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SIMPLIFIED STANDARD PENETRATION TEST PERFORMANCE-BASED ASSESSMENT OF LIQUEFACTION AND EFFECTS

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16. Abstract

The purpose of the research presented is to provide the benefit of the full performance-based probabilistic earthquake hazard analysis, without requiring special software, training, and experience, while using Standard Penetration Test (SPT) data from site soil borings. To do this, simplified models of liquefaction triggering, lateral spread displacements, post-liquefaction settlements, and seismic slope displacements that approximate the results of the full probabilistic analysis were developed. These simplified methods are designed to require only a few calculations programmed into a spreadsheet and a provided liquefaction parameter map. The simplified procedures are based on the Boulanger and Idriss (2012) probabilistic liquefaction triggering; Youd et al. (2002) for lateral spread; Cetin et al. (2009) and (Ishihara and Yoshimine (1992) for post-liquefaction settlements; and lastly, Rathje & Saygili (2009), and Bray & Travasarou (2007) for seismic slope displacement empirical models. The new simplified procedures are based on retrieving a reference parameter value (i.e. CSR^{ref} (%), $\log D_H^{ref}$, etc.) from a hazard-targeted liquefaction parameter map, and calculating site-specific correction factors to adjust the reference value to represent the site-specific conditions. The simplified procedures were validated by comparing the results of the simplified analysis with a full performance-based analysis for 10 cities of varying seismicity. The results show that the simplified procedure is within 5% error of the full performance-based procedure. These maps were created for Alaska (only liquefaction triggering and lateral spread), Connecticut, Idaho, Montana, South Carolina, Oregon, and Utah at the 475, 1033, and 2475 year return periods. The simplified procedures were compared with the deterministic and pseudo-probabilistic procedures. The deterministic procedure significantly overpredicts hazard in regions of low seismicity, slightly overpredicts hazard in regions of medium seismicity, and slightly underpredicts hazard in areas of high seismicity when compared to the simplified procedure at the 475 and 2475 year return periods. The pseudo-probabilistic procedure returns results very similar to the simplified method at the 1033 year return period.

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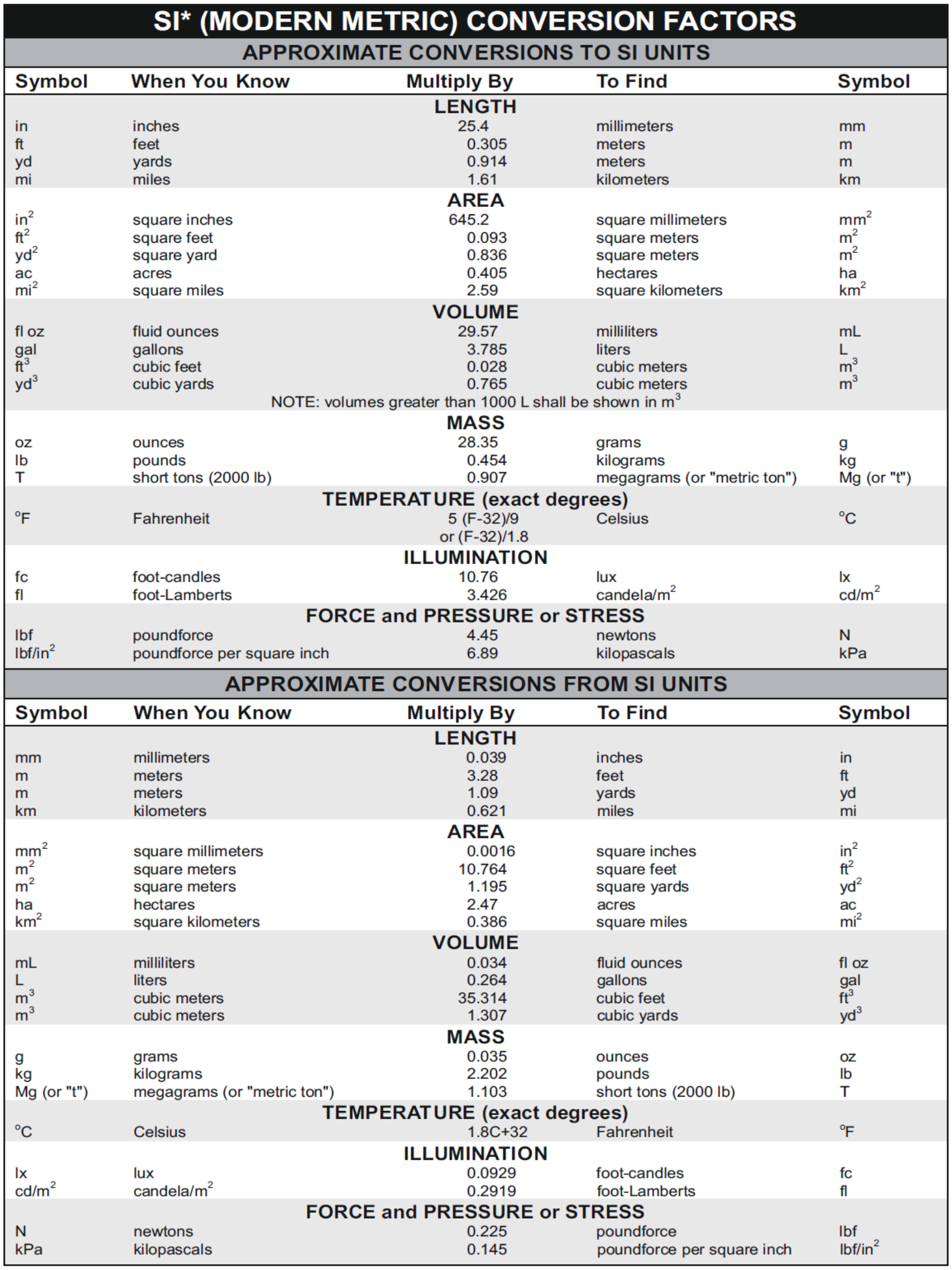
UNIT CONVERSION FACTORS

Units used in this report and not conforming to the UDOT standard unit of measurement (U.S. Customary system) are given below with their U.S. Customary equivalents:



SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. (Adapted from FHWA report template, Revised March 2003)

Note: Gravitational acceleration (symbolized g) is used in this report as a unit measure of acceleration, or the intensity of the earth's gravitational field at the surface of the earth: 1 g is about 9.8 m/s^2 or 32.2 ft/s^2.

LIST OF ACRONYMS

AASHTO	American Association of State Highway and Transportation Officials
EDP	Engineering Demand Parameter
FHWA	Federal Highway Administration
GMPE	Ground Motion Predictive Equation
IM	Intensity Measure
PBEE	Performance-Based Earthquake Engineering
PEER	Pacific Earthquake Engineering Research
PSHA	Probabilistic Seismic Hazard Analysis
UDOT	Utah Department of Transportation
USGS	United States Geological Survey

LIST OF TERMS

Liquefaction Triggering Terms

a_{max}	peak ground surface acceleration
CRR	cyclic resistance ratio
$CRR_{PL=50\%}$	median CRR (CRR corresponding to a probability of liquefaction of 50%)
CSR	cyclic stress ratio
CSR^{ref}	uniform hazard estimate of CSR associated with the reference soil profile
CSR^{site}	site-specific uniform hazard estimate of CSR
ΔCSR_{σ}	correction factor for vertical stress
ΔCSR_{Fpga}	correction factor for soil amplification
ΔCSR_{rd}	correction factor for shear stress reduction
ΔCSR_{MSF}	correction factor for magnitude scaling factor
$\Delta CSR_{K\sigma}$	correction factor for overburden pressure
ΔCSR	difference between CSR^{site} and CSR^{ref} values
FC	fines content (%)
FS_L	factor of safety against liquefaction triggering
FS_L^{site}	site-specific uniform hazard estimate of FS_L
F_{PGA}	soil amplification factor
K_{σ}	overburden correction factor (Idriss and Boulanger model)
MSF	magnitude scaling factor
M_w	mean moment magnitude
N	SPT blow count (uncorrected)
$(N_1)_{60}$	SPT resistance corrected to 60% efficiency and 1 atm pressure
$(N_1)_{60,cs}$	clean sand-equivalent SPT corrected to 60% efficiency and 1 atm pressure
N_{req}	SPT resistance required to resist or prevent liquefaction
N_{req}^{ref}	uniform hazard estimate of N_{req} associated with the reference soil profile
N_{req}^{site}	site-specific uniform hazard estimate of N_{req}
ΔN_L	difference between N_{site} and N_{req} values
P_a	atmospheric pressure (1 atm, 101.3 kPa, 0.2116 psf)
PGA	peak ground acceleration
P_L	probability of liquefaction
r_d	shear stress reduction coefficient
SPT	Standard Penetration Test
$V_{s,12}$	average shear wave velocity in upper 12 m (39.37 ft) of soil profile
z	depth to middle of soil profile layer
γ	unit weight of soil (i.e. pcf, kN/m^3, etc.)
σ_{ε}	error term for either model + parametric uncertainty or parametric uncertainty
σ_T	error term for both model and parametric uncertainty

σ_v	total vertical stress in the soil
σ'_v	effective vertical stress in the soil
$\Lambda_{\mathrm{FS_L}*}$	mean annual rate of not exceeding some given value of FS_L
λ_{Nreq*}	mean annual rate of not exceeding some given value of N_{req}
τ_{cyc}	equivalent uniform cyclic shear stress
Φ	standard normal cumulative distribution function

Lateral Spread Displacement Terms

D_H	median computed permanent lateral spread displacement (m)
R	closest horizontal distance from the site to the source (km)
M	earthquake moment magnitude
W	free-face ratio (%)
S	ground slope (%)
T_{15}	cumulative thickness (in upper 20 m) of all saturated soil layers with corrected SPT blowcounts (i.e., $(N_1)_{60}$) less than 15 blows/foot (m)
F_{15}	average fines content of the soil comprising T_{15} (%)
$D50_{15}$	average mean grain size of the soil comprising T_{15} (mm)
$\mathscr{L}$	Loading Parameter
$\mathscr{S}$	Site Parameter
$\mathscr{D}$	transformed (e.g. log, ln, square root) lateral spread displacement
ε	uncertainty term (used in lateral spread displacement model)
$\left[\log D_H\right]^{site}$	logarithm of the lateral spread displacement adjusted for site-specific conditions
$\left[\log D_H\right]^{ref}$	logarithm of the lateral spread displacement corresponding to the reference site
ΔD_H	adjustment factor for lateral spread displacement
D_H^{site}	site-specific hazard-targeted lateral spread displacement

Post-Liquefaction Free-Field Settlement Terms

CRR	cyclic resistance ratio
CRR^{ref}	cyclic resistance ratio associated with the reference soil profile
CRR^{site}	cyclic resistance ratio for the site profile
CSR	cyclic stress ratio
CSR^{ref}	uniform hazard estimate of CSR associated with the reference soil profile
CSR^{site}	uniform hazard estimate of CSR associated with the site specific soil profile
$CSR_{SS,20,1D,atm}$	adjusted CSR to account for multi-directional shaking effects

CSR^{site}	site-specific uniform hazard estimate of CSR
DF_i	depth factor for soil sub-layer
D_R	relative density
FC	fines content (%)
F_{PGA}	soil amplification factor
FS_{Liq}	factor of safety against liquefaction triggering
FS_L^{site}	site-specific uniform hazard estimate of FS_L
F_α	limiting factor of safety (used in Ishihara and Yoshimine model)
F_α^{ref}	limiting factor of safety associated with reference soil profile
F_α^{site}	limiting factor of safety associate with site soil profile
K_{md}	multidirectional correction factor for unidirectional applied loading
K_{Mw}	magnitude correction factor
K_σ	non-linear increase in cyclic resistance correction factor
min(.)	use minimum value inside parentheses mathematical operator
M_w	mean moment magnitude
N	SPT blow count (uncorrected)
$(N_1)_{60}$	SPT resistance corrected to 60% efficiency and 1 atm pressure
$(N_1)_{60,cs}$	clean sand-equivalent SPT corrected to 60% efficiency and 1 atm pressure
N_{req}	SPT resistance required to resist or prevent liquefaction
N_{req}^{ref}	uniform hazard estimate of N_{req} associated with the reference soil profile
N_{req}^{site}	site-specific uniform hazard estimate of N_{req}
N_{site}	standard penetration test resistance of site profile layer
P_a	atmospheric pressure (1 atm, 101.3 kPa, 0.2116 psf)
PGA	peak ground acceleration
P_L	probability of liquefaction
$s_{profile}$	estimated total settlement for soil profile using equivalent strain approach
SPT	Standard Penetration Test
t_i	thickness of soil sub-layer
$V_{s,12}$	average shear wave velocity in upper 12 m (39.37 ft) of soil profile
z_{cr}	maximum depth at which vertical strain can occur ($z_{cr} = 18$ *meters)*
$\Delta\varepsilon$	site-specific adjustment factor
ε_v	vertical strain

$\varepsilon_{v,calibrated}^{site}$	site-specific strain calibrated for model non-linearity
ε_v^{ref}	vertical strain for the reference soil profile
ε_v^{site}	site-specific vertical strain
$\varepsilon_{v,eqv.}$	equivalent vertical strain for entire soil profile
$\varepsilon_{v,max}$	maximum limiting vertical strain for a soil layer
γ	unit weight of soil (e.g. pcf, kN/m^3, etc.)
γ_{max}	maximum limiting shear strain
γ_{min}	minimum limiting shear strain
$\lambda_{\varepsilon,v,i}$	mean annual rate of exceeding vertical strain
$\mu_{ln\varepsilon}$	mean value of the natural logarithm of vertical strain
σ_ε	error term for either model + parametric uncertainty or parametric uncertainty
σ'_{vo}	effective vertical stress in the soil
Φ	standard normal cumulative distribution function
Φ^{-1}	inverse standard normal cumulative distribution function

Seismic Slope Displacement Terms

$\ln D$	natural logarithm of seismic slope displacement (cm)
k_y	yield acceleration (g)
PGA	peak ground acceleration (g)
M	earthquake moment magnitude (g)
σ_{ln}	standard deviation for the scalar model
λ_D	mean annual rate of not exceeding a seismic slope displacement value
D	seismic slope displacement (cm)
GM_i	single ground motion parameter
T_s	initial fundamental period of the sliding mass (s)
f_a	soil amplification factor (from AASHTO 2012 Values of site factor table)
$\ln D^{site}$	natural log of seismic slope displacement adjusted for the site-specific conditions
$\ln D^{ref}$	natural log of seismic slope displacement corresponding to the reference site
$\Delta \ln D$	adjustment factor for seismic slope displacement

k_y^{site}	yield acceleration adjusted for site-specific conditions (g)
PGA^{site}	peak ground acceleration adjusted for site-specific conditions (g)
k_y^{ref}	yield acceleration for the corresponding to the reference site (g)
PGA^{ref}	peak ground acceleration corresponding to the reference site (g)
f_a^{site}	soil amplification factor adjusted for site-specific conditions
f_a^{ref}	soil amplification factor corresponding to the reference site

EXECUTIVE SUMMARY

The purpose of the research presented is to provide the benefit of the full performance-based probabilistic earthquake hazard analysis, without requiring special software, training, and experience while using Standard Penetration Test (SPT) data from site soil borings. To do this, simplified models of liquefaction triggering, lateral spread displacements, post-liquefaction settlements, and seismic slope displacements that approximate the results of the full probabilistic analysis were developed. These simplified methods are designed to require only a few calculations programmed into a spreadsheet and a provided liquefaction parameter map. This report provides the derivation and validation of these simplified models, addressing Tasks 1 through 8 of the pooled fund study number FHWA TPF-5(296) as specified in the research contract.

The simplified procedure using the Boulanger and Idriss (2012) probabilistic liquefaction triggering model is derived based on principles from the Mayfield et al. (2010) derivation of the simplified procedure for the Cetin et al. (2004) probabilistic liquefaction triggering model. The simplified procedure for predicting lateral spread displacements is derived based on the Youd et al. (2002) empirical model. The simplified procedure for vertical strains in a soil profile is derived based on the Cetin et al. (2009) and Ishihara and Yoshimine (1992) volumetric strain models. The simplified procedure for seismic slope displacements is derived based on the Rathje and Saygili (2009), and Bray and Travasarou (2007) simplified empirical Newmark sliding block models. The new simplified procedures are based on retrieving a reference parameter value (i.e. CSR^{ref} (%), log $D_H{}^{ref}, \varepsilon_v^{ref}$, D^{ref}) from a hazard-targeted liquefaction parameter map, and calculating site-specific correction factors to adjust the reference value to represent the site-specific conditions. The simplified procedures were validated by comparing the results of the simplified analysis with a full performance-based analysis for 10 cities of varying seismicity. The results show that the simplified procedure is within 5% error of the full performance-based procedure.

To ensure that spatial bias is not introduced into the liquefaction parameter maps, a grid spacing evaluation was performed. The grid spacings determined in the evaluation were used in the development of the liquefaction parameter maps. These maps were created for Alaska (only for liquefaction triggering and lateral spread are included in this report), Connecticut, Idaho, Montana, South Carolina, and Utah at the 475, 1033, and 2475 year return periods. An addendum to this report will include completed maps for Alaska and Oregon.

The simplified procedures were compared with the deterministic and pseudo-probabilistic procedures. The deterministic procedure significantly overpredicts hazard in regions of low seismicity, slightly overpredicts hazard in regions of medium seismicity, and slightly underpredicts hazard in areas of high seismicity when compared to the simplified procedure at the 475 and 2475 year return periods. The pseudo-probabilistic procedure returns results very similar to the simplified method at the 1033 year return period.

To assist in implementing the simplified procedures, a tool was created to perform the simplified calculations, called *SPLiq*. *SPLiq* is available in spreadsheet form and provides an easily implemented procedure. A step-by-step process is provided in a user’s manual additional to this report, and will assist in the use of the *SPLiq* tool in those states for which liquefaction parameter maps have been developed.

1.0 INTRODUCTION

1.1 Problem Statement

The purpose of the research presented is to develop a procedure that provides the benefit of the full performance-based probabilistic earthquake hazard analysis, without requiring special software, training, and experience, while using Standard Penetration Test (SPT) data from site soil borings. To do this, simplified models of liquefaction triggering, lateral spread displacements, post-liquefaction free-field settlement and seismic slope displacements were developed that approximate the results of the full probabilistic analysis. The simplified models need to be validated to ensure that the simplified models provide results that adequately approximate the results from full performance-based models at a given return period.

1.2 Objectives

The objective of this report is to provide simplified performance-based procedures to the members of the pooled fund study TPF-5(296) technical advisory committee (TAC) which closely approximate the results of full probabilistic analyses for liquefaction initiation, lateral spread displacement, post-liquefaction free-field settlements, and seismic slope displacements. This was done by performing the following steps:

- Introduce the original models used to determine liquefaction hazards (i.e. liquefaction triggering, lateral spread displacement, post-liquefaction settlement, and seismic slope displacements) and provide in-depth derivations that demonstrate the development of the simplified methods

- Validate the simplified models by performing a site-specific analysis for several different sites using the simplified and full models

- Assess proper grid spacing for map development

- Create the hazard-targeted liquefaction, lateral spread, post-liquefaction settlement, and seismic slope displacement parameter maps

- Compare the simplified procedure with deterministic methods
- Develop a tool to streamline the simplified procedure

These objectives specifically address Tasks 1, 2, 3, 4 5, 6, 7 and 8 of the TPF-5(296) research contract.

1.3 Scope

The states included in this research were: Alaska, Connecticut, Idaho, Montana, South Carolina, Utah, and Oregon. Hazard-targeted liquefaction parameter maps were developed for these states only with the exception of maps for Alaska (for post-liquefaction settlement and seismic slope displacement) and Oregon which will use the 2014 USGS deaggregation data when it becomes available. However, the same principles used in the simplified procedure provided in this report should apply similarly to other states. The final products of this research are: 1) a final report describing the findings of the research, 2) liquefaction parameter maps for the states mentioned at the 475, 1033, and 2475 year return periods, and 3) *SPLiq*, a spreadsheet that performs the simplified procedures outlined in the report.

1.4 Outline of Report

The research conducted for this project is documented in the following sections of this report:

- Derivation of the Simplified Models
- Validation of the Simplified Models
- Grid Spacing Study
- Development of the Parameter Maps
- Comparison with Deterministic Analyses
- Guide to the Simplified Procedure & Validation
- Conclusions
- Appendices

2.0 DERIVATION OF THE SIMPLIFIED MODELS

2.1 Overview

This section describes the derivation of the simplified liquefaction triggering, lateral spread displacement, post-liquefaction settlement, and seismic slope displacement models. The original models will be introduced and the derivation process for the simplified models will be described in detail.

2.2 Performance-based Liquefaction Triggering Evaluation

This section will provide the necessary background to understand the simplified performance-based liquefaction triggering procedure. A brief discussion regarding empirical liquefaction triggering models will be provided, followed by a discussion of performance-based implementation of those models.

2.2.1 Empirical Liquefaction Triggering Models

While the use of liquefaction hazard maps can provide a useful preliminary assessment of liquefaction hazard for a site, most professionals rely upon site-specific liquefaction triggering assessment for use in design. One of the most widely used methods of assessment in engineering practice today is the simplified empirical procedure (Seed and Idriss 1971; Seed 1979; Seed and Idriss 1982; and Seed et al. 1985). According to this simplified procedure, liquefaction triggering is evaluated by comparing the seismic loading of the soil to the soil's resistance to liquefaction triggering. Seismic loading is typically characterized using a cyclic stress ratio, *CSR*, which is computed as:

$$CSR = \frac{\tau_{cyc}}{\sigma_v'} = 0.65\frac{a_{\max}}{g}\frac{\sigma_v}{\sigma_v'}r_d \tag{1}$$

where τ_{cyc} is the equivalent uniform cyclic shear stress, σ_v' is the effective vertical stress in the soil, $a_{\max}/g$ is the peak ground surface acceleration as a fraction of gravity, σ_v is the total vertical stress in the soil, and r_d is a shear stress reduction coefficient.

Soil resistance to liquefaction triggering is characterized by performing some in-situ soil test (e.g., standard penetration resistance, cone penetration resistance, shear wave velocity, etc.) and comparing its results to those from documented case histories of liquefaction triggering. Based on observation and/or statistical regression, a function for the in-situ test can be delineated that separates the "liquefaction" case histories from the "non-liquefaction" case histories. This delineated boundary is referred to as the cyclic resistance ratio, *CRR*, and represents the unique combinations of *CSR* and in-situ soil test values at which liquefaction triggers.

Engineers and geologists commonly quantify liquefaction triggering using a factor of safety against liquefaction triggering, FS_L. This parameter is calculated as:

$$FS_L = \frac{\text{Resistance}}{\text{Loading}} = \frac{CRR}{CSR} \tag{2}$$

Kramer and Mayfield (2007) and Mayfield et al. (2010) introduced an alternative method to quantifying liquefaction triggering. If using the standard penetration test (SPT), then *CRR* is a function of $(N_1)_{60-cs}$, which is the clean sand-equivalent, corrected SPT resistance for the soil layer. However, for a given level of seismic loading (i.e., *CSR*), the SPT resistance required to resist or prevent liquefaction, N_{req}, can be back-calculated from the *CRR* function. This term N_{req} can be used to compute FS_L using a modified form of Equation (2) as:

$$FS_L = \frac{CRR}{CSR} = \frac{CRR\left((N_1)_{60-cs}\right)}{CRR\left(N_{req}\right)} \tag{3}$$

where $CRR(N)$ denotes that *CRR* is a function of given value of SPT resistance, *N*.

Mayfield et al. (2010) defined the relationship between the actual SPT resistance for the given layer, N_{site}, and N_{req} as:

$$\Delta N_L = N_{site} - N_{req} \tag{4}$$

The relationship between *CSR*, *CRR*, N_{site}, and N_{req} is shown graphically in Figure 2-1, after Mayfield et al. (2010).

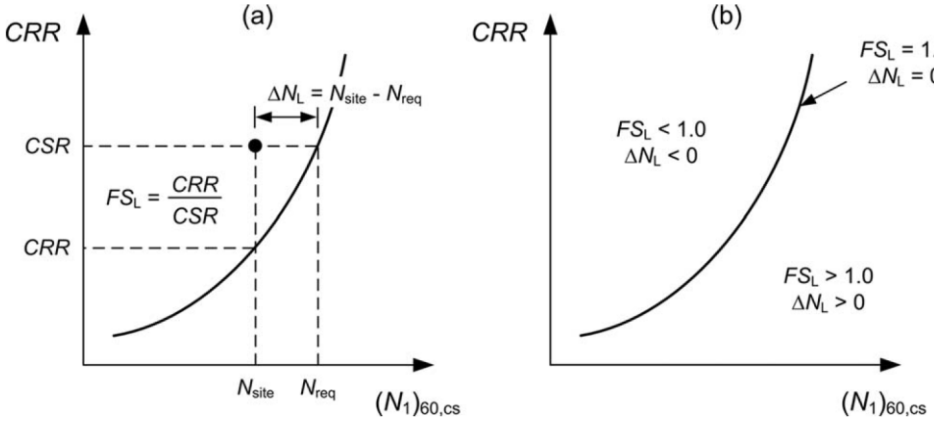


Figure 2-1 Schematic illustration of: (a) definitions of FS_L and ΔN_L; (b) relationship between FS_L and ΔN_L (after Mayfield et al. 2010)

2.2.2 Performance-based Liquefaction Triggering Assessment

Simplified empirical liquefaction triggering procedures require the selection of seismic loading parameters (i.e., peak ground surface acceleration $a_{\max}$ and moment magnitude M_w) to characterize a representative or design earthquake. When analyzing the liquefaction hazard from a single seismic source, the process of selecting seismic loading parameters is relatively straightforward and simple. However, few seismic environments exist where only a single seismic source can contribute to liquefaction hazard. In more complex seismic environments, seismic hazard is usually calculated with a probabilistic seismic hazard analysis (PSHA), which often produces a wide range of seismic loading parameter combinations, each associated with a different likelihood of occurrence. Despite the wide variety of possible seismic loading parameter combinations produced by a PSHA, engineers must select a single set of seismic loading parameters that adequately characterize the complex seismicity of the site. Conventional approaches to liquefaction triggering assessment typically utilize the deaggregation results associated with the PSHA for $a_{\max}$ at a targeted hazard level or return period to obtain that single set of seismic loading parameters. Engineers select either the median or mean moment magnitude from the deaggregation results, and subsequently couple this selected magnitude with the $a_{\max}$ value associated with the targeted return period. Unfortunately, these conventional approaches were shown by Kramer and Mayfield (2007) to introduce bias into the computed liquefaction triggering hazard.

Potential biases introduced into the liquefaction triggering assessment through the improper and/or incomplete utilization of probabilistic ground motions and liquefaction triggering models could be reduced through the implementation of a performance-based approach (Franke et al. 2014a). Kramer and Mayfield (2007) presented such an approach, which utilized the probabilistic framework for performance-based earthquake engineering (PBEE) developed by the Pacific Earthquake Engineering Research Center (Cornell and Krawinkler 2000; Krawinkler 2002; Deierlein et al. 2003). This implementation of the PEER PBEE framework assigned the joint occurrence of M_w and $a_{\max}$ as an intensity measure, and either FS_L or N_{req} as the engineering demand parameter.

Kramer and Mayfield (2007) demonstrated that a hazard curve for FS_L could be developed using the following relationship:

$$\Lambda_{FS_L^*} = \sum_{j=1}^{N_M} \sum_{i=1}^{N_{a_{\max}}} P\left[FS_L < FS_L^* \mid a_{\max_i}, m_j\right] \Delta\lambda_{a_{\max_i}, m_j} \tag{5}$$

where $\Lambda_{FS_L^*}$ is the mean annual rate of *not* exceeding some given value of factor of safety, FS_L^*; $P\left[FS_L < FS_L^* \mid a_{\max_i}, \mathrm{m}_j\right]$ is the conditional probability that the actual factor of safety is less than FS_L^* given peak ground surface acceleration $a_{\max_i}$ and moment magnitude m_j; $\Delta\lambda_{a_{\max_i}, m_j}$ is the incremental joint mean annual rate of exceedance for $a_{\max_i}$ and m_j; and N_M and $N_{a_{\max}}$ are the number of magnitude and peak ground acceleration increments into which the intensity measure “hazard space” is subdivided.

The conditional probability component of Equation (5) can be solved with any selected probabilistic liquefaction triggering relationship, but that relationship must be manipulated to compute the desired probability. Assuming the inclusion of parametric uncertainty (i.e., uncertainty in SPT resistance and seismic loading), Kramer and Mayfield (2007) solved the conditional probability term using the Cetin et al. (2004) liquefaction triggering relationship as:

$$P\left[FS_L < FS_L^* \mid a_{\max_i}, m_j\right] = \Phi\left[-\frac{(N_1)_{60}(1+0.004FC) - 13.79\left(FS_L^* \cdot CSR_i\right) - 29.06\ln\left(m_j\right) - 3.82\ln\left(\frac{\sigma_v'}{p_a}\right) + 0.06FC + 15.25}{4.21}\right] \tag{6}$$

where Φ represents the standard normal cumulative distribution function, $\left(N_1\right)_{60}$ is the SPT resistance corrected for atmospheric pressure and hammer energy as computed using Cetin et al. (2004); FC is the fines content (in percent); CSR_i is equal to Equation (1) using $a_{\max_i}$ as input; and p_a is atmospheric pressure (in the same units as σ_v').

Franke et al. (2014b) solved the conditional probability component of Equation (5) using the Boulanger and Idriss (2012) probabilistic liquefaction triggering relationship as:

$$P\left[FS_L < FS_L^* \mid a_{\max,i}, m_j\right] = \Phi\left[-\frac{\frac{(N_1)_{60,cs}}{14.1} + \left(\frac{(N_1)_{60,cs}}{126}\right)^2 - \left(\frac{(N_1)_{60,cs}}{23.6}\right)^3 + \left(\frac{(N_1)_{60,cs}}{25.4}\right)^4 - 2.67 - \ln\left(CSR_{i,j} \cdot FS_L^*\right)}{\sigma_\varepsilon}\right] \tag{7}$$

$$CSR_{i,j} = 0.65\frac{a_{\max,i}}{g}\frac{\sigma_v}{\sigma_v'}\left(r_d\right)_j\frac{1}{\left(MSF\right)_j}\frac{1}{K_\sigma} \tag{8}$$

where $\left(N_1\right)_{60}$ is the SPT resistance corrected for atmospheric pressure and hammer energy as computed using Idriss and Boulanger (2008, 2010); $\left(MSF\right)_j$ is the magnitude scaling factor for magnitude m_j and is computed according to Idriss and Boulanger (2008); $\left(r_d\right)_j$ is the depth reduction factor for magnitude m_j and is computed according to Idriss and Boulanger (2008); K_σ the depth correction factor and is computed according to Idriss and Boulanger (2008), and σ_ε is equal to either 0.13 for model uncertainty alone or 0.277 for total (i.e., model + parametric) uncertainty.

Similar to the relationship for computing a hazard curve for FS_L, Kramer and Mayfield (2007) derived a relationship for computing a hazard curve for N_{req} as:

$$\lambda_{N^*_{req}} = \sum_{j=1}^{N_M} \sum_{i=1}^{N_{a_{\max}}} P\left[N_{req} > N^*_{req} \mid a_{\max_i}, m_j \right] \Delta\lambda_{a_{\max_i}, m_j} \tag{9}$$

where $\lambda_{N^*_{req}}$ is the mean annual rate of exceeding some given clean sand-equivalent required SPT resistance, N^*_{req}, and $P\left[N_{req} > N^*_{req} \mid a_{\max_i}, \mathrm{m}_j \right]$ is the conditional probability that the actual N_{req} is greater than N^*_{req} given peak ground surface acceleration $a_{\max_i}$ and moment magnitude m_j. Kramer and Mayfield (2007) and Mayfield et al. (2010) used the Cetin et al. (2004) probabilistic liquefaction triggering relationship (assuming the inclusion of parametric uncertainty) to solve the conditional probability component of Equation (9) as:

$$P\left[N_{req} > N^*_{req} \mid a_{\max_i}, m_j \right] = \Phi\left[-\frac{N^*_{req} - 13.79\left(CSR_i\right) - 29.06\ln\left(m_j\right) - 3.82\ln\left(\dfrac{\sigma_v'}{p_a}\right) + 15.25}{4.21} \right] \tag{10}$$

Franke and Wright (2013) substituted the Boulanger and Idriss (2012) model for the Cetin et al. (2004) model to develop an alternative conditional probability term for Equation (9) as:

$$P\left[N_{req} > N^*_{req} \mid a_{\max,i}, m_j \right] = \Phi\left[-\frac{\dfrac{N^*_{req}}{14.1} + \left(\dfrac{N^*_{req}}{126}\right)^2 - \left(\dfrac{N^*_{req}}{23.6}\right)^3 + \left(\dfrac{N^*_{req}}{25.4}\right)^4 - 2.67 - \ln CSR_{i,j}}{\sigma_\varepsilon} \right] \tag{11}$$

where $CSR_{i,j}$ is computed with Equation (8), and σ_{ε} is equal to either 0.13 for model uncertainty alone or 0.277 for total (i.e., model + parametric) uncertainty.

2.3 Simplified Liquefaction Triggering Model

The Kramer and Mayfield (2007) performance-based liquefaction triggering procedure summarized in Section 2.2.2 is an effective solution to mitigating the deficiencies introduced by the conventional liquefaction triggering approach, which utilizes probabilistic ground motions and a liquefaction triggering relationship in a deterministic manner. Unfortunately, the Kramer and Mayfield procedure is relatively sophisticated and difficult for many engineers and geologists to apply in a practical manner. Specialized computational tools such as *WSliq* (Kramer 2008) and *PBliquefY* (Franke et al. 2014c) have been developed to assist these professionals in implementing the performance-based procedure. However, even the availability of computational tools is not sufficient for many professionals, who routinely need to perform and/or validate liquefaction triggering hazard calculations in a rapid and efficient manner.

An ideal solution to this dilemma would be the introduction of a new liquefaction analysis procedure that combined the simplicity and user-friendliness of traditional liquefaction hazard maps with the flexibility and power of a site-specific performance-based liquefaction triggering analysis. Mayfield et al. (2010) introduced such a procedure, which was patterned after the map-based procedure used in most seismic codes and provisions for developing probabilistic ground motions for engineering design. Franke et al. (2014d) later refined the Mayfield et al. simplified procedure for easier implementation in seismic codes and provisions.

Mayfield et al. (2010) demonstrated with the Cetin et al. (2004) liquefaction model that probabilistic estimates of liquefaction resistance (i.e. N_{req}) can be computed for a reference soil profile across a grid of locations to develop contour plots called liquefaction parameter maps. A liquefaction parameter map incorporating N_{req} can be a useful tool to evaluate the seismic demand for liquefaction at a given return period because N_{req} is directly related to CSR (i.e. Figure 2-1). Mayfield et al. demonstrated how these mapped "reference" values of N_{req} could be adjusted for site-specific conditions and used to develop site-specific uniform hazard estimates of N_{req} (i.e., N_{req}^{site}) and/or FS_L (i.e., FS_L^{site}) at the targeted return period or hazard level. The derivation of the simplified method for the Cetin et al. (2004) liquefaction triggering model will not be included in this report, but is presented in detail in Mayfield et al. (2010) and Franke et al. (2014d).

Because many engineers desire to evaluate liquefaction initiation hazard using either the Youd et al. (2001) or the Idriss and Boulanger (2008) (which is very similar to Youd et al. 2001) liquefaction triggering curves for the SPT, a simplified uniform hazard liquefaction procedure that incorporates the Boulanger and Idriss (2012) probabilistic liquefaction model can be developed through an approach similar to that used by Mayfield et al. (2010).

2.3.1 Simplified Procedure Using the Boulanger and Idriss (2012) Probabilistic Liquefaction Triggering Model

According to the probabilistic liquefaction triggering relationship developed by Boulanger and Idriss (2012), the probability of liquefaction P_L is given as:

$$P_L = \Phi\left[-\frac{\ln\left(CRR_{P_L=50\%}\right)-\ln\left(CSR\right)}{\sigma_T}\right] \tag{12}$$

where Φ represents the standard normal cumulative distribution function, σ_T is the total uncertainty of the liquefaction model, and $CRR_{P_L=50\%}$ is the cyclic resistance ratio corresponding to a probability of liquefaction of 50% (i.e. median *CRR*), which is computed as:

$$CRR_{P_L=50\%} = \exp\left[\left(\frac{(N_1)_{60,cs}}{14.1}\right)+\left(\frac{(N_1)_{60,cs}}{126}\right)^2-\left(\frac{(N_1)_{60,cs}}{23.6}\right)^3+\left(\frac{(N_1)_{60,cs}}{25.4}\right)^4-2.67\right] \tag{13}$$

Unlike the Mayfield et al. (2010) simplified liquefaction procedure, which incorporates the Cetin et al. (2004) liquefaction model, the simplified uniform hazard liquefaction procedure for the Boulanger and Idriss (2012) liquefaction model cannot be derived to solve for N_{req}^{site} in a convenient manner because of the 4th-order polynomial equation in *CRR* (i.e. Equation (13)).

Fortunately, this simplified procedure can be modified to incorporate *CRR* and *CSR* instead of N_{req}, which greatly simplifies the derivation of the new procedure, and also makes it somewhat more intuitive.

Figure 2-2 presents a generic soil profile representing a reference site originally introduced by Mayfield et al. (2010) and used for the simplified Cetin et al. (2004) procedure. This reference soil profile can be used with a full performance-based liquefaction analysis incorporating the Boulanger and Idriss (2012) probabilistic liquefaction model (Franke and Wright 2013) to find N_{req} at a depth of 6 meters for the targeted return period (T_R) or hazard level. Because the value of N_{req} associated with the reference soil profile does not represent any actual soil profile, Mayfield et al. (2010) distinguished it using the term N_{req}^{ref}. By substituting N_{req}^{ref} into Equation (13), the median *CSR* associated with the reference site (i.e. CSR^{ref}) at the targeted return period can be computed. In other words, CSR^{ref} represents a uniform hazard estimate of the seismic loading that must be overcome to prevent liquefaction triggering if the reference soil profile existed at the site of interest. By computing similar hazard-targeted values of CSR^{ref} at different locations across a geographic area, contoured liquefaction parameter maps for CSR^{ref} can be constructed. These maps will be called *liquefaction loading maps* because they convey information regarding the seismic loading affecting liquefaction triggering, and to distinguish them from liquefaction parameter maps, which convey information regarding N_{req}^{ref}. Because *CSR* is often a decimal value less than unity, mapping the percent of *CSR*, $CSR^{ref}(\%)$ allows for more precise contour mapping, as well as easier interpretation and interpolation for design engineers. Figure 2-3 presents a liquefaction loading map of $CSR^{ref}(\%)$ at a return period of 1,033 years for a portion of the Salt Lake Valley in Utah.

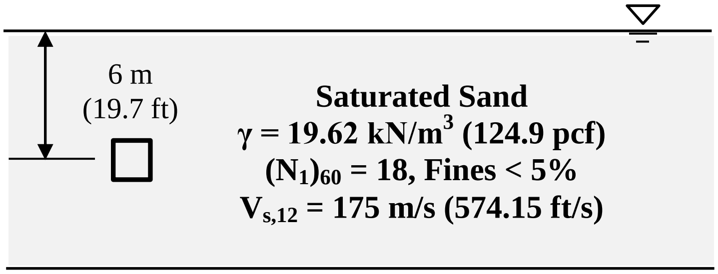


Figure 2-2. Reference soil profile used to develop liquefaction loading maps in the proposed simplified uniform hazard liquefaction procedure

Figure 2-3. Liquefaction loading map (T_R = 1,033 years) showing contours of CSR^{ref} $(\%)$ for a portion of the Salt Lake Valley in Utah.

In interpreting a liquefaction loading map such as the one presented in Figure 2-3, a qualitative assessment of relative liquefaction hazard across a geographic area at the targeted return period can be made. Higher values of $CSR^{ref}(\%)$ imply higher levels of seismic loading for liquefaction triggering. Soils located in areas of higher $CSR^{ref}(\%)$ will need greater SPT resistance to prevent liquefaction triggering than soils located in areas of lower $CSR^{ref}(\%)$. However, a liquefaction loading map by itself tells the engineer nothing regarding the actual liquefaction hazard at a site because the map does not account for site-specific soil conditions. A procedure will subsequently be derived and presented to correct the mapped liquefaction loading values to site-specific liquefaction loading values, which can be used to compute site-specific performance-based estimates of liquefaction triggering hazard at a targeted return period.

A liquefaction loading map should not be confused with a liquefaction hazard map, which attempts to account for actual soil conditions at each mapped location. The difficulty in obtaining site-specific subsurface data for all locations across a geologic region is significant, indeed. Furthermore, liquefaction hazard maps tell the engineer nothing regarding the liquefaction triggering hazard with depth in the actual soils at the site. Thus, liquefaction hazard maps constitute a preliminary hazard assessment and planning tool, and can be very helpful to engineers if used properly. However, liquefaction hazard map results should be interpreted with caution and an understanding that local site conditions and actual liquefaction hazard may deviate significantly from what is mapped.

2.3.1.1 Site-Specific Correction for CSR^{ref}

Because CSR^{ref} was developed using the reference soil profile, it must be corrected for site-specific soil conditions and depths to be used in computing site-specific uniform hazard values of FS_L, P_L, and N_{req}. If CSR^{site} represents the site-specific uniform hazard value of CSR, then CSR^{ref} and CSR^{site} can be related as:

$$\ln\left(CSR^{site}\right) = \ln\left(CSR^{ref}\right) + \Delta CSR \tag{14}$$

where ΔCSR is a site-specific correction factor. Rearranging Equation (14), we can solve for ΔCSR as:

$$\Delta CSR = \ln\left(CSR^{site}\right) - \ln\left(CSR^{ref}\right) = \ln\left(\frac{CSR^{site}}{CSR^{ref}}\right) \tag{15}$$

Similar to Equation (8), the magnitude- and stress-corrected CSR for level or near-level ground according to Boulanger and Idriss (2012) is computed as:

$$CSR_{M=7.5,\sigma_v'=1atm} = 0.65\frac{\sigma_v}{\sigma_v'}\frac{a_{\max}}{g}r_d\frac{1}{MSF}\frac{1}{K_\sigma} = 0.65\frac{\sigma_v}{\sigma_v'}\frac{\left(F_{pga}\cdot PGA_{rock}\right)}{g}r_d\frac{1}{MSF}\frac{1}{K_\sigma} \tag{16}$$

where F_{pga} is the soil amplification factor corresponding to the peak ground acceleration (PGA), and PGA_{rock} is the PGA corresponding to bedrock (i.e. V_s=760 m/s). Equations for r_d, MSF, and K_σ as defined in Idriss and Boulanger (2008, 2010) are provided in later sections of this report. If Equation (16) is substituted into Equation (15), then Equation (15) can be rewritten as:

$$\Delta CSR = \ln\left[\frac{0.65\left(\dfrac{\sigma_v}{\sigma_v'}\right)^{site}\left(\dfrac{F_{pga}^{site}\cdot PGA_{rock}^{site}}{g}\right)\cdot r_d^{site}\cdot\left(\dfrac{1}{MSF^{site}}\right)\cdot\left(\dfrac{1}{K_\sigma^{site}}\right)}{0.65\left(\dfrac{\sigma_v}{\sigma_v'}\right)^{ref}\left(\dfrac{F_{pga}^{ref}\cdot PGA_{rock}^{ref}}{g}\right)\cdot r_d^{ref}\cdot\left(\dfrac{1}{MSF^{ref}}\right)\cdot\left(\dfrac{1}{K_\sigma^{ref}}\right)}\right] \tag{17}$$

Because there should be no difference in the ground motions between the reference soil profile and the actual soil profile, $PGA_{rock}^{site} = PGA_{rock}^{ref}$. Therefore, Equation (17) can be simplified as:

$$\begin{aligned}\Delta CSR &= \ln\left(\frac{\left(\sigma_v/\sigma_v'\right)^{site}}{\left(\sigma_v/\sigma_v'\right)^{ref}}\right) + \ln\left(\frac{F_{pga}^{site}}{F_{pga}^{ref}}\right) + \ln\left(\frac{r_d^{site}}{r_d^{ref}}\right) - \ln\left(\frac{MSF^{site}}{MSF^{ref}}\right) - \ln\left(\frac{K_\sigma^{site}}{K_\sigma^{ref}}\right) \\ &= \Delta CSR_\sigma + \Delta CSR_{F_{pga}} + \Delta CSR_{r_d} + \Delta CSR_{MSF} + \Delta CSR_{K_\sigma}\end{aligned} \tag{18}$$

where ΔCSR_{σ}, ΔCSR_{Fpga}, ΔCSR_{rd}, ΔCSR_{MSF}, and $\Delta CSR_{K\sigma}$ are site-specific correction factors for stress, soil amplification, shear stress reduction, earthquake magnitude, and overburden pressure, respectively.

2.3.1.2 Correction for Vertical Stress, ΔCSR_{σ}

The relationship for the stress correction factor, ΔCSR_{σ} is defined as:

$$\Delta CSR_{\sigma} = \ln\left[\frac{\left(\sigma_v / \sigma_v'\right)^{site}}{\left(\sigma_v / \sigma_v'\right)^{ref}}\right] \tag{19}$$

If the liquefaction parameter map for CSR^{ref} (%) was developed using the reference soil profile shown in Figure 2-2, then Equation (19) can be simplified as:

$$\Delta CSR_{\sigma} = \ln\left[\frac{\left(\sigma_v / \sigma_v'\right)^{site}}{2}\right] \tag{20}$$

Mayfield et al. (2010) used weight-volume relationships to investigate the possibility of simplifying the stress correction factor in their simplified procedure. By substituting specific gravity and void ratio for the vertical stress terms, and then by assuming that the site-specific void ratio and specific gravity were the same as those used in the reference soil profile, Mayfield et al. developed a simplified equation for their stress correction factor that was simply a function of depth and depth to groundwater. Mayfield et al. demonstrated that this simplified equation was quite insensitive to changes in void ratio, and thus introduced relatively little error into their computed results. A similar investigation was performed with ΔCSR_{σ} in this study to evaluate the possibility of developing a simplified relationship for Equation (20). However, we found that a simplified equation after the manner demonstrated by Mayfield et al. introduces significant error into the computed results of our proposed simplified liquefaction procedure, likely due to the fact that our proposed procedure is based on a natural logarithm function (i.e. Equation (15)), whereas the Mayfield et al. (2010) simplified procedure is based on a linear relationship.

2.3.1.3 Correction for Soil Amplification, ΔCSR_{Fpga}

The relationship for the soil amplification factor, ΔCSR_{Fpga} is defined as:

$$\Delta CSR_{F_{pga}} = \ln\left(\frac{F_{pga}^{site}}{F_{pga}^{ref}}\right) \tag{21}$$

If the value of F_{pga}^{ref} for the reference soil profile is fixed at 1, then the correction factor for soil amplification can be written as:

$$\Delta CSR_{F_{pga}} = \ln\left(\frac{F_{pga}^{site}}{1}\right) = \ln\left(F_{pga}^{site}\right) \tag{22}$$

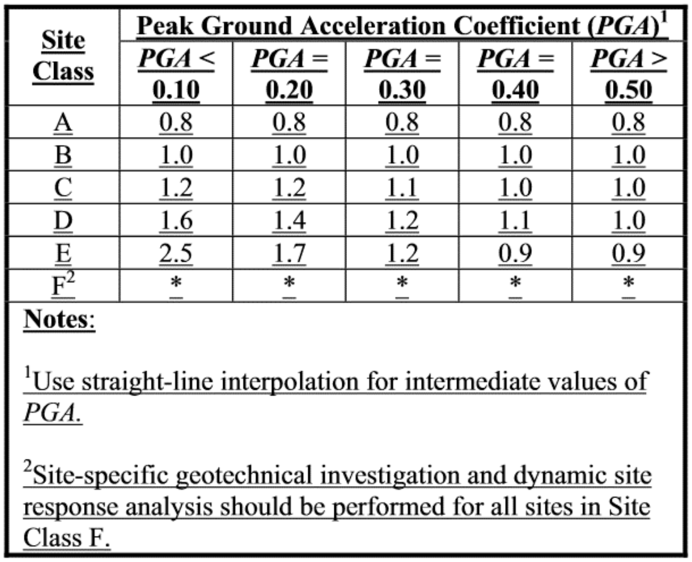
Thus the only parameter required to calculate the soil amplification factor is the F_{pga}^{site} value from AASHTO 2012 Table 3.10.3.2-1 corresponding to the site of interest. This table is included here as a reference (Table 2-1). The *PGA* value used to determine F_{pga}^{site} from the table should be calculated from the USGS 2008 (USGS 1996 for Alaska) interactive deaggregation website for the return period of interest (e.g., 2% probability of exceedance in 21 years, T_R = 1039).

If an engineer prefers to use an empirical model for soil amplification, such as the Stewart et al. (2003) model, the ΔCSR_{Fpga} term can be adjusted for the desired model. For example, in the Stewart et al. (2003) model, the median amplification factor F_{pga} is defined as:

$$F_{pga} = \exp\left[a + b\ln\left(PGA_{rock}\right)\right] \tag{23}$$

where PGA_{rock} is in units of g, a and b are regression coefficients defined by Stewart et al. (2003).

Table 2-1. Values of Site Factor, F_{pga}, at Zero-Period on Acceleration Spectrum (from AASHTO 2012 Table 3.10.3.2-1)



Site Class	Peak Ground Acceleration Coefficient (*PGA*)[1]				
	PGA < 0.10	*PGA* = 0.20	*PGA* = 0.30	*PGA* = 0.40	*PGA* > 0.50
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9
F[2]	*	*	*	*	*

Notes:

[1] Use straight-line interpolation for intermediate values of *PGA*.

[2] Site-specific geotechnical investigation and dynamic site response analysis should be performed for all sites in Site Class F.

Using Equation (23), the correction for the soil amplification factor can be written as:

$$\Delta CSR_{F_{pga}} = \ln\left(\frac{F_{pga}^{site}}{F_{pga}^{ref}}\right) = \ln\left(\frac{\exp\left(a^{site} + b^{site}\ln\left(PGA_{rock}^{site}\right)\right)}{\exp\left(a^{ref} + b^{ref}\ln\left(PGA_{rock}^{ref}\right)\right)}\right)$$
$$= \left(a^{site} + b^{site}\ln\left(PGA_{rock}^{site}\right)\right) - \left(a^{ref} + b^{ref}\ln\left(PGA_{rock}^{ref}\right)\right) \tag{24}$$

There should be no difference between PGA_{rock}^{site} and PGA_{rock}^{ref}, so Equation (24) can be simplified to:

$$\Delta CSR_{F_{pga}} = \left(a^{site} - a^{ref}\right) + \ln\left(PGA_{rock}\right)\left(b^{site} - b^{ref}\right) \tag{25}$$

If the liquefaction parameter map for CSR^{ref} (%) was developed using the reference soil profile shown in Figure 2-2, then a^{ref} = - 0.15, b^{ref} = - 0.13 (see Stewart et al., 2003), and Equation (25) would become:

$$\Delta CSR_{F_{pga}} = \left(a^{site} + 0.15\right) + \ln\left(PGA_{rock}^{site}\right)\left(b^{site} + 0.13\right) \tag{26}$$

2.3.1.4 Correction for Shear Stress Reduction, ΔCSR_{rd}

The shear stress reduction factor, r_d, was defined by Boulanger and Idriss (2012, 2014) as:

$$r_d = \exp\left[\alpha + \beta \cdot M_w\right] \tag{27}$$

$$\alpha = -1.012 - 1.126\sin\left(\frac{z}{11.73} + 5.133\right) \tag{28}$$

$$\beta = 0.106 + 0.118\sin\left(\frac{z}{11.28} + 5.142\right) \tag{29}$$

where z represents sample depth in meters and M_w is the mean moment magnitude. Thus the equation for ΔCSR_{rd} becomes:

$$\Delta CSR_{r_d} = \ln\left(\frac{r_d^{site}}{r_d^{ref}}\right) = \ln\left(\frac{\exp\left(\alpha^{site} + \beta^{site} \cdot \mathrm{M}_w^{site}\right)}{\exp\left(\alpha^{ref} + \beta^{ref} \cdot \mathrm{M}_w^{ref}\right)}\right) \tag{30}$$

Both the site soil profile and the reference soil profile experience the same ground motions, so $M_w^{site} = M_w^{ref}$. Therefore, Equation (30) can be written as:

$$\Delta CSR_{r_d} = \left(\alpha^{site} - \alpha^{ref}\right) + M_w^{site}\left(\beta^{site} - \beta^{ref}\right) \tag{31}$$

Mayfield et al. (2010) demonstrated that the r_d term in the Cetin et al. (2004) model is relatively insensitive to the value of M_w for a particular range (M_w = 5.97 to 7.70). This observation allowed the correction factor for r_d to use a standard M_w value of 6.5 for all analyses. In this study, the r_d value from the Boulanger and Idriss (2012) model was found to be quite sensitive to M_w. This sensitivity is clear in Figure 2-4, which illustrates the variability of r_d with depth and M_w (5.5 to 8.0). Due to the significant discrepancy between r_d values for different M_w, the simplified Boulanger and Idriss (2012) method requires M_w^{site} to remain in Equation (31). For the reference soil profile used in this study (Figure 2-2), α^{ref} = -0.3408 and β^{ref} = 0.0385. Thus Equation (31) becomes:

$$\Delta CSR_{r_d} = \left(\alpha^{site} + 0.341\right) + M_w^{site}\left(\beta^{site} - 0.0385\right) \tag{32}$$

Equation (32) can also be written in terms of depth to the site-specific soil layer (in meters) from the ground surface, z^{site} as:

$$\Delta CSR_{r_d} = \left(-0.6712 - 1.126\sin\left(\frac{z^{site}}{11.73} + 5.133\right)\right) + M_w^{site}\left(0.0675 + 0.118\sin\left(\frac{z^{site}}{11.28} + 5.142\right)\right) \tag{33}$$

where the value of M_w^{site} is the mean moment magnitude from the 2008 (1996 for Alaska) USGS interactive deaggregation website for the return period of interest (e.g., 2% probability of exceedance in 21 years, T_R = 1039). The value of ΔCSR_{rd} varies with depth, and therefore must be calculated for each layer in the site-specific soil profile.

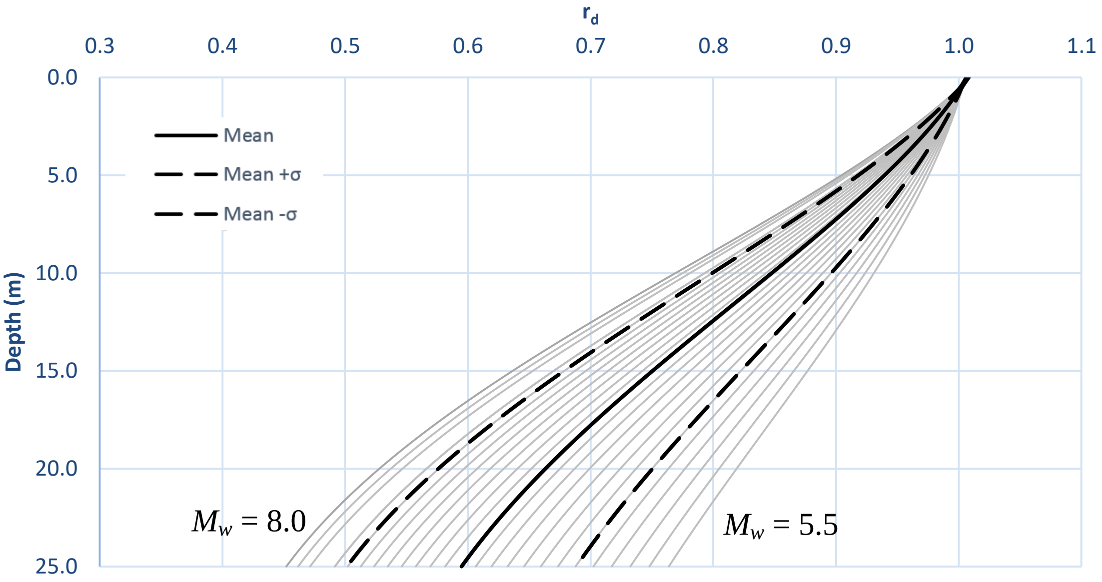


Figure 2-4. Shear stress reduction factor (r_d) vs. depth for a range of M_w values (5.5 to 8.0) according to the Boulanger and Idriss (2012) model.

2.3.1.5 Correction for Magnitude Scaling Factor, ΔCSR_{MSF}

If the *MSF* as calculated in the Idriss and Boulanger (2008, 2010) model is to be used, then there should be no difference in the earthquake magnitude between the reference soil profile and the actual soil profile. In this case, $MSF^{site} = MSF^{ref}$ which indicates that $\Delta CSR_{MSF} = 0$ and therefore ΔCSR_{MSF} can be excluded from Equation (18).

If the MSF as calculated in the updated Boulanger and Idriss (2014) model is to be used, then $MSF = f\left(N_{1,60,cs}\right)$. Because MSF is a function of $N_{1,60,cs}$, it is possible that $MSF^{site} \neq MSF^{ref}$ because it is likely that $\left(N_1\right)_{60,cs}$ varies with depth in the actual soil profile. Thus ΔCSR_{MSF} must be included in Equation (18). Using the equation for MSF from the updated Boulanger and Idriss (2014) model, this correction factor can be written as:

$$\Delta CSR_{MSF} = -\ln\left(\frac{MSF^{site}}{MSF^{ref}}\right) = -\ln\left(\frac{1+\left(MSF_{\max}^{site}-1\right)\left(8.64\exp\left(\frac{-M_w^{site}}{4}\right)-1.325\right)}{1+\left(MSF_{\max}^{ref}-1\right)\left(8.64\exp\left(\frac{-M_w^{ref}}{4}\right)-1.325\right)}\right) \tag{34}$$

$$MSF_{\max} = 1.09+\left(\frac{\left(N_1\right)_{60,cs}}{31.5}\right)^2 \leq 2.2 \tag{35}$$

where $\left(N_1\right)_{60,cs}$ represents the clean sand-equivalent SPT resistance value corrected to 60% efficiency and 1 atm overburden pressure as computed using the equations provided by Idriss and Boulanger (2008, 2010). Note that there is no difference in the magnitude of the ground motions between the reference map and the site. Thus, M_w^{ref} can be replaced with M_w^{site}. Therefore, if the liquefaction parameter map for CSR^{ref} (%) was developed using the reference soil profile shown in Figure 2-2, then $MSF_{\max}^{ref}$ = 1.417 and Equation (34) can be written as:

$$\Delta CSR_{MSF} = -\ln\left[\frac{1+\left(MIN\begin{cases}\left(\frac{\left(N_1\right)_{60,cs}^{site}}{31.5}\right)^2+0.09\\ 1.2\end{cases}\right)\cdot\left(8.64\exp\left(\frac{-M_w^{site}}{4}\right)-1.325\right)}{3.603\exp\left(\frac{-M_w^{site}}{4}\right)+0.447}\right] \tag{36}$$

The value of ΔCSR_{MSF} must be calculated for each layer in the soil profile because $MSF_{\max}^{site}$ is a function of $\left(N_1\right)_{60,cs}$, which likely varies throughout the soil profile. The value of M_w^{site} is the mean moment magnitude from the 2008 (1996 for Alaska) USGS interactive deaggregation website for the return period of interest (e.g., 2% probability of exceedance in 21 years, T_R = 1039). This should be the same value as M_w^{site} used to calculate the ΔCSR_{rd} term in Equation (33).

2.3.1.6 Correction for Overburden Pressure, $\Delta CSR_{K\sigma}$

Both the 2012 and 2014 versions of the Boulanger and Idriss model use the same overburden correction factor, K_σ:

$$K_\sigma = 1 - C_\sigma \ln\left(\frac{\sigma'_v}{P_a}\right) \leq 1.1 \tag{37}$$

$$C_\sigma = \frac{1}{18.9 - 2.55\sqrt{\left(N_1\right)_{60,cs}}} \leq 0.3 \tag{38}$$

where P_a is 1 atmosphere of pressure (i.e. 1 atm, 101.3 kPa, 0.2116 psf). Note that the value $(N_1)_{60,cs}$ must be computed using the equations found in Idriss and Boulanger (2008, 2010). Idriss and Boulanger (2010) commented that the K_σ limit of 1.1 has a somewhat negligible effect. Therefore, the simplified method derived here will not use the restriction on K_σ. However, the limit of 0.3 for values of C_σ will be incorporated. Now the correction term $\Delta CSR_{K\sigma}$ can be written as:

$$\Delta CSR_{K_\sigma} = -\ln\left(\frac{K_\sigma^{site}}{K_\sigma^{ref}}\right) = -\ln\left(\frac{1 - C_\sigma^{site}\ln\left(\frac{\left(\sigma'_v\right)^{site}}{P_a}\right)}{1 - C_\sigma^{ref}\ln\left(\frac{\left(\sigma'_v\right)^{ref}}{P_a}\right)}\right) \tag{39}$$

If the liquefaction parameter map for CSR^{ref} (%) was developed using the reference soil profile shown in Figure 2-2, then C_σ^{ref} = 0.147, K_σ^{ref} = 1.0682, and Equation (39) would become:

$$\Delta CSR_{K_\sigma} = -\ln\left(\frac{1-\left(MIN\begin{cases} 0.3 \\ \dfrac{1}{18.9-2.55\sqrt{\left(N_1\right)^{site}_{60,cs}}} \end{cases} \right)\cdot\ln\left(\dfrac{\left(\sigma'_v\right)^{site}}{P_a} \right)}{1.0682} \right) \tag{40}$$

Note that if $\left(N_1\right)_{60,cs}$ is restricted to ≤ 37 then the coefficient C_σ as defined in Equation (38) will remain below its maximum value of 0.3.

2.3.1.7 Equations for CSR^{site}, N^{site}_{req}, FS_L, and P_L

Once the $CSR^{ref}\left(\%\right)$ is obtained from the appropriate (i.e. hazard-targeted) map and the appropriate correction factors are computed using Equations (20), (22), (33), (36) (neglected if using Idriss and Boulanger 2008 *MSF* instead of the updated Boulanger and Idriss 2014 *MSF*) and (40), the site-specific hazard-targeted CSR^{site} can be computed for site-specific soil layer *i* using the following equation (from Equation (14)):

$$\left(CSR^{site}\right)_i = \exp\left[\ln\left(\frac{CSR^{ref}(\%)}{100}\right) + \left(\Delta CSR_\sigma\right)_i + \left(\Delta CSR_{F_{pga}}\right)_i + \left(\Delta CSR_{r_d}\right)_i + \left(\Delta CSR_{MSF}\right)_i + \left(\Delta CSR_{K_\sigma}\right)_i \right] \tag{41}$$

This $\left(CSR^{site}\right)$ value can then be used to calculate N^{site}_{req}, FS_L, or P_L for site-specific soil layer *i*. To calculate the value of $\left(N^{site}_{req}\right)_i$, solve the following polynomial iteratively (from Equation (13)):

$$0 = \left(\frac{\left(N^{site}_{req}\right)_i}{14.1}\right) + \left(\frac{\left(N^{site}_{req}\right)_i}{126}\right)^2 - \left(\frac{\left(N^{site}_{req}\right)_i}{23.6}\right)^3 + \left(\frac{\left(N^{site}_{req}\right)_i}{25.4}\right)^4 - 2.67 - \ln\left(\left(CSR^{site}\right)_i\right) \tag{42}$$

Alternatively, the following closed-form regression equation will provide a very close approximation of N^{site}_{req} given CSR^{site} (R^2=0.999):

$$\begin{aligned}\left(N_{req}^{site}\right)_i = 1.237\cdot\left(\ln\left(\frac{1}{\left(CSR^{site}\right)_i}\right)\right)^4 - 4.9183\cdot\left(\ln\left(\frac{1}{\left(CSR^{site}\right)_i}\right)\right)^3 \\ +1.7624\cdot\left(\ln\left(\frac{1}{\left(CSR^{site}\right)_i}\right)\right)^2 - 5.4733\cdot\left(\ln\left(\frac{1}{\left(CSR^{site}\right)_i}\right)\right) + 33.65\end{aligned} \tag{43}$$

Equation (43) is valid for $0.08 \le \left(CSR^{site}\right)_i \le 1.26$. Outside of these bounds, the polynomial should be solved iteratively.

To solve for the uniform-hazard FS_L for the soil layer *i*, use Equation (13) as:

$$\left(FS_L\right)_i = \frac{\left(CRR^{site}\right)_i}{\left(CSR^{site}\right)_i} = \frac{\exp\left[\left(\frac{\left(\left(N_1\right)_{60,cs}\right)_i}{14.1}\right) + \left(\frac{\left(\left(N_1\right)_{60,cs}\right)_i}{126}\right)^2 - \left(\frac{\left(\left(N_1\right)_{60,cs}\right)_i}{23.6}\right)^3 + \left(\frac{\left(\left(N_1\right)_{60,cs}\right)_i}{25.4}\right)^4 - 2.67\right]}{\left(CSR^{site}\right)_i} \tag{44}$$

To solve for the uniform hazard P_L for the soil layer *i*, use the following relationship:

$$\left(P_L\right)_i = \Phi\left[-\frac{\ln\left(\frac{\left(CRR^{site}\right)_i}{\left(CSR^{site}\right)_i}\right)}{\sigma_\varepsilon}\right] = \Phi\left[-\frac{\ln\left(\left(FS_L\right)_i\right)}{\sigma_\varepsilon}\right] \tag{45}$$

Where σ_ε is 0.13 if parametric uncertainty (i.e., uncertainty in measuring $\left(N_1\right)_{60,cs}$ and estimating seismic loading) is neglected, and σ_ε is 0.277 if parametric uncertainty is considered. Because it is impossible to completely eliminate uncertainty when measuring parameters such as $\left(N_1\right)_{60,cs}$ in the field, it is recommended that σ_ε = 0.277.

2.4 Empirical Lateral Spread Displacement Model

The simplified lateral spread displacement model is derived from the widely-used empirical lateral spread model originally presented by Bartlett and Youd (1995). Their model was regressed from a large database of lateral spread case histories from Japan and the western

United States, and a large number of parameters related to soil properties, slope geometry, and level of ground motion were statistically evaluated. Bartlett and Youd identified the parameters that produced the best regression, and from those parameters regressed their original empirical predictive relationship. Youd et al. (2002) later updated their original empirical model by using an expanded and corrected version of the 1995 database. The updated Bartlett and Youd empirical model has since been adopted as the state of practice in much of the world, and it is routinely applied on a wide variety of projects in all types of seismic environments. The Youd et al. (2002) updated empirical model is given as:

$$\begin{aligned}\overline{\log D_H} &= b_0 + b_1 M + b_2 \log R^* + b_3 R + b_4 \log W + b_5 \log S \\ &\quad + b_6 \log T_{15} + b_7 \log\left(100 - F_{15}\right) + b_8 \log\left(D50_{15} + 0.1\right)\end{aligned} \tag{46}$$

where

D_H = median computed permanent lateral spread displacement (m)
M = earthquake moment magnitude
R = the closest horizontal distance from the site to the source (km)
W = the free-face ratio (%)
S = the ground slope (%)
T_{15} = the cumulative thickness (in upper 20 m) of all saturated soil layers with corrected Standard Penetration Test (SPT) blowcounts (i.e., $(N_1)_{60}$) less than 15 blows/foot (m)
F_{15} = the average fines content of the soil comprising T_{15} (%)
$D50_{15}$ = the average mean grain size of the soil comprising T_{15} (mm)

and R* is computed as

$$R^* = R + 10^{0.89M - 5.64} \tag{47}$$

Model coefficients b_0 through b_8 are given in Table 2-2.

Table 2-2 Regression coefficients for the Youd et al. (2002) empirical lateral spread model

Model	b_0	b_1	b_2	b_3	b_4	b_5	b_6	b_7	b_8
Ground slope	-16.213	1.532	-1.406	-0.012	0	0.338	0.540	3.413	-0.795
Free Face	-16.713	1.532	-1.406	-0.012	0.592	0	0.540	3.413	-0.795

2.4.1 Full Performance-based Lateral Spread Model

Kramer et al. (2007) suggested that performance-based estimates of lateral spread displacement could be computed by modifying an empirical lateral spreading model in such a way so as to insert it directly into a probabilistic seismic hazard analysis (PSHA). Such a modification could be performed by separating the model terms associated with seismic loading (i.e. the Loading Parameter, $\mathscr{L}$) from the model terms associated with local site and geometry conditions (i.e. the Site Parameter, $\mathscr{S}$). Therefore, a modified form of any given empirical lateral spread model could be written as:

$$\mathscr{D} = \mathscr{L} - \mathscr{S} + \varepsilon \tag{48}$$

where $\mathscr{D}$ is the transformed (e.g. log, ln, square root) lateral spread displacement, and $\mathscr{L}$, $\mathscr{S}$, and ε represent the apparent loading, site, and uncertainty terms.

Following the Kramer et al. (2007) framework, Franke and Kramer (2014) demonstrated how the Youd et al. (2002) empirical model for lateral spread displacement could be adapted to develop fully probabilistic estimates of lateral spread displacement. The performance-based form of the Youd et al. (2002) was shown to be:

$$\log D_H = \mathscr{L} - \mathscr{S} + \varepsilon \tag{49}$$

where

$$\mathscr{L} = b_1 M + b_2 \log R^* + b_3 R \tag{50}$$

$$\mathscr{S} = -\left(b_0 + b_4 \log W + b_5 \log S + b_6 \log T_{15} + b_7 \log\left(100 - F_{15}\right) + b_8 \log\left(D50_{15} + 0.1\right)\right) \tag{51}$$

$$\varepsilon = \sigma_{\log D_H} \Phi^{-1}\left[P\right] \tag{52}$$

$$\sigma_{\log D_H} = 0.197 \tag{53}$$

If computing the probability of exceeding some given displacement, *d*, Equation (53) can be incorporated as:

$$P\left[D_H > d\right] = 1 - \Phi\left[\frac{\log d - \overline{\log D_H}}{\sigma_{\log D_H}}\right] = 1 - \Phi\left[\frac{\log d - \overline{\log D_H}}{0.197}\right] \tag{54}$$

Because a given site should produce a single value of $\mathscr{S}$ to be used in design, the left side of Equation (49) can be thought of as a simple linear function of $\mathscr{L}$ with a constant y-intercept equal to $\mathscr{S}$ and a data spread characterized by ε, as shown in Figure 2-5. Because $\mathscr{S}$ is considered a constant value in the performance-based analysis, multiple lateral spread hazard curves could be developed for a site for different values of $\mathscr{S}$ (Figure 2-6). Thus, the effect of varying site and/or geometry conditions when computing probabilistic lateral spread displacements could be evaluated.

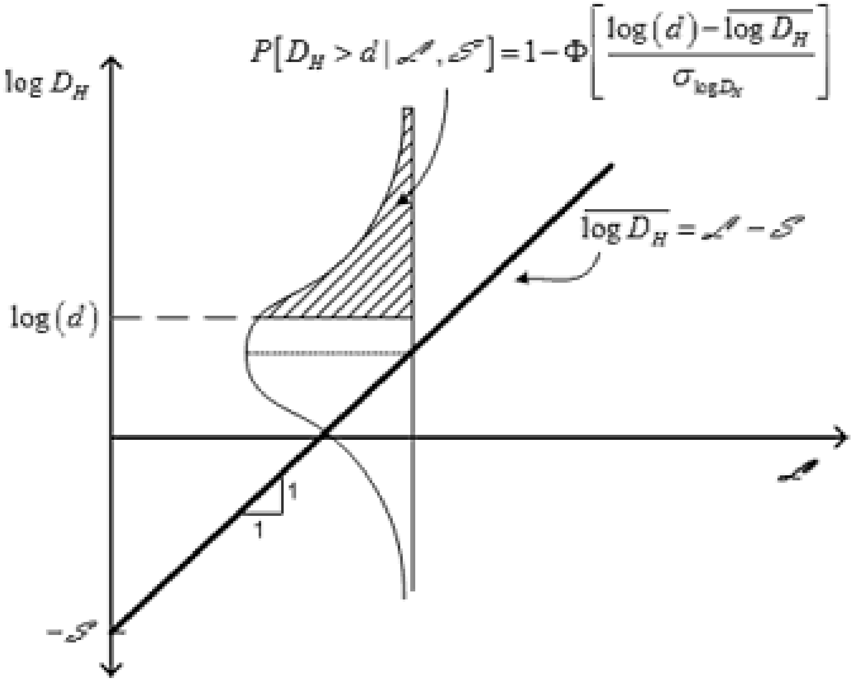


Figure 2-5 Schematic diagram of the fully probabilistic lateral spread model with Youd et al. (2002) (after Franke and Kramer 2014)

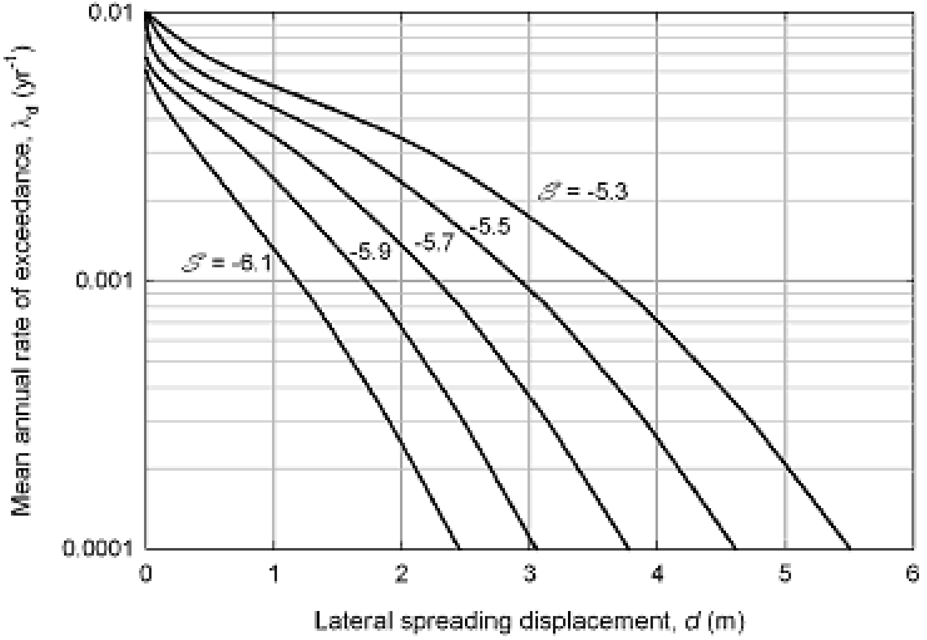


Figure 2-6 Variations of lateral spread hazard curves as a function of the site term, $\mathscr{S}$ (after Kramer et al. 2007)

Though it is not an actual or measurable ground motion parameter, the apparent loading parameter in Equation (50) is a function of magnitude and distance and attenuates in a manner similar to measurable ground motion intensity measures described by traditional Ground Motion Prediction Equations (GMPEs). In the context of the Youd et al. (2002) model, the apparent loading term, therefore, acts in a manner analogous to an Intensity Measure (*IM)*, the variation of whose median value with *M* and *R* is described by Equation (50).

By incorporating Equations (50) and (51) into the probabilistic framework presented in Equation (54) and assigning all of the uncertainty in the Youd et al. (2002) model to the conditional displacement calculation, a performance-based model can be expressed in terms of lateral spread displacement conditional upon the site parameter as:

$$\lambda_{D_H|\mathscr{S}}(d\,|\,\mathscr{S}) = \sum_{i=1}^{N_{\mathscr{L}}} P\left[D_H > d\,|\,\mathscr{S},\mathscr{L}_i\right]\Delta\lambda_{\mathscr{L}_i} \tag{55}$$

where $\lambda_{D_H|\mathscr{S}}(d\,|\,\mathscr{S})$ is the mean annual rate of exceeding a displacement d conditional upon site conditions S, $N_{\mathscr{L}}$ is the number of loading parameter increments required to span the range of possible $\mathscr{L}$ values, and $\Delta\lambda_{\mathscr{L}_i}$ is the increment of the apparent loading parameter in hazard space. For a single source, Equation (55) can also be written as:

$$\lambda_{D_H|\mathscr{S}}\left(d\,|\,\mathscr{S}\right)=\nu\sum_{i=1}^{N_{\mathscr{L}}}P\left[D_H>d\,|\,\mathscr{S},\mathscr{L}_i\right]P\left[\mathscr{L}_i\right] \tag{56}$$

where ν is the mean annual rate of exceeding a minimum magnitude of interest for a given seismic source. Because the loading parameter is a function of magnitude and distance (which are commonly assumed to be independent in PSHA work) and can be affected by multiple seismic sources, Equation (56) can be rewritten as:

$$\lambda_{D_H|\mathscr{S}}\left(d\,|\,\mathscr{S}\right)=\sum_{i=1}^{N_S}\nu_i\sum_{j=1}^{N_M}\sum_{k=1}^{N_R}P\left[D_H>d\,|\,\mathscr{S},M=m_j,R=r_k\right]P\left[M=m_j,R=r_k\right] \tag{57}$$

which is very similar to the PSHA framework commonly used to compute uniform hazard estimates of ground motions. Therefore, Equations (49) through (54) can be incorporated into common seismic hazard analysis software such as *EZ-FRISK* or *OpenSHA* to develop uniform hazard estimates of lateral spread displacement and displacement hazard curves.

2.4.2 Simplified Performance-based Lateral Spread Model

If a generic reference site is used to compute $\mathscr{S}$, then a series of performance-based lateral spread analyses could be performed across a grid to develop contour maps of lateral spread displacement corresponding to various return periods of interest. These maps are called lateral spread reference maps. For example, a reference site for the derivation of the simplified performance-based lateral spread procedure is presented in Figure 2-7. This profile was chosen based on the profile used to develop the full performance-based method to be consistent. Values of 3.0m, 20%, and 0.2mm are computed for the lateral spread parameters T_{15}, F_{15}, and $D50_{15}$, respectively. As shown in Figure 2-7, the geometry of the site constitutes a ground slope condition with ground slope (i.e. S) equal to 1%. The resulting value of $\mathscr{S}$ for the reference site, as computed from Equation (51), is therefore equal to 9.043.

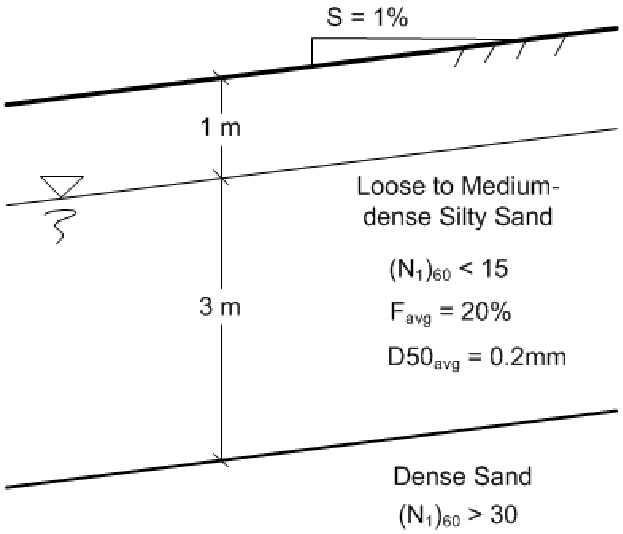


Figure 2-7 Reference soil profile used to derive the simplified performance-based lateral spread approximation

The lateral spread displacement corresponding to the generic reference site could therefore be obtained from the appropriate map and adjusted in order to provide site-specific lateral spread displacements corresponding to the desired return period. The equation for this site-specific adjustment is given as:

$$\left[\log D_H\right]^{site} = \left[\log D_H\right]^{ref} + \Delta D_H \tag{58}$$

where $\left[\log D_H\right]^{site}$ is the logarithm of the lateral spread displacement adjusted for site-specific conditions, $\left[\log D_H\right]^{ref}$ is the logarithm of the lateral spread displacement corresponding to the reference site (obtained from the map), and ΔD_H is the adjustment factor computed by the engineer. By substituting Equation (49) into Equation (58), the adjustment factor can be written as:

$$\Delta D_H = \left(\mathscr{L} - \mathscr{S}\right)^{site} - \left(\mathscr{L} - \mathscr{S}\right)^{ref} = \left(\mathscr{L}^{site} - \mathscr{L}^{ref}\right) + \left(\mathscr{S}^{ref} - \mathscr{S}^{site}\right) \tag{59}$$

However, because $\mathscr{L}^{site} = \mathscr{L}^{ref}$, Equation (59) can be simplified as:

$$\Delta D_H = \mathscr{S}^{ref} - \mathscr{S}^{site} \tag{60}$$

If Equation (51) is substituted for $\mathscr{S}$, then Equation (60) can be rewritten as:

$$\begin{aligned}\Delta D_H = &-\left[b_0 + b_4 \log W + b_5 \log S + b_6 \log T_{15} + b_7 \log\left(100 - F_{15}\right) + b_8 \log\left(D50_{15} + 0.1\right)\right]^{ref} \\ &+\left[b_0 + b_4 \log W + b_5 \log S + b_6 \log T_{15} + b_7 \log\left(100 - F_{15}\right) + b_8 \log\left(D50_{15} + 0.1\right)\right]^{site}\end{aligned} \tag{61}$$

By simplifying Equation (61) and inserting model coefficients and parameters for the reference site, the adjustment factor can be computed as:

$$\begin{aligned}\Delta D_H = &\; b_0^{site} + b_4^{site} \log\left(W^{site}\right) + b_5^{site} \log\left(S^{site}\right) + 0.540 \log\left(\frac{T_{15}^{site}}{3}\right) \\ &+3.413 \log\left(\frac{100 - F_{15}^{site}}{80}\right) - 0.795 \log\left(\frac{D50_{15}^{site} + 0.1}{0.3}\right) + 16.213\end{aligned} \tag{62}$$

where b_4^{site} and b_5^{site} denote site-specific geometry coefficients dependent on the geometry model (i.e. ground slope or free-face) and are provided in Table 2-3. Parameters with the '*site*' superscript denote site-specific soil and geometry parameters determined from the site-specific soil information provided by the engineer.

Table 2-3 Site-specific geometry coefficients for computing the adjustment factor, ΔD_H

Model	b_0^{site}	b_4^{site}	b_5^{site}
Ground Slope	-16.213	0	0.338
Free Face	-16.713	0.592	0

Once the reference lateral spread displacement is obtained from the appropriate (i.e. hazard-targeted) map and the adjustment factor is computed using Equation (62) and Table 2-3, the site-specific hazard-targeted lateral spread displacement (in meters) can be computed as:

$$D_H^{site} = 10^{\left(\left[\log D_H\right]^{ref} + \Delta D_H\right)} \tag{63}$$

2.5 Performance-Based Post-liquefaction Free-field Settlement Models

This section will provide a brief overview of the Cetin et al. (2009) and Ishihara and Yoshimine (1992) post-liquefaction free-field settlement models and how they fit into the PEER performance-based earthquake engineering framework.

2.5.1 Cetin et al. (2009) Settlement Model

The Cetin et al (2009) method involves creating hazard curves of strain and, subsequently, settlement for each sublayer in a soil profile. Mayfield et al. (2010) demonstrated the relationship between the cyclic stress ratio, *CSR* and the minimum SPT resistance required to resist liquefaction triggering, N_{req} as:

$$CSR = CRR(N_{req}) \tag{64}$$

where CRR is the cyclic resistance ratio (i.e., the soil's resistance to liquefaction triggering). Mayfield (2010) further showed that the CRR for a given soil layer could be computed with the Cetin et al. (2004) probabilistic liquefaction triggering model as:

$$CRR = \exp\left[\frac{N_{req}^{Cetin} - 29.06\ln M_w - 3.82\ln\left(\frac{\sigma_{vo}^{'}}{p_a}\right) + 15.25 + \sigma_e \Phi^{-1}\left(P_L\right)}{13.79}\right] \tag{65}$$

where N_{req}^{Cetin} is the N_{req} according to the Cetin et al. (2004) probabilistic liquefaction triggering curves, M_w is earthquake moment magnitude, $\sigma_{vo}^{'}$ is initial vertical effective stress, p_a is atmospheric pressure (in same units as $\sigma_{vo}^{'}$), σ_e is the estimated model and parameter uncertainty (standard deviation), and $\Phi^{-1}\left(P_L\right)$ is the inverse standard cumulative normal distribution of the probability of liquefaction (P_L). Cetin et al. (2004) used the simplifying assumptions of M_w = 7.5, $\sigma_{vo}^{'}$ = 1 atm. If these assumptions are combined with the assumption that P_L = 50% (focusing solely on the median liquefaction triggering curve), then Equation (65) can be simplified as:

$$CRR = \exp\left[\frac{N_{req}^{Cetin} - 29.06 * \ln(7.5) + 15.25}{13.79}\right] \tag{66}$$

Cetin et al (2004) showed that if parametric uncertainty is excluded, the coefficients 29.06, 15.25, and 13.79 change to 29.53, 16.85, and 13.32, respectively.

Cetin et al. (2009) also observed that effects from multi-directional shaking have a significant impact on the observed post-liquefaction volumetric strains. Cetin et al. (2009) computed the equivalent *CSR* at 20 cycles of one-dimensional direct simple shear loading at 1.0 atmosphere of confining stress, $CSR_{SS,20,1D,1atm}$ as:

$$CSR_{SS,20,1D,1atm} = \frac{CSR_{field}}{K_{md} K_{M_w} K_{\sigma}} \tag{67}$$

where CSR_{field} is the *CSR* computed in Equation (68), K_{md} is the correction factor to convert the multidirectionally applied CSR_{field} value to the value of a unidirectionally applied laboratory *CSR*, K_{M_w} is the correction factor to convert the *CSR* to a value corresponding to a M_w = 7.5 earthquake, and K_{σ} is the correction factor used to account for the nonlinear increase in cyclic resistance to shear stresses with increasing confining effective stresses. Because the assumptions M_w = 7.5 and $\sigma_{vo}^{'}$ = 1 atm were already used in computing N_{req}^{Cetin}, Equation (67) can be simplified as:

$$CSR_{SS,20,1D,1atm} = \frac{CSR_{field}}{K_{md}} \tag{69}$$

$$K_{md} = 0.361 \cdot \ln(D_R) - 0.579 \tag{70}$$

where D_R is the relative density (in percent) of the soil layer. D_R is often approximated as:

$$D_R\left(\%\right) \approx \sqrt{\frac{\left(N_1\right)_{60,CS}}{60}} \tag{71}$$

Once the $CSR_{SS,20,1D,1atm}$ values for each N_{req} have been obtained for each sublayer in the soil profile, the strain hazard curves for each sublayer can be calculated.

The methodology used to compute the strain hazard curves is that of the PEER framework, which computes the mean annual rate of exceeding some engineering design parameter (EDP) given some intensity measure(s) (IM). Kramer et al (2014) showed that the mean annual rate of exceeding some engineering demand parameter, *edp* as a function of intensity measure, *im* is given as:

$$\lambda_{edp} = \sum_{i=1}^{N_{IM}} P\left[EDP > edp \middle| IM = im_i\right] \Delta\lambda_{IM}(im_i) \tag{72}$$

Kramer et al (2008) and Kramer et al (2014) demonstrated that applying Equation (72) to the analysis of liquefaction-induced settlement yields:

$$\lambda_{\varepsilon_{vi}} = \sum_{m=1}^{N_{CSR}} P\left[\varepsilon_{vi} > \varepsilon_{vi}^* \middle| CSR_i, N_i\right] \Delta\lambda_{CSR} \tag{73}$$

where ε_{vi} is the strain of a given sublayer, CSR_i is the $CSR_{SS,20,1D,1atm}$ computed in Equation (69), N_i is the $N_{1,60,CS}$ computed from the blow count of a standard penetration test (SPT), and $\Delta\lambda_{CSR}$ is the incremental joint mean annual rate of exceedance for the given CSR. Furthermore, Kramer et al (2008) and Kramer et al (2014) explained that:

$$P\left[\varepsilon_v > \varepsilon_v^* \middle| CSR, N\right] = \Phi\left[\frac{\mu_{\ln \varepsilon_v} - \ln \varepsilon_v^*}{\sigma_{\ln \varepsilon_v}}\right] \tag{74}$$

where $\Phi(\cdot)$ is the standard normal cumulative distribution function, $\mu_{\ln \varepsilon_v}$ is the mean computed value of $\ln \varepsilon_v$, and $\sigma_{\ln \varepsilon_v}$ is the standard deviation of the probability function which was found to be 0.61 by Cetin et al (2009). Cetin et al (2009) showed that the mean value of $\ln \varepsilon_v$ can be computed as:

$$\varepsilon_v = \frac{\left[1.879 \ln\left[\frac{780.416 \ln(CSR_{SS,20,1D,1atm}) - N_{1,60,CS} + 2,442.465}{636.613 N_{1,60,CS} + 306.732}\right] + 5.583\right]}{100} \tag{75}$$

$$\lim: 5 \le N_{1,60,CS} \le 40, \quad 0.05 \le \mathrm{CSR}_{SS,20,1D,1atm} \le 0.60$$

By repeating Equations (73) and (74) for a wide range of strain values, a hazard curve of free-field post-liquefaction volumetric strains can be developed for each soil sublayer.

The strains computed in Equation (75) do not consider the uncertainty in the soil response, (i.e. the likelihood that the soil will liquefy given some level of ground shaking). This uncertainty is represented by the probability of liquefaction (P_L). which was shown by Ulmer et al (2015) to be computed as:

$$P_L = \Phi\left[-\frac{N_{site} - N_{req}}{4.21}\right] \tag{76}$$

If parametric uncertainty is ignored, the denominator of Equation (76) becomes 2.7. To account for P_L, the mean value of $\ln \varepsilon_v$ computed in Equation (75) is multiplied by the P_L computed in Equation (76).

Kramer et al (2008) explained that direct computation of volumetric strain distributions from any volumetric strain relationship has been found to produce significant probabilities of unrealistically large strain values, thus causing the assumption of log-normally distributed volumetric strains. For low values of $N_{1,60,\mathrm{CS}}$, the slope of the lognormal function increased dramatically, resulting in infinitely increasing values of strain with decreasing values of $N_{1,60,\mathrm{CS}}$. Extensive experimentation, however, has shown that soil has a limited ability to densify, and must be governed by some limiting maximum volumetric strain. Huang (2008) performed a study to find the maximum limiting value of vertical strain using the deterministic soil models of Tokimatsu and Seed (1987), Ishihara and Yoshimine (1992), Shamoto et al (1998), and Wu and Seed (2004). A weighted average of the four relationships was used to create a recommended relationship for the estimated mean limiting volumetric strain as shown in Figure 2-8.

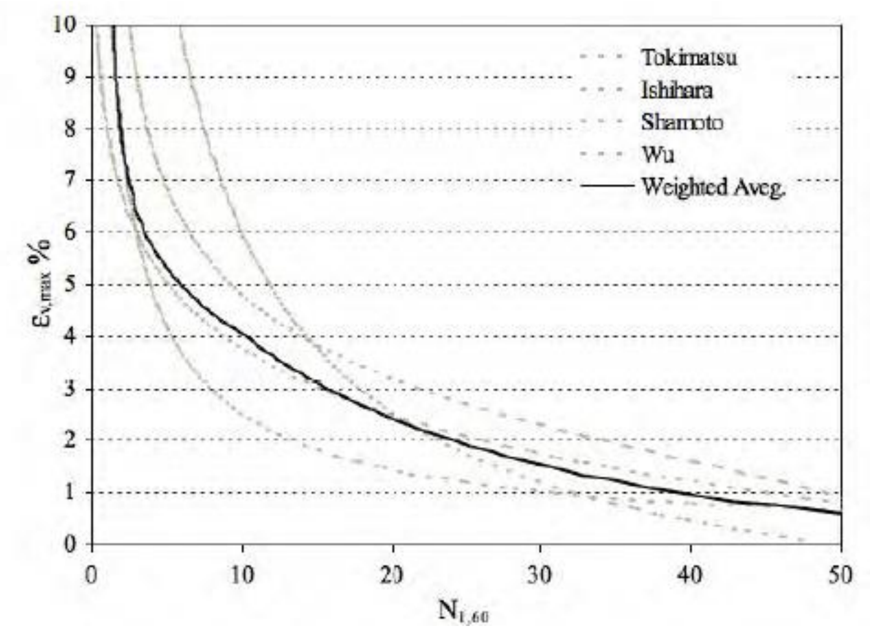


Figure 2-8 Mean limiting strain relationship derived from deterministic vertical strain models (after Huang, 2008)

The relationship for the recommended mean limiting volumetric strain shown in Figure 2-8 can be approximated as:

$$\bar{\varepsilon}_{v,\max}(\%) = 9.2081 - 2.24\ln\left[(N_1)_{60,CS}\right] \tag{77}$$

The approximation found in Equation (77) was used for this study. Huang (2008) suggested that, because the maximum strain relationship is approximate, $\bar{\varepsilon}_{v,\max}$ be uniformly distributed over a range of 0.5*$\bar{\varepsilon}_{v,\max}$ to 1.5*$\bar{\varepsilon}_{v,\max}$. In this study, $\bar{\varepsilon}_{v,\max}$ was distributed uniformly over this recommended range using increments of 0.02*$\bar{\varepsilon}_{v,\max}$.

Once the hazard curves were computed and weighted according to the recommendations of Huang (2008), settlement hazard curves were computed. The details of the settlement computation will be provided later in this section.

2.5.2 Ishihara and Yoshimine (1992) Settlement Model

The Ishihara and Yoshimine (1992) method is similar to the Cetin et al (2009) method, except that instead of computing strains as a function of CSR, strains are computed as a function of the factor of safety against liquefaction (FS$_L$). Hazard curves of strain and settlement are computed for each sublayer in a soil profile. The FS$_L$ is computed for Boulanger and Idriss (2012) N_{req} values from 1 to 49 using the following relationship provided by Ulmer et al (2015):

$$FS_L = \exp\left[\begin{array}{l}\left(\frac{N_{1,60,CS} - N_{req}}{14.1}\right) + \left(\frac{N_{1,60,CS}{}^2 - N_{req}{}^2}{126^2}\right) - \left(\frac{N_{1,60,CS}{}^3 - N_{req}{}^3}{23.6^3}\right) \\ + \left(\frac{N_{1,60,CS}{}^4 - N_{req}{}^4}{25.4^4}\right)\end{array}\right] \tag{78}$$

Once the FS_{liq} values for each N_{req} have been obtained for each sublayer in the soil profile, the strain hazard curves for each sublayer can be computed. This is done using the PEER framework as explained in the Cetin et al (2009) method. Equation (73) can be adjusted to account for the change in intensity measure (from CSR to FS_{liq}) as expressed by:

$$\lambda_{\varepsilon_{vi}} = \sum_{m=1}^{N_{FS_{liq}}} P\left[\varepsilon_{vi} > \varepsilon_{vi}^{*} \middle| FS_{L_i}, N_i\right] \Delta\Lambda_{FS_L} \tag{79}$$

Equation (74) is utilized again, with $\sigma_{\ln\varepsilon_v}$ = 1.12. Idriss and Boulanger (2008) approximate Ishihara and Yoshimine (1992) volumetric strain curves as:

$$\varepsilon_v = 1.5 \cdot \exp\left(-0.369\sqrt{(N_1)_{60,CS}}\right) \cdot \min\left(0.08, \gamma_{\max}\right) \tag{80}$$

where $\min(\cdot)$ signifies the use of the minimum value found within the parenthesis, and $\gamma_{\max}$ is the limiting shear strain and is computed as:

$$\gamma_{\max} = 0 \text{ if } FS_L \geq 2 \tag{81}$$

$$\gamma_{\max} = \min\left(\gamma_{\lim}, 0.035(2\text{-}FS_L)\left(\frac{1\text{-F}_\alpha}{FS_L\text{-F}_\alpha}\right)\right) \quad \text{if } 2 > FS_L > \text{F}_\alpha \tag{82}$$

$$\gamma_{\max} = \gamma_{\lim} \text{ if } \text{FS}_L \leq \text{F}_\alpha \tag{83}$$

where $\gamma_{\lim}$ is computed as:

$$\gamma_{\lim} = 1.859\left(1.1 - \sqrt{\frac{N_{1,60,CS}}{46}}\right)^3 \geq 0 \tag{84}$$

and F_α is computed as:

$$F_\alpha = .032 + 4.7D_R - 6.0(D_R)^2 \tag{85}$$

where D_R is the relative density of the soil sublayer as a decimal.

It should be mentioned that the strains computed in Equation (80) do not consider the likelihood of liquefaction occurring, or P_L. To account for P_L, the following equation can be applied as demonstrated by Ulmer et al (2015):

$$P_L = \Phi\left[\ln\left(FS_L^{-3.61}\right)\right] \tag{86}$$

where FS_L is computed with the Boulanger and Idriss (2012) probabilistic liquefaction triggering curves. If parametric uncertainty is ignored in the Boulanger and Idriss (2012) model, then the exponent in Equation (86) becomes -7.69. To account for P_L, the mean value of $\ln \varepsilon_v$ computed in Equation (80) is multiplied by the P_L computed in Equation (86).

The maximum strain considerations introduced by Huang (2008) are also considered with the Ishihara and Yoshimine (1992) model, with $\bar{\varepsilon}_{v,\max}$ uniformly distributed over a range of 0.5* $\bar{\varepsilon}_{v,\max}$ to 1.5* $\bar{\varepsilon}_{v,\max}$.

2.5.3 Settlement Computation

The method proposed by Cetin et al. (2009) to compute the settlement from the strain hazard curves introduced an equivalent strain for the entire soil profile, defined as

$$\varepsilon_{v,\mathrm{eqv.}} = \frac{\sum(\varepsilon_{v,i} \cdot t_i \cdot DF_i)}{\sum(t_i \cdot DF_i)} \tag{87}$$

where $\varepsilon_{v,eqv.}$ is the equivalent strain for the soil profile; $\varepsilon_{v,i}$ is the strain for a given sublayer in the soil profile; t_i is the thickness of the given susceptible sublayer; and DF_i is the depth weighting factor of the given soil sublayer and is computed as:

$$DF_i = 1 - \frac{d_i}{18m} \tag{88}$$

where d_i is the depth of the given sublayer in meters. Because settlement is a function of strain, depth, and thickness of the soil layer, it is compatible with the Cetin et al. (2009) and Ishihara and Yoshimine (1992) models. The settlement for the soil profile is then computed as:

$$s_{profile} = \phi \cdot \varepsilon_{v,eqv.} \sum t_i \tag{89}$$

where $s_{profile}$ is the computed settlement for the soil profile and ϕ is a calibration factor for observed post-liquefaction case histories and is equal to 0.9 for the Ishihara and Yoshimine (1992) model and 1.15 for the Cetin et al. model (Cetin et al. 2009).

2.6 Simplified Post-liquefaction Free-field Settlement Models

The performance-based approximation of vertical strains in a soil layer summarized in Sections 2.5.1 and 2.5.2 is an effective solution to mitigating the deficiencies introduced by the conventional (i.e. "pseudo-probabilistic") approximation of vertical strains, which utilizes probabilistic ground motions to estimate vertical strains in a deterministic manner. Unfortunately, the performance-based approach is complex and difficult for many engineers to use in a practical manner. Specialized computational tools such as *PBliquefY* (Franke et al. 2014c) have been developed to aid in the implementation of the performance-based procedure; however, performing a performance-based analysis may still not be practical for professionals who routinely need to perform and/or validate vertical strain hazard calculations in a rapid and efficient manner.

An ideal solution to this dilemma would be the introduction of a new liquefaction analysis procedure that combined the simplicity and user-friendliness of traditional liquefaction hazard maps with the flexibility and power of a site-specific performance-based liquefaction triggering analysis. Mayfield et al. (2010) developed a simplified, map-based procedure that could be used to approximate performance-based liquefaction triggering using the Cetin et al. (2004) liquefaction triggering model. Franke et al. (2014d) then refined the Mayfield et al. simplified procedure for easier implementation in seismic codes and provisions.

Mayfield et al. (2010) introduced the idea, using the Cetin et al. (2004) liquefaction model, that probabilistic approximations of SPT resistance required to resist liquefaction can be computed for a *reference* soil profile (see Figure 2-9) across a grid of geographic locations to develop contour plots called liquefaction parameter maps. These liquefaction parameter maps serve as a proxy for the seismic loading that affects liquefaction triggering and that can be expected for a given return period. Since site-specific soil conditions are most likely different from the reference profile, Mayfield et al. demonstrated how the mapped reference parameter values could be adjusted for site-specific conditions.

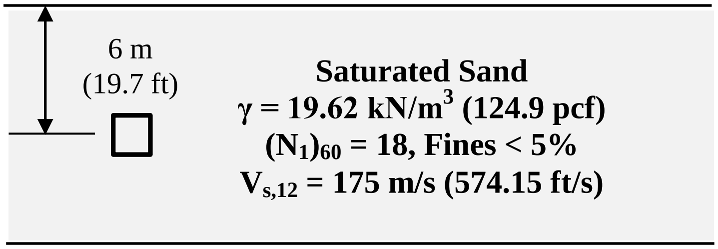


Figure 2-9 Reference soil profile used to develop liquefaction loading maps in the proposed simplified uniform hazard liquefaction procedure

In a similar manner to the Mayfield et al. (2010) liquefaction triggering procedure, vertical strains for a *reference* profile can be probabilistically computed across a grid of geographic locations. The calculated reference strains, ε_v^{ref} , will be an indication of ground motions; however, they will need to be adjusted for site-specific conditions. A detailed derivation of the vertical strain correction, both for the Ishihara and Yoshimine (1992) and Cetin et al. (2009) vertical strain models, will be given.

The simplified performance-based post-liquefaction settlement procedure using the Ishihara and Yoshimine (1992) strain model builds upon the recently developed simplified performance-based liquefaction triggering procedure in that it requires both the CSR^{ref} and CSR^{site} from the Boulanger and Idriss (2012) triggering model. Similarly, the simplified post-liquefaction settlement procedure using the Cetin et al. (2009) strain model will require both N_{req}^{ref} and N_{req}^{site} obtained from the simplified performance-based liquefaction triggering procedure using the Cetin et al. (2004) triggering model. The Year 1 Final Report of this study included the derivation of the simplified performance-based liquefaction triggering procedure using the Boulanger and Idriss (2012) model. Please refer to Mayfield et al. (2010) for clarification on the simplified performance-based liquefaction triggering procedure using the Cetin et al. (2004) model.

2.6.1 Site-Specific Correction for Reference Strain using the Cetin et al. (2009) Model

Because ε_v^{ref} was developed using the reference soil profile, it must be corrected for site-specific soil conditions and depths to be used in computing site-specific uniform hazard values of

ε_v^{site}. If ε_v^{site} represents the site-specific uniform hazard value of vertical strain for a particular soil layer, then ε_v^{ref} and ε_v^{site} can be related as:

$$\ln(\varepsilon_{v,approx}^{site} + 0.01) = \ln(\varepsilon_{v,approx}^{ref} + 0.01) \cdot \Delta\varepsilon \tag{90}$$

where $\Delta\varepsilon$ is a site-specific correction factor. A value of 0.01 was added to both ε_v^{site} and ε_v^{ref} to prevent a value of zero from occurring in the natural log operators. Rearranging Equation (90), we can solve for the correction factor $\Delta\varepsilon$ as:

$$\Delta\varepsilon = \frac{\ln(\varepsilon_{v,approx}^{site} + 0.01)}{\ln(\varepsilon_{v,approx}^{ref} + 0.01)} \tag{91}$$

Thus, the strain correction factor for a given soil sublayer can be estimated if values of ε_v^{ref} and ε_v^{site} are approximated from the reference soil information and the actual soil sublayer information, respectively. Using the knowledge and assumptions presented in Equations (67), (69), (70), and (75), and by treating the reference soil profile shown in Figure 2-9 as a single soil layer (i.e., $i = 1$), ε_v^{ref} can be approximated using the Cetin et al. (2009) post-liquefaction volumetric strain model at a given return period as:

$$\varepsilon_{v,approx}^{ref} \approx 0.01 \cdot \left[1.879 \cdot \left[\frac{780.416 \cdot \ln\left(\frac{CRR(N_{req}^{ref})}{0.866} \right) + 2424.465}{11,765.766} \right] + 5.583 \right] \cdot \left[\Phi\left(-\frac{18 - N_{req}^{ref}}{4.21} \right) \right] \tag{92}$$

where N_{req}^{ref} is the minimum SPT resistance value pertaining to the Cetin et al. (2004) triggering model required to resist liquefaction in the reference soil sublayer shown in Figure 2-9, and is obtained from the appropriate liquefaction parameter map at the desired return period. Note that Equation (92) also assumes the incorporation of P_L in the computation of volumetric strains.

$\varepsilon_{v,approx}^{site}$ is approximated in a similar manner to $\varepsilon_{v,approx}^{ref}$ using the Cetin et al. (2009) strain model:

$$\varepsilon_{v,approx}^{site} \approx 0.01 \cdot \left[1.879 \cdot \left[\frac{780.416 \cdot \ln\left(\dfrac{CRR(N_{req}^{site})}{0.361 \cdot \ln\left(D_R^{site}\right) - 0.579} \right) - \left(N_1\right)_{60,CS}^{site} + 2442.465}{636.613 \cdot \left(N_1\right)_{60,CS}^{site} + 306.732} \right] + 5.583 \right] \cdot \left[\Phi\left(-\frac{\left(N_1\right)_{60,CS}^{site} - N_{req}^{site}}{4.21} \right) \right] \tag{93}$$

where N_{req}^{site} is the site-specific minimum SPT resistance required to prevent liquefaction triggering using the Cetin et al. (2004) model, as computed using the simplified performance-based liquefaction triggering procedure (see Year 1 Final Report); $\left(N_1\right)_{60,CS}^{site}$ is the site-specific, clean sand-equivalent SPT resistance for the soil sublayer of interest; and D_R^{site} is the corresponding site-specific relative density of the soil sublayer of interest (in percent) and is calculated from Equation (71).

Once the correction factor for a given soil sublayer is computed using Equations (91) through (93), site-specific adjusted strains can be computed for a given soil sublayer as:

$$\varepsilon_v^{site} = \exp\left[\Delta\varepsilon \cdot \ln\left(\varepsilon_v^{ref} + 0.01 \right) \right] - 0.01 \tag{94}$$

where ε_v^{ref} is the reference adjusted strain obtained from the appropriate Cetin post-liquefaction settlement parameter map at a return period of interest.

Due to the non-linearity of the model, a calibration equation was developed to correct the bias. The final simplified site strain can be calculated as:

$$\varepsilon_{v,calibrated}^{site} = 6.6896 \cdot \left(\varepsilon_v^{site} \right)^2 + 0.8833 \cdot \varepsilon_v^{site} \tag{95}$$

where ε_v^{site} is the site strain as calculated in equation (94). Once $\varepsilon_{v,calibrated}^{site}$ has been computed, equations (87) and (89) may be applied to obtain the equivalent strain and settlement for the entire profile.

2.6.2 Site-Specific Correction for Reference Strain using the Ishihara and Yoshimine (1992) Model

The framework presented in Section 2.6.1 can also be applied to the Ishihara and Yoshimine (1992) settlement model. We can use Equation (90) to again define the correction factor, $\Delta\varepsilon$.

If the reference soil profile is treated as a single layer (i.e., $i=1$), then the adjusted reference strain using the Ishihara and Yoshimine (1992) model as demonstrated by Idriss and Boulanger (2008) and later calibrated to observed post-liquefaction settlement case histories by Cetin et al. (2009) can be approximated as:

$$\varepsilon_{v,approx}^{ref} \approx \left[0.3135 \cdot \min\begin{bmatrix} 0.08 \\ \gamma_{\max}^{ref} \end{bmatrix} \right] \cdot \Phi\left[\ln\left(FS_L^{ref\,-3.61} \right) \right] \tag{96}$$

where FS_L^{ref} is the factor of safety against liquefaction triggering for the reference soil sublayer at the return period of interest using the Boulanger and Idriss (2012) model with the simplified performance-based liquefaction triggering procedure (see Year 1 Final Report); and where $\gamma_{\max}^{ref}$ is the limiting shear strain for the reference soil sublayer and is computed as:

$$\gamma_{\max}^{ref} = 0 \;\text{ if }\; \mathrm{FS}_{liq}^{ref} \;\geq\; 2 \tag{97}$$

$$\gamma_{\max}^{ref} = \min\begin{pmatrix} \gamma_{\lim}^{ref} \\ 0.035(2 - FS_L^{ref})\left(\dfrac{0.3806}{FS_L^{ref} - 0.6194} \right) \end{pmatrix} \quad \text{if } 2 > FS_L^{ref} > 0.6194 \tag{98}$$

and where $\gamma_{\lim}^{ref}$ is computed as:

$$\gamma_{\max}^{ref} = 0.1985 \;\text{ if }\; \mathrm{FS}_L^{ref} \;\leq\; 0.6194 \tag{99}$$

$$\gamma_{\lim}^{ref} = 1.859\left(1.1 - \sqrt{\frac{\left(N_1\right)_{60,CS}^{ref}}{46}}\right)^3 \geq 0 \quad \text{if } FS_L^{ref} > 0.6194 \tag{100}$$

The site-specific adjusted strain for a given soil sublayer $\varepsilon_{v,approx}^{site}$ can be approximated using the Ishihara and Yoshimine (1992) model as:

$$\varepsilon_{v,approx}^{site} \approx \left[1.5 \cdot \exp\left[-0.369 \cdot \sqrt{\left(N_1\right)_{60,CS}^{site}}\right] \cdot \min\left[\begin{matrix} 0.08 \\ \gamma_{\max}^{site} \end{matrix}\right]\right] \cdot \Phi\left[\ln\left(FS_L^{site-3.61}\right)\right] \tag{101}$$

where $\left(N_1\right)_{60,CS}^{site}$ is the Idriss and Boulanger (2008) clean sand-equivalent SPT resistance value for the soil sublayer of interest; FS_L^{site} is the site-specific factor of safety against liquefaction triggering for the soil sublayer of interest at the return period of interest from the simplified performance-based liquefaction triggering procedure; $\gamma_{\max}^{site}$ is the site-specific limiting shear strain for the soil sublayer and is computed as:

$$\gamma_{\max}^{site} = 0 \quad \text{if } FS_L^{site} \geq 2 \tag{102}$$

$$\gamma_{\max}^{site} = \min\begin{pmatrix} \gamma_{\lim}^{site} \\ 0.035(2 - FS_L^{site})\left(\dfrac{1 - F_\alpha^{site}}{FS_L^{site} - F_\alpha^{site}}\right) \end{pmatrix} \quad if \;\; 2 > FS_L^{site} > F_\alpha^{site} \tag{103}$$

$$\gamma_{\max}^{site} = \gamma_{\lim}^{site} \quad \text{if } FS_L^{site} \leq F_\alpha^{site} \tag{104}$$

where $\gamma_{\lim}^{site}$ is computed as:

$$\gamma_{\lim}^{site} = 1.859\left(1.1 - \sqrt{\frac{\left(N_1\right)_{60,CS}^{site}}{46}}\right)^3 \geq 0 \tag{105}$$

and F_α^{site} is a limiting factor of safety computed as:

$$F_\alpha^{site} = 0.032 + 0.69\sqrt{\left(N_1\right)_{60,CS}^{site}} - 0.13\left(N_1\right)_{60,CS}^{site} \tag{106}$$

The correction factor $\Delta\varepsilon$ for a given soil sublayer using the Ishihara and Yoshimine (1992) model can then be computed as:

$$\Delta\varepsilon = \frac{\ln\left(\varepsilon_{v,approx}^{site} + 0.01\right)}{\ln\left(\varepsilon_{v,approx}^{ref} + 0.01\right)} \tag{107}$$

where $\varepsilon_{v,approx}^{ref}$ and $\varepsilon_{v,approx}^{site}$ are approximated at the return period of interest using Equations (96) and (101), respectively.

Once $\Delta\varepsilon$ has been computed for the desired soil sublayer, the site-specific, adjusted post-liquefaction volumetric strain for the soil sublayer can be computed as:

$$\varepsilon_{v}^{site} = \exp\left[\Delta\varepsilon \cdot \ln\left(\varepsilon_{v}^{ref} + 0.01\right)\right] - 0.01 \tag{108}$$

where ε_{v}^{ref} is the reference volumetric strain obtained from the appropriate Ishihara and Yoshimine settlement parameter map at the desired return period.

Again, due to the non-linearity of the model, a calibration equation was developed for the Ishihara and Yoshimine strain:

$$\varepsilon_{v,calibrated}^{site} = -142.91 \cdot \left(\varepsilon_{v}^{site}\right)^{3} + 16.3285 \cdot \left(\varepsilon_{v}^{site}\right)^{2} + 0.6802 \cdot \varepsilon_{v}^{site} \tag{109}$$

Equations (87) and (89) from section 2.5.3 can then be applied to $\varepsilon_{v,calibrated}^{site}$ to obtain equivalent strain and settlement, respectively.

2.6.3 Simplified Strain Summary

The simplified method consists of obtaining a reference strain value from a liquefaction parameter map. The reference strains are calculated for the reference profile using the full performance-based methodology. The obtained reference strain value must then be corrected for site-specific conditions using the equations presented in section 2.6.1 if using the Cetin et al. (2009) model and section 2.6.2 if using the Ishihara and Yoshimine (1992) model.

2.7 Performance-Based Newmark Seismic Slope Displacement Models

Probabilistic assessment of earthquake-induced sliding displacements of natural slopes is often based on permanent sliding displacement due to earthquake shaking. Empirical probabilistic seismic slope displacement models developed by Rathje and Saygili (2009) and Bray and Travasarou (2007) were used to create a numerical tool to compute the full performance-based seismic slope displacement. The capability to evaluate these models in a probabilistic manner was then added to *PBLiquefY*.

2.7.1 Rathje and Saygili (2009) Model

The Rathje and Saygili (2009) model is an update and improvement of the Saygili and Rathje (2008) model. The revised model includes a magnitude term that reduces scatter in the model, and it also includes an improved estimate of the standard deviation. The Rathje and Saygili (2009) model presents both a scalar and vector models. For the purposes of this study the scalar model is the only one used. The empirical displacement model is based on rigid sliding block displacements computed from recorded horizontal acceleration-time histories. Over 2,000 motions were used, and each was scaled by factors of 1.0, 2.0 and 3.0. Displacements were calculated for k_y values of 0.05, 0.1, 0.2 and 0.3. The proposed model presented in 2009 was the following:

$$\begin{aligned}\ln D = 4.89 - 4.85\left(\frac{k_y}{a_{\max}}\right) - 19.64\left(\frac{k_y}{a_{\max}}\right)^2 + 42.49\left(\frac{k_y}{a_{\max}}\right)^3 - 29.06\left(\frac{k_y}{a_{\max}}\right)^4 \\ +0.72\ln\left(a_{\max}\right) + 0.89\left(M-6\right)\end{aligned} \tag{110}$$

where D is the seismic slope displacement in units of cm is, k_y is the yield acceleration and $a_{\max}$ is peak ground surface acceleration both in units of g., and M is the earthquake moment magnitude. The overall standard deviation for this new model is 0.95.

2.7.2 Bray and Travasarou (2007) Model

The Bray and Travasarou (2007) model utilizes a nonlinear fully coupled stick-slip sliding block model. The model separates the probability of “zero” displacement from the distribution of “nonzero” displacement, so that very low values do not bias the results. For the

Newmark rigid sliding block case (T_s=0), the natural logarithm of the seismic displacement can be computed as:

$$\begin{aligned}\ln(D) = &-0.22 - 2.83\ln(k_y) - 0.333\left(\ln(k_y)\right)^2 + 0.566\ln(k_y)\ln(a_{\max}) \\ &+3.04\ln(a_{\max}) - 0.244\left(\ln(a_{\max})\right)^2 + 0.278(M-7)\end{aligned} \tag{111}$$

where the standard deviation for this model is 0.67.

The methodology presented by Bray and Travasarou can be used to calculate the probability of the seismic displacement exceeding a selected threshold of displacement (*d*) for a specified earthquake scenario and slope properties.

2.7.3 Performance-based Implementation of Seismic Slope Displacement Models

The performance-based application of a seismic slope displacement model involves the incorporation of a probabilistic hazard framework (Rathje and Saygili 2008). A hazard curve showing the mean annual rate of exceeding a seismic slope displacement d^* can be computed as:

$$\lambda_{d^*} = \sum P\left[D > d^* \mid \mathrm{GM}_i, k_y\right] \cdot \Delta\lambda_{GM} \tag{112}$$

where $\sum P\left[D > d^* \mid \mathrm{GM}_i, k_y\right]$ is the conditional probability of exceeding displacement d^* given a ground motion level *i*, and $\Delta\lambda_{GM}$ is the incremental mean annual rate of exceedance from the ground motion hazard curve. The sum in the equation represents the integration over all possible ground motion levels. Because only a single ground motion parameter is used to predict D, this approach is considered a scalar probabilistic assessment.

2.8 Simplified Performance-Based Seismic Slope Displacement Procedure

The simplified performance-based seismic slope displacement procedure seeks to approximate displacements calculated by the full-performance based seismic slope displacement procedure described in Section 2.7.3. The models described above will be incorporated in the simplified procedure at specific return periods.

The simplified seismic slope displacement model is derived from the following equation:

$$\ln D^{site} = \ln D^{ref} + \Delta \ln D \tag{113}$$

where D^{site} is the actual performance-based seismic slope displacement at the desired return period, D^{ref} is a reference performance-based seismic slope displacement based on a constant set of reference conditions, and $\Delta \ln D$ is a displacement correction function.

While a series of performance-based analyses can be performed with a constant set of reference conditions to compute $\ln D^{ref}$ at a desired return period across a geographic area, the values of $\ln D^{site}$ and $\Delta \ln D$ are unknown and must be approximated. The value of $\ln D^{site}$ can be approximated with the Rathje and Saygili (2009) model as:

$$\begin{aligned}\ln D^{site} \approx\ & 4.89 - 4.85\left(\frac{k_y^{site}}{a_{\max}}\right) - 19.64\left(\frac{k_y^{site}}{a_{\max}}\right)^2 + 42.49\left(\frac{k_y^{site}}{a_{\max}}\right)^3 \\ & -29.06\left(\frac{k_y^{site}}{a_{\max}}\right)^4 + 0.72\ln\left(a_{\max}\right) + 0.89\left(M-6\right)\end{aligned} \tag{114}$$

where $a_{\max}$ is obtained from the seismic hazard curve for $a_{\max}$ at the return period of interest, and k_y^{site} is the site-specific yield acceleration, which is usually estimated using a two-dimensional pseudo-static slope stability analysis.

Using the Bray and Travasarou (2007) model, the same approximation is computed as:

$$\begin{aligned}\ln D^{site} \approx & -0.22 - 2.83\ln\left(k_y^{site}\right) - 0.333\left(\ln\left(k_y^{site}\right)\right)^2 + 0.566\ln\left(k_y^{site}\right)\ln\left(a_{\max}\right) \\ & +3.04\ln\left(a_{\max}\right) - 0.244\left(\ln\left(a_{\max}\right)\right)^2 + 0.278\left(M-7\right)\end{aligned} \tag{115}$$

Similarly, the reference seismic slope displacement can be approximated in order to compute $\Delta \ln D$. The reference seismic slope displacement can be approximated using the Rathje and Saygili (2009) model as:

$$\begin{aligned}\ln D^{ref} \approx\ & 4.89 - 4.85\left(\frac{k_y^{ref}}{a_{\max}^{ref}}\right) - 19.64\left(\frac{k_y^{ref}}{a_{\max}^{ref}}\right)^2 + 42.49\left(\frac{k_y^{ref}}{a_{\max}^{ref}}\right)^3 \\ & -29.06\left(\frac{k_y^{ref}}{a_{\max}^{ref}}\right)^4 + 0.72\ln\left(a_{\max}^{ref}\right) + 0.89\left(M-6\right)\end{aligned} \tag{116}$$

where k_y^{ref} is the constant reference yield acceleration, and $a_{\max}^{ref}$ is the peak ground surface acceleration at the return period of interest from the seismic hazard curve corresponding to the reference soil condition.

Using the Bray and Travasarou (2007) model, the reference seismic slope displacement can be approximated as:

$$\begin{aligned}\ln D^{ref} \approx & -0.22 - 2.83\ln\left(k_y^{ref}\right) - 0.333\left(\ln\left(k_y^{ref}\right)\right)^2 + 0.566\ln\left(k_y^{ref}\right)\ln\left(a_{\max}^{ref}\right) \\ & +3.04\ln\left(a_{\max}^{ref}\right) - 0.244\left(\ln\left(a_{\max}^{ref}\right)\right)^2 + 0.278\left(M-7\right)\end{aligned} \tag{117}$$

With approximated values of $\ln D^{ref}$ and $\ln D^{site}$, we can now approximate $\Delta\ln D$ as:

$$\Delta\ln D = \ln D^{site} - \ln D^{ref} \tag{118}$$

Substituting Equations (114) and (116) into Equation (118), $\Delta\ln D$ for the Rathje and Saygili (2009) model can be represented as:

$$\begin{aligned}\left(\Delta\ln D\right)_{rathje} \approx & \frac{4.85}{PGA}\left(\frac{k_y^{ref}}{f_a^{ref}} - \frac{k_y^{site}}{f_a^{site}}\right) + \frac{19.64}{(PGA)^2}\left[\left(\frac{k_y^{ref}}{f_a^{ref}}\right)^2 - \left(\frac{k_y^{site}}{f_a^{site}}\right)^2\right] \\ & + \frac{42.49}{(PGA)^3}\left[\left(\frac{k_y^{site}}{f_a^{site}}\right)^3 - \left(\frac{k_y^{ref}}{f_a^{ref}}\right)^3\right] + \frac{29.06}{(PGA)^4}\left[\left(\frac{k_y^{ref}}{f_a^{ref}}\right)^4 - \left(\frac{k_y^{site}}{f_a^{site}}\right)^4\right] + 0.79\ln\left(\frac{f_a^{site}}{f_a^{ref}}\right)\end{aligned} \tag{119}$$

where PGA is the hazard-targeted peak ground acceleration corresponding to rock (i.e., $V_{s,30} = 760$ m/s); and f_a^{ref} and f_a^{site} are the reference and site-specific soil amplification factors (see Year 1 Quarter 1 Update Report).

Similarly, $\Delta\ln D$ can be approximate for the Bray and Travasarou (2007) model as:

$$\begin{aligned}\left(\Delta\ln D\right)_{bray} = & 2.83\left[\ln\left(\frac{k_y^{ref}}{f_a^{ref}}\right) - \ln\left(\frac{k_y^{site}}{f_a^{site}}\right)\right] + 0.333\left[\ln\left(\frac{k_y^{ref}}{f_a^{ref}}\right)^2 - \ln\left(\frac{k_y^{site}}{f_a^{site}}\right)^2\right] \\ & +0.566\ln(PGA)\left[\ln\left(\frac{k_y^{site}}{f_a^{site}}\right) - \ln\left(\frac{k_y^{ref}}{f_a^{ref}}\right)\right]\end{aligned} \tag{120}$$

With this simplified performance-based approach for estimating seismic slope displacements, an engineer can compute uniform hazard estimates of seismic slope displacement at a targeted hazard level in a relatively simple manner. Certain assumptions are needed as inputs such as the yield acceleration for the specific slope using limit equilibrium slope stability methods. It is also required to obtain the probabilistic estimate of PGA from the USGS NSHMP website for rock (i.e., $V_{s,30} = 760$ m/s) at the targeted hazard level. A site-specific soil amplification factor for the ground motion is obtained from either the AASHTO seismic design provisions (based on soil site classification) or from a site-specific site response analysis.

Once approximations of $\Delta \ln D$ are available, site-specific, hazard-targeted estimates of seismic slope displacement can be computed as:

$$D^{site} = \exp\left[\ln D^{ref} + \Delta \ln D\right] = (D^{ref})\exp\left[\Delta \ln D\right] \tag{121}$$

where D^{ref} is obtained from the appropriate seismic slope displacement reference parameter map.

2.9 Summary

The derivations of the simplified liquefaction triggering and lateral spread displacement models show how to approximate a full performance-based analysis using simple calculations and mapped reference parameters. The simplified liquefaction triggering procedure is based on the Boulanger and Idriss (2012) probabilistic model while the simplified lateral spread displacement model is based on the Youd et al. (2002) empirical model. The simplified post-liquefaction free-field settlement model is based on the Cetin et al. (2009) and Ishihara and Yoshimine (1992) volumetric strain models, while the simplified seismic slope displacement procedure is based on Rathje and Saygili (2009), and Bray and Travasarou (2007) seismic slope displacement models.

3.0 VALIDATION OF THE SIMPLIFIED MODELS

3.1 Overview

The effectiveness of the simplified performance-based procedure introduced in this report depends on how closely they approximate the results of a complete site-specific probabilistic seismic hazard analysis. To evaluate the accuracy of the introduced simplified procedures, a comparison between the simplified and full performance-based methods will be performed for ten sites throughout the United States. These sites will be evaluated for three different return periods: 475, 1033, and 2475 years.

3.1.1 Sites used in the Analysis

The sites chosen for the analysis were selected based on the range of seismicity of each site, as well as their distribution across the United States. Table 3-1 lists the location of these sites as well as their latitudes and longitudes.

Table 3-1 Locations used for the validation of the simplified models

Site	Latitude	Longitude
Butte	46.003	-112.533
Charleston	32.726	-79.931
Eureka	40.802	-124.162
Memphis	35.149	-90.048
Portland	45.523	-122.675
Salt Lake City	40.755	-111.898
San Francisco	37.775	-122.418
San Jose	37.339	-121.893
Santa Monica	34.015	-118.492
Seattle	47.53	-122.3

The tools used to validate the liquefaction triggering model did not allow any sites in Alaska at this point, so the site Anchorage, Alaska (Latitude 61.217, Longitude -149.9) was not used in the validation process for that model. However, the tools used to validate the lateral spread displacement model did have the ability to analyze sites in Alaska, so the Anchorage site was used in the validation process for that model. When the post-liquefaction settlement and the seismic slope displacement models were validated, the USGS 1996 Deaggregation website was still available, so the Anchorage, AK point was used in the validation process.

3.2 Simplified Liquefaction Triggering Model Validation

To calculate the site-specific CSR^{site}, an assumed soil profile was applied at each site. The parameters associated with this soil profile are presented in Figure 3-1.

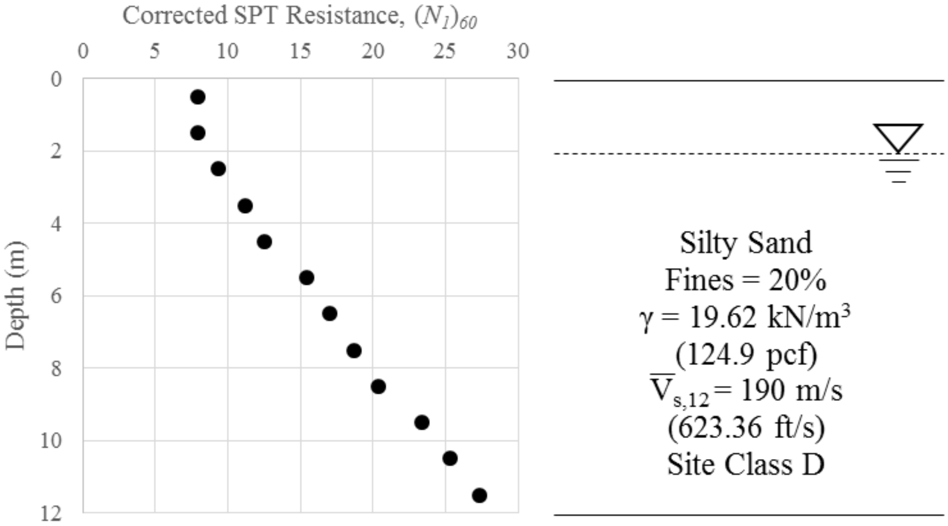


Figure 3-1 Site-specific soil profile used to validate the simplified performance-based model

3.2.1 PBLiquefY

The site-specific analysis for the full performance-based method was performed using PBLiquefY (Franke et al., 2014c). PBLiquefY was also used to create the liquefaction loading maps used to determine the reference value (i.e. CSR^{ref} (%)) necessary for the simplified method. The 2008 USGS ground motion deaggregations were used in both the full and simplified methods.

3.2.2 Validation of the Simplified Performance-Based Cetin et al. (2004) Model

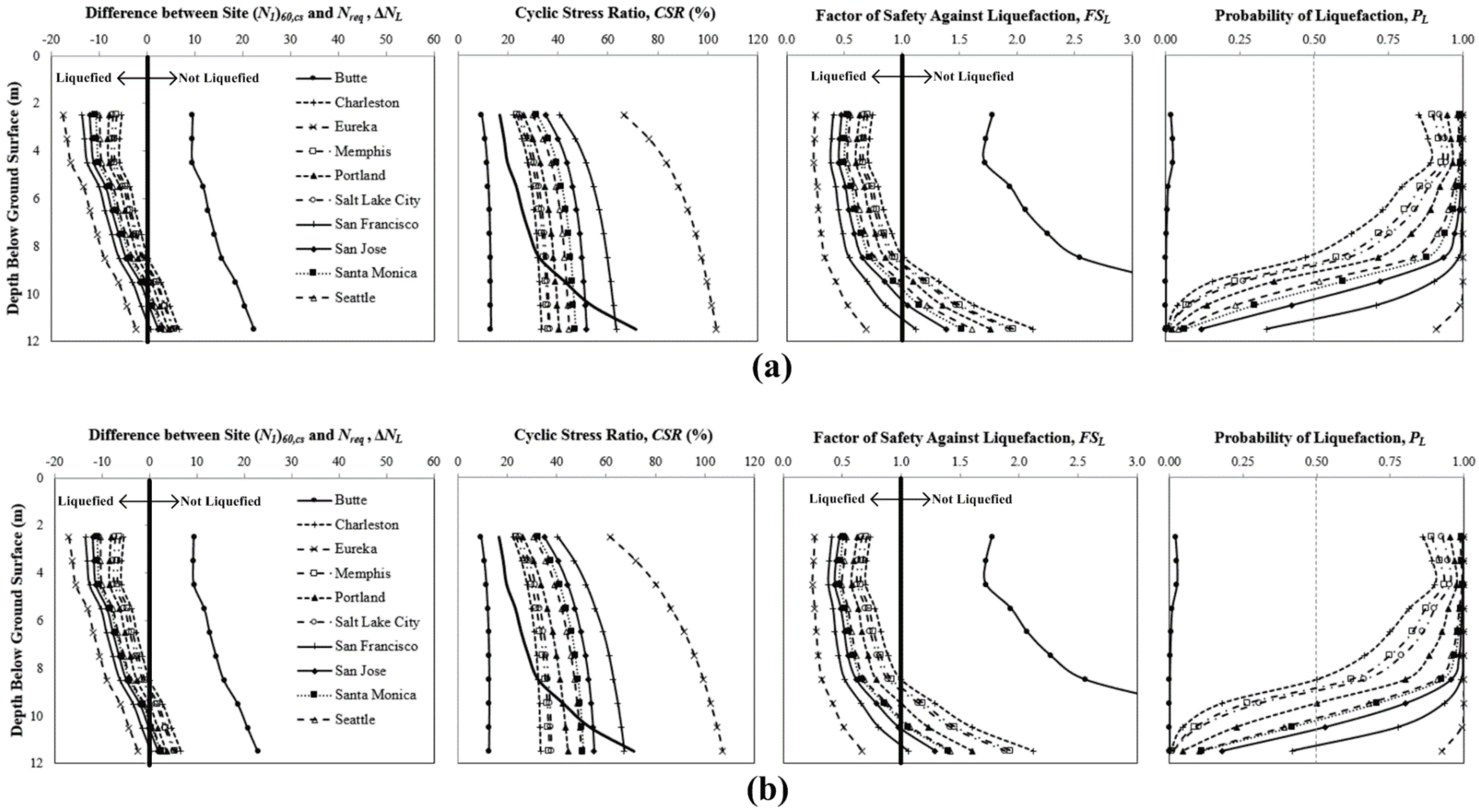
Although the simplified performance-based Cetin et al. (2004) model will not be validated in this report, other publications have verified the use of the simplified Cetin et al.

(2004) model (Mayfield et al. 2010; Franke et al 2014d). Mayfield et al. (2010) showed that the computed uniform hazard liquefaction results from the simplified method closely match the liquefaction hazard results from the full performance-based liquefaction analysis at the targeted return period. In future quarterly reports, contour maps of N_{req} from the Cetin et al. (2004) model will be included along with contour maps of CSR^{ref} (%) from the Boulanger and Idriss (2014) model.

3.2.3 Validation of the Simplified Performance-Based Boulanger and Idriss (2012) Model

Using liquefaction loading maps (created using PBLiquefY) and the soil profile selected for the site specific analysis, the value of CSR^{site} was determined for each layer of the site-specific soil profile and for each site using the simplified performance-based method (raw data can be found in the Appendix). These CSR^{site} values were converted to N_{req} values using Equation (42). The resulting N_{req} values are displayed in Figure 3-2 along with the N_{req} values computed using the full performance-based method. Also included in this plot is N_{site}, which is the in-situ clean sand-equivalent SPT resistance of the site soil profile. Note that both the full performance-based and simplified performance-based methods yield almost identical results for each city represented in this analysis. Overall, the difference between the two methods is within an acceptable amount (within 3.41% on average with a maximum difference of 2.25 blow counts for N_{req}).

The direct comparison of the two methods for three different return periods can be seen in Figure 3-3. Each point on this plot represents a single layer in the site soil profile located in one city for one return period (a total of 300 points). As seen in this plot, the simplified method provides a good approximation of the results from a full probabilistic analysis (R^2 value between 0.996 and 0.997) and provides predictions of N_{req} that account for uncertainty in the model parameters without the need for a full probabilistic analysis. It may seem that the high R^2 values are too good to be true; however, it is important to note that this is a mathematically derived relationship and is expected to be closely correlated with the results of a full probabilistic analysis. If these two values (N_{req} from the simplified method and N_{req} from the full method) were randomly selected samples from a natural population, then these R^2 values would be reason for suspicion.



(a)

(b)

Figure 3-2 ΔN_L, $CSR_{M=7.5,\sigma'_v=1atm}(\%)$, FS_L, and P_L with depth as calculated using (a) the new simplified procedure, and (b) the full performance-based procedure (T_R = 1,033 years)

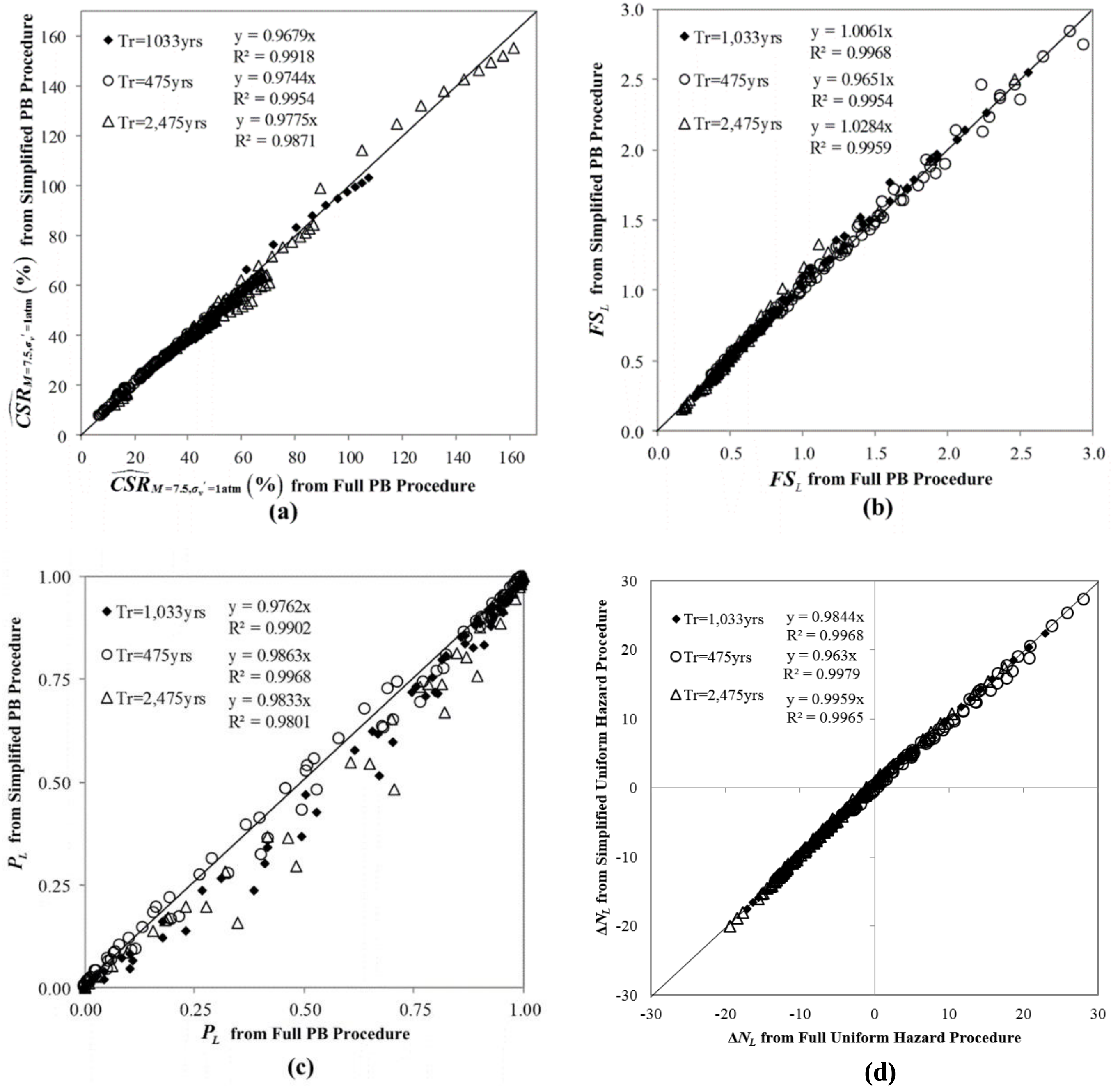


Figure 3-3 Comparative scatter plots for simplified and full performance-based procedures for (a) $CSR_{M=7.5,\sigma_v'=1atm}(\%)$, (b) FS_L, (c) P_L, and (d) ΔN_L

3.2.3.1 Boulanger and Idriss (2014) Updated MSF Term

During the production of this report, a revised Boulanger and Idriss (2014) model was published. This revised model included a new definition of the *MSF* (as explained previously). Though this report discussed the derivation of the simplified performance-based procedure for both the updated Boulanger and Idriss (2014) model and the previous Boulanger and Idriss (2012) model, the remainder of this research will be based on the 2012 version of the *MSF*. This includes validation of the simplified performance-based liquefaction triggering procedure, map development, etc. However, the *SPLiq* software developed as part of this research will allow the user to specify the use of the 2014 *MSF* term if desired.

3.3 Simplified Lateral Spread Displacement Model Validation

To evaluate the site-specific lateral displacement, a soil profile was assumed for each site. These soil parameters are presented in Figure 3-4. Values of 1.0m, 25%, and 1.0mm were computed for the lateral spread parameters T_{15}, F_{15}, and $D50_{15}$, respectively. As shown in Figure 3-4, the geometry of the site constitutes a ground slope condition with ground slope (i.e. S) equal to 1%. The resulting value of $\mathscr{S}$ for the site, as computed from Equation (51), is therefore equal to 9.846.

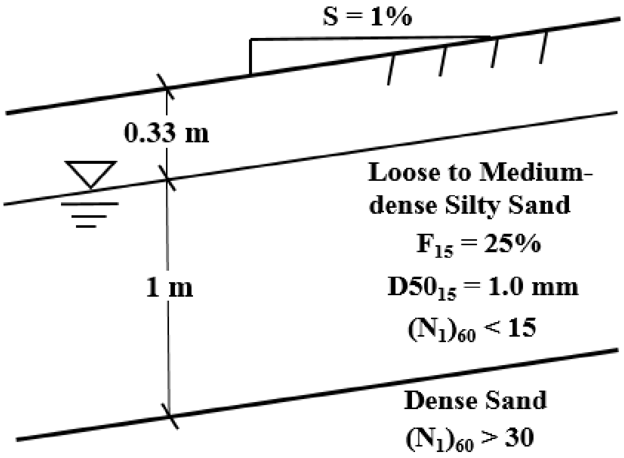


Figure 3-4 Site-specific soil profile used in the simplified lateral spread displacement model validation

3.3.1 EZ-FRISK

To perform the site-specific analysis for both the simplified and full performance-based models, the software EZ-FRISK (Risk Engineering 2013) was utilized. For this analysis, the USGS 2008 seismic source model (Petersen et al. 2008) was used for all locations but Anchorage, Alaska. The 1996 USGS seismic source model was used for that location.

3.3.2 Comparison of Results

Using EZ-FRISK and the soil profile selected for the site specific analysis, the lateral spread displacement was determined for each site using the simplified and full-performance based models. The results of analysis can be seen in Table 3-2. As can be seen in this table, the results of the analysis for both models resulted in relatively similar results, with the values from the simplified method falling on average within 3.9% of those predicted by full model. The observed discrepancy between the simplified and full performance-based models was no greater than 0.073 m at any site or any return period.

Table 3-2 Lateral spread displacements (m) for the site specific analysis using the two models for the three desired return periods

	Simplified Model			**Full PB Model**		
Site	**475 Yrs**	**1033 Yrs**	**2475 Yrs**	**475 Yrs**	**1033 Yrs**	**2475 Yrs**
Butte	0.001	0.003	0.008	0.001	0.003	0.008
Charleston	0.001	0.017	0.068	0.001	0.015	0.065
Eureka	0.738	2.321	3.737	0.728	2.248	3.724
Memphis	0.003	0.033	0.067	0.003	0.025	0.065
Portland	0.038	0.152	0.333	0.036	0.152	0.334
Salt Lake City	0.162	0.437	0.726	0.167	0.438	0.726
San Francisco	0.744	1.095	1.493	0.745	1.081	1.492
San Jose	0.312	0.574	0.857	0.312	0.574	0.857
Santa Monica	0.171	0.400	0.719	0.172	0.400	0.719
Seattle	0.054	0.162	0.343	0.053	0.162	0.344
Anchorage	0.045	0.536	1.187	0.045	0.566	1.250

Overall, the difference between the simplified and full performance based model is within an acceptable amount of error (defined by this report as 5%). The closeness of the fit is apparent when the results of both analyses are plotted against each other, which can be seen in Figure 3-5 (these are actual displacement values, not averages). The R^2 values for each return period are larger than 0.9995, indicating that the approximation of the full method is very good. These high R^2 values, as well as the lack of scatter of the results, seem to be too close for a simplified method; however, because this is a mathematically derived relationship it is expected that the results be closely correlated with those of the full probabilistic analysis. If the fit was not so close, than the mathematically derived equation would be suspect.

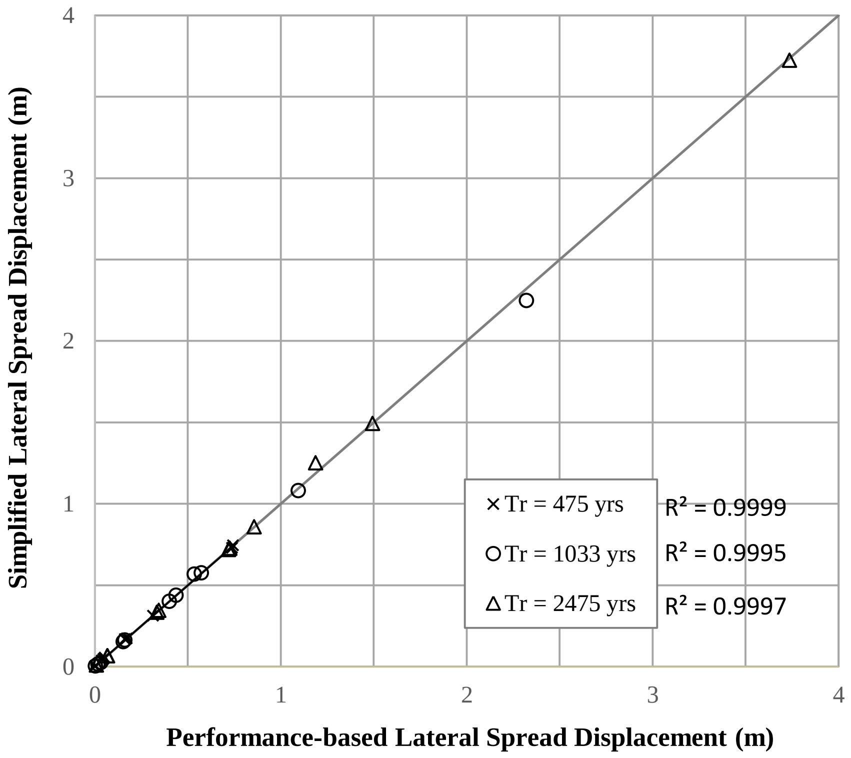


Figure 3-5 Comparison of lateral spread displacements for the simplified and full performance-based models

3.4 Simplified Post-liquefaction Free-field Settlement Model Validation

3.4.1 *PBLiquefY*

The site-specific analysis for the full performance-based method was performed using *PBLiquefY* (Franke et al., 2014c). *PBLiquefY* was also used to create the liquefaction loading maps used to determine the reference values (e.g. $CSR^{ref}(\%), \varepsilon_v^{ref}$) necessary to perform the simplified settlement procedure. The 2008 USGS ground motion deaggregations were used in both the full and simplified methods.

3.4.2 Site Profiles

A full performance-based analysis was performed for five different soil profiles. The proposed simplified procedure was performed for the same soil profiles using both the Cetin et al. (2009) and Ishihara and Yoshimine (1992) models as explained in Section 2.6. Soil properties throughout the five profiles generally remained constant, with the exception of the SPT resistance values. The soil properties for the five different soil profiles were as follows:

- Depths ranging from 0 to 18 meters.
- Soil Type: Silty Sand (SM)
- $V_{s,12}$: 190 meters per second
- Plasticity Index: 0
- Liquid Limit: 30 %
- Water Content: 30%
- Fines Content: 0 to 10 %
- Unit Weight: 19.62 kN per cubic meter

The water table on three of the analyzed profiles existed two meters below grade while the other two profiles had a water table at ground surface. N_{field} (field observed SPT resistance) values for the five different profiles can be seen in Figure 3-6.

