WIDE-AREA AUGMENTATION SYSTEM PERFORMANCE ANALYSIS REPORT

Report #8

Reporting Period: January 01 to March 31, 2004

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Executive Summary

Since 1999 the WAAS Group at the William J. Hughes Technical Center has reported GPS performance as measured against the GPS Standard Positioning Service (SPS) Signal Specification. These quarterly reports are known as the PAN (Performance Analysis Network) Report. In addition to that report, the WAAS/NSTB Team reports on the performance of the Wide-Area Augmentation System (WAAS). This report is the eighth such WAAS quarterly report. This report covers WAAS performance during the period from January 1, 2004 to March 31, 2004. This period is the 3rd quarter in which the WAAS is a fully commissioned system in the National Airspace System (NAS).

During this quarter the first upgrade to the WAAS was installed. One part of this upgrade was to change the configuration for the WAAS External Interface (WEI) configuration for the Technical Center. The WEI is the source for all WAAS data that is presented in this document. This upgrade lowered dramatically the number of lost messages over the WEI.

The following table shows observations for accuracy and availability made during the reporting period. See the body of the report for additional results in accuracy, availability, continuity, safety index, range accuracy, WAAS broadcast message rates and GEO ranging availability. Please note that the results in the below table are valid when the Localizer Approach with Vertical Guidance (LPV) service is available. LPV service is available when the calculated Horizontal Protection Level (HPL) is less than 40 meters and the Vertical Protection Level (VPL) is less than 50 meters.

Parameter	Site/Maximum	Site/Minimum
95% Horizontal Accuracy	Minneapolis 1.184 meters	Kansas City 0.728 meters
95% Vertical Accuracy	Oakland 2.138 meters	Washington DC 1.063 meters
LPV Instantaneous Availability (HPL < 40 meters & VPL < 50 meters)	Dallas 99.977%	San Angelo 98.5%
95% HPL	San Angelo 28.230 meters	Chicago 17.132 meters
95% VPL	San Angelo 44.234 meters	Kansas City 27.663 meters

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1.0 INTRODUCTION

The FAA began monitoring GPS SPS performance in order to ensure the safe and effective use of the satellite navigation system in the National Airspace System (NAS). The Wide Area Augmentation System (WAAS) adds more timely integrity monitoring of GPS and improves position accuracy and availability of GPS within the WAAS coverage area.

Objectives of this report are:

a. To evaluate and monitor the ability of WAAS to augment GPS by characterizing important performance parameters.
b. To analyze the effects of GPS satellite operation and maintenance, and ionospheric activity on the WAAS performance.
c. To investigate any GPS and WAAS anomalies and determine their impact on potential users.
d. To archive performance of GPS and WAAS for future evaluations.

The WAAS data transmitted from GEO satellite PRN#122 (AORW) and PRN#134 (POR) were used in the evaluation. Table 1.1 and Table 1.2 list NSTB and WAAS reference station receivers used in Precision Approach (PA) and Non-Precision Approach (NPA) evaluation process, respectively. This report presents results from three months of data, collected from January 1, 2004 to March 31, 2004.

Table 1-1 PA Sites

	Number of Days Evaluated	Number of Samples
NSTB:		
Anderson	90	7744203
Atlantic City	73	6319741
Grand Forks	82	7067400
Great Falls	89	7723673
Oklahoma City	76	6576257
Prescott	79	6806389
San Angelo	84	7229837
WAAS:		
Albuquerque	90	7792782
Atlanta	90	7794391
Billings	80	6870955
Boston	90	7785899
Chicago	90	7791643
Cleveland	90	7794242
Dallas	90	7787534
Denver	90	7792233
Houston	88	7607554
Jacksonville	90	7794961
Kansas City	85	7360058
Los Angeles	90	7792815
Memphis	90	7790328
Miami	90	7787438
Minneapolis	90	7790793
New York	90	7791136
Oakland	90	7788559
Salt Lake City	90	7790554
Seattle	84	7291339
Washington DC	90	7800920

Table 1-2 NPA Sites

Location	Number of Days Evaluated	Number of Samples
Albuquerque	90	7797365
Anchorage	90	7804681
Atlanta	90	7798287
Billings	88	7572069
Boston	90	7792723
Cleveland	90	7799185
Cold Bay	90	7751008
Honolulu	90	7758547
Houston	88	7613448
Juneau	88	7624640
Kansas City	85	7372170
Los Angeles	90	7800895
Miami	90	7794614
Minneapolis	90	7797499
Oakland	90	7797241
San Juan	90	7800877
Salt Lake City	90	7799995
Seattle	86	7424468
Washington DC	90	7805770

The report is divided to seven performance categories listed below. This report also includes WAAS LPV Service Availability at Selected Airports, WAAS Deterministic Code Noise and Multipath (CNMP) Bounding Analysis, and WAAS Equipment Outage Report. In addition, an analysis of the comparison of GPS broadcast orbits versus the International Geodynamics GPS Service (IGS) precise orbits is presented. This analysis includes data from January 1, 2002 to December 31, 2003. This analysis will be included in this report once per year.

1. WAAS Position Accuracy
2. WAAS Operational Service Availability
3. Coverage
4. Continuity
5. Integrity
6. WAAS Range Domain Accuracy
7. GEO Ranging Performance

Table 1.3 lists the performance parameters evaluated for the WAAS in this report. Please note that these are the performance parameters associated with the WAAS IOC system. These requirements are extracted from the FAA Specification FAA-E-2892B Change 1. In future reports the performance parameters will be derived from FAA Specification FAA-E-2976, as applicable.

Table 1-3 WAAS Performance Parameters

Performance Parameter	Expected WAAS Performance
PA Accuracy Horizontal	≤ 7.6m error 95% of the time
PA Accuracy Vertical	≤ 7.6m error 95% of the time
NPA Accuracy Horizontal	≤ 100m error 95% of the time ≤ 556m error 99.999% of the time
Availability LPV*	Not Defined for Current WAAS phase
Availability LNAV/VNAV*	Not Defined for Current WAAS phase
Coverage LPV	Not Defined for Current WAAS phase For this report - 95% availability of 75% of CONUS
Coverage LNAV/VNAV	95% availability of 75% of CONUS
Coverage NPA	99.9% availability of 75% of service volume
NPA Continuity of Navigation	≥ 99.999% of the time
NPA Continuity of Fault Detection	≥ 99.999% of the time
PA Continuity of Function (LNAV/VNAV and LPV)	1-5.5 x 10^{-5} per approach
LPV Availability	≥ 95% of the time within the service volume
LNAV/VNAV Availability	≥ 95% of the time within the service volume
Integrity	≤ 4 X 10e-8 HMI's per approach

* Instantaneous availability (i.e. Availability is calculated every second.)

1.1 Event Summary

Table 1.4 lists test events that occurred during the reporting period that affected WAAS performance or the ability to determine the WAAS performance. These events include GPS or WAAS anomalies, relevant receiver malfunctions, and receiver maintenance conducted.

Table 1-4 Test Events

Date	Sites	Events
1/1/04 to 1/2/04	Grand Forks	Grand Forks outage (since 1250 day 3, 12/24/03).
1/15/04 to 1/16/04	Bangor	Bangor outage.
1/20/04 to 1/22/04	Seattle	Seattle outage.
1/21/04 to 1/22/04	Atlantic City	Atlantic City outage.
1/23/04 to 1/28/04	Grand Forks	Grand Forks outage.
1/22/04 to 1/30/04	Prescott	Prescott outage.
1/26/04 to 1/28/04	Greenwood	Greenwood outage.
2/2/04 to 2/4/04	Seattle	Seattle outage.
2/4/04 to end of Qtr.	Bangor	Bangor outage.
2/13/04	N/A	SV decommissioned—PRN 23.
2/19/04 to 3/25/04	Greenwood	Greenwood outage.
2/21/04 to 2/25/04	Kansas City	Kansas City outage.
2/28/04 to 3/4/04	Oklahoma City	Oklahoma City outage.
3/8/04 to 3/17/04	Billings	Billings outage. WRE-B used for analysis instead of WRE-A
3/9/04 to 3/12/04	All sites	Iono Storm. Max Kp 5, 6, 5, 5. LPV Coverage 94%, 67%, 96%, 95%. This storm was a primary factor in the tripping of the WAAS User Position Monitor (UPM).
3/10/04 to 3/12/04	Houston	Houston outage.
3/12/04 to 3/26/04	Atlantic City	Atlantic City outage.

1.2 Report Overview

Section 2 provides the vertical and horizontal position accuracies from data collected, on a daily basis, at one-second intervals. The 95% accuracy index and the maximum accuracy for the reporting period are tabulated. The daily 95% accuracy index is plotted graphically for each receiver. Histograms of the vertical and horizontal error distribution are provided for three receivers within the WAAS service area.

Section 3 summarizes the WAAS instantaneous availability performance, at each receiver, for three operational service levels during the reporting period. Daily availability is also plotted for each receiver evaluated.

Section 4 provides the percent of coverage provided by WAAS on a daily basis. Monthly roll-up graphs presented indicate the portions of service volume covered, and the percentage of time that WAAS was available.

Section 5 provides the percentage of time continuity requirements were met during the reporting period for each receiver. Please note that these continuity requirements are from the WAAS Specification FAA-E-2892B Change 1. The definition for continuity is being evaluated from an operational perspective. The continuity analysis will be reported to reflect this new definition in future reports.

Section 6 summarizes the number of HMI's detected during the reporting period and presents a safety margin index for each receiver. The safety index reflects the amount of over bounding of position error by WAAS protection levels. This section also includes update rates of WAAS messages transmitted from AORW and POR.

Section 7 provides the UDRE and GIVE bounding percentage and the 95% index of the range and ionospheric accuracy for each satellite tracked by the WAAS receiver in Houston.

Section 8 provides the GEO ranging performance for AORW and POR.

Section 9 summarizes WAAS anomalies and problems identified during the reporting period, which adversely affect WAAS performance described in Table 1.3.

Section 10 provides WAAS LPV availability and outages at selected airports.

Section 11 provides the assessment of WAAS CNMP bounding for 75 WAAS receivers.

Section 12 summarizes WAAS equipment outages and GUS switchovers.

Section 13 compares GPS broadcast orbits versus the IGS precise orbits.

2.0 WAAS POSITION ACCURACY

Navigation error data, collected from WAAS and NSTB reference stations, was processed to determine position accuracy at each location. This was accomplished by utilizing the GPS/WAAS position solution tool to compute a MOPS-weighted least squares user navigation solution, and WAAS horizontal and vertical protection levels (HPL & VPL), once every second. The user position calculated for each receiver was compared to the surveyed position of the antenna to assess position error associated with the WAAS SIS over time. The position errors were analyzed and statistics were generated for two operational service levels: WAAS LPV, and WAAS LNAV/VNAV, as shown in Table 2.1. For this evaluation, the WAAS operational service level is considered available at a given time and location, if the computed WAAS HPL and VPL are within the horizontal and vertical alarm limits (HAL & VAL) specified in Table 2.1.

Table 2-1 Operational Service Levels

WAAS Operational Service Levels	Horizontal Alert Limit HAL (meters)	Vertical Alert Limit VAL (meters)
LPV (LOC/VNAV)	40	50
LNAV/VNAV	556	50

Table 2.2 shows PA horizontal and vertical position accuracy maintained for 95% of the time at LPV and LNAV/VNAV operational service levels for the quarter. The table also includes 95% SPS accuracy for certain locations. Figures 2.1 to 2.4 show the daily horizontal and vertical 95% accuracy for LNAV/VNAV operational service level for the period. Note that WAAS accuracy statistics presented are compiled only when all WAAS corrections (fast, long term, and ionospheric) for at least 4 satellites are available. This is referred to as PA navigation mode. The percentage of time that PA navigation mode was supported by WAAS at each receiver is also shown in Table 2.2. A user is considered to be in NPA navigation mode if only WAAS fast and long term corrections are available to a user (no ionospheric corrections). Table 2.3 shows NPA horizontal position accuracy for 95% and 99.999% of the time. This table also shows the maximum NPA horizontal position error for the quarter. Figures 2.5 shows the daily horizontal 95% accuracy for NPA.

During the evaluated period, the 95% horizontal and vertical accuracy at all evaluated sites were less than 7.6 meters for both WAAS operational service levels. The maximum horizontal and vertical LPV errors are 1.184 at Minneapolis and 2.138 meters at Oakland, respectively. The minimum horizontal and vertical LPV errors are 0.728 meters at Kansas City and 1.063 meters at Washington DC, respectively. The maximum 95% and 99.999% horizontal errors are 7.026 meters and 18.642 meters both at Honolulu. The minimum 95% and 99.999% horizontal errors are 2.154 meters and 4.189 meters, both at Anchorage.

Table 2.4 shows the maximum horizontal and vertical position errors while the caluculated HPL and VPL met the LPV service levels. Also shown is the ratio of the maximum position error divided by the calculated protection level for that second. In future reports the maximum of the quantity position error divided by protection level will be reported.

Figures 2.6 to 2.14 show the distributions of the vertical and horizontal errors in triangle charts and 2-D histogram plots for the quarter at three locations, Oklahoma City, Washington DC and Seattle. The triangle charts show the distributions of vertical position errors (VPE) versus vertical protection levels (VPL) and horizontal position errors (HPE) versus horizontal protection levels (HPL). The horizontal axis is the position error and the vertical axis is the WAAS protection levels. Lower protection levels equate to better availability. The diagonal line shows the point where error equals protection level. Above and to the left of the diagonal line in the chart, errors are bounded (WAAS is providing integrity in the position domain); below and to the right, errors are not bounded (HMI could be present). The horizontal lines at various protection levels represent the various operational service levels as defined in Table 2.1. The 2-D histogram plots contain four histograms showing the distributions of vertical and horizontal position errors and normalized position errors. The left top and bottom histograms show the distributions of the actual vertical and horizontal errors. The horizontal axis is the position errors and the vertical axis is the total count of data samples (log scale) in each 0.1-meter bin. The right top and bottom histograms show the distributions of the actual vertical and horizontal errors normalized by one-sigma value of the protection level; vertical - (VPL/5.33) and horizontal - (HPL/6.0). The horizontal axis is the standard units and vertical axis is the observed distribution of normalized errors data samples in each 0.1-sigma bin. Narrowness of the normalized error distributions shows very good observed safety performance.

Table 2-2 PA 95% Horizontal and Vertical Accuracy

Location	Horizontal LPV (HAL=40m) (Meters)	Horizontal LNAV (HAL=556m) (Meters)	Vertical LPV/VNAV, LPV (VAL=50m) (Meters)	Percentage in PA mode (%)	SPS Accuracy	
					95% Horizontal (Meters)	95% Vertical (Meters)
Anderson	0.827	0.828	1.243	99.98667	*	*
Atlantic City	0.864	0.868	1.273	99.98361	*	*
Grand Forks	0.903	0.907	1.488	99.97800	*	*
Great Falls	0.983	0.984	1.352	99.98994	*	*
Oklahoma City	0.775	0.775	1.095	99.98587	*	*
Prescott	0.975	0.977	1.312	99.99943	*	*
San Angelo	0.877	0.878	1.477	99.98603	*	*
Albuquerque	0.784	0.784	1.171	99.98669	4.215	5.418
Atlanta	0.744	0.744	1.238	99.98691	4.340	5.730
Billings	0.913	0.914	1.530	99.98615	4.175	5.448
Boston	0.894	0.898	1.339	99.98659	4.096	5.331
Chicago	0.746	0.749	1.086	99.97962	*	*
Cleveland	0.832	0.834	1.247	99.98261	4.258	5.307
Dallas	0.900	0.900	1.755	99.98671	*	*
Denver	0.841	0.842	1.427	99.97910	*	*
Houston	0.890	0.890	1.333	99.98644	4.433	5.974
Jacksonville	1.062	1.063	1.391	99.98672	*	*
Kansas City	0.728	0.729	1.071	99.97816	4.279	5.974
Los Angeles	1.090	1.090	1.746	99.99905	4.407	5.733
Memphis	0.897	0.898	1.250	99.98272	*	*
Miami	0.994	0.995	1.669	99.98671	4.572	6.445
Minneapolis	1.184	1.189	1.710	99.97955	4.283	5.367
New York	1.062	1.066	1.270	99.98663	*	*
Oakland	0.969	0.970	2.138	99.99896	4.368	5.604
Salt Lake City	0.898	0.898	1.445	99.99913	4.284	5.373
Seattle	1.150	1.150	1.719	99.99899	4.366	5.392
Washington DC	0.864	0.867	1.063	99.98709	4.111	5.246

* SPS accuracy not computed for this location.

Table 2-3 NPA 95% and 99.999% Horizontal Accuracy

Location	95% Horizontal (meters)	99.999% Horizontal (meters)	Percentage in NPA mode (%)	Maximum Horizontal Error
Albuquerque	2.534	8.589	99.983865	13.401
Anchorage	2.154	4.189	99.981701	4.365
Atlanta	2.459	6.534	99.984688	15.916
Billings	2.617	7.182	99.986821	9.305
Boston	2.165	6.634	99.984539	7.081
Cleveland	2.249	6.907	99.984473	10.851
Cold Bay	2.567	5.749	99.982786	8.244
Honolulu	7.026	18.642	99.978763	20.797
Houston	2.846	6.317	99.983853	6.689
Juneau	2.210	4.740	99.988085	5.044
Kansas City	2.443	7.794	99.982131	20.569
Los Angeles	2.916	7.473	99.997091	15.529
Miami	2.686	6.958	99.983805	12.511
Minneapolis	3.165	7.325	99.985325	14.247
Oakland	2.764	8.322	99.996716	9.702
Salt Lake City	2.578	6.947	99.996728	7.952
San Juan	3.171	9.947	99.983555	10.368
Seattle	2.655	8.816	99.996024	14.553
Washington DC	2.470	5.604	99.984866	7.520

Table 2-4 Maximum Position Errors and Position Error/Protection Level Ratio

Location	Horizontal Error (m)	Horizontal Error/HPL	Vertical Error (m)	Vertical Error/VPL
Anderson	3.108	0.128	6.003	0.311
Atlantic City	4.111	0.115	4.293	0.089
Grand Forks	3.894	0.180	8.605	0.325
Great Falls	3.586	0.131	5.640	0.122
Oklahoma City	2.711	0.076	4.860	0.099
Prescott	2.816	0.076	5.051	0.102
San Angelo	3.082	0.092	6.503	0.139
Albuquerque	2.549	0.088	5.231	0.121
Atlanta	5.190	0.176	7.460	0.151
Billings	4.027	0.239	7.054	0.263
Boston	3.484	0.142	6.770	0.154
Chicago	3.010	0.101	7.541	0.152
Cleveland	4.984	0.195	7.051	0.280
Dallas	4.464	0.278	7.329	0.265
Denver	2.908	0.112	5.979	0.223
Houston	2.662	0.114	5.904	0.217
Jacksonville	4.611	0.185	6.087	0.235
Kansas City	2.611	0.075	4.424	0.102
Los Angeles	4.751	0.173	6.461	0.149
Memphis	4.080	0.133	4.883	0.108
Miami	2.961	0.084	6.092	0.184
Minneapolis	5.798	0.233	9.133	0.244
New York	4.171	0.104	5.419	0.131
Oakland	4.800	0.187	7.979	0.194
Salt Lake City	3.772	0.176	5.130	0.203
Seattle	4.222	0.156	6.437	0.133
Washington DC	3.234	0.119	5.320	0.116

