# Appendix D
## Geotechnical Report

SAGE EARTH SCIENCE
GEOPHYSICAL SURVEYS

November 4, 2021 Wilding 2021-06-07.1 (Vp)

**RE: SEISMIC REFRACTION SURVEY – UPPER WENATCHEE FLOOD PLAIN RECONNECTION**

Based on the site conditions and project objectives, Sage Earth Science conducted a series of seismic refraction profiles to map the depth to rock and determine overburden and rock velocities at the Chelan County site. The fieldwork was performed on October 7th and 8th, 2021. The results are presented in this report.

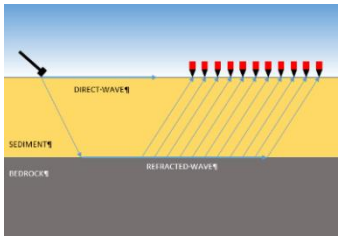

Figure 1. Sesimc refraction schematic


Figure 2. seismograph


Figure 3a,b. shallow water seismic geophone and seismic source

***P-wave survey (refraction)***
Given a physical setting of increasing density with depth, and by measuring the travel time of a compression wave (*p-wave*) between known points, the seismic refraction method can be used to determine the depth to a refracting horizon(s), the seismic velocity of the refracting horizon(s), as well as thickness and velocities of the overlying materials.

Profiles were centered at locations as directed by the customer. Data were acquired in accordance with ASTM standard, **ASTM D 5777-00** *Standard Guide for Using the Seismic Refraction Method for Subsurface Investigation.* Data were reduced using PlotRefra™ seismic refraction tomographic inversion software produced by Geometrics Inc.

Sage Earth Science used a 24-channel engineering seismograph and 16 lb. sledgehammer to perform the acoustic travel time measurements. Data are collected in 150-foot arrays using 24 geophones, one placed every 6.56 feet along profile. Six records distributed across each 24-channel array (spread) were obtained.

For geophone locations below the waterline, extended geophone spikes were used. For shot point locations, below the waterline, a 20lb bar against a steel plate was used rather than a conventional hamper source.

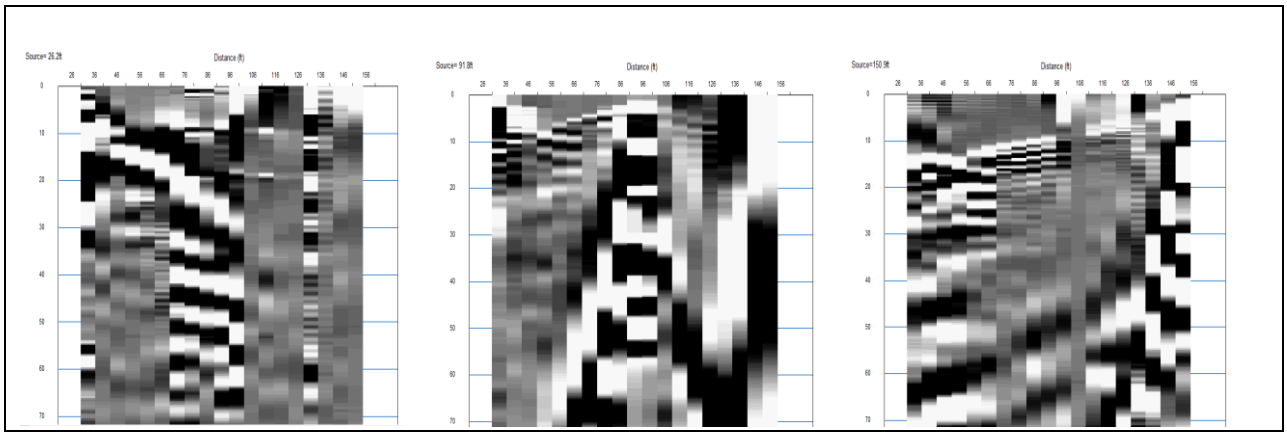
Figure 4. Typical field records. Profile P1

