III. DATA REQUIREMENTS

3.1 Hydrologic Data

Design Storms

In most mining locations, estimation of runoff hydrology must be used in place of measured data. This process begins by characterizing the design storm. Surface mining regulations specify that the design of many mine area features must safely pass the peak runoff of a storm of specified return period and duration. When calculating runoff, the storm volume associated with the specified return period (of a given duration) and the arrangement of intensities occurring within that storm must be determined. In general, the existence and length of record of on-site rain gages, as well as size and location of the mineland watershed will determine methods and considerations involved in determining the character and magnitude of the storm.

There are a number of methods available for determining rainfall volume and the distribution of rainfall intensities. In this manual we recommend the use of the National Oceanic and Atmospheric Administration's (NOAA) atlases for determination of rainfall volume and the Soil Conservation Service's (SCS) rainfall distributions for determining the distribution of rainfall intensity. Both rainfall volume and rainfall intensity distributions can be developed from local weather station information or from judicious application of other methods. The time and effort required for such analysis is not warranted for small areas, therefore methods presented in this manual are reasonably accurate for design of small area sediment control structures.

The use of the NOAA atlases is discussed in detail in the next section of this chapter (3.2). The SCS storm distributions are discussed in the remainder of this section.

Distribution of Storm Rainfall

The time distribution of storm rainfall used in this manual and commonly used with hydrologic methods for small areas is the Type I or Type II storms. The Type I distribution represents the Coastal side of the Sierra Nevada and Cascade Mountains in California, Oregon and Washington, Alaska and Hawaii. Type II distribution represents the remaining states, Puerto Rico and Virgin

Islands. These distributions, shown in Figure 3.1, are based on the generalized rainfall depth-duration relationships shown in National Weather Service (NWS) Technical Papers. The curves are established for 24-hour storms with a period of intense rainfall. The recommended procedure for shorter duration events is to center the event duration around the steepest portion of the curve. For use with this manual, the Type I and Type II storms are simplified.

Superimposed on the curvilinear distributions are a series of segmental lines which approximate the actual distributions closely. Five linear segments are needed to approximate the Type II distribution and six linear segments are needed for the Type I distribution. Rainfall intensity is constant over each segment. The linear distribution will slightly overestimate the rainfall intensity at the beginning of the 24-hour storm and underestimate the intensity toward the end of a 24-hour storm. Both distributions have a period of intense rainfall which lasts for approximately an hour. The linear distribution will give the mean rainfall intensity of the curvilinear distribution for this intense period. Use of linear segments to approximate the Type I and Type II storm distributions is necessary to reduce the computational effort required to predict the sediment yield. Tables 3.1 and 3.2 give the linearized values of the 24-hour rainfall distribution for the Type II and Type I storms, respectively.

3.2 Climatic Data

Data Requirements

Climatic data used to design and select erosion control structures and treatments include rainfall volumes, durations, and intensities. Climatic characteristics important for designing revegetation include local temperature, growing season, distribution of annual rainfall and local wind velocities.

Data Acquisition

The most common approach to obtaining point values of precipitation is through the use of the NOAA publications. Currently there are three publications by NOAA that are in regular use. In chronological order, the first is Technical Paper No. 40 (TP-40) by Herschfield (1961). This paper collected