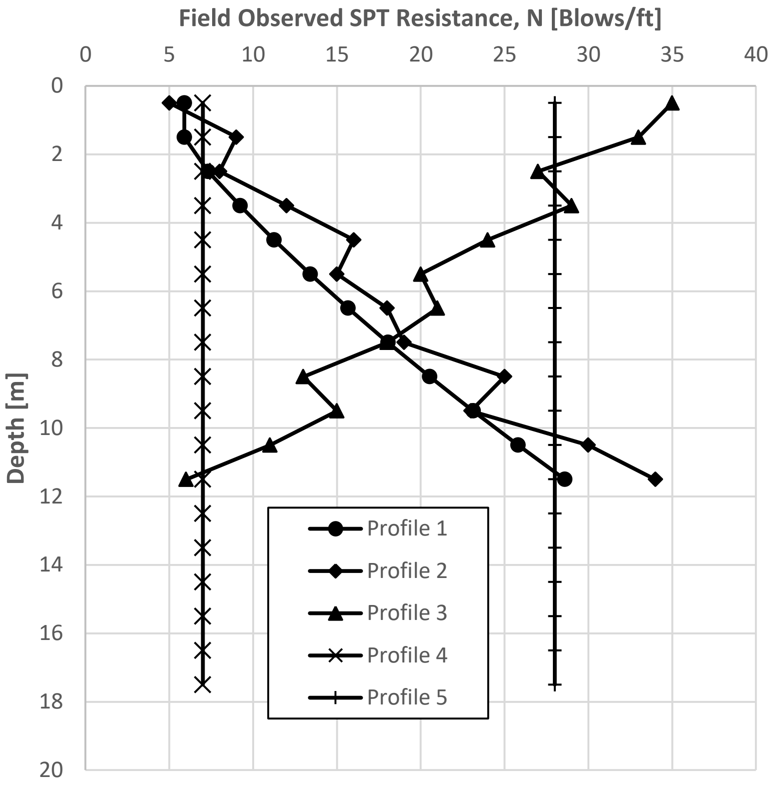


Figure 3-6 Field-observed SPT resistances for each soil profile.

3.4.3 Validation of the Simplified Performance-Based Cetin et al. (2009) Model

Individual sub-layer strains and total surface settlements were computed using both the full performance-based method and the proposed simplified procedure. Once the full performance based method was computed along with the simplified method, the sub-layer strains and settlements were plotted against each other. The results for sub-layer strains can be seen in Figure 3-7 and Figure 3-8 with the abscissa as the full performance-based results; the simplified method values are plotted as the ordinate points. Ideally the plotted values should line up on a 1:1 (i.e., 45-degree angle) line.

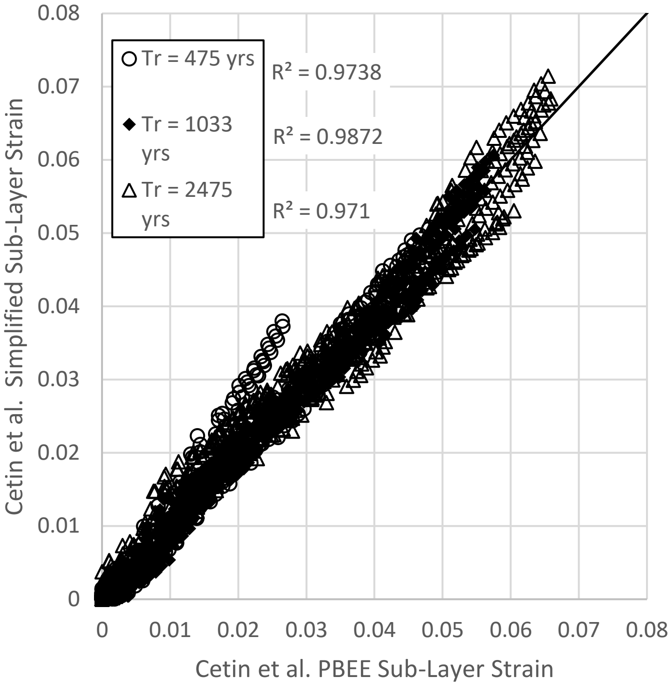


Figure 3-7 Individual Sublayer Cetin et al. Performance based strain vs. simplified strain separated by return period

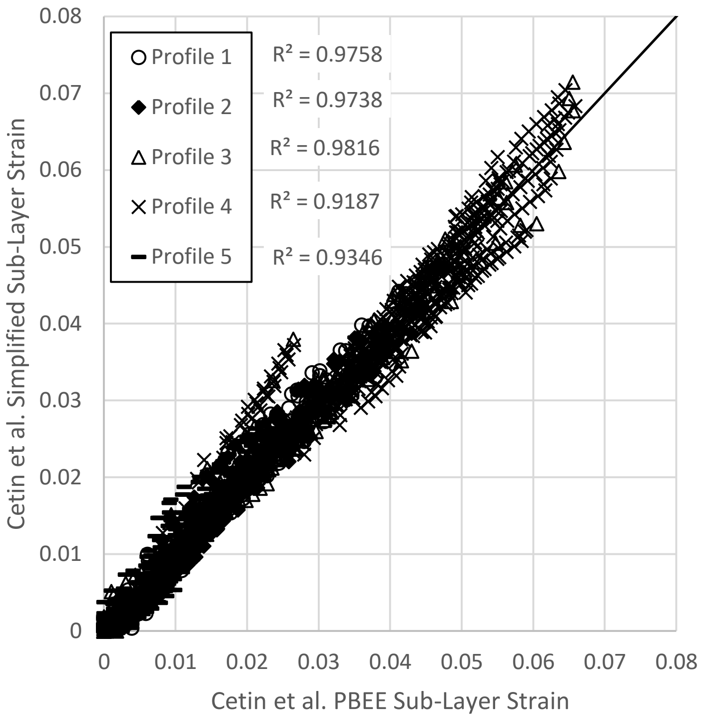


Figure 3-8 Sub-layer Cetin et al. Performance based strain vs. simplified strain separated by profile

Figure 3-7 and Figure 3-8 demonstrate a close relationship between the full performance-based method and the proposed simplified method. The high R^2 values indicate relatively low scatter along the relationship.

The plots associated with the Cetin et al. (2009) volumetric strain model demonstrate a close relationship between the full performance-based method and the proposed simplified procedure. Areas of highest scatter exist for the data associated with profile 4. Profile 4 could be considered as a "worst case scenario" where field observed SPT resistance is a uniform 7 blows per foot throughout the entire profile which is 18 meters thick.

3.4.4 Validation of the Simplified Performance-Based Ishihara and Yoshimine Model

The full performance based results were also plotted against the proposed simplified method utilizing the Ishihara and Yoshimine (1992) settlement model. The results are presented in Figure 3-9 and Figure 3-10. Again, an ideal fit would be a 1:1 slope trend in the data.

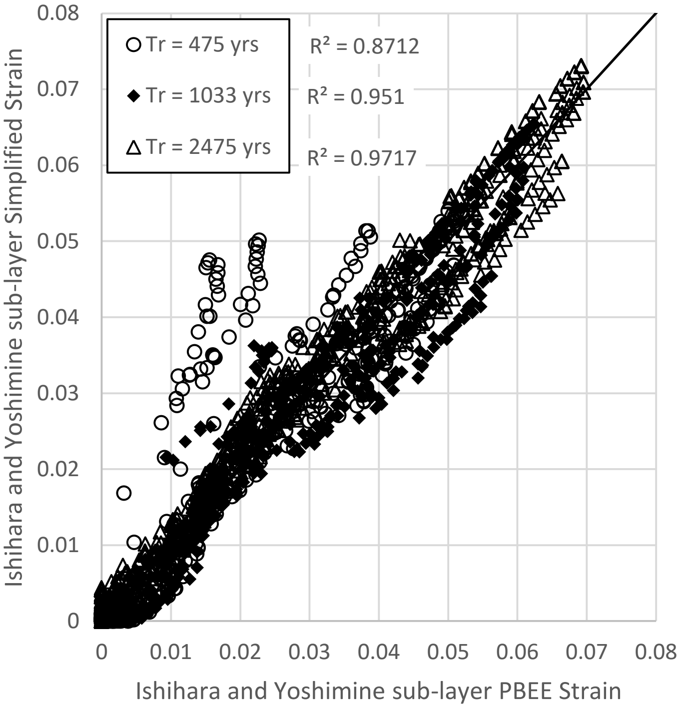


Figure 3-9 Ishihara and Yoshimine (1992) sub-layer PBEE strains vs. simplified strains separated by return period

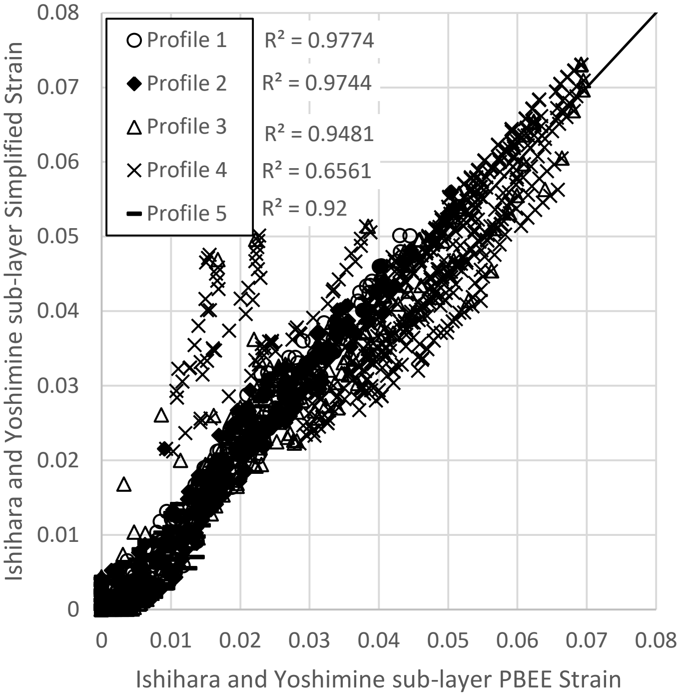


Figure 3-10 Ishihara and Yoshimine (1992) sub-layer PBEE strains vs. simplified strain separated by profile

The reader will note that there is more scatter in the Ishihara and Yoshimine results shown in Figure 3-9 and Figure 3-10 than in the Cetin et al. results shown in Figure 3-7 and Figure 3-8. Reasons/explanations for this increased scatter include the quadratic nature of the Boulanger and Idriss (2012) liquefaction triggering relationship upon which the Ishihara and Yoshimine strains are being computed, and the highly non-linear nature of the Ishihara and Yoshimine relationships between FS_L and ε_v itself. The reader must also remember that the simplified performance-based strain estimation procedure presented here inherently incorporates the inaccuracies/errors from the simplified performance-based liquefaction triggering procedure as well as its own inaccuracies/errors. Therefore, much of the scatter that is apparent in Figure 3-7 through Figure 3-10 can be attributed to these compounding errors, and will always be a challenge associated with the simplified performance-based computation of liquefaction effects that are conditional upon liquefaction triggering analysis results. Furthermore, most of the scatter shown in Figure 3-7 through Figure 3-10 is associated with Soil Profile #4, which was created to represent a "worst case scenario" in which all of the soil from the ground surface to a depth of 18 meters has $\left(N_1\right)_{60}$ values less than 8 blows per 0.33 meter. This scatter appears aggravated further in areas of low seismicity (i.e., where probabilistic PGA estimates are less than 0.2g) at low return periods (e.g., 475 years). Fortunately, the scatter in the results is considerably smaller for more typical soil conditions in which the SPT resistances were either greater than 8 blows per 0.33 meter, or are more varied in SPT resistance and are not uniformly small.

The overarching challenge here is that the simplified method is attempting to closely approximate the performance-based results of a very complex, non-linear liquefaction effect using a simple linear transfer function. As such, some level of scatter in the approximation is going to be inevitable. However, the more important questions that should be asked are, "Does the simplified procedure accurately approximate the full performance-based procedure *on average*?", and "Are the scatter in the simplified procedure and any associated predictive errors going to negatively impact my engineering decisions in design?" The first question is answered by evaluating the trendlines of the data points in Figure 3-7 through Figure 3-10, which showed trendlines with slopes ranging from 0.99 to 1.01. Therefore, the data suggests that, on average, the simplified performance-based volumetric strain prediction procedure will accurately approximate the results of the full performance-based volumetric strain prediction procedure over many calculations.

The second important question can be addressed by evaluating the computed ground surface settlements for each soil profile/site/return period combination. Ground surface settlement plots comparing simplified performance-based settlements with the full performance-based settlements are presented in Figure 3-11 through Figure 3-14. Figure 3-11 and Figure 3-12 demonstrate that the simplified performance-based procedure for the Cetin et al. (2009) approach provides a good approximation of the full-performance-based procedure, with trendlines showing slopes of 1.0 and R^2 values greater than 0.968 for all three return periods and all five soil profiles. Figures 3-13 and 3-14 demonstrate that the simplified performance-based procedure for the Ishihara and Yoshimine (1992) approach is slightly less precise than the procedure for the Cetin et al. (2009) approach, with trendlines also showing slopes of 1.0, but R^2 values greater than 0.922 for all three return periods and all five soil profiles. However, note from Figure 3-13 and Figure 3-14 that the simplified performance-based procedure closely approximates the settlements from the full performance-based procedure at predicted settlements that are less than 30 cm (i.e., 1 foot) for all soil profiles and return periods. Only Soil Profile #5 shows some slight deviation from the trendline at one of 30 possible site/return period combinations within this predictive range. Therefore, it appears that significant error in the predicted post-liquefaction settlement will likely only occur in the instance that more than 30 cm of ground surface settlement is predicted. In such cases, it is likely that such errors would not substantially change or affect the likely remediation that would be recommended by design engineers.

Because the simplified performance-based volumetric strain procedure closely approximates the volumetric strains from the full performance-based procedure on average, and because the procedure's computed post-liquefaction ground surface settlements accurately and precisely approximate the post-liquefaction ground surface settlements from the full performance-based procedure, it can be assumed to provide a reasonable approximation of the full performance-based procedure for most typical design situations in most seismic environments in the U.S. The engineer must be aware that the simplified performance-based procedure incorporating the Ishihara and Yoshimine (1992) volumetric strain model shows less precision in its ability to approximate the full performance-based approach when more than 30 cm (i.e., 1 foot) of total post-liquefaction settlement is predicted, particularly when a large portion of the soil profile has very low SPT resistances (i.e., $\left(N_1\right)_{60} < 8$ blowcounts per 0.33 meter).

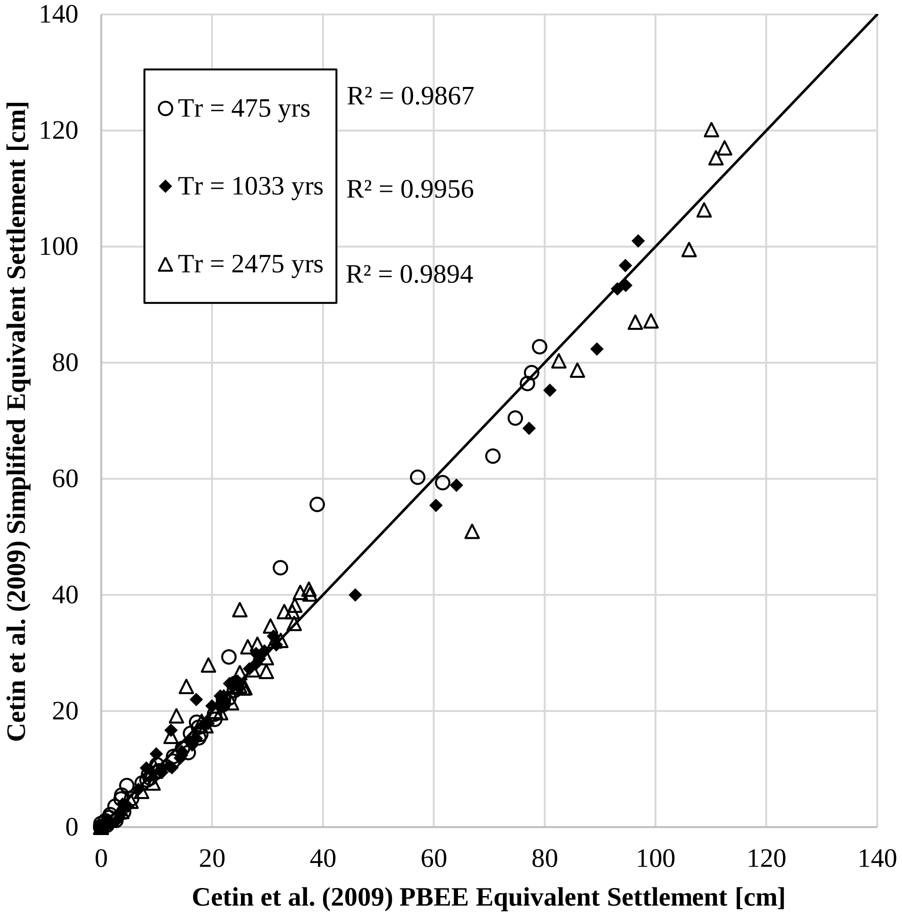


Figure 3-11 Cetin et al. (2009) PBEE settlements vs. simplified procedure settlements separated by return period

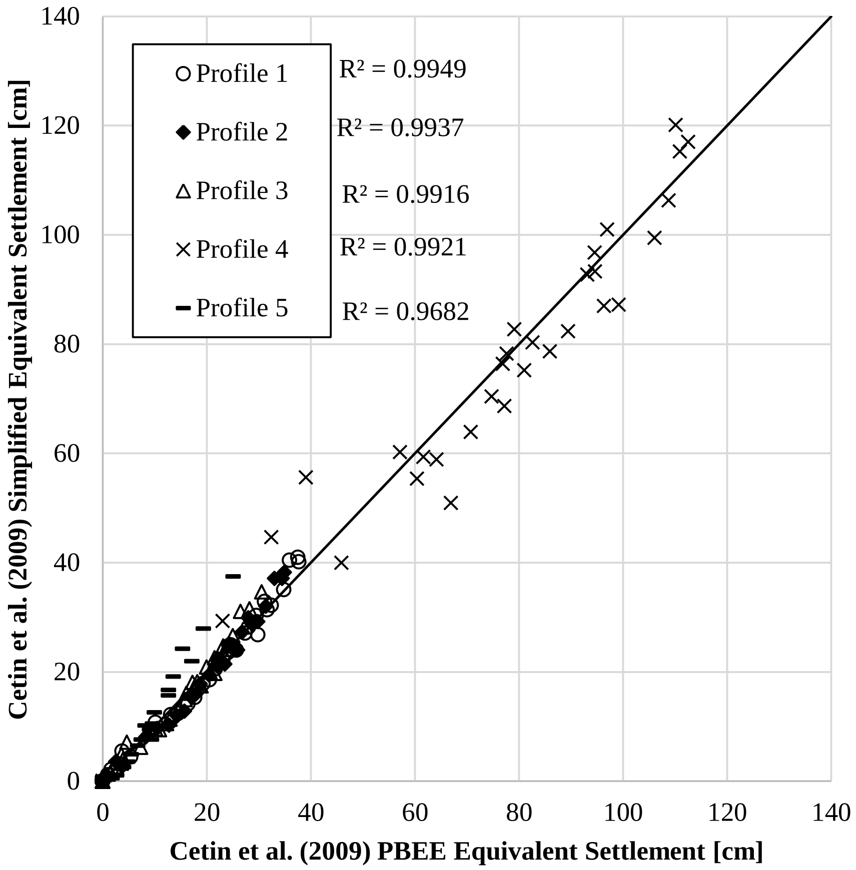


Figure 3-12 Cetin et al. (2009) PBEE settlements vs. simplified method settlements separated by soil profile

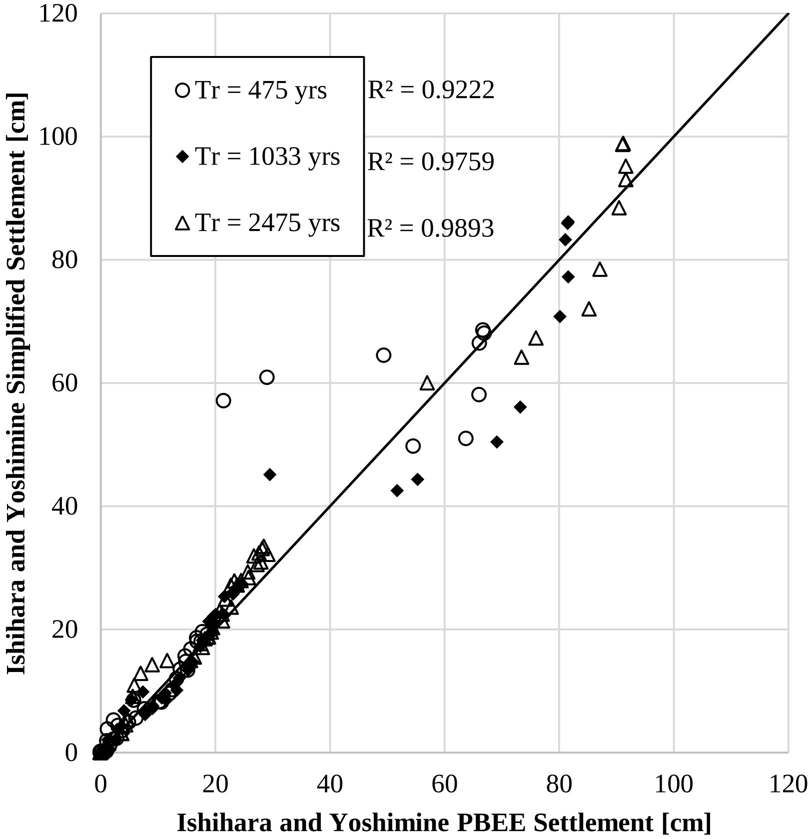


Figure 3-13 Ishihara and Yoshimine (1992) PBEE settlements vs. simplified settlements separated by return period

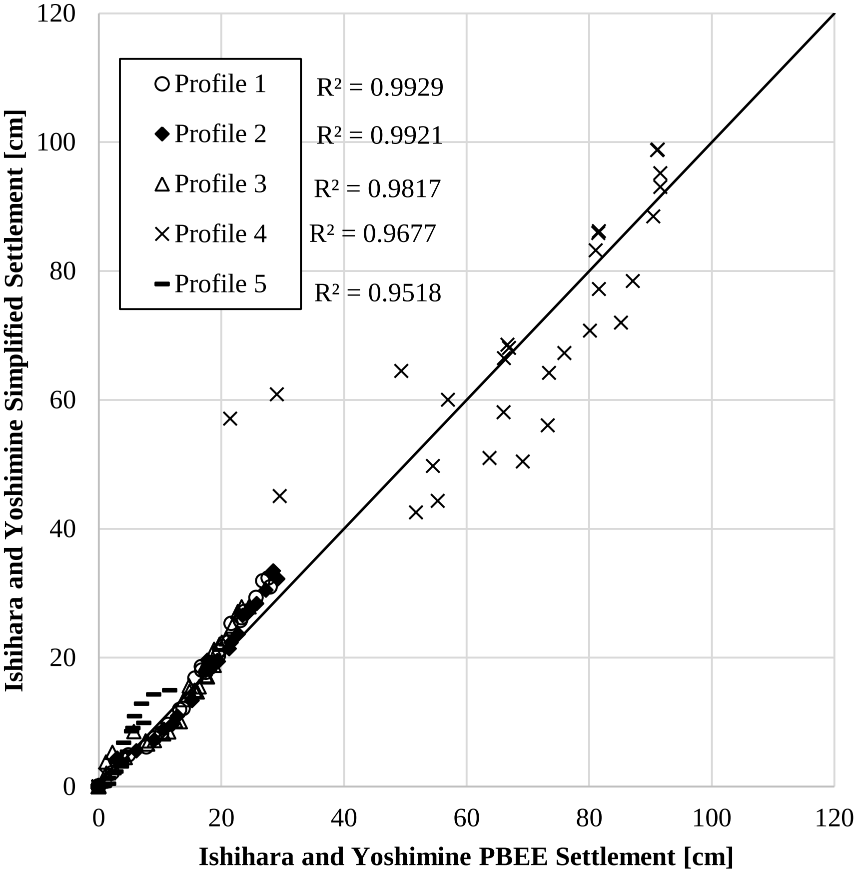


Figure 3-14 Ishihara and Yoshimine (1992) PBEE settlements vs. simplified settlements separated by soil profile

3.4.5 Discussion

Some engineers may interpret from Figure 3-7 through Figure 3-14 that the simplified performance-based settlement procedure tends to over-predict settlements for very loose soils (i.e., N<8). However, this interpretation is not accurate. Note from Figure 3-12 and Figure 3-14, Soil Profile #4 showed both over-prediction and under-prediction in this scatter about the 45-degree line. In addition, overall settlement predictions, even with the very loose soil layers included, tend to be good approximations of the full performance-based settlements (as shown in Figure 3-11 through Figure 3-14) – particularly when the predicted settlements are less than about 30 cm (i.e., 1 foot).

Finally, some engineers may interpret these results as stating that low-seismicity areas should not be concerned with quantifying liquefaction-induced settlements. This statement stems from the perception that our simplified procedures tends to over-predict strains in areas of low seismicity, which is not true. Just as many cases of under-prediction were observed as were cases of over-prediction in areas of low seismicity. It can therefore be concluded that very loose soil layers in areas of low seismicity tend to show more scatter in their predicted post-liquefaction strains. However, when considering all of the strains collectively, the simplified procedure closely approximates the results from the full performance-based procedure on average. This is why the total computed settlements at the ground surface (as discussed above) tend reasonably approximate of the full performance-based procedure. Rather than infer generic and generalized recommendations based on these limited results, it is recommended that liquefaction hazards should be evaluated consistently everywhere, and that design decisions should be objectively based on the results of those evaluations.

3.5 Simplified Seismic Slope Displacement Model Validation

To evaluate the accuracy of the simplified performance-based procedure for seismic slope displacements, reference parameters of $k_y^{ref} = 0.1g$ and $f_a^{ref} = 1.0$ were selected. Values of k_y^{site} ranging from 0.1g to 0.5g were selected for the "site-specific" site conditions. Values of PGA and mean M were obtained for the ten selected U.S. cities from the 2008 USGS deaggregation for three return periods: 475 years, 1,033 years, and 2,475 years. Values of f_a^{site} were obtained from current AASHTO seismic design provisions using tabulated values of f_{pga} as a function of PGA. Subsequent values of mean M, PGA, and f_{pga} for the three return periods are summarized in Table 3-3 for the ten cities evaluated in this study.

Table 3-3 Summary of Magnitude, PGA and f_a site used for each city used in the validation

Site	Tr = 475			Tr = 1033			Tr = 2475		
	Mean M	PGA	f_a	Mean M	PGA	f_a	Mean M	PGA	f_a
Butte	6.03	0.0834	1.600	6.03	0.1206	1.559	6.05	0.1785	1.443
Charleston	6.61	0.1513	1.497	6.87	0.3680	1.132	7.00	0.7287	1.000
Eureka	7.33	0.6154	1.000	7.40	0.9662	1.000	7.45	1.4004	1.000
Memphis	6.98	0.1604	1.479	7.19	0.3346	1.165	7.24	0.5711	1.000
Portland	7.24	0.1990	1.402	7.29	0.2980	1.204	7.31	0.4366	1.063
Salt Lake City	6.75	0.2126	1.375	6.84	0.4030	1.097	6.90	0.6717	1.000
San Francisco	7.31	0.4394	1.061	7.38	0.5685	1.000	7.44	0.7254	1.000
San Jose	6.66	0.4560	1.044	6.67	0.5627	1.000	6.66	0.6911	1.000
Santa Monica	6.74	0.3852	1.115	6.79	0.5372	1.000	6.84	0.7415	1.000
Seattle	6.75	0.3110	1.189	6.82	0.4444	1.056	6.88	0.6432	1.000

The full performance-based seismic slope displacement equation as described in Section 2.7.3 was implemented in *PBLiquefY* with the reference values described above to compute D^{ref} for the ten U.S. Cities at the three return periods of interest. Additionally, *PBLiquefY* was used to compute site-specific, full performance-based values of D^{site} using the selected values of k_y^{site} at each of the ten cities for all three return periods. Site-specific values of k_y^{site} were then used to compute simplified approximations of D^{site} using Equations (119), (120), and (121) and the seismic loading values summarized in Table 3-3.

Figure 3-15 and Figure 3-16 below show the comparison of the full and simplified performance-based seismic slope displacement predictions for both the Rathje and Saygili (2009) and Bray and Travasarou (2007) models, respectively.

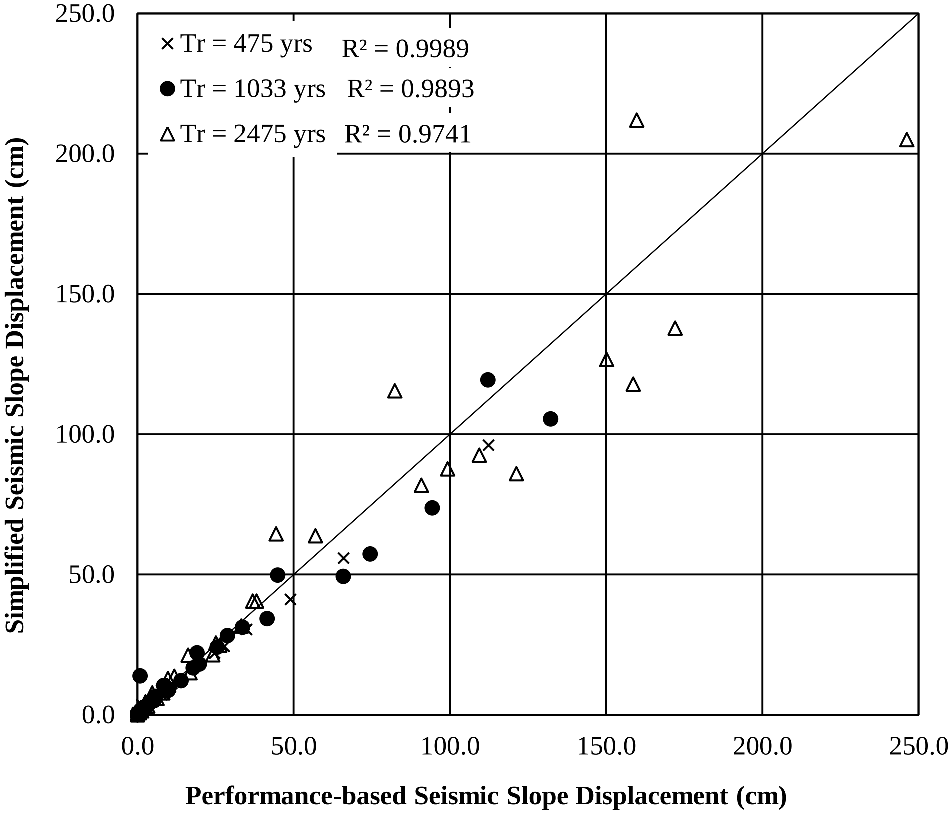


Figure 3-15 Comparison of seismic slope displacements for the simplified and full performance-based models based on Rathje and Saygili (2009)

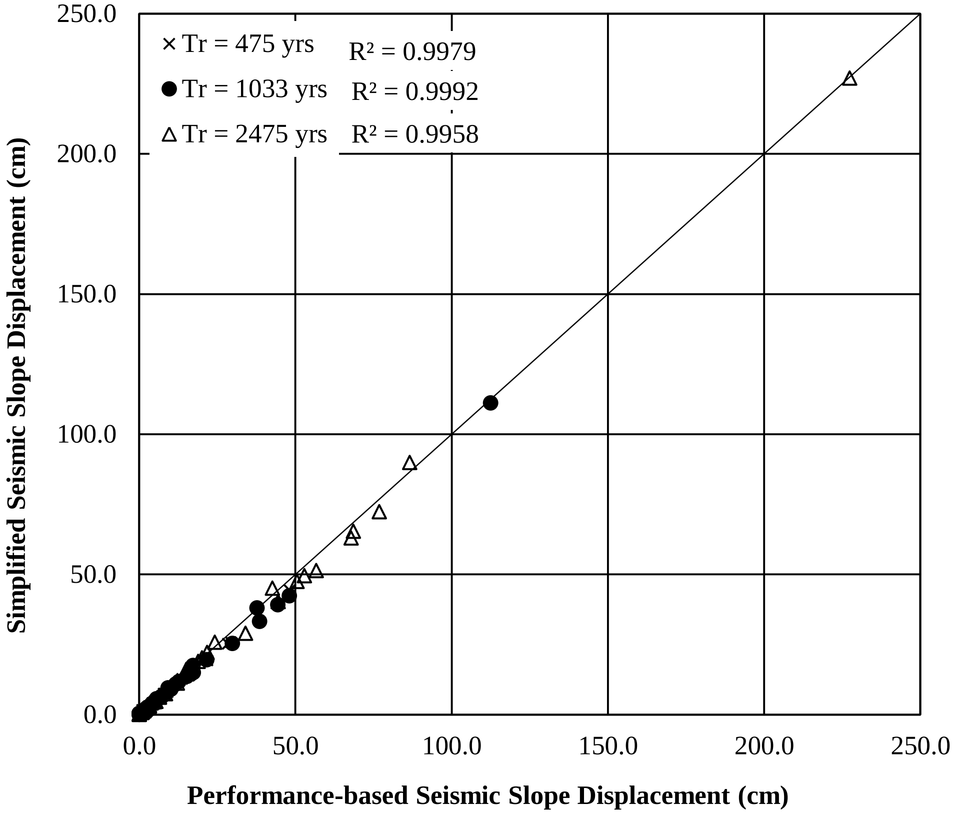


Figure 3-16 Comparison of seismic slope displacements for the simplified and full performance-based models based on Bray and Travasarou (2007)

As seen in Figure 3-15 and Figure 3-16, there is generally a good correlation between the full-performance based procedure and the simplified performance-based procedure with both models, although the simplified procedure using the Bray and Travasarou (2007) model provides a better approximation of the full performance-based results than the procedure using the Rathje and Saygili (2009) model. The Rathje and Saygili (2009) model incorporates a 4th-order polynomial function of $\left(k_y/PGA\right)$, which can lead to greater discrepancies between the simplified performance-based slope displacements and the full performance-based slope displacements at higher predicted displacements. Nevertheless, relatively high R^2 values indicate that the correlation accounts for nearly all of the variability in the computed response data. The average discrepancy across all return periods and yield accelerations included in this study for the simplified procedure using the Rathje and Saygili (2009) model was 4.9 cm. The average discrepancy for the simplified procedure using the Bray and Travasarou (2007) model was 0.8 cm. However, note that the simplified procedure incorporating the Rathje and Saygili (2009) model accurately and precisely approximates the results of the full performance-based procedure up to predicted displacements of about 50 cm, which is a much greater displacement than what is typically considered acceptable for most bridge foundations. For predicted displacements greater than 50 cm, the engineer should interpret the results with caution, understanding that the simplified Rathje and Saygili (2009) results may be imprecise. From these results we can conclude that the simplified procedure for approximating probabilistic seismic slope displacements will adequately approximate the results of a full performance-based procedure for most practical design applications, particularly if an allowable limit state of 30 cm (i.e., 12 inches) is specified for foundation design.

3.6 Summary

Ten sites throughout the United States were analyzed using both the full and simplified probabilistic procedures for three different return periods: 475, 1033, and 2475 years. The simplified liquefaction triggering method and the simplified lateral spread displacement models provided reasonable approximations of their respective full probabilistic methods. Both the simplified post-liquefaction free-field settlement procedure and the simplified seismic slope displacement procedure demonstrated accurate and precise approximations of their respective full performance-based procedures at predicted slope displacements of 30 cm or less. At greater predicted displacements, the simplified procedure with the Rathje and Saygili (2009) model showed more scatter in its ability to approximate the full performance-based procedure. Caution and engineering judgment should be used when such circumstances are encountered in design.

4.0 EVALUATION OF GRID SPACING

4.1 Overview

Because biases due to spacing of grid points in gridded seismic hazard analyses are known to exist, the grid spacing study will evaluate the potential for bias to occur due to grid spacing effects in a gridded probabilistic liquefaction, lateral spread, post-liquefaction settlement, and seismic slope displacement hazard assessment. Because the states involved in this study comprise areas of varying seismicity levels, evaluations will be performed in each of the states to assess the optimum grid spacing for development of liquefaction and lateral spread parameter maps in future tasks.

The grid spacing assessment was performed by comparing interpolated results from a simple 4-point grid placed in various parts of the country with site-specific results. The difference between the interpolated and site-specific results was quantified. By minimizing these computed differences, the optimum grid spacing for the liquefaction parameter maps in each state was obtained.

Note that this grid spacing study does not provide estimates of accuracy between the simplified performance-based method and the full performance-based method. The measurements of error calculated in this grid spacing study reflect only the error involved in interpolation between grid points. For more information on the accuracy of the methods please refer to Chapter 2.0 and 3.0.

4.2 Performance-based Liquefaction Triggering Evaluation

This section will describe the methods used to derive a correlation between optimum grid spacing and *PGA* for simplified performance-based liquefaction triggering evaluation. The purpose of this correlation was to provide a simple, readily-available, well-defined set of rules for proper grid spacing across the states of interest. This set of rules is necessary because it is impractical to perform an infinite number of full performance-based analyses to create the liquefaction contour maps. It was necessary to determine a finite number of points to analyze.

The set of rules created in this grid spacing study was used to define the optimum number of points which would be feasible to analyze in the amount of time given and would yield an acceptable amount of error due to interpolation between analyzed points.

4.2.1 Methodology for Preliminary Study

The preliminary grid spacing study first focused on four cities in areas of varying seismicity: Berkeley, California; Salt Lake City, Utah; Butte, Montana; and Clemson, South Carolina with *PGA* values as shown in Table 4-1. Though Berkeley is not located in one of the funding states for this research, it was used as an extreme in the range of *PGA* values. The more rigorous grid spacing study to follow incorporates a higher number of cities within the funding states. This preliminary study was used to decide whether *PGA* had an effect on optimum grid spacing.

Table 4-1 Cities Used in Preliminary Grid Spacing Study

City	Anchor Point		*PGA* (g) (T_R = 2475 years)
	Latitude	Longitude	
Berkeley, CA	37.872	-122.273	1.1340
Salt Lake City, UT	40.755	-111.898	0.6478
Butte, MT	46.003	-112.533	0.1785
Clemson, SC	34.683	-82.837	0.1439

Using a square grid (like the one shown in Figure 4-1) with the city's anchor point as the center of the square, several grid spacings were tested. This preliminary testing process included grid spacings of 1, 2, 4, 8, 16, 25, 35, and 50 km (0.62, 1.24, 2.49, 4.97, 9.94, 15.5, 21.7 and 31.1 mi). Then a full performance-based liquefaction analysis was performed at each corner point and the center anchor point to solve for Standard Penetration Test (SPT) blowcount (clean-sand equivalent and corrected to 1 atm pressure and 60% hammer efficiency) required to resist liquefaction (i.e. N_{req}) and percent cyclic stress ratio (i.e. *CSR*%) at three return periods (475, 1033, and 2475 years). This process was repeated for each city in the preliminary study.

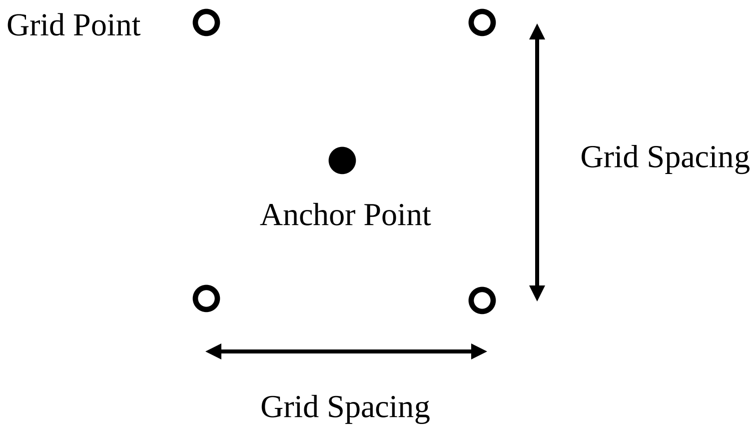


Figure 4-1 Layout of grid points centered on city's anchor point.

An estimate of the liquefaction hazard at the center point (i.e. the interpolated value of either N^{ref}_{req} or CSR^{ref} %) was calculated using the four corner points. This interpolated value was then compared to the actual value of the center point as calculated using a full performance-based liquefaction analysis. The difference between the interpolated value and the true value at the center is called the error term. The error terms were normalized to the actual values at the anchor points by calculating the percent error term as follows:

$$PercentError = \frac{|\,InterpolatedValue - ActualValue\,|}{ActualValue} \times 100\% \qquad (122)$$

The maximum percent error (i.e. the maximum percent error across all return periods for a given anchor point) became the deciding parameter in selecting optimum grid spacing for a given location. The relationship between maximum percent error and grid spacing was analyzed for each city and is discussed in the following section.

4.2.2 Results of Preliminary Study

The relationship between maximum percent error and grid spacing was analyzed for each city and is displayed in Figure 4-2, Figure 4-3, Figure 4-4, and Figure 4-5. As can be seen in these figures, the relationship between maximum percent error and grid spacing is different for each city. Berkeley had the highest *PGA* value (1.1340g) out of the cities used in this preliminary study and required the smallest grid spacing (approximately 5 km or 3.107 mi) to restrict the maximum percent error to 5%. On the other hand, the maximum percent error for

Clemson, which had the lowest *PGA* value (0.1439g), never exceeded 1% even with 50km (31.07 mi) grid spacing. Based on these graphs, it appears that seismicity (or *PGA*) has an impact on optimum grid spacing.

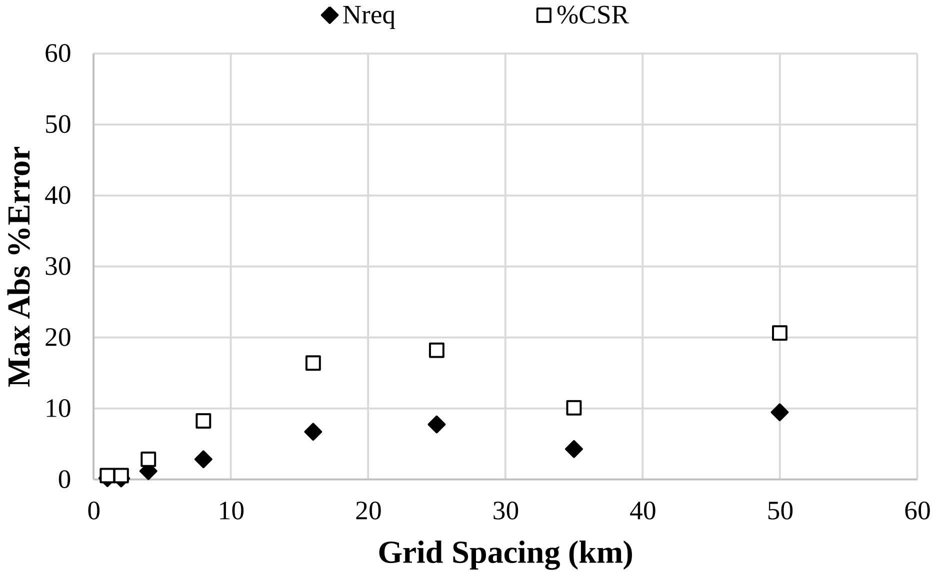


Figure 4-2 Variation of maximum absolute percent error with increasing distance between grid points (Berkeley, CA).

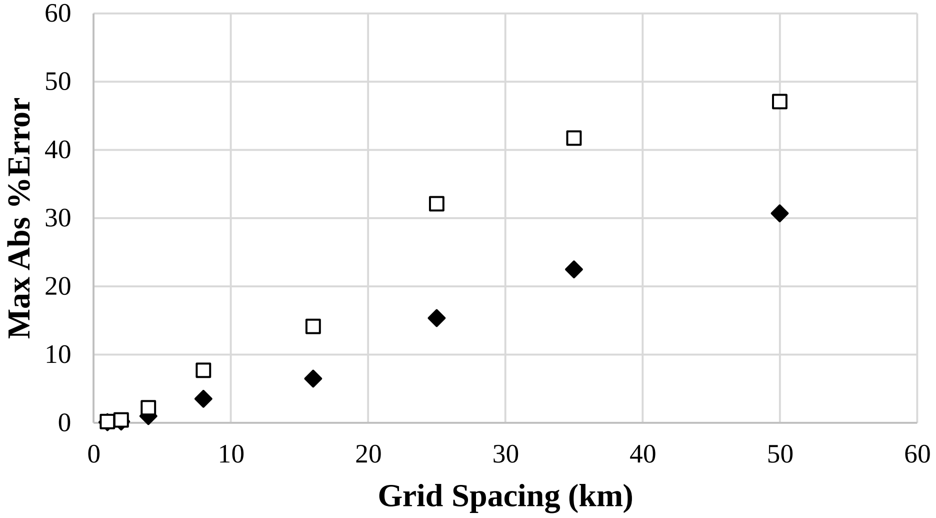


Figure 4-3 Variation of maximum absolute percent error with increasing distance between grid points (Salt Lake City, UT).

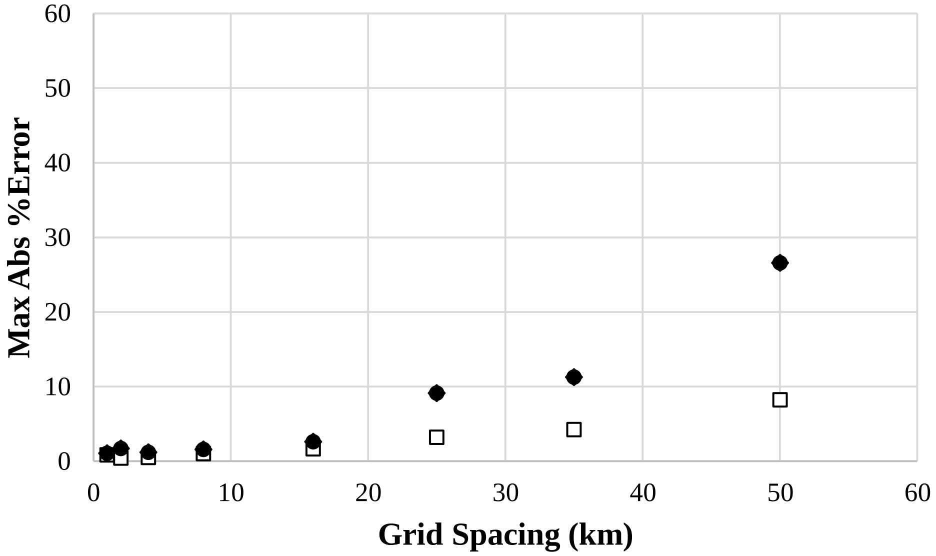


Figure 4-4 Variation of maximum absolute percent error with increasing distance between grid points (Butte, MT).

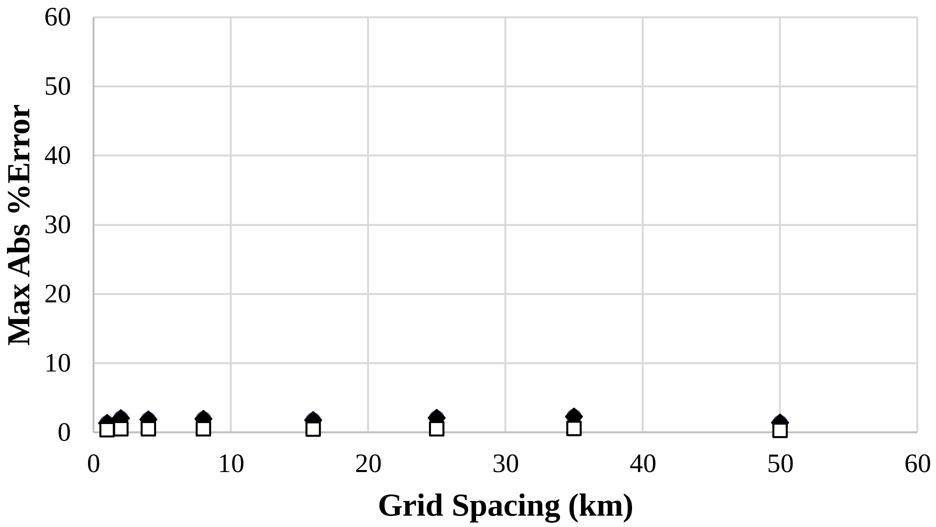


Figure 4-5 Variation of maximum absolute percent error with increasing distance between grid points (Clemson, SC).

4.2.3 Methodology for Grid Spacing Study

Based on the data from the preliminary study, it was hypothesized that *PGA* was a major factor in the relationship between grid spacing and maximum percent error. Specifically, it was hypothesized that as *PGA* increases, the optimum grid spacing decreases. To estimate the effect of *PGA* on optimum grid spacing, a similar study was conducted focusing on 35 cities from a wide range of *PGA* values (Figure 4-6).

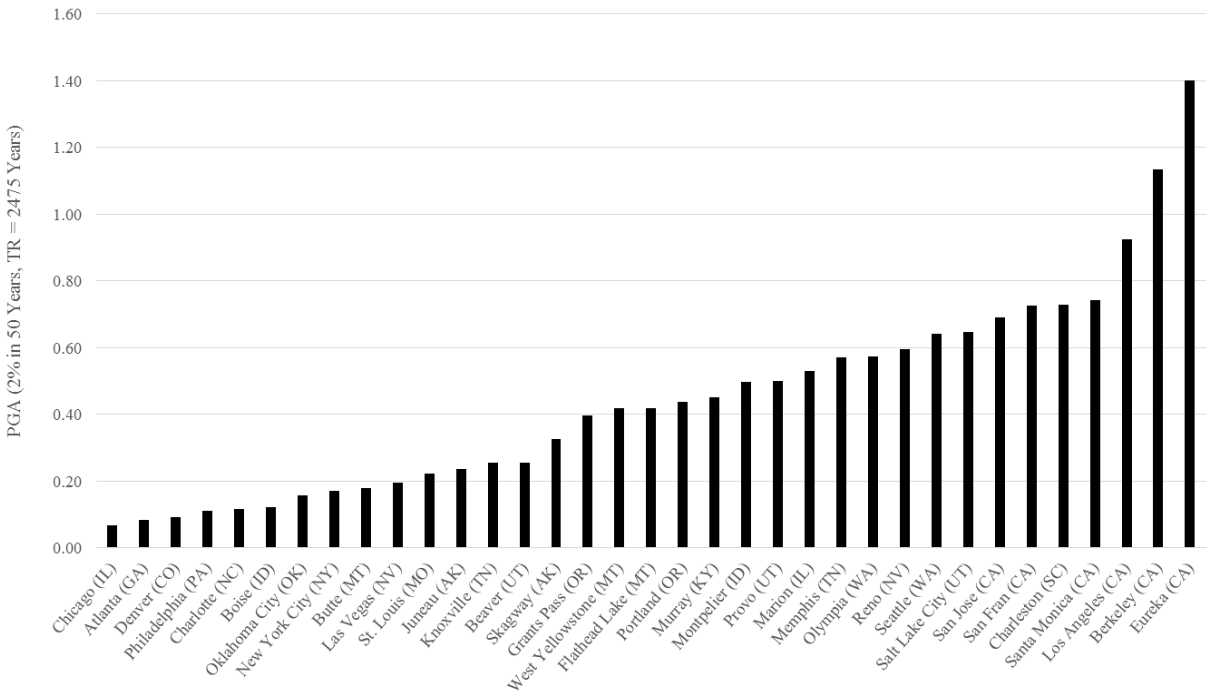


Figure 4-6 Range of *PGA* values for cities included in final grid spacing study.

The desired outcome of the final grid spacing study was to create a correlation between *PGA* and optimum grid spacing in km. An equation for the best-fit trend line alone would not be sufficient, because defining grid points to use in an analysis does not work well with non-integer values for grid spacing and constantly changing distances between points. Therefore, it was necessary to divide the different cities into *PGA* "bins" or defined ranges of values. These bins were determined using the USGS 2008 *PGA* hazard map (T_r = 2475 years) as shown in Figure 4-7. The *PGA* hazard map was chosen because it was clear and readily available as a well-documented definition of which areas in the country had significantly different seismicity levels compared to other areas' seismicity levels. The objective of this study was to determine the optimum grid spacing for each color bin.

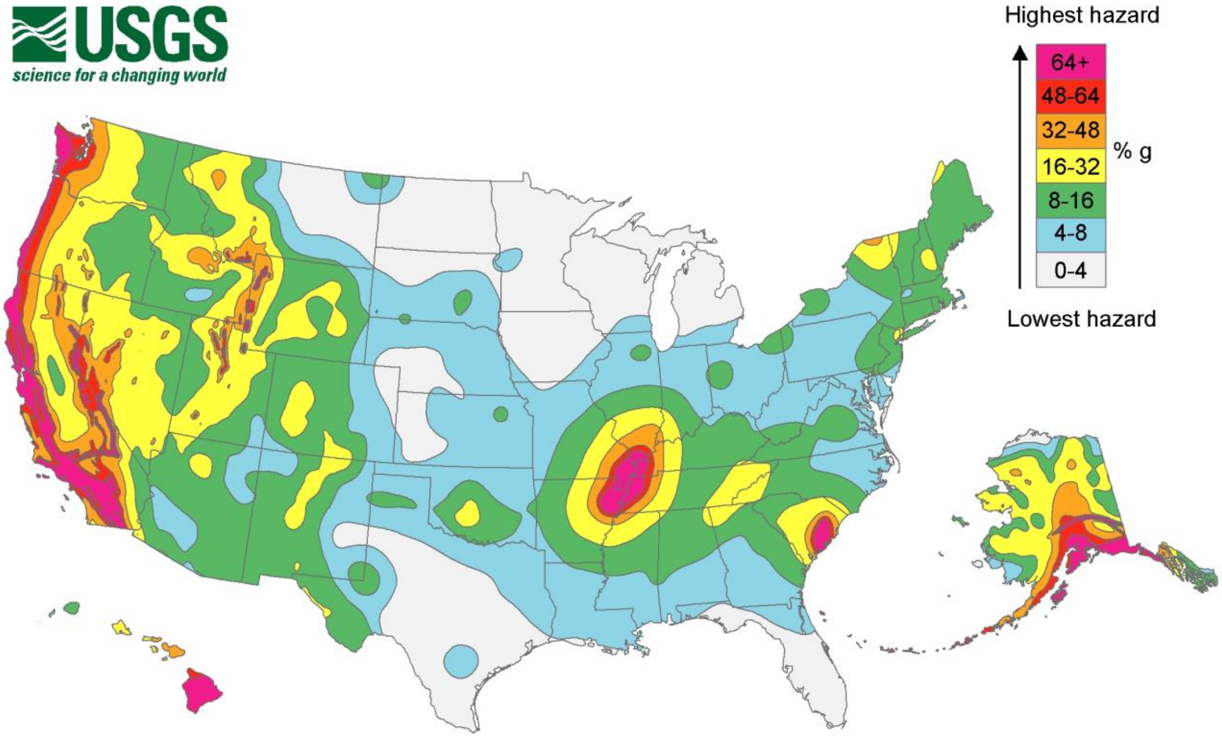


Figure 4-7 USGS 2008 *PGA* hazard map (T_r = 2475 years).

As in the preliminary study, a full performance-based analysis was performed at the anchor point of each city and at the corners of the grid surrounding the anchor point. This was repeated for multiple grid spacings until the percent error was within a reasonable amount. It was determined that "optimum grid spacing" would be defined as the smallest grid spacing (i.e shortest distance between grid points) which yielded a maximum percent error of 5% across all return periods based on *CSR*%. This definition is used because when the maximum percent error based on *CSR*% is limited to 5%, the interpolated value of N_{req} is within 1.5 blow counts of the actual value calculated at the anchor point, as shown in Figure 4-8. This seemed to be a reasonable amount of error, considering the inherent error in obtaining SPT blow counts during soil exploration at a site. If the definition of optimum grid spacing was defined as the smallest grid spacing which yielded a maximum difference of 1.5 blow counts, then the values of percent error based on *CSR*% may be unacceptably high. For example, as shown in Figure 4-8, if the maximum difference in N_{req} is 1.5 blow counts, the percent error in *CSR*% could be as high as

22.5%, which could cause substantial inaccuracies. Thus the definition of optimum grid spacing was defined based on *CSR*% and not N_{req}.

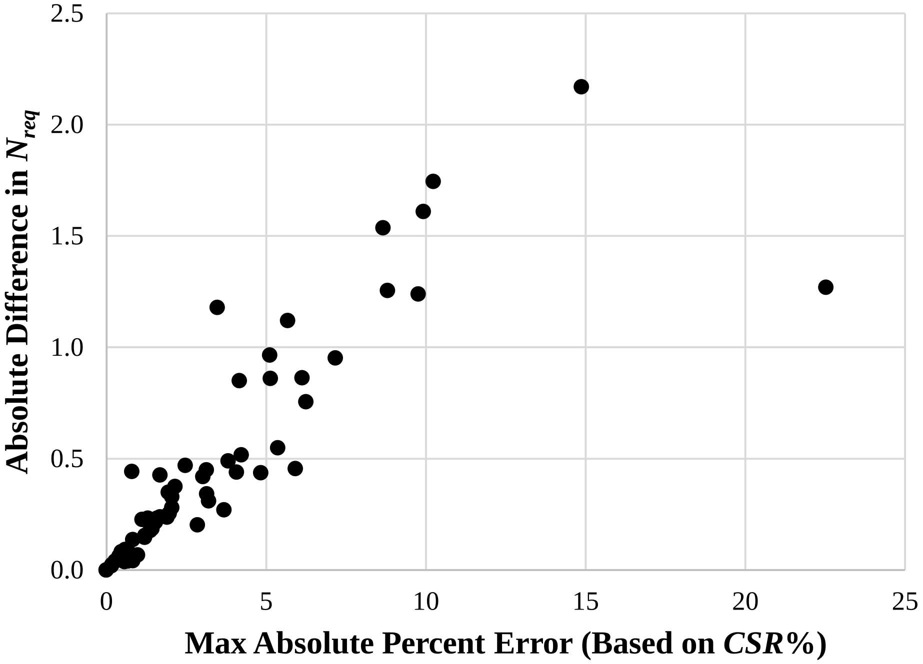


Figure 4-8 Comparison of difference in N_{req} to max absolute percent error based on *CSR*%.

Optimum grid spacing was determined using a plot of maximum percent error vs grid spacing in km. Unique plots were created for each city to determine the optimum grid spacing. Sample plots are provided in Figure 4-9, Figure 4-10, and Figure 4-11. Some cities' data followed a linear trend line while others followed a polynomial trend line. In each case, a reasonable best-fit line was used to determine optimum grid spacing. Some of the cities selected for this study did not reach a maximum percent error of 5%, even when the grid spacing was increased to 50 km (31.07 mi) or more. To avoid extrapolation, such cities (Hartford, CT, *PGA* = 0.0915; Bridgeport, CT, *PGA* = 0.1149; Clemson, SC, *PGA* = 0.1439; Anchorage, AK, *PGA* = 0.6161) were excluded from the final correlation between *PGA* and optimum grid spacing. A description of the final correlation between *PGA* and optimum grid spacing is included in the following section.

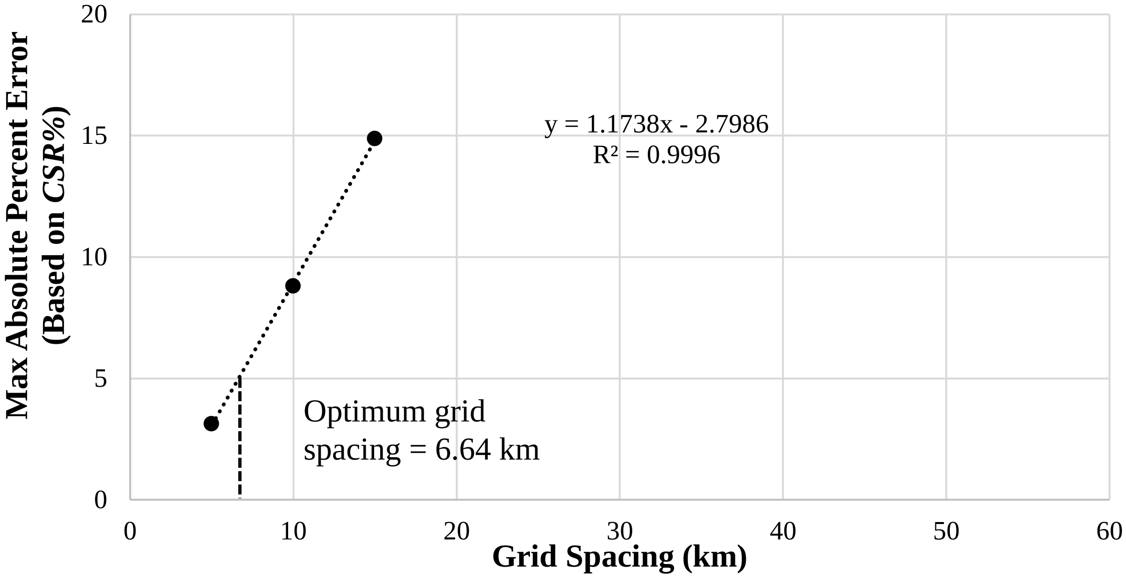


Figure 4-9 Variation of maximum percent error (based on *CSR*%) with increasing distance between grid points for Eureka, CA. (Pink zone, *PGA* = 1.4004)

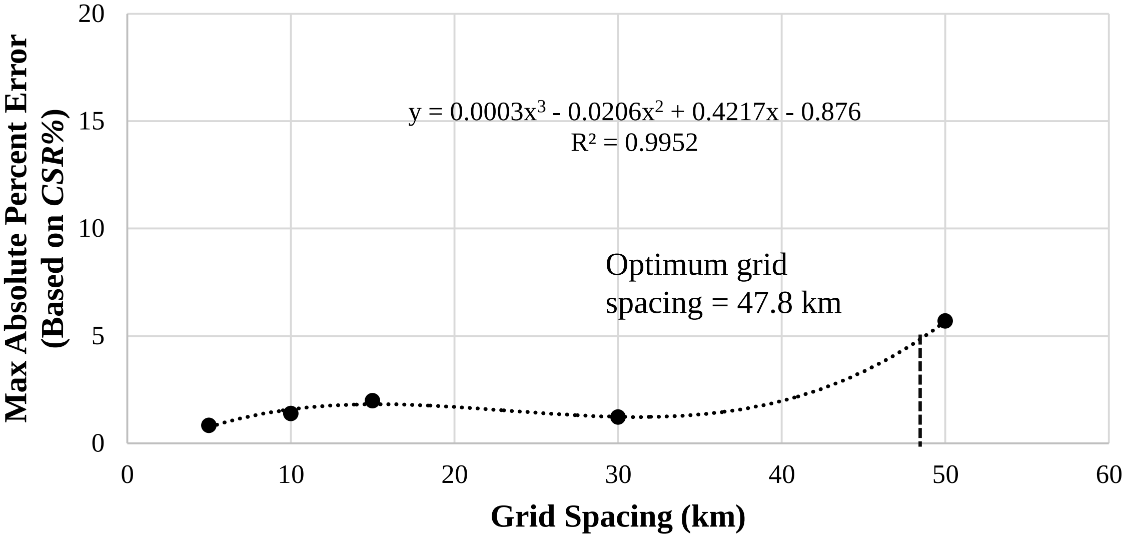


Figure 4-10 Variation of maximum percent error (based on *CSR*%) with increasing distance between grid points for West Yellowstone, MT. (Orange zone, *PGA* = 0.4187)

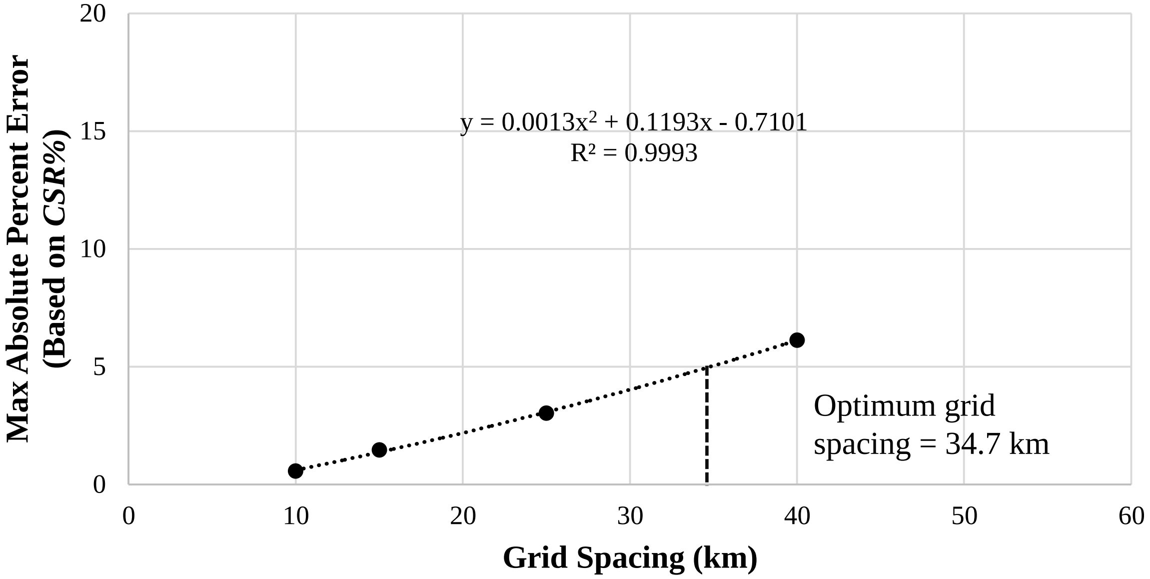


Figure 4-11 Variation of maximum percent error (based on *CSR*%) with increasing distance between grid points for Boise, ID. (Green zone, *PGA* = 0.1232)

4.2.4 *PGA* Correlation

As described in the previous section, optimum grid spacing was determined for each city included in the study that reached at least a maximum percent error of 5% based on *CSR*% (not N_{req}). Optimum grid spacing was then plotted against *PGA* as shown in Figure 4-12. The vertical dashed lines indicate the boundaries between *PGA* bins as defined in the USGS 2008 *PGA* hazard map. The general trend of the points ($R^2 = 0.628$) supports the hypothesis that as *PGA* increases the optimum grid spacing decreases. A hand-drawn lower bound was used to determine the optimum grid spacing based on *PGA*. The lower bound line was chosen as a conservative estimate of optimum grid spacing.

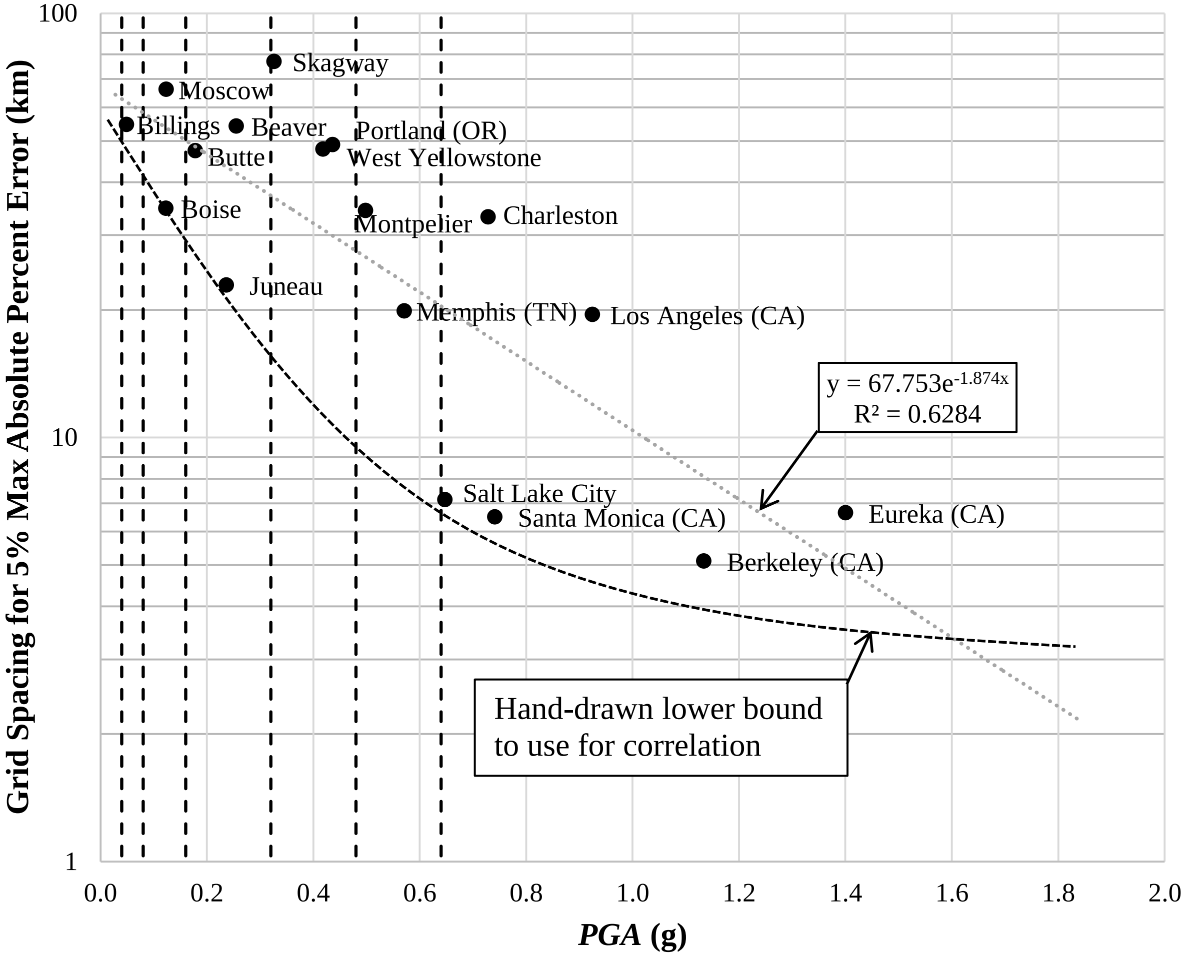


Figure 4-12 Correlation between *PGA* and optimum grid spacing to achieve 5% maximum absolute percent error (based on *CSR*%).

The hand-drawn lower bound shown in Figure 4-12 was used to determine the set of rules for selecting grid spacing in the mapping procedure. Within each *PGA* bin, a lower-bound value for optimum grid spacing was selected. The set of rules includes one optimum grid spacing distance for each *PGA* bin included in the study. Table 4-2 summarizes this set of rules.

Table 4-2 Proposed Set of Rules to Determine Optimum Grid Spacing within a *PGA* Range

PGA	Color	Spacing (km)	Spacing (mi)
0 - 0.04	Gray	50	31.1
0.04 - 0.08	Blue	50	31.1
0.08 - 0.16	Green	30	18.6
0.16 - 0.32	Yellow	20	12.4
0.32 - 0.48	Orange	12	7.5
0.48 - 0.64	Red	8	5.0
0.64+	Pink	4	2.5

In summary, the correlation determined in this study provided a set of rules to use when creating liquefaction loading maps for *CSR*% and liquefaction parameter maps for N_{req}.

4.3 Empirical Lateral Spread Displacement Model

This section will describe the methods used to derive the optimum grid spacing to ensure accuracy of interpolated points determined by the simplified performance-based lateral spread displacement evaluation. To ensure accuracy of the maps, interpolation between grid points must result in values reasonably close to the results of an actual analysis at the same location. It was determined that if the interpolated result was within 5% of an actual analysis at that site, then the result was acceptable.

4.3.1 Methodology for Grid Spacing Study

The methodology used to derive the optimum grid spacing for the simplified lateral spread displacement model began with the selection of three cities in each state that represent three different levels of seismic hazard (with the exception of Connecticut which had essentially uniform hazard across the state). Using the USGS 1996 and 2008 deaggregation websites the PGA at each site was determined for the 2475 year return period. The hazard level at each site as well as the hazard range for each state was found based on the same representation seen in the USGS 2008 PGA hazard map for the 2475 year return period. This map and the subdivision of hazard level can be seen in Figure 4-7, and a table listing each city with its corresponding *PGA* and hazard zone can be seen in Table 4-3.

Table 4-3 Grid Spacing Analysis Sites and *PGA*

State	Site	*PGA*	Hazard Zone
Alaska	Anchorage	0.618	Red
	Fairbanks	0.414	Orange
	Juneau	0.237	Yellow
Connecticut	Hartford	0.093	Green
	Norwich	0.086	Green
	Danbury	0.121	Green
Idaho	Salmon	0.375	Orange
	Boise	0.136	Green
	Pocatello	0.199	Yellow
Montana	Butte	0.179	Yellow
	Glendive	0.028	Grey
	Billings	0.050	Blue
South Carolina	Charleston	0.733	Pink
	Greenville	0.142	Green
	Columbia	0.225	Yellow
Utah	Salt Lake City	0.665	Pink
	Moab	0.087	Green
	Cedar City	0.285	Yellow

To assess the grid spacing, the reference lateral spread displacement, D_H^{ref}, was found at each city and then four locations surrounding the city at a set grid spacing. Using the city as an anchor point, the four points were selected equidistant from the center creating a square. The grid spacing is then the length of the sides of the square. This arrangement can be seen in Figure 4-1. Using the four surrounding points, a value was interpolated at the center of the points and then compared to the actual value found at the site. This process was repeated for several grid spacings and the % error was calculated. An example of this process can be seen for the city of Charleston, South Carolina at a grid spacing of 15 km (9.32 mi) in Table 4-4.

Table 4-4 Grid Spacing Interpolation Example Calculation for Charleston, South Carolina (32.783, -79.933) at 15 km (9.32 mi) grid spacing.

Grid Spacing - 15 km (9.32 mi)		
Latitude	Longitude	D_H^{ref} (m)
32.850	-80.000	0.829
32.716	-80.000	0.522
32.850	-79.866	0.479
32.716	-79.866	0.333
Interpolated D_H^{ref} (m)		**0.541**
Actual D_H^{ref} (m)		**0.513**
Error (%)		**5.41%**

This process was repeated for each city in the analysis at grid spacings of 5, 10, 15, 20, 25, 30, 40, and 50 km (3.1, 6.21, 9.32, 12.4, 15.5, 18.6, 24.9, and 31.1 mi). The grid spacing, where the error is 5% or less, was then plotted against *PGA* to get an idea of how the grid spacing differs from site to site. This plot can be seen in Figure 4-13.

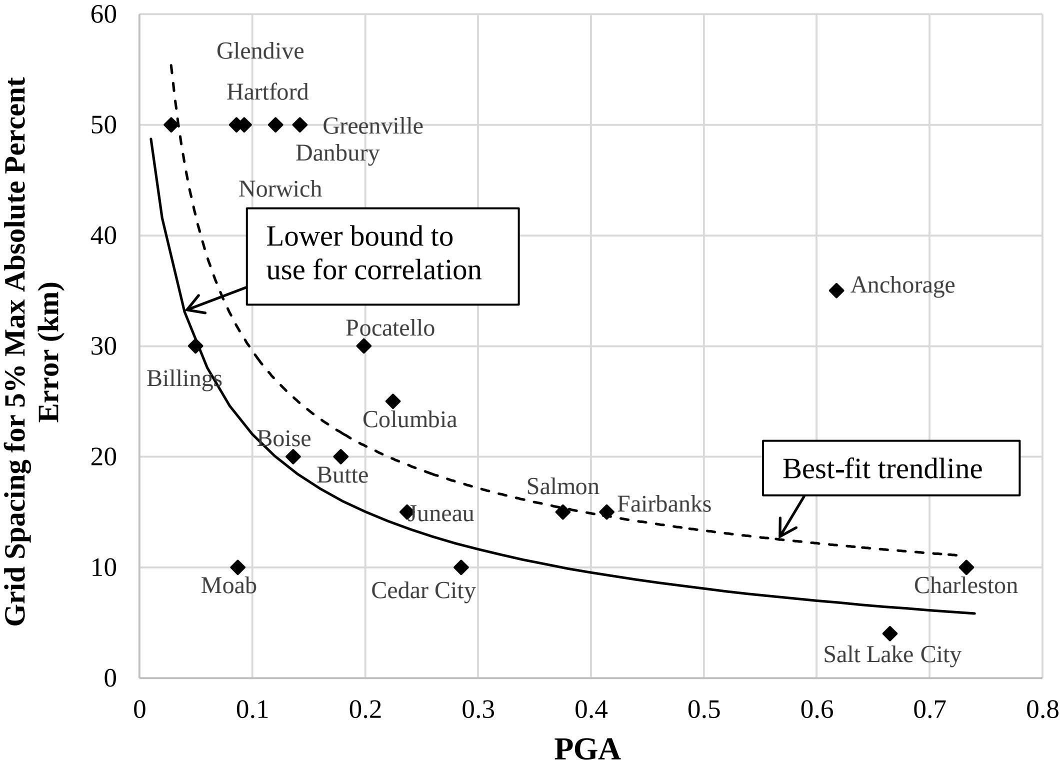


Figure 4-13 Grid spacing based on 5% error plotted against PGA for all sites.

As can be seen in this plot, there is significant scatter of the results. The seismic loading of each location can be very different, so the way that the lateral spread analysis attenuates could be influenced heavily by this. In order to address this uncertainty, a line was fit to the data (dashed line) than a lower bound (solid line) was drawn to represent the minimum grid spacing. This lower envelope was used for all locations, with the exception of Utah and Alaska. Utah was found to require a much finer grid spacing overall and so a specific grid spacing was created to account for this. Alaska was given a slightly coarser grid spacing for two reasons: the first was due to the analysis showing Alaska being overall higher on this plot, and second that Alaska has significantly more surface area than the rest of the states and required more analysis than the rest of the states combined. These proposed grid spacings can be seen in Table 4-5.

Table 4-5 Proposed Grid Spacing for Analysis Based on *PGA* Zone

PGA	Color	General (km)	Utah (km)	Alaska (km)
0 - 0.04	Gray	40	25	45
0.04 - 0.08	Blue	30	20	35
0.08 - 0.16	Green	20	15	25
0.16 - 0.32	Yellow	15	12	20
0.32 - 0.48	Orange	12	10	15
0.48 - 0.64	Red	8	7	10
0.64+	Pink	5	4	8

4.4 Performance-based Post-Liquefaction Settlement Evaluation

This section will describe the methods used to derive a correlation between optimum grid spacing and *PGA* for the simplified performance-based post-liquefaction settlement evaluation. The purpose of this correlation was to provide a simple, readily-available, well-defined set of rules for proper grid spacing across the states of interest. This set of rules is necessary because it is impractical to perform an infinite number of full performance-based analyses to create the liquefaction hazard contour maps. It was necessary to determine a finite number of points to analyze. The set of rules created in this grid spacing study was used to define the optimum number of points which would be feasible to analyze in the amount of time given and would yield an acceptable amount of error due to interpolation between analyzed points.

4.4.1 Methodology for Grid Spacing Study

Year 1 of this study performed a preliminary study in which it was hypothesized that expected *PGA* values have an effect on optimum grid spacing. Specifically, it was hypothesized that as *PGA* increases, the optimum grid spacing decreases. Please see the Year 1 report for more details on the preliminary study. This report builds on the premise introduced in Year 1 that *PGA* has an effect on the optimum grid spacing.

To estimate the effect of *PGA* on optimum grid spacing, a study was conducted also focusing on 35 cities with a wide range of *PGA* values (Figure 4-6). For each city, the coordinates for an “anchor point” were selected. Using a square grid (like the one shown in Figure 4-1), a full performance-based liquefaction analysis was run for the anchor point using the reference soil profile to obtain values of $\varepsilon_{Cetin}^{ref}$ and $\varepsilon_{IshiharaYoshi\min e}^{ref}$ at three different return periods (475, 1033, and 2475 years). The full performance-based method was also run for four surrounding coordinates at varying grid spacings. The testing process included grid spacings of 1, 2, 4, 8, 16, 25, 35, and 50 kilometers (0.62, 1.24, 2.49, 4.97, 9.94, 15.5, 21.7, and 31.1 miles, respectively).

An estimate of the liquefaction hazard at the center point (i.e. the interpolated value of either $\varepsilon_{Cetin}^{ref}$ or $\varepsilon_{IshiharaYoshi\min e}^{ref}$) was calculated from the four corner points using a direct average of the four corner points. This interpolated value was then compared to the actual value of the center anchor point as calculated using a full performance-based liquefaction analysis. The absolute difference between the interpolated value and the true value at the center is called the error term. The error terms were calculated for each city at each grid spacing as follows:

$$AbsoluteError_{CITY,x} = \left| InterpolatedValue_{CITY,x} - AnchorValue_{CITY} \right| \qquad (123)$$

where *CITY* indicates the city of interest and *x* is the grid spacing in question.

The error term calculated in equation (124) is different from the error term introduced in the Year 1 study which is a percent error. The absolute error was chosen as the error term for post-liquefaction strains due to the nature of the extremely small strain values. Even with very small magnitude strain values, slight fluctuations in strain values can lead to a high percent error even if the change is considered negligible.

The desired outcome of the grid spacing study was to create a correlation between *PGA* and optimum grid spacing in km. An equation for the best-fit trend line of *PGA* vs. optimum grid spacing alone would not be sufficient, because defining grid points to use in an analysis does not work well with non-integer values for grid spacing and constantly changing distances between points. Therefore, it was necessary to divide the different cities into *PGA* "bins" or defined ranges of values. These bins were determined using the USGS 2008 *PGA* hazard map (T_r = 2475 years) as shown in Figure 4-7. The *PGA* hazard map was chosen because it was clear and readily available as a well-documented definition of which areas in the country had significantly different seismicity levels compared to other areas' seismicity levels. Therefore, the objective of this study was to determine the optimum grid spacing for each color bin.

The maximum absolute error (i.e. the maximum absolute error between the Cetin (2009) and Ishihara and Yoshimine (1992) models across all return periods for a given anchor point) became the deciding parameter in selecting optimum grid spacing for a given location. The relationship between maximum absolute error and grid spacing was analyzed for each city and is discussed in the following section.

4.4.2 Results of Grid Spacing Study

The relationship between absolute error and grid spacing was analyzed for each city. It was determined that "optimum grid spacing" would be defined as the smallest grid spacing (i.e shortest distance between grid points) which yielded a maximum absolute error of 0.0015 (0.15%) across all return periods based on vertical strain. For example, if a full performance based analysis was run for an anchor point and returned a strain value of 0.02 (2%), an absolute error of 0.0015 means that the interpolated value from the four corner points would lie within 0.0185 and 0.0215 (1.85%-2.15%). In other words, for the reference soil profile as seen in Figure 2-9 which 12 is meters thick, an absolute error of 0.15% would result in settlement error of ±1.8 cm. This seemed to be a reasonable amount of error, considering fluctuations in settlement of 1.8 cm would not necessarily change decision making and mitigation procedures.

It is again worth noting that this study was performed in an attempt to limit spatial biases for *reference profile*. This study does not ensure that the simplified performance-based strains in the site profile will be within ±0.15% of the full performance-based method. For a review on the accuracy of the simplified versus full performance-based method see the Year 2, Quarter 1 report of this study.

Optimum grid spacing was determined using a plot of absolute error vs grid spacing in km. Unique plots were created for each city to determine the optimum grid spacing. Sample plots are provided in Figure 4-14, Figure 4-15, and Figure 4-16. Some cities' data followed a linear trend line while others followed a polynomial, or even logarithmic, trend line. In each case, a reasonable best-fit curve or line was used to determine optimum grid spacing. Some of the cities selected for this study, particularly those with low *PGA* values, did not reach a maximum absolute error of 0.0015 even when the grid spacing was increased to 50 km (31.07 mi) or more. To avoid extrapolation, a maximum grid spacing threshold of 50 km was set, regardless of how low the error was. A description of the final correlation between *PGA* and optimum grid spacing is included in the following section.

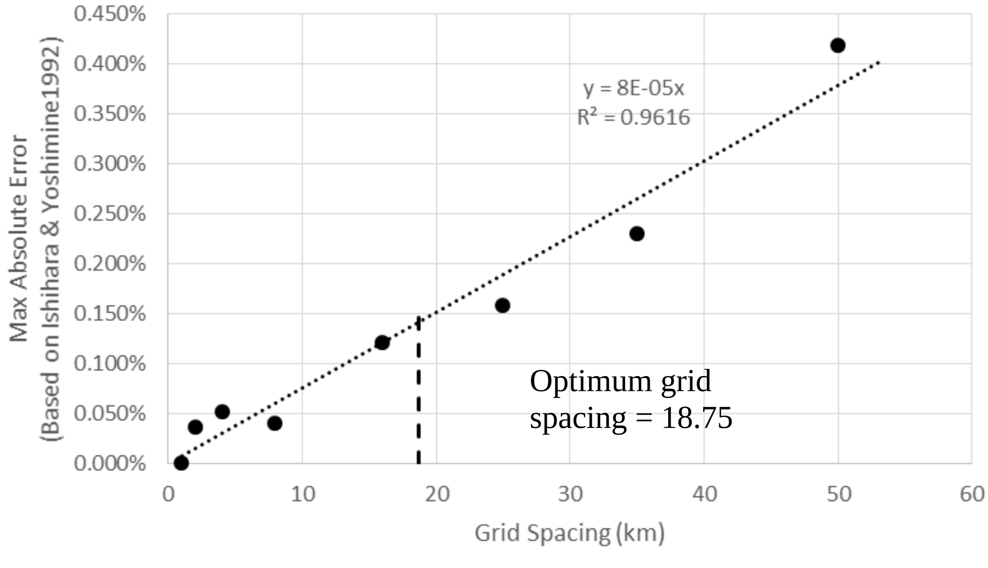


Figure 4-14 Variation of maximum percent error (based on Ishihara & Yoshimine 1992) with increasing distance between grid points for Eureka, CA. (Pink zone, *PGA* = 1.4004)

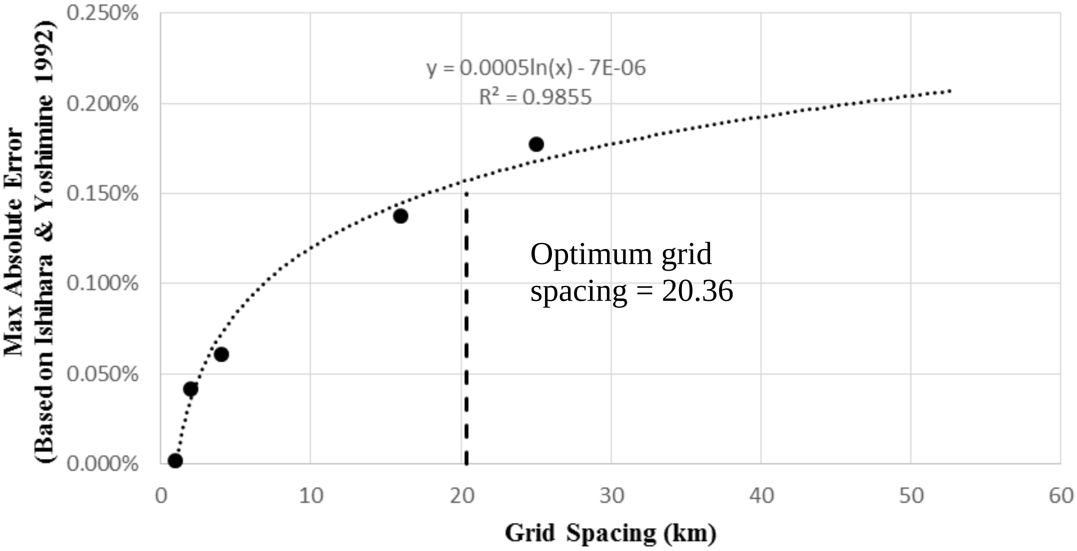


Figure 4-15 Variation of maximum percent error (based on Ishihara & Yoshimine 1992) with increasing distance between grid points for Portland, OR. (Orange zone, *PGA* = 0.4366)

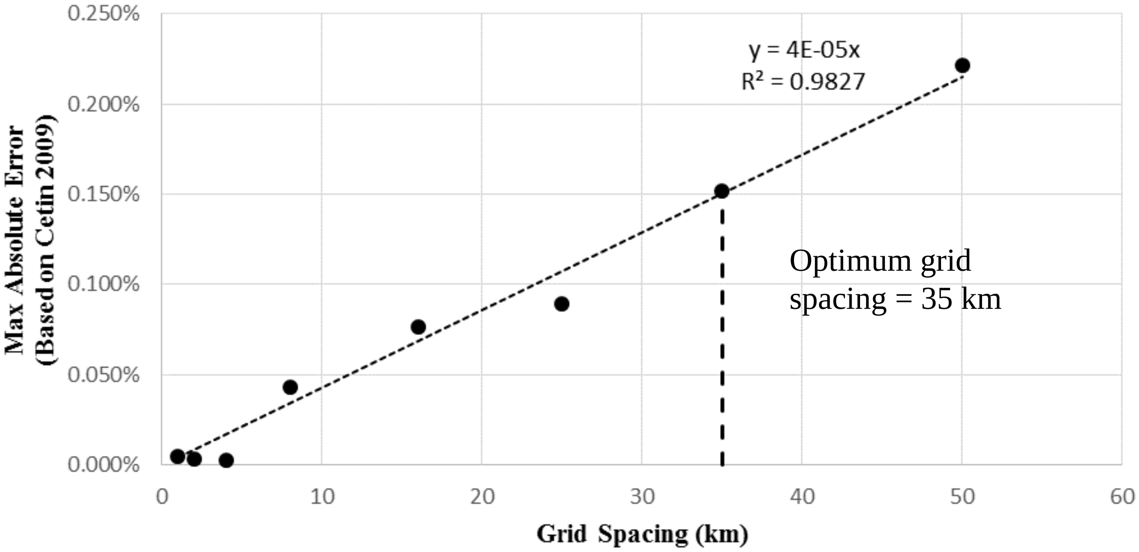


Figure 4-16 Variation of maximum percent error (based on Cetin 2009) with increasing distance between grid points for Butte, MT. (Yellow zone, *PGA* = 0.1785)

<u>4.4.3 *PGA* Correlation</u>

As described in the previous section, optimum grid spacing was determined for each city included in the study that reached at least a maximum absolute error of 0.0015 based on either reference strain (Cetin 2009 or Ishihara and Yoshimine 1992). Optimum grid spacing was then plotted against *PGA* as shown in Figure 4-17. The vertical dashed lines indicate the boundaries between *PGA* bins as defined in the USGS 2008 *PGA* hazard map. The general trend of the points supports the hypothesis that as *PGA* increases the optimum grid spacing decreases. A hand-drawn lower bound was used to determine the optimum grid spacing based on *PGA*. The lower bound line was chosen as a conservative estimate of optimum grid spacing.

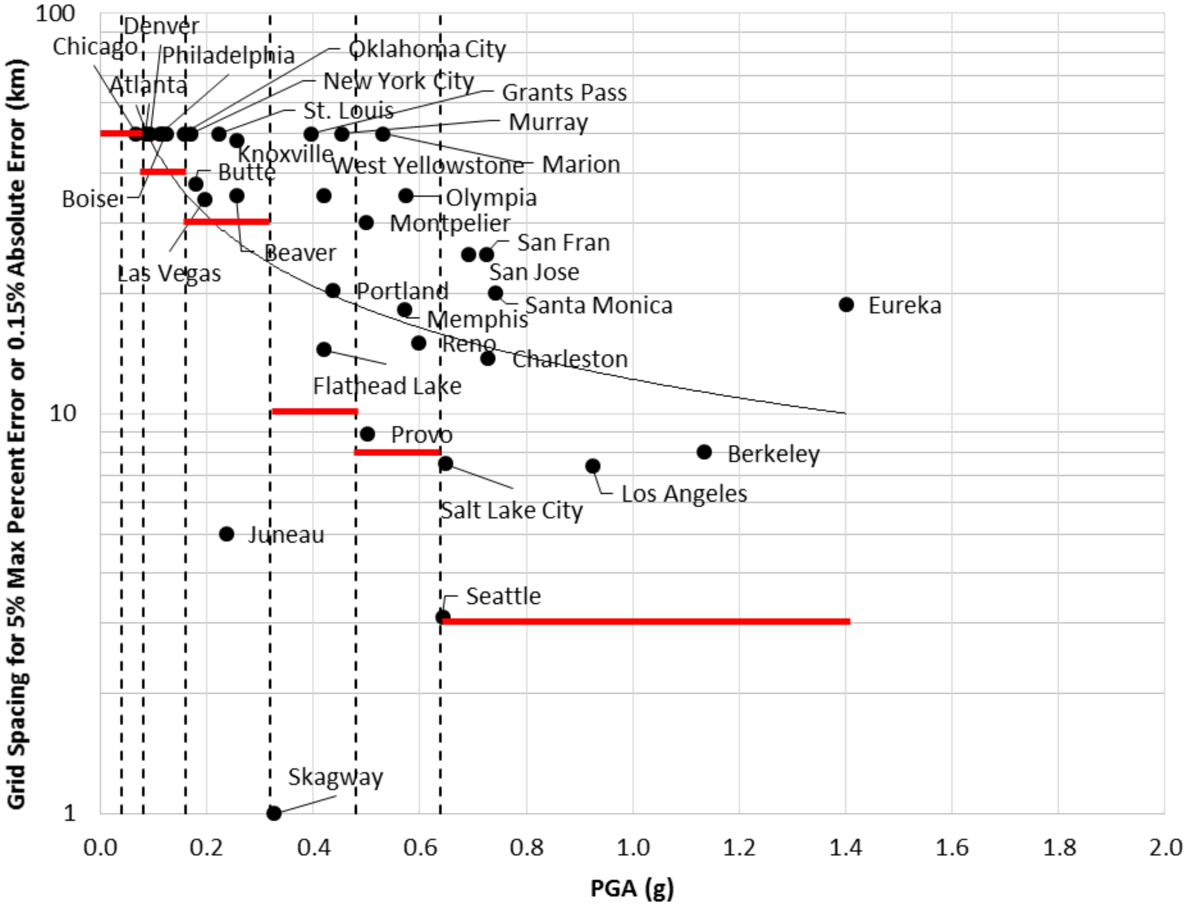


Figure 4-17 Correlation between *PGA* and optimum grid spacing to achieve 0.0015 maximum absolute error (based on minimum grid spacing between Cetin 2009 and Ishihara & Yoshimine 1992)

The hand-drawn lower bound shown in Figure 4-17 was used to determine the set of rules for selecting grid spacing in the mapping procedure. Within each *PGA* bin, a lower-bound value for optimum grid spacing was selected. The set of rules includes one optimum grid spacing distance for each *PGA* bin included in the study. Table 4-6 summarizes this set of rules.

Table 4-6 Proposed Set of Rules to Determine Optimum Grid Spacing within a *PGA* Range

PGA	Color	Spacing (km)	Spacing (mi)
0 - 0.04	Gray	50	31.1
0.04 - 0.08	Blue	50	31.1
0.08 - 0.16	Green	40	24.9
0.16 - 0.32	Yellow	30	18.6
0.32 - 0.48	Orange	10	6.21
0.48 - 0.64	Red	8	4.97
0.64+	Pink	3	1.86

In summary, the correlation determined in this study provided a set of rules to use when creating liquefaction parameter maps for $\varepsilon^{ref}_{Cetin}$ and $\varepsilon^{ref}_{IshiharaYoshi\min e}$

4.5 Seismic Slope Displacement Model

This section will describe the methods used to derive the optimum grid spacing to ensure accuracy of interpolated points determined by the simplified performance-based seismic slope displacement evaluation. To ensure accuracy of the maps, interpolation between grid points must result in values reasonably close to the results of an actual analysis at the same location. A common way to ensure that the mean value will be within a range is that of a 95% confidence interval, or a corresponding 5% error. For this study, it was determined that if the interpolated result was within 5% of an actual value computed at that site, then the result was acceptable. A few cities were analyzed using the absolute difference instead of the 5% error as it will be discussed in the following section because as a percentage these did not meet the criteria. When looking at the absolute difference between the interpolated value and the actual value at the anchor point corresponding optimum grid spacings to displacements, no greater than 5cm were recommended for the specific cities.

4.5.1 Methodology for Grid Spacing Study

The methodology used to derive the optimum grid spacing for the simplified seismic slope displacement model was the same as described in the previously addressed lateral spread displacement model. Using the USGS 1996 and 2008 Deaggregation websites the PGA at each site was determined for the 2475 year return period. The hazard level at each site as well as the hazard range for each state was found based on the same representation seen in the USGS 2008 PGA hazard map for the 2475 year return period shown in Figure 4-7.

The grid spacing for the corresponding hazard zone was determined by calculating seismic slope displacements on a grid as seen in Figure 4-1. This process was repeated at 2 km, 4 km, 8 km, 16 km, 25 km, 35 km, and 50 km grid spacing, and the % error was calculated as shown in Equation (125) . A plot of each city and simplified seismic slope displacement method was generated and using best fit lines the optimum grid spacing corresponding to 5 % error was identified as shown in the figures below.

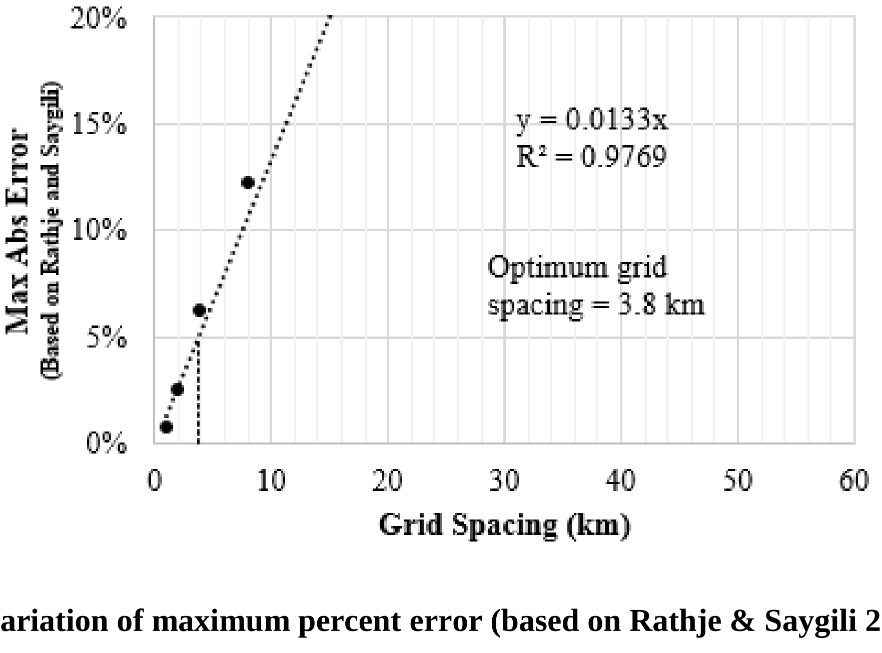


Figure 4-18 Variation of maximum percent error (based on Rathje & Saygili 2009) with increasing distance between grid points for Eureka, CA. (Pink zone, PGA = 1.4004)

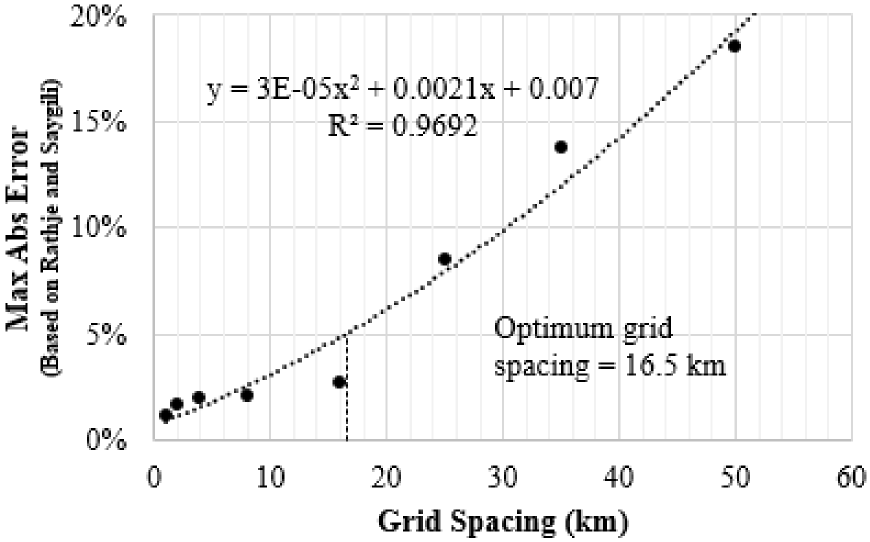


Figure 4-19 Variation of maximum percent error (based on Rathje & Saygili 2009) with increasing distance between grid points for Portland, OR. (Orange zone, *PGA* = 0.4366)

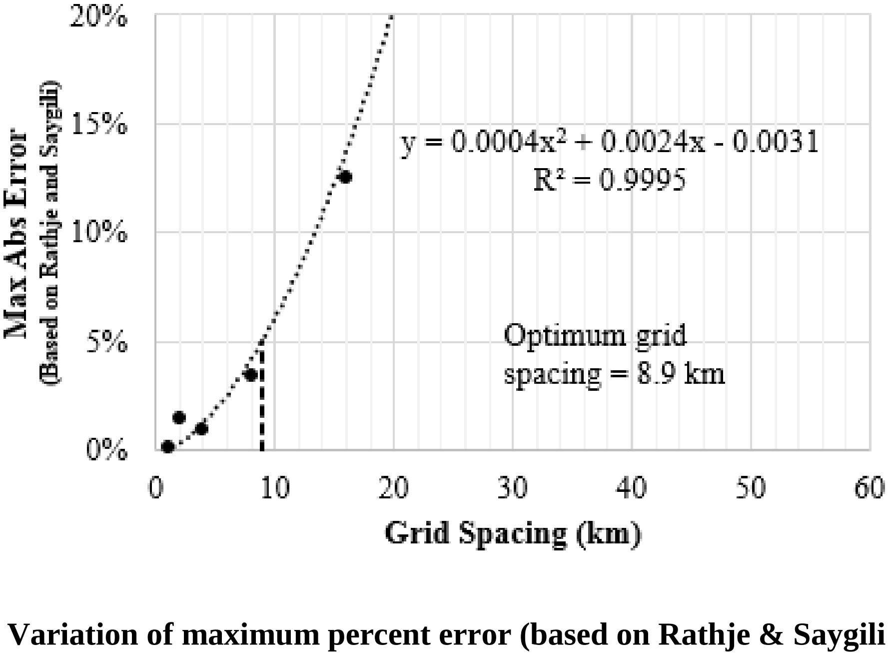


Figure 4-20 Variation of maximum percent error (based on Rathje & Saygili 2009) with increasing distance between grid points for Butte, MT. (Yellow zone, *PGA* = 0.1785)

This process was repeated for each city shown in Figure 4-6. The grid spacing, where the absolute difference was 5 cm or less, was plotted against *PGA* to get an idea of how the grid spacing differs from site to site. This plot can be seen in Figure 4-21 below.

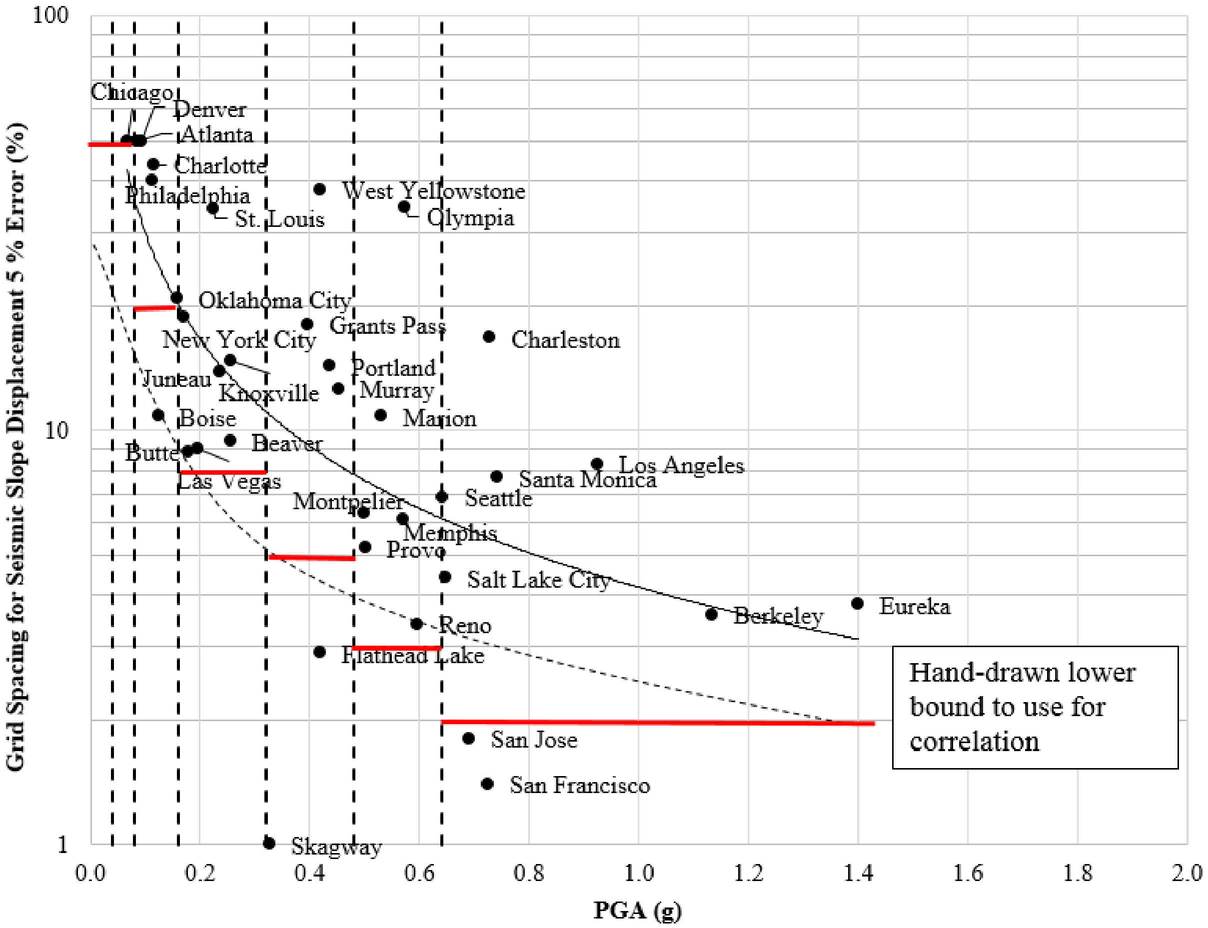


Figure 4-21 Grid spacing based on 5% Error plotted against PGA for all sites.

Figure 4-21 shows significant scatter of the results. The seismic loading at the different locations seems to be a factor affecting the seismic slope displacement analysis' results. A way to address the uncertainty is with the use of a best fit line to identify a trend in the data's behavior and then draw a dashed line just below it as the lower bound to identify the recommended grid spacing for the cities analyzed. The proposed grid spacing for each PGA interval was hand drawn with the red lines.

Five out of the thirty five cities used in the study did not meet the criteria of 5% error. These cities were Skagway (AK), Flathead (MT), Salt Lake City (UT), San Jose (CA), and San Francisco (CA). After this observation, the absolute difference in centimeters was calculated for these cities. The criteria was to use 5 cm as the maximum allowable difference between the actual value and the interpolated value and the proposed spacing the cities not meeting the 5% error criteria. Once a grid spacing was assigned to the cities not meeting the criteria, an overall grid spacing was proposed as shown below in Table 4-7.

Table 4-7 Proposed Grid Spacing for Seismic Slope Displacement Analysis

PGA	Color	Spacing (km)	Spacing (mi)
0 - 0.04	Gray	50	31.1
0.04 - 0.08	Blue	50	31.1
0.08 - 0.16	Green	20	12.4
0.16 - 0.32	Yellow	8	5.0
0.32 - 0.48	Orange	5	3.1
0.48 - 0.64	Red	3	1.9
0.64+	Pink	2	1.2

4.6 Summary

Based on the analysis outlined here, the grid spacing necessary to maintain accuracy in the interpolated results was found. The grid spacings should result on average 5% difference between an interpolated value and the result if an analysis were performed at the same site for liquefaction initiation, lateral spread, and seismic slope displacement. For post liquefaction settlement, the grid spacing should result on an absolute difference of 0.0015 between an interpolated value and the result if an analysis were performed at the same site. These grid spacings will be very important in creating the grid of points that will be used in the analysis.

5.0 MAP DEVELOPMENT

5.1 Overview

Now that the optimum grid spacing between points has been determined, the grid points used in the analysis need to be determined, then those points need to be analyzed and the hazard parameters calculated. Once the analysis has been conducted for each grid, than those points will be used to create the liquefaction, lateral spread, post-liquefaction settlement and seismic slope displacement parameter maps for the target return periods.

This process required the use of several specialized software programs. To create the grid spacing and the maps the Geographical Information System (GIS) software ArcMap, developed by ESRI Incorporated, was used extensively. To perform the simplified liquefaction initiation analysis the software *PBLiquefY*, developed in house at BYU by Franke et al. (2014), was utilized. To perform the simplified lateral spread displacement analysis, the program EZ-FRISK created by Risk Engineering (2013) was used.

5.2 Creating the Grid Points

The process was started by dividing each state into sections based on the USGS 2008 *PGA* hazard map. This was done using GIS shapefiles downloaded from the USGS website representing the 2008 hazard map. Each *PGA* hazard zone was assigned a grid spacing based on the suggested grid spacing from the previous section. Then using ArcMap, a grid of points with latitude and longitude, was generated for each hazard zone at the specified grid spacing. All the zones were then combined into one general grid for the state.

Additionally, the representatives for each state involved in the research was asked to provide any areas which they felt constituted an “Area of Concern” (AOC). These areas were anywhere that a reduction in grid spacing was thought necessary to provide a more refined hazard surface. Each AOC was then accounted for by modifying the general grid spacing rules to reduce grid spacing in each AOC. This was accomplished differently for the different methods used in this report. For the liquefaction initiation method each AOC was elevated by two hazard levels and the grid spacing for that area was based off the higher hazard. For example, if the

AOC was in the "green" section of the hazard map the grid spacing in the AOC would be reduced to that of the "orange" level. The lateral spread displacement model increased all AOC to the "red" level and used that reduced grid spacing for each example. PBLiquefY (2014) has the capability of calculating liquefaction settlements and seismic slope displacements simultaneously for a given geographic coordinate; therefore, in order to limit the number of performance based analysis runs, the governing (finer) grid spacing was run for both liquefaction settlement and slope displacement. The governing grid spacing in all PGA zones was seismic slope displacement. All the zones were then combined into one general grid for the state. An example of the subdivision and the overall grid of points for Utah can be seen in Figure 5-1.

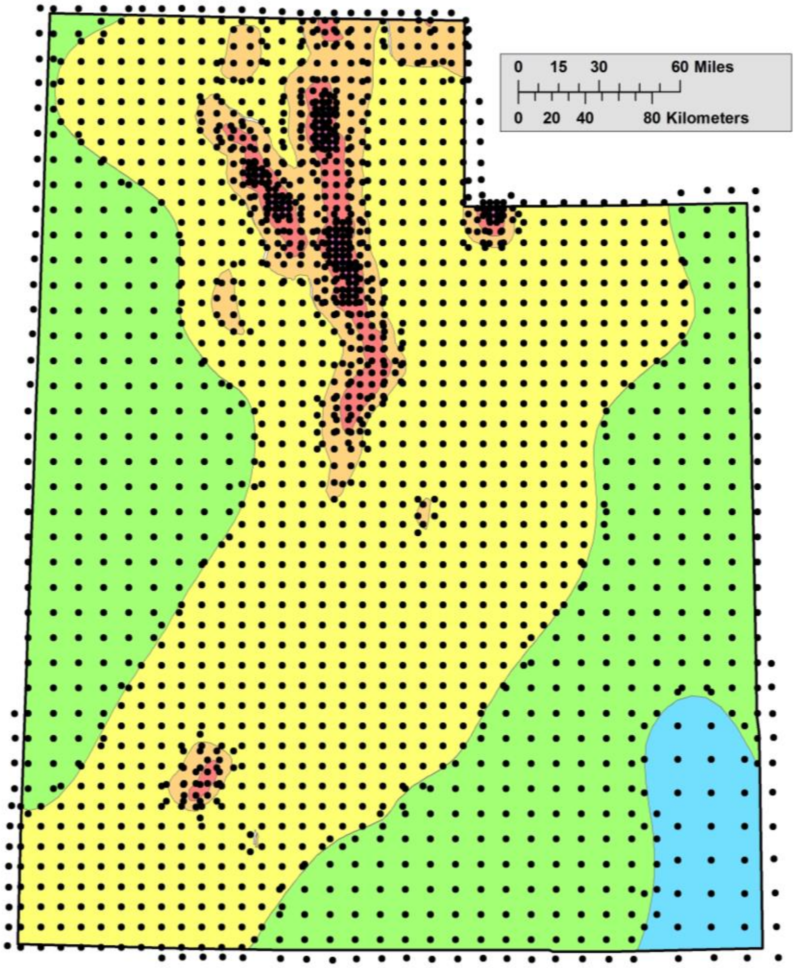


Figure 5-1 Grid points for Utah combined with USGS 2008 PGA hazard map.

5.3 Analysis of the Grid Points

Once the grid points were developed for all the states, the location of each of the points was evaluated for liquefaction and lateral spread hazard using the reference soil profiles discussed in the previous report. Each point was analyzed for the 475, 1033, and 2475 year return periods. Once all of the points for a particular state were successfully run, the results were compiled and then imported back into ArcMap to begin the process of making the parameter maps.

5.3.1 Analysis of the Liquefaction Initiation, Post-Liquefaction Settlement, and Seismic Slope Displacement Models Grid Points

The grid points used in the liquefaction initiation, post-liquefaction settlement, and seismic slope displacement methods were analyzed using the USGS 2008 deaggregations for Connecticut, Idaho, Montana, South Carolina, and Utah while the USGS 1996 deaggregations were used for Alaska (complete maps for liquefaction initiation are provided in this report, but complete maps for post-liquefaction settlement and seismic slope displacement maps will be made available when data is released by the USGS). Maps for Oregon will be created in the future when the 2014 USGS deaggregations become available. The process utilized the ability of PBLiquefY to run multiple sites sequentially.

5.3.2 Analysis of the Lateral Spread Displacement Model Grid Points

Analyzing the grid points in EZ-FRISK requires that a seismic source model be used. To analyze the points in Connecticut, Idaho, Montana, South Carolina, and Utah the USGS 2008 seismic source model. For Alaska, the USGS 1998 gridded source model and the USGS 2002 seismic source models were used to analyze the grid points. Only area sources and faults were considered within 300 km of each site, with the exception of subduction zone sources which were considered within 500 km.

5.4 Creation of the Maps

Once the analyzed grid points were imported back into ArcMap the points needed to be turned into a contour map. This was done by converting the individual points into a surface raster using the Kriging tool. This tool interpolates between each point and makes a surface with a value at every point. In order to ensure that the contours of each state run all the way to the border, the state shape is buffered slightly. The Kriging raster is created based on this buffered shape. Once the Kriging raster is made, the raster surface needs to be converted into a contour.

To make the contour from the Kriging, first the spacing of the contours needs to be determined. It is important that the contour spacing be fine enough that the detail of the map can be read, but far enough apart that the contours can be read. The spacing will vary from map to map based on this process. An example of a Kriging raster and contour for the state of Utah can be seen in Figure 5-2.

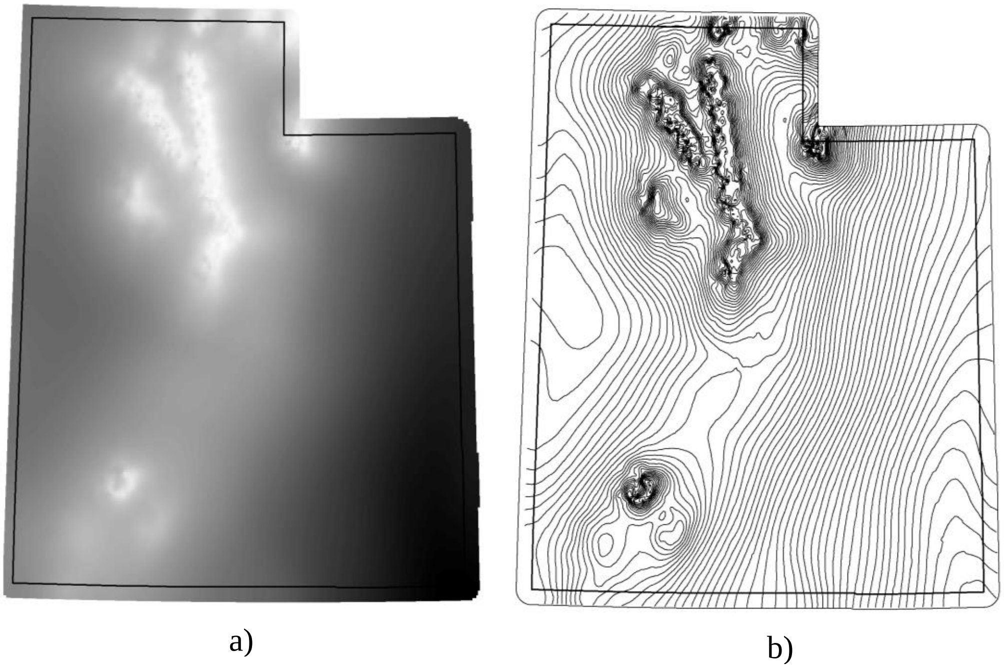

a) b)

Figure 5-2 a) Kriging raster and b) contours for Utah (T_r = 2475 yrs).

Once the proper contour spacing is determined for each map, the contour is labeled and clipped to fit the state shapefile. Then a basemap and reference features are added to provide more detail about the topography to the parameter maps. An example of a completed liquefaction parameter map of N_{req} can be seen in Figure 5-3.

Each model has different parameters represented by the contours on the map. The liquefaction initiation model has two different parameters and therefore two different maps. The first parameter is the reference value of *CSR*% as calculated using the Boulanger and Idriss (2014) model. *CSR* is usually given as a decimal but was changed to a percent to make reading the maps easier. The second parameter is the reference value for N_{req} as calculated using the Cetin et al. (2004) model and is given in units of SPT blowcounts. The lateral spread parameter map shows the reference value of displacement, D_H^{ref} as calculated using the Youd et al. (2002) model, and is given in units of Log (meters). For post-liquefaction settlement the first parameter is the reference value of strain, $\varepsilon_{Cetin}^{ref}$, as calculated using the Cetin (2009) model. Strain is usually given as a decimal but was changed to a percent to make reading the maps easier. The second parameter is the reference value for strain, $\varepsilon_{IshiharaYoshi\min e}^{ref}$, as calculated using the Ishihara & Yoshimine (1992) model and is also as a percent. The seismic slope displacement parameter maps seismic slope displacement for the Rathje and Saygili (2009) model ($D_{Rathje\&Saygili}^{ref}$) in centimeters, and Bray and Travasarou (2007) model ($D_{Bray\&Travasarou}^{ref}$) also in centimeters. Careful attention needs to be given to the labeling of each map to ensure that map has the correct parameter and that the reference value used in the later steps of the simplified method are accurately read from the contours.

For this report, maps of *CSR*%, N_{req}, D_H^{ref}, $\varepsilon_{Cetin}^{ref}$, $\varepsilon_{IshiharaYoshi\min e}^{ref}$, $D_{Rathje\&Saygili}^{ref}$ and $D_{Bray\&Travasarou}^{ref}$ were made for each state at the 475, 1033, and 2475 year return periods with the exception of Alaska maps for the post-liquefaction settlement and seismic slope parameters as explained before. Connecticut was also an exception for the 475 and 1033 year return periods for *CSR*% and the 475 year return period for N_{req}. The maps for Connecticut show no variation in those values and have uniform hazard ($N_{req} = 1$, *CSR*% = 4.65%) across the state. Consequently, those maps were not included. Additionally, maps for the cities of Anchorage, AK; Boise, ID; Butte, MT; Charleston, SC; and Salt Lake City, UT were created. These maps can be viewed in the Appendix: liquefaction parameter maps in Appendix B, lateral spread hazard maps in Appendix C, post-liquefaction settlement hazard maps in Appendix D, and seismic slope displacement hazard maps in Appendix E. The contours were adjusted for each map to make reading it as user friendly as possible.

These maps were provided to show the potential types of parameter maps that can be created. Using the Kriging rasters that will be provided at the culmination of this research, each state can create maps of any area in their state and determine the contour spacing and scale.

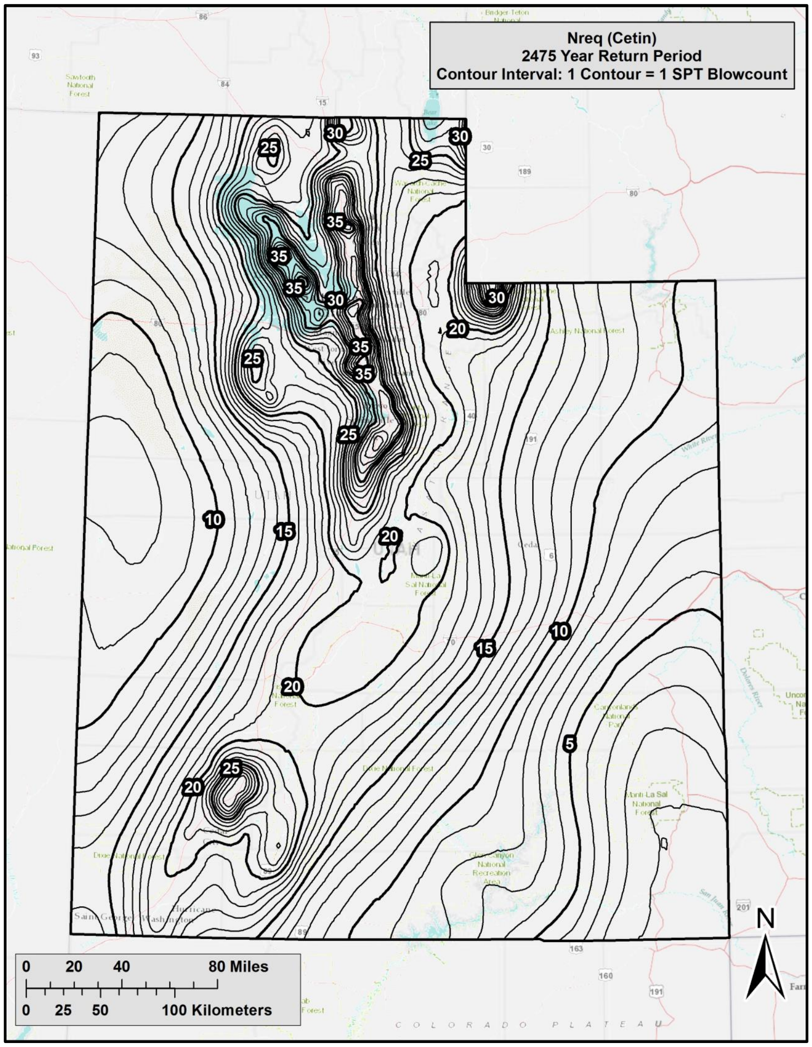


Figure 5-3 N_{req} for Utah (T_r = 2475 years).

5.5 Summary

To create the parameter and hazard maps, the state is subdivided into zones and a grid spacing for each zone is assigned. A grid of points is generated in ArcMap based on this grid spacing. Then the points are analyzed using the specified performance-based analytical software (PBLiquefy, EZ-FRISK). These points are then imported into ArcMap and converted to a

Kriging raster that is then used to create a contour of the reference parameter. Sample maps for the states participating in this research study can be seen in the Appendix.

6.0 COMPARISON OF PROBABILISTIC AND DETERMINISTIC ANALYSES

6.1 Overview

This section provides comparisons between the pseudo-probabilistic, deterministic, and simplified performance-based procedures for estimating liquefaction initiation hazard, lateral spread displacement, post-liquefaction settlement, and seismic slope displacement. The purpose of these comparisons is to identify how the deterministic procedure should be used in the proposed simplified procedure.

6.2 Methodology

Three cities of varying seismicity were selected for the comparison study: San Francisco (high seismicity), Salt Lake City (medium seismicity), and Butte (low seismicity). For each city, three analyses were performed: probabilistic (simplified performance-based procedure developed as part of this research), pseudo-probabilistic (AASHTO), and deterministic. A description of each analysis type is provided below.

6.2.1 Simplified Performance-Based Seismic Hazard Analysis

The simplified performance-based procedures involve retrieving a specified liquefaction hazard parameter from a hazard-targeted map developed using full probabilistic analyses. The probabilistic analyses which created the liquefaction loading and lateral spread parameter maps involve creating hazard curves which consider all possible combinations of the required seismic hazard analysis variables and their respective likelihoods. Examples of these variables would be: maximum horizontal ground acceleration, a_{max}, moment magnitude, M_w, or site-to-source distance, R. These processes are discussed in greater detail in the previously submitted update reports: Update Report Year 1 Quarter 1 and Update Report Year 2 Quarter 1 for the simplified performance-based methods, and Update Report Year 1 Quarter 2 and Update Report Year 2 Quarter 2 for the development of the liquefaction loading, lateral spread, post-liquefaction settlement, and seismic slope displacement parameter maps.

The parameters used for the comparison of deterministic and simplified methods for this study were: for liquefaction initiation, $CSR\%^{ref}$; for lateral spread, D_H^{ref}; for post-liquefaction settlement, ε^{ref}; and for seismic slope displacement, D^{ref}. Each of the parameters were found at the target cities for the 475, 1033, and 2475 year return periods.

6.2.1.1 Simplified Liquefaction Initiation

For the simplified liquefaction initiation procedure the appropriate uniform hazard-targeted liquefaction loading map was identified for each site and values of $CSR\%^{ref}$ were obtained for the necessary return periods. These $CSR\%^{ref}$ values were adjusted for soil characteristics associated with the same assumed soil profile as was used in the validation of the simplified method (shown in Figure 3-1) to estimate $CSR\%^{site}$ values. This same soil profile was used for all three analyses (probabilistic, pseudo-probabilistic, and deterministic). The values of $CSR\%^{site}$ were used to calculate factor of safety against liquefaction (FS_L), and clean-sand equivalent SPT blow count required to resist liquefaction initiation (N_{req}). This process was previously described in greater detail in the derivation of the simplified procedure.

6.2.1.2 Simplified Lateral Spread Displacements

For the simplified performance-based procedure the appropriate lateral spread parameter map was identified for each site and values of D_H^{ref} were obtained for the necessary return periods. Using a generic soil profile (shown in Figure 6-1), the values of D_H^{ref} were corrected and the D_H^{site} was determined for each city at the targeted return periods. The additional analyses (pseudo-probabilistic and deterministic) for the comparison utilized the same soil profile. This process was previously described in greater detail in the derivation of the simplified procedure.

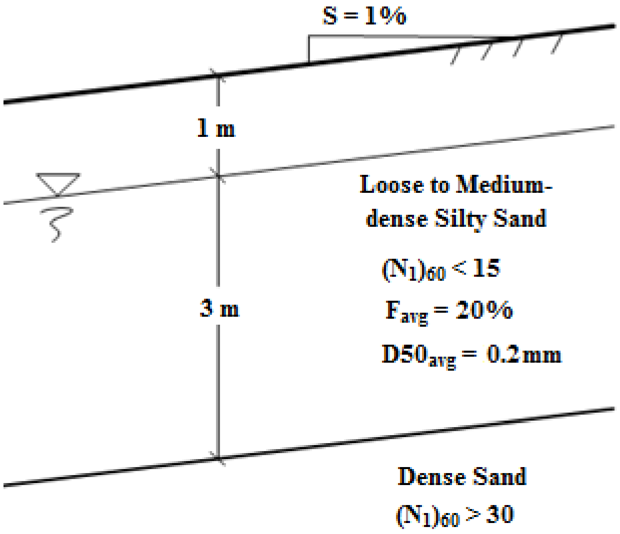


Figure 6-1 Soil profile used for the lateral spread displacement comparison study.

6.2.1.3 Simplified Post-Liquefaction Settlements

For the simplified liquefaction settlement procedure the appropriate uniform hazard-targeted liquefaction loading map was identified for each site and values of $\varepsilon_{v,Cetin}(\%)^{ref}$ and $\varepsilon_{v,I\&Y}(\%)^{ref}$ were obtained for the necessary return periods. These reference strain values were adjusted for soil characteristics associated with an assumed soil profile (shown in Figure 6-2) to estimate $\varepsilon_{v,Cetin}^{site}$ and $\varepsilon_{v,\mathrm{I\&Y}}^{site}$ values. This same soil profile was used for all three analyses (probabilistic, pseudo-probabilistic, and deterministic) to compute site strains at the selected locations. This process is described in greater detail in Chapter 2.0 and 3.0.

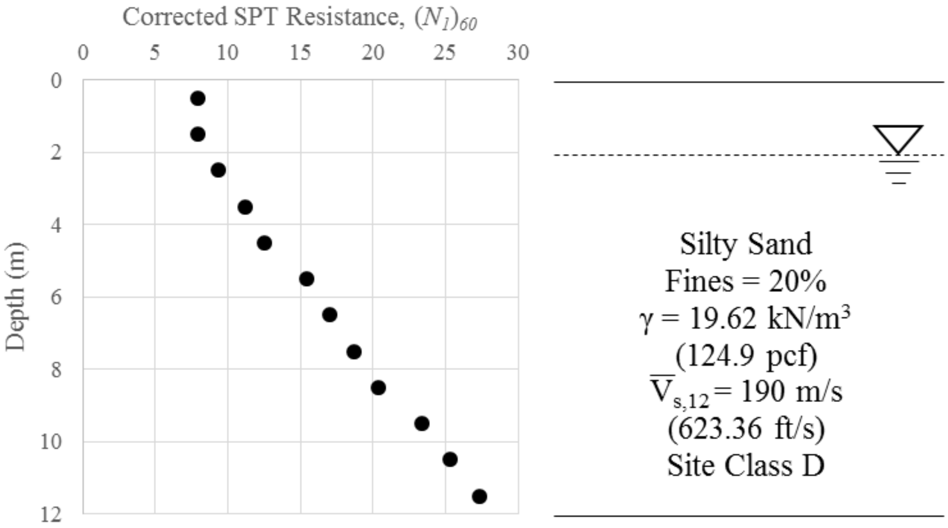


Figure 6-2 Soil profile used for the liquefaction initiation comparison study.

6.2.1.4 Simplified Seismic Slope Displacements

For the simplified performance-based procedure the appropriate seismic slope displacement parameter map was identified for each site and values of D^{ref} were obtained for the necessary return periods, D^{ref} values could also be obtained using the reference parameter interpolation tool with the known latitude and longitude of the site in question. Using a generic yield acceleration value, $k_y = 0.1$ g, the values of D^{ref} were corrected and the D^{site} was determined for each city at the targeted return periods. The additional analyses (pseudo-probabilistic and deterministic) for the comparison utilized the same k_y reference value. The simplified procedure is described in greater depth in Chapter 2.0 and 3.0.

6.2.2 Deterministic Procedure

In the deterministic procedure, ground motions are obtained through a Deterministic Seismic Hazard Analysis (DSHA). A DSHA involves deterministically assessing the seismic sources in the nearby region of the site of interest and identifying the source which produces the highest hazard in the area. The software EZ-FRISK was used to identify the top five seismic sources within 200 km for San Francisco, Butte, and Salt Lake City. The 2008 USGS Seismic Source Model within EZ-FRISK does not include some smaller faults in low seismic regions, such as Butte. Thus, the governing fault for Butte (Rocker Fault) was identified using the USGS quaternary fault database (USGS et al., 2006). In the case of Salt Lake City and San Francisco, EZ-FRISK provided values of M_w, PGA, and R for both the 50th (i.e. median) and 84th (i.e. median + σ) percentiles according using the New Generation Attenuation (NGA) models for the Western United States (Boore and Atkinson, 2008; Campbell and Bozorgnia, 2008; and Chiou and Youngs, 2008) and weighting schemes shown in Table 6-1. For Butte, the 50th and 84th percentile M_w values were estimated using a correlation with surface rupture length developed by Wells and Coppersmith (1994), and PGA was calculated using the same three (NGA) models based on measured dimensions and assumed characteristics of the Rocker Fault. Summaries of the seismic sources considered in this DSHA and details of the Rocker Fault calculations are provided in Tables A.1 and A.2, respectively, in the appendix. Once the model inputs have been determined through the DSHA they are entered into the respective empirical liquefaction hazard models. A summary of the governing input variables utilized in the deterministic liquefaction initiation and lateral spread displacement models are provided in Table 6-2.

Table 6-1 NGA model weights used in the deterministic procedure.

Attenuation Model	Weight
Boore & Atkinson (2008)	0.333
Campbell & Bozorgnia (2008)	0.333
Chiou & Youngs (2008)	0.333

Table 6-2 Input variables used in the deterministic models (a_{max} calculated using F_{pga} from AASHTO code).

Location	Latitude	Longitude	Distance [km]	Mean M_w	Median (50%)		Median + σ (84%)	
					PGA	a_{max}	PGA	a_{max}
Butte	46.003	-112.533	4.92	6.97	0.5390	0.5390	0.9202	0.9202
Salt Lake City	40.755	-111.898	1.02	7.00	0.5911	0.5911	1.005	1.005
San Francisco	37.775	-122.418	12.4	8.05	0.3175	0.3754	0.5426	0.5426

6.2.2.1 Liquefaction Initiation

Estimations of liquefaction initiation potential (FS_L, N_{req}, and CSR%) were calculated deterministically using equations from the Idriss and Boulanger (2008) liquefaction triggering model. CSR% is found using the following equation:

$$CSR(\%) = 0.65 \frac{a_{\max}}{g} \frac{\sigma_v}{\sigma_v{}'} \left(r_d\right) \frac{1}{\left(MSF\right)} \frac{1}{K_\sigma} (100\%) \tag{126}$$

where σ_v is the total vertical stress in the soil; $\sigma_v{}'$ is the effective vertical stress in the soil; $a_{\max}/g$ is the peak ground surface acceleration as a fraction of gravity; MSF is the magnitude scaling factor as computed according to Idriss and Boulanger (2008); r_d is the depth reduction factor according to Idriss and Boulanger (2008); and K_σ the depth correction factor and is computed according to Idriss and Boulanger (2008). FS_L is calculated as:

$$FS_L = \frac{CRR}{CSR} = \frac{100 \cdot CRR}{CSR(\%)} \tag{127}$$

$$CRR_{P_L=50\%} = \exp\left[\left(\frac{\left(N_1\right)_{60,cs}}{14.1}\right) + \left(\frac{\left(N_1\right)_{60,cs}}{126}\right)^2 - \left(\frac{\left(N_1\right)_{60,cs}}{23.6}\right)^3 + \left(\frac{\left(N_1\right)_{60,cs}}{25.4}\right)^4 - 2.8\right] \tag{128}$$

where $\left(N_1\right)_{60,cs}$ represents the clean sand-equivalent SPT resistance value corrected to 60% efficiency and 1 atm overburden pressure as computed using the equations provided by Idriss and Boulanger (2008, 2010). N_{req} is solved iteratively from the following polynomial:

$$0 = \left(\frac{N_{req}}{14.1}\right) + \left(\frac{N_{req}{}^2}{126}\right) - \left(\frac{N_{req}{}^3}{23.6}\right) + \left(\frac{N_{req}{}^4}{25.4}\right) - 2.8 - \ln\left(CSR\right) \tag{129}$$

6.2.2.2 Lateral Spread Displacement

Estimations of lateral spread displacement for the deterministic process were found using the equation from the Youd et al (2002) empirical lateral spread model. The model is a regression based on seismic loading parameters and site specific soil parameters. The seismic loading inputs are shown in Table 6-2, and the site specific soil inputs were drawn from the soil profile seen in Figure 6-1. With these values the lateral spread displacement, D_H, is found using the following equation:

$$\begin{aligned}\overline{\log D_H} &= b_0 + b_1 M + b_2 \log R^* + b_3 R + b_4 \log W + b_5 \log S \\ &\quad + b_6 \log T_{15} + b_7 \log\left(100 - F_{15}\right) + b_8 \log\left(D50_{15} + 0.1\right)\end{aligned} \tag{130}$$

where D_H is the median computed permanent lateral spread displacement (m), M is the earthquake moment magnitude, R is the closest horizontal distance from the site to the source (km), W is the free-face ratio (%), S is the ground slope (%), T_{15} is the cumulative thickness (in upper 20 m) of all saturated soil layers with corrected Standard Penetration Test (SPT) blowcounts (i.e., $(N_1)_{60}$) less than 15 blows/foot (m), F_{15} is the average fines content of the soil comprising T_{15} (%), $D50_{15}$ is the average mean grain size of the soil comprising T_{15} (mm), and R* which is computed as:

$$R^* = 10^{(0.89M - 5.64)} + R \tag{131}$$

The model coefficients b_0 through b_8 are given in Table 2-2.

6.2.2.3 Post-Liquefaction Settlement

Estimations of liquefaction settlement potential ($\varepsilon_{v,Cetin}$ and $\varepsilon_{v,I\&Y}$) were calculated deterministically using equations from the Ishihara and Yoshimine (1992) and Cetin et al. (2009) liquefaction settlement models. The vertical strain in a soil layer is calculated from the Ishihara and Yoshimine model as:

$$\varepsilon_{v,I\&\mathrm{Y}} = 1.5 \cdot \exp\left(-0.369\sqrt{\left(N_1\right)_{60cs}}\right) \cdot \min\begin{pmatrix} 0.08 \\ \gamma_{\max} \end{pmatrix} \tag{132}$$

where $\left(N_1\right)_{60cs}$ is the Idriss and Boulanger (2008) clean sand equivalent standard penetration resistance corrected for overburden of 1 atmosphere and 60 percent hammer efficiency. $\gamma_{\max}$ is a maximum limiting shear strain and is calculated as:

$$\gamma_{\max} = 0 \tag{133}$$

if $FS_{liq} \geq 2$:

$$\gamma_{\max} = \min\begin{pmatrix} \gamma_{\lim} \\ 0.035\left(2 - FS_{liq}\right)\left(\dfrac{1 - F_{\alpha}}{FS_{liq} - F_{\alpha}}\right) \end{pmatrix} \tag{134}$$

if $2 > FS_{liq} > F_{\alpha}$, and:

$$\gamma_{\max} = \gamma_{\lim} \tag{135}$$

if $FS_{liq} \leq F_{\alpha}$.

F_{α} and $\gamma_{\lim}$ as introduced in equation (134) are computed as:

$$\begin{aligned} F_{\alpha} &= 0.032 + 0.69\sqrt{\left(N_1\right)_{60cs}} - 0.13\left(N_1\right)_{60cs} \\ \gamma_{\lim} &= 1.859\left(1.1 - \sqrt{\frac{\left(N_1\right)_{60cs}}{46}}\right) \geq 0 \end{aligned} \tag{136}$$

FS_{liq} is the factor of safety against liquefaction and is explained in Chapter 2.0.

The vertical strain in a soil layer can be calculated from the Cetin et al. (2009) model as:

$$\begin{aligned} &\varepsilon_{v,Cetin} = 1.879 \cdot \ln\left[\frac{780.416 \cdot \ln\left(CSR_{SS,20,1D,1atm}\right) - N_{1,60,cs} + 2442.465}{636.613 N_{1,60,cs} + 306.732}\right] + 5.583 \\ &\lim: 5 \leq N_{1,60,cs} \leq 40, 0.05 \leq CSR_{SS,20,1D,1atm} \leq 0.6 \end{aligned} \tag{137}$$

where $CSR_{SS,20,1D,1atm}$ is the field cyclic stress ratio value equivalent to unidirectional, 20 loading cycle simple shear test performed under a confining stress of 100 kPa and is computed as explained by Cetin et al. (2009). $N_{1,60,cs}$ is the corrected clean sand equivalent SPT resistance.

6.2.2.4 Seismic Slope Displacement

Estimations of seismic slope displacement for the deterministic process were found using the equation (138) from the Rathje and Saygili (2009) and equation (139) from Bray and

Travasarou (2007) seismic slope displacement models. Both models are based on the seismic loading inputs as shown in Table 6-2, and the site specific yield acceleration used is 0.1g. With these values the seismic slope displacement, D^{site}, is found using the following equations for:

$$\begin{aligned}\ln D = 4.89 - 4.85\left(\frac{\mathrm{k}_y}{PGA}\right) - 19.64\left(\frac{\mathrm{k}_y}{PGA}\right)^2 + 42.49\left(\frac{\mathrm{k}_y}{PGA}\right)^3 - 29.06\left(\frac{\mathrm{k}_y}{PGA}\right)^4 \\ +0.72\ln(PGA) + 0.89(\mathrm{M}-6)\end{aligned} \tag{138}$$

$$\begin{aligned}\ln D = -0.22 - 2.83\ln(k_y) - 0.333\left(\ln(k_y)\right)^2 + 0.566\ln(k_y)\ln(\mathrm{PGA}) + 3.04\ln(\mathrm{PGA}) \\ -0.244\left(\ln(\mathrm{PGA})\right)^2 + 0.278(M-7)\end{aligned} \tag{139}$$

where *D* is the median computed seismic slope displacement (cm) at the site, k_y is the yield acceleration, *PGA* is the peak ground acceleration, and *M* is the earthquake moment magnitude.

6.2.3 Pseudo-probabilistic Seismic Hazard Analysis

In the pseudo-probabilistic procedure, the variables used in the empirical liquefaction hazard models are obtained from a Probabilistic Seismic Hazard Analysis (PSHA). Then these variables are used in the same deterministic procedure outlined previously for both the liquefaction initiation and lateral spread displacements. To find these variables using a PSHA the USGS 2008 interactive deaggregation website (USGS 2008) was utilized. This procedure involved entering the latitude and longitude of the target cities, then selecting the return period for the analysis. Using this tool, the mean magnitude (M_w), peak ground acceleration (*PGA*) for rock, and source-to-site distance (*R*) were obtained for a return period of 1,039 years for each city of interest. The resulting values are summarized in Table 6-3.

Table 6-3 Input values found using USGS 2008 Deaggregations (T_R = 1,039 years).

Location	Latitude	Longitude	Distance (km)	Mean M_w	PGA	F_{pga}
Butte	46.003	-112.533	24.9	6.03	0.1206	1.559
Salt Lake City	40.755	-111.898	4.20	6.84	0.4030	1.097
San Francisco	37.775	-122.418	12.0	7.38	0.5685	1.000

6.3 Results

Each city was evaluated using the three analysis types discussed previously (probabilistic, pseudo-probabilistic, and deterministic). The following plots allow comparisons between the three methods and help explain the purpose of deterministic analyses within the proposed simplified performance-based procedures.

6.3.1 Performance-based Liquefaction Triggering Assessment

6.3.1.1 Pseudo-probabilistic vs. Simplified Performance-based

In each of the three cities analyzed, the results from the pseudo-probabilistic procedure suggested greater liquefaction hazard than the results from the performance-based procedure. The direct comparison of both methods is provided in Figure 6-3.

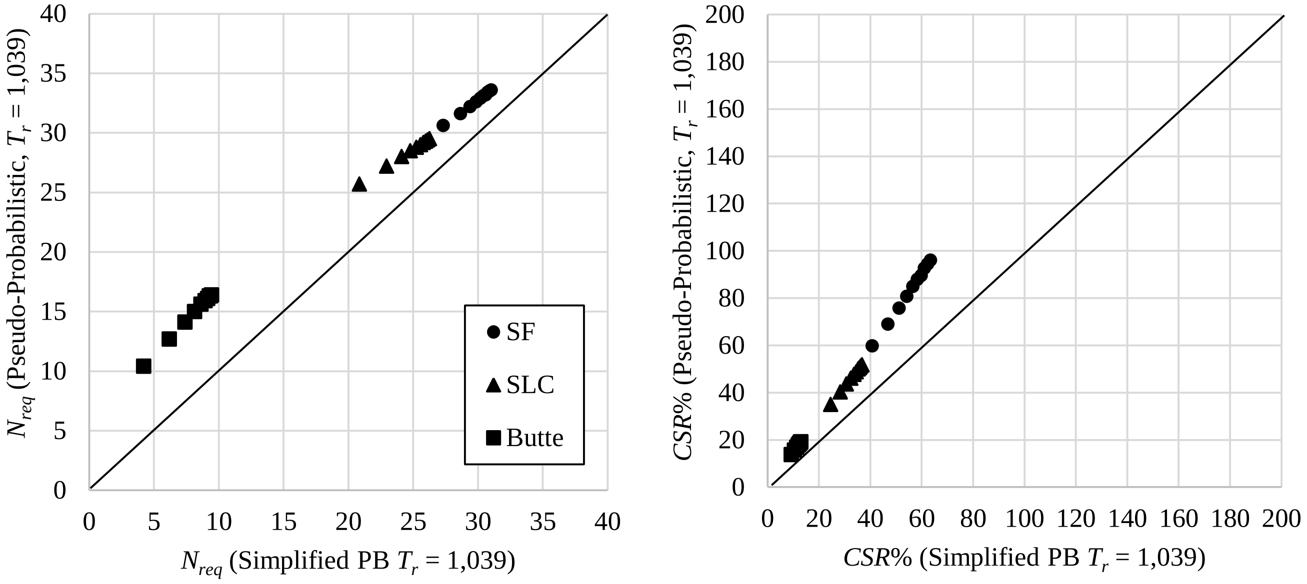


Figure 6-3 Comparison of pseudo-probabilistic and simplified performance-based values of N_{req}, CSR%, and FS_L.