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*Table 1 Seismic Survey recording parameters*

| | |
|---|---|
| Test location | Upper Wenatchee River Chelan County Washington |
| Test Date | 10/07/2021 – 10/08/2021 |
| Recording instrument | DMT Summit Extreme Pro |
| S/N | SUX1018 |
| geophone natural period | 4.5 Hz. |
| geophone/station spacing | 6.56 ft. (2 meters) |
| number of channels | 24 |
| spread length | 150 ft. |
| sample rate | 0.25 millisecond |
| number of samples | 4000 per channel |
| record length | 1.0 seconds |
| low pass filter | ½ Nyquist |
| low cut filter | 1 Hz. |
| seismic source | 16 lb. sledgehammer / 20lb bar |
| source location | Stations 1,5,10,15,20, and 24 |
| Analysis software | Refra™ Tomographic inversion, Geometrics, Inc. |

***Discussion***

The following figures show the compression wave velocity profile at the approximate locations shown in figure 4.

The compression wave velocity at the site is characterized by a contrast between high density saturated gravels and rock. Velocites below 11,000 fps are considered dense saturated sediment. Velocities above 11,000 are considered rock. These descriptions should be correlated with direct physical descriptions from road cuts, test holes and test pits to better characterize the nature and potential rippability of the materials.

As a general guide, quoting from the ASTM standard, **ASTM D 5777-00** *Standard Guide for Using the Seismic Refraction Method for Subsurface Investigation*

> *The seismic refraction method provides the velocity of compressional P-waves in subsurface materials.* ***Although the P-wave velocity can be a good indicator of the type of soil or rock, it is not a unique indicator. Each type of sediment or rock has a wide range of seismic velocities, and many of these ranges significantly overlap****. While the seismic refraction technique measures the seismic velocity of seismic waves in earth materials, it is the interpreter who based on knowledge of the local conditions or other data, or both, must interpret the seismic refraction data and arrive at a geologically reasonable solution*
>
> > *5.2.2. According to Mooney (8), P-wave velocities are generally greater for:*
> > *1. Denser rocks than lighter rocks*
> > *2. Older rocks than younger rocks*
> > *3. Igneous rocks than sedimentary rocks*
> > *4. Solid rocks than rocks with crack and fractures*
> > *5. Unweathered rocks than weathered rocks*
> > *6. Consolidated sediments than unconsolidated sediments*
> > *7. Water saturated rocks/sediments than unsaturated rocks/sediments*
> > *8. Wet soils than dry soils*

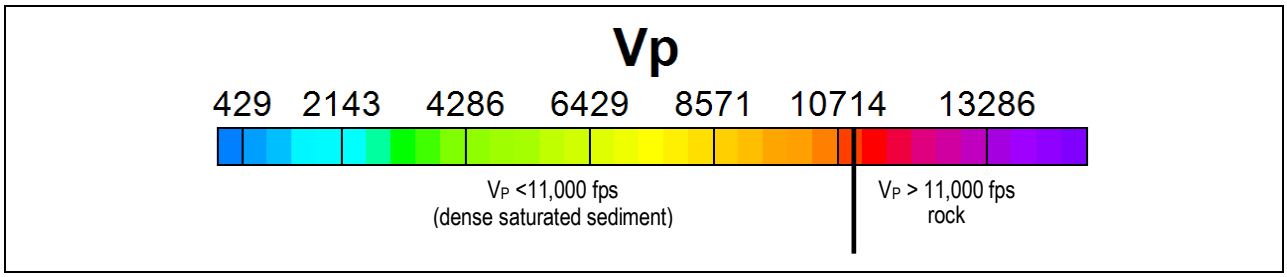



Figure 5. velocity ranges, color scale

The velocity ranges are interpreted from a number of criteria including typical values for sediment and rock as well as inflection points in the individual vertical velocity profiles observed in these data sets. The numbers chosen are intended to reflect the materials found at this site and are applied to all profiles throughout the project area. These velocity and descriptions should be correlated with other site information including test pits, bore holes, and other supporting sources where available to better correlate velocity ranges and materials encountered.