Figure 2•1 95% Horizontal Accuracy at LNAV/VNAV

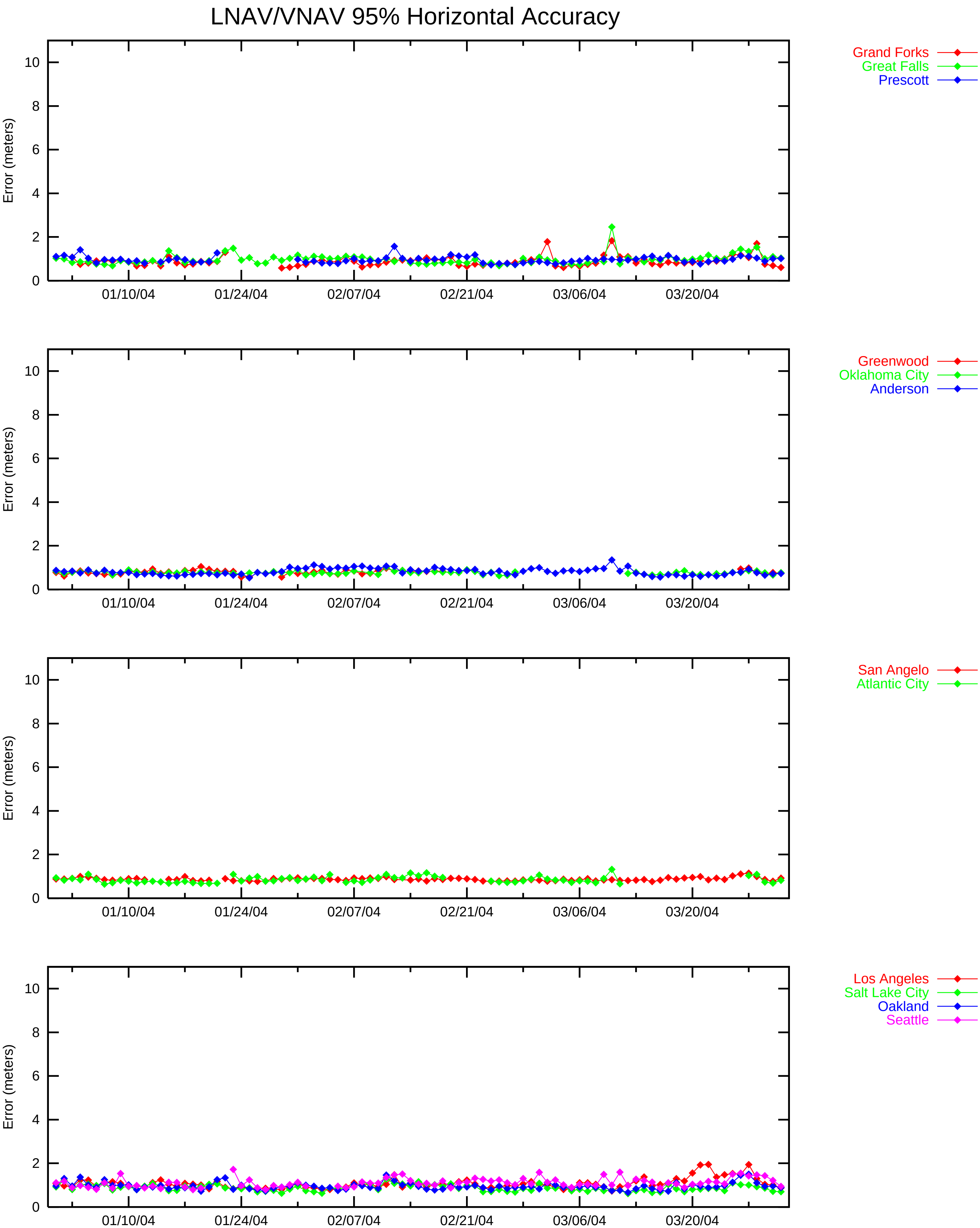


Figure 2•2 95% Horizontal Accuracy at LNAV/VNAV

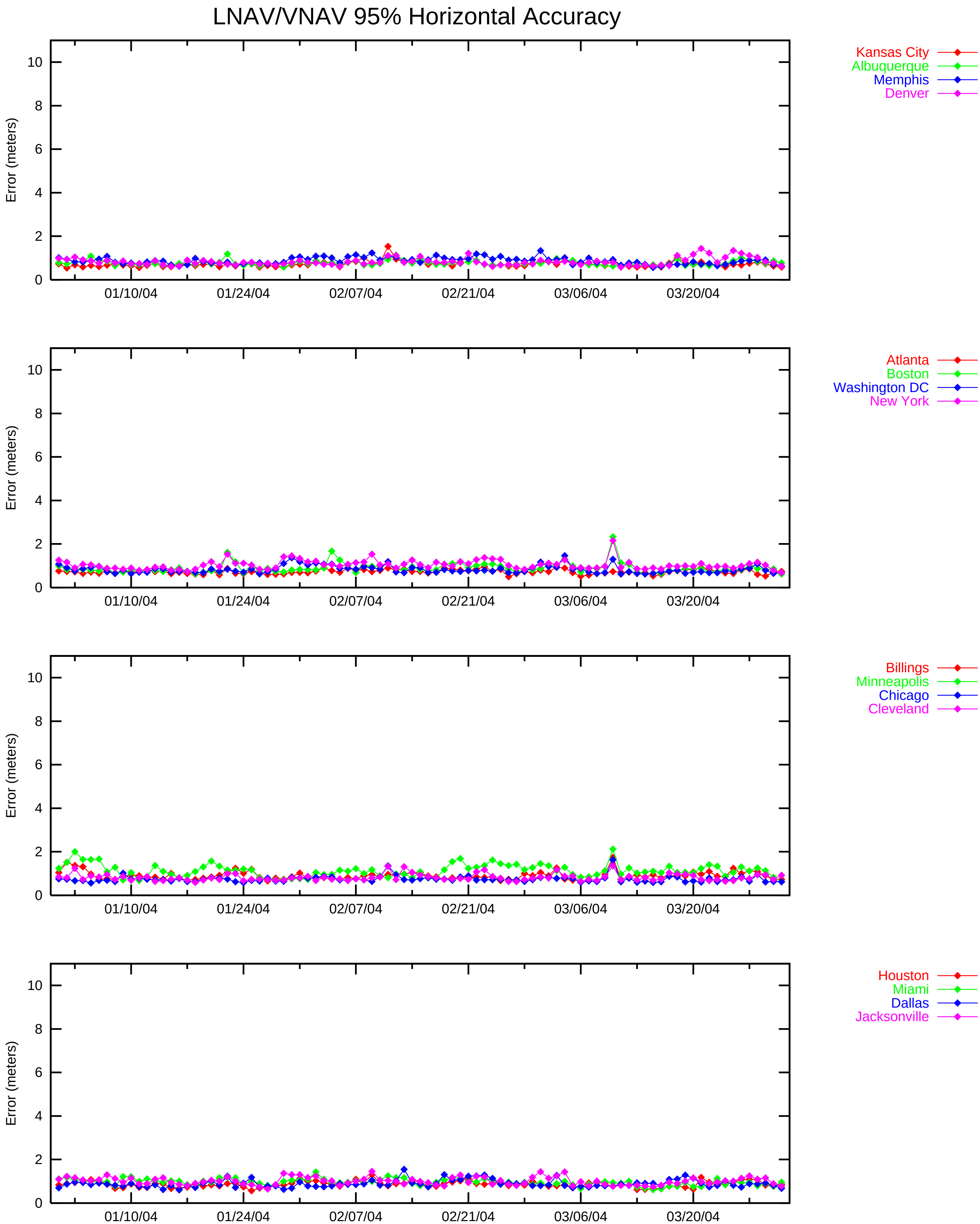


Figure 2•3 95% Vertical Accuracy at LNAV/VNAV

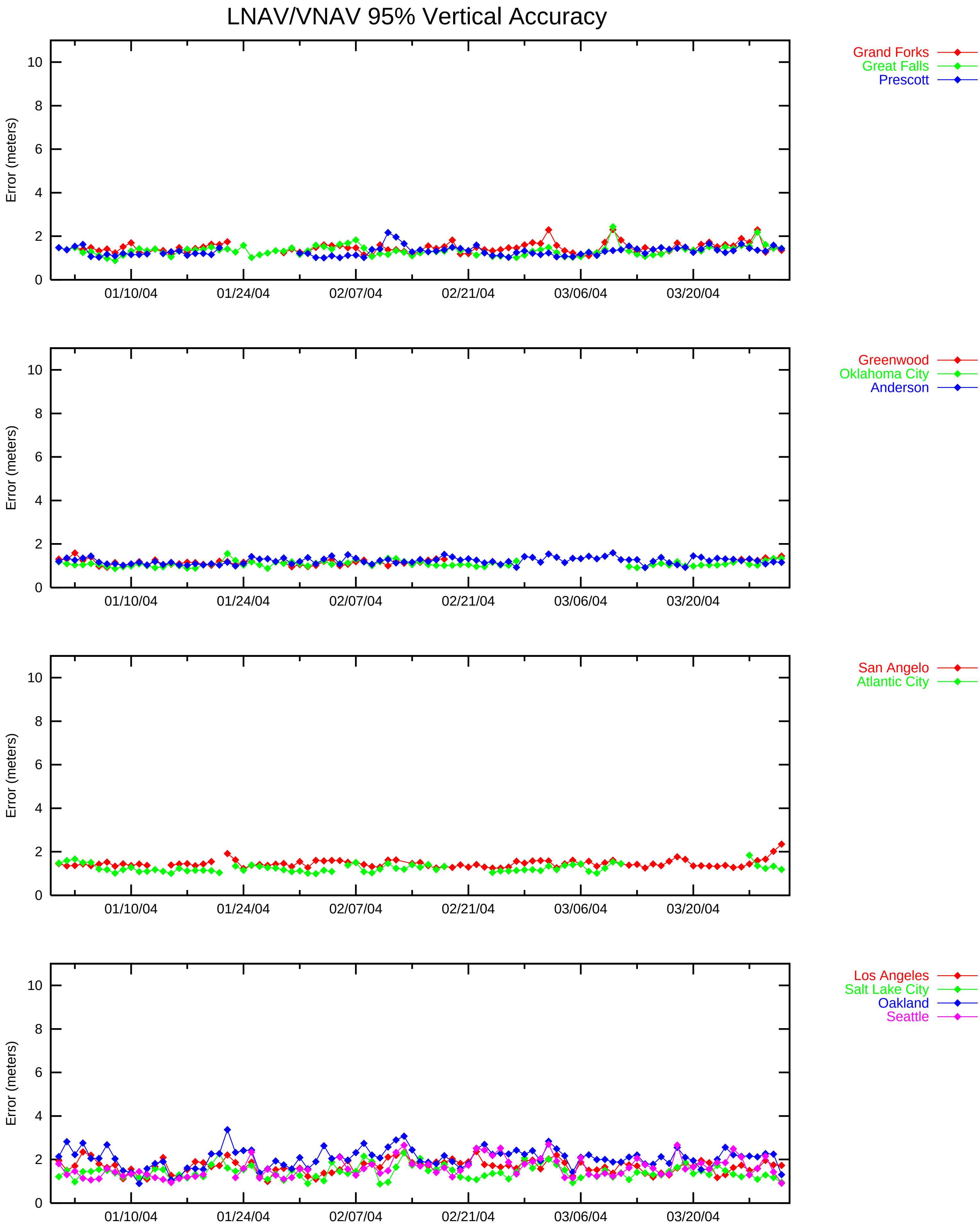


Figure 2•4 95% Vertical Accuracy at LNAV/VNAV

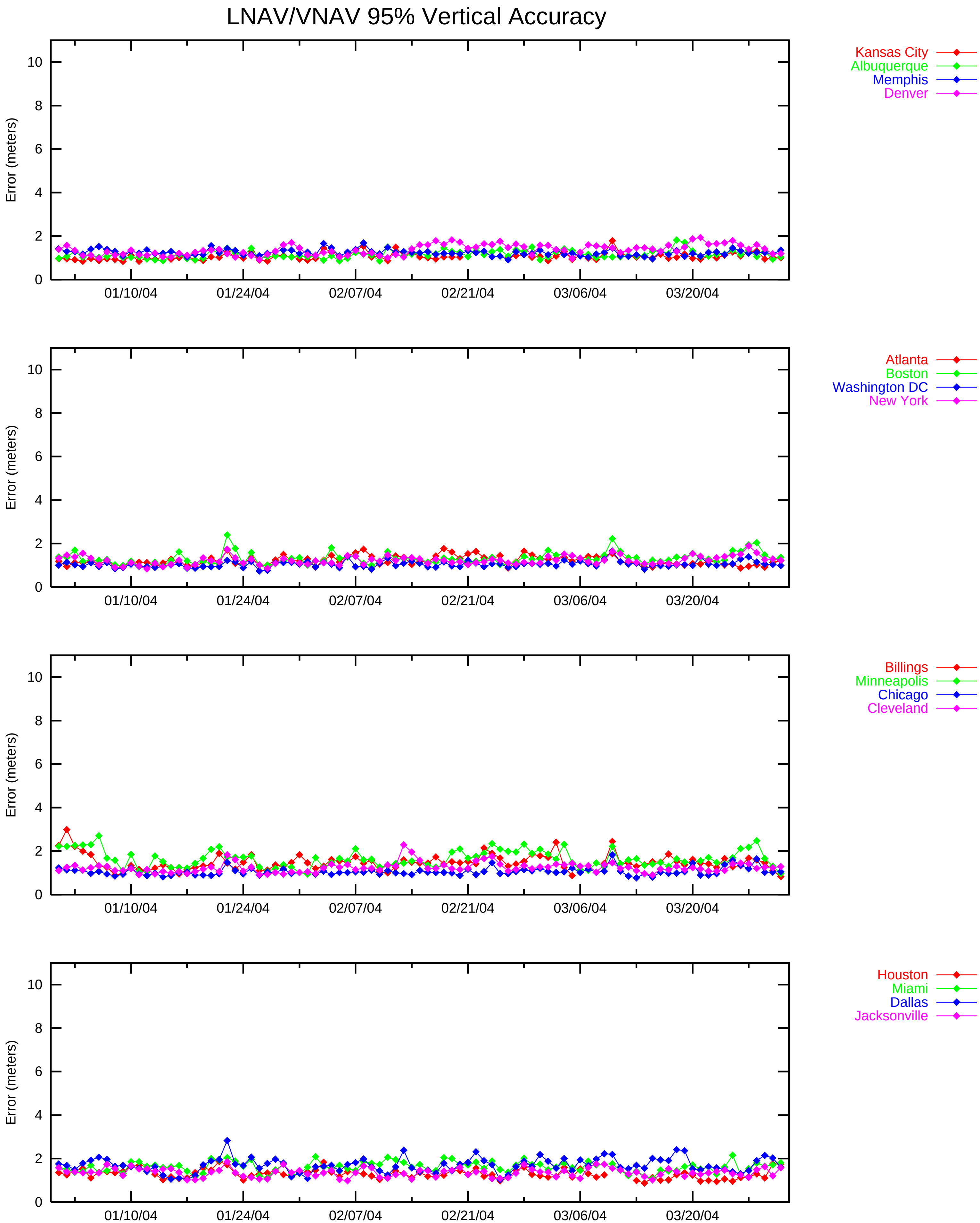


Figure 2•5 NPA 95% Horizontal Accuracy

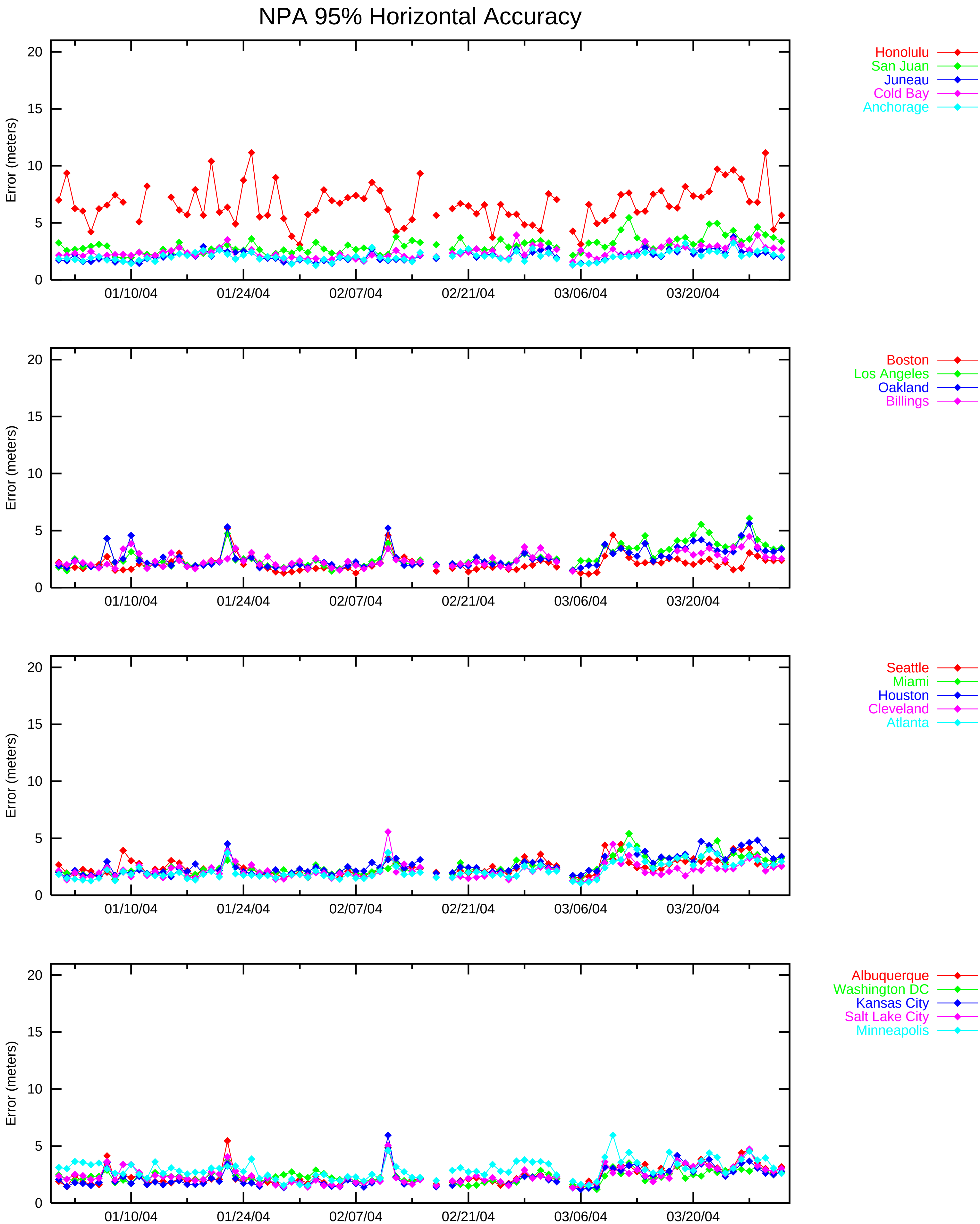


Figure 2•6 Horizontal Triangle Chart for Oklahoma City

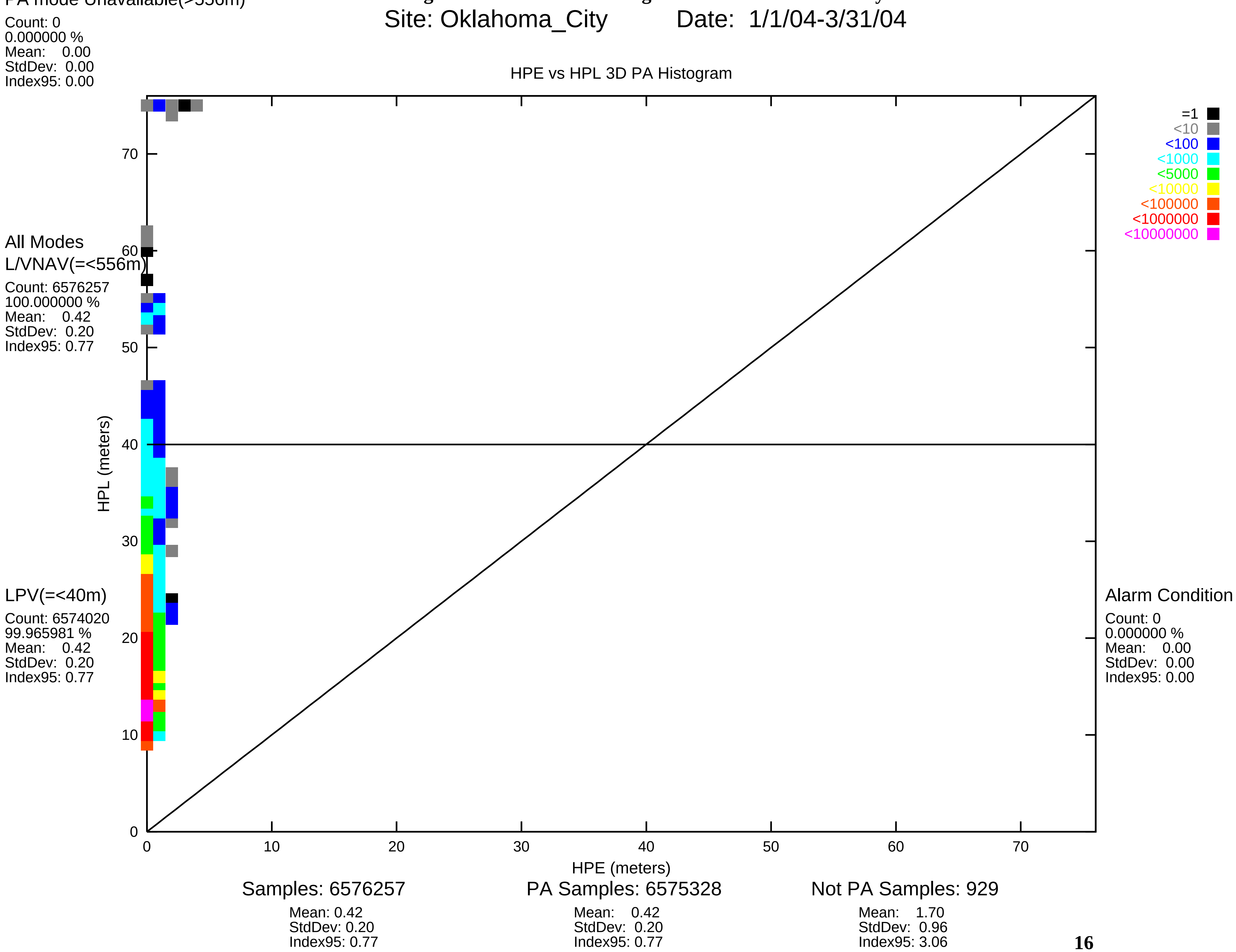


Figure 2•7 Vertical Triangle Chart for Oklahoma City

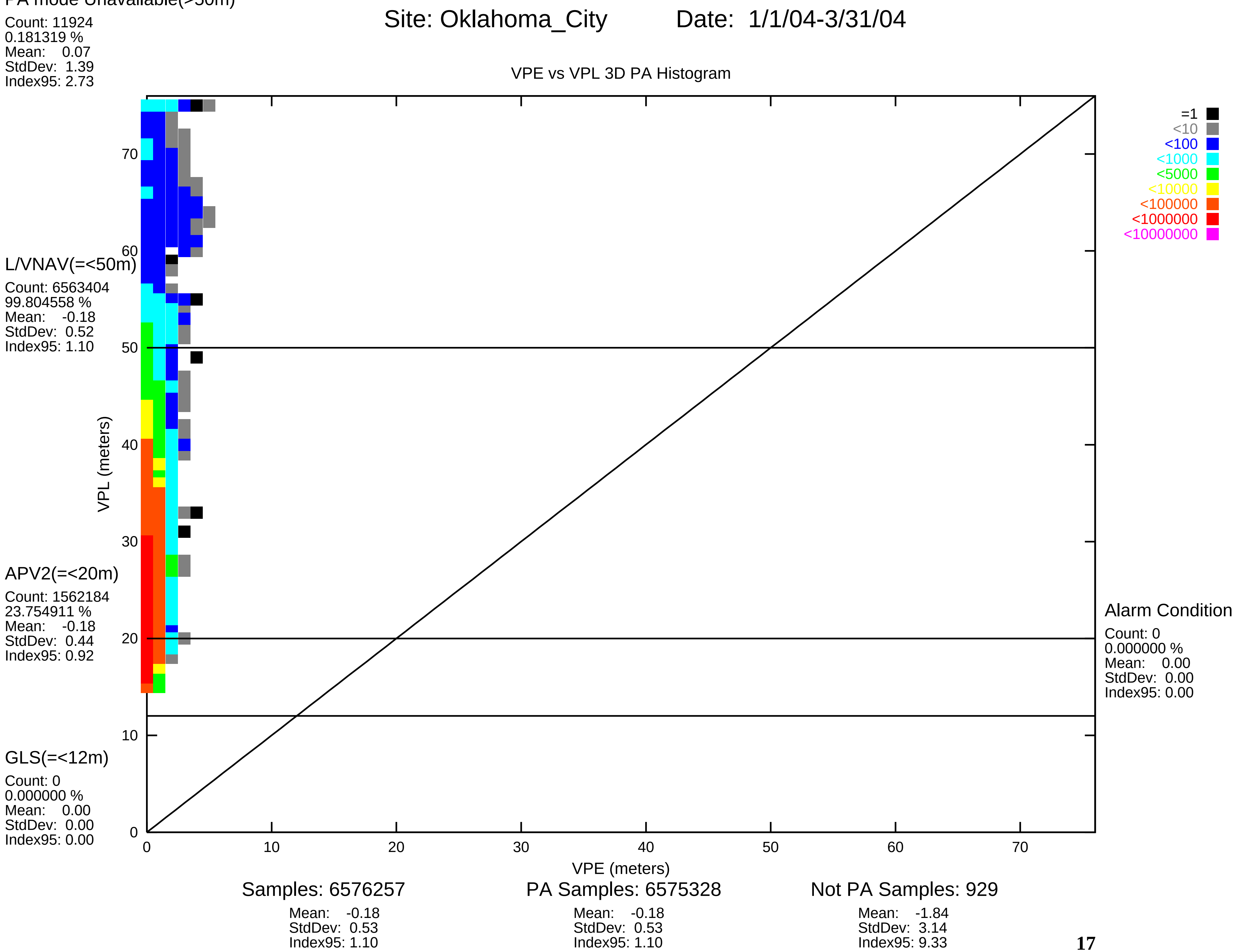


Figure 2•8 2-D Histogram for Oklahoma City

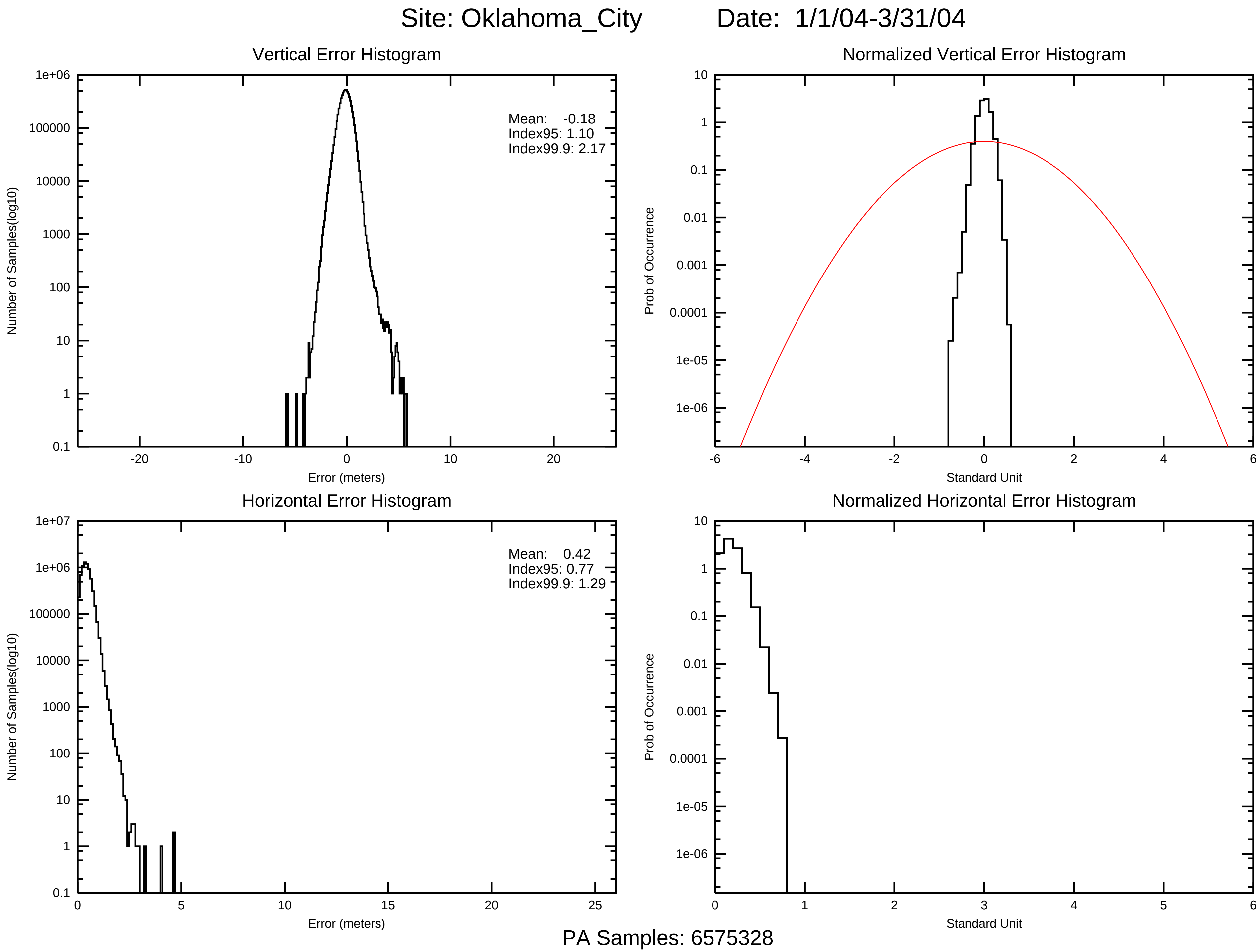


Figure 2•9 Horizontal Triangle Chart for Washington, DC

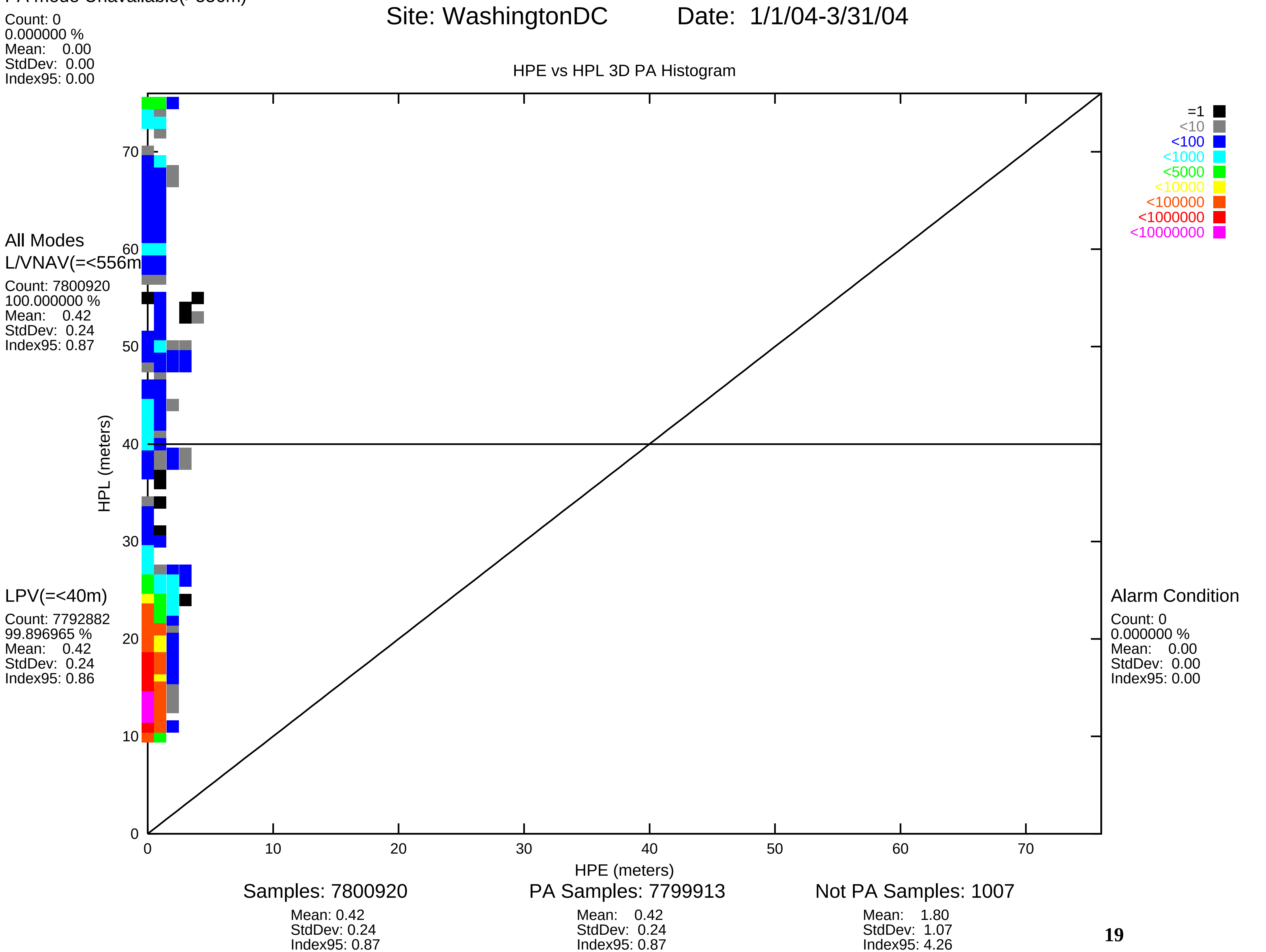


Figure 2•10 Vertical Triangle Chart for Washington, DC

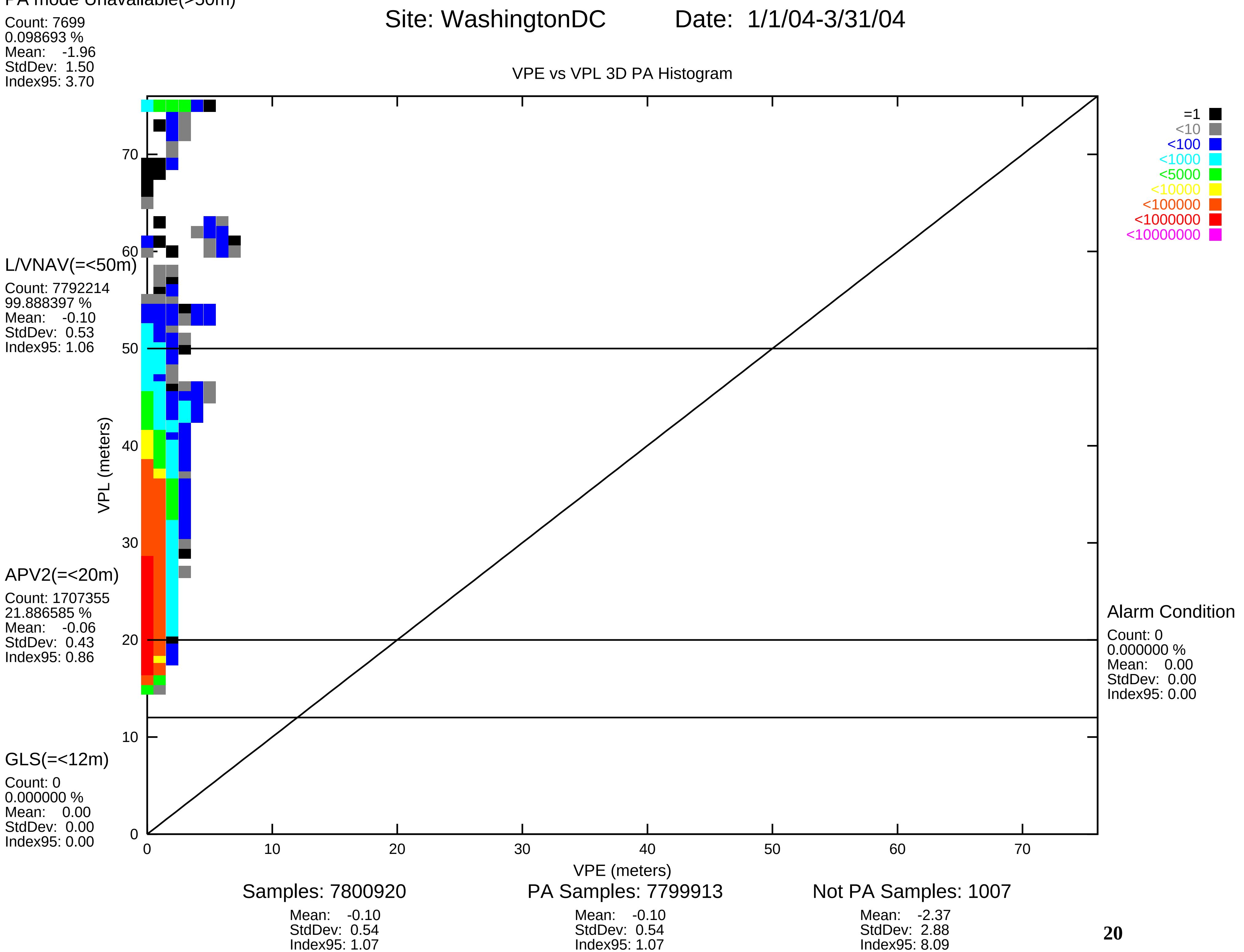


Figure 2•11 2-D Histogram for Washington, DC

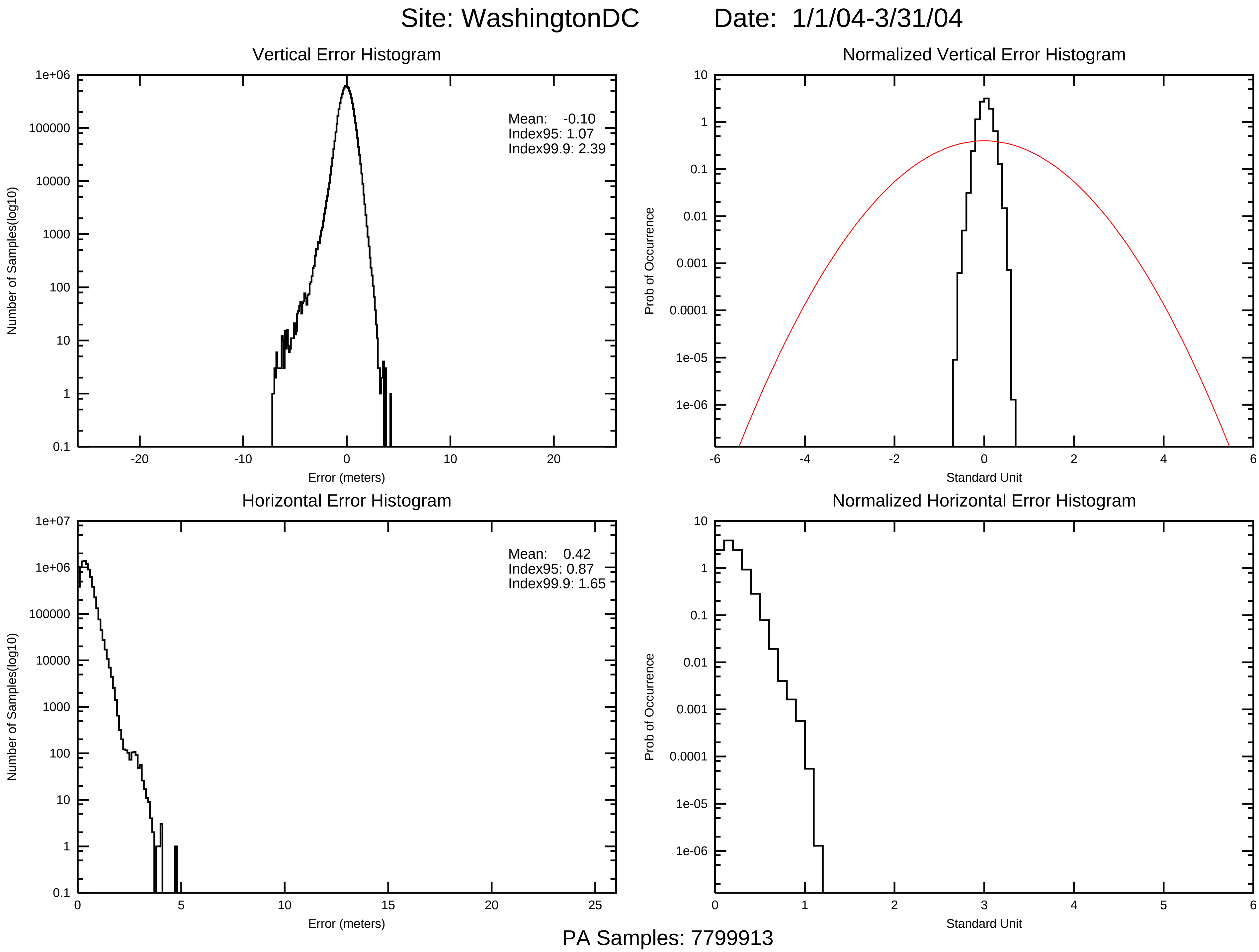


Figure 2•12 Horizontal Triangle Chart for Seattle

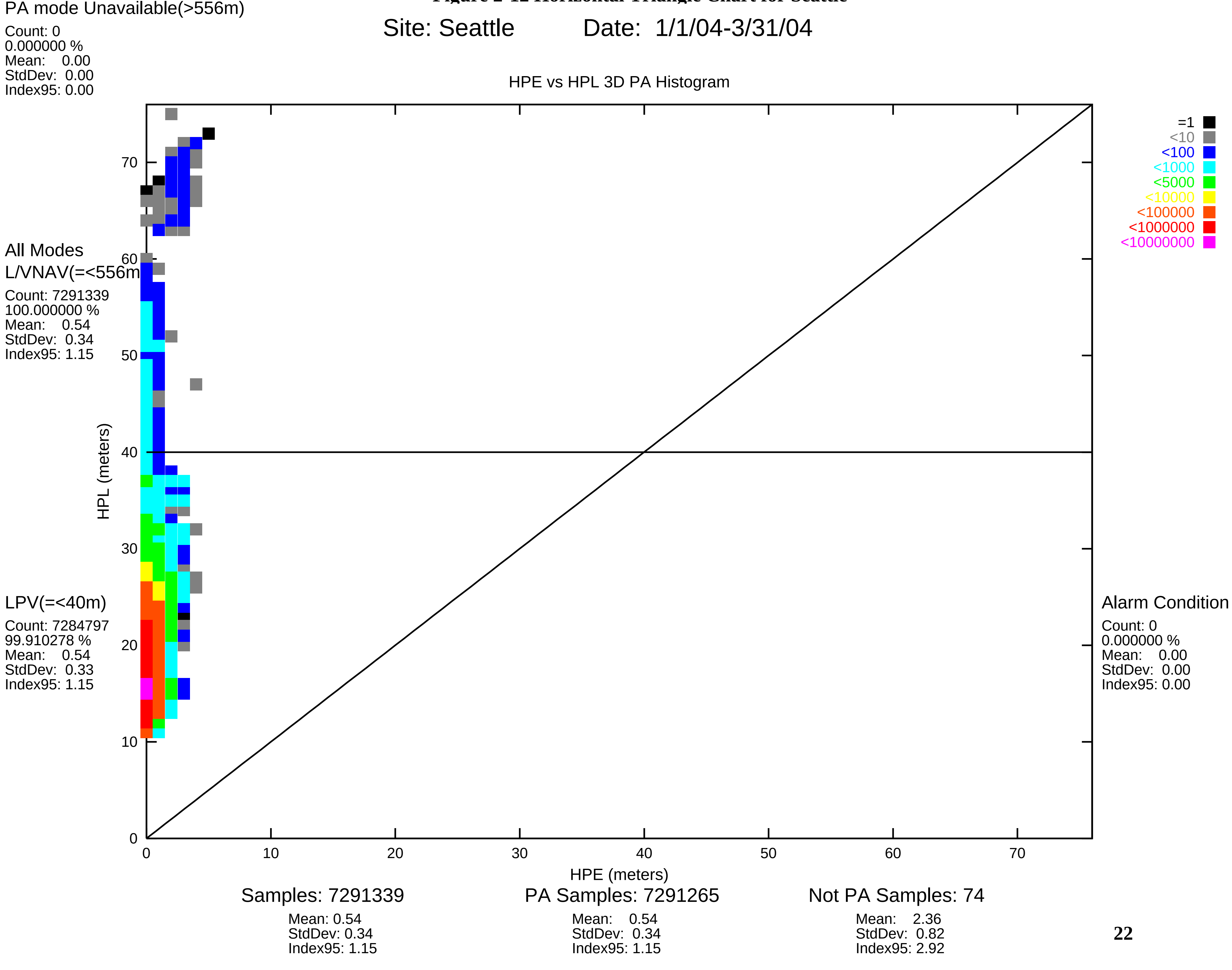


Figure 2•13 Vertical Triangle Chart for Seattle

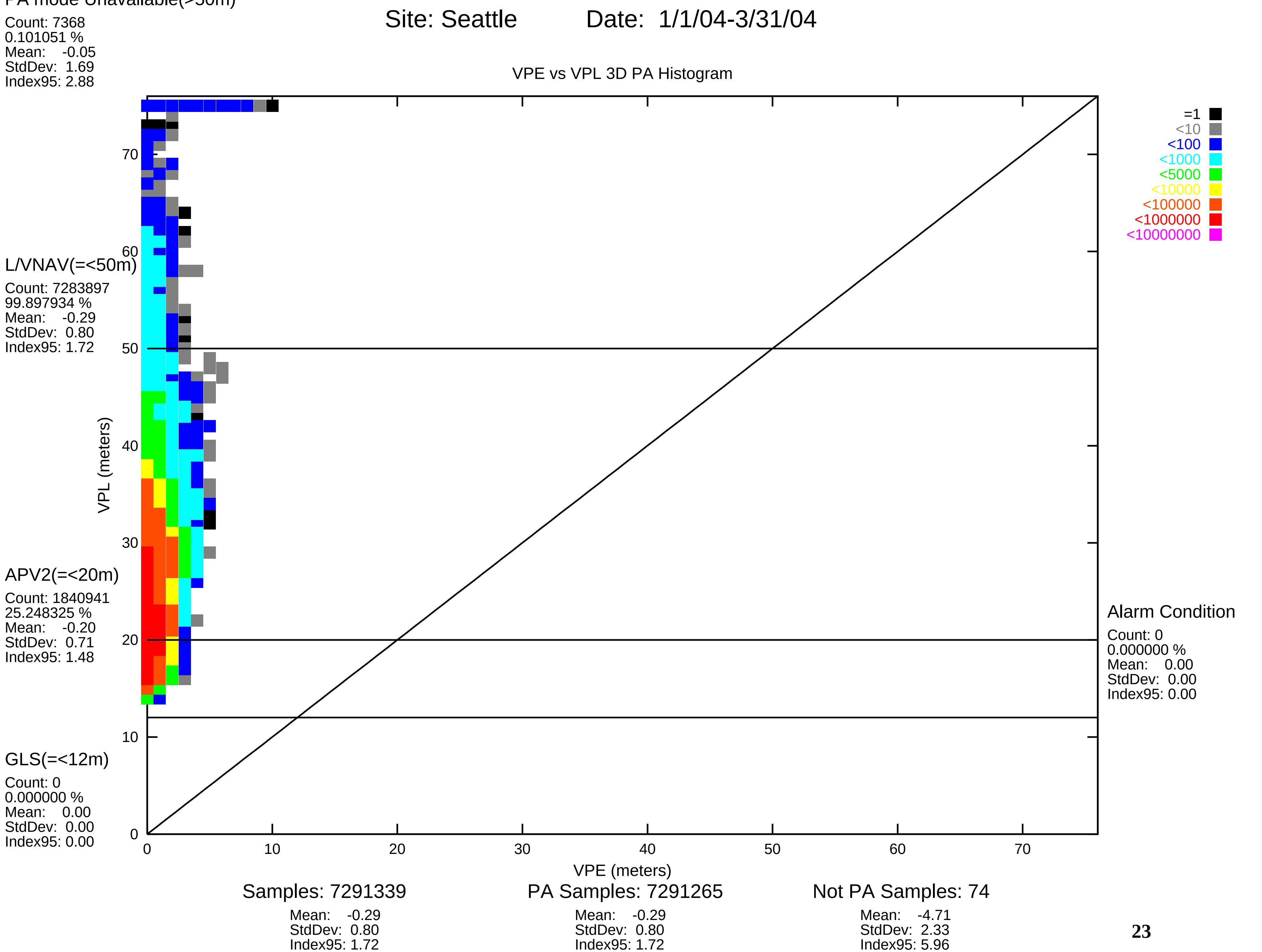
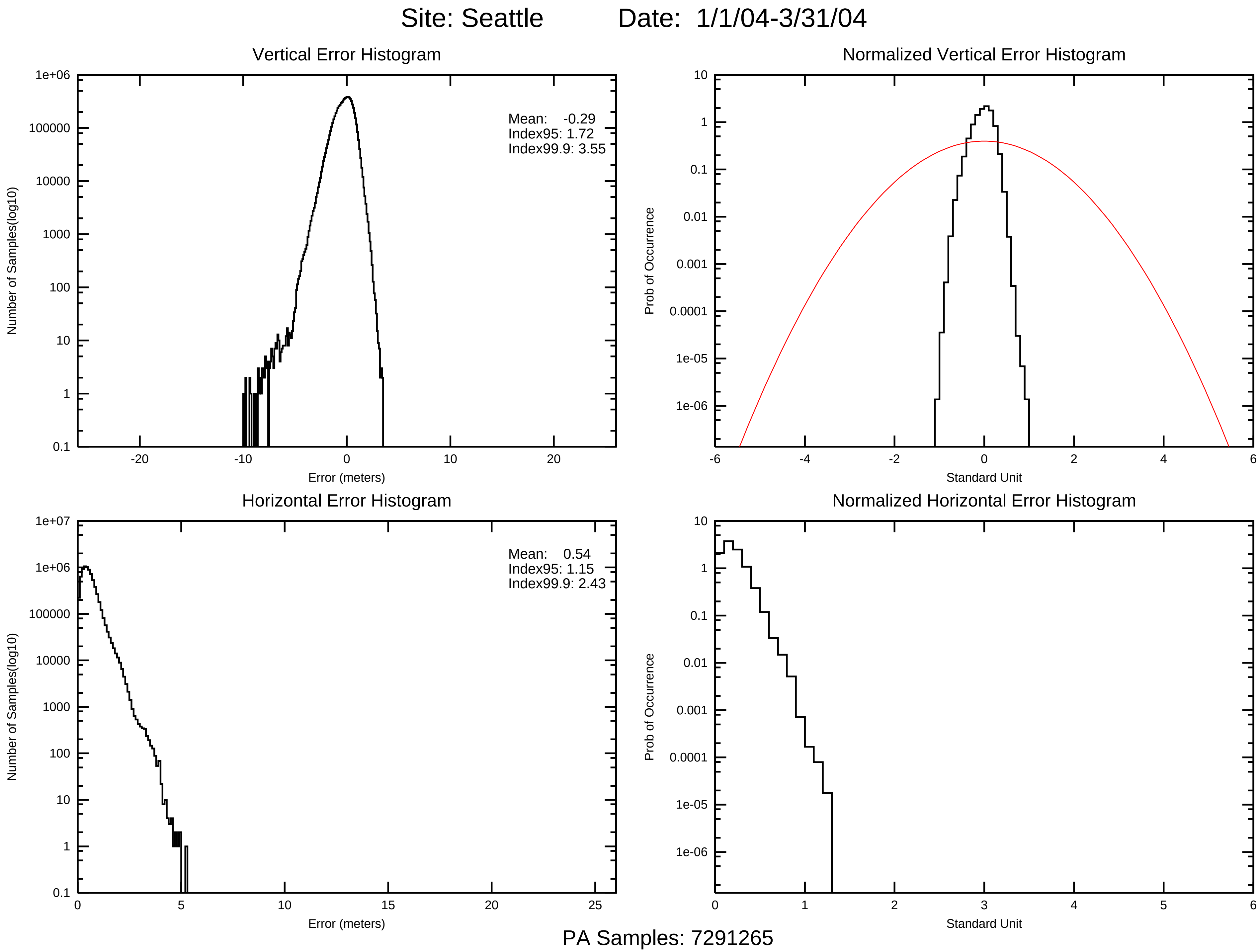


Figure 2•14 2-D Histogram for Seattle



3.0 AVAILABILITY

WAAS availability evaluation estimates the probability that the WAAS can provide service for the operational service levels (LPV and LNAV/VNAV) defined in Table 2.1. At each receiver, the WAAS message, along with the GPS/GEO satellites tracked, were used to produce WAAS protection levels in accordance with the WAAS MOPS. Table 3.1 shows the protection levels that were maintained for 95% of the time for each receiver location for the quarter. The table also included the percentage in PA mode as described in section 2.0. Table 3.2 presents the percentage of time that WAAS operational service levels were available at each receiver location. Figures 3.1 through 3.4 show the daily instantaneous availability of LNAV/VNAV and LPV service levels for the evaluated period.

The geographic location of each receiver evaluated is depicted in Figure 3.5 and 3.6, along with the 95% VPL value, the WAAS LPV and the LNAV/VNAV instantaneous availability percentage at each location for the quarter.

Table 3-1 95% Protection Level