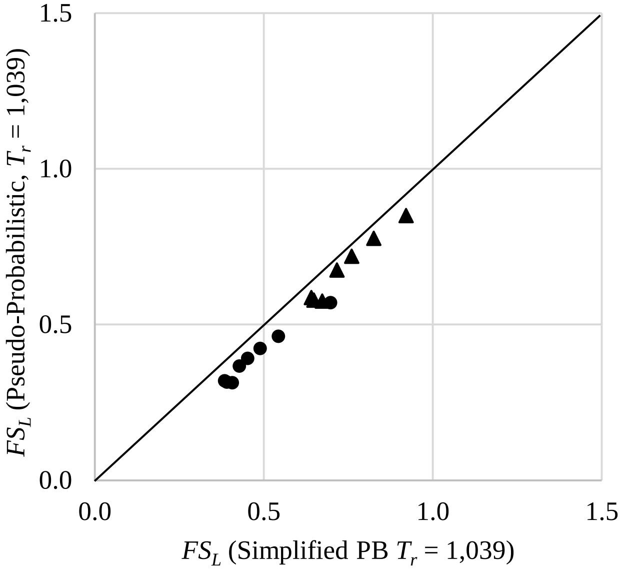


Figure 6-3 (continued) Comparison of pseudo-probabilistic and simplified performance-based values of N_{req}, CSR%, and FS_L.

6.3.1.2 Deterministic vs. Simplified Performance-based

Direct comparison plots (Figure 6-4 through Figure 6-6) show that the deterministic analyses frequently over-predicted liquefaction hazard. This over-prediction is especially evident in the case of Butte where the simplified performance-based method estimated N_{req} values as low as 3.1% of the deterministic N_{req} values. This discrepancy could be because the likelihood of the large Rocker Fault near Butte rupturing and achieving the 50% ground motion is very low. Therefore, in the simplified performance-based approach (which incorporates likelihoods of seismic events in the calculations), the associated N_{req} is much lower. These comparison plots also highlight the significant discrepancy between the 50th and 84th percentile ground motions. In the case of San Francisco at the 2,475-year return period, the 50th percentile ground motions under-predict N_{req} while the 84th percentile ground motions over-predict N_{req}. This discrepancy produces a dilemma for the engineer who has to decide which ground motions appropriately characterize the liquefaction hazard for the given site. However, the simplified performance-based procedure does not depend on this decision and can provide a more consistent estimate of liquefaction hazard.

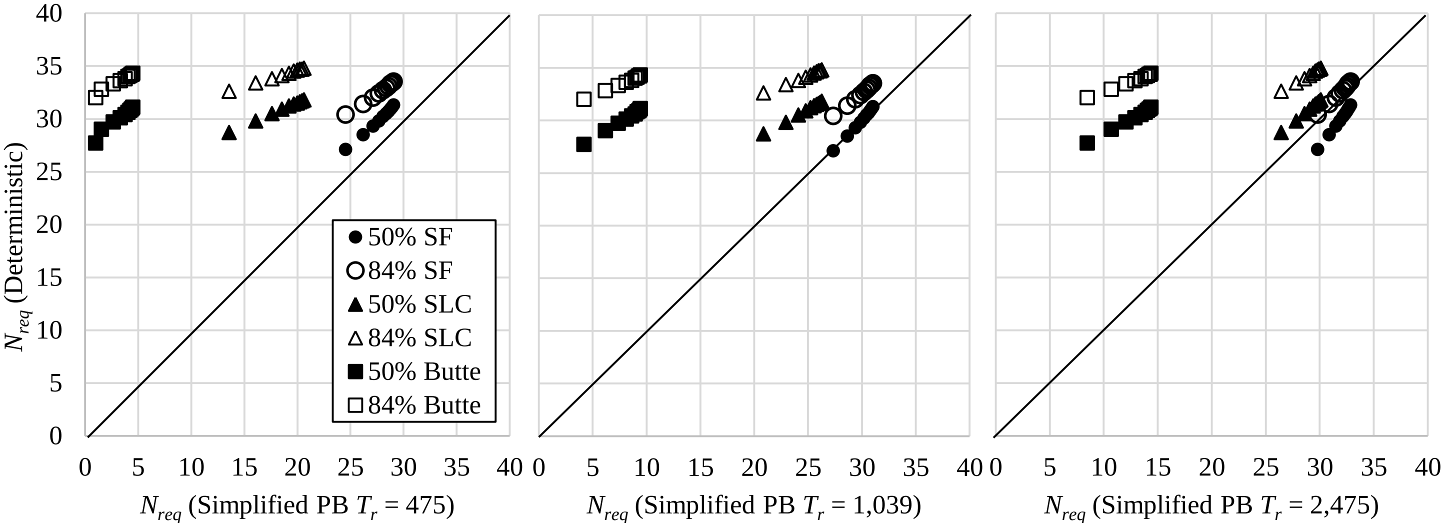


Figure 6-4 Comparison of deterministic and simplified performance-based values of N_{req}.

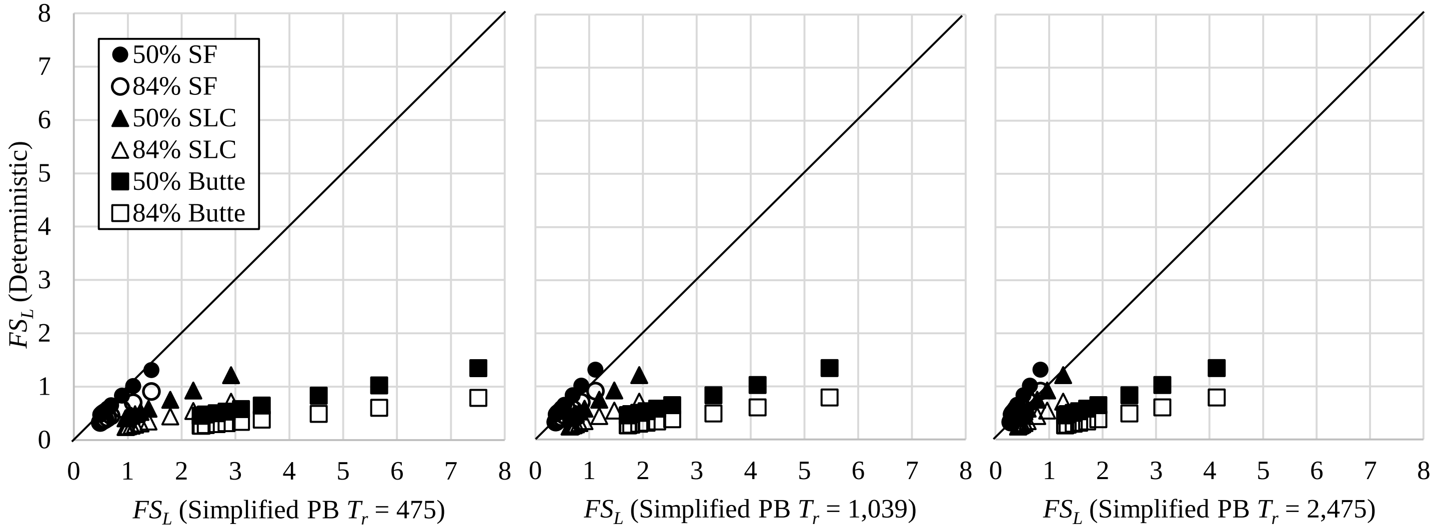


Figure 6-5 Comparison of deterministic and simplified performance-based values of FS_L.

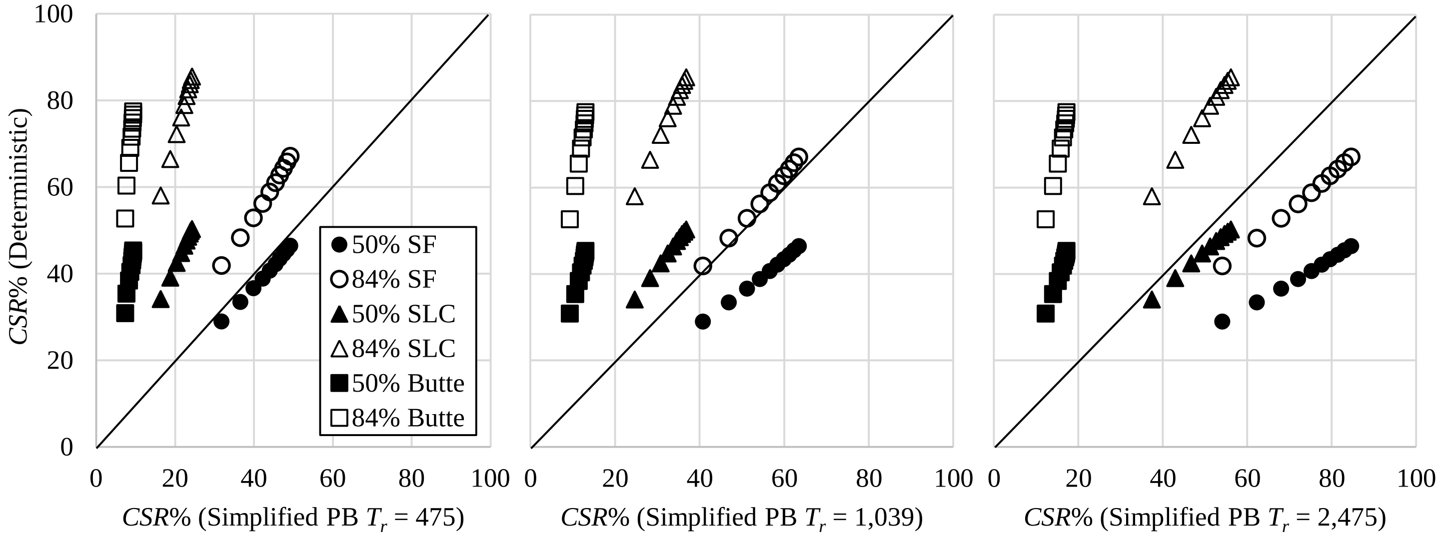


Figure 6-6 Comparison of deterministic and simplified performance-based values of $CSR\%$.

6.3.2 Empirical Lateral Spread Displacement Model

Once the analysis of the different lateral spread displacement methods was completed, the data was examined and several charts were created, one for each city. These charts compare, side by side, the results of the simplified, pseudo-probabilistic, and deterministic analyses. These charts can be seen in Figure 6-7, Figure 6-8, and Figure 6-9.

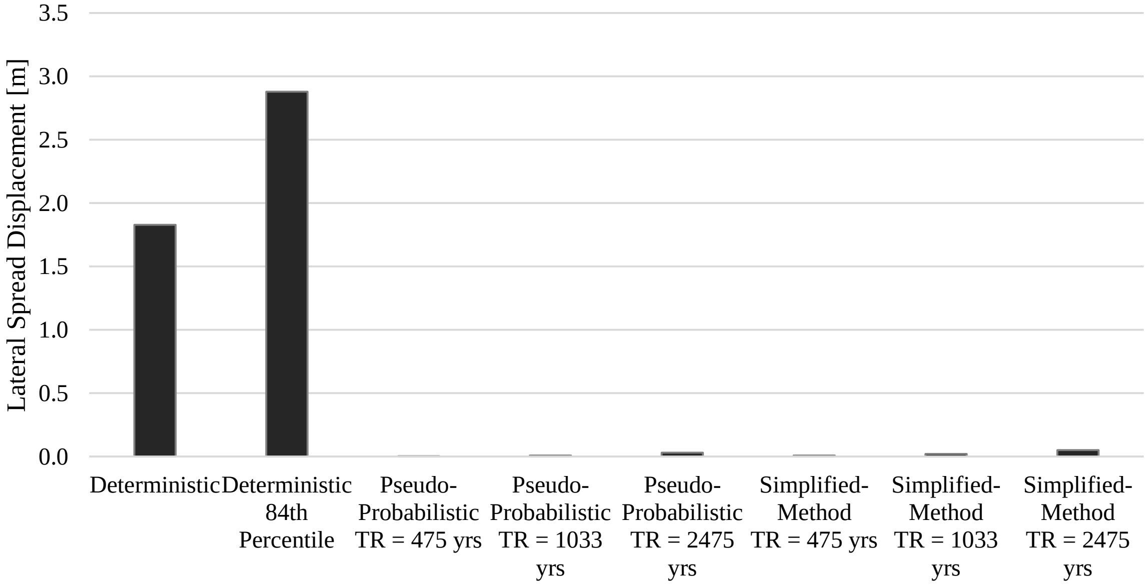


Figure 6-7 Comparison of Deterministic, Pseudo-probabilistic, and Simplified methods for Butte, MT (Latitude 46.033, Longitude -112.533).

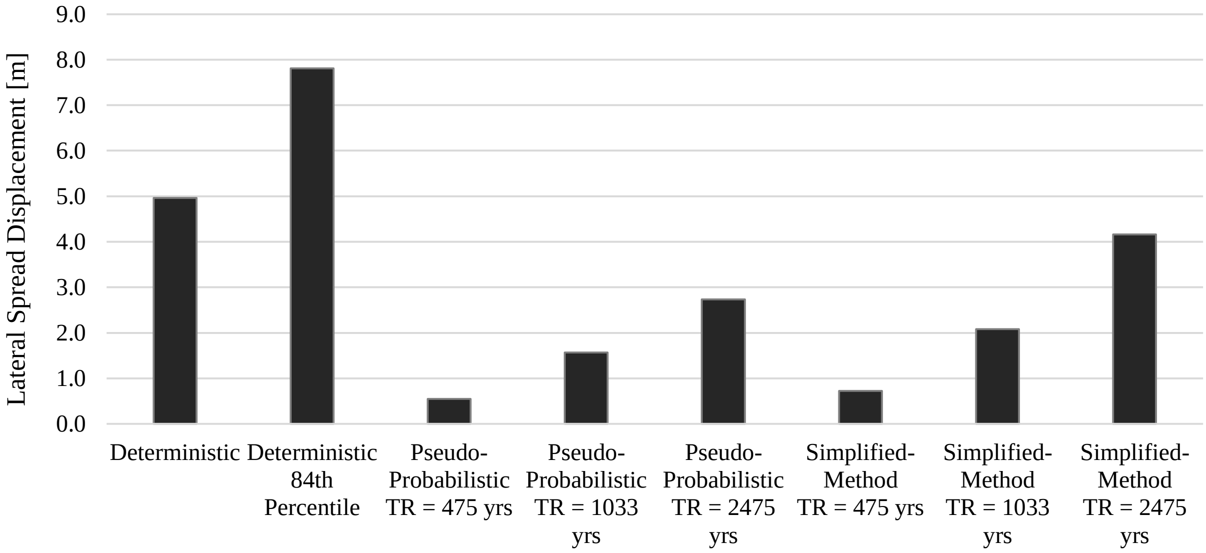


Figure 6-8 Comparison of Deterministic, Pseudo-probabilistic, and Simplified methods for Salt Lake City, UT (Latitude 40.755, Longitude -111.898).

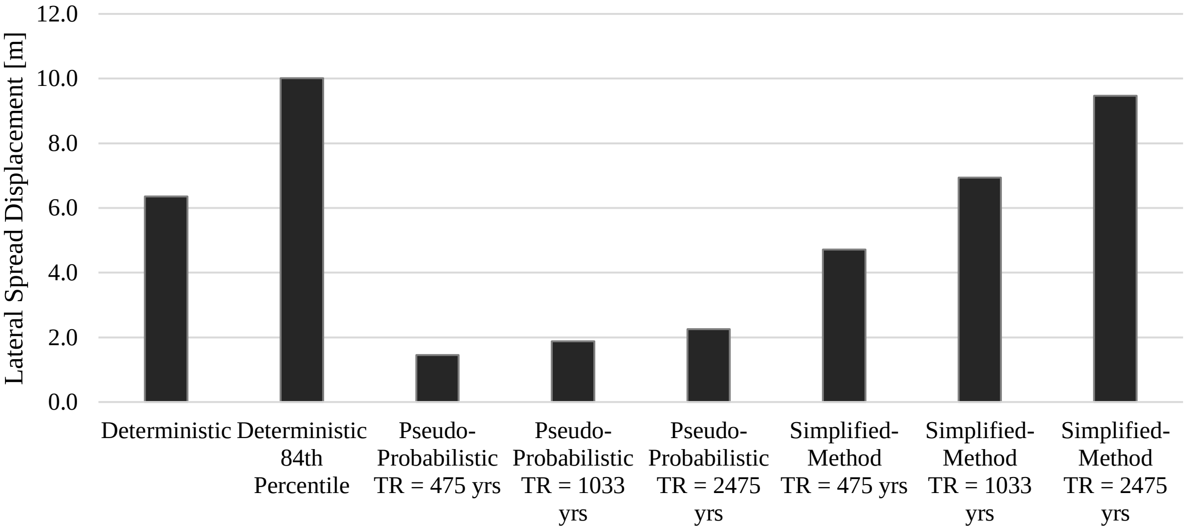


Figure 6-9 Comparison of Deterministic, Pseudo-probabilistic, and Simplified methods for San Francisco, CA (Latitude 37.775, Longitude -122.418).

The different cities are associated with regions of differing seismicity, and the deterministic comparisons with the simplified results yield some interesting conclusions. In the city with low seismicity, Butte seen in Figure 6-7, the deterministic method massively over-predicts the displacements predicted by the simplified and pseudo-probabilistic methods. This result can be attributed to the deterministic procedure not accounting for the likelihood of the Rocker fault rupturing, and predicts a displacement that may have an extremely low probability of occurring. The medium seismicity city, Salt Lake City seen in Figure 6-8, shows as well that the deterministic method predicts displacements higher than the simplified and pseudo-probabilistic procedures. In San Francisco, the high seismicity city, the results are much more similar at the 2475 return period, as can be seen in Figure 6-9. In this area the simplified method for the 2475 year return period predicts a slightly higher displacement than the deterministic mean value. The deterministic 84th percentile still predicts a higher value than the simplified method at the 2475 year return period.

6.3.3 Post-Liquefaction Settlement Model

6.3.3.1 Pseudo-probabilistic vs. Simplified Performance-based

The results from the pseudo-probabilistic procedure suggested greater liquefaction hazard than the results from the performance-based procedure in Salt Lake City and Butte. These two cities are considered medium and low seismicity areas, respectively. The results indicate that in areas of high seismicity, such as San Francisco, the performance-based procedure suggests higher liquefaction hazard than the pseudo-probabilistic procedure. The direct comparison of the Cetin et al. (2009) model is shown in Figure 6-10 and the direct comparison of the Ishihara and Yoshimine (1992) model can be seen in Figure 6-11.

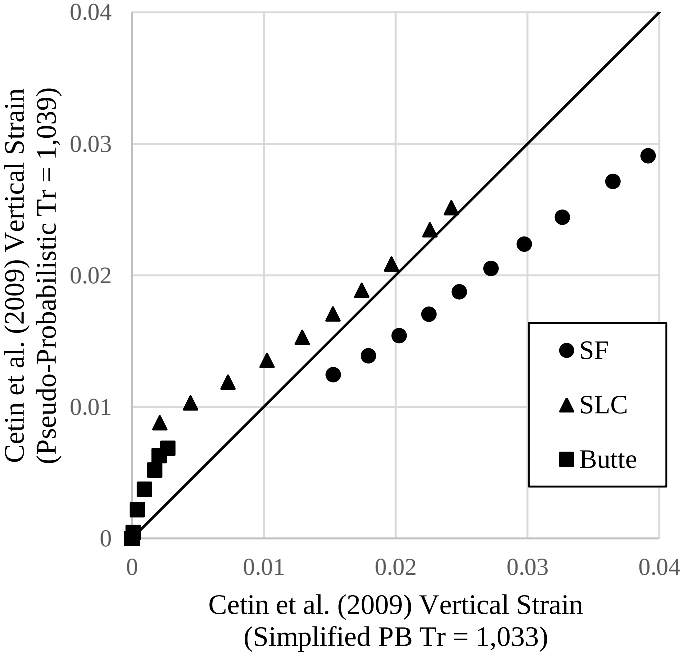


Figure 6-10 Comparison of pseudo-probabilistic and simplified performance-based values of vertical strain using the Cetin et al. (2009) model.

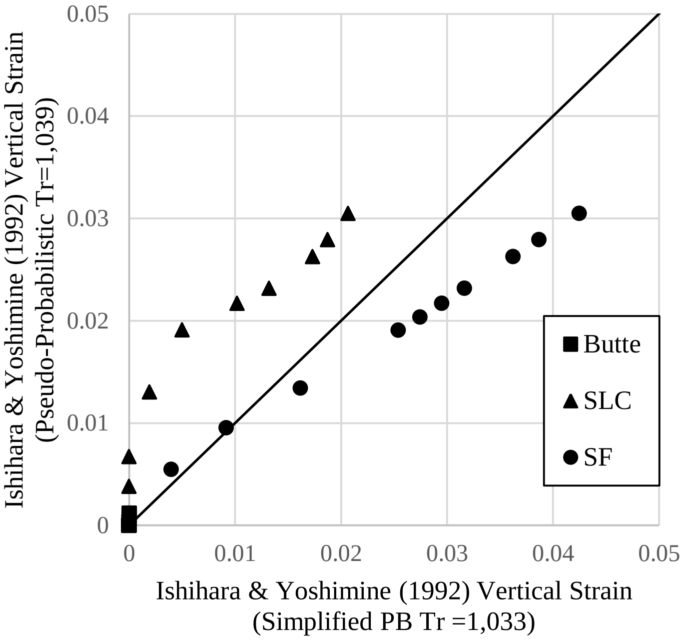


Figure 6-11 Comparison of pseudo-probabilistic and simplified performance-based values of vertical strain using the Ishihara and Yoshimine (1992) model.

6.3.3.2 Deterministic vs. Simplified Performance-based

Direct comparison plots (Figure 6-12 through Figure 6-17) show that the deterministic analyses frequently over-predicted liquefaction hazard in areas of low and medium seismicity. This over-prediction is especially evident in the case of Butte where the simplified performance-based method estimated strain values much lower than the deterministic strains. This discrepancy could be because the likelihood of the large Rocker Fault near Butte rupturing and achieving the 50% ground motion is very low. Therefore, in the simplified performance-based approach (which incorporates likelihoods of seismic events in the calculations), the associated strains are much lower.

In areas of high seismicity, such as San Francisco, the performance-based procedure closely matches the deterministic hazard at the 475-year return period. In the 1,033 and 2,475-year return periods, the performance-based method over-predicts the deterministic settlement hazard. This is consistent with the expectation that the performance-based method may predict unrealistically high values of liquefaction hazard in areas of high seismicity.

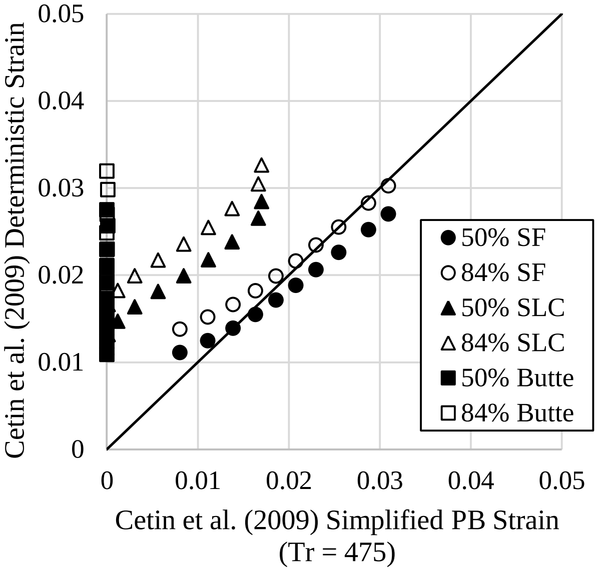


Figure 6-12 Comparison of deterministic and performance-based vertical strains for the Cetin et al. model (PB Return Period = 475 years).

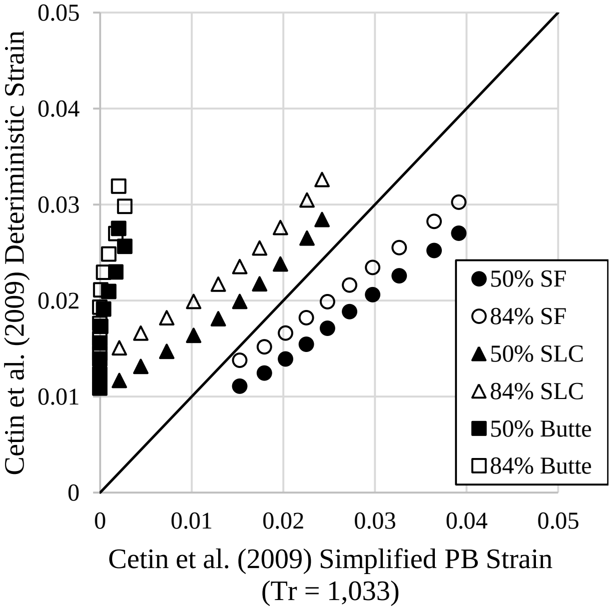


Figure 6-13 Comparison of deterministic and performance-based vertical strains for the Cetin et al. model (PB Return Period = 1,033 years).

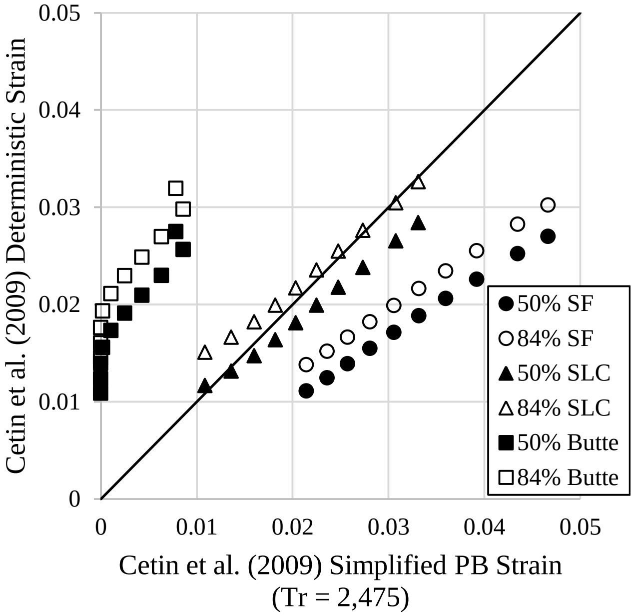


Figure 6-14 Comparison of deterministic and performance-based vertical strains for the Cetin et al. model (PB Return Period = 2,475 years).

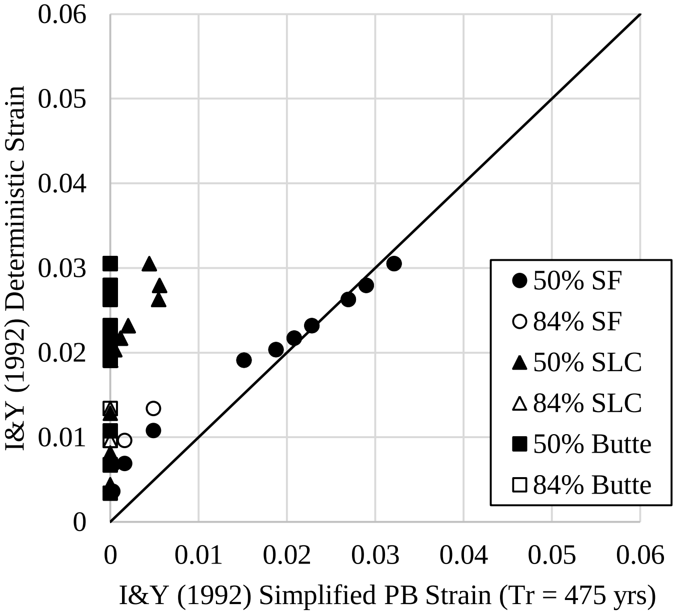


Figure 6-15 Comparison of deterministic and performance-based vertical strains for the Ishihara & Yoshimine (1992) model (PB Return Period = 475 years).

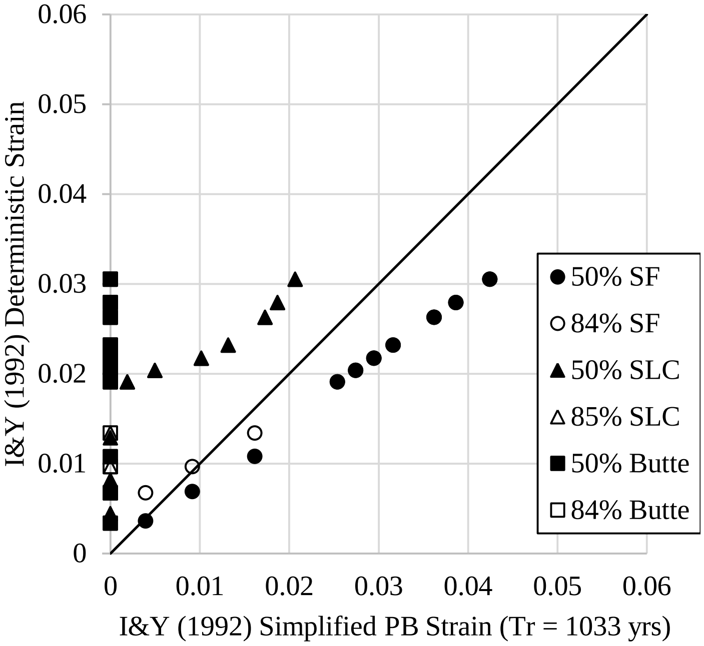


Figure 6-16 Comparison of deterministic and performance-based vertical strains for the Ishihara & Yoshimine (1992) model (PB Return Period = 1,033 years).

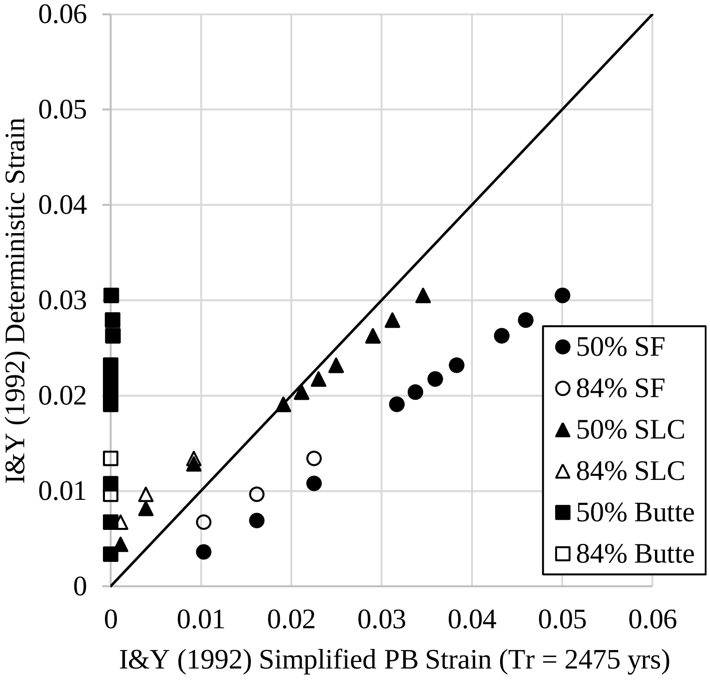


Figure 6-17 Comparison of deterministic and performance-based vertical strains for the Ishihara & Yoshimine (1992) model (PB Return Period = 2,475 years).

6.3.4 Seismic Slope Displacement Model

Once the analysis of the different methods was completed, the data was examined and charts were created for each city. These charts compare, side by side, the results of the simplified, pseudo-probabilistic, and deterministic analyses using both Rathje & Saygili (2009) and Bray & Travasarou (2007) method. These charts can be seen below.

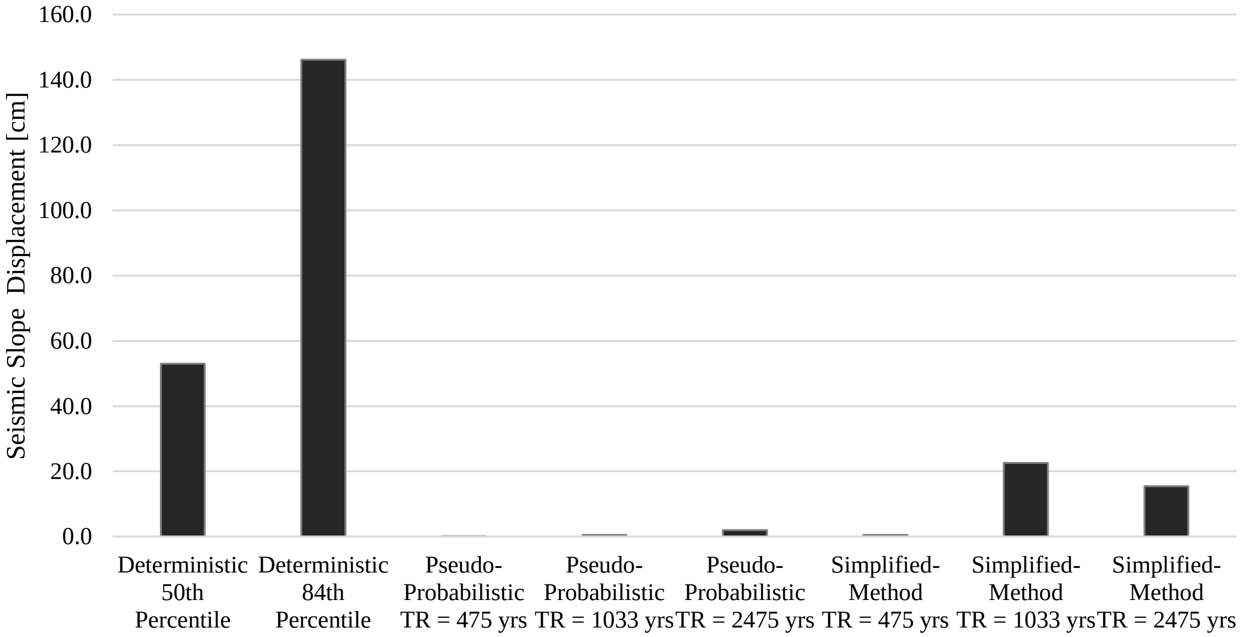


Figure 6-18 Comparison of Deterministic, Pseudo-probabilistic, and Simplified methods using Rathje and Saygili (2009) for Butte, MT (Latitude 46.033, Longitude -112.533).

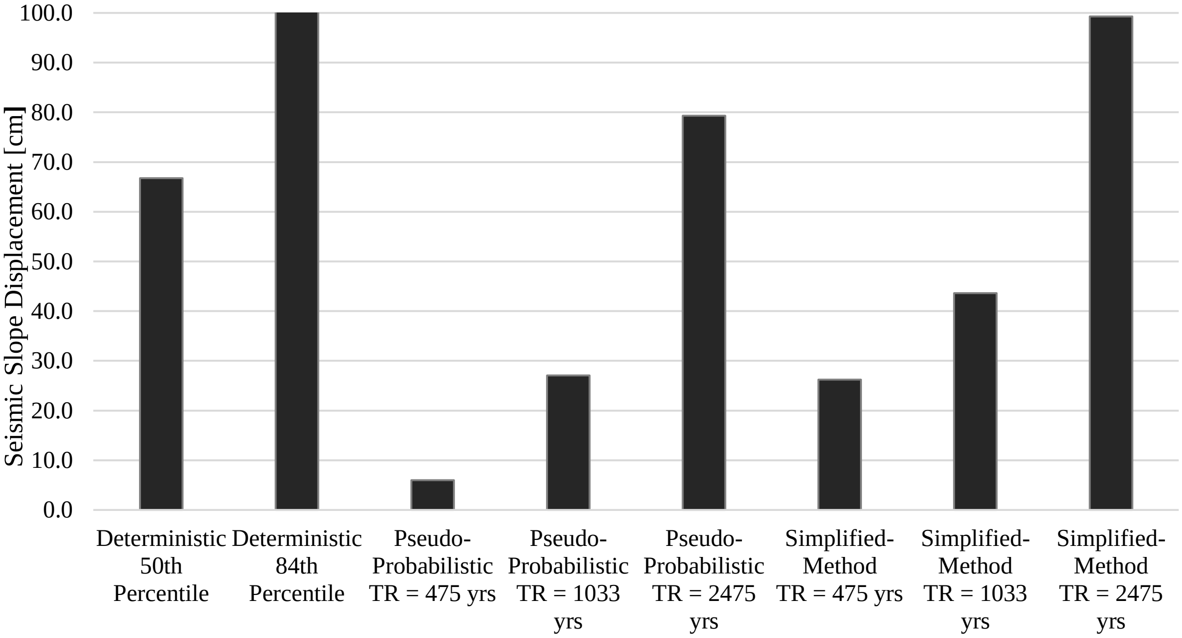


Figure 6-19 Comparison of Deterministic, Pseudo-probabilistic, and Simplified methods using Rathje and Saygili (2009) for Salt Lake City, UT (Latitude 40.755, Longitude -111.898).

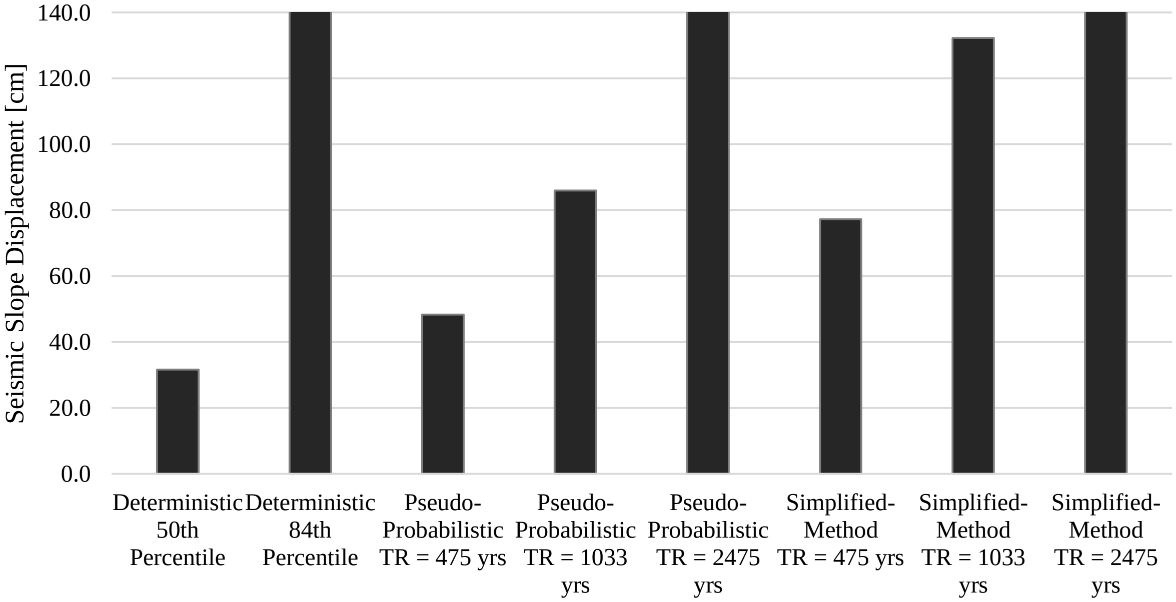


Figure 6-20 Comparison of Deterministic, Pseudo-probabilistic, and Simplified methods using Rathje and Saygili (2009) for San Francisco, CA (Latitude 37.775, Longitude -122.418).

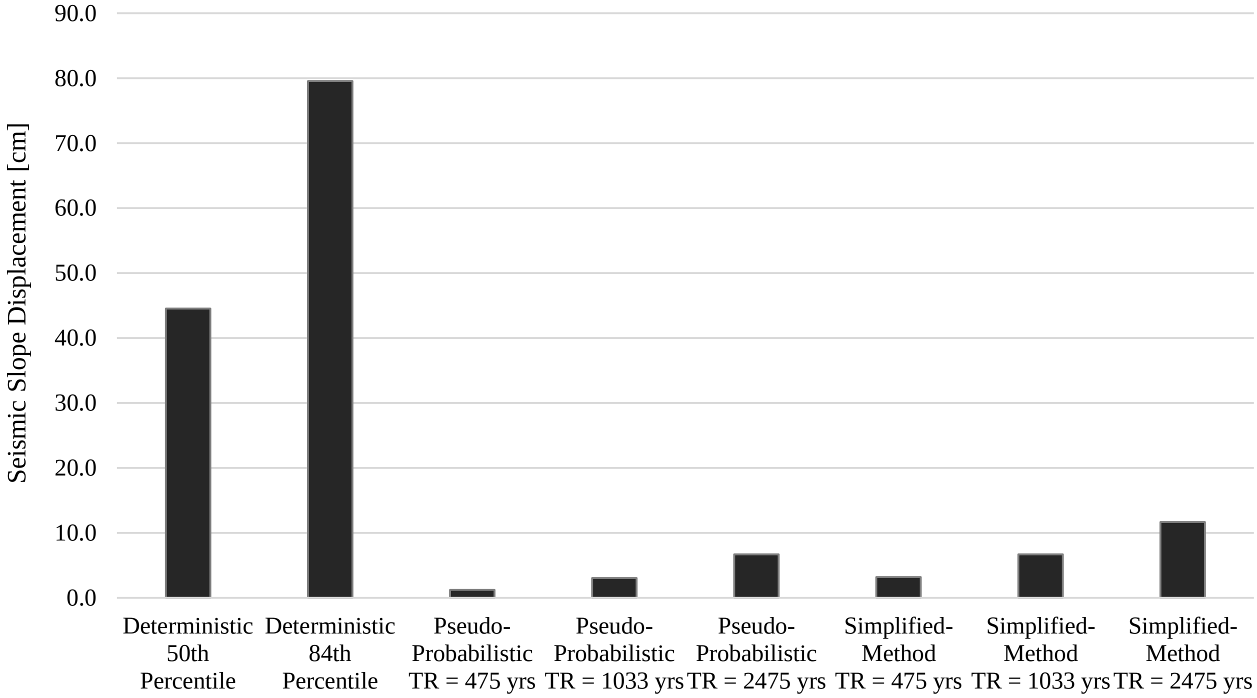


Figure 6-21 Comparison of Deterministic, Pseudo-probabilistic, and Simplified methods using Bray and Travasarou (2007) for Butte, MT (Latitude 46.033, Longitude -112.533).

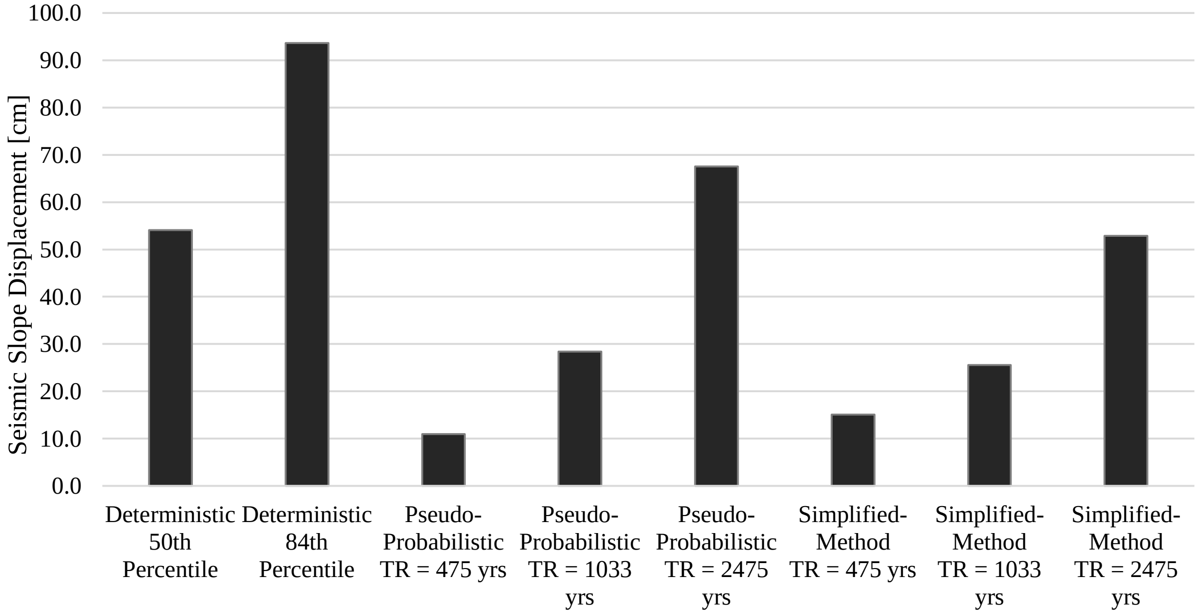


Figure 6-22 Comparison of Deterministic, Pseudo-probabilistic, and Simplified methods using Bray and Travasarou (2007) for Salt Lake City, UT (Latitude 40.755, Longitude -111.898).

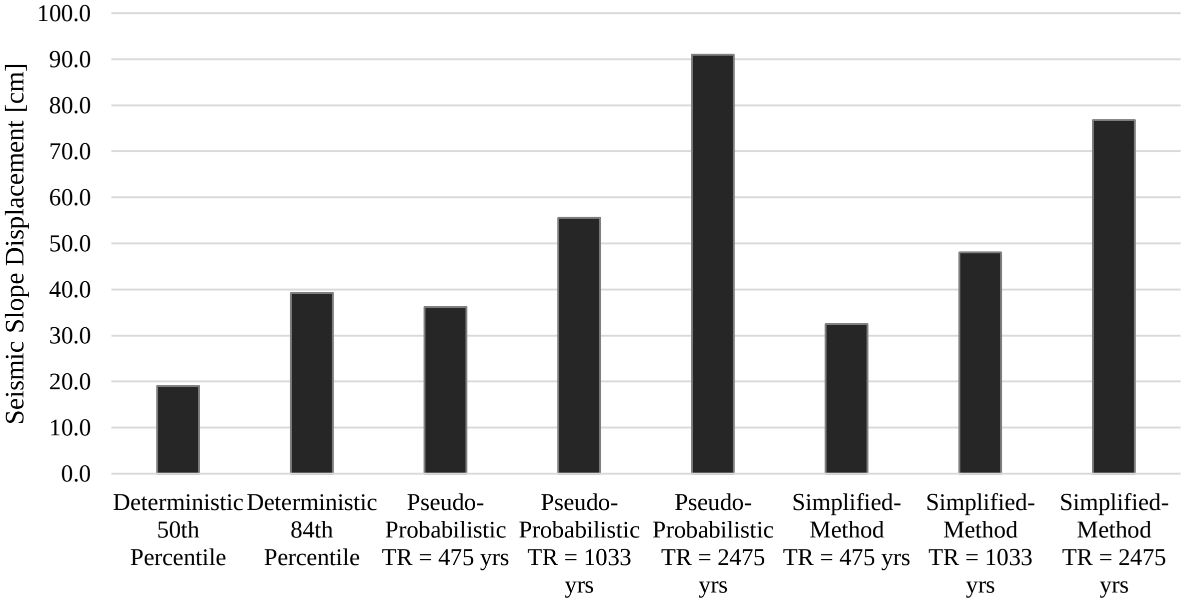


Figure 6-23 Comparison of Deterministic, Pseudo-probabilistic, and Simplified methods using Bray and Travasarou (2007) for San Francisco, CA (Latitude 37.775, Longitude -122.418).

The different seismicity areas represented by the plots shown previously, and the deterministic comparisons with the simplified results show interesting conclusions. Figure 6-18 shows the deterministic method highly over predicts the displacements predicted by the simplified and pseudo-probabilistic methods in areas of low seismicity such as Butte using the Rathje & Saygili method. This result can be attributed to the deterministic procedure not accounting for the likelihood of the Rocker fault rupturing, and predicts a displacement with extremely low probability of occurring. Similar behavior can also be observed in Figure 6-21 when the Bray & Travasarou method is used in Butte.

The medium seismicity city, Salt Lake City seen in Figure 6-19 using the Rathje & Saygili method, shows that the deterministic method predicts displacements higher than the simplified and pseudo-probabilistic procedures at return periods of 475 and 1,033 years. This is not the case for the 2,475 year return period in which the simplified and pseudo-probabilistic procedures slightly over estimate displacements. The Bray & Travasarou method in the same area, as observed in Figure 6-22, showed at all return periods that the 84th percentile of the deterministic procedure over predicted displacements when compared to those computed with the simplified and pseudo-probabilistic procedures.

In San Francisco, the high seismicity city, similar results for deterministic, simplified, and pseudo-probabilistic procedures at the 2,475 return period were calculated, as shown in Figure 6-20 when using the Rathje & Saygili method. When the Bray and Travasarou model is used as shown in Figure 6-23 the simplified and pseudo-probabilistic methods seem to over predict seismic slope displacements.

6.4 Summary

This study analyzed several hazards: liquefaction triggering, lateral spread, post-liquefaction settlement, and seismic slope displacement. The deterministic methods predicted significantly more earthquake induced hazard than probabilistic methods in Butte—an area of low seismicity. The deterministic results also generally showed more earthquake induced hazards than the probabilistic results at high return periods in Salt Lake City—an area of medium seismicity. In San Francisco—an area of high seismicity—the deterministic methods predicted slightly lower hazards than the probabilistic method, particularly at higher return periods. These results suggest that the deterministic results could be used as an upper-bound in areas of high seismicity, but in areas of low seismicity, the deterministic analysis could be optional. Engineers performing analyses in areas of medium to high seismicity could choose to use a deterministic analysis as a "reality check" against the simplified performance-based results. If both deterministic and performance-based methods are considered, the *lower of the deterministic and the probabilistic results* should govern the design.

This rule may seem counter-intuitive, but the idea is not completely foreign—when developing a spectral acceleration design envelope, seismic building code (e.g., IBC 2012) permits that the lower of the deterministic and probabilistic accelerations be used in design. Likewise, in a liquefaction hazard analysis, the lower value should govern. If the deterministic value is lower than the performance-based value, the combination of multiple seismic sources in the performance-based analysis may suggest greater liquefaction hazard than would be caused by a single earthquake event. Therefore, the deterministic analysis provides a type of "reality check" against the performance-based analysis, and the deterministic results should be accepted. If the performance-based value is lower than the deterministic value, the nearby governing fault may have a significantly low likelihood of rupturing within the design life of the structure. In this case, the deterministic results could be considered too extreme (especially for some projects which do not need to be designed to withstand such large events). Therefore, the performance-based results should be accepted as a representation of the more *likely* liquefaction hazard.

7.0 VALIDATION OF THE SIMPLIFIED LIQUEFACTION ASSESSMENT TOOL: *SPLIQ*

7.1 Overview

This section provides a final validation of *SPLiq*. The purpose of this validation is not to prove the accuracy of the methods as presented in Chapter 3.0. This validation will compare full performance-based analyses against results generated with *SPLiq* at 15 different locations throughout the states included in this study. For a detailed explanation of how *SPLiq* is used, please refer to the *SPLiq* User's Manual accompanying this report.

7.2 Selection of Sites for Validation

To select sites for the validation of *SPLiq*, three different locations representing main cities within the states included in this study were selected. Table 7-1 below shows the list of the sites used and their corresponding *PGA* and magnitude corresponding to 475, 1033, and 2475 year return periods.

Table 7-1 Sites Selected for *SPLiq* Validation

				T_R = 475 yrs		T_R = 1033 yrs		T_R = 2475 yrs	
STATE	**CITY**	**LAT**	**LONG**	**PGA**	**M**	**PGA**	**M**	**PGA**	**M**
UT	SLC	40.636	-111.905	0.204	6.71	0.391	6.80	0.638	6.85
	Nephi	39.681	-111.839	0.133	6.44	0.240	6.60	0.400	6.72
	Hurricane	37.177	-113.288	0.091	6.22	0.149	6.34	0.241	6.51
ID	Boise	43.619	-116.219	0.056	6.06	0.083	6.08	0.123	6.09
	Idaho Falls	43.494	-112.036	0.085	6.09	0.120	6.07	0.174	6.08
	Challis	44.505	-114.23	0.178	6.06	0.258	6.12	0.375	6.21
MT	Billings	45.768	-108.488	0.024	6.00	0.034	6.01	0.050	6.01
	Butte	46.003	-112.555	0.082	6.03	0.119	6.04	0.176	6.05
	Missoula	46.869	-113.983	0.088	6.03	0.132	6.06	0.198	6.08
SC	Charleston	32.794	-79.946	0.156	6.61	0.376	6.88	0.740	7.01
	Columbia	34.01	-81.05	0.075	6.46	0.136	6.51	0.224	6.42
	Greenville	34.853	-82.383	0.051	6.14	0.084	6.09	0.143	6.00
CT	Hartford	41.766	-72.654	0.028	5.84	0.050	5.89	0.092	5.89
	New Haven	41.338	-72.935	0.029	5.75	0.053	5.80	0.099	5.84
	Stamford	41.056	-73.542	0.035	5.61	0.072	5.64	0.148	5.70

7.3 Liquefaction Triggering Validation

Five soil profiles that displayed a wide range of SPT resistance values over depths ranging from 0 to 18 meters were selected. These profiles were used for the *SPLiq* validation of both liquefaction triggering and liquefaction settlement. The SPT profiles used in this validation study can be seen in Figure 7-1.

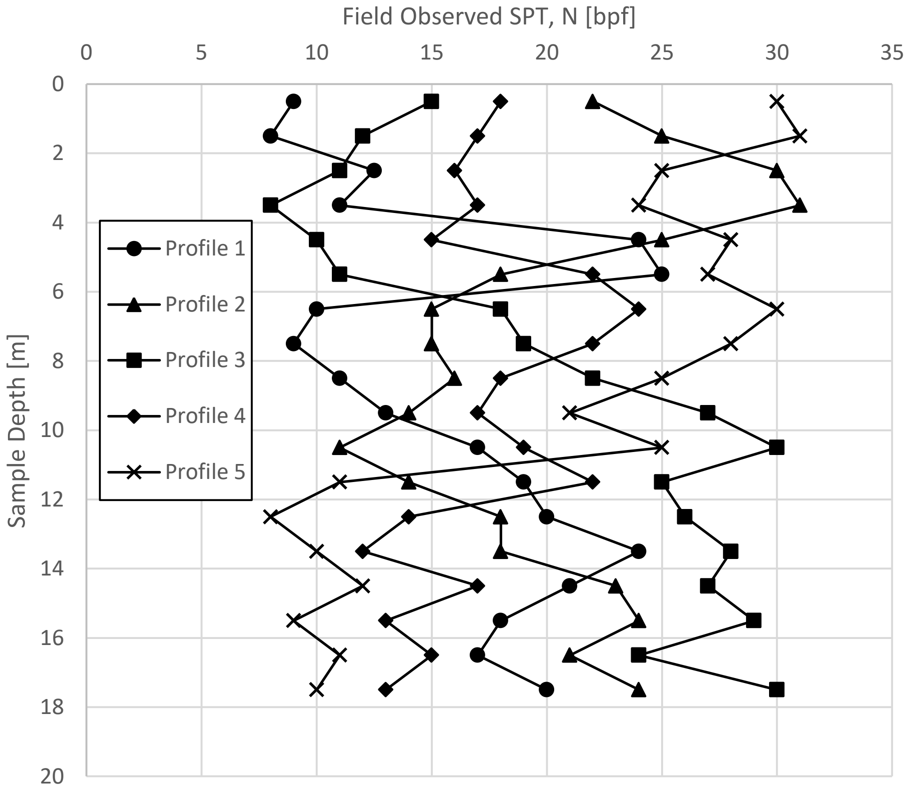


Figure 7-1 SPT resistance profiles used for liquefaction triggering and liquefaction settlement validation.

Figure 7-2 is a comparison plot of the Cetin et al. (2004) liquefaction triggering model. Figure 7-3 displays the comparison plot of the Boulanger and Idriss (2012) liquefaction triggering model. The plotted parameter is Δ*Nreq*, the change in SPT blowcounts required to bring the factor of safety against liquefaction to unity for a given return period. Positive Δ*Nreq* values indicate that the soil layer analyzed will likely have a factor of safety against liquefaction less than 1 for the return period of question.

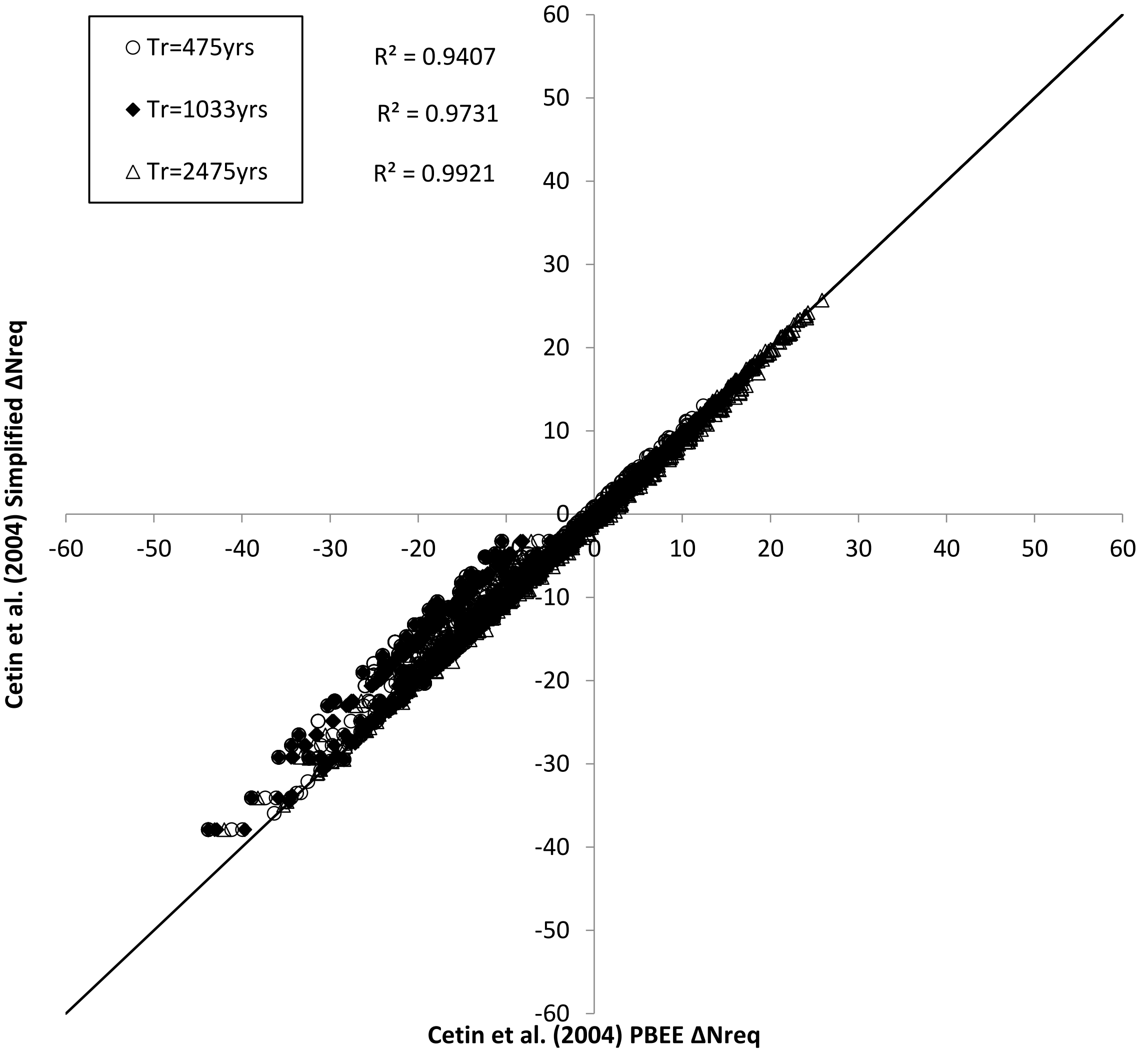


Figure 7-2 *SPLiq* validation results for liquefaction triggering Cetin et al. 2004 model

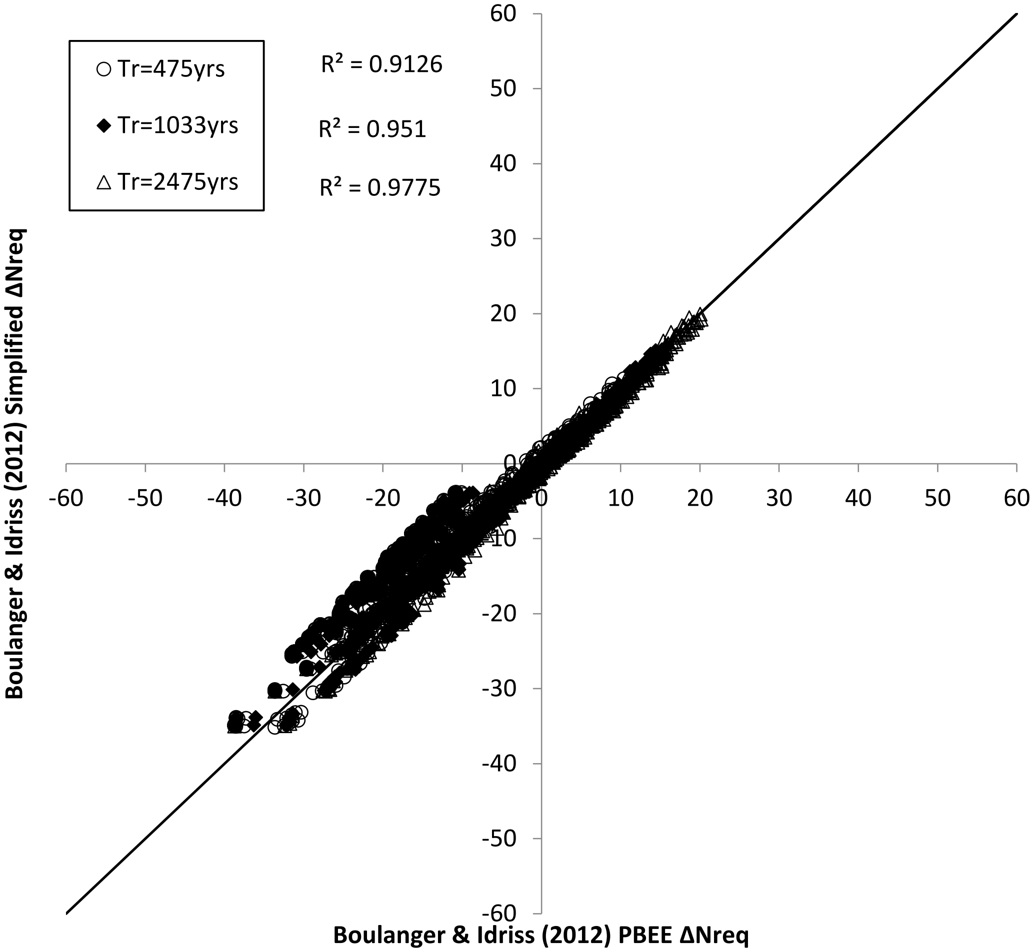


Figure 7-3 *SPLiq* validation results for liquefaction triggering based on the Boulanger and Idriss 2012 model

The results indicate that *SPLiq* provides a close fit to the full performance based liquefaction triggered procedure for both the Cetin et al. (2004) and Boulanger & Idriss (2012) models, particularly for positive Δ*Nreq* values. The increased spread in the negative Δ*Nreq* range is attributed to *SPLiq* placing a minimum Nreq threshold on calculation. *SPLiq* will not allow Nreq values less than zero; therefore, any instance where Nreq would be less than 0, *SPLiq* will automatically assign an Nreq value of 1. This creates the higher scatter in areas of low seismicity or where site recorded SPT values are high.

7.4 Lateral Spread Validation

To evaluate the site-specific lateral displacement, a soil profile was assumed for each site. These soil parameters are presented in Figure 3-4 as was done in the original validation for the method. For this validation five different $\mathscr{S}$ parameter values were selected which made up the 5 different soil profiles to test. The $\mathscr{S}$ parameters tested were 7.5, 8.5, 9.5, 10.5 as computed using Equation (51). Each soil profile was then tested at all 15 locations selected for this validation at 475, 1033, and 2475 year return periods.

7.4.1 EZ-FRISK

To perform the site-specific analysis for both the simplified and full performance-based models, the software EZ-FRISK (Risk Engineering 2013) was utilized. For this analysis, the USGS 2008 seismic source model (Petersen et al. 2008) was used.

Figure 7-4 below shows the comparison between the full performance-based lateral spread analyses against the displacements computed using *SPLiq*. The average discrepancy between both the full performance-based method and the simplified method was always less than 0.02 m with less than 5% error in most cases.

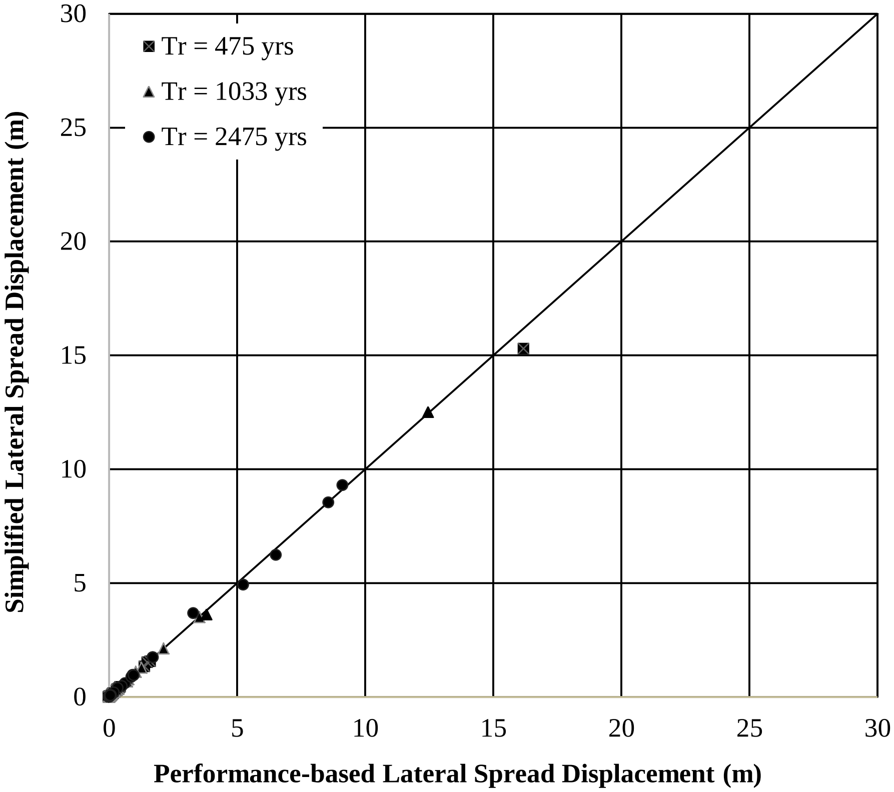


Figure 7-4 ***SPLiq*** **validation results for lateral spread analysis based on the Youd et al. 2002 model**

7.5 Post- Liquefaction Settlement

The 5 soil profiles shown in Figure 7-1 were used for the validation of liquefaction settlement using *SPLiq*. *SPLiq* was used to compute simplified performance-based ground surface settlements at 15 locations using the 5 different soil profiles. The validation results can be seen in Figure 7-5 and Figure 7-6.

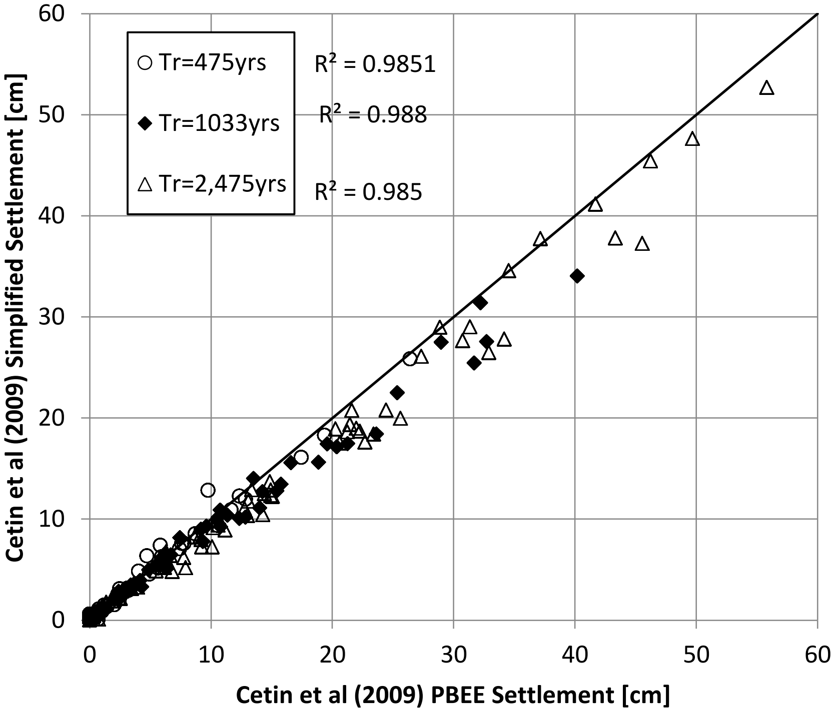


Figure 7-5 *SPLiq* validation results based on the Cetin et al (2009) model.

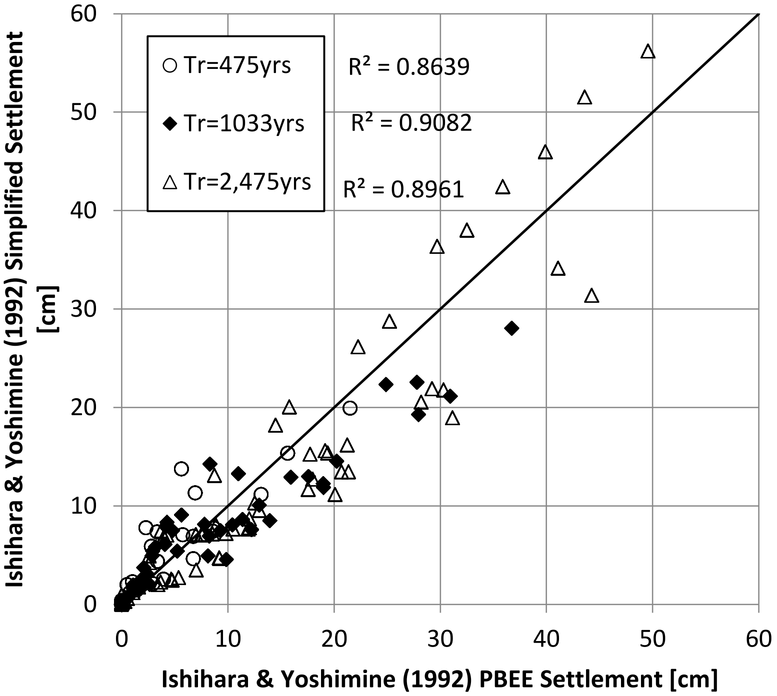


Figure 7-6 *SPLiq* validation results based on the Ishihara & Yoshimine (1992) model.

The *SPLiq* liquefaction settlement results indicate that the Ishihara & Yoshimine (1992) simplified model contains a higher amount of scatter than the Cetin et al. (2009) model. These results are not new, however, as they are similar to the validation results presented in Chapter 3 of this report. The results lie within the anticipated range of scatter. Engineers using *SPLiq* to estimate liquefaction settlement should be aware of Figure 7-5 and Figure 7-6. Both the Cetin et al (2009) and Ishihara & Yoshimine (1992) models show a more compact scatter pattern at calculated settlements less than 15 cm (5.9 in).

7.6 Seismic Slope Displacement

The validation of the seismic slope displacement model embedded in *SPLiq* was performed for all 15 sites presented in Table 7-1. As was the case of the original validation, in this case PBLiquefY was also used to compute the full performance-based site specific seismic slope displacements in the areas of interest. These were later compared to the results generated by *SPLiq*. The data generated for both the Rathje & Saygili (2009) and the Bray & Travasarou (2007) models are shown below.

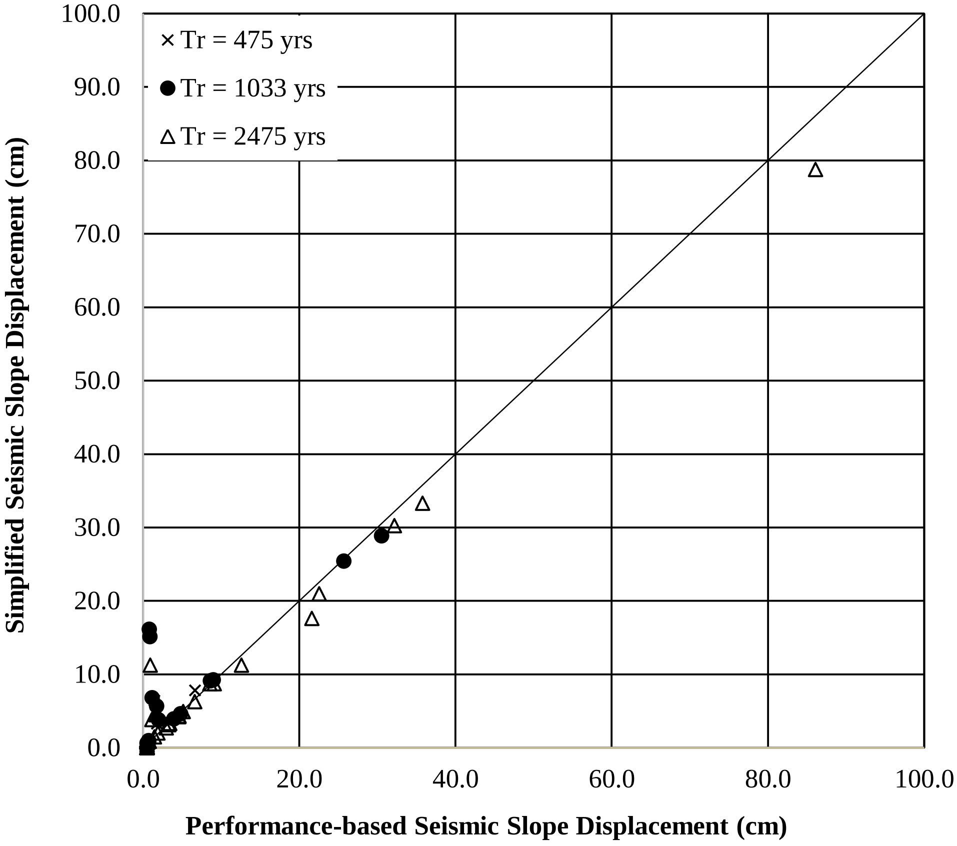


Figure 7-7 *SPLiq* validation of seismic slope displacement for the Rathje and Saygili (2009) model.

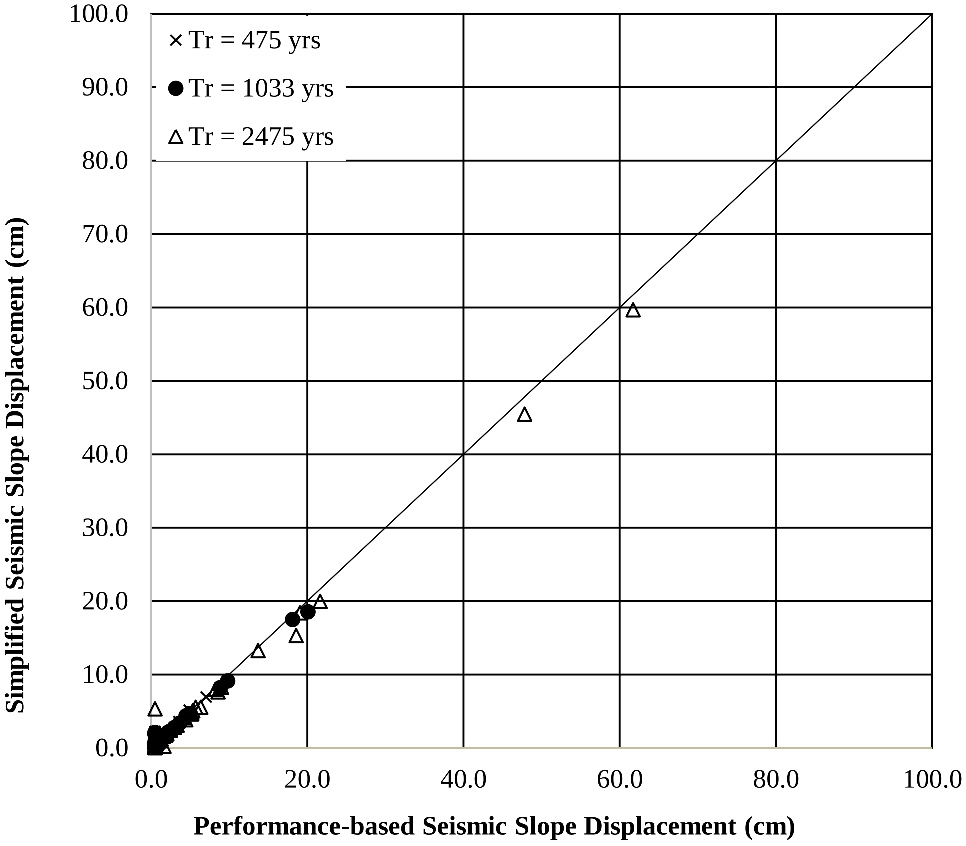


Figure 7-8 *SPLiq* validation of seismic slope displacement for the Bray and Travasarou (2007) model.

From the validation exercise the Rathje & Saygili (2009) model presented slight over prediction of displacements in certain areas. After testing the sites of concern a few times, we concluded that this model will slightly over predict displacements in areas of relatively low *PGA* when the k_y value is very close to 0.1 g (which was the value used in the generation of reference parameters). This is a limitation of the original model, and not one of the simplified methodology presented in this report. *SPLiq* was programmed so that when the combination of variables could result in unreasonable computed displacements for the site of interest, the user will be prompted to adjust the k_y value entered and the Rathje & Saygili (2009) displacement will not be reported in the final summary of results generated by *SPLiq*. Values computed using the Bray & Travasarou (2007) model were always within the 5 % margin established in the original validation. More detail in generating an appropriate k_y value for the site can be found in the *SPLiq* User's Manual.

8.0 CONCLUSIONS

8.1 Summary

The purpose of the research performed was to provide the benefit of the full performance-based probabilistic earthquake hazard analysis, without requiring special software, training, and experience. To accomplish this goal, simplified models of liquefaction triggering, lateral spread displacements, post-liquefaction settlement, and seismic slope displacements were developed that reasonably approximate the results of full performance-based analyses. The objective of this report was to introduce the original models used to determine earthquake hazards (i.e. liquefaction triggering, lateral spread displacement, post-liquefaction settlement, and seismic slope displacement), provide in-depth derivations that demonstrate the development of the simplified methods, validate the simplified models by performing a site-specific analysis for several different sites using the simplified and full models, determine sufficient grid spacings for the development of the liquefaction parameter maps, develop the liquefaction parameter maps for the targeted states at the 475, 1033, and 2475 year return periods, compare the results of the simplified methods against deterministic and pseudo-probabilistic procedures, and then introduce a tool for performing the calculations for the simplified methods.

8.2 Findings

8.2.1 Derivation of the Simplified Procedures

The derivations of the simplified liquefaction triggering, lateral spread displacement, post-liquefaction settlement, and seismic slope displacement models show how to approximate a full performance-based analysis using simple calculations and mapped reference parameters. The simplified liquefaction triggering procedure is based on the Boulanger and Idriss (2012) probabilistic model, the simplified lateral spread displacement model is based on the Youd et al. (2002) empirical model, the post-liquefaction settlement model is based on the Cetin et al. (2009) and Ishihara and Yoshimine (1992) volumetric strain models, and the seismic slope displacement model is based on the Rathje & Saygili (2009) and the Bray & Travasarou (2007) probabilistic models.

8.2.2 Validation of the Simplified Procedures

Ten sites throughout the United States were analyzed using both the full and simplified probabilistic procedures for three different return periods: 475, 1033, and 2475 years. The simplified liquefaction triggering method, the simplified lateral spread displacement, the simplified post-liquefaction settlement, and the seismic slope models provided reasonable approximations of their respective full probabilistic methods. This shows that the simplified procedures derived in this report can be used to approximate the results of a full probabilistic procedure without the need for special software, training, and experience.

8.2.3 Evaluation of Grid Spacing

A grid spacing necessary to maintain accuracy in the interpolated results was found for the liquefaction triggering, lateral spread displacement, post-liquefaction settlement, and seismic slope displacement models. These grid spacings resulted on average with a 5% difference between an interpolated value and the result if an analysis were performed at the same site. These grid spacings were very important in creating the grid of points that was used in the analysis.

8.2.4 Map Development

The liquefaction parameter maps were developed for each state by subdividing them into zones and assigning a grid spacing for each zone. The grid points were then generated in ArcMap based on this grid spacing. The points were analyzed using the specified performance-based analytical software (PBLiquefY, EZ-FRISK), then imported into ArcMap and converted to a Kriging raster that is then used to create a contour of the specific reference parameter.

8.2.5 Comparison with Deterministic Procedures

The results of this study show, for the 475, 1033, and 2475 year return periods for liquefaction initiation, lateral spread displacement, post-liquefaction settlement, and seismic slope displacement, that deterministic methods severely over-predicted liquefaction hazard in areas of low seismicity. The deterministic results slightly over-predicted liquefaction hazards in areas of medium seismicity. And in areas of high seismicity the deterministic methods slightly under-predicted liquefaction hazard. These results suggest that the deterministic results could be used as an upper-bound in areas of high seismicity, but in areas of low seismicity, the deterministic analysis could be optional. Engineers performing analyses in areas of medium to high seismicity could choose to use a deterministic analysis as a "reality check" against the simplified performance-based results.

8.3 Limitations and Challenges

During the production of this report, a revised Boulanger and Idriss (2014) model was published. This revised model included a new definition of the *MSF* (as explained previously). Though this report discussed the derivation of the simplified performance-based procedure for both the updated Boulanger and Idriss (2014) model and the previous Boulanger and Idriss (2012) model, the 2012 version of the *MSF* was used throughout the report.

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APPENDIX A: Supplementary Validation Data

The following tables are supplementary to the validation results of this report but are too lengthy to include in the body of the text. The values in Table A- 1 are values used in the calculation of CSR^{site} for each of the ten cities in the study. The values of $\%CSR^{ref}$ were retrieved from the hazard-targeted liquefaction parameter maps created using PBLiquefY. The values of mean M and PGA were retrieved from the 2008 USGS deaggregation website. Values of F_{pga} were retrieved from AASHTO 2012 Table 3.10.3.2-1. Table A- 2 displays the results of the simplified liquefaction triggering procedure while Table A- 3 displays the results of the full probabilistic liquefaction triggering procedure.

Depth conversions: 2.5 m (8.20 ft), 3.5 m (11.48 ft), 4.5 m (14.76 ft), 5.5 m (18.04 ft), 6.5 m (21.33 ft), 7.5 m (24.61 ft), 8.5 m (27.89 ft), 9.5 m (31.17 ft), 10.5 m (34.45 ft), 11.5 m (37.73 ft)

Table A- 1 Parameters Used in Simplified Liquefaction Triggering Procedure

Location	$T_R = 1033$				$T_R = 475$				$T_R = 2475$			
	$\%CSR^{ref}$	Mean M	PGA	F_{pga}	$\%CSR^{ref}$	Mean M	PGA	F_{pga}	$\%CSR^{ref}$	Mean M	PGA	F_{pga}
Butte	10.37	6.03	0.1206	1.559	7.434	6.03	0.0834	1.600	14.671	6.05	0.1785	1.443
Charleston	33.46	6.87	0.3680	1.132	12.750	6.61	0.1513	1.497	66.794	7.00	0.7287	1.000
Eureka	109.64	7.40	0.9662	1.000	67.819	7.33	0.6154	1.000	162.159	7.45	1.4004	1.000
Memphis	34.73	7.19	0.3346	1.165	14.811	6.98	0.1604	1.479	61.245	7.24	0.5711	1.000
Portland	37.08	7.29	0.2980	1.204	23.485	7.24	0.1990	1.402	55.225	7.31	0.4366	1.063
Salt Lake City	38.09	6.84	0.4030	1.097	20.724	6.75	0.2126	1.375	62.332	6.90	0.6717	1.000
San Francisco	68.49	7.38	0.5685	1.000	50.860	7.31	0.4394	1.061	90.113	7.44	0.7254	1.000
San Jose	57.89	6.67	0.5627	1.000	45.322	6.66	0.4560	1.044	72.345	6.66	0.6911	1.000
Santa Monica	52.70	6.79	0.5372	1.000	37.984	6.74	0.3852	1.115	71.788	6.84	0.7415	1.000
Seattle	47.29	6.82	0.4444	1.056	32.213	6.75	0.3110	1.189	67.879	6.88	0.6432	1.000

Table A- 2 Results from Simplified Liquefaction Triggering Procedure

			T_R = 1033 Simple PB (Idriss & Boulanger)				T_R = 475 Simple PB (Idriss & Boulanger)				T_R = 2475 Simple PB (Idriss & Boulanger)			
	Depth (m)	$N_{1,60,cs}$ site	N_{req}	$\%CSR^{site}$	FS_L	P_L	N_{req}	$\%CSR^{site}$	FS_L	P_L	N_{req}	$\%CSR^{site}$	FS_L	P_L
Butte	2.5	13.78	4.568	9.528	1.747	0.022	1.000	7.434	2.375	0.002	8.740	12.467	1.335	0.148
	3.5	15.62	6.554	10.867	1.691	0.029	2.029	7.994	2.299	0.001	10.965	14.223	1.292	0.177
	4.5	16.95	7.780	11.749	1.681	0.030	3.144	8.642	2.285	0.001	12.344	15.377	1.284	0.183
	5.5	19.87	8.522	12.301	1.892	0.011	3.811	9.049	2.572	0.000	13.178	16.104	1.445	0.092
	6.5	21.47	9.030	12.688	2.021	0.006	4.266	9.335	2.748	0.000	13.749	16.615	1.544	0.059
	7.5	23.12	9.356	12.940	2.213	0.002	4.553	9.518	3.008	0.000	14.111	16.945	1.690	0.029
	8.5	24.83	9.553	13.094	2.487	0.001	4.729	9.633	3.381	0.000	14.336	17.153	1.899	0.010
	9.5	27.79	9.685	13.197	3.238	0.000	4.846	9.709	4.401	0.000	14.484	17.291	2.471	0.001
	10.5	29.76	9.772	13.265	4.036	0.000	4.921	9.757	5.486	0.000	14.581	17.382	3.080	0.000
	11.5	31.81	9.848	13.325	5.346	0.000	4.990	9.803	7.268	0.000	14.669	17.465	4.079	0.000
Charleston	2.5	13.78	18.765	21.832	0.762	0.836	6.850	11.076	1.503	0.071	26.706	38.365	0.434	0.999
	3.5	15.62	21.090	25.043	0.734	0.868	9.023	12.683	1.449	0.090	28.077	44.043	0.417	0.999
	4.5	16.95	22.393	27.241	0.725	0.877	10.406	13.769	1.434	0.097	28.842	47.955	0.412	0.999
	5.5	19.87	23.158	28.716	0.810	0.776	11.284	14.485	1.606	0.044	29.299	50.607	0.460	0.997
	6.5	21.47	23.688	29.836	0.860	0.708	11.919	15.016	1.708	0.027	29.620	52.638	0.487	0.995
	7.5	23.12	24.052	30.657	0.934	0.597	12.362	15.393	1.860	0.013	29.846	54.151	0.529	0.989
	8.5	24.83	24.312	31.273	1.041	0.442	12.676	15.664	2.079	0.004	30.011	55.306	0.589	0.972
	9.5	27.79	24.519	31.781	1.344	0.143	12.921	15.878	2.691	0.000	30.145	56.276	0.759	0.840
	10.5	29.76	24.691	32.215	1.662	0.033	13.120	16.053	3.335	0.000	30.259	57.122	0.937	0.593
	11.5	31.81	24.855	32.643	2.182	0.002	13.310	16.221	4.392	0.000	30.368	57.957	1.229	0.228
Eureka	2.5	13.78	30.898	62.315	0.267	1.000	26.775	38.616	0.431	0.999	33.360	92.041	0.181	1.000
	3.5	15.62	31.855	71.732	0.256	1.000	28.158	44.432	0.414	0.999	34.124	105.987	0.173	1.000
	4.5	16.95	32.412	78.334	0.252	1.000	28.938	48.494	0.407	0.999	34.576	115.783	0.171	1.000
	5.5	19.87	32.757	82.929	0.281	1.000	29.413	51.310	0.454	0.998	34.860	122.624	0.190	1.000
	6.5	21.47	33.008	86.554	0.296	1.000	29.754	53.520	0.479	0.996	35.069	128.038	0.200	1.000
	7.5	23.12	33.193	89.368	0.320	1.000	30.000	55.226	0.518	0.991	35.223	132.260	0.216	1.000
	8.5	24.83	33.334	91.620	0.355	1.000	30.187	56.581	0.576	0.977	35.342	135.660	0.240	1.000
	9.5	27.79	33.453	93.596	0.457	0.998	30.343	57.761	0.740	0.862	35.443	138.653	0.308	1.000
	10.5	29.76	33.559	95.388	0.561	0.981	30.479	58.825	0.910	0.633	35.533	141.378	0.379	1.000
	11.5	31.81	33.661	97.183	0.733	0.869	30.611	59.888	1.190	0.265	35.620	144.113	0.494	0.995
Memphis	2.5	13.78	19.764	23.120	0.720	0.882	8.898	12.588	1.322	0.157	25.676	34.955	0.476	0.996
	3.5	15.62	22.022	26.578	0.692	0.909	11.242	14.450	1.272	0.193	27.188	40.195	0.457	0.998
	4.5	16.95	23.285	28.978	0.681	0.917	12.754	15.731	1.255	0.206	28.034	43.841	0.450	0.998
	5.5	19.87	24.039	30.628	0.760	0.839	13.730	16.598	1.402	0.111	28.543	46.355	0.502	0.994
	6.5	21.47	24.570	31.908	0.804	0.785	14.452	17.261	1.486	0.076	28.906	48.315	0.531	0.989
	7.5	23.12	24.946	32.882	0.871	0.691	14.974	17.755	1.613	0.042	29.166	49.812	0.575	0.977
	8.5	24.83	25.225	33.645	0.968	0.547	15.361	18.129	1.796	0.017	29.361	50.991	0.639	0.947
	9.5	27.79	25.454	34.299	1.246	0.214	15.681	18.444	2.317	0.001	29.523	52.009	0.822	0.761
	10.5	29.76	25.652	34.882	1.535	0.061	15.955	18.718	2.860	0.000	29.663	52.918	1.012	0.483
	11.5	31.81	25.841	35.461	2.009	0.006	16.220	18.986	3.752	0.000	29.799	53.825	1.324	0.156

			T_R = 1033 Simple PB (Idriss & Boulanger)				T_R = 475 Simple PB (Idriss & Boulanger)				T_R = 2475 Simple PB (Idriss & Boulanger)			
	Depth (m)	$N_{1,60,cs}$ site	N_{req}	$\%CSR^{site}$	FS_L	P_L	N_{req}	$\%CSR^{site}$	FS_L	P_L	N_{req}	$\%CSR^{site}$	FS_L	P_L
Portland	2.5	13.78	21.346	25.447	0.654	0.937	16.028	18.792	0.886	0.669	25.152	33.443	0.498	0.994
	3.5	15.62	23.426	29.272	0.628	0.954	18.582	21.609	0.851	0.721	26.736	38.474	0.478	0.996
	4.5	16.95	24.583	31.940	0.618	0.959	20.091	23.570	0.838	0.739	27.621	41.987	0.470	0.997
	5.5	19.87	25.274	33.783	0.689	0.911	21.011	24.920	0.934	0.598	28.155	44.417	0.524	0.990
	6.5	21.47	25.765	35.227	0.728	0.874	21.668	25.975	0.987	0.518	28.537	46.324	0.554	0.984
	7.5	23.12	26.116	36.336	0.788	0.805	22.137	26.780	1.069	0.405	28.812	47.790	0.599	0.968
	8.5	24.83	26.379	37.213	0.875	0.685	22.486	27.413	1.188	0.267	29.019	48.953	0.665	0.929
	9.5	27.79	26.597	37.974	1.125	0.335	22.775	27.960	1.528	0.063	29.192	49.965	0.855	0.714
	10.5	29.76	26.786	38.657	1.385	0.120	23.025	28.449	1.882	0.011	29.342	50.874	1.052	0.427
	11.5	31.81	26.968	39.341	1.811	0.016	23.265	28.937	2.462	0.001	29.488	51.785	1.376	0.125
Salt Lake City	2.5	13.78	20.465	24.103	0.691	0.909	13.594	16.475	1.010	0.485	25.979	35.895	0.464	0.997
	3.5	15.62	22.608	27.641	0.665	0.930	16.118	18.883	0.973	0.539	27.431	41.183	0.446	0.998
	4.5	16.95	23.789	30.059	0.657	0.935	17.651	20.521	0.962	0.555	28.235	44.806	0.441	0.998
	5.5	19.87	24.479	31.680	0.735	0.867	18.585	21.613	1.077	0.395	28.712	47.246	0.493	0.995
	6.5	21.47	24.955	32.906	0.779	0.816	19.242	22.432	1.143	0.314	29.044	49.099	0.522	0.990
	7.5	23.12	25.282	33.804	0.847	0.726	19.694	23.025	1.244	0.216	29.275	50.466	0.567	0.980
	8.5	24.83	25.513	34.472	0.945	0.581	20.012	23.460	1.388	0.118	29.442	51.493	0.632	0.951
	9.5	27.79	25.698	35.022	1.220	0.236	20.263	23.812	1.794	0.017	29.576	52.346	0.816	0.768
	10.5	29.76	25.851	35.491	1.508	0.069	20.470	24.109	2.220	0.002	29.687	53.078	1.009	0.488
	11.5	31.81	25.996	35.950	1.982	0.007	20.667	24.399	2.920	0.000	29.795	53.798	1.324	0.155
San Francisco	2.5	13.78	26.864	38.946	0.427	0.999	24.088	30.742	0.541	0.987	29.389	51.161	0.325	1.000
	3.5	15.62	28.240	44.826	0.410	0.999	25.811	35.367	0.520	0.991	30.490	58.910	0.312	1.000
	4.5	16.95	29.017	48.943	0.403	0.999	26.769	38.596	0.512	0.992	31.124	64.350	0.307	1.000
	5.5	19.87	29.491	51.807	0.449	0.998	27.346	40.831	0.570	0.979	31.516	68.146	0.341	1.000
	6.5	21.47	29.833	54.061	0.474	0.996	27.757	42.583	0.602	0.966	31.802	71.150	0.360	1.000
	7.5	23.12	30.081	55.810	0.513	0.992	28.053	43.931	0.652	0.939	32.011	73.488	0.390	1.000
	8.5	24.83	30.270	57.205	0.569	0.979	28.275	45.000	0.724	0.878	32.171	75.370	0.432	0.999
	9.5	27.79	30.429	58.427	0.731	0.871	28.460	45.929	0.930	0.603	32.307	77.025	0.555	0.983
	10.5	29.76	30.568	59.533	0.899	0.649	28.622	46.766	1.145	0.313	32.427	78.532	0.682	0.917
	11.5	31.81	30.702	60.642	1.175	0.280	28.777	47.602	1.497	0.073	32.544	80.043	0.890	0.663
San Jose	2.5	13.78	25.188	33.542	0.496	0.994	22.491	27.421	0.607	0.964	27.607	41.926	0.397	1.000
	3.5	15.62	26.722	38.422	0.478	0.996	24.368	31.409	0.585	0.973	28.854	48.023	0.383	1.000
	4.5	16.95	27.562	41.734	0.473	0.997	25.390	34.113	0.579	0.976	29.546	52.158	0.379	1.000
	5.5	19.87	28.051	43.924	0.530	0.989	25.981	35.900	0.648	0.941	29.953	54.892	0.424	0.999
	6.5	21.47	28.387	45.558	0.563	0.981	26.385	37.232	0.689	0.911	30.233	56.928	0.451	0.998
	7.5	23.12	28.614	46.728	0.613	0.961	26.656	38.185	0.750	0.851	30.423	58.385	0.490	0.995
	8.5	24.83	28.773	47.576	0.685	0.914	26.845	38.875	0.838	0.739	30.556	59.438	0.548	0.985
	9.5	27.79	28.895	48.252	0.886	0.670	26.991	39.425	1.084	0.386	30.659	60.278	0.709	0.893
	10.5	29.76	28.995	48.814	1.097	0.370	27.108	39.880	1.342	0.144	30.742	60.975	0.878	0.681
	11.5	31.81	29.089	49.359	1.443	0.093	27.220	40.320	1.767	0.020	30.821	61.649	1.156	0.301

			T_R = 1033 Simple PB (Idriss & Boulanger)				T_R = 475 Simple PB (Idriss & Boulanger)				T_R = 2475 Simple PB (Idriss & Boulanger)			
	Depth (m)	$N_{1,60,cs}$ site	N_{req}	$\%CSR^{site}$	FS_L	P_L	N_{req}	$\%CSR^{site}$	FS_L	P_L	N_{req}	$\%CSR^{site}$	FS_L	P_L
Santa Monica	2.5	13.78	23.956	30.437	0.547	0.985	20.730	24.493	0.680	0.918	27.485	41.406	0.402	0.999
	3.5	15.62	25.656	34.894	0.527	0.990	22.832	28.070	0.655	0.937	28.756	47.486	0.387	1.000
	4.5	16.95	26.586	37.933	0.521	0.991	23.985	30.504	0.647	0.942	29.465	51.641	0.382	1.000
	5.5	19.87	27.130	39.964	0.582	0.975	24.655	32.124	0.724	0.878	29.886	54.427	0.428	0.999
	6.5	21.47	27.505	41.493	0.618	0.959	25.114	33.338	0.769	0.828	30.180	56.534	0.454	0.998
	7.5	23.12	27.762	42.606	0.672	0.924	25.426	34.217	0.837	0.740	30.384	58.076	0.493	0.995
	8.5	24.83	27.944	43.427	0.750	0.851	25.644	34.860	0.934	0.597	30.529	59.225	0.550	0.985
	9.5	27.79	28.088	44.098	0.969	0.545	25.816	35.382	1.208	0.248	30.645	60.169	0.710	0.892
	10.5	29.76	28.207	44.666	1.199	0.257	25.955	35.818	1.495	0.073	30.742	60.973	0.878	0.681
	11.5	31.81	28.320	45.220	1.575	0.050	26.088	36.244	1.966	0.007	30.835	61.763	1.153	0.303
Seattle	2.5	13.78	23.208	28.820	0.578	0.976	19.016	22.145	0.752	0.849	26.908	39.111	0.426	0.999
	3.5	15.62	25.007	33.047	0.556	0.983	21.304	25.380	0.724	0.878	28.247	44.864	0.410	0.999
	4.5	16.95	25.991	35.934	0.550	0.985	22.577	27.583	0.716	0.886	28.993	48.806	0.405	0.999
	5.5	19.87	26.566	37.864	0.615	0.961	23.320	29.050	0.801	0.788	29.436	51.455	0.452	0.998
	6.5	21.47	26.964	39.323	0.652	0.939	23.830	30.151	0.851	0.720	29.745	53.465	0.480	0.996
	7.5	23.12	27.237	40.389	0.709	0.893	24.176	30.948	0.925	0.611	29.960	54.942	0.521	0.991
	8.5	24.83	27.431	41.180	0.791	0.801	24.419	31.533	1.033	0.454	30.114	56.050	0.581	0.975
	9.5	27.79	27.584	41.828	1.022	0.469	24.610	32.008	1.335	0.148	30.238	56.967	0.750	0.850
	10.5	29.76	27.711	42.380	1.263	0.200	24.765	32.406	1.652	0.035	30.342	57.752	0.927	0.608
	11.5	31.81	27.833	42.920	1.660	0.034	24.913	32.795	2.172	0.003	30.441	58.524	1.217	0.239

Table A- 3 Results from Full Probabilistic Liquefaction Triggering Procedure

			T_R = 1033 Full PB (Idriss & Boulanger)				T_R = 475 Full PB (Idriss & Boulanger)				T_R = 2475 Full PB (Idriss & Boulanger)			
	Depth (m)	$N_{1,60,cs}$ site	N_{req}	$\%CSR^{site}$	FS_L	P_L	N_{req}	$\%CSR^{site}$	FS_L	P_L	N_{req}	$\%CSR^{site}$	FS_L	P_L
Butte	2.5	13.78	4.38	9.408	1.77	0.020	1	7.434	2.24	0.002	8.89	12.581	1.32	0.156
	3.5	15.62	6.29	10.682	1.72	0.025	1.62	7.767	2.37	0.001	11.09	14.325	1.28	0.184
	4.5	16.95	7.47	11.522	1.72	0.026	2.65	8.350	2.37	0.001	12.47	15.486	1.28	0.190
	5.5	19.87	8.21	12.067	1.93	0.009	3.29	8.730	2.67	0.000	13.36	16.266	1.43	0.098
	6.5	21.47	8.68	12.421	2.07	0.004	3.68	8.968	2.86	0.000	13.91	16.761	1.53	0.062
	7.5	23.12	8.94	12.619	2.27	0.002	3.88	9.092	3.15	0.000	14.27	17.092	1.68	0.031
	8.5	24.83	9.07	12.719	2.56	0.000	3.96	9.142	3.56	0.000	14.46	17.269	1.89	0.011
	9.5	27.79	9.09	12.735	3.36	0.000	3.95	9.136	4.68	0.000	14.52	17.325	2.47	0.001
	10.5	29.76	9.02	12.681	4.22	0.000	3.87	9.086	5.89	0.000	14.48	17.287	3.10	0.000
	11.5	31.81	8.9	12.589	5.66	0.000	3.73	8.999	7.92	0.000	14.37	17.185	4.15	0.000
Charleston	2.5	13.78	19.25	22.443	0.74	0.860	6.38	10.745	1.55	0.057	26.94	39.232	0.42	0.999
	3.5	15.62	21.54	25.762	0.71	0.889	8.39	12.202	1.51	0.070	28.37	45.472	0.40	0.999
	4.5	16.95	22.85	28.104	0.70	0.899	9.63	13.154	1.50	0.071	29.2	50.012	0.39	1.000
	5.5	19.87	23.68	29.819	0.78	0.815	10.42	13.781	1.69	0.029	29.75	53.497	0.44	0.999
	6.5	21.47	24.23	31.076	0.83	0.756	10.9	14.170	1.81	0.016	30.13	56.163	0.46	0.998
	7.5	23.12	24.6	31.984	0.89	0.655	11.18	14.399	1.99	0.007	30.41	58.281	0.49	0.995
	8.5	24.83	24.86	32.654	1.00	0.504	11.3	14.498	2.25	0.002	30.61	59.879	0.54	0.986
	9.5	27.79	25.03	33.108	1.29	0.179	11.31	14.507	2.95	0.000	30.76	61.127	0.70	0.902
	10.5	29.76	25.13	33.381	1.60	0.044	11.22	14.432	3.71	0.000	30.86	61.984	0.86	0.702
	11.5	31.81	25.19	33.547	2.12	0.003	11.06	14.300	4.98	0.000	30.94	62.684	1.14	0.322
Eureka	2.5	13.78	30.81	61.553	0.27	1.000	27.15	40.044	0.42	0.999	33.2	89.482	0.19	1.000
	3.5	15.62	31.88	72.010	0.26	1.000	28.59	46.600	0.39	1.000	34.08	105.096	0.18	1.000
	4.5	16.95	32.55	80.128	0.25	1.000	29.44	51.481	0.38	1.000	34.66	117.738	0.17	1.000
	5.5	19.87	32.98	86.133	0.27	1.000	30	55.225	0.42	0.999	35.02	126.741	0.18	1.000
	6.5	21.47	33.33	91.557	0.28	1.000	30.4	58.203	0.44	0.998	35.34	135.607	0.19	1.000
	7.5	23.12	33.58	95.759	0.30	1.000	30.7	60.622	0.47	0.997	35.58	142.853	0.20	1.000
	8.5	24.83	33.78	99.337	0.33	1.000	30.93	62.596	0.52	0.991	35.75	148.324	0.22	1.000
	9.5	27.79	33.93	102.156	0.42	0.999	31.11	64.217	0.67	0.929	35.89	153.055	0.28	1.000
	10.5	29.76	34.07	104.896	0.51	0.992	31.25	65.527	0.82	0.767	36.01	157.281	0.34	1.000
	11.5	31.81	34.18	107.127	0.67	0.930	31.36	66.588	1.07	0.404	36.13	161.673	0.44	0.998
Memphis	2.5	13.78	20.09	23.568	0.71	0.895	8.43	12.232	1.36	0.133	26.17	36.513	0.46	0.998
	3.5	15.62	22.35	27.163	0.68	0.921	10.62	13.942	1.32	0.159	27.73	42.462	0.43	0.999
	4.5	16.95	23.66	29.775	0.66	0.931	11.99	15.076	1.31	0.165	28.64	46.863	0.42	0.999
	5.5	19.87	24.5	31.733	0.73	0.869	12.9	15.859	1.47	0.083	29.24	50.252	0.46	0.997
	6.5	21.47	25.08	33.244	0.77	0.826	13.49	16.382	1.57	0.053	29.67	52.963	0.48	0.996
	7.5	23.12	25.49	34.403	0.83	0.746	13.87	16.725	1.71	0.026	29.98	55.083	0.52	0.991
	8.5	24.83	25.8	35.334	0.92	0.616	14.08	16.917	1.93	0.009	30.23	56.904	0.57	0.978
	9.5	27.79	26.02	36.025	1.19	0.269	14.18	17.009	2.51	0.000	30.43	58.437	0.73	0.871
	10.5	29.76	26.18	36.546	1.46	0.084	14.17	17.000	3.15	0.000	30.58	59.634	0.90	0.652
	11.5	31.81	26.3	36.946	1.93	0.009	14.1	16.935	4.21	0.000	30.69	60.539	1.18	0.278

			T_R = 1033 Full PB (Idriss & Boulanger)				T_R = 475 Full PB (Idriss & Boulanger)				T_R = 2475 Full PB (Idriss & Boulanger)			
	Depth (m)	$N_{1,60,cs}$ site	N_{req}	$\%CSR^{site}$	FS_L	P_L	N_{req}	$\%CSR^{site}$	FS_L	P_L	N_{req}	$\%CSR^{site}$	FS_L	P_L
Portland	2.5	13.78	21.9	26.367	0.63	0.952	15.62	18.383	0.91	0.640	25.97	35.866	0.46	0.997
	3.5	15.62	24.02	30.584	0.60	0.967	18.2	21.153	0.87	0.694	27.61	41.939	0.44	0.999
	4.5	16.95	25.27	33.771	0.58	0.974	19.78	23.142	0.85	0.717	28.59	46.600	0.42	0.999
	5.5	19.87	26.09	36.251	0.64	0.945	20.82	24.628	0.94	0.581	29.25	50.312	0.46	0.997
	6.5	21.47	26.68	38.271	0.67	0.926	21.56	25.795	0.99	0.508	29.74	53.429	0.48	0.996
	7.5	23.12	27.13	39.965	0.72	0.886	22.09	26.698	1.07	0.400	30.11	56.017	0.51	0.992
	8.5	24.83	27.48	41.387	0.79	0.806	22.48	27.402	1.19	0.266	30.43	58.437	0.56	0.983
	9.5	27.79	27.76	42.595	1.00	0.495	22.77	27.949	1.53	0.063	30.69	60.539	0.71	0.896
	10.5	29.76	27.99	43.638	1.23	0.230	22.99	28.379	1.89	0.011	30.89	62.245	0.86	0.707
	11.5	31.81	28.18	44.537	1.60	0.045	23.15	28.701	2.48	0.001	31.08	63.942	1.11	0.348
Salt Lake City	2.5	13.78	21.06	24.996	0.67	0.929	13.29	16.203	1.03	0.461	26.28	36.878	0.45	0.998
	3.5	15.62	23.18	28.762	0.64	0.947	15.77	18.532	0.99	0.512	27.78	42.684	0.43	0.999
	4.5	16.95	24.38	31.438	0.63	0.953	17.29	20.120	0.98	0.527	28.65	46.916	0.42	0.999
	5.5	19.87	25.13	33.381	0.70	0.904	18.28	21.247	1.10	0.371	29.21	50.072	0.46	0.997
	6.5	21.47	25.65	34.877	0.74	0.866	18.94	22.050	1.16	0.293	29.6	52.504	0.49	0.995
	7.5	23.12	25.99	35.930	0.80	0.794	19.38	22.611	1.27	0.197	29.87	54.314	0.53	0.990
	8.5	24.83	26.24	36.745	0.89	0.668	19.66	22.981	1.42	0.104	30.07	55.727	0.58	0.974
	9.5	27.79	26.41	37.320	1.15	0.313	19.83	23.210	1.84	0.014	30.22	56.829	0.75	0.848
	10.5	29.76	26.52	37.702	1.42	0.103	19.9	23.305	2.30	0.001	30.33	57.662	0.93	0.606
	11.5	31.81	26.58	37.913	1.88	0.011	19.91	23.319	3.06	0.000	30.39	58.125	1.23	0.231
San Francisco	2.5	13.78	27.22	40.322	0.41	0.999	24.51	31.758	0.52	0.990	29.39	51.169	0.33	1.000
	3.5	15.62	28.66	46.969	0.39	1.000	26.25	36.778	0.50	0.994	30.6	59.797	0.31	1.000
	4.5	16.95	29.5	51.861	0.38	1.000	27.26	40.482	0.49	0.995	31.32	66.199	0.30	1.000
	5.5	19.87	30.04	55.511	0.42	0.999	27.91	43.270	0.54	0.987	31.81	71.239	0.33	1.000
	6.5	21.47	30.47	58.752	0.44	0.999	28.38	45.522	0.56	0.981	32.16	75.235	0.34	1.000
	7.5	23.12	30.76	61.127	0.47	0.997	28.71	47.237	0.61	0.965	32.46	78.955	0.36	1.000
	8.5	24.83	30.97	62.950	0.52	0.991	28.95	48.560	0.67	0.925	32.67	81.736	0.40	1.000
	9.5	27.79	31.16	64.680	0.66	0.933	29.15	49.716	0.86	0.708	32.82	83.819	0.51	0.993
	10.5	29.76	31.31	66.102	0.81	0.777	29.3	50.615	1.06	0.420	32.94	85.545	0.63	0.955
	11.5	31.81	31.43	67.278	1.06	0.418	29.41	51.294	1.39	0.118	33.04	87.027	0.82	0.765
San Jose	2.5	13.78	25.67	34.937	0.48	0.996	23	28.399	0.59	0.973	27.74	42.506	0.39	1.000
	3.5	15.62	27.25	40.442	0.45	0.998	24.89	32.734	0.56	0.981	29.08	49.306	0.37	1.000
	4.5	16.95	28.16	44.441	0.44	0.998	25.95	35.803	0.55	0.984	29.88	54.383	0.36	1.000
	5.5	19.87	28.75	47.453	0.49	0.995	26.64	38.127	0.61	0.963	30.44	58.516	0.40	1.000
	6.5	21.47	29.15	49.716	0.52	0.992	27.09	39.809	0.64	0.944	30.79	61.382	0.42	0.999
	7.5	23.12	29.46	51.607	0.55	0.983	27.41	41.095	0.70	0.904	31.04	63.578	0.45	0.998
	8.5	24.83	29.67	52.963	0.62	0.960	27.63	42.026	0.77	0.821	31.28	65.814	0.50	0.994
	9.5	27.79	29.82	53.971	0.79	0.800	27.78	42.684	1.00	0.498	31.45	67.478	0.63	0.950
	10.5	29.76	29.92	54.662	0.98	0.530	27.88	43.133	1.24	0.218	31.57	68.694	0.78	0.816
	11.5	31.81	29.99	55.154	1.29	0.178	27.93	43.362	1.64	0.037	31.65	69.526	1.03	0.465

			T_R = 1033 Full PB (Idriss & Boulanger)				T_R = 475 Full PB (Idriss & Boulanger)				T_R = 2475 Full PB (Idriss & Boulanger)			
	Depth (m)	$N_{1,60,cs}$ site	N_{req}	$\%CSR^{site}$	FS_L	P_L	N_{req}	$\%CSR^{site}$	FS_L	P_L	N_{req}	$\%CSR^{site}$	FS_L	P_L
Santa Monica	2.5	13.78	24.77	32.419	0.51	0.992	21.24	25.278	0.66	0.934	27.6	41.896	0.40	1.000
	3.5	15.62	26.46	37.492	0.49	0.995	23.34	29.092	0.63	0.951	28.94	48.504	0.38	1.000
	4.5	16.95	27.43	41.178	0.48	0.996	24.53	31.808	0.62	0.957	29.75	53.497	0.37	1.000
	5.5	19.87	28.02	43.778	0.53	0.989	25.28	33.799	0.69	0.911	30.28	57.281	0.41	0.999
	6.5	21.47	28.47	45.978	0.56	0.982	25.78	35.272	0.73	0.875	30.65	60.207	0.43	0.999
	7.5	23.12	28.76	47.507	0.60	0.966	26.13	36.382	0.79	0.806	30.89	62.245	0.46	0.997
	8.5	24.83	28.97	48.674	0.67	0.927	26.38	37.217	0.88	0.685	31.08	63.942	0.51	0.993
	9.5	27.79	29.13	49.598	0.86	0.705	26.55	37.807	1.13	0.329	31.24	65.432	0.65	0.938
	10.5	29.76	29.24	50.252	1.06	0.410	26.65	38.163	1.40	0.111	31.35	66.490	0.81	0.783
	11.5	31.81	29.32	50.737	1.40	0.110	26.71	38.379	1.86	0.013	31.43	67.278	1.06	0.418
Seattle	2.5	13.78	24.06	30.676	0.54	0.986	19.42	22.663	0.73	0.867	27.4	41.053	0.41	0.999
	3.5	15.62	25.87	35.551	0.52	0.991	21.72	26.061	0.71	0.896	28.82	47.835	0.38	1.000
	4.5	16.95	26.92	39.157	0.50	0.993	23.04	28.479	0.69	0.907	29.67	52.963	0.37	1.000
	5.5	19.87	27.61	41.939	0.55	0.983	23.88	30.264	0.77	0.829	30.24	56.979	0.41	0.999
	6.5	21.47	28.09	44.107	0.58	0.975	24.45	31.609	0.81	0.775	30.66	60.290	0.43	0.999
	7.5	23.12	28.45	45.876	0.62	0.956	24.84	32.602	0.88	0.680	30.96	62.861	0.46	0.998
	8.5	24.83	28.72	47.291	0.69	0.911	25.11	33.326	0.98	0.533	31.22	65.243	0.50	0.994
	9.5	27.79	28.92	48.391	0.88	0.673	25.3	33.856	1.26	0.200	31.43	67.278	0.64	0.949
	10.5	29.76	29.09	49.364	1.08	0.385	25.43	34.228	1.56	0.053	31.6	69.004	0.78	0.820
	11.5	31.81	29.22	50.132	1.42	0.102	25.5	34.432	2.07	0.004	31.73	70.374	1.01	0.482

The following tables are supplementary to the validation of this report. Table A- 4 and Table A- 5 show the results from the simplified seismic slope displacement procedure. The D^{ref} values were generated from PBLiquefY using a k_y^{ref} value of 0.1 g. To calculate D^{site}, equation (121) was used with a f_a^{ref} value of 1, k_y^{site} of 0.1, 0.2, 0.3, 0.4, and 0.5 g and f_a^{site} values from Table 3-3. Table A- 6 shows the results of the full probabilistic seismic slope displacement procedure. These values were all generated from PBLiquefY with k_y^{site} of 0.1, 0.2, 0.3, 0.4, and 0.5 g and f_a^{site} values from Table 3-3.

Table A-7 shows the supplementary validations data for the volumetric strains based off the Cetin et al. 2009 model. Table A-8 displays the Ishihara and Yoshimine 1992 volumetric strain model supplementary validation data.

Table A- 4 Results from Simplified Seismic Slope Displacement Procedure based on Rathje & Saygili 2009

	Site	D^{ref} Rathje & Saygili (cm)			ΔlnD (Rathje & Saygili)			D^{site} Rathje & Saygili (cm)		
		475 Yrs.	1033 Yrs.	2475 Yrs.	475 Yrs.	1033 Yrs.	2475 Yrs.	475 Yrs.	1033 Yrs.	2475 Yrs.
k_y^{ref}=0.1 k_y^{site}=0.1	Butte	<0.5	<0.5	0.7	15.3	3.3	1.5	0.0	13.8	3.2
	Charleston	<0.5	12.5	81.8	2.0	0.4	0.0	3.6	18.1	81.8
	Eureka	96.0	280.1	670.9	0.0	0.0	0.0	96.0	280.1	670.9
	Memphis	0.5	17.5	92.6	1.8	0.5	0.0	3.0	28.2	92.6
	Portland	2.9	18.5	72.9	1.3	0.6	0.2	11.1	34.3	86.0
	Salt Lake City	2.6	24.0	87.6	1.2	0.3	0.0	8.8	31.2	87.6
	San Francisco	47.6	105.5	205.0	0.2	0.0	0.0	55.8	105.5	205.0
	San Jose	36.7	73.7	137.8	0.1	0.0	0.0	41.1	73.7	137.8
	Santa Monica	22.2	57.2	126.6	0.3	0.0	0.0	30.4	57.2	126.6
	Seattle	12.5	42.7	117.8	0.6	0.1	0.0	21.9	49.4	117.8
k_y^{ref}=0.1 k_y^{site}=0.2	Butte	<0.5	<0.5	0.7	-33.7	-6.1	-1.7	0.0	0.0	0.1
	Charleston	<0.5	12.5	81.8	-2.6	-1.5	-1.2	0.0	2.7	25.6
	Eureka	96.0	280.1	670.9	-1.4	-0.9	-0.5	24.4	119.3	387.1
	Memphis	0.5	17.5	92.6	-2.2	-1.5	-1.5	0.1	3.9	21.3
	Portland	2.9	18.5	72.9	-1.5	-1.5	-1.6	0.7	4.1	15.0
	Salt Lake City	2.6	24.0	87.6	-1.4	-1.5	-1.3	0.6	5.1	24.8
	San Francisco	47.6	105.5	205.0	-1.6	-1.5	-1.2	9.8	24.1	63.8
	San Jose	36.7	73.7	137.8	-1.6	-1.5	-1.2	7.4	16.7	40.5
	Santa Monica	22.2	57.2	126.6	-1.5	-1.5	-1.1	4.8	12.2	40.5
	Seattle	12.5	42.7	117.8	-1.5	-1.6	-1.3	2.8	8.7	31.6
k_y^{ref}=0.1 k_y^{site}=0.3	Butte	<0.5	<0.5	0.7	-347.7	-66.1	-14.1	0.0	0.0	0.0
	Charleston	<0.5	12.5	81.8	-26.2	-3.5	-2.3	0.0	0.4	8.5
	Eureka	96.0	280.1	670.9	-2.6	-1.7	-1.2	7.1	49.7	212.0
	Memphis	0.5	17.5	92.6	-20.9	-3.8	-2.8	0.0	0.4	5.8
	Portland	2.9	18.5	72.9	-9.8	-4.4	-3.2	0.0	0.2	3.0
	Salt Lake City	2.6	24.0	87.6	-8.1	-3.3	-2.4	0.0	0.9	7.8
	San Francisco	47.6	105.5	205.0	-3.2	-2.8	-2.3	2.0	6.5	21.2
	San Jose	36.7	73.7	137.8	-3.1	-2.8	-2.4	1.6	4.5	12.9
	Santa Monica	22.2	57.2	126.6	-3.4	-2.9	-2.2	0.8	3.1	13.7
	Seattle	12.5	42.7	117.8	-4.1	-3.2	-2.5	0.2	1.8	9.6
k_y^{ref}=0.1 k_y^{site}=0.4	Butte	<0.5	<0.5	0.7	-1368.6	-277.9	-60.2	0.0	0.0	0.0
	Charleston	<0.5	12.5	81.8	-112.9	-7.7	-3.3	0.0	0.0	3.2
	Eureka	96.0	280.1	670.9	-3.8	-2.5	-1.8	2.1	22.0	115.5
	Memphis	0.5	17.5	92.6	-90.1	-9.5	-4.2	0.0	0.0	1.4
	Portland	2.9	18.5	72.9	-40.8	-13.1	-5.8	0.0	0.0	0.2
	Salt Lake City	2.6	24.0	87.6	-32.6	-6.5	-3.5	0.0	0.0	2.6
	San Francisco	47.6	105.5	205.0	-5.8	-4.2	-3.3	0.1	1.6	7.8
	San Jose	36.7	73.7	137.8	-5.6	-4.3	-3.4	0.1	1.0	4.5
	Santa Monica	22.2	57.2	126.6	-7.0	-4.5	-3.2	0.0	0.6	5.1
	Seattle	12.5	42.7	117.8	-11.6	-5.7	-3.7	0.0	0.1	3.1
k_y^{ref}=0.1 k_y^{site}=0.5	Butte	<0.5	<0.5	0.7	-3757.7	-798.4	-180.7	0.0	0.0	0.0
	Charleston	<0.5	12.5	81.8	-333.6	-18.8	-4.4	0.0	0.0	1.1
	Eureka	96.0	280.1	670.9	-5.6	-3.3	-2.3	0.3	10.4	64.5
	Memphis	0.5	17.5	92.6	-267.9	-25.1	-6.6	0.0	0.0	0.1
	Portland	2.9	18.5	72.9	-122.8	-36.8	-12.3	0.0	0.0	0.0
	Salt Lake City	2.6	24.0	87.6	-98.0	-14.7	-4.9	0.0	0.0	0.7
	San Francisco	47.6	105.5	205.0	-12.1	-6.7	-4.4	0.0	0.1	2.6
	San Jose	36.7	73.7	137.8	-11.2	-6.8	-4.7	0.0	0.1	1.3
	Santa Monica	22.2	57.2	126.6	-16.6	-7.7	-4.3	0.0	0.0	1.8
	Seattle	12.5	42.7	117.8	-31.9	-11.8	-5.2	0.0	0.0	0.6

Table A- 5 Results from Simplified Seismic Slope Displacement Procedure based on Bray & Travasarou 2007

	Site	D^{ref} Bray & Travasarou (cm)			ΔlnD (Bray & Travasarou)			D^{site} Bray & Travasarou (cm)		
		475 Yrs.	**1033 Yrs.**	**2475 Yrs.**	**475 Yrs.**	**1033 Yrs.**	**2475 Yrs.**	**475 Yrs.**	**1033 Yrs.**	**2475 Yrs.**
k_y^{ref}=0.1 k_y^{site}=0.1	Butte	0.5	0.7	2.1	1.2	1.0	0.8	1.7	2.1	4.7
	Charleston	1.2	10.9	47.4	0.9	0.2	0.0	3.0	13.6	47.4
	Eureka	44.3	111.1	227.0	0.0	0.0	0.0	44.3	111.1	227.0
	Memphis	1.7	11.6	40.3	0.9	0.3	0.0	4.1	15.4	40.3
	Portland	3.7	10.5	26.1	0.7	0.4	0.1	7.5	15.0	29.0
	Salt Lake City	3.8	16.6	49.5	0.7	0.2	0.0	7.4	19.6	49.5
	San Francisco	23.3	42.3	72.3	0.1	0.0	0.0	25.8	42.3	72.3
	San Jose	23.4	39.1	63.0	0.1	0.0	0.0	25.2	39.1	63.0
	Santa Monica	15.9	33.2	65.4	0.2	0.0	0.0	19.3	33.2	65.4
	Seattle	10.0	23.1	51.4	0.3	0.1	0.0	13.9	25.4	51.4
k_y^{ref}=0.1 k_y^{site}=0.2	Butte	0.5	0.7	2.1	-0.6	-0.6	-0.8	0.3	0.4	1.0
	Charleston	1.2	10.9	47.4	-0.7	-1.2	-1.2	0.6	3.4	14.5
	Eureka	44.3	111.1	227.0	-1.2	-1.1	-0.9	12.7	38.0	89.9
	Memphis	1.7	11.6	40.3	-0.7	-1.1	-1.3	0.8	3.7	11.2
	Portland	3.7	10.5	26.1	-0.8	-1.1	-1.2	1.6	3.5	7.5
	Salt Lake City	3.8	16.6	49.5	-0.9	-1.2	-1.2	1.6	5.0	14.7
	San Francisco	23.3	42.3	72.3	-1.3	-1.3	-1.2	6.7	11.8	22.1
	San Jose	23.4	39.1	63.0	-1.3	-1.3	-1.2	6.6	10.8	18.9
	Santa Monica	15.9	33.2	65.4	-1.2	-1.3	-1.2	4.8	9.0	20.2
	Seattle	10.0	23.1	51.4	-1.1	-1.3	-1.2	3.3	6.6	15.0
k_y^{ref}=0.1 k_y^{site}=0.3	Butte	0.5	0.7	2.1	-1.8	-1.8	-1.8	0.1	0.1	0.3
	Charleston	1.2	10.9	47.4	-1.8	-2.1	-2.0	0.2	1.3	6.3
	Eureka	44.3	111.1	227.0	-2.1	-1.8	-1.6	5.3	17.5	45.1
	Memphis	1.7	11.6	40.3	-1.8	-2.1	-2.2	0.3	1.4	4.6
	Portland	3.7	10.5	26.1	-1.9	-2.1	-2.2	0.6	1.3	2.9
	Salt Lake City	3.8	16.6	49.5	-1.9	-2.2	-2.1	0.6	1.9	6.2
	San Francisco	23.3	42.3	72.3	-2.2	-2.2	-2.0	2.6	4.8	9.5
	San Jose	23.4	39.1	63.0	-2.2	-2.2	-2.1	2.6	4.4	8.1
	Santa Monica	15.9	33.2	65.4	-2.1	-2.2	-2.0	1.9	3.6	8.7
	Seattle	10.0	23.1	51.4	-2.1	-2.2	-2.1	1.2	2.6	6.3
k_y^{ref}=0.1 k_y^{site}=0.4	Butte	0.5	0.7	2.1	-2.8	-2.6	-2.7	0.0	0.1	0.1
	Charleston	1.2	10.9	47.4	-2.6	-2.9	-2.7	0.1	0.6	3.2
	Eureka	44.3	111.1	227.0	-2.8	-2.5	-2.2	2.6	9.4	25.8
	Memphis	1.7	11.6	40.3	-2.6	-2.9	-2.9	0.1	0.7	2.3
	Portland	3.7	10.5	26.1	-2.7	-2.9	-2.9	0.3	0.6	1.4
	Salt Lake City	3.8	16.6	49.5	-2.7	-2.9	-2.7	0.3	0.9	3.2
	San Francisco	23.3	42.3	72.3	-2.9	-2.9	-2.7	1.3	2.4	4.9
	San Jose	23.4	39.1	63.0	-2.9	-2.9	-2.7	1.2	2.2	4.1
	Santa Monica	15.9	33.2	65.4	-2.9	-2.9	-2.7	0.9	1.8	4.5
	Seattle	10.0	23.1	51.4	-2.9	-2.9	-2.8	0.6	1.2	3.2
k_y^{ref}=0.1 k_y^{site}=0.5	Butte	0.5	0.7	2.1	-3.5	-3.4	-3.3	0.0	0.0	0.1
	Charleston	1.2	10.9	47.4	-3.3	-3.5	-3.2	0.0	0.3	1.9
	Eureka	44.3	111.1	227.0	-3.4	-3.0	-2.6	1.5	5.6	16.2
	Memphis	1.7	11.6	40.3	-3.3	-3.5	-3.5	0.1	0.4	1.3
	Portland	3.7	10.5	26.1	-3.3	-3.5	-3.5	0.1	0.3	0.8
	Salt Lake City	3.8	16.6	49.5	-3.4	-3.5	-3.3	0.1	0.5	1.8
	San Francisco	23.3	42.3	72.3	-3.5	-3.5	-3.2	0.7	1.3	2.8
	San Jose	23.4	39.1	63.0	-3.5	-3.5	-3.3	0.7	1.2	2.4
	Santa Monica	15.9	33.2	65.4	-3.5	-3.5	-3.2	0.5	1.0	2.6
	Seattle	10.0	23.1	51.4	-3.5	-3.5	-3.4	0.3	0.7	1.8

Table A- 6 Results from Full Probabilisitic Seismic Slope Displacement Procedure

	Site	Latitude	Longitude	Full PB Method Rathje & Saygili			Full PB Method Bray & Travasarou		
				D^{site} (cm)			D^{site} (cm)		
				475 Yrs	**1033 Yrs**	**2475 Yrs**	**475 Yrs**	**1033 Yrs**	**2475 Yrs**
$k_y^{ref}=0.1$ $k_y^{site}=0.1$	Butte	46.003	-112.533	<0.5	0.8	3.3	1.0	2.4	5.3
	Charleston	32.726	-79.931	1.4	19.8	90.9	3.1	15.3	50.5
	Eureka	40.802	-124.162	112.4	313.9	759.3	48.2	112.5	227.4
	Memphis	35.149	-90.048	2.6	28.8	109.4	4.2	16.5	44.4
	Portland	45.523	-122.675	11.0	41.5	121.3	8.1	17.3	34.0
	Salt Lake City	40.755	-111.898	7.7	33.6	99.3	7.8	21.7	52.9
	San Francisco	37.775	-122.418	66.0	132.3	246.2	29.3	48.1	76.8
	San Jose	37.339	-121.893	48.9	94.3	172.1	28.4	44.4	67.8
	Santa Monica	34.015	-118.492	35.0	74.5	150.2	21.8	38.5	68.5
	Seattle	47.53	-122.3	24.7	65.9	158.7	15.9	29.8	56.6
$k_y^{ref}=0.1$ $k_y^{site}=0.2$	Butte	46.003	-112.533	<0.5	<0.5	<0.5	<0.5	<0.5	1.1
	Charleston	32.726	-79.931	<0.5	2.7	25.1	0.6	3.7	14.9
	Eureka	40.802	-124.162	27.7	112.1	330.0	13.7	37.8	86.5
	Memphis	35.149	-90.048	<0.5	3.7	24.1	0.8	3.9	12.3
	Portland	45.523	-122.675	<0.5	3.9	16.8	1.7	3.9	8.4
	Salt Lake City	40.755	-111.898	<0.5	5.4	26.3	1.7	5.4	15.5
	San Francisco	37.775	-122.418	10.6	25.5	57.0	7.4	12.7	21.7
	San Jose	37.339	-121.893	8.3	17.8	36.9	7.2	11.7	18.9
	Santa Monica	34.015	-118.492	4.9	14.0	38.2	5.3	10.2	20.1
	Seattle	47.53	-122.3	2.6	9.9	33.2	3.7	7.4	15.8
$k_y^{ref}=0.1$ $k_y^{site}=0.3$	Butte	46.003	-112.533	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
	Charleston	32.726	-79.931	<0.5	<0.5	7.9	<0.5	1.4	6.3
	Eureka	40.802	-124.162	7.7	44.9	159.8	5.7	17.3	42.7
	Memphis	35.149	-90.048	<0.5	<0.5	6.3	<0.5	1.5	5.0
	Portland	45.523	-122.675	<0.5	<0.5	2.3	0.6	1.4	3.2
	Salt Lake City	40.755	-111.898	<0.5	0.9	8.1	0.6	2.1	6.5
	San Francisco	37.775	-122.418	1.7	5.8	16.2	2.8	5.1	9.0
	San Jose	37.339	-121.893	1.4	3.9	9.8	2.8	4.7	7.7
	Santa Monica	34.015	-118.492	0.7	3.1	11.8	2.0	4.0	8.5
	Seattle	47.53	-122.3	<0.5	1.5	8.5	1.3	2.9	6.5
$k_y^{ref}=0.1$ $k_y^{site}=0.4$	Butte	46.003	-112.533	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
	Charleston	32.726	-79.931	<0.5	<0.5	2.5	<0.5	0.7	3.2
	Eureka	40.802	-124.162	2.1	19.1	82.4	2.9	9.3	24.2
	Memphis	35.149	-90.048	<0.5	<0.5	1.4	<0.5	0.7	2.5
	Portland	45.523	-122.675	<0.5	<0.5	<0.5	<0.5	0.6	1.5
	Salt Lake City	40.755	-111.898	<0.5	<0.5	2.6	<0.5	1.0	3.3
	San Francisco	37.775	-122.418	<0.5	1.1	4.7	1.3	2.5	4.5
	San Jose	37.339	-121.893	<0.5	0.7	2.6	1.3	2.3	3.9
	Santa Monica	34.015	-118.492	<0.5	0.5	4.0	0.9	2.0	4.3
	Seattle	47.53	-122.3	<0.5	<0.5	2.2	0.6	1.4	3.2
$k_y^{ref}=0.1$ $k_y^{site}=0.5$	Butte	46.003	-112.533	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
	Charleston	32.726	-79.931	<0.5	<0.5	0.6	<0.5	<0.5	1.8
	Eureka	40.802	-124.162	<0.5	8.4	44.4	1.6	5.5	15.1
	Memphis	35.149	-90.048	<0.5	<0.5	<0.5	<0.5	<0.5	1.4
	Portland	45.523	-122.675	<0.5	<0.5	<0.5	<0.5	<0.5	0.8
	Salt Lake City	40.755	-111.898	<0.5	<0.5	0.6	<0.5	0.5	1.9
	San Francisco	37.775	-122.418	<0.5	<0.5	1.1	0.7	1.4	2.5
	San Jose	37.339	-121.893	<0.5	<0.5	0.6	0.7	1.2	2.2
	Santa Monica	34.015	-118.492	<0.5	<0.5	1.2	0.5	1.1	2.5
	Seattle	47.53	-122.3	<0.5	<0.5	<0.5	<0.5	0.7	1.8

Table A- 7 Cetin Volumetric Strain supplementary validation data

Soil Profile					Simplified Procedure					Full PBEE	
Profile	Location	T_R	Sample Depth [m]	$(N_1)_{60,CS}^{site}$	N_{req}^{site}	Δε	ε_v^{ref}	ε_v^{site}	$\varepsilon_{v,equiv}$	$\varepsilon_{v,equiv}$	ε_v^{site}
1	Butte	475	2.5	10.63	3.01	1	0	3.06E-18	1.6876E-05	0	0
			3.5	12.63	5.79	0.997611	0	9.78E-05			0
			4.5	15.14	7.46	0.999204	0	3.24E-05			0
			5.5	17.28	8.52	1	0	3.06E-18			0
			6.5	19.3	9.16	1	0	3.06E-18			0
			7.5	21.31	9.51	1	0	3.06E-18			0
			8.5	23.31	9.62	1	0	3.06E-18			0
			9.5	25.27	9.55	1	0	3.06E-18			0
			10.5	27.15	9.36	1	0	3.06E-18			0
			11.5	29.01	9.1	1	0	3.06E-18			0
		2475	2.5	10.63	11.42	0.891544	0.0013	0.007815	0.0038784	0.0046912	0.00901
			3.5	12.63	14.21	0.882104	0.0013	0.008608			0.01083
			4.5	15.14	15.88	0.910827	0.0013	0.00632			0.00729
			5.5	17.28	16.93	0.940659	0.0013	0.004299			0.00559
			6.5	19.3	17.58	0.972204	0.0013	0.002489			0.00356
			7.5	21.31	17.93	1.001389	0.0013	0.001064			0.00118
			8.5	23.31	18.04	1.021715	0.0013	0.000193			0
			9.5	25.27	17.97	1.031451	0.0013	0			0
			10.5	27.15	17.78	1.034526	0.0013	0			0
			11.5	29.01	17.52	1.035157	0.0013	0			0
		1033	2.5	10.63	7.59	0.955102	0	0.002064	0.00102126	0.0008533	0.00264
			3.5	12.63	10.37	0.943005	0	0.002711			0.00226
			4.5	15.14	12.04	0.961836	0	0.001722			0.00123
			5.5	17.28	13.1	0.977851	0	0.000956			0
			6.5	19.3	13.74	0.990239	0	0.000408			0
			7.5	21.31	14.09	0.99734	0	0.000109			0
			8.5	23.31	14.2	1.000015	0	0			0
			9.5	25.27	14.13	1.000532	0	0			0
			10.5	27.15	13.94	1.000532	0	0			0
			11.5	29.01	13.68	1.000532	0	0			0
1	Charleston	475	2.5	10.63	9.26	0.922723	0	0.003898	0.00187682	0.0014218	0.00356
			3.5	12.63	12.05	0.909841	0	0.004723			0.00328
			4.5	15.14	13.72	0.934976	0	0.003165			0.00252
			5.5	17.28	14.77	0.958916	0	0.001869			0.00157
			6.5	19.3	15.42	0.980367	0	0.000842			0
			7.5	21.31	15.77	0.995884	0	0.000169			0
			8.5	23.31	15.88	1.003739	0	0			0
			9.5	25.27	15.81	1.006284	0	0			0
			10.5	27.15	15.62	1.006744	0	0			0
			11.5	29.01	15.36	1.006744	0	0			0
		2475	2.5	10.63	27.96	0.952548	0.0227	0.030569	0.02166175	0.0214254	0.03155
			3.5	12.63	30.75	0.966423	0.0227	0.028336			0.0281
			4.5	15.14	32.42	0.988206	0.0227	0.025116			0.02545
			5.5	17.28	33.47	1.006147	0.0227	0.022701			0.02215
			6.5	19.3	34.12	1.023278	0.0227	0.020576			0.02055
			7.5	21.31	34.47	1.040893	0.0227	0.01856			0.019
			8.5	23.31	34.58	1.059395	0.0227	0.01661			0.01522
			9.5	25.27	34.51	1.079489	0.0227	0.014669			0.01333

			10.5	27.15	34.32	1.102829	0.0227	0.012623			0.0114
			11.5	29.01	34.06	1.133268	0.0227	0.010252			0.00936
		1033	2.5	10.63	19.72	0.944922	0.013	0.018414	0.01078697	0.0126263	0.01999
			3.5	12.63	22.51	0.955289	0.013	0.017196			0.01944
			4.5	15.14	24.17	0.97878	0.013	0.014661			0.01606
			5.5	17.28	25.23	0.999932	0.013	0.012617			0.01412
			6.5	19.3	25.88	1.023568	0.013	0.010568			0.01213
			7.5	21.31	26.22	1.053755	0.013	0.008267			0.01026
			8.5	23.31	26.33	1.093395	0.013	0.005703			0.00865
			9.5	25.27	26.27	1.142258	0.013	0.003124			0.00507
			10.5	27.15	26.07	1.193914	0.013	0.000949			0.00326
			11.5	29.01	25.82	1.237485	0.013	0			0.00106
1	Eureka	475	2.5	10.63	28.1	0.952865	0.0216	0.029008	0.02043331	0.0209146	0.03066
			3.5	12.63	30.88	0.966811	0.0216	0.026845			0.02701
			4.5	15.14	32.55	0.988591	0.0216	0.023742			0.02442
			5.5	17.28	33.61	1.006475	0.0216	0.021423			0.0229
			6.5	19.3	34.25	1.023636	0.0216	0.019374			0.01922
			7.5	21.31	34.6	1.041217	0.0216	0.017436			0.01756
			8.5	23.31	34.71	1.059646	0.0216	0.015566			0.0156
			9.5	25.27	34.64	1.079575	0.0216	0.013713			0.01363
			10.5	27.15	34.45	1.102579	0.0216	0.011769			0.01161
			11.5	29.01	34.19	1.132467	0.0216	0.009523			0.00944
		2475	2.5	10.63	40.02	0.950731	0.0335	0.04716	0.03561148	0.0325997	0.04635
			3.5	12.63	42.81	0.965705	0.0335	0.043868			0.04219
			4.5	15.14	44.48	0.98652	0.0335	0.039652			0.03707
			5.5	17.28	45.53	1.003292	0.0335	0.036534			0.03304
			6.5	19.3	46.18	1.018869	0.0335	0.03384			0.03018
			7.5	21.31	46.53	1.034375	0.0335	0.031339			0.02701
			8.5	23.31	46.64	1.049905	0.0335	0.028999			0.02583
			9.5	25.27	46.57	1.065264	0.0335	0.026838			0.02228
			10.5	27.15	46.38	1.08014	0.0335	0.024877			0.02058
			11.5	29.01	46.12	1.094946	0.0335	0.023047			0.01885
		1033	2.5	10.63	34.7	0.951316	0.0271	0.037122	0.02729223	0.0274852	0.03983
			3.5	12.63	37.48	0.965991	0.0271	0.034415			0.03528
			4.5	15.14	39.15	0.987201	0.0271	0.030817			0.03132
			5.5	17.28	40.2	1.004425	0.0271	0.028145			0.02854
			6.5	19.3	40.85	1.020578	0.0271	0.025824			0.02528
			7.5	21.31	41.2	1.036818	0.0271	0.023657			0.02377
			8.5	23.31	41.31	1.053241	0.0271	0.021621			0.0203
			9.5	25.27	41.24	1.069642	0.0271	0.019731			0.01866
			10.5	27.15	41.05	1.085729	0.0271	0.018007			0.01685
			11.5	29.01	40.79	1.102175	0.0271	0.016365			0.01489
1	Memphis	475	2.5	10.63	11.48	0.8847	0.0017	0.009105	0.00478839	0.0032654	0.00621
			3.5	12.63	14.27	0.875472	0.0017	0.00994			0.0061
			4.5	15.14	15.93	0.904254	0.0017	0.007471			0.00579
			5.5	17.28	16.99	0.93372	0.0017	0.005319			0.00342
			6.5	19.3	17.64	0.96524	0.0017	0.003368			0.00284
			7.5	21.31	17.98	0.994723	0.0017	0.001816			0.00198
			8.5	23.31	18.09	1.015259	0.0017	0.000869			0
			9.5	25.27	18.03	1.025148	0.0017	0.000447			0
			10.5	27.15	17.83	1.02834	0.0017	0.000316			0
			11.5	29.01	17.58	1.028997	0.0017	0.000289			0
		2475	2.5	10.63	26.88	0.952915	0.0221	0.029693	0.02084148	0.0223492	0.03259
			3.5	12.63	29.67	0.966609	0.0221	0.027533			0.02905
			4.5	15.14	31.34	0.988498	0.0221	0.024361			0.02654
			5.5	17.28	32.39	1.006586	0.0221	0.021977			0.02336

			6.5	19.3	33.04	1.023947	0.0221	0.01987			0.02179
			7.5	21.31	33.39	1.041968	0.0221	0.017855			0.01826
			8.5	23.31	33.5	1.061305	0.0221	0.01587			0.01658
			9.5	25.27	33.43	1.083195	0.0221	0.013823			0.0148
			10.5	27.15	33.24	1.109906	0.0221	0.011582			0.01299
			11.5	29.01	32.98	1.145444	0.0221	0.008981			0.00903
		1033	2.5	10.63	20.81	0.94212	0.0141	0.020204	0.01231925	0.0142887	0.0228
			3.5	12.63	23.59	0.953506	0.0141	0.018787			0.02019
			4.5	15.14	25.26	0.976282	0.0141	0.016184			0.01876
			5.5	17.28	26.32	0.996264	0.0141	0.014129			0.01505
			6.5	19.3	26.97	1.017746	0.0141	0.012131			0.01304
			7.5	21.31	27.31	1.044287	0.0141	0.00993			0.01092
			8.5	23.31	27.42	1.079035	0.0141	0.007435			0.00909
			9.5	25.27	27.35	1.123903	0.0141	0.004753			0.00755
			10.5	27.15	27.16	1.17509	0.0141	0.002289			0.00584
			11.5	29.01	26.9	1.224489	0.0141	0.000384			0.00389
1	Portland	475	2.5	10.63	17.72	0.900522	0.0092	0.018621	0.01058604	0.0113698	0.01979
			3.5	12.63	20.5	0.907747	0.0092	0.017718			0.01884
			4.5	15.14	22.17	0.93168	0.0092	0.014962			0.01539
			5.5	17.28	23.23	0.954779	0.0092	0.012607			0.01378
			6.5	19.3	23.87	0.98241	0.0092	0.010131			0.01014
			7.5	21.31	24.22	1.018105	0.0092	0.007399			0.00859
			8.5	23.31	24.33	1.06289	0.0092	0.004584			0.00505
			9.5	25.27	24.26	1.111511	0.0092	0.002139			0.00331
			10.5	27.15	24.07	1.152771	0.0092	0.000458			0.00105
			11.5	29.01	23.81	1.179429	0.0092	0			0
		2475	2.5	10.63	26.08	0.949783	0.0241	0.03298	0.02331514	0.0259157	0.03794
			3.5	12.63	28.87	0.963275	0.0241	0.030682			0.03465
			4.5	15.14	30.54	0.98517	0.0241	0.027253			0.03079
			5.5	17.28	31.59	1.003316	0.0241	0.024666			0.02797
			6.5	19.3	32.24	1.020823	0.0241	0.022369			0.02492
			7.5	21.31	32.59	1.039182	0.0241	0.020151			0.0217
			8.5	23.31	32.7	1.059312	0.0241	0.017923			0.01845
			9.5	25.27	32.63	1.08292	0.0241	0.015554			0.01506
			10.5	27.15	32.44	1.112608	0.0241	0.012907			0.01342
			11.5	29.01	32.18	1.152077	0.0241	0.00988			0.01179
		1033	2.5	10.63	22.15	0.940207	0.0189	0.027089	0.0178509	0.0188178	0.02871
			3.5	12.63	24.93	0.952387	0.0189	0.025255			0.02659
			4.5	15.14	26.6	0.974665	0.0189	0.022169			0.02386
			5.5	17.28	27.65	0.993771	0.0189	0.019774			0.02075
			6.5	19.3	28.3	1.013405	0.0189	0.01753			0.01709
			7.5	21.31	28.65	1.036375	0.0189	0.015155			0.01552
			8.5	23.31	28.76	1.065651	0.0189	0.012474			0.01201
			9.5	25.27	28.69	1.104197	0.0189	0.009448			0.01025
			10.5	27.15	28.5	1.151669	0.0189	0.006371			0.00855
			11.5	29.01	28.24	1.20376	0.0189	0.003654			0.00511
1	SLC	475	2.5	10.63	15.83	0.894003	0.0076	0.017011	0.00933661	0.0087834	0.01526
			3.5	12.63	18.62	0.896985	0.0076	0.016652			0.01576
			4.5	15.14	20.29	0.92296	0.0076	0.013752			0.01228
			5.5	17.28	21.34	0.949702	0.0076	0.011153			0.01067
			6.5	19.3	21.99	0.98209	0.0076	0.008449			0.00893
			7.5	21.31	22.34	1.022624	0.0076	0.005633			0.00527
			8.5	23.31	22.45	1.068195	0.0076	0.003072			0.0035
			9.5	25.27	22.38	1.109232	0.0076	0.001201			0.00124
			10.5	27.15	22.19	1.136256	0.0076	0.000153			0
			11.5	29.01	21.93	1.14926	0.0076	0			0