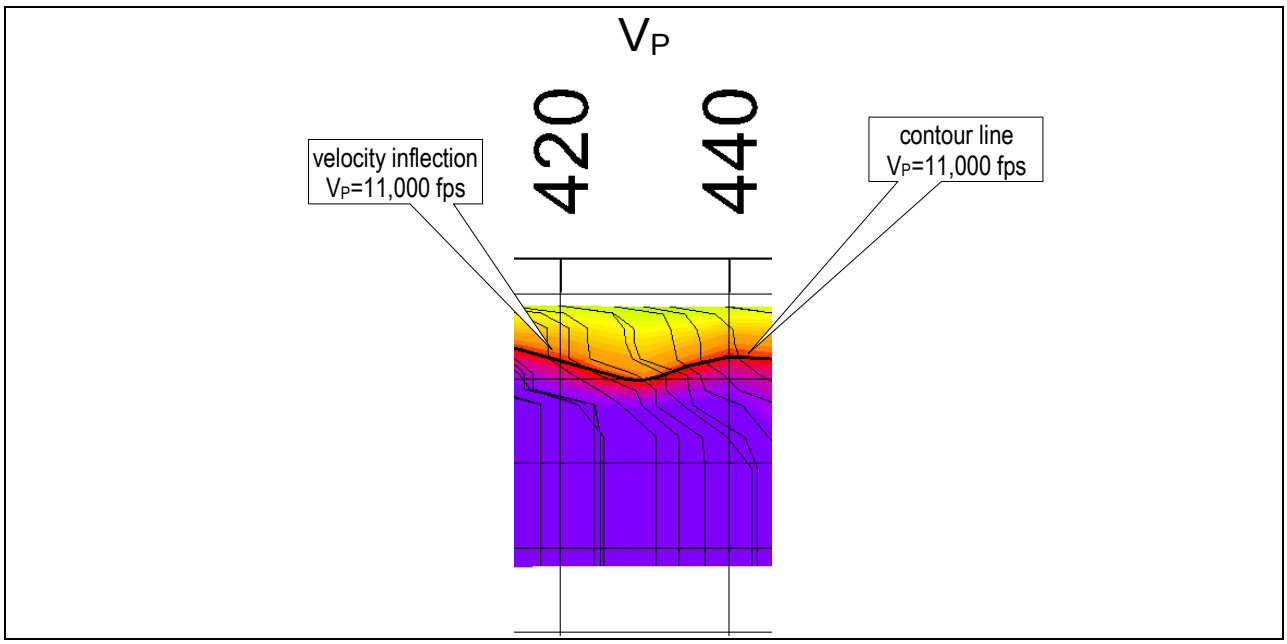



Figure 6. Material interface