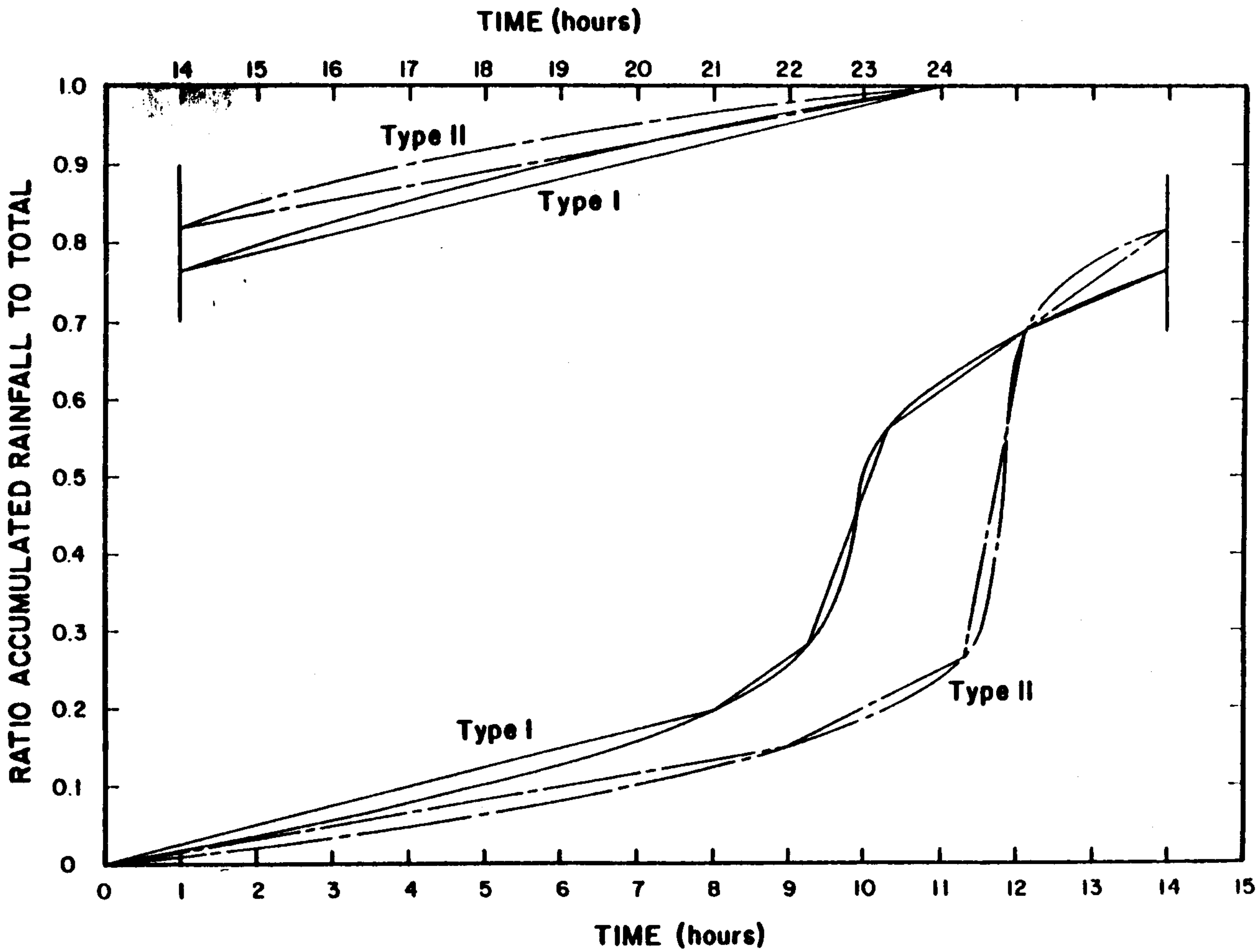


Figure 3.1. Twenty-four hour rainfall distribution (after Kent, 1968).

Table 3.1. Twenty-four Hour Type II Storm.

Time (hours)	P/P_t
0.00	0.000
9.00	0.150
11.25	0.250
12.17	0.695
14.00	0.820
24.00	1.000

Note: P = rainfall (at time in table)
P_t = total precipitation at 24 hours

Table 3.2. Twenty-four Hour Type I Storm.

Time (hours)	P/P_t
0.00	0.000
8.00	0.190
9.33	0.290
10.33	0.585
12.00	0.685
14.00	0.770
24.00	1.000