		2475	2.5	10.63	27.06	0.952748	0.0245	0.033103	0.02355876	0.0237945	0.03555
			3.5	12.63	29.85	0.966472	0.0245	0.030768			0.0322
			4.5	15.14	31.51	0.988389	0.0245	0.027339			0.0282
			5.5	17.28	32.57	1.006401	0.0245	0.024773			0.02553
			6.5	19.3	33.22	1.023719	0.0245	0.0225			0.02223
			7.5	21.31	33.56	1.041719	0.0245	0.020321			0.01903
			8.5	23.31	33.67	1.0609	0.0245	0.018187			0.01768
			9.5	25.27	33.6	1.082461	0.0245	0.015998			0.01424
			10.5	27.15	33.41	1.108578	0.0245	0.013612			0.01277
			11.5	29.01	33.16	1.143098	0.0245	0.010848			0.00914
		1033	2.5	10.63	21.4	0.948283	0.0177	0.024245	0.01549816	0.016799	0.02496
			3.5	12.63	24.18	0.960149	0.0177	0.022598			0.02472
			4.5	15.14	25.85	0.982846	0.0177	0.019701			0.02172
			5.5	17.28	26.91	1.002502	0.0177	0.017436			0.01836
			6.5	19.3	27.55	1.023315	0.0177	0.015259			0.01686
			7.5	21.31	27.9	1.048277	0.0177	0.012913			0.0131
			8.5	23.31	28.01	1.080747	0.0177	0.010241			0.01144
			9.5	25.27	27.94	1.123223	0.0177	0.007291			0.00803
			10.5	27.15	27.75	1.173542	0.0177	0.004447			0.00676
			11.5	29.01	27.49	1.225119	0.0177	0.00211			0.00321
1	San Fran	475	2.5	10.63	25.2	0.949686	0.0226	0.03095	0.02155216	0.0210946	0.03011
			3.5	12.63	27.98	0.96303	0.0226	0.028776			0.02848
			4.5	15.14	29.65	0.985018	0.0226	0.025481			0.02581
			5.5	17.28	30.7	1.003318	0.0226	0.022988			0.02233
			6.5	19.3	31.35	1.021111	0.0226	0.020761			0.0207
			7.5	21.31	31.7	1.040063	0.0226	0.018581			0.01717
			8.5	23.31	31.81	1.061482	0.0226	0.016335			0.01547
			9.5	25.27	31.74	1.087625	0.0226	0.013872			0.0138
			10.5	27.15	31.55	1.12124	0.0226	0.011099			0.01014
			11.5	29.01	31.29	1.165178	0.0226	0.008036			0.00839
		2475	2.5	10.63	32.45	0.951473	0.0333	0.046647	0.03488472	0.0327585	0.04643
			3.5	12.63	35.24	0.965911	0.0333	0.043498			0.04214
			4.5	15.14	36.91	0.987296	0.0333	0.039199			0.03898
			5.5	17.28	37.96	1.004733	0.0333	0.035991			0.03499
			6.5	19.3	38.61	1.021165	0.0333	0.033189			0.03019
			7.5	21.31	38.96	1.03777	0.0333	0.030559			0.02714
			8.5	23.31	39.07	1.054654	0.0333	0.028076			0.02415
			9.5	25.27	39	1.071657	0.0333	0.025753			0.02287
			10.5	27.15	38.81	1.088672	0.0333	0.023595			0.01962
			11.5	29.01	38.55	1.106993	0.0333	0.02144			0.01629
		1033	2.5	10.63	28.58	0.952371	0.0286	0.039177	0.02858211	0.0270398	0.03973
			3.5	12.63	31.37	0.966341	0.0286	0.036495			0.03508
			4.5	15.14	33.04	0.988066	0.0286	0.032658			0.03108
			5.5	17.28	34.09	1.005928	0.0286	0.029778			0.02829
			6.5	19.3	34.74	1.022945	0.0286	0.027246			0.02511
			7.5	21.31	35.09	1.040374	0.0286	0.024846			0.02372
			8.5	23.31	35.2	1.058523	0.0286	0.022538			0.0205
			9.5	25.27	35.13	1.077856	0.0286	0.020276			0.01721
			10.5	27.15	34.94	1.099665	0.0286	0.017944			0.01575
			11.5	29.01	34.68	1.127522	0.0286	0.015269			0.01228
1	San Jose	475	2.5	10.63	23.17	0.952489	0.0213	0.028609	0.01927922	0.0200739	0.0293
			3.5	12.63	25.95	0.965269	0.0213	0.026639			0.02742
			4.5	15.14	27.62	0.987612	0.0213	0.023472			0.02472
			5.5	17.28	28.67	1.006509	0.0213	0.021043			0.02137
			6.5	19.3	29.32	1.025455	0.0213	0.018815			0.01977
			7.5	21.31	29.67	1.046806	0.0213	0.016528			0.01633

			8.5	23.31	29.78	1.073015	0.0213	0.014009			0.01484
			9.5	25.27	29.71	1.107222	0.0213	0.011139			0.01141
			10.5	27.15	29.52	1.150873	0.0213	0.008054			0.00988
			11.5	29.01	29.26	1.20262	0.0213	0.005077			0.00686
		2475	2.5	10.63	29.38	0.952443	0.0338	0.047286	0.03516337	0.0312521	0.04531
			3.5	12.63	32.16	0.966571	0.0338	0.044174			0.04121
			4.5	15.14	33.83	0.988231	0.0338	0.039776			0.03605
			5.5	17.28	34.88	1.006006	0.0338	0.036476			0.0338
			6.5	19.3	35.53	1.022895	0.0338	0.033575			0.02911
			7.5	21.31	35.88	1.040126	0.0338	0.030832			0.02624
			8.5	23.31	35.99	1.057922	0.0338	0.028209			0.02328
			9.5	25.27	35.92	1.076511	0.0338	0.025678			0.02043
			10.5	27.15	35.73	1.09676	0.0338	0.023142			0.01735
			11.5	29.01	35.47	1.121769	0.0338	0.020299			0.01439
		1033	2.5	10.63	26.1	0.953812	0.0272	0.036848	0.02637278	0.0256463	0.03696
			3.5	12.63	28.89	0.967365	0.0272	0.034361			0.03589
			4.5	15.14	30.56	0.989351	0.0272	0.030647			0.02996
			5.5	17.28	31.61	1.007571	0.0272	0.027844			0.02724
			6.5	19.3	32.26	1.025146	0.0272	0.025352			0.02418
			7.5	21.31	32.61	1.043571	0.0272	0.022946			0.02101
			8.5	23.31	32.72	1.063762	0.0272	0.020527			0.01802
			9.5	25.27	32.65	1.087421	0.0272	0.017956			0.01684
			10.5	27.15	32.46	1.117152	0.0272	0.015081			0.0136
			11.5	29.01	32.2	1.156685	0.0272	0.011786			0.01042
1	Santa Monica	475	2.5	10.63	21.63	0.946942	0.0181	0.025017	0.01614304	0.017865	0.02742
			3.5	12.63	24.42	0.958868	0.0181	0.023325			0.02534
			4.5	15.14	26.08	0.981518	0.0181	0.02037			0.02255
			5.5	17.28	27.14	1.000994	0.0181	0.018074			0.01925
			6.5	19.3	27.79	1.021376	0.0181	0.01589			0.01758
			7.5	21.31	28.13	1.045805	0.0181	0.013532			0.0141
			8.5	23.31	28.24	1.077295	0.0181	0.010862			0.01266
			9.5	25.27	28.17	1.11862	0.0181	0.007891			0.0093
			10.5	27.15	27.98	1.168218	0.0181	0.004977			0.00621
			11.5	29.01	27.72	1.220181	0.0181	0.002527			0.00487
		2475	2.5	10.63	29.13	0.952209	0.0301	0.041498	0.03049678	0.0302798	0.04326
			3.5	12.63	31.92	0.966258	0.0301	0.038686			0.04073
			4.5	15.14	33.59	0.987932	0.0301	0.034692			0.03548
			5.5	17.28	34.64	1.005728	0.0301	0.031697			0.03114
			6.5	19.3	35.29	1.022651	0.0301	0.029065			0.02851
			7.5	21.31	35.64	1.039934	0.0301	0.026577			0.02574
			8.5	23.31	35.75	1.057824	0.0301	0.024195			0.02288
			9.5	25.27	35.68	1.076612	0.0301	0.021888			0.01997
			10.5	27.15	35.49	1.097288	0.0301	0.019559			0.01689
			11.5	29.01	35.23	1.123102	0.0301	0.016928			0.01375
		1033	2.5	10.63	24.77	0.95381	0.0258	0.03486	0.02453259	0.0243569	0.03496
			3.5	12.63	27.56	0.967054	0.0258	0.032522			0.03373
			4.5	15.14	29.23	0.989186	0.0258	0.028926			0.02977
			5.5	17.28	30.28	1.007651	0.0258	0.026198			0.02512
			6.5	19.3	30.93	1.025687	0.0258	0.023747			0.02386
			7.5	21.31	31.28	1.045078	0.0258	0.021328			0.02075
			8.5	23.31	31.39	1.067348	0.0258	0.018798			0.01764
			9.5	25.27	31.32	1.095016	0.0258	0.015986			0.0145
			10.5	27.15	31.13	1.130783	0.0258	0.01282			0.01129
			11.5	29.01	30.87	1.1769	0.0258	0.009395			0.00994
1	Seattle	475	2.5	10.63	20.02	0.939978	0.0151	0.021809	0.0133331	0.0153664	0.02446
			3.5	12.63	22.8	0.950667	0.0151	0.020408			0.02213

			4.5	15.14	24.47	0.973781	0.0151	0.017621			0.0192
			5.5	17.28	25.53	0.99448	0.0151	0.01538			0.01773
			6.5	19.3	26.18	1.017364	0.0151	0.01315			0.01408
			7.5	21.31	26.52	1.046358	0.0151	0.010652			0.01235
			8.5	23.31	26.63	1.08448	0.0151	0.007845			0.01088
			9.5	25.27	26.56	1.132354	0.0151	0.00495			0.00778
			10.5	27.15	26.37	1.183782	0.0151	0.002459			0.00436
			11.5	29.01	26.11	1.229164	0.0151	0.000681			0.00244
		2475	2.5	10.63	28.15	0.953088	0.0282	0.038466	0.02795938	0.028201	0.04168
			3.5	12.63	30.93	0.967045	0.0282	0.035824			0.03879
			4.5	15.14	32.6	0.988826	0.0282	0.032031			0.03335
			5.5	17.28	33.66	1.006708	0.0282	0.029189			0.02914
			6.5	19.3	34.3	1.023864	0.0282	0.026673			0.02622
			7.5	21.31	34.65	1.041433	0.0282	0.024292			0.02315
			8.5	23.31	34.76	1.059838	0.0282	0.02199			0.02018
			9.5	25.27	34.69	1.079706	0.0282	0.019707			0.01708
			10.5	27.15	34.5	1.102587	0.0282	0.017313			0.01574
			11.5	29.01	34.24	1.132268	0.0282	0.014541			0.01227
		1033	2.5	10.63	23.83	0.951105	0.0224	0.030436	0.02085441	0.0217059	0.03204
			3.5	12.63	26.61	0.964093	0.0224	0.028344			0.03023
			4.5	15.14	28.28	0.986292	0.0224	0.025057			0.02613
			5.5	17.28	29.34	1.004885	0.0224	0.022558			0.02321
			6.5	19.3	29.98	1.023414	0.0224	0.020274			0.01994
			7.5	21.31	30.33	1.043786	0.0224	0.017978			0.01875
			8.5	23.31	30.44	1.068118	0.0224	0.015502			0.01542
			9.5	25.27	30.37	1.099379	0.0224	0.012694			0.01199
			10.5	27.15	30.18	1.139745	0.0224	0.009597			0.01043
			11.5	29.01	29.92	1.189564	0.0224	0.006451			0.00875
2	Butte	475	2.5	10.53	3.00714	1	0	3.06E-18	3.0646E-18	0	0
			3.5	15.26	5.7933	1	0	3.06E-18			0
			4.5	19.88	7.46115	1	0	3.06E-18			0
			5.5	18.02	8.51608	1	0	3.06E-18			0
			6.5	20.69	9.16444	1	0	3.06E-18			0
			7.5	21.05	9.51046	1	0	3.06E-18			0
			8.5	26.59	9.62099	1	0	3.06E-18			0
			9.5	23.69	9.55229	1	0	3.06E-18			0
			10.5	29.67	9.36062	1	0	3.06E-18			0
			11.5	32.46	9.10304	1	0	3.06E-18			0
		2475	2.5	10.53	11.4249	0.88826	0.0013	0.008086	0.00231838	0.0032595	0.01021
			3.5	15.26	14.2111	0.953185	0.0013	0.003543			0.00402
			4.5	19.88	15.8789	1.009609	0.0013	0.000701			0.00149
			5.5	18.02	16.9339	0.957943	0.0013	0.003269			0.00457
			6.5	20.69	17.5822	0.997294	0.0013	0.001251			0.00295
			7.5	21.05	17.9282	0.997558	0.0013	0.001239			0.00294
			8.5	26.59	18.0388	1.033768	0.0013	0			0
			9.5	23.69	17.9701	1.02477	0.0013	7E-05			0
			10.5	29.67	17.7784	1.035179	0.0013	0			0
			11.5	32.46	17.5208	1.035199	0.0013	0			0
		1033	2.5	10.53	7.58716	0.952922	0	0.002178	0.00049117	0.000315	0.00224
			3.5	15.26	10.3733	0.985314	0	0.000621			0
			4.5	19.88	12.0412	0.998992	0	4.11E-05			0
			5.5	18.02	13.0961	0.985497	0	0.000613			0
			6.5	20.69	13.7445	0.996639	0	0.000138			0
			7.5	21.05	14.0905	0.996614	0	0.000139			0
			8.5	26.59	14.201	1.000532	0	0			0
			9.5	23.69	14.1323	1.000251	0	0			0

			10.5	29.67	13.9406	1.000532	0	0			0
			11.5	32.46	13.6831	1.000532	0	0			0
2	Charleston	475	2.5	10.53	9.26354	0.919723	0	0.004085	0.00094432	0.0006733	0.00312
			3.5	15.26	12.0497	0.96971	0	0.001337			0.00177
			4.5	19.88	13.7176	0.999793	0	8.44E-06			0
			5.5	18.02	14.7725	0.971439	0	0.001255			0
			6.5	20.69	15.4208	0.994069	0	0.000245			0
			7.5	21.05	15.7669	0.994113	0	0.000243			0
			8.5	26.59	15.8774	1.006665	0	0			0
			9.5	23.69	15.8087	1.004659	0	0			0
			10.5	29.67	15.617	1.006744	0	0			0
			11.5	32.46	15.3594	1.006744	0	0			0
		2475	2.5	10.53	27.9618	0.951136	0.0227	0.030804	0.01946917	0.0192621	0.031
			3.5	15.26	30.748	0.997525	0.0227	0.023836			0.02459
			4.5	19.88	32.4158	1.038245	0.0227	0.018853			0.0182
			5.5	18.02	33.4707	1.013723	0.0227	0.02174			0.02118
			6.5	20.69	34.1191	1.036829	0.0227	0.019011			0.01835
			7.5	21.05	34.4651	1.038433	0.0227	0.018832			0.01843
			8.5	26.59	34.5756	1.093517	0.0227	0.013414			0.01257
			9.5	23.69	34.5069	1.063546	0.0227	0.016194			0.01554
			10.5	29.67	34.3153	1.14062	0.0227	0.009725			0.00966
			11.5	32.46	34.0577	1.203634	0.0227	0.005829			0.00657
		1033	2.5	10.53	19.7206	0.943143	0.013	0.018629	0.00888826	0.0111304	0.02148
			3.5	15.26	22.5067	0.996836	0.013	0.012903			0.01524
			4.5	19.88	24.1746	1.059839	0.013	0.007842			0.01032
			5.5	18.02	25.2295	1.01101	0.013	0.011627			0.01289
			6.5	20.69	25.8779	1.047514	0.013	0.008716			0.01169
			7.5	21.05	26.2239	1.04885	0.013	0.008619			0.01178
			8.5	26.59	26.3344	1.17399	0.013	0.001729			0.00443
			9.5	23.69	26.2657	1.103544	0.013	0.005119			0.00707
			10.5	29.67	26.074	1.244054	0.013	0			0.00131
			11.5	32.46	25.8165	1.274067	0.013	0			0
2	Eureka	475	2.5	10.53	28.0968	0.951478	0.0216	0.029231	0.01833304	0.019118	0.03016
			3.5	15.26	30.883	0.997841	0.0216	0.022518			0.02333
			4.5	19.88	32.5508	1.038497	0.0216	0.017726			0.0187
			5.5	18.02	33.6057	1.014062	0.0216	0.020497			0.02189
			6.5	20.69	34.2541	1.03713	0.0216	0.017873			0.01895
			7.5	21.05	34.6001	1.038737	0.0216	0.0177			0.01703
			8.5	26.59	34.7106	1.093382	0.0216	0.012522			0.01292
			9.5	23.69	34.6419	1.063738	0.0216	0.015172			0.01598
			10.5	29.67	34.4503	1.139625	0.0216	0.009027			0.00979
			11.5	32.46	34.1927	1.201758	0.0216	0.00531			0.00651
		2475	2.5	10.53	40.02	0.949497	0.0335	0.047442	0.0332176	0.030395	0.04754
			3.5	15.26	42.81	0.992935	0.0335	0.038431			0.03797
			4.5	19.88	44.48	1.029676	0.0335	0.032079			0.02942
			5.5	18.02	45.53	1.009901	0.0335	0.035368			0.03212
			6.5	20.69	46.18	1.030516	0.0335	0.031945			0.02802
			7.5	21.05	46.53	1.032259	0.0335	0.03167			0.0284
			8.5	26.59	46.64	1.074914	0.0335	0.025551			0.02181
			9.5	23.69	46.57	1.053127	0.0335	0.028534			0.02424
			10.5	29.67	46.38	1.098604	0.0335	0.022612			0.01731
			11.5	32.46	46.12	1.119868	0.0335	0.020216			0.01441
		1033	2.5	10.53	34.6958	0.950035	0.0271	0.037367	0.02517577	0.0248289	0.03928
			3.5	15.26	37.482	0.994617	0.0271	0.02964			0.03014
			4.5	19.88	39.1498	1.032757	0.0271	0.024184			0.0247
			5.5	18.02	40.2047	1.011369	0.0271	0.027126			0.02759

			6.5	20.69	40.8531	1.032872	0.0271	0.024169			0.02312
			7.5	21.05	41.1991	1.034582	0.0271	0.023946			0.02344
			8.5	26.59	41.3096	1.079951	0.0271	0.018612			0.01603
			9.5	23.69	41.2409	1.056695	0.0271	0.021211			0.02077
			10.5	29.67	41.0493	1.10613	0.0271	0.015988			0.01338
			11.5	32.46	40.7917	1.132817	0.0271	0.013603			0.01012
2	Memphis	475	2.5	10.53	11.4807	0.881549	0.0017	0.009385	0.00309611	0.0021653	0.00767
			3.5	15.26	14.2669	0.946243	0.0017	0.004504			0.00373
			4.5	19.88	15.9347	1.002919	0.0017	0.001426			0
			5.5	18.02	16.9897	0.951053	0.0017	0.004206			0.00213
			6.5	20.69	17.638	0.99051	0.0017	0.002024			0.00176
			7.5	21.05	17.9841	0.990779	0.0017	0.00201			0.00174
			8.5	26.59	18.0946	1.02755	0.0017	0.000348			0
			9.5	23.69	18.0259	1.018325	0.0017	0.000736			0
			10.5	29.67	17.8342	1.029022	0.0017	0.000288			0
			11.5	32.46	17.5766	1.029045	0.0017	0.000287			0
		2475	2.5	10.53	26.8838	0.951471	0.0221	0.029929	0.01862041	0.0204465	0.03391
			3.5	15.26	29.67	0.998231	0.0221	0.023053			0.02586
			4.5	19.88	31.3378	1.039713	0.0221	0.018098			0.01961
			5.5	18.02	32.3927	1.014292	0.0221	0.021021			0.02242
			6.5	20.69	33.0411	1.037839	0.0221	0.018302			0.01964
			7.5	21.05	33.3871	1.039419	0.0221	0.01813			0.01969
			8.5	26.59	33.4976	1.099007	0.0221	0.012465			0.01212
			9.5	23.69	33.4289	1.065748	0.0221	0.015438			0.01687
			10.5	29.67	33.2373	1.153765	0.0221	0.008428			0.00942
			11.5	32.46	32.9797	1.223143	0.0221	0.004506			0.00644
		1033	2.5	10.53	20.8078	0.940476	0.0141	0.020415	0.01035401	0.0124403	0.0222
			3.5	15.26	23.594	0.991679	0.0141	0.014583			0.01613
			4.5	19.88	25.2618	1.048283	0.0141	0.009622			0.01282
			5.5	18.02	26.3168	1.006233	0.0141	0.013176			0.0158
			6.5	20.69	26.9651	1.038683	0.0141	0.010372			0.01236
			7.5	21.05	27.3111	1.040065	0.0141	0.010261			0.01256
			8.5	26.59	27.4217	1.154709	0.0141	0.003203			0.00506
			9.5	23.69	27.353	1.088105	0.0141	0.006847			0.00945
			10.5	29.67	27.1613	1.232542	0.0141	0.00011			0.00232
			11.5	32.46	26.9037	1.274546	0.0141	0			0
2	Portland	475	2.5	10.53	17.7174	0.898562	0.0092	0.018872	0.00839562	0.0091143	0.0192
			3.5	15.26	20.5036	0.955628	0.0092	0.012526			0.01369
			4.5	19.88	22.1714	1.027861	0.0092	0.006733			0.00724
			5.5	18.02	23.2264	0.968085	0.0092	0.011371			0.01284
			6.5	20.69	23.8747	1.011191	0.0092	0.007891			0.00814
			7.5	21.05	24.2207	1.012335	0.0092	0.007809			0.00807
			8.5	26.59	24.3313	1.138003	0.0092	0.001023			0.00257
			9.5	23.69	24.2626	1.073748	0.0092	0.003988			0.00536
			10.5	29.67	24.0709	1.182606	0.0092	0			0
			11.5	32.46	23.8133	1.194647	0.0092	0			0
		2475	2.5	10.53	26.0823	0.948333	0.0241	0.033236	0.02085727	0.0225717	0.03723
			3.5	15.26	28.8685	0.995235	0.0241	0.025791			0.02838
			4.5	19.88	30.5363	1.037323	0.0241	0.020367			0.02128
			5.5	18.02	31.5912	1.011126	0.0241	0.023618			0.02517
			6.5	20.69	32.2396	1.035014	0.0241	0.020638			0.02107
			7.5	21.05	32.5856	1.03657	0.0241	0.020455			0.02126
			8.5	26.59	32.6961	1.100382	0.0241	0.013956			0.01474
			9.5	23.69	32.6274	1.064064	0.0241	0.017426			0.01879
			10.5	29.67	32.4358	1.161106	0.0241	0.009257			0.01042
			11.5	32.46	32.1782	1.233434	0.0241	0.005035			0.00754

		1033	2.5	10.53	22.1459	0.938669	0.0189	0.027329	0.01547905	0.0163027	0.02798
			3.5	15.26	24.9321	0.987778	0.0189	0.020502			0.02163
			4.5	19.88	26.5999	1.038183	0.0189	0.014979			0.01549
			5.5	18.02	27.6548	1.00271	0.0189	0.018726			0.01969
			6.5	20.69	28.3032	1.03139	0.0189	0.015649			0.01509
			7.5	21.05	28.6492	1.032819	0.0189	0.015507			0.01509
			8.5	26.59	28.7597	1.132288	0.0189	0.00755			0.00981
			9.5	23.69	28.691	1.073295	0.0189	0.011831			0.01226
			10.5	29.67	28.4994	1.213271	0.0189	0.00322			0.00582
			11.5	32.46	28.2418	1.269812	0.0189	0.00097			0.00271
2	SLC	475	2.5	10.53	15.8333	0.891571	0.0076	0.017308	0.00700709	0.0072078	0.01653
			3.5	15.26	18.6194	0.954978	0.0076	0.010681			0.0107
			4.5	19.88	20.2873	1.035025	0.0076	0.004878			0.00578
			5.5	18.02	21.3422	0.965818	0.0076	0.009752			0.00969
			6.5	20.69	21.9906	1.015402	0.0076	0.006094			0.0068
			7.5	21.05	22.3366	1.016342	0.0076	0.006033			0.0068
			8.5	26.59	22.4471	1.127484	0.0076	0.000478			0
			9.5	23.69	22.3784	1.078287	0.0076	0.002577			0.00385
			10.5	29.67	22.1867	1.15051	0.0076	0			0
			11.5	32.46	21.9292	1.154399	0.0076	0			0
		2475	2.5	10.53	27.0598	0.951327	0.0245	0.033354	0.02116828	0.0217209	0.0369
			3.5	15.26	29.846	0.998019	0.0245	0.02594			0.02782
			4.5	19.88	31.5138	1.039356	0.0245	0.020597			0.02037
			5.5	18.02	32.5687	1.014102	0.0245	0.02374			0.02447
			6.5	20.69	33.2171	1.037566	0.0245	0.020808			0.02031
			7.5	21.05	33.5631	1.03915	0.0245	0.020622			0.02048
			8.5	26.59	33.6736	1.097888	0.0245	0.014556			0.0137
			9.5	23.69	33.6049	1.065245	0.0245	0.017729			0.01619
			10.5	29.67	33.4133	1.151326	0.0245	0.010248			0.00948
			11.5	32.46	33.1557	1.219793	0.0245	0.005988			0.00699
		1033	2.5	10.53	21.3975	0.946675	0.0177	0.024476	0.01324899	0.0149202	0.02633
			3.5	15.26	24.1836	0.997222	0.0177	0.018024			0.01943
			4.5	19.88	25.8515	1.051263	0.0177	0.01265			0.0149
			5.5	18.02	26.9064	1.012064	0.0177	0.016409			0.01737
			6.5	20.69	27.5548	1.042921	0.0177	0.013394			0.01448
			7.5	21.05	27.9008	1.044336	0.0177	0.013265			0.01469
			8.5	26.59	28.0113	1.153245	0.0177	0.005519			0.00765
			9.5	23.69	27.9426	1.089239	0.0177	0.009605			0.01182
			10.5	29.67	27.7509	1.233967	0.0177	0.001758			0.00361
			11.5	32.46	27.4934	1.282962	0.0177	2.96E-05			0.00188
2	San Fran	475	2.5	10.53	25.1953	0.948248	0.0226	0.031193	0.01914822	0.0192203	0.03156
			3.5	15.26	27.9815	0.99553	0.0226	0.024023			0.0249
			4.5	19.88	29.6493	1.038715	0.0226	0.01873			0.01857
			5.5	18.02	30.7043	1.011273	0.0226	0.021969			0.02135
			6.5	20.69	31.3526	1.035779	0.0226	0.019057			0.01854
			7.5	21.05	31.6986	1.037312	0.0226	0.018886			0.01859
			8.5	26.59	31.8092	1.107258	0.0226	0.012203			0.01129
			9.5	23.69	31.7405	1.066663	0.0226	0.015824			0.01587
			10.5	29.67	31.5488	1.1748	0.0226	0.007439			0.00883
			11.5	32.46	31.2912	1.248464	0.0226	0.003589			0.0046
		2475	2.5	10.53	32.4538	0.950133	0.0333	0.04695	0.03225553	0.0300164	0.04761
			3.5	15.26	35.24	0.995248	0.0333	0.037705			0.03612
			4.5	19.88	36.9078	1.034073	0.0333	0.031128			0.02984
			5.5	18.02	37.9627	1.011859	0.0333	0.034751			0.03211
			6.5	20.69	38.6111	1.033799	0.0333	0.031171			0.02815
			7.5	21.05	38.9571	1.035481	0.0333	0.030911			0.0285

			8.5	26.59	39.0676	1.082447	0.0333	0.024366			0.02059
			9.5	23.69	38.9989	1.058247	0.0333	0.02757			0.02456
			10.5	29.67	38.8073	1.111444	0.0333	0.020941			0.01688
			11.5	32.46	38.5497	1.145683	0.0333	0.017405			0.01263
		1033	2.5	10.53	28.5838	0.950963	0.0286	0.039457	0.02600219	0.0243433	0.0391
			3.5	15.26	31.37	0.997155	0.0286	0.031163			0.03012
			4.5	19.88	33.0378	1.037524	0.0286	0.025225			0.02297
			5.5	18.02	34.0927	1.013424	0.0286	0.028639			0.02738
			6.5	20.69	34.7411	1.036323	0.0286	0.025387			0.02307
			7.5	21.05	35.0871	1.037939	0.0286	0.02517			0.02336
			8.5	26.59	35.1976	1.091066	0.0286	0.018837			0.01686
			9.5	23.69	35.1289	1.062533	0.0286	0.022053			0.01903
			10.5	29.67	34.9373	1.134289	0.0286	0.014666			0.01286
			11.5	32.46	34.6797	1.193012	0.0286	0.010097			0.00826
2	San Jose	475	2.5	10.53	23.1656	0.95098	0.0213	0.028849	0.01688376	0.0177867	0.03072
			3.5	15.26	25.9517	0.999693	0.0213	0.021895			0.02213
			4.5	19.88	27.6196	1.047293	0.0213	0.016479			0.01784
			5.5	18.02	28.6745	1.015076	0.0213	0.020012			0.02035
			6.5	20.69	29.3229	1.042096	0.0213	0.017014			0.01771
			7.5	21.05	29.6689	1.043577	0.0213	0.01686			0.01779
			8.5	26.59	29.7794	1.132819	0.0213	0.009259			0.01084
			9.5	23.69	29.7107	1.079746	0.0213	0.013409			0.01335
			10.5	29.67	29.5191	1.212763	0.0213	0.004566			0.00535
			11.5	32.46	29.2615	1.279086	0.0213	0.001708			0.00263
		2475	2.5	10.53	29.3758	0.951084	0.0338	0.047596	0.03226069	0.0287253	0.04673
			3.5	15.26	32.162	0.997053	0.0338	0.038105			0.03504
			4.5	19.88	33.8298	1.037052	0.0338	0.031306			0.02703
			5.5	18.02	34.8847	1.01341	0.0338	0.035177			0.03298
			6.5	20.69	35.5331	1.036085	0.0338	0.031456			0.0272
			7.5	21.05	35.8791	1.037717	0.0338	0.031203			0.02756
			8.5	26.59	35.9896	1.088906	0.0338	0.024099			0.01826
			9.5	23.69	35.9209	1.061794	0.0338	0.027664			0.02392
			10.5	29.67	35.7293	1.127867	0.0338	0.01965			0.01499
			11.5	32.46	35.4717	1.180924	0.0338	0.014649			0.00907
		1033	2.5	10.53	26.1018	0.952358	0.0272	0.037125	0.02370425	0.0232951	0.03833
			3.5	15.26	28.888	0.999452	0.0272	0.029064			0.02934
			4.5	19.88	30.5558	1.041697	0.0272	0.023182			0.02227
			5.5	18.02	31.6107	1.015413	0.0272	0.026707			0.02638
			6.5	20.69	32.2591	1.039391	0.0272	0.023474			0.02226
			7.5	21.05	32.6051	1.040954	0.0272	0.023276			0.02257
			8.5	26.59	32.7156	1.104916	0.0272	0.01622			0.01449
			9.5	23.69	32.6469	1.06853	0.0272	0.019987			0.01841
			10.5	29.67	32.4553	1.165746	0.0272	0.011106			0.01086
			11.5	32.46	32.1977	1.238323	0.0272	0.006491			0.00678
2	Santa Monica	475	2.5	10.53	21.6289	0.945343	0.0181	0.025252	0.01386216	0.0156261	0.0288
			3.5	15.26	24.4151	0.995476	0.0181	0.018703			0.02007
			4.5	19.88	26.0829	1.048389	0.0181	0.013298			0.01589
			5.5	18.02	27.1378	1.010368	0.0181	0.017043			0.01816
			6.5	20.69	27.7862	1.040542	0.0181	0.014018			0.01551
			7.5	21.05	28.1322	1.041963	0.0181	0.013885			0.01565
			8.5	26.59	28.2427	1.148086	0.0181	0.006084			0.00701
			9.5	23.69	28.174	1.085501	0.0181	0.010227			0.01114
			10.5	29.67	27.9824	1.22923	0.0181	0.002153			0.0033
			11.5	32.46	27.7248	1.280721	0.0181	0.000276			0.00171
		2475	2.5	10.53	29.1328	0.950816	0.0301	0.041786	0.02784939	0.0272555	0.0445
			3.5	15.26	31.919	0.996841	0.0301	0.033162			0.03481

			4.5	19.88	33.5868	1.036939	0.0301	0.026994			0.02668
			5.5	18.02	34.6417	1.013169	0.0301	0.030515			0.03036
			6.5	20.69	35.2901	1.035904	0.0301	0.02714			0.02671
			7.5	21.05	35.6361	1.037531	0.0301	0.026911			0.02506
			8.5	26.59	35.7466	1.089246	0.0301	0.02044			0.01766
			9.5	23.69	35.6779	1.061747	0.0301	0.023697			0.02126
			10.5	29.67	35.4863	1.129424	0.0301	0.016327			0.01231
			11.5	32.46	35.2287	1.184211	0.0301	0.011737			0.00813
		1033	2.5	10.53	24.7748	0.952305	0.0258	0.035135	0.02187845	0.0211163	0.03644
			3.5	15.26	27.561	1	0.0258	0.0273			0.02737
			4.5	19.88	29.2288	1.04403	0.0258	0.021453			0.0202
			5.5	18.02	30.2837	1.015736	0.0258	0.025074			0.02407
			6.5	20.69	30.9321	1.040718	0.0258	0.021854			0.02005
			7.5	21.05	31.2781	1.042246	0.0258	0.021668			0.02024
			8.5	26.59	31.3886	1.115897	0.0258	0.014078			0.01214
			9.5	23.69	31.3199	1.072817	0.0258	0.018215			0.01619
			10.5	29.67	31.1283	1.186813	0.0258	0.008742			0.00835
			11.5	32.46	30.8707	1.260485	0.0258	0.004644			0.00443
2	Seattle	475	2.5	10.53	20.018	0.938262	0.0151	0.022041	0.01115503	0.0136692	0.02586
			3.5	15.26	22.8042	0.990968	0.0151	0.015744			0.01874
			4.5	19.88	24.472	1.051852	0.0151	0.010216			0.0123
			5.5	18.02	25.527	1.005193	0.0151	0.014305			0.01669
			6.5	20.69	26.1753	1.040352	0.0151	0.011142			0.01374
			7.5	21.05	26.5213	1.041696	0.0151	0.011031			0.01394
			8.5	26.59	26.6319	1.163732	0.0151	0.003363			0.00541
			9.5	23.69	26.5632	1.094344	0.0151	0.007196			0.00935
			10.5	29.67	26.3715	1.236041	0.0151	0.000441			0.00283
			11.5	32.46	26.1139	1.269091	0.0151	0			0
		2475	2.5	10.53	28.1468	0.951702	0.0282	0.038738	0.02537841	0.0259541	0.043
			3.5	15.26	30.933	0.998061	0.0282	0.030534			0.03296
			4.5	19.88	32.6008	1.038697	0.0282	0.02465			0.02444
			5.5	18.02	33.6557	1.014291	0.0282	0.028053			0.02836
			6.5	20.69	34.3041	1.037348	0.0282	0.024829			0.02441
			7.5	21.05	34.6501	1.038956	0.0282	0.024616			0.0247
			8.5	26.59	34.7606	1.09345	0.0282	0.018241			0.01683
			9.5	23.69	34.6919	1.063919	0.0282	0.021504			0.02073
			10.5	29.67	34.5003	1.139383	0.0282	0.013928			0.01288
			11.5	32.46	34.2427	1.201191	0.0282	0.009304			0.00821
		1033	2.5	10.53	23.8272	0.949614	0.0224	0.030684	0.0183932	0.0194093	0.03327
			3.5	15.26	26.6133	0.997747	0.0224	0.023492			0.02583
			4.5	19.88	28.2812	1.043547	0.0224	0.018004			0.01829
			5.5	18.02	29.3361	1.013253	0.0224	0.021502			0.02239
			6.5	20.69	29.9845	1.039238	0.0224	0.018472			0.01809
			7.5	21.05	30.3305	1.040736	0.0224	0.018308			0.01813
			8.5	26.59	30.441	1.122935	0.0224	0.010821			0.01155
			9.5	23.69	30.3723	1.074243	0.0224	0.01492			0.01585
			10.5	29.67	30.1807	1.199689	0.0224	0.005889			0.00734
			11.5	32.46	29.9231	1.270042	0.0224	0.002576			0.00308
3	Butte	475	2.5	34.1	3.01	1	0	3.06E-18	0.00142317	0.0012936	0
			3.5	36.03	5.79	1	0	3.06E-18			0
			4.5	29.53	7.46	1	0	3.06E-18			0
			5.5	23.83	8.52	1	0	3.06E-18			0
			6.5	24.04	9.16	1	0	3.06E-18			0
			7.5	19.98	9.51	1	0	3.06E-18			0
			8.5	14.11	9.62	0.980512	0	0.000835			0
			9.5	15.66	9.55	0.993707	0	0.00026			0

			10.5	11.26	9.36	0.931386	0	0.003375			0.00347
			11.5	6.22	9.1	0.772586	0	0.018629			0.01789
		2475	2.5	34.1	11.42	1.035199	0.0013	0	0.00536733	0.0063639	0
			3.5	36.03	14.21	1.035199	0.0013	0			0
			4.5	29.53	15.88	1.035199	0.0013	0			0
			5.5	23.83	16.93	1.030424	0.0013	0			0
			6.5	24.04	17.58	1.028647	0.0013	0			0
			7.5	19.98	17.93	0.97897	0.0013	0.002139			0.00383
			8.5	14.11	18.04	0.84133	0.0013	0.012563			0.01401
			9.5	15.66	17.97	0.877771	0.0013	0.008986			0.01007
			10.5	11.26	17.78	0.789391	0.0013	0.019169			0.0228
			11.5	6.22	17.52	0.706509	0.0013	0.035147			0.04158
		1033	2.5	34.1	7.59	1.000532	0	0	0.00345523	0.003407	0
			3.5	36.03	10.37	1.000532	0	0			0
			4.5	29.53	12.04	1.000532	0	0			0
			5.5	23.83	13.1	1.000532	0	0			0
			6.5	24.04	13.74	1.000488	0	0			0
			7.5	19.98	14.09	0.992149	0	0.000326			0
			8.5	14.11	14.2	0.892492	0	0.005933			0.00679
			9.5	15.66	14.13	0.932312	0	0.00332			0.00339
			10.5	11.26	13.94	0.821795	0	0.012318			0.01249
			11.5	6.22	13.68	0.706773	0	0.030719			0.02888
3	Charleston	475	2.5	34.1	9.26	1.006744	0	0	0.00419332	0.0031275	0
			3.5	36.03	12.05	1.006744	0	0			0
			4.5	29.53	13.72	1.006744	0	0			0
			5.5	23.83	14.77	1.006136	0	0			0
			6.5	24.04	15.42	1.0057	0	0			0
			7.5	19.98	15.77	0.984275	0	0.000667			0
			8.5	14.11	15.88	0.859568	0	0.008584			0.00643
			9.5	15.66	15.81	0.900532	0	0.005358			0.00481
			10.5	11.26	15.62	0.796108	0	0.015378			0.01181
			11.5	6.22	15.36	0.698677	0	0.032589			0.02362
		2475	2.5	34.1	27.96	1.347623	0.0227	0	0.01583149	0.0158159	0
			3.5	36.03	30.75	1.340124	0.0227	0.000194			0
			4.5	29.53	32.42	1.172516	0.0227	0.007623			0.00876
			5.5	23.83	33.47	1.07207	0.0227	0.015365			0.01443
			6.5	24.04	34.12	1.069611	0.0227	0.015601			0.01417
			7.5	19.98	34.47	1.028126	0.0227	0.020005			0.01903
			8.5	14.11	34.58	0.967642	0.0227	0.028147			0.02806
			9.5	15.66	34.51	0.98459	0.0227	0.025627			0.02673
			10.5	11.26	34.32	0.93558	0.0227	0.03351			0.03426
			11.5	6.22	34.06	0.864534	0.0227	0.048872			0.0504
		1033	2.5	34.1	19.7206	1.28275	0.013	0	0.00815784	0.0095289	0
			3.5	36.03	22.5067	1.282737	0.013	0			0
			4.5	29.53	24.1746	1.265567	0.013	0			0
			5.5	23.83	25.2295	1.130776	0.013	0.003679			0.00648
			6.5	24.04	25.8779	1.120725	0.013	0.00419			0.00604
			7.5	19.98	26.2239	1.030286	0.013	0.010027			0.01241
			8.5	14.11	26.3344	0.950344	0.013	0.017769			0.02081
			9.5	15.66	26.2657	0.969996	0.013	0.015575			0.01709
			10.5	11.26	26.074	0.915173	0.013	0.022282			0.0242
			11.5	6.22	25.8165	0.839343	0.013	0.035323			0.03739
3	Eureka	475	2.5	34.1	28.0968	1.347972	0.0216	0	0.01492001	0.015286	0
			3.5	36.03	30.883	1.340113	0.0216	0			0
			4.5	29.53	32.5508	1.170995	0.0216	0.007027			0.00892
			5.5	23.83	33.6057	1.072141	0.0216	0.014385			0.01484

			6.5	24.04	34.2541	1.069746	0.0216	0.014606			0.0146
			7.5	19.98	34.6001	1.028481	0.0216	0.018824			0.01968
			8.5	14.11	34.7106	0.968079	0.0216	0.026655			0.02745
			9.5	15.66	34.6419	0.985002	0.0216	0.024232			0.02404
			10.5	11.26	34.4503	0.936047	0.0216	0.031819			0.03239
			11.5	6.22	34.1927	0.86504	0.0216	0.046628			0.04507
		2475	2.5	34.1	40.02	1.179897	0.0335	0.014499	0.0301022	0.0265829	0.01093
			3.5	36.03	42.81	1.172759	0.0335	0.015107			0.00941
			4.5	29.53	44.48	1.106253	0.0335	0.021725			0.01611
			5.5	23.83	45.53	1.058176	0.0335	0.027817			0.02498
			6.5	24.04	46.18	1.057319	0.0335	0.027938			0.02481
			7.5	19.98	46.53	1.023431	0.0335	0.033086			0.03071
			8.5	14.11	46.64	0.970184	0.0335	0.042927			0.04015
			9.5	15.66	46.57	0.985258	0.0335	0.039897			0.03733
			10.5	11.26	46.38	0.941029	0.0335	0.049418			0.04747
			11.5	6.22	46.12	0.875371	0.0335	0.067724			0.06556
		1033	2.5	34.1	34.6958	1.261011	0.0271	0.005238	0.02161463	0.0210457	0.0052
			3.5	36.03	37.482	1.241703	0.0271	0.006234			0.0052
			4.5	29.53	39.1498	1.116936	0.0271	0.014989			0.01222
			5.5	23.83	40.2047	1.062567	0.0271	0.020529			0.01956
			6.5	24.04	40.8531	1.061338	0.0271	0.020671			0.01935
			7.5	19.98	41.1991	1.025253	0.0271	0.025184			0.02579
			8.5	14.11	41.3096	0.969342	0.0271	0.033822			0.0342
			9.5	15.66	41.2409	0.985111	0.0271	0.031156			0.03106
			10.5	11.26	41.0493	0.939086	0.0271	0.039527			0.04022
			11.5	6.22	40.7917	0.871353	0.0271	0.055744			0.05627
3	Memphis	475	2.5	34.1	11.4807	1.029045	0.0017	0.000287	0.00621314	0.004032	0
			3.5	36.03	14.2669	1.029045	0.0017	0.000287			0
			4.5	29.53	15.9347	1.029045	0.0017	0.000287			0
			5.5	23.83	16.9897	1.024088	0.0017	0.000491			0
			6.5	24.04	17.638	1.022273	0.0017	0.000568			0
			7.5	19.98	17.9841	0.972139	0.0017	0.002983			0.00103
			8.5	14.11	18.0946	0.835417	0.0017	0.014118			0.0092
			9.5	15.66	18.0259	0.871419	0.0017	0.010321			0.00766
			10.5	11.26	17.8342	0.784113	0.0017	0.021106			0.01442
			11.5	6.22	17.5766	0.702044	0.0017	0.037975			0.02647
		2475	2.5	34.1	26.8838	1.347067	0.0221	0	0.01516711	0.0164597	0
			3.5	36.03	29.67	1.342326	0.0221	0			0
			4.5	29.53	31.3378	1.190503	0.0221	0.006208			0.00707
			5.5	23.83	32.3927	1.075433	0.0221	0.014526			0.01401
			6.5	24.04	33.0411	1.072466	0.0221	0.014801			0.0157
			7.5	19.98	33.3871	1.02886	0.0221	0.019304			0.02023
			8.5	14.11	33.4976	0.967383	0.0221	0.027415			0.03082
			9.5	15.66	33.4289	0.98456	0.0221	0.024908			0.02769
			10.5	11.26	33.2373	0.934969	0.0221	0.032749			0.03687
			11.5	6.22	32.9797	0.863276	0.0221	0.048046			0.05266
		1033	2.5	34.1	20.8078	1.290603	0.0141	0	0.00913039	0.0107039	0
			3.5	36.03	23.594	1.29054	0.0141	0			0
			4.5	29.53	25.2618	1.261344	0.0141	0			0.00175
			5.5	23.83	26.3168	1.11251	0.0141	0.005382			0.00714
			6.5	24.04	26.9651	1.103504	0.0141	0.005904			0.00861
			7.5	19.98	27.3111	1.023892	0.0141	0.011596			0.01321
			8.5	14.11	27.4217	0.950082	0.0141	0.019205			0.02148
			9.5	15.66	27.353	0.968973	0.0141	0.016988			0.01984
			10.5	11.26	27.1613	0.915644	0.0141	0.023828			0.0265
			11.5	6.22	26.9037	0.840815	0.0141	0.037209			0.03928

3	Portland	475	2.5	34.1	17.7174	1.196712	0.0092	0	0.0082857	0.0088749	0
			3.5	36.03	20.5036	1.196712	0.0092	0			0
			4.5	29.53	22.1714	1.191914	0.0092	0			0
			5.5	23.83	23.2264	1.101421	0.0092	0.002601			0.00325
			6.5	24.04	23.8747	1.091371	0.0092	0.003084			0.00469
			7.5	19.98	24.2207	0.989957	0.0092	0.009512			0.0104
			8.5	14.11	24.3313	0.898569	0.0092	0.018871			0.0191
			9.5	15.66	24.2626	0.91936	0.0092	0.016338			0.01758
			10.5	11.26	24.0709	0.863433	0.0092	0.023841			0.02588
			11.5	6.22	23.8133	0.789775	0.0092	0.037942			0.03809
		2475	2.5	34.1	26.0823	1.339966	0.0241	0.000707	0.01713037	0.0187369	0
			3.5	36.03	28.8685	1.336782	0.0241	0.000811			0
			4.5	29.53	30.5363	1.200662	0.0241	0.006791			0.00885
			5.5	23.83	31.5912	1.074867	0.0241	0.016334			0.01651
			6.5	24.04	32.2396	1.071407	0.0241	0.016678			0.01601
			7.5	19.98	32.5856	1.025776	0.0241	0.021752			0.02335
			8.5	14.11	32.6961	0.963689	0.0241	0.030614			0.03411
			9.5	15.66	32.6274	0.980988	0.0241	0.027881			0.03134
			10.5	11.26	32.4358	0.931117	0.0241	0.036415			0.043
			11.5	6.22	32.1782	0.859189	0.0241	0.053021			0.06047
		1033	2.5	34.1	22.1459	1.300316	0.0189	0	0.01296204	0.0137767	0
			3.5	36.03	24.9321	1.300098	0.0189	0			0
			4.5	29.53	26.5999	1.249879	0.0189	0.001703			0.00244
			5.5	23.83	27.6548	1.093622	0.0189	0.010226			0.00999
			6.5	24.04	28.3032	1.086203	0.0189	0.010795			0.01146
			7.5	19.98	28.6492	1.018939	0.0189	0.016934			0.01747
			8.5	14.11	28.7597	0.950351	0.0189	0.025554			0.02737
			9.5	15.66	28.691	0.968594	0.0189	0.022977			0.0244
			10.5	11.26	28.4994	0.91662	0.0189	0.030971			0.03294
			11.5	6.22	28.2418	0.84288	0.0189	0.04657			0.05045
3	SLC	475	2.5	34.1	15.8333	1.154773	0.0076	0	0.00787746	0.0074606	0
			3.5	36.03	18.6194	1.154773	0.0076	0			0
			4.5	29.53	20.2873	1.153732	0.0076	0			0
			5.5	23.83	21.3422	1.101967	0.0076	0.001506			0.00106
			6.5	24.04	21.9906	1.093637	0.0076	0.001869			0.00266
			7.5	19.98	22.3366	0.990687	0.0076	0.007803			0.00725
			8.5	14.11	22.4471	0.88097	0.0076	0.01865			0.0173
			9.5	15.66	22.3784	0.905014	0.0076	0.015713			0.01585
			10.5	11.26	22.1867	0.843386	0.0076	0.024082			0.02212
			11.5	6.22	21.9292	0.768815	0.0076	0.038911			0.03627
		2475	2.5	34.1	27.0598	1.34725	0.0245	0.000638	0.01733688	0.017972	0
			3.5	36.03	29.846	1.342115	0.0245	0.000805			0
			4.5	29.53	31.5138	1.187328	0.0245	0.007856			0.0089
			5.5	23.83	32.5687	1.07471	0.0245	0.016761			0.01534
			6.5	24.04	33.2171	1.07184	0.0245	0.01705			0.01503
			7.5	19.98	33.5631	1.028643	0.0245	0.021886			0.02273
			8.5	14.11	33.6736	0.967341	0.0245	0.030625			0.03382
			9.5	15.66	33.6049	0.984478	0.0245	0.027925			0.02919
			10.5	11.26	33.4133	0.934989	0.0245	0.036362			0.04077
			11.5	6.22	33.1557	0.863409	0.0245	0.052773			0.05822
		1033	2.5	34.1	21.3975	1.304753	0.0177	0	0.01129721	0.0126863	0
			3.5	36.03	24.1836	1.304641	0.0177	0			0
			4.5	29.53	25.8515	1.266734	0.0177	0.000563			0.00114
			5.5	23.83	26.9064	1.112052	0.0177	0.008013			0.00929
			6.5	24.04	27.5548	1.103661	0.0177	0.00858			0.01077
			7.5	19.98	27.9008	1.02915	0.0177	0.014686			0.01513

			8.5	14.11	28.0113	0.957373	0.0177	0.022975			0.02541
			9.5	15.66	27.9426	0.97609	0.0177	0.02053			0.02238
			10.5	11.26	27.7509	0.923007	0.0177	0.028093			0.03122
			11.5	6.22	27.4934	0.848109	0.0177	0.042859			0.04854
3	San Fran	475	2.5	34.1	25.1953	1.335505	0.0226	0.000313	0.01571825	0.0150126	0
			3.5	36.03	27.9815	1.333561	0.0226	0.000374			0
			4.5	29.53	29.6493	1.216591	0.0226	0.005111			0.00534
			5.5	23.83	30.7043	1.079073	0.0226	0.014646			0.01309
			6.5	24.04	31.3526	1.074921	0.0226	0.015033			0.0147
			7.5	19.98	31.6986	1.02612	0.0226	0.020166			0.01914
			8.5	14.11	31.8092	0.962989	0.0226	0.028782			0.02854
			9.5	15.66	31.7405	0.980498	0.0226	0.02613			0.02503
			10.5	11.26	31.5488	0.930113	0.0226	0.034405			0.03331
			11.5	6.22	31.2912	0.857649	0.0226	0.050533			0.04797
		2475	2.5	34.1	32.4538	1.30423	0.0333	0.006181	0.02740267	0.0245235	0.00304
			3.5	36.03	35.24	1.284581	0.0333	0.00722			0.0044
			4.5	29.53	36.9078	1.126209	0.0333	0.019354			0.01463
			5.5	23.83	37.9627	1.064602	0.0333	0.026696			0.02362
			6.5	24.04	38.6111	1.063149	0.0333	0.026894			0.02345
			7.5	19.98	38.9571	1.025898	0.0333	0.03242			0.03069
			8.5	14.11	39.0676	0.968667	0.0333	0.04292			0.04179
			9.5	15.66	38.9989	0.98478	0.0333	0.039684			0.03707
			10.5	11.26	38.8073	0.937877	0.0333	0.049812			0.04895
			11.5	6.22	38.5497	0.869155	0.0333	0.069308			0.06503
		1033	2.5	34.1	28.5838	1.346275	0.0286	0.002248	0.02151319	0.020169	0.00188
			3.5	36.03	31.37	1.336948	0.0286	0.002603			0.00151
			4.5	29.53	33.0378	1.163386	0.0286	0.012262			0.01062
			5.5	23.83	34.0927	1.070546	0.0286	0.021109			0.01819
			6.5	24.04	34.7411	1.068327	0.0286	0.021367			0.01986
			7.5	19.98	35.0871	1.027785	0.0286	0.02656			0.02556
			8.5	14.11	35.1976	0.967811	0.0286	0.036223			0.03555
			9.5	15.66	35.1289	0.984628	0.0286	0.03324			0.03257
			10.5	11.26	34.9373	0.935942	0.0286	0.042564			0.04157
			11.5	6.22	34.6797	0.865239	0.0286	0.060613			0.05748
3	San Jose	475	2.5	34.1	23.1656	1.325674	0.0213	0.000116	0.01400302	0.0140145	0
			3.5	36.03	25.9517	1.325175	0.0213	0.000132			0
			4.5	29.53	27.6196	1.253826	0.0213	0.002705			0.00335
			5.5	23.83	28.6745	1.097252	0.0213	0.011931			0.01248
			6.5	24.04	29.3229	1.09098	0.0213	0.012448			0.01217
			7.5	19.98	29.6689	1.030789	0.0213	0.018223			0.01825
			8.5	14.11	29.7794	0.964006	0.0213	0.026828			0.02731
			9.5	15.66	29.7107	0.98213	0.0213	0.024218			0.02409
			10.5	11.26	29.5191	0.930266	0.0213	0.032339			0.03218
			11.5	6.22	29.2615	0.856265	0.0213	0.048186			0.04665
		2475	2.5	34.1	29.3758	1.342961	0.0338	0.004587	0.02699332	0.0230305	0.00133
			3.5	36.03	32.162	1.331086	0.0338	0.005128			0.00104
			4.5	29.53	33.8298	1.153375	0.0338	0.017108			0.01278
			5.5	23.83	34.8847	1.069299	0.0338	0.026635			0.02107
			6.5	24.04	35.5331	1.067313	0.0338	0.026904			0.02273
			7.5	19.98	35.8791	1.027702	0.0338	0.032789			0.02965
			8.5	14.11	35.9896	0.968328	0.0338	0.043801			0.0405
			9.5	15.66	35.9209	0.984994	0.0338	0.040406			0.03772
			10.5	11.26	35.7293	0.936686	0.0338	0.051005			0.04768
			11.5	6.22	35.4717	0.866393	0.0338	0.071405			0.06554
		1033	2.5	34.1	26.1018	1.345735	0.0272	0.001724	0.01961717	0.0187036	0
			3.5	36.03	28.888	1.342504	0.0272	0.001839			0

			4.5	29.53	30.5558	1.205406	0.0272	0.008414			0.00875
			5.5	23.83	31.6107	1.079347	0.0272	0.018804			0.01768
			6.5	24.04	32.2591	1.075886	0.0272	0.019176			0.01734
			7.5	19.98	32.6051	1.030122	0.0272	0.024683			0.02468
			8.5	14.11	32.7156	0.967792	0.0272	0.034285			0.03433
			9.5	15.66	32.6469	0.98516	0.0272	0.031326			0.03137
			10.5	11.26	32.4553	0.935088	0.0272	0.040558			0.04027
			11.5	6.22	32.1977	0.862867	0.0272	0.058463			0.05614
3	Santa Monica	475	2.5	34.1	21.6289	1.305028	0.0181	0	0.0117508	0.0127982	0
			3.5	36.03	24.4151	1.304889	0.0181	0			0
			4.5	29.53	26.0829	1.263325	0.0181	0.000866			0.001
			5.5	23.83	27.1378	1.107572	0.0181	0.008632			0.01054
			6.5	24.04	27.7862	1.09947	0.0181	0.009199			0.01008
			7.5	19.98	28.1322	1.02719	0.0181	0.015304			0.01605
			8.5	14.11	28.2427	0.956384	0.0181	0.023669			0.02679
			9.5	15.66	28.174	0.97497	0.0181	0.021191			0.02348
			10.5	11.26	27.9824	0.922177	0.0181	0.028866			0.03148
			11.5	6.22	27.7248	0.847548	0.0181	0.043852			0.04429
		2475	2.5	34.1	29.1328	1.343917	0.0301	0.002952	0.02313403	0.0217706	0.00161
			3.5	36.03	31.919	1.332837	0.0301	0.003399			0.00128
			4.5	29.53	33.5868	1.156007	0.0301	0.013968			0.01001
			5.5	23.83	34.6417	1.069392	0.0301	0.022752			0.02059
			6.5	24.04	35.2901	1.067342	0.0301	0.023003			0.0203
			7.5	19.98	35.6361	1.027477	0.0301	0.028351			0.02707
			8.5	14.11	35.7466	0.967938	0.0301	0.038362			0.03957
			9.5	15.66	35.6779	0.984645	0.0301	0.035272			0.03507
			10.5	11.26	35.4863	0.936235	0.0301	0.044928			0.04651
			11.5	6.22	35.2287	0.865834	0.0301	0.063585			0.06435
		1033	2.5	34.1	24.7748	1.338748	0.0258	0.001438	0.01816325	0.0173968	0
			3.5	36.03	27.561	1.337235	0.0258	0.001491			0
			4.5	29.53	29.2288	1.229356	0.0258	0.006226			0.00664
			5.5	23.83	30.2837	1.086177	0.0258	0.016847			0.01554
			6.5	24.04	30.9321	1.081626	0.0258	0.017304			0.01514
			7.5	19.98	31.2781	1.030767	0.0258	0.023093			0.02236
			8.5	14.11	31.3886	0.96679	0.0258	0.032567			0.03375
			9.5	15.66	31.3199	0.98448	0.0258	0.02966			0.02896
			10.5	11.26	31.1283	0.933623	0.0258	0.038719			0.03938
			11.5	6.22	30.8707	0.860582	0.0258	0.056315			0.05518
3	Seattle	475	2.5	34.1	20.018	1.27941	0.0151	0	0.00987561	0.0112699	0
			3.5	36.03	22.8042	1.279388	0.0151	0			0
			4.5	29.53	24.472	1.259451	0.0151	0			0
			5.5	23.83	25.527	1.120769	0.0151	0.005594			0.00722
			6.5	24.04	26.1753	1.111009	0.0151	0.006163			0.0086
			7.5	19.98	26.5213	1.023905	0.0151	0.012556			0.01435
			8.5	14.11	26.6319	0.946169	0.0151	0.020989			0.02303
			9.5	15.66	26.5632	0.965502	0.0151	0.018583			0.02184
			10.5	11.26	26.3715	0.911367	0.0151	0.025952			0.02966
			11.5	6.22	26.1139	0.836145	0.0151	0.04026			0.042
		2475	2.5	34.1	28.1468	1.348228	0.0282	0.002025	0.0209712	0.0212369	0.00186
			3.5	36.03	30.933	1.340221	0.0282	0.002322			0.0015
			4.5	29.53	32.6008	1.170529	0.0282	0.011449			0.01072
			5.5	23.83	33.6557	1.072282	0.0282	0.020537			0.0181
			6.5	24.04	34.3041	1.069906	0.0282	0.020808			0.01968
			7.5	19.98	34.6501	1.028708	0.0282	0.025998			0.02674
			8.5	14.11	34.7606	0.968334	0.0282	0.035589			0.03896
			9.5	15.66	34.6919	0.98525	0.0282	0.032627			0.03454

			10.5	11.26	34.5003	0.936309	0.0282	0.04188			0.04406
			11.5	6.22	34.2427	0.865313	0.0282	0.059801			0.06359
		1033	2.5	34.1	23.8272	1.328673	0.0224	0.000456	0.01523002	0.0162518	0
			3.5	36.03	26.6133	1.327866	0.0224	0.000482			0
			4.5	29.53	28.2812	1.242006	0.0224	0.003782			0.004
			5.5	23.83	29.3361	1.089884	0.0224	0.013506			0.01324
			6.5	24.04	29.9845	1.084377	0.0224	0.013992			0.01483
			7.5	19.98	30.3305	1.0286	0.0224	0.019669			0.02041
			8.5	14.11	30.441	0.963262	0.0224	0.028474			0.0318
			9.5	15.66	30.3723	0.98116	0.0224	0.025787			0.02883
			10.5	11.26	30.1807	0.929833	0.0224	0.034157			0.03737
			11.5	6.22	29.9231	0.856383	0.0224	0.050471			0.05476
4	Butte	475	0.5	9.77	3.4288	0.995592	0	0.000181	0.0141604	0.0111318	0
			1.5	9.77	7.51685	0.935006	0	0.003164			0.00204
			2.5	9.77	9.32013	0.888823	0	0.006205			0.00529
			3.5	10.59	10.406	0.88595	0	0.006421			0.005
			4.5	10.74	11.1017	0.872638	0	0.007472			0.00775
			5.5	10.09	11.525	0.842156	0	0.010203			0.00947
			6.5	9.53	11.7294	0.820438	0	0.012468			0.0114
			7.5	9.08	11.746	0.806719	0	0.014057			0.0139
			8.5	8.69	11.6023	0.798269	0	0.015102			0.01484
			9.5	8.33	11.3314	0.793217	0	0.015753			0.01428
			10.5	8	10.9751	0.790655	0	0.016091			0.01583
			11.5	7.71	10.5808	0.78998	0	0.016181			0.01557
			12.5	7.44	10.1947	0.789681	0	0.016221			0.01536
			13.5	7.19	9.85419	0.78897	0	0.016316			0.01514
			14.5	6.97	9.58258	0.78765	0	0.016494			0.01683
			15.5	6.77	9.38911	0.785181	0	0.016831			0.0164
			16.5	6.59	9.2716	0.781624	0	0.017325			0.01787
			17.5	6.42	9.22088	0.776884	0	0.018			0.01722
		2475	0.5	9.77	11.8466	0.853975	0.0013	0.011236	0.02460863	0.0323323	0.01202
			1.5	9.77	15.9346	0.782263	0.0013	0.020245			0.02214
			2.5	9.77	17.7379	0.76429	0.0013	0.023176			0.0266
			3.5	10.59	18.8238	0.768582	0.0013	0.022447			0.02523
			4.5	10.74	19.5194	0.765569	0.0013	0.022957			0.02799
			5.5	10.09	19.9428	0.753472	0.0013	0.025102			0.02934
			6.5	9.53	20.1472	0.744467	0.0013	0.026806			0.03295
			7.5	9.08	20.1638	0.738091	0.0013	0.028071			0.03304
			8.5	8.69	20.0201	0.733305	0.0013	0.029055			0.0359
			9.5	8.33	19.7492	0.729454	0.0013	0.029868			0.03691
			10.5	8	19.3929	0.726325	0.0013	0.030544			0.03798
			11.5	7.71	18.9986	0.72386	0.0013	0.031086			0.03741
			12.5	7.44	18.6125	0.721556	0.0013	0.031599			0.03884
			13.5	7.19	18.272	0.719245	0.0013	0.032123			0.03813
			14.5	6.97	18.0004	0.716991	0.0013	0.03264			0.0397
			15.5	6.77	17.8069	0.714606	0.0013	0.033196			0.04084
			16.5	6.59	17.6894	0.712122	0.0013	0.033784			0.04026
			17.5	6.42	17.6387	0.709438	0.0013	0.03443			0.04125
		1033	0.5	9.77	8.00883	0.923501	0	0.00385	0.01930997	0.0221663	0.00313
			1.5	9.77	12.0969	0.819754	0	0.012544			0.01282
			2.5	9.77	13.9002	0.784589	0	0.016912			0.01671
			3.5	10.59	14.986	0.786199	0	0.016691			0.01665
			4.5	10.74	15.6817	0.778981	0	0.017699			0.01712
			5.5	10.09	16.105	0.760285	0	0.020526			0.02039
			6.5	9.53	16.3094	0.747504	0	0.022657			0.02224
			7.5	9.08	16.326	0.739181	0	0.024139			0.02479

			8.5	8.69	16.1824	0.733476	0	0.025201			0.0255
			9.5	8.33	15.9115	0.729325	0	0.025998			0.02492
			10.5	8	15.5551	0.726315	0	0.026589			0.02615
			11.5	7.71	15.1608	0.724259	0	0.027			0.0278
			12.5	7.44	14.7748	0.722419	0	0.027372			0.02723
			13.5	7.19	14.4342	0.720477	0	0.027769			0.02694
			14.5	6.97	14.1626	0.71843	0	0.028194			0.0283
			15.5	6.77	13.9691	0.716002	0	0.028704			0.02985
			16.5	6.59	13.8516	0.713236	0	0.029295			0.02934
			17.5	6.42	13.8009	0.710039	0	0.029992			0.03044
4	Charleston	475	0.5	9.77	9.68521	0.885041	0	0.006491	0.02156844	0.0156491	0.00587
			1.5	9.77	13.7733	0.791634	0	0.015961			0.01143
			2.5	9.77	15.5765	0.765034	0	0.019777			0.013
			3.5	10.59	16.6624	0.768038	0	0.019314			0.01324
			4.5	10.74	17.3581	0.76308	0	0.020082			0.01442
			5.5	10.09	17.7814	0.748104	0	0.022553			0.01668
			6.5	9.53	17.9858	0.737542	0	0.02444			0.01712
			7.5	9.08	18.0024	0.730398	0	0.02579			0.01997
			8.5	8.69	17.8587	0.725269	0	0.026797			0.01912
			9.5	8.33	17.5879	0.721324	0	0.027595			0.02062
			10.5	8	17.2315	0.718268	0	0.028227			0.02016
			11.5	7.71	16.8372	0.715989	0	0.028707			0.02185
			12.5	7.44	16.4512	0.713892	0	0.029154			0.02159
			13.5	7.19	16.1106	0.711748	0	0.029618			0.02134
			14.5	6.97	15.839	0.709594	0	0.03009			0.02106
			15.5	6.77	15.6455	0.707206	0	0.030622			0.02271
			16.5	6.59	15.528	0.704621	0	0.031207			0.0223
			17.5	6.42	15.4773	0.701743	0	0.031869			0.02384
		2475	0.5	9.77	28.3835	0.938484	0.0227	0.032989	0.03878484	0.0399041	0.03321
			1.5	9.77	32.4715	0.922866	0.0227	0.035878			0.03603
			2.5	9.77	34.2748	0.916762	0.0227	0.037069			0.03876
			3.5	10.59	35.3607	0.923743	0.0227	0.03571			0.03616
			4.5	10.74	36.0563	0.923342	0.0227	0.035787			0.03778
			5.5	10.09	36.4797	0.913913	0.0227	0.037636			0.03806
			6.5	9.53	36.684	0.906123	0.0227	0.039231			0.04042
			7.5	9.08	36.7007	0.90015	0.0227	0.040496			0.04106
			8.5	8.69	36.557	0.89529	0.0227	0.041553			0.04389
			9.5	8.33	36.2861	0.891058	0.0227	0.042494			0.04494
			10.5	8	35.9298	0.88735	0.0227	0.043335			0.046
			11.5	7.71	35.5355	0.884201	0.0227	0.044062			0.04514
			12.5	7.44	35.1494	0.881218	0.0227	0.044762			0.04632
			13.5	7.19	34.8088	0.878313	0.0227	0.045453			0.04602
			14.5	6.97	34.5372	0.875599	0.0227	0.046108			0.04721
			15.5	6.77	34.3438	0.872918	0.0227	0.046763			0.04837
			16.5	6.59	34.2262	0.870296	0.0227	0.047413			0.04803
			17.5	6.42	34.1755	0.867609	0.0227	0.048088			0.04915
		1033	0.5	9.77	20.1422	0.926664	0.013	0.020718	0.02675788	0.0291824	0.02213
			1.5	9.77	24.2303	0.903152	0.013	0.02402			0.02645
			2.5	9.77	26.0335	0.894802	0.013	0.025293			0.02725
			3.5	10.59	27.1194	0.901373	0.013	0.024287			0.02622
			4.5	10.74	27.8151	0.900355	0.013	0.024441			0.02772
			5.5	10.09	28.2384	0.88994	0.013	0.02606			0.02811
			6.5	9.53	28.4428	0.881503	0.013	0.027438			0.02891
			7.5	9.08	28.4594	0.875159	0.013	0.028514			0.03167
			8.5	8.69	28.3157	0.870118	0.013	0.029396			0.0326
			9.5	8.33	28.0449	0.865832	0.013	0.030165			0.0338

			10.5	8	27.6885	0.862158	0.013	0.030837			0.03335
			11.5	7.71	27.2942	0.859101	0.013	0.031407			0.03464
			12.5	7.44	26.9082	0.856212	0.013	0.031954			0.03436
			13.5	7.19	26.5676	0.853375	0.013	0.0325			0.03568
			14.5	6.97	26.296	0.850693	0.013	0.033023			0.0354
			15.5	6.77	26.1025	0.847992	0.013	0.033558			0.0367
			16.5	6.59	25.985	0.845302	0.013	0.034098			0.03636
			17.5	6.42	25.9343	0.842501	0.013	0.034669			0.0376
4	Eureka	475	0.5	9.77	28.5185	0.938851	0.0216	0.031334	0.03690356	0.037157	0.03252
			1.5	9.77	32.6065	0.923307	0.0216	0.034106			0.03401
			2.5	9.77	34.4098	0.917228	0.0216	0.035249			0.03527
			3.5	10.59	35.4957	0.924215	0.0216	0.033938			0.03481
			4.5	10.74	36.1913	0.923821	0.0216	0.034011			0.0346
			5.5	10.09	36.6147	0.914404	0.0216	0.035792			0.03526
			6.5	9.53	36.819	0.906621	0.0216	0.037328			0.03796
			7.5	9.08	36.8357	0.900651	0.0216	0.038547			0.03882
			8.5	8.69	36.692	0.895793	0.0216	0.039566			0.03979
			9.5	8.33	36.4211	0.891561	0.0216	0.040474			0.04089
			10.5	8	36.0648	0.887852	0.0216	0.041286			0.0403
			11.5	7.71	35.6705	0.884702	0.0216	0.041988			0.04158
			12.5	7.44	35.2844	0.881717	0.0216	0.042663			0.04275
			13.5	7.19	34.9438	0.878811	0.0216	0.04333			0.04395
			14.5	6.97	34.6722	0.876096	0.0216	0.043962			0.04364
			15.5	6.77	34.4788	0.873415	0.0216	0.044595			0.04486
			16.5	6.59	34.3612	0.870793	0.0216	0.045222			0.04456
			17.5	6.42	34.3105	0.868107	0.0216	0.045873			0.04578
		2475	0.5	9.77	40.4435	0.938726	0.0335	0.049969	0.05568359	0.0536036	0.04923
			1.5	9.77	44.5315	0.928113	0.0335	0.052586			0.0519
			2.5	9.77	46.3348	0.923821	0.0335	0.053681			0.05134
			3.5	10.59	47.4207	0.930949	0.0335	0.051874			0.04924
			4.5	10.74	48.1163	0.931039	0.0335	0.051851			0.04943
			5.5	10.09	48.5397	0.922622	0.0335	0.053992			0.05167
			6.5	9.53	48.744	0.915539	0.0335	0.055859			0.05363
			7.5	9.08	48.7607	0.910007	0.0335	0.057362			0.0544
			8.5	8.69	48.617	0.905408	0.0335	0.058642			0.05516
			9.5	8.33	48.3461	0.901318	0.0335	0.059803			0.05772
			10.5	8	47.9898	0.897667	0.0335	0.060859			0.05848
			11.5	7.71	47.5955	0.894516	0.0335	0.061786			0.05948
			12.5	7.44	47.2094	0.891522	0.0335	0.062679			0.0605
			13.5	7.19	46.8688	0.888627	0.0335	0.063555			0.06154
			14.5	6.97	46.5972	0.885949	0.0335	0.064376			0.06259
			15.5	6.77	46.4038	0.883345	0.0335	0.065185			0.06365
			16.5	6.59	46.2862	0.880836	0.0335	0.065973			0.06342
			17.5	6.42	46.2355	0.878302	0.0335	0.066779			0.06447
		1033	0.5	9.77	35.1175	0.938593	0.0271	0.039627	0.04508365	0.0457251	0.04133
			1.5	9.77	39.2055	0.926202	0.0271	0.042216			0.04314
			2.5	9.77	41.0088	0.921252	0.0271	0.043295			0.04444
			3.5	10.59	42.0947	0.928341	0.0271	0.041758			0.04221
			4.5	10.74	42.7903	0.928253	0.0271	0.041777			0.04231
			5.5	10.09	43.2137	0.919453	0.0271	0.043693			0.04454
			6.5	9.53	43.418	0.912099	0.0271	0.045358			0.04517
			7.5	9.08	43.4347	0.906397	0.0271	0.04669			0.04594
			8.5	8.69	43.291	0.901695	0.0271	0.047816			0.04849
			9.5	8.33	43.0201	0.897546	0.0271	0.048832			0.04949
			10.5	8	42.6638	0.893868	0.0271	0.04975			0.05047
			11.5	7.71	42.2695	0.890713	0.0271	0.05055			0.05186

			12.5	7.44	41.8834	0.887719	0.0271	0.051322			0.05096
			13.5	7.19	41.5428	0.884816	0.0271	0.05208			0.05207
			14.5	6.97	41.2712	0.88212	0.0271	0.052794			0.05317
			15.5	6.77	41.0778	0.879484	0.0271	0.053502			0.05429
			16.5	6.59	40.9602	0.87693	0.0271	0.054197			0.054
			17.5	6.42	40.9095	0.874336	0.0271	0.054911			0.05513
4	Memphis	475	0.5	9.77	11.9024	0.847595	0.0017	0.012745	0.02684683	0.0188564	0.00822
			1.5	9.77	15.9904	0.77696	0.0017	0.022261			0.01402
			2.5	9.77	17.7937	0.759287	0.0017	0.025339			0.01766
			3.5	10.59	18.8796	0.763575	0.0017	0.024562			0.01796
			4.5	10.74	19.5753	0.76062	0.0017	0.025095			0.01713
			5.5	10.09	19.9986	0.748656	0.0017	0.027358			0.01933
			6.5	9.53	20.203	0.739738	0.0017	0.029157			0.02012
			7.5	9.08	20.2196	0.733418	0.0017	0.030493			0.02298
			8.5	8.69	20.0759	0.728669	0.0017	0.031533			0.02237
			9.5	8.33	19.805	0.724845	0.0017	0.032392			0.02368
			10.5	8	19.4487	0.721736	0.0017	0.033107			0.02335
			11.5	7.71	19.0544	0.719283	0.0017	0.033681			0.02476
			12.5	7.44	18.6683	0.716991	0.0017	0.034225			0.02456
			13.5	7.19	18.3278	0.714693	0.0017	0.034779			0.02436
			14.5	6.97	18.0562	0.712452	0.0017	0.035326			0.02578
			15.5	6.77	17.8627	0.710083	0.0017	0.035914			0.02552
			16.5	6.59	17.7452	0.707617	0.0017	0.036534			0.02523
			17.5	6.42	17.6945	0.704954	0.0017	0.037216			0.02654
		2475	0.5	9.77	27.3055	0.938566	0.0221	0.032115	0.03800647	0.041527	0.03404
			1.5	9.77	31.3935	0.922278	0.0221	0.035076			0.03869
			2.5	9.77	33.1968	0.91594	0.0221	0.036294			0.03932
			3.5	10.59	34.2827	0.922896	0.0221	0.034959			0.03877
			4.5	10.74	34.9783	0.922432	0.0221	0.035047			0.0385
			5.5	10.09	35.4017	0.912882	0.0221	0.036895			0.04052
			6.5	9.53	35.606	0.905008	0.0221	0.038486			0.04285
			7.5	9.08	35.6227	0.898983	0.0221	0.039746			0.04346
			8.5	8.69	35.479	0.894094	0.0221	0.040797			0.04427
			9.5	8.33	35.2081	0.889847	0.0221	0.04173			0.0453
			10.5	8	34.8518	0.886134	0.0221	0.042563			0.04633
			11.5	7.71	34.4575	0.882989	0.0221	0.04328			0.04745
			12.5	7.44	34.0714	0.880009	0.0221	0.043971			0.0486
			13.5	7.19	33.7308	0.877105	0.0221	0.044654			0.04828
			14.5	6.97	33.4592	0.874388	0.0221	0.045301			0.04943
			15.5	6.77	33.2658	0.8717	0.0221	0.045951			0.05057
			16.5	6.59	33.1482	0.869065	0.0221	0.046597			0.0502
			17.5	6.42	33.0975	0.86636	0.0221	0.047269			0.0513
		1033	0.5	9.77	21.2295	0.925136	0.0141	0.022473	0.02842732	0.030988	0.02468
			1.5	9.77	25.3175	0.903521	0.0141	0.025658			0.02705
			2.5	9.77	27.1208	0.895595	0.0141	0.026918			0.02964
			3.5	10.59	28.2067	0.902222	0.0141	0.025861			0.02847
			4.5	10.74	28.9023	0.901312	0.0141	0.026004			0.02817
			5.5	10.09	29.3257	0.891087	0.0141	0.027658			0.03059
			6.5	9.53	29.5301	0.882777	0.0141	0.029068			0.03102
			7.5	9.08	29.5467	0.87651	0.0141	0.030172			0.03373
			8.5	8.69	29.403	0.871511	0.0141	0.03108			0.0347
			9.5	8.33	29.1321	0.867244	0.0141	0.031873			0.03419
			10.5	8	28.7758	0.863573	0.0141	0.03257			0.03535
			11.5	7.71	28.3815	0.860508	0.0141	0.033163			0.03661
			12.5	7.44	27.9954	0.857611	0.0141	0.033732			0.0363
			13.5	7.19	27.6549	0.85477	0.0141	0.034298			0.03758

			14.5	6.97	27.3833	0.852089	0.0141	0.034841			0.03729
			15.5	6.77	27.1898	0.849398	0.0141	0.035393			0.03853
			16.5	6.59	27.0723	0.846726	0.0141	0.035949			0.03818
			17.5	6.42	27.0216	0.84395	0.0141	0.036536			0.03938
4	Portland	475	0.5	9.77	18.1391	0.879808	0.0092	0.021408	0.02865581	0.0297872	0.02145
			1.5	9.77	22.2271	0.852338	0.0092	0.025616			0.02664
			2.5	9.77	24.0304	0.84349	0.0092	0.02711			0.02706
			3.5	10.59	25.1163	0.84957	0.0092	0.026076			0.02779
			4.5	10.74	25.8119	0.848384	0.0092	0.026275			0.02711
			5.5	10.09	26.2353	0.838166	0.0092	0.028045			0.02946
			6.5	9.53	26.4397	0.829949	0.0092	0.029543			0.03195
			7.5	9.08	26.4563	0.823812	0.0092	0.030707			0.0326
			8.5	8.69	26.3126	0.818972	0.0092	0.031654			0.03349
			9.5	8.33	26.0417	0.814889	0.0092	0.032472			0.033
			10.5	8	25.6854	0.811416	0.0092	0.033184			0.03415
			11.5	7.71	25.2911	0.808546	0.0092	0.033782			0.03538
			12.5	7.44	24.905	0.805837	0.0092	0.034355			0.03505
			13.5	7.19	24.5645	0.803169	0.0092	0.034929			0.03632
			14.5	6.97	24.2929	0.800635	0.0092	0.035481			0.03799
			15.5	6.77	24.0994	0.798067	0.0092	0.03605			0.03722
			16.5	6.59	23.9819	0.795494	0.0092	0.036628			0.03884
			17.5	6.42	23.9312	0.792799	0.0092	0.037242			0.03803
		2475	0.5	9.77	26.504	0.935268	0.0241	0.035625	0.04213059	0.0479216	0.04071
			1.5	9.77	30.592	0.918505	0.0241	0.038918			0.04446
			2.5	9.77	32.3953	0.912007	0.0241	0.040269			0.04522
			3.5	10.59	33.4812	0.918916	0.0241	0.038834			0.0449
			4.5	10.74	34.1768	0.918404	0.0241	0.038939			0.04432
			5.5	10.09	34.6002	0.908793	0.0241	0.040954			0.0464
			6.5	9.53	34.8045	0.900883	0.0241	0.042684			0.04807
			7.5	9.08	34.8212	0.89484	0.0241	0.044053			0.05058
			8.5	8.69	34.6775	0.889946	0.0241	0.045192			0.0513
			9.5	8.33	34.4066	0.885703	0.0241	0.046201			0.05224
			10.5	8	34.0503	0.882001	0.0241	0.0471			0.05318
			11.5	7.71	33.656	0.878869	0.0241	0.047873			0.0542
			12.5	7.44	33.2699	0.875903	0.0241	0.048617			0.05524
			13.5	7.19	32.9293	0.87301	0.0241	0.049353			0.0563
			14.5	6.97	32.6577	0.870302	0.0241	0.050052			0.05735
			15.5	6.77	32.4643	0.867617	0.0241	0.050754			0.05839
			16.5	6.59	32.3468	0.864982	0.0241	0.051452			0.05804
			17.5	6.42	32.296	0.862274	0.0241	0.05218			0.05906
		1033	0.5	9.77	22.5676	0.924283	0.0189	0.02966	0.03634379	0.0391326	0.03
			1.5	9.77	26.6556	0.904389	0.0189	0.033171			0.03528
			2.5	9.77	28.4589	0.896914	0.0189	0.034584			0.03783
			3.5	10.59	29.5448	0.903601	0.0189	0.033318			0.03679
			4.5	10.74	30.2404	0.90281	0.0189	0.033465			0.03648
			5.5	10.09	30.6638	0.892795	0.0189	0.035386			0.03854
			6.5	9.53	30.8681	0.884627	0.0189	0.037026			0.04075
			7.5	9.08	30.8848	0.878445	0.0189	0.038313			0.04129
			8.5	8.69	30.7411	0.873492	0.0189	0.039374			0.04206
			9.5	8.33	30.4702	0.869247	0.0189	0.040305			0.04306
			10.5	8	30.1139	0.865578	0.0189	0.041127			0.04408
			11.5	7.71	29.7196	0.862505	0.0189	0.041827			0.04519
			12.5	7.44	29.3335	0.859597	0.0189	0.042499			0.04631
			13.5	7.19	28.9929	0.856751	0.0189	0.043168			0.04597
			14.5	6.97	28.7213	0.854071	0.0189	0.043806			0.04712
			15.5	6.77	28.5279	0.851391	0.0189	0.044453			0.04822

			16.5	6.59	28.4104	0.848738	0.0189	0.045103			0.04982
			17.5	6.42	28.3596	0.845991	0.0189	0.045785			0.04891
4	SLC	475	0.5	9.77	16.2549	0.868523	0.0076	0.020327	0.02909594	0.0276003	0.01859
			1.5	9.77	20.343	0.832958	0.0076	0.0258			0.02314
			2.5	9.77	22.1463	0.82288	0.0076	0.027557			0.02511
			3.5	10.59	23.2321	0.828646	0.0076	0.02654			0.0258
			4.5	10.74	23.9278	0.827193	0.0076	0.026793			0.02531
			5.5	10.09	24.3511	0.816749	0.0076	0.028676			0.02742
			6.5	9.53	24.5555	0.808437	0.0076	0.030256			0.02976
			7.5	9.08	24.5721	0.80228	0.0076	0.031475			0.03064
			8.5	8.69	24.4285	0.797466	0.0076	0.032459			0.03152
			9.5	8.33	24.1576	0.793442	0.0076	0.033302			0.03268
			10.5	8	23.8012	0.790046	0.0076	0.034029			0.03221
			11.5	7.71	23.4069	0.787264	0.0076	0.034635			0.03348
			12.5	7.44	23.0209	0.784642	0.0076	0.035215			0.03316
			13.5	7.19	22.6803	0.782049	0.0076	0.035798			0.03447
			14.5	6.97	22.4087	0.779576	0.0076	0.036362			0.0341
			15.5	6.77	22.2152	0.77705	0.0076	0.036946			0.0354
			16.5	6.59	22.0977	0.774501	0.0076	0.037544			0.035
			17.5	6.42	22.047	0.771815	0.0076	0.038184			0.03619
		2475	0.5	9.77	27.4815	0.938466	0.0245	0.035702	0.04200648	0.0465573	0.03876
			1.5	9.77	31.5695	0.922293	0.0245	0.038868			0.04241
			2.5	9.77	33.3728	0.915995	0.0245	0.040171			0.04468
			3.5	10.59	34.4587	0.922954	0.0245	0.038734			0.04219
			4.5	10.74	35.1543	0.922501	0.0245	0.038826			0.04204
			5.5	10.09	35.5777	0.912972	0.0245	0.04081			0.04571
			6.5	9.53	35.782	0.905112	0.0245	0.042517			0.04771
			7.5	9.08	35.7987	0.899097	0.0245	0.043869			0.0482
			8.5	8.69	35.655	0.894213	0.0245	0.044996			0.05091
			9.5	8.33	35.3841	0.889969	0.0245	0.045998			0.05186
			10.5	8	35.0278	0.886257	0.0245	0.046892			0.05283
			11.5	7.71	34.6335	0.883112	0.0245	0.047663			0.05388
			12.5	7.44	34.2474	0.880131	0.0245	0.048404			0.05497
			13.5	7.19	33.9068	0.877227	0.0245	0.049137			0.05406
			14.5	6.97	33.6352	0.874512	0.0245	0.049832			0.05514
			15.5	6.77	33.4418	0.871825	0.0245	0.050529			0.05619
			16.5	6.59	33.3242	0.869192	0.0245	0.051221			0.05781
			17.5	6.42	33.2735	0.866491	0.0245	0.05194			0.05882
		1033	0.5	9.77	21.8191	0.931692	0.0177	0.026716	0.03317519	0.0373115	0.02838
			1.5	9.77	25.9072	0.910742	0.0177	0.030142			0.03355
			2.5	9.77	27.7104	0.902963	0.0177	0.031509			0.0356
			3.5	10.59	28.7963	0.909669	0.0177	0.030328			0.03486
			4.5	10.74	29.492	0.908806	0.0177	0.030478			0.03415
			5.5	10.09	29.9153	0.898599	0.0177	0.0323			0.03614
			6.5	9.53	30.1197	0.890291	0.0177	0.033855			0.03828
			7.5	9.08	30.1363	0.884015	0.0177	0.035073			0.0408
			8.5	8.69	29.9926	0.879	0.0177	0.036076			0.04163
			9.5	8.33	29.7218	0.87471	0.0177	0.036954			0.04098
			10.5	8	29.3654	0.871012	0.0177	0.037727			0.04204
			11.5	7.71	28.9711	0.86792	0.0177	0.038385			0.04319
			12.5	7.44	28.5851	0.864996	0.0177	0.039017			0.04436
			13.5	7.19	28.2445	0.862131	0.0177	0.039645			0.04565
			14.5	6.97	27.9729	0.85943	0.0177	0.040246			0.04518
			15.5	6.77	27.7794	0.856724	0.0177	0.040857			0.04633
			16.5	6.59	27.6619	0.85404	0.0177	0.041471			0.04591
			17.5	6.42	27.6112	0.851256	0.0177	0.042117			0.047

4	San Fran	475	0.5	9.77	25.617	0.934939	0.0226	0.033523	0.03995644	0.0382221	0.03386
			1.5	9.77	29.705	0.917549	0.0226	0.036803			0.03504
			2.5	9.77	31.5083	0.910838	0.0226	0.038145			0.03641
			3.5	10.59	32.5942	0.917719	0.0226	0.036769			0.03561
			4.5	10.74	33.2898	0.917148	0.0226	0.036882			0.03553
			5.5	10.09	33.7132	0.907432	0.0226	0.038844			0.03797
			6.5	9.53	33.9176	0.899451	0.0226	0.040528			0.03862
			7.5	9.08	33.9342	0.893365	0.0226	0.041857			0.03949
			8.5	8.69	33.7905	0.888447	0.0226	0.042961			0.04049
			9.5	8.33	33.5196	0.884194	0.0226	0.043938			0.04174
			10.5	8	33.1633	0.88049	0.0226	0.044806			0.04122
			11.5	7.71	32.769	0.877363	0.0226	0.045552			0.0424
			12.5	7.44	32.3829	0.874402	0.0226	0.046269			0.0436
			13.5	7.19	32.0424	0.871512	0.0226	0.046979			0.04483
			14.5	6.97	31.7708	0.868803	0.0226	0.047654			0.04453
			15.5	6.77	31.5773	0.866113	0.0226	0.048333			0.04575
			16.5	6.59	31.4598	0.863469	0.0226	0.04901			0.04545
			17.5	6.42	31.4091	0.860746	0.0226	0.049717			0.04666
		2475	0.5	9.77	32.8755	0.938344	0.0333	0.0497	0.05651386	0.0543496	0.04922
			1.5	9.77	36.9635	0.925031	0.0333	0.052992			0.05148
			2.5	9.77	38.7668	0.919746	0.0333	0.054356			0.0528
			3.5	10.59	39.8527	0.926806	0.0333	0.052541			0.05077
			4.5	10.74	40.5483	0.926628	0.0333	0.052586			0.04904
			5.5	10.09	40.9717	0.917641	0.0333	0.054909			0.05298
			6.5	9.53	41.176	0.910158	0.0333	0.056921			0.05495
			7.5	9.08	41.1927	0.904374	0.0333	0.058525			0.0557
			8.5	8.69	41.049	0.899624	0.0333	0.059876			0.05658
			9.5	8.33	40.7781	0.89545	0.0333	0.061088			0.05733
			10.5	8	40.4218	0.891762	0.0333	0.062179			0.05985
			11.5	7.71	40.0275	0.888608	0.0333	0.063128			0.06087
			12.5	7.44	39.6414	0.885616	0.0333	0.064042			0.06191
			13.5	7.19	39.3008	0.882712	0.0333	0.064941			0.06297
			14.5	6.97	39.0292	0.88001	0.0333	0.065789			0.06202
			15.5	6.77	38.8358	0.87736	0.0333	0.066631			0.06308
			16.5	6.59	38.7182	0.874785	0.0333	0.06746			0.06485
			17.5	6.42	38.6675	0.872164	0.0333	0.068314			0.0659
		1033	0.5	9.77	29.0055	0.938447	0.0286	0.04203	0.04877385	0.04683	0.04115
			1.5	9.77	33.0935	0.923192	0.0286	0.045381			0.04446
			2.5	9.77	34.8968	0.917214	0.0286	0.046762			0.04571
			3.5	10.59	35.9827	0.924209	0.0286	0.04515			0.0435
			4.5	10.74	36.6783	0.923843	0.0286	0.045233			0.04354
			5.5	10.09	37.1017	0.914481	0.0286	0.047406			0.04567
			6.5	9.53	37.306	0.906738	0.0286	0.04928			0.04613
			7.5	9.08	37.3227	0.900793	0.0286	0.050766			0.0489
			8.5	8.69	37.179	0.895949	0.0286	0.052009			0.0498
			9.5	8.33	36.9081	0.891726	0.0286	0.053117			0.05084
			10.5	8	36.5518	0.88802	0.0286	0.054108			0.05186
			11.5	7.71	36.1575	0.88487	0.0286	0.054965			0.05097
			12.5	7.44	35.7714	0.881885	0.0286	0.055789			0.05208
			13.5	7.19	35.4308	0.87898	0.0286	0.056603			0.0532
			14.5	6.97	35.1592	0.876268	0.0286	0.057373			0.05431
			15.5	6.77	34.9658	0.873591	0.0286	0.058143			0.05543
			16.5	6.59	34.8482	0.870976	0.0286	0.058905			0.05514
			17.5	6.42	34.7975	0.868299	0.0286	0.059696			0.05626
4	San Jose	475	0.5	9.77	23.5872	0.936913	0.0213	0.03118	0.03779694	0.0375174	0.03295
			1.5	9.77	27.6753	0.917793	0.0213	0.034617			0.03578

			2.5	9.77	29.4786	0.910523	0.0213	0.036011			0.03687
			3.5	10.59	30.5645	0.917346	0.0213	0.034701			0.03423
			4.5	10.74	31.2601	0.916626	0.0213	0.034837			0.03595
			5.5	10.09	31.6834	0.906621	0.0213	0.03678			0.03651
			6.5	9.53	31.8878	0.89844	0.0213	0.038442			0.03717
			7.5	9.08	31.9045	0.892232	0.0213	0.03975			0.03805
			8.5	8.69	31.7608	0.887244	0.0213	0.04083			0.03906
			9.5	8.33	31.4899	0.882954	0.0213	0.041781			0.04022
			10.5	8	31.1336	0.879237	0.0213	0.042622			0.04184
			11.5	7.71	30.7392	0.876114	0.0213	0.043341			0.04107
			12.5	7.44	30.3532	0.873159	0.0213	0.044032			0.0423
			13.5	7.19	30.0126	0.870269	0.0213	0.044717			0.04356
			14.5	6.97	29.741	0.867552	0.0213	0.045371			0.04328
			15.5	6.77	29.5475	0.864842	0.0213	0.046032			0.04452
			16.5	6.59	29.43	0.862167	0.0213	0.046694			0.04424
			17.5	6.42	29.3793	0.859401	0.0213	0.047387			0.04546
		2475	0.5	9.77	29.7975	0.938728	0.0338	0.050508	0.05803215	0.0532105	0.04824
			1.5	9.77	33.8855	0.923907	0.0338	0.054229			0.05007
			2.5	9.77	35.6888	0.918083	0.0338	0.055763			0.05134
			3.5	10.59	36.7747	0.925096	0.0338	0.05392			0.04915
			4.5	10.74	37.4703	0.924772	0.0338	0.054004			0.04932
			5.5	10.09	37.8937	0.91549	0.0338	0.056459			0.05142
			6.5	9.53	38.098	0.9078	0.0338	0.058576			0.05335
			7.5	9.08	38.1147	0.901889	0.0338	0.060257			0.05413
			8.5	8.69	37.971	0.897064	0.0338	0.061663			0.05501
			9.5	8.33	37.7001	0.892849	0.0338	0.062919			0.0576
			10.5	8	37.3438	0.889146	0.0338	0.064043			0.05833
			11.5	7.71	36.9495	0.885994	0.0338	0.065015			0.05938
			12.5	7.44	36.5634	0.883006	0.0338	0.065951			0.06045
			13.5	7.19	36.2228	0.880099	0.0338	0.066874			0.06152
			14.5	6.97	35.9512	0.877388	0.0338	0.067747			0.0626
			15.5	6.77	35.7578	0.874716	0.0338	0.068618			0.06367
			16.5	6.59	35.6402	0.872109	0.0338	0.069479			0.06344
			17.5	6.42	35.5895	0.869443	0.0338	0.070371			0.0645
		1033	0.5	9.77	26.5235	0.939243	0.0272	0.039706	0.04672578	0.0456954	0.03997
			1.5	9.77	30.6115	0.922422	0.0272	0.043262			0.04324
			2.5	9.77	32.4148	0.915901	0.0272	0.04472			0.04429
			3.5	10.59	33.5007	0.92284	0.0272	0.04317			0.04193
			4.5	10.74	34.1963	0.922327	0.0272	0.043283			0.04207
			5.5	10.09	34.6197	0.912678	0.0272	0.045457			0.0441
			6.5	9.53	34.824	0.904735	0.0272	0.047325			0.04665
			7.5	9.08	34.8407	0.898668	0.0272	0.048801			0.04743
			8.5	8.69	34.697	0.893753	0.0272	0.050029			0.04818
			9.5	8.33	34.4261	0.889493	0.0272	0.051117			0.04923
			10.5	8	34.0698	0.885775	0.0272	0.052086			0.05027
			11.5	7.71	33.6755	0.88263	0.0272	0.052919			0.05158
			12.5	7.44	33.2894	0.879651	0.0272	0.053721			0.05273
			13.5	7.19	32.9488	0.876746	0.0272	0.054514			0.05191
			14.5	6.97	32.6772	0.874026	0.0272	0.055266			0.05305
			15.5	6.77	32.4838	0.87133	0.0272	0.056023			0.05419
			16.5	6.59	32.3662	0.868684	0.0272	0.056775			0.05391
			17.5	6.42	32.3155	0.865964	0.0272	0.057558			0.05503
4	Santa Monica	475	0.5	9.77	22.0506	0.930538	0.0181	0.027513	0.03402503	0.0361089	0.03095
			1.5	9.77	26.1386	0.909906	0.0181	0.030957			0.03349
			2.5	9.77	27.9419	0.902214	0.0181	0.032334			0.03432
			3.5	10.59	29.0278	0.908922	0.0181	0.03113			0.03367

			4.5	10.74	29.7234	0.908081	0.0181	0.031279			0.03328
			5.5	10.09	30.1468	0.897922	0.0181	0.033126			0.0358
			6.5	9.53	30.3511	0.889648	0.0181	0.034703			0.0364
			7.5	9.08	30.3678	0.883394	0.0181	0.03594			0.03724
			8.5	8.69	30.2241	0.878391	0.0181	0.036959			0.03822
			9.5	8.33	29.9532	0.87411	0.0181	0.037851			0.03938
			10.5	8	29.5969	0.870417	0.0181	0.038637			0.04067
			11.5	7.71	29.2026	0.867326	0.0181	0.039306			0.04019
			12.5	7.44	28.8165	0.864404	0.0181	0.039949			0.04143
			13.5	7.19	28.4759	0.86154	0.0181	0.040588			0.04269
			14.5	6.97	28.2043	0.858843	0.0181	0.041199			0.04239
			15.5	6.77	28.0109	0.856141	0.0181	0.041819			0.04363
			16.5	6.59	27.8934	0.853464	0.0181	0.042443			0.04332
			17.5	6.42	27.8426	0.850688	0.0181	0.043098			0.04454
		2475	0.5	9.77	29.5545	0.938416	0.0301	0.044444	0.05134801	0.0525522	0.04619
			1.5	9.77	33.6425	0.923468	0.0301	0.047861			0.0509
			2.5	9.77	35.4458	0.917599	0.0301	0.04927			0.05029
			3.5	10.59	36.5317	0.924605	0.0301	0.047593			0.04823
			4.5	10.74	37.2273	0.924268	0.0301	0.047672			0.04995
			5.5	10.09	37.6507	0.914964	0.0301	0.049916			0.05036
			6.5	9.53	37.855	0.90726	0.0301	0.051851			0.05225
			7.5	9.08	37.8717	0.901339	0.0301	0.053388			0.05498
			8.5	8.69	37.728	0.89651	0.0301	0.054674			0.05549
			9.5	8.33	37.4571	0.892294	0.0301	0.055821			0.05615
			10.5	8	37.1008	0.88859	0.0301	0.056849			0.05714
			11.5	7.71	36.7065	0.88544	0.0301	0.057738			0.05818
			12.5	7.44	36.3204	0.882453	0.0301	0.058593			0.05924
			13.5	7.19	35.9798	0.879548	0.0301	0.059437			0.06031
			14.5	6.97	35.7082	0.876837	0.0301	0.060235			0.06138
			15.5	6.77	35.5148	0.874164	0.0301	0.061032			0.06245
			16.5	6.59	35.3972	0.871555	0.0301	0.061821			0.06219
			17.5	6.42	35.3465	0.868886	0.0301	0.062638			0.06324
		1033	0.5	9.77	25.1965	0.93881	0.0258	0.037691	0.04478326	0.0449944	0.03823
			1.5	9.77	29.2845	0.921028	0.0258	0.041323			0.04284
			2.5	9.77	31.0878	0.914182	0.0258	0.042807			0.04369
			3.5	10.59	32.1737	0.921078	0.0258	0.041312			0.04128
			4.5	10.74	32.8693	0.920476	0.0258	0.041441			0.04289
			5.5	10.09	33.2927	0.910667	0.0258	0.043588			0.0433
			6.5	9.53	33.497	0.902616	0.0258	0.045428			0.04578
			7.5	9.08	33.5137	0.896483	0.0258	0.046879			0.0463
			8.5	8.69	33.37	0.891533	0.0258	0.048083			0.04887
			9.5	8.33	33.0991	0.887256	0.0258	0.049147			0.04793
			10.5	8	32.7428	0.883536	0.0258	0.050091			0.04898
			11.5	7.71	32.3485	0.880397	0.0258	0.0509			0.05036
			12.5	7.44	31.9624	0.877426	0.0258	0.051679			0.05176
			13.5	7.19	31.6218	0.874525	0.0258	0.05245			0.05093
			14.5	6.97	31.3502	0.871805	0.0258	0.053183			0.05206
			15.5	6.77	31.1568	0.869101	0.0258	0.053922			0.0532
			16.5	6.59	31.0392	0.86644	0.0258	0.054658			0.05487
			17.5	6.42	30.9885	0.863698	0.0258	0.055428			0.05401
4	Seattle	475	0.5	9.77	20.4397	0.922204	0.0151	0.024312	0.03086935	0.0341644	0.02795
			1.5	9.77	24.5277	0.899367	0.0151	0.027877			0.03174
			2.5	9.77	26.331	0.891175	0.0151	0.029261			0.03251
			3.5	10.59	27.4169	0.897734	0.0151	0.028148			0.03139
			4.5	10.74	28.1125	0.896751	0.0151	0.028312			0.03118
			5.5	10.09	28.5359	0.886433	0.0151	0.030089			0.03345

			6.5	9.53	28.7403	0.878068	0.0151	0.0316			0.0341
			7.5	9.08	28.7569	0.871774	0.0151	0.032782			0.03691
			8.5	8.69	28.6132	0.866766	0.0151	0.03375			0.03787
			9.5	8.33	28.3423	0.862504	0.0151	0.034594			0.03704
			10.5	8	27.986	0.858846	0.0151	0.035334			0.0382
			11.5	7.71	27.5917	0.8558	0.0151	0.035961			0.03987
			12.5	7.44	27.2056	0.852921	0.0151	0.036563			0.03914
			13.5	7.19	26.8651	0.850095	0.0151	0.037163			0.04042
			14.5	6.97	26.5935	0.847424	0.0151	0.037738			0.04013
			15.5	6.77	26.4	0.844738	0.0151	0.038325			0.04138
			16.5	6.59	26.2825	0.842065	0.0151	0.038917			0.04106
			17.5	6.42	26.2318	0.839282	0.0151	0.039543			0.04227
		2475	0.5	9.77	28.5685	0.939082	0.0282	0.041297	0.04804717	0.0512393	0.04438
			1.5	9.77	32.6565	0.923564	0.0282	0.044662			0.04883
			2.5	9.77	34.4598	0.917494	0.0282	0.046047			0.04956
			3.5	10.59	35.5457	0.924484	0.0282	0.044455			0.04753
			4.5	10.74	36.2413	0.924093	0.0282	0.044543			0.04742
			5.5	10.09	36.6647	0.914678	0.0282	0.046704			0.04945
			6.5	9.53	36.869	0.906897	0.0282	0.048566			0.05155
			7.5	9.08	36.8857	0.900928	0.0282	0.050042			0.05213
			8.5	8.69	36.742	0.89607	0.0282	0.051275			0.05439
			9.5	8.33	36.4711	0.891838	0.0282	0.052373			0.05537
			10.5	8	36.1148	0.888128	0.0282	0.053355			0.05636
			11.5	7.71	35.7205	0.884977	0.0282	0.054203			0.05741
			12.5	7.44	35.3344	0.881991	0.0282	0.055019			0.05848
			13.5	7.19	34.9938	0.879084	0.0282	0.055824			0.05956
			14.5	6.97	34.7222	0.876369	0.0282	0.056587			0.06064
			15.5	6.77	34.5288	0.873688	0.0282	0.057351			0.06171
			16.5	6.59	34.4112	0.871066	0.0282	0.058107			0.06142
			17.5	6.42	34.3605	0.86838	0.0282	0.058892			0.06246
		1033	0.5	9.77	24.2488	0.935833	0.0224	0.033068	0.03977663	0.0432123	0.03496
			1.5	9.77	28.3369	0.917333	0.0224	0.036531			0.04077
			2.5	9.77	30.1402	0.910257	0.0224	0.03794			0.04148
			3.5	10.59	31.2261	0.917098	0.0224	0.036576			0.04082
			4.5	10.74	31.9217	0.916429	0.0224	0.036708			0.04074
			5.5	10.09	32.345	0.906527	0.0224	0.038703			0.04099
			6.5	9.53	32.5494	0.898416	0.0224	0.040412			0.04292
			7.5	9.08	32.5661	0.892252	0.0224	0.041758			0.04557
			8.5	8.69	32.4224	0.887289	0.0224	0.042872			0.04642
			9.5	8.33	32.1515	0.883014	0.0224	0.043854			0.04745
			10.5	8	31.7952	0.879302	0.0224	0.044724			0.04851
			11.5	7.71	31.4009	0.876179	0.0224	0.045468			0.04965
			12.5	7.44	31.0148	0.873223	0.0224	0.046184			0.04917
			13.5	7.19	30.6742	0.870334	0.0224	0.046894			0.05049
			14.5	6.97	30.4026	0.867621	0.0224	0.04757			0.05164
			15.5	6.77	30.2092	0.864919	0.0224	0.048252			0.05279
			16.5	6.59	30.0916	0.862255	0.0224	0.048935			0.05245
			17.5	6.42	30.0409	0.859505	0.0224	0.049649			0.05357
5	Butte	475	0.5	37.29	3.4288	1	0	3.06E-18	3.0646E-18	0	0
			1.5	37.29	7.51685	1	0	3.06E-18			0
			2.5	37.29	9.32013	1	0	3.06E-18			0
			3.5	40.54	10.406	1	0	3.06E-18			0
			4.5	41.15	11.1017	1	0	3.06E-18			0
			5.5	38.57	11.525	1	0	3.06E-18			0
			6.5	36.34	11.7294	1	0	3.06E-18			0
			7.5	34.52	11.746	1	0	3.06E-18			0

			8.5	32.94	11.6023	1	0	3.06E-18			0
			9.5	31.52	11.3314	1	0	3.06E-18			0
			10.5	30.2	10.9751	1	0	3.06E-18			0
			11.5	29.03	10.5808	1	0	3.06E-18			0
			12.5	27.95	10.1947	1	0	3.06E-18			0
			13.5	26.98	9.85419	1	0	3.06E-18			0
			14.5	26.09	9.58258	1	0	3.06E-18			0
			15.5	25.29	9.38911	1	0	3.06E-18			0
			16.5	24.56	9.2716	1	0	3.06E-18			0
			17.5	23.89	9.22088	1	0	3.06E-18			0
		2475	0.5	37.29	11.8466	1.035199	0.0013	0	0	0	0
			1.5	37.29	15.9346	1.035199	0.0013	0			0
			2.5	37.29	17.7379	1.035199	0.0013	0			0
			3.5	40.54	18.8238	1.035199	0.0013	0			0
			4.5	41.15	19.5194	1.035199	0.0013	0			0
			5.5	38.57	19.9428	1.035199	0.0013	0			0
			6.5	36.34	20.1472	1.035199	0.0013	0			0
			7.5	34.52	20.1638	1.035199	0.0013	0			0
			8.5	32.94	20.0201	1.03519	0.0013	0			0
			9.5	31.52	19.7492	1.035138	0.0013	0			0
			10.5	30.2	19.3929	1.035011	0.0013	0			0
			11.5	29.03	18.9986	1.034795	0.0013	0			0
			12.5	27.95	18.6125	1.034446	0.0013	0			0
			13.5	26.98	18.272	1.033924	0.0013	0			0
			14.5	26.09	18.0004	1.033122	0.0013	0			0
			15.5	25.29	17.8069	1.031938	0.0013	0			0
			16.5	24.56	17.6894	1.030195	0.0013	0			0
			17.5	23.89	17.6387	1.027701	0.0013	0			0
		1033	0.5	37.29	8.00883	1.000532	0	0	0	0	0
			1.5	37.29	12.0969	1.000532	0	0			0
			2.5	37.29	13.9002	1.000532	0	0			0
			3.5	40.54	14.986	1.000532	0	0			0
			4.5	41.15	15.6817	1.000532	0	0			0
			5.5	38.57	16.105	1.000532	0	0			0
			6.5	36.34	16.3094	1.000532	0	0			0
			7.5	34.52	16.326	1.000532	0	0			0
			8.5	32.94	16.1824	1.000532	0	0			0
			9.5	31.52	15.9115	1.000532	0	0			0
			10.5	30.2	15.5551	1.000532	0	0			0
			11.5	29.03	15.1608	1.000532	0	0			0
			12.5	27.95	14.7748	1.000532	0	0			0
			13.5	26.98	14.4342	1.000532	0	0			0
			14.5	26.09	14.1626	1.000532	0	0			0
			15.5	25.29	13.9691	1.000532	0	0			0
			16.5	24.56	13.8516	1.000532	0	0			0
			17.5	23.89	13.8009	1.000442	0	0			0
5	Charleston	475	0.5	37.29	9.68521	1.006744	0	0	0	0	0
			1.5	37.29	13.7733	1.006744	0	0			0
			2.5	37.29	15.5765	1.006744	0	0			0
			3.5	40.54	16.6624	1.006744	0	0			0
			4.5	41.15	17.3581	1.006744	0	0			0
			5.5	38.57	17.7814	1.006744	0	0			0
			6.5	36.34	17.9858	1.006744	0	0			0
			7.5	34.52	18.0024	1.006744	0	0			0
			8.5	32.94	17.8587	1.006744	0	0			0
			9.5	31.52	17.5879	1.006744	0	0			0

			10.5	30.2	17.2315	1.006744	0	0			0
			11.5	29.03	16.8372	1.006744	0	0			0
			12.5	27.95	16.4512	1.006729	0	0			0
			13.5	26.98	16.1106	1.006678	0	0			0
			14.5	26.09	15.839	1.006575	0	0			0
			15.5	25.29	15.6455	1.006384	0	0			0
			16.5	24.56	15.528	1.006043	0	0			0
			17.5	23.89	15.4773	1.005468	0	0			0
		2475	0.5	37.29	28.3835	1.357973	0.0227	0	0.00453097	0.0043642	0
			1.5	37.29	32.4715	1.335021	0.0227	0.000354			0.00199
			2.5	37.29	34.2748	1.308377	0.0227	0.001242			0.00108
			3.5	40.54	35.3607	1.338443	0.0227	0.000246			0
			4.5	41.15	36.0563	1.337474	0.0227	0.000277			0
			5.5	38.57	36.4797	1.290363	0.0227	0.001898			0.00263
			6.5	36.34	36.684	1.234887	0.0227	0.004249			0.00442
			7.5	34.52	36.7007	1.192328	0.0227	0.006454			0.00658
			8.5	32.94	36.557	1.162515	0.0227	0.008251			0.00722
			9.5	31.52	36.2861	1.141559	0.0227	0.009659			0.00819
			10.5	30.2	35.9298	1.125844	0.0227	0.010801			0.00912
			11.5	29.03	35.5355	1.114166	0.0227	0.011702			0.01032
			12.5	27.95	35.1494	1.104356	0.0227	0.012496			0.01144
			13.5	26.98	34.8088	1.095934	0.0227	0.013205			0.01261
			14.5	26.09	34.5372	1.088154	0.0227	0.013884			0.01395
			15.5	25.29	34.3438	1.080985	0.0227	0.014531			0.01315
			16.5	24.56	34.2262	1.07419	0.0227	0.015164			0.01442
			17.5	23.89	34.1755	1.067713	0.0227	0.015785			0.01571
		1033	0.5	37.29	20.1422	1.28275	0.013	0	0.00023282	0.0008714	0
			1.5	37.29	24.2303	1.282713	0.013	0			0
			2.5	37.29	26.0335	1.282458	0.013	0			0
			3.5	40.54	27.1194	1.282713	0.013	0			0
			4.5	41.15	27.8151	1.282707	0.013	0			0
			5.5	38.57	28.2384	1.282029	0.013	0			0
			6.5	36.34	28.4428	1.278523	0.013	0			0
			7.5	34.52	28.4594	1.270264	0.013	0			0
			8.5	32.94	28.3157	1.257475	0.013	0			0
			9.5	31.52	28.0449	1.241961	0.013	0			0.00131
			10.5	30.2	27.6885	1.225096	0.013	0			0.00254
			11.5	29.03	27.2942	1.209137	0.013	0.000397			0.00376
			12.5	27.95	26.9082	1.193325	0.013	0.000971			0.00299
			13.5	26.98	26.5676	1.178011	0.013	0.001566			0.00421
			14.5	26.09	26.296	1.162387	0.013	0.002216			0.00544
			15.5	25.29	26.1025	1.146824	0.013	0.002911			0.00666
			16.5	24.56	25.985	1.131186	0.013	0.003659			0.00788
			17.5	23.89	25.9343	1.115731	0.013	0.004452			0.00712
5	Eureka	475	0.5	37.29	28.5185	1.359082	0.0216	0	0.00407054	0.0042774	0
			1.5	37.29	32.6065	1.334761	0.0216	0			0
			2.5	37.29	34.4098	1.307207	0.0216	0.000845			0.00125
			3.5	40.54	35.4957	1.338359	0.0216	0			0
			4.5	41.15	36.1913	1.337348	0.0216	0			0
			5.5	38.57	36.6147	1.288828	0.0216	0.001491			0.00296
			6.5	36.34	36.819	1.232939	0.0216	0.003782			0.00483
			7.5	34.52	36.8357	1.190652	0.0216	0.005904			0.00687
			8.5	32.94	36.692	1.161249	0.0216	0.00762			0.0075
			9.5	31.52	36.4211	1.140651	0.0216	0.008957			0.00845
			10.5	30.2	36.0648	1.125216	0.0216	0.010041			0.00937
			11.5	29.03	35.6705	1.113736	0.0216	0.010896			0.01055

			12.5	27.95	35.2844	1.104079	0.0216	0.011649			0.01165
			13.5	26.98	34.9438	1.095776	0.0216	0.012323			0.01282
			14.5	26.09	34.6722	1.088095	0.0216	0.01297			0.01217
			15.5	25.29	34.4788	1.081007	0.0216	0.013586			0.01337
			16.5	24.56	34.3612	1.074281	0.0216	0.014189			0.01471
			17.5	23.89	34.3105	1.067861	0.0216	0.014782			0.014
		2475	0.5	37.29	40.4435	1.227495	0.0335	0.010868	0.01808805	0.0121072	0.0079
			1.5	37.29	44.5315	1.169899	0.0335	0.015355			0.00979
			2.5	37.29	46.3348	1.155219	0.0335	0.016678			0.00911
			3.5	40.54	47.4207	1.177418	0.0335	0.014708			0.00757
			4.5	41.15	48.1163	1.177267	0.0335	0.014721			0.00779
			5.5	38.57	48.5397	1.151156	0.0335	0.017059			0.00936
			6.5	36.34	48.744	1.134127	0.0335	0.018726			0.01123
			7.5	34.52	48.7607	1.121703	0.0335	0.020019			0.01342
			8.5	32.94	48.617	1.11165	0.0335	0.021116			0.01599
			9.5	31.52	48.3461	1.103105	0.0335	0.022087			0.01663
			10.5	30.2	47.9898	1.095438	0.0335	0.022988			0.01729
			11.5	29.03	47.5955	1.088804	0.0335	0.023792			0.01819
			12.5	27.95	47.2094	1.082612	0.0335	0.024563			0.01907
			13.5	26.98	46.8688	1.076886	0.0335	0.025295			0.02
			14.5	26.09	46.5972	1.071346	0.0335	0.026021			0.02294
			15.5	25.29	46.4038	1.066066	0.0335	0.026729			0.02212
			16.5	24.56	46.2862	1.060935	0.0335	0.027432			0.02311
			17.5	23.89	46.2355	1.055941	0.0335	0.028133			0.02437
		1033	0.5	37.29	35.1175	1.326782	0.0271	0.002369	0.01060596	0.0082865	0.00246
			1.5	37.29	39.2055	1.232029	0.0271	0.006763			0.00539
			2.5	37.29	41.0088	1.196302	0.0271	0.008907			0.00647
			3.5	40.54	42.0947	1.241602	0.0271	0.006239			0.00468
			4.5	41.15	42.7903	1.239981	0.0271	0.006326			0.00477
			5.5	38.57	43.2137	1.182491	0.0271	0.009825			0.00655
			6.5	36.34	43.418	1.150275	0.0271	0.012184			0.00853
			7.5	34.52	43.4347	1.132027	0.0271	0.013669			0.00898
			8.5	32.94	43.291	1.119528	0.0271	0.014756			0.01146
			9.5	31.52	43.0201	1.109805	0.0271	0.015643			0.01219
			10.5	30.2	42.6638	1.101465	0.0271	0.016434			0.01308
			11.5	29.03	42.2695	1.094425	0.0271	0.017124			0.01409
			12.5	27.95	41.8834	1.087922	0.0271	0.017781			0.015
			13.5	26.98	41.5428	1.08193	0.0271	0.018403			0.01612
			14.5	26.09	41.2712	1.076121	0.0271	0.019022			0.01726
			15.5	25.29	41.0778	1.070564	0.0271	0.019629			0.01843
			16.5	24.56	40.9602	1.065139	0.0271	0.020236			0.01963
			17.5	23.89	40.9095	1.059837	0.0271	0.020844			0.02082
5	Memphis	475	0.5	37.29	11.9024	1.029045	0.0017	0.000287	0.0002978	0	0
			1.5	37.29	15.9904	1.029045	0.0017	0.000287			0
			2.5	37.29	17.7937	1.029045	0.0017	0.000287			0
			3.5	40.54	18.8796	1.029045	0.0017	0.000287			0
			4.5	41.15	19.5753	1.029045	0.0017	0.000287			0
			5.5	38.57	19.9986	1.029045	0.0017	0.000287			0
			6.5	36.34	20.203	1.029045	0.0017	0.000287			0
			7.5	34.52	20.2196	1.029045	0.0017	0.000287			0
			8.5	32.94	20.0759	1.029035	0.0017	0.000287			0
			9.5	31.52	19.805	1.028979	0.0017	0.00029			0
			10.5	30.2	19.4487	1.028845	0.0017	0.000295			0
			11.5	29.03	19.0544	1.028619	0.0017	0.000304			0
			12.5	27.95	18.6683	1.028254	0.0017	0.000319			0
			13.5	26.98	18.3278	1.027712	0.0017	0.000341			0

			14.5	26.09	18.0562	1.026882	0.0017	0.000376			0
			15.5	25.29	17.8627	1.025661	0.0017	0.000426			0
			16.5	24.56	17.7452	1.02387	0.0017	0.000501			0
			17.5	23.89	17.6945	1.021315	0.0017	0.000608			0
		2475	0.5	37.29	27.0355	1.352932	0.0221	0	0.0036699	0.0045251	0
			1.5	37.29	31.1235	1.340863	0.0221	0			0
			2.5	37.29	32.9268	1.323042	0.0221	0.000516			0.00138
			3.5	40.54	34.0127	1.342785	0.0221	0			0
			4.5	41.15	34.7083	1.342189	0.0221	0			0
			5.5	38.57	35.1317	1.309223	0.0221	0.000977			0.00284
			6.5	36.34	35.336	1.260379	0.0221	0.002826			0.00455
			7.5	34.52	35.3527	1.216777	0.0221	0.00482			0.00654
			8.5	32.94	35.209	1.183458	0.0221	0.006608			0.00705
			9.5	31.52	34.9381	1.158946	0.0221	0.008093			0.0099
			10.5	30.2	34.5818	1.140214	0.0221	0.009339			0.01072
			11.5	29.03	34.1875	1.126279	0.0221	0.010334			0.01182
			12.5	27.95	33.8014	1.114648	0.0221	0.011211			0.01286
			13.5	26.98	33.4608	1.104762	0.0221	0.011993			0.01396
			14.5	26.09	33.1892	1.095717	0.0221	0.01274			0.01308
			15.5	25.29	32.9958	1.087477	0.0221	0.013446			0.01434
			16.5	24.56	32.8782	1.079762	0.0221	0.014131			0.01549
			17.5	23.89	32.8275	1.072507	0.0221	0.014798			0.01679
		1033	0.5	37.29	21.2295	1.290611	0.0141	0	0.00049726	0.0013035	0
			1.5	37.29	25.3175	1.29047	0.0141	0			0
			2.5	37.29	27.1208	1.289822	0.0141	0			0
			3.5	40.54	28.2067	1.290487	0.0141	0			0
			4.5	41.15	28.9023	1.29047	0.0141	0			0
			5.5	38.57	29.3257	1.288883	0.0141	0			0
			6.5	36.34	29.5301	1.282199	0.0141	0			0
			7.5	34.52	29.5467	1.268755	0.0141	0			0
			8.5	32.94	29.403	1.250389	0.0141	0			0.00125
			9.5	31.52	29.1321	1.230211	0.0141	0.000189			0.00231
			10.5	30.2	28.7758	1.209926	0.0141	0.000904			0.0033
			11.5	29.03	28.3815	1.191846	0.0141	0.001596			0.00433
			12.5	27.95	27.9954	1.174757	0.0141	0.002303			0.00539
			13.5	26.98	27.6549	1.158843	0.0141	0.003011			0.0065
			14.5	26.09	27.3833	1.14316	0.0141	0.003759			0.00762
			15.5	25.29	27.1898	1.128018	0.0141	0.004533			0.00875
			16.5	24.56	27.0723	1.113223	0.0141	0.005342			0.00989
			17.5	23.89	27.0216	1.098963	0.0141	0.006175			0.00905
5	Portland	475	0.5	37.29	18.1391	1.196712	0.0092	0	0.00014022	0.0005316	0
			1.5	37.29	22.2271	1.196712	0.0092	0			0
			2.5	37.29	24.0304	1.196686	0.0092	0			0
			3.5	40.54	25.1163	1.196711	0.0092	0			0
			4.5	41.15	25.8119	1.19671	0.0092	0			0
			5.5	38.57	26.2353	1.196613	0.0092	0			0
			6.5	36.34	26.4397	1.195831	0.0092	0			0
			7.5	34.52	26.4563	1.193338	0.0092	0			0
			8.5	32.94	26.3126	1.188467	0.0092	0			0
			9.5	31.52	26.0417	1.181352	0.0092	0			0
			10.5	30.2	25.6854	1.172347	0.0092	0			0.00182
			11.5	29.03	25.2911	1.162719	0.0092	9.8E-05			0.00123
			12.5	27.95	24.905	1.15217	0.0092	0.00048			0.00258
			13.5	26.98	24.5645	1.141023	0.0092	0.000904			0.00388
			14.5	26.09	24.2929	1.128712	0.0092	0.001399			0.00309
			15.5	25.29	24.0994	1.115518	0.0092	0.001961			0.00425

			16.5	24.56	23.9819	1.10133	0.0092	0.002605			0.00539
			17.5	23.89	23.9312	1.086406	0.0092	0.003331			0.00651
		2475	0.5	37.29	26.504	1.34336	0.0241	0.000597	0.00467667	0.0047642	0
			1.5	37.29	30.592	1.334364	0.0241	0.000891			0
			2.5	37.29	32.3953	1.319781	0.0241	0.001392			0.00148
			3.5	40.54	33.4812	1.335827	0.0241	0.000843			0
			4.5	41.15	34.1768	1.335355	0.0241	0.000858			0
			5.5	38.57	34.6002	1.307837	0.0241	0.001824			0.00276
			6.5	36.34	34.8045	1.263048	0.0241	0.00364			0.00424
			7.5	34.52	34.8212	1.220339	0.0241	0.005708			0.00606
			8.5	32.94	34.6775	1.186357	0.0241	0.007636			0.00833
			9.5	31.52	34.4066	1.160762	0.0241	0.00928			0.01088
			10.5	30.2	34.0503	1.140951	0.0241	0.010682			0.0115
			11.5	29.03	33.656	1.126137	0.0241	0.011811			0.01234
			12.5	27.95	33.2699	1.113755	0.0241	0.012812			0.01319
			13.5	26.98	32.9293	1.103238	0.0241	0.013706			0.01412
			14.5	26.09	32.6577	1.093631	0.0241	0.014559			0.01508
			15.5	25.29	32.4643	1.084899	0.0241	0.015367			0.01608
			16.5	24.56	32.3468	1.076753	0.0241	0.016149			0.0171
			17.5	23.89	32.296	1.069128	0.0241	0.016908			0.01815
		1033	0.5	37.29	22.5676	1.300415	0.0189	0	0.00172442	0.0023365	0
			1.5	37.29	26.6556	1.299886	0.0189	0			0
			2.5	37.29	28.4589	1.298133	0.0189	2.6E-05			0
			3.5	40.54	29.5448	1.299969	0.0189	0			0
			4.5	41.15	30.2404	1.299922	0.0189	0			0
			5.5	38.57	30.6638	1.295963	0.0189	9.44E-05			0
			6.5	36.34	30.8681	1.282882	0.0189	0.00052			0
			7.5	34.52	30.8848	1.26122	0.0189	0.001278			0.00281
			8.5	32.94	30.7411	1.235816	0.0189	0.002258			0.00335
			9.5	31.52	30.4702	1.210969	0.0189	0.003323			0.00588
			10.5	30.2	30.1139	1.188078	0.0189	0.004409			0.00641
			11.5	29.03	29.7196	1.16894	0.0189	0.005402			0.00706
			12.5	27.95	29.3335	1.151706	0.0189	0.006369			0.00796
			13.5	26.98	28.9929	1.136276	0.0189	0.007299			0.00906
			14.5	26.09	28.7213	1.121578	0.0189	0.008246			0.01008
			15.5	25.29	28.5279	1.107805	0.0189	0.009191			0.01123
			16.5	24.56	28.4104	1.094695	0.0189	0.010146			0.01236
			17.5	23.89	28.3596	1.082335	0.0189	0.011099			0.01352
5	SLC	475	0.5	37.29	16.2549	1.154773	0.0076	0	6.944E-05	0.0001592	0
			1.5	37.29	20.343	1.154773	0.0076	0			0
			2.5	37.29	22.1463	1.154773	0.0076	0			0
			3.5	40.54	23.2321	1.154773	0.0076	0			0
			4.5	41.15	23.9278	1.154773	0.0076	0			0
			5.5	38.57	24.3511	1.154766	0.0076	0			0
			6.5	36.34	24.5555	1.154632	0.0076	0			0
			7.5	34.52	24.5721	1.154025	0.0076	0			0
			8.5	32.94	24.4285	1.152526	0.0076	0			0
			9.5	31.52	24.1576	1.149907	0.0076	0			0
			10.5	30.2	23.8012	1.14607	0.0076	0			0
			11.5	29.03	23.4069	1.141445	0.0076	0			0
			12.5	27.95	23.0209	1.135829	0.0076	0.000168			0
			13.5	26.98	22.6803	1.129315	0.0076	0.000409			0.00181
			14.5	26.09	22.4087	1.12146	0.0076	0.00071			0.00138
			15.5	25.29	22.2152	1.112298	0.0076	0.001075			0.00296
			16.5	24.56	22.0977	1.101613	0.0076	0.001521			0.00237
			17.5	23.89	22.047	1.089467	0.0076	0.002056			0.00374

		2475	0.5	37.29	27.4815	1.353543	0.0245	0.000438	0.00508039	0.0046167	0
			1.5	37.29	31.5695	1.338417	0.0245	0.000928			0
			2.5	37.29	33.3728	1.317778	0.0245	0.001645			0.0013
			3.5	40.54	34.4587	1.340779	0.0245	0.000849			0
			4.5	41.15	35.1543	1.340069	0.0245	0.000873			0
			5.5	38.57	35.5777	1.302488	0.0245	0.002215			0.00274
			6.5	36.34	35.782	1.250965	0.0245	0.004415			0.00442
			7.5	34.52	35.7987	1.207335	0.0245	0.006675			0.00644
			8.5	32.94	35.655	1.175022	0.0245	0.008633			0.00895
			9.5	31.52	35.3841	1.15166	0.0245	0.010224			0.00977
			10.5	30.2	35.0278	1.133956	0.0245	0.011541			0.0106
			11.5	29.03	34.6335	1.120817	0.0245	0.012585			0.01171
			12.5	27.95	34.2474	1.109843	0.0245	0.013503			0.01275
			13.5	26.98	33.9068	1.100497	0.0245	0.014321			0.01384
			14.5	26.09	33.6352	1.091926	0.0245	0.015102			0.01494
			15.5	25.29	33.4418	1.084093	0.0245	0.015841			0.01417
			16.5	24.56	33.3242	1.076733	0.0245	0.016559			0.01525
			17.5	23.89	33.2735	1.069781	0.0245	0.01726			0.0164
		1033	0.5	37.29	21.8191	1.304786	0.0177	0	0.00108598	0.0017392	0
			1.5	37.29	25.9072	1.304523	0.0177	0			0
			2.5	37.29	27.7104	1.303491	0.0177	0			0
			3.5	40.54	28.7963	1.30456	0.0177	0			0
			4.5	41.15	29.492	1.304533	0.0177	0			0
			5.5	38.57	29.9153	1.3021	0.0177	0			0
			6.5	36.34	30.1197	1.292896	0.0177	0			0
			7.5	34.52	30.1363	1.275902	0.0177	0.000257			0.00154
			8.5	32.94	29.9926	1.254204	0.0177	0.001001			0.00254
			9.5	31.52	29.7218	1.231582	0.0177	0.001852			0.00347
			10.5	30.2	29.3654	1.20973	0.0177	0.002754			0.00437
			11.5	29.03	28.9711	1.190821	0.0177	0.003606			0.00537
			12.5	27.95	28.5851	1.17335	0.0177	0.004457			0.00641
			13.5	26.98	28.2445	1.15738	0.0177	0.005293			0.0075
			14.5	26.09	27.9729	1.141894	0.0177	0.006162			0.00856
			15.5	25.29	27.7794	1.127155	0.0177	0.007046			0.00967
			16.5	24.56	27.6619	1.112934	0.0177	0.007955			0.01071
			17.5	23.89	27.6112	1.099377	0.0177	0.008878			0.01005
5	San Fran	475	0.5	37.29	25.617	1.337314	0.0226	0.000256	0.003668	0.0035997	0
			1.5	37.29	29.705	1.33201	0.0226	0.000423			0
			2.5	37.29	31.5083	1.321972	0.0226	0.00075			0
			3.5	40.54	32.5942	1.332894	0.0226	0.000395			0
			4.5	41.15	33.2898	1.332586	0.0226	0.000405			0
			5.5	38.57	33.7132	1.312962	0.0226	0.001055			0.0019
			6.5	36.34	33.9176	1.275515	0.0226	0.002445			0.00221
			7.5	34.52	33.9342	1.235389	0.0226	0.004189			0.00425
			8.5	32.94	33.7905	1.200985	0.0226	0.005933			0.00645
			9.5	31.52	33.5196	1.173855	0.0226	0.007497			0.00713
			10.5	30.2	33.1633	1.152276	0.0226	0.008876			0.00991
			11.5	29.03	32.769	1.135906	0.0226	0.010011			0.01097
			12.5	27.95	32.3829	1.122125	0.0226	0.011031			0.01198
			13.5	26.98	32.0424	1.110384	0.0226	0.01195			0.01105
			14.5	26.09	31.7708	1.099643	0.0226	0.012833			0.01227
			15.5	25.29	31.5773	1.08989	0.0226	0.013672			0.01338
			16.5	24.56	31.4598	1.080818	0.0226	0.014486			0.0146
			17.5	23.89	31.4091	1.072374	0.0226	0.015274			0.01581
		2475	0.5	37.29	32.8755	1.354464	0.0333	0.003857	0.01348696	0.0093631	0.0017
			1.5	37.29	36.9635	1.273808	0.0333	0.007824			0.00408

			2.5	37.29	38.7668	1.231502	0.0333	0.010459			0.00634
			3.5	40.54	39.8527	1.282802	0.0333	0.007318			0.00473
			4.5	41.15	40.5483	1.280888	0.0333	0.007424			0.00464
			5.5	38.57	40.9717	1.212308	0.0333	0.011809			0.00779
			6.5	36.34	41.176	1.167562	0.0333	0.015396			0.00918
			7.5	34.52	41.1927	1.14222	0.0333	0.01774			0.01108
			8.5	32.94	41.049	1.126113	0.0333	0.019364			0.0132
			9.5	31.52	40.7781	1.114543	0.0333	0.0206			0.01566
			10.5	30.2	40.4218	1.105189	0.0333	0.021645			0.01615
			11.5	29.03	40.0275	1.097589	0.0333	0.022525			0.01703
			12.5	27.95	39.6414	1.090716	0.0333	0.023346			0.01978
			13.5	26.98	39.3008	1.08446	0.0333	0.024114			0.0206
			14.5	26.09	39.0292	1.078429	0.0333	0.024875			0.02156
			15.5	25.29	38.8358	1.072675	0.0333	0.02562			0.02251
			16.5	24.56	38.7182	1.067064	0.0333	0.026364			0.0235
			17.5	23.89	38.6675	1.06158	0.0333	0.027109			0.02464
		1033	0.5	37.29	29.0055	1.360366	0.0286	0.001737	0.00804798	0.0061015	0
			1.5	37.29	33.0935	1.330758	0.0286	0.002845			0.00133
			2.5	37.29	34.8968	1.300048	0.0286	0.004136			0.00201
			3.5	40.54	35.9827	1.335015	0.0286	0.002678			0.00155
			4.5	41.15	36.6783	1.333854	0.0286	0.002723			0.00147
			5.5	38.57	37.1017	1.280527	0.0286	0.005042			0.00305
			6.5	36.34	37.306	1.2237	0.0286	0.008117			0.00634
			7.5	34.52	37.3227	1.182706	0.0286	0.01082			0.00839
			8.5	32.94	37.179	1.1549	0.0286	0.012933			0.01072
			9.5	31.52	36.9081	1.135619	0.0286	0.01455			0.01127
			10.5	30.2	36.5518	1.121185	0.0286	0.01585			0.01201
			11.5	29.03	36.1575	1.1104	0.0286	0.016875			0.01485
			12.5	27.95	35.7714	1.101273	0.0286	0.017781			0.01564
			13.5	26.98	35.4308	1.093378	0.0286	0.018594			0.01663
			14.5	26.09	35.1592	1.086035	0.0286	0.019376			0.01767
			15.5	25.29	34.9658	1.079226	0.0286	0.020123			0.01874
			16.5	24.56	34.8482	1.072732	0.0286	0.020857			0.01983
			17.5	23.89	34.7975	1.066505	0.0286	0.021581			0.02094
5	San Jose	475	0.5	37.29	23.5872	1.325987	0.0213	0.000107	0.00236865	0.002676	0
			1.5	37.29	27.6753	1.324723	0.0213	0.000146			0
			2.5	37.29	29.4786	1.321287	0.0213	0.000254			0
			3.5	40.54	30.5645	1.324933	0.0213	0.00014			0
			4.5	41.15	31.2601	1.324838	0.0213	0.000142			0
			5.5	38.57	31.6834	1.31748	0.0213	0.000375			0
			6.5	36.34	31.8878	1.297236	0.0213	0.001052			0.00144
			7.5	34.52	31.9045	1.268334	0.0213	0.00212			0.00209
			8.5	32.94	31.7608	1.23804	0.0213	0.003383			0.00456
			9.5	31.52	31.4899	1.210717	0.0213	0.004667			0.00515
			10.5	30.2	31.1336	1.186959	0.0213	0.00591			0.00782
			11.5	29.03	30.7392	1.167882	0.0213	0.007002			0.00873
			12.5	27.95	30.3532	1.1512	0.0213	0.008033			0.00977
			13.5	26.98	30.0126	1.136604	0.0213	0.008999			0.01099
			14.5	26.09	29.741	1.122967	0.0213	0.009958			0.01011
			15.5	25.29	29.5475	1.110396	0.0213	0.010895			0.01132
			16.5	24.56	29.43	1.098591	0.0213	0.011823			0.01249
			17.5	23.89	29.3793	1.087576	0.0213	0.012734			0.01367
		2475	0.5	37.29	29.7975	1.362946	0.0338	0.003729	0.01170142	0.0074297	0
			1.5	37.29	33.8855	1.323528	0.0338	0.005486			0.00273
			2.5	37.29	35.6888	1.288125	0.0338	0.007306			0.00301
			3.5	40.54	36.7747	1.328918	0.0338	0.00523			0.00105

			4.5	41.15	37.4703	1.327515	0.0338	0.005296			0.00295
			5.5	38.57	37.8937	1.26727	0.0338	0.008501			0.00585
			6.5	36.34	38.098	1.210332	0.0338	0.012312			0.00715
			7.5	34.52	38.1147	1.172035	0.0338	0.015412			0.01093
			8.5	32.94	37.971	1.146909	0.0338	0.017727			0.01102
			9.5	31.52	37.7001	1.129656	0.0338	0.019462			0.01339
			10.5	30.2	37.3438	1.116682	0.0338	0.020853			0.01594
			11.5	29.03	36.9495	1.106872	0.0338	0.021956			0.01674
			12.5	27.95	36.5634	1.098467	0.0338	0.022938			0.01748
			13.5	26.98	36.2228	1.091113	0.0338	0.023827			0.01834
			14.5	26.09	35.9512	1.08421	0.0338	0.024687			0.01928
			15.5	25.29	35.7578	1.077755	0.0338	0.025515			0.02029
			16.5	24.56	35.6402	1.071556	0.0338	0.026332			0.02117
			17.5	23.89	35.5895	1.065571	0.0338	0.027142			0.02222
		1033	0.5	37.29	26.5235	1.349187	0.0272	0.001601	0.00607804	0.004808	0
			1.5	37.29	30.6115	1.340054	0.0272	0.001928			0
			2.5	37.29	32.4148	1.325298	0.0272	0.002482			0.00151
			3.5	40.54	33.5007	1.341538	0.0272	0.001874			0
			4.5	41.15	34.1963	1.341059	0.0272	0.001892			0
			5.5	38.57	34.6197	1.313236	0.0272	0.002959			0.00294
			6.5	36.34	34.824	1.268107	0.0272	0.004959			0.00448
			7.5	34.52	34.8407	1.22518	0.0272	0.007228			0.00622
			8.5	32.94	34.697	1.191076	0.0272	0.009336			0.00848
			9.5	31.52	34.4261	1.165414	0.0272	0.011131			0.00907
			10.5	30.2	34.0698	1.145561	0.0272	0.012658			0.01175
			11.5	29.03	33.6755	1.130719	0.0272	0.013887			0.01271
			12.5	27.95	33.2894	1.118315	0.0272	0.014976			0.01364
			13.5	26.98	32.9488	1.107779	0.0272	0.015948			0.01465
			14.5	26.09	32.6772	1.098154	0.0272	0.016875			0.01566
			15.5	25.29	32.4838	1.089406	0.0272	0.017752			0.0167
			16.5	24.56	32.3662	1.081244	0.0272	0.018602			0.01775
			17.5	23.89	32.3155	1.073602	0.0272	0.019425			0.0188
5	Santa Monica	475	0.5	37.29	22.0506	1.305076	0.0181	0	0.00124759	0.0019594	0
			1.5	37.29	26.1386	1.304747	0.0181	0			0
			2.5	37.29	27.9419	1.303523	0.0181	0			0
			3.5	40.54	29.0278	1.304795	0.0181	0			0
			4.5	41.15	29.7234	1.304763	0.0181	0			0
			5.5	38.57	30.1468	1.301918	0.0181	0			0
			6.5	36.34	30.3511	1.291598	0.0181	0			0
			7.5	34.52	30.3678	1.273175	0.0181	0.000527			0.00137
			8.5	32.94	30.2241	1.250266	0.0181	0.001337			0.00229
			9.5	31.52	29.9532	1.226855	0.0181	0.00225			0.00314
			10.5	30.2	29.5969	1.20458	0.0181	0.003206			0.00596
			11.5	29.03	29.2026	1.185516	0.0181	0.0041			0.00687
			12.5	27.95	28.8165	1.168048	0.0181	0.004985			0.00782
			13.5	26.98	28.4759	1.152189	0.0181	0.00585			0.00881
			14.5	26.09	28.2043	1.136899	0.0181	0.006742			0.00984
			15.5	25.29	28.0109	1.122421	0.0181	0.007644			0.01095
			16.5	24.56	27.8934	1.108516	0.0181	0.008567			0.01005
			17.5	23.89	27.8426	1.095309	0.0181	0.009499			0.01128
		2475	0.5	37.29	29.5545	1.361955	0.0301	0.002263	0.00924498	0.0065679	0
			1.5	37.29	33.6425	1.325695	0.0301	0.003698			0.00109
			2.5	37.29	35.4458	1.291657	0.0301	0.005242			0.00354
			3.5	40.54	36.5317	1.330732	0.0301	0.003487			0.00132
			4.5	41.15	37.2273	1.329402	0.0301	0.003542			0.00125
			5.5	38.57	37.6507	1.271139	0.0301	0.006276			0.00458

			6.5	36.34	37.855	1.214062	0.0301	0.009641			0.00603
			7.5	34.52	37.8717	1.174878	0.0301	0.012446			0.00998
			8.5	32.94	37.728	1.14893	0.0301	0.014571			0.01016
			9.5	31.52	37.4571	1.131077	0.0301	0.016173			0.01264
			10.5	30.2	37.1008	1.11768	0.0301	0.017457			0.01327
			11.5	29.03	36.7065	1.107593	0.0301	0.018474			0.01409
			12.5	27.95	36.3204	1.098985	0.0301	0.019377			0.01682
			13.5	26.98	35.9798	1.091481	0.0301	0.020192			0.01776
			14.5	26.09	35.7082	1.084458	0.0301	0.02098			0.01868
			15.5	25.29	35.5148	1.077907	0.0301	0.021736			0.01965
			16.5	24.56	35.3972	1.071628	0.0301	0.022482			0.02064
			17.5	23.89	35.3465	1.065578	0.0301	0.02322			0.02165
		1033	0.5	37.29	25.1965	1.340061	0.0258	0.001392	0.00490955	0.003941	0
			1.5	37.29	29.2845	1.335998	0.0258	0.001535			0
			2.5	37.29	31.0878	1.327723	0.0258	0.001832			0
			3.5	40.54	32.1737	1.336681	0.0258	0.001511			0
			4.5	41.15	32.8693	1.336432	0.0258	0.001519			0
			5.5	38.57	33.2927	1.319966	0.0258	0.002119			0.00167
			6.5	36.34	33.497	1.286068	0.0258	0.003484			0.00386
			7.5	34.52	33.5137	1.247589	0.0258	0.005275			0.00575
			8.5	32.94	33.37	1.213304	0.0258	0.007123			0.00789
			9.5	31.52	33.0991	1.185596	0.0258	0.008821			0.00855
			10.5	30.2	32.7428	1.163212	0.0258	0.010343			0.00926
			11.5	29.03	32.3485	1.146077	0.0258	0.011609			0.01024
			12.5	27.95	31.9624	1.131573	0.0258	0.012756			0.01117
			13.5	26.98	31.6218	1.119173	0.0258	0.013794			0.01216
			14.5	26.09	31.3502	1.107804	0.0258	0.014797			0.01319
			15.5	25.29	31.1568	1.097468	0.0258	0.015753			0.0143
			16.5	24.56	31.0392	1.087854	0.0258	0.016681			0.01529
			17.5	23.89	30.9885	1.078917	0.0258	0.01758			0.01638
5	Seattle	475	0.5	37.29	20.4397	1.27941	0.0151	0	0.00055446	0.0012932	0
			1.5	37.29	24.5277	1.279355	0.0151	0			0
			2.5	37.29	26.331	1.279024	0.0151	0			0
			3.5	40.54	27.4169	1.279358	0.0151	0			0
			4.5	41.15	28.1125	1.279349	0.0151	0			0
			5.5	38.57	28.5359	1.278489	0.0151	0			0
			6.5	36.34	28.7403	1.274286	0.0151	0			0
			7.5	34.52	28.7569	1.264805	0.0151	0			0
			8.5	32.94	28.6132	1.250618	0.0151	0			0.0015
			9.5	31.52	28.3423	1.233873	0.0151	0.000516			0.0027
			10.5	30.2	27.986	1.216064	0.0151	0.001159			0.00377
			11.5	29.03	27.5917	1.199495	0.0151	0.001803			0.00487
			12.5	27.95	27.2056	1.183298	0.0151	0.00248			0.00596
			13.5	26.98	26.8651	1.167789	0.0151	0.003174			0.00507
			14.5	26.09	26.5935	1.152126	0.0151	0.003924			0.00616
			15.5	25.29	26.4	1.136666	0.0151	0.004718			0.00723
			16.5	24.56	26.2825	1.121259	0.0151	0.005566			0.00828
			17.5	23.89	26.2318	1.106146	0.0151	0.006457			0.00932
		2475	0.5	37.29	28.5685	1.359625	0.0282	0.001618	0.00755818	0.0061035	0
			1.5	37.29	32.6565	1.334782	0.0282	0.00253			0.00132
			2.5	37.29	34.4598	1.30689	0.0282	0.003664			0.00201
			3.5	40.54	35.5457	1.338447	0.0282	0.002389			0.00155
			4.5	41.15	36.2413	1.337421	0.0282	0.002428			0.00147
			5.5	38.57	36.6647	1.288378	0.0282	0.004488			0.00304
			6.5	36.34	36.869	1.232344	0.0282	0.007385			0.00639
			7.5	34.52	36.8857	1.190161	0.0282	0.010044			0.00845

