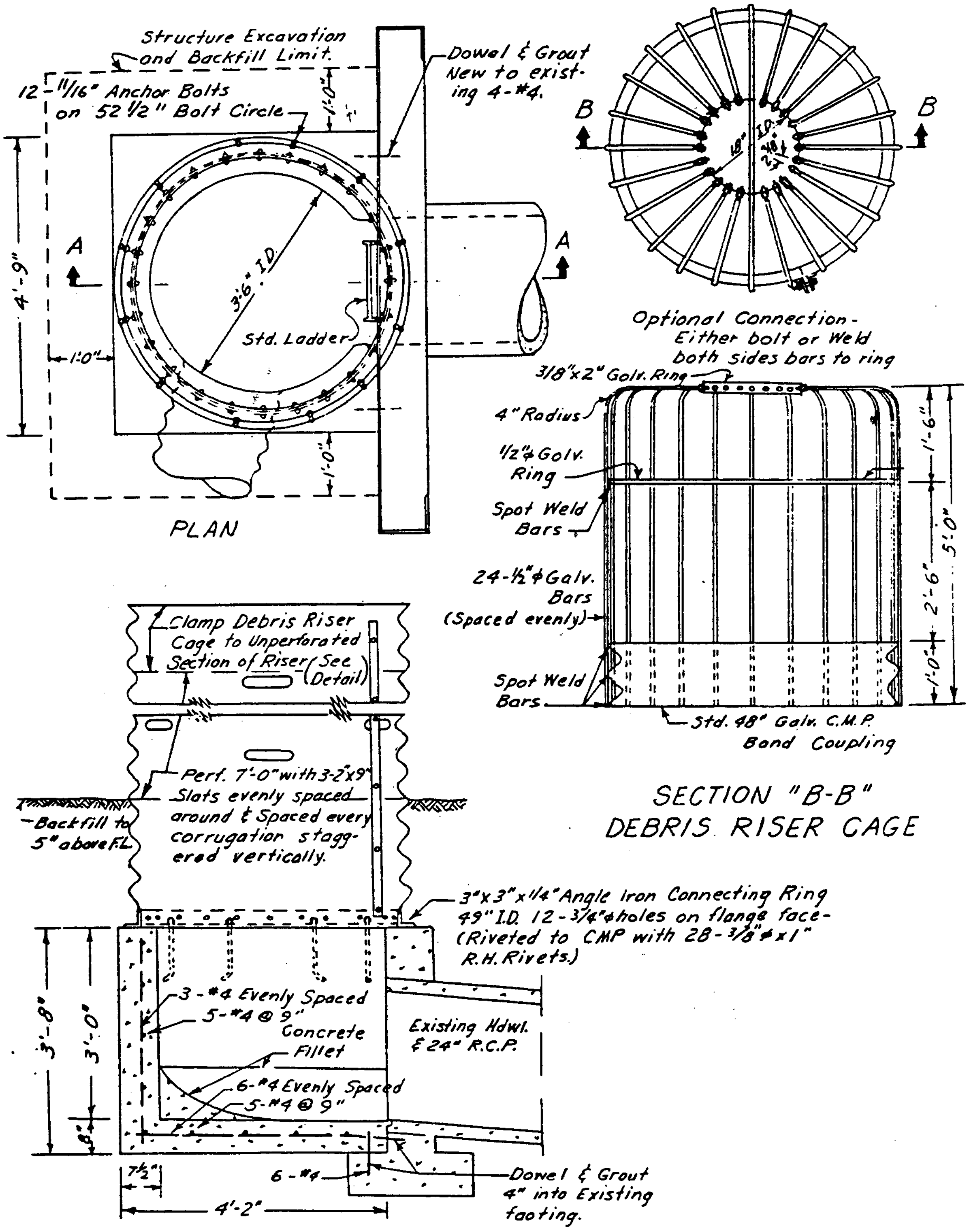
Revision	Date

WRC ENGINEERING

REFERENCE:
USDOT, FHWA, HEC NO. 9, 1971

FIGURE 1303
1 OF 3

DEBRIS RISER (TYPICAL)