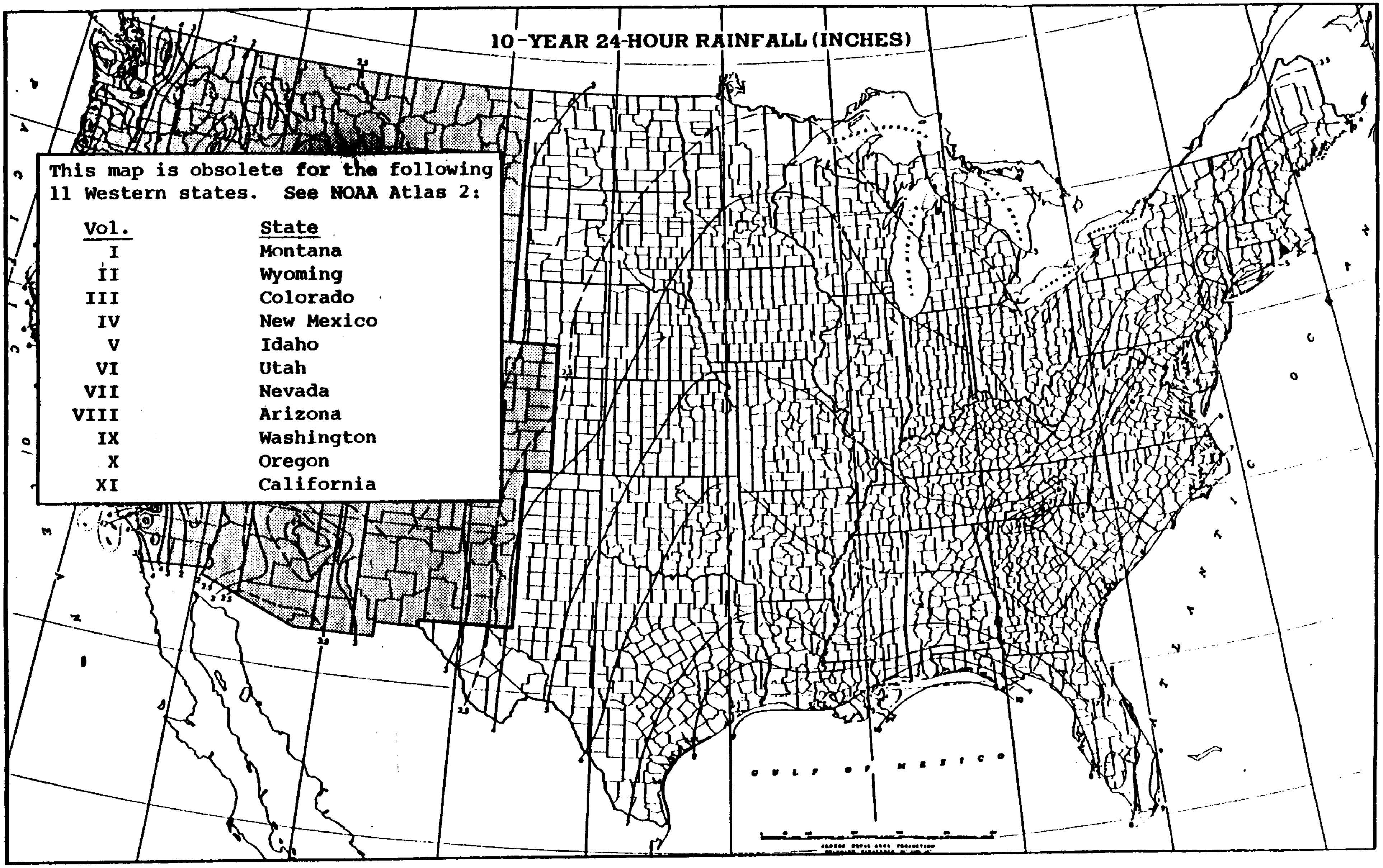
Note: P = rainfall (at the time in the table)
P_t = total precipitation at 24 hours

the results of depth-duration-frequency analysis investigations for the conterminous United States performed by the National Weather Service (NWS) and its precursor agency, the Weather Bureau. The maps presented in TP-40 are considered most reliable in relatively flat regions. However, in the western United States, the effects of mountainous terrain often cause large variations in precipitation. To correct this problem, the "Precipitation Frequency Atlas of the Western United States" (Miller, et al., 1973) in several volumes was introduced by NOAA. This publication contains much larger scale rainfall-duration-frequency maps than TP-40 and it corrects for such factors as slope, elevation, distance to moisture, location, normal annual precipitation, barriers to airflow, and surface roughness, not included in TP-40. For Alaska, the publication used is TP-47, "Probable Maximum Precipitation and Rainfall-Frequency Data for Alaska." Storms in the eastern United States are still characterized by TP-40. A more recent document for storms of 5 to 60 minutes duration has been published by NWS (1977), under the title "Five to 60 Minute Precipitation Frequency for the Eastern and Central United States, (HYDRO-35)." For 24-hour duration events, the rainfall atlas for the Western United States, TP-40 and TP-47 are recommended for use with this manual.