			8.5	32.94	36.742	1.160909	0.0282	0.01218			0.01078
			9.5	31.52	36.4711	1.140442	0.0282	0.013838			0.01132
			10.5	30.2	36.1148	1.125107	0.0282	0.015178			0.01201
			11.5	29.03	35.7205	1.113698	0.0282	0.016234			0.01483
			12.5	27.95	35.3344	1.104096	0.0282	0.017164			0.01558
			13.5	26.98	34.9938	1.095835	0.0282	0.017995			0.01656
			14.5	26.09	34.7222	1.088189	0.0282	0.018792			0.01757
			15.5	25.29	34.5288	1.08113	0.0282	0.019551			0.01859
			16.5	24.56	34.4112	1.074428	0.0282	0.020294			0.01963
			17.5	23.89	34.3605	1.068027	0.0282	0.021025			0.02069
		1033	0.5	37.29	24.2488	1.32926	0.0224	0.000437	0.00312358	0.0032622	0
			1.5	37.29	28.3369	1.327167	0.0224	0.000504			0
			2.5	37.29	30.1402	1.322128	0.0224	0.000669			0
			3.5	40.54	31.2261	1.32752	0.0224	0.000493			0
			4.5	41.15	31.9217	1.327376	0.0224	0.000498			0
			5.5	38.57	32.345	1.316918	0.0224	0.000842			0
			6.5	36.34	32.5494	1.291372	0.0224	0.001746			0.00263
			7.5	34.52	32.5661	1.258221	0.0224	0.003068			0.0048
			8.5	32.94	32.4224	1.225805	0.0224	0.004546			0.005
			9.5	31.52	32.1515	1.197939	0.0224	0.005985			0.0075
			10.5	30.2	31.7952	1.174495	0.0224	0.007333			0.00826
			11.5	29.03	31.4009	1.15608	0.0224	0.008491			0.00927
			12.5	27.95	31.0148	1.140226	0.0224	0.009564			0.01025
			13.5	26.98	30.6742	1.126511	0.0224	0.010553			0.0113
			14.5	26.09	30.4026	1.113821	0.0224	0.011522			0.01243
			15.5	25.29	30.2092	1.10221	0.0224	0.012458			0.01349
			16.5	24.56	30.0916	1.091368	0.0224	0.013376			0.01467
			17.5	23.89	30.0409	1.081287	0.0224	0.014271			0.01579

Table A- 8 Ishihara and Yoshimine Volumetric Strain Model Supplementary Validation Data

Soil Profile					Simplified Procedure					Full PBEE	
Profile	Location	T_R	Sample Depth [m]	$(N_1)_{60,CS}^{site}$	CSR^{site}	$\Delta\varepsilon$	ε_v^{ref}	ε_v^{site}	$\varepsilon_{v,equiv}$	$\varepsilon_{v,equiv}$	ε_v^{site}
1	Butte	475	2.5	11.53	0.0704	1	0	2.36E-18	2.3599E-18	0	0
			3.5	15.64	0.0798	1	0	2.36E-18			0
			4.5	18.75	0.086	1	0	2.36E-18			0
			5.5	18.45	0.0906	1	0	2.36E-18			0
			6.5	20.69	0.0933	1	0	2.36E-18			0
			7.5	20.8	0.0952	1	0	2.36E-18			0
			8.5	25.92	0.0962	1	0	2.36E-18			0
			9.5	24.26	0.0967	1	0	2.36E-18			0
			10.5	30.55	0.0976	1	0	2.36E-18			0
			11.5	33.75	0.0985	1	0	2.36E-18			0
		2475	2.5	11.53	0.12532	0.976904	0	0.000784	0.00016665	0.0002379	0.00169
			3.5	15.64	0.14204	0.991704	0	0.000267			0
			4.5	18.75	0.15304	1.000391	0	0			0
			5.5	18.45	0.1612	0.994223	0	0.000185			0
			6.5	20.69	0.1661	1.002122	0	0			0
			7.5	20.8	0.16946	1.001383	0	0			0
			8.5	25.92	0.17135	1.006927	0	0			0
			9.5	24.26	0.17223	1.006654	0	0			0
			10.5	30.55	0.17388	1.006927	0	0			0
			11.5	33.75	0.17558	1.006927	0	0			0
		1033	2.5	11.53	0.09577	0.998254	0	5.5E-05	1.2986E-05	0	0
			3.5	15.64	0.10853	0.999358	0	2.01E-05			0
			4.5	18.75	0.11692	0.999877	0	3.85E-06			0
			5.5	18.45	0.12314	0.999522	0	1.5E-05			0
			6.5	20.69	0.12685	0.999949	0	1.59E-06			0
			7.5	20.8	0.1294	0.999921	0	2.47E-06			0
			8.5	25.92	0.13082	1	0	2.36E-18			0
			9.5	24.26	0.13146	1	0	2.36E-18			0
			10.5	30.55	0.1327	1	0	2.36E-18			0
			11.5	33.75	0.13397	1	0	2.36E-18			0
1	Charleston	475	2.5	11.53	0.11133	0.991561	0	0.000272	6.983E-05	0	0
			3.5	15.64	0.12666	0.996394	0	0.000114			0
			4.5	18.75	0.13703	0.999366	0	1.99E-05			0
			5.5	18.45	0.14499	0.996844	0	9.99E-05			0
			6.5	20.69	0.15011	0.99977	0	7.22E-06			0
			7.5	20.8	0.15393	0.999379	0	1.95E-05			0
			8.5	25.92	0.15648	1.001177	0	0			0
			9.5	24.26	0.15815	1.00116	0	0			0
			10.5	30.55	0.16058	1.001177	0	0			0
			11.5	33.75	0.16309	1.001177	0	0			0
		2475	2.5	11.53	0.38562	0.930521	0.024	0.035168	0.02078472	0.020756	0.036
			3.5	15.64	0.43986	0.977171	0.024	0.027178			0.02797
			4.5	18.75	0.47725	1.007352	0.024	0.022798			0.02261
			5.5	18.45	0.50656	1.004339	0.024	0.023209			0.02333
			6.5	20.69	0.5262	1.024277	0.024	0.020591			0.0208
			7.5	20.8	0.5415	1.025069	0.024	0.020492			0.02061
			8.5	25.92	0.55253	1.076778	0.024	0.014768			0.01244

			9.5	24.26	0.56057	1.055126	0.024	0.016993			0.01566
			10.5	30.55	0.57142	1.300478	0.024	0.001672			0.00213
			11.5	33.75	0.58269	1.373545	0.024	0			0
		1033	2.5	11.53	0.21945	0.938813	0.0148	0.020255	0.00803964	0.0101237	0.02047
			3.5	15.64	0.2501	0.998241	0.0148	0.01334			0.0158
			4.5	18.75	0.2711	1.049711	0.0148	0.008899			0.0103
			5.5	18.45	0.28745	1.026647	0.0148	0.010735			0.01222
			6.5	20.69	0.29826	1.10785	0.0148	0.005191			0.00968
			7.5	20.8	0.30657	1.093532	0.0148	0.005996			0.00929
			8.5	25.92	0.31243	1.311244	0.0148	0			0.00294
			9.5	24.26	0.31657	1.248661	0.0148	0			0.00454
			10.5	30.55	0.32227	1.361041	0.0148	0			0
			11.5	33.75	0.32819	1.361289	0.0148	0			0
1	Eureka	475	2.5	11.53	0.3882	0.930517	0.0249	0.036504	0.0217792	0.0197741	0.03389
			3.5	15.64	0.4437	0.977154	0.0249	0.02834			0.02691
			4.5	18.75	0.4826	1.007294	0.0249	0.023852			0.02135
			5.5	18.45	0.5136	1.004309	0.0249	0.02427			0.02227
			6.5	20.69	0.535	1.02418	0.0249	0.021588			0.01947
			7.5	20.8	0.5522	1.024979	0.0249	0.021485			0.0193
			8.5	25.92	0.5653	1.075003	0.0249	0.015753			0.01257
			9.5	24.26	0.5754	1.054412	0.0249	0.01795			0.01401
			10.5	30.55	0.5885	1.290198	0.0249	0.002334			0.00374
			11.5	33.75	0.6021	1.372944	0.0249	0			0
		2475	2.5	11.53	0.9252	0.930467	0.0364	0.053701	0.0357747	0.0324897	0.05073
			3.5	15.64	1.0585	0.976992	0.0364	0.043864			0.04056
			4.5	18.75	1.1523	1.006857	0.0364	0.03819			0.03443
			5.5	18.45	1.2274	1.004139	0.0364	0.038684			0.03563
			6.5	20.69	1.28	1.0237	0.0364	0.035225			0.03134
			7.5	20.8	1.3226	1.024619	0.0364	0.035068			0.03142
			8.5	25.92	1.3553	1.065498	0.0364	0.028596			0.02324
			9.5	24.26	1.3811	1.051768	0.0364	0.030661			0.02659
			10.5	30.55	1.4143	1.192662	0.0364	0.014099			0.01482
			11.5	33.75	1.4489	1.267362	0.0364	0.008673			0.0063
		1033	2.5	11.53	0.62637	0.930467	0.0315	0.046436	0.02979371	0.0268497	0.0435
			3.5	15.64	0.71639	0.976992	0.0315	0.037177			0.03433
			4.5	18.75	0.77957	1.006857	0.0315	0.031965			0.02953
			5.5	18.45	0.83011	1.004139	0.0315	0.032416			0.02893
			6.5	20.69	0.86526	1.023701	0.0315	0.029275			0.02617
			7.5	20.8	0.89366	1.024619	0.0315	0.029133			0.02628
			8.5	25.92	0.91532	1.065563	0.0315	0.023331			0.01815
			9.5	24.26	0.93231	1.051775	0.0315	0.025176			0.02139
			10.5	30.55	0.95422	1.198528	0.0315	0.010306			0.00979
			11.5	33.75	0.97706	1.313213	0.0315	0.004042			0.00256
1	Memphis	475	2.5	11.53	0.12653	0.974325	0	0.000879	0.00021386	0	0
			3.5	15.64	0.14431	0.989517	0	0.00034			0
			4.5	18.75	0.15655	0.99885	0	3.62E-05			0
			5.5	18.45	0.16614	0.990467	0	0.000309			0
			6.5	20.69	0.17256	0.999926	0	2.31E-06			0
			7.5	20.8	0.17754	0.998219	0	5.61E-05			0
			8.5	25.92	0.18112	1.007062	0	0			0
			9.5	24.26	0.18372	1.006259	0	0			0
			10.5	30.55	0.18724	1.007078	0	0			0
			11.5	33.75	0.19089	1.007078	0	0			0
		2475	2.5	11.53	0.35136	0.930646	0.0252	0.036952	0.02171207	0.0215159	0.03676
			3.5	15.64	0.40142	0.977517	0.0252	0.028694			0.0285
			4.5	18.75	0.43631	1.008152	0.0252	0.024104			0.02353

			5.5	18.45	0.464	1.004695	0.0252	0.024592			0.02419
			6.5	20.69	0.48299	1.025125	0.0252	0.021816			0.02167
			7.5	20.8	0.49811	1.025728	0.0252	0.021738			0.02143
			8.5	25.92	0.50941	1.10447	0.0252	0.013224			0.0138
			9.5	24.26	0.51805	1.058364	0.0252	0.01782			0.01667
			10.5	30.55	0.52937	1.324315	0.0252	0.001354			0.00223
			11.5	33.75	0.54115	1.374282	0.0252	4.93E-05			0
		1033	2.5	11.53	0.2324	0.935179	0.0157	0.022059	0.00983784	0.0118566	0.02246
			3.5	15.64	0.26543	0.990969	0.0157	0.015109			0.01613
			4.5	18.75	0.2884	1.03447	0.0157	0.010941			0.01374
			5.5	18.45	0.30657	1.018441	0.0157	0.012365			0.01457
			6.5	20.69	0.31898	1.056179	0.0157	0.0092			0.01114
			7.5	20.8	0.32882	1.049023	0.0157	0.009751			0.01272
			8.5	25.92	0.33612	1.289401	0.0157	0			0.00382
			9.5	24.26	0.34165	1.213278	0.0157	0.001259			0.00665
			10.5	30.55	0.34894	1.363665	0.0157	0			0
			11.5	33.75	0.35652	1.364682	0.0157	0			0
1	Portland	475	2.5	11.53	0.18889	0.85374	0.0072	0.020261	0.0061792	0.0068744	0.01758
			3.5	15.64	0.21581	0.915694	0.0072	0.012503			0.01057
			4.5	18.75	0.23457	1.045697	0.0072	0.003169			0.00662
			5.5	18.45	0.24945	0.981705	0.0072	0.006851			0.0081
			6.5	20.69	0.25966	1.066047	0.0072	0.002271			0.00532
			7.5	20.8	0.26779	1.052836	0.0072	0.002841			0.00668
			8.5	25.92	0.27387	1.185236	0.0072	0			0
			9.5	24.26	0.27851	1.150365	0.0072	0			0.00101
			10.5	30.55	0.28459	1.202662	0.0072	0			0
			11.5	33.75	0.29093	1.202662	0.0072	0			0
		2475	2.5	11.53	0.33616	0.93075	0.0296	0.043514	0.02624585	0.0253137	0.0423
			3.5	15.64	0.38424	0.977815	0.0296	0.034453			0.03365
			4.5	18.75	0.41785	1.008822	0.0296	0.029282			0.02728
			5.5	18.45	0.44462	1.004998	0.0296	0.029886			0.02996
			6.5	20.69	0.46309	1.025828	0.0296	0.026706			0.02572
			7.5	20.8	0.4779	1.026279	0.0296	0.02664			0.02536
			8.5	25.92	0.48906	1.123313	0.0296	0.015101			0.0154
			9.5	24.26	0.4977	1.0608	0.0296	0.021956			0.01963
			10.5	30.55	0.50893	1.334644	0.0296	0.002515			0.00307
			11.5	33.75	0.52063	1.374416	0.0296	0.001281			0
		1033	2.5	11.53	0.25579	0.932084	0.0205	0.029554	0.01484601	0.0169453	0.03151
			3.5	15.64	0.29234	0.983728	0.0205	0.021694			0.02334
			4.5	18.75	0.31786	1.021843	0.0205	0.017006			0.01824
			5.5	18.45	0.33817	1.011006	0.0205	0.018251			0.0205
			6.5	20.69	0.35216	1.039562	0.0205	0.015109			0.01608
			7.5	20.8	0.36335	1.037402	0.0205	0.015332			0.01761
			8.5	25.92	0.37177	1.250932	0.0205	0.00196			0.0074
			9.5	24.26	0.37826	1.162135	0.0205	0.005804			0.01112
			10.5	30.55	0.38672	1.36537	0.0205	0			0
			11.5	33.75	0.39553	1.369222	0.0205	0			0
1	SLC	475	2.5	11.53	0.1656	0.817047	0.0049	0.021514	0.00488151	0.0033768	0.0091
			3.5	15.64	0.18858	0.970165	0.0049	0.005403			0.00582
			4.5	18.75	0.20423	1.030802	0.0049	0.002243			0.00225
			5.5	18.45	0.21634	0.994205	0.0049	0.004003			0.00469
			6.5	20.69	0.22424	1.041274	0.0049	0.00181			0.00273
			7.5	20.8	0.23024	1.034256	0.0049	0.002097			0.00243
			8.5	25.92	0.23437	1.098245	0.0049	0			0
			9.5	24.26	0.2372	1.086409	0.0049	0.000239			0
			10.5	30.55	0.24118	1.101812	0.0049	0			0

			11.5	33.75	0.2453	1.101812	0.0049	0			0
		2475	2.5	11.53	0.36081	0.930594	0.0271	0.03973	0.02376167	0.0236852	0.04072
			3.5	15.64	0.41129	0.97739	0.0271	0.03114			0.03171
			4.5	18.75	0.44591	1.007891	0.0271	0.026338			0.02552
			5.5	18.45	0.47292	1.004588	0.0271	0.026829			0.02797
			6.5	20.69	0.49084	1.02491	0.0271	0.023916			0.02387
			7.5	20.8	0.50465	1.025588	0.0271	0.023824			0.02359
			8.5	25.92	0.51444	1.099995	0.0271	0.015193			0.01337
			9.5	24.26	0.52141	1.058027	0.0271	0.019697			0.01792
			10.5	30.55	0.53097	1.323466	0.0271	0.002			0.0025
			11.5	33.75	0.54088	1.374288	0.0271	0.00055			0
		1033	2.5	11.53	0.24226	0.935731	0.0184	0.025879	0.01213972	0.0143017	0.02723
			3.5	15.64	0.27604	0.989942	0.0184	0.018366			0.02037
			4.5	18.75	0.29915	1.031667	0.0184	0.013817			0.01505
			5.5	18.45	0.31711	1.018096	0.0184	0.015192			0.01727
			6.5	20.69	0.32896	1.05101	0.0184	0.012019			0.01458
			7.5	20.8	0.33803	1.048279	0.0184	0.012262			0.01449
			8.5	25.92	0.34439	1.284986	0.0184	0.000208			0.00466
			9.5	24.26	0.34885	1.207038	0.0184	0.002653			0.00854
			10.5	30.55	0.35503	1.368828	0.0184	0			0
			11.5	33.75	0.36144	1.370141	0.0184	0			0
1	San Fran	475	2.5	11.53	0.30901	0.931174	0.0255	0.037295	0.02130471	0.0206609	0.0359
			3.5	15.64	0.3532	0.978902	0.0255	0.02886			0.02752
			4.5	18.75	0.3841	1.01109	0.0255	0.024043			0.02232
			5.5	18.45	0.40871	1.006119	0.0255	0.024744			0.025
			6.5	20.69	0.42569	1.028238	0.0255	0.021742			0.02049
			7.5	20.8	0.4393	1.028236	0.0255	0.021743			0.02025
			8.5	25.92	0.44956	1.16349	0.0255	0.008862			0.01138
			9.5	24.26	0.4575	1.068369	0.0255	0.017017			0.0158
			10.5	30.55	0.46782	1.351905	0.0255	0.00068			0.00171
			11.5	33.75	0.47858	1.374398	0.0255	0.000125			0
		2475	2.5	11.53	0.51425	0.930467	0.0379	0.05589	0.03719463	0.0316771	0.05031
			3.5	15.64	0.58832	0.976995	0.0379	0.045924			0.04014
			4.5	18.75	0.6404	1.006868	0.0379	0.040128			0.03407
			5.5	18.45	0.68213	1.004142	0.0379	0.040635			0.03521
			6.5	20.69	0.71126	1.023712	0.0379	0.037087			0.03109
			7.5	20.8	0.73487	1.024627	0.0379	0.036927			0.03104
			8.5	25.92	0.75297	1.066179	0.0379	0.03016			0.02382
			9.5	24.26	0.76725	1.05188	0.0379	0.032376			0.02661
			10.5	30.55	0.78559	1.214645	0.0379	0.013321			0.01031
			11.5	33.75	0.80473	1.347954	0.0379	0.005182			0.00143
		1033	2.5	11.53	0.39147	0.930511	0.0325	0.048043	0.03041742	0.0273664	0.04444
			3.5	15.64	0.44767	0.977137	0.0325	0.038619			0.03553
			4.5	18.75	0.48708	1.00725	0.0325	0.033257			0.03085
			5.5	18.45	0.51857	1.004289	0.0325	0.033759			0.03175
			6.5	20.69	0.54044	1.024127	0.0325	0.030502			0.02751
			7.5	20.8	0.55808	1.024937	0.0325	0.030374			0.02771
			8.5	25.92	0.5715	1.074241	0.0325	0.023327			0.01696
			9.5	24.26	0.58199	1.054145	0.0325	0.026029			0.02138
			10.5	30.55	0.59555	1.285906	0.0325	0.005733			0.00571
			11.5	33.75	0.60967	1.372653	0.0325	0.002273			0
1	San Jose	475	2.5	11.53	0.27563	0.932687	0.0257	0.037223	0.0200339	0.0194827	0.0346
			3.5	15.64	0.31368	0.982523	0.0257	0.028475			0.02639
			4.5	18.75	0.33949	1.018251	0.0257	0.023229			0.02133
			5.5	18.45	0.35936	1.010345	0.0257	0.02432			0.02383
			6.5	20.69	0.37221	1.036765	0.0257	0.020821			0.01966

			7.5	20.8	0.38185	1.035918	0.0257	0.020927			0.0194
			8.5	25.92	0.38837	1.234667	0.0257	0.004912			0.00975
			9.5	24.26	0.3927	1.1454	0.0257	0.010237			0.01365
			10.5	30.55	0.39893	1.368489	0.0257	0.000306			0
			11.5	33.75	0.40538	1.373918	0.0257	0.000176			0
		2475	2.5	11.53	0.42143	0.930482	0.0379	0.055973	0.0367947	0.0313626	0.05048
			3.5	15.64	0.47961	0.977051	0.0379	0.045995			0.04042
			4.5	18.75	0.51907	1.007041	0.0379	0.040173			0.0345
			5.5	18.45	0.54945	1.004211	0.0379	0.040701			0.03555
			6.5	20.69	0.5691	1.023934	0.0379	0.037123			0.03146
			7.5	20.8	0.58384	1.024804	0.0379	0.036971			0.03154
			8.5	25.92	0.5938	1.071952	0.0379	0.029365			0.02146
			9.5	24.26	0.60043	1.053529	0.0379	0.032184			0.02565
			10.5	30.55	0.60996	1.277081	0.0379	0.008929			0.00752
			11.5	33.75	0.61981	1.37221	0.0379	0.004187			0
		1033	2.5	11.53	0.33715	0.930758	0.0326	0.048149	0.02951814	0.026139	0.04474
			3.5	15.64	0.38373	0.977848	0.0326	0.038631			0.03404
			4.5	18.75	0.41533	1.008965	0.0326	0.033103			0.02961
			5.5	18.45	0.43967	1.005133	0.0326	0.033751			0.03062
			6.5	20.69	0.45543	1.026223	0.0326	0.0303			0.02641
			7.5	20.8	0.46727	1.026719	0.0326	0.030222			0.0264
			8.5	25.92	0.47529	1.136821	0.0326	0.016356			0.0152
			9.5	24.26	0.48065	1.063548	0.0326	0.024851			0.01903
			10.5	30.55	0.48832	1.34403	0.0326	0.0033			0.00249
			11.5	33.75	0.49626	1.374556	0.0326	0.002247			0
1	Santa Monica	475	2.5	11.53	0.24619	0.934663	0.0213	0.030356	0.01486946	0.016896	0.03181
			3.5	15.64	0.28033	0.988205	0.0213	0.022124			0.02352
			4.5	18.75	0.30358	1.029142	0.0213	0.017081			0.01869
			5.5	18.45	0.32155	1.016448	0.0213	0.018539			0.02091
			6.5	20.69	0.33328	1.04862	0.0213	0.015013			0.01673
			7.5	20.8	0.34216	1.046248	0.0213	0.015255			0.01636
			8.5	25.92	0.34826	1.280341	0.0213	0.001331			0.00587
			9.5	24.26	0.35243	1.2015	0.0213	0.004297			0.01071
			10.5	30.55	0.35831	1.368576	0.0213	0			0
			11.5	33.75	0.36439	1.370068	0.0213	0			0
		2475	2.5	11.53	0.41621	0.930485	0.0355	0.052374	0.03388735	0.0303704	0.04966
			3.5	15.64	0.47424	0.977061	0.0355	0.042617			0.03956
			4.5	18.75	0.51394	1.007065	0.0355	0.036997			0.03395
			5.5	18.45	0.5448	1.004219	0.0355	0.037506			0.03474
			6.5	20.69	0.56515	1.023954	0.0355	0.034073			0.03072
			7.5	20.8	0.58074	1.024817	0.0355	0.033929			0.03094
			8.5	25.92	0.59166	1.072144	0.0355	0.026668			0.01964
			9.5	24.26	0.59933	1.053561	0.0355	0.029363			0.02353
			10.5	30.55	0.60995	1.277086	0.0355	0.007625			0.00536
			11.5	33.75	0.62095	1.372155	0.0355	0.003286			0
		1033	2.5	11.53	0.30594	0.931317	0.0291	0.04265	0.0247921	0.0240348	0.04121
			3.5	15.64	0.34848	0.979237	0.0291	0.033538			0.03243
			4.5	18.75	0.37752	1.01185	0.0291	0.028207			0.0264
			5.5	18.45	0.40003	1.006653	0.0291	0.02901			0.02877
			6.5	20.69	0.41479	1.029447	0.0291	0.025611			0.02483
			7.5	20.8	0.42604	1.029447	0.0291	0.025611			0.02452
			8.5	25.92	0.43385	1.180968	0.0291	0.009994			0.01194
			9.5	24.26	0.43925	1.084288	0.0291	0.018678			0.0177
			10.5	30.55	0.44681	1.358796	0.0291	0.00158			0.00161
			11.5	33.75	0.45463	1.374469	0.0291	0.001132			0
1	Seattle	475	2.5	11.53	0.22259	0.934767	0.0177	0.025043	0.01067121	0.013356	0.0266

			3.5	15.64	0.25347	0.993271	0.0177	0.017178			0.01996
			4.5	18.75	0.27451	1.040434	0.0177	0.012332			0.01452
			5.5	18.45	0.29078	1.021877	0.0177	0.014098			0.01659
			6.5	20.69	0.30141	1.09684	0.0177	0.007915			0.01208
			7.5	20.8	0.30947	1.083348	0.0177	0.008853			0.01376
			8.5	25.92	0.31502	1.305374	0.0177	0			0.00231
			9.5	24.26	0.31882	1.242087	0.0177	0.001165			0.00691
			10.5	30.55	0.32418	1.357554	0.0177	0			0
			11.5	33.75	0.32972	1.357834	0.0177	0			0
		2475	2.5	11.53	0.39313	0.930509	0.0336	0.049589	0.03155366	0.0286644	0.04774
			3.5	15.64	0.44806	0.977135	0.0336	0.040033			0.03773
			4.5	18.75	0.48571	1.007263	0.0336	0.034566			0.03188
			5.5	18.45	0.51505	1.004303	0.0336	0.035078			0.0325
			6.5	20.69	0.53447	1.024185	0.0336	0.031744			0.02866
			7.5	20.8	0.54941	1.025	0.0336	0.031612			0.02882
			8.5	25.92	0.55996	1.07571	0.0336	0.024206			0.01883
			9.5	24.26	0.56744	1.054775	0.0336	0.027083			0.02118
			10.5	30.55	0.57773	1.29671	0.0336	0.005688			0.00511
			11.5	33.75	0.58839	1.37339	0.0336	0.002594			0
		1033	2.5	11.53	0.28969	0.931822	0.0265	0.038709	0.02153649	0.0216914	0.03861
			3.5	15.64	0.33003	0.980551	0.0265	0.029936			0.0297
			4.5	18.75	0.35761	1.014502	0.0265	0.024768			0.02343
			5.5	18.45	0.37902	1.008081	0.0265	0.025689			0.02564
			6.5	20.69	0.39312	1.032384	0.0265	0.022337			0.0218
			7.5	20.8	0.40388	1.031958	0.0265	0.022393			0.02148
			8.5	25.92	0.4114	1.206849	0.0265	0.006808			0.01171
			9.5	24.26	0.41665	1.112949	0.0265	0.013551			0.014
			10.5	30.55	0.42395	1.364264	0.0265	0.000658			0.00184
			11.5	33.75	0.43151	1.374162	0.0265	0.000409			0
2	Butte	475	2.5	13.78	0.074	1	0	2.36E-18	2.3599E-18	0	0
			3.5	15.62	0.077	1	0	2.36E-18			0
			4.5	16.95	0.084	1	0	2.36E-18			0
			5.5	19.87	0.088	1	0	2.36E-18			0
			6.5	21.47	0.09	1	0	2.36E-18			0
			7.5	23.12	0.092	1	0	2.36E-18			0
			8.5	24.83	0.093	1	0	2.36E-18			0
			9.5	27.79	0.094	1	0	2.36E-18			0
			10.5	29.76	0.094	1	0	2.36E-18			0
			11.5	31.81	0.095	1	0	2.36E-18			0
		2475	2.5	13.78	0.123	0.997796	0	6.96E-05	7.0678E-05	0	0
			3.5	15.62	0.14	0.993482	0	0.000209			0
			4.5	16.95	0.152	0.991571	0	0.000272			0
			5.5	19.87	0.159	1.001881	0	0			0
			6.5	21.47	0.164	1.004534	0	0			0
			7.5	23.12	0.167	1.006244	0	0			0
			8.5	24.83	0.169	1.006874	0	0			0
			9.5	27.79	0.17	1.006927	0	0			0
			10.5	29.76	0.171	1.006927	0	0			0
			11.5	31.81	0.172	1.006927	0	0			0
		1033	2.5	13.78	0.093	0.999782	0	6.83E-06	5.1158E-06	0	0
			3.5	15.62	0.106	0.999555	0	1.4E-05			0
			4.5	16.95	0.115	0.999435	0	1.77E-05			0
			5.5	19.87	0.12	0.999962	0	1.2E-06			0
			6.5	21.47	0.124	1	0	2.36E-18			0
			7.5	23.12	0.126	1	0	2.36E-18			0
			8.5	24.83	0.128	1	0	2.36E-18			0

			9.5	27.79	0.129	1	0	2.36E-18			0
			10.5	29.76	0.129	1	0	2.36E-18			0
			11.5	31.81	0.13	1	0	2.36E-18			0
2	Charleston	475	2.5	13.78	0.109	0.998818	0	3.72E-05	3.017E-05	0	0
			3.5	15.62	0.124	0.99737	0	8.31E-05			0
			4.5	16.95	0.135	0.99649	0	0.000111			0
			5.5	19.87	0.142	0.99991	0	2.81E-06			0
			6.5	21.47	0.147	1.000673	0	0			0
			7.5	23.12	0.151	1.001089	0	0			0
			8.5	24.83	0.154	1.001177	0	0			0
			9.5	27.79	0.156	1.001177	0	0			0
			10.5	29.76	0.158	1.001177	0	0			0
			11.5	31.81	0.159	1.001177	0	0			0
		2475	2.5	13.78	0.401	0.957261	0.024	0.030401	0.01965701	0.019439	0.02986
			3.5	15.62	0.461	0.976884	0.024	0.027223			0.02791
			4.5	16.95	0.502	0.990124	0.024	0.025226			0.02542
			5.5	19.87	0.529	1.017043	0.024	0.021513			0.02179
			6.5	21.47	0.551	1.030724	0.024	0.019795			0.01998
			7.5	23.12	0.567	1.044549	0.024	0.018168			0.01633
			8.5	24.83	0.579	1.059668	0.024	0.016507			0.0147
			9.5	27.79	0.589	1.14267	0.024	0.009288			0.00804
			10.5	29.76	0.598	1.241567	0.024	0.003831			0.00464
			11.5	31.81	0.606	1.337602	0.024	0.000609			0.00173
		1033	2.5	13.78	0.223	0.982116	0.0148	0.015006	0.0068497	0.0086592	0.01553
			3.5	15.62	0.255	0.994368	0.0148	0.013727			0.01576
			4.5	16.95	0.278	1.004678	0.0148	0.012714			0.01464
			5.5	19.87	0.293	1.065489	0.0148	0.007772			0.00911
			6.5	21.47	0.304	1.140414	0.0148	0.003583			0.00713
			7.5	23.12	0.313	1.205384	0.0148	0.001129			0.00534
			8.5	24.83	0.319	1.267475	0.0148	0			0.00356
			9.5	27.79	0.324	1.343862	0.0148	0			0
			10.5	29.76	0.328	1.359461	0.0148	0			0
			11.5	31.81	0.333	1.361289	0.0148	0			0
2	Eureka	475	2.5	13.78	0.404	0.957247	0.0249	0.031638	0.02067058	0.0186401	0.02711
			3.5	15.62	0.465	0.976874	0.0249	0.028385			0.02687
			4.5	16.95	0.508	0.990113	0.0249	0.026338			0.02434
			5.5	19.87	0.537	1.016993	0.0249	0.02253			0.02049
			6.5	21.47	0.56	1.030628	0.0249	0.020769			0.01856
			7.5	23.12	0.578	1.044305	0.0249	0.019109			0.01668
			8.5	24.83	0.592	1.058993	0.0249	0.017442			0.01492
			9.5	27.79	0.605	1.139264	0.0249	0.010155			0.00994
			10.5	29.76	0.616	1.229563	0.0249	0.004784			0.00427
			11.5	31.81	0.627	1.329255	0.0249	0.00111			0.00135
		2475	2.5	13.78	0.993	0.957095	0.0364	0.047931	0.03439393	0.0310811	0.04316
			3.5	15.62	1.143	0.976787	0.0364	0.043905			0.04055
			4.5	16.95	1.249	0.990045	0.0364	0.041319			0.03703
			5.5	19.87	1.323	1.016731	0.0364	0.036431			0.03201
			6.5	21.47	1.381	1.030137	0.0364	0.034137			0.03072
			7.5	23.12	1.426	1.04318	0.0364	0.032008			0.02715
			8.5	24.83	1.463	1.05594	0.0364	0.030022			0.02573
			9.5	27.79	1.495	1.120822	0.0364	0.021329			0.02082
			10.5	29.76	1.525	1.173313	0.0364	0.015829			0.01691
			11.5	31.81	1.554	1.221286	0.0364	0.0118			0.01161
		1033	2.5	13.78	0.663	0.957095	0.0315	0.040969	0.02861684	0.0257079	0.03749
			3.5	15.62	0.763	0.976787	0.0315	0.037215			0.03431
			4.5	16.95	0.834	0.990045	0.0315	0.034829			0.03228

			5.5	19.87	0.883	1.016731	0.0315	0.030366			0.02712
			6.5	21.47	0.921	1.030138	0.0315	0.028293			0.02553
			7.5	23.12	0.951	1.043181	0.0315	0.026381			0.02383
			8.5	24.83	0.975	1.055948	0.0315	0.024606			0.02047
			9.5	27.79	0.996	1.121013	0.0315	0.016934			0.01401
			10.5	29.76	1.015	1.174845	0.0315	0.012084			0.01011
			11.5	31.81	1.034	1.231915	0.0315	0.008116			0.00635
2	Memphis	475	2.5	13.78	0.124	0.997173	0	8.94E-05	9.221E-05	0	0
			3.5	15.62	0.142	0.991754	0	0.000266			0
			4.5	16.95	0.155	0.988839	0	0.000363			0
			5.5	19.87	0.164	1.000103	0	0			0
			6.5	21.47	0.17	1.003423	0	0			0
			7.5	23.12	0.175	1.00573	0	0			0
			8.5	24.83	0.179	1.006837	0	0			0
			9.5	27.79	0.182	1.007078	0	0			0
			10.5	29.76	0.185	1.007078	0	0			0
			11.5	31.81	0.187	1.007078	0	0			0
		2475	2.5	13.78	0.365	0.9576	0.0252	0.032015	0.02053796	0.0202722	0.03061
			3.5	15.62	0.419	0.977099	0.0252	0.028761			0.02846
			4.5	16.95	0.457	0.9903	0.0252	0.026704			0.02629
			5.5	19.87	0.484	1.017573	0.0252	0.022812			0.02269
			6.5	21.47	0.504	1.031635	0.0252	0.020984			0.02089
			7.5	23.12	0.52	1.046317	0.0252	0.019198			0.0174
			8.5	24.83	0.532	1.063526	0.0252	0.017254			0.016
			9.5	27.79	0.542	1.176242	0.0252	0.007849			0.00971
			10.5	29.76	0.552	1.273413	0.0252	0.003066			0.00461
			11.5	31.81	0.561	1.35272	0.0252	0.000573			0.00189
		1033	2.5	13.78	0.236	0.974286	0.0157	0.016982	0.0083923	0.0101623	0.01736
			3.5	15.62	0.271	0.987869	0.0157	0.015445			0.01608
			4.5	16.95	0.296	0.998794	0.0157	0.014286			0.01493
			5.5	19.87	0.313	1.040368	0.0157	0.010448			0.01263
			6.5	21.47	0.326	1.093373	0.0157	0.006658			0.01082
			7.5	23.12	0.336	1.167282	0.0157	0.002922			0.0074
			8.5	24.83	0.343	1.236932	0.0157	0.000554			0.00407
			9.5	27.79	0.35	1.333308	0.0157	0			0.00183
			10.5	29.76	0.356	1.359812	0.0157	0			0
			11.5	31.81	0.362	1.364657	0.0157	0			0
2	Portland	475	2.5	13.78	0.189	0.910193	0.0072	0.013084	0.00545391	0.0054327	0.00941
			3.5	15.62	0.217	0.913603	0.0072	0.012722			0.01048
			4.5	16.95	0.237	0.9196	0.0072	0.012102			0.01061
			5.5	19.87	0.25	1.054338	0.0072	0.002774			0.00503
			6.5	21.47	0.261	1.092705	0.0072	0.001251			0.00465
			7.5	23.12	0.269	1.131906	0.0072	2.18E-05			0.00231
			8.5	24.83	0.275	1.166606	0.0072	0			0.00167
			9.5	27.79	0.281	1.198747	0.0072	0			0
			10.5	29.76	0.286	1.202511	0.0072	0			0
			11.5	31.81	0.291	1.202662	0.0072	0			0
		2475	2.5	13.78	0.348	0.957925	0.0296	0.038103	0.02494455	0.0235875	0.03531
			3.5	15.62	0.4	0.977295	0.0296	0.034545			0.03358
			4.5	16.95	0.436	0.990462	0.0296	0.032268			0.03136
			5.5	19.87	0.462	1.018072	0.0296	0.027859			0.02672
			6.5	21.47	0.481	1.032472	0.0296	0.025749			0.02342
			7.5	23.12	0.497	1.047834	0.0296	0.023634			0.02018
			8.5	24.83	0.509	1.066574	0.0296	0.021239			0.01706
			9.5	27.79	0.519	1.195063	0.0296	0.009339			0.01184
			10.5	29.76	0.529	1.28942	0.0296	0.004242			0.00683

			11.5	31.81	0.538	1.358756	0.0296	0.001739			0.00121
		1033	2.5	13.78	0.26	0.965616	0.0205	0.024241	0.01342025	0.0153228	0.02415
			3.5	15.62	0.3	0.981524	0.0205	0.021992			0.02329
			4.5	16.95	0.327	0.993672	0.0205	0.020386			0.02256
			5.5	19.87	0.346	1.028962	0.0205	0.016224			0.0172
			6.5	21.47	0.361	1.049081	0.0205	0.014158			0.01556
			7.5	23.12	0.372	1.109401	0.0205	0.009097			0.01382
			8.5	24.83	0.381	1.187243	0.0205	0.004529			0.01054
			9.5	27.79	0.389	1.308862	0.0205	0.000263			0.00351
			10.5	29.76	0.396	1.355545	0.0205	0			0
			11.5	31.81	0.403	1.368673	0.0205	0			0
2	SLC	475	2.5	13.78	0.165	0.986699	0.0049	0.004417	0.00243443	0.0025551	0.00476
			3.5	15.62	0.189	0.967474	0.0049	0.005573			0.00577
			4.5	16.95	0.205	0.969148	0.0049	0.005467			0.0057
			5.5	19.87	0.216	1.035855	0.0049	0.00203			0.00248
			6.5	21.47	0.224	1.057849	0.0049	0.00118			0.00137
			7.5	23.12	0.23	1.077964	0.0049	0.0005			0
			8.5	24.83	0.234	1.092692	0.0049	5.34E-05			0
			9.5	27.79	0.238	1.101467	0.0049	0			0
			10.5	29.76	0.241	1.101812	0.0049	0			0
			11.5	31.81	0.244	1.101812	0.0049	0			0
		2475	2.5	13.78	0.375	0.957465	0.0271	0.034613	0.02251435	0.021717	0.03361
			3.5	15.62	0.43	0.977016	0.0271	0.031203			0.03166
			4.5	16.95	0.468	0.990235	0.0271	0.029044			0.02955
			5.5	19.87	0.493	1.017422	0.0271	0.02496			0.02479
			6.5	21.47	0.512	1.031416	0.0271	0.023037			0.02144
			7.5	23.12	0.527	1.045955	0.0271	0.021162			0.01815
			8.5	24.83	0.537	1.062981	0.0271	0.019118			0.01518
			9.5	27.79	0.546	1.173092	0.0271	0.009214			0.00964
			10.5	29.76	0.554	1.272014	0.0271	0.003891			0.0049
			11.5	31.81	0.561	1.352723	0.0271	0.001121			0
		1033	2.5	13.78	0.247	0.971776	0.0184	0.020667	0.01071251	0.0125916	0.02139
			3.5	15.62	0.283	0.986989	0.0184	0.018726			0.02031
			4.5	16.95	0.308	0.998789	0.0184	0.01732			0.01948
			5.5	19.87	0.325	1.038064	0.0184	0.013202			0.01391
			6.5	21.47	0.337	1.072955	0.0184	0.010187			0.01203
			7.5	23.12	0.346	1.154354	0.0184	0.004989			0.01067
			8.5	24.83	0.353	1.227552	0.0184	0.001908			0.00633
			9.5	27.79	0.359	1.332745	0.0184	0			0.00136
			10.5	29.76	0.364	1.363958	0.0184	0			0
			11.5	31.81	0.368	1.370081	0.0184	0			0
2	San Fran	475	2.5	13.78	0.318	0.959149	0.0255	0.032159	0.0200483	0.0187199	0.02956
			3.5	15.62	0.366	0.978071	0.0255	0.028994			0.02746
			4.5	16.95	0.4	0.991079	0.0255	0.026959			0.02512
			5.5	19.87	0.423	1.019825	0.0255	0.022849			0.02149
			6.5	21.47	0.441	1.035183	0.0255	0.02086			0.01976
			7.5	23.12	0.455	1.05266	0.0255	0.018762			0.01635
			8.5	24.83	0.466	1.08636	0.0255	0.015172			0.01314
			9.5	27.79	0.476	1.233243	0.0255	0.004908			0.00613
			10.5	29.76	0.485	1.318484	0.0255	0.001629			0.00256
			11.5	31.81	0.493	1.36719	0.0255	0.000297			0
		2475	2.5	13.78	0.541	0.957097	0.0379	0.050058	0.03596443	0.030759	0.04456
			3.5	15.62	0.623	0.976788	0.0379	0.045966			0.04013
			4.5	16.95	0.68	0.990046	0.0379	0.043329			0.03826
			5.5	19.87	0.72	1.016736	0.0379	0.038326			0.03364
			6.5	21.47	0.752	1.030148	0.0379	0.03597			0.03044

			7.5	23.12	0.777	1.043211	0.0379	0.033776			0.02706
			8.5	24.83	0.797	1.056061	0.0379	0.031716			0.02402
			9.5	27.79	0.814	1.122533	0.0379	0.022527			0.01834
			10.5	29.76	0.83	1.181755	0.0379	0.016197			0.01383
			11.5	31.81	0.846	1.254968	0.0379	0.010323			0.00799
		1033	2.5	13.78	0.408	0.957229	0.0325	0.042479	0.0291332	0.025915	0.03861
			3.5	15.62	0.469	0.976865	0.0325	0.03867			0.03523
			4.5	16.95	0.513	0.990104	0.0325	0.036239			0.03347
			5.5	19.87	0.543	1.01696	0.0325	0.03165			0.02845
			6.5	21.47	0.566	1.030572	0.0325	0.029496			0.02503
			7.5	23.12	0.584	1.04419	0.0325	0.027453			0.02367
			8.5	24.83	0.599	1.058681	0.0325	0.025399			0.02074
			9.5	27.79	0.612	1.137933	0.0325	0.016159			0.01372
			10.5	29.76	0.623	1.224997	0.0325	0.009174			0.00889
			11.5	31.81	0.635	1.325895	0.0325	0.00396			0.00263
2	San Jose	475	2.5	13.78	0.283	0.962903	0.0257	0.031713	0.01868768	0.0175121	0.02852
			3.5	15.62	0.324	0.980817	0.0257	0.028746			0.02634
			4.5	16.95	0.352	0.99358	0.0257	0.026764			0.02583
			5.5	19.87	0.37	1.026181	0.0257	0.022173			0.02059
			6.5	21.47	0.384	1.04483	0.0257	0.019834			0.01712
			7.5	23.12	0.394	1.077577	0.0257	0.016188			0.01594
			8.5	24.83	0.401	1.164253	0.0257	0.008907			0.01115
			9.5	27.79	0.407	1.297609	0.0257	0.002361			0.00305
			10.5	29.76	0.411	1.355251	0.0257	0.000637			0
			11.5	31.81	0.416	1.372996	0.0257	0.000198			0
		2475	2.5	13.78	0.44	0.957145	0.0379	0.050132	0.03546239	0.0297578	0.04306
			3.5	15.62	0.504	0.976816	0.0379	0.046043			0.0404
			4.5	16.95	0.547	0.99007	0.0379	0.043405			0.03878
			5.5	19.87	0.576	1.016841	0.0379	0.038383			0.03213
			6.5	21.47	0.597	1.03037	0.0379	0.036005			0.02906
			7.5	23.12	0.613	1.043781	0.0379	0.033754			0.02799
			8.5	24.83	0.624	1.057801	0.0379	0.031513			0.02306
			9.5	27.79	0.632	1.134604	0.0379	0.021159			0.01669
			10.5	29.76	0.64	1.214175	0.0379	0.0134			0.0109
			11.5	31.81	0.647	1.320694	0.0379	0.006498			0.00372
		1033	2.5	13.78	0.349	0.957919	0.0326	0.042493	0.02813201	0.0240106	0.03728
			3.5	15.62	0.4	0.977316	0.0326	0.038731			0.034
			4.5	16.95	0.434	0.990507	0.0326	0.036308			0.03201
			5.5	19.87	0.457	1.018254	0.0326	0.031571			0.02729
			6.5	21.47	0.474	1.032845	0.0326	0.029272			0.02408
			7.5	23.12	0.486	1.048839	0.0326	0.0269			0.02108
			8.5	24.83	0.495	1.06902	0.0326	0.02412			0.01854
			9.5	27.79	0.502	1.209797	0.0326	0.010266			0.01041
			10.5	29.76	0.508	1.303757	0.0326	0.004946			0.00454
			11.5	31.81	0.514	1.363889	0.0326	0.002598			0
2	Santa Monica	475	2.5	13.78	0.251	0.969819	0.0213	0.024729	0.01329842	0.0147203	0.02419
			3.5	15.62	0.288	0.985306	0.0213	0.02252			0.02346
			4.5	16.95	0.313	0.997367	0.0213	0.020908			0.02284
			5.5	19.87	0.329	1.036146	0.0213	0.016314			0.01772
			6.5	21.47	0.342	1.061681	0.0213	0.013735			0.01428
			7.5	23.12	0.351	1.145609	0.0213	0.007276			0.01105
			8.5	24.83	0.357	1.221765	0.0213	0.003414			0.00889
			9.5	27.79	0.363	1.329891	0.0213	9.39E-07			0.00113
			10.5	29.76	0.367	1.363344	0.0213	0			0
			11.5	31.81	0.371	1.369986	0.0213	0			0
		2475	2.5	13.78	0.434	0.957155	0.0355	0.046641	0.03259001	0.028555	0.04258

			3.5	15.62	0.498	0.976822	0.0355	0.042664			0.03953
			4.5	16.95	0.542	0.990073	0.0355	0.040113			0.03798
			5.5	19.87	0.571	1.016854	0.0355	0.035281			0.0316
			6.5	21.47	0.593	1.03039	0.0355	0.033005			0.02834
			7.5	23.12	0.609	1.043826	0.0355	0.030854			0.02555
			8.5	24.83	0.621	1.057889	0.0355	0.028718			0.02102
			9.5	27.79	0.631	1.134755	0.0355	0.018956			0.01482
			10.5	29.76	0.64	1.214175	0.0355	0.01175			0.00848
			11.5	31.81	0.648	1.320252	0.0355	0.005416			0.00258
		1033	2.5	13.78	0.316	0.959336	0.0291	0.037136	0.02341361	0.0219754	0.03391
			3.5	15.62	0.362	0.978288	0.0291	0.033703			0.03238
			4.5	16.95	0.394	0.991327	0.0291	0.031481			0.03032
			5.5	19.87	0.415	1.020486	0.0291	0.026909			0.02571
			6.5	21.47	0.43	1.036458	0.0291	0.024629			0.0227
			7.5	23.12	0.442	1.055052	0.0291	0.022165			0.01971
			8.5	24.83	0.451	1.103188	0.0291	0.016657			0.01532
			9.5	27.79	0.457	1.251159	0.0291	0.005786			0.00708
			10.5	29.76	0.463	1.331602	0.0291	0.002443			0.00235
			11.5	31.81	0.469	1.370177	0.0291	0.001251			0
2	Seattle	475	2.5	13.78	0.225	0.977825	0.0177	0.019038	0.00919409	0.0114473	0.01914
			3.5	15.62	0.258	0.989907	0.0177	0.017571			0.01987
			4.5	16.95	0.281	1.000499	0.0177	0.016356			0.01885
			5.5	19.87	0.296	1.053433	0.0177	0.011193			0.01338
			6.5	21.47	0.307	1.130719	0.0177	0.005838			0.01176
			7.5	23.12	0.315	1.198748	0.0177	0.002659			0.00717
			8.5	24.83	0.321	1.261529	0.0177	0.0006			0.00443
			9.5	27.79	0.326	1.339553	0.0177	0			0
			10.5	29.76	0.33	1.35586	0.0177	0			0
			11.5	31.81	0.334	1.357834	0.0177	0			0
		2475	2.5	13.78	0.409	0.957225	0.0336	0.043956	0.03020297	0.0265271	0.03903
			3.5	15.62	0.47	0.976862	0.0336	0.040086			0.03769
			4.5	16.95	0.511	0.990108	0.0336	0.03761			0.03411
			5.5	19.87	0.539	1.016982	0.0336	0.032924			0.02954
			6.5	21.47	0.56	1.030628	0.0336	0.030716			0.02633
			7.5	23.12	0.575	1.044367	0.0336	0.028606			0.02338
			8.5	24.83	0.587	1.059238	0.0336	0.026449			0.02059
			9.5	27.79	0.596	1.141116	0.0336	0.016703			0.01355
			10.5	29.76	0.605	1.236858	0.0336	0.009016			0.00849
			11.5	31.81	0.613	1.334902	0.0336	0.004007			0.00214
		1033	2.5	13.78	0.298	0.960807	0.0265	0.033293	0.02022742	0.0197525	0.03172
			3.5	15.62	0.341	0.979318	0.0265	0.030138			0.02964
			4.5	16.95	0.371	0.992214	0.0265	0.028077			0.02729
			5.5	19.87	0.391	1.022825	0.0265	0.023613			0.02271
			6.5	21.47	0.406	1.03992	0.0265	0.021369			0.01937
			7.5	23.12	0.417	1.060894	0.0265	0.018844			0.01633
			8.5	24.83	0.425	1.133809	0.0265	0.011774			0.01345
			9.5	27.79	0.432	1.274629	0.0265	0.003564			0.00662
			10.5	29.76	0.438	1.344239	0.0265	0.0012			0.00277
			11.5	31.81	0.443	1.371968	0.0265	0.000464			0
3	Butte	475	2.5	31.55	0.0644	1	0	2.36E-18	6.1054E-05	0.000101	0
			3.5	33.24	0.0743	1	0	2.36E-18			0
			4.5	26.77	0.0842	1	0	2.36E-18			0
			5.5	23.88	0.0898	1	0	2.36E-18			0
			6.5	23.83	0.093	1	0	2.36E-18			0
			7.5	19.78	0.0952	1	0	2.36E-18			0
			8.5	14.01	0.0961	0.999677	0	1.01E-05			0

			9.5	16.11	0.0963	0.999982	0	5.75E-07			0
			10.5	11.6	0.0955	0.998385	0	5.09E-05			0
			11.5	6.53	0.0941	0.972204	0	0.000959			0.00171
		2475	2.5	31.55	0.1146	1.006927	0	0	0.00500985	0.0048723	0
			3.5	33.24	0.1322	1.006927	0	0			0
			4.5	26.77	0.1499	1.006927	0	0			0
			5.5	23.88	0.1597	1.006835	0	0			0
			6.5	23.83	0.1655	1.006692	0	0			0
			7.5	19.78	0.1695	0.996795	0	0.000102			0
			8.5	14.01	0.1712	0.883621	0	0.005593			0.00885
			9.5	16.11	0.1714	0.951212	0	0.001815			0.00382
			10.5	11.6	0.1702	0.740508	0	0.022587			0.018
			11.5	6.53	0.1677	0.63808	0	0.048009			0.04375
		1033	2.5	31.55	0.0875	1	0	2.36E-18	0.00229371	0.0014078	0
			3.5	33.24	0.101	1	0	2.36E-18			0
			4.5	26.77	0.1145	1	0	2.36E-18			0
			5.5	23.88	0.122	1	0	2.36E-18			0
			6.5	23.83	0.1264	1	0	2.36E-18			0
			7.5	19.78	0.1295	0.999683	0	9.96E-06			0
			8.5	14.01	0.1307	0.985296	0	0.000485			0
			9.5	16.11	0.1309	0.99469	0	0.000169			0
			10.5	11.6	0.1299	0.960154	0	0.001435			0.00155
			11.5	6.53	0.128	0.678925	0	0.036215			0.02204
3	Charleston	475	2.5	31.55	0.1018	1.001177	0	0	0.00421615	0.0013592	0
			3.5	33.24	0.1179	1.001177	0	0			0
			4.5	26.77	0.1342	1.001177	0	0			0
			5.5	23.88	0.1437	1.001177	0	0			0
			6.5	23.83	0.1496	1.001177	0	0			0
			7.5	19.78	0.154	0.997448	0	8.06E-05			0
			8.5	14.01	0.1563	0.936488	0	0.002494			0.00167
			9.5	16.11	0.1574	0.971605	0	0.000982			0
			10.5	11.6	0.1571	0.775642	0	0.016814			0.00324
			11.5	6.53	0.1558	0.641656	0	0.04689			0.01682
		2475	2.5	31.55	0.3525	1.374538	0.024	0	0.01660981	0.0174502	0
			3.5	33.24	0.4095	1.374589	0.024	0			0
			4.5	26.77	0.4674	1.189249	0.024	0.006375			0.00848
			5.5	23.88	0.502	1.055727	0.024	0.016928			0.01437
			6.5	23.83	0.5244	1.053133	0.024	0.01721			0.01577
			7.5	19.78	0.5417	1.016173	0.024	0.021626			0.02292
			8.5	14.01	0.5519	0.95965	0.024	0.03			0.03221
			9.5	16.11	0.558	0.981767	0.024	0.026473			0.02823
			10.5	11.6	0.5592	0.931341	0.024	0.035015			0.03848
			11.5	6.53	0.5566	0.856457	0.024	0.051045			0.05674
		1033	2.5	31.55	0.2006	1.361289	0.0148	0	0.00733153	0.0089121	0
			3.5	33.24	0.2328	1.361289	0.0148	0			0
			4.5	26.77	0.2655	1.354059	0.0148	0			0
			5.5	23.88	0.2849	1.28188	0.0148	0			0.00368
			6.5	23.83	0.2972	1.261621	0.0148	0			0.00297
			7.5	19.78	0.3067	1.039948	0.0148	0.009648			0.01129
			8.5	14.01	0.3121	0.953274	0.0148	0.018369			0.01998
			9.5	16.11	0.3151	0.979295	0.0148	0.015313			0.01752
			10.5	11.6	0.3154	0.923024	0.0148	0.022481			0.02531
			11.5	6.53	0.3135	0.848185	0.0148	0.035676			0.03892
3	Eureka	475	2.5	31.55	0.35481	1.374523	0.0249	0	0.01739166	0.0164205	0
			3.5	33.24	0.41311	1.374591	0.0249	0			0
			4.5	26.77	0.47264	1.184061	0.0249	0.007186			0.00837

			5.5	23.88	0.50898	1.055003	0.0249	0.017884			0.01468
			6.5	23.83	0.53321	1.052516	0.0249	0.018163			0.01407
			7.5	19.78	0.55249	1.016127	0.0249	0.022646			0.02172
			8.5	14.01	0.56466	0.95965	0.0249	0.031226			0.03023
			9.5	16.11	0.5727	0.981765	0.0249	0.027615			0.02784
			10.5	11.6	0.57585	0.931342	0.0249	0.036346			0.03536
			11.5	6.53	0.57515	0.856457	0.0249	0.0526			0.05092
		2475	2.5	31.55	0.8457	1.244254	0.0364	0.010159	0.03099781	0.0272772	0.00631
			3.5	33.24	0.98545	1.290586	0.0364	0.00733			0.00309
			4.5	26.77	1.12844	1.091282	0.0364	0.025006			0.02008
			5.5	23.88	1.21637	1.048942	0.0364	0.0311			0.02663
			6.5	23.83	1.2756	1.048567	0.0364	0.031158			0.02641
			7.5	19.78	1.32315	1.015953	0.0364	0.036568			0.03367
			8.5	14.01	1.35386	0.95965	0.0364	0.047397			0.04426
			9.5	16.11	1.37474	0.98176	0.0364	0.042923			0.04097
			10.5	11.6	1.384	0.931344	0.0364	0.053505			0.05011
			11.5	6.53	1.38403	0.856459	0.0364	0.070924			0.06956
		1033	2.5	31.55	0.57257	1.341271	0.0315	0.002966	0.02487968	0.0223397	0.00131
			3.5	33.24	0.66696	1.361627	0.0315	0.002272			0
			4.5	26.77	0.76346	1.092538	0.0315	0.020024			0.01572
			5.5	23.88	0.82262	1.048972	0.0315	0.025564			0.02171
			6.5	23.83	0.86231	1.048582	0.0315	0.025618			0.02132
			7.5	19.78	0.89404	1.015953	0.0315	0.03049			0.02854
			8.5	14.01	0.91436	0.95965	0.0315	0.040468			0.03975
			9.5	16.11	0.928	0.98176	0.0315	0.036307			0.03582
			10.5	11.6	0.93378	0.931344	0.0315	0.046249			0.04402
			11.5	6.53	0.93332	0.856459	0.0315	0.063584			0.06098
3	Memphis	475	2.5	31.55	0.11567	1.007078	0	0	0.00587889	0.0025415	0
			3.5	33.24	0.13436	1.007078	0	0			0
			4.5	26.77	0.15332	1.007078	0	0			0
			5.5	23.88	0.16464	1.006884	0	0			0
			6.5	23.83	0.17197	1.0066	0	0			0
			7.5	19.78	0.17762	0.991624	0	0.00027			0
			8.5	14.01	0.18093	0.827966	0	0.010351			0.00471
			9.5	16.11	0.18287	0.922326	0	0.003216			0.00298
			10.5	11.6	0.18323	0.722442	0	0.02609			0.00865
			11.5	6.53	0.18235	0.633028	0	0.049615			0.02225
		2475	2.5	31.55	0.32118	1.374578	0.0252	4.25E-05	0.01719662	0.0182215	0
			3.5	33.24	0.37373	1.374578	0.0252	4.25E-05			0
			4.5	26.77	0.42729	1.231185	0.0252	0.004861			0.00895
			5.5	23.88	0.45981	1.062209	0.0252	0.017397			0.01577
			6.5	23.83	0.48134	1.057749	0.0252	0.017889			0.01512
			7.5	19.78	0.49833	1.016529	0.0252	0.022953			0.02371
			8.5	14.01	0.50888	0.959647	0.0252	0.031661			0.03465
			9.5	16.11	0.51566	0.98178	0.0252	0.028018			0.029
			10.5	11.6	0.51803	0.931334	0.0252	0.036819			0.04071
			11.5	6.53	0.51692	0.85645	0.0252	0.053148			0.05885
		1033	2.5	31.55	0.21244	1.364682	0.0157	0	0.00790512	0.0101061	0
			3.5	33.24	0.24712	1.364682	0.0157	0			0
			4.5	26.77	0.28243	1.35161	0.0157	0			0
			5.5	23.88	0.30381	1.256335	0.0157	4.05E-05			0.00444
			6.5	23.83	0.31789	1.231673	0.0157	0.000703			0.00544
			7.5	19.78	0.32896	1.030576	0.0157	0.011276			0.01332
			8.5	14.01	0.33577	0.954162	0.0157	0.019468			0.02203
			9.5	16.11	0.34008	0.978341	0.0157	0.016512			0.01957
			10.5	11.6	0.34147	0.924908	0.0157	0.023567			0.02724

			11.5	6.53	0.34056	0.850288	0.0157	0.037004			0.04211
3	Portland	475	2.5	31.55	0.17267	1.202662	0.0072	0	0.00789272	0.0085573	0
			3.5	33.24	0.20092	1.202662	0.0072	0			0
			4.5	26.77	0.22972	1.201548	0.0072	0			0
			5.5	23.88	0.2472	1.173484	0.0072	0			0.002
			6.5	23.83	0.25877	1.161669	0.0072	0			0.00146
			7.5	19.78	0.26791	1.003867	0.0072	0.005409			0.00861
			8.5	14.01	0.27358	0.847611	0.0072	0.02119			0.02027
			9.5	16.11	0.27722	0.875245	0.0072	0.017247			0.0162
			10.5	11.6	0.2785	0.817057	0.0072	0.026316			0.02672
			11.5	6.53	0.2779	0.749409	0.0072	0.040943			0.04284
		2475	2.5	31.55	0.30729	1.374533	0.0296	0.001278	0.02087671	0.0209683	0
			3.5	33.24	0.35773	1.374533	0.0296	0.001278			0
			4.5	26.77	0.40921	1.250943	0.0296	0.006043			0.00958
			5.5	23.88	0.44061	1.066775	0.0296	0.021214			0.01714
			6.5	23.83	0.46151	1.061116	0.0296	0.021916			0.01824
			7.5	19.78	0.4781	1.016829	0.0296	0.028047			0.02746
			8.5	14.01	0.48855	0.959622	0.0296	0.037782			0.04058
			9.5	16.11	0.4954	0.981771	0.0296	0.033758			0.03544
			10.5	11.6	0.49803	0.931304	0.0296	0.043399			0.04613
			11.5	6.53	0.49733	0.856422	0.0296	0.060531			0.06647
		1033	2.5	31.55	0.23382	1.369222	0.0205	0	0.01119608	0.0148217	0
			3.5	33.24	0.27217	1.369222	0.0205	0			0
			4.5	26.77	0.31129	1.340454	0.0205	0			0.00117
			5.5	23.88	0.33512	1.209936	0.0205	0.003513			0.00939
			6.5	23.83	0.35096	1.181935	0.0205	0.004784			0.01005
			7.5	19.78	0.36351	1.022894	0.0205	0.016889			0.01956
			8.5	14.01	0.37138	0.956385	0.0205	0.025624			0.03119
			9.5	16.11	0.37652	0.979305	0.0205	0.022296			0.02781
			10.5	11.6	0.37844	0.927782	0.0205	0.030295			0.03699
			11.5	6.53	0.37782	0.853113	0.0205	0.045407			0.05633
3	SLC	475	2.5	31.55	0.15138	1.101812	0.0049	0	0.00944688	0.0064142	0
			3.5	33.24	0.17557	1.101812	0.0049	0			0
			4.5	26.77	0.2	1.101756	0.0049	0			0
			5.5	23.88	0.21438	1.093771	0.0049	2.22E-05			0
			6.5	23.83	0.22348	1.089559	0.0049	0.000145			0
			7.5	19.78	0.23034	1.005679	0.0049	0.003406			0.00318
			8.5	14.01	0.23413	0.79134	0.0049	0.025979			0.01619
			9.5	16.11	0.2361	0.826749	0.0049	0.019991			0.01141
			10.5	11.6	0.23601	0.75496	0.0049	0.033464			0.0228
			11.5	6.53	0.23432	0.687036	0.0049	0.051345			0.03851
		2475	2.5	31.55	0.32982	1.374581	0.0271	0.000542	0.0189301	0.0197306	0
			3.5	33.24	0.38291	1.374581	0.0271	0.000542			0
			4.5	26.77	0.43669	1.221054	0.0271	0.006307			0.00843
			5.5	23.88	0.46865	1.060491	0.0271	0.019407			0.01501
			6.5	23.83	0.48916	1.056667	0.0271	0.019858			0.01611
			7.5	19.78	0.50487	1.016452	0.0271	0.025097			0.02562
			8.5	14.01	0.5139	0.959648	0.0271	0.034219			0.03866
			9.5	16.11	0.519	0.98178	0.0271	0.030411			0.03374
			10.5	11.6	0.5196	0.931336	0.0271	0.039582			0.04594
			11.5	6.53	0.51667	0.856452	0.0271	0.056303			0.06401
		1033	2.5	31.55	0.22145	1.370141	0.0184	0	0.00944374	0.0127556	0
			3.5	33.24	0.257	1.370141	0.0184	0			0
			4.5	26.77	0.29296	1.35216	0.0184	0			0
			5.5	23.88	0.31425	1.244652	0.0184	0.001347			0.00656
			6.5	23.83	0.32784	1.220314	0.0184	0.002162			0.0073

			7.5	19.78	0.33818	1.030988	0.0184	0.013884			0.01647
			8.5	14.01	0.34403	0.95766	0.0184	0.022601			0.0282
			9.5	16.11	0.34724	0.981616	0.0184	0.019395			0.02306
			10.5	11.6	0.34743	0.928555	0.0184	0.027027			0.03411
			11.5	6.53	0.34526	0.853689	0.0184	0.041394			0.053
3	San Fran	475	2.5	31.55	0.28247	1.374398	0.0255	0.000125	0.01642643	0.0165228	0
			3.5	33.24	0.32884	1.374398	0.0255	0.000125			0
			4.5	26.77	0.37616	1.28691	0.0255	0.002683			0.006
			5.5	23.88	0.40502	1.107304	0.0255	0.013216			0.01314
			6.5	23.83	0.42423	1.077834	0.0255	0.016026			0.01418
			7.5	19.78	0.43949	1.017965	0.0255	0.023099			0.02253
			8.5	14.01	0.44909	0.959559	0.0255	0.032087			0.03275
			9.5	16.11	0.45539	0.981782	0.0255	0.028402			0.02829
			10.5	11.6	0.4578	0.931216	0.0255	0.037287			0.03788
			11.5	6.53	0.45715	0.856337	0.0255	0.053689			0.05186
		2475	2.5	31.55	0.47009	1.36792	0.0379	0.004336	0.03098842	0.0259753	0
			3.5	33.24	0.54773	1.372993	0.0379	0.004133			0
			4.5	26.77	0.62716	1.098655	0.0379	0.025554			0.0187
			5.5	23.88	0.67597	1.04931	0.0379	0.032786			0.02697
			6.5	23.83	0.70883	1.048768	0.0379	0.032874			0.02656
			7.5	19.78	0.73519	1.015956	0.0379	0.038467			0.03324
			8.5	14.01	0.75218	0.95965	0.0379	0.049516			0.04581
			9.5	16.11	0.7637	0.98176	0.0379	0.044966			0.04018
			10.5	11.6	0.76877	0.931344	0.0379	0.055693			0.05154
			11.5	6.53	0.76871	0.856459	0.0379	0.073003			0.06921
		1033	2.5	31.55	0.35785	1.374499	0.0325	0.002214	0.02453254	0.0219274	0
			3.5	33.24	0.41679	1.374591	0.0325	0.002211			0
			4.5	26.77	0.47701	1.179781	0.0325	0.01245			0.01279
			5.5	23.88	0.51389	1.054537	0.0325	0.025974			0.02025
			6.5	23.83	0.5386	1.052179	0.0325	0.026306			0.02151
			7.5	19.78	0.55832	1.016105	0.0325	0.031789			0.02974
			8.5	14.01	0.5709	0.95965	0.0325	0.041997			0.0407
			9.5	16.11	0.5793	0.981764	0.0325	0.037758			0.03502
			10.5	11.6	0.58279	0.931342	0.0325	0.047863			0.04498
			11.5	6.53	0.58238	0.856457	0.0325	0.065272			0.06229
3	San Jose	475	2.5	31.55	0.25196	1.373918	0.0257	0.000176	0.01501628	0.0154595	0
			3.5	33.24	0.29204	1.373918	0.0257	0.000176			0
			4.5	26.77	0.33247	1.32893	0.0257	0.001363			0.00216
			5.5	23.88	0.35612	1.180275	0.0257	0.00787			0.01103
			6.5	23.83	0.37094	1.154472	0.0257	0.009581			0.01395
			7.5	19.78	0.38202	1.022886	0.0257	0.022607			0.02147
			8.5	14.01	0.38796	0.959471	0.0257	0.032307			0.03104
			9.5	16.11	0.39089	0.982216	0.0257	0.028523			0.02873
			10.5	11.6	0.39039	0.930937	0.0257	0.037562			0.03608
			11.5	6.53	0.38723	0.856039	0.0257	0.054015			0.052
		2475	2.5	31.55	0.38523	1.374092	0.0379	0.004112	0.03014823	0.0252533	0
			3.5	33.24	0.44652	1.374592	0.0379	0.004093			0
			4.5	26.77	0.50834	1.150734	0.0379	0.019365			0.0154
			5.5	23.88	0.54449	1.052328	0.0379	0.032374			0.02433
			6.5	23.83	0.56715	1.050812	0.0379	0.032616			0.02559
			7.5	19.78	0.58409	1.016039	0.0379	0.038528			0.03363
			8.5	14.01	0.59318	0.95965	0.0379	0.0496			0.04599
			9.5	16.11	0.59766	0.981763	0.0379	0.045047			0.04048
			10.5	11.6	0.59689	0.931343	0.0379	0.05578			0.05165
			11.5	6.53	0.59206	0.856459	0.0379	0.073084			0.06925
		1033	2.5	31.55	0.3082	1.374562	0.0326	0.002247	0.02363531	0.0209747	0

			3.5	33.24	0.35725	1.374562	0.0326	0.002247			0
			4.5	26.77	0.40674	1.253697	0.0326	0.007485			0.00953
			5.5	23.88	0.4357	1.068192	0.0326	0.024229			0.01814
			6.5	23.83	0.45387	1.062741	0.0326	0.02496			0.01919
			7.5	19.78	0.46747	1.017095	0.0326	0.03176			0.02843
			8.5	14.01	0.47479	0.959649	0.0326	0.042148			0.04086
			9.5	16.11	0.47843	0.981824	0.0326	0.037891			0.03532
			10.5	11.6	0.47786	0.931325	0.0326	0.048026			0.04515
			11.5	6.53	0.47404	0.85644	0.0326	0.065442			0.06238
3	Santa Monica	475	2.5	31.55	0.22505	1.370068	0.0213	0	0.01133013	0.0139291	0
			3.5	33.24	0.26099	1.370068	0.0213	0			0
			4.5	26.77	0.2973	1.349803	0.0213	0			0.00178
			5.5	23.88	0.31865	1.237473	0.0213	0.002791			0.00719
			6.5	23.83	0.33214	1.213205	0.0213	0.003775			0.00954
			7.5	19.78	0.3423	1.029469	0.0213	0.017044			0.01819
			8.5	14.01	0.3479	0.957485	0.0213	0.026604			0.03074
			9.5	16.11	0.3508	0.981289	0.0213	0.023078			0.02681
			10.5	11.6	0.35063	0.928481	0.0213	0.031438			0.03565
			11.5	6.53	0.34808	0.853643	0.0213	0.046824			0.05081
		2475	2.5	31.55	0.38046	1.374194	0.0355	0.003213	0.02766615	0.0242404	0
			3.5	33.24	0.44152	1.374592	0.0355	0.003198			0
			4.5	26.77	0.50331	1.155207	0.0355	0.016851			0.01363
			5.5	23.88	0.53989	1.052596	0.0355	0.029508			0.02244
			6.5	23.83	0.56322	1.050964	0.0355	0.029755			0.02364
			7.5	19.78	0.58099	1.016045	0.0355	0.035421			0.03283
			8.5	14.01	0.59104	0.95965	0.0355	0.046124			0.04445
			9.5	16.11	0.59656	0.981763	0.0355	0.0417			0.03934
			10.5	11.6	0.59688	0.931343	0.0355	0.052184			0.05025
			11.5	6.53	0.59316	0.856458	0.0355	0.069637			0.06952
		1033	2.5	31.55	0.27966	1.374469	0.0291	0.001132	0.01913499	0.0193853	0
			3.5	33.24	0.32444	1.374469	0.0291	0.001132			0
			4.5	26.77	0.36971	1.29379	0.0291	0.003851			0.00689
			5.5	23.88	0.39642	1.119625	0.0291	0.015039			0.01517
			6.5	23.83	0.41338	1.092747	0.0291	0.017752			0.01608
			7.5	19.78	0.42622	1.018741	0.0291	0.027167			0.02646
			8.5	14.01	0.43339	0.959636	0.0291	0.037079			0.03819
			9.5	16.11	0.43723	0.981936	0.0291	0.03307			0.03488
			10.5	11.6	0.43724	0.931269	0.0291	0.042659			0.04425
			11.5	6.53	0.43428	0.856381	0.0291	0.059726			0.06091
3	Seattle	475	2.5	31.55	0.20347	1.357834	0.0177	0	0.00911403	0.0118192	0
			3.5	33.24	0.23598	1.357834	0.0177	0			0
			4.5	26.77	0.26883	1.349661	0.0177	0			0
			5.5	23.88	0.28816	1.273877	0.0177	0.000271			0.00473
			6.5	23.83	0.30038	1.253465	0.0177	0.000827			0.00562
			7.5	19.78	0.30961	1.035475	0.0177	0.012787			0.01584
			8.5	14.01	0.31469	0.950637	0.0177	0.022682			0.02773
			9.5	16.11	0.31735	0.97641	0.0177	0.019216			0.02229
			10.5	11.6	0.31723	0.920638	0.0177	0.027299			0.03234
			11.5	6.53	0.31496	0.846031	0.0177	0.04182			0.04841
		2475	2.5	31.55	0.35936	1.374486	0.0336	0.002557	0.02549798	0.0231295	0
			3.5	33.24	0.41715	1.374591	0.0336	0.002554			0
			4.5	26.77	0.47567	1.181087	0.0336	0.013079			0.01262
			5.5	23.88	0.5104	1.054864	0.0336	0.02707			0.02006
			6.5	23.83	0.53265	1.052553	0.0336	0.027403			0.02134
			7.5	19.78	0.54965	1.016138	0.0336	0.033064			0.0306
			8.5	14.01	0.55937	0.95965	0.0336	0.043465			0.04379

			9.5	16.11	0.56482	0.981767	0.0336	0.039156			0.0386
			10.5	11.6	0.56535	0.931342	0.0336	0.049407			0.0493
			11.5	6.53	0.56205	0.856457	0.0336	0.066858			0.06809
		1033	2.5	31.55	0.26481	1.374162	0.0265	0.000409	0.01629799	0.0178859	0
			3.5	33.24	0.30726	1.374162	0.0265	0.000409			0
			4.5	26.77	0.35021	1.313116	0.0265	0.002157			0.00447
			5.5	23.88	0.3756	1.150203	0.0265	0.010499			0.01339
			6.5	23.83	0.39177	1.12331	0.0265	0.012646			0.01442
			7.5	19.78	0.40406	1.020284	0.0265	0.023961			0.02335
			8.5	14.01	0.41097	0.959494	0.0265	0.033526			0.03638
			9.5	16.11	0.41473	0.981942	0.0265	0.02971			0.03111
			10.5	11.6	0.41487	0.931073	0.0265	0.038857			0.04385
			11.5	6.53	0.41219	0.85619	0.0265	0.055488			0.05997
4	Butte	475	0.5	10.52	0.11026	0.986073	0	0.000458	0.00116087	0.0006681	0
			1.5	10.52	0.11808	0.972956	0	0.000931			0
			2.5	11.15	0.12062	0.975157	0	0.000848			0
			3.5	11.77	0.12148	0.979843	0	0.000677			0
			4.5	10.86	0.12186	0.968882	0	0.001086			0
			5.5	10.9	0.12117	0.971012	0	0.001004			0
			6.5	10.11	0.1201	0.96148	0	0.001381			0
			7.5	9.46	0.1185	0.95298	0	0.001738			0.00165
			8.5	8.92	0.11651	0.946469	0	0.002026			0.0013
			9.5	8.84	0.11422	0.954515	0	0.001672			0.00152
			10.5	8.43	0.11174	0.953957	0	0.001696			0.00136
			11.5	8.06	0.10912	0.955009	0	0.001651			0.00128
			12.5	7.74	0.10639	0.95776	0	0.001534			0.00125
			13.5	7.45	0.10361	0.961286	0	0.001389			0.00129
			14.5	7.19	0.10082	0.965249	0	0.001229			0.00137
			15.5	6.95	0.09805	0.969144	0	0.001076			0.00148
			16.5	6.73	0.09533	0.972839	0	0.000935			0.00162
			17.5	6.54	0.09268	0.976456	0	0.0008			0.00179
		2475	0.5	10.52	0.19609	0.69085	0	0.033192	0.03704523	0.0351966	0.0299
			1.5	10.52	0.21004	0.683781	0	0.034961			0.03291
			2.5	11.15	0.21458	0.691028	0	0.033149			0.03084
			3.5	11.77	0.21613	0.6994	0	0.031142			0.02879
			4.5	10.86	0.21685	0.686021	0	0.034393			0.03125
			5.5	10.9	0.21565	0.687025	0	0.034141			0.03154
			6.5	10.11	0.21378	0.676662	0	0.03681			0.03447
			7.5	9.46	0.21097	0.668543	0	0.039003			0.03776
			8.5	8.92	0.20747	0.66201	0	0.040832			0.03826
			9.5	8.84	0.20343	0.66195	0	0.040849			0.03843
			10.5	8.43	0.19906	0.657281	0	0.042191			0.03903
			11.5	8.06	0.19442	0.653163	0	0.043399			0.04029
			12.5	7.74	0.1896	0.649767	0	0.044412			0.0414
			13.5	7.45	0.18469	0.646826	0	0.045301			0.04233
			14.5	7.19	0.17975	0.644372	0	0.046051			0.04203
			15.5	6.95	0.17485	0.642275	0	0.046698			0.04235
			16.5	6.73	0.17003	0.640561	0	0.047231			0.042
			17.5	6.54	0.16533	0.639439	0	0.047582			0.04357
		1033	0.5	10.52	0.14989	0.746346	0	0.021536	0.02783855	0.0182477	0.00934
			1.5	10.52	0.16053	0.725185	0	0.025533			0.0143
			2.5	11.15	0.16398	0.734915	0	0.02363			0.01212
			3.5	11.77	0.16515	0.748451	0	0.021166			0.01033
			4.5	10.86	0.16567	0.724966	0	0.025577			0.01576
			5.5	10.9	0.16473	0.727468	0	0.025076			0.01426
			6.5	10.11	0.16327	0.710801	0	0.028558			0.01839

			7.5	9.46	0.1611	0.698731	0	0.031299			0.0216
			8.5	8.92	0.15839	0.689929	0	0.033419			0.0222
			9.5	8.84	0.15528	0.692402	0	0.032813			0.02273
			10.5	8.43	0.15191	0.68744	0	0.034037			0.02343
			11.5	8.06	0.14834	0.683697	0	0.034982			0.02321
			12.5	7.74	0.14463	0.681413	0	0.035568			0.02457
			13.5	7.45	0.14086	0.680106	0	0.035907			0.02417
			14.5	7.19	0.13707	0.679801	0	0.035986			0.02462
			15.5	6.95	0.1333	0.680251	0	0.03587			0.02458
			16.5	6.73	0.1296	0.681465	0	0.035555			0.02314
			17.5	6.54	0.12599	0.683762	0	0.034966			0.02375
4	Charleston	475	0.5	10.52	0.17312	0.707521	0	0.029284	0.03523838	0.0132427	0.01079
			1.5	10.52	0.18597	0.694294	0	0.032355			0.0127
			2.5	11.15	0.19063	0.70194	0	0.030552			0.0117
			3.5	11.77	0.19273	0.711591	0	0.028385			0.01089
			4.5	10.86	0.19417	0.693957	0	0.032436			0.0128
			5.5	10.9	0.19397	0.694799	0	0.032234			0.0111
			6.5	10.11	0.19321	0.681882	0	0.035448			0.01345
			7.5	9.46	0.19164	0.672118	0	0.038026			0.014
			8.5	8.92	0.18946	0.664509	0	0.040125			0.01524
			9.5	8.84	0.1868	0.664519	0	0.040123			0.01567
			10.5	8.43	0.18383	0.65926	0	0.041619			0.01502
			11.5	8.06	0.18058	0.654699	0	0.042946			0.0169
			12.5	7.74	0.17714	0.650988	0	0.044046			0.01671
			13.5	7.45	0.17357	0.647794	0	0.045007			0.01654
			14.5	7.19	0.16991	0.645131	0	0.045818			0.01682
			15.5	6.95	0.16623	0.642834	0	0.046525			0.0151
			16.5	6.73	0.16256	0.640919	0	0.04712			0.01536
			17.5	6.54	0.15894	0.639596	0	0.047533			0.01562
		2475	0.5	10.52	0.59703	0.917411	0.024	0.037695	0.03962546	0.0453767	0.04398
			1.5	10.52	0.64265	0.917411	0.024	0.037695			0.04311
			2.5	11.15	0.66028	0.925642	0.024	0.036094			0.04111
			3.5	11.77	0.6693	0.933457	0.024	0.03462			0.04066
			4.5	10.86	0.67624	0.92189	0.024	0.036818			0.04398
			5.5	10.9	0.67766	0.922412	0.024	0.036716			0.04209
			6.5	10.11	0.67727	0.911886	0.024	0.038797			0.0458
			7.5	9.46	0.67416	0.902833	0.024	0.040651			0.04611
			8.5	8.92	0.66897	0.895016	0.024	0.042299			0.04815
			9.5	8.84	0.66211	0.893834	0.024	0.042552			0.04826
			10.5	8.43	0.65415	0.887669	0.024	0.043888			0.04907
			11.5	8.06	0.64519	0.881947	0.024	0.045151			0.05011
			12.5	7.74	0.63547	0.876871	0.024	0.046291			0.05115
			13.5	7.45	0.62519	0.87216	0.024	0.047364			0.05216
			14.5	7.19	0.61452	0.867844	0.024	0.04836			0.05335
			15.5	6.95	0.60362	0.863777	0.024	0.04931			0.05455
			16.5	6.73	0.59261	0.859976	0.024	0.050207			0.05575
			17.5	6.54	0.58162	0.856634	0.024	0.051003			0.05694
		1033	0.5	10.52	0.34025	0.908671	0.0148	0.024663	0.02625172	0.0319565	0.02914
			1.5	10.52	0.36601	0.908587	0.0148	0.024676			0.03016
			2.5	11.15	0.37575	0.916745	0.0148	0.023416			0.0295
			3.5	11.77	0.38056	0.924506	0.0148	0.022265			0.02857
			4.5	10.86	0.38413	0.913006	0.0148	0.023988			0.03049
			5.5	10.9	0.38454	0.913522	0.0148	0.023908			0.03058
			6.5	10.11	0.38389	0.903082	0.0148	0.025555			0.03269
			7.5	9.46	0.38167	0.89411	0.0148	0.027039			0.03309
			8.5	8.92	0.37827	0.886365	0.0148	0.028372			0.03394

			9.5	8.84	0.37391	0.885194	0.0148	0.028577			0.03411
			10.5	8.43	0.36893	0.879087	0.0148	0.029669			0.03497
			11.5	8.06	0.36339	0.873421	0.0148	0.030709			0.03617
			12.5	7.74	0.35743	0.868393	0.0148	0.031655			0.03589
			13.5	7.45	0.35117	0.863728	0.0148	0.032552			0.03706
			14.5	7.19	0.34471	0.859454	0.0148	0.03339			0.03844
			15.5	6.95	0.33814	0.855427	0.0148	0.034194			0.03844
			16.5	6.73	0.33154	0.851663	0.0148	0.034959			0.03785
			17.5	6.54	0.32498	0.848354	0.0148	0.035641			0.0392
4	Eureka	475	0.5	10.52	0.59874	0.917412	0.0249	0.039076	0.04103425	0.0408315	0.03835
			1.5	10.52	0.64559	0.917412	0.0249	0.039076			0.03808
			2.5	11.15	0.66461	0.925642	0.0249	0.037446			0.03724
			3.5	11.77	0.67518	0.933458	0.0249	0.035944			0.03665
			4.5	10.86	0.68385	0.921891	0.0249	0.038183			0.03894
			5.5	10.9	0.68709	0.922412	0.0249	0.03808			0.03899
			6.5	10.11	0.68864	0.911887	0.0249	0.040198			0.04096
			7.5	9.46	0.68753	0.902834	0.0249	0.042082			0.04171
			8.5	8.92	0.68439	0.895017	0.0249	0.043755			0.04393
			9.5	8.84	0.67957	0.893834	0.0249	0.044012			0.04385
			10.5	8.43	0.67365	0.887669	0.0249	0.045366			0.04479
			11.5	8.06	0.66668	0.881948	0.0249	0.046646			0.04579
			12.5	7.74	0.65891	0.876871	0.0249	0.0478			0.04681
			13.5	7.45	0.65049	0.872161	0.0249	0.048885			0.04785
			14.5	7.19	0.64159	0.867845	0.0249	0.049891			0.04765
			15.5	6.95	0.63235	0.863778	0.0249	0.05085			0.04875
			16.5	6.73	0.62288	0.859977	0.0249	0.051755			0.04988
			17.5	6.54	0.61329	0.856635	0.0249	0.052557			0.04901
		2475	0.5	10.52	1.4252	0.917413	0.0364	0.056647	0.05875164	0.0565891	0.05476
			1.5	10.52	1.53767	0.917413	0.0364	0.056647			0.05465
			2.5	11.15	1.5841	0.925644	0.0364	0.054781			0.05265
			3.5	11.77	1.61059	0.93346	0.0364	0.053035			0.05035
			4.5	10.86	1.63272	0.921893	0.0364	0.055628			0.05363
			5.5	10.9	1.64204	0.922414	0.0364	0.05551			0.05365
			6.5	10.11	1.64744	0.911889	0.0364	0.057913			0.05557
			7.5	9.46	1.64658	0.902836	0.0364	0.060009			0.05752
			8.5	8.92	1.64091	0.895019	0.0364	0.061836			0.05952
			9.5	8.84	1.6313	0.893836	0.0364	0.062114			0.05951
			10.5	8.43	1.61903	0.887671	0.0364	0.063564			0.06154
			11.5	8.06	1.60428	0.88195	0.0364	0.064915			0.0625
			12.5	7.74	1.58755	0.876873	0.0364	0.066115			0.06348
			13.5	7.45	1.56924	0.872163	0.0364	0.067229			0.06576
			14.5	7.19	1.5497	0.867847	0.0364	0.068248			0.06655
			15.5	6.95	1.52926	0.86378	0.0364	0.069206			0.06755
			16.5	6.73	1.50818	0.859978	0.0364	0.0701			0.06857
			17.5	6.54	1.48672	0.856637	0.0364	0.070882			0.06958
		1033	0.5	10.52	0.96545	0.917413	0.0315	0.049272	0.0513641	0.0500851	0.04862
			1.5	10.52	1.04137	0.917413	0.0315	0.049272			0.04851
			2.5	11.15	1.07249	0.925644	0.0315	0.047472			0.04619
			3.5	11.77	1.09007	0.93346	0.0315	0.0458			0.04406
			4.5	10.86	1.10463	0.921893	0.0315	0.048288			0.0475
			5.5	10.9	1.11049	0.922414	0.0315	0.048174			0.04752
			6.5	10.11	1.11367	0.911889	0.0315	0.050502			0.04946
			7.5	9.46	1.11258	0.902836	0.0315	0.052551			0.05186
			8.5	8.92	1.10823	0.895019	0.0315	0.054353			0.05192
			9.5	8.84	1.10119	0.893836	0.0315	0.054628			0.05387
			10.5	8.43	1.09235	0.887671	0.0315	0.056072			0.05439

			11.5	8.06	1.08185	0.88195	0.0315	0.057427			0.05493
			12.5	7.74	1.07001	0.876873	0.0315	0.058638			0.05591
			13.5	7.45	1.05711	0.872163	0.0315	0.05977			0.05888
			14.5	7.19	1.04341	0.867847	0.0315	0.060813			0.0579
			15.5	6.95	1.02911	0.86378	0.0315	0.0618			0.05894
			16.5	6.73	1.01442	0.859978	0.0315	0.062725			0.05998
			17.5	6.54	0.9995	0.856637	0.0315	0.063541			0.06101
4	Memphis	475	0.5	10.52	0.19595	0.691044	0	0.033145	0.0375847	0.0179467	0.01432
			1.5	10.52	0.2109	0.683543	0	0.035022			0.01608
			2.5	11.15	0.21666	0.690276	0	0.033334			0.01524
			3.5	11.77	0.21959	0.697899	0	0.031495			0.0146
			4.5	10.86	0.22183	0.68446	0	0.034788			0.01614
			5.5	10.9	0.22226	0.684863	0	0.034686			0.01641
			6.5	10.11	0.22209	0.674526	0	0.037378			0.01843
			7.5	9.46	0.22103	0.666377	0	0.039603			0.02083
			8.5	8.92	0.21929	0.659745	0	0.041479			0.02185
			9.5	8.84	0.217	0.659083	0	0.04167			0.02008
			10.5	8.43	0.21435	0.654144	0	0.043109			0.02119
			11.5	8.06	0.21137	0.649683	0	0.044437			0.02295
			12.5	7.74	0.20814	0.645837	0	0.045602			0.02256
			13.5	7.45	0.20473	0.642347	0	0.046676			0.02219
			14.5	7.19	0.2012	0.639224	0	0.047649			0.02233
			15.5	6.95	0.19759	0.63634	0	0.048559			0.02249
			16.5	6.73	0.19394	0.633707	0	0.049398			0.02263
			17.5	6.54	0.19031	0.631488	0	0.050111			0.02275
		2475	0.5	10.52	0.54253	0.917403	0.0252	0.039567	0.04153387	0.0469255	0.04459
			1.5	10.52	0.58471	0.917403	0.0252	0.039567			0.04411
			2.5	11.15	0.60161	0.925634	0.0252	0.037927			0.04353
			3.5	11.77	0.61081	0.93345	0.0252	0.036414			0.043
			4.5	10.86	0.61824	0.921883	0.0252	0.038668			0.04459
			5.5	10.9	0.62073	0.922404	0.0252	0.038565			0.04307
			6.5	10.11	0.62165	0.911878	0.0252	0.040694			0.0467
			7.5	9.46	0.62014	0.902826	0.0252	0.042589			0.0484
			8.5	8.92	0.61678	0.895009	0.0252	0.044271			0.0491
			9.5	8.84	0.61189	0.893826	0.0252	0.044529			0.05049
			10.5	8.43	0.606	0.887661	0.0252	0.045889			0.05129
			11.5	8.06	0.59919	0.88194	0.0252	0.047175			0.05231
			12.5	7.74	0.59164	0.876863	0.0252	0.048333			0.05333
			13.5	7.45	0.58353	0.872153	0.0252	0.049422			0.05431
			14.5	7.19	0.57501	0.867837	0.0252	0.050432			0.05546
			15.5	6.95	0.5662	0.86377	0.0252	0.051394			0.05663
			16.5	6.73	0.55722	0.859969	0.0252	0.052301			0.05779
			17.5	6.54	0.54816	0.856627	0.0252	0.053105			0.05895
		1033	0.5	10.52	0.35906	0.910867	0.0157	0.025755	0.02737298	0.0341593	0.031
			1.5	10.52	0.38687	0.910823	0.0157	0.025762			0.03183
			2.5	11.15	0.39793	0.918997	0.0157	0.02447			0.03141
			3.5	11.77	0.40388	0.926766	0.0157	0.023288			0.03072
			4.5	10.86	0.40865	0.915261	0.0157	0.025054			0.03251
			5.5	10.9	0.41012	0.915778	0.0157	0.024972			0.03264
			6.5	10.11	0.41056	0.905321	0.0157	0.02666			0.03285
			7.5	9.46	0.40938	0.896331	0.0157	0.02818			0.03509
			8.5	8.92	0.40696	0.888568	0.0157	0.029544			0.03757
			9.5	8.84	0.40354	0.887394	0.0157	0.029755			0.03753
			10.5	8.43	0.39945	0.881273	0.0157	0.030871			0.03836
			11.5	8.06	0.39476	0.875593	0.0157	0.031935			0.03803
			12.5	7.74	0.38958	0.870552	0.0157	0.032901			0.03926

			13.5	7.45	0.38404	0.865876	0.0157	0.033817			0.04032
			14.5	7.19	0.37824	0.861591	0.0157	0.034673			0.04165
			15.5	6.95	0.37225	0.857553	0.0157	0.035493			0.04163
			16.5	6.73	0.36616	0.853779	0.0157	0.036272			0.04097
			17.5	6.54	0.36004	0.850462	0.0157	0.036968			0.04228
4	Portland	475	0.5	10.52	0.29167	0.803407	0.0072	0.02889	0.03070156	0.0336771	0.03059
			1.5	10.52	0.31435	0.802984	0.0072	0.028973			0.03109
			2.5	11.15	0.32343	0.810213	0.0072	0.027584			0.03044
			3.5	11.77	0.32838	0.817138	0.0072	0.026301			0.02996
			4.5	10.86	0.33237	0.806791	0.0072	0.028235			0.03158
			5.5	10.9	0.33371	0.807243	0.0072	0.028148			0.03167
			6.5	10.11	0.3342	0.797944	0.0072	0.029973			0.03345
			7.5	9.46	0.33339	0.789982	0.0072	0.031604			0.03561
			8.5	8.92	0.33159	0.783122	0.0072	0.033062			0.03612
			9.5	8.84	0.32896	0.782089	0.0072	0.033286			0.03623
			10.5	8.43	0.32579	0.776685	0.0072	0.034474			0.03899
			11.5	8.06	0.32213	0.771674	0.0072	0.035604			0.03844
			12.5	7.74	0.31807	0.767229	0.0072	0.036628			0.0398
			13.5	7.45	0.31371	0.763106	0.0072	0.037597			0.04084
			14.5	7.19	0.30913	0.759329	0.0072	0.0385			0.04015
			15.5	6.95	0.3044	0.75577	0.0072	0.039365			0.04011
			16.5	6.73	0.29957	0.752446	0.0072	0.040184			0.04143
			17.5	6.54	0.2947	0.749524	0.0072	0.040914			0.04273
		2475	0.5	10.52	0.51866	0.917373	0.0296	0.046352	0.04841854	0.0537913	0.05189
			1.5	10.52	0.55919	0.917373	0.0296	0.046352			0.05151
			2.5	11.15	0.57559	0.925604	0.0296	0.044593			0.0492
			3.5	11.77	0.58467	0.933419	0.0296	0.042961			0.0472
			4.5	10.86	0.59209	0.921853	0.0296	0.045389			0.05197
			5.5	10.9	0.5948	0.922374	0.0296	0.045278			0.05044
			6.5	10.11	0.59604	0.911849	0.0296	0.047557			0.05378
			7.5	9.46	0.59497	0.902796	0.0296	0.04957			0.05563
			8.5	8.92	0.59214	0.89498	0.0296	0.051346			0.05612
			9.5	8.84	0.58786	0.893797	0.0296	0.051617			0.05762
			10.5	8.43	0.58261	0.887632	0.0296	0.053045			0.05812
			11.5	8.06	0.57647	0.881911	0.0296	0.054386			0.05909
			12.5	7.74	0.56962	0.876835	0.0296	0.055589			0.06156
			13.5	7.45	0.56223	0.872125	0.0296	0.056716			0.06214
			14.5	7.19	0.55442	0.867809	0.0296	0.057756			0.0632
			15.5	6.95	0.54632	0.863742	0.0296	0.058742			0.06428
			16.5	6.73	0.53803	0.859941	0.0296	0.059669			0.06535
			17.5	6.54	0.52965	0.856599	0.0296	0.060487			0.06642
		1033	0.5	10.52	0.39475	0.913847	0.0205	0.032789	0.0346091	0.0452415	0.04252
			1.5	10.52	0.42555	0.913835	0.0205	0.032792			0.04336
			2.5	11.15	0.43798	0.922034	0.0205	0.031306			0.04121
			3.5	11.77	0.44482	0.929822	0.0205	0.029942			0.03894
			4.5	10.86	0.4504	0.918294	0.0205	0.031977			0.04206
			5.5	10.9	0.45239	0.918813	0.0205	0.031883			0.04213
			6.5	10.11	0.45326	0.908327	0.0205	0.033819			0.04567
			7.5	9.46	0.45236	0.899309	0.0205	0.035551			0.0459
			8.5	8.92	0.45012	0.891522	0.0205	0.037097			0.04984
			9.5	8.84	0.44678	0.890344	0.0205	0.037335			0.04793
			10.5	8.43	0.4427	0.884203	0.0205	0.038593			0.05067
			11.5	8.06	0.43795	0.878504	0.0205	0.039787			0.05165
			12.5	7.74	0.43266	0.873447	0.0205	0.040867			0.05265
			13.5	7.45	0.42695	0.868755	0.0205	0.041887			0.0536
			14.5	7.19	0.42094	0.864456	0.0205	0.042837			0.05474

			15.5	6.95	0.4147	0.860405	0.0205	0.043744			0.05392
			16.5	6.73	0.40833	0.856618	0.0205	0.044603			0.05508
			17.5	6.54	0.40189	0.85329	0.0205	0.045367			0.05624
4	SLC	475	0.5	10.52	0.2571	0.737781	0.0049	0.037505	0.03980131	0.0304979	0.02799
			1.5	10.52	0.27639	0.736553	0.0049	0.037807			0.02819
			2.5	11.15	0.28355	0.743278	0.0049	0.036176			0.02758
			3.5	11.77	0.28694	0.749876	0.0049	0.034625			0.02511
			4.5	10.86	0.28938	0.739855	0.0049	0.037			0.02859
			5.5	10.9	0.28941	0.740294	0.0049	0.036893			0.0287
			6.5	10.11	0.28862	0.731518	0.0049	0.039061			0.03058
			7.5	9.46	0.28664	0.72409	0.0049	0.040964			0.03268
			8.5	8.92	0.28377	0.717731	0.0049	0.042642			0.03338
			9.5	8.84	0.28017	0.716815	0.0049	0.042888			0.03353
			10.5	8.43	0.2761	0.711834	0.0049	0.044238			0.03423
			11.5	8.06	0.27161	0.707226	0.0049	0.045511			0.03536
			12.5	7.74	0.26683	0.703151	0.0049	0.046655			0.03665
			13.5	7.45	0.26182	0.699378	0.0049	0.04773			0.03607
			14.5	7.19	0.25669	0.695931	0.0049	0.048725			0.03745
			15.5	6.95	0.25149	0.692691	0.0049	0.04967			0.03745
			16.5	6.73	0.24628	0.689672	0.0049	0.050561			0.03883
			17.5	6.54	0.24112	0.687032	0.0049	0.051346			0.03818
		2475	0.5	10.52	0.55924	0.917405	0.0271	0.042423	0.04443844	0.052626	0.04969
			1.5	10.52	0.60166	0.917405	0.0271	0.042423			0.05079
			2.5	11.15	0.6178	0.925636	0.0271	0.040728			0.04892
			3.5	11.77	0.62582	0.933452	0.0271	0.039162			0.04636
			4.5	10.86	0.63184	0.921885	0.0271	0.041495			0.04958
			5.5	10.9	0.63266	0.922406	0.0271	0.041388			0.04964
			6.5	10.11	0.63175	0.911881	0.0271	0.043586			0.05112
			7.5	9.46	0.62828	0.902828	0.0271	0.045536			0.05475
			8.5	8.92	0.62286	0.895011	0.0271	0.047263			0.05527
			9.5	8.84	0.61586	0.893828	0.0271	0.047528			0.05671
			10.5	8.43	0.60784	0.887663	0.0271	0.048921			0.05748
			11.5	8.06	0.59889	0.881942	0.0271	0.050234			0.05824
			12.5	7.74	0.58926	0.876865	0.0271	0.051416			0.06056
			13.5	7.45	0.57912	0.872155	0.0271	0.052524			0.06148
			14.5	7.19	0.56865	0.867839	0.0271	0.053551			0.06257
			15.5	6.95	0.55798	0.863772	0.0271	0.054527			0.06367
			16.5	6.73	0.54726	0.859971	0.0271	0.055446			0.06477
			17.5	6.54	0.53658	0.856629	0.0271	0.05626			0.06585
		1033	0.5	10.52	0.37575	0.914479	0.0184	0.029391	0.03111954	0.0427113	0.03893
			1.5	10.52	0.40412	0.914455	0.0184	0.029395			0.04004
			2.5	11.15	0.41481	0.922661	0.0184	0.027999			0.03958
			3.5	11.77	0.42003	0.930457	0.0184	0.026719			0.03719
			4.5	10.86	0.42388	0.918915	0.0184	0.02863			0.0404
			5.5	10.9	0.42423	0.919435	0.0184	0.028542			0.04045
			6.5	10.11	0.4234	0.908939	0.0184	0.030363			0.04213
			7.5	9.46	0.42084	0.899914	0.0184	0.031998			0.0457
			8.5	8.92	0.41697	0.892122	0.0184	0.033462			0.04625
			9.5	8.84	0.41205	0.890943	0.0184	0.033687			0.04635
			10.5	8.43	0.40643	0.884798	0.0184	0.034881			0.04702
			11.5	8.06	0.4002	0.879095	0.0184	0.036017			0.04796
			12.5	7.74	0.39352	0.874034	0.0184	0.037046			0.04896
			13.5	7.45	0.38651	0.869339	0.0184	0.03802			0.04993
			14.5	7.19	0.37928	0.865037	0.0184	0.038928			0.05113
			15.5	6.95	0.37194	0.860983	0.0184	0.039797			0.05234
			16.5	6.73	0.36457	0.857195	0.0184	0.040621			0.05355

			17.5	6.54	0.35725	0.853864	0.0184	0.041355			0.05472
4	San Fran	475	0.5	10.52	0.47677	0.917284	0.0255	0.040052	0.04202804	0.041346	0.03925
			1.5	10.52	0.51402	0.917283	0.0255	0.040052			0.03909
			2.5	11.15	0.5291	0.925513	0.0255	0.038402			0.03854
			3.5	11.77	0.53744	0.933328	0.0255	0.03688			0.03602
			4.5	10.86	0.54426	0.921762	0.0255	0.039148			0.03997
			5.5	10.9	0.54675	0.922283	0.0255	0.039044			0.038
			6.5	10.11	0.5479	0.911759	0.0255	0.041186			0.04001
			7.5	9.46	0.54691	0.902708	0.0255	0.043091			0.0428
			8.5	8.92	0.54431	0.894892	0.0255	0.044781			0.04338
			9.5	8.84	0.54037	0.893709	0.0255	0.04504			0.04495
			10.5	8.43	0.53555	0.887545	0.0255	0.046406			0.04585
			11.5	8.06	0.52991	0.881825	0.0255	0.047697			0.04683
			12.5	7.74	0.52361	0.876749	0.0255	0.048859			0.04784
			13.5	7.45	0.51682	0.872039	0.0255	0.049952			0.04892
			14.5	7.19	0.50964	0.867723	0.0255	0.050965			0.04864
			15.5	6.95	0.50219	0.863657	0.0255	0.05193			0.04971
			16.5	6.73	0.49458	0.859856	0.0255	0.05284			0.05079
			17.5	6.54	0.48687	0.856515	0.0255	0.053646			0.05189
		2475	0.5	10.52	0.79229	0.917413	0.0379	0.058852	0.06094475	0.0562647	0.05437
			1.5	10.52	0.85477	0.917413	0.0379	0.058852			0.0543
			2.5	11.15	0.88053	0.925644	0.0379	0.056977			0.0523
			3.5	11.77	0.8952	0.93346	0.0379	0.055219			0.05015
			4.5	10.86	0.90743	0.921893	0.0379	0.057829			0.05329
			5.5	10.9	0.91253	0.922414	0.0379	0.05771			0.0533
			6.5	10.11	0.91546	0.911889	0.0379	0.060121			0.05524
			7.5	9.46	0.91489	0.902836	0.0379	0.062217			0.05721
			8.5	8.92	0.91166	0.895019	0.0379	0.064039			0.05921
			9.5	8.84	0.90623	0.893836	0.0379	0.064315			0.05919
			10.5	8.43	0.89932	0.887671	0.0379	0.065757			0.06122
			11.5	8.06	0.89104	0.88195	0.0379	0.067095			0.06218
			12.5	7.74	0.88165	0.876873	0.0379	0.068282			0.06316
			13.5	7.45	0.87139	0.872163	0.0379	0.06938			0.06559
			14.5	7.19	0.86046	0.867847	0.0379	0.070382			0.06621
			15.5	6.95	0.84902	0.86378	0.0379	0.071323			0.06721
			16.5	6.73	0.83723	0.859978	0.0379	0.072198			0.06821
			17.5	6.54	0.82524	0.856637	0.0379	0.072962			0.06922
		1033	0.5	10.52	0.60352	0.917412	0.0325	0.05092	0.05302163	0.0503382	0.04823
			1.5	10.52	0.65092	0.917412	0.0325	0.05092			0.04816
			2.5	11.15	0.67029	0.925642	0.0325	0.049101			0.04769
			3.5	11.77	0.68118	0.933458	0.0325	0.047408			0.04546
			4.5	10.86	0.69018	0.921891	0.0325	0.049926			0.04715
			5.5	10.9	0.69373	0.922412	0.0325	0.049811			0.04715
			6.5	10.11	0.6956	0.911887	0.0325	0.052161			0.04911
			7.5	9.46	0.69479	0.902834	0.0325	0.054227			0.05127
			8.5	8.92	0.69194	0.895017	0.0325	0.05604			0.0533
			9.5	8.84	0.68741	0.893835	0.0325	0.056316			0.05328
			10.5	8.43	0.68176	0.887669	0.0325	0.057767			0.05407
			11.5	8.06	0.67506	0.881948	0.0325	0.059125			0.05631
			12.5	7.74	0.66753	0.876871	0.0325	0.060338			0.05727
			13.5	7.45	0.65935	0.872161	0.0325	0.06147			0.05825
			14.5	7.19	0.65067	0.867845	0.0325	0.062511			0.05924
			15.5	6.95	0.64162	0.863778	0.0325	0.063496			0.06026
			16.5	6.73	0.63233	0.859977	0.0325	0.064418			0.06128
			17.5	6.54	0.62291	0.856635	0.0325	0.065229			0.06231
4	San Jose	475	0.5	10.52	0.42836	0.916968	0.0257	0.040345	0.04232681	0.04118	0.03939

			1.5	10.52	0.46028	0.916964	0.0257	0.040346			0.03922
			2.5	11.15	0.47194	0.925191	0.0257	0.03869			0.03861
			3.5	11.77	0.4773	0.933004	0.0257	0.037162			0.0361
			4.5	10.86	0.48105	0.921441	0.0257	0.039439			0.03809
			5.5	10.9	0.48074	0.921962	0.0257	0.039334			0.03813
			6.5	10.11	0.47906	0.911441	0.0257	0.041484			0.04014
			7.5	9.46	0.47539	0.902392	0.0257	0.043394			0.04292
			8.5	8.92	0.47022	0.894579	0.0257	0.045089			0.04346
			9.5	8.84	0.46384	0.893397	0.0257	0.045349			0.04303
			10.5	8.43	0.45669	0.887235	0.0257	0.046719			0.04598
			11.5	8.06	0.44885	0.881516	0.0257	0.048013			0.04696
			12.5	7.74	0.44053	0.876442	0.0257	0.049178			0.04797
			13.5	7.45	0.43187	0.871734	0.0257	0.050273			0.049
			14.5	7.19	0.423	0.86742	0.0257	0.051288			0.04877
			15.5	6.95	0.41404	0.863355	0.0257	0.052254			0.04984
			16.5	6.73	0.4051	0.859556	0.0257	0.053165			0.05093
			17.5	6.54	0.39627	0.856216	0.0257	0.053972			0.05004
		2475	0.5	10.52	0.65495	0.917413	0.0379	0.058939	0.06103151	0.0563062	0.05442
			1.5	10.52	0.70375	0.917413	0.0379	0.058939			0.05435
			2.5	11.15	0.72159	0.925644	0.0379	0.057065			0.05234
			3.5	11.77	0.72978	0.933459	0.0379	0.055306			0.05018
			4.5	10.86	0.73551	0.921892	0.0379	0.057916			0.05333
			5.5	10.9	0.73504	0.922414	0.0379	0.057798			0.05335
			6.5	10.11	0.73248	0.911888	0.0379	0.060209			0.05528
			7.5	9.46	0.72686	0.902835	0.0379	0.062304			0.05725
			8.5	8.92	0.71895	0.895018	0.0379	0.064126			0.05925
			9.5	8.84	0.7092	0.893836	0.0379	0.064402			0.05923
			10.5	8.43	0.69826	0.887671	0.0379	0.065843			0.06126
			11.5	8.06	0.68628	0.881949	0.0379	0.067181			0.06223
			12.5	7.74	0.67356	0.876873	0.0379	0.068367			0.0632
			13.5	7.45	0.66031	0.872162	0.0379	0.069464			0.06561
			14.5	7.19	0.64675	0.867846	0.0379	0.070466			0.06625
			15.5	6.95	0.63306	0.863779	0.0379	0.071406			0.06725
			16.5	6.73	0.61939	0.859978	0.0379	0.07228			0.06826
			17.5	6.54	0.60589	0.856636	0.0379	0.073043			0.06926
		1033	0.5	10.52	0.52392	0.917393	0.0326	0.051087	0.05318939	0.0503977	0.04828
			1.5	10.52	0.56298	0.917393	0.0326	0.051087			0.04821
			2.5	11.15	0.57729	0.925623	0.0326	0.049266			0.04773
			3.5	11.77	0.58388	0.933439	0.0326	0.047571			0.04554
			4.5	10.86	0.5885	0.921872	0.0326	0.050092			0.04718
			5.5	10.9	0.58818	0.922393	0.0326	0.049977			0.04719
			6.5	10.11	0.58618	0.911868	0.0326	0.052329			0.04915
			7.5	9.46	0.58174	0.902816	0.0326	0.054396			0.05135
			8.5	8.92	0.57546	0.894999	0.0326	0.05621			0.05338
			9.5	8.84	0.56771	0.893816	0.0326	0.056487			0.05333
			10.5	8.43	0.55901	0.887651	0.0326	0.057938			0.05411
			11.5	8.06	0.54948	0.88193	0.0326	0.059296			0.05639
			12.5	7.74	0.53935	0.876853	0.0326	0.060509			0.05735
			13.5	7.45	0.52879	0.872143	0.0326	0.061641			0.05834
			14.5	7.19	0.51799	0.867827	0.0326	0.062682			0.05933
			15.5	6.95	0.50708	0.86376	0.0326	0.063666			0.06034
			16.5	6.73	0.49618	0.859959	0.0326	0.064588			0.06137
			17.5	6.54	0.48541	0.856617	0.0326	0.065399			0.06238
4	Santa Monica	475	0.5	10.52	0.38227	0.914422	0.0213	0.034004	0.03585593	0.0407945	0.03846
			1.5	10.52	0.41093	0.914403	0.0213	0.034008			0.03808
			2.5	11.15	0.42154	0.922609	0.0213	0.032492			0.03725

			3.5	11.77	0.42656	0.930403	0.0213	0.031098			0.03666
			4.5	10.86	0.43016	0.918865	0.0213	0.033177			0.0389
			5.5	10.9	0.43016	0.919384	0.0213	0.033081			0.03894
			6.5	10.11	0.42895	0.90889	0.0213	0.035055			0.04088
			7.5	9.46	0.42598	0.899866	0.0213	0.03682			0.04161
			8.5	8.92	0.42166	0.892074	0.0213	0.038393			0.04386
			9.5	8.84	0.41627	0.890895	0.0213	0.038635			0.04374
			10.5	8.43	0.41018	0.88475	0.0213	0.039915			0.04466
			11.5	8.06	0.40348	0.879048	0.0213	0.041127			0.04566
			12.5	7.74	0.39632	0.873988	0.0213	0.042224			0.04668
			13.5	7.45	0.38885	0.869293	0.0213	0.043259			0.04771
			14.5	7.19	0.38119	0.864991	0.0213	0.044221			0.04751
			15.5	6.95	0.37342	0.860937	0.0213	0.04514			0.04861
			16.5	6.73	0.36566	0.857149	0.0213	0.04601			0.04973
			17.5	6.54	0.35796	0.853818	0.0213	0.046783			0.05087
		2475	0.5	10.52	0.64553	0.917413	0.0355	0.055311	0.05741962	0.0565826	0.05481
			1.5	10.52	0.69428	0.917413	0.0355	0.055311			0.05466
			2.5	11.15	0.71264	0.925643	0.0355	0.053453			0.05266
			3.5	11.77	0.72161	0.933459	0.0355	0.051717			0.05036
			4.5	10.86	0.72823	0.921892	0.0355	0.054296			0.05363
			5.5	10.9	0.72882	0.922413	0.0355	0.054179			0.05364
			6.5	10.11	0.7274	0.911888	0.0355	0.056574			0.05554
			7.5	9.46	0.72301	0.902835	0.0355	0.058666			0.05749
			8.5	8.92	0.71636	0.895018	0.0355	0.060494			0.05949
			9.5	8.84	0.7079	0.893835	0.0355	0.060772			0.05947
			10.5	8.43	0.69825	0.88767	0.0355	0.062225			0.0615
			11.5	8.06	0.68755	0.881949	0.0355	0.063581			0.06246
			12.5	7.74	0.67607	0.876872	0.0355	0.064787			0.06344
			13.5	7.45	0.66402	0.872162	0.0355	0.065907			0.06574
			14.5	7.19	0.6516	0.867846	0.0355	0.066934			0.0665
			15.5	6.95	0.63899	0.863779	0.0355	0.067901			0.06751
			16.5	6.73	0.62633	0.859978	0.0355	0.068804			0.06853
			17.5	6.54	0.61375	0.856636	0.0355	0.069595			0.06954
		1033	0.5	10.52	0.47478	0.917331	0.0291	0.045595	0.04765275	0.0504007	0.04867
			1.5	10.52	0.5105	0.91733	0.0291	0.045595			0.04852
			2.5	11.15	0.52385	0.925561	0.0291	0.043847			0.04621
			3.5	11.77	0.53026	0.933376	0.0291	0.042227			0.04408
			4.5	10.86	0.53493	0.921809	0.0291	0.044638			0.04749
			5.5	10.9	0.53514	0.922331	0.0291	0.044528			0.04751
			6.5	10.11	0.53387	0.911806	0.0291	0.046792			0.04943
			7.5	9.46	0.53041	0.902754	0.0291	0.048794			0.0518
			8.5	8.92	0.52528	0.894938	0.0291	0.050562			0.05383
			9.5	8.84	0.51882	0.893755	0.0291	0.050832			0.0538
			10.5	8.43	0.51149	0.887591	0.0291	0.052254			0.05434
			11.5	8.06	0.50339	0.88187	0.0291	0.053591			0.05683
			12.5	7.74	0.49473	0.876794	0.0291	0.054791			0.05781
			13.5	7.45	0.48566	0.872084	0.0291	0.055915			0.05879
			14.5	7.19	0.47633	0.867768	0.0291	0.056953			0.0598
			15.5	6.95	0.46687	0.863701	0.0291	0.057938			0.06083
			16.5	6.73	0.45739	0.8599	0.0291	0.058865			0.0599
			17.5	6.54	0.44798	0.856559	0.0291	0.059683			0.06095
4	Seattle	475	0.5	10.52	0.34558	0.906341	0.0177	0.029736	0.03148406	0.0393701	0.03785
			1.5	10.52	0.3715	0.906271	0.0177	0.029749			0.03738
			2.5	11.15	0.38112	0.914408	0.0177	0.028342			0.03688
			3.5	11.77	0.38568	0.922146	0.0177	0.027051			0.03424
			4.5	10.86	0.38897	0.910683	0.0177	0.028979			0.03785

			5.5	10.9	0.389	0.911198	0.0177	0.028891			0.0379
			6.5	10.11	0.38794	0.900787	0.0177	0.030726			0.03826
			7.5	9.46	0.38528	0.891839	0.0177	0.032373			0.04051
			8.5	8.92	0.38141	0.884114	0.0177	0.033846			0.04101
			9.5	8.84	0.37657	0.882947	0.0177	0.034072			0.04104
			10.5	8.43	0.3711	0.876856	0.0177	0.035274			0.04394
			11.5	8.06	0.36508	0.871204	0.0177	0.036416			0.04498
			12.5	7.74	0.35864	0.866188	0.0177	0.037451			0.04404
			13.5	7.45	0.35192	0.861536	0.0177	0.03843			0.0451
			14.5	7.19	0.34502	0.857272	0.0177	0.039343			0.04696
			15.5	6.95	0.33803	0.853256	0.0177	0.040216			0.04616
			16.5	6.73	0.33103	0.849502	0.0177	0.041044			0.04738
			17.5	6.54	0.3241	0.846202	0.0177	0.041781			0.04859
		2475	0.5	10.52	0.60947	0.917412	0.0336	0.052492	0.05459946	0.055878	0.05356
			1.5	10.52	0.65563	0.917412	0.0336	0.052492			0.05325
			2.5	11.15	0.67313	0.925642	0.0336	0.050657			0.05115
			3.5	11.77	0.68178	0.933458	0.0336	0.048947			0.05073
			4.5	10.86	0.68824	0.921891	0.0336	0.051489			0.0522
			5.5	10.9	0.68902	0.922412	0.0336	0.051373			0.05223
			6.5	10.11	0.68791	0.911887	0.0336	0.053742			0.05406
			7.5	9.46	0.68401	0.902834	0.0336	0.05582			0.05796
			8.5	8.92	0.67797	0.895017	0.0336	0.057641			0.05994
			9.5	8.84	0.67023	0.893835	0.0336	0.057919			0.05995
			10.5	8.43	0.66136	0.88767	0.0336	0.059373			0.06197
			11.5	8.06	0.6515	0.881948	0.0336	0.060732			0.06294
			12.5	7.74	0.64088	0.876871	0.0336	0.061944			0.06392
			13.5	7.45	0.62972	0.872161	0.0336	0.063074			0.064
			14.5	7.19	0.61821	0.867845	0.0336	0.064112			0.06503
			15.5	6.95	0.60649	0.863778	0.0336	0.065092			0.06606
			16.5	6.73	0.59471	0.859977	0.0336	0.066009			0.06711
			17.5	6.54	0.58299	0.856635	0.0336	0.066815			0.06815
		1033	0.5	10.52	0.4494	0.917128	0.0265	0.041679	0.04368263	0.0495047	0.04788
			1.5	10.52	0.48329	0.917126	0.0265	0.041679			0.04732
			2.5	11.15	0.49601	0.925355	0.0265	0.039998			0.04535
			3.5	11.77	0.50218	0.933168	0.0265	0.038445			0.04476
			4.5	10.86	0.50672	0.921604	0.0265	0.040758			0.04622
			5.5	10.9	0.50705	0.922125	0.0265	0.040652			0.04628
			6.5	10.11	0.50597	0.911603	0.0265	0.042834			0.048
			7.5	9.46	0.50283	0.902553	0.0265	0.04477			0.05031
			8.5	8.92	0.49811	0.894738	0.0265	0.046486			0.05265
			9.5	8.84	0.49213	0.893556	0.0265	0.046748			0.05267
			10.5	8.43	0.48532	0.887393	0.0265	0.048134			0.05481
			11.5	8.06	0.47779	0.881673	0.0265	0.049441			0.05573
			12.5	7.74	0.46971	0.876598	0.0265	0.050616			0.0567
			13.5	7.45	0.46124	0.871889	0.0265	0.051721			0.05769
			14.5	7.19	0.45252	0.867574	0.0265	0.052743			0.05878
			15.5	6.95	0.44367	0.863509	0.0265	0.053716			0.05985
			16.5	6.73	0.43479	0.859709	0.0265	0.054633			0.05898
			17.5	6.54	0.42598	0.856368	0.0265	0.055444			0.06008
5	Butte	475	0.5	38.63	0.07424	1	0	2.36E-18	2.3599E-18	0	0
			1.5	38.63	0.08837	1	0	2.36E-18			0
			2.5	37.76	0.09618	1	0	2.36E-18			0
			3.5	36.48	0.10234	1	0	2.36E-18			0
			4.5	34.15	0.10873	1	0	2.36E-18			0
			5.5	35.45	0.10972	1	0	2.36E-18			0
			6.5	33.79	0.11242	1	0	2.36E-18			0

			7.5	32.35	0.11364	1	0	2.36E-18			0
			8.5	31.07	0.11379	1	0	2.36E-18			0
			9.5	31.42	0.11302	1	0	2.36E-18			0
			10.5	30.36	0.11197	1	0	2.36E-18			0
			11.5	29.4	0.11045	1	0	2.36E-18			0
			12.5	28.51	0.10859	1	0	2.36E-18			0
			13.5	27.7	0.10649	1	0	2.36E-18			0
			14.5	26.94	0.10422	1	0	2.36E-18			0
			15.5	26.23	0.10185	1	0	2.36E-18			0
			16.5	25.57	0.09943	1	0	2.36E-18			0
			17.5	24.94	0.097	1	0	2.36E-18			0
		2475	0.5	38.63	0.13203	1.006927	0	0	0	0	0
			1.5	38.63	0.15719	1.006927	0	0			0
			2.5	37.76	0.17109	1.006927	0	0			0
			3.5	36.48	0.18208	1.006927	0	0			0
			4.5	34.15	0.19347	1.006927	0	0			0
			5.5	35.45	0.19528	1.006927	0	0			0
			6.5	33.79	0.20011	1.006927	0	0			0
			7.5	32.35	0.20231	1.006927	0	0			0
			8.5	31.07	0.20262	1.006927	0	0			0
			9.5	31.42	0.20129	1.006927	0	0			0
			10.5	30.36	0.19946	1.006927	0	0			0
			11.5	29.4	0.1968	1.006927	0	0			0
			12.5	28.51	0.19353	1.006927	0	0			0
			13.5	27.7	0.18982	1.006927	0	0			0
			14.5	26.94	0.18581	1.006927	0	0			0
			15.5	26.23	0.18161	1.006927	0	0			0
			16.5	25.57	0.17733	1.006897	0	0			0
			17.5	24.94	0.17304	1.00684	0	0			0
		1033	0.5	38.63	0.14275	1	0	2.36E-18	1.9649E-07	0	0
			1.5	38.63	0.16994	1	0	2.36E-18			0
			2.5	37.76	0.18494	1	0	2.36E-18			0
			3.5	36.48	0.19679	1	0	2.36E-18			0
			4.5	34.15	0.20908	1	0	2.36E-18			0
			5.5	35.45	0.21099	1	0	2.36E-18			0
			6.5	33.79	0.21618	1	0	2.36E-18			0
			7.5	32.35	0.21852	1	0	2.36E-18			0
			8.5	31.07	0.21881	1	0	2.36E-18			0
			9.5	31.42	0.21733	1	0	2.36E-18			0
			10.5	30.36	0.21531	1	0	2.36E-18			0
			11.5	29.4	0.2124	1	0	2.36E-18			0
			12.5	28.51	0.20882	1	0	2.36E-18			0
			13.5	27.7	0.20477	1	0	2.36E-18			0
			14.5	26.94	0.2004	0.999974	0	8.2E-07			0
			15.5	26.23	0.19584	0.999876	0	3.87E-06			0
			16.5	25.57	0.19119	0.999737	0	8.26E-06			0
			17.5	24.94	0.18653	0.999561	0	1.38E-05			0
5	Charleston	475	0.5	38.63	0.11656	1.001177	0	0	0	0	0
			1.5	38.63	0.13918	1.001177	0	0			0
			2.5	37.76	0.15199	1.001177	0	0			0
			3.5	36.48	0.16236	1.001177	0	0			0
			4.5	34.15	0.17324	1.001177	0	0			0
			5.5	35.45	0.17564	1.001177	0	0			0
			6.5	33.79	0.18086	1.001177	0	0			0
			7.5	32.35	0.18378	1.001177	0	0			0
			8.5	31.07	0.18504	1.001177	0	0			0

			9.5	31.42	0.18483	1.001177	0	0			0
			10.5	30.36	0.1842	1.001177	0	0			0
			11.5	29.4	0.1828	1.001177	0	0			0
			12.5	28.51	0.18081	1.001177	0	0			0
			13.5	27.7	0.17838	1.001177	0	0			0
			14.5	26.94	0.17563	1.001177	0	0			0
			15.5	26.23	0.17266	1.001177	0	0			0
			16.5	25.57	0.16954	1.001177	0	0			0
			17.5	24.94	0.16635	1.001164	0	0			0
		2475	0.5	38.63	0.40199	1.374589	0.024	0	0.00193855	0.0022484	0
			1.5	38.63	0.48096	1.374589	0.024	0			0
			2.5	37.76	0.52646	1.374589	0.024	0			0
			3.5	36.48	0.56385	1.374589	0.024	0			0
			4.5	34.15	0.60336	1.37404	0.024	0			0
			5.5	35.45	0.61363	1.374589	0.024	0			0
			6.5	33.79	0.63398	1.37173	0.024	0			0
			7.5	32.35	0.64649	1.342499	0.024	0.000483			0.00156
			8.5	31.07	0.65334	1.279918	0.024	0.002353			0.00366
			9.5	31.42	0.65514	1.297725	0.024	0.001759			0.00223
			10.5	30.36	0.65548	1.238585	0.024	0.003959			0.00421
			11.5	29.4	0.6531	1.194404	0.024	0.006094			0.00794
			12.5	28.51	0.64863	1.159122	0.024	0.00818			0.00993
			13.5	27.7	0.64254	1.12984	0.024	0.010218			0.01047
			14.5	26.94	0.63521	1.103809	0.024	0.012301			0.01293
			15.5	26.23	0.62697	1.080097	0.024	0.014447			0.01372
			16.5	25.57	0.61807	1.064808	0.024	0.015969			0.01452
			17.5	24.94	0.60874	1.059294	0.024	0.016546			0.0158
		1033	0.5	38.63	0.22909	1.361289	0.0148	0	2.2431E-07	0.000198	0
			1.5	38.63	0.27392	1.361289	0.0148	0			0
			2.5	37.76	0.2996	1.361289	0.0148	0			0
			3.5	36.48	0.3206	1.361289	0.0148	0			0
			4.5	34.15	0.34273	1.361289	0.0148	0			0
			5.5	35.45	0.34821	1.361289	0.0148	0			0
			6.5	33.79	0.35935	1.361289	0.0148	0			0
			7.5	32.35	0.36601	1.361289	0.0148	0			0
			8.5	31.07	0.36943	1.360491	0.0148	0			0
			9.5	31.42	0.36998	1.360954	0.0148	0			0
			10.5	30.36	0.36968	1.358225	0.0148	0			0
			11.5	29.4	0.36785	1.350737	0.0148	0			0
			12.5	28.51	0.36483	1.337558	0.0148	0			0
			13.5	27.7	0.36091	1.320361	0.0148	0			0.00139
			14.5	26.94	0.35632	1.30075	0.0148	0			0.00266
			15.5	26.23	0.35122	1.28061	0.0148	0			0.00388
			16.5	25.57	0.34579	1.261267	0.0148	0			0.00309
			17.5	24.94	0.34014	1.242636	0.0148	7.27E-05			0.0044
5	Eureka	475	0.5	38.63	0.40314	1.374591	0.0249	0	0.00220309	0.0023434	0
			1.5	38.63	0.48316	1.374591	0.0249	0			0
			2.5	37.76	0.52991	1.374591	0.0249	0			0
			3.5	36.48	0.5688	1.374591	0.0249	0			0
			4.5	34.15	0.61014	1.373929	0.0249	0			0
			5.5	35.45	0.62218	1.374591	0.0249	0			0
			6.5	33.79	0.64463	1.371124	0.0249	3.85E-05			0
			7.5	32.35	0.65932	1.338226	0.0249	0.000861			0.00135
			8.5	31.07	0.6684	1.271497	0.0249	0.003011			0.00342
			9.5	31.42	0.67242	1.288739	0.0249	0.002384			0.00398
			10.5	30.36	0.67502	1.231172	0.0249	0.004709			0.00597

			11.5	29.4	0.67486	1.189357	0.0249	0.006877			0.00774
			12.5	28.51	0.67255	1.15524	0.0249	0.009019			0.00989
			13.5	27.7	0.66854	1.126911	0.0249	0.011098			0.0105
			14.5	26.94	0.66319	1.101603	0.0249	0.01322			0.01103
			15.5	26.23	0.65681	1.078409	0.0249	0.01541			0.01388
			16.5	25.57	0.64964	1.063498	0.0249	0.016954			0.01474
			17.5	24.94	0.6419	1.05827	0.0249	0.017522			0.01411
		2475	0.5	38.63	0.95959	1.374593	0.0364	0.003519	0.00921434	0.0071795	0
			1.5	38.63	1.15079	1.374593	0.0364	0.003519			0
			2.5	37.76	1.26304	1.374517	0.0364	0.003522			0
			3.5	36.48	1.35684	1.360403	0.0364	0.004063			0
			4.5	34.15	1.45673	1.278297	0.0364	0.008023			0.00544
			5.5	35.45	1.4869	1.319439	0.0364	0.005851			0.00235
			6.5	33.79	1.54214	1.265463	0.0364	0.008789			0.00795
			7.5	32.35	1.57902	1.232909	0.0364	0.010948			0.01025
			8.5	31.07	1.60257	1.204681	0.0364	0.013098			0.01313
			9.5	31.42	1.61413	1.212584	0.0364	0.012468			0.01382
			10.5	30.36	1.62232	1.188027	0.0364	0.0145			0.01543
			11.5	29.4	1.62397	1.164186	0.0364	0.016697			0.0173
			12.5	28.51	1.62043	1.140725	0.0364	0.019095			0.01938
			13.5	27.7	1.61278	1.118277	0.0364	0.021628			0.02192
			14.5	26.94	1.60188	1.096304	0.0364	0.024349			0.02246
			15.5	26.23	1.58842	1.075015	0.0364	0.027228			0.02319
			16.5	25.57	1.57298	1.061242	0.0364	0.029225			0.02422
			17.5	24.94	1.55606	1.056736	0.0364	0.029901			0.0252
		1033	0.5	38.63	0.65004	1.374593	0.0315	0.001864	0.00608929	0.0045623	0
			1.5	38.63	0.77936	1.374593	0.0315	0.001864			0
			2.5	37.76	0.85512	1.374593	0.0315	0.001864			0
			3.5	36.48	0.91832	1.374502	0.0315	0.001867			0
			4.5	34.15	0.98557	1.327639	0.0315	0.003471			0.00114
			5.5	35.45	1.00558	1.36433	0.0315	0.002185			0
			6.5	33.79	1.04249	1.304391	0.0315	0.004411			0.00221
			7.5	32.35	1.06693	1.246793	0.0315	0.007247			0.00685
			8.5	31.07	1.08233	1.208323	0.0315	0.009628			0.0098
			9.5	31.42	1.0896	1.217585	0.0315	0.009014			0.00848
			10.5	30.36	1.09458	1.189507	0.0315	0.01096			0.01026
			11.5	29.4	1.09512	1.164644	0.0315	0.012913			0.01213
			12.5	28.51	1.09217	1.140877	0.0315	0.015003			0.01437
			13.5	27.7	1.08644	1.118334	0.0315	0.017208			0.01669
			14.5	26.94	1.07854	1.096328	0.0315	0.019589			0.01715
			15.5	26.23	1.06893	1.075026	0.0315	0.022126			0.01978
			16.5	25.57	1.05801	1.061247	0.0315	0.023897			0.0206
			17.5	24.94	1.04611	1.056739	0.0315	0.024499			0.0218
5	Memphis	475	0.5	38.63	0.13193	1.007078	0	0	0	0	0
			1.5	38.63	0.15784	1.007078	0	0			0
			2.5	37.76	0.17275	1.007078	0	0			0
			3.5	36.48	0.18499	1.007078	0	0			0
			4.5	34.15	0.19792	1.007078	0	0			0
			5.5	35.45	0.20126	1.007078	0	0			0
			6.5	33.79	0.2079	1.007078	0	0			0
			7.5	32.35	0.21196	1.007078	0	0			0
			8.5	31.07	0.21417	1.007078	0	0			0
			9.5	31.42	0.21472	1.007078	0	0			0
			10.5	30.36	0.21478	1.007078	0	0			0
			11.5	29.4	0.21396	1.007078	0	0			0
			12.5	28.51	0.21245	1.007078	0	0			0

			13.5	27.7	0.21041	1.007078	0	0			0
			14.5	26.94	0.20797	1.006973	0	0			0
			15.5	26.23	0.20523	1.00674	0	0			0
			16.5	25.57	0.20228	1.006374	0	0			0
			17.5	24.94	0.19918	1.005868	0	0			0
		2475	0.5	38.63	0.36529	1.374578	0.0252	4.25E-05	0.00191431	0.0022974	0
			1.5	38.63	0.4376	1.374578	0.0252	4.25E-05			0
			2.5	37.76	0.47968	1.374578	0.0252	4.25E-05			0
			3.5	36.48	0.51458	1.374578	0.0252	4.25E-05			0
			4.5	34.15	0.55161	1.374513	0.0252	4.4E-05			0
			5.5	35.45	0.56208	1.374578	0.0252	4.25E-05			0
			6.5	33.79	0.58192	1.373662	0.0252	6.36E-05			0
			7.5	32.35	0.5947	1.356954	0.0252	0.000465			0.00183
			8.5	31.07	0.60236	1.307971	0.0252	0.001857			0.00377
			9.5	31.42	0.60545	1.322329	0.0252	0.001413			0.00232
			10.5	30.36	0.60724	1.268489	0.0252	0.003256			0.00403
			11.5	29.4	0.60654	1.21587	0.0252	0.005612			0.00732
			12.5	28.51	0.60389	1.169408	0.0252	0.008282			0.00929
			13.5	27.7	0.59972	1.136758	0.0252	0.010568			0.01158
			14.5	26.94	0.59437	1.108643	0.0252	0.012857			0.01395
			15.5	26.23	0.58811	1.083528	0.0252	0.015186			0.01454
			16.5	25.57	0.58116	1.06728	0.0252	0.016851			0.01535
			17.5	24.94	0.57373	1.061088	0.0252	0.01752			0.01638
		1033	0.5	38.63	0.24175	1.364682	0.0157	0	2.2209E-05	0.000345	0
			1.5	38.63	0.28953	1.364682	0.0157	0			0
			2.5	37.76	0.31728	1.364682	0.0157	0			0
			3.5	36.48	0.34025	1.364682	0.0157	0			0
			4.5	34.15	0.3646	1.364682	0.0157	0			0
			5.5	35.45	0.37138	1.364682	0.0157	0			0
			6.5	33.79	0.38432	1.364682	0.0157	0			0
			7.5	32.35	0.39258	1.364664	0.0157	0			0
			8.5	31.07	0.39745	1.362454	0.0157	0			0
			9.5	31.42	0.39929	1.363489	0.0157	0			0
			10.5	30.36	0.40027	1.357417	0.0157	0			0
			11.5	29.4	0.3996	1.343458	0.0157	0			0
			12.5	28.51	0.39765	1.321867	0.0157	0			0.00122
			13.5	27.7	0.3947	1.296319	0.0157	0			0.00223
			14.5	26.94	0.39097	1.269232	0.0157	0			0.00308
			15.5	26.23	0.38665	1.242751	0.0157	0.000395			0.00584
			16.5	25.57	0.38189	1.218003	0.0157	0.001111			0.00663
			17.5	24.94	0.37683	1.19446	0.0157	0.001889			0.00766
5	Portland	475	0.5	38.63	0.19638	1.202662	0.0072	0	0	0	0
			1.5	38.63	0.23526	1.202662	0.0072	0			0
			2.5	37.76	0.25788	1.202662	0.0072	0			0
			3.5	36.48	0.27664	1.202662	0.0072	0			0
			4.5	34.15	0.29655	1.202662	0.0072	0			0
			5.5	35.45	0.30218	1.202662	0.0072	0			0
			6.5	33.79	0.31284	1.202662	0.0072	0			0
			7.5	32.35	0.31971	1.202662	0.0072	0			0
			8.5	31.07	0.32384	1.202643	0.0072	0			0
			9.5	31.42	0.3255	1.202662	0.0072	0			0
			10.5	30.36	0.32646	1.202199	0.0072	0			0
			11.5	29.4	0.32608	1.200027	0.0072	0			0
			12.5	28.51	0.32466	1.194915	0.0072	0			0
			13.5	27.7	0.32242	1.186667	0.0072	0			0
			14.5	26.94	0.31954	1.175631	0.0072	0			0.0019

			15.5	26.23	0.31617	1.162833	0.0072	0			0.00126
			16.5	25.57	0.31244	1.149379	0.0072	0			0.00259
			17.5	24.94	0.30844	1.135571	0.0072	0			0.0039
		2475	0.5	38.63	0.34922	1.374533	0.0296	0.001278	0.00332269	0.0029214	0
			1.5	38.63	0.41849	1.374533	0.0296	0.001278			0
			2.5	37.76	0.45893	1.374533	0.0296	0.001278			0
			3.5	36.48	0.49255	1.374533	0.0296	0.001278			0
			4.5	34.15	0.52827	1.374533	0.0296	0.001278			0
			5.5	35.45	0.5386	1.374533	0.0296	0.001278			0
			6.5	33.79	0.55794	1.374073	0.0296	0.001291			0
			7.5	32.35	0.57056	1.362003	0.0296	0.001641			0.00146
			8.5	31.07	0.5783	1.320395	0.0296	0.003019			0.00471
			9.5	31.42	0.58167	1.33294	0.0296	0.002574			0.00334
			10.5	30.36	0.58379	1.283292	0.0296	0.004507			0.00602
			11.5	29.4	0.58354	1.231688	0.0296	0.007079			0.00926
			12.5	28.51	0.58142	1.184863	0.0296	0.010043			0.01293
			13.5	27.7	0.57783	1.144581	0.0296	0.013184			0.0148
			14.5	26.94	0.57309	1.112174	0.0296	0.016183			0.01683
			15.5	26.23	0.56746	1.086131	0.0296	0.018942			0.01716
			16.5	25.57	0.56115	1.069214	0.0296	0.020917			0.01973
			17.5	24.94	0.55436	1.062529	0.0296	0.021739			0.02066
		1033	0.5	38.63	0.26578	1.369222	0.0205	0	0.0002674	0.0010288	0
			1.5	38.63	0.31848	1.369222	0.0205	0			0
			2.5	37.76	0.34921	1.369222	0.0205	0			0
			3.5	36.48	0.37474	1.369222	0.0205	0			0
			4.5	34.15	0.40185	1.369222	0.0205	0			0
			5.5	35.45	0.40965	1.369222	0.0205	0			0
			6.5	33.79	0.42429	1.369222	0.0205	0			0
			7.5	32.35	0.4338	1.368775	0.0205	0			0
			8.5	31.07	0.43961	1.362312	0.0205	0			0
			9.5	31.42	0.44208	1.364942	0.0205	0			0
			10.5	30.36	0.4436	1.351037	0.0205	0			0.0015
			11.5	29.4	0.44332	1.325862	0.0205	0			0.00204
			12.5	28.51	0.44162	1.293295	0.0205	0.00067			0.00405
			13.5	27.7	0.4388	1.259401	0.0205	0.001679			0.0078
			14.5	26.94	0.43511	1.226401	0.0205	0.002849			0.00956
			15.5	26.23	0.43074	1.195713	0.0205	0.004136			0.01014
			16.5	25.57	0.42587	1.167654	0.0205	0.005509			0.01272
			17.5	24.94	0.42063	1.141012	0.0205	0.007015			0.0138
5	SLC	475	0.5	38.63	0.17311	1.101812	0.0049	0	2.5378E-06	0	0
			1.5	38.63	0.20685	1.101812	0.0049	0			0
			2.5	37.76	0.22608	1.101812	0.0049	0			0
			3.5	36.48	0.24173	1.101812	0.0049	0			0
			4.5	34.15	0.25819	1.101812	0.0049	0			0
			5.5	35.45	0.26207	1.101812	0.0049	0			0
			6.5	33.79	0.27017	1.101812	0.0049	0			0
			7.5	32.35	0.27488	1.101812	0.0049	0			0
			8.5	31.07	0.27714	1.101812	0.0049	0			0
			9.5	31.42	0.27722	1.101812	0.0049	0			0
			10.5	30.36	0.27666	1.101812	0.0049	0			0
			11.5	29.4	0.27495	1.101655	0.0049	0			0
			12.5	28.51	0.27235	1.100928	0.0049	0			0
			13.5	27.7	0.26909	1.099392	0.0049	0			0
			14.5	26.94	0.26533	1.09691	0.0049	0			0
			15.5	26.23	0.26122	1.093598	0.0049	2.72E-05			0
			16.5	25.57	0.25686	1.089741	0.0049	0.00014			0

			17.5	24.94	0.25237	1.085462	0.0049	0.000267			0
		2475	0.5	38.63	0.37654	1.374581	0.0271	0.000542	0.00257252	0.002316	0
			1.5	38.63	0.45028	1.374581	0.0271	0.000542			0
			2.5	37.76	0.49258	1.374581	0.0271	0.000542			0
			3.5	36.48	0.52722	1.374581	0.0271	0.000542			0
			4.5	34.15	0.56374	1.37445	0.0271	0.000546			0
			5.5	35.45	0.57289	1.374581	0.0271	0.000542			0
			6.5	33.79	0.59137	1.37342	0.0271	0.000572			0
			7.5	32.35	0.6025	1.355082	0.0271	0.001055			0.00191
			8.5	31.07	0.6083	1.304792	0.0271	0.002631			0.00385
			9.5	31.42	0.60938	1.320489	0.0271	0.002096			0.00247
			10.5	30.36	0.60907	1.267332	0.0271	0.004088			0.00418
			11.5	29.4	0.60624	1.216072	0.0271	0.006578			0.00743
			12.5	28.51	0.60146	1.171037	0.0271	0.009355			0.00928
			13.5	27.7	0.59519	1.137685	0.0271	0.011847			0.01146
			14.5	26.94	0.58779	1.109659	0.0271	0.014277			0.01376
			15.5	26.23	0.57957	1.08454	0.0271	0.01675			0.01422
			16.5	25.57	0.57077	1.068239	0.0271	0.018518			0.01501
			17.5	24.94	0.56161	1.061965	0.0271	0.019236			0.01796
		1033	0.5	38.63	0.25299	1.370141	0.0184	0	5.7409E-05	0.0005548	0
			1.5	38.63	0.30244	1.370141	0.0184	0			0
			2.5	37.76	0.33074	1.370141	0.0184	0			0
			3.5	36.48	0.35385	1.370141	0.0184	0			0
			4.5	34.15	0.3782	1.370141	0.0184	0			0
			5.5	35.45	0.38415	1.370141	0.0184	0			0
			6.5	33.79	0.39634	1.370141	0.0184	0			0
			7.5	32.35	0.40358	1.370062	0.0184	0			0
			8.5	31.07	0.40723	1.36713	0.0184	0			0
			9.5	31.42	0.40771	1.36854	0.0184	0			0
			10.5	30.36	0.40726	1.361509	0.0184	0			0
			11.5	29.4	0.40511	1.346503	0.0184	0			0.00177
			12.5	28.51	0.40167	1.324439	0.0184	0			0.00279
			13.5	27.7	0.39723	1.29925	0.0184	0			0.00359
			14.5	26.94	0.39205	1.273168	0.0184	0.000517			0.00423
			15.5	26.23	0.38633	1.248106	0.0184	0.001239			0.00678
			16.5	25.57	0.38023	1.225015	0.0184	0.001996			0.00733
			17.5	24.94	0.37391	1.20327	0.0184	0.002799			0.00815
5	San Fran	475	0.5	38.63	0.32101	1.374398	0.0255	0.000125	0.00143916	0.0017461	0
			1.5	38.63	0.38469	1.374398	0.0255	0.000125			0
			2.5	37.76	0.42186	1.374398	0.0255	0.000125			0
			3.5	36.48	0.45277	1.374398	0.0255	0.000125			0
			4.5	34.15	0.4856	1.374398	0.0255	0.000125			0
			5.5	35.45	0.4951	1.374398	0.0255	0.000125			0
			6.5	33.79	0.51288	1.374344	0.0255	0.000127			0
			7.5	32.35	0.52447	1.368739	0.0255	0.000259			0
			8.5	31.07	0.53159	1.341603	0.0255	0.000956			0.0012
			9.5	31.42	0.53468	1.350565	0.0255	0.000715			0.00162
			10.5	30.36	0.53664	1.312166	0.0255	0.001826			0.00389
			11.5	29.4	0.53641	1.265865	0.0255	0.003484			0.00557
			12.5	28.51	0.53446	1.220362	0.0255	0.005537			0.00886
			13.5	27.7	0.53116	1.180074	0.0255	0.007793			0.009
			14.5	26.94	0.5268	1.143701	0.0255	0.01026			0.01122
			15.5	26.23	0.52162	1.110395	0.0255	0.012944			0.0138
			16.5	25.57	0.51583	1.079176	0.0255	0.01589			0.01443
			17.5	24.94	0.50958	1.067883	0.0255	0.017069			0.01552
		2475	0.5	38.63	0.53345	1.374593	0.0379	0.00407	0.00881507	0.005572	0