Location	95% HPL (meters)	95% VPL (meters)	Percentage in PA mode
Anderson	17.871	31.021	99.98667
Atlantic City	21.224	36.590	99.98361
Grand Forks	25.622	35.405	99.97800
Great Falls	25.045	35.887	99.98994
Oklahoma City	20.703	34.622	99.98587
Prescott	27.041	43.271	99.99943
San Angelo	28.230	44.234	99.98603
Albuquerque	20.059	32.434	99.98669
Atlanta	17.284	30.109	99.98691
Billings	19.590	27.989	99.98615
Boston	24.289	41.234	99.98659
Chicago	17.132	28.742	99.97962
Cleveland	18.498	31.127	99.98261
Dallas	18.666	32.060	99.98671
Denver	17.958	28.581	99.97910
Houston	21.688	36.109	99.98644
Jacksonville	17.985	34.179	99.98672
Kansas City	16.250	27.633	99.97816
Los Angeles	27.815	41.470	99.99905
Memphis	16.610	30.298	99.98272
Miami	21.694	40.847	99.98671
Minneapolis	18.892	29.366	99.97955
New York	21.177	37.512	99.98663
Oakland	27.836	40.608	99.99896
Salt Lake City	19.489	28.568	99.99913
Seattle	22.693	30.928	99.99899
Washington DC	18.047	32.076	99.98709

Table 3-2 Average Quarterly Availability Statistics

Location	LPV (HAL = 40m VAL = 50m) Percentage of time	LNAV/VNAV (HAL= 556m VAL = 50m) Percentage of time
Anderson	0.99964	0.99972
Atlantic City	0.99674	0.99738
Elko	0.99773	0.99797
Grand Forks	0.98908	0.98913
Great Falls	0.99869	0.99907
Oklahoma City	0.99804	0.99805
Prescott	0.99083	0.99247
San Angelo	0.98498	0.98567
Albuquerque	0.99961	0.99967
Atlanta	0.99955	0.99955
Billings	0.99937	0.99949
Boston	0.99275	0.99335
Chicago	0.99825	0.99833
Cleveland	0.99839	0.99852
Dallas	0.99977	0.99977
Denver	0.99976	0.99977
Houston	0.99939	0.99939
Jacksonville	0.99966	0.99966
Kansas City	0.99932	0.99933
Los Angeles	0.98927	0.99022
Memphis	0.99948	0.99949
Miami	0.99242	0.99255
Minneapolis	0.99848	0.99860
New York	0.99637	0.99664
Oakland	0.99275	0.99365
Salt Lake City	0.99982	0.99983
Seattle	0.99876	0.99898
Washington DC	0.99878	0.99888

During the evaluated period, the maximum 95% HPL and VPL are 28.230 meters and 44.234 meters, both at San Angelo. The minimum 95% HPL and VPL are 16.250 meters in Kansas City and 27.633 meters, both at Kansas City. LNAV/VNAV instantaneous availability ranges between 98.6% and 100%. LPV instantaneous availability ranges between 98.5% and 100%. Note that there were no major ionospheric storms during this quarter that would lower the availability of WAAS.

