EXHIBIT F

SOIL EROSION CALCULATION

ENV AMERICA

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BY CHK'D
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ENV AMERICA

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SUB-TASK NO.
BY CHK'D
SHEET 2 OF 19

PURPOSE:

CALCULATE THE RATE OF EROSION DURING THE POST-CLOSURE PERIOD OF THE LANDFILL SURFACE USING THE UNIVERSAL SOIL LOSS EQUATION (USLE).

REFERENCES:

- EROSION AND SEDIMENT CONTROL HANDBOOK COPYRIGHT 1986 BY McGRAW-HILL, INC.
- USDA SOIL CONSERVATION SERVICE, DAVIS CALIFORNIA "GUIDE [illegible] EROSION AND SEDIMENT CONTROL" [illegible] 1984.
- EPA TECHNICAL GUIDANCE DOCUMENT (EPA, 1989)

TOP SOIL COVER EROSION CALCS.

USING THE UNIVERSAL SOIL LOSS EQUATION TO ESTIMATE SOIL LOSS, THE GENERAL FORM OF THE UNIVERSAL LOSS EQUATION IS:

$$A = R \times K \times LS \times C \times P$$

WHERE: A = SOIL LOSS, TONS/ACRE-YEAR

R = RAINFALL EROSION INDEX (RAINFALL AND RUNOFF FACTOR).

K = SOIL ERODIBILITY FACTOR, TONS/ACRE/UNIT OF "R".

LS = SLOPE LENGTH AND STEEPNESS FACTOR, (DIMENSIONLESS).

C = VEGETATIVE COVER FACTOR, (DIMENSIONLESS).

P = EROSION CONTROL PRACTICE FACTOR, (DIMENSIONLESS).

$R = 16.55\,P^{2.17}$ FOR TYPE I STORM (SEE SHEET 10).

WHERE, P = RAINFALL 6-HR STORM = 1.0 INCH (SEE SHEET 12).

$R = 16.55(1.0)^{2.17} = 16.55 \approx 17$

$$\boxed{R = 17}$$

SOIL ERODIBILITY FACTOR "K"

THE SOIL ERODIBILITY FACTOR "K" IS A MEASURE OF THE SUSCEPTIBILITY OF SOIL PARTICLES TO DETACHMENT AND TRANSPORT BY RAINFALL & RUNOFF. THE DETERMINATION OF THE K VALUE SHOULD BE BASED ON THE SOIL TEXTURE. THE PROPOSED COVER SOIL TEXTURE IS EXPECTED TO CONSIST OF 75% SAND, 17% SILT AND 8% CLAY. BASED ON THE GRAIN SIZE DATA ON SHEET 14. ENTERING THE TRIANGULAR NOMOGRAPH ON SHEET 15 WITH 75% SAND AND 8% CLAY THE "K" VALUE WILL BE 0.2. THE TRIANGULAR NOMOGRAPH ASSUMES 2% ORGANIC MATTER. ASSUMING THE TOPSOIL CONTAINS 2% ORGANIC MATTER, THERE IS NO NEED FOR ADJUSTMENT. THE EROSION AND SEDIMENT CONTROL HANDBOOK REQUIRES FURTHER ADJUSTMENT FOR "K" VALUE BASED ON ROCK CONTENT. THE EROSION AND SEDIMENT CONTROL HANDBOOK DEFINES ROCK CONTENT AS THE PERCENT (BY VOLUME) OF SOIL PARTICLES GREATER THAN 2 mm. ASSUMING ROCK CONTENT IN THE RANGE OF 15-35%, THE ADJUSTED

"K" VALUE WOULD BE 0.10 (SEE TABLE 5.3b ON SHEET 16).

$K = 0.1$

COVER FACTOR "C":

THE COVER FACTOR "C" IS THE RATIO OF SOIL FROM LAND CROPPED UNDER SPECIFIED CONDITIONS TO THE CORRESPONDING LOSS CLEAN TILLED, CONTINUOUS FALLOW. THE LANDFILL WILL BE COVERED BY NON-IRRIGATED NATURAL VEGETATION. FROM TABLE 1 ON PAGE 17 USE A "C" VALUE OF 0.01.

$C = 0.01$

EROSION CONTROL PRACTICE "P":

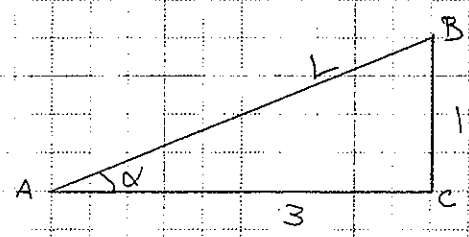
THE EROSION AND SEDIMENT CONTROL HANDBOOK DEFINES THE EROSION CONTROL FACTOR AS THE RATIO OF SOIL LOSS WITH A GIVEN SURFACE CONDITION TO SOIL LOSS WITH UPLAND-DOWN-HILL PLOWING. IN AGRICULTURAL USES OF THE USLE, "P" IS USED TO DESCRIBE PLOWING AND TILLAGE PRACTICES. IN CONSTRUCTION SITE APPLICATIONS, "P" FACTOR REFLECTS THE ROUGHENING OF THE SOIL SURFACE BY TRACTOR TREADS OR BY ROUGH GRADING. USING TABLE 5.7 ON SHEET 18, THE "P" FACTOR WILL BE 0.9.