The procedure for using the NOAA atlases to obtain point rainfall volumes is quite straightforward. Isopluvial maps are printed for storms of 2-, 10-, 25- and 100-year return periods for separate states in the West and for the eastern United States as a whole. Figure 3.2 shows the 10-year, 24-hour rainfall distribution for contiguous U.S. from TP-40; use of this figure is not recommended for the western U.S.

3.3 Determination of Runoff Volume Using the Curve Number Method

The SCS peak flow and hydrograph procedures estimate direct runoff based on a soil curve number (CN) (SCS, 1956). This method was developed for use with nonrecording rain gages to predict total volume of runoff from total volume of rainfall. In their publication, Design of Small Dams, (U.S. Bureau of Reclamation, 1977) summarized and modified the SCS method for use in predicting runoff volume during a storm. Their modification of the SCS method is used in this manual.



This map is obsolete for the following 11 Western states. See NOAA Atlas 2:

Vol.	State
I	Montana
II	Wyoming
III	Colorado
IV	New Mexico
V	Idaho
VI	Utah
VII	Nevada
VIII	Arizona
IX	Washington
X	Oregon
XI	California

Figure 3.2. Isopluvial map showing the 10-year 24-hour rainfall (NOAA, TP40).

Values of CN range from 0 to 100, representing infinite and zero infiltration rates, respectively. Impervious surfaces will have a CN in the upper 90's. Pasture, range, or reclaimed soil can have CN's from about 40, for deep, well-drained sands and gravels, to 80, for clays or saturated soils. Data requirements for using the curve number method include soil type (see section 3.4), cover, land treatment, land use, antecedent moisture condition, and rainfall.

The amount of rainfall in a period of 5 to 30 days preceding a particular storm is referred to as antecedent rainfall, and the resulting condition of the watershed in regard to potential runoff is referred to as an antecedent condition. In general, the heavier the antecedent rainfall, the greater the direct runoff that occurs from a given storm. The effects of infiltration and evapotranspiration during the antecedent period are also important, as they may increase or lessen the effect of antecedent rainfall.

Because of the difficulties of determining antecedent storm conditions from data normally available, the andecedent moisture conditions (AMC) are reduced to the following three cases:

AMC-I. A condition of watershed soils where the soils are dry but not to the wilting point, and when satisfactory plowing or cultivation takes place.

AMC-II. The average case for annual floods, that is, an average of the conditions which have preceded the occurrence of the maximum annual flood on numerous watersheds.

AMC-III. When heavy rainfall or light rainfall and low temperatures have occurred during the five days previous to the given storm, and the soil is nearly saturated.

Curve numbers for one antecedent moisture condition may be converted to a different antecedent moisture condition by the use of Table 3.1. The corresponding curve number for AMC-I and AMN-III can be obtained from columns 2 and 3 of Table 3.3. For example, a CN of 73 for AMC-II gives curve numbers for AMC-I and AMC-III of 54 and 87, respectively.

Watershed soil determinations are used in the preparation of hydrologic soil-cover complexes, which in turn are used in estimating direct runoff. Four major soil groups are used. The soils are classified on the basis of intake of water at the end of long-duration storms occurring after prior

Table 3.3. Curve Numbers (CN) and Constants (from USBR, 1977).

(1) CN for Condition II	(2) CN for Conditions I	(3) CN for Conditions III	(1) CN for Condition II	(2) CN for Conditions I	(3) CN for Conditions III
100	100	100	60	40	78
99	97	100	59	39	77
98	94	99	58	38	76
97	91	99	57	37	75
96	89	99	56	36	75
95	87	98	55	35	74
94	85	98	54	34	73
93	83	98	53	33	72
92	81	97	52	32	71
91	80	97	51	31	70
90	78	96	50	31	70
89	76	96	49	30	69
88	75	95	48	29	68
87	73	95	47	28	67
86	72	94	46	27	66
85	70	94	45	26	65
84	68	93	44	25	64
83	67	93	43	25	63
82	66	92	42	24	62
81	64	92	41	23	61
80	63	91	40	22	60
79	62	91	39	21	59
78	60	90	38	21	58
77	59	89	37	20	57
76	58	89	36	19	56
75	57	88	35	18	55
74	55	88	34	18	54
73	54	87	33	17	53
72	53	86	32	16	52
71	52	86	31	16	51
70	51	85	30	15	50
69	50	84			
68	48	84	25	12	43
67	47	83	20	9	37
66	46	82	15	6	30
65	45	82	10	4	22
64	44	81	5	2	13
63	43	80	0	0	0
62	42	79			
61	41	78			

wetting and opportunity for swelling and without the protective effects of vegetation.