PLAN

SECTION "B-B"
DEBRIS RISER CAGE

SECTION "A-A"
CMP RISER & JUNCTION BOX

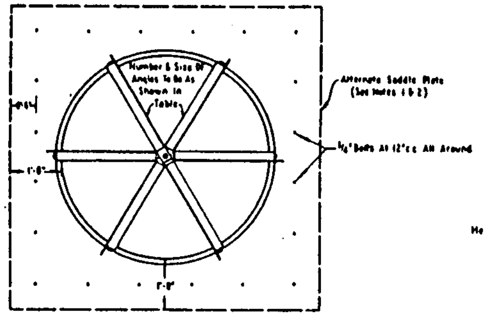
Revision	Date

REFERENCE:
USDOT, FHWA, HEC NO. 9, 1971

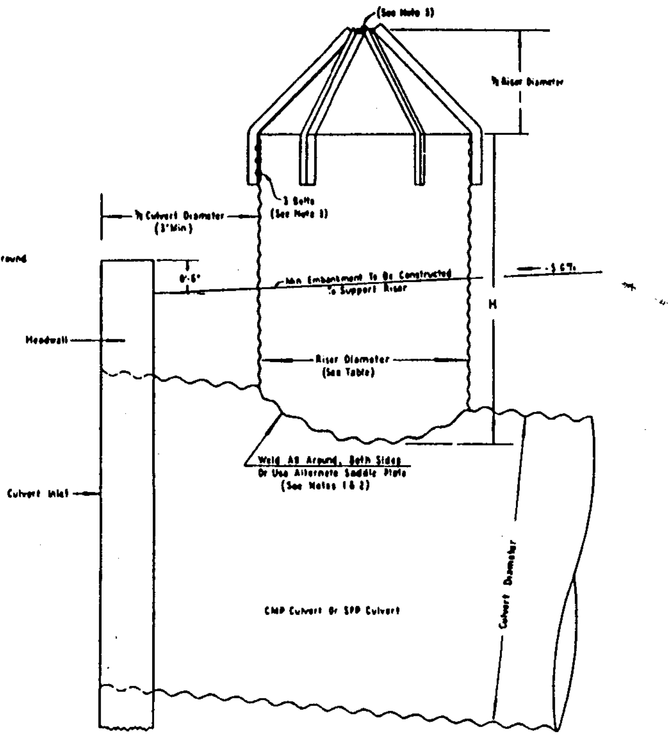
FIGURE 1303
2 OF 3

REFERENCE:

