TERRA ASSOCIATES, Inc.
Consultants in Geotechnical Engineering, Geology
and
Environmental Earth Sciences

April 10, 2015
Project No. T-6930

Mr. Terry Caffey
227 Bellevue Way NE, #174
Bellevue, Washington 98004

Subject: Off-Site Slope Evaluation
Duke's Landing
NE 47th Street
Redmond, Washington

Reference: Geotechnical Report, Duke's Landing, Project No. T-6930, prepared by Terra Associates, Inc., dated December 8, 2014

Dear Mr. Caffey:

As requested by Eric LaBrie of ESM Consulting Engineers, LLC, we performed a geotechnical evaluation of the off-site slope area located immediately west and north of the southwestern corner of the subject property. The purpose of our work was to determine if the slope conditions meeting criteria defining a landslide hazard area per the Redmond Zoning Code (RZC) are present, and to determine an appropriate buffer width from the LHA if present.

OBSERVATIONS

The off-site slope area is a predominantly east-northeast facing hillside forming the back yards of three residences located immediately west of the Duke's Landing site. Based on our observations and field measurements using hand instruments, we estimate that the slope areas are generally about 10 to 20 feet high with inclinations that are typically flatter than 40 percent. The exception to this is a localized north-facing slope area approximately 60 feet to 80 feet north of the southwestern property corner, which we estimated to be inclined at about 45 to 60 percent. We did not observe any indications of instability, significant erosion, or groundwater seepage on the slope areas.

We investigated soil conditions on the slope by hand excavating a shallow test hole adjacent to the west property margin. The soils observed in the test hole generally consist of medium dense to dense fine sandy silt to silty fine sand, which is consistent with the dense to very dense, glacially-consolidated silt observed in nearby Test Pits TP-5 and TP-6 of our referenced geotechnical study. The slope areas are generally vegetated with brush and scattered mature deciduous and coniferous trees. We observed an old-growth stump and several relatively-straight and large-diameter conifers growing on the slope.

DISCUSSION

Section 21.64.060A.1.b of the RZC defines landslide hazard areas as "...areas potentially subject to significant or severe risk of landslides based on a combination of geologic, topographic, and hydrogeologic factors.

They include areas susceptible because of any combination of bedrock, soil, slope, slope aspect, structure, hydrology, or other factors. They are areas of the landscape that are at a high risk of failure or that presently exhibit downslope movement of soil and/or rocks and that are separated from the underlying stationary part of the slope by a definite plane of separation. The plane of separation may be thick or thin and may be composed of multiple failure zones depending on local conditions, including soil type, slope gradient, and groundwater regime." Landslide hazard areas include the following:

i. Areas of historic failures, such as:

   a. Areas designated as quaternary slumps or landslides on maps published by the United States Geologic Survey (USGS).

   b. Those areas designated by the United States Department of Agriculture (USDA) Soil Conservation Service (SCS) as having a "severe" limitation for building site development.

ii. Areas containing a combination of slopes steeper than 15 percent, springs or groundwater seepage, and hillsides intersecting geologic contacts with a relatively permeable sediment overlying a relatively impermeable sediment or bedrock.

iii. Areas that have shown movement during the Holocene epoch (from 10,000 years ago to the present) or which are underlain or covered by mass wastage debris of that epoch.

iv. Slopes that are parallel or subparallel to planes of weakness in subsurface materials.

v. Slopes having gradients steeper than 80 percent subject to rockfall during seismic shaking.

vi. Areas potentially unstable as a result of rapid stream incision, stream bank erosion, and undercutting by wave action.

vii. Any area with a slope 40 percent or steeper with a vertical relief of 10 feet or more.

As discussed, the localized north-facing slope area located adjacent to the west property margin, approximately 60 feet to 80 feet north of the southwestern property corner, is greater than 10 feet in height with an inclination that we estimated to be about 45 to 60 percent. The geometry of this slope area meets the criteria for a landslide hazard area given in above Item vii. The approximate location of this slope area is shown on Figure 1.