			1.5	38.63	0.63971	1.374593	0.0379	0.00407			0
			2.5	37.76	0.70206	1.374593	0.0379	0.00407			0
			3.5	36.48	0.75415	1.374593	0.0379	0.00407			0
			4.5	34.15	0.80962	1.35876	0.0379	0.004715			0.00194
			5.5	35.45	0.82632	1.373437	0.0379	0.004116			0
			6.5	33.79	0.85694	1.336629	0.0379	0.005698			0.00295
			7.5	32.35	0.87735	1.271977	0.0379	0.009213			0.00627
			8.5	31.07	0.89036	1.219911	0.0379	0.012898			0.01003
			9.5	31.42	0.89669	1.231677	0.0379	0.011988			0.01099
			10.5	30.36	0.90115	1.195755	0.0379	0.014922			0.0135
			11.5	29.4	0.90197	1.167306	0.0379	0.017597			0.01662
			12.5	28.51	0.89991	1.142027	0.0379	0.020266			0.01824
			13.5	27.7	0.89557	1.118864	0.0379	0.022973			0.0204
			14.5	26.94	0.88943	1.096587	0.0379	0.025831			0.02277
			15.5	26.23	0.88186	1.075162	0.0379	0.028828			0.02326
			16.5	25.57	0.8732	1.061324	0.0379	0.0309			0.02416
			17.5	24.94	0.86372	1.056784	0.0379	0.031603			0.02501
		1033	0.5	38.63	0.40636	1.374591	0.0325	0.002211	0.00528458	0.0033442	0
			1.5	38.63	0.48715	1.374591	0.0325	0.002211			0
			2.5	37.76	0.53444	1.374591	0.0325	0.002211			0
			3.5	36.48	0.57386	1.374591	0.0325	0.002211			0
			4.5	34.15	0.61579	1.373824	0.0325	0.002235			0
			5.5	35.45	0.62819	1.374591	0.0325	0.002211			0
			6.5	33.79	0.65114	1.370711	0.0325	0.002336			0
			7.5	32.35	0.66628	1.335805	0.0325	0.00357			0.00256
			8.5	31.07	0.67577	1.267384	0.0325	0.006676			0.00498
			9.5	31.42	0.68018	1.284675	0.0325	0.005793			0.004
			10.5	30.36	0.68315	1.228839	0.0325	0.008926			0.00838
			11.5	29.4	0.68334	1.187601	0.0325	0.011833			0.01174
			12.5	28.51	0.68136	1.154013	0.0325	0.014649			0.01339
			13.5	27.7	0.67765	1.126062	0.0325	0.017347			0.0153
			14.5	26.94	0.67258	1.101014	0.0325	0.020069			0.01742
			15.5	26.23	0.66645	1.077991	0.0325	0.022848			0.01984
			16.5	25.57	0.6595	1.063195	0.0325	0.024784			0.02041
			17.5	24.94	0.65196	1.058048	0.0325	0.025486			0.02144
5	San Jose	475	0.5	38.63	0.28842	1.373918	0.0257	0.000176	0.00077732	0.0010293	0
			1.5	38.63	0.34447	1.373918	0.0257	0.000176			0
			2.5	37.76	0.37629	1.373918	0.0257	0.000176			0
			3.5	36.48	0.4021	1.373918	0.0257	0.000176			0
			4.5	34.15	0.4292	1.373918	0.0257	0.000176			0
			5.5	35.45	0.43532	1.373918	0.0257	0.000176			0
			6.5	33.79	0.44844	1.373918	0.0257	0.000176			0
			7.5	32.35	0.45589	1.372907	0.0257	0.0002			0
			8.5	31.07	0.45923	1.36341	0.0257	0.00043			0
			9.5	31.42	0.45896	1.367538	0.0257	0.000329			0
			10.5	30.36	0.45761	1.350747	0.0257	0.000754			0.00145
			11.5	29.4	0.45436	1.323642	0.0257	0.001521			0.00201
			12.5	28.51	0.44965	1.291104	0.0257	0.002589			0.00403
			13.5	27.7	0.44385	1.258853	0.0257	0.003835			0.00782
			14.5	26.94	0.43724	1.228358	0.0257	0.005215			0.00961
			15.5	26.23	0.43006	1.20058	0.0257	0.00667			0.01022
			16.5	25.57	0.42251	1.175638	0.0257	0.008161			0.01283
			17.5	24.94	0.41475	1.15228	0.0257	0.009737			0.01393
		2475	0.5	38.63	0.44098	1.374592	0.0379	0.004093	0.00793152	0.0043398	0
			1.5	38.63	0.52668	1.374592	0.0379	0.004093			0
			2.5	37.76	0.57534	1.374592	0.0379	0.004093			0

			3.5	36.48	0.6148	1.374592	0.0379	0.004093			0
			4.5	34.15	0.65623	1.372708	0.0379	0.004167			0
			5.5	35.45	0.66559	1.374592	0.0379	0.004093			0
			6.5	33.79	0.68566	1.367933	0.0379	0.004359			0
			7.5	32.35	0.69704	1.324342	0.0379	0.006316			0.0034
			8.5	31.07	0.70215	1.256242	0.0379	0.010272			0.00861
			9.5	31.42	0.70173	1.273362	0.0379	0.009159			0.00778
			10.5	30.36	0.69968	1.224413	0.0379	0.012584			0.01017
			11.5	29.4	0.6947	1.185422	0.0379	0.015901			0.01499
			12.5	28.51	0.6875	1.153216	0.0379	0.0191			0.01623
			13.5	27.7	0.67863	1.125977	0.0379	0.022169			0.01811
			14.5	26.94	0.66853	1.101262	0.0379	0.02527			0.02026
			15.5	26.23	0.65755	1.078377	0.0379	0.028427			0.02272
			16.5	25.57	0.64601	1.063622	0.0379	0.030615			0.02337
			17.5	24.94	0.63414	1.058467	0.0379	0.031409			0.02431
		1033	0.5	38.63	0.35275	1.374562	0.0326	0.002247	0.00419619	0.0025296	0
			1.5	38.63	0.42134	1.374562	0.0326	0.002247			0
			2.5	37.76	0.46029	1.374562	0.0326	0.002247			0
			3.5	36.48	0.49189	1.374562	0.0326	0.002247			0
			4.5	34.15	0.52507	1.374562	0.0326	0.002247			0
			5.5	35.45	0.53261	1.374562	0.0326	0.002247			0
			6.5	33.79	0.54871	1.374226	0.0326	0.002258			0
			7.5	32.35	0.55787	1.364286	0.0326	0.002584			0
			8.5	31.07	0.56201	1.328362	0.0326	0.003903			0.00358
			9.5	31.42	0.56173	1.341093	0.0326	0.00341			0.00237
			10.5	30.36	0.56015	1.298122	0.0326	0.005202			0.00545
			11.5	29.4	0.55622	1.251385	0.0326	0.007618			0.0082
			12.5	28.51	0.55052	1.207859	0.0326	0.010402			0.01174
			13.5	27.7	0.54347	1.170319	0.0326	0.013306			0.01354
			14.5	26.94	0.53543	1.136767	0.0326	0.016362			0.0155
			15.5	26.23	0.52669	1.106225	0.0326	0.019576			0.01778
			16.5	25.57	0.5175	1.077804	0.0326	0.022981			0.01846
			17.5	24.94	0.50805	1.068264	0.0326	0.02422			0.01935
5	Santa Monica	475	0.5	38.63	0.25738	1.370068	0.0213	0	0.00014683	0.0006315	0
			1.5	38.63	0.30754	1.370068	0.0213	0			0
			2.5	37.76	0.33611	1.370068	0.0213	0			0
			3.5	36.48	0.35935	1.370068	0.0213	0			0
			4.5	34.15	0.38379	1.370068	0.0213	0			0
			5.5	35.45	0.38952	1.370068	0.0213	0			0
			6.5	33.79	0.40154	1.370068	0.0213	0			0
			7.5	32.35	0.4085	1.369951	0.0213	0			0
			8.5	31.07	0.41181	1.366637	0.0213	0			0
			9.5	31.42	0.41188	1.368234	0.0213	0			0
			10.5	30.36	0.41101	1.360654	0.0213	0			0
			11.5	29.4	0.40843	1.344966	0.0213	0			0.00155
			12.5	28.51	0.40453	1.322391	0.0213	0.000181			0.00239
			13.5	27.7	0.39964	1.297014	0.0213	0.000845			0.00497
			14.5	26.94	0.39402	1.271012	0.0213	0.001621			0.00525
			15.5	26.23	0.38787	1.246211	0.0213	0.002467			0.00743
			16.5	25.57	0.38137	1.223487	0.0213	0.003343			0.00967
			17.5	24.94	0.37466	1.202167	0.0213	0.004266			0.01051
		2475	0.5	38.63	0.43464	1.374592	0.0355	0.003198	0.00673394	0.003634	0
			1.5	38.63	0.5196	1.374592	0.0355	0.003198			0
			2.5	37.76	0.56821	1.374592	0.0355	0.003198			0
			3.5	36.48	0.60792	1.374592	0.0355	0.003198			0
			4.5	34.15	0.64974	1.372936	0.0355	0.003258			0

			5.5	35.45	0.65996	1.374592	0.0355	0.003198			0
			6.5	33.79	0.68091	1.368377	0.0355	0.003424			0
			7.5	32.35	0.69334	1.325779	0.0355	0.005164			0.00227
			8.5	31.07	0.69962	1.257	0.0355	0.008814			0.00628
			9.5	31.42	0.70045	1.274036	0.0355	0.007798			0.00551
			10.5	30.36	0.69967	1.224415	0.0355	0.010994			0.00987
			11.5	29.4	0.69599	1.185188	0.0355	0.014089			0.01101
			12.5	28.51	0.69007	1.152896	0.0355	0.017079			0.01444
			13.5	27.7	0.68244	1.125649	0.0355	0.019955			0.01622
			14.5	26.94	0.67354	1.100958	0.0355	0.022868			0.01801
			15.5	26.23	0.66371	1.078106	0.0355	0.025845			0.02035
			16.5	25.57	0.65324	1.063384	0.0355	0.027914			0.02296
			17.5	24.94	0.64237	1.05826	0.0355	0.028663			0.02387
		1033	0.5	38.63	0.31967	1.374469	0.0291	0.001132	0.00233599	0.0018191	0
			1.5	38.63	0.38206	1.374469	0.0291	0.001132			0
			2.5	37.76	0.41767	1.374469	0.0291	0.001132			0
			3.5	36.48	0.44671	1.374469	0.0291	0.001132			0
			4.5	34.15	0.47727	1.374469	0.0291	0.001132			0
			5.5	35.45	0.48459	1.374469	0.0291	0.001132			0
			6.5	33.79	0.49975	1.374463	0.0291	0.001132			0
			7.5	32.35	0.50865	1.370389	0.0291	0.001245			0
			8.5	31.07	0.51301	1.348764	0.0291	0.001885			0.00101
			9.5	31.42	0.51336	1.356983	0.0291	0.001634			0.00146
			10.5	30.36	0.51253	1.325859	0.0291	0.002641			0.00351
			11.5	29.4	0.50957	1.285821	0.0291	0.004183			0.0069
			12.5	28.51	0.50497	1.244693	0.0291	0.006116			0.00804
			13.5	27.7	0.49913	1.20755	0.0291	0.008229			0.01005
			14.5	26.94	0.49237	1.173984	0.0291	0.010496			0.012
			15.5	26.23	0.48493	1.143728	0.0291	0.012879			0.01431
			16.5	25.57	0.47704	1.116168	0.0291	0.015369			0.0169
			17.5	24.94	0.46888	1.089607	0.0291	0.018091			0.01766
5	Seattle	475	0.5	38.63	0.23268	1.357834	0.0177	0	1.2747E-05	0.0003611	0
			1.5	38.63	0.27803	1.357834	0.0177	0			0
			2.5	37.76	0.30388	1.357834	0.0177	0			0
			3.5	36.48	0.32492	1.357834	0.0177	0			0
			4.5	34.15	0.34704	1.357834	0.0177	0			0
			5.5	35.45	0.35225	1.357834	0.0177	0			0
			6.5	33.79	0.36315	1.357834	0.0177	0			0
			7.5	32.35	0.36948	1.357834	0.0177	0			0
			8.5	31.07	0.3725	1.356929	0.0177	0			0
			9.5	31.42	0.37261	1.357451	0.0177	0			0
			10.5	30.36	0.37186	1.354559	0.0177	0			0
			11.5	29.4	0.36956	1.346853	0.0177	0			0
			12.5	28.51	0.36607	1.333555	0.0177	0			0.00167
			13.5	27.7	0.36169	1.316453	0.0177	0			0.00284
			14.5	26.94	0.35664	1.297153	0.0177	0			0.0038
			15.5	26.23	0.3511	1.277493	0.0177	0.000178			0.00467
			16.5	25.57	0.34525	1.258739	0.0177	0.000678			0.00551
			17.5	24.94	0.33921	1.240769	0.0177	0.001206			0.00651
		2475	0.5	38.63	0.41036	1.374591	0.0336	0.002554	0.00561538	0.0034591	0
			1.5	38.63	0.49067	1.374591	0.0336	0.002554			0
			2.5	37.76	0.5367	1.374591	0.0336	0.002554			0
			3.5	36.48	0.57436	1.374591	0.0336	0.002554			0
			4.5	34.15	0.61406	1.373858	0.0336	0.002578			0
			5.5	35.45	0.62392	1.374591	0.0336	0.002554			0
			6.5	33.79	0.64394	1.371165	0.0336	0.002669			0

			7.5	32.35	0.65594	1.339378	0.0336	0.003829			0.00228
			8.5	31.07	0.66213	1.275	0.0336	0.006788			0.00654
			9.5	31.42	0.66317	1.293564	0.0336	0.00584			0.00552
			10.5	30.36	0.66271	1.234904	0.0336	0.009141			0.00811
			11.5	29.4	0.65949	1.192839	0.0336	0.012134			0.01152
			12.5	28.51	0.65415	1.158151	0.0336	0.015078			0.01323
			13.5	27.7	0.6472	1.129255	0.0336	0.017909			0.01517
			14.5	26.94	0.63902	1.103465	0.0336	0.020761			0.01731
			15.5	26.23	0.62995	1.079898	0.0336	0.02366			0.01966
			16.5	25.57	0.62026	1.064698	0.0336	0.025688			0.02023
			17.5	24.94	0.61018	1.059239	0.0336	0.026449			0.02122
		1033	0.5	38.63	0.30258	1.374162	0.0265	0.000409	0.00126859	0.0015597	0
			1.5	38.63	0.36169	1.374162	0.0265	0.000409			0
			2.5	37.76	0.39548	1.374162	0.0265	0.000409			0
			3.5	36.48	0.42306	1.374162	0.0265	0.000409			0
			4.5	34.15	0.4521	1.374162	0.0265	0.000409			0
			5.5	35.45	0.45914	1.374162	0.0265	0.000409			0
			6.5	33.79	0.47363	1.374162	0.0265	0.000409			0
			7.5	32.35	0.48219	1.37199	0.0265	0.000463			0
			8.5	31.07	0.48647	1.356971	0.0265	0.000849			0.00135
			9.5	31.42	0.48695	1.362961	0.0265	0.000692			0.00176
			10.5	30.36	0.48631	1.338832	0.0265	0.001356			0.00212
			11.5	29.4	0.48365	1.304247	0.0265	0.002458			0.00397
			12.5	28.51	0.47943	1.266114	0.0265	0.003914			0.00733
			13.5	27.7	0.47404	1.230269	0.0265	0.005561			0.00931
			14.5	26.94	0.46776	1.197305	0.0265	0.00736			0.01163
			15.5	26.23	0.46084	1.167523	0.0265	0.009259			0.0121
			16.5	25.57	0.45347	1.140598	0.0265	0.011233			0.0147
			17.5	24.94	0.44584	1.11499	0.0265	0.013369			0.01583

APPENDIX B: Sample Liquefaction Parameter Maps

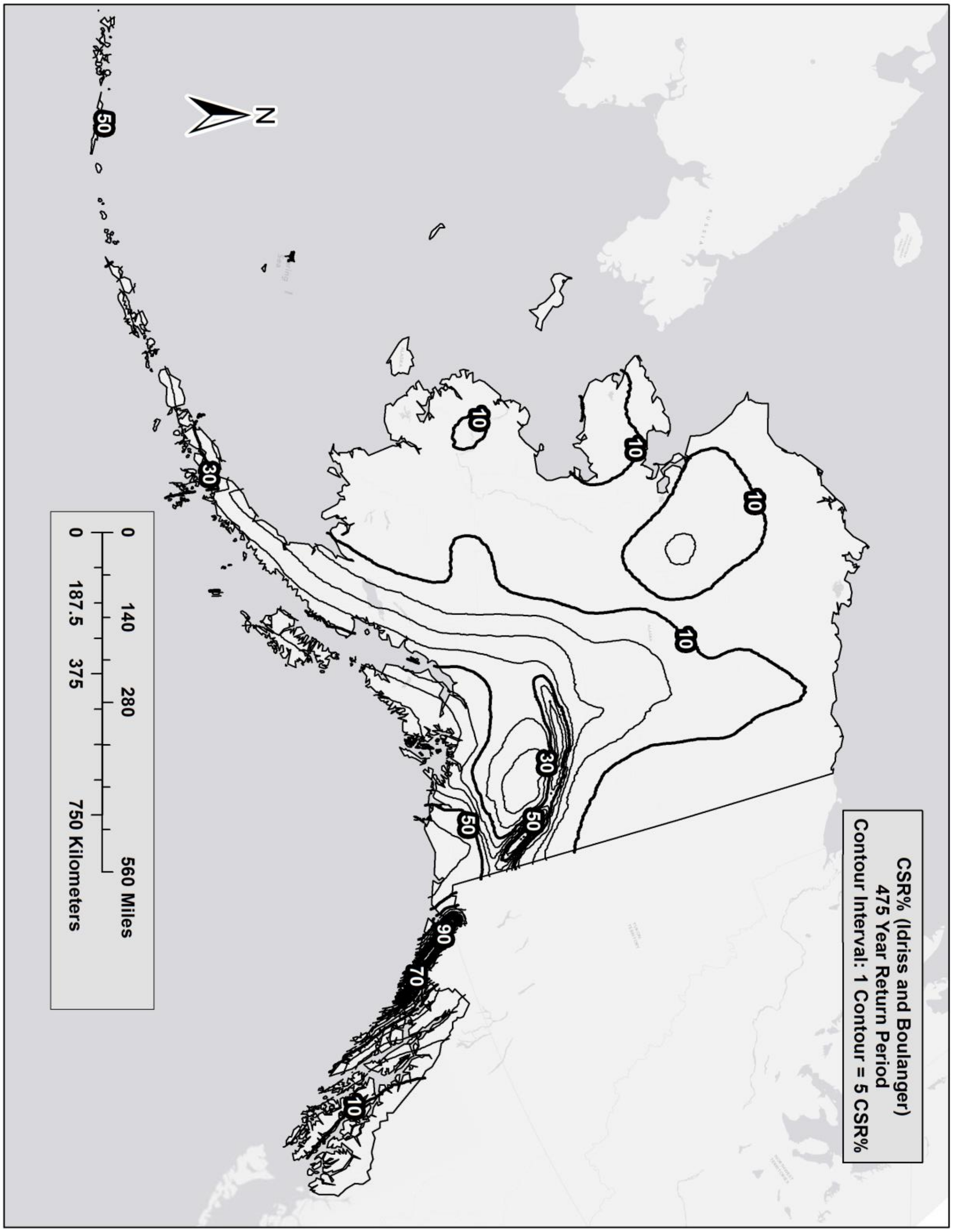


Figure B- 1 CSR% for Alaska (T_R = 475 years)

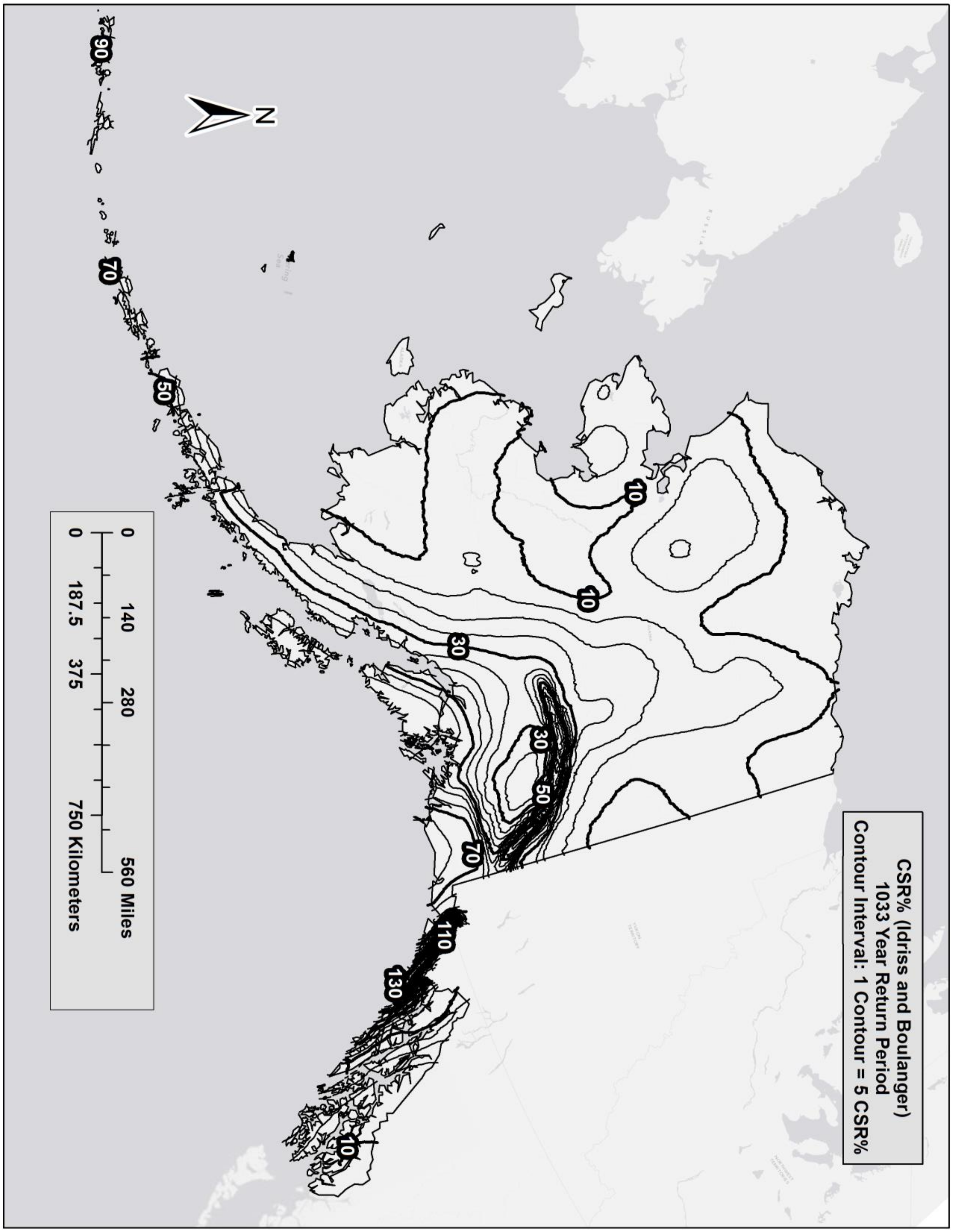


Figure B- 2 CSR% for Alaska (T_R = 1033 years)

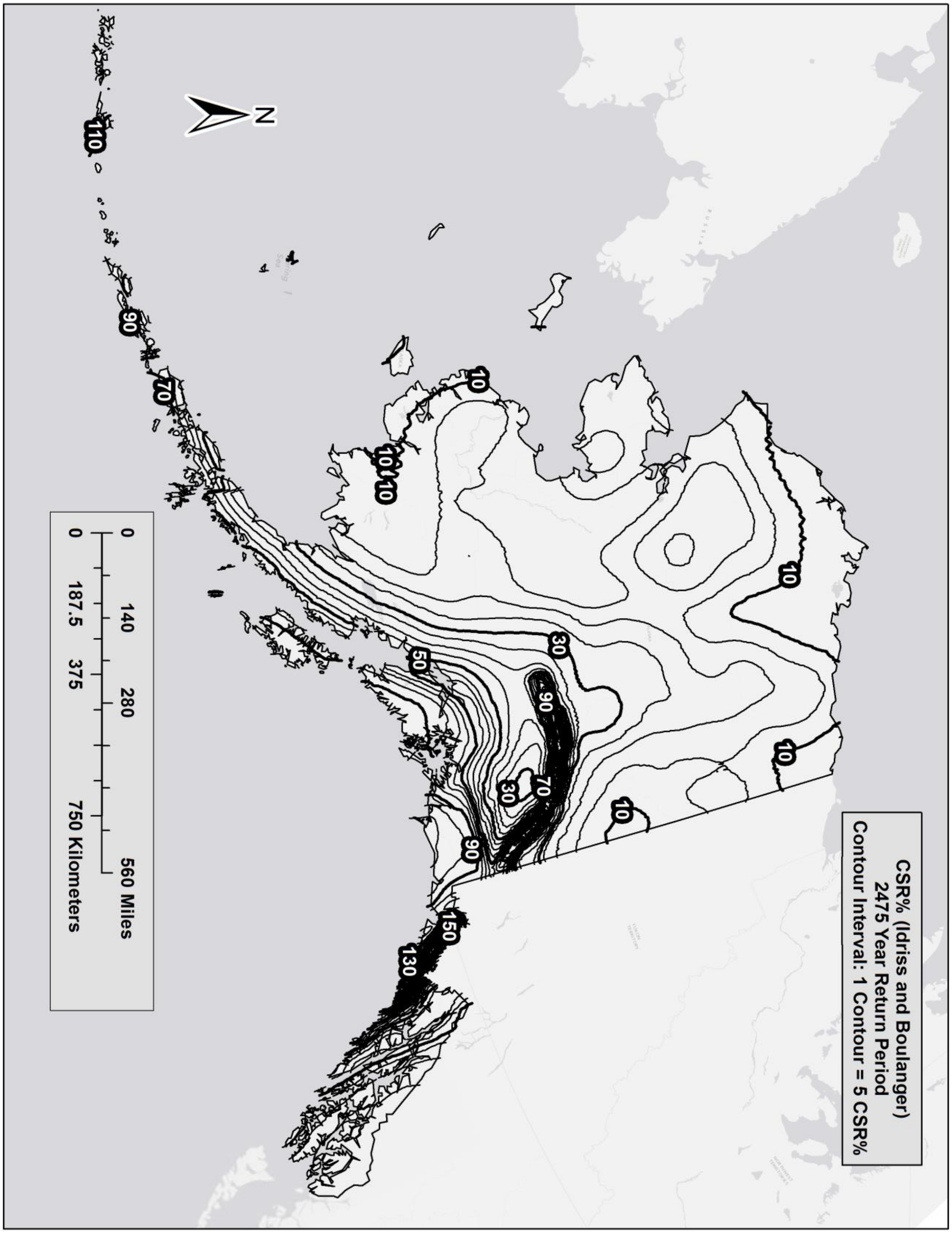


Figure B- 3 CSR% for Alaska (T_R = 2475 years)

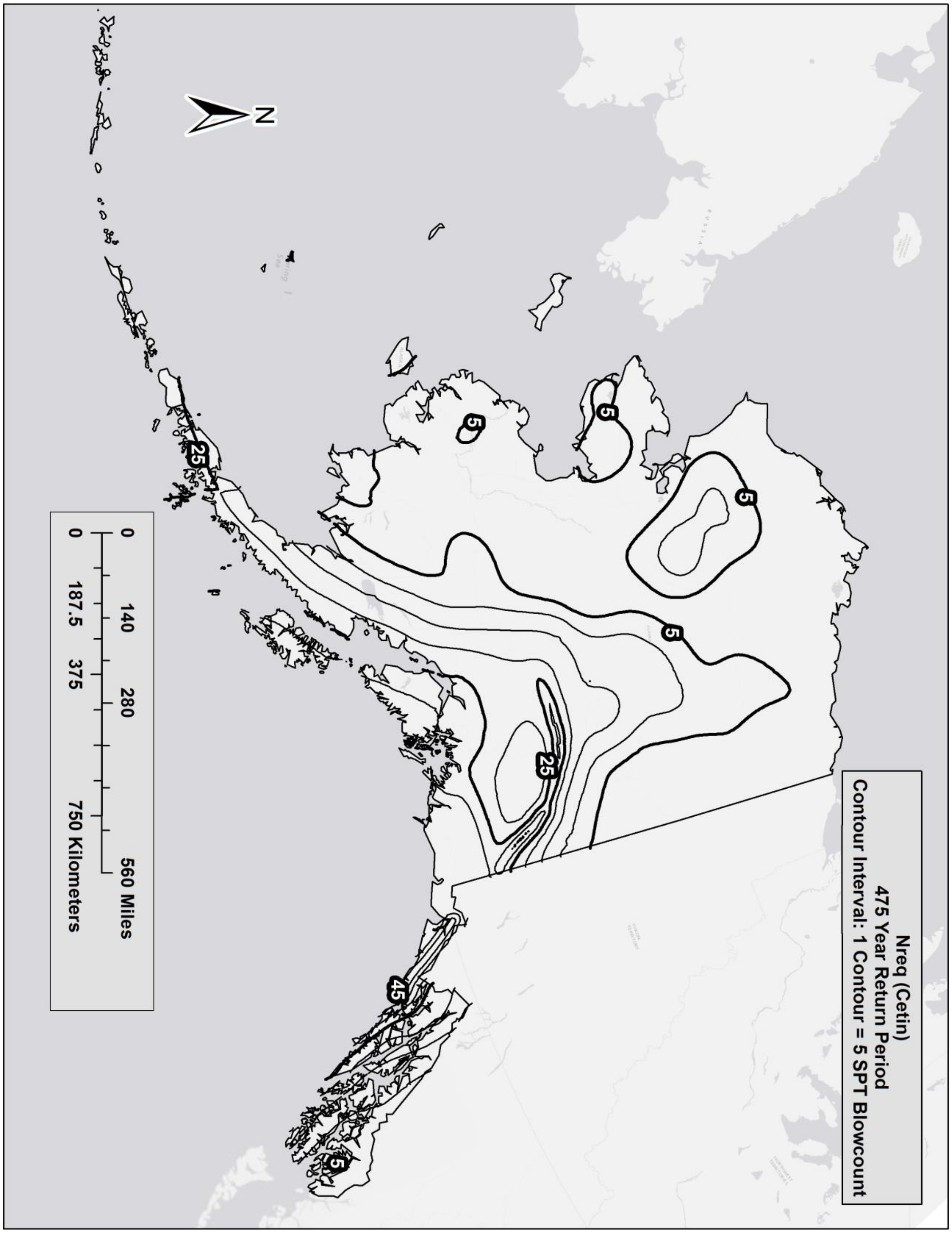


Figure B- 4 N_{req} for Alaska (T_R = 475 years)

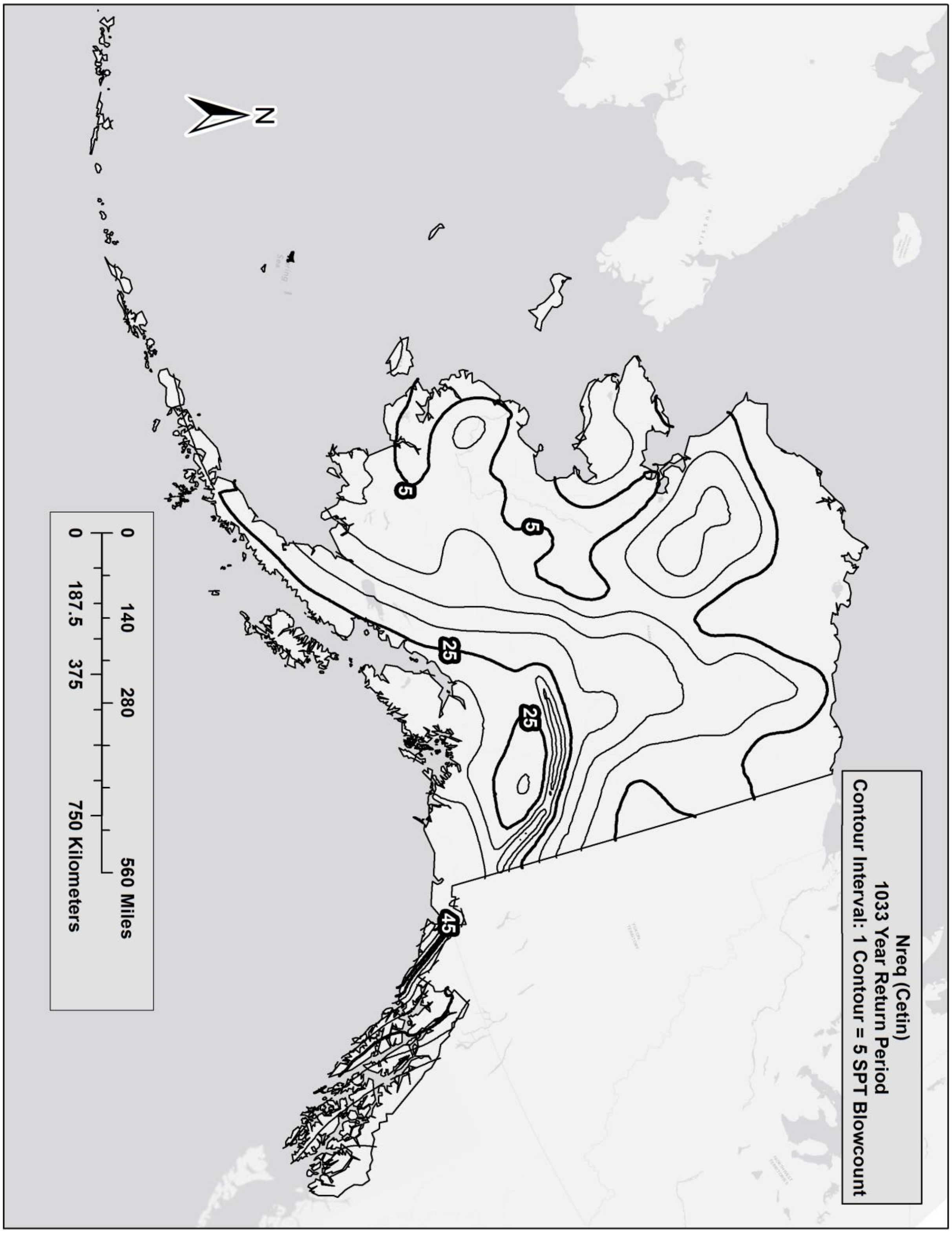


Figure B- 5 N_{req} for Alaska (T_R = 1033 years)

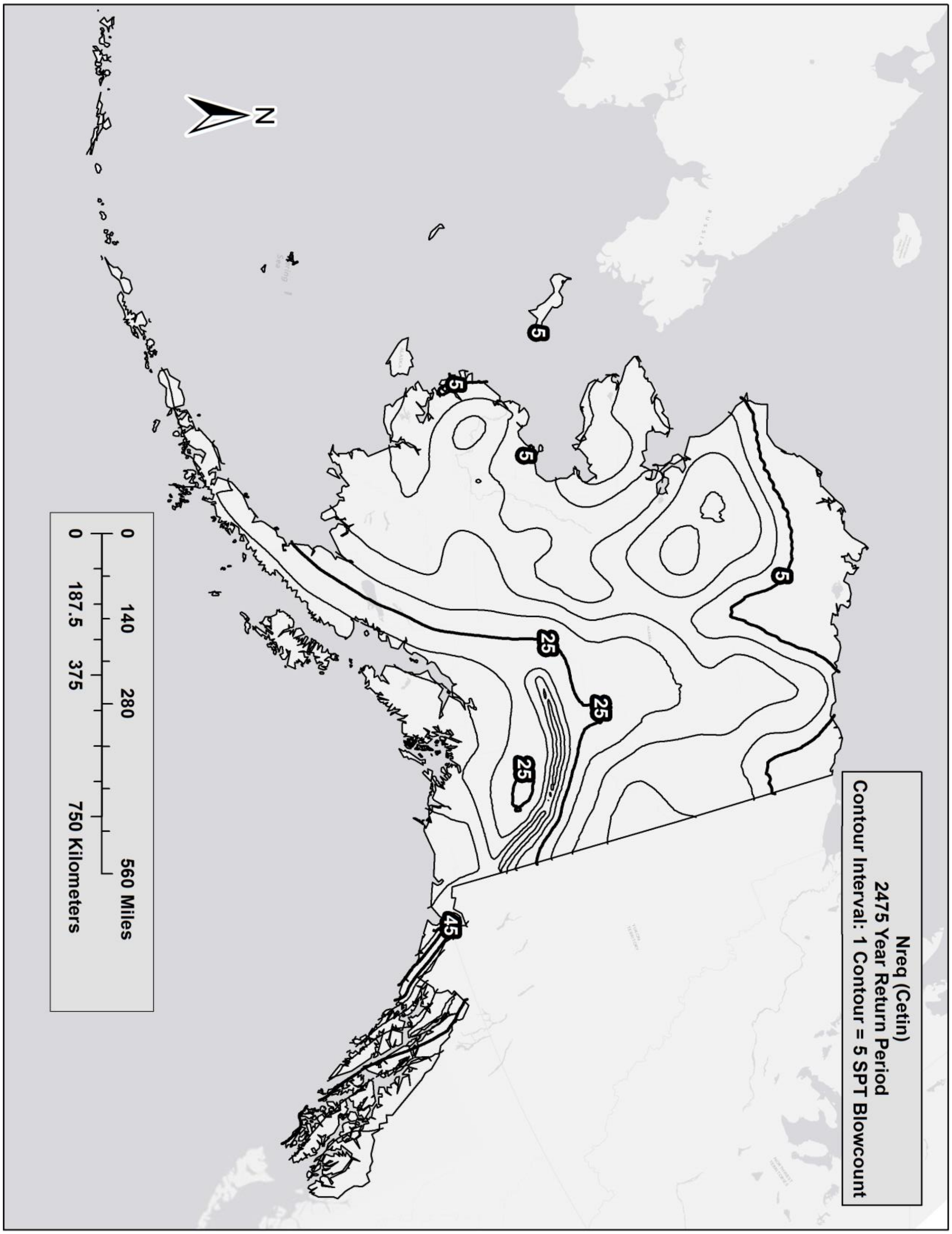


Figure B- 6 N_{req} for Alaska (T_R = 2475 years)

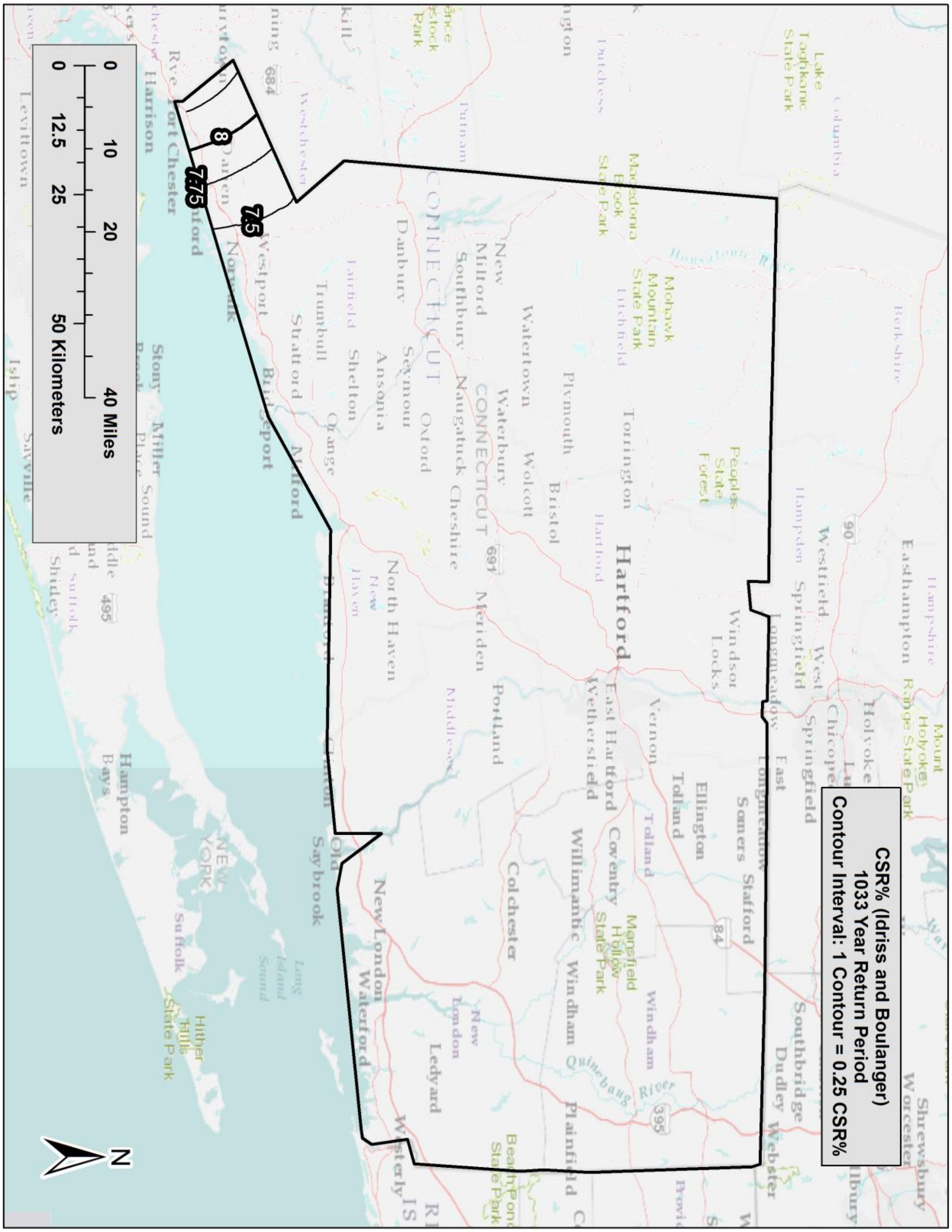


Figure B- 7 CSR% for Connecticut (T_R = 1033 years)

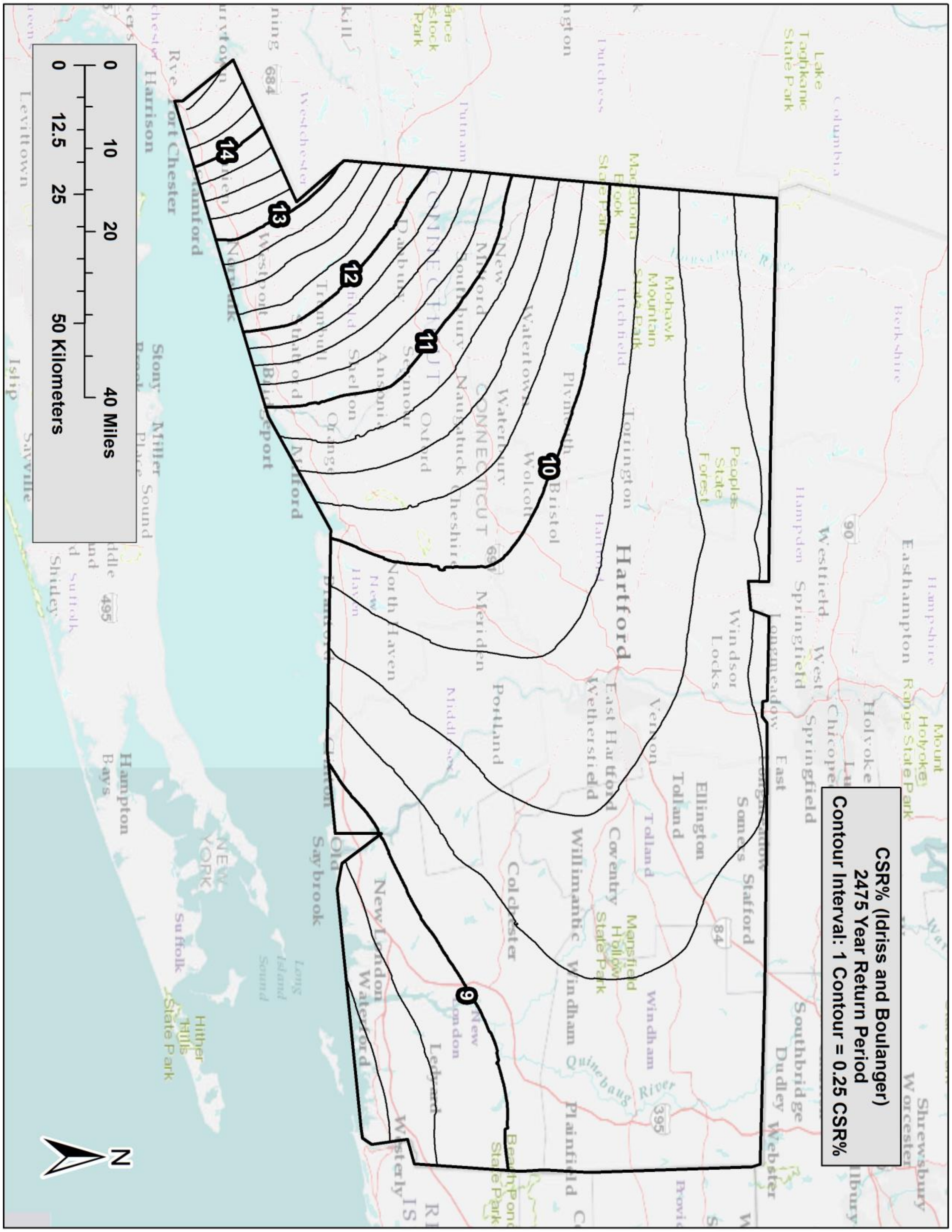


Figure B- 8 CSR% for Connecticut (T_R = 2475 years)

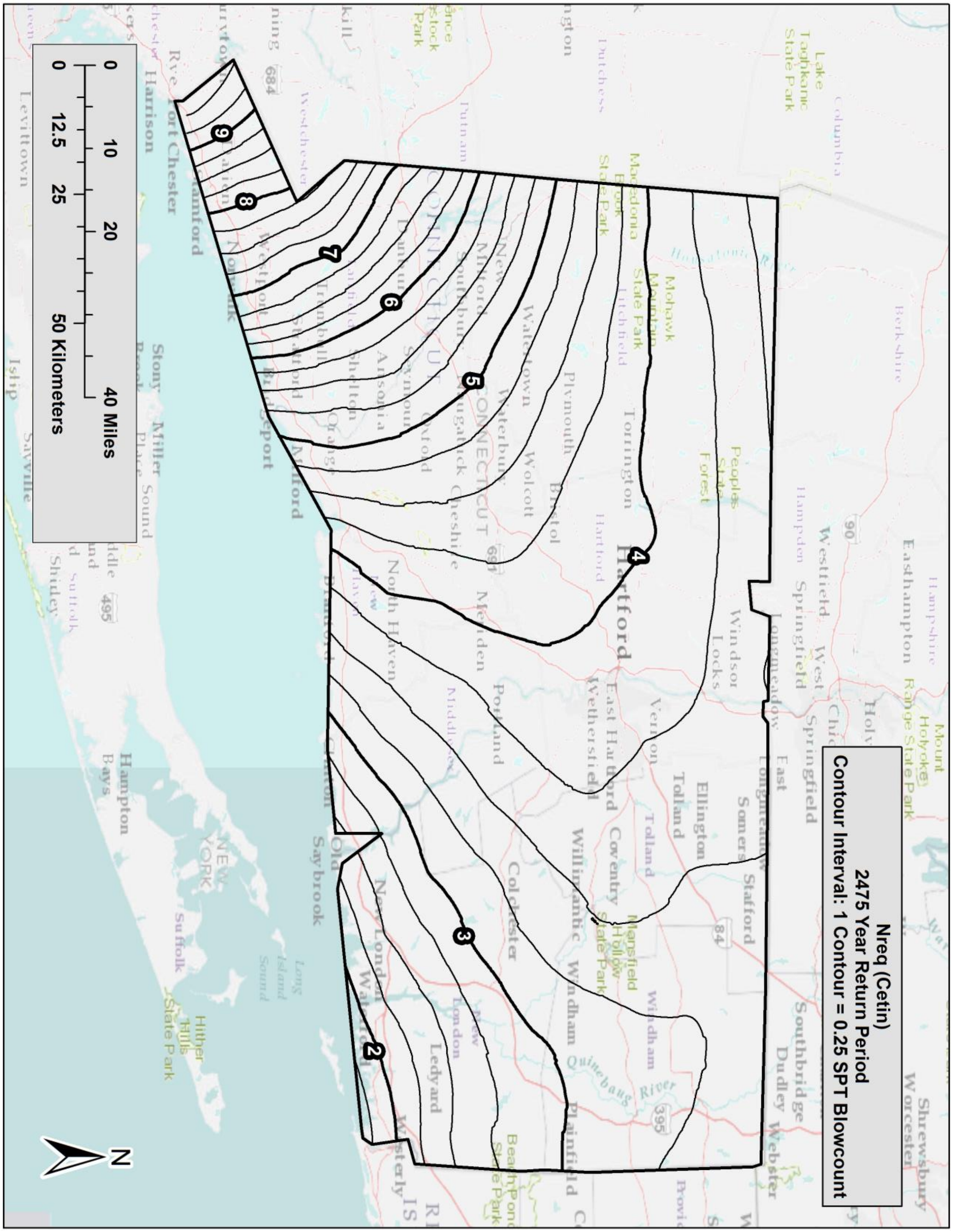


Figure B- 9 N_{req} for Connecticut (T_R = 2475 years)

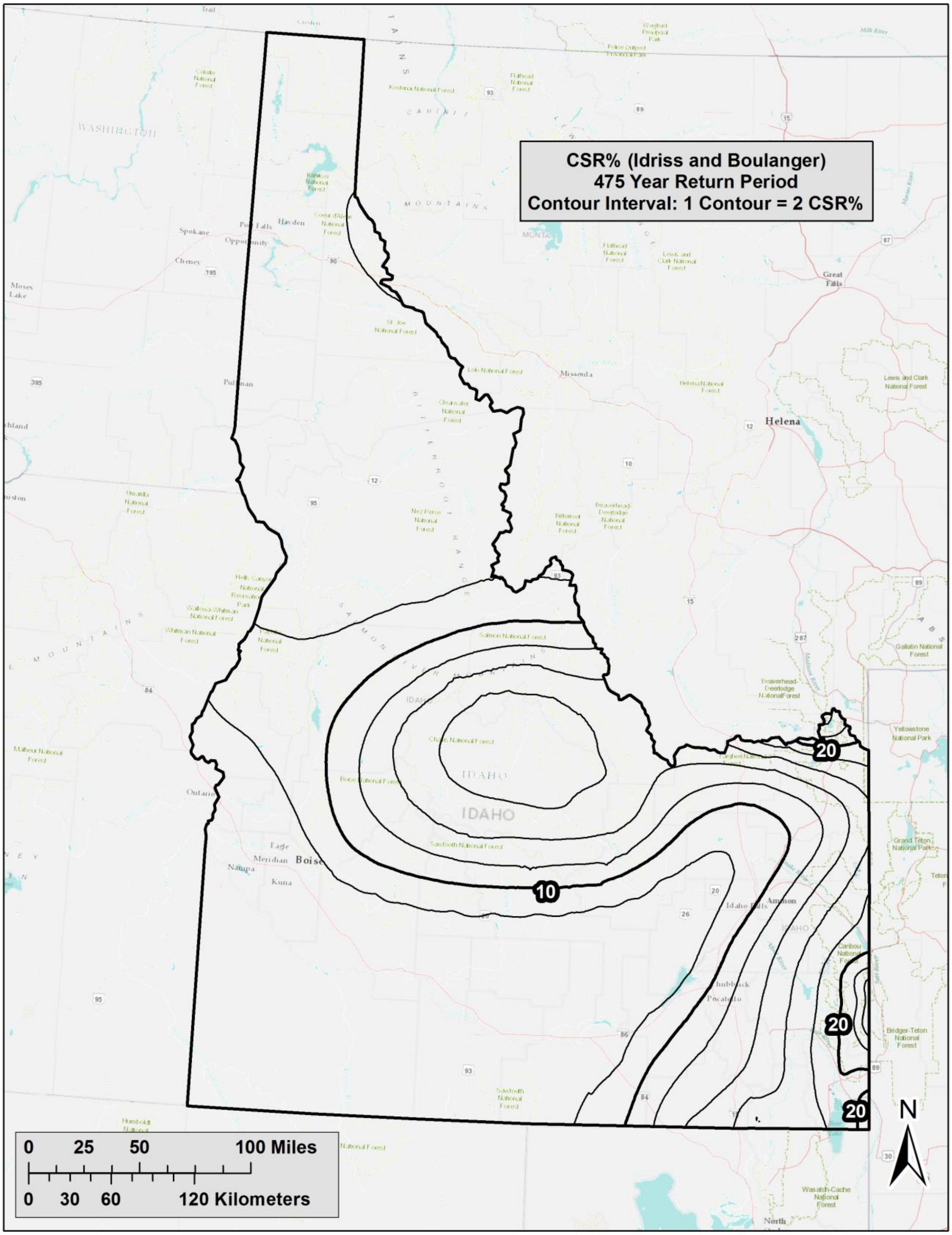


Figure B- 10 CSR% for Idaho (T_R = 475 years)

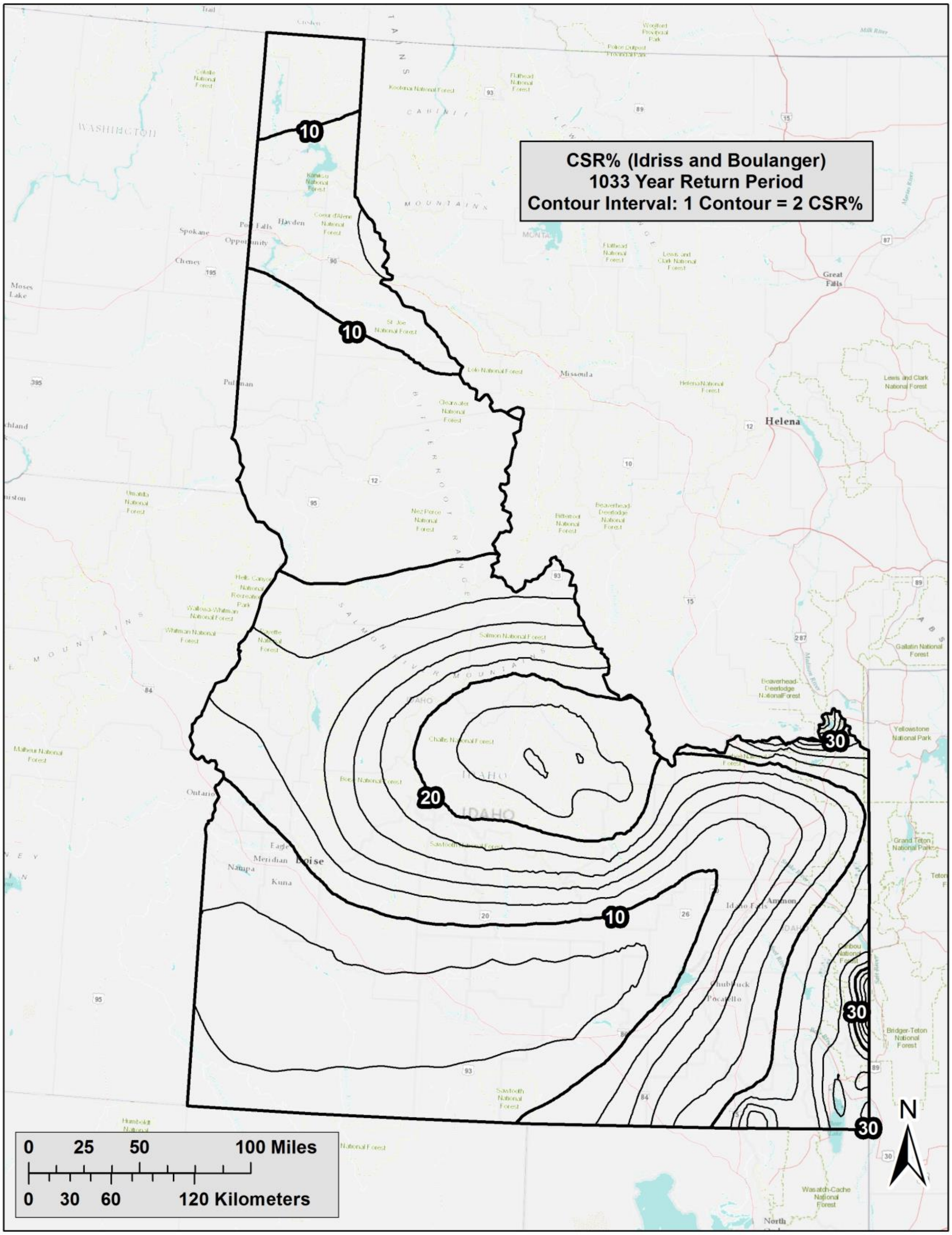


Figure B- 11 CSR% for Idaho (T_R = 1033 years)

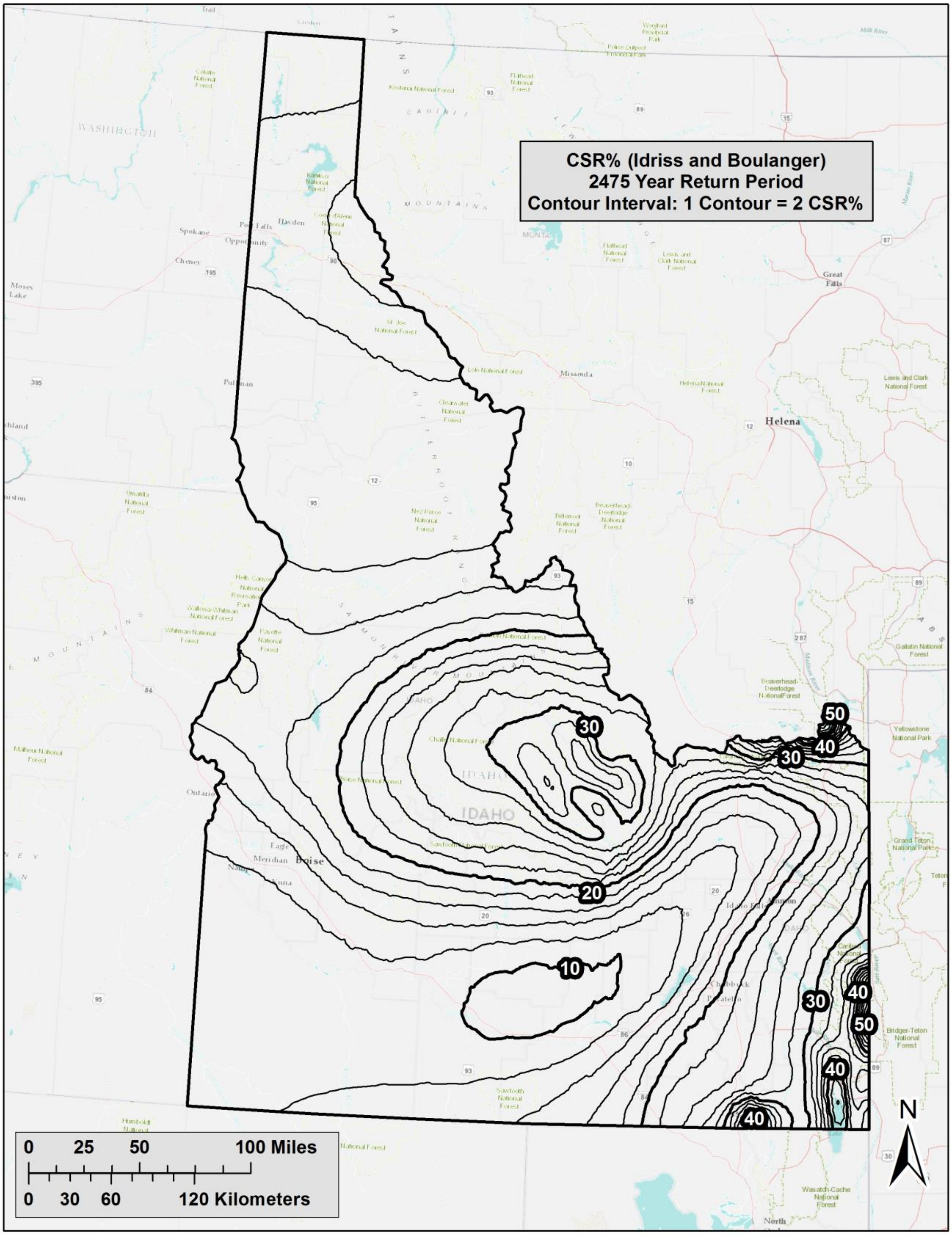


Figure B- 12 CSR% for Idaho (T_R = 2475 years)

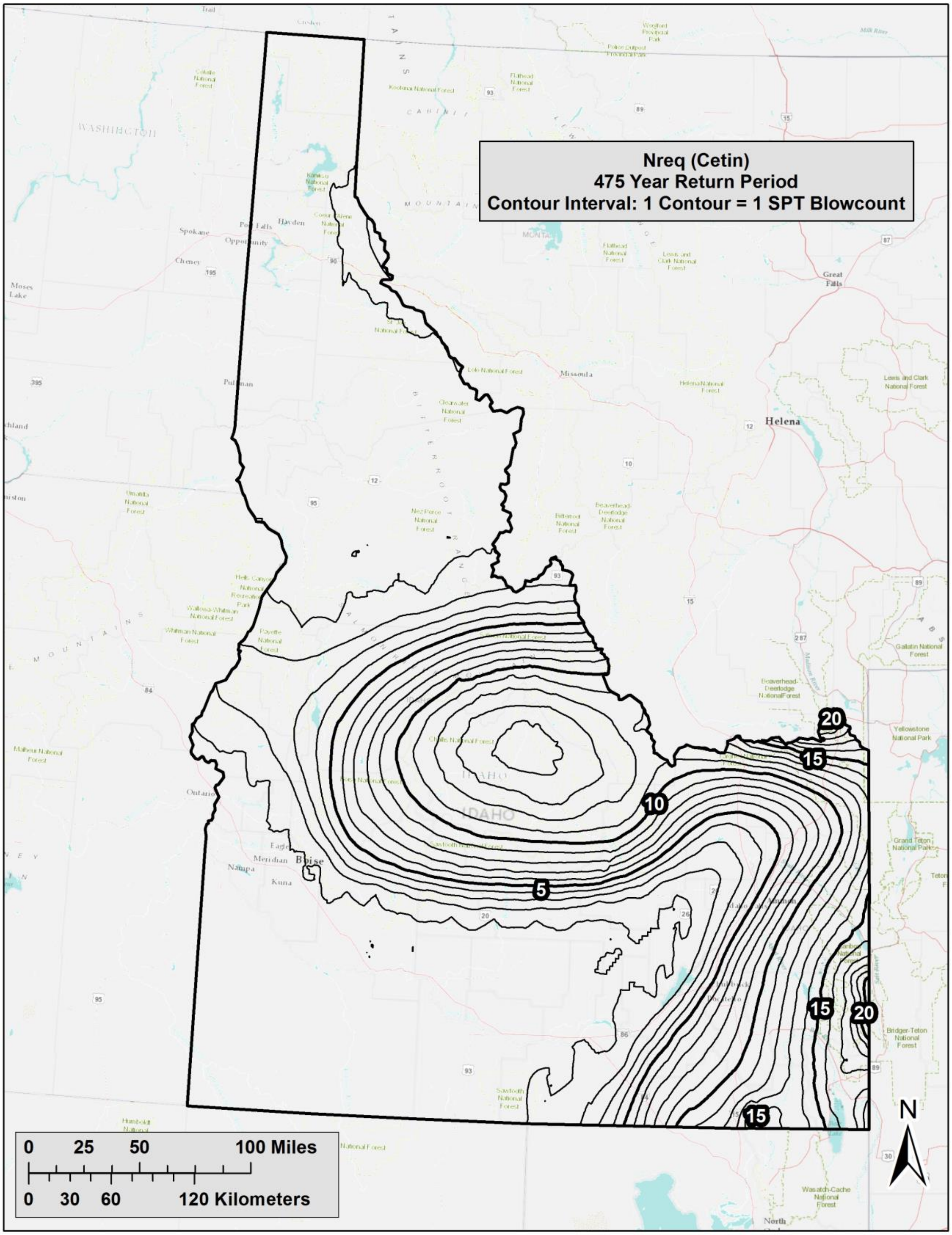


Figure B- 13 N_{req} for Idaho (T_R = 475 years)

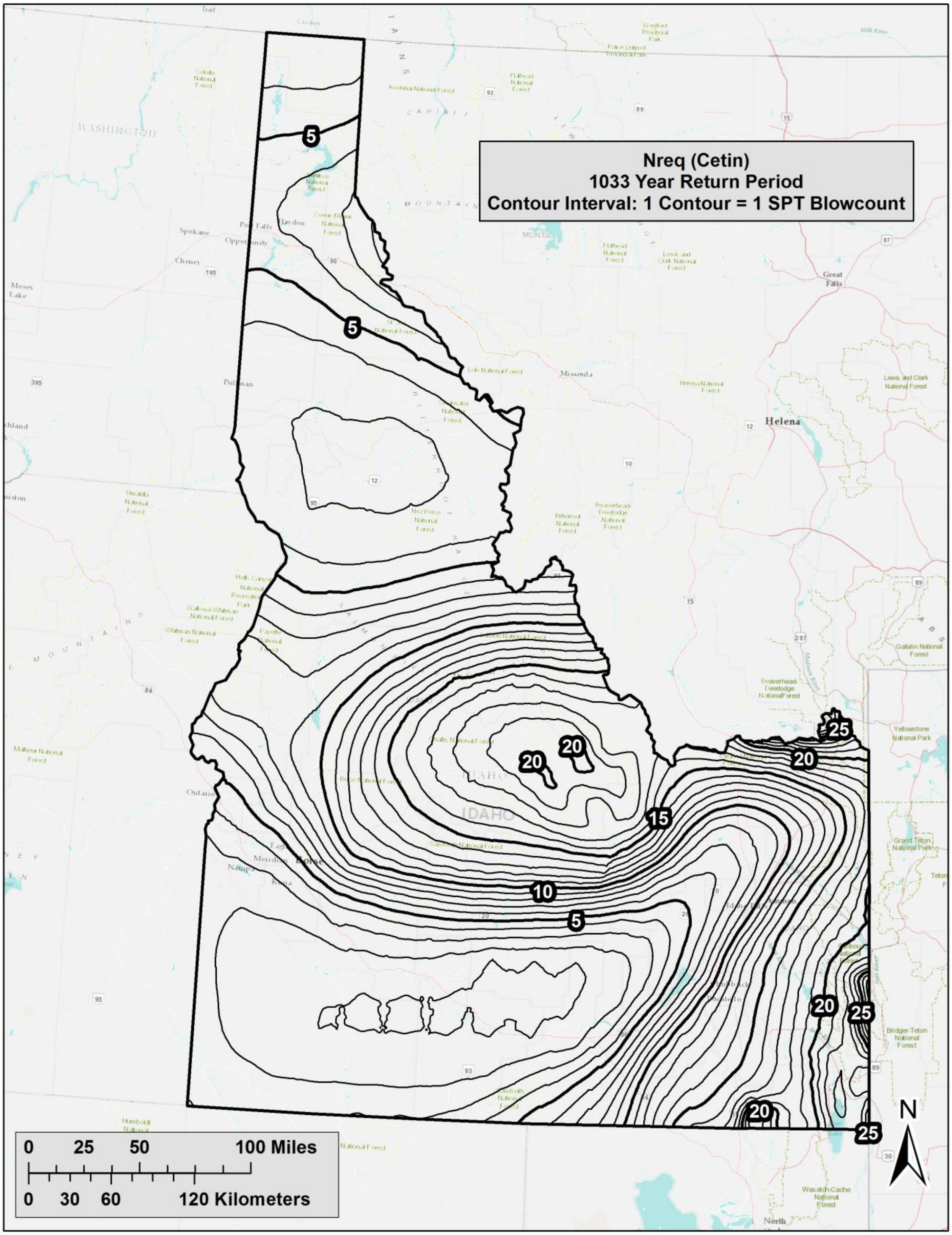


Figure B- 14 N_{req} for Idaho (T_R = 1033 years)

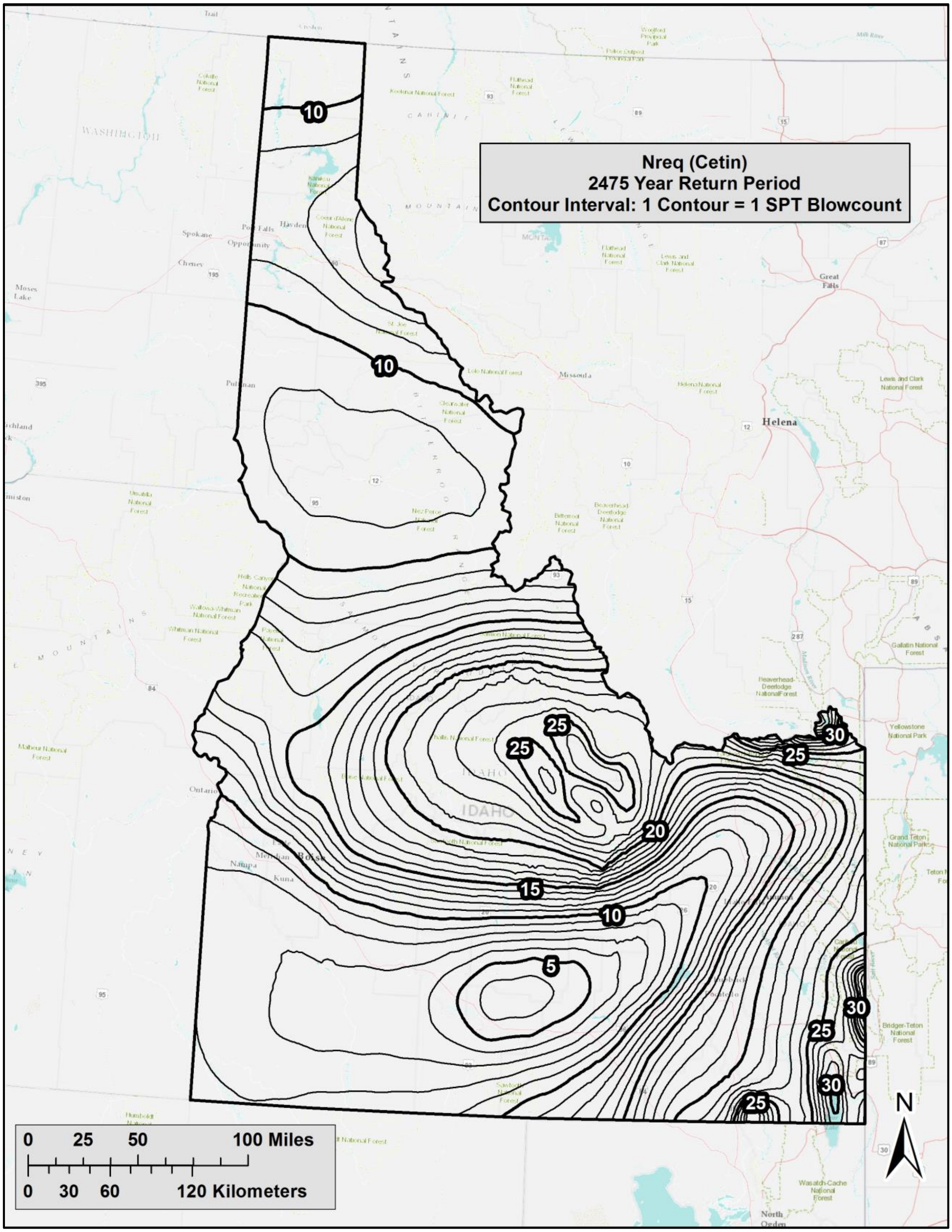


Figure B- 15 N_{req} for Idaho (T_R = 2475 years)

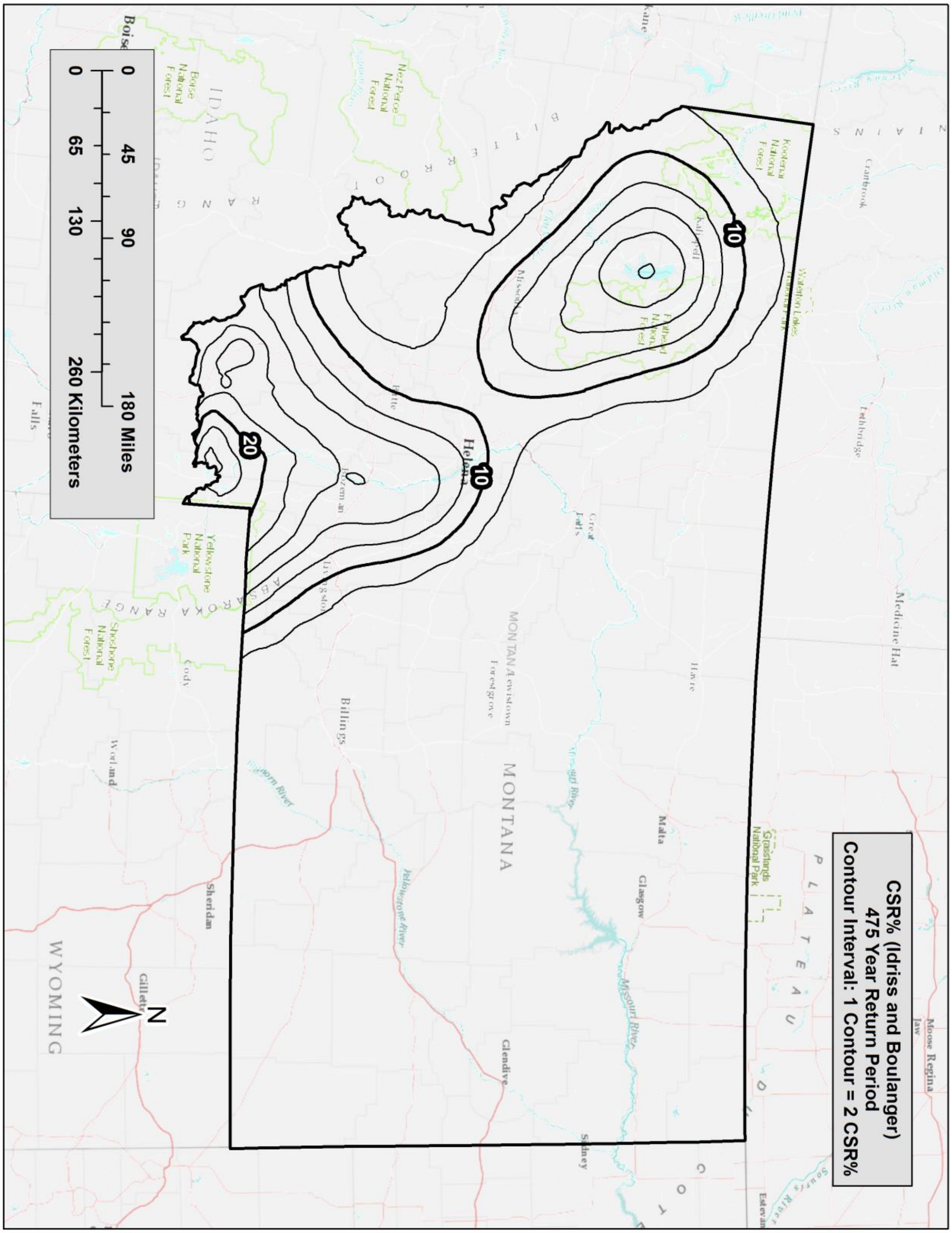


Figure B- 16 CSR% for Montana (T_R = 475 years)

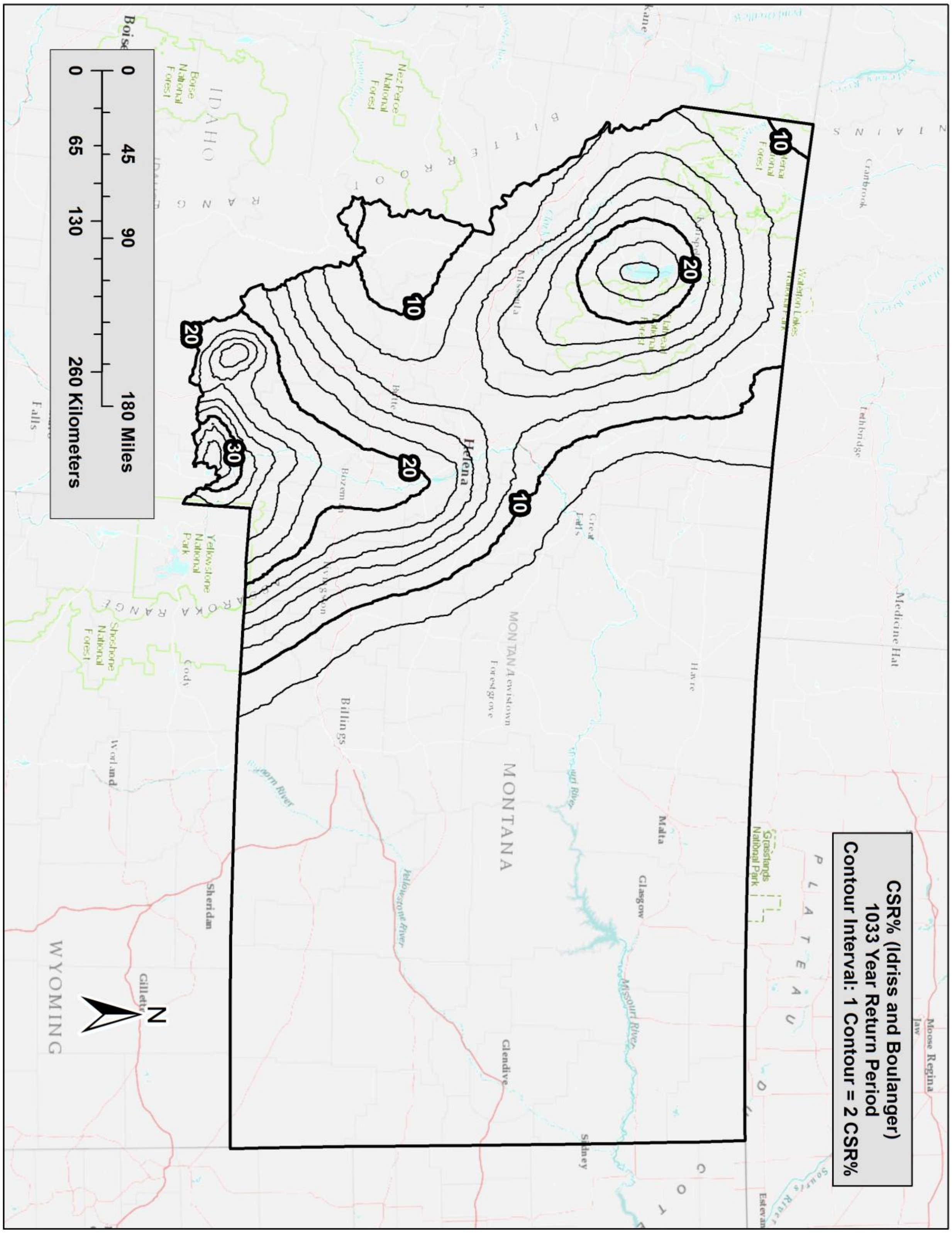


Figure B- 17 CSR% for Montana (T_R = 1033 years)

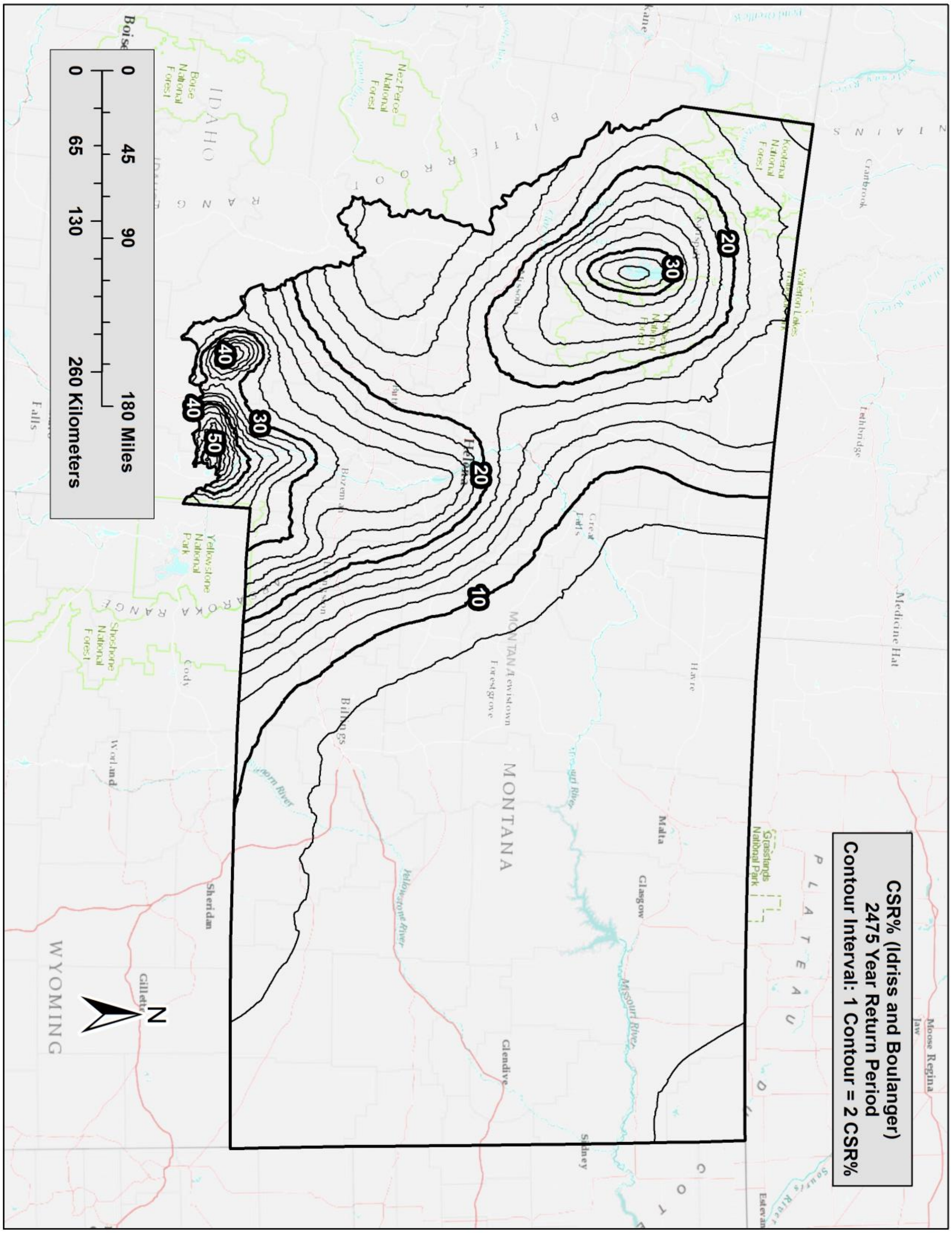


Figure B- 18 CSR% for Montana (T_R = 2475 years)

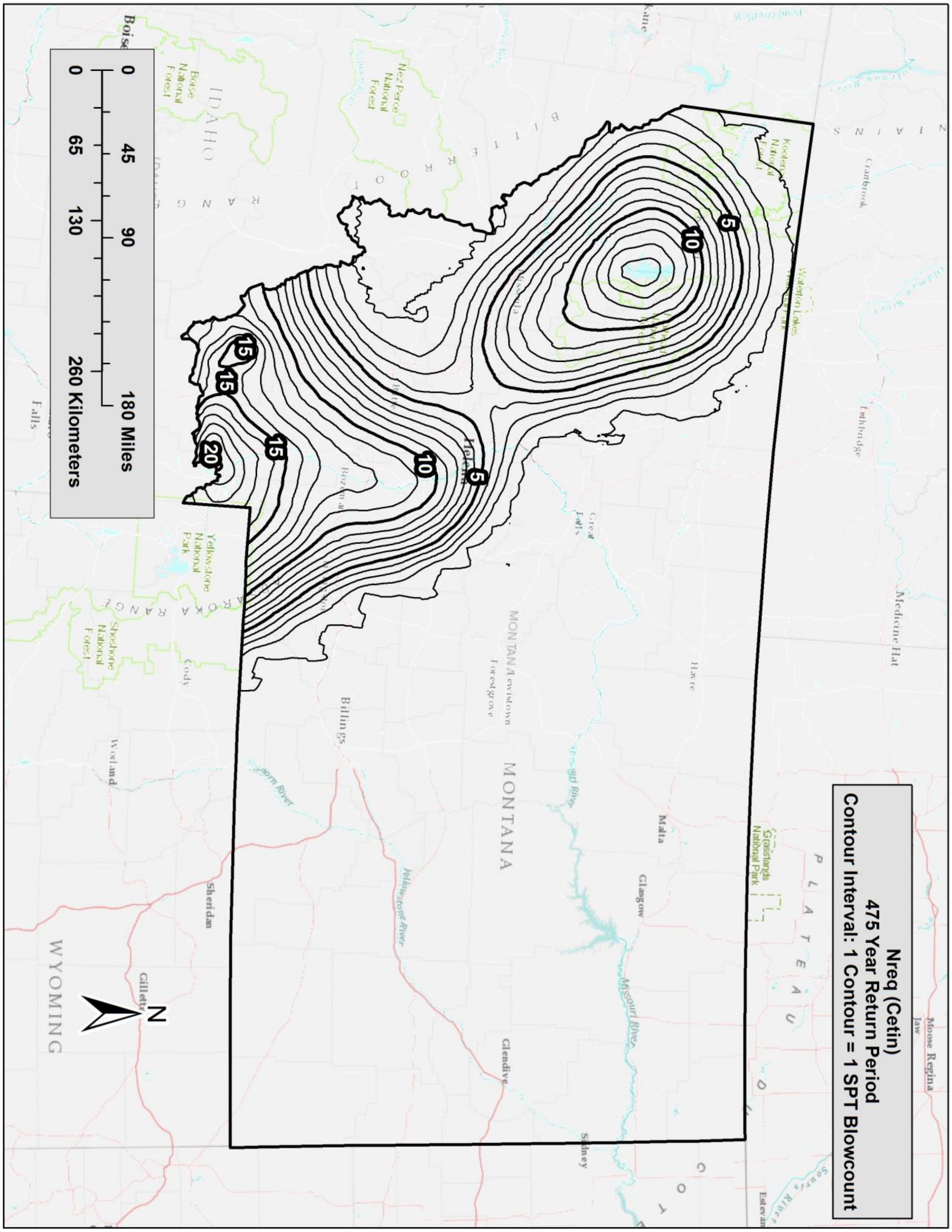


Figure B- 19 N_{req} for Montana (T_R = 475 years)

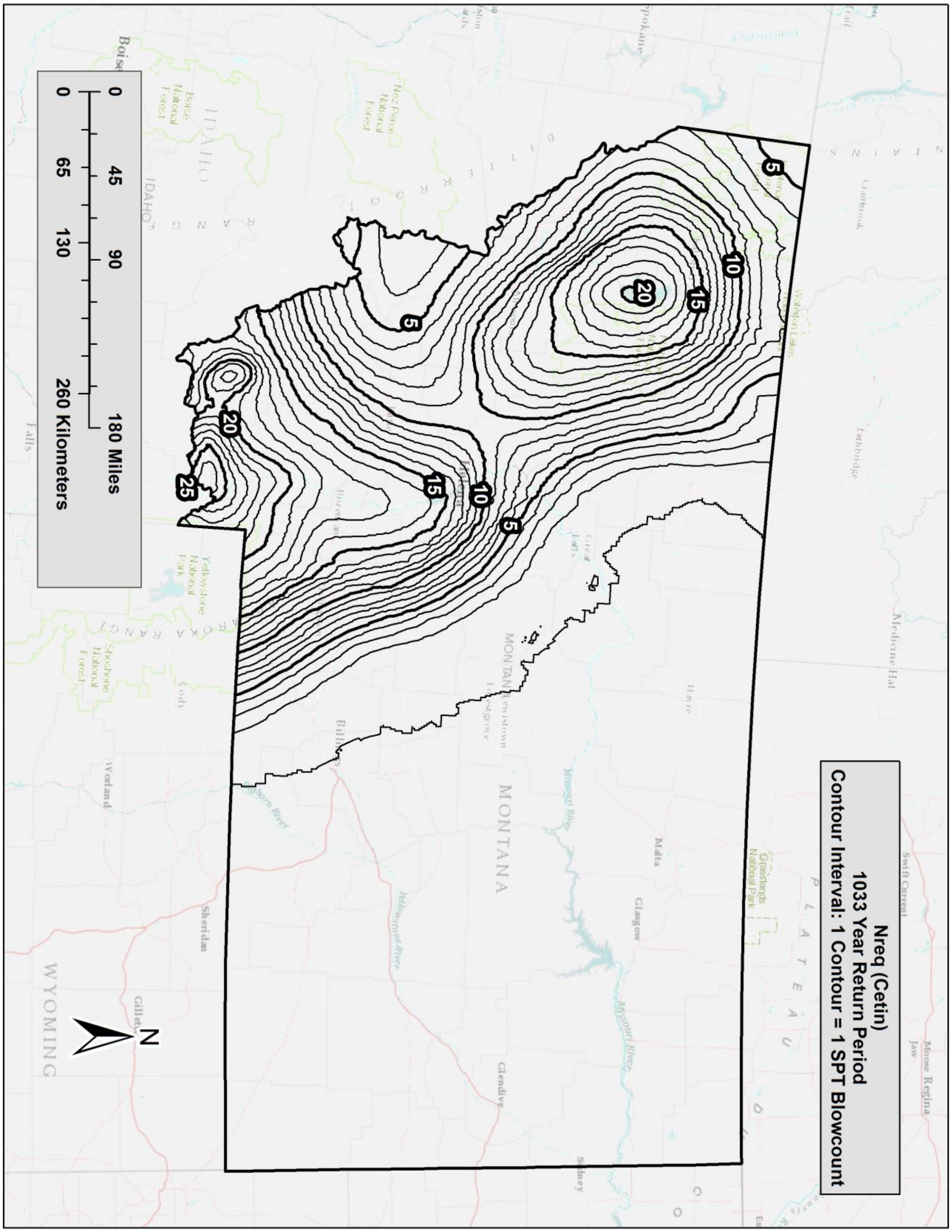


Figure B- 20 N_{req} for Montana (T_R = 1033 years)

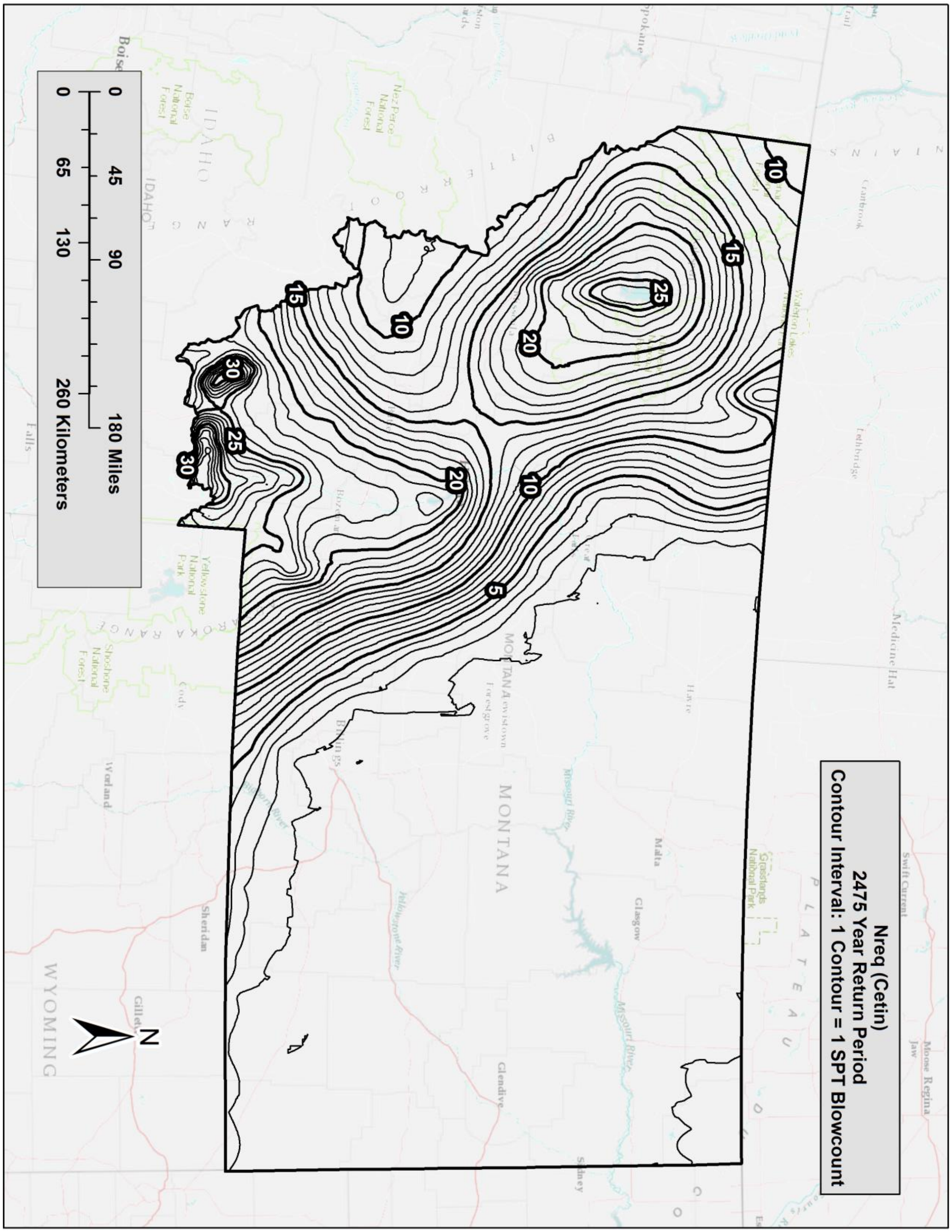


Figure B- 21 N_{req} for Montana (T_R = 2475 years)

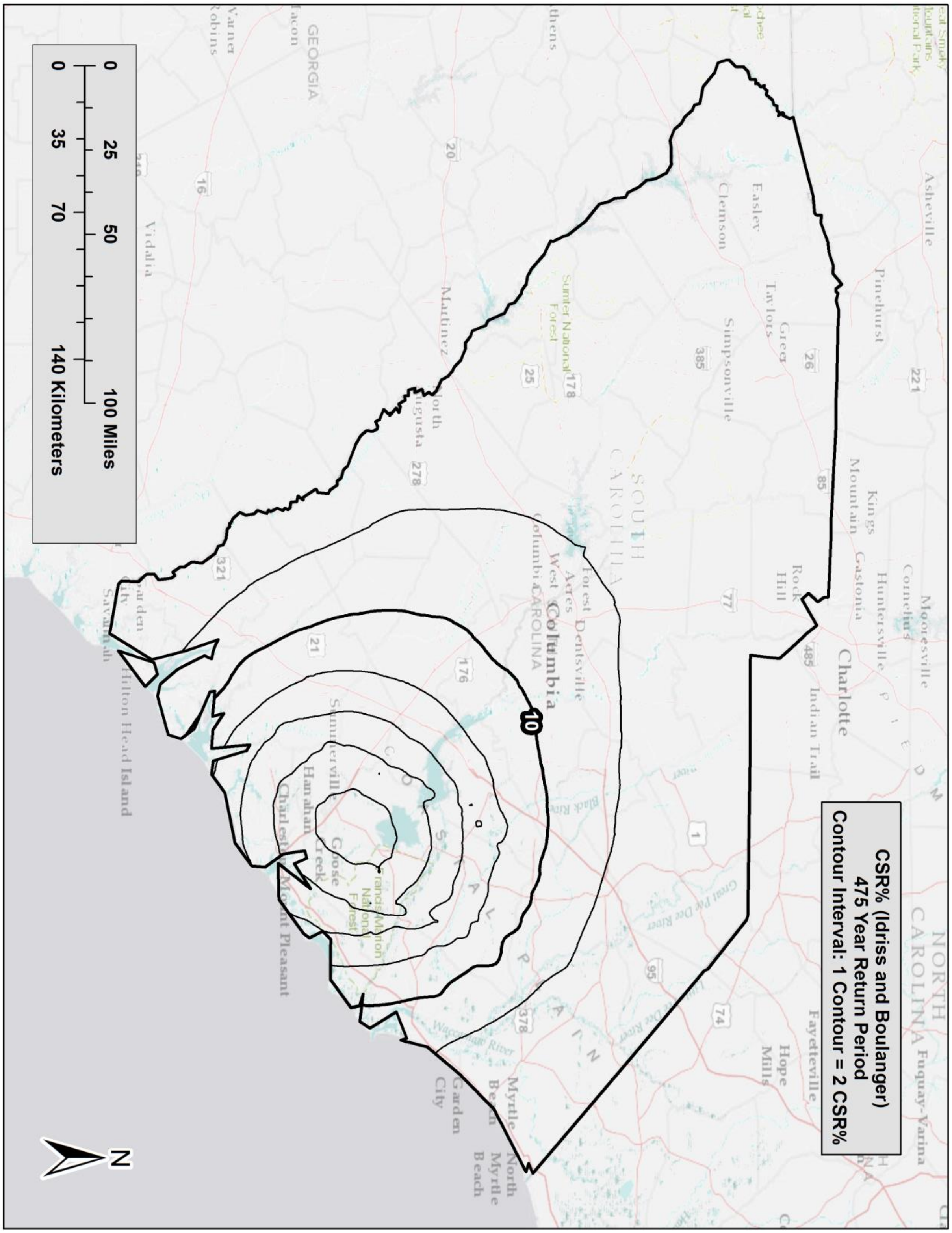


Figure B- 22 CSR% for South Carolina (T_R = 475 years)

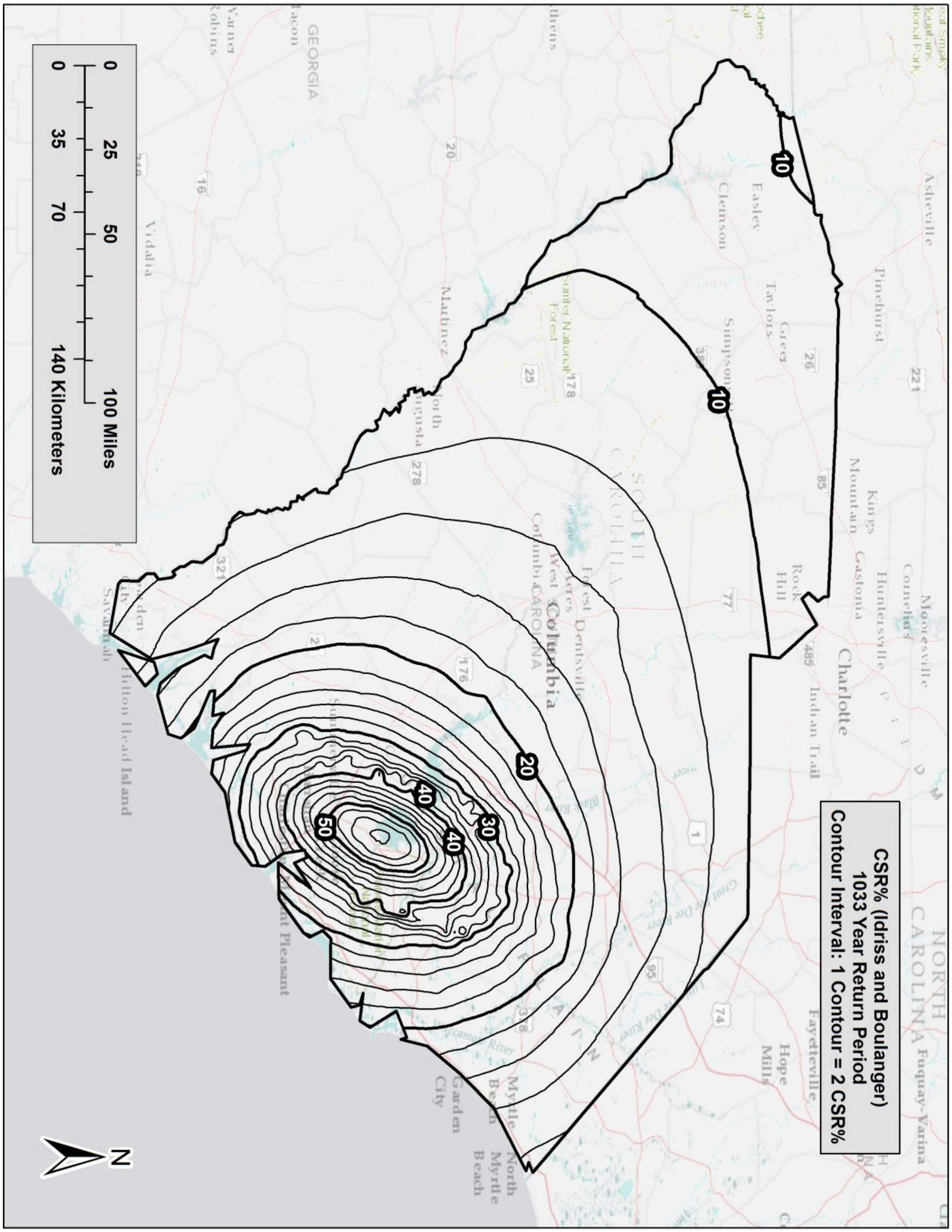


Figure B- 23 CSR% for South Carolina (T_R = 1033 years)

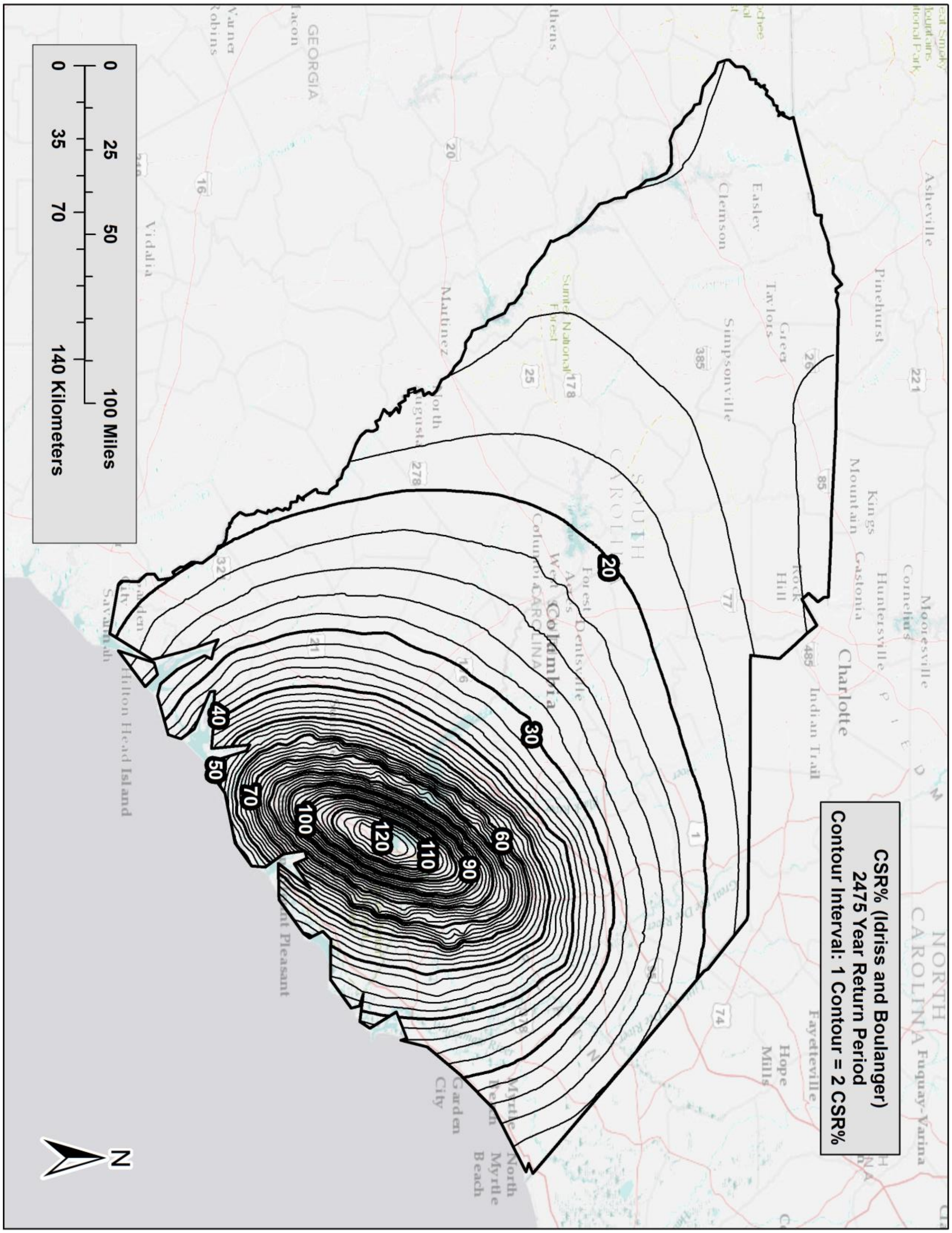


Figure B- 24 CSR% for South Carolina (T_R = 2475 years)

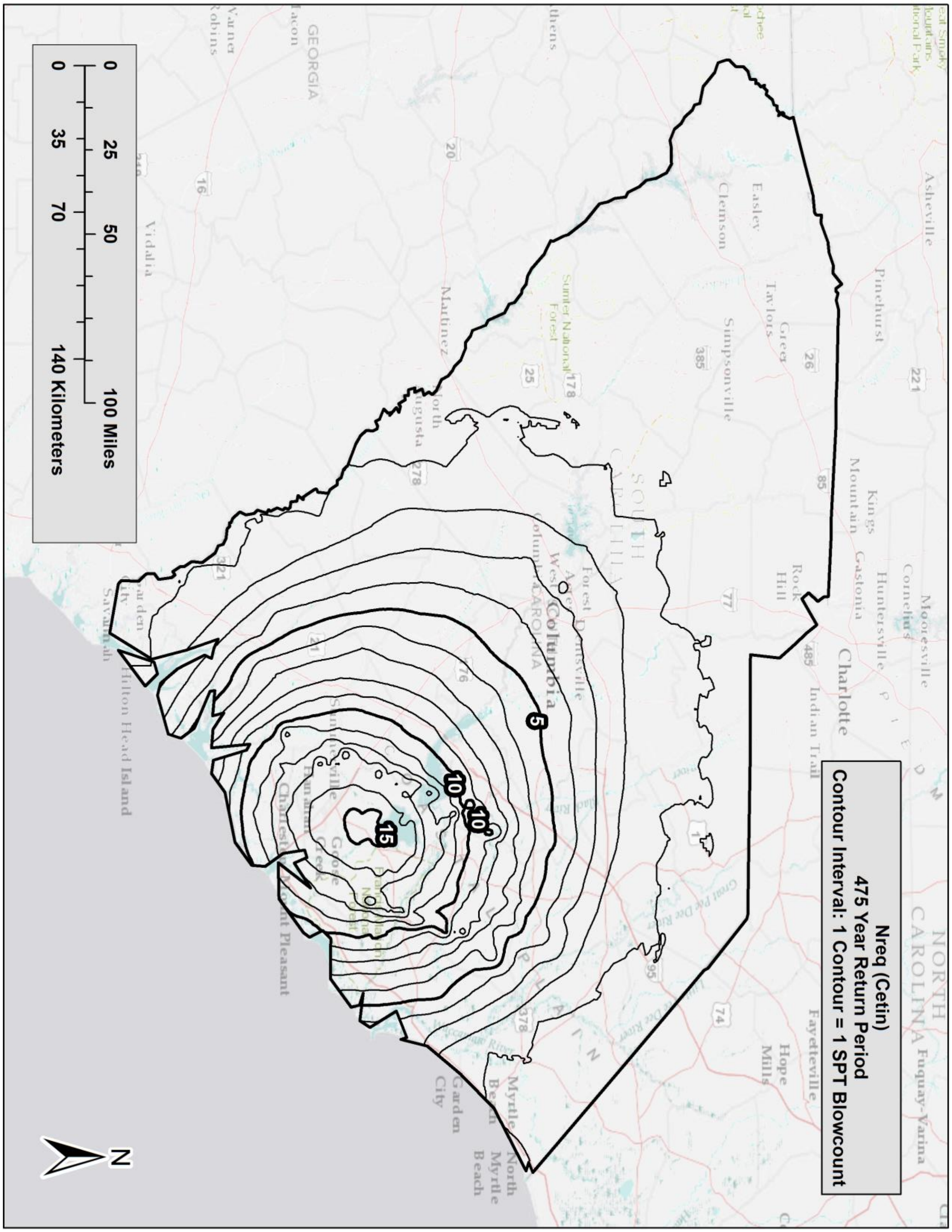


Figure B- 25 N_{req} for South Carolina (T_R = 475 years)

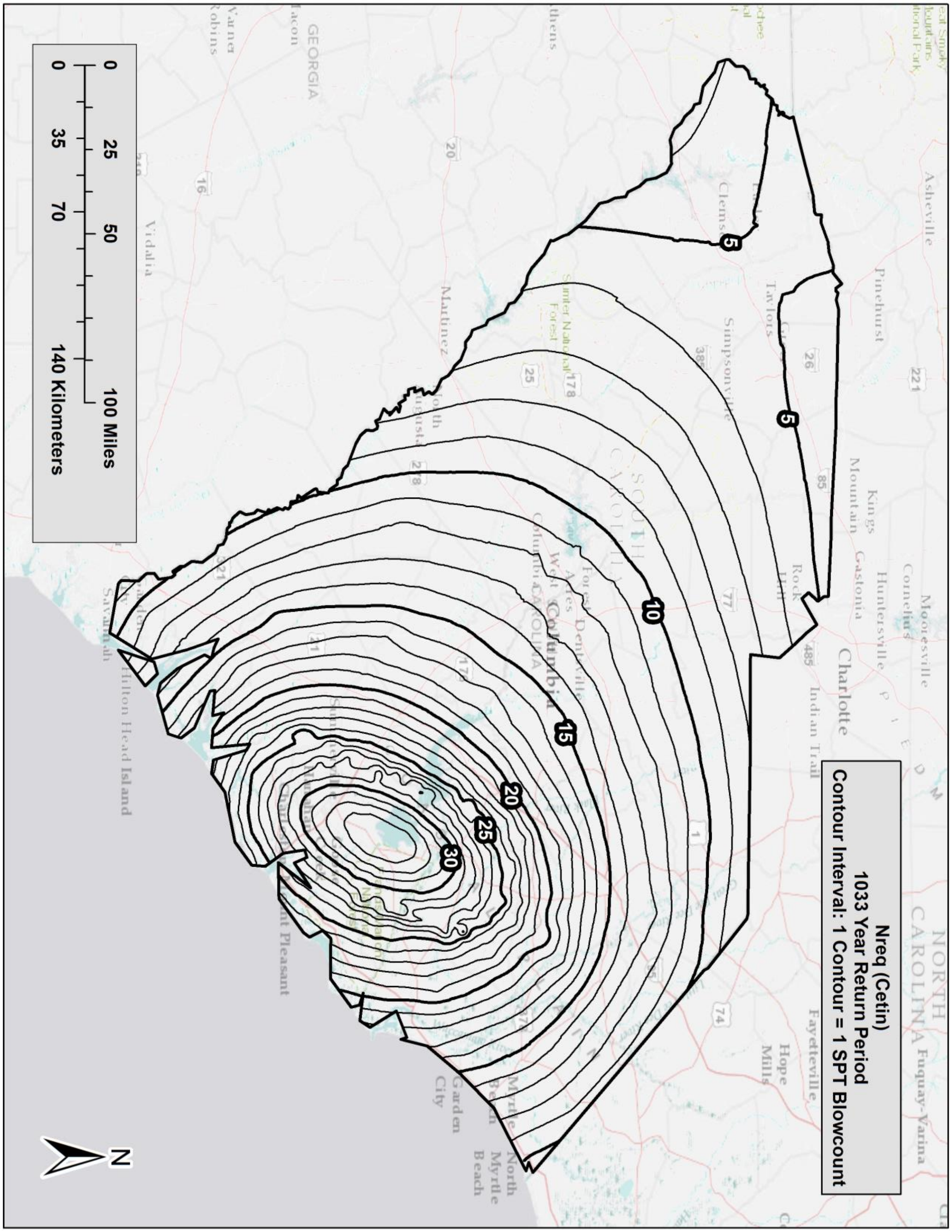


Figure B- 26 N_{req} for South Carolina (T_R = 1033 years)

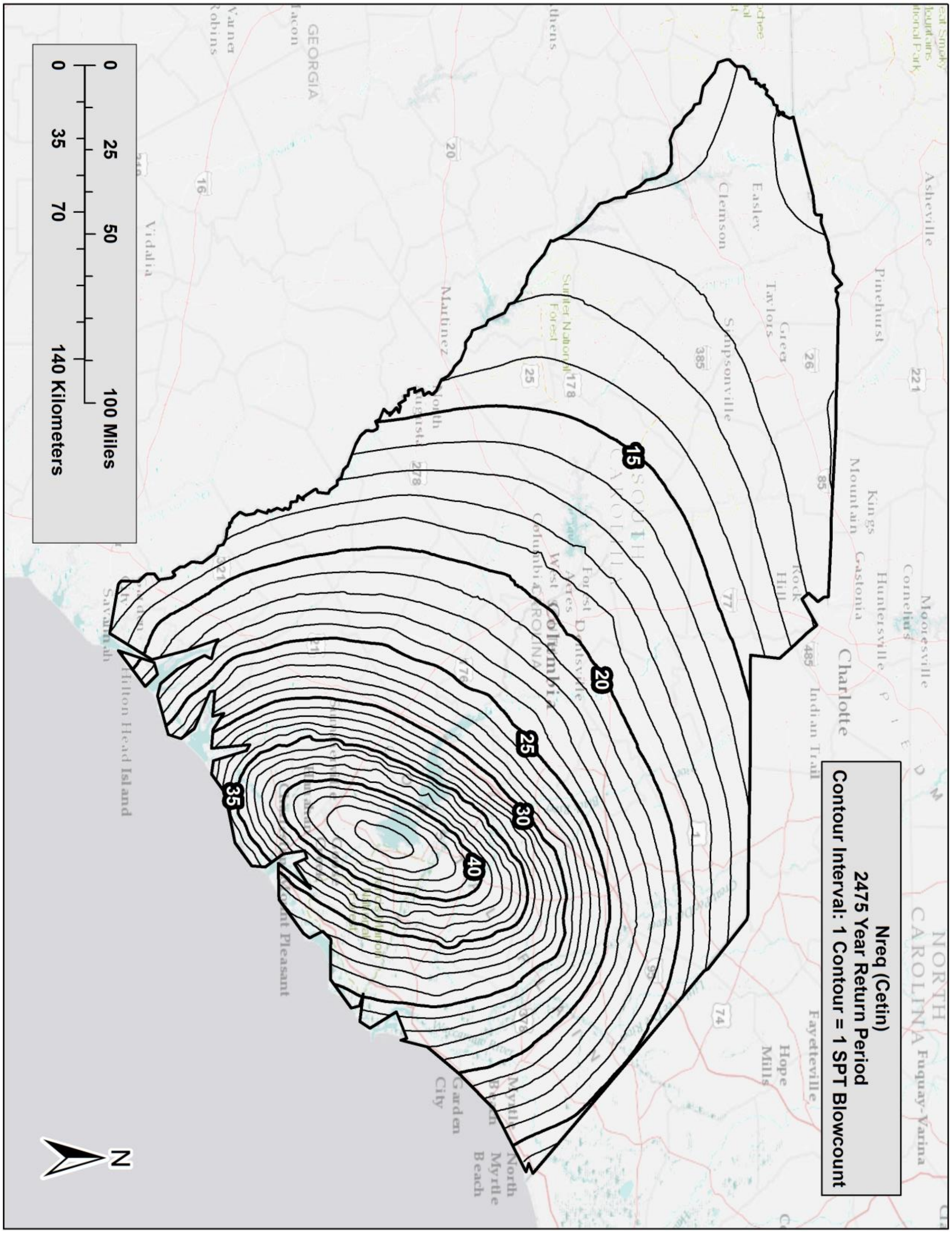


Figure B- 27 N_{req} for South Carolina (T_R = 2475 years)

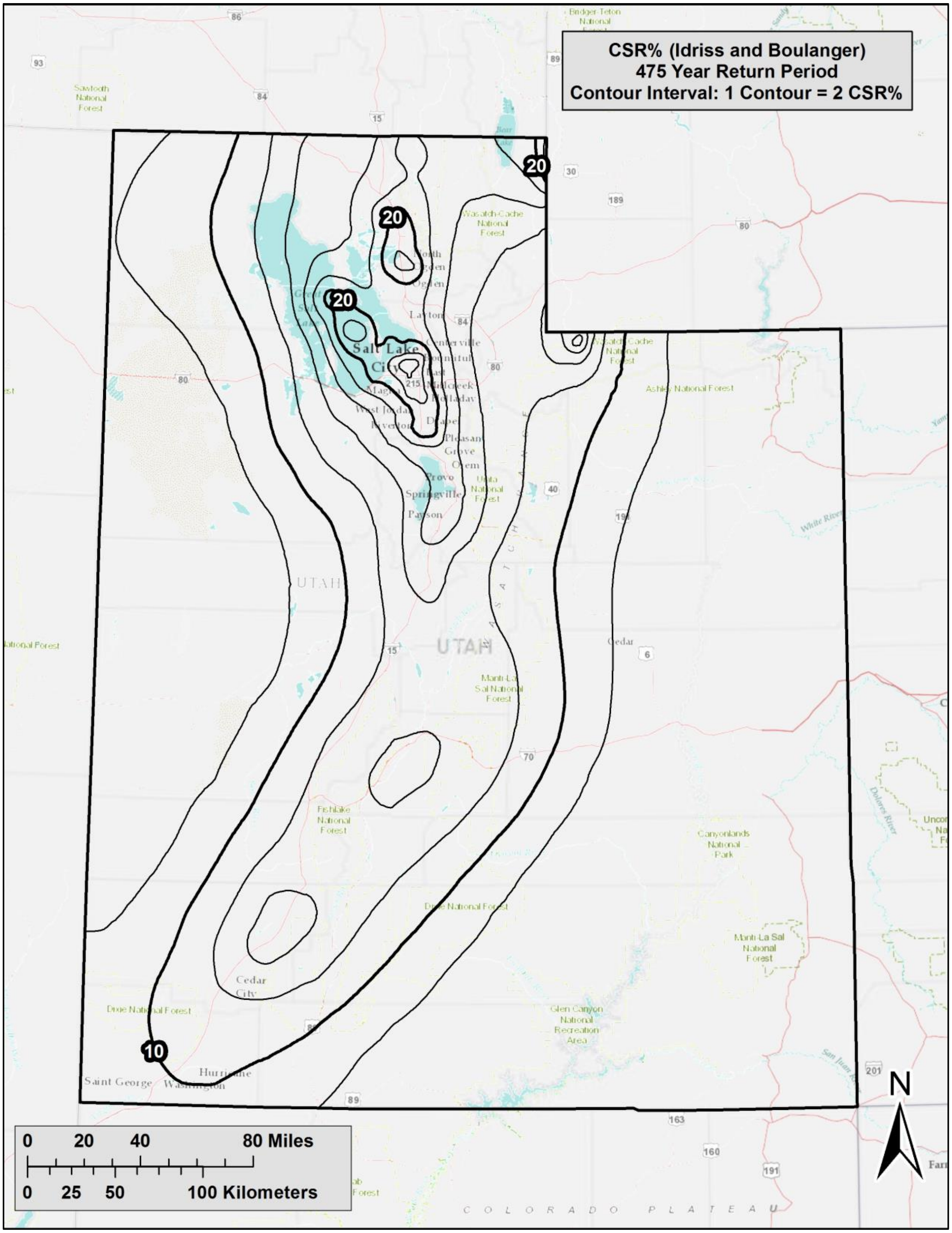


Figure B- 28 CSR% Utah (T_R = 475 years)

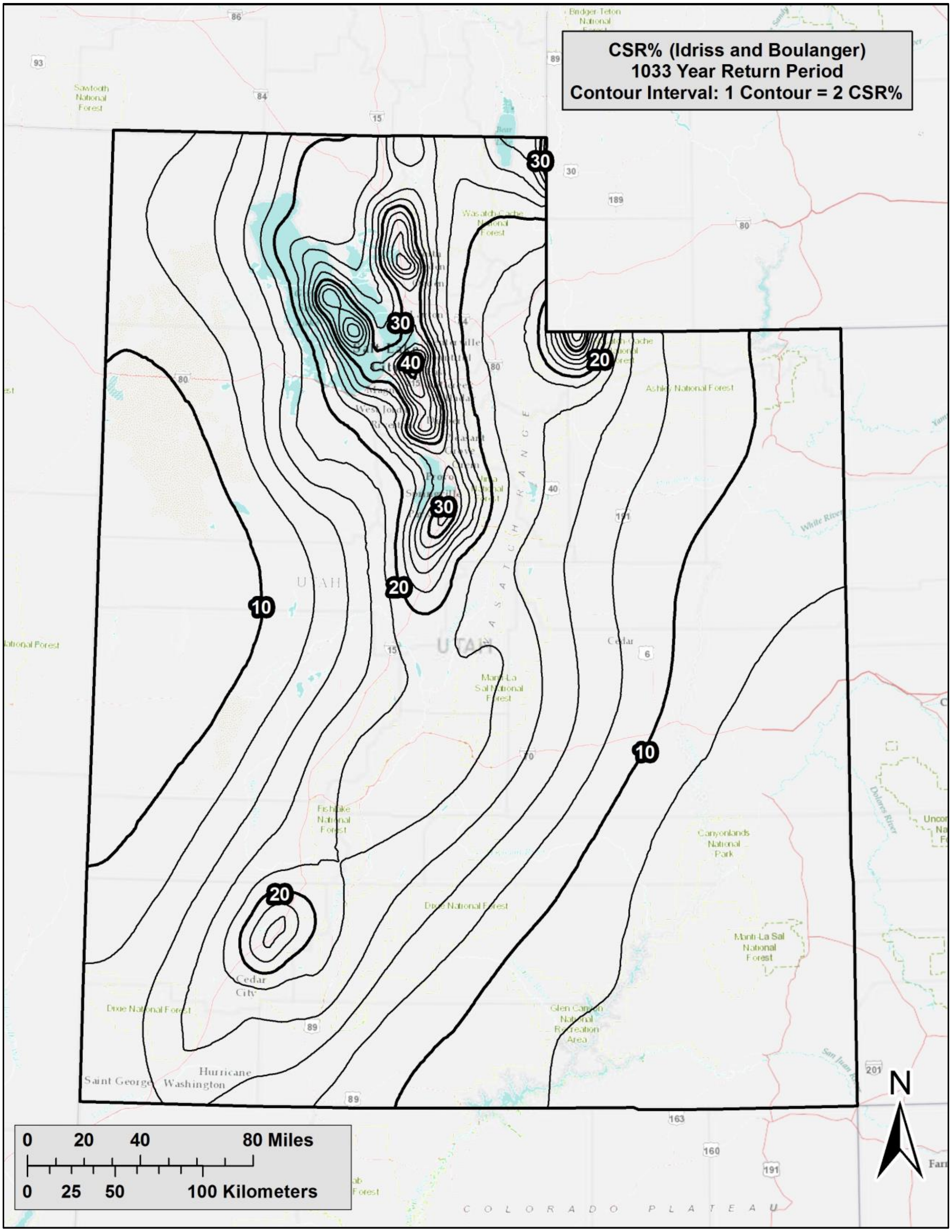


Figure B- 29 CSR% Utah (T_R = 1033 years)

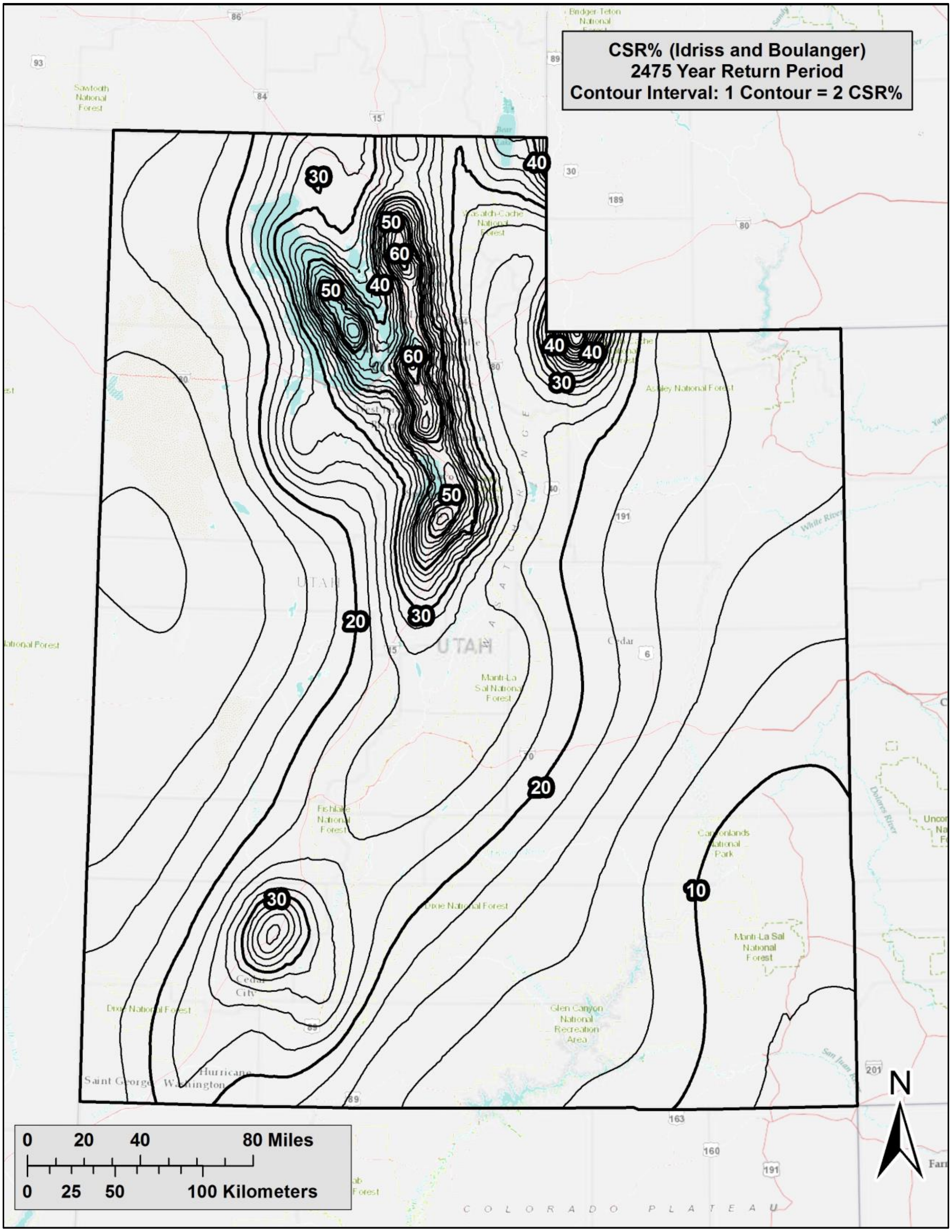


Figure B- 30 CSR% Utah (T_R = 2475 years)

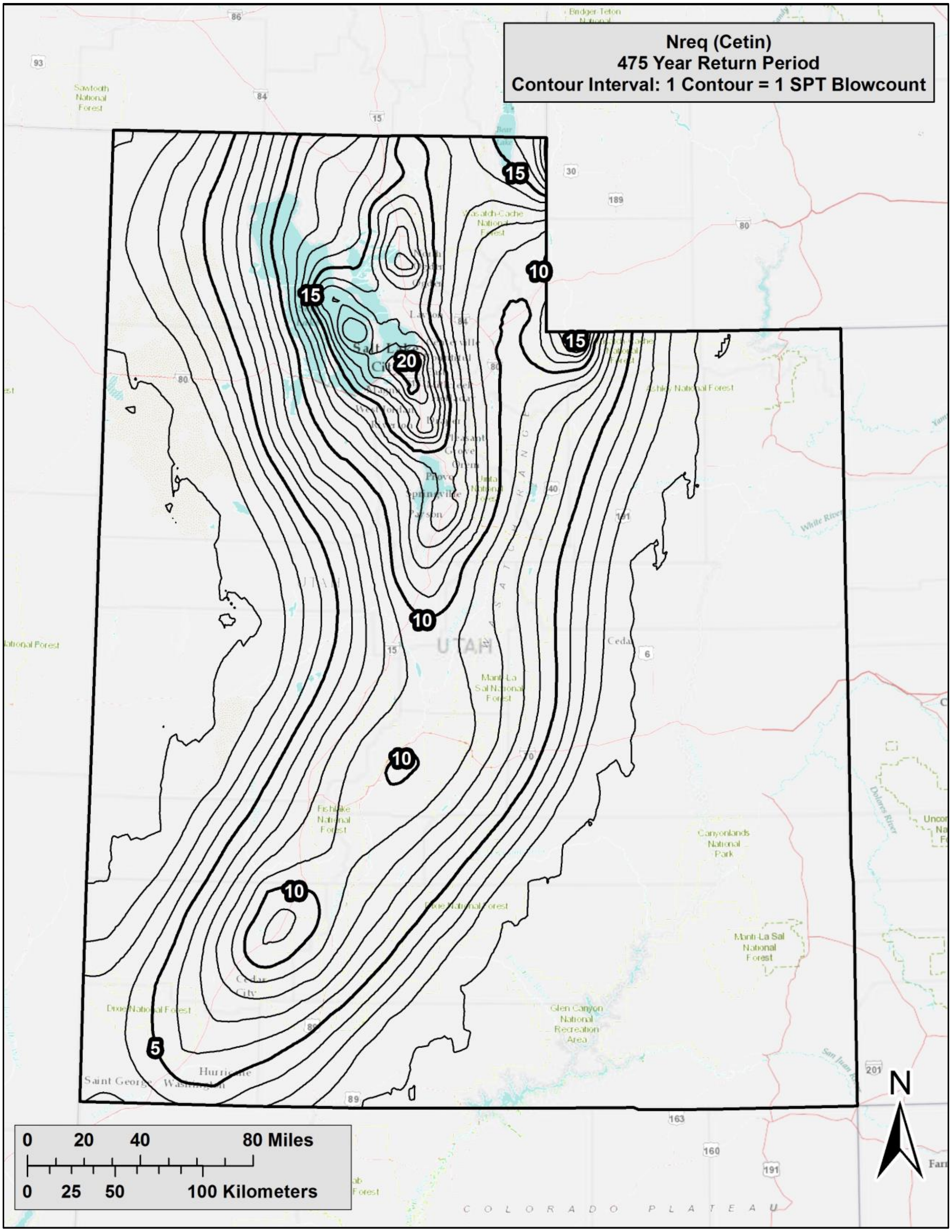


Figure B- 31 N_{req} Utah (T_R = 475 years)

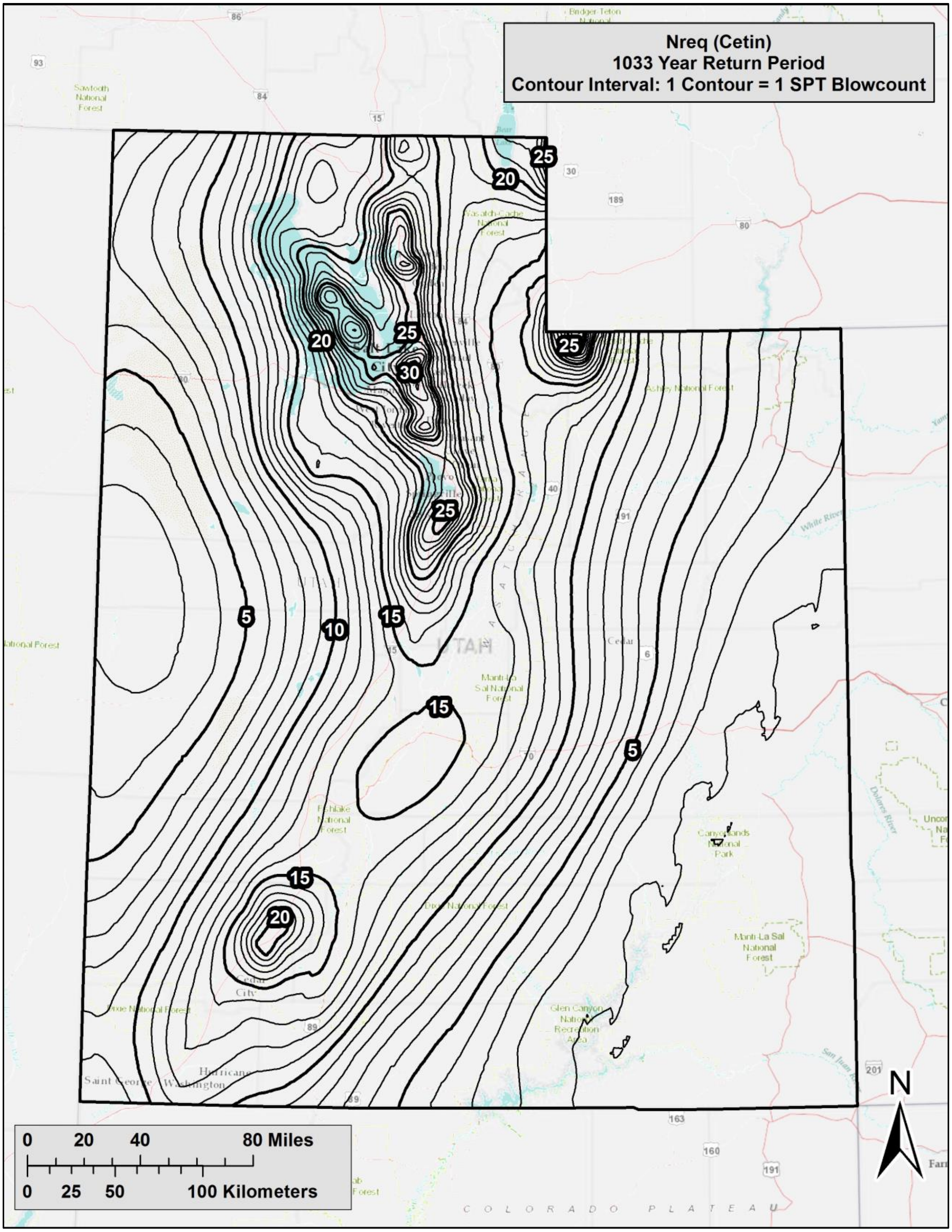


Figure B- 32 N_{req} Utah (T_R = 1033 years)

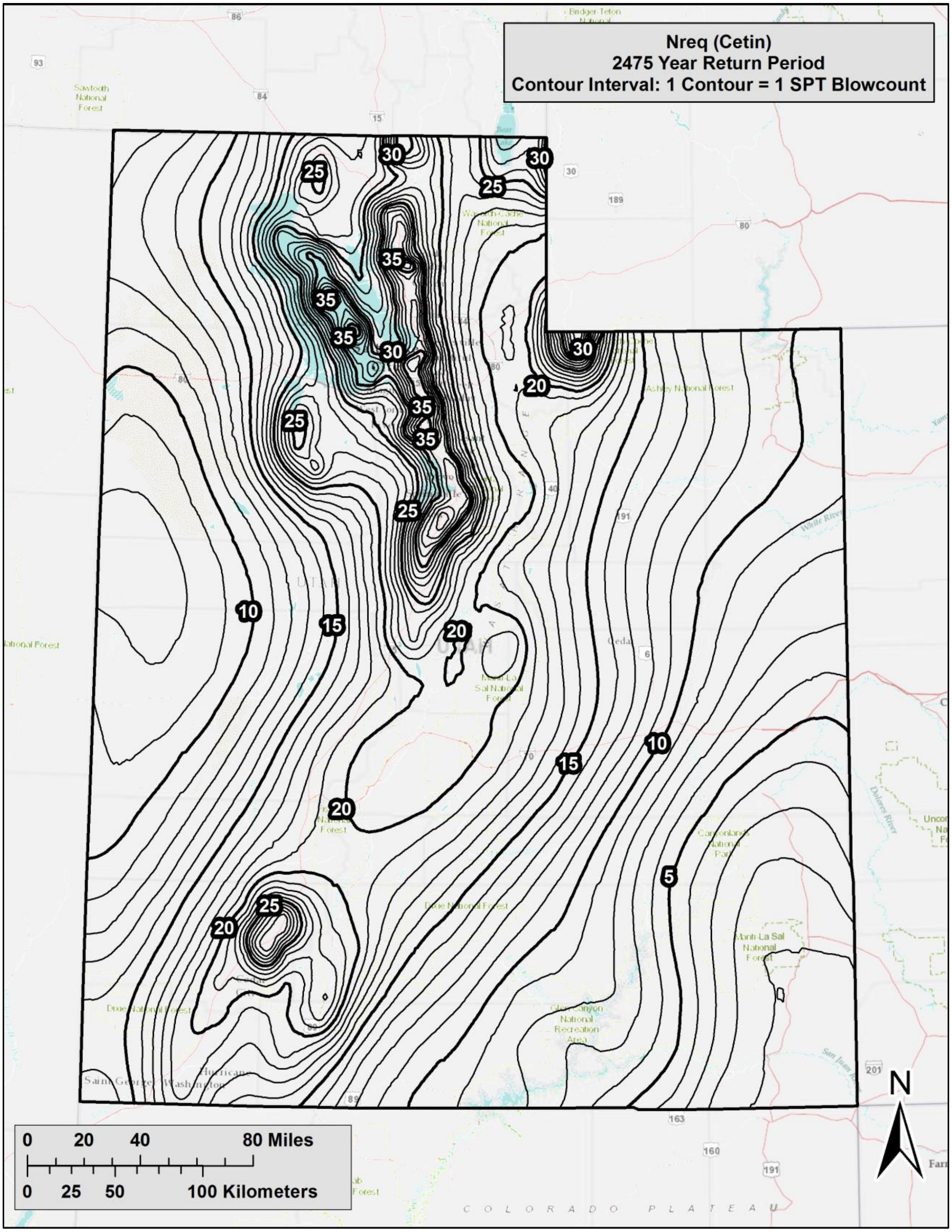


Figure B- 33 N_{req} Utah (T_R = 2475 years)

APPENDIX C: Sample Lateral Spread Hazard Maps

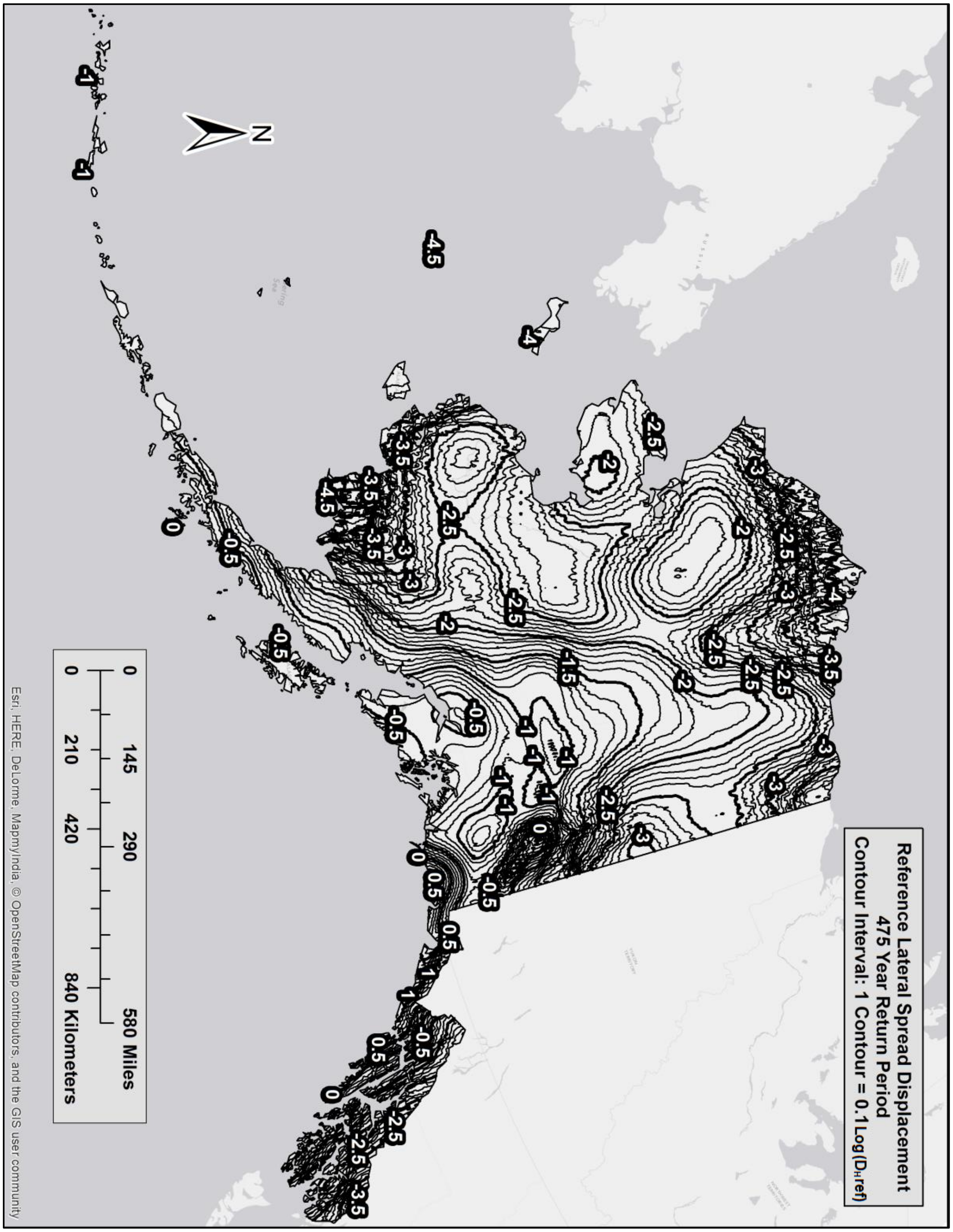
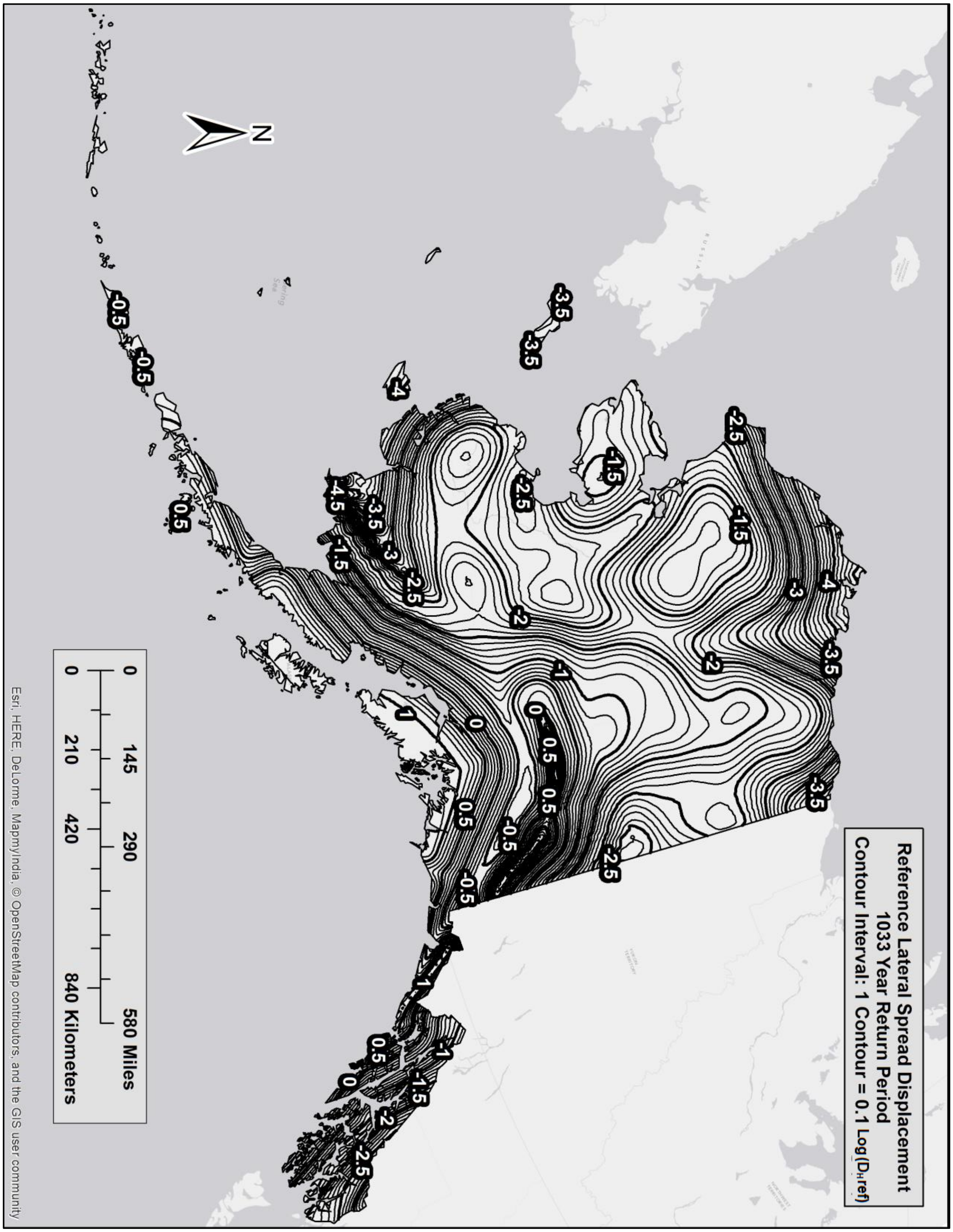


Figure C- 1 Log D_H^{ref} for Alaska (T_R = 475 years)



Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community

Figure C- 2 Log D_H^{ref} for Alaska (T_R = 1033 years)