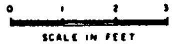
USDOT, FHWA, HEC NO. 9, 1971

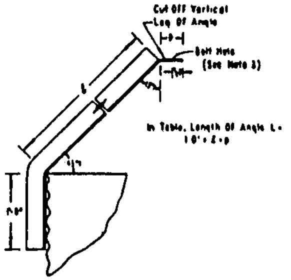


TOP VIEW
No Scale



ELEVATION
No Scale





In Table, Length Of Angle L = 1'0" + ℓ + p

CAGE ANGLE DETAIL
No Scale

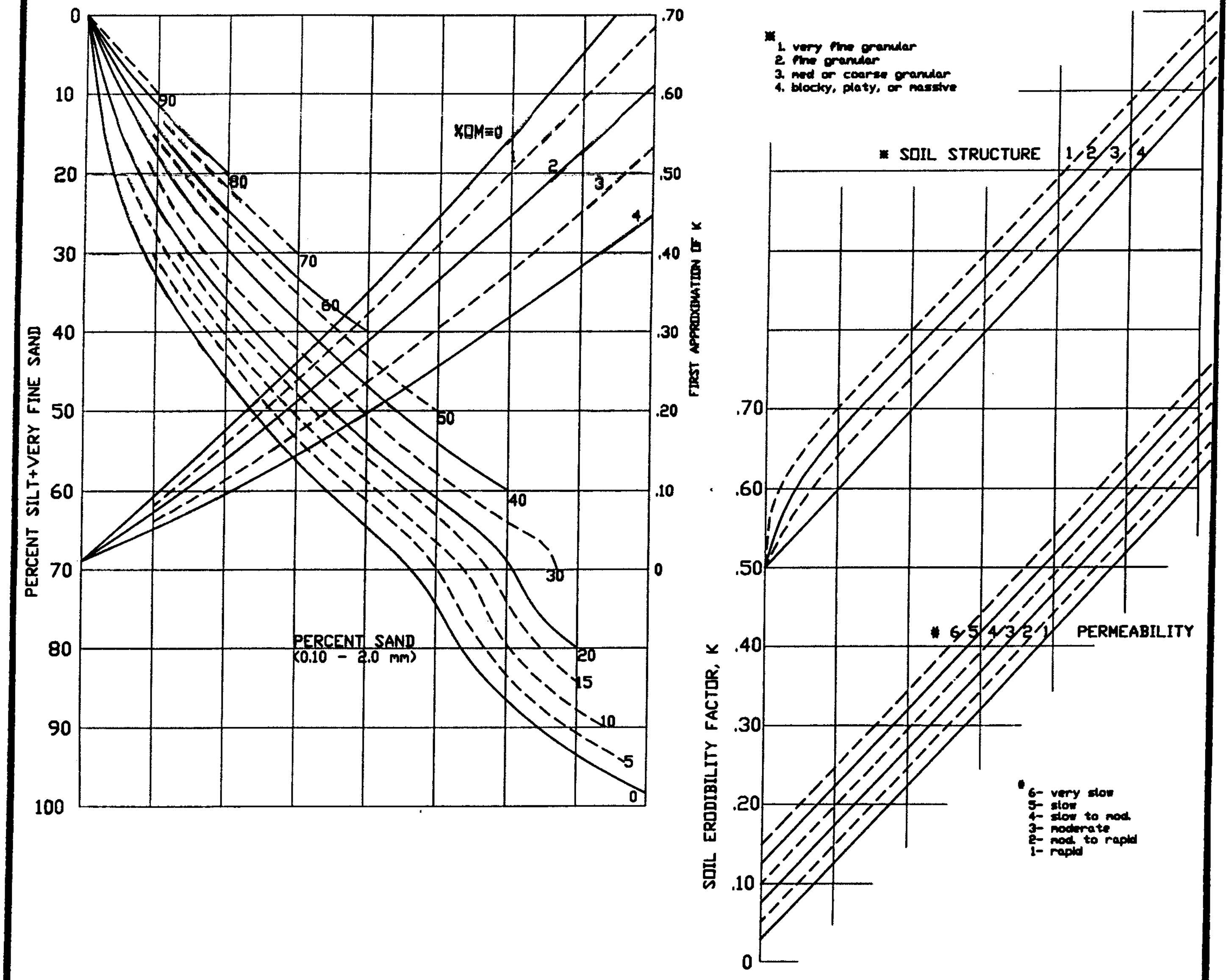
CULVERT DIAM.	RISER			RISER CAGE				
	C.M.P		H*	STEEL				
	DIAM	GAGE		ANGLE SIZE	NO. OF PIECES	LENGTH, FT.		
INCHES	INCHES		FEET			ℓ	p	L
36	24	14	4	2" x 2" x 1/4"	4	1'-5"	2"	2'-7"
42	24	14	4	2" x 2" x 1/4"		1'-5"	2"	2'-7"
48	30	14	4	2 1/2" x 2 1/2" x 1/4"		1'-10"	3"	3'-1"
54	36	12	4			2'-1"	3"	3'-4"
60	42	12	6			2'-6"	3"	3'-9"
66	42	12	6			2'-6"	3"	3'-9"
72	48	12	6			2'-10"	3"	4'-1"
78	48	12	6			2'-10"	3"	4'-1"
84	54	12	6	3" x 3" x 1/4"		3'-3"	3"	4'-6"
90	60	10	8			3'-6"	3"	4'-9"
96	60	10	8			3'-6"	3"	4'-9"
102	66	10	8			3'-11"	3"	5'-2"
108	72	10	8	3 1/2" x 3 1/2" x 5/16"		4'-3"	4"	5'-7"
114	72	10	8			4'-3"	4"	5'-7"
120	78	8	8			4'-8"	4"	6'-0"
126	84	8	10			5'-0"	4"	6'-4"
132	84	8	10			5'-0"	4"	6'-4"
138	90	8	10		6	5'-4"	7"	6'-11"
144	96	8	10			5'-8"	7"	7'-3"
150	96	8	10			5'-8"	7"	7'-3"
156	102†	12	12	4" x 4" x 5/16"	8	6'-0"	11"	7'-11"
162	108†	12	12			6'-5"	11"	8'-4"
168	108†	12	12			6'-5"	11"	8'-4"
174	114†	10	12			6'-9"	11"	8'-8"
180	120†	10	12			7'-1"	11"	9'-0"