Figure 3•1 LNAV/VNAV Instantaneous Availability

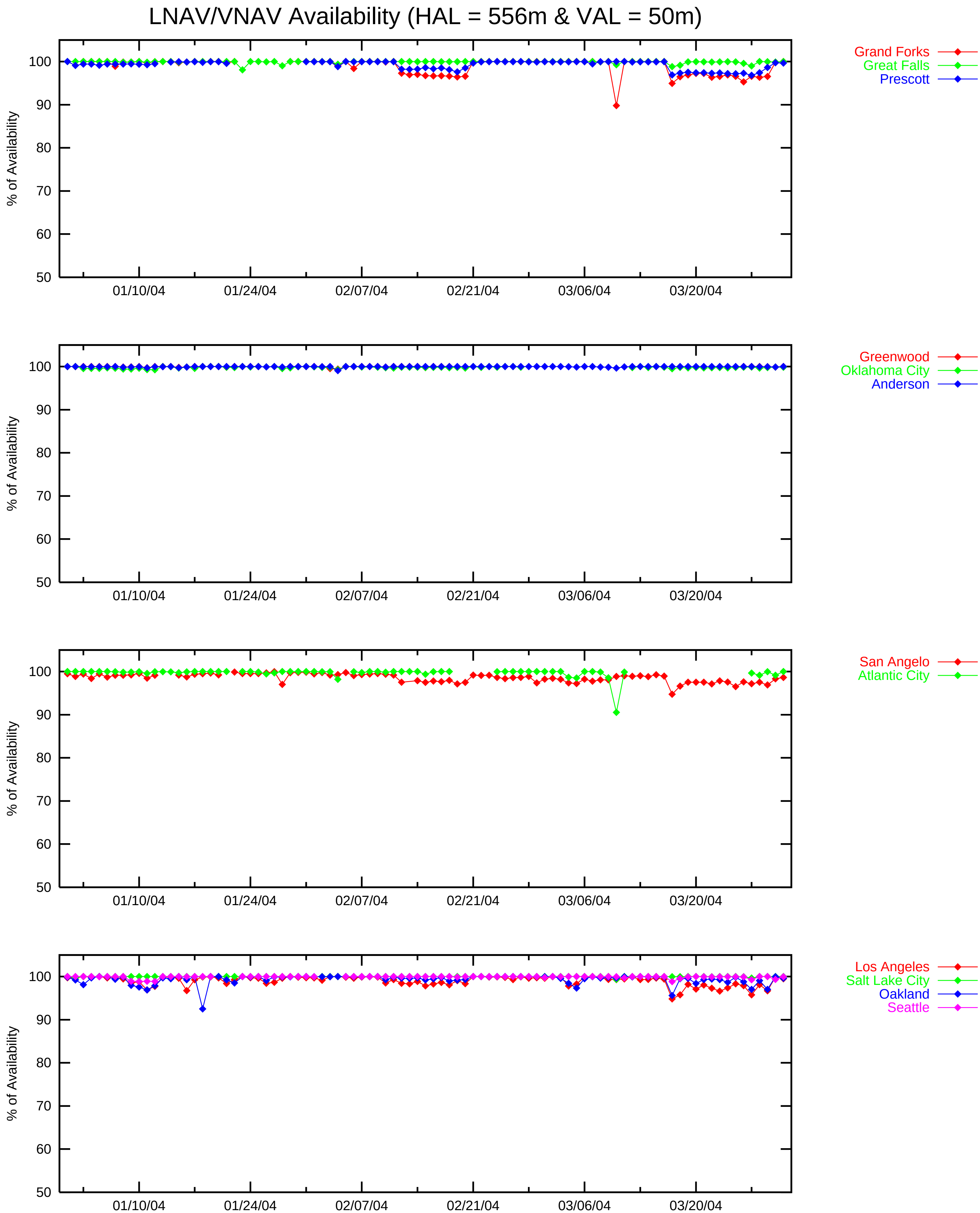


Figure 3•2 LNAV/VNAV Instantaneous Availability

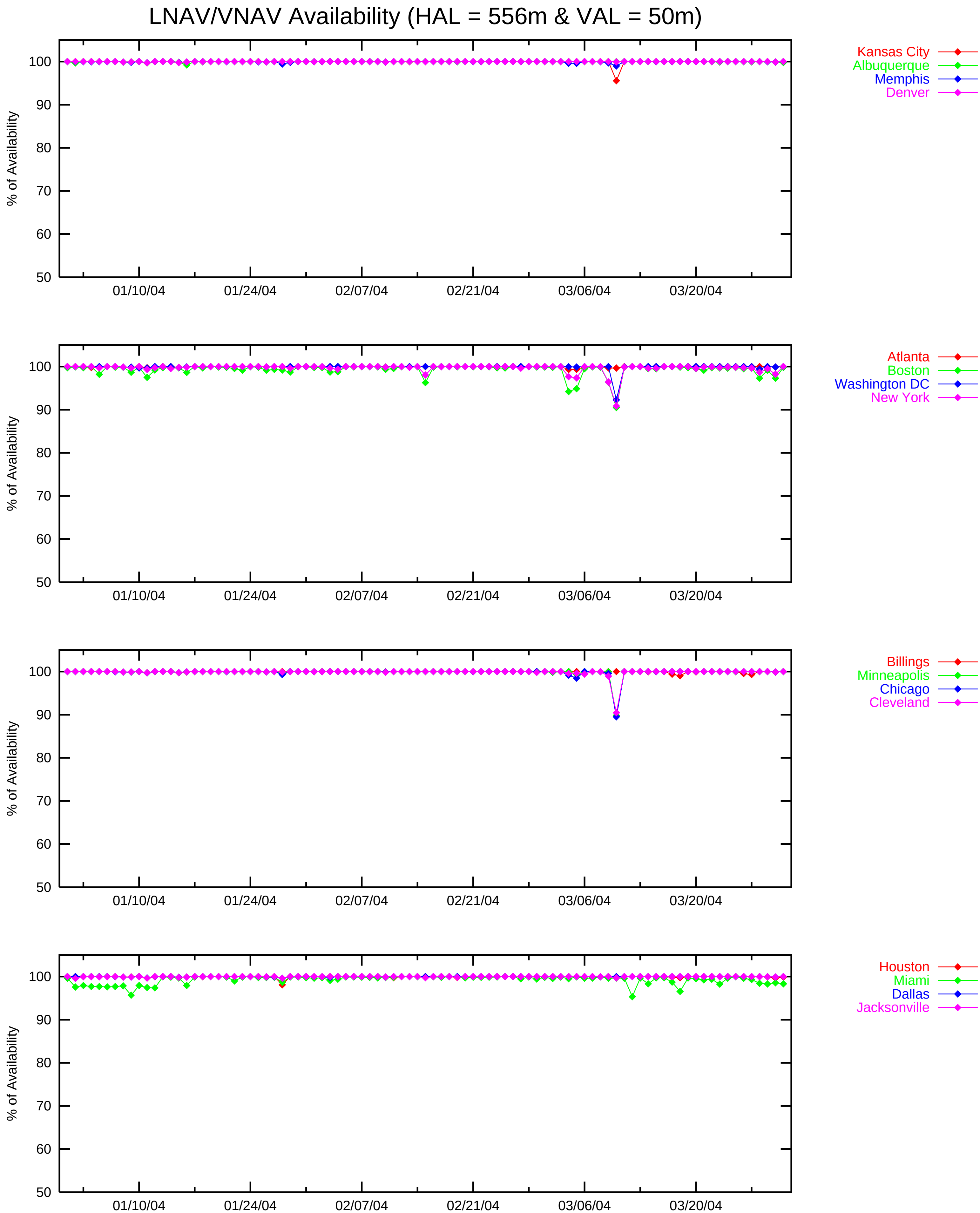


Figure 3•3 LPV Instantaneous Availability

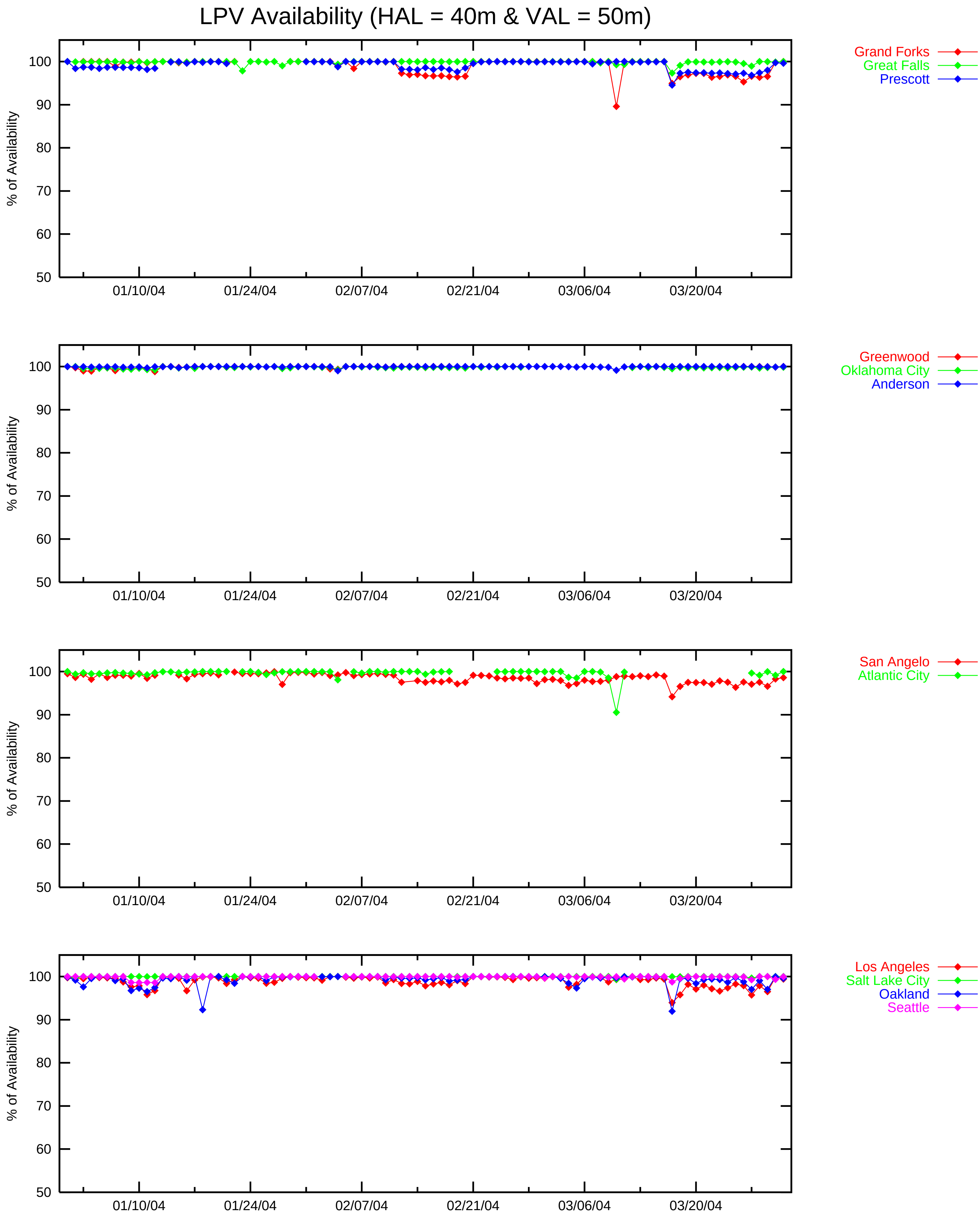


Figure 3•4 LPV Instantaneous Availability

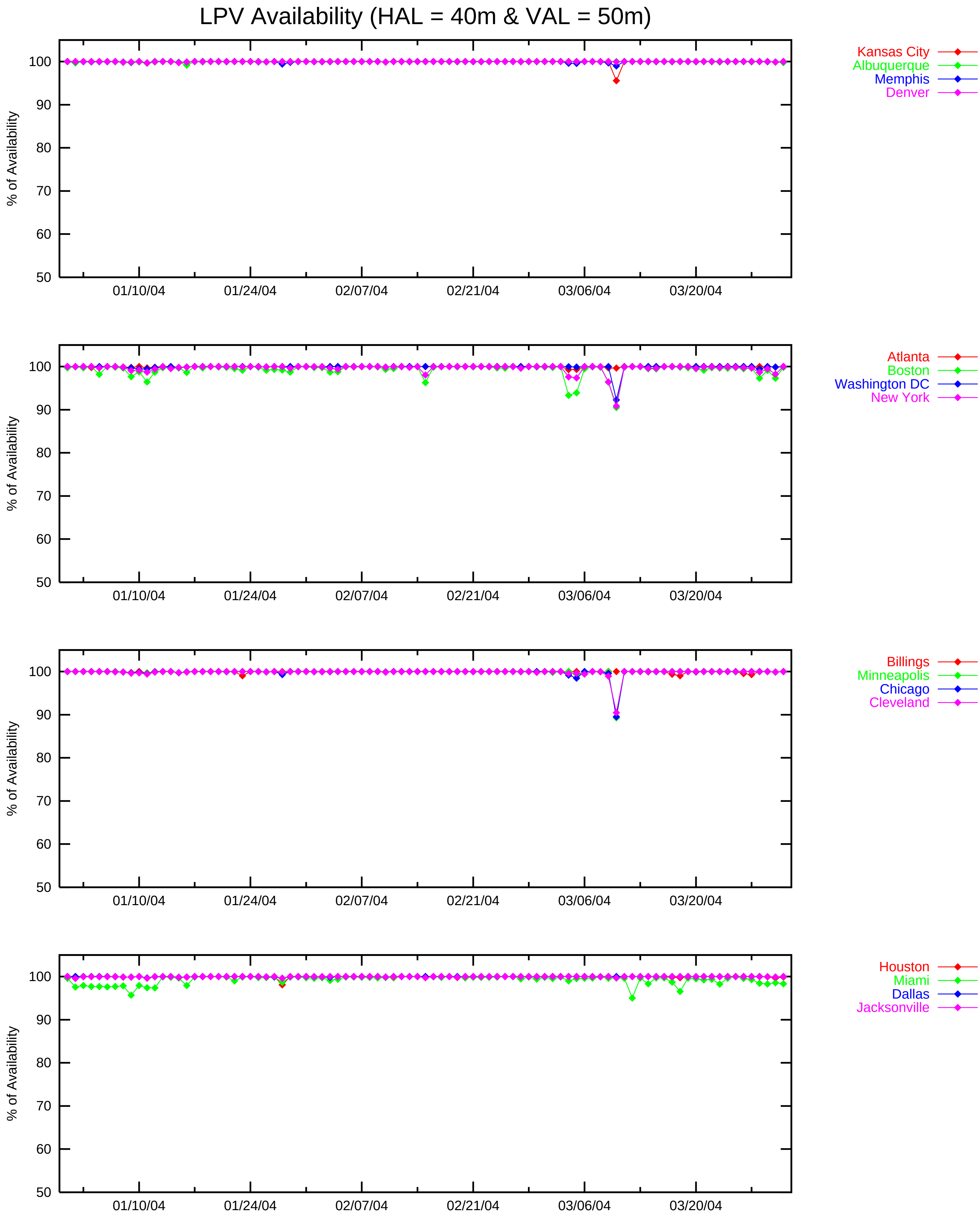


Figure 3•5 95% VPL , LPV and LNAV/VNAV Availability – NSTB sites

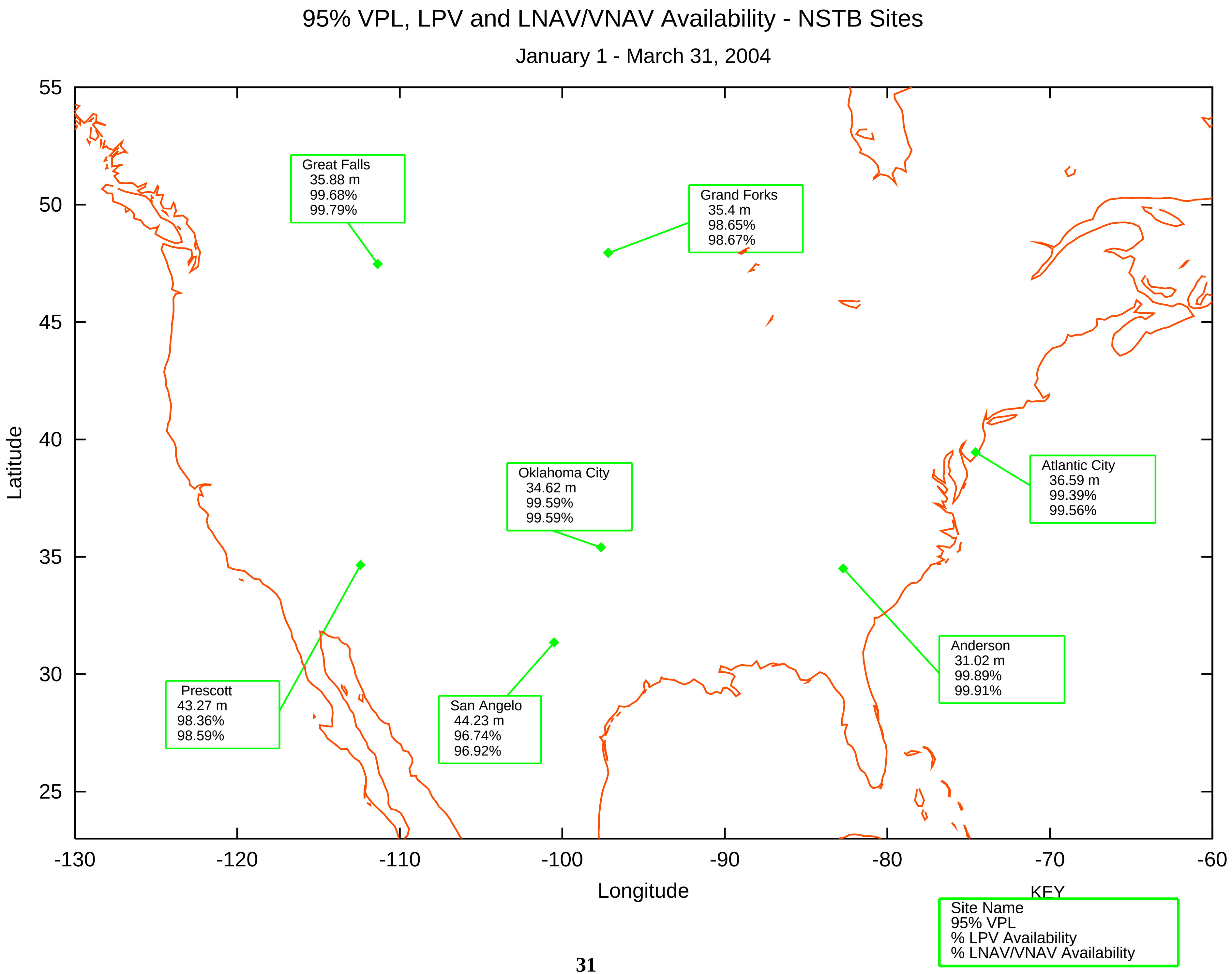
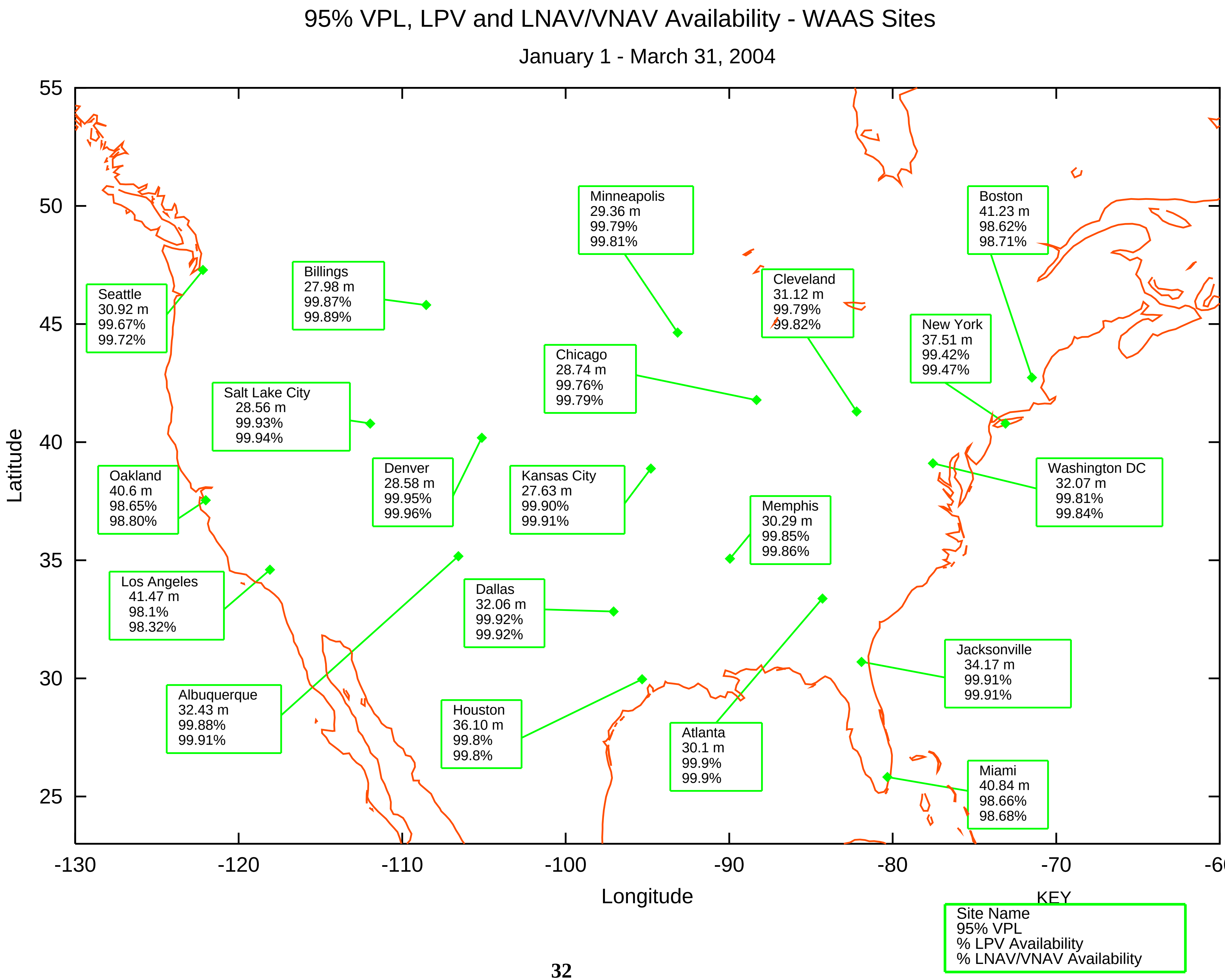


Figure 3•6 95% VPL , LPV and LNAV/VNAV Availability – WAAS sites



4.0 COVERAGE

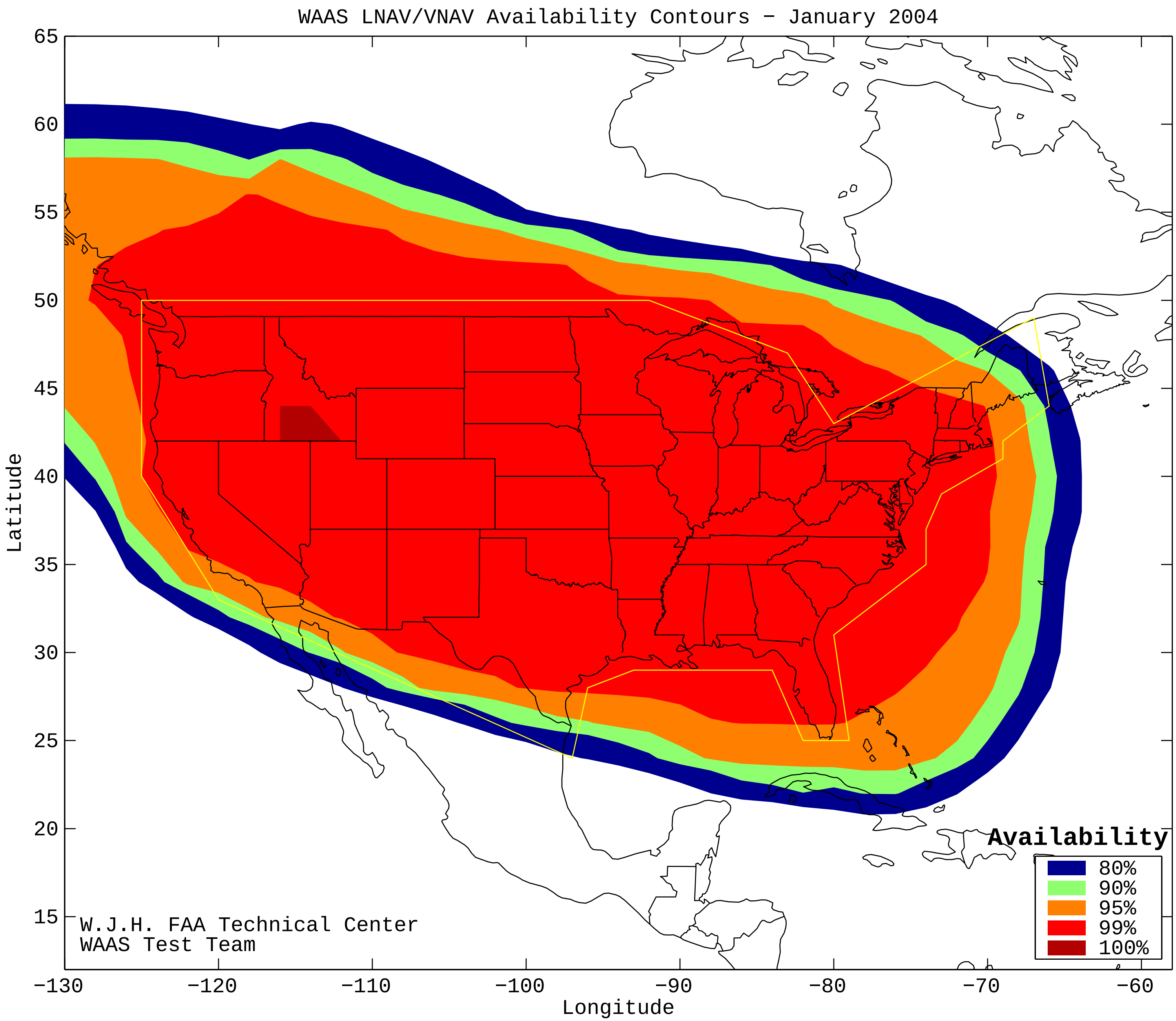
WAAS coverage area evaluation estimates the percent of service volume where WAAS is providing LPV, LNAV/VNAV and NPA services. The WAAS message and the GPS/GEO satellite status are used to determine WAAS availability across North America. For PA coverage, protection levels were calculated at two-minute intervals and at two degree spacing over PA service volume, while NPA coverage was calculated at two-minute intervals and five degree spacing over NPA service volume.

Daily analysis for PA was conducted for both LPV and LNAV/VNAV service levels. Figures 4.1 to 4.3 and 4.5 to 4.7 show the WAAS LNAV/VNAV and LPV coverage area for each month for this quarter, respectively. Figures 4.4 and 4.8 show the rollup WAAS LNAV/VNAV and LPV coverage for the quarter. The coverage plots also provide 100, 99, 95, 90 and 80% availability contours. Figure 4.13 shows the daily WAAS LNAV/VNAV and LPV coverage at 99% availability and ionosphere Kp index values for this quarter. The drop in the LNAV/VNAV and LPV coverage on March 10 is due to all satellites being set to Not Monitored. The reason all the satellites were set to Not Monitored is due to the trip of the User Position Monitor (UPM) at the Minneapolis reference station. The UPM is part of the WAAS safety architecture that ensures no HMI is transmitted to users. In this case, the trip only occurred for the POR satellite. The root cause of the problem was higher than normal ionospheric activity on this day so there were differences in the measured versus calculated ionoshperic delays . The monitor tripped only on the POR satellite because the WAAS message scheduler permits the long term corrections to be calculated separately for each GEO. Raytheon continues to research this anomaly.

In Figure 4-14, the most of the drops in NPA coverage is due to GUS switchovers. The switchovers cause a loss of WAAS service for a period of up to 5 minutes, for LNAV/VNAV and LPV users. For enroute/NPA users the time of lost service is shorter. On March 8, March 10, and March 17 the cause of the drop is not due to GUS switchovers. On March 8 a type 0 message was transmitted by WAAS for one second causing, per the MOPS, all data in the user to be discarded and then reacquired. Note that there was 100% WAAS NPA coverage at 99% availability. On March 10 the WAAS UPM tripped. This caused all satellites to go to ‘Not Monitored’ and therefore caused a loss of NPA service. Please see the previous paragraph for more information on the UPM. On March 17 two satellites, PRN 5 and 6 were out of service. The reduction in the number of available GPS satellites caused a loss of 100% coverage with 100% availability at the far western edge of the WAAS service volume. This loss of NPA coverage is in the Pacific Ocean between Alaska and Hawaii.

Figure 4.9 to 4.11 show the NPA coverage area of each month and Figure 4.12 shows the rollup NPA coverage for the quarter. Daily analysis for NPA was based on a 99.9% availability requirement. The NPA coverage plots also provide 100, 99.9 and 99% availability contours. Figure 4.14 shows the daily NPA coverage at 99.9% availability and ionosphere Kp index values for this quarter. Drops in NPA coverage on October 2, October 15, November 20, December 2, December 12, December 18, and December 20 are caused by GUS switchovers.