velocity estimation

Glen Carpenter / principal

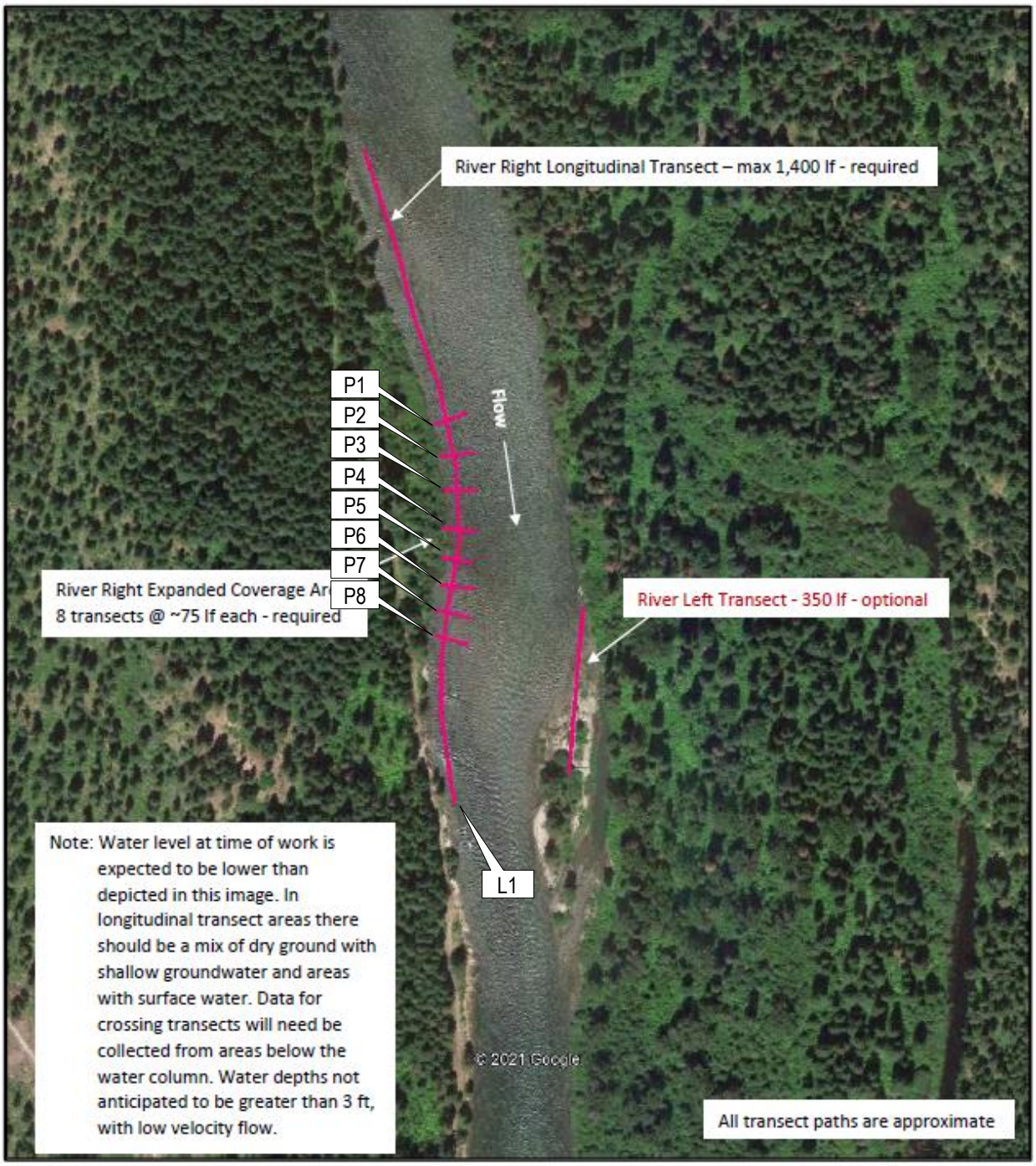