DEBRIS RISER (TYPICAL)

Revision	Date

FIGURE 1303
3 OF 3

SOIL ERODIBILITY NOMOGRAPH USED TO DETERMINE FACTOR K (TONS/ACRE) FOR SPECIFIC TOPSOILS OR SUBSOIL HORIZONS

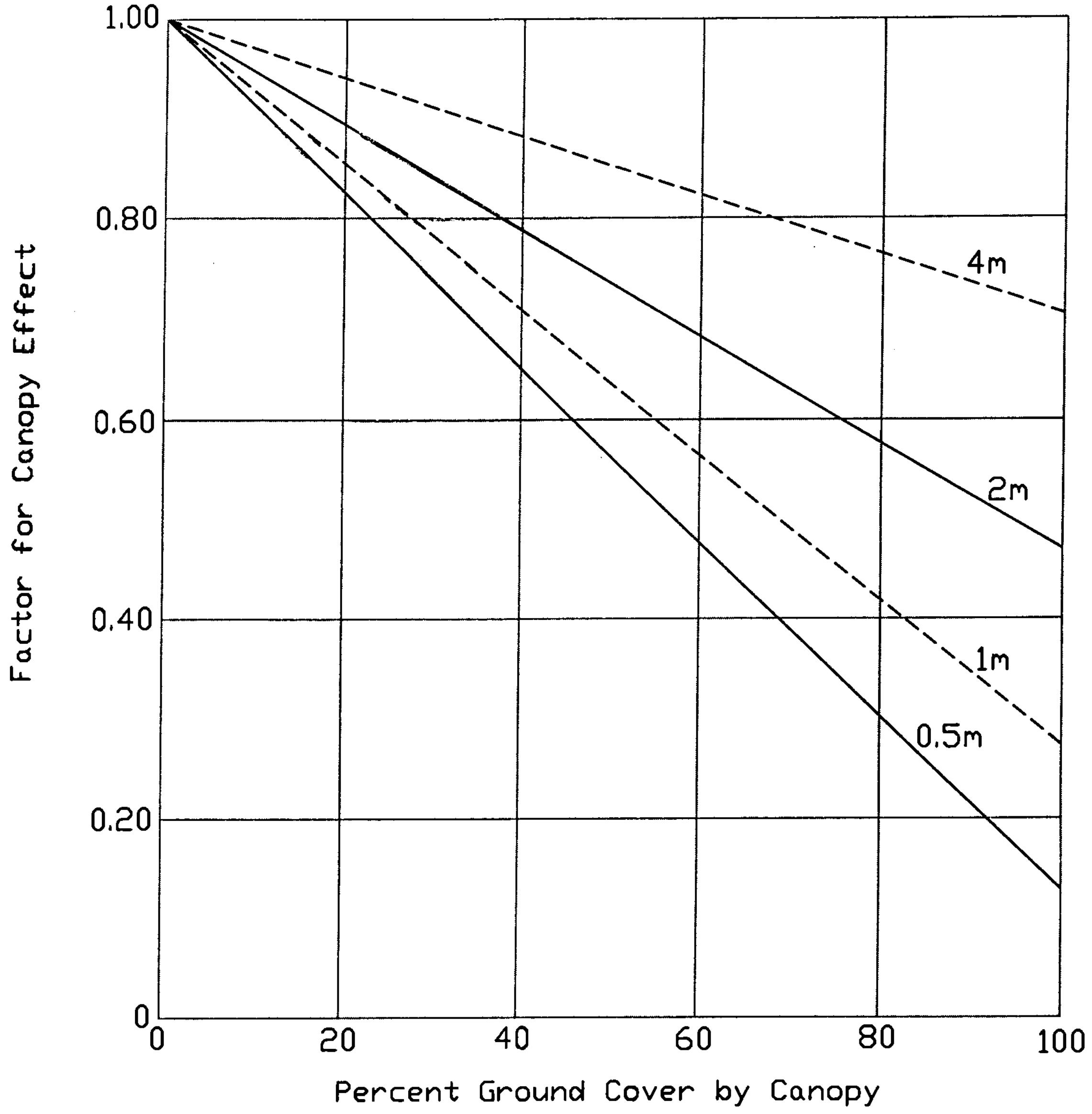


Revision	Date

REFERENCE: A Soil-Erodibility Nomograph for Farmland and Construction Sites, 1971