$$\boxed{P = 0.9}$$

LENGTH-SLOPE FACTOR "LS":

THE "LS" FACTOR DESCRIBES THE COMBINED EFFECT OF SLOPE LENGTH AND SLOPE GRADIENT. THE CACTUS ROAD LANDFILL SIDE SLOPES HAVE A SLOPE RATIO OF 3:1. THE TOP DECK GRADE IS THREE (3)

PERCENT. SIDE SLOPE LENGTH IS THE DISTANCE OF OVERLAND FLOW TO THE NEAREST DIVERSION CHANNEL. FOR THE EASE OF CALCULATIONS, DETERMINE LENGTH FACTOR FOR SIDE SLOPE GRADIENT 3:1. SCALING DISTANCES FROM THE MAP AND MULTIPLYING BY LENGTH FACTOR GIVES THE OVERLAND LENGTH "L".



FROM TRIANGLE ABC, THE ANGLE $\alpha = \tan^{-1}\left(\frac{BC}{AC}\right)$

$= \tan^{-1}\left(\frac{1}{2}\right) = 18.43°$, AND

L IS: $L = \frac{AC}{\cos\alpha} = \frac{AC}{\cos(18.43)} = \frac{AC}{0.95} = 1.05\,AC$

THE CONSTANT <u>1.05</u> IS THE LENGTH FACTOR, AND <u>AC</u> IS THE DISTANCE SCALED OFF THE GRADING PLAN.

FOR THE TOP DECK DUE TO THE FACT THAT ANGLE α IS SMALL AND COSINE OF THE ANGLE IS APPROXIMATELY EQUAL TO 1, THERFORE THE LENGTH FACTOR WILL BE EQUAL TO 1.

$A = R \cdot K \cdot C \cdot P \cdot LS$

$R = 17$

$K = 0.1$

$C = 0.01$

$P = 0.9$

$A = 17 \times 0.1 \times 0.01 \times 0.9\ LS$

$$\boxed{A = 0.02\ LS}$$

AREA	MAXIMUM SCALED DISTANCE (FT)	CALCULATED DISTANCE (FT)	SLOPE RATIO	SLOPE GRADIENT (%)	LS*	A=0.02LS
SIDE SLOPES	200**	17	3:1	34	9.67	0.19
TOP DECK	350	350	30:1	3	0.42	0.01

* TABLE A ON PAGE 19 WAS USED TO CALCULATE LS FACTOR

** $L = 160 \times 1.05 = 168'$, CONSERVATIVELY ASSUME 200 FT.

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CONCLUSION:

THE MAXIMUM AMOUNT OF SOIL EROSION ON SIDE SLOPES IS 0.19 TONS/AC-YR, AND ON THE TOP DECK IS 0.01 TONS/AC-YR. EPA TECHNICAL GUIDANCE DOCUMENT (EPA, 1989) REQUIRES THAT EROSION RATE SHALL NOT EXCEED 2 TONS/AC-YR. THE MAXIMUM CALCULATED EROSION RATE FOR THE SITE IS 0.12 TONS/AC-YR, WHIS IS BELOW THE EROSION CRITERION SUGGESTED BY EPA.

APPENDIX A

DETERMINING "R" VALUES

California is divided into three zones for determining "R" values. Figure A-1 shows their general boundaries and they are defined by Major Land Resource Area (MLRA) as follows:

Frozen Soil Area	includes MLRAs 21 and 23
R Zone 1	includes MLRAs 14, 15, 16, 17, 18, 19, 20, and 22
R Zone 2	includes MLRAs 4, 5, 26, 29, 30, and 31

R values in the Frozen Soil Area are based on the equation

$$R = -58.282 + 8.735P - 0.149P^2$$

where P = average annual precipitation in inches

R values in R Zone 1 are based on the equation

$$R = 16.55P^{2.17}$$

where P = the 2 year 6 hour precipitation value for the desired location as shown in NOAA Atlas 2 "Precipitation Frequency Atlas of the Western United States, Volume XI California."