Figure 4•1 WAAS LNAV/VNAV Coverage - January



CONUS Coverage at 95% Availability = 97.17
CONUS Coverage at 99% Availability = 92.71
CONUS Coverage at 100% Availability = 2.024

SL = LNAV

Figure 4•2 WAAS LNAV/VNAV Coverage - February

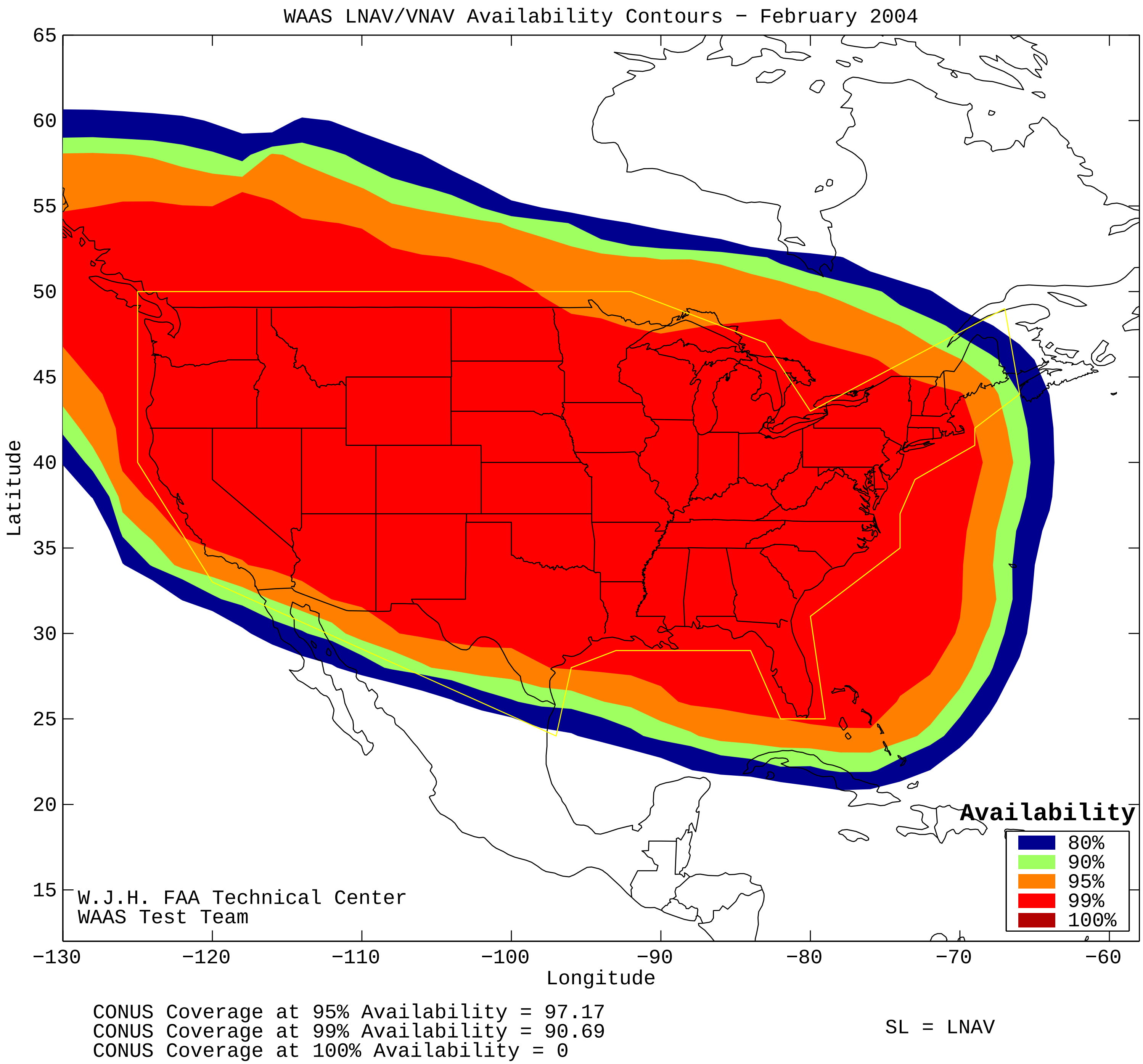
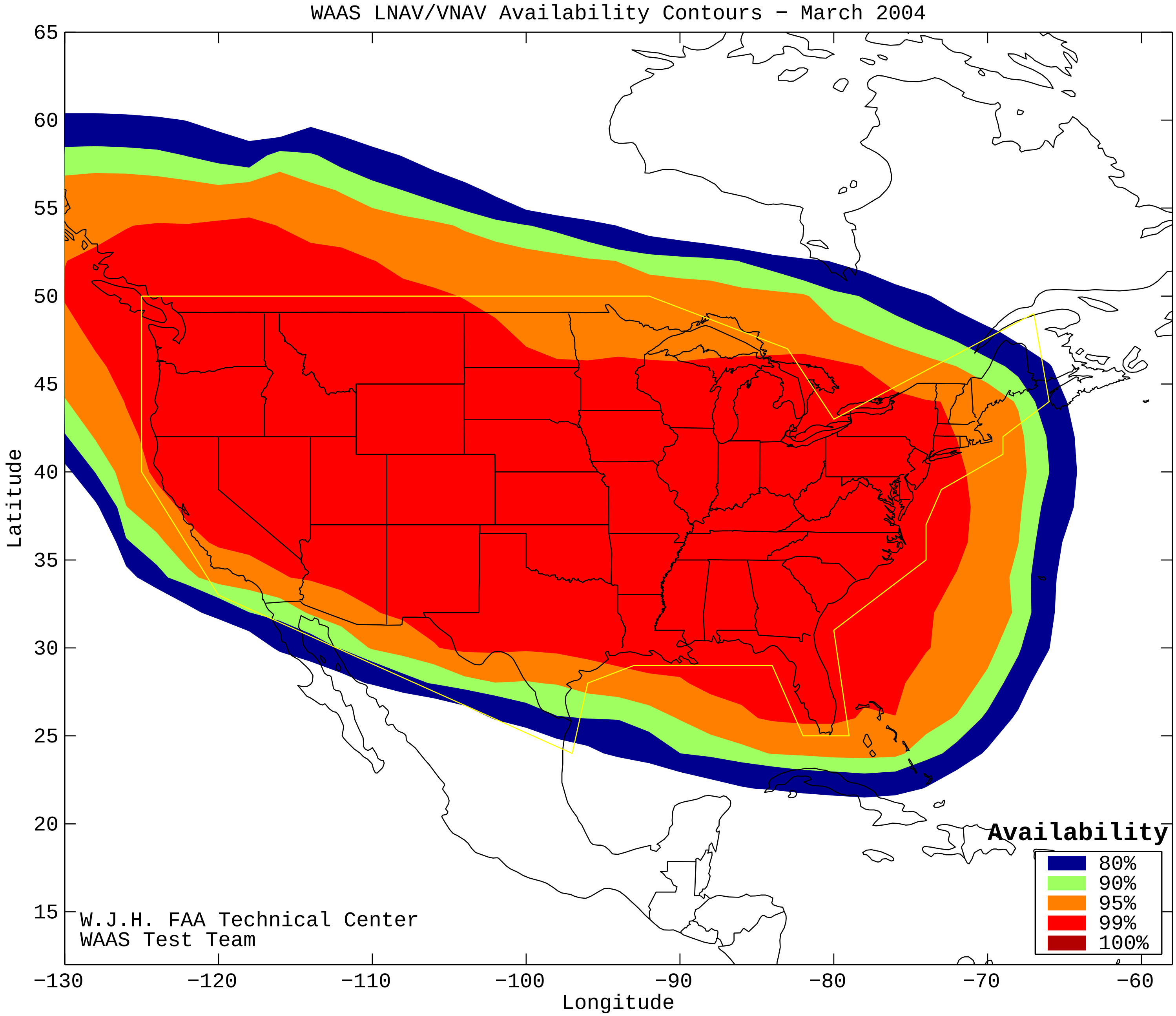


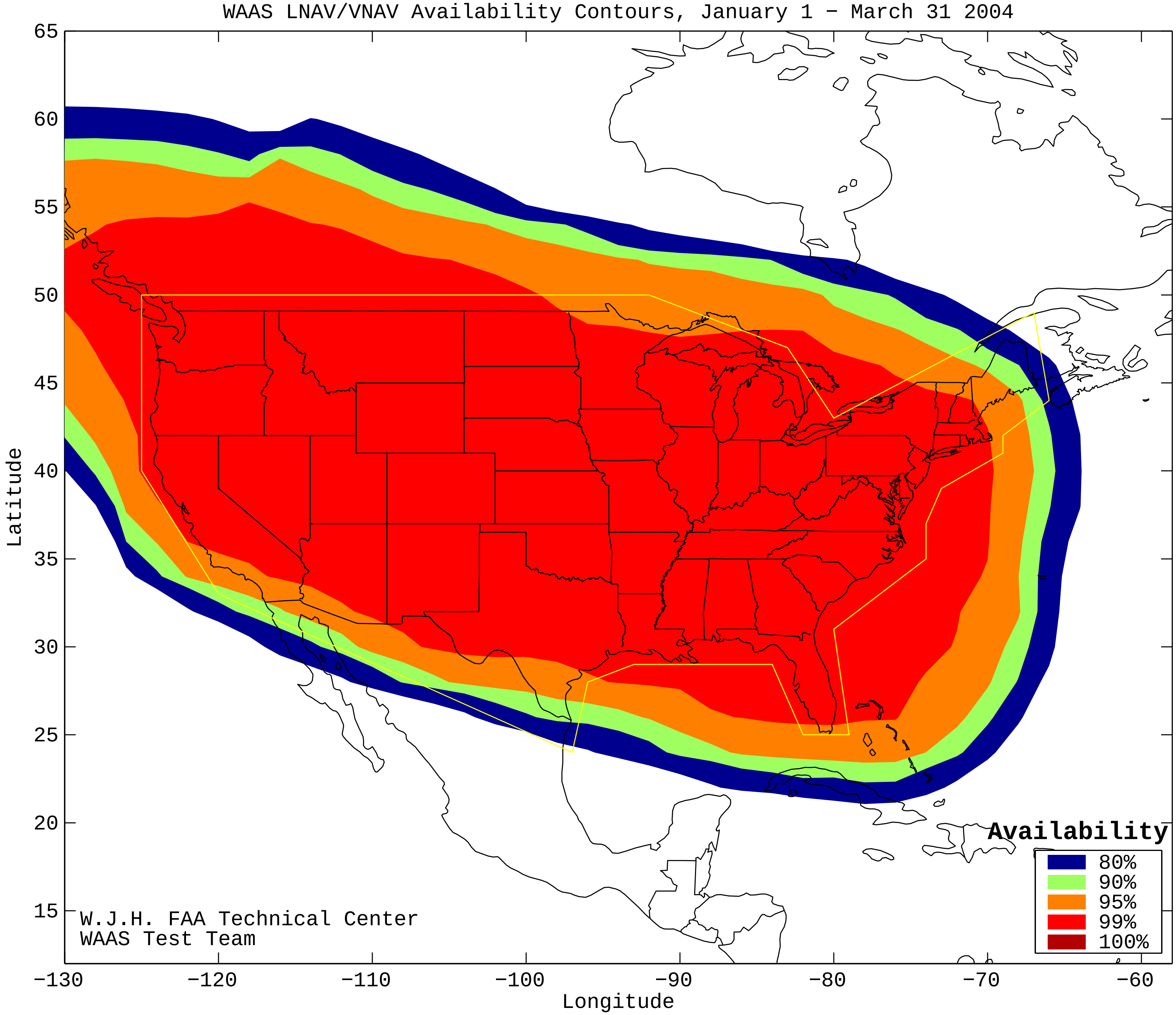
Figure 4•3 WAAS LNAV/VNAV Coverage – March



CONUS Coverage at 95% Availability = 94.33
CONUS Coverage at 99% Availability = 85.02
CONUS Coverage at 100% Availability = 0

SL = LNAV

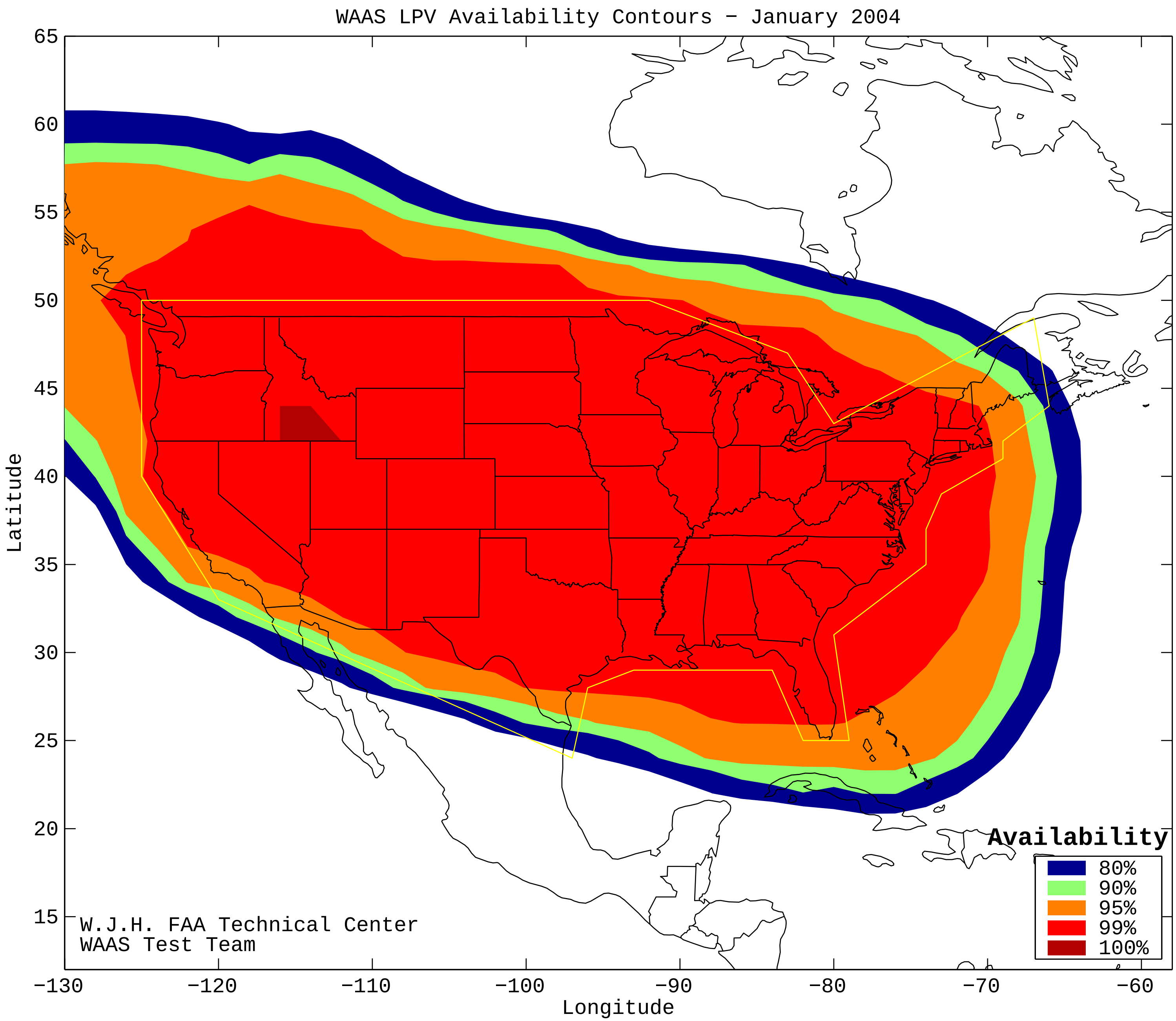
Figure 4•4 WAAS LNAV/VNAV Coverage for the Quarter



CONUS Coverage at 95% Availability = 96.36
CONUS Coverage at 99% Availability = 89.47
CONUS Coverage at 100% Availability = 0

SL = LNAV

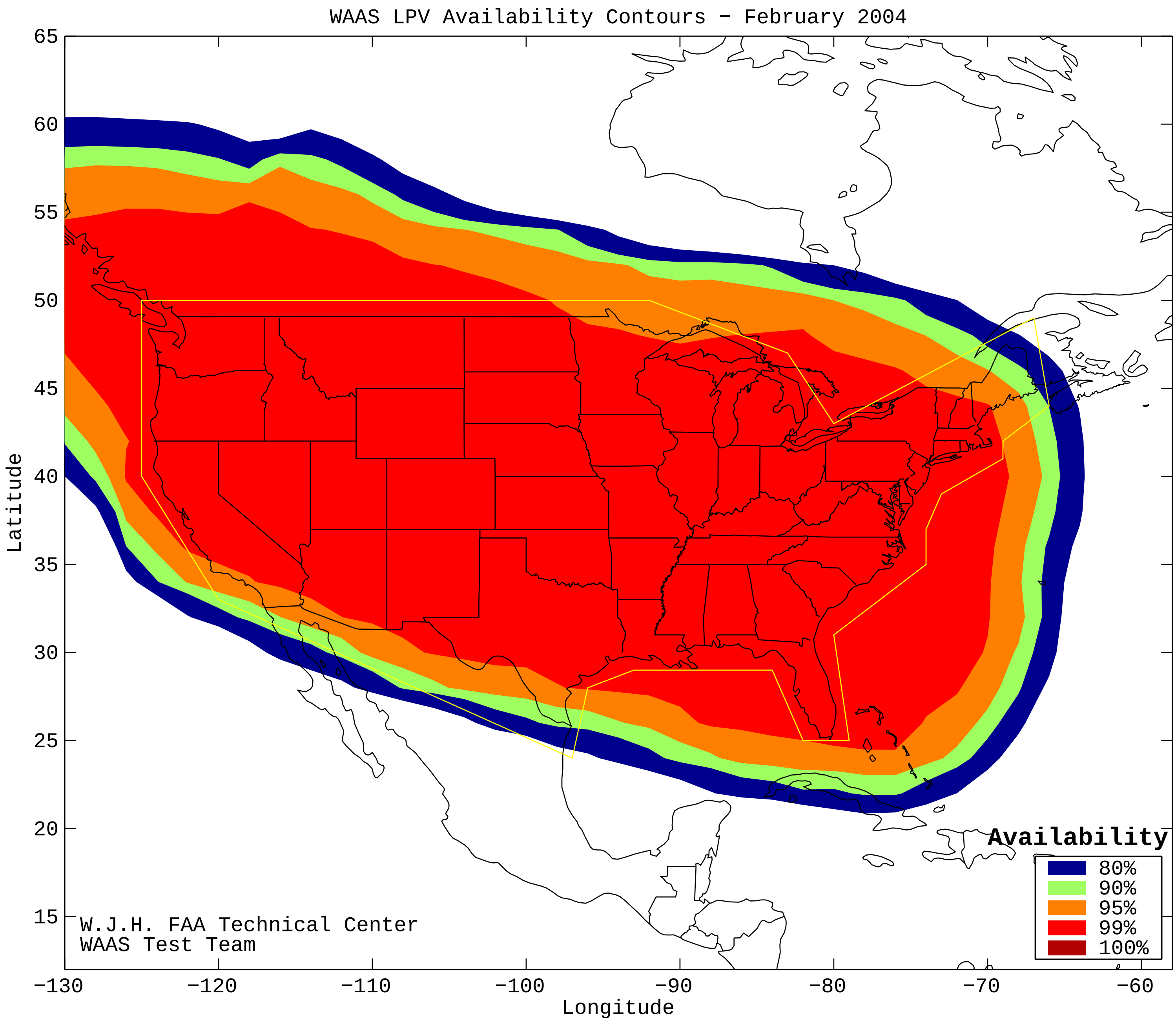
Figure 4•5 WAAS LPV Coverage - January



CONUS Coverage at 95% Availability = 97.17
CONUS Coverage at 99% Availability = 91.5
CONUS Coverage at 100% Availability = 2.024

SL = LPV

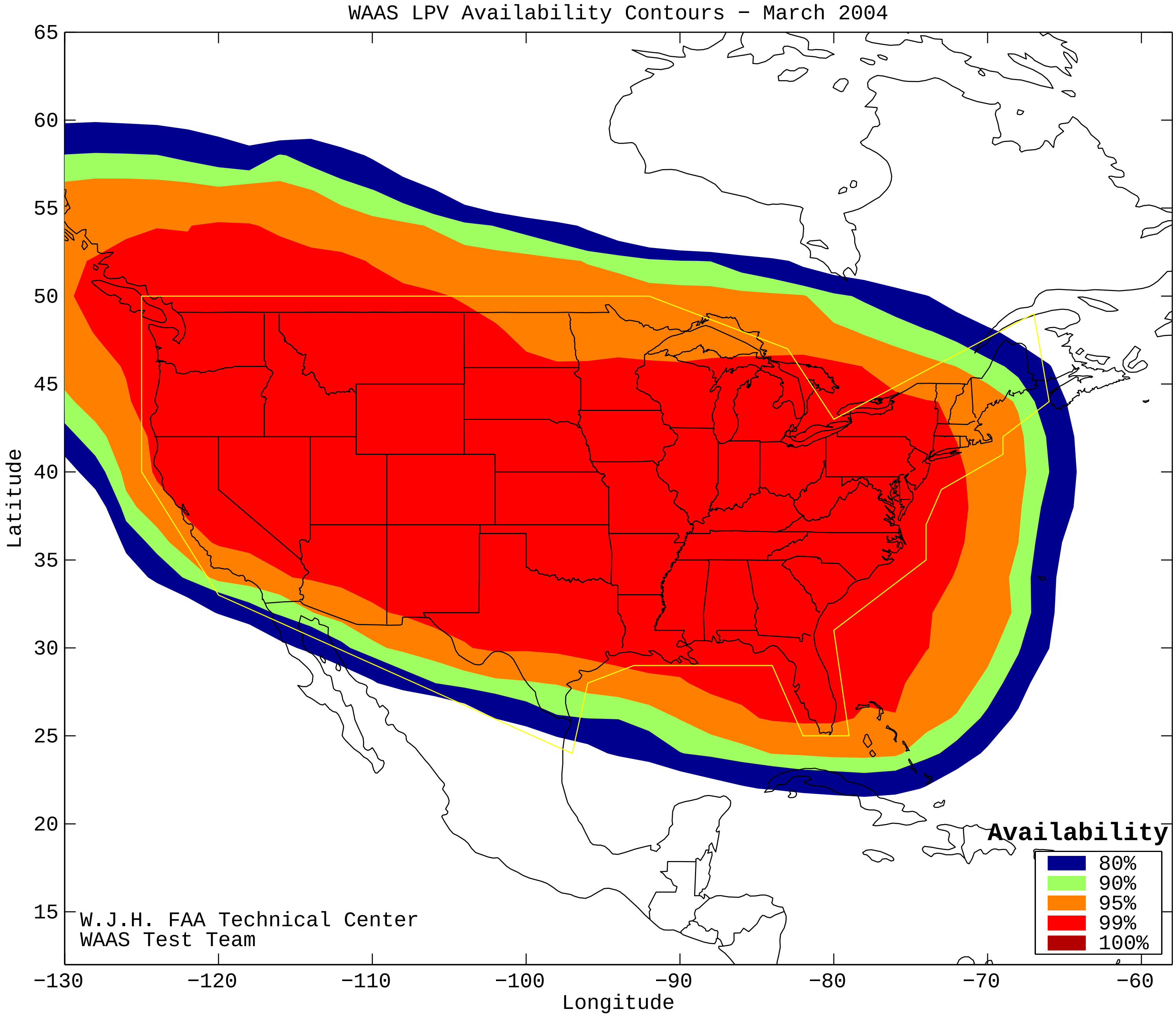
Figure 4•6 WAAS LPV Coverage - February



CONUS Coverage at 95% Availability = 96.76
CONUS Coverage at 99% Availability = 90.28
CONUS Coverage at 100% Availability = 0