FIGURE 1303a

INFLUENCE OF VEGETAL CANOPY

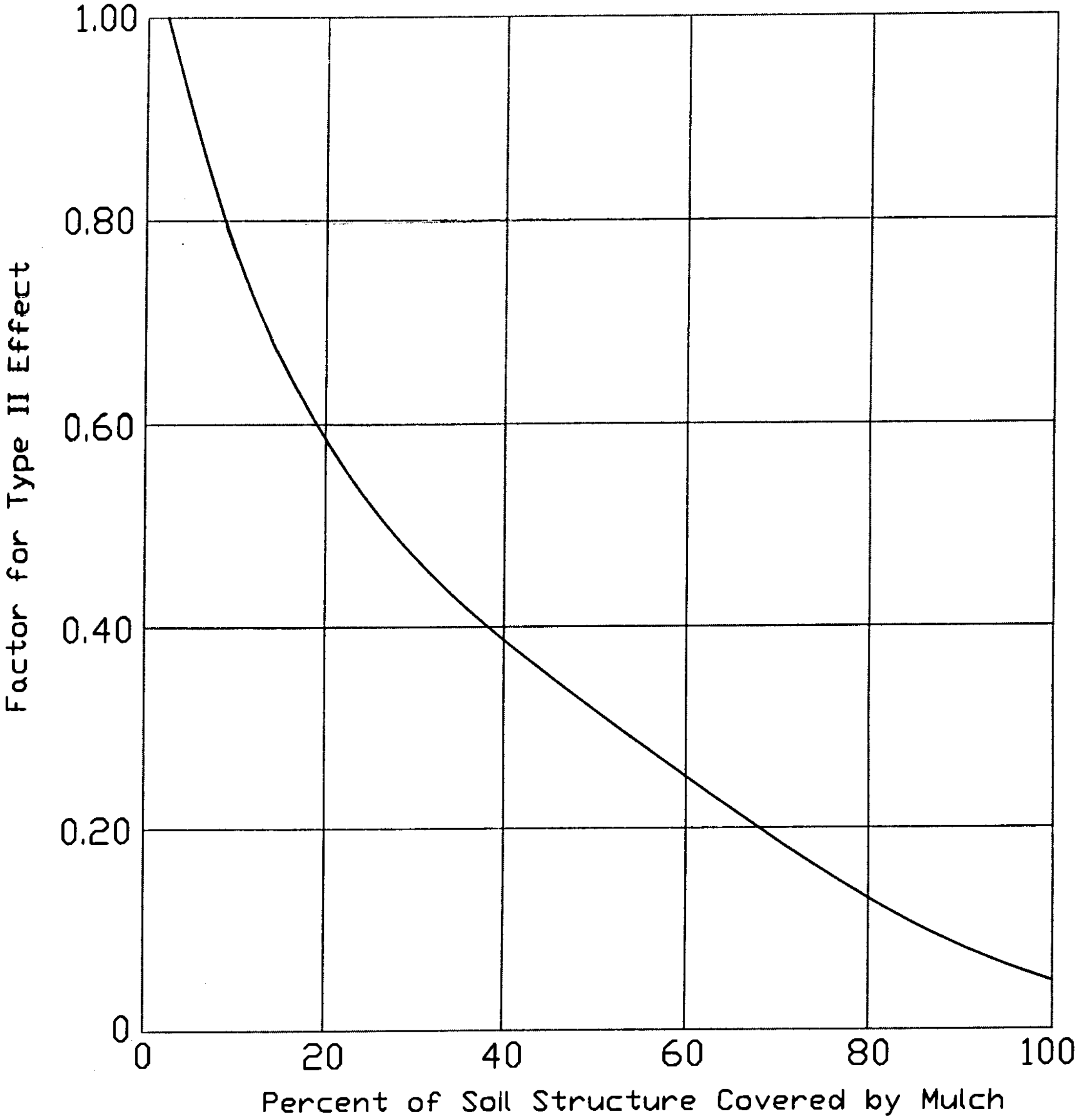


Revision	Date

REFERENCE: A Soil-Erodibility Nomograph for Farmland and Construction Sites, 1971