R values in R Zone 2 are based on the equation

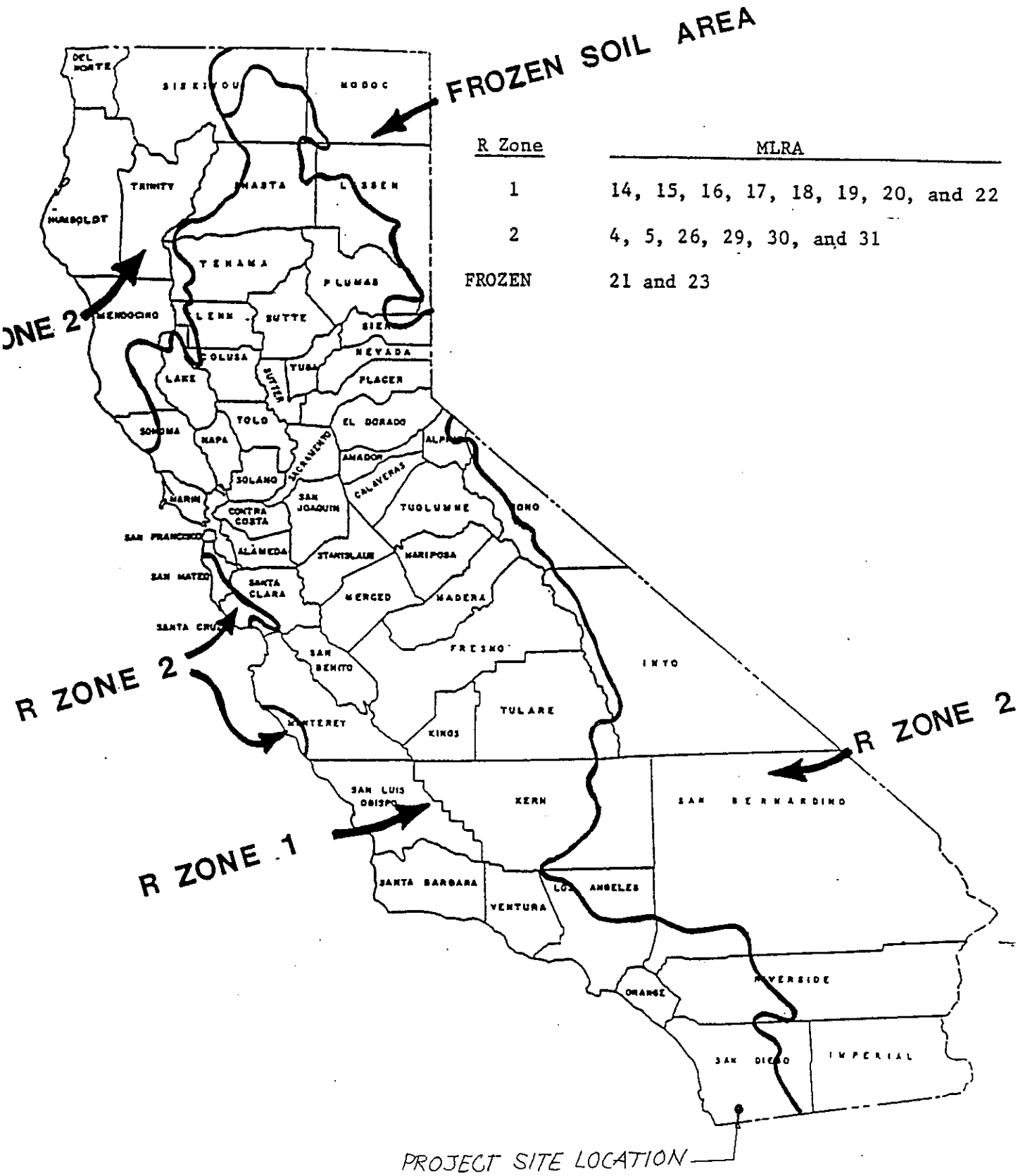
$$R = 27P^{2.17}$$

where P = the 2 year 6 hour precipitation value

R values in California will be obtained using the appropriate part of Table A-1 or an R factor map based on Table A-1.

R values will be rounded to the nearest 5 units and lowest R value will be 10.