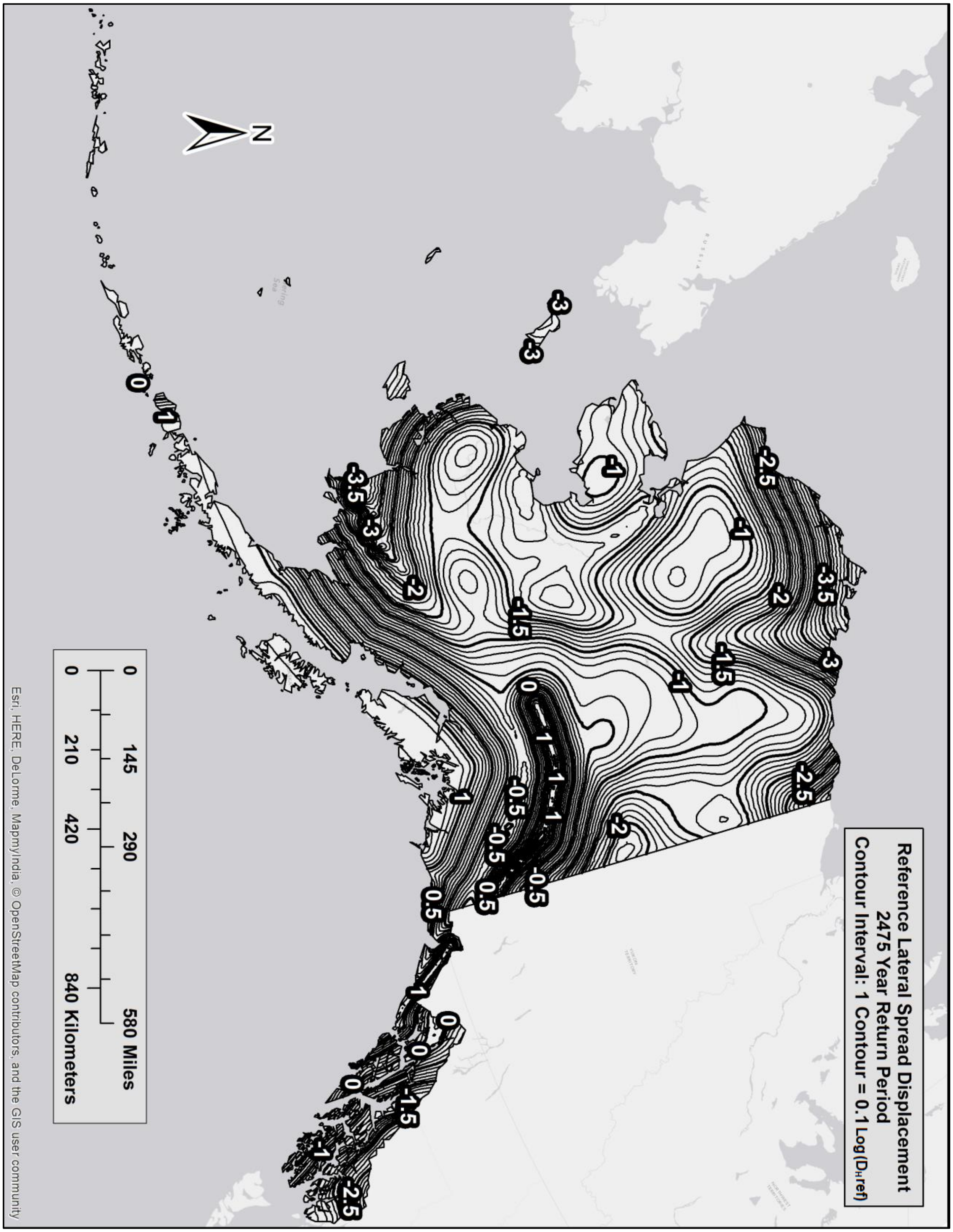
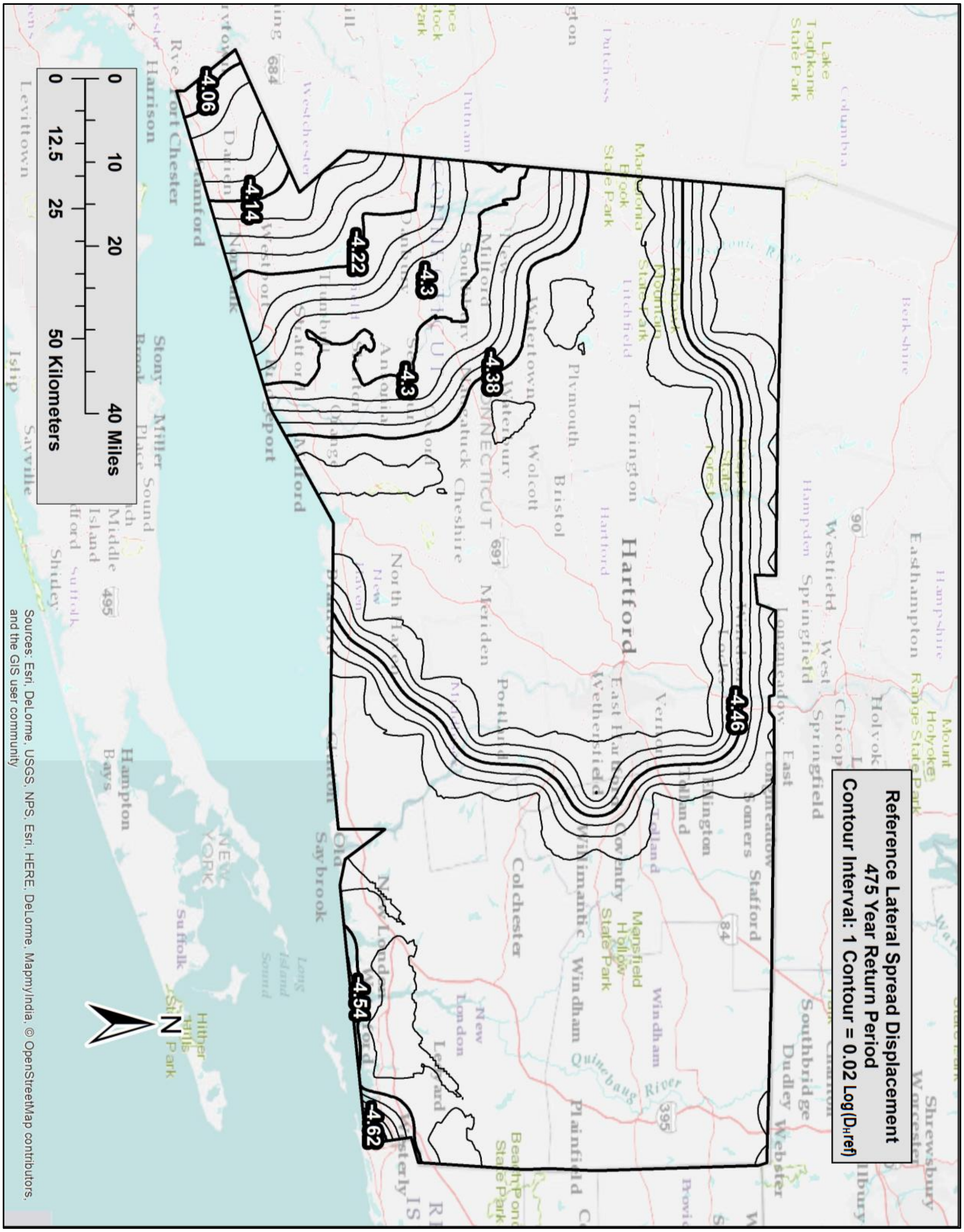
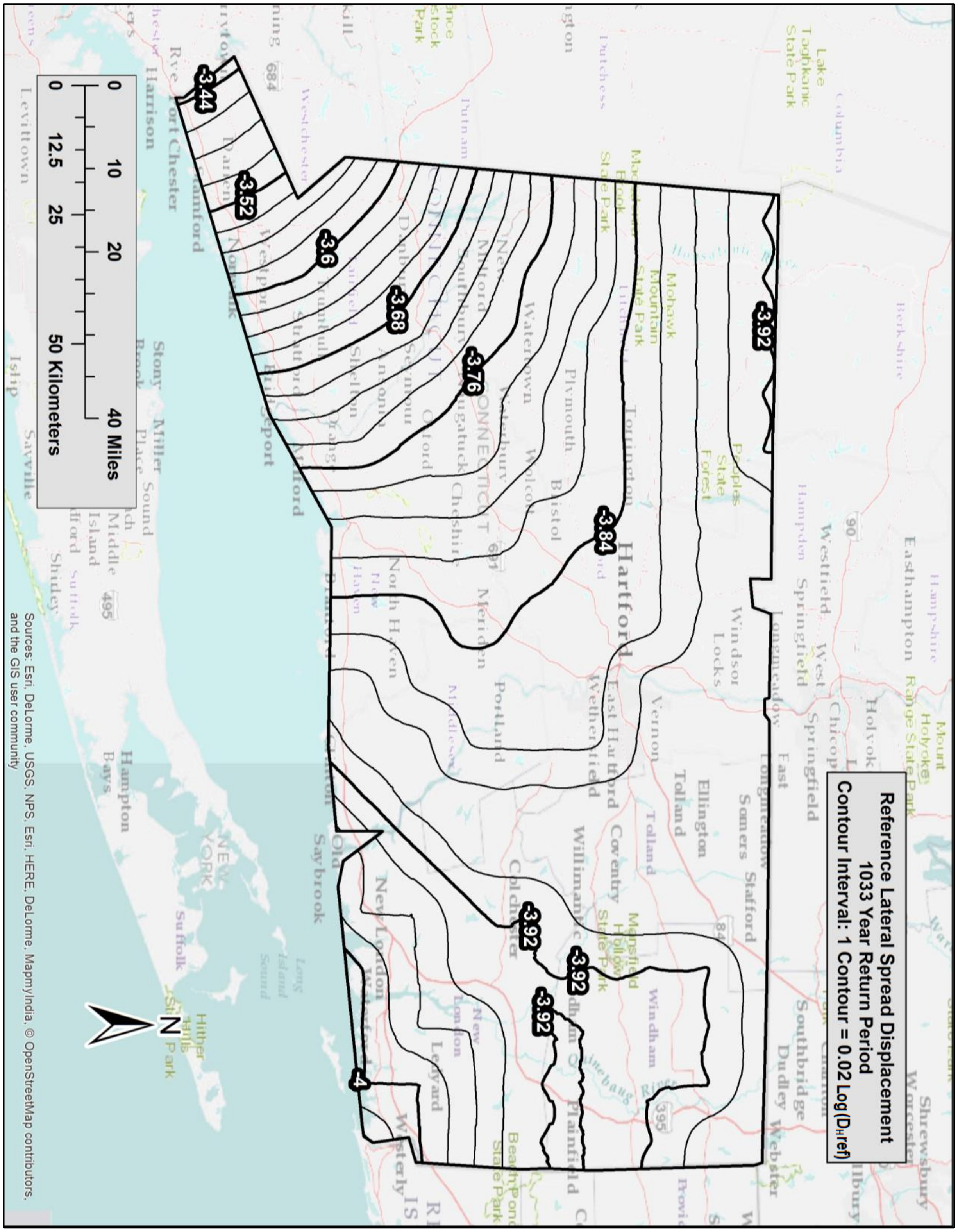


Figure C- 3 Log D_H^{ref} for Alaska (T_R = 2475 years)



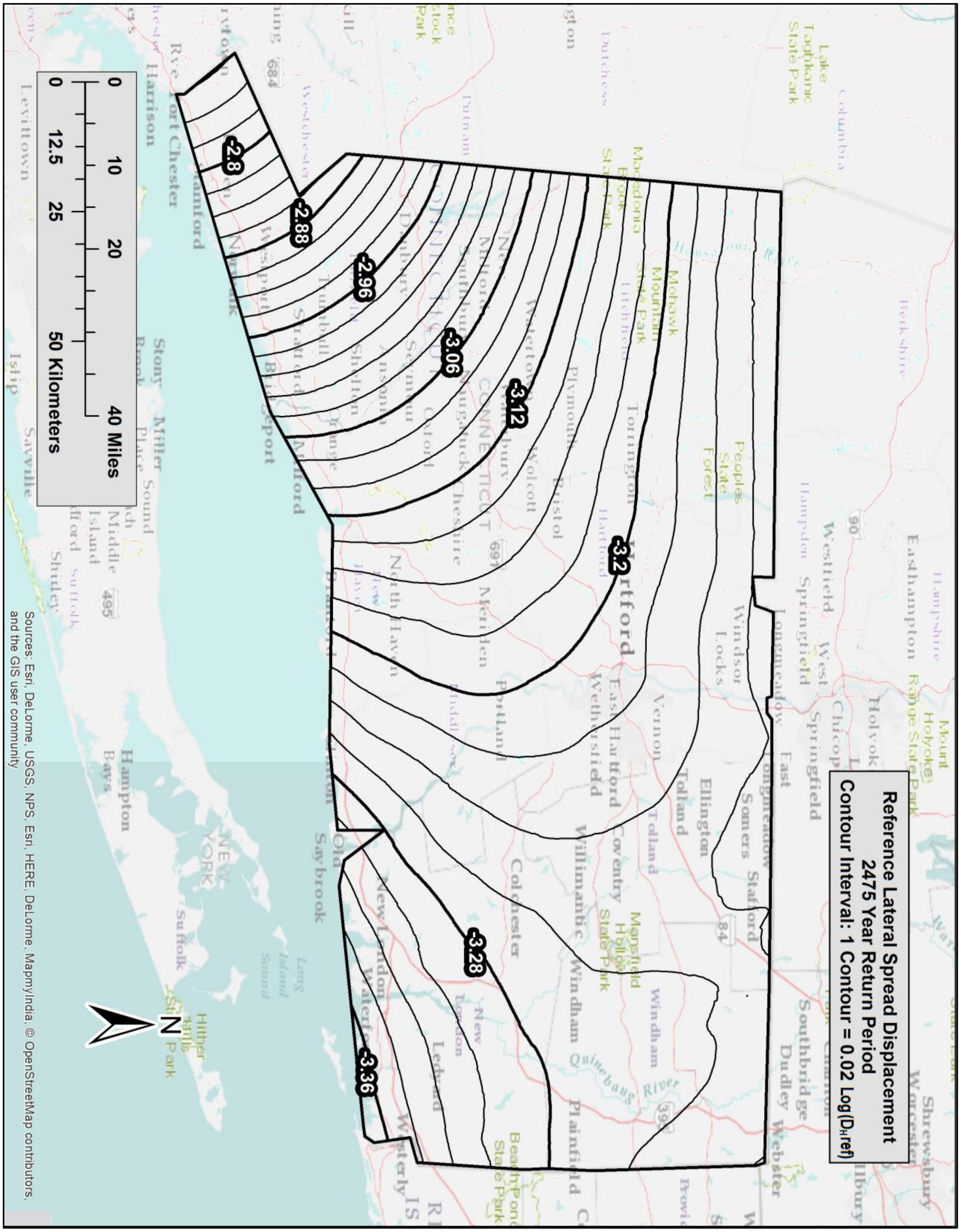
Sources: Esri, DeLorme, USGS, NPS, Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community

Figure C- 4 Log D_H^{ref} for Connecticut (T_R = 475 years)



Sources: Esri, DeLorme, USGS, NPS, Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community

Figure C- 5 Log D_H^{ref} for Connecticut (T_R = 1033 years)



Sources: Esri, DeLorme, USGS, NPS, Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community

Figure C- 6 Log D_H^{ref} for Connecticut (T_R = 2475 years)

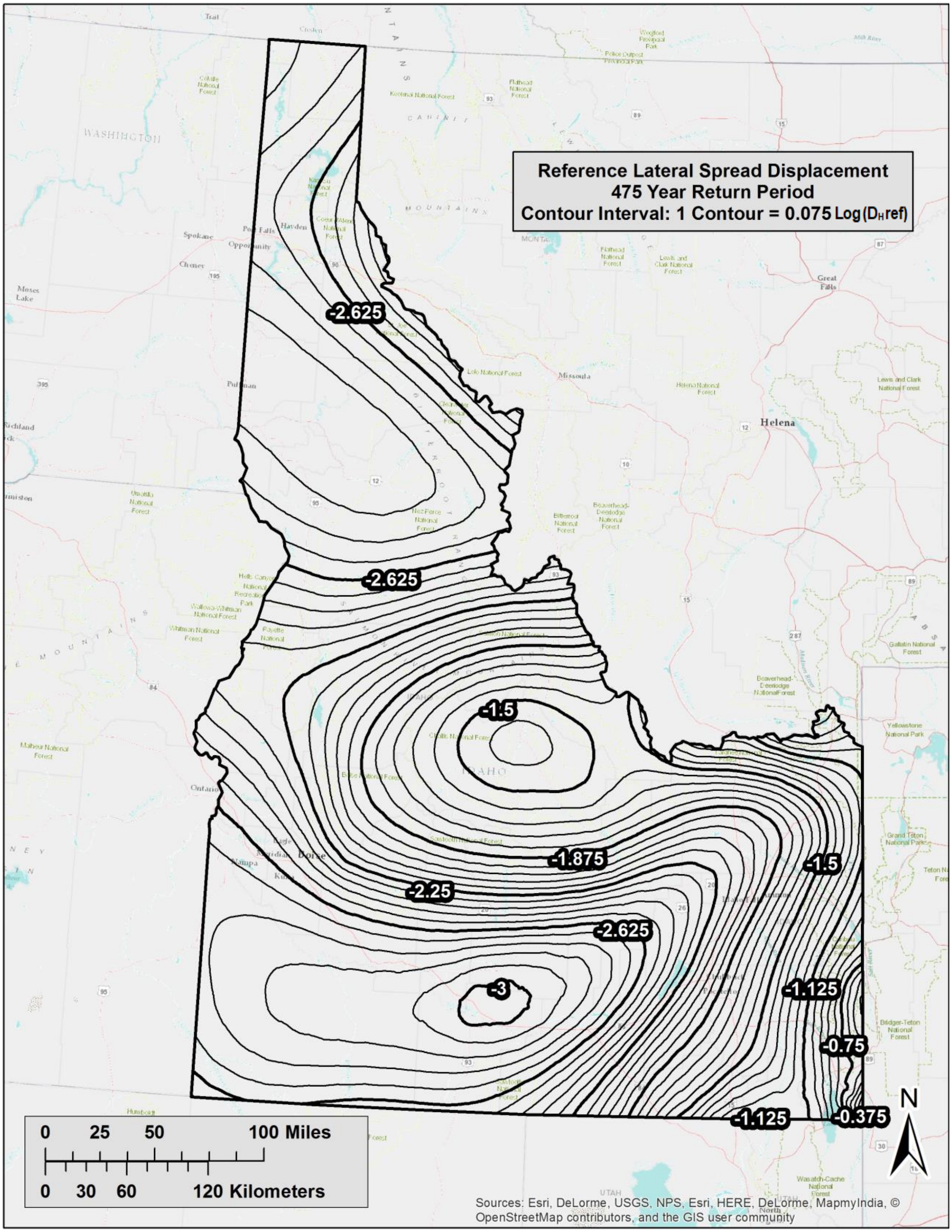


Figure C- 7 Log D_H^{ref} for Idaho (T_R = 475 years)

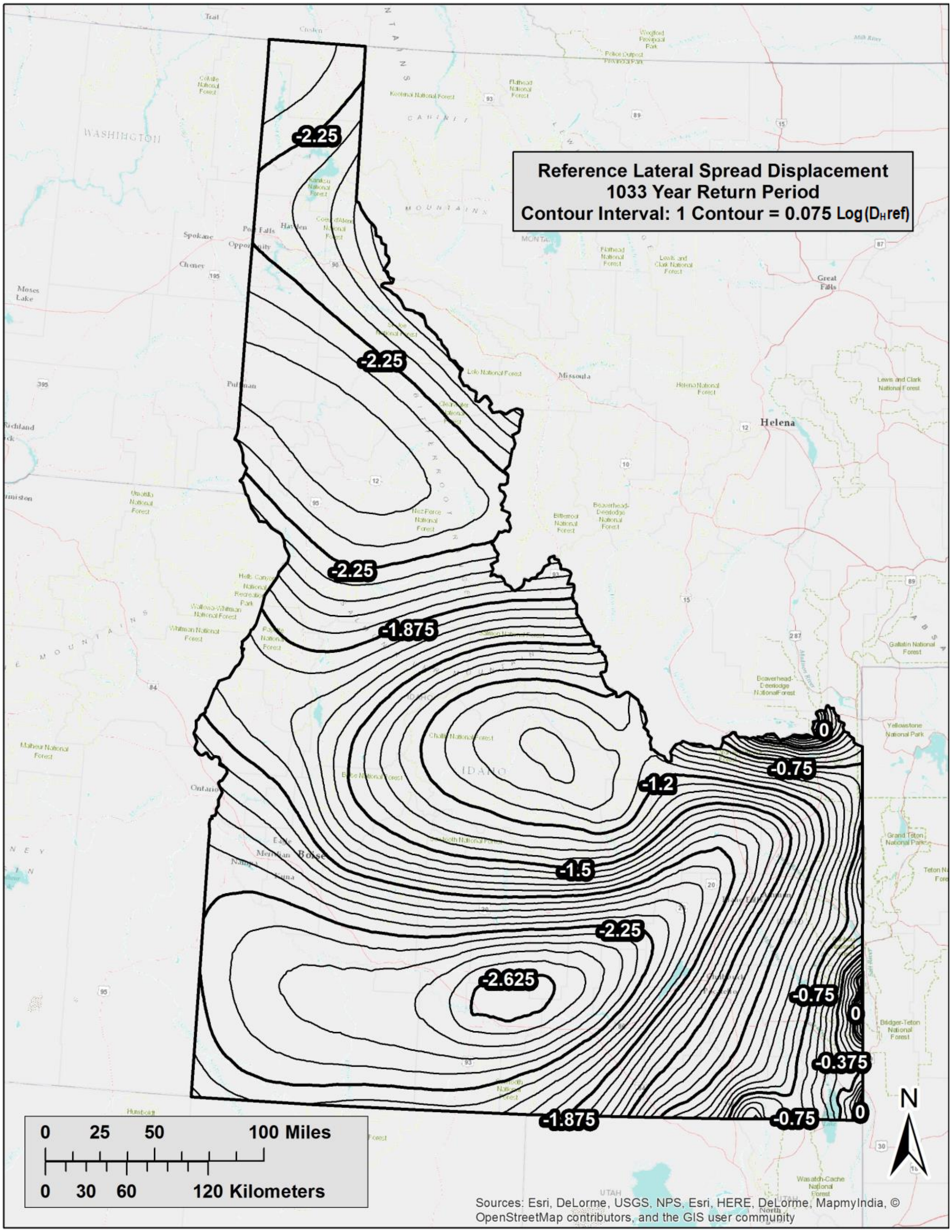


Figure C- 8 Log D_H^{ref} for Idaho (T_R = 1033 years)

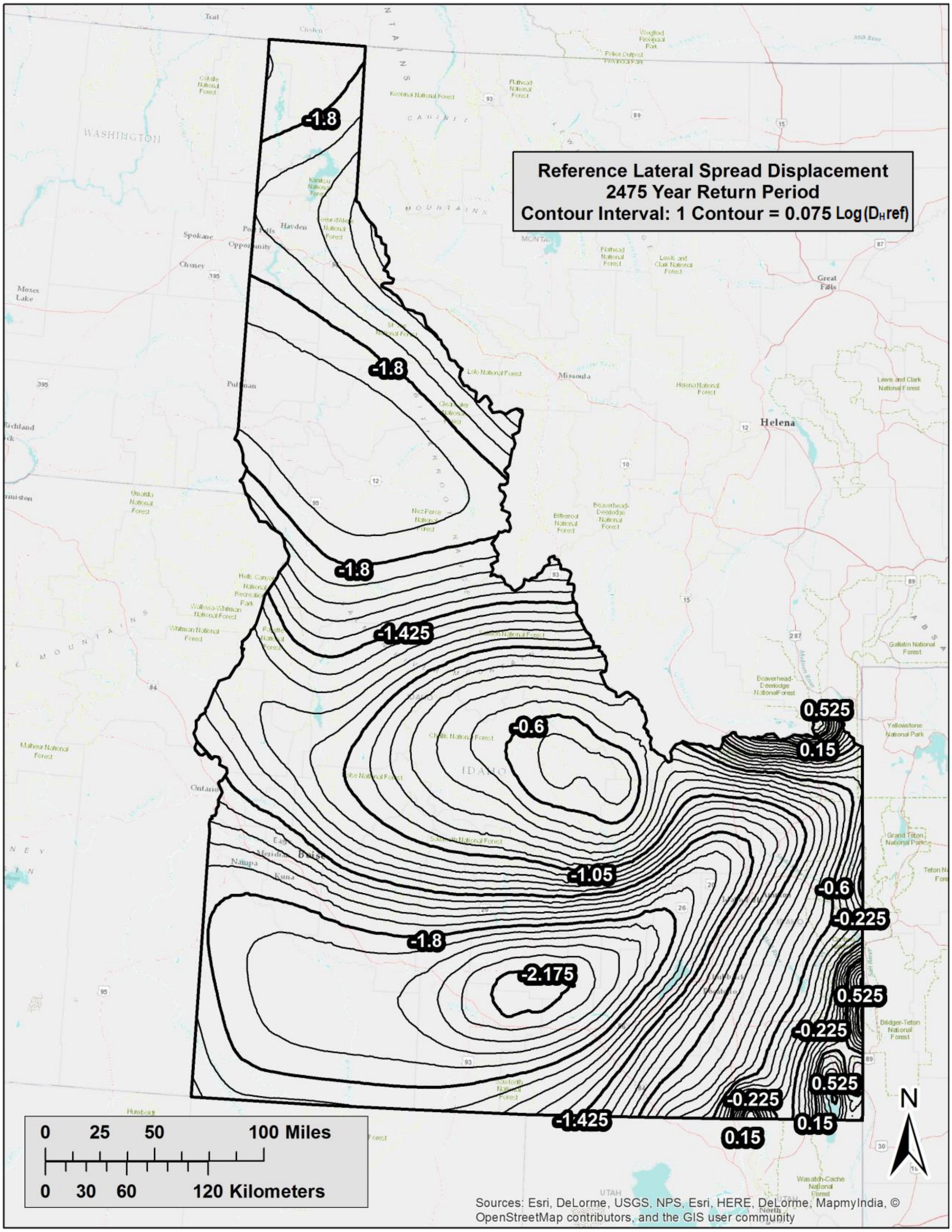


Figure C- 9 Log D_H^{ref} for Idaho (T_R = 2475 years)

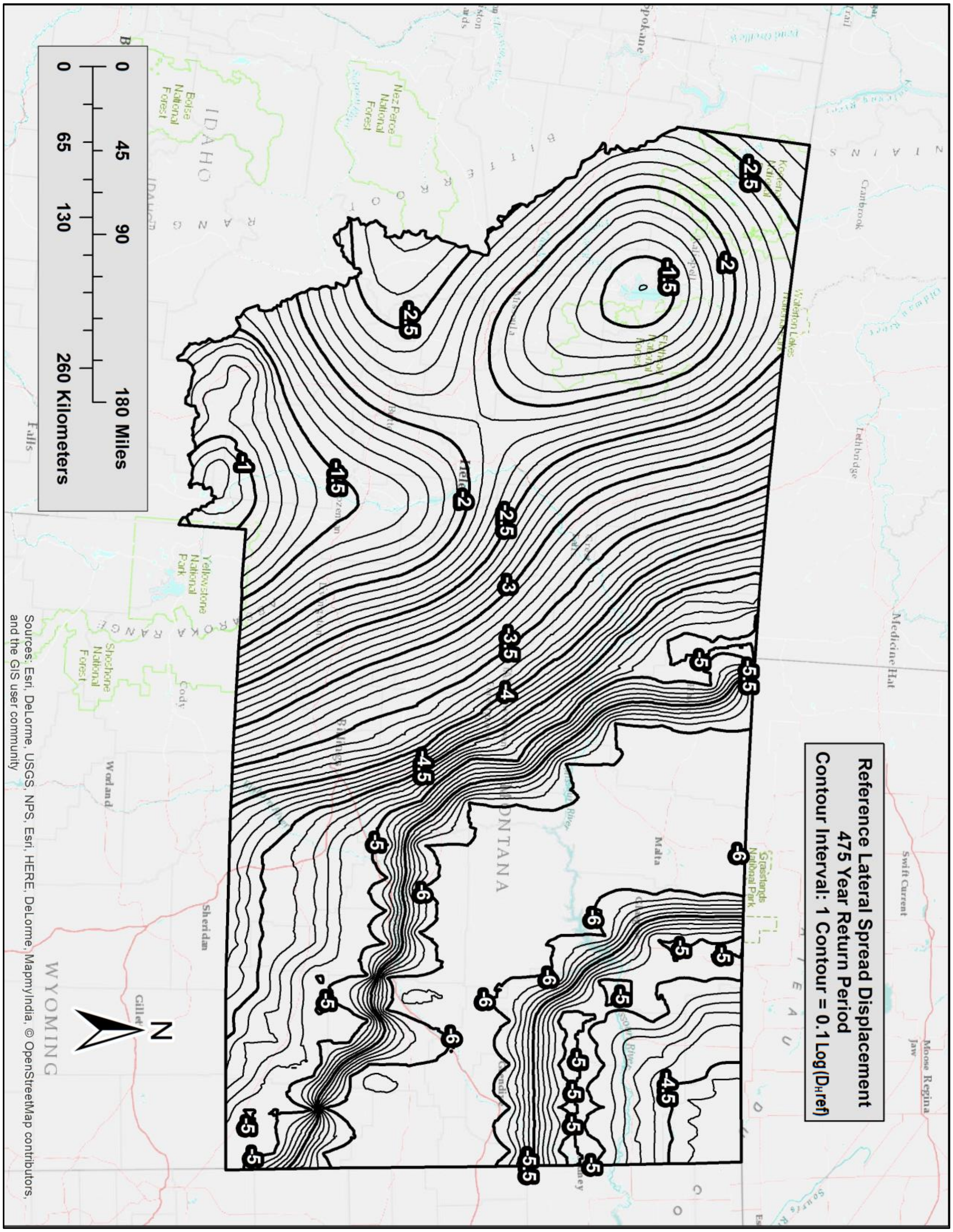


Figure C- 10 Log D_H^{ref} for Montana (T_R = 475 years)

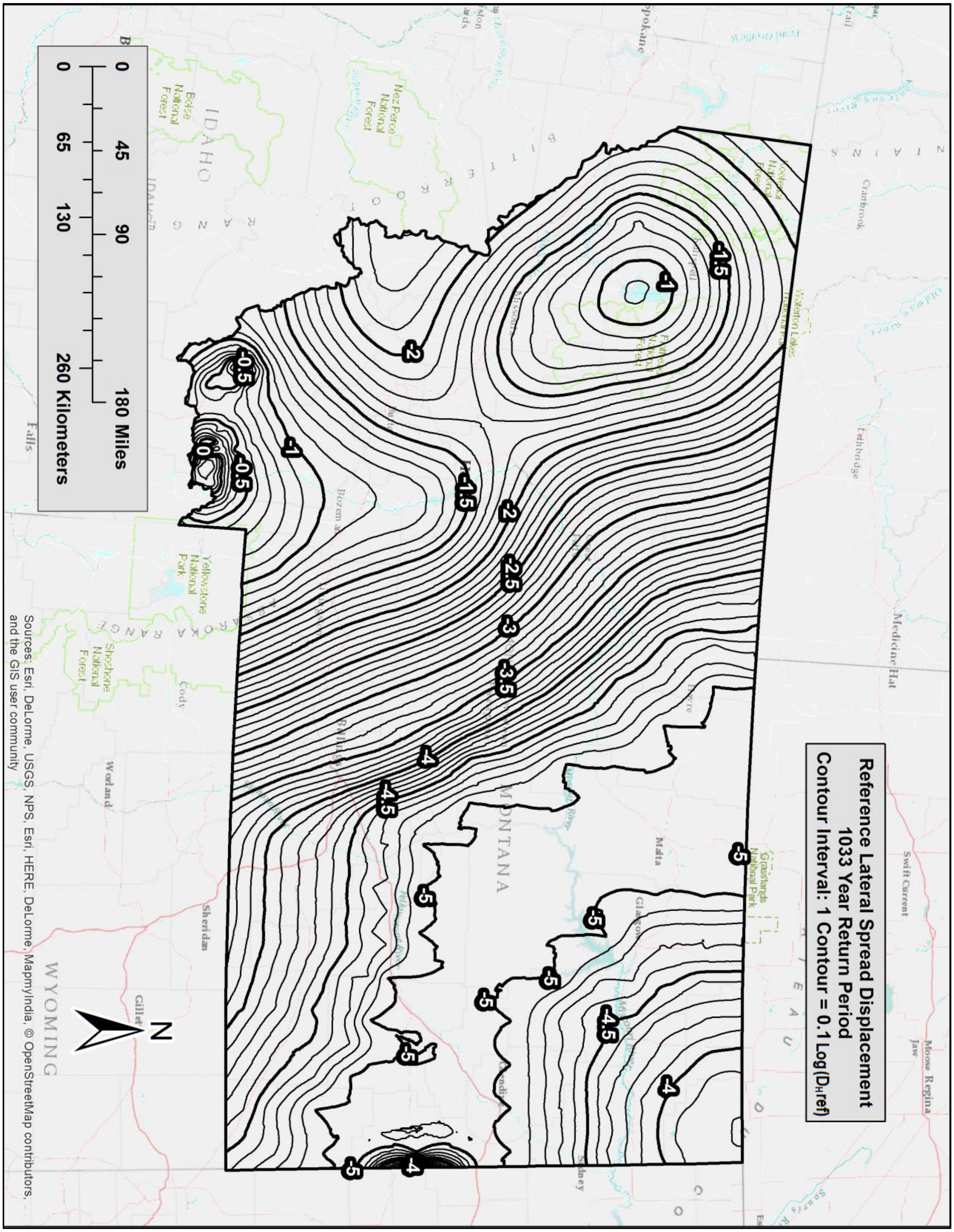


Figure C- 11 Log D_H^{ref} for Montana (T_R = 1033 years)

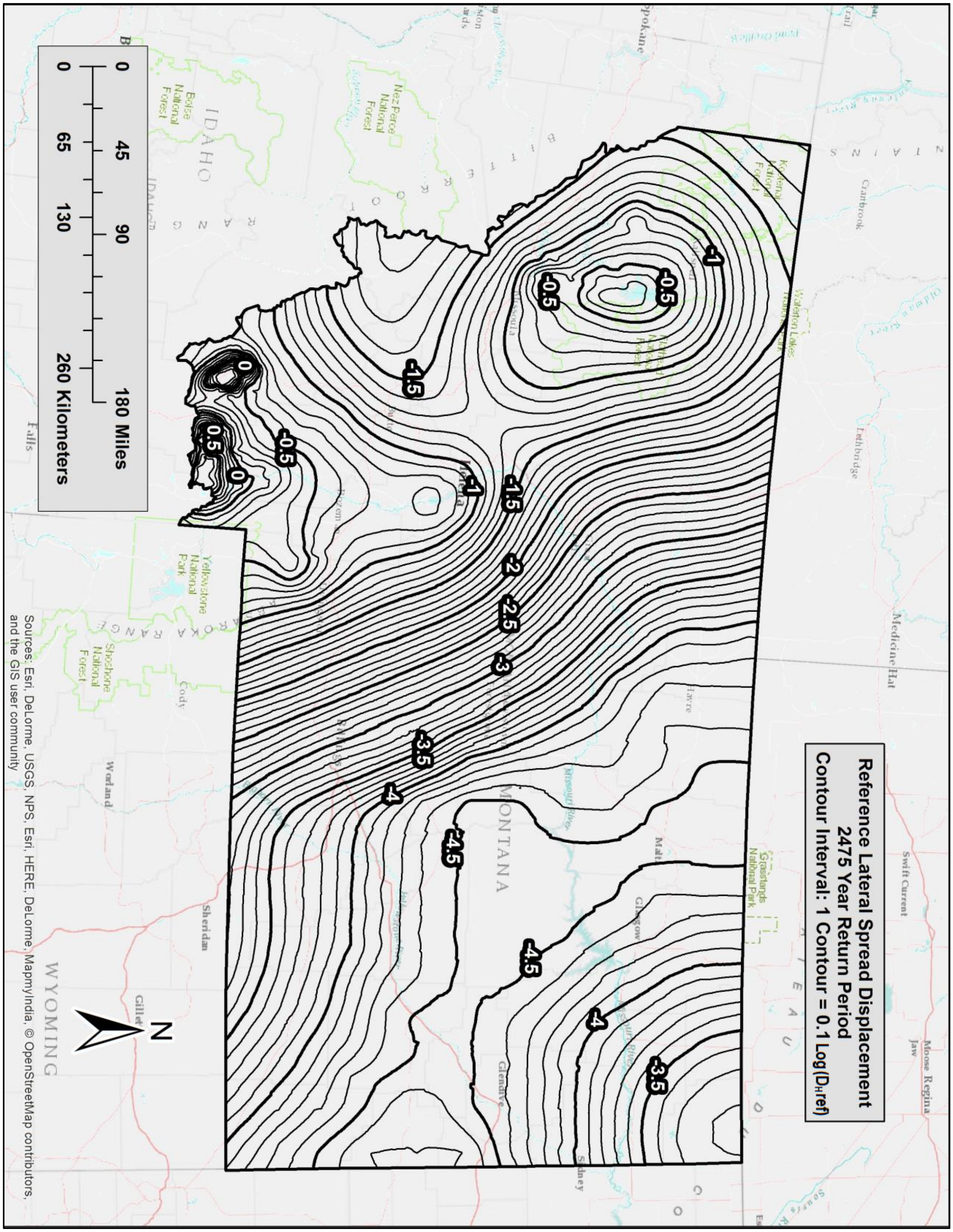
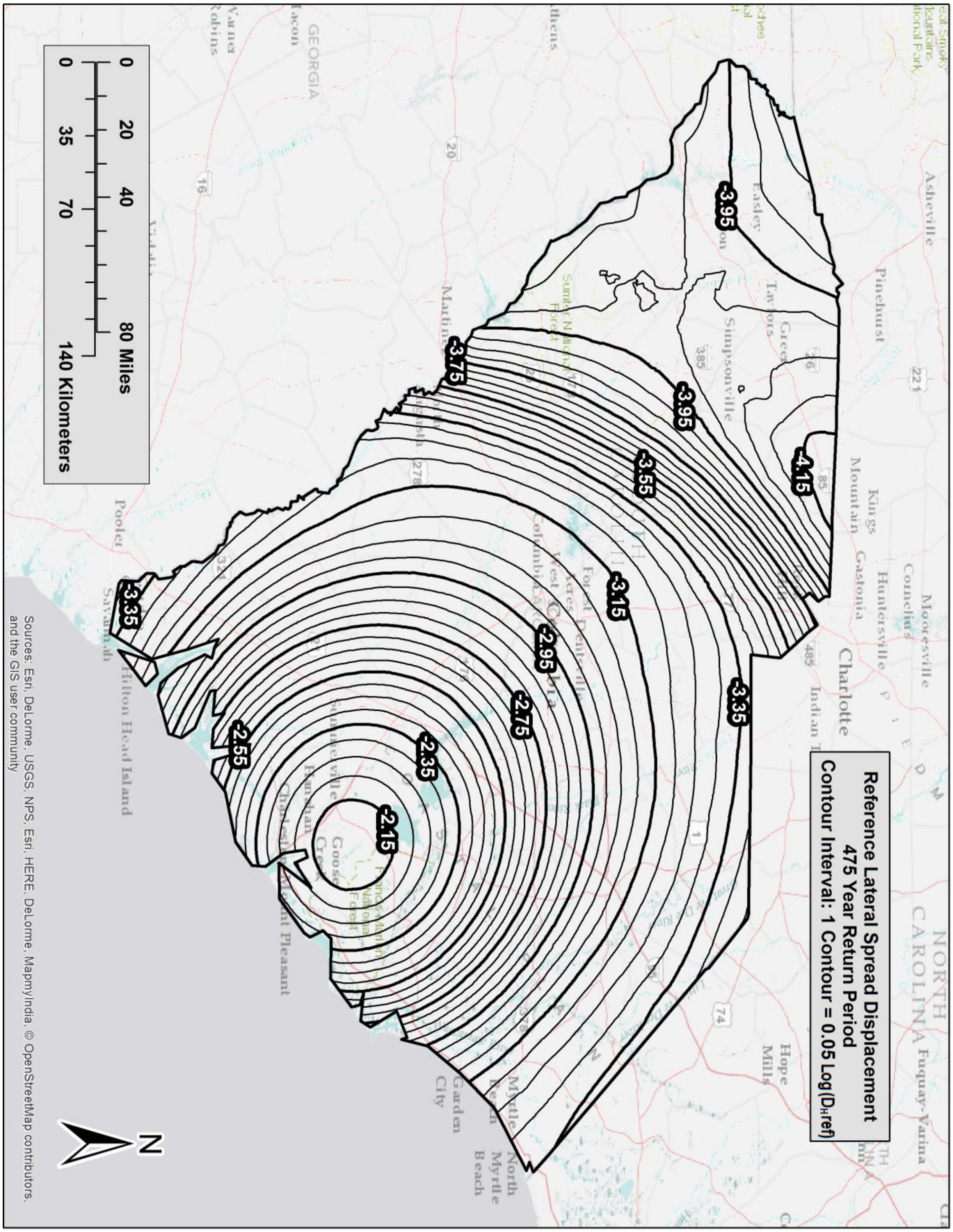
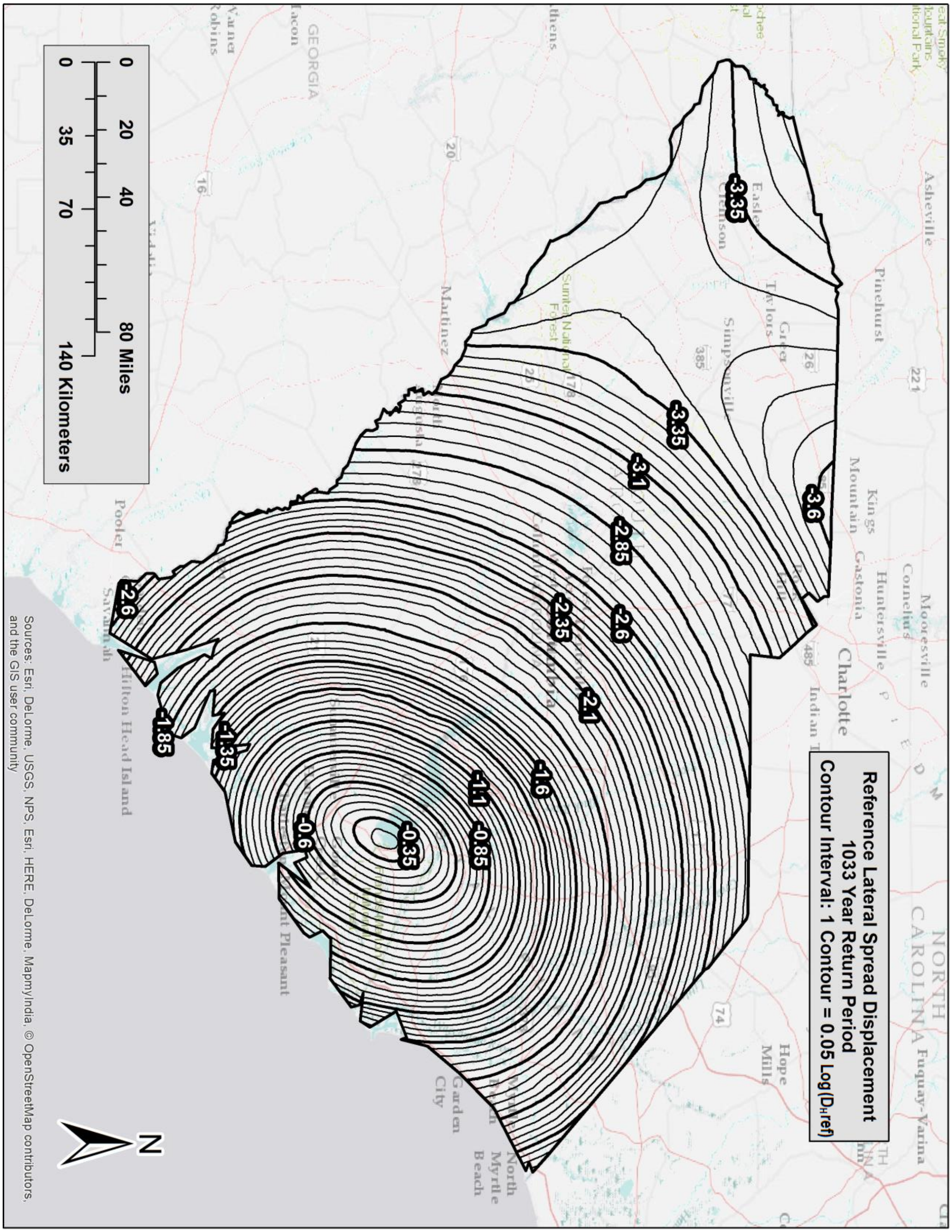


Figure C- 12 Log D_H^{ref} for Montana (T_R = 2475 years)



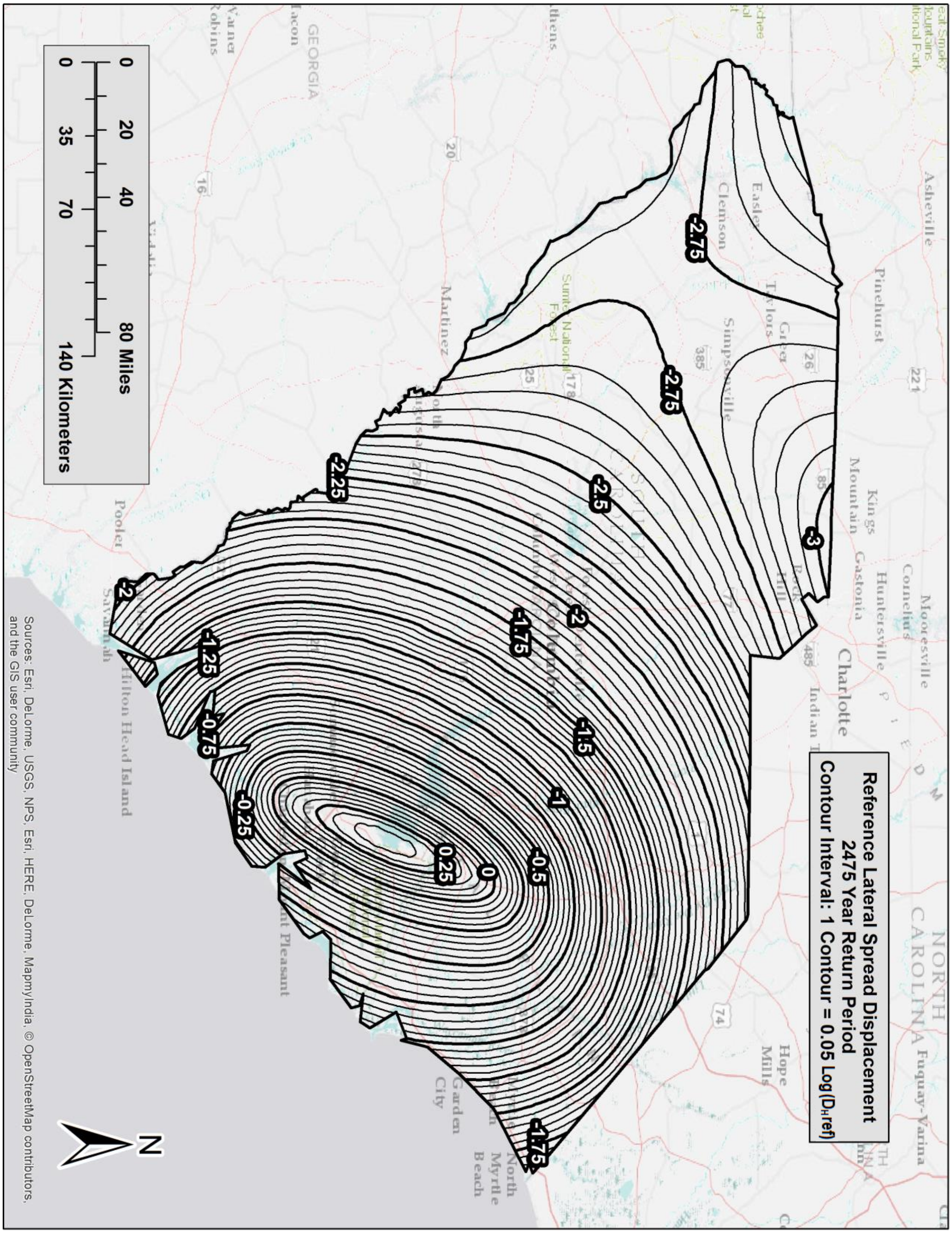
Sources: Esri, DeLorme, USGS, NPS, Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community

Figure C- 13 Log D_H^{ref} for South Carolina (T_R = 475 years)



Sources: Esri, DeLorme, USGS, NPS, Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community

Figure C- 14 Log D_H^{ref} for South Carolina (T_R = 1033 years)



Sources: Esri, DeLorme, USGS, NPS, Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community

Figure C- 15 Log D_H^{ref} for South Carolina (T_R = 2475 years)

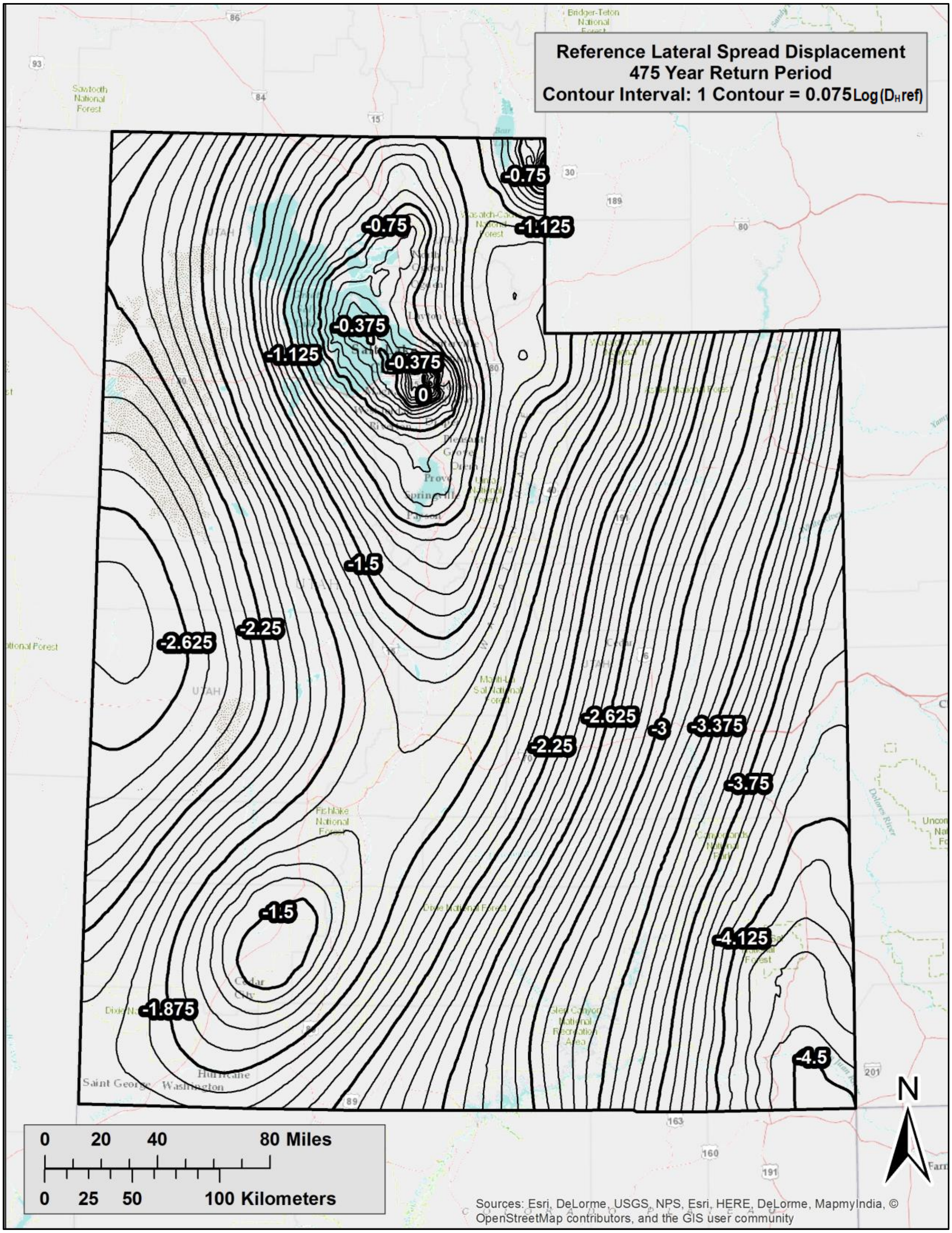
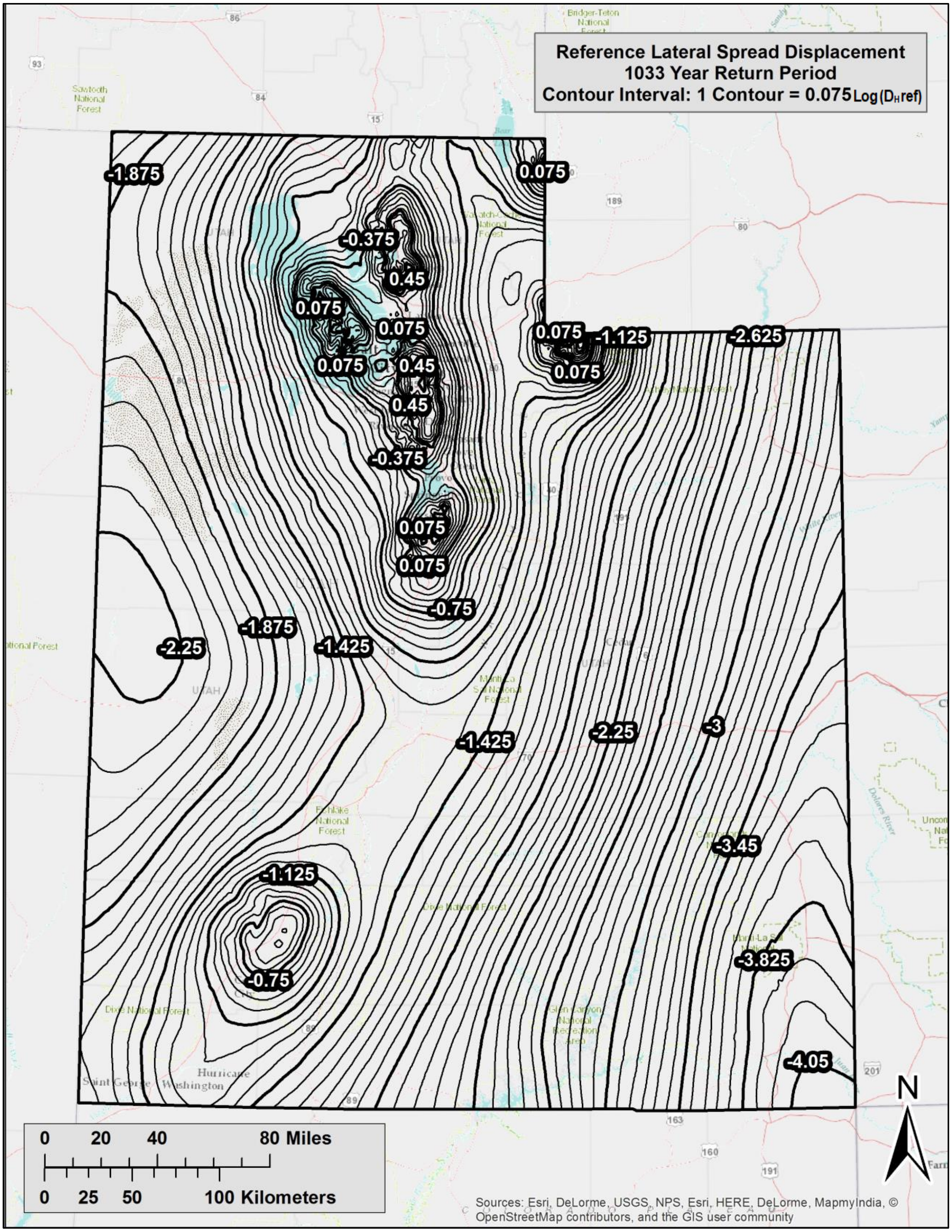
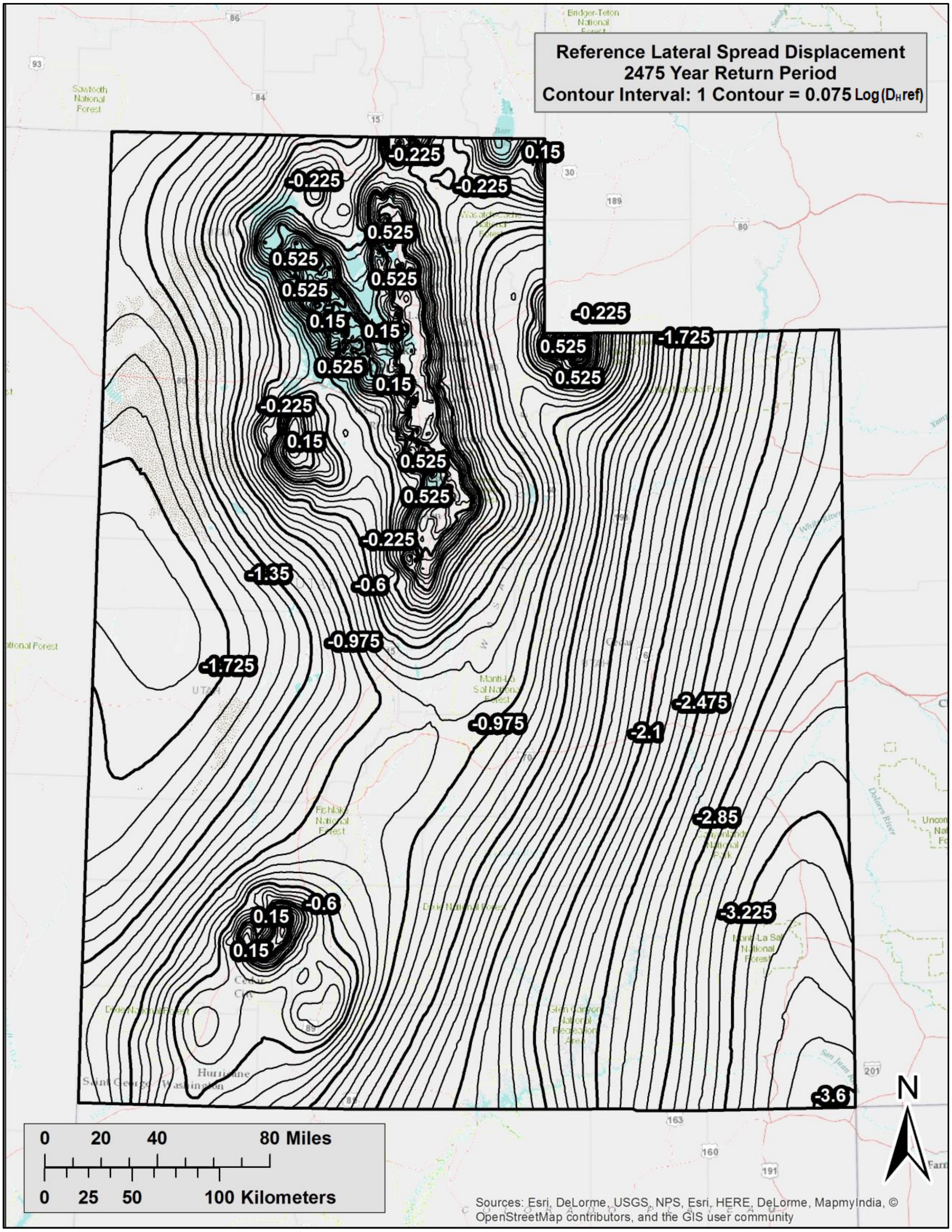


Figure C- 16 Log D_H^{ref} for Utah (T_R = 475 years)



Sources: Esri, DeLorme, USGS, NPS, Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community

Figure C- 17 Log D_H^{ref} for Utah (T_R = 1033 years)



Sources: Esri, DeLorme, USGS, NPS, Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community

Figure C- 18 Log D_H^{ref} for Utah (T_R = 2475 years)

APPENDIX D: Sample Post-Liquefaction Settlement Maps

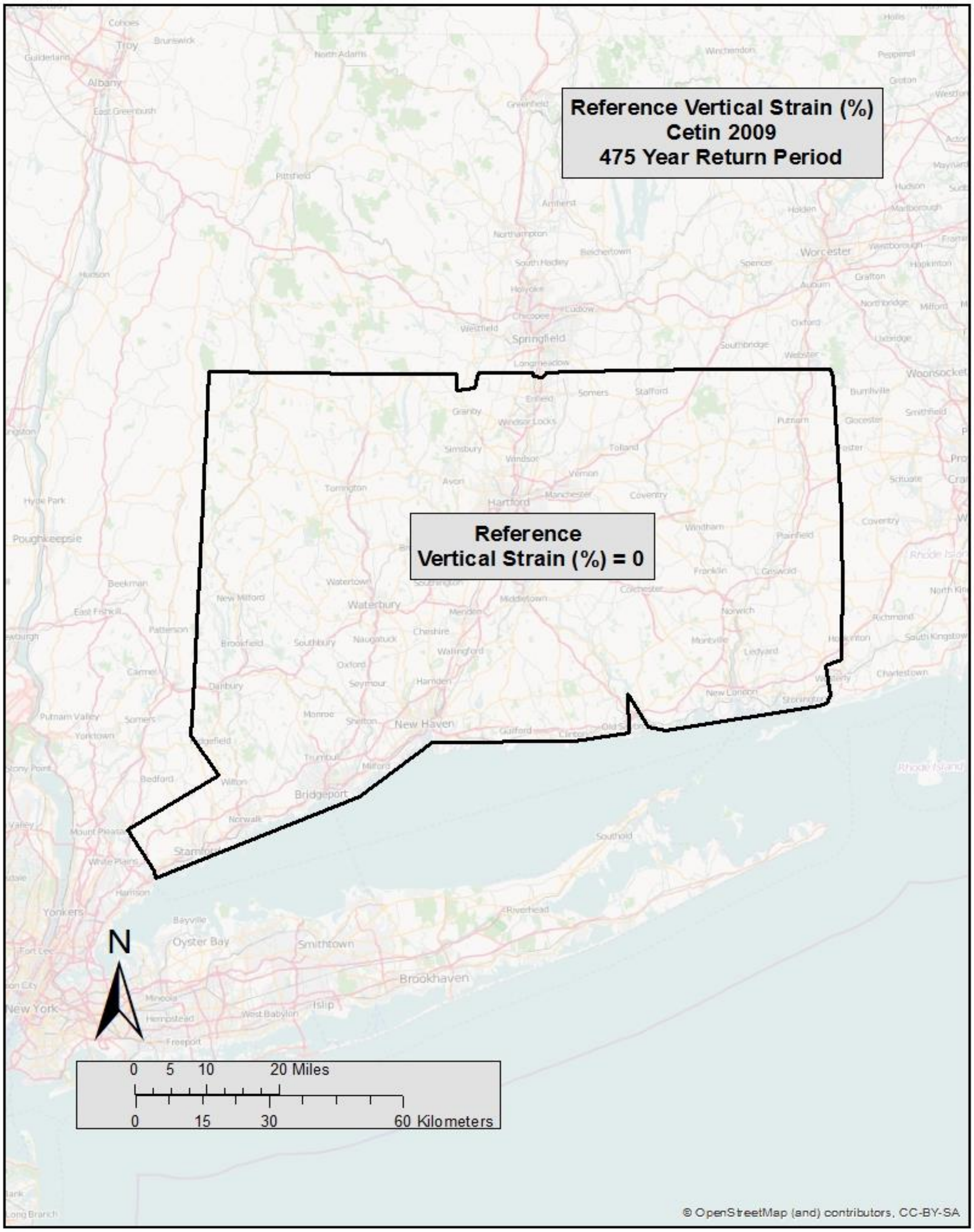


Figure D- 1 Cetin et al. (2009) Post-Liquefaction Settlement (ε^{ref}) Map for Connecticut (Tr=475)

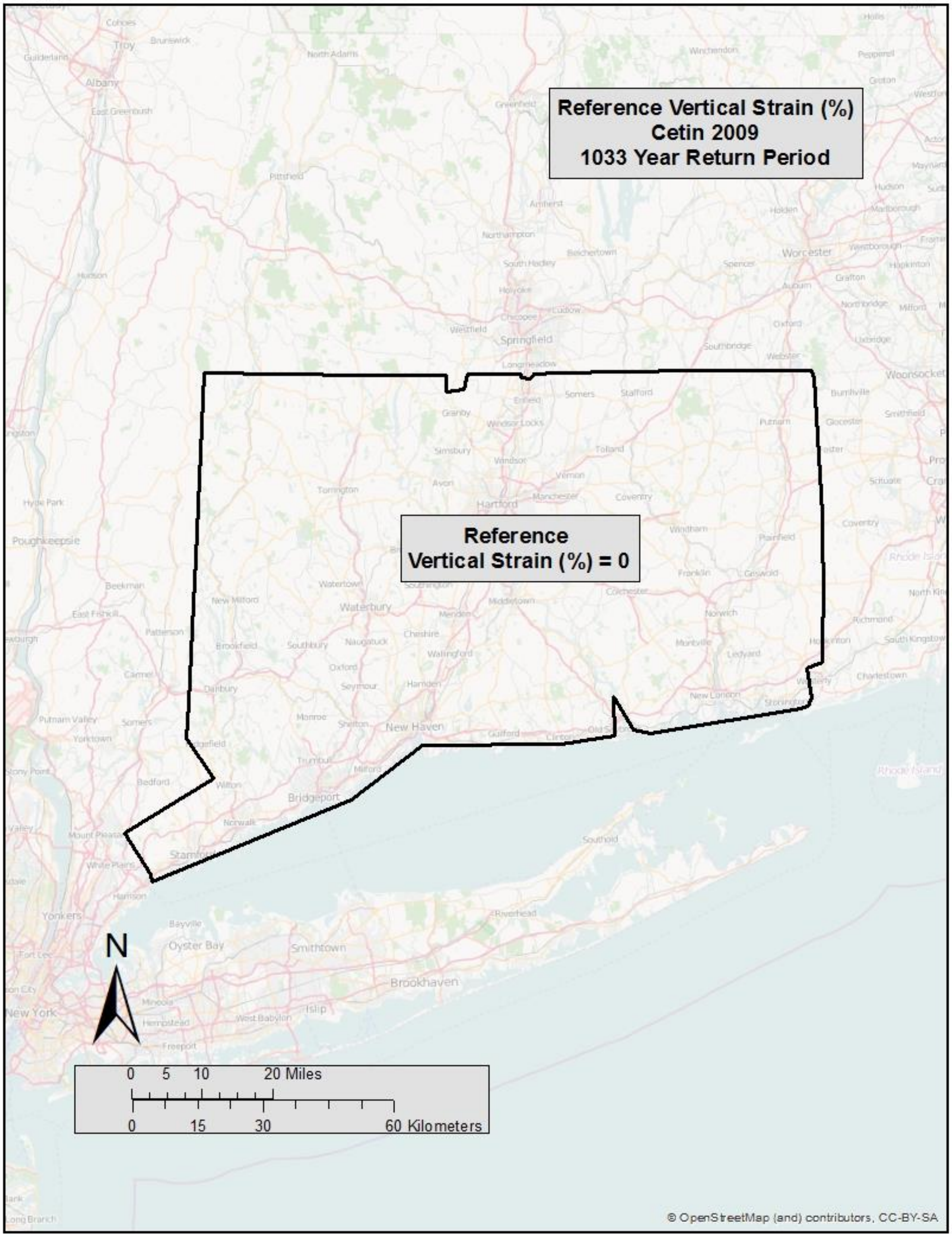


Figure D- 2 Cetin et al. (2009) Post-Liquefaction Settlement (ε^{ref}) Map for Connecticut (Tr= 1,033)

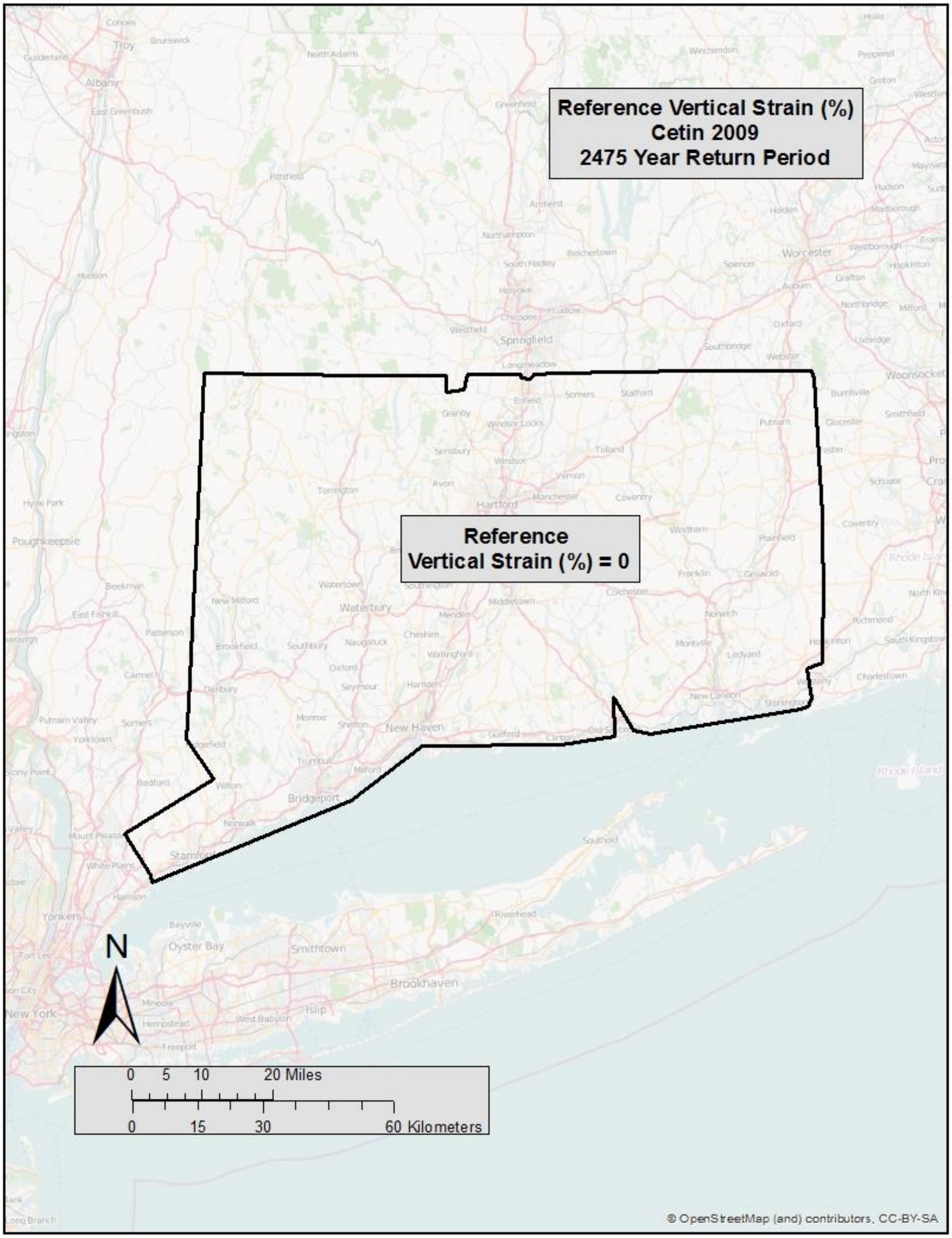


Figure D- 3 Cetin et al. (2009) Post-Liquefaction Settlement (ε^{ref}) Map for Connecticut (Tr=2,475)

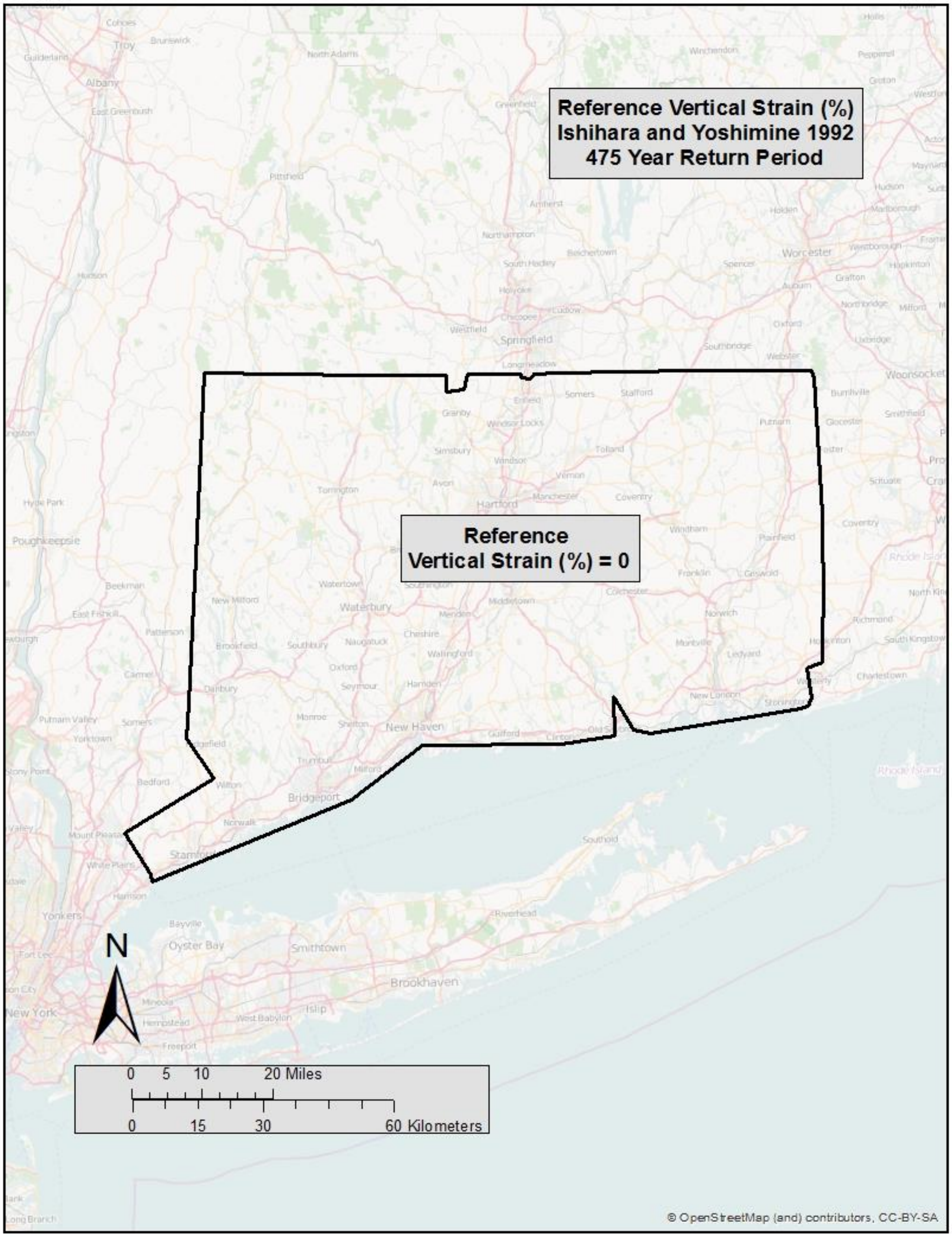


Figure D- 4 Ishihara and Yoshimine (1992) Post-Liquefaction Settlement (ε^{ref}) Map for Connecticut (Tr = 475)

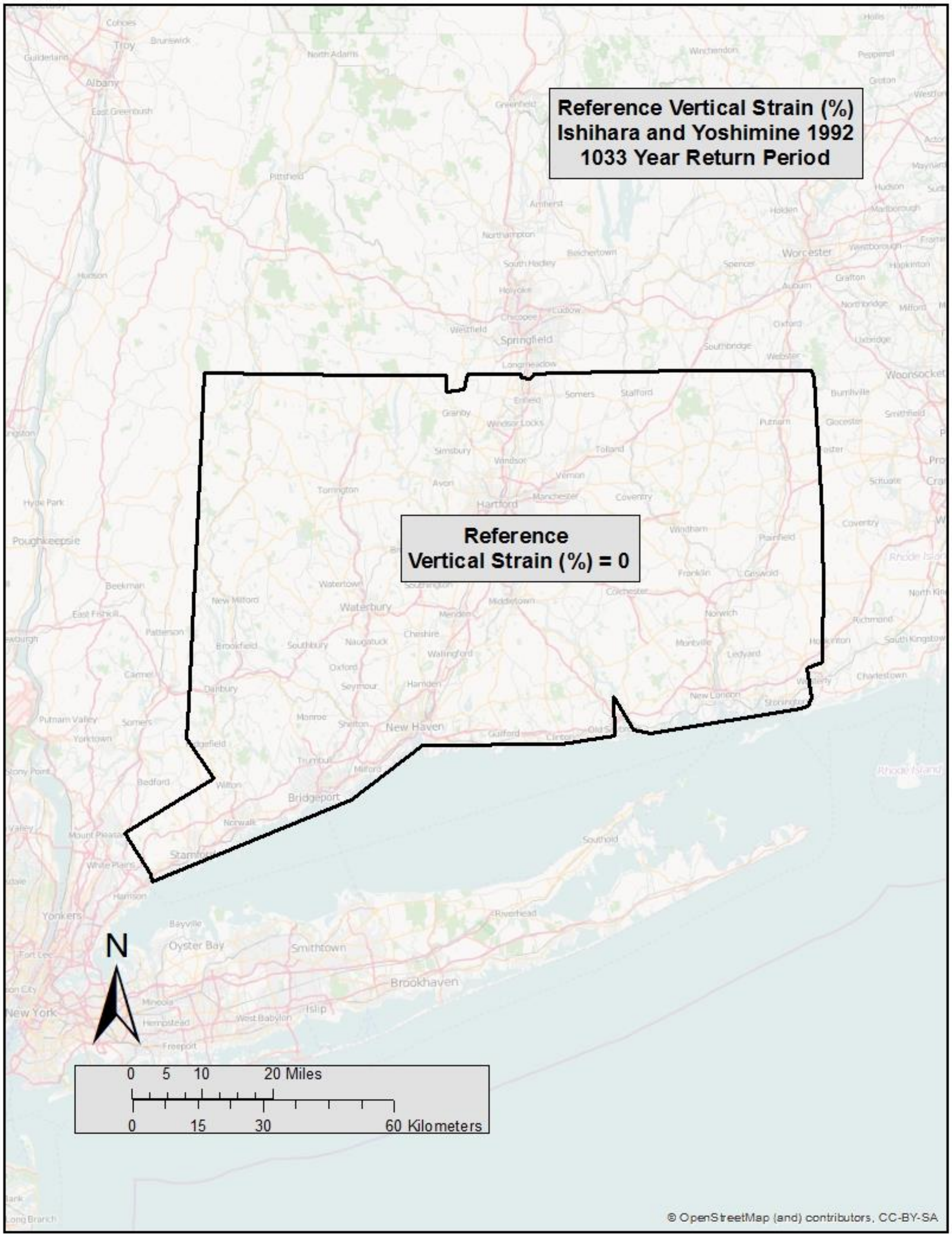


Figure D- 5 Ishihara and Yoshimine (1992) Post-Liquefaction Settlement *(ε^{ref})* Map for Connecticut (Tr = 1,033)

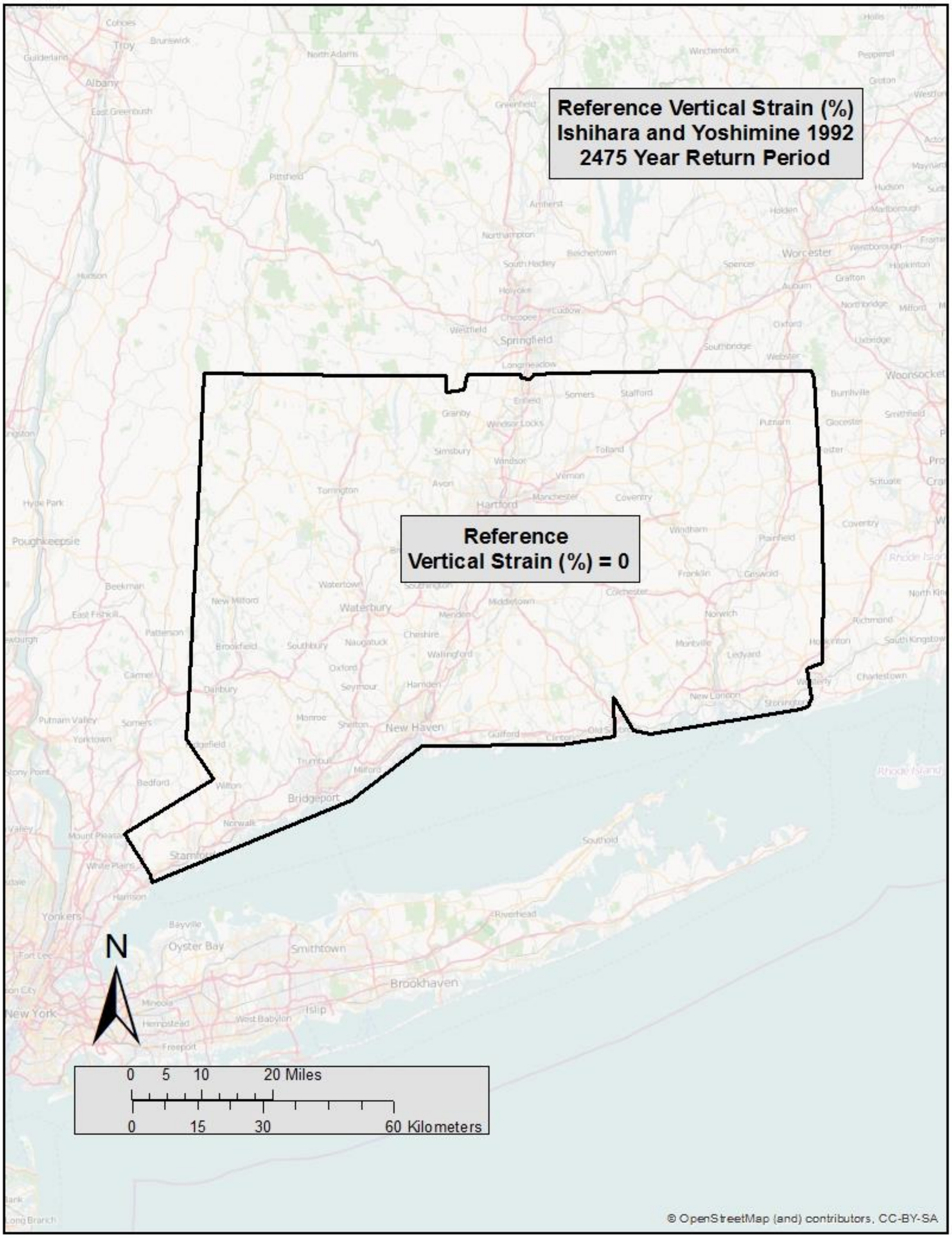


Figure D- 6 Ishihara and Yoshimine (1992) Post-Liquefaction Settlement (ε^{ref}) Map for Connecticut (Tr = 2,475)

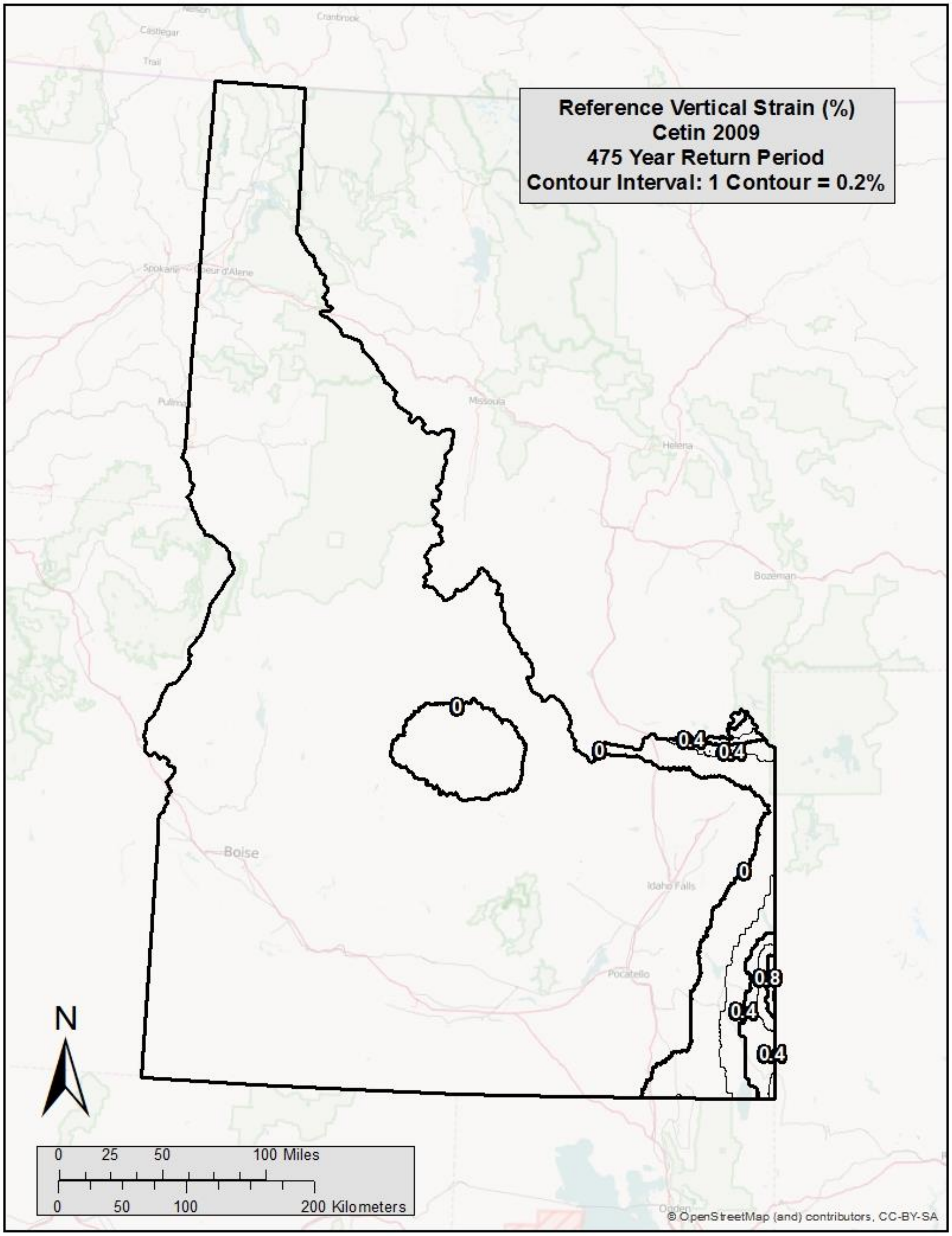


Figure D- 7 Cetin et al. (2009) Post-Liquefaction Settlement (ε^{ref}) Map for Idaho (Tr = 475)

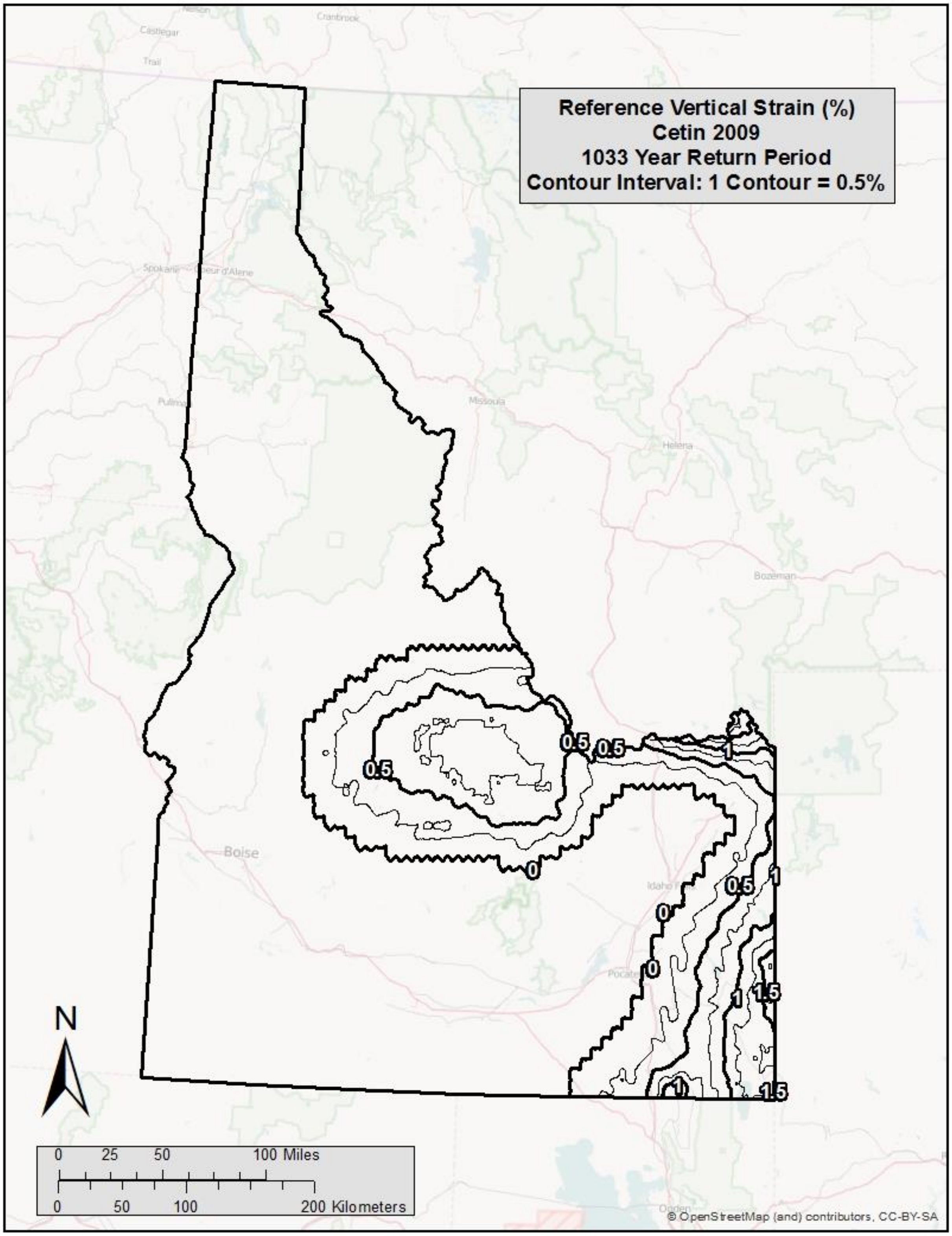


Figure D- 8 Cetin et al. (2009) Post-Liquefaction Settlement *(ε^{ref})* Map for Idaho (Tr=1,033)

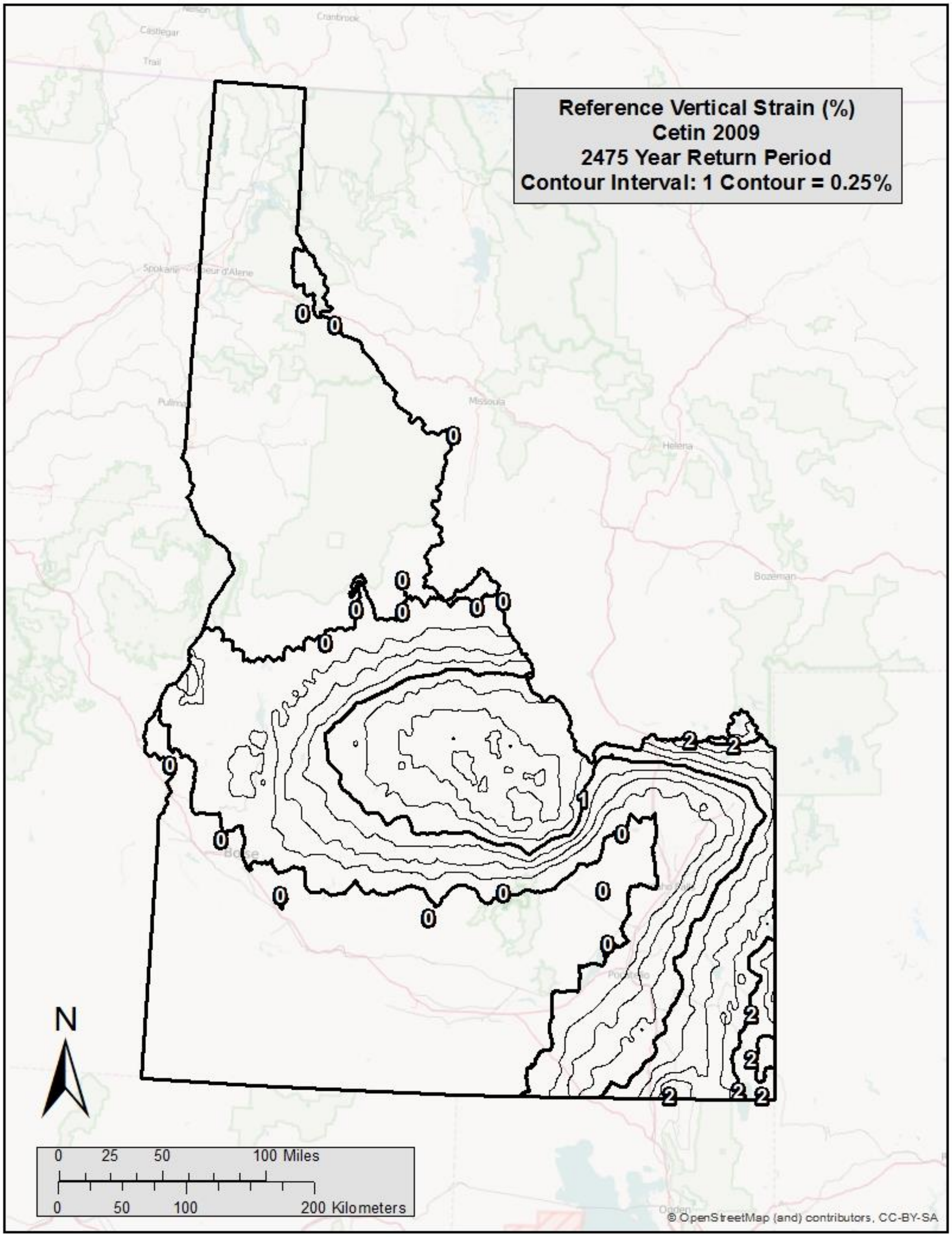


Figure D- 9 Cetin et al. (2009) Post-Liquefaction Settlement *(ε^{ref})* Map for Idaho (Tr=2,475)

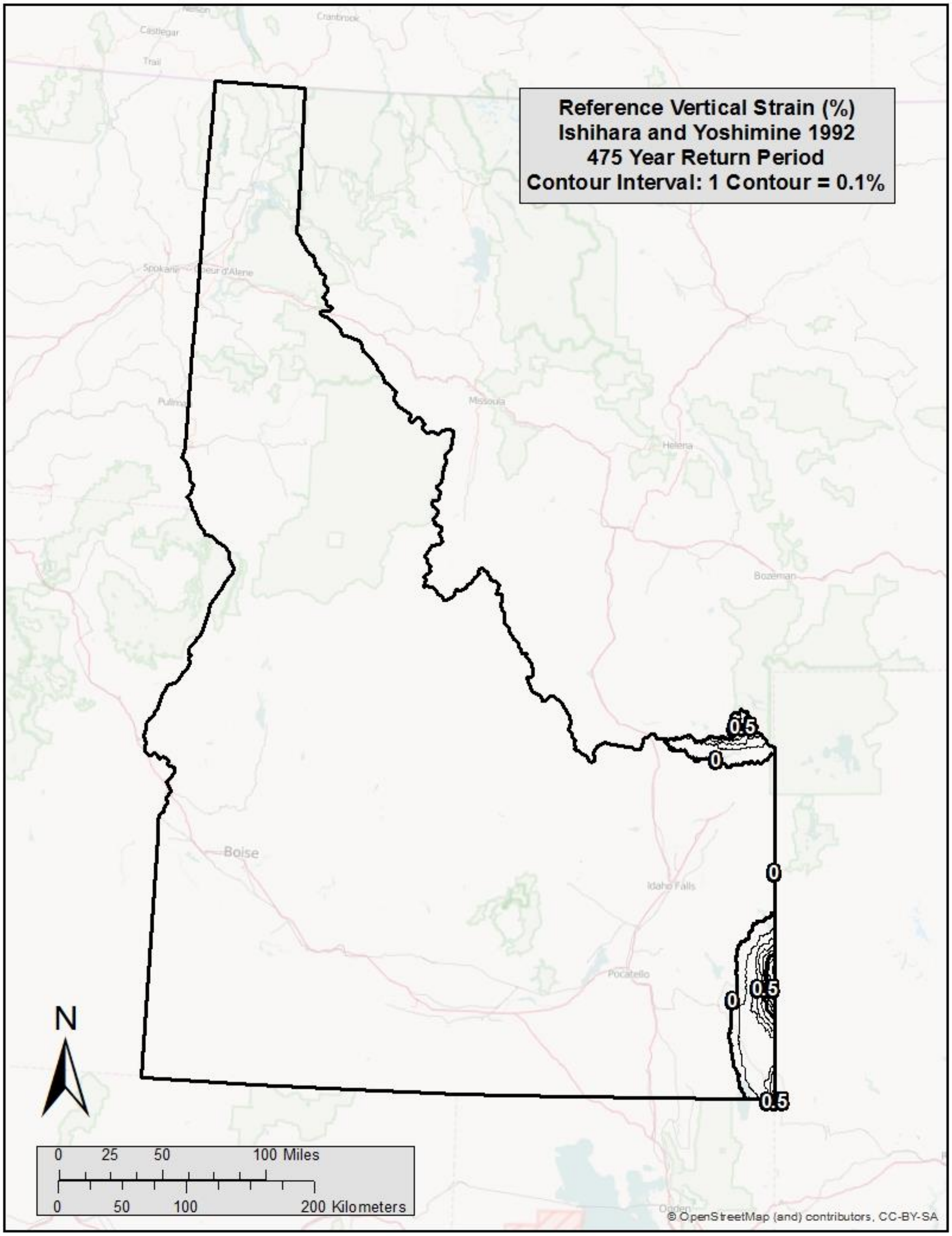


Figure D- 10 Ishihara and Yoshimine (1992) Post-Liquefaction Settlement (ε^{ref}) Map for Idaho (Tr = 475)

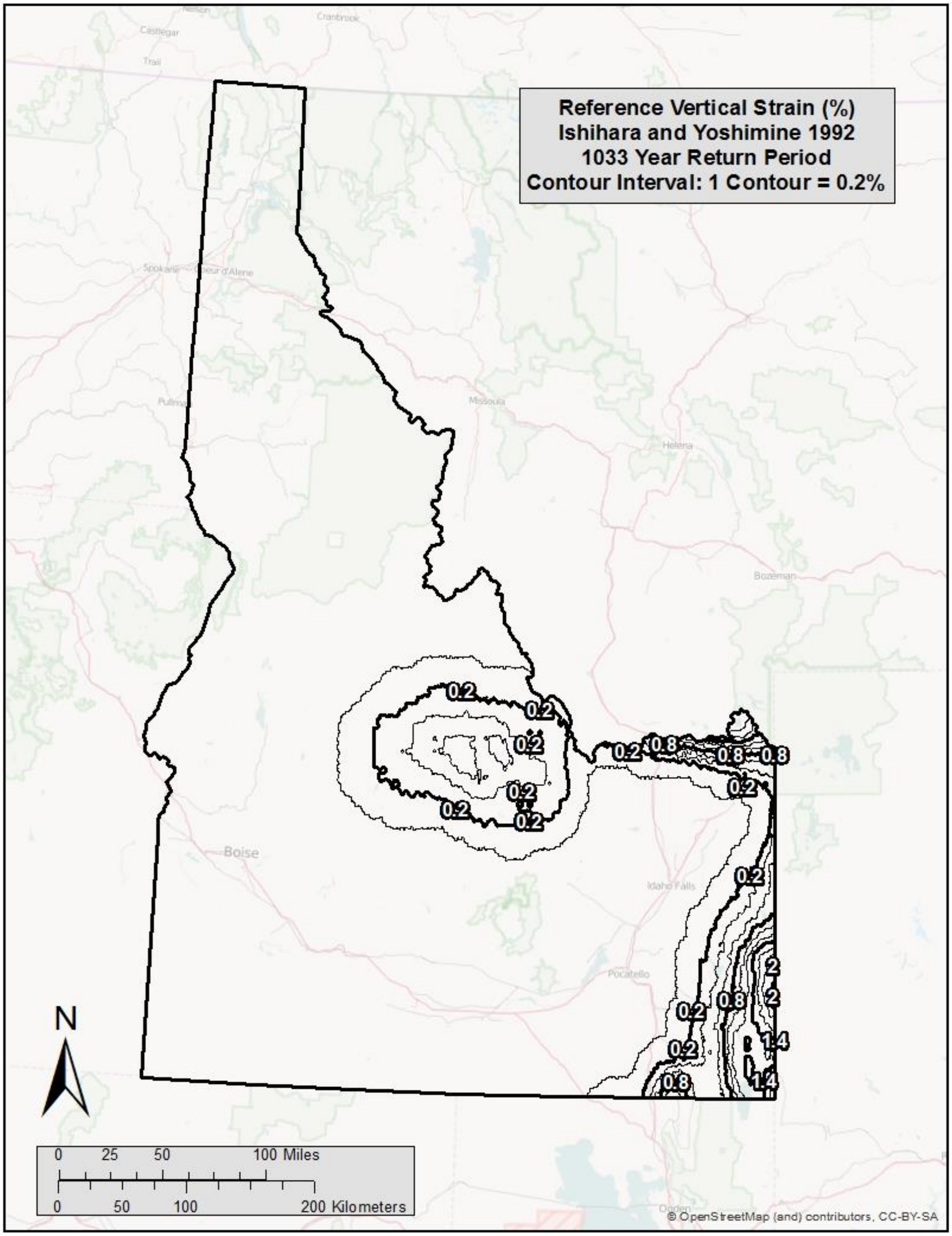


Figure D- 11 Ishihara and Yoshimine (1992) Post-Liquefaction Settlement *(ε^{ref})* Map for Idaho (Tr = 1,033)

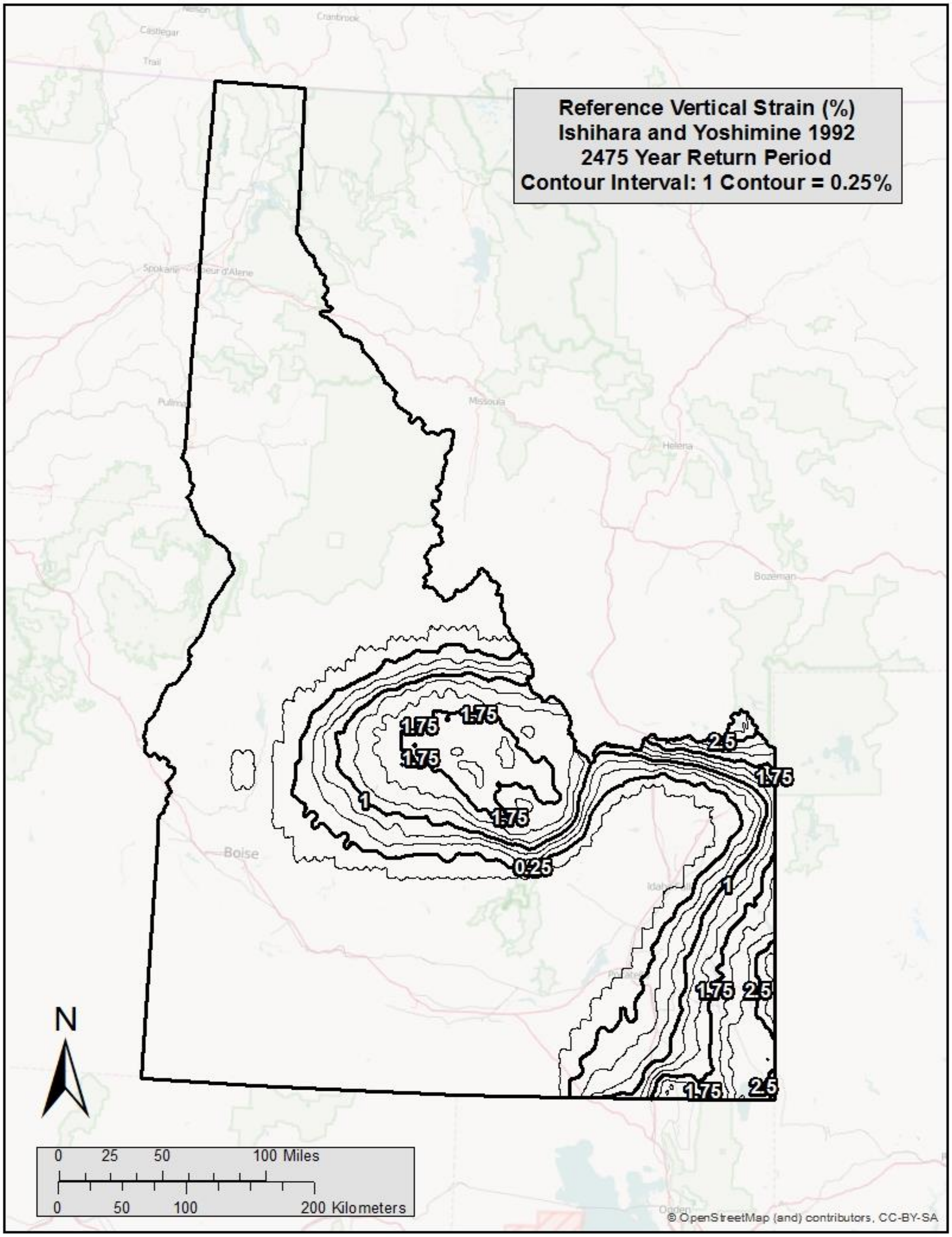


Figure D- 12 Ishihara and Yoshimine (1992) Post-Liquefaction Settlement *(ε^{ref})* Map for Idaho (Tr = 2,475)

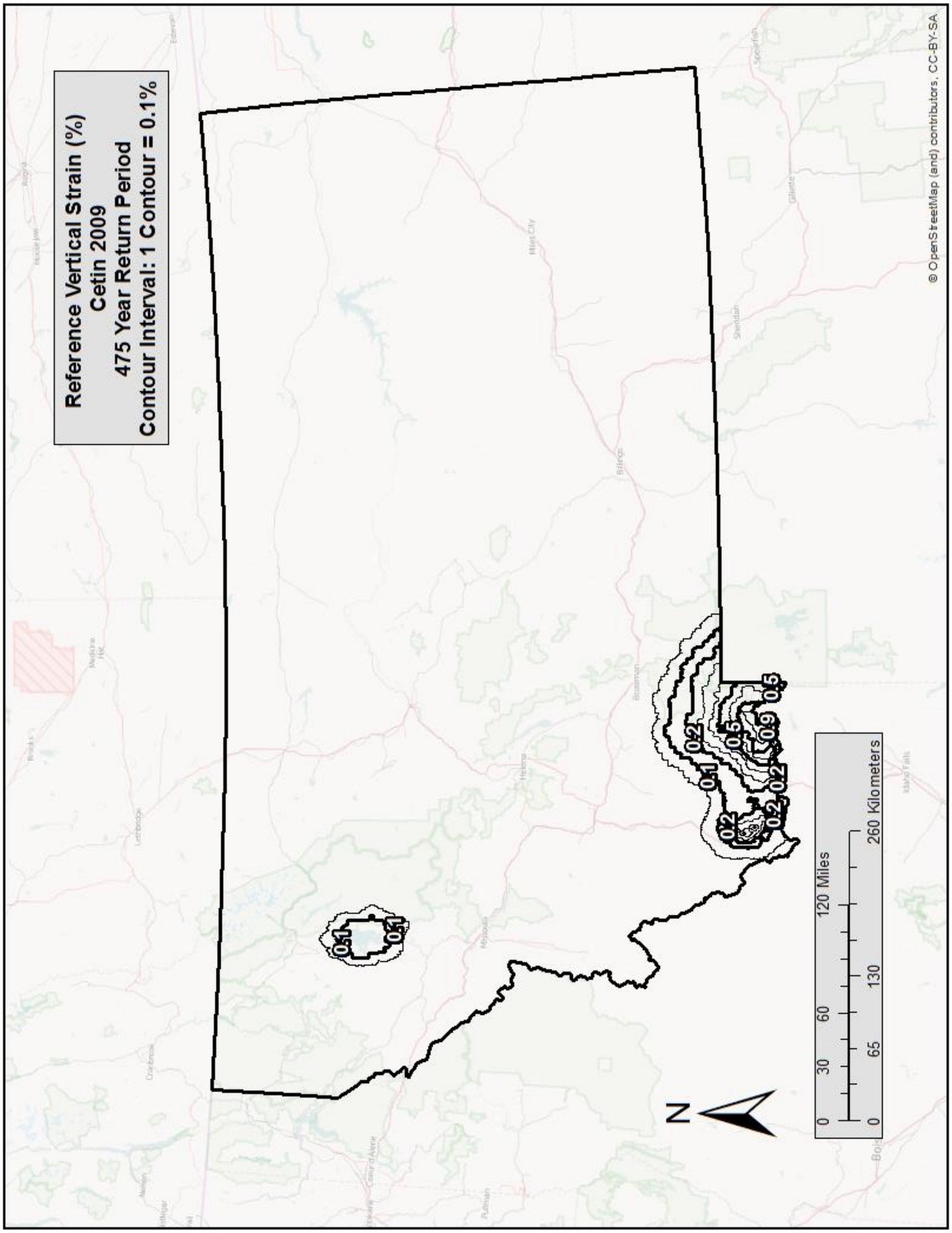


Figure D- 13 Cetin et al. (2009) Post-Liquefaction Settlement (ε^{ref}) Map for Montana (Tr=475)

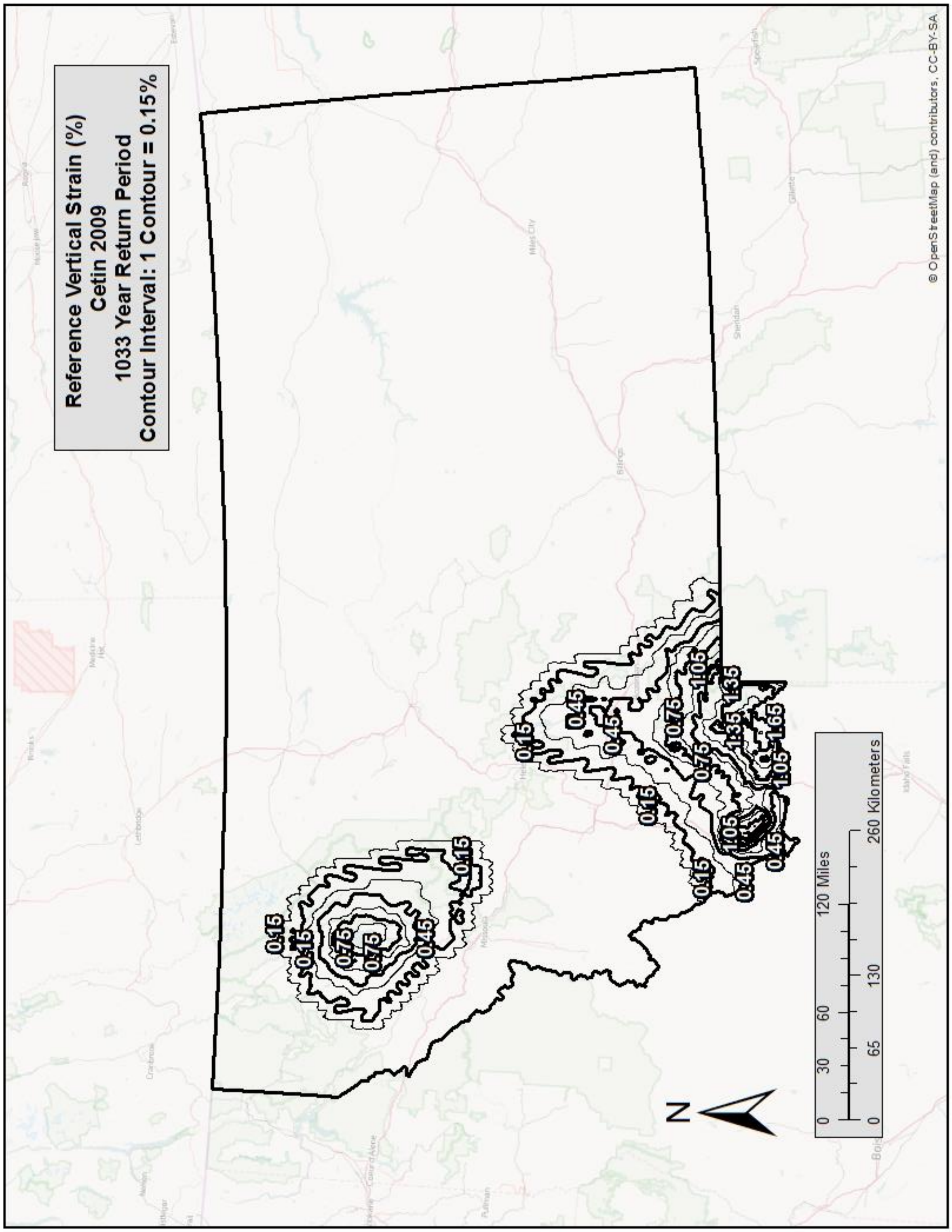


Figure D- 14 Cetin et al. (2009) Post-Liquefaction Settlement *(ε^{ref})* Map for Montana (Tr=1,033)

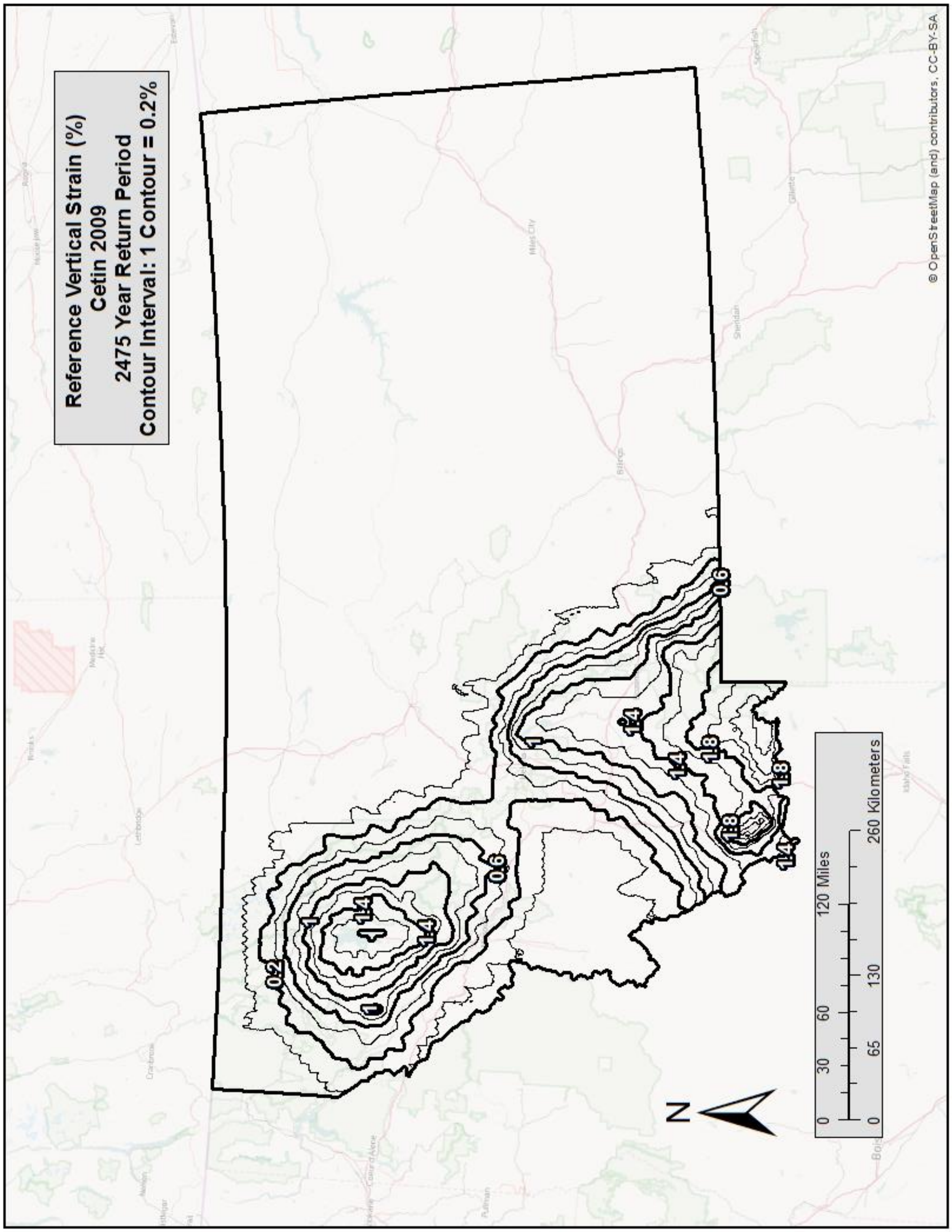


Figure D- 15 Cetin et al. (2009) Post-Liquefaction Settlement (ε^{ref}) Map for Montana (Tr=2,475)

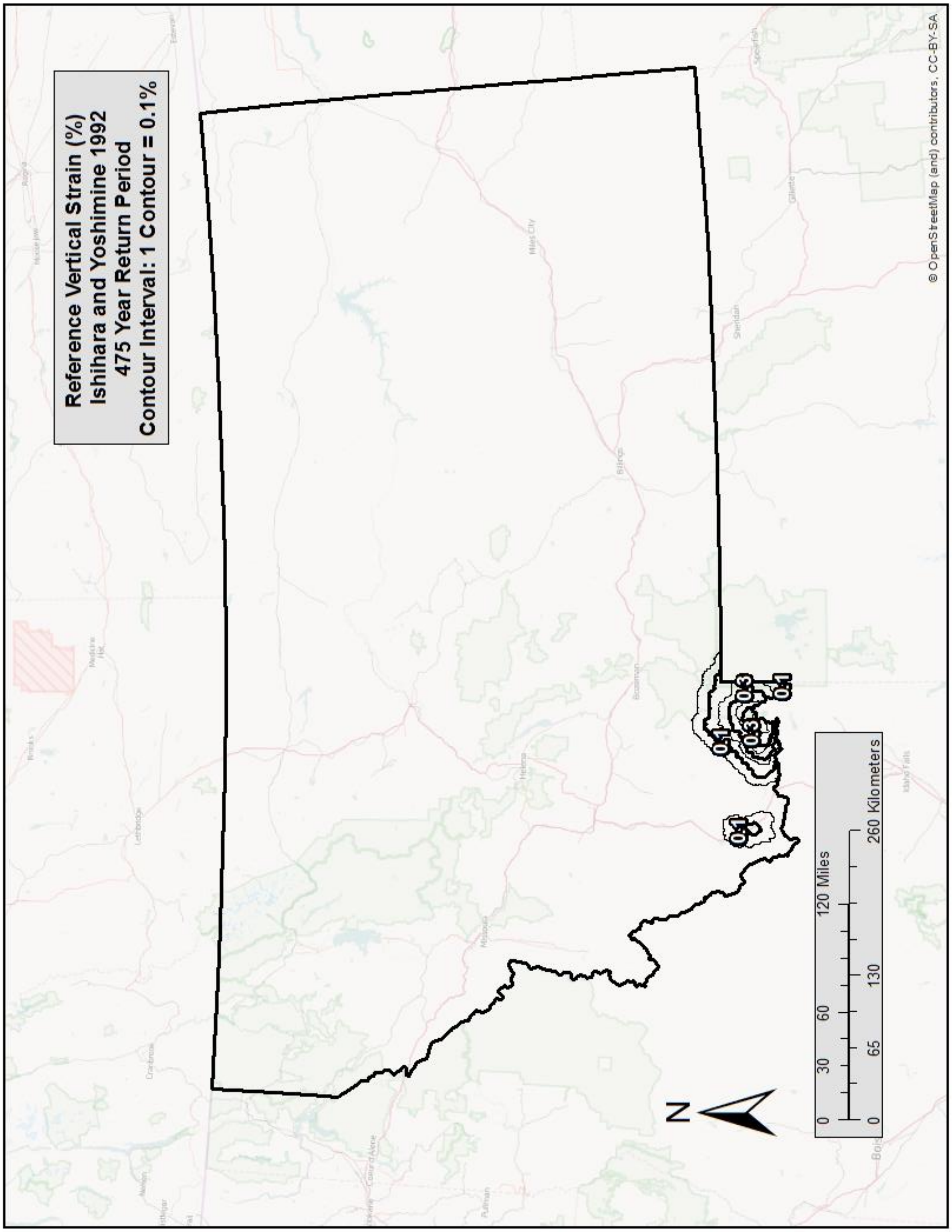


Figure D- 16 Ishihara and Yoshimine (1992) Post-Liquefaction Settlement *(ε^{ref})* Map for Montana (Tr = 475)

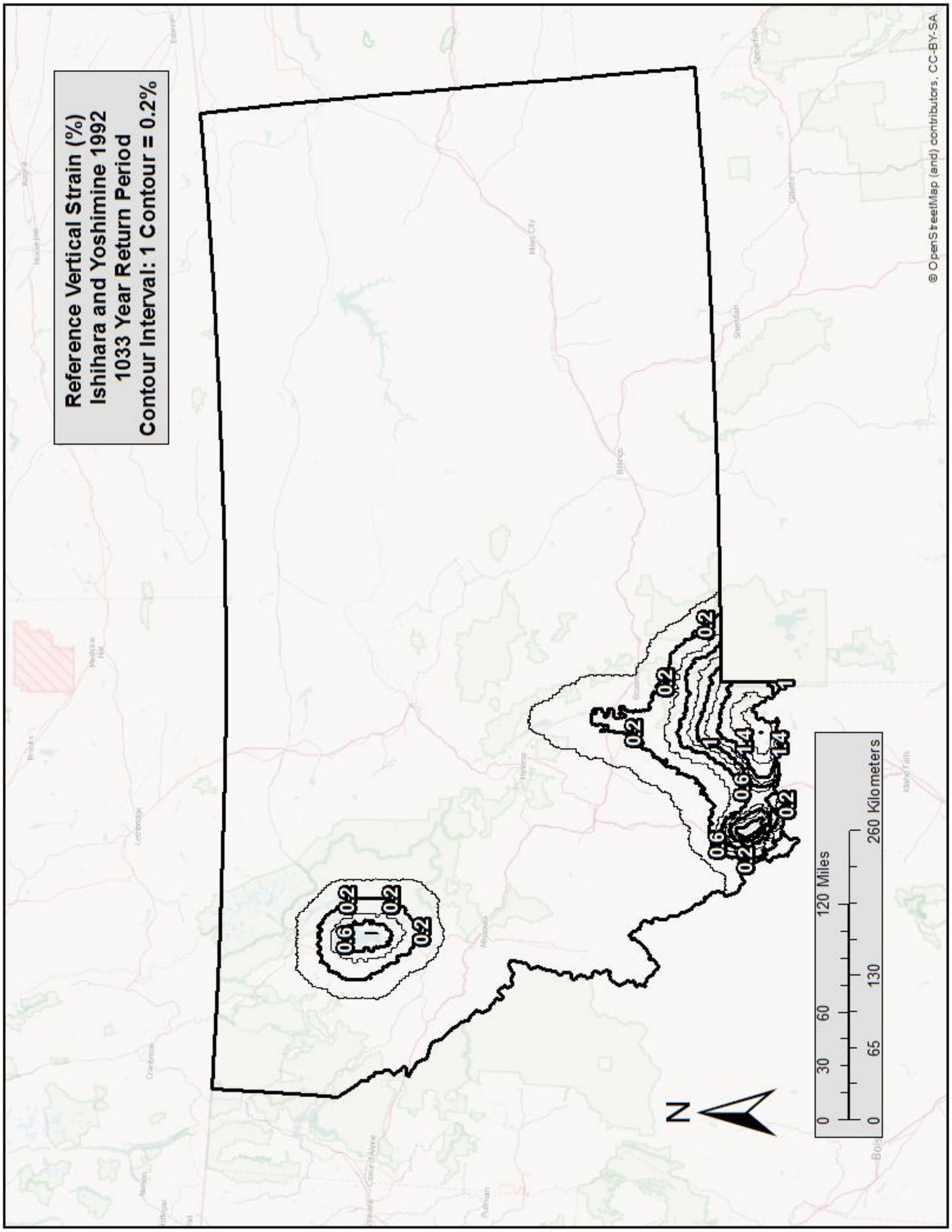


Figure D- 17 Ishihara and Yoshimine (1992) Post-Liquefaction Settlement *(ε^{ref})* Map for Montana (Tr = 1,033)

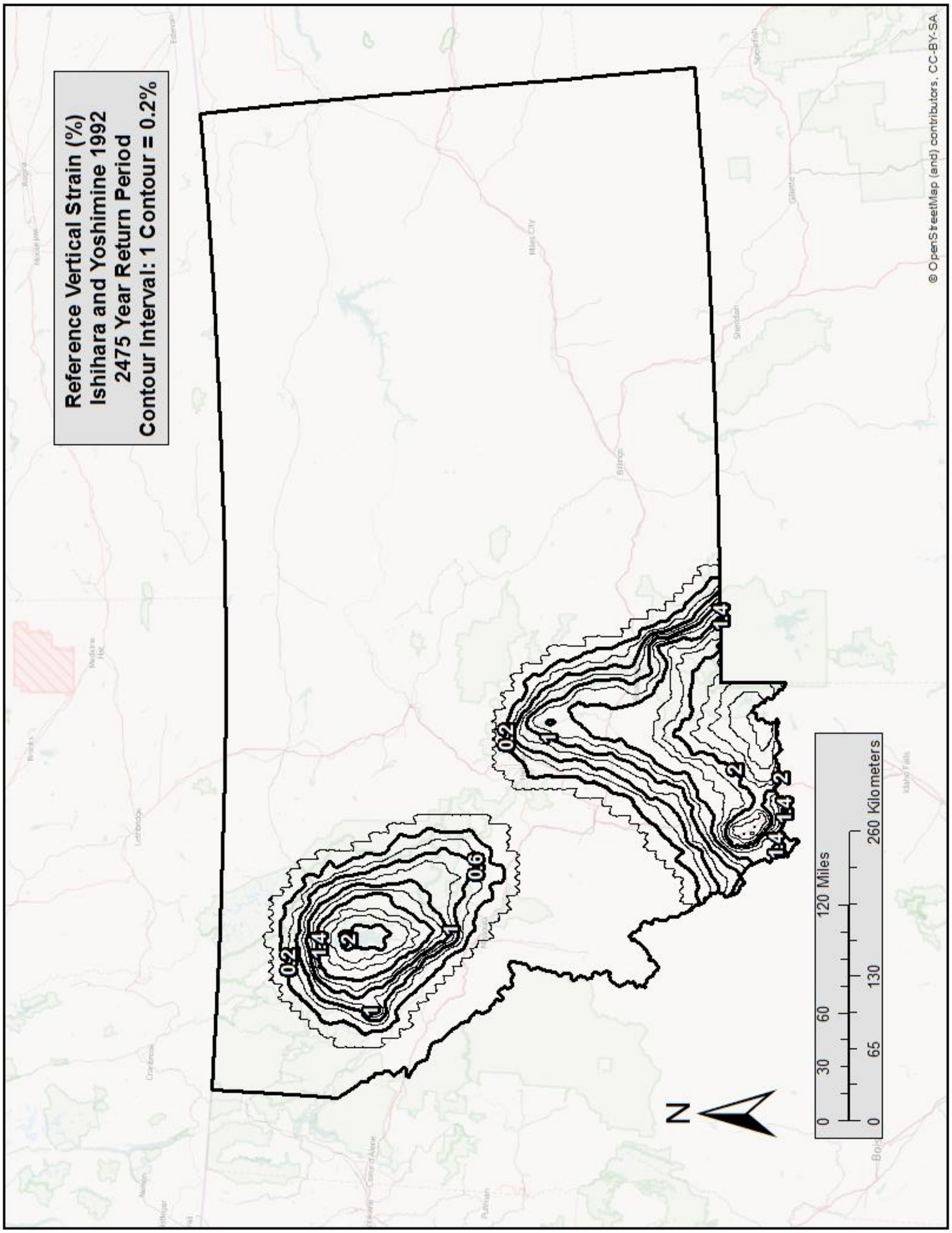


Figure D- 18 Ishihara and Yoshimine (1992) Post-Liquefaction Settlement *(ε^{ref})* Map for Montana (Tr = 2,475)

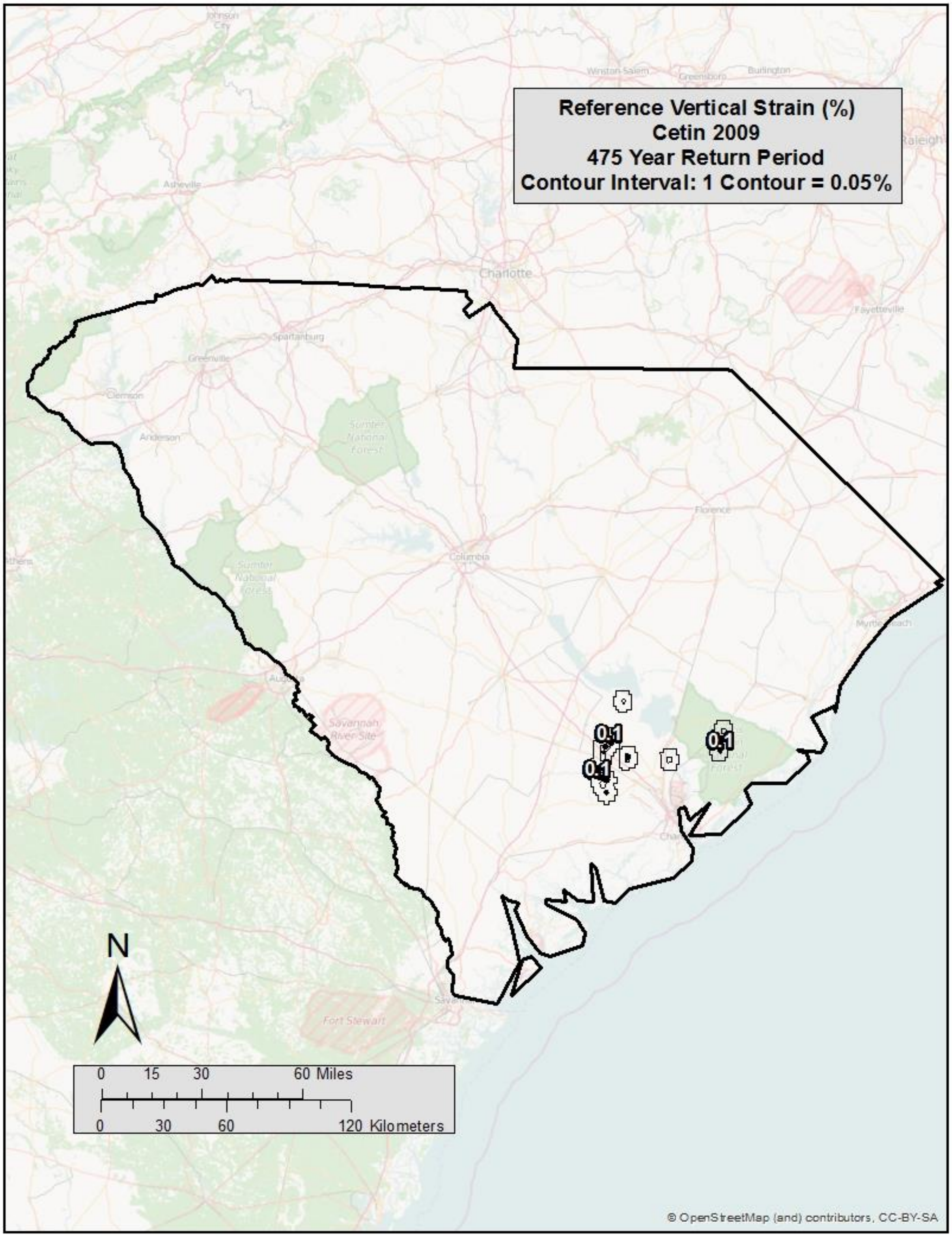


Figure D- 19 Cetin et al. (2009) Post-Liquefaction Settlement (ε^{ref}) Map for South Carolina (Tr = 475)

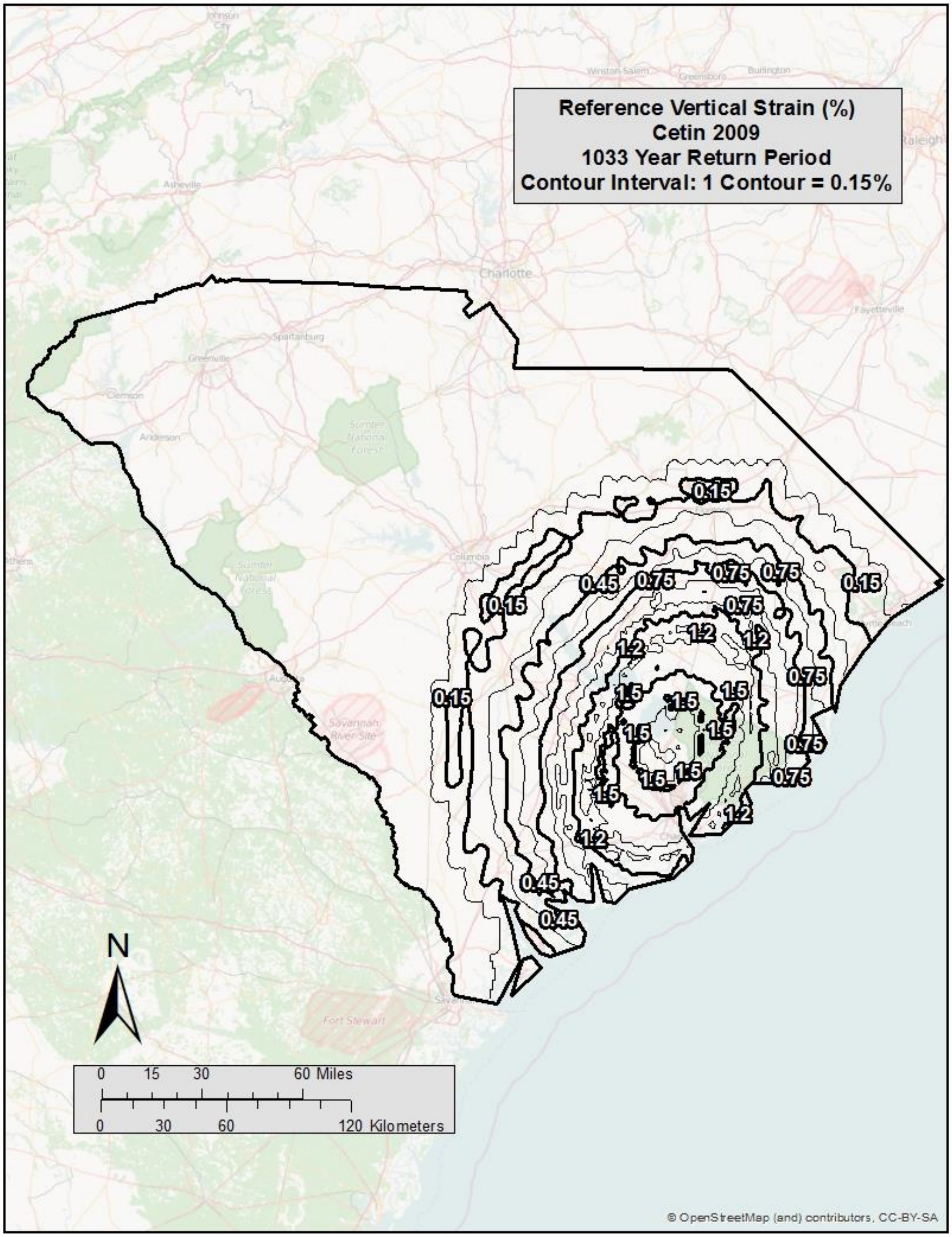


Figure D- 20 Cetin et al. (2009) Post-Liquefaction Settlement (ε^{ref}) Map for South Carolina (Tr = 1,033)

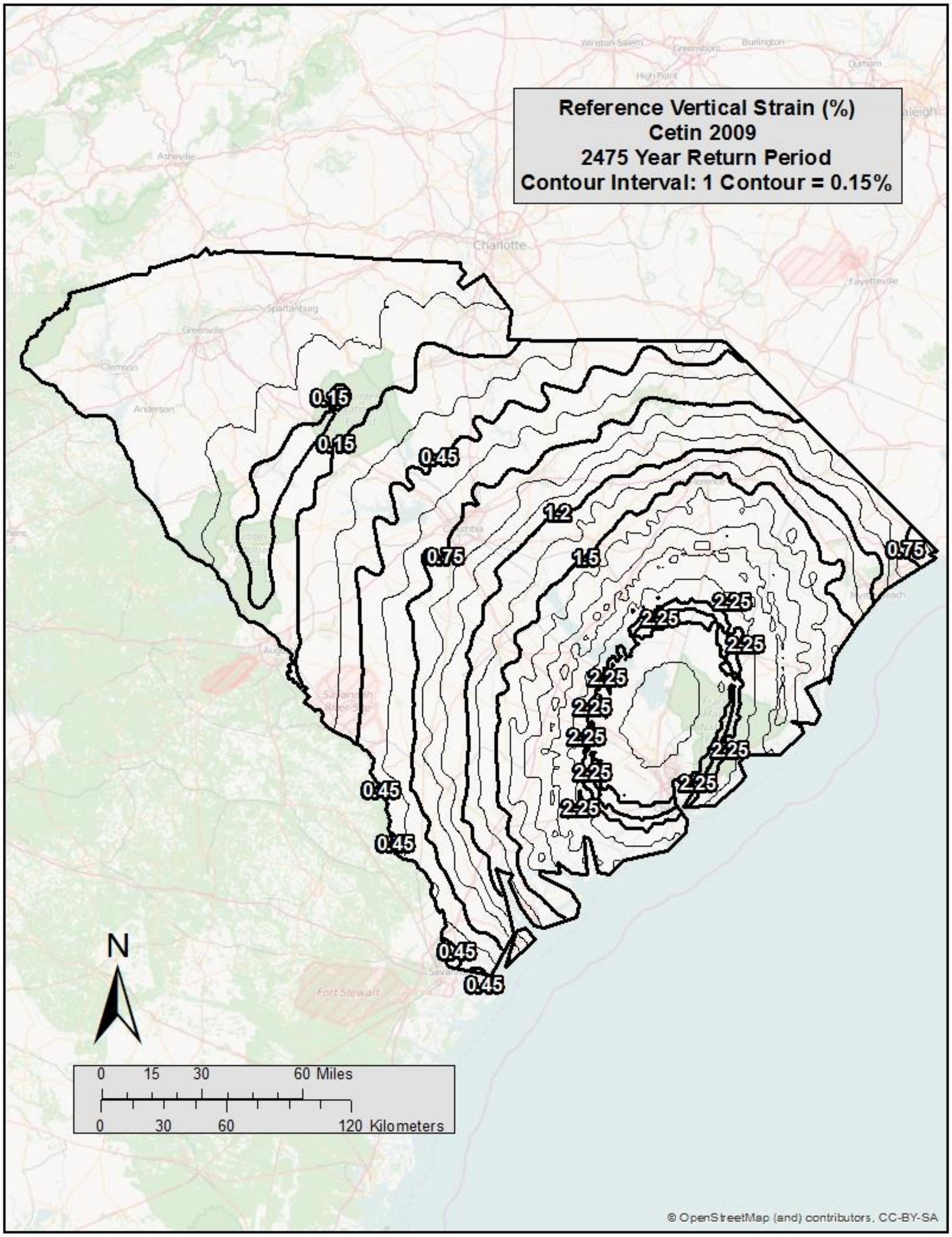


Figure D- 21 Cetin et al. (2009) Post-Liquefaction Settlement (ε^{ref}) Map for South Carolina (Tr = 2,475)

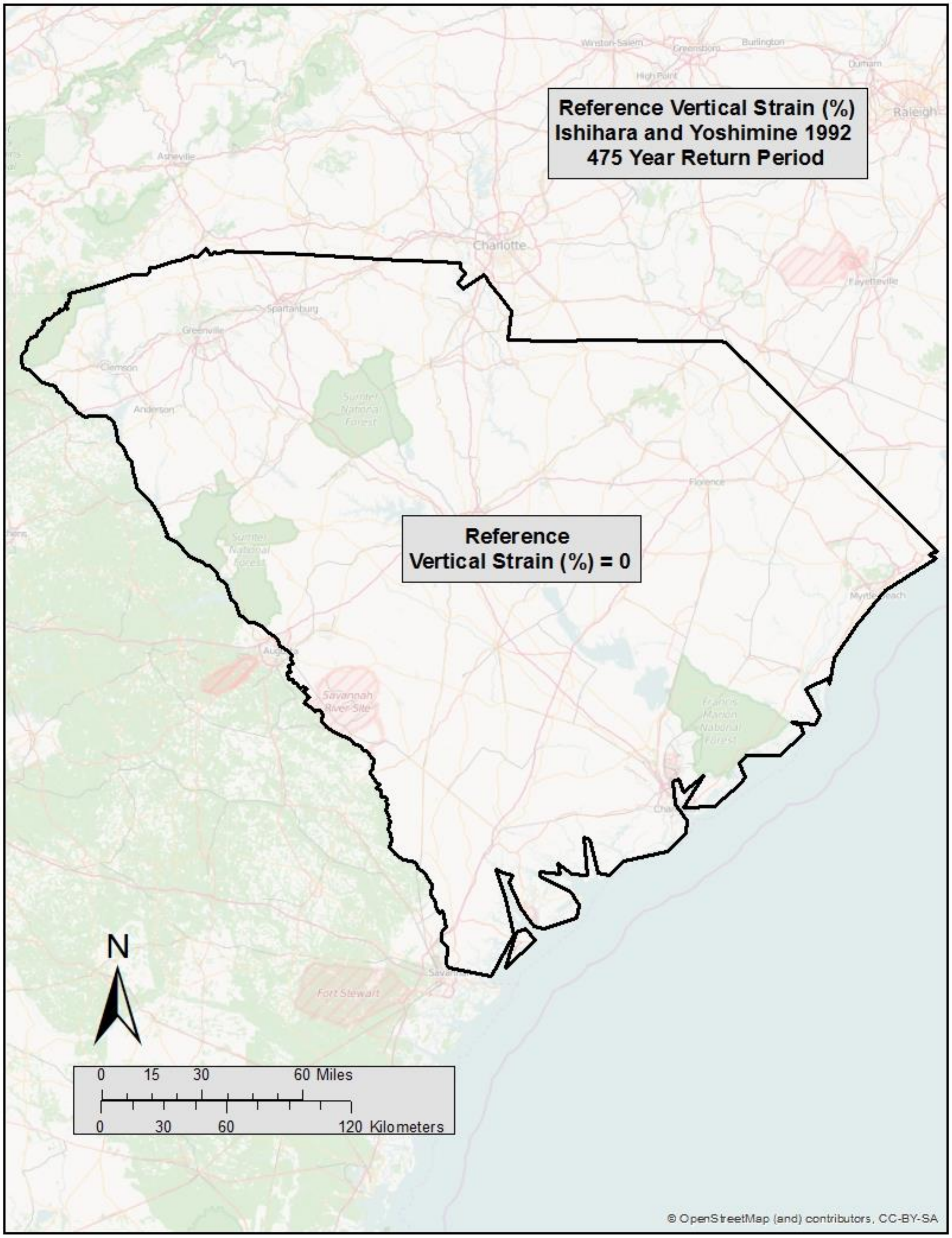


Figure D- 22 Ishihara and Yoshimine (1992) Post-Liquefaction Settlement (ε^{ref}) Map for South Carolina (Tr = 475)

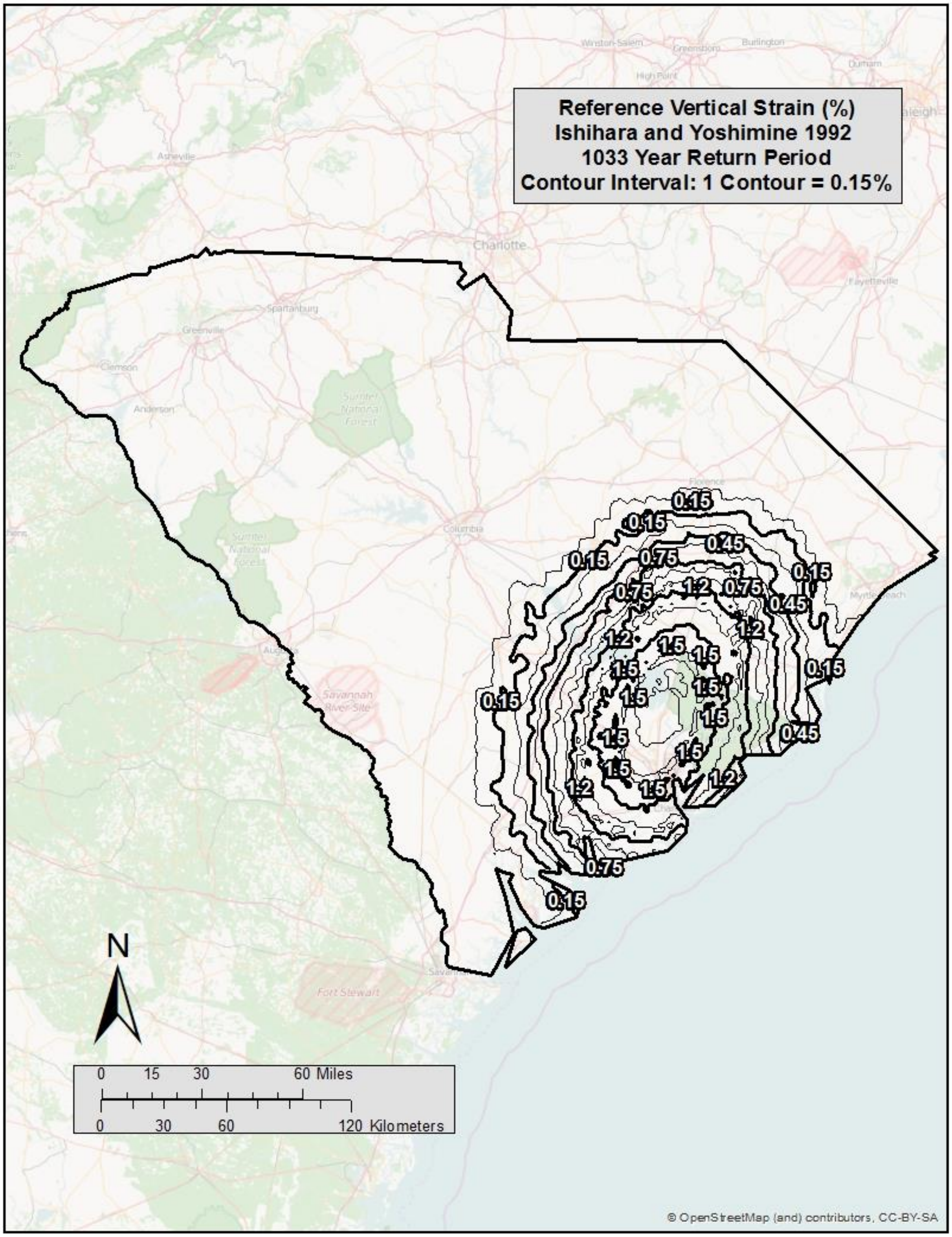


Figure D- 23 Ishihara and Yoshimine (1992) Post-Liquefaction Settlement (ε^{ref}) Map for South Carolina (Tr = 1,033)