FIGURE 1303b

EFFECT OF PLANT RESIDUES OR CLOSE-GROWING STEMS AT THE SOIL SURFACE

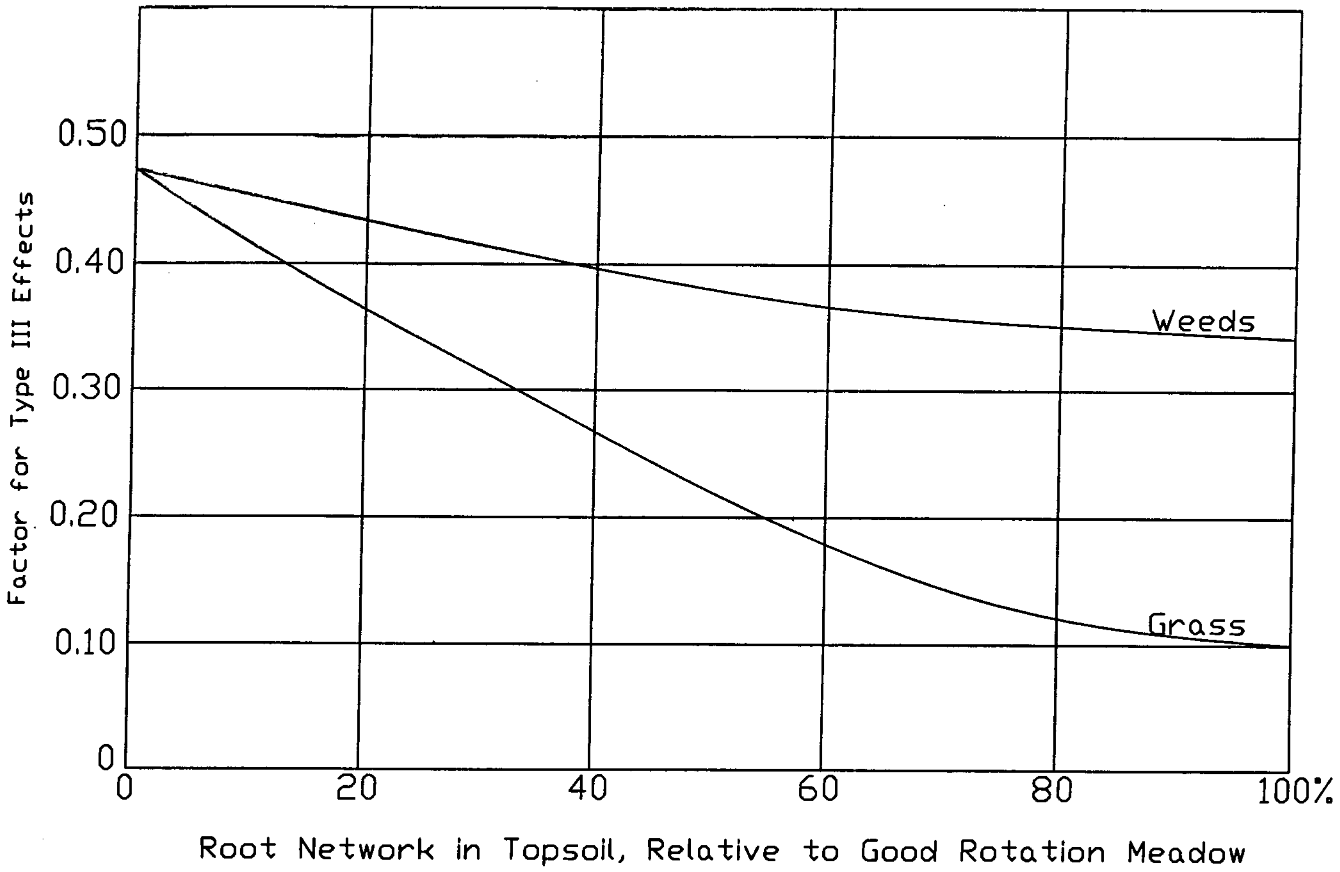


Revision	Date

REFERENCE: Estimating the Cover and Management Factor for Undisturbed Areas, 1972

FIGURE 1303c

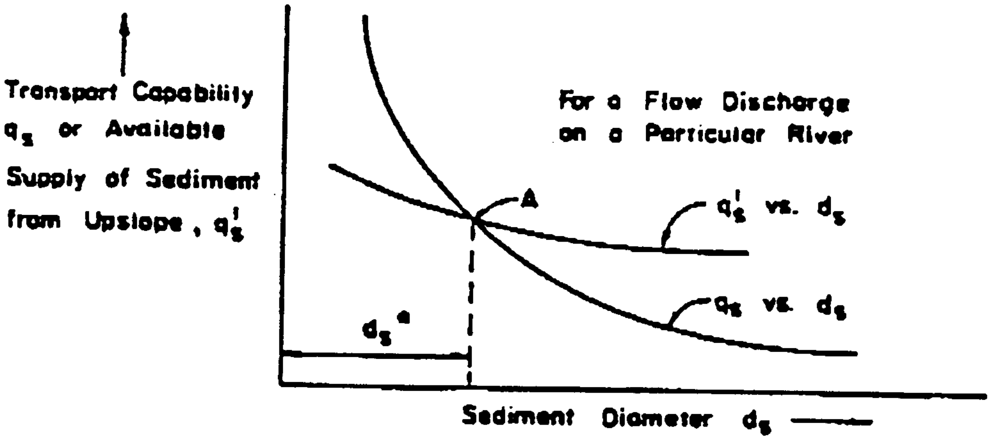
TYPE III EFFECTS ON UNDISTURBED LAND AREAS



Revision	Date

REFERENCE: Estimating the Cover and Management Factor for Undisturbed Areas, 1972