SL = LPV

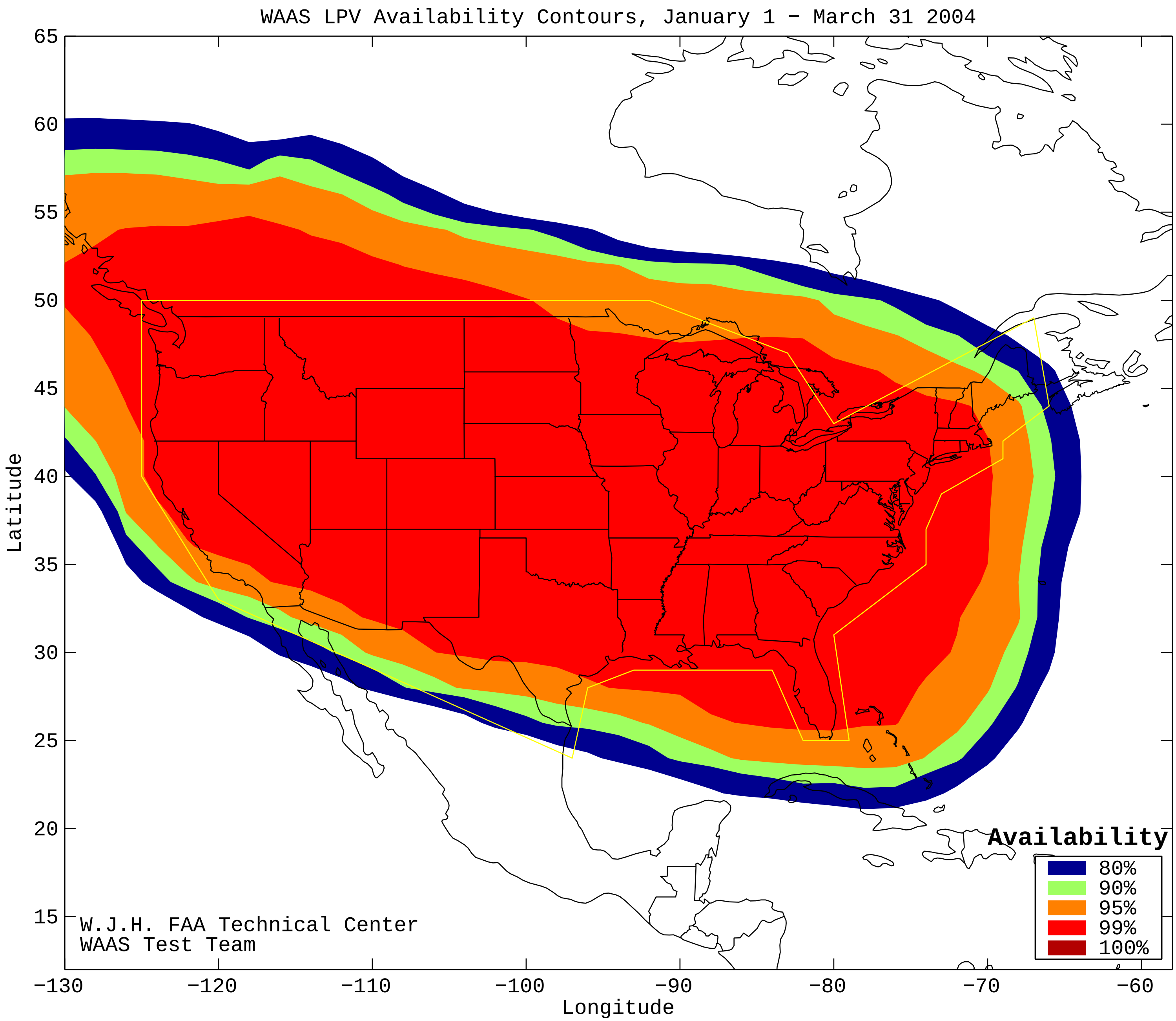
Figure 4•7 WAAS LPV Coverage - March



CONUS Coverage at 95% Availability = 93.52
CONUS Coverage at 99% Availability = 84.62
CONUS Coverage at 100% Availability = 0

SL = LPV

Figure 4•8 WAAS LPV Coverage for the Quarter



CONUS Coverage at 95% Availability = 96.36
CONUS Coverage at 99% Availability = 88.66
CONUS Coverage at 100% Availability = 0