Figure 7a. Profile location map

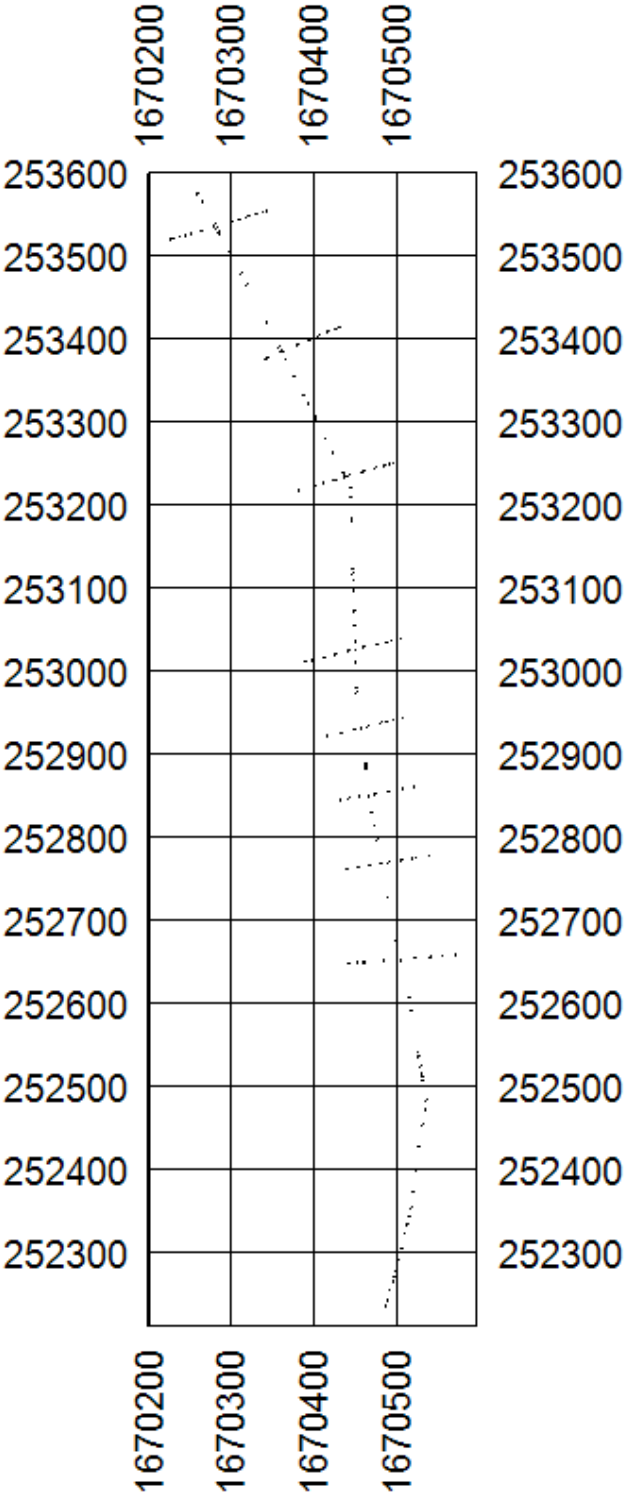
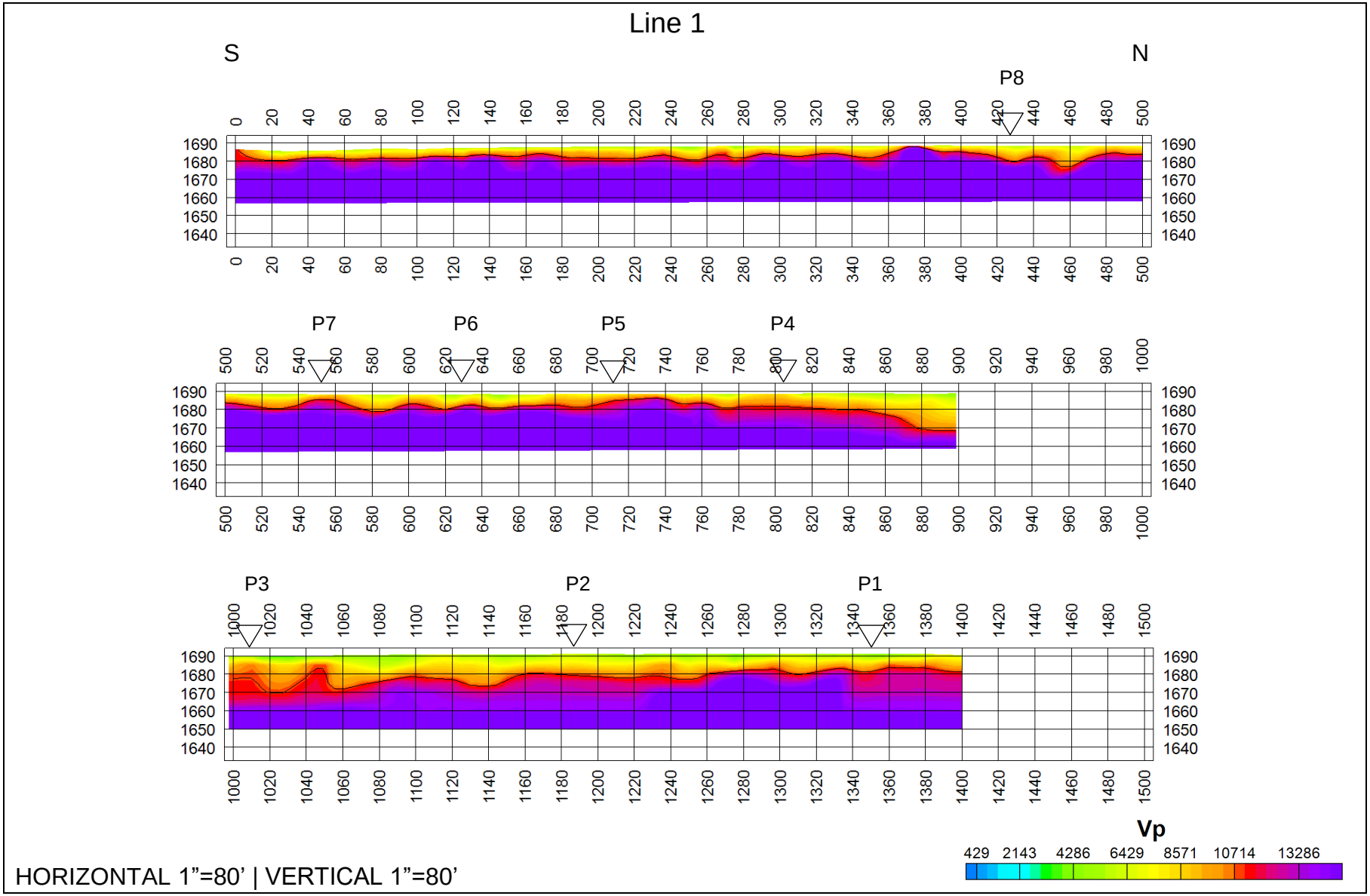