Figure A-1. R Factor Zones in California

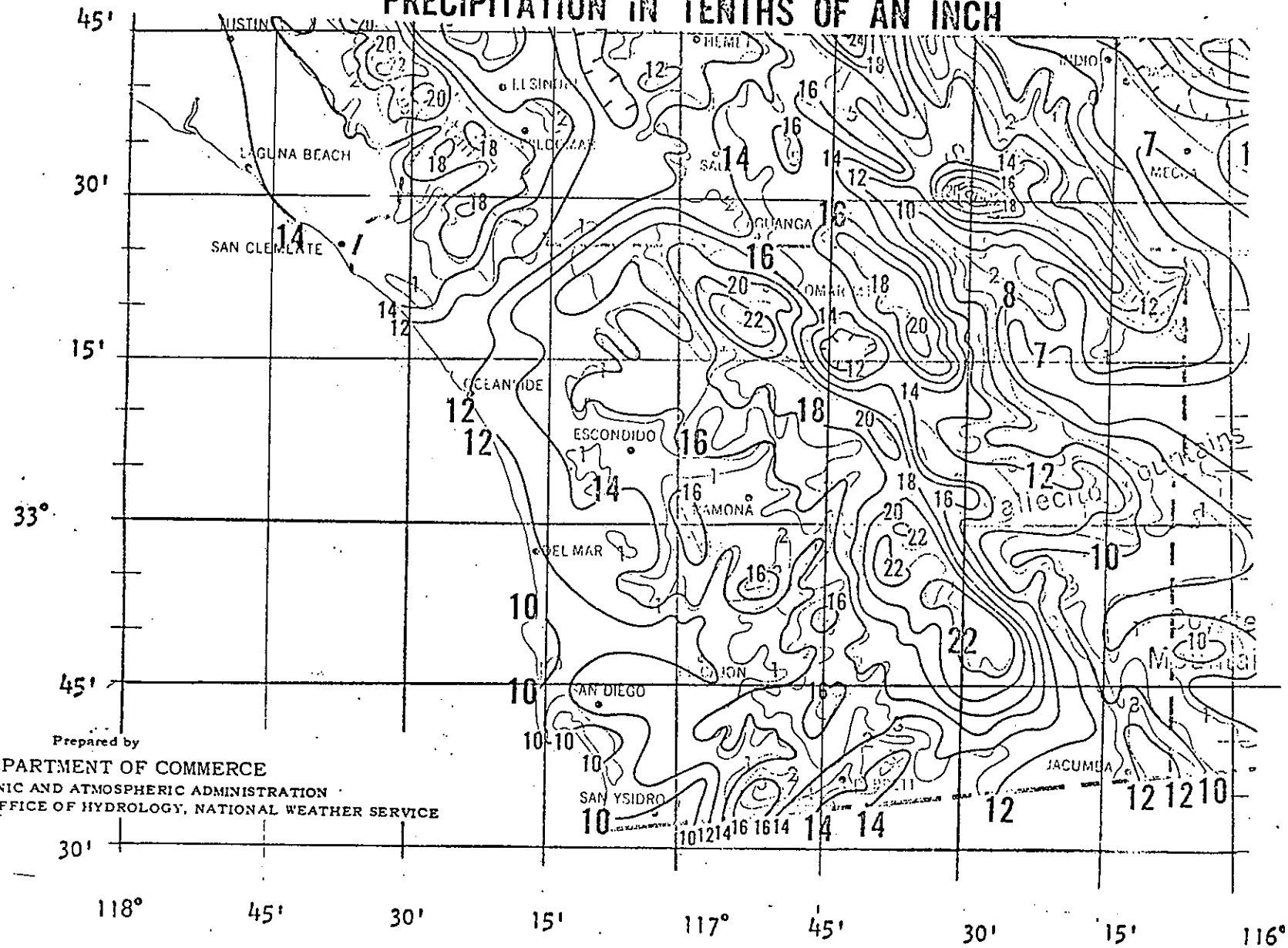


R Zone	MLRA
1	14, 15, 16, 17, 18, 19, 20, and 22
2	4, 5, 26, 29, 30, and 31
FROZEN	21 and 23