SL = LPV

Figure 4•9 WAAS NPA Coverage - January

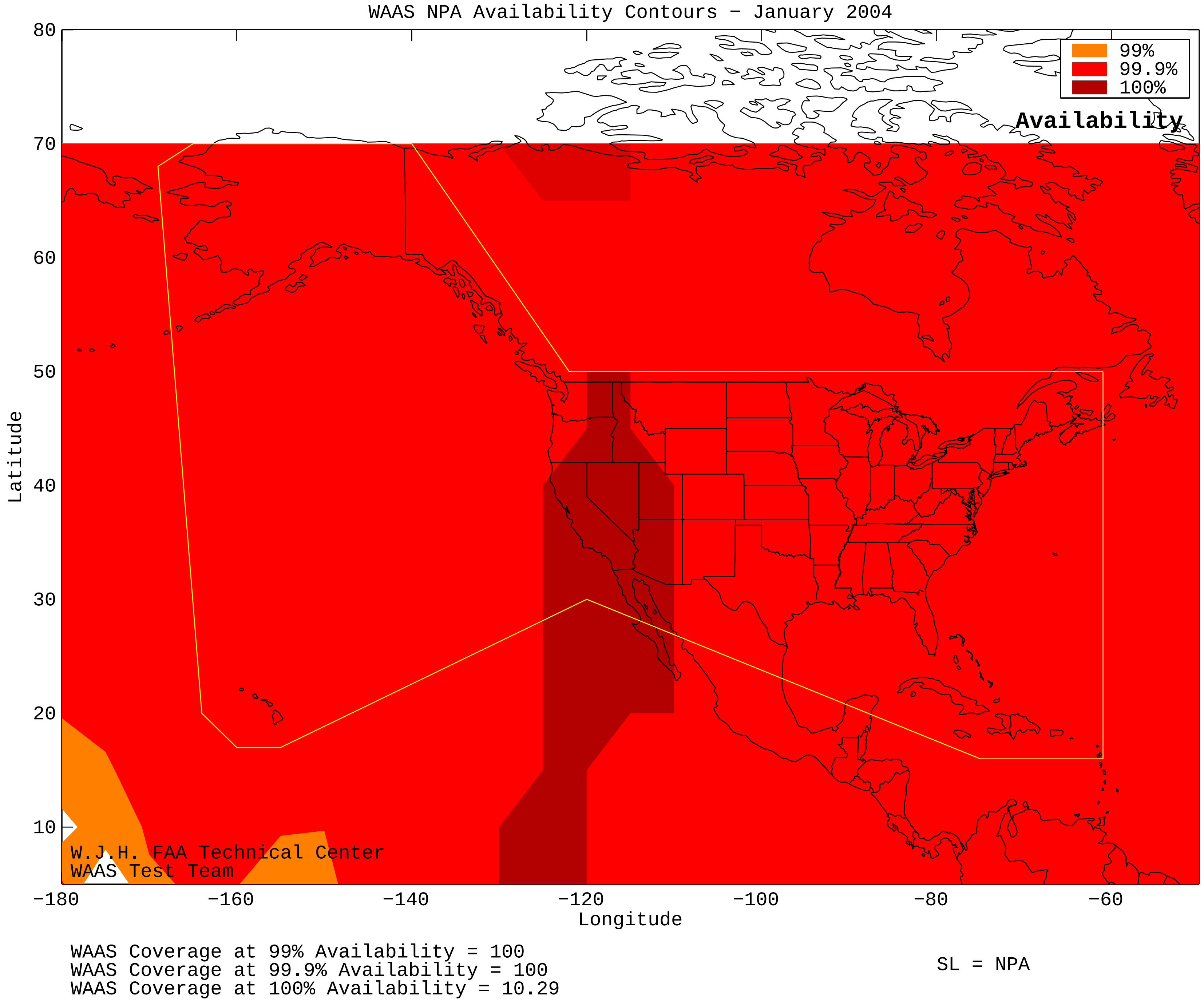


Figure 4•10 WAAS NPA Coverage – February

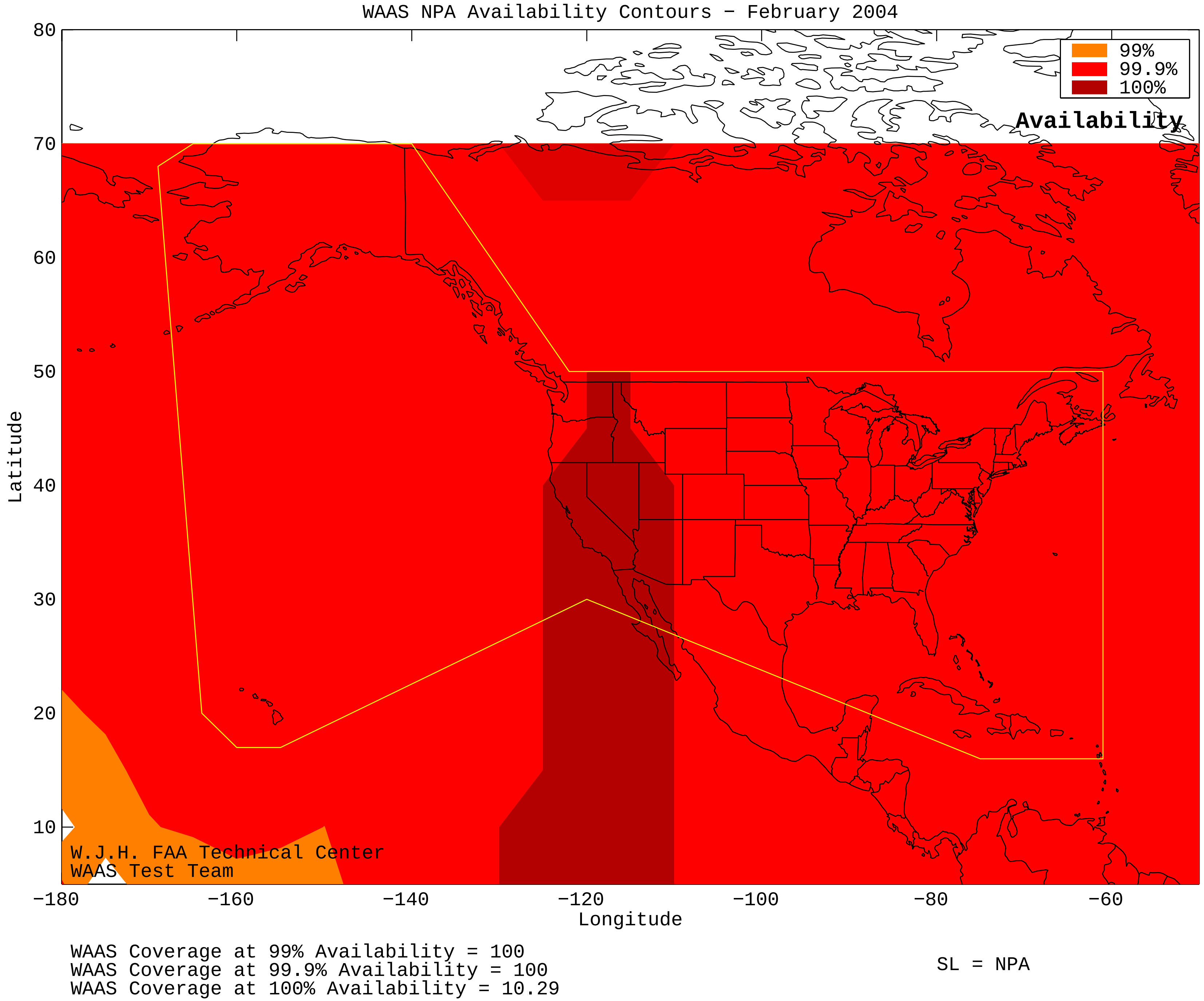


Figure 4•11 WAAS NPA Coverage - March

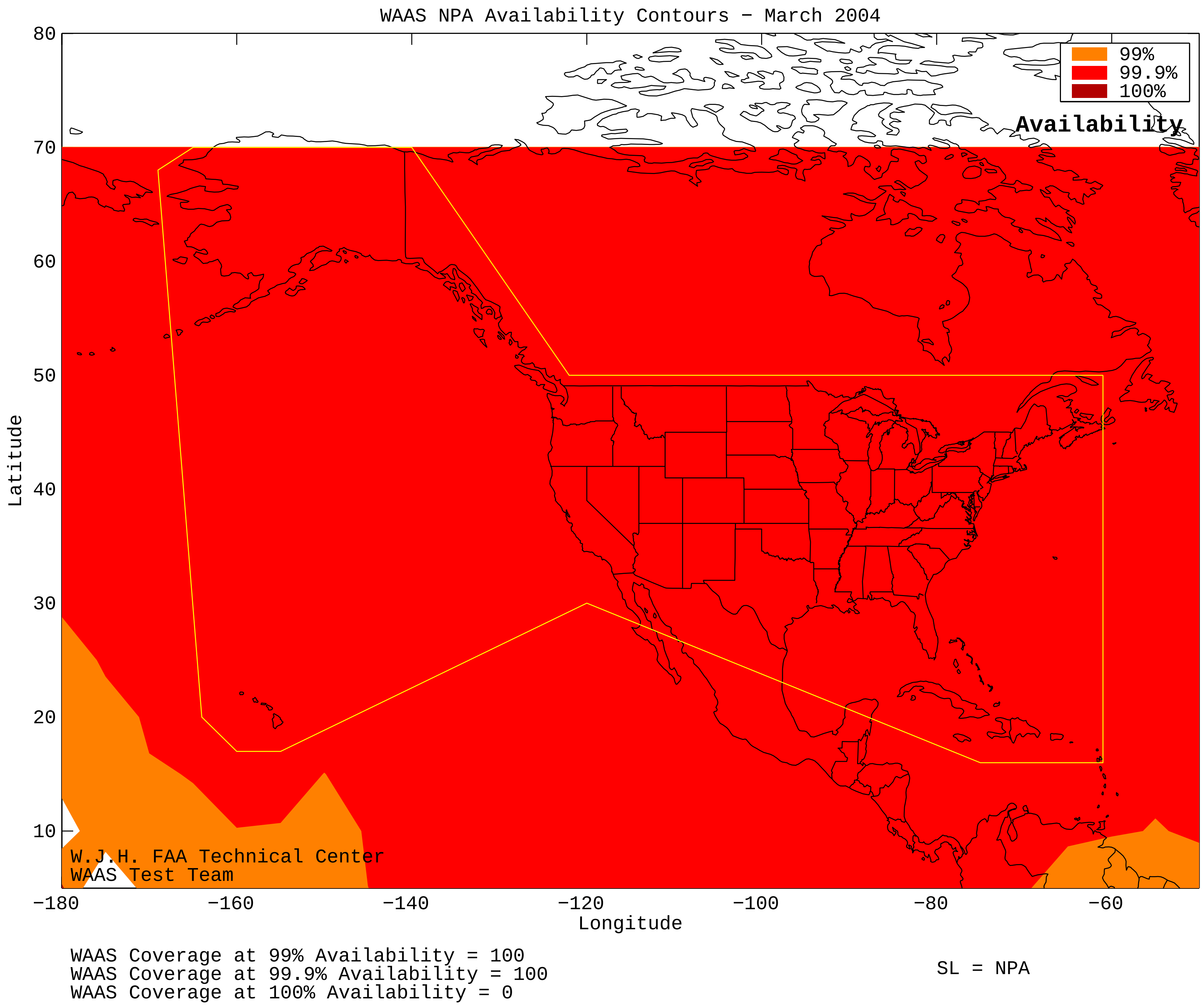


Figure 4•12 WAAS NPA Coverage for the Quarter

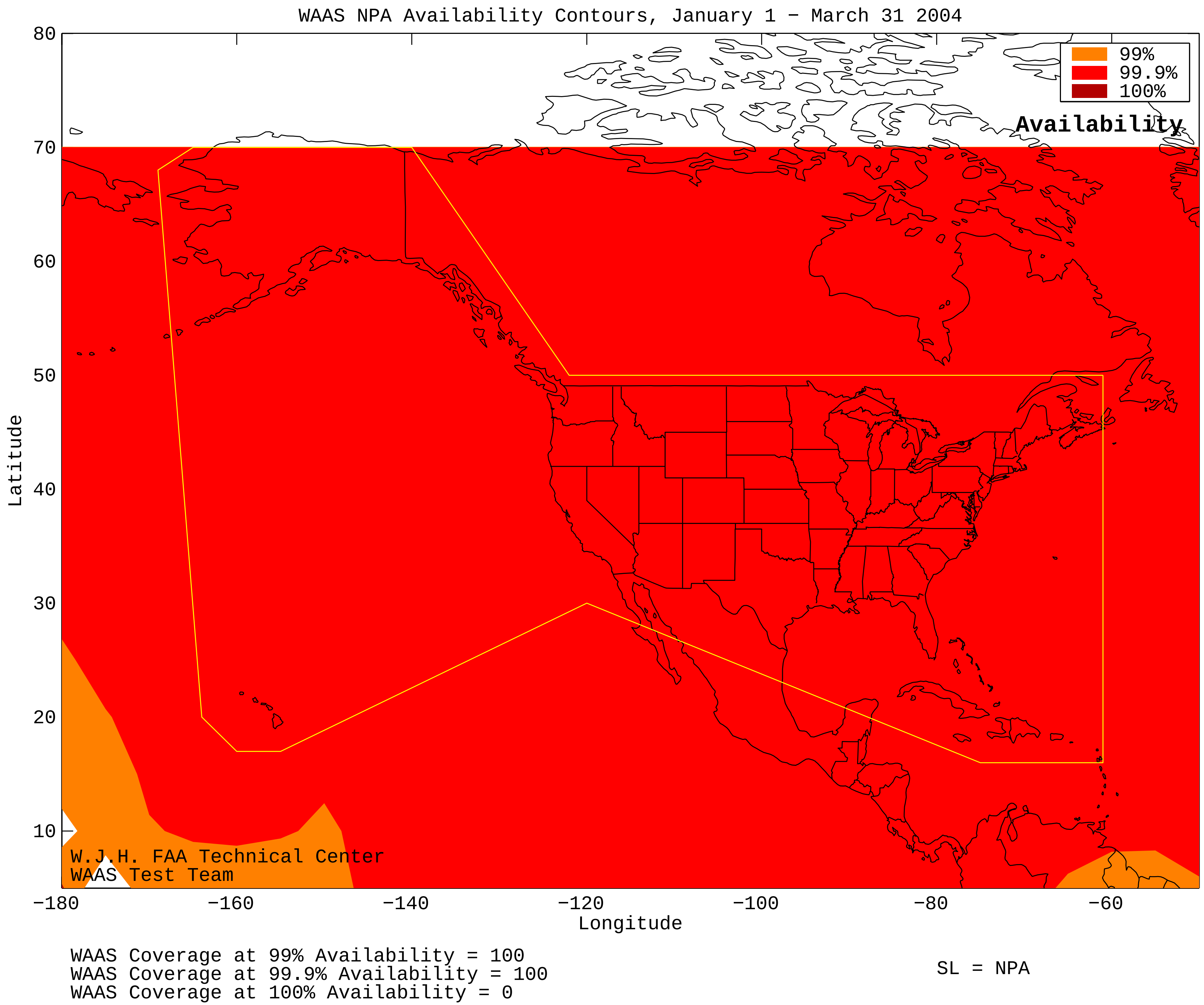


Figure 4-13 Daily WAAS LNAV/VNAV and LPV Coverage

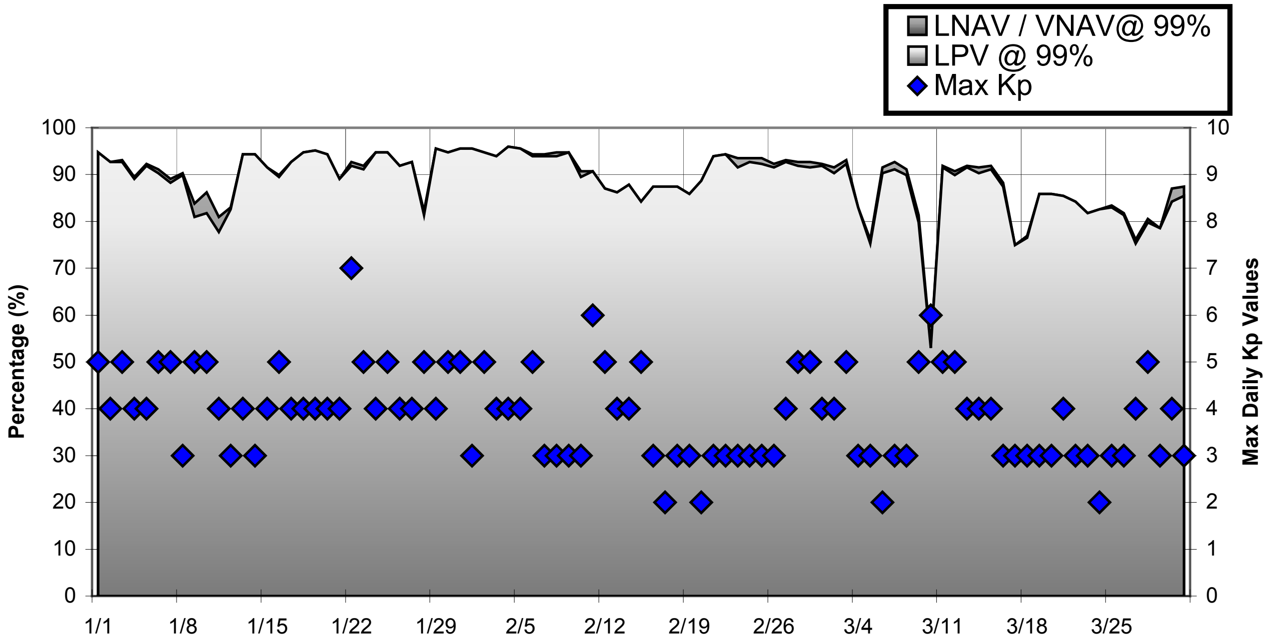
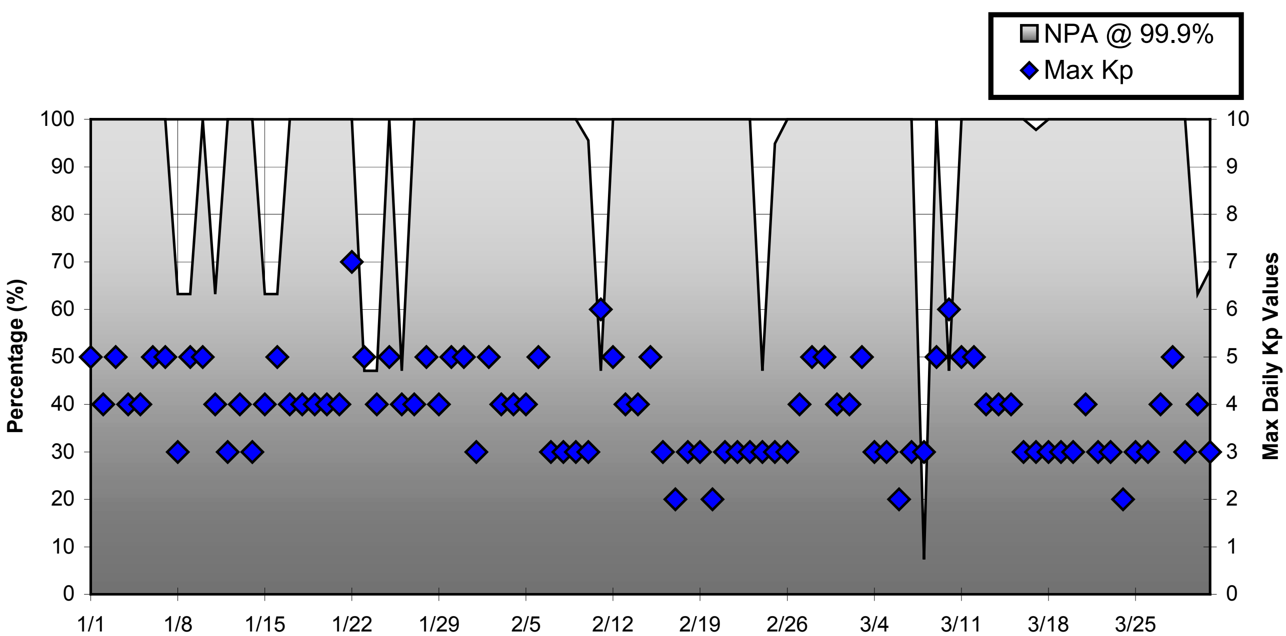


Figure 4-14 Daily NPA Coverage



5.0 CONTINUITY

The definition of PA and NPA continuity and availability definitions are based on the definition from the WAAS specification FAA-E-2892B Change 1. Future reports will use a different definition for continuity and availability to better reflect how these parameters affect operational performance of WAAS.

5.1 PA Continuity of Function

PA continuity of function was evaluated by monitoring the WAAS accuracy and integrity performance. Navigation error data for each reference site was divided into multiple bins consisting of 150 data samples. The position accuracy and integrity performance data for each bin was analyzed and statistics were generated to evaluate the data as follows:

- The horizontal and vertical position errors are less than 7.6 meter 95% of the time for each bin.
- No HMIs have occurred in the horizontal or vertical dimensions.
- User position tool maintains PA mode of operation as defined in Section 2.0.

If the above conditions are met, then the continuity flag is set to “1” to indicate the continuity of function is met for that particular flight segment. The continuity of function percentile statistic was computed for each site by summing the continuity flags of “1” together and dividing by the total number of test segments (bins) accumulated. Table 5.1 shows the PA Continuity of Function probability ranges from 0.999735 (Kansas City) to 0.999961 (Salt Lake City).

Table 5-1 PA Continuity of Function

Location	PA Continuity of Function
Anderson	0.999787
Atlantic City	0.999739
Grand Forks	0.999745
Great Falls	0.999806
Oklahoma City	0.999772
Prescott	0.999912
San Angelo	0.999751
Albuquerque	0.999788
Atlanta	0.999788
Billings	0.999782
Boston	0.999769
Chicago	0.999769
Cleveland	0.999769
Dallas	0.999788
Denver	0.999769
Houston	0.999783
Jacksonville	0.999788
Kansas City	0.999735
Los Angeles	0.999942
Memphis	0.999769
Miami	0.999769
Minneapolis	0.999653
New York	0.999788
Oakland	0.999884
Salt Lake City	0.999961
Seattle	0.999877
Washington DC	0.999788

5.2 NPA Continuity of Navigation

NPA continuity of navigation was evaluated by monitoring the accuracy performance throughout each flight hour. Navigation error data for each site was divided into multiple bins consisting of 3600 data samples. The position accuracy data for each bin was analyzed and statistics were generated to evaluate the data. If the horizontal position error is less than 100 meters 95% of the time, then the continuity of navigation flag is set to "1" to indicate the continuity of navigation is met for that particular flight hour. The continuity of navigation percentile statistic was computed for each reference site by summing the continuity of navigation flags of "1" together and dividing by the total number of test hours (bins) accumulated. The NPA Continuity of Navigation column of Table 5.2 shows all evaluated sites passed the requirements with the maximum probability of 1.

5.3 NPA Continuity of Fault Detection

NPA continuity of fault detection was evaluated by monitoring the integrity performance throughout each flight hour. Navigation error data for each reference site was divided into multiple bins consisting of 3600 data samples. The horizontal and vertical position error data for each bin was analyzed and statistics were generated to evaluate the data as follows:

- No HMIs have occurred in the horizontal dimension.
- User maintains NPA navigation mode of operation as defined in Section 2.0.

If the above conditions are met, then the continuity of fault detection flag is set to "1" to indicate the continuity of fault detection is met for that particular flight hour. The continuity of fault detection percentile statistic was computed for each reference site by summing the continuity of fault detection flags of "1" together and dividing by the total number of test hours (bins) accumulated. The NPA Continuity of Fault Detection column of Table 5.2 shows the probability ranges from 1.00 (Bangor) to 0.988863 (Honolulu). These statistics do not include Receiver Autonomous Integrity Monitoring (RAIM)/Fault Detection and Exclusion (FDE) integrity functions.

Table 5-2 NPA Continuity

Location	Continuity of Navigation	Continuity of Fault Detection (Excluding RAIM/FDE)
Albuquerque	1	0.993075
Anchorage	1	0.994001
Atlanta	1	0.993539
Billings	1	0.993821
Boston	1	0.993531
Cleveland	1	0.993536
Cold Bay	1	0.994891
Honolulu	1	0.988863
Houston	1	0.992904
Juneau	1	0.994332
Kansas City	1	0.993649
Los Angeles	1	0.997231
Miami	1	0.993068
Minneapolis	1	0.993998
Oakland	1	0.997230
Salt Lake City	1	0.997693
San Juan	1	0.993078
Seattle	1	0.997092
Washington DC	1	0.993542

5.4 LPV Availability

LPV availability was evaluated by monitoring the accuracy, integrity and availability performance throughout each flight segment. Navigation error data for each reference site was divided into multiple bins consisting of 150 data samples. The position accuracy, integrity and availability performance data for each bin was analyzed and statistics were generated to evaluate the data as follows:

- The horizontal and vertical position errors are less than 7.6 meter 95% of the time for each bin.
- No HMIs have occurred in the horizontal or vertical dimensions.
- User maintains PA mode of operation as defined in section 2.0.
- VPL is less than or equal to 50m and HPL is less than or equal to 40 m.

If the above conditions are met, then the continuity of function flag is set to “1” to indicate the LPV availability is met for that particular flight segment. The availability percentile statistic was computed for each reference site by summing the continuity of function flags of “1” together and dividing by the total number of test segments (bins) accumulated. LPV Availability column of Table 5.3 shows the probability for availability ranges from 96.7402% (San Angelo) to 99.9519% (Denver).

5.5 LNAV/VNAV Availability

LNAV/VNAV availability was evaluated by monitoring the accuracy, integrity and availability performance throughout each flight segment. Navigation error data for each reference site was divided into multiple bins consisting of 150 data samples. The position accuracy, integrity and availability performance data for each bin was analyzed and statistics were generated to evaluate the data as follows:

- The horizontal and vertical position errors are less than 7.6 meter 95% of the time for each bin.
- No HMIs have occurred in the horizontal or vertical dimensions.
- User maintains PA mode of operation as defined in section 2.0.
- VPL is less than or equal to 50m and HPL is less than or equal to 556 m.

If the above conditions are met, then the continuity of function flag is set to “1” to indicate the LNAV/VNAV availability is met for that particular flight segment. The availability percentile statistic was computed for each reference site by summing the continuity of function flags of “1” together and dividing by the total number of test segments (bins) accumulated. LNAV/VNAV Availability column of Table 5.3 shows the availability ranges from 96.9269% (San Angelo) to 99.9653% (Denver).

5.6 NPA Availability