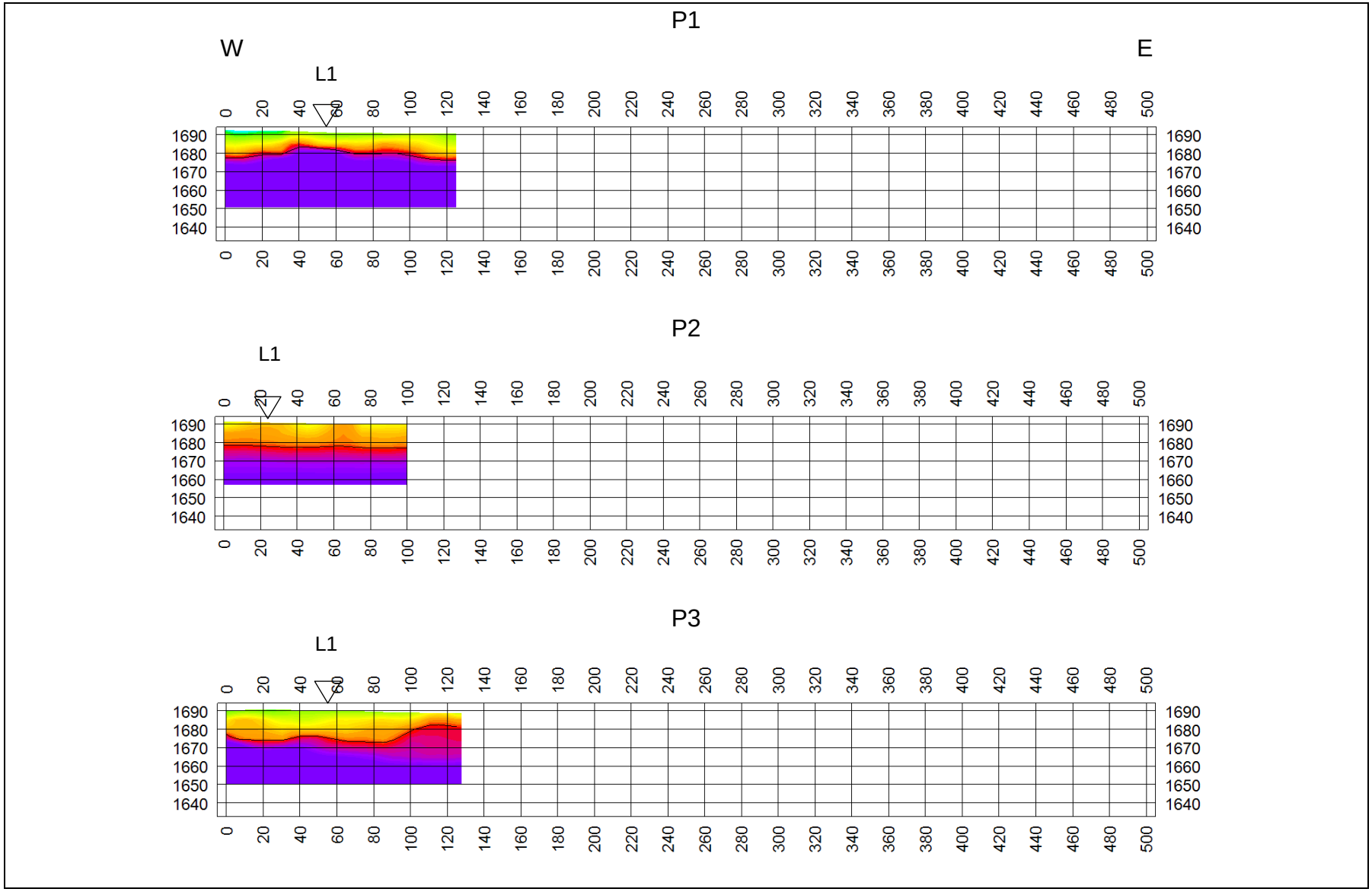
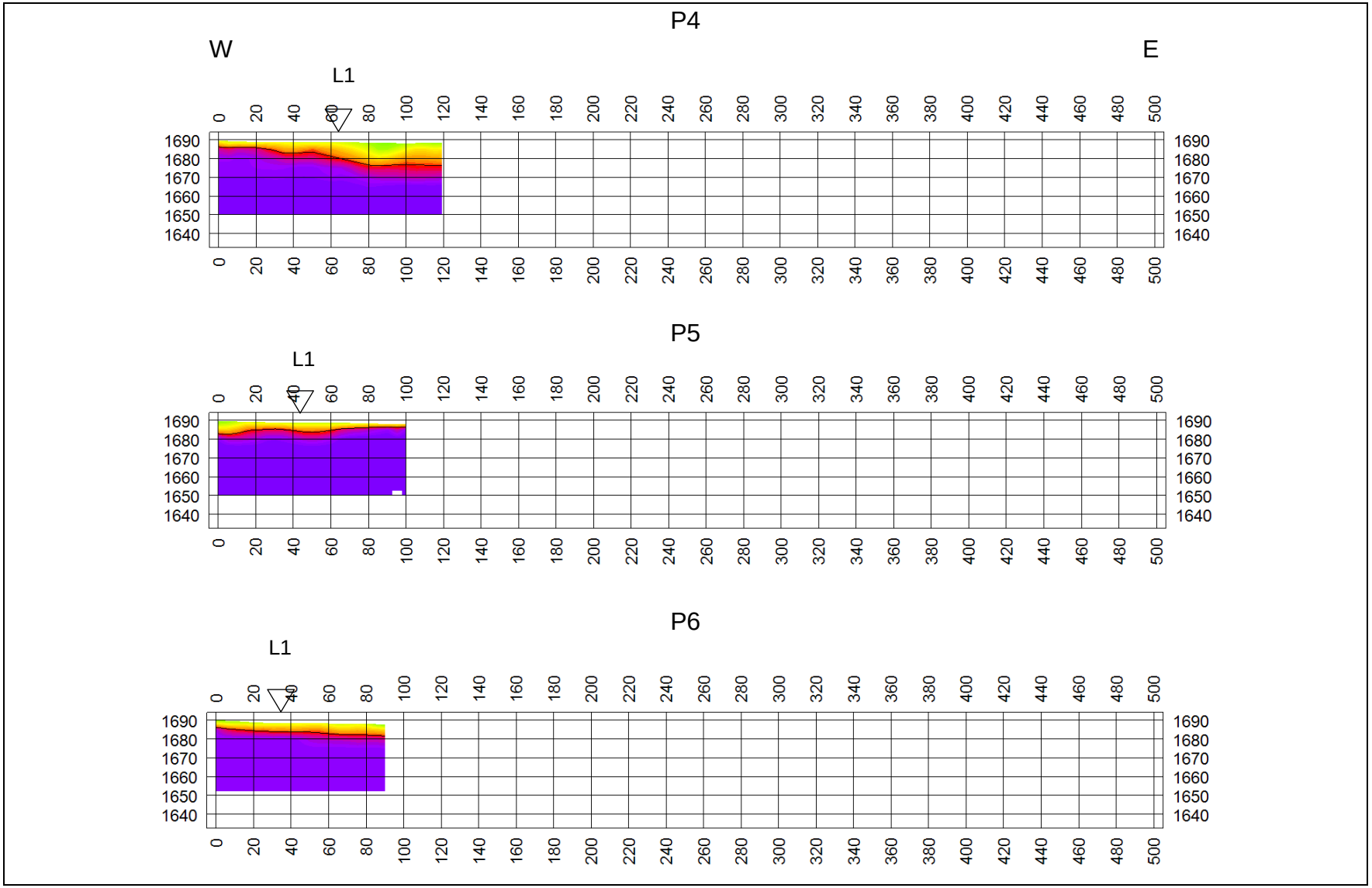