COUNTY OF SAN DIEGO
DEPARTMENT OF SANITATION &
FLOOD CONTROL

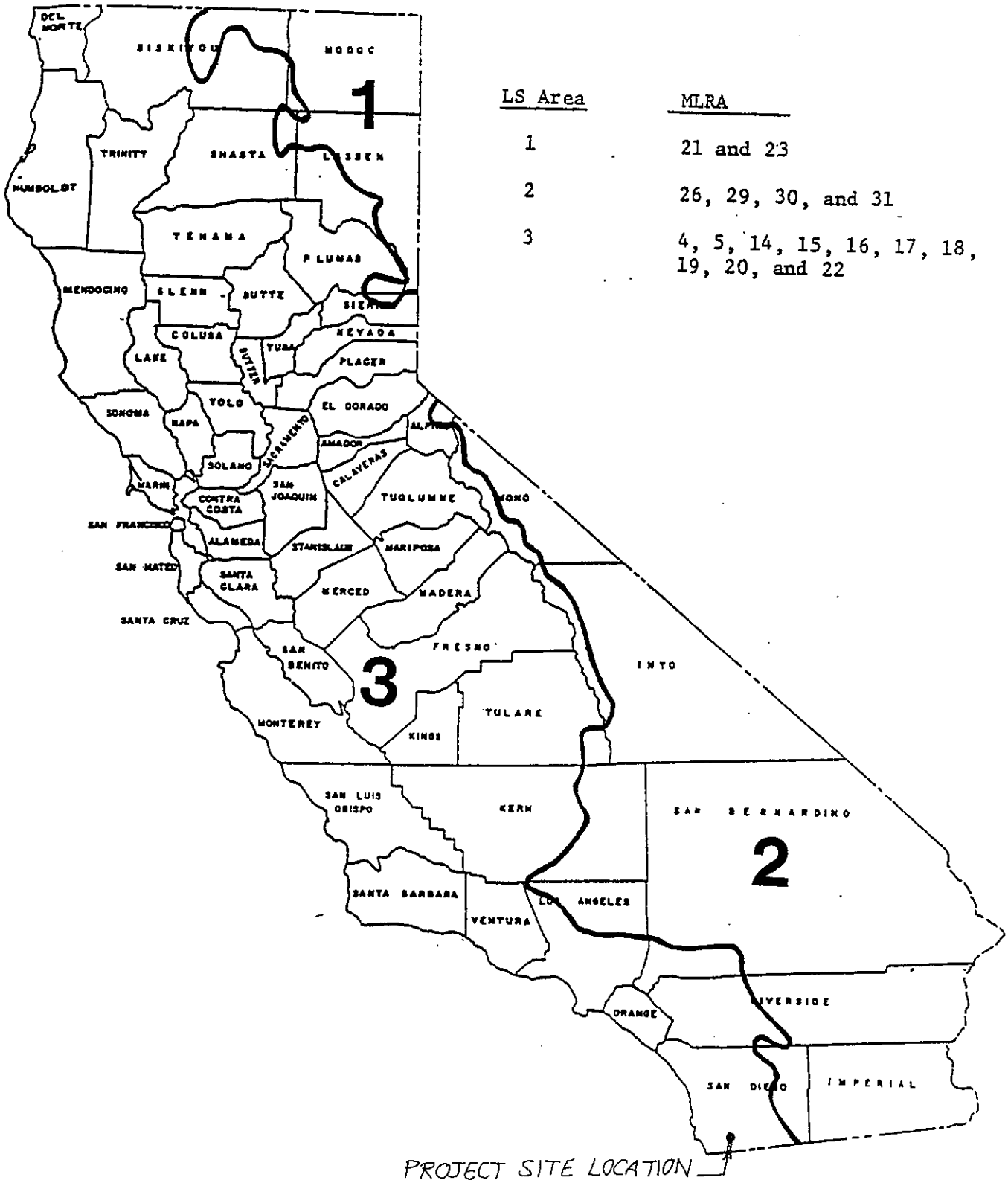
2-YEAR 6-HOUR PRECIPITATION

—10— ISOPLUVIALS OF 2-YEAR 6-HOUR PRECIPITATION IN TENTHS OF AN INCH



Prepared by
U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
SPECIAL STUDIES BRANCH, OFFICE OF HYDROLOGY, NATIONAL WEATHER SERVICE

Figure 1: LS Areas in California.



LS Area	MLRA
1	21 and 23
2	26, 29, 30, and 31
3	4, 5, 14, 15, 16, 17, 18, 19, 20, and 22

ENV AMERICA

SITE INFORMATION
HYDROLOGY MODEL
CACTUS ROAD LANDFILL

DATE 5-21-96
CONT. NO. MCU
TASK NO.
SUB-TASK NO.
BY M. Raub CHK'D
SHEET OF

SITE LATITUDE / LONGITUDE

- Source - USGS OTAY MESA, CA 7.5 min Quad.
  Latitude 32° 33.82' = 32° 33' 49"
  Longitude 116° 59.61' = 32° 59' 36"

ANTICIPATED VEG. LAYER
GRAIN SIZE DISTRIBUTION

- No samples of Linda vista Fm, the planned vegetative layer source were tested. Assume that grain size of Auto Shredder Waste is representative.

Sample	Gvl/Sand	Silt	Clay (0.005mm)
B1-35	73	18	9
B2-5	65	17	18
B3-10	81	15	4
B4-10	82	15	3
B5-5	77	14	9
B6-5	74	20	6
→ AVERAGE	75	17	8