Section 21.64.060B.2 of the RZC states that a minimum buffer width of 50 feet shall be applied to the top, toe, and sides of a landslide hazard area. However, per RZC Section 21.64.060B.3, the buffer may be reduced to a minimum width of 15 feet provided a qualified professional demonstrates through technical studies that the reduction will adequately protect the proposed and surrounding development from the critical landslide hazard.

Given our observations, it is our opinion that a 15-foot buffer would adequately mitigate any potential hazard associated with the landslide hazard area provided that conditions on and above the slope, including drainage, do not change from existing conditions. The use of the reduced buffer width is supported by the results of our slope stability analysis discussed below.

Stability Analysis

We performed stability analyses of the steep slope area using the computer program WINSTABL. The slope model and soil parameters used for our analyses are based on our estimate of slope geometry and our past experience with similar soils. The parameters used are shown on the attached WINSTABL output report.

Analyses were performed on a section line identified on Figure 1 as Section A-A' for both static and pseudostatic (seismic) conditions for the existing slope. The pseudostatic analysis used a horizontal earthquake coefficient value of 0.15g to model ground motions expected from a severe earthquake. The seismic acceleration of 0.15g was based on current USGS seismic hazard maps for a seismic event having a 10 percent probability of exceedance in a 50-year period. The USGS map indicates the subject site is located within an area where the peak horizontal ground acceleration for this return period is expected to range between 0.25g and 0.3g. Our analysis considered a horizontal acceleration equal to one-half the maximum value of this range. The lowest safety factors determined by our analyses are presented in the following table:

Section Analyzed	Minimum Safety Factors	
	Static	Pseudostatic
A-A'	3.42	2.56

The results of the stability analyses indicate that the slope is stable with respect to deep-seated failure under static and pseudostatic conditions. The safety factors listed above are higher than the minimum safety factors considered acceptable for stable slopes by local geotechnical engineering practice.

LIMITATIONS

We prepared this report in accordance with generally accepted geotechnical engineering practices. No other warranty, expressed or implied, is made. This report is the copyrighted property of Terra Associates, Inc., and is intended for specific application to the Duke's Landing project in Redmond, Washington, and for the exclusive use of Mr. Terry Caffey and his authorized representatives.

Sincerely yours,
TERRA ASSOCIATES, INC.