NPA availability was evaluated by monitoring the accuracy, integrity and availability performance throughout each flight hour. Navigation error data for each reference site was divided into multiple bins consisting of 3600 data samples. The horizontal and vertical position error data for each bin was analyzed and statistics were generated to evaluate the data as follows:

- The horizontal position errors are less than 100 meters 95% of time for each bin
- No HMIs have occurred in the horizontal dimension.
- User maintains NPA navigation mode of operation as defined in Section 2.0.
- HPL is less than or equal to 556 meters.

If the above conditions are met, then the availability flag is set to “1” to indicate NPA availability is met for that particular flight hour. The NPA availability percentile statistic was computed for each reference site by summing the availability flags of “1” together and dividing by the total number of test hours (bins) accumulated.

The NPA Availability column of Table 5.4 shows the availability ranges from 100% (Bangor) to 98.7007% (Honolulu). These statistics do not include RAIM/FDE integrity functions.

Table 5-3 LPV and LNAV/VNAV Availability

Location	LPV Availability	LNAV/VNAV Availability
Anderson	0.998935	0.999186
Atlantic City	0.993994	0.995656
Grand Forks	0.986561	0.986731
Great Falls	0.996873	0.997922
Oklahoma City	0.995871	0.995894
Prescott	0.983604	0.985984
San Angelo	0.967402	0.969269
Albuquerque	0.998864	0.999114
Atlanta	0.999018	0.999057
Billings	0.998712	0.998908
Boston	0.986281	0.987148
Chicago	0.997689	0.997921
Cleveland	0.997921	0.998229
Dallas	0.999210	0.999229
Denver	0.999519	0.999653
Houston	0.998067	0.998087
Jacksonville	0.999115	0.999153
Kansas City	0.999062	0.999123
Los Angeles	0.981002	0.983235
Memphis	0.998575	0.998652
Miami	0.986649	0.986880
Minneapolis	0.997939	0.998171
New York	0.994281	0.994743
Oakland	0.986577	0.988021
Salt Lake City	0.999365	0.999442
Seattle	0.996750	0.997264
Washington DC	0.998154	0.998404

Table 5-4 NPA Availability

Location	NPA Availability (Excluding RAIM/FDE)
Albuquerque	0.993075
Anchorage	0.994001
Atlanta	0.993078
Billings	0.993821
Boston	0.993531
Cleveland	0.993075
Cold Bay	0.994891
Honolulu	0.987007
Houston	0.992904
Juneau	0.994332
Kansas City	0.993161
Los Angeles	0.997231
Miami	0.993068
Minneapolis	0.993536
Oakland	0.997230
Salt Lake City	0.997693
San Juan	0.993078
Seattle	0.997092
Washington DC	0.993081

6.0 INTEGRITY

6.1 HMI Analysis

Analysis of integrity includes the identification and evaluation of HMI (hazardously misleading information), as well as the generation of a safety index to illustrate the margin of safety that WAAS protection levels are providing. The safety margin index (shown in Table 6.1) is a metric that shows how well the protection levels are bounding the maximum observed error. The process for determining this index involves normalizing the largest error observed at a site. This is accomplished by dividing this maximum observed error by the WAAS estimated standard deviation of the error. The safety margin requirement, 5.33 standard units for vertical and 6 standard units for horizontal, is then divided by this maximum normalized error.

Table 6-1Safety Margin Index and HMI Statistics

Location	Safety Index		Number of HMIs
	Horizontal	Vertical	
Anderson	5.45	3.14	0
Atlantic City	6.67	6.66	0
Grand Forks	5.00	3.14	0
Great Falls	5.45	6.66	0
Oklahoma City	8.57	6.66	0
Prescott	6.67	7.61	0
San Angelo	4.29	6.66	0
Albuquerque	5.00	4.85	0
Atlanta	5.45	5.33	0
Billings	4.29	3.81	0
Boston	5.00	5.33	0
Chicago	6.00	4.85	0
Cleveland	5.00	3.55	0
Dallas	3.75	3.81	0
Denver	5.45	4.10	0
Houston	7.50	4.44	0
Jacksonville	5.00	4.10	0
Kansas City	6.67	6.66	0
Los Angeles	6.00	5.92	0
Memphis	4.62	5.92	0
Miami	7.50	5.33	0
Minneapolis	4.00	3.81	0
New York	6.00	6.66	0
Oakland	5.45	4.44	0
Salt Lake City	6.00	4.85	0
Seattle	5.00	4.85	0
Washington DC	5.45	7.61	0

An observed safety margin index of greater than one indicates safe bounding of the greatest observed error, less than one indicates that the maximum error was not bounded, and a result equal to one means that the error was equal to the protection level. As evidenced by the statistics in the above table, the safety margin index never drops below 2.0 at any site. Also, Table 6.1 shows the number of HMIs that occurred during the quarter, of which there were none.

An HMI occurs if the position error exceeds the protection level in the vertical or horizontal dimensions at any time and 6.2 seconds or more passes before this event is corrected by WAAS.

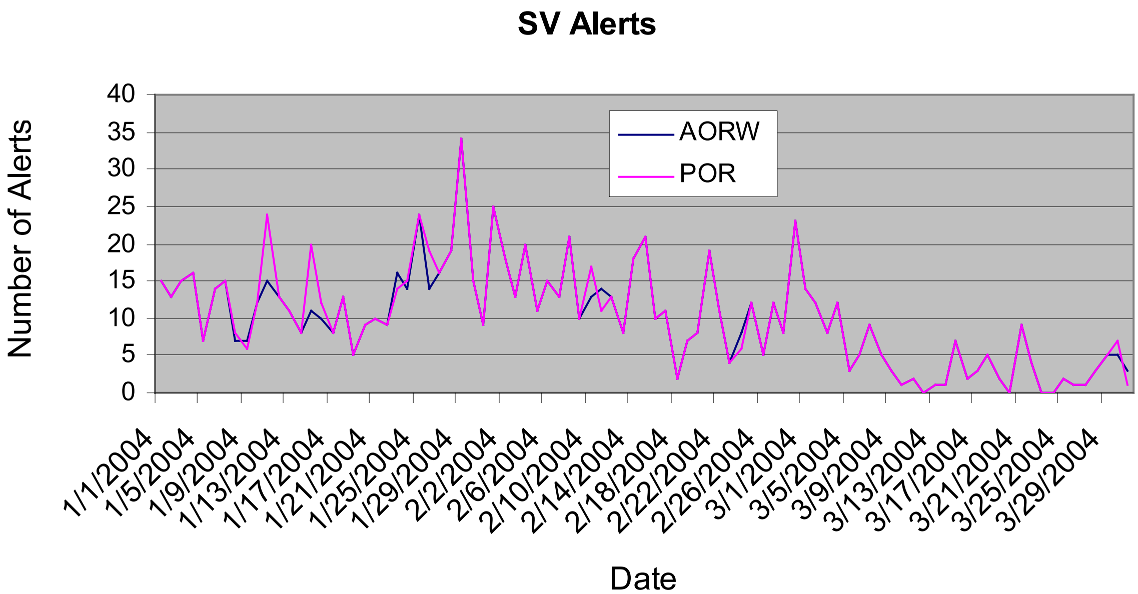
6.2 Broadcast Alerts

The WAAS transmits alert messages to protect the users from satellite degradation or severe ionospheric activity, both of which can cause unsafe conditions for a user. Space Vehicle (SV) alerts increase the User Differential Range Error (UDRE) of satellites, which can reduce the weighting of the satellite in the navigation solution, or completely exclude it from the navigation solution. Ionospheric Grid Point (IGP) alerts increase the Grid Ionospheric Vertical Error (GIVE) of IGP's, which can affect the usage of satellites whose pierce points are in the vicinity of the IGP. An increase in either UDRE's or GIVE's after an alert effectively increases the user protection levels (HPL and VPL), which affect the availability. Additionally, if an alert message sequence lasts for more than 12 seconds, WAAS fast corrections can time out, causing continuity of fault detection to not be met for that flight segment. Table 6.2 shows the total number of alerts and the average number of alerts per day. Figure 6.1 shows the number of SV alerts that occurred daily during the reporting period. Often the number of alerts on one GEO is the same as the number of alerts on the other GEO. Therefore, lines tend to overlap in most points on this plot. Note that after March 11 the number of alerts drops dramatically. This is a result of the upgrade made to the WAAS on that date.

Table 6-2 WAAS SV Alert

	Number of Alerts		Average Alerts Per Day	
Message Type	**AORW**	**POR**	**AORW**	**POR**
2	402	401	4.41758	4.40659
3	335	335	3.68131	3.68131
6	4	4	0.04395	0.04395
24	164	188	1.80219	2.06593
26	0	0	0	0
Total Alerts	905	928	9.94505	10.19780

Figure 6-1 SV Daily Alert Trends



6.3 Availability of WAAS Messages (AORW & POR)

For an accurate and current user position to be calculated, the content of the WAAS message must be broadcast and received within precise time specifications. This aspect of the WAAS is critical to maintaining integrity requirements. Each message type in the WAAS SIS has a specific amount of time for which it must be received anew. Although the content of every message is relevant to the functionality of the system, the importance of different messages varies along with the frequency with which they must be received. Table 6.3 lists the maximum intervals at which each message must broadcast to meet system requirements.

GUS switchovers or broadcast WAAS alerts can interrupt the normal broadcast message stream. If these events occur at a time when the maximum interval of a specific message is approaching, that message may be delayed, resulting in its late transmittal.

All late messages statistics reported during the quarter were caused by GEO SIS outages, GUS switchovers and SV alerts except message type 7 and 10. Occasionally, message type 7 and 10 were late and they were not caused by GEO SIS outages, GUS switchovers or SV alerts. The lateness of type 7 and type 10 messages has little or no impact on user performance and safety. Tables 6.4 to 6.8 show fast correction, long correction, ephemeris covariance, ionosphere correction, and ionospheric mask message rates statistics broadcasted on AORW. The message rates statistics for POR are shown in table 6.9 to 6.13.

Table 6-3 Update Rates for WAAS