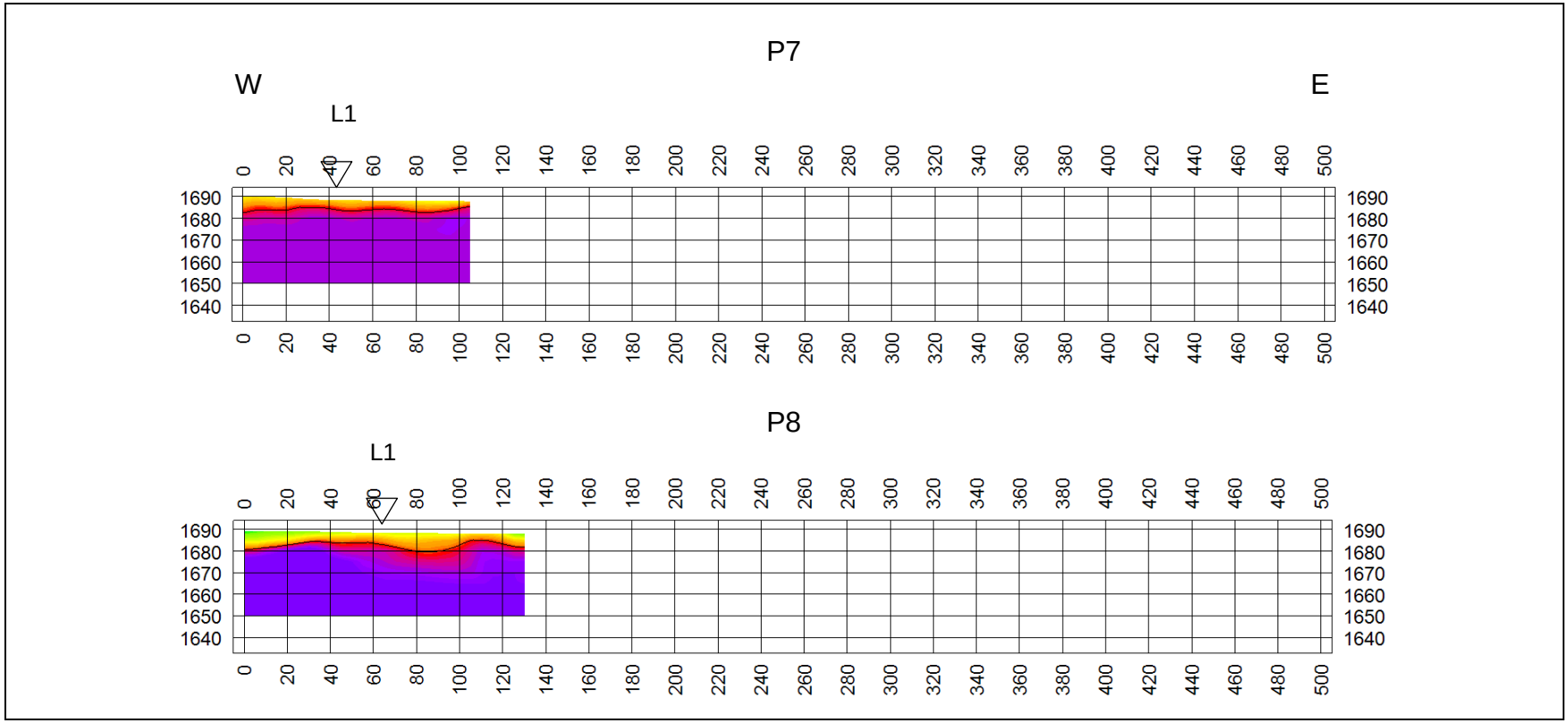

Figure 7b. Profile location map. WA-North state plane coordinates, elevations are in NAVD88, feet




HORIZONTAL 1”=80’ | VERTICAL 1”=80’


P1
W
E
L1
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460 480 500
1690
1680
1670
1660
1650
1640
P2
L1
P3
L1


P4
W
E
L1
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460 480 500
1690
1680
1670
1660
1650
1640
P5
L1
P6
L1


P7
W
E
L1
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460 480 500
1690
1680
1670
1660
1650
1640
P8
L1
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460 480 500
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