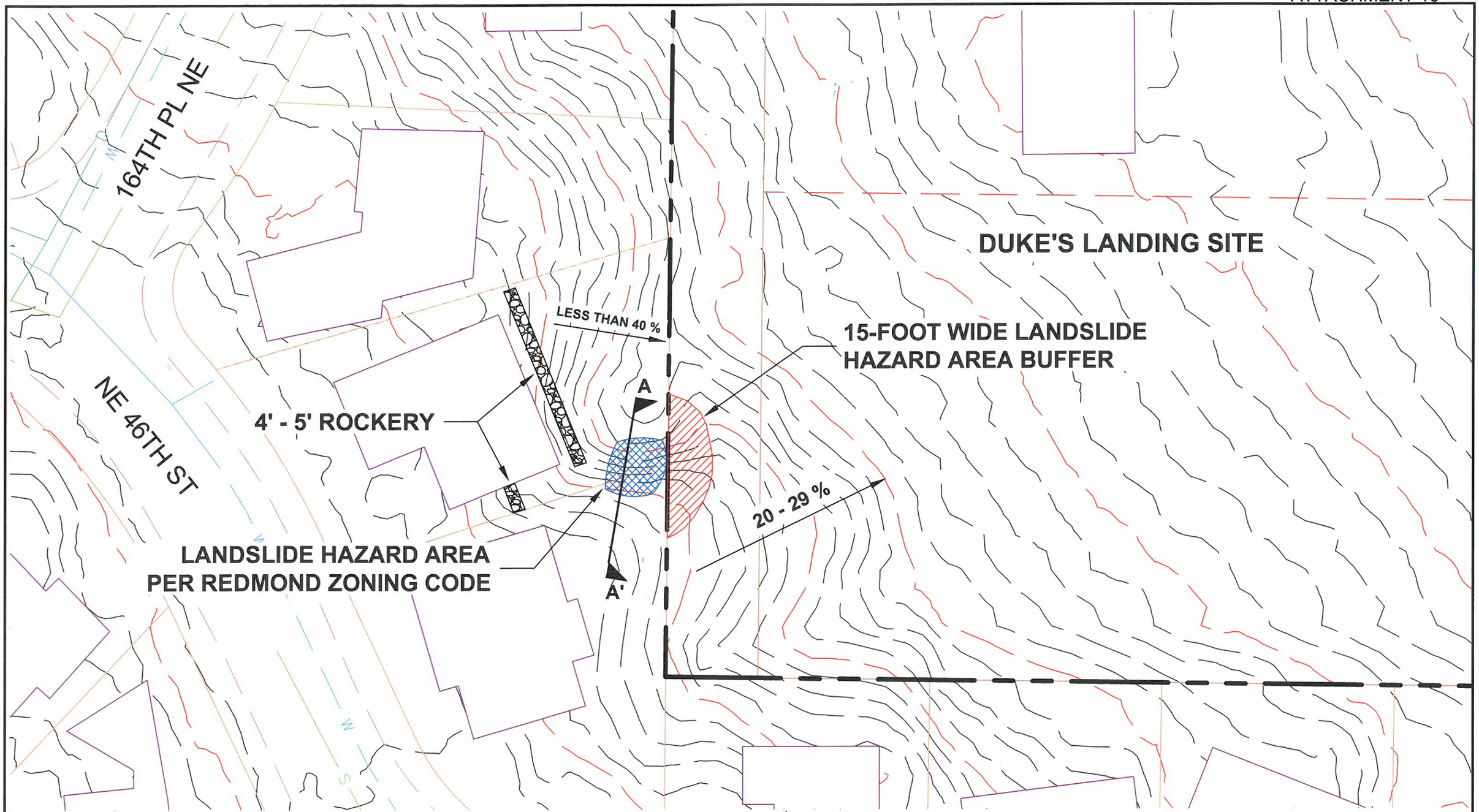
State of Washington
Engineering Geologist
1218
Licensed Geologist
JOHN C. SADLER

4-10-15

John C. Sadler, L.E.G., L.H.G.
Project Manager/Engineering Geologist

Encl: Figure 1 – Off-Site Slope Evaluation Plan
WINSTABL Output

cc: Mr. Evan Mann, ESM Consulting Engineers, LLC



NOTE:

THIS SITE PLAN IS SCHEMATIC. ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE. IT IS INTENDED FOR REFERENCE ONLY AND SHOULD NOT BE USED FOR DESIGN OR CONSTRUCTION PURPOSES.

REFERENCE:

ESM CONSULTING ENGINEERS, LLC

0 30 60

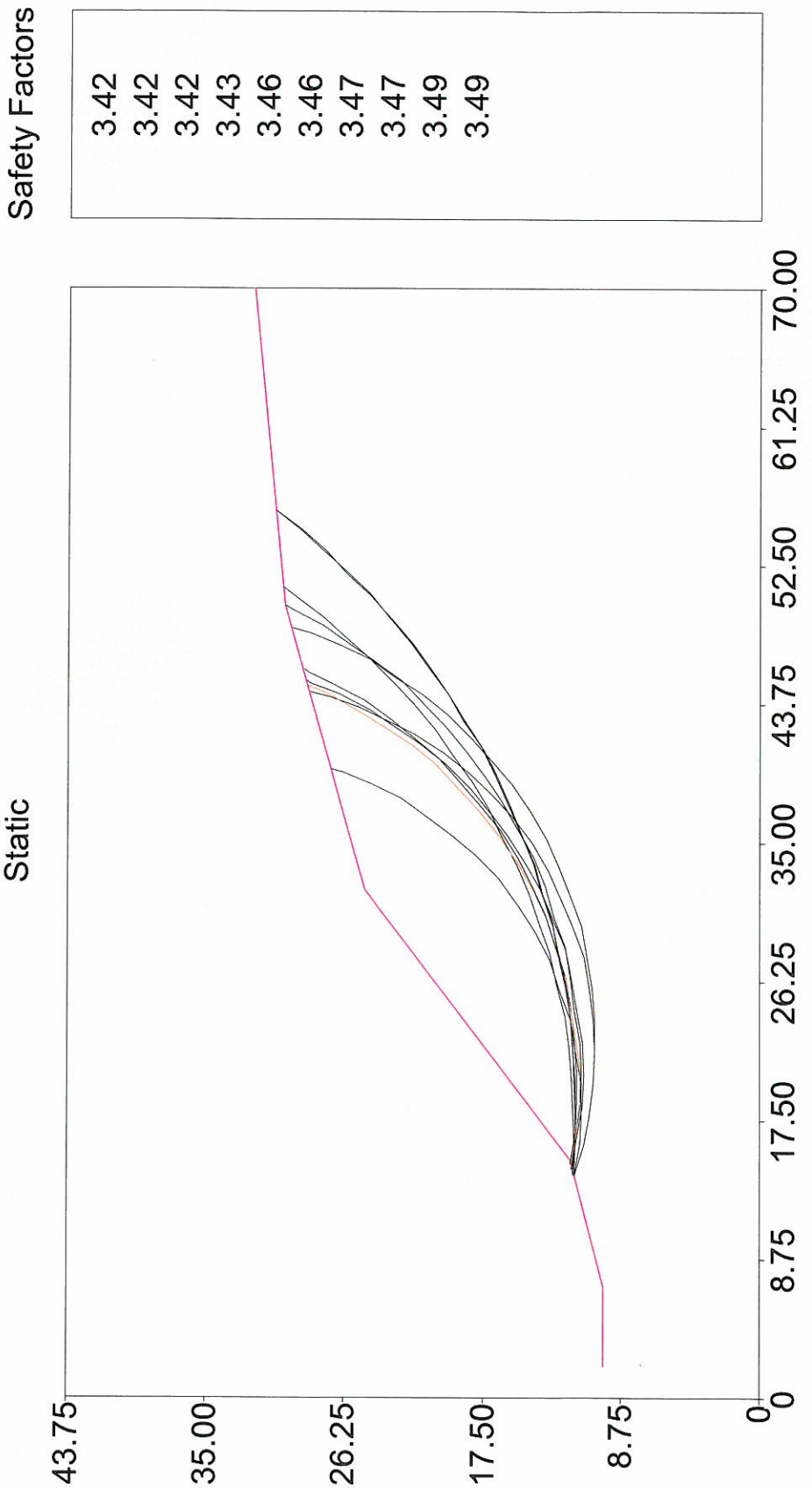
APPROXIMATE SCALE IN FEET

Terra Associates, Inc.

Consultants in Geotechnical Engineering
Geology and
Environmental Earth Sciences

OFF-SITE SLOPE EVALUATION PLAN
DUKE'S LANDING
REDMOND, WASHINGTON

Proj. No.T-6930	Date APR 2015	Figure 1


Static
Safety Factors
3.42
3.42
3.42
3.43
3.46
3.46
3.47
3.47
3.49
3.49
43.75
35.00
26.25
17.50
8.75
0
0
8.75
17.50
26.25
35.00
43.75
52.50
61.25
70.00

** PCSTABL6 **

by
Purdue University

modified by
Peter J. Bosscher
University of Wisconsin-Madison

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer`s Method of Slices

PROBLEM DESCRIPTION Static

BOUNDARY COORDINATES

5 Top Boundaries
5 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Below	Type Bnd
1	2.00	10.00	7.00	10.00	1	
2	7.00	10.00	15.00	12.00	1	
3	15.00	12.00	32.00	25.00	1	
4	32.00	25.00	50.00	30.00	1	
5	50.00	30.00	70.00	32.00	1	

ISOTROPIC SOIL PARAMETERS

1 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	120.0	120.0	500.0	34.0	0.00	0.0	0

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.