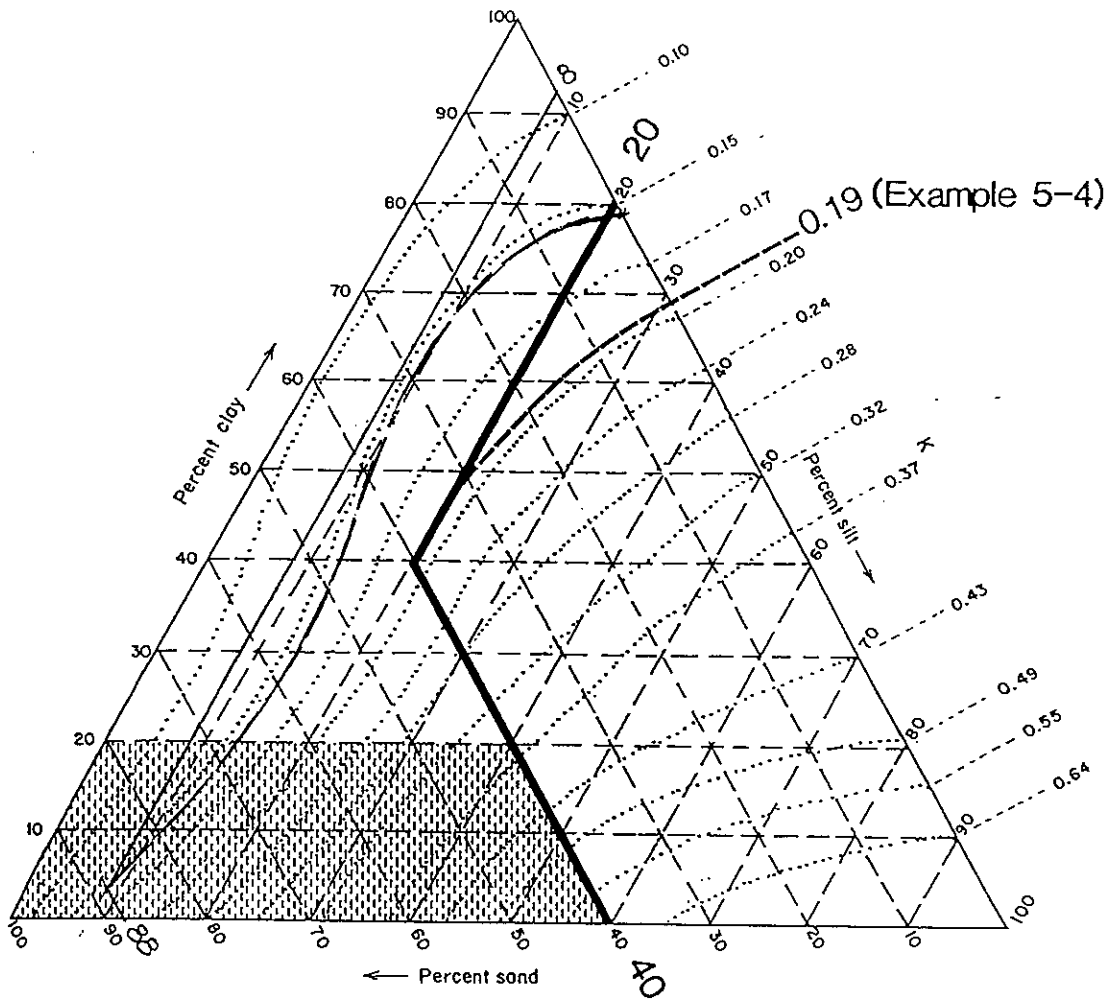


Fig. 5.6 Triangular nomograph for estimating K value. (6) See Table 5.3 for adjustments to K value under certain conditions.

EXAMPLE 5.4

Given: A soil with the following particle size distribution.

Component	Size, mm	Fraction, %
Sand	2.0–0.1	30
Very fine sand	0.1–0.05	10
Silt	0.05–0.002	20
Clay	Less than 0.002	40

Find: Texture and K value.

Solution: Entering Fig. 5.1 with 40 percent total sand and 20 percent silt, the texture is found to be on the border between clay and clay loam. Entering Fig. 5.6 with the same percents (see bold lines), the K value is found to be 0.19.

Table 5.3 describes adjustments to the K factor. Adjustment 1 is a correction for very

TABLE 5.3 Adjustments to K Value (6)

1. For soils with greater than 15% *very fine sand* (vfs) make the following adjustment:
   a. If texture is *coarser than loam* (shaded area in Fig. 5.6): Subtract 5% from the % vfs and add the difference to the silt content. Consider the remaining 5% vfs to be part of the % total sand.
   b. If texture is *loam and finer* (outside shaded area on Fig. 5.6), subtract 10% from the % vfs and add the difference to the silt content. Consider the remaining 10% vfs to be part of the % total sand.
   c. Find the K value by using the adjusted sand and silt contents.
2. The nomograph assumes 2% organic matter, structure other than granular, and 0–15% rock content. The correction factors are as follows.
   a. Organic matter: Add or subtract correction factor to K value as indicated in the following table.

K value	Correction factor when percent organic matter is 0	1	2	3	4
Greater than 0.40	+0.14	+0.07	0	−0.07	−0.14
0.20–0.40	+0.10	+0.05	0	−0.05	−0.10
Less than 0.20	+0.06	+0.03	0	−0.03	−0.06

   b. Rock content: Rock content is defined as the percent (by volume) of soil particles greater than 2 mm.

Unadjusted K value from Fig. 5.6	K values adjusted for rock content as follows 15–35%	35–60%	60–75%
0.10	0.05	0.05	0.02
0.15	0.10	0.05	0.02
0.17	0.10	0.05	0.02
0.20	0.10	0.05	0.02
0.24	0.15	0.10	0.05
0.28	0.15	0.10	0.05
0.32	0.17	0.10	0.05
0.37	0.20	0.10	0.05
0.43	0.24	0.15	0.10
0.49	0.28	0.15	0.10
0.55	0.32	0.17	0.10
0.64	0.37	0.20	0.15

   Add or subtract the correction factors at the right to the K value to correct for the following structures and permeabilities.

   c. Structure:

Very fine granular	−0.09
Fine granular	−0.06
Moderate or coarse granular	−0.03

   d. Permeability:

Compact soil or pH greater than 9.0	+0.03
Many medium or coarse pores	−0.03

Soil Loss Equation "C" Factors for California Cropping Systems

It is not intended that the tables following include all cropping systems in California. The cropping systems and "C" factors listed are to provide examples for helping conservationists make accurate estimates of "C" values for cropping systems within their work areas.

Table 1, below, provides criteria that should enable most conservationists to make "Average Annual C" estimates for a cropping system with fair accuracy once they know the tillage and crop residue practices for the system and relate these to the periods of precipitation causing erosion.

TABLE 1

Soil Management Practice	Estimated "C"
* 1. Continuous clean tilled fallow (Research plots)	1.00
2. Continuous tilled fallow, 1000 lb. straw per acre maintained on soil surface	0.50
3. Continuous bare soil surface - untilled	0.50
4. Orchard Cover Crop - spring disked	0.25
5. Orchard strip Cover Crop, untilled, mowed	0.10
6. Continuous annual grass or legume pasture or hay (100% cover)	0.01
7. Continuous perennial grass (100% cover)	0.003

* Item 1 represents a condition induced by continuous loose fallow over a period of several years. Thus, for practical purposes, Average Annual "C" on agricultural land would always be less than 1.00.