In the definitions that follow, the infiltration rate is the rate at which water enters the soil at the surface and which is controlled by surface conditions, and the percolation is the rate at which the water moves in the soil and which is controlled by the soil horizons. The hydrologic soil groups, as defined by SCS soil scientists, are as follows:

> Group A (low runoff potential). Soils having high infiltration rates even when thoroughly wetted and consisting chiefly of deep, well- to excessively-drained sands or gravels. These soils have a high rate of percolation.
>
> Group B. Soils having moderate infiltration rates when thoroughly wetted and consisting chiefly of moderately deep to deep, moderately well to well-drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of percolation.
>
> Group C. Soils having slow infiltration rates when thoroughly wetted and consisting chiefly of soils with a layer that impedes downward movement of water, or soils with moderately fine to fine texture. These soils have a slow rate of percolation.
>
> Group D (high runoff potential). Soils having very slow infiltration rates when thoroughly wetted and consisting chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very slow rate of water percolation.

The classification of soils into the hydrologic soil groups may be done on the basis of soils data, provided soil survey maps and reports are available. If such maps are not available, the soils will have to be classified on the basis of judgment utilizing any soils data which are discussed in the following section.

3.4 Soils Data

Data Requirements

Specific properties and characteristics of the soil are required to compute sediment transport capacities under a given set of climatic, vegetative, and slope conditions. The required soil parameters used in the design procedure are particle size distribution and erodibility expressed as a K_e factor. The K_e erodibility factor is a component in Wischmeier and Smith's (1965)

Universal Soil Loss Equation, and is used here to determine the roughness coefficient in the Simplified Sediment Yield Method. If a K_e factor has not been previously determined for the particular soil of interest, e.g. a mine soil, then the textural classification of the soil must be known to determine K_e.

Generally, soil physical properties occurring at a specific site can be identified using information given in standard SCS soil surveys. These investigations consist of classifying physical, chemical and biological characteristics of soils extending to depths of up to 6 feet. The U.S. Department of Agriculture (USDA) publishes reports and maps of their soil surveys, usually on a county basis. In addition, many smaller areas, individual farms and land surrounding urban areas are mapped and published as separate reports.

These soil surveys, if in print, can be obtained from the Superintendent of Documents, Washington, DC. Out-of-print maps and unpublished reports may be available from the USDA, county extension offices, colleges, universities and libraries. Local and regional offices of the Bureau of Reclamation have special area maps for most river basins in the western states. These maps and accompanying reports usually include physical and chemical properties of soils to a depth of approximately four feet.

Often, information on particle size distribution for disturbed soils and mine soils in a mining area is not available. However, testing may have been done during the premining stages of a mining operation and these data may be sufficient to determine the particle size classes.

Soil information should be evaluated to determine which soil condition will represent the worst case over the duration of mining operation. For example, final grading and topsoil application often leads to the greatest potential erosion condition until vegetation is established. Soil information and the mine operation schedule should be reviewed together and the worst case condition clearly identified.

Data from field observations and sediment sampling may be required to supplement survey data and assess site-specific conditions. These data are necessary if soil surveys have not been done or if conditions and characteristics of mine soil are not included in a soil survey.

Field data collection and laboratory analysis by a soil scientist may be necessary to evaluate soil characteristics at a particular mine site. Sediment size classes can be determined using the standard mechanical sieve method (Black, 1965; Dept. of the Army, 1970). The soil textural class can be determined by a series of field and laboratory tests. Likewise, structure and permeability can be measured in the field, while organic matter content requires laboratory analysis.

Simplified Soils Data Procedure

A simplified procedure for determining particle size distribution is presented for use with this manual, although a detailed procedure, Appendix A, for defining a distribution on a site-specific basis is recommended. For the simplified procedure, only the textural classifications of the mine soils at a site are needed. A textural class is simply a name given to each soil which designates the ranges of sand, silt, and clay sizes it contains. This class can be obtained from SCS soil series descriptions, other soil survey data in the vicinity, soil data from the mine plan, field estimation by a soil scientist or laboratory analysis. After determining the textural classification, the corresponding particle size groups are then determined from Table 3.4.