CONCEPT OF CONTROLLING SEDIMENT TRANSPORT RATES

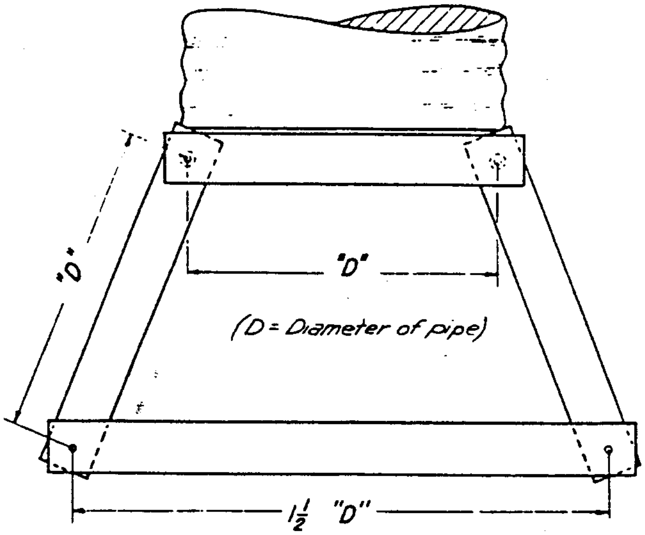


Revision	Date

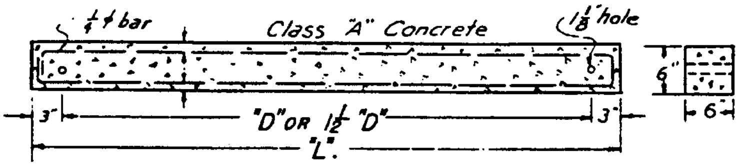
REFERENCE: River Mechanics, 1971

FIGURE 1303e

DEBRIS CRIB
(TYPICAL)

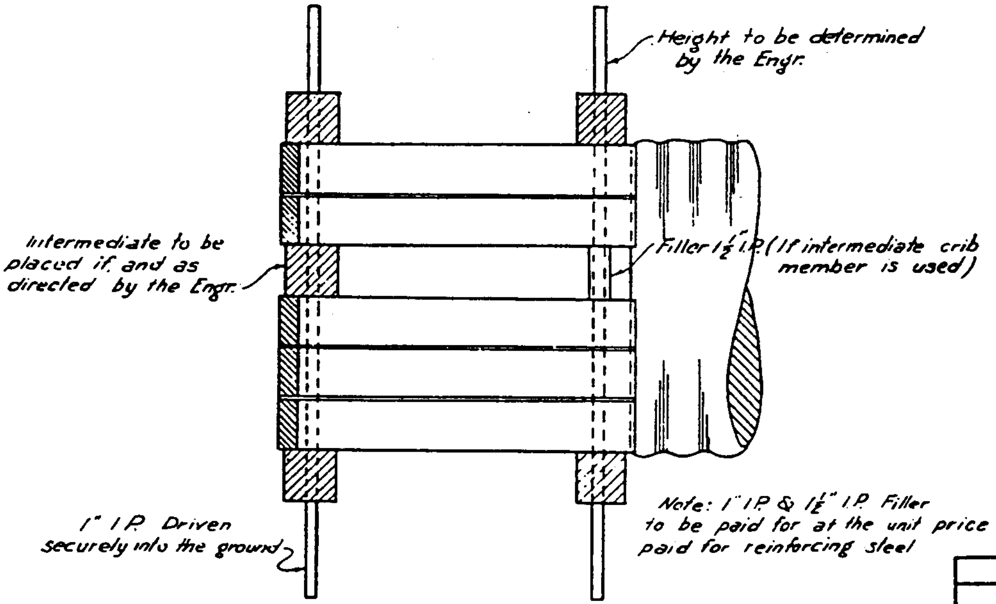


PLAN



CRIB MEMBER

When "L" is 4' or more use double amount of R.S. shown.



ELEVATION

Revision	Date

WRC ENGINEERING

REFERENCE:

USDOT, FHWA, HEC NO. 9, 1971

FIGURE 1304