100 Trial Surfaces Have Been Generated.

10 Surfaces Initiate From Each Of 10 Points Equally Spaced Along The Ground Surface Between X = 14.00 ft.
and X = 15.00 ft.

Each Surface Terminates Between X = 32.00 ft.
and X = 70.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y = 5.00 ft.

2.00 ft. Line Segments Define Each Trial Failure Surface.

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Bishop Method * *

Failure Surface Specified By 20 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	14.67	11.92
2	16.65	11.63

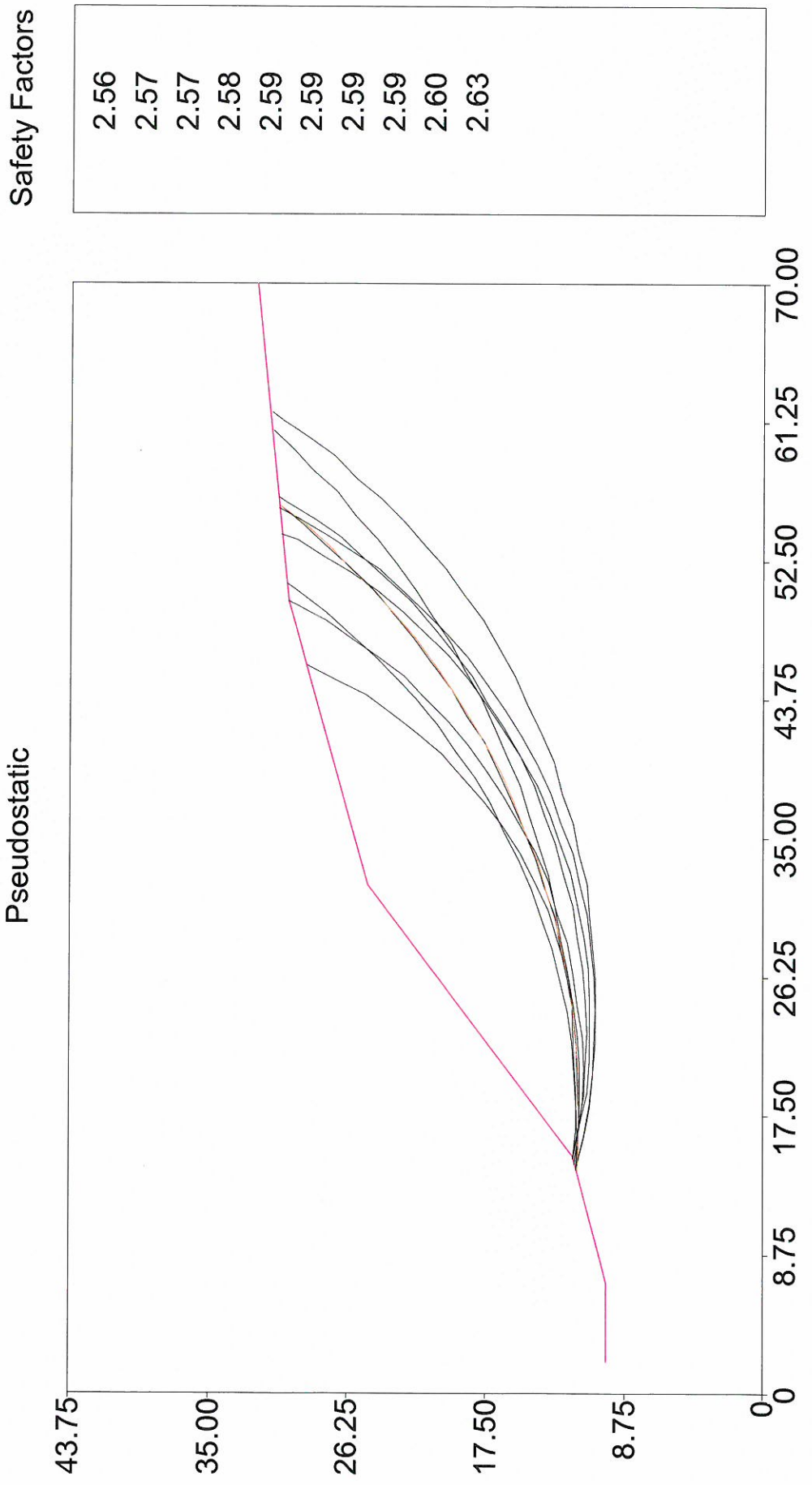
3	18.64	11.49
4	20.64	11.50
5	22.64	11.65
6	24.61	11.95
7	26.56	12.39
8	28.48	12.97
9	30.34	13.69
10	32.15	14.54
11	33.90	15.52
12	35.56	16.63
13	37.14	17.86
14	38.63	19.19
15	40.01	20.64
16	41.29	22.18
17	42.45	23.81
18	43.49	25.52
19	44.40	27.30
20	44.95	28.60