These values are not recommended for use if more detailed soils data are available at a mine site. A design particle size distribution from more detailed soils data can be determined from the guidelines given in Appendix A.

3.5 Topographic Data

Data Requirements

Topographic data which needs to be collected or measured include average slope, changes in slope (both parallel and perpendicular to the slope), slope length, width and geometric shape. If the geometric shape of the area of disturbance is irregular, some geometric simplification is required for use with the sediment yield computation procedure.

Data Acquisition

Sources of topographic information may be obtained from U.S. Geological Survey topographic maps and topographic maps specially produced for the area at a large scale by the SCS or county agencies. Often, the mining company will have a large scale map which can be used to determine topographic data.

Table 3.4. Suggested Particle Size Distributions of Soil Textural Classes (For use only if requirements and data acquisition in Appendix A cannot be met).

Textural Class	Clay (<0.002 mm) %	P_1 Silt (0.002-0.05 mm) %	P_2 Very Fine Sand (0.05-0.1 mm) %	P_3 Fine, Medium Coarse Sand (0.1-1.0 mm) %	P_4 Very Coarse Sand (1.0-2.0 mm) %
Sand	2	10	15	35	38
Loamy Sand	5	15	20	40	20
Sandy Loam	5	25	20	20	30
Loam	10	30	10	25	25
Silty Loam	20	60	5	15	--
Silt	5	90	5	--	--
Sandy Clay Loam	25	25	10	30	10
Clay Loam	30	40	10	10	10
Silty Clay Loam	35	55	5	--	5
Sandy Clay	55	5	5	10	25
Silty Clay	45	45	5	5	--
Clay	65	20	10	5	--

Field measurements or estimates may be the most expedient and satisfactory approach on many small areas.

If the geometric shape of the area is irregular, it is not suitable for analysis, and geometric simplification is required. The approach to this problem consists of selecting a number of planes to represent the area, sometimes referred to as an "open book" approximation. An example of a simplified geometric approximation of a small area is illustrated in Figure 3.3. The drainage pattern, in this case, is the intersection of the two planes (i.e., an open book). The irregular geometric shape in Figure 3.3a could be approximated by more than 2 planes if the size of the area and heterogeneity of the slopes and soils justify the extra effort required to meet reclamation standards.

After transforming an irregularly shaped area into a planar representation, the appropriate widths, lengths and slopes can be determined and used in the sediment yield calculations. Sediment yield calculation must be carried out for each plane.