In general, erosion from rainfall in California occurs during the 6 month period between November 1 and April 30. Thus "C" values in the state relate almost entirely to condition of the soil surface during these winter months. Bare tilled soil surface will give "C" values approaching 1.0. Non-tillage of bare surface, or light surface mulches on a tilled surface will reduce erosion and "C" values to about half (0.5). A complete cover of annual grasses and weeds during the winter months will reduce soil losses to about one-tenth on tilled cropland as compared to clean tilled fallow, giving a "C" value of 0.1.

Excepting non-tilled orchards with cover crop, California cropping systems will usually have average annual "C" values between 0.1 and 0.5 with high crop yield stubble mulch systems producing low values and clean-tilled low crop yield systems the higher values.

TABLE 5.7 *P* Factors for Construction Sites (Adapted from Ref. 15)

Surface condition	*P* value
Compacted and smooth	1.3
Trackwalked along contour*	1.2
Trackwalked up and down slope†	0.9
Punched straw	0.9
Rough, irregular cut	0.9
Loose to 12-in (30-cm) depth	0.8

*Tread marks oriented up and down slope.

†Tread marks oriented parallel to contours, as in Figs. 6.9 and 6.10.

P values appropriate for construction sites are listed in Table 5.7.

- A surface that is compacted and smoothed by grading equipment is highly susceptible to sheet runoff and is assigned a *P* value of 1.3.
- Trackwalking is given a value of 1.2 if the vehicle traverses along the contour. The *P* value is relatively high because the depressions left by cross-slope tracking resemble up-and-down furrows and worsen runoff conditions.
- Trackwalking up and down slope reduces *P* to 0.9. The tread marks act as slope benches; they reduce runoff velocity and trap soil particles (see Fig. 6.10).
- Punched straw is assigned a *P* value of 0.9 because the action of punching the straw into the soil roughens the surface and creates a trackwalking effect.
- When the soil surface is disked or otherwise loosened to a depth of 1 ft, a slightly lower *P* value of 0.8 may be used. This condition is unlikely to occur on a construction site because compaction, not loosening, is required when fill slopes are constructed.

Clearly, changing the surface condition does not provide much direct reduction in soil loss; all the *P* values are close to 1.0. However, roughening the soil surface is essential before seeding because it greatly increases plant establishment (see Chap. 6) and thus also reduces the *C* factor. Vegetation, mulch, slope length, and gradient have far more significant effects on the erosion process and provide greater opportunities to reduce soil loss.

5.2g Combined Effects of LS, *C*, and *P*

Of the five factors in the USLE, the *R*, LS, and *C* factors have the widest range. Although *R* for a site is constant and *K* is essentially a constant, slope length and gradient, cover, and, to a limited extent, surface condition can be manipulated. Slope length and vegetative cover are the most effective and easily implemented measures.

Table 5.8 compares the effect on the soil loss estimates of varying LS, *C*, and *P*. For example, a building pad with a 1 percent slope, smooth surface, and no cover has a fractional soil loss potential. A 2:1 slope, common between terraced

MLRA: 4, 5, 14, 15, 16, 17, 18, 19, 20, 22

TABLE "A"

WHERE: ℓ = length in feet along slope
s = slope in %/100
$m = 0.2$ for $s < 0.01$
$m = 0.3$ for s of 0.01 to 0.035
$m = 0.4$ for s of 0.036 to 0.045
$m = 0.5$ for $s > 0.045$

For slopes of 9% or flatter:

$$LS = \left[\left(\frac{\ell}{72.6}\cos(\tan^{-1}s)\right)^m \left[65.41 \sin^2(\tan^{-1}s) + 4.56 \sin(\tan^{-1}s) + 0.065\right]\right.$$

For slopes steeper than 9%:

$$LS = \left[\left(\frac{\ell}{72.6}\cos(\tan^{-1}s)\right)^{0.50}\left[\frac{\sin(\tan\text{-}1s)}{\sin 5.143}\right]^{1.4}\right.$$