Circle Center At X = 19.6 ; Y = 38.9 and Radius, 27.4

*** 3.418 ***

Failure Surface Specified By 21 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	14.78	11.94
2	16.76	11.68
3	18.76	11.55
4	20.76	11.55
5	22.75	11.70
6	24.73	11.99
7	26.68	12.42
8	28.60	12.98
9	30.48	13.67
10	32.30	14.49
11	34.06	15.44
12	35.76	16.51
13	37.37	17.69
14	38.89	18.98
15	40.33	20.38
16	41.66	21.87
17	42.88	23.45
18	43.99	25.11
19	44.99	26.85
20	45.85	28.65
21	45.94	28.87


Safety Factors
2.56
2.57
2.57
2.58
2.59
2.59
2.59
2.59
2.60
2.63
Pseudostatic
43.75
35.00
26.25
17.50
8.75
0
0
8.75
17.50
26.25
35.00
43.75
52.50
61.25
70.00

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--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer`s Method of Slices

PROBLEM DESCRIPTION Pseudostatic

BOUNDARY COORDINATES

5 Top Boundaries
5 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Below Bnd	Type
1	2.00	10.00	7.00	10.00	1	
2	7.00	10.00	15.00	12.00	1	
3	15.00	12.00	32.00	25.00	1	
4	32.00	25.00	50.00	30.00	1	
5	50.00	30.00	70.00	32.00	1	

ISOTROPIC SOIL PARAMETERS

1 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	120.0	120.0	500.0	34.0	0.00	0.0	0

A Horizontal Earthquake Loading Coefficient
Of0.150 Has Been Assigned

A Vertical Earthquake Loading Coefficient
Of0.000 Has Been Assigned

Cavitation Pressure = 0.0 psf

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.

100 Trial Surfaces Have Been Generated.

10 Surfaces Initiate From Each Of 10 Points Equally Spaced Along The Ground Surface Between X = 14.00 ft.
and X = 15.00 ft.

Each Surface Terminates Between X = 32.00 ft.
and X = 70.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y = 5.00 ft.

2.00 ft. Line Segments Define Each Trial Failure Surface.

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Bishop Method * *

Failure Surface Specified By 26 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	14.00	11.75
2	16.00	11.64
3	18.00	11.61
4	20.00	11.66
5	21.99	11.80
6	23.98	12.02
7	25.96	12.32
8	27.92	12.71
9	29.86	13.17
10	31.79	13.72
11	33.69	14.34
12	35.56	15.05
13	37.40	15.83
14	39.21	16.68
15	40.98	17.61
16	42.71	18.62
17	44.40	19.69
18	46.04	20.83
19	47.63	22.04
20	49.17	23.32
21	50.66	24.66
22	52.09	26.05
23	53.46	27.51
24	54.77	29.02
25	56.01	30.59
26	56.02	30.60

Circle Center At X = 17.7 ; Y = 59.8 and Radius, 48.2

*** 2.564 ***

Failure Surface Specified By 25 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	14.11	11.78
2	16.11	11.67
3	18.11	11.65
4	20.11	11.71
5	22.10	11.85
6	24.09	12.07