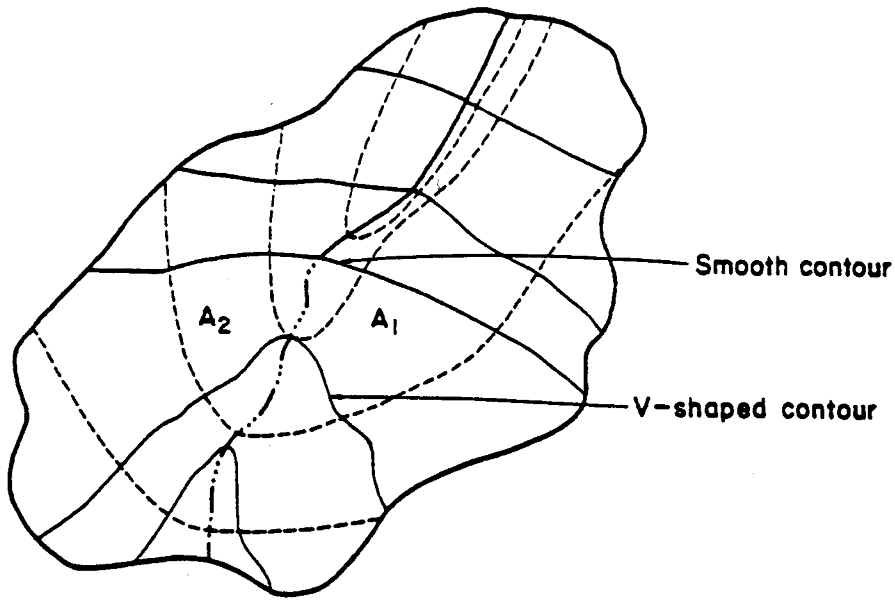
3.6 Revegetation Data

Data Requirements

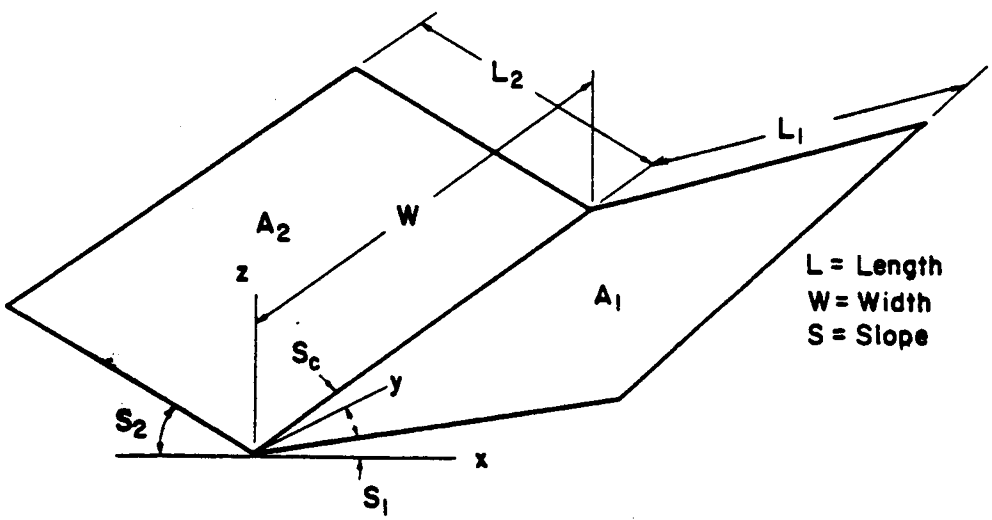
Vegetative data required at a site generally include identification of existing vegetation by species composition, native versus introduced species, productivity and cover density. The yearly and seasonal variability on both undisturbed and disturbed areas, pest problems, and animals supported by the vegetation should also be noted. Knowledge of the productivity of subsoil and overburden may be necessary if these materials are to be used as a postmining plant media.

Physical characteristics of a site which need to be identified are elevation, length and grade of slopes, aspect, geometry (see section 3.5), and projected mine soil type (see section 3.4). Climatic characteristics include local temperature, growing season, distribution of precipitation and local wind velocities (see section 3.2).

In addition, information on legal and regulatory requirements, land management goals, preliminary land use and planned postmining land use is necessary.



(a) Original topographic map of disturbed mine area subdivided into two areas (A_1 and A_2).



(b) Open book plane representation.

Figure 3.3. Transformation of a topographic map into a planar geometric representation of the watershed (after Wooding).

The types of data required to select introduced or native species to revegetate a site include plant growth, drought resistance or tolerance to stress, mineral nutrition requirements, reproduction characteristics, and germination rates. Seed and seedling availability, species compatibility, maintenance, cost, plant succession and adaptability to available planting methods are also important factors.

Data Acquisition

Baseline vegetative data may be available from the U.S. Forest Service, SCS (soil series publications) and related state agencies. For example, technical standards and specifications for critical area planting are available on a state by state basis for some states, eg. SCS (1981). These standards describe optimum conditions relating to topsoil, fertilizer, seed bed preparation, seeding method, timing, mulch, irrigation, and seed selection, rates and application. Data from State and Federal wildlife agencies and published lists of endangered species can also be utilized to meet the vegetative data requirements. Information on hybrid plant breeding is available from Crops Research Laboratory, Utah State University, Logan Utah. Two sources of data for retrieving computerized information on plant species in the semi-arid west are the Reclamation Research office at Montana State University, Bozeman, Montana and the Plant Informaiton Network (P.I.N.), Department of Botany and Plant Pathology at Colorado State University, Fort Collins, Colorado. Another source that should not be overlooked is the local SCS field offices. These offices offer excellent assistance with revegetation and critical area planting methods.

Direct field observations, measurements, and mine plan reports are useful for acquiring data on physical characteristics of a particular site. A vegetation specialist may be required to gather site-specific data using exclosures, plots, and transects on site.

Sources of climatic and local weather data will vary depending on the state in which the mining site is located. Data may be obtained from NWS publications, SCS publications, U.S. Geological Survey-Water Resources Division records, and state or local agencies which may monitor and record local climatic data.