SLOPE LENGTH IN FEET

Percent Slope	25	50	75	100	125	150	200	250	300	350	400	450	500	550	600	700	800	1000	1200
0.5	0.07	0.08	0.09	0.10	0.10	0.10	0.11	0.11	0.12	0.12	0.13	0.13	0.13	0.13	0.14	0.14	0.14	0.15	0.16
1.0	0.09	0.10	0.12	0.13	0.14	0.15	0.16	0.17	0.18	0.19	0.20	0.20	0.21	0.22	0.22	0.23	0.24	0.26	0.27
2.0	0.13	0.16	0.18	0.20	0.21	0.23	0.25	0.26	0.28	0.29	0.30	0.32	0.33	0.33	0.34	0.36	0.37	0.40	0.42
3.0	0.19	0.23	0.26	0.29	0.31	0.32	0.35	0.38	0.40	0.42	0.43	0.45	0.46	0.48	0.49	0.51	0.54	0.57	0.60
4.0	0.23	0.30	0.36	0.40	0.44	0.47	0.53	0.58	0.62	0.65	0.70	0.73	0.76	0.79	0.82	0.87	0.92	1.00	1.08
5.0	0.27	0.38	0.46	0.53	0.60	0.65	0.76	0.85	0.93	1.00	1.07	1.13	1.20	1.25	1.31	1.41	1.51	1.69	1.85
6.0	0.34	0.47	0.58	0.67	0.75	0.82	0.95	1.06	1.16	1.26	1.34	1.42	1.50	1.57	1.65	1.78	1.90	2.12	2.33
7.0	0.41	0.58	0.71	0.82	0.92	1.01	1.16	1.30	1.43	1.54	1.65	1.75	1.84	1.93	2.02	2.18	2.33	2.60	2.85
8.0	0.49	0.70	0.86	0.99	1.11	1.21	1.40	1.56	1.71	1.85	1.98	2.10	2.21	2.32	2.42	2.62	2.80	3.13	3.43
9.0	0.59	0.83	1.01	1.17	1.31	1.43	1.66	1.85	2.03	2.19	2.34	2.48	2.62	2.75	2.87	3.10	3.31	3.70	4.06
10.0	0.68	0.96	1.17	1.35	1.51	1.66	1.92	2.14	2.35	2.53	2.71	2.87	3.03	3.18	3.32	3.58	3.83	4.28	4.69
12.0	0.87	1.23	1.51	1.74	1.95	2.13	2.46	2.75	3.02	3.26	3.48	3.69	3.89	4.08	4.27	4.61	4.93	5.51	6.03
14.0	1.08	1.52	1.86	2.15	2.40	2.63	3.04	3.40	3.73	4.02	4.30	4.56	4.81	5.04	5.27	5.69	6.08	6.80	7.45
16.0	1.29	1.82	2.23	2.58	2.88	3.16	3.65	4.08	4.47	4.82	5.16	5.47	5.77	6.05	6.32	6.82	7.29	8.15	8.93
18.0	1.51	2.14	2.62	3.02	3.38	3.70	4.27	4.78	5.23	5.65	6.04	6.41	6.76	7.09	7.40	7.99	8.55	9.56	10.5
20.0	1.74	2.46	3.01	3.48	3.89	4.26	4.92	5.50	6.02	6.51	6.96	7.38	7.78	8.16	8.52	9.20	9.84	11.0	12.0
22.0	1.97	2.79	3.42	3.94	4.41	4.83	5.58	6.24	6.83	7.38	7.89	8.37	8.82	9.25	9.66	10.4	11.2	12.5	13.7
24.0	2.21	3.12	3.83	4.42	4.94	5.41	6.25	6.99	7.65	8.26	8.84	9.37	9.88	10.4	10.8	11.7	12.5	14.0	15.3
26.0	2.45	3.46	4.24	4.90	5.48	6.00	6.93	7.74	8.48	9.16	9.80	10.4	11.0	11.5	12.0	13.0	13.9	15.5	17.0
28.0	2.69	3.81	4.66	5.38	6.02	6.59	7.61	8.51	9.32	10.1	10.8	11.4	12.0	12.6	13.2	14.2	15.2	17.0	18.6
30.0	2.93	4.15	5.08	5.87	6.56	7.19	8.30	9.28	10.2	11.0	11.7	12.4	13.1	13.8	14.4	15.5	16.6	18.6	20.3
32.0	3.18	4.49	5.50	6.35	7.10	7.78	8.99	10.0	11.0	11.9	12.7	13.5	14.2	14.9	15.6	16.8	18.0	20.1	22.0
34.0	3.42	4.84	5.92	6.84	7.65	8.38	9.67	10.8	11.8	12.8	13.7	14.5	15.3	16.0	16.8	18.1	19.3	21.6	23.7
36.0	3.66	5.18	6.34	7.32	8.18	8.97	10.4	11.6	12.7	13.7	14.6	15.5	16.4	17.2	17.9	19.4	20.7	23.2	25.4
38.0	3.90	5.52	6.75	7.80	8.72	9.55	11.0	12.3	13.5	14.6	15.6	16.5	17.4	18.3	19.1	20.6	22.1	24.7	27.0
40.0	4.14	5.85	7.16	8.27	9.25	10.1	11.7	13.1	14.3	15.5	16.5	17.5	18.5	19.4	20.3	21.9	23.4	26.2	28.7
45.0	4.71	6.67	8.17	9.43	10.5	11.5	13.3	14.9	16.3	17.6	18.9	20.0	21.1	22.1	23.1	24.9	26.7	29.8	32.7
50.0	5.27	7.45	9.12	10.5	11.8	12.9	14.9	16.7	18.2	19.7	21.1	22.3	23.6	24.7	25.8	27.9	29.8	33.3	36.5
55.0	5.79	8.18	10.0	11.6	12.9	14.2	16.4	18.3	20.0	21.7	23.1	24.6	25.9	27.1	28.4	30.6	32.7	36.6	40.1
60.0	6.27	8.87	10.9	12.5	14.0	15.4	17.7	19.8	21.7	23.5	25.1	26.6	28.1	29.4	30.7	33.2	35.5	39.7	43.5