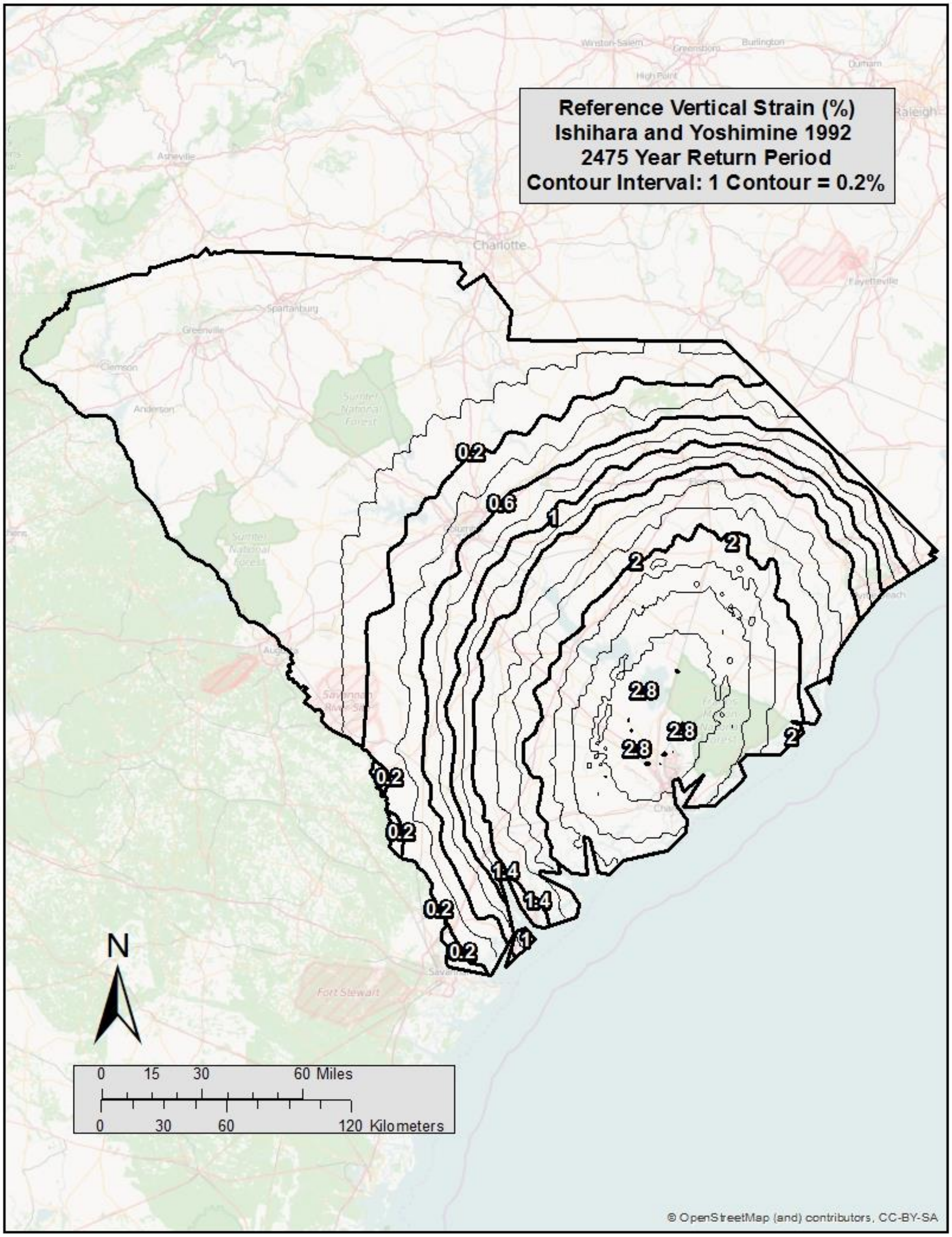


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Figure D- 24 Ishihara and Yoshimine (1992) Post-Liquefaction Settlement *(ε^{ref})* Map for South Carolina (Tr = 2,475)

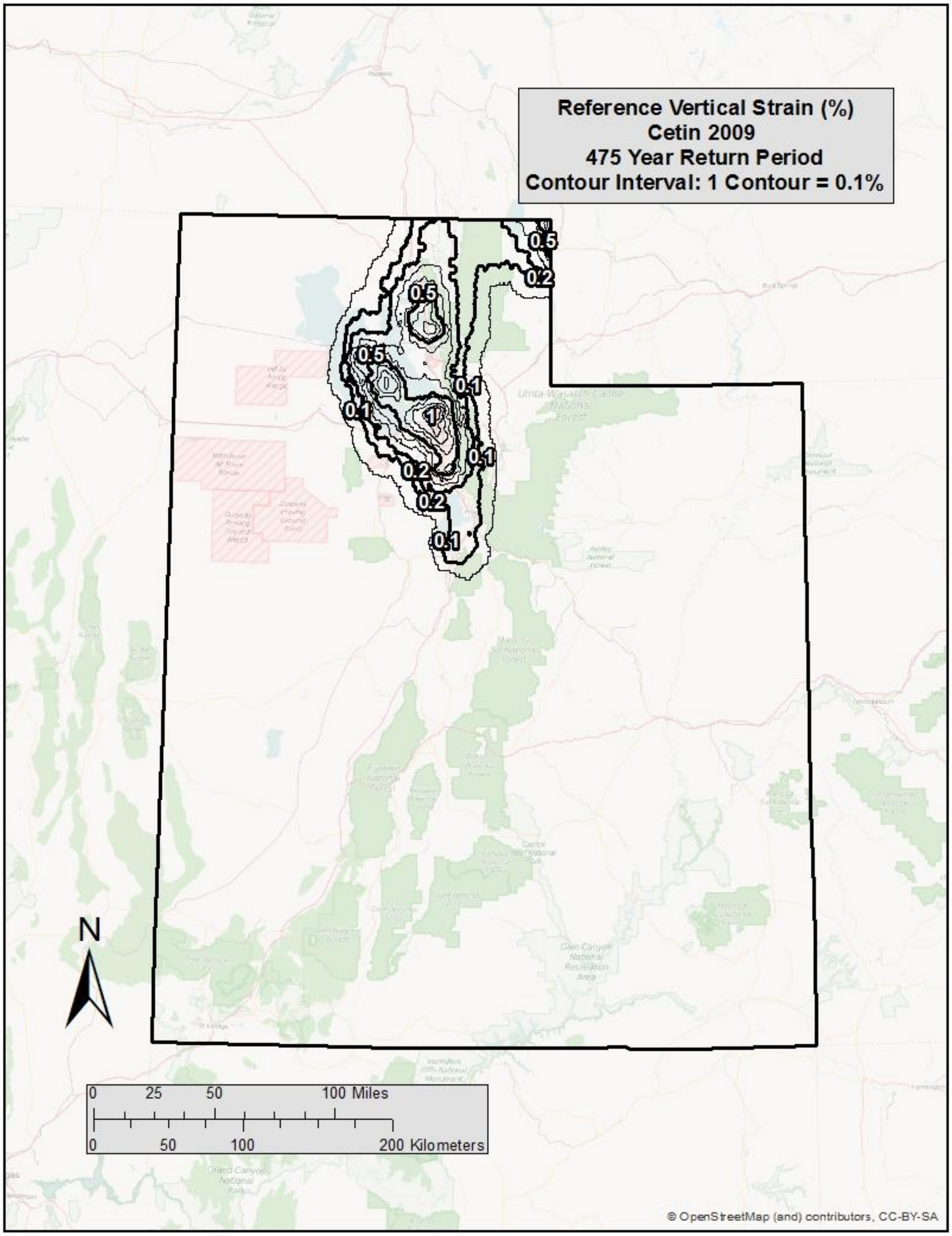

Figure D- 25 Cetin et al. (2009) Post-Liquefaction Settlement (ε^{ref}) Map for Utah (Tr = 475)

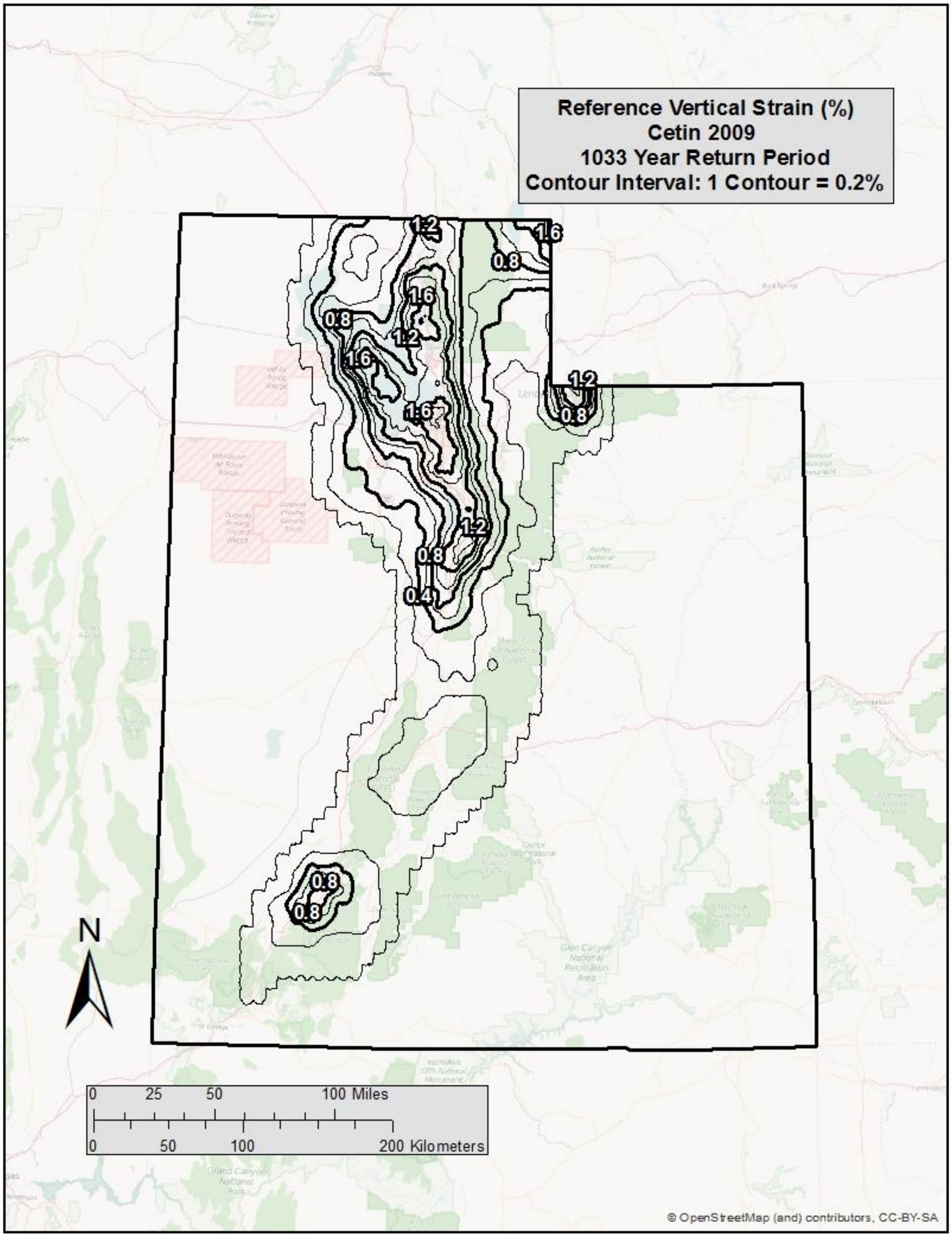

Figure D- 26 Cetin et al. (2009) Post-Liquefaction Settlement (ε^{ref}) Map for Utah (Tr=1,033)

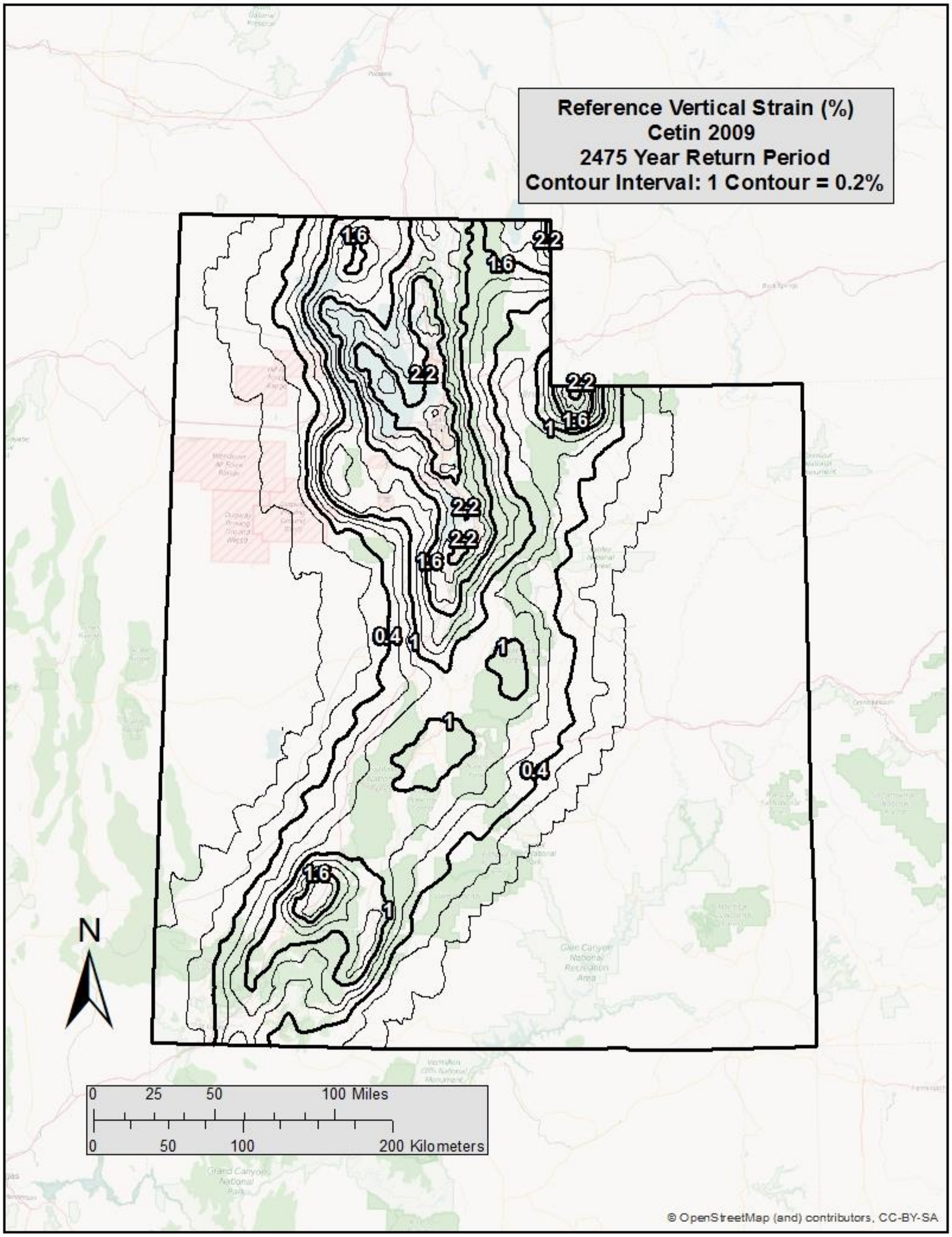

Figure D- 27 Cetin et al. (2009) Post-Liquefaction Settlement (ε^{ref}) Map for Utah (Tr=2,475)

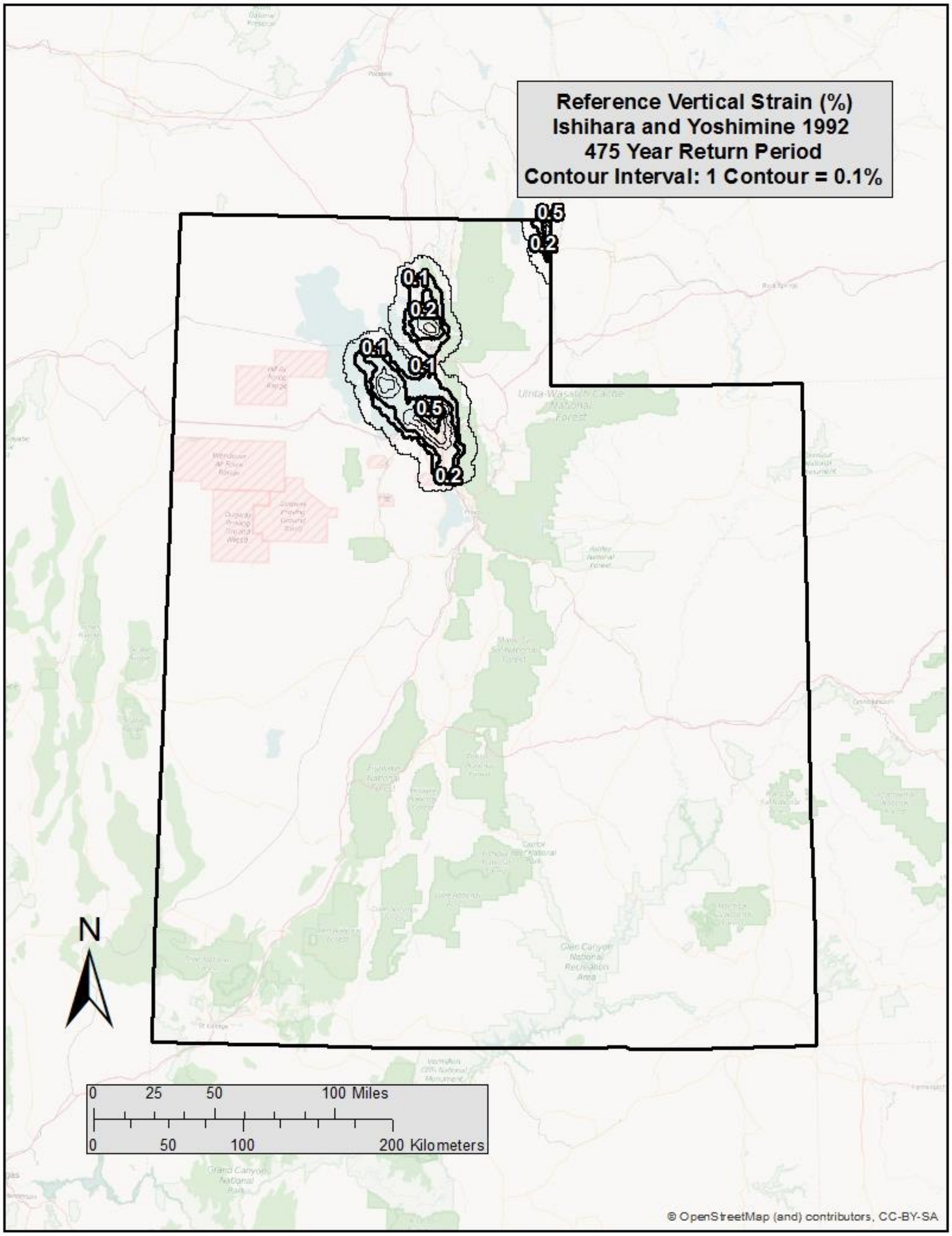

Figure D- 28 Ishihara and Yoshimine (1992) Post-Liquefaction Settlement (ε^{ref}) Map for Utah (Tr = 475)

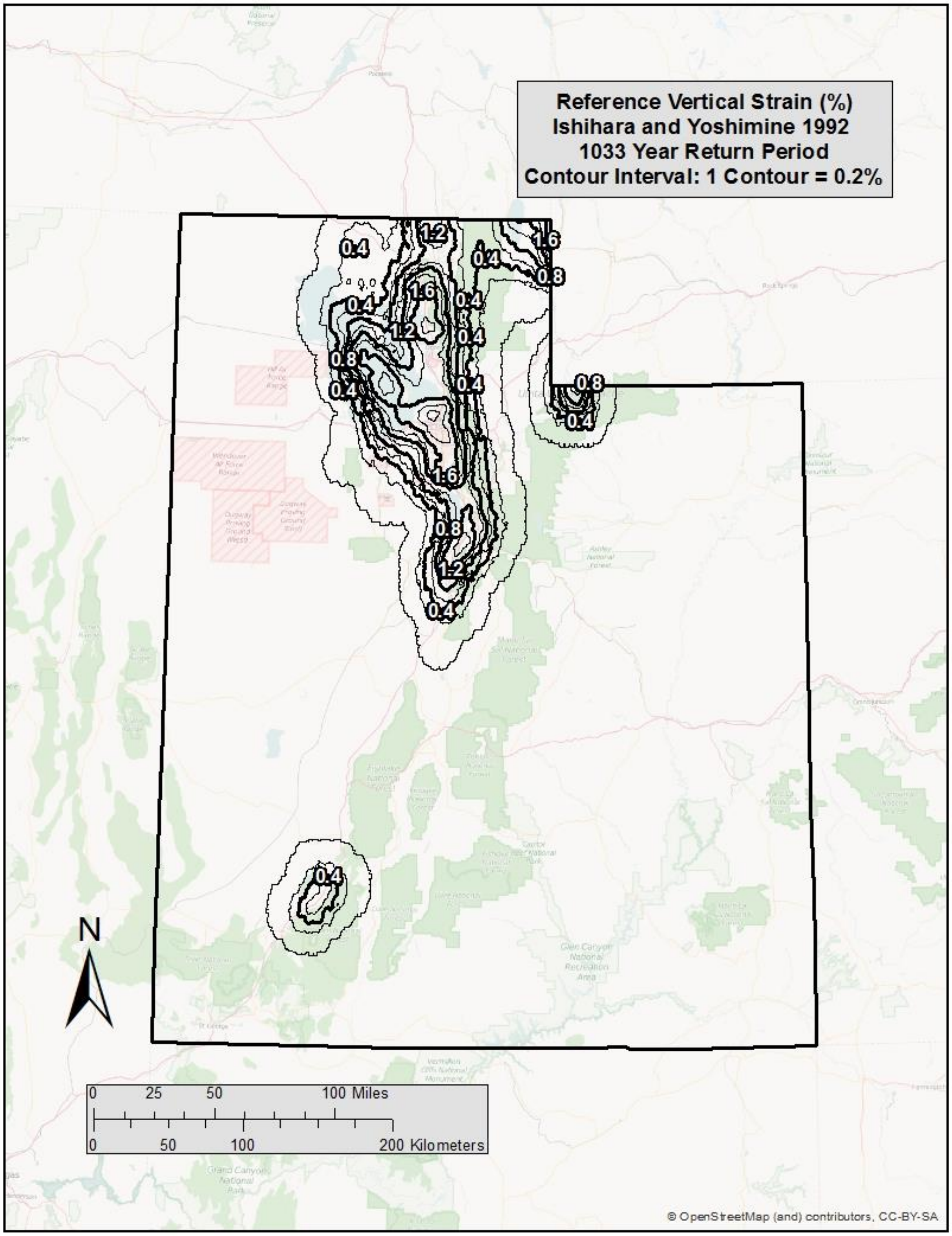

Figure D- 29 Ishihara and Yoshimine (1992) Post-Liquefaction Settlement *(ε^{ref})* Map for Utah (Tr = 1,033)

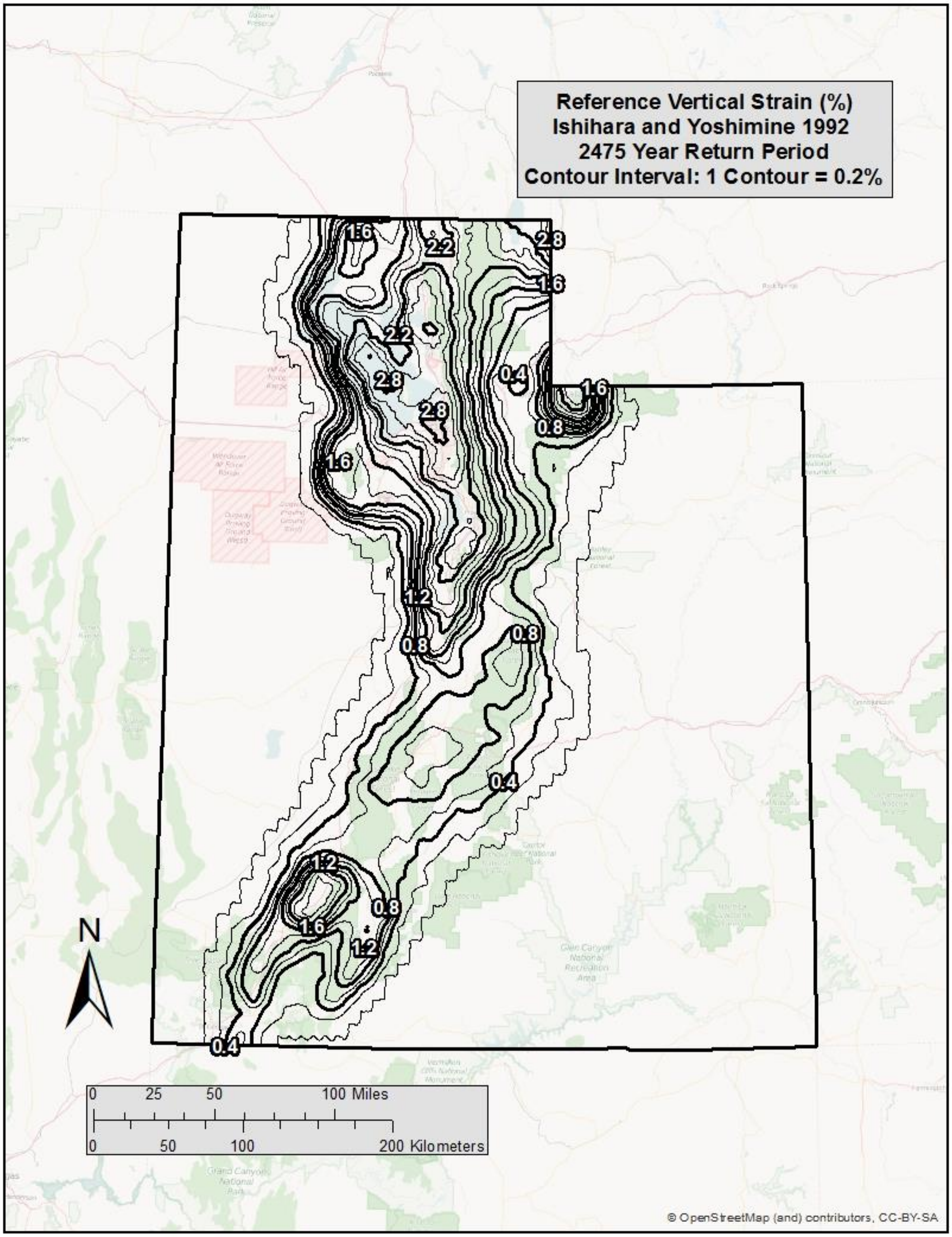

Figure D- 30 Ishihara and Yoshimine (1992) Post-Liquefaction Settlement *(ε^{ref})* Map for Utah (Tr = 2,475)

APPENDIX E: Sample Seismic Slope Displacement Maps

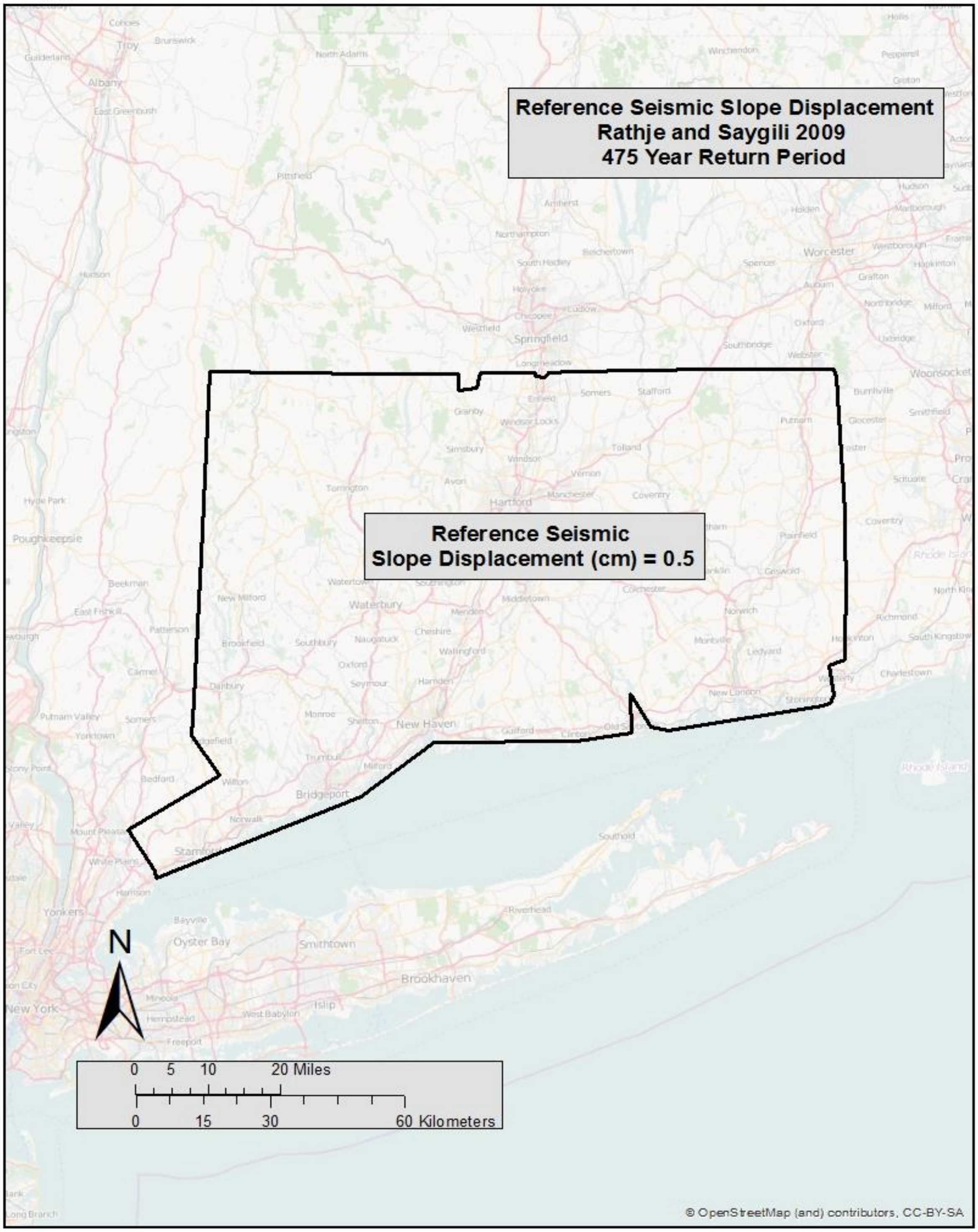

Figure E- 1 Rathje and Saygili (2009) Seismic Slope Displacement *(D^{ref})* Map for Connecticut (Tr = 475)

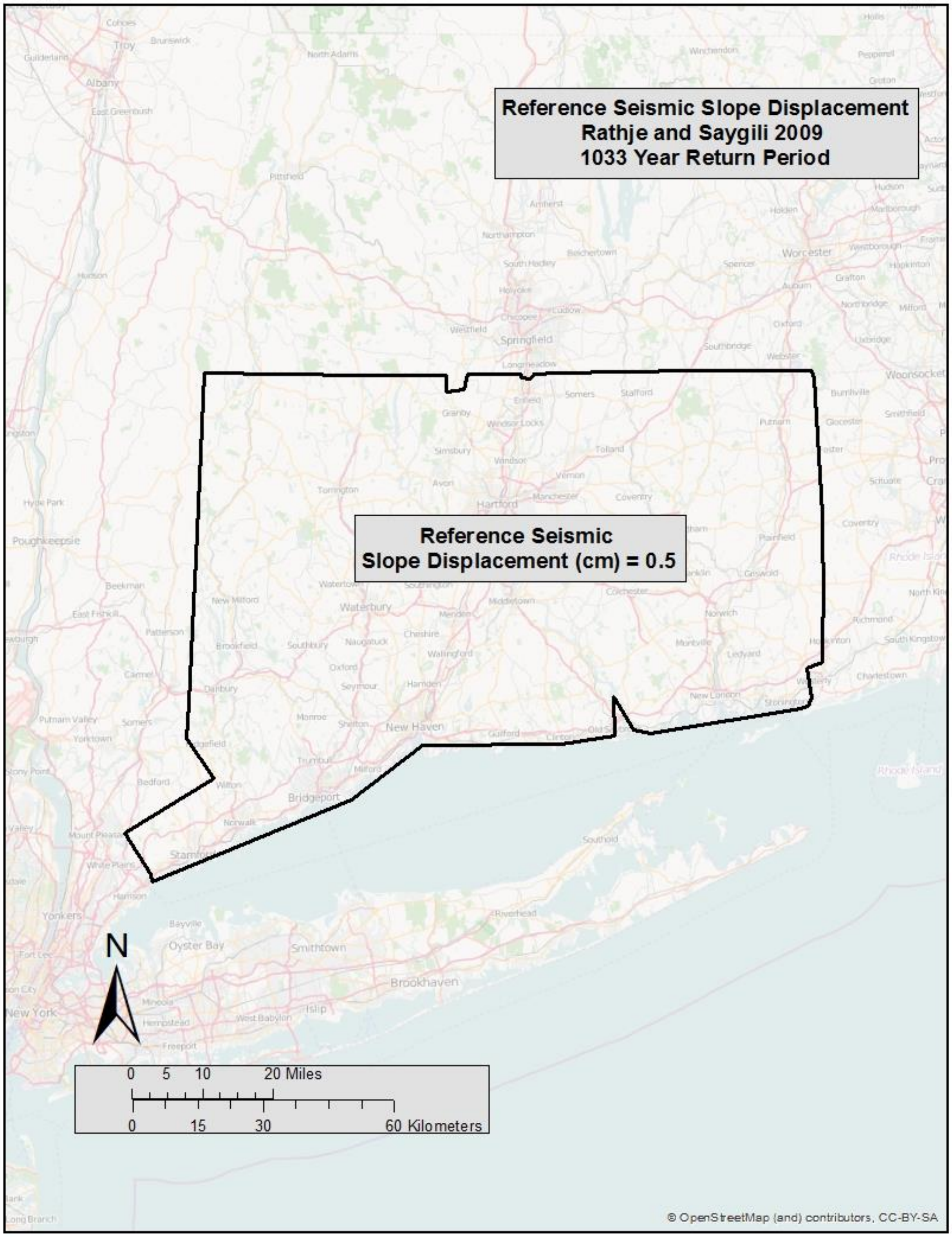

Figure E- 2 Rathje and Saygili (2009) Seismic Slope Displacement *(D^{ref})* Map for Connecticut (Tr = 1,033)

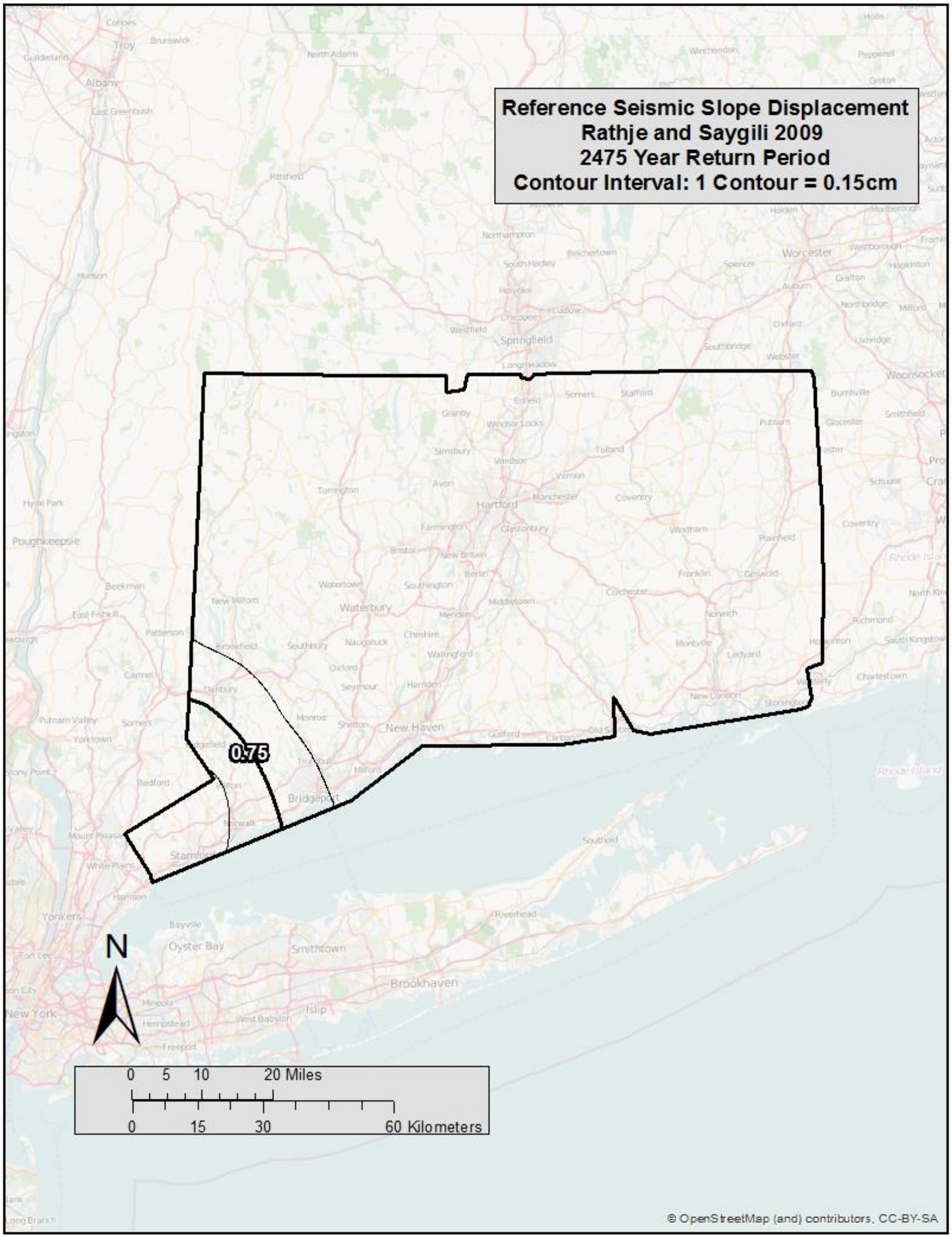

Figure E- 3 Rathje and Saygili (2009) Seismic Slope Displacement *(D^{ref})* Map for Connecticut (Tr = 2,475)

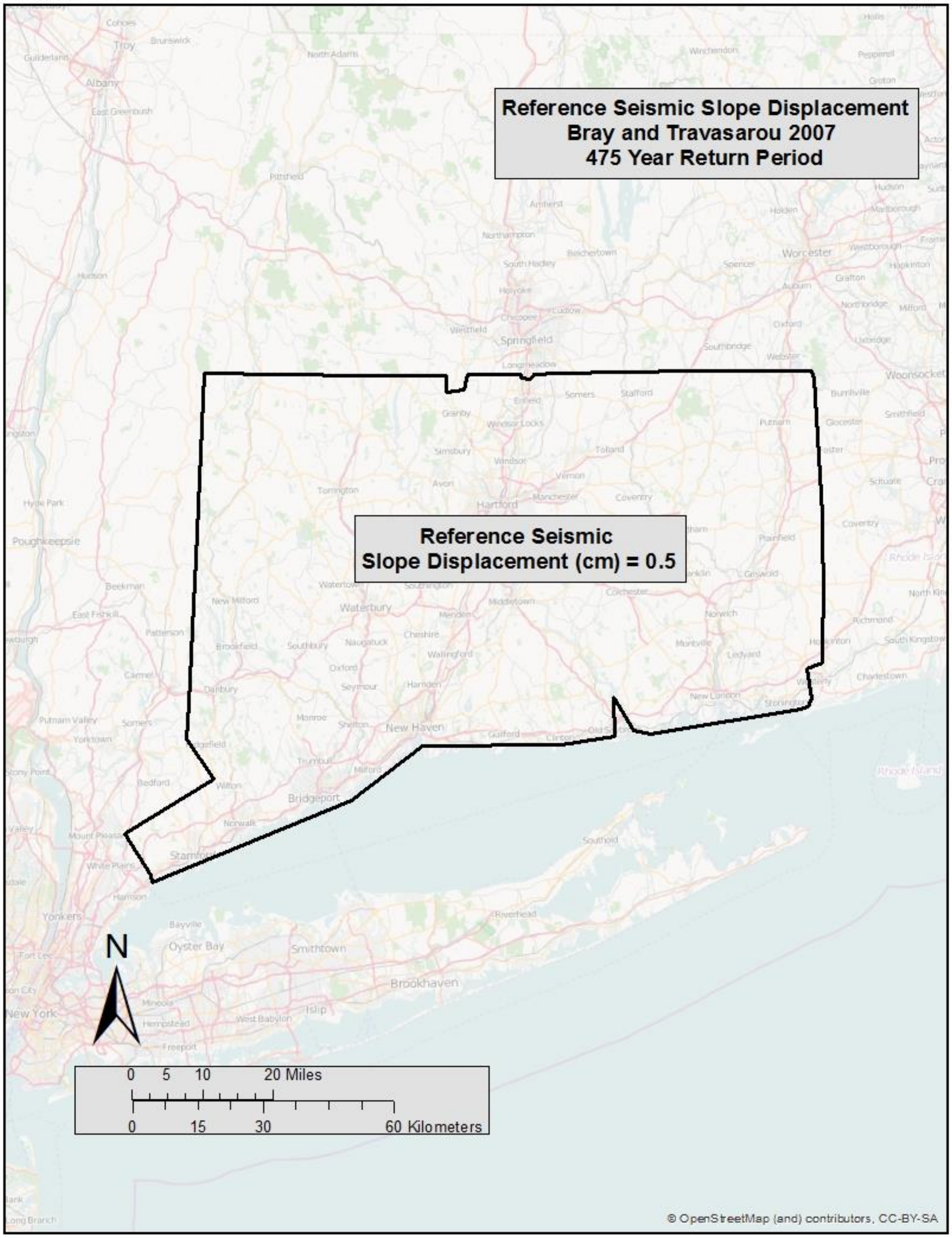

Figure E- 4 Bray and Travasarou (2007) Seismic Slope Displacement *(D^{ref})* Map for Connecticut (Tr = 475)

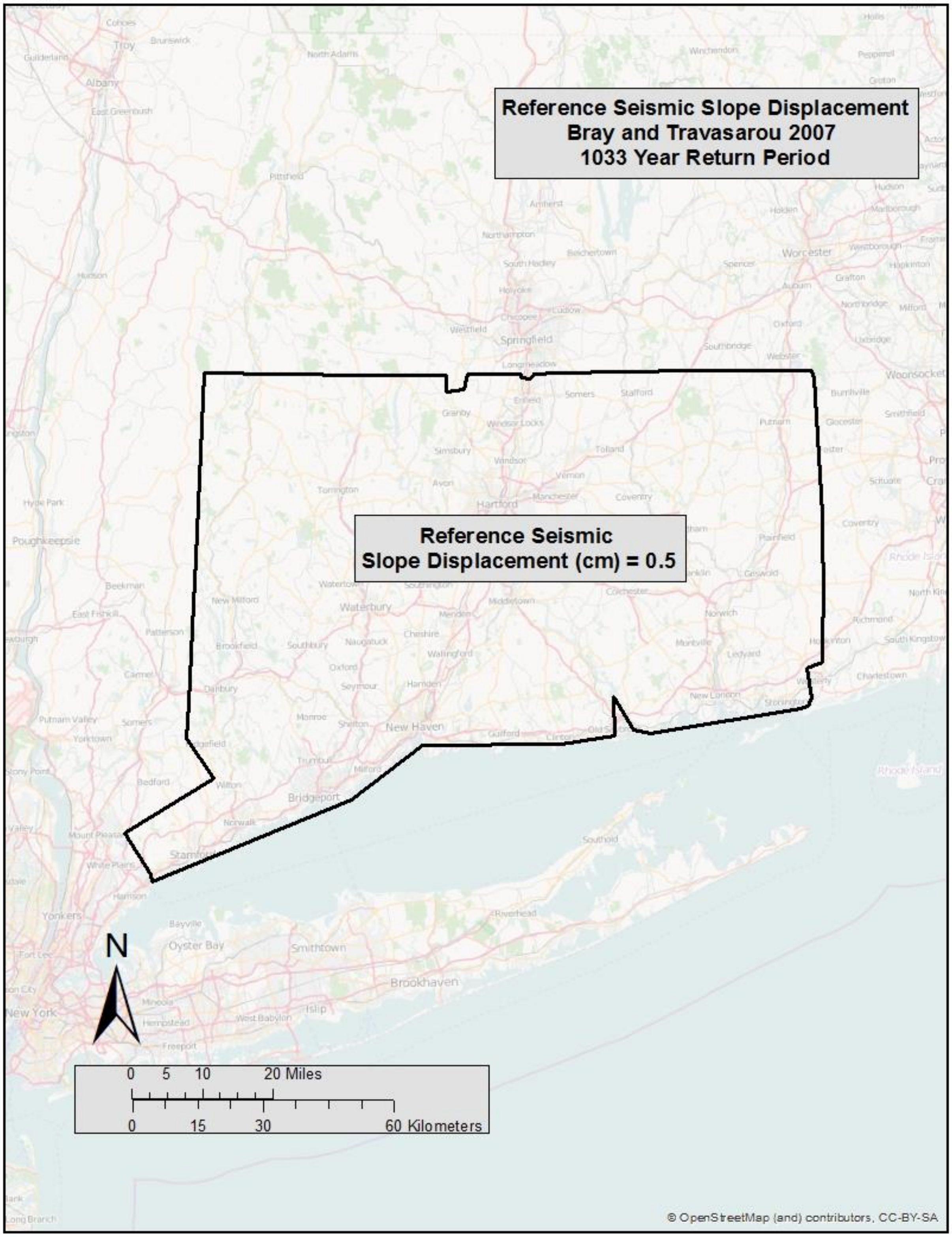

Figure E- 5 Bray and Travasarou (2007) Seismic Slope Displacement *(D^{ref})* Map for Connecticut (Tr = 1,033)

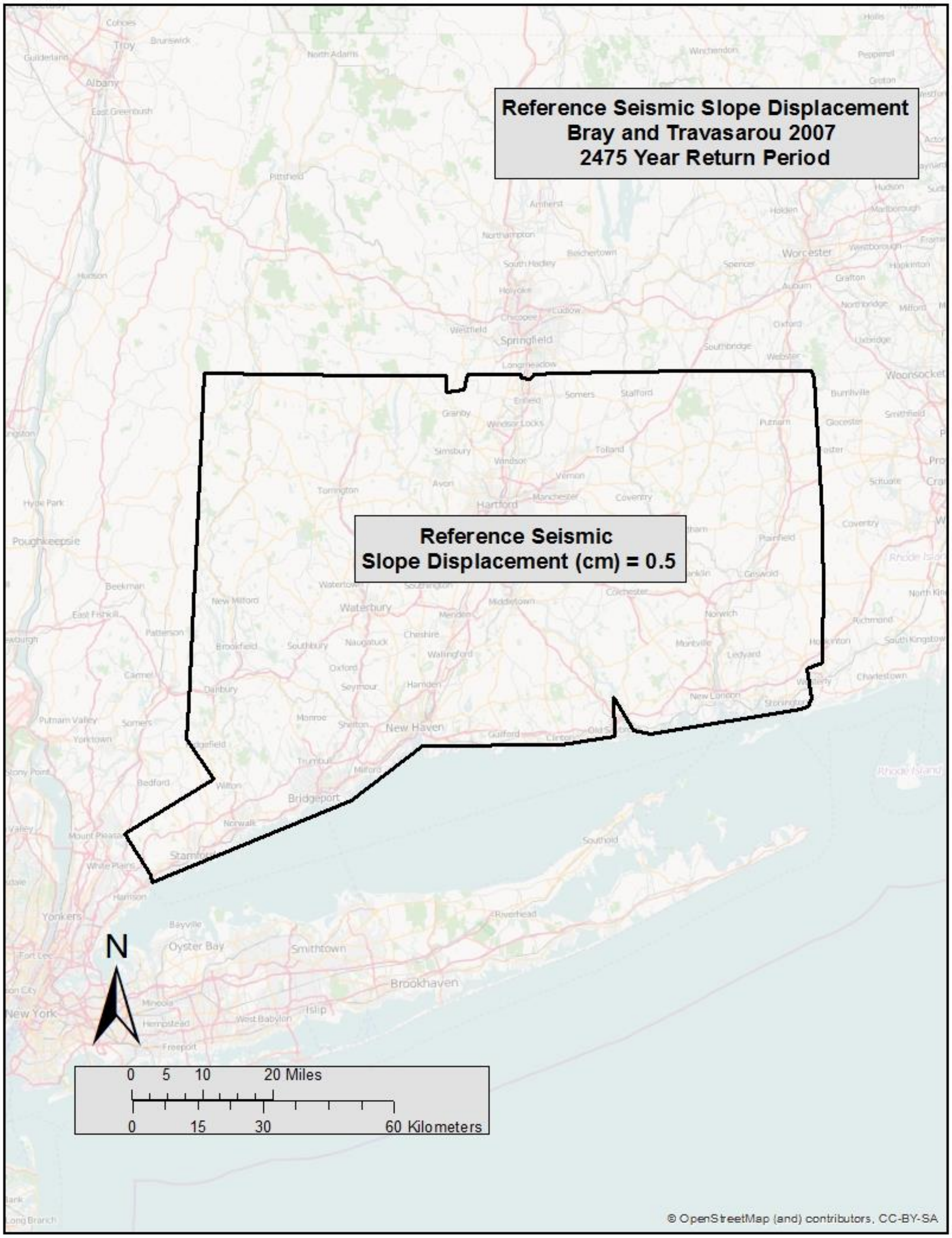

Figure E- 6 Bray and Travasarou (2007) Seismic Slope Displacement *(D^{ref})* Map for Connecticut (Tr = 2,475)

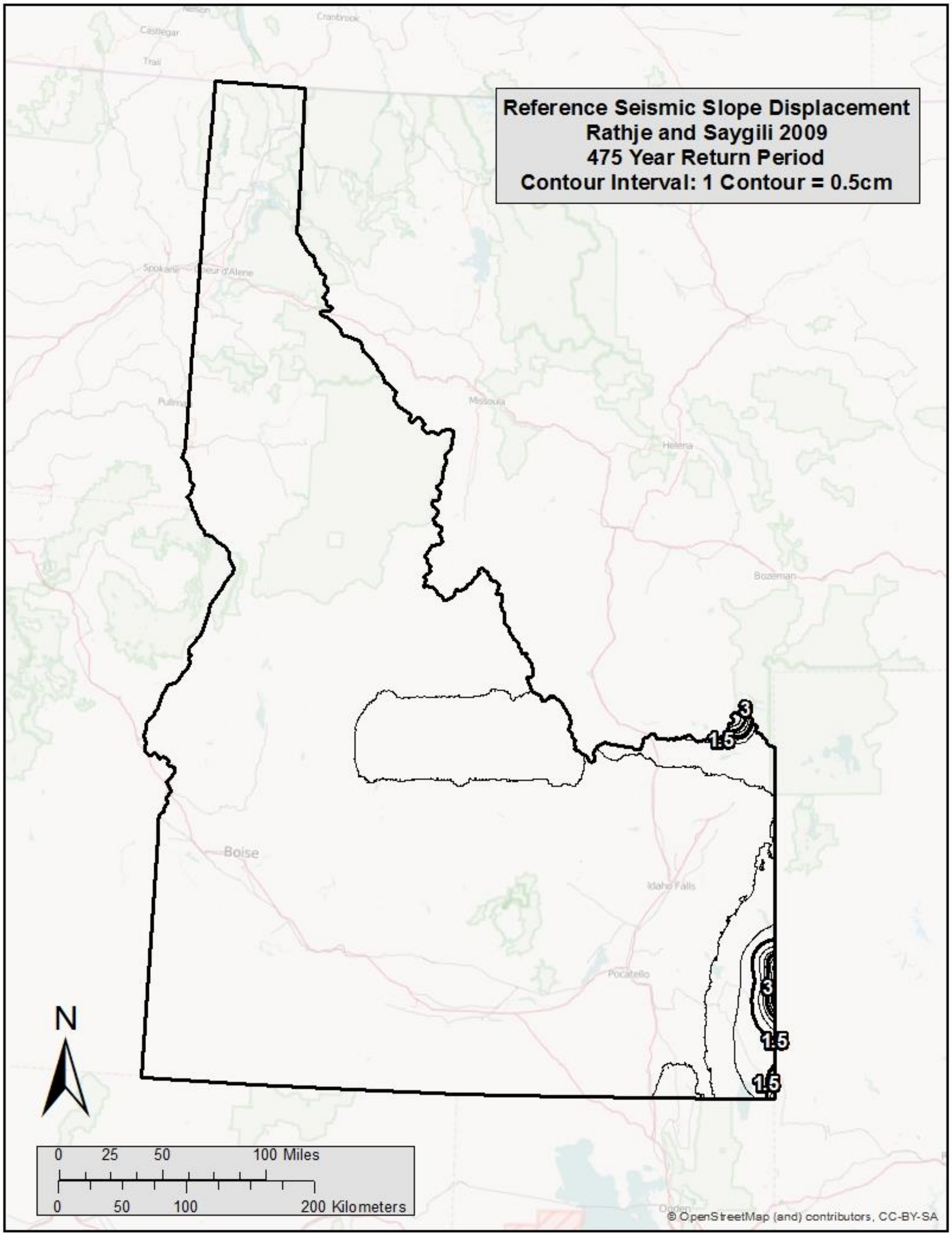

Figure E- 7 Rathje and Saygili (2009) Seismic Slope Displacement *(D^{ref})* Map for Idaho (Tr= 475)

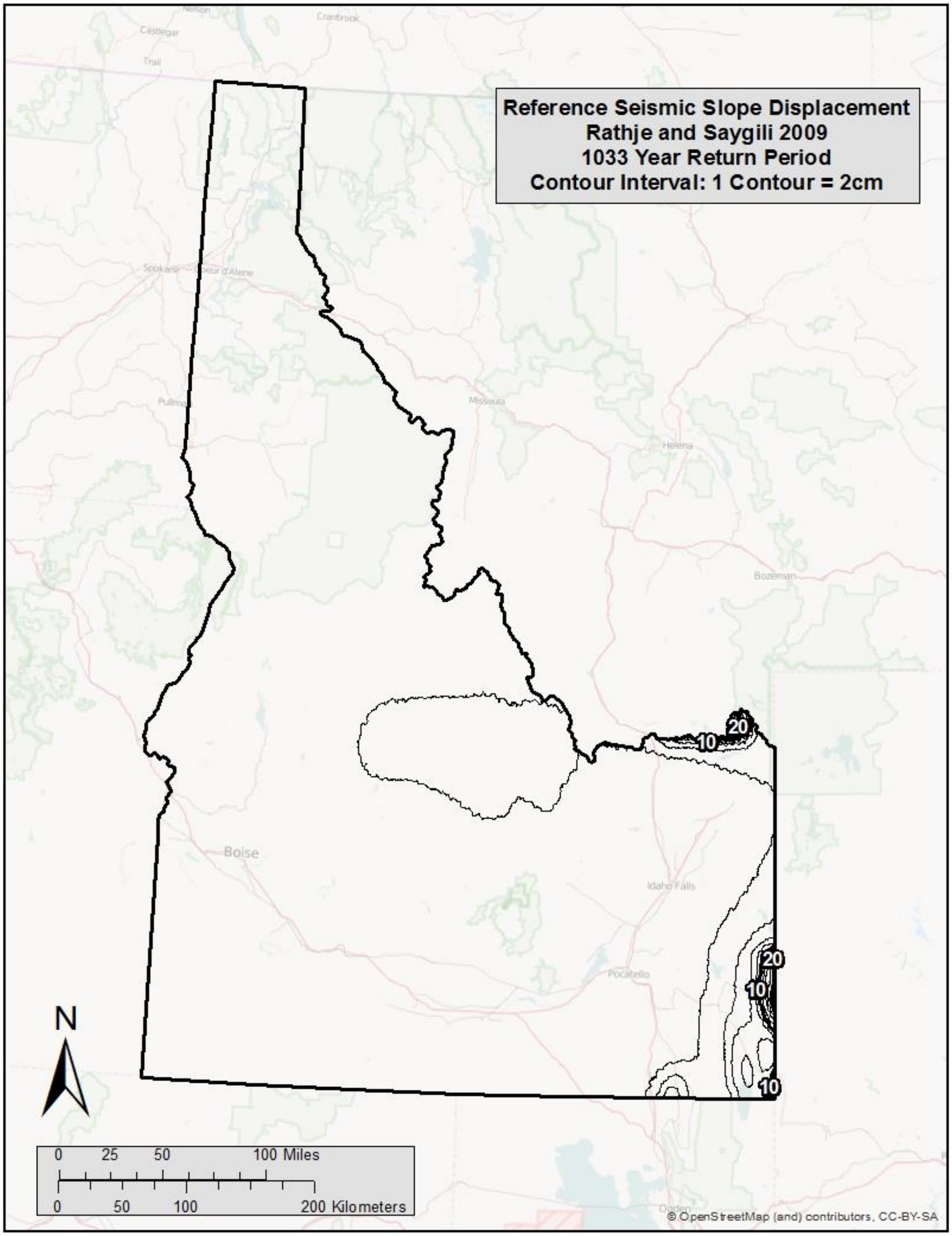

Figure E- 8 Rathje and Saygili (2009) Seismic Slope Displacement *(D^{ref})* Map for Idaho (Tr= 1,033)

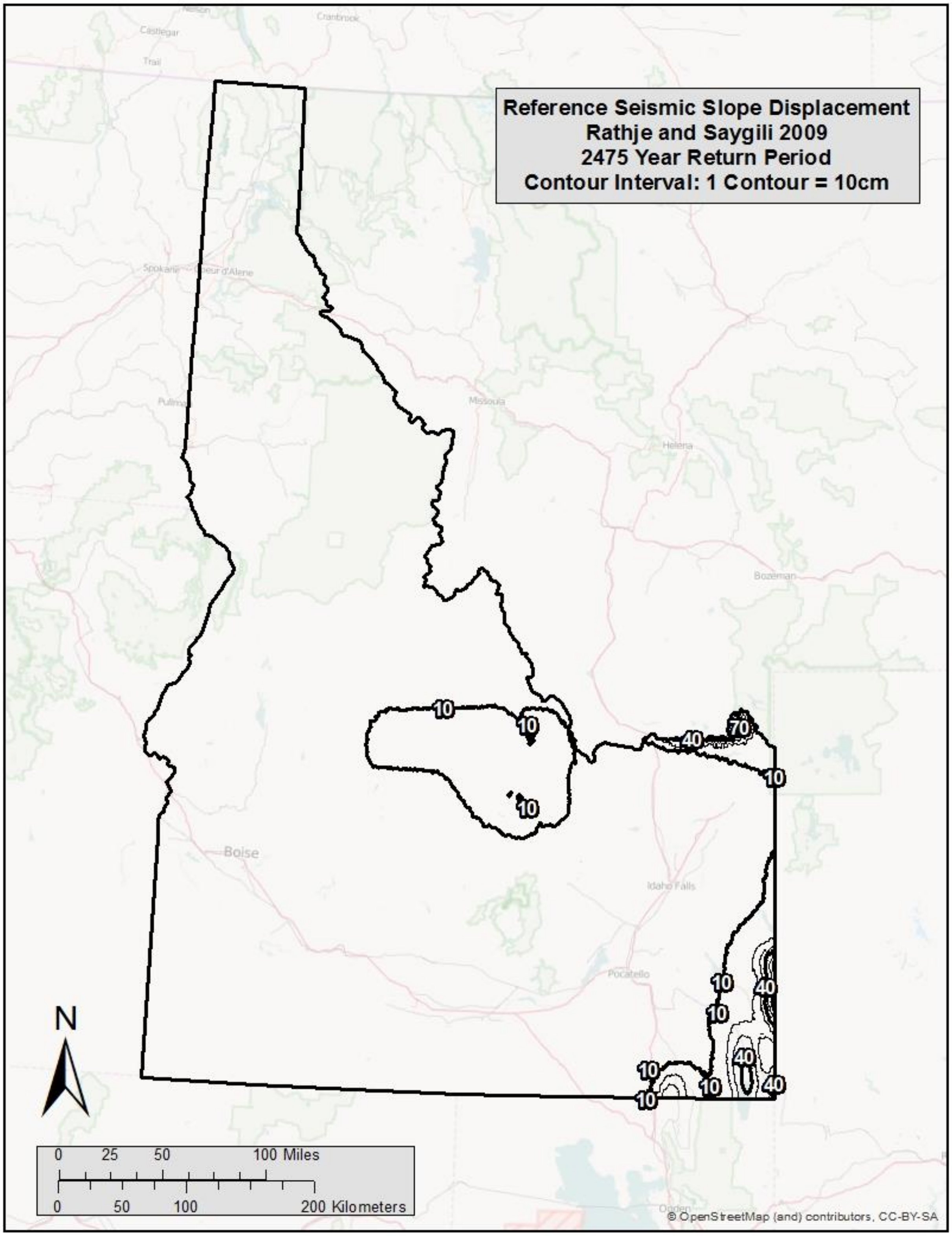

Figure E- 9 Rathje and Saygili (2009) Seismic Slope Displacement *(D^{ref})* Map for Idaho (Tr= 2,475)

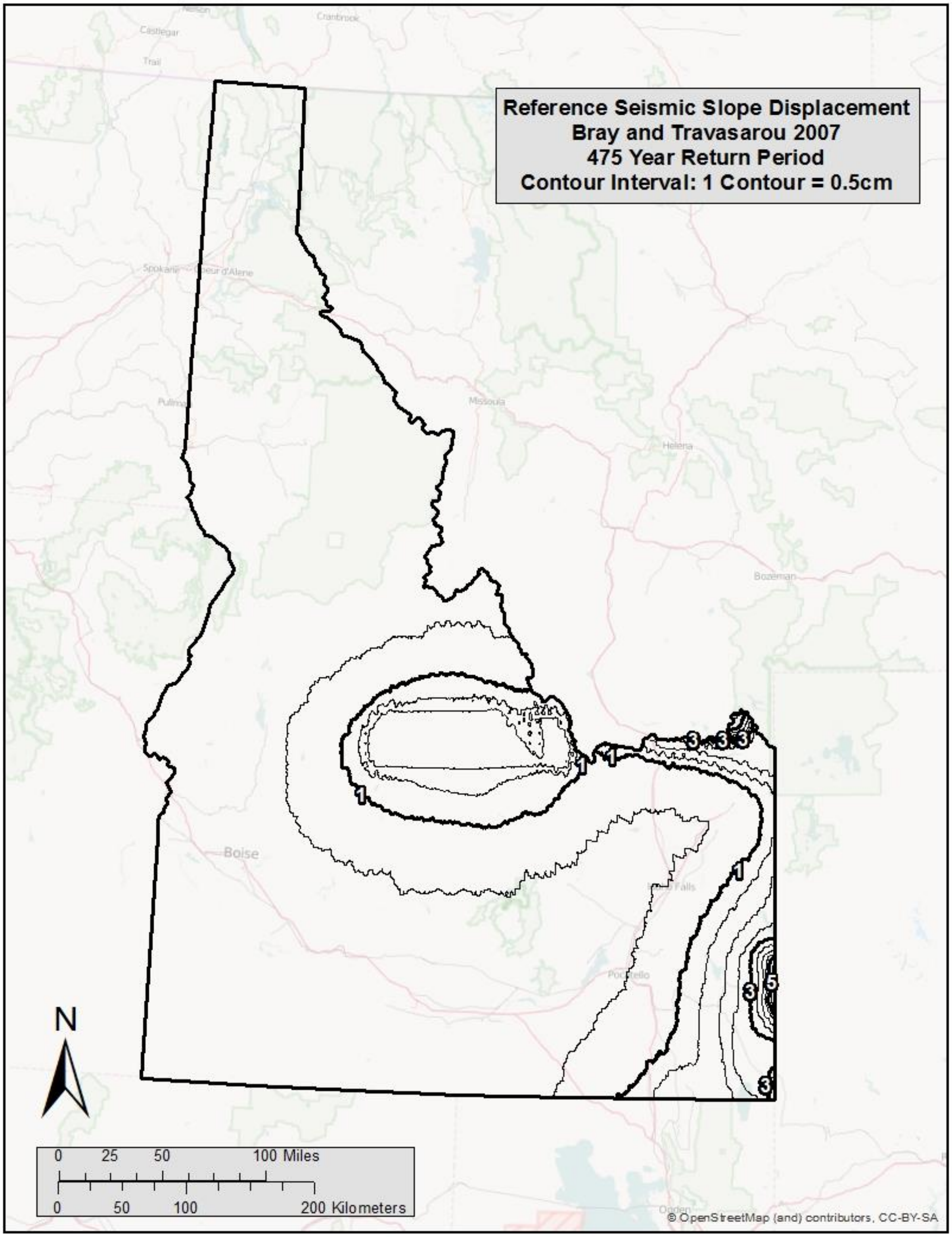

Figure E- 10 Bray and Travasarou (2007) Seismic Slope Displacement (D^{ref}) Map for Idaho (Tr = 475)

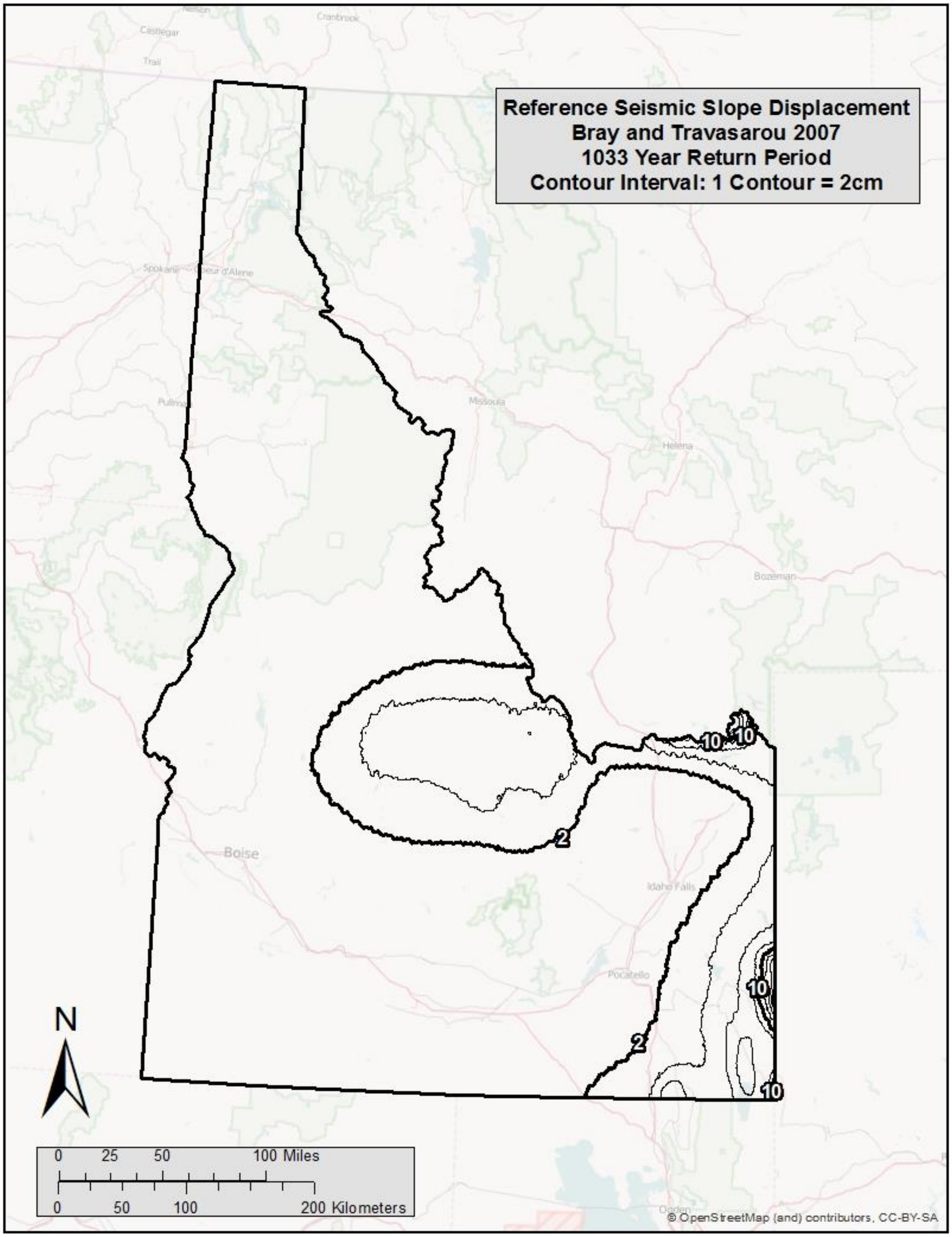

Figure E- 11 Bray and Travasarou (2007) Seismic Slope Displacement *(D^{ref})* Map for Idaho (Tr = 1,033)

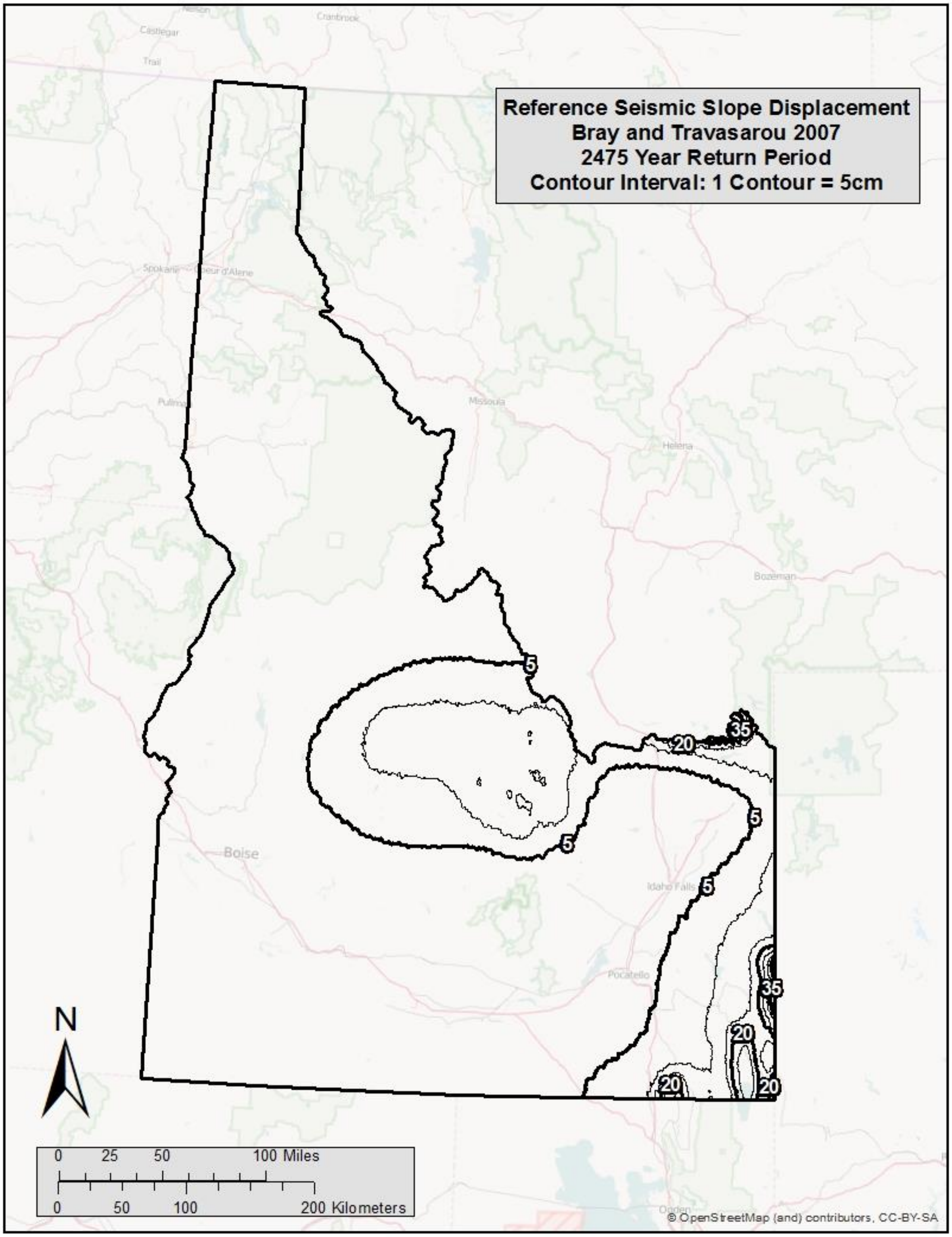

Figure E- 12 Bray and Travasarou (2007) Seismic Slope Displacement *(D^{ref})* Map for Idaho (Tr = 2,475)

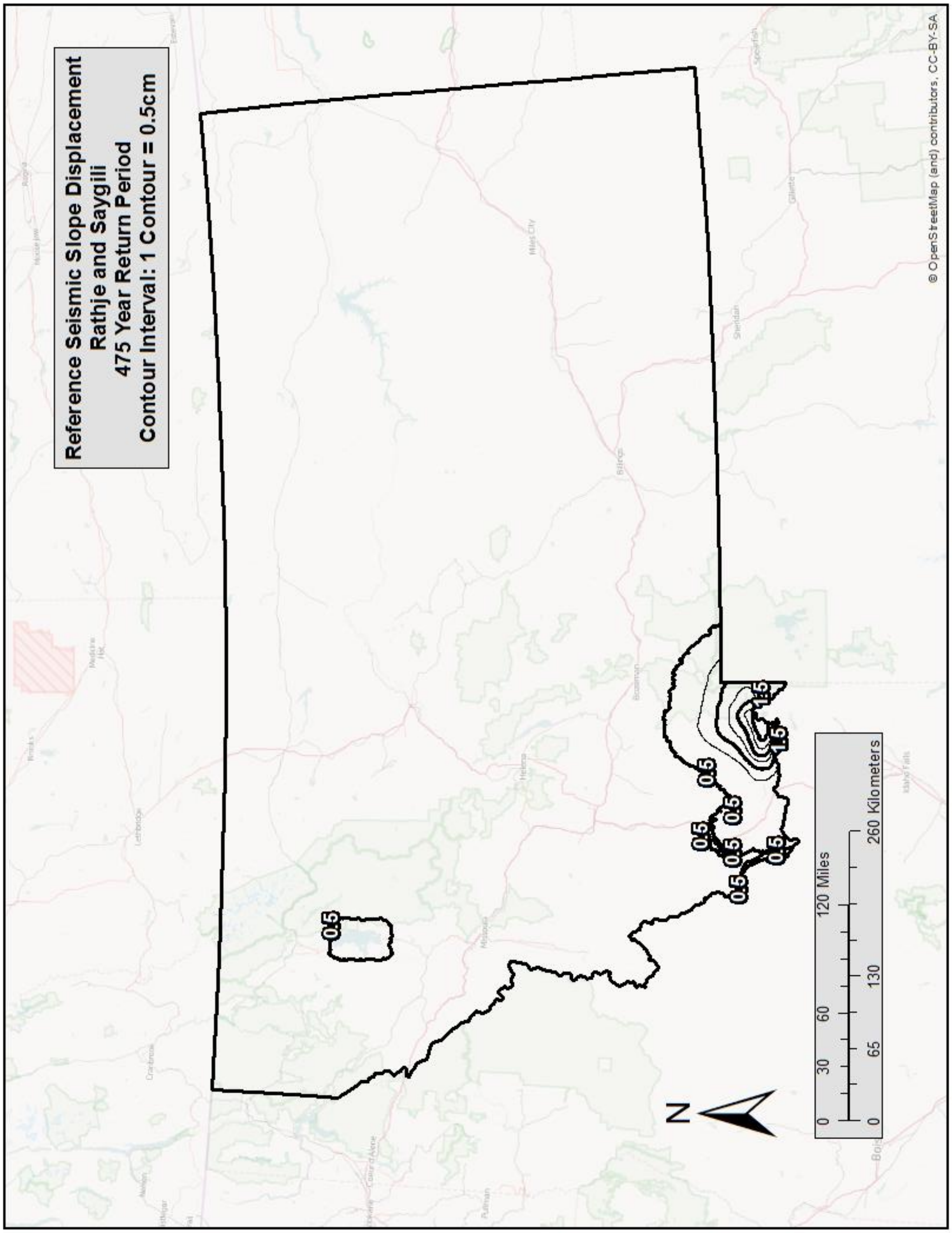

Figure E- 13 Rathje and Saygili (2009) Seismic Slope Displacement *(D^{ref})* Map for Montana (Tr = 475)

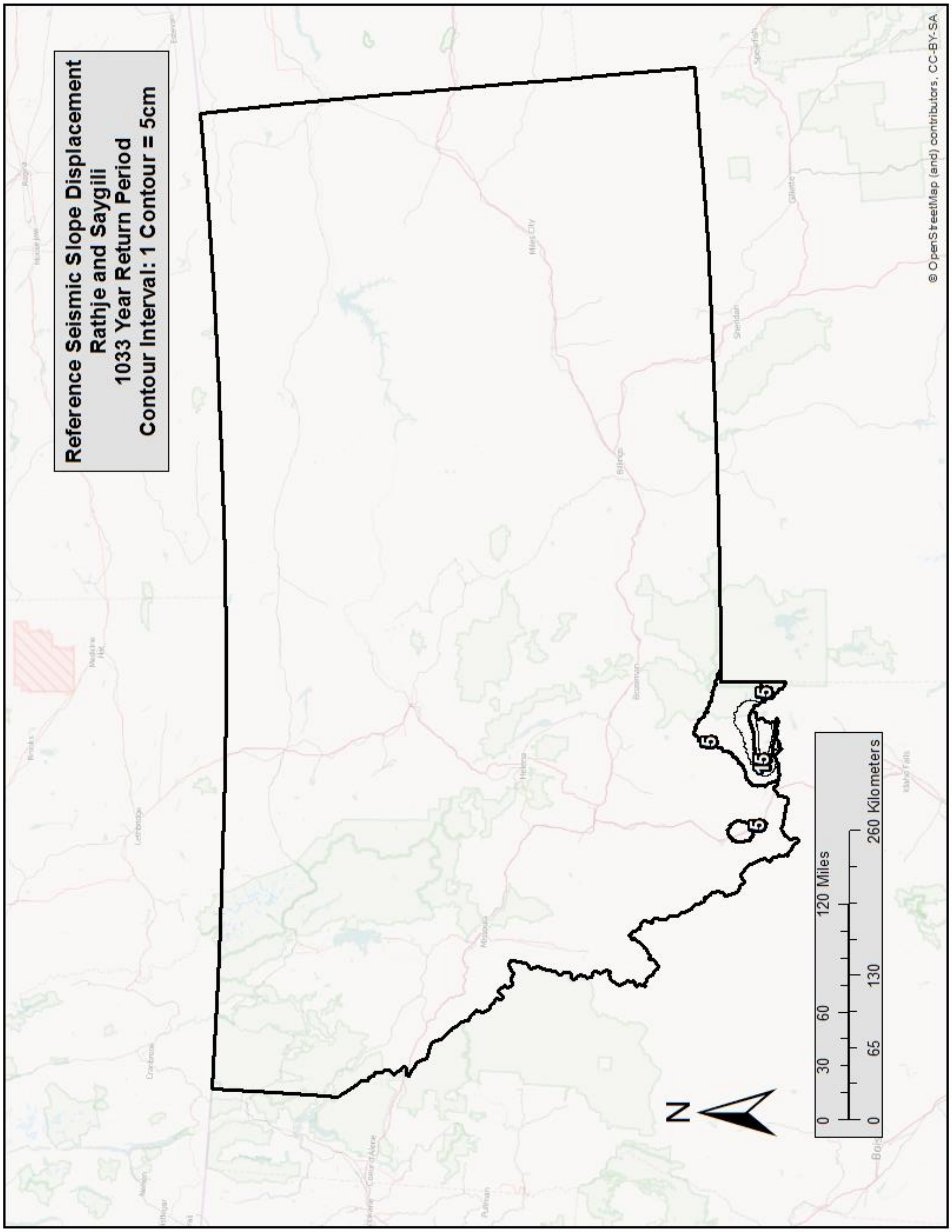

Figure E- 14 Rathje and Saygili (2009) Seismic Slope Displacement *(D ^{ref})* Map for Montana (Tr = 1,033)

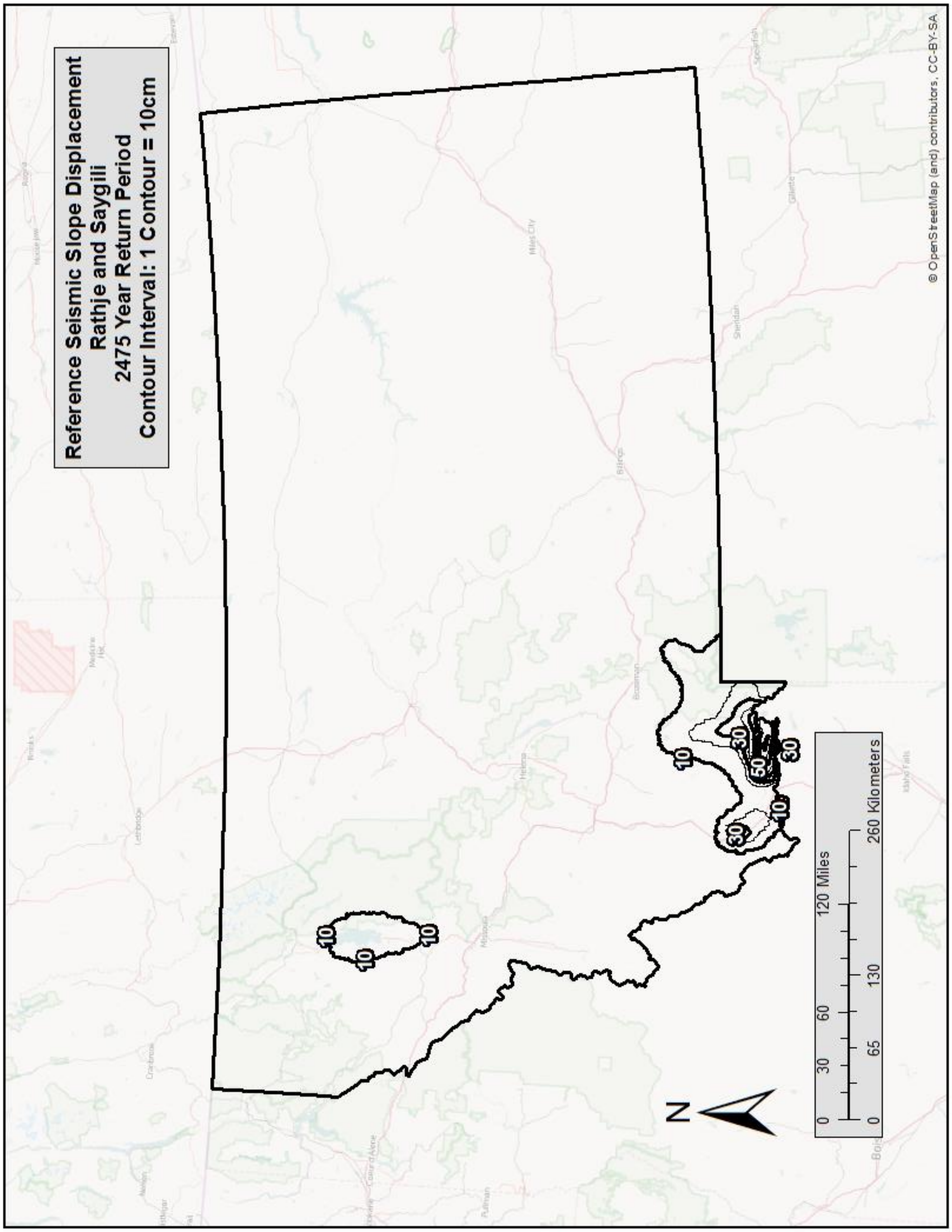

Figure E- 15 Rathje and Saygili (2009) Seismic Slope Displacement *(D^{ref})* Map for Montana (Tr = 2,475)

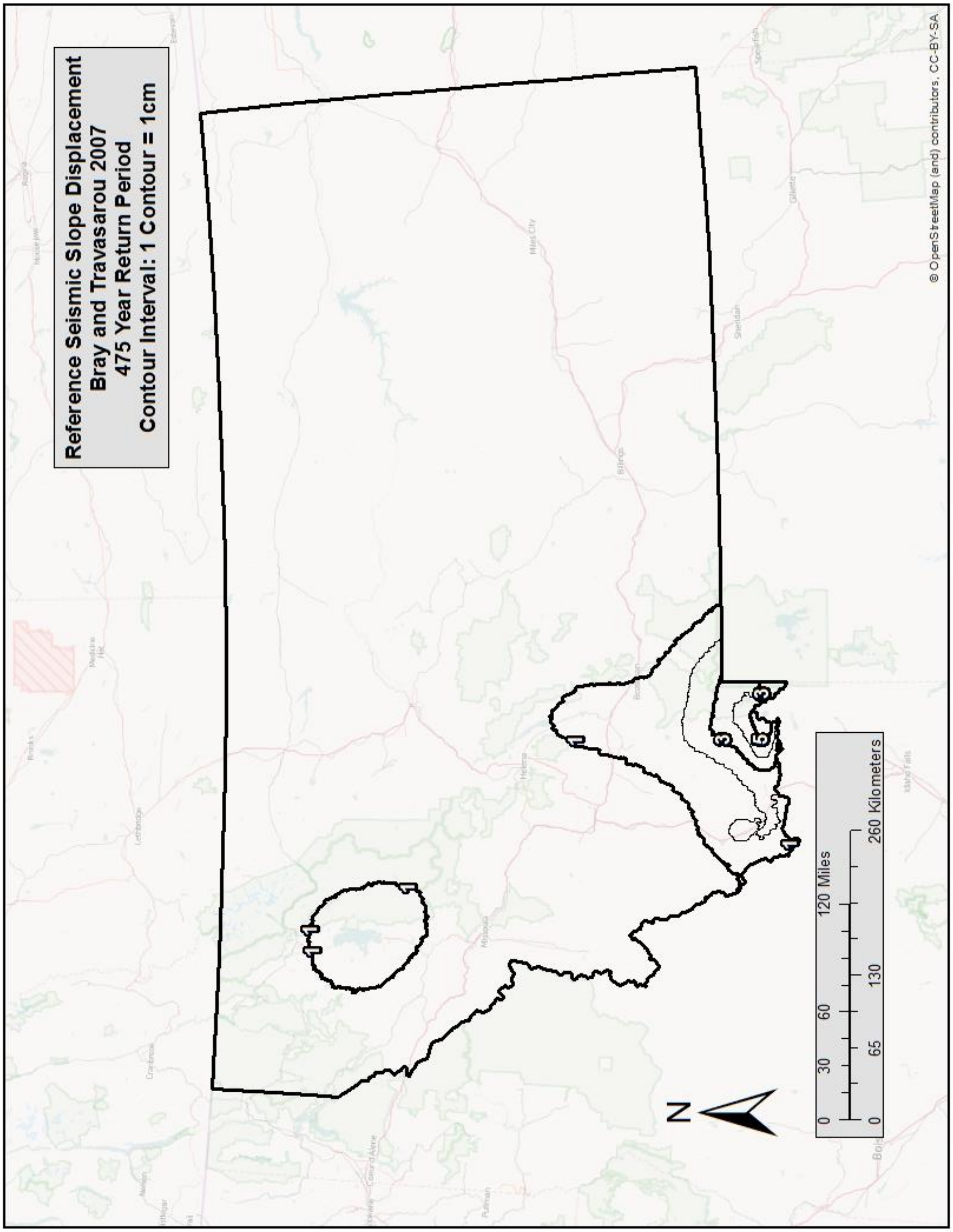

Figure E- 16 Bray and Travasarou (2007) Seismic Slope Displacement *(D^{ref})* Map for Montana (Tr = 475)

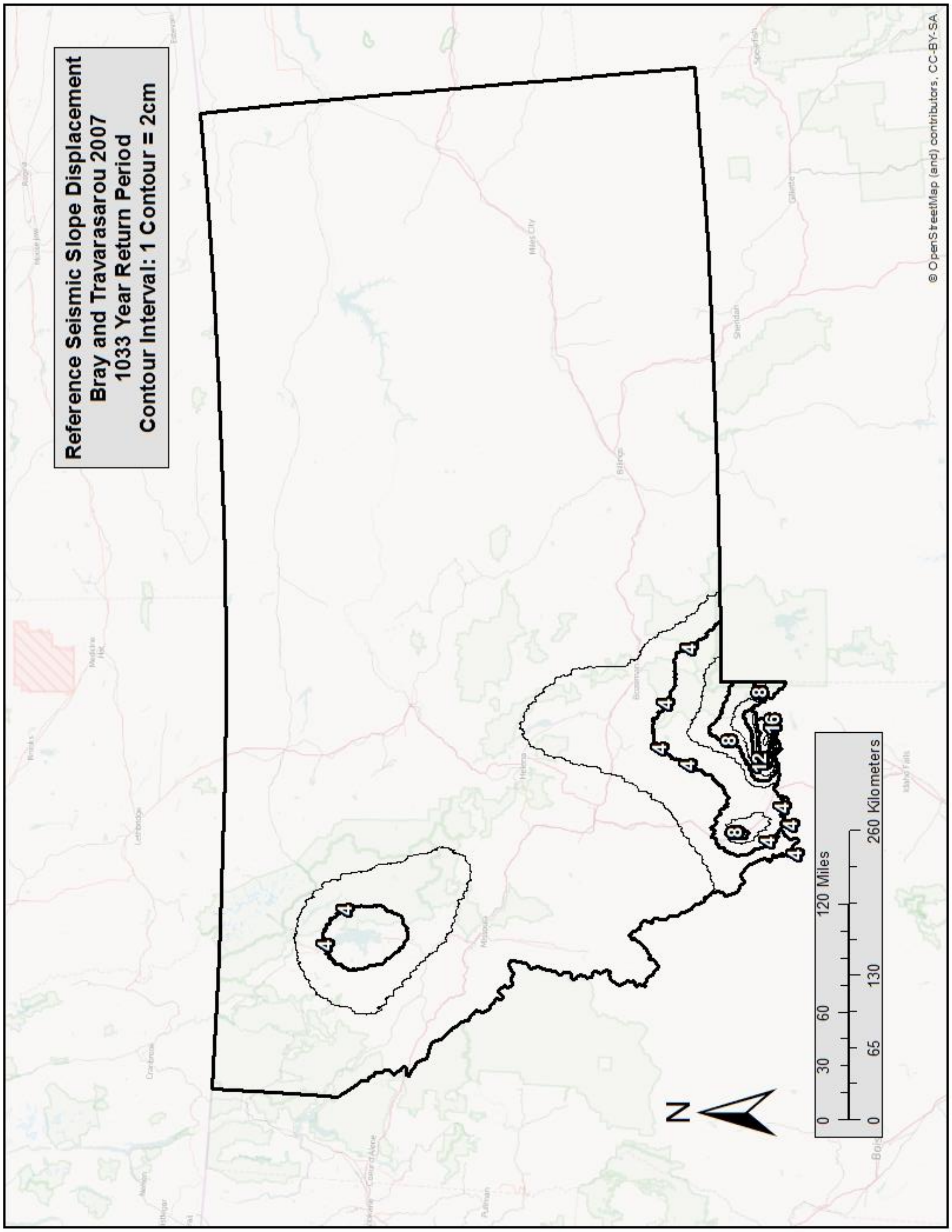

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Figure E- 17 Bray and Travasarou (2007) Seismic Slope Displacement *(D^{ref})* Map for Montana (Tr = 1,033)

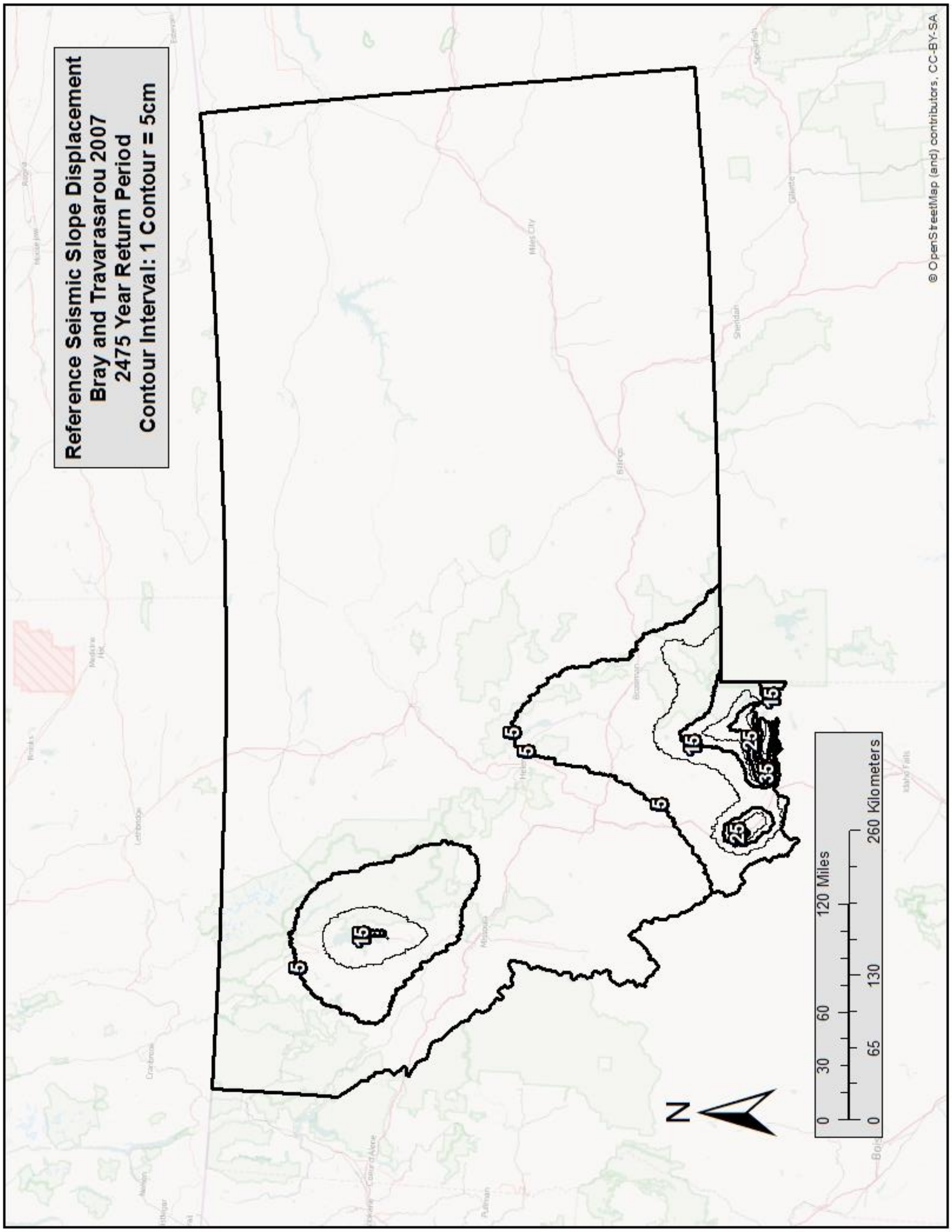

Figure E- 18 Bray and Travasarou (2007) Seismic Slope Displacement *(D^{ref})* Map for Montana (Tr = 2,475)

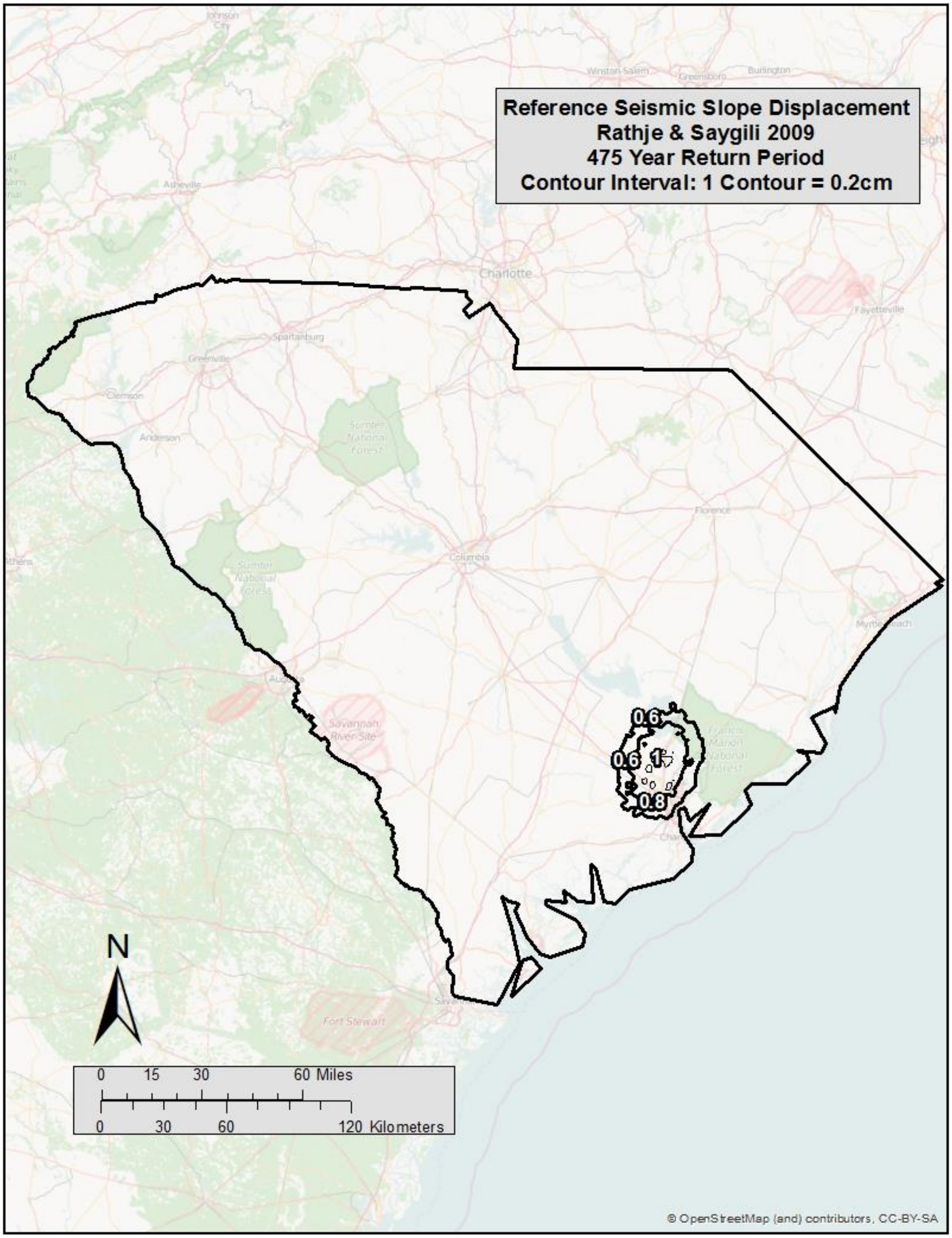

Figure E- 19 Rathje and Saygili (2009) Seismic Slope Displacement *(D^{ref})* Map for South Carolina (Tr = 475)

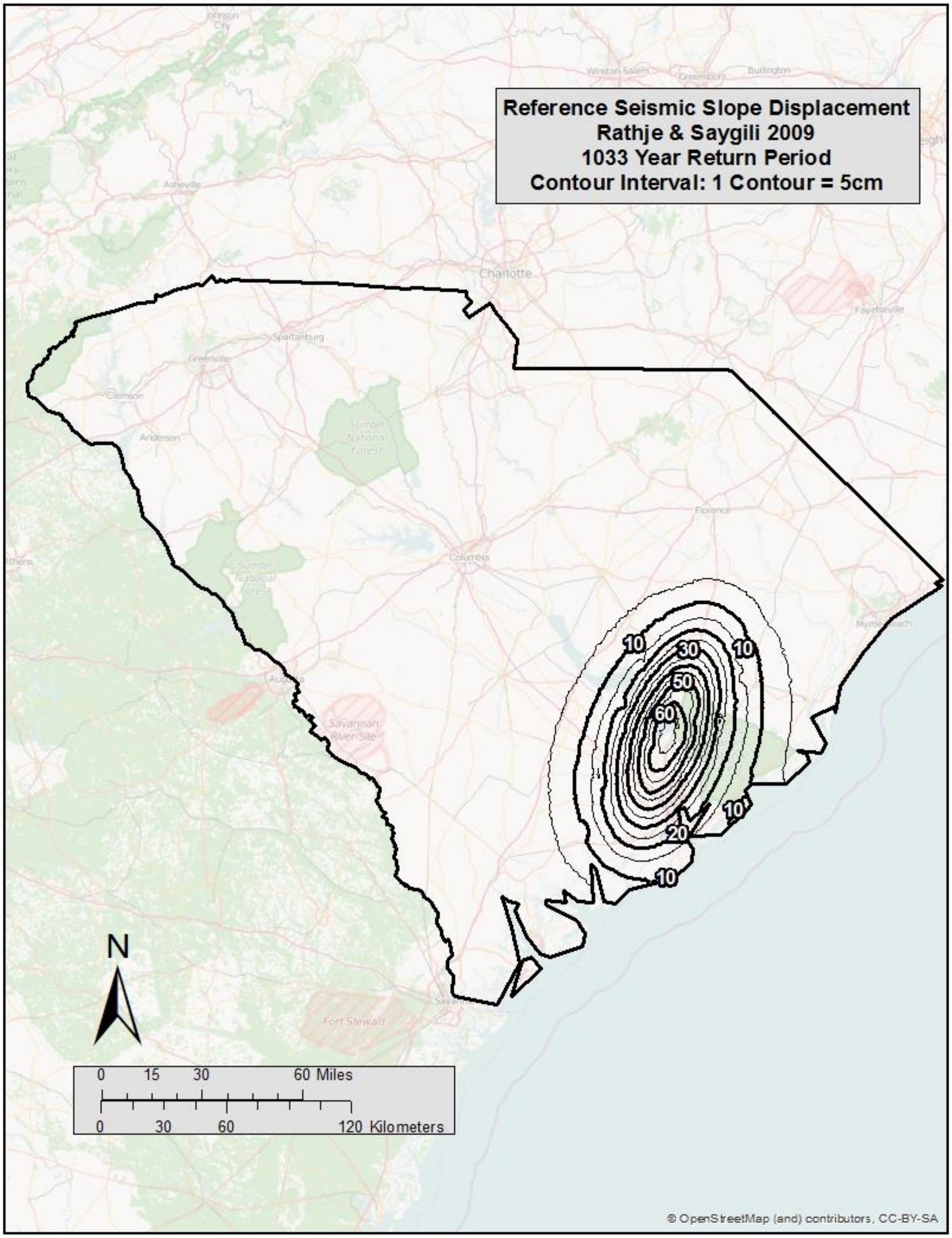

Figure E- 20 Rathje and Saygili (2009) Seismic Slope Displacement *(D^{ref})* Map for South Carolina (Tr = 1,033)

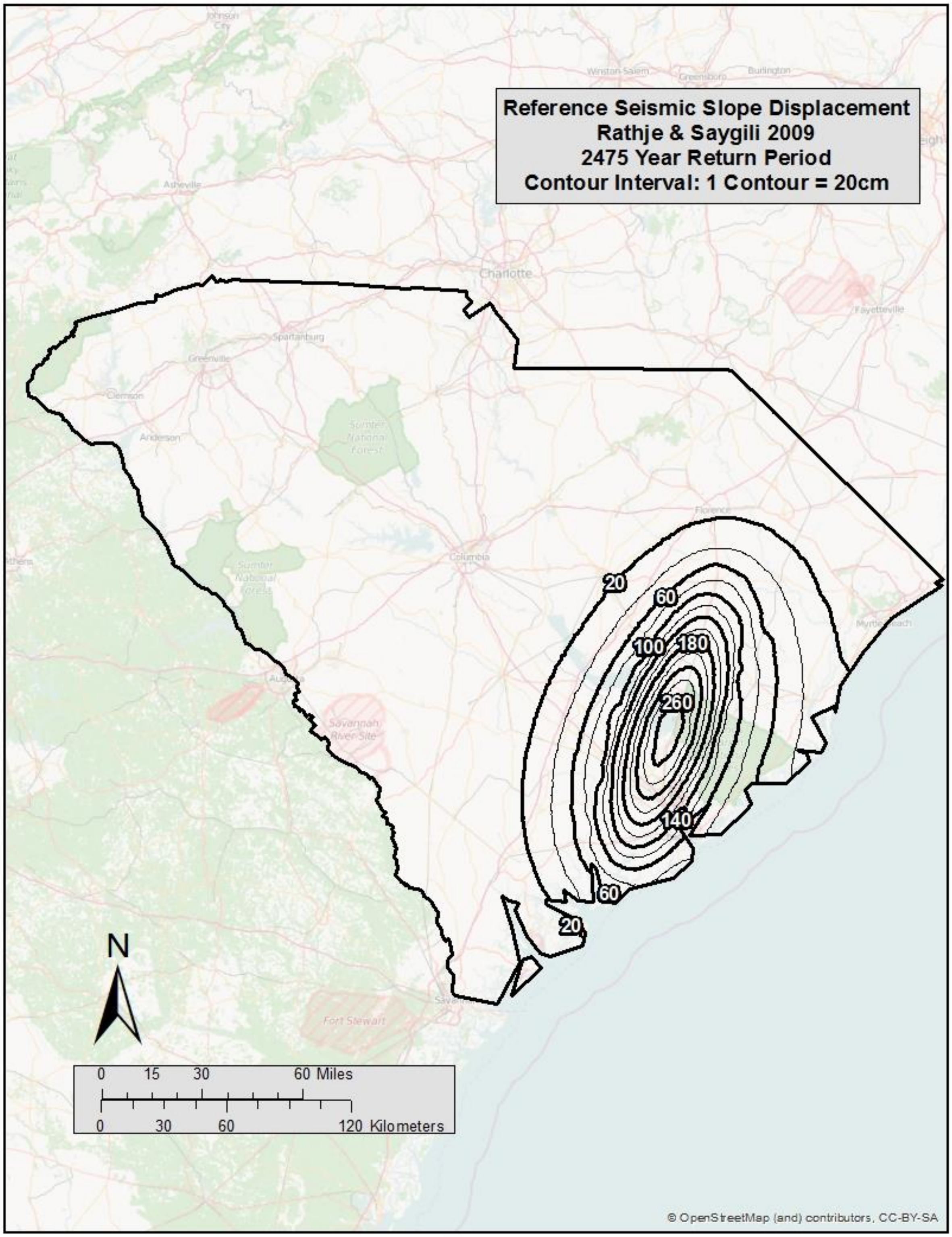

Figure E- 21 Rathje and Saygili (2009) Seismic Slope Displacement *(D^{ref})* Map for South Carolina (Tr = 2,475)

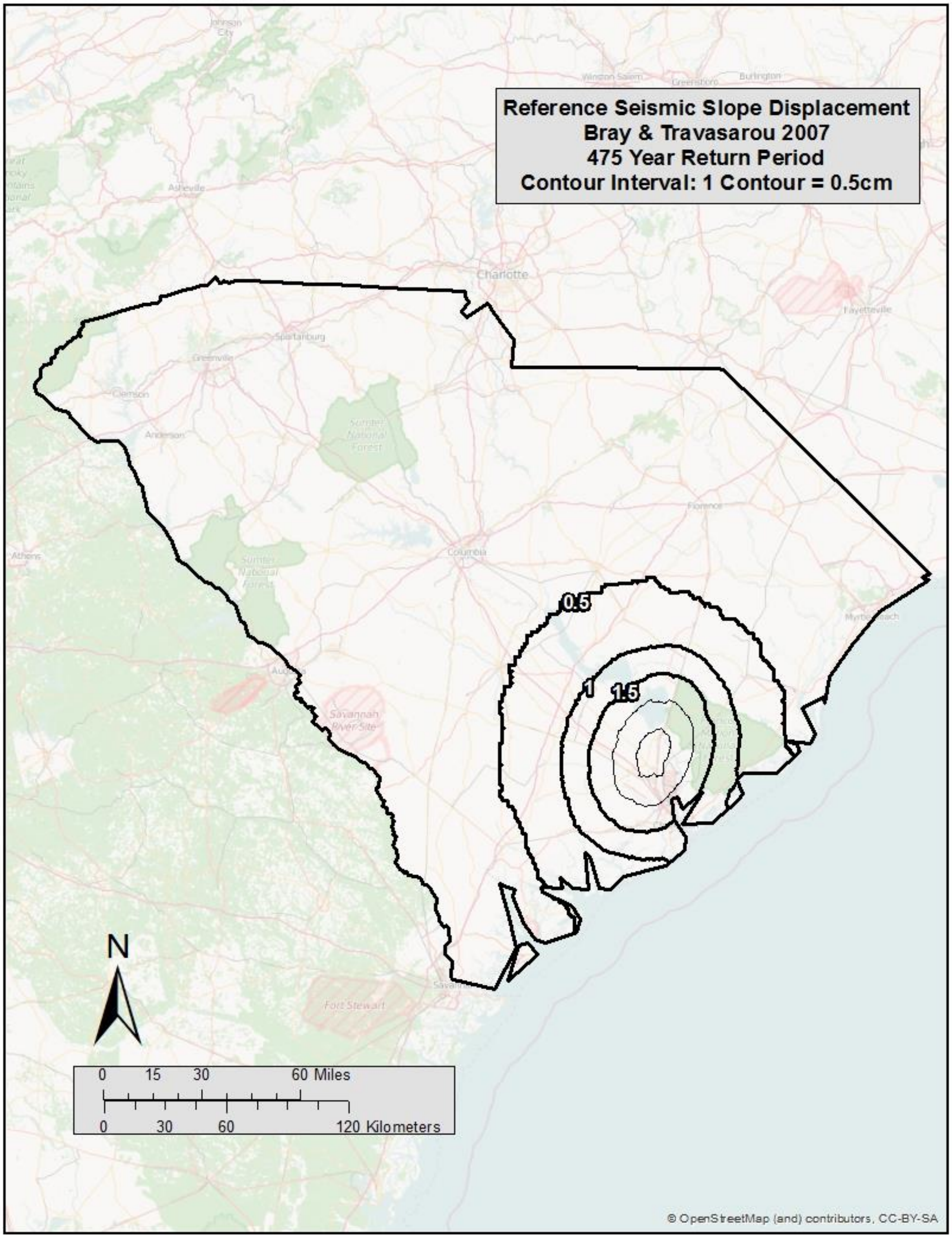

Figure E- 22 Bray and Travasarou (2007) Seismic Slope Displacement *(D^{ref})* Map for South Carolina (Tr = 475)

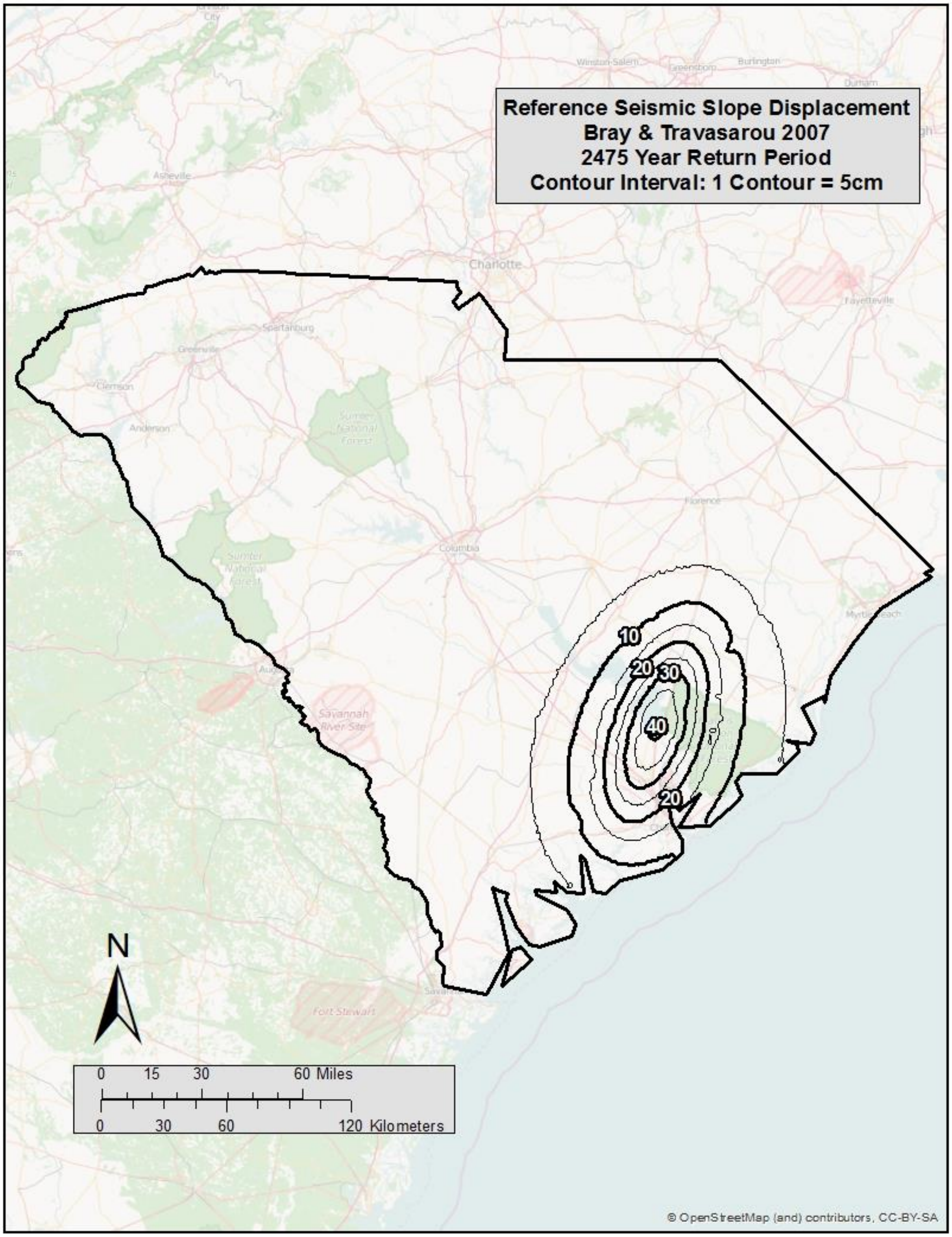

Figure E- 23 Bray and Travasarou (2007) Seismic Slope Displacement *(D^{ref})* Map for South Carolina (Tr = 1,033)

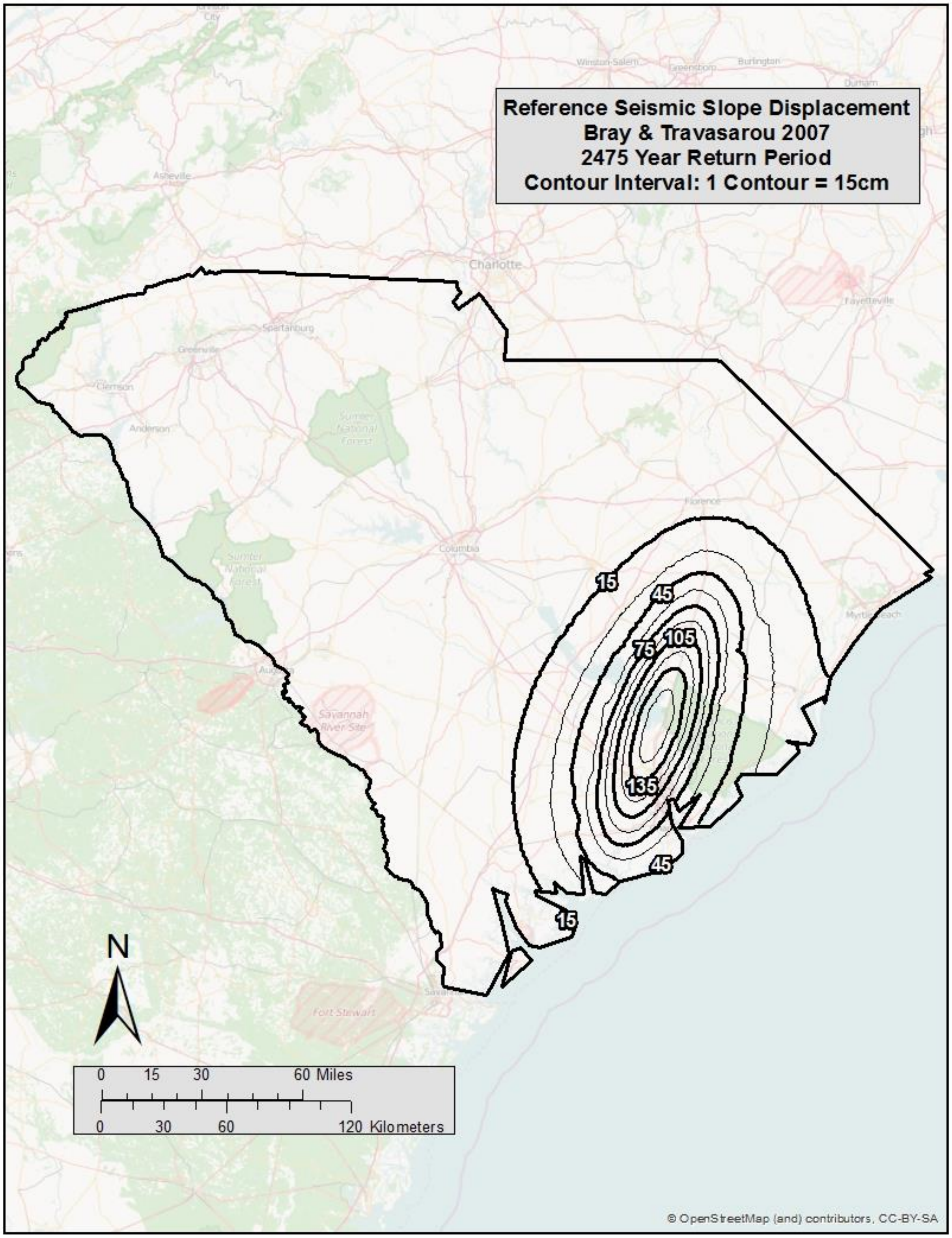

Figure E- 24 Bray and Travasarou (2007) Seismic Slope Displacement *(D^{ref})* Map for South Carolina (Tr = 2,475)

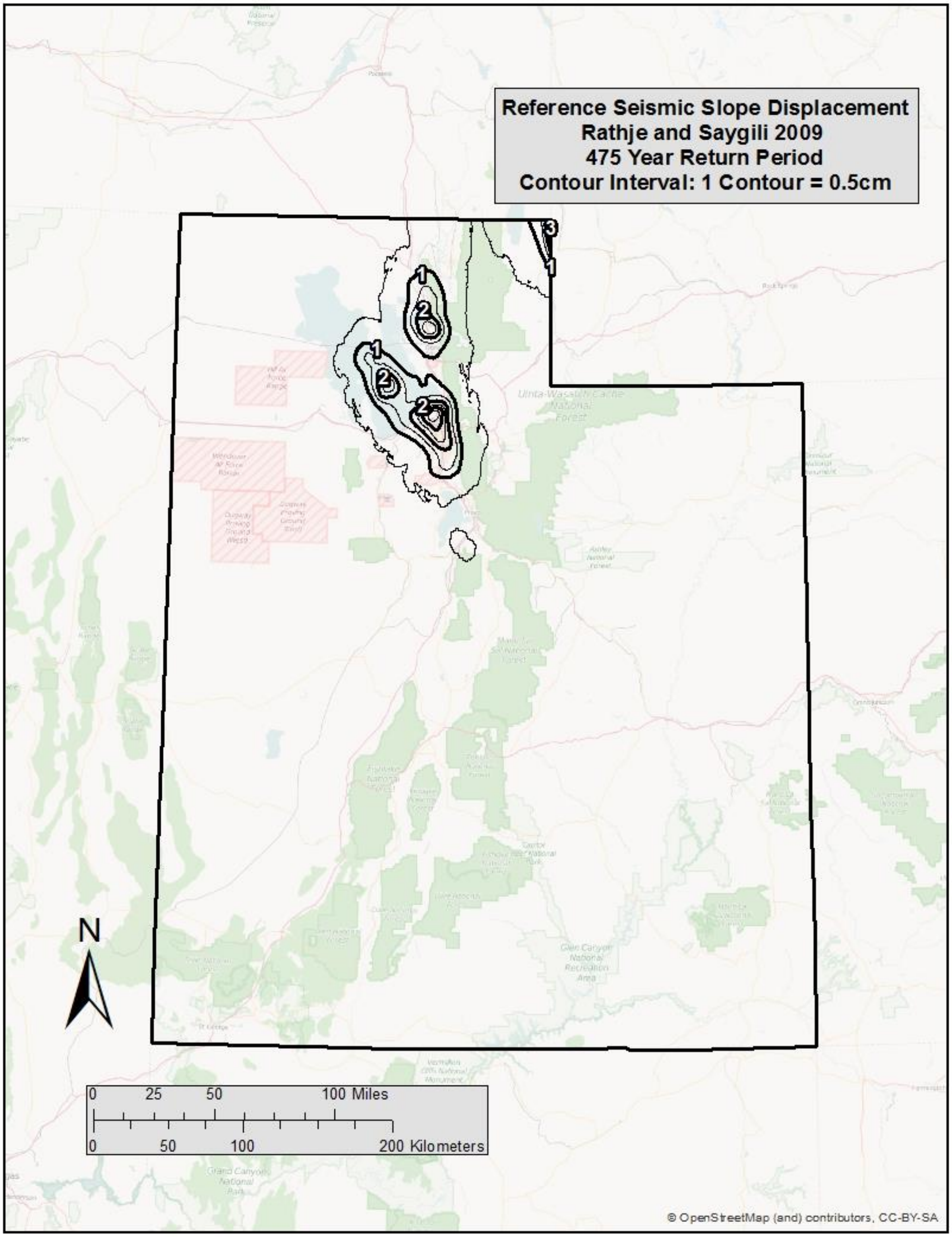

Figure E- 25 Rathje and Saygili (2009) Seismic Slope Displacement (D^{ref}) Map for Utah (Tr= 475)

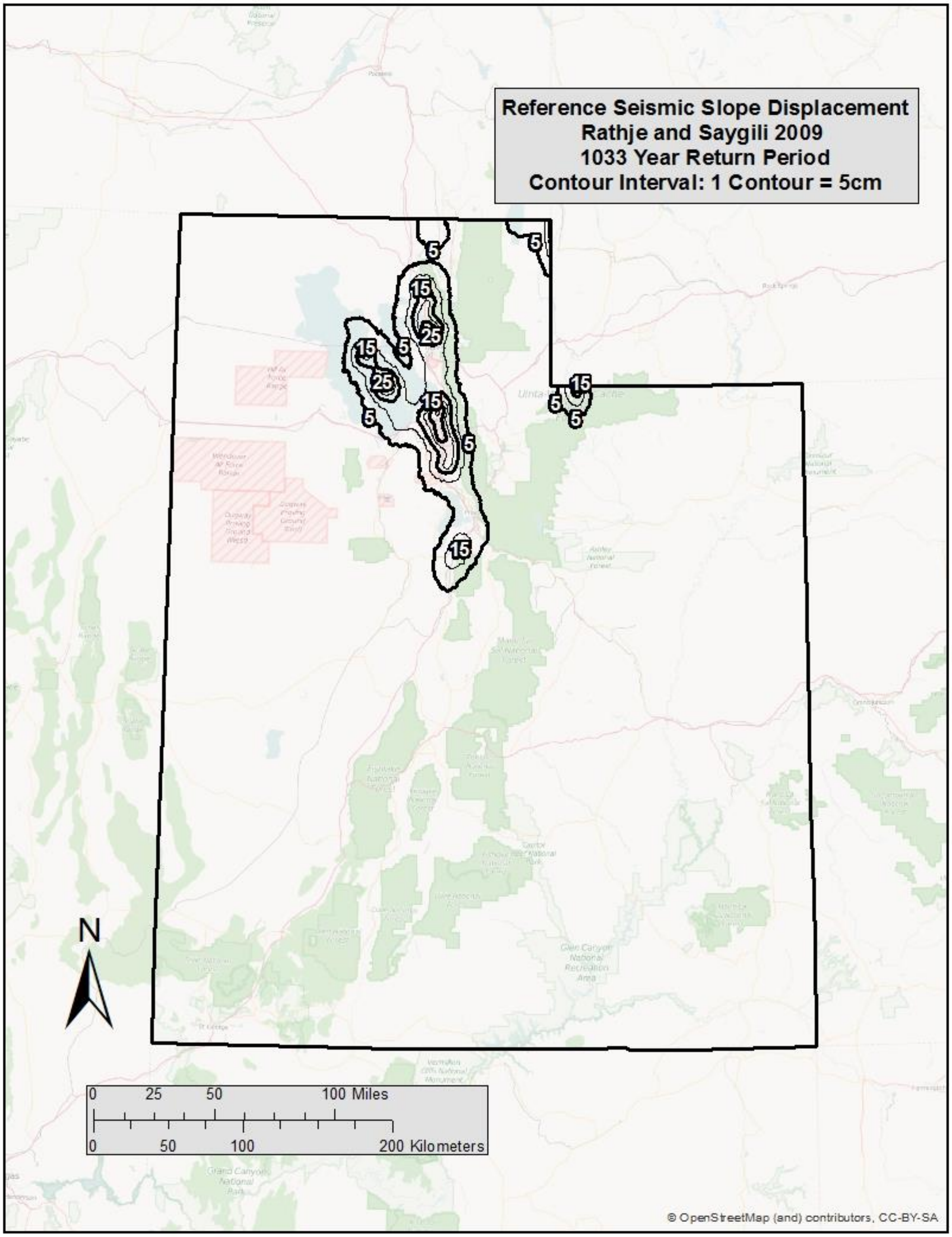

Figure E- 26 Rathje and Saygili (2009) Seismic Slope Displacement (D^{ref}) Map for Utah (Tr= 1,033)

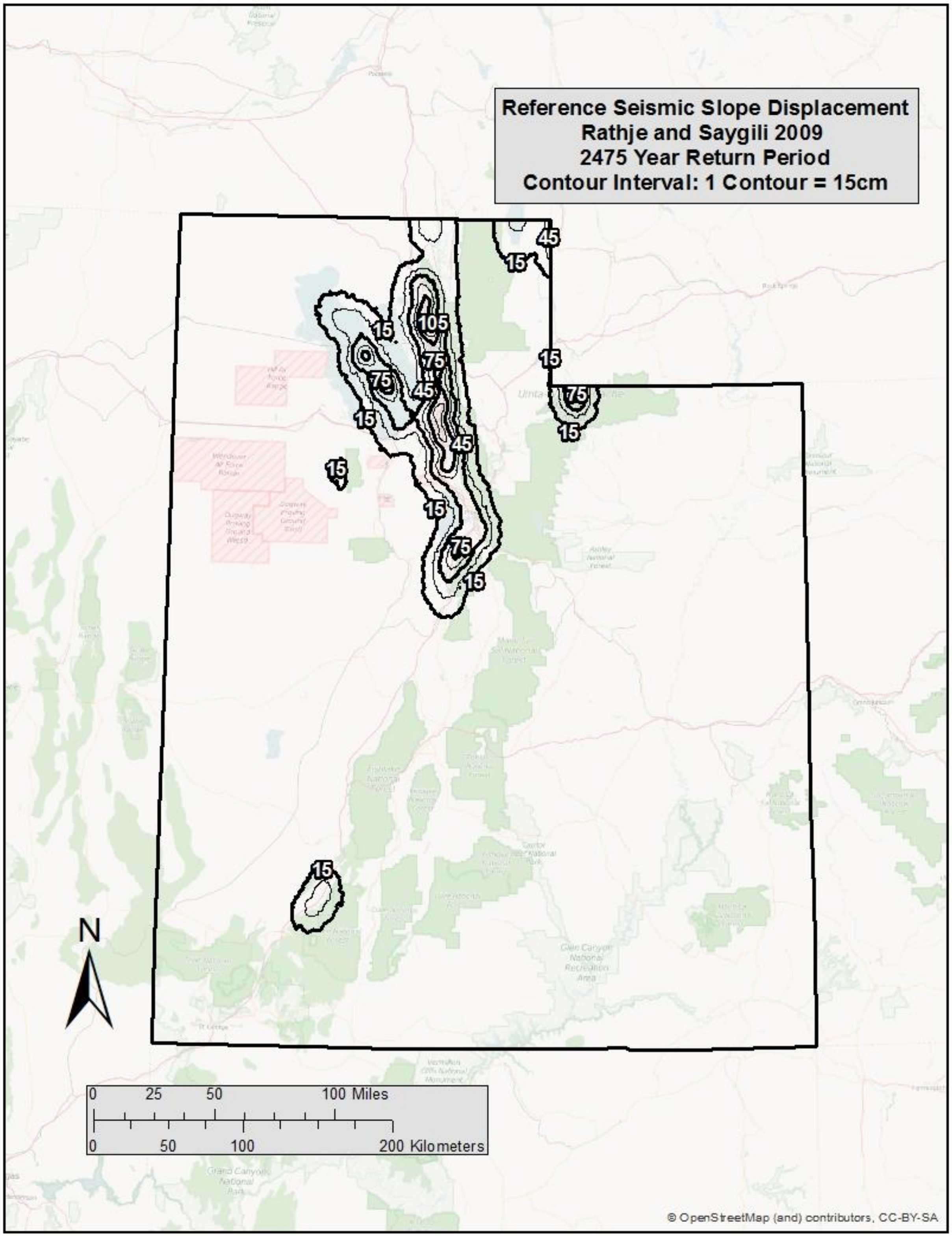

Figure E- 27 Rathje and Saygili (2009) Seismic Slope Displacement *(D^{ref})*Map for Utah (Tr= 2,475)

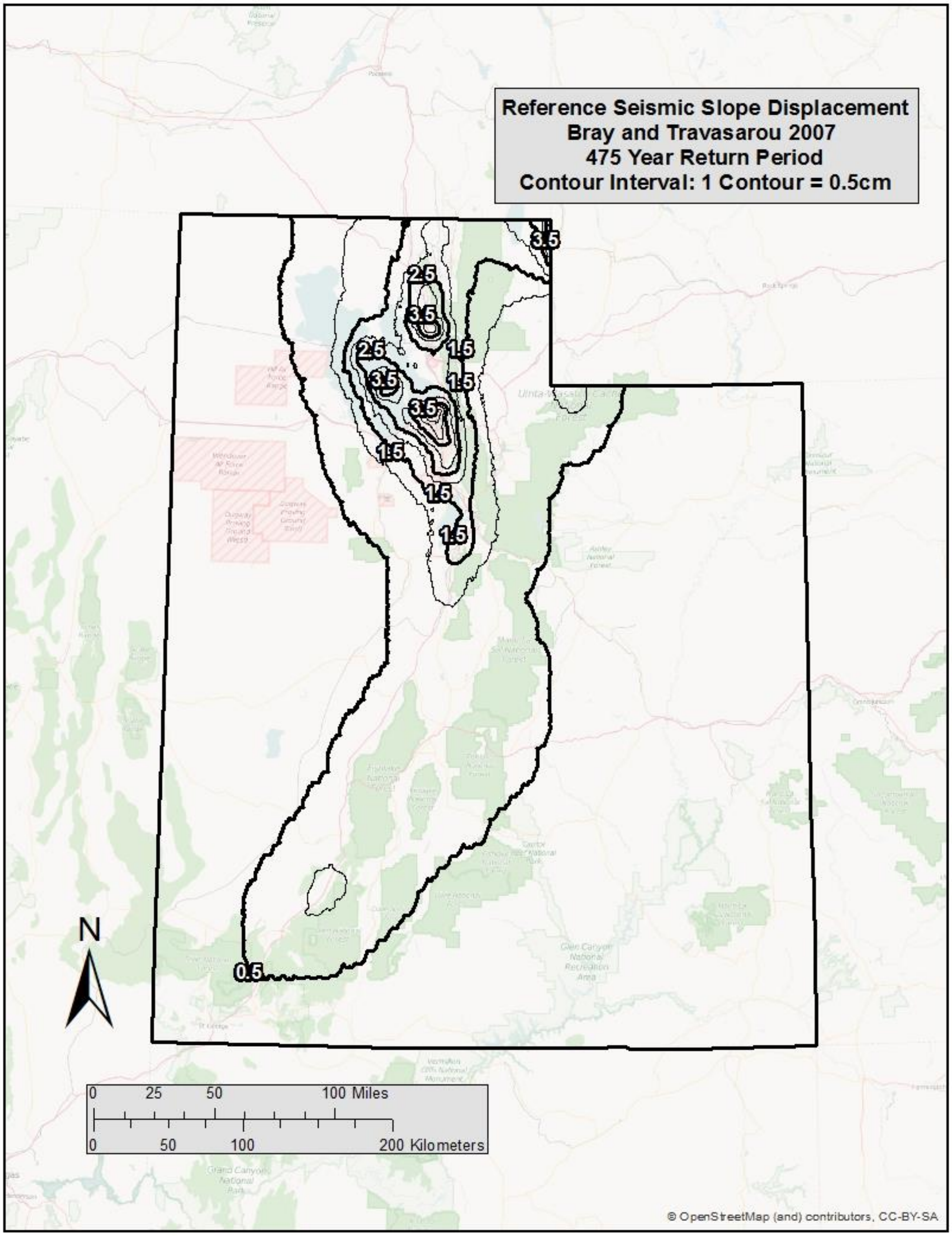

Figure E- 28 Bray and Travasarou (2007) Seismic Slope Displacement *(D^{ref})* Map for Utah (Tr = 475)

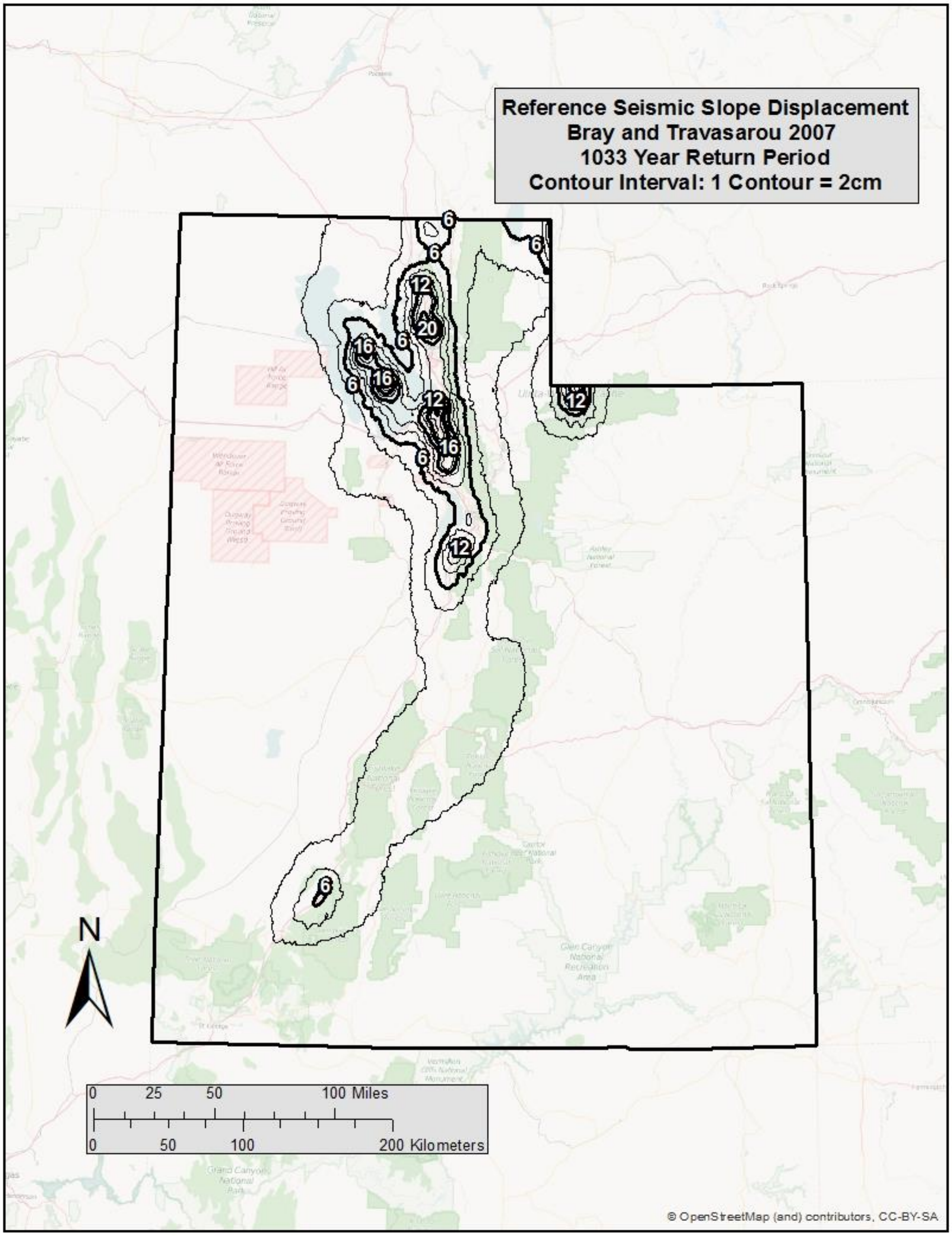

Figure E- 29 Bray and Travasarou (2007) Seismic Slope Displacement *(D^{ref})* Map for Utah (Tr = 1,033)

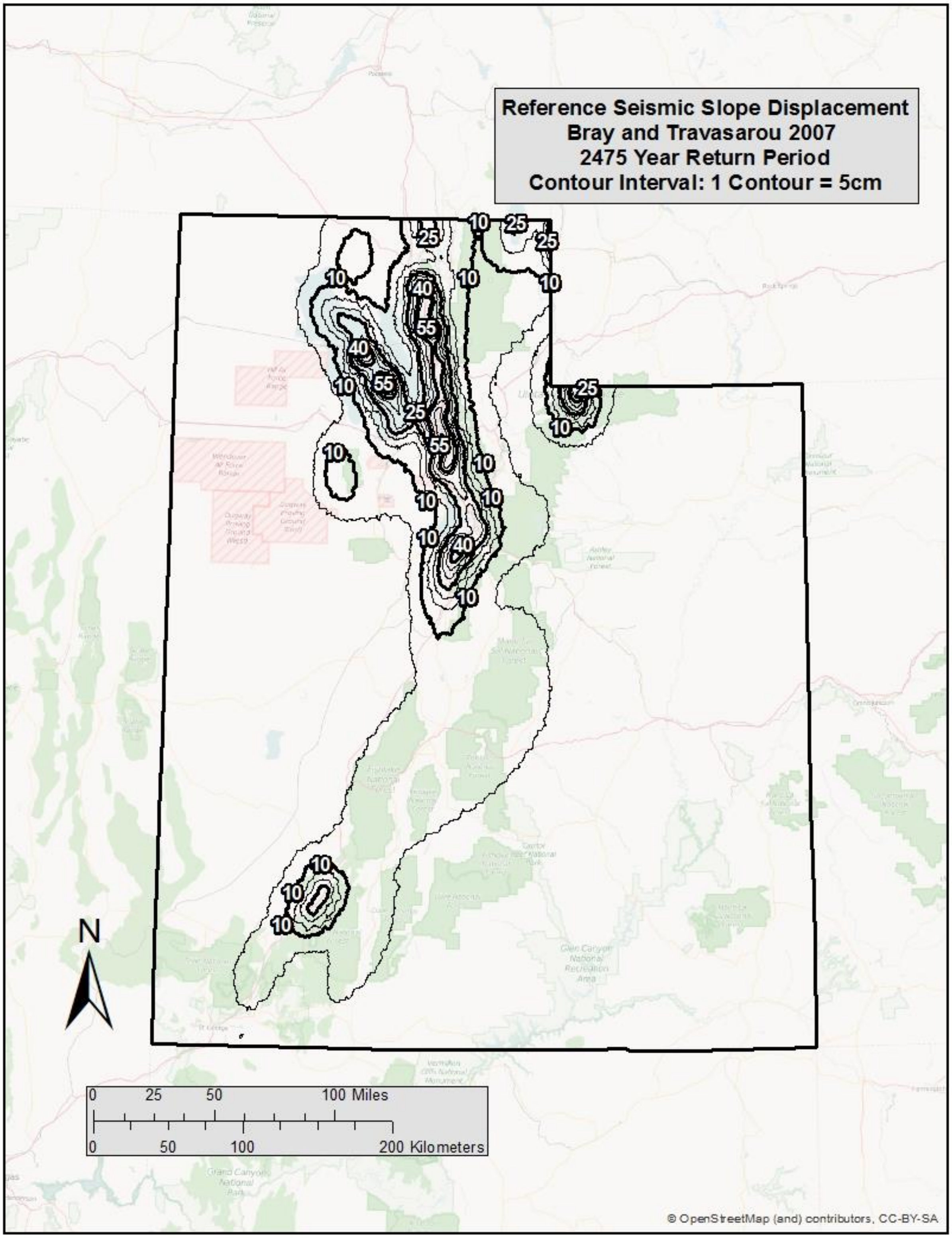

Figure E- 30 Bray and Travasarou (2007) Seismic Slope Displacement *(D^{ref})* Map for Utah (Tr = 2,475)

APPENDIX F: Deterministic Data and Rocker Fault Sample Calculations

Table F- 1 Faults Considered in Deterministic Analysis

					Median Acceleration			(Median + 1 St. Dev) Acceleration		
					T_R = 1033			T_R = 1033		
		Seismic Source	**Dist (km)**	**Mag**	***PGA***	F_{pga}	a_{max}	***PGA***	F_{pga}	a_{max}
San Francisco										
	1	Northern San Andreas	10.77	8.05	0.3175	1.183	0.3754	0.5426	1.0	0.5426
	2	San Gregorio Connected	16.64	7.5	0.2139	1.372	0.2935	0.3660	1.134	0.4150
	3	Hayward-Rodgers Creek	18.23	7.33	0.1918	1.416	0.2717	0.3282	1.172	0.3846
	4	Mount Diablo Thrust	36.08	6.7	0.1050	1.590	0.1670	0.1811	1.438	0.2604
	5	Calaveras	34.28	7.03	0.0981	1.6	0.1570	0.1682	1.464	0.2462
Salt Lake City										
	1	Wasatch Fault, SLC Section	1.02	7	0.5911	1.0	0.5911	1.0050	1.0	1.0050
	2	West Valley Fault Zone	2.19	6.48	0.5694	1.0	0.5694	0.9842	1.0	0.9842
	3	Morgan Fault	25.04	6.52	0.0989	1.6	0.1583	0.1713	1.457	0.2497
	4	Great Salt Lake Fault zone, Antelope Section	25.08	6.93	0.1016	1.597	0.1622	0.1742	1.452	0.2529
	5	Oquirrh-Southern, Oquirrh Mountain Fault	30.36	7.17	0.0958	1.6	0.1532	0.1641	1.472	0.2415
Butte										
	1	Rocker Fault	4.92	6.97	0.5390	1.0	0.5390	0.9202	1.0	0.9202
	2	Georgia Gulch Fault	45.91	6.42	0.0435	1.6	0.0696	0.0754	1.6	0.1206
	3	Helena Valley Fault	75.56	6.6	0.0294	1.6	0.0470	0.0507	1.6	0.0812
	4	Canyon Ferry Fault	81.32	6.92	0.0327	1.6	0.0523	0.0561	1.6	0.0898
	5	Blacktail Fault	84.27	6.94	0.0317	1.6	0.0508	0.0545	1.6	0.0872
	6	Madison Fault	86.51	7.45	0.0420	1.6	0.0671	0.0719	1.6	0.1150

Table F- 2 Characteristics of Rocker Fault (near Butte) and Calculations to Determine *PGA* and M_w.

*M_w calculated based on
Wells and Coppersmith (1994): Length = 43 km
(Use "all" slip type, because it's a normal fault and the # of normal events is small)

*PGA calculated based on NGA equations (Linda Al Atik, PEER 2009)
BA08, CB08, and CY08 used with equal weighting

M_w =	6.97		
Dip =	70	degrees	(Another fault near Butte, has a dip of 70-75 degrees)
Depth to bottom of rupture =	16	km	(Assumed)
R_x =	4.92	km	(measured using Google Earth)
Z_TOR =	0	km	(Assumed)
Width =	17.03	km	
R_jb =	0	km	(Assuming the site is on the hanging wall side)
R_rup =	1.68	km	
V_s30 =	760	m/s	
U=	0		
F_RV=	0		
F_NM =	1		
F_HW =	1		
F_measured =	0		
Z_1 =	DEFAULT		
Z_2.5=	DEFAULT		
F_AS=	0		
HW Taper =	1		
--> PGA (50%) =	0.5390	g	(From NGA spreadsheet)
--> PGA (84%) =	0.9202	g	(From NGA spreadsheet)