Additional sources of revegetation data are listed below.

3.7 References

Revegetation Data References

Brown, D. 1977. "Equipment for Reclaiming Strip-Mined Land," USDA Forest Service, Equipment Development Center, Fort Missoula, MT, No. 7728-2503, 58 p., illus.

Brown, R.W., R.S. Johnston and D.A. Johnson. 1978. "Rehabilitation of Alpine Tundra Disturbances," J. Soil and Water Conserv. 33:154-160.

Croft, K. and C.M. McKell. 1977. "Sources of Seeds and Planting Materials in the Western States for Land Rahabilitation Projects," Utah Agricultural Station Land Rehabilitation Series No. 4.

Cook, C.W. and C.D. Boham. 1977. "Techniques for Vegetation Measurements and Analysis for a Pre and Post Mining Inventory," Colorado State University, Range Science Dep., Science Series 28.

Milner, C. and R.E. Hughes. 1968. "Methods for the Measurement of the Primary Production of Grassland," International Biological Programme (IBP) Handbook No. 6.

Mirov, N.T. and C.J. Kraebel. 1939. "Collecting and Handling Seeds of Wild Plants," Civilian Conservation Corps, Forestry Publ. 5.

Packer, P.E., C.E. Jensen, E.L. Noble and J.A. Marshall. 1978. "A Prediction Model to Estimate Revegetation Potentials of Land Surface Mined for Coal in the West," Proceedings of the International Congress on Energy and the Ecosystem, University of North Dakota, Grand Forks, ND.

Plummer, P., D.R. Christensen and S.B. Monsen. 1968. "Restoring Big-Game Range in Utah," Publication No. 68-3, Utah Division of Fish and Game, Ephraim, Utah.

U.S. Department of Agriculture. 1948. "Woody-Plant Seed Manual," Misc. Publ. 654.

U.S. Forest Service. 1962. "Range Research Methods," a symposium sponsored by the Division of Range and Wildlife Habitat Research, USDA For. Serv., Miscellaneous Publication No. 940.

U.S. Forest Service. 1979. User Guide to Vegetation, Mining and Reclamation in the West, USDA For. Serv., Gen. Tech. Rpt. INT-64.

U.S. Soil Conservation Service. In press. "Plant Materials for Use on Surface Mined Lands in Arid and Semi-Arid Regions," USDA Handbook (SCS-TP 157), Lincoln, Neb.

Utah State Agr. Exp. Station. 1979. "Selection, Propagation and Field Establishment of Native Species on Disturbed Arid Lands," Institute for Land Rehabilitation, Bulletin 500.

Other Data References

Black, C.A. (ed). 1965. Methods of Soil Analysis, Agron. Mongr. Ser. 9, Amer. Soc. Agron., Madison, WI, 1572 p.

Department of the Army. 1970. Laboratory Soils Testing, Engr. Manual No. 1110-2-1906.

Herschfield, D.M. 1961. Rainfall Frequency Atlas for the U.S. for Durations from 30 Minutes to 24 Hours and Return Periods from 1 to 100 Years, U.S. Weather Bureau Tech. Rpt. 40, May.

Kent, K.M. 1968. A Method for Estimating Volume and Rate of Runoff in Small Watersheds, USDA, SCS-TP-149.

Miller, J.F., R.H. Frederick, R.J. Tracey. 1973. Precipitation-Frequency Atlas of the Western United States, NOAA Atlas, National Weather Service, Silver Spring, MD

National Weather Service. 1977. Five- to 60-Minute Precipitation Frequency for the Eastern and Central United States, NOAA Memorandum, NWS HYDRO-35.

Soil Conservation Service. 1956. Estimating Direct Runoff Amounts from Storm Rainfall, Cnetral Technical Unit, SCS.

Soil Conservation Service. 1981. Standards and Specifications: Critical Area Planting, Tech. Guide Section IV, SCS, Denver, CO.

U.S. Bureau of Reclamation. 1977. Design of Small Dams, Water Res. Tech. Pub., USDI.

Wischmeier, W.H. and D.D. Smith. 1965. Predicting Rainfall Erosion Losses from Croplands East of the Rocky Mountains, Agr. Hdbk. 282, USDA, Washington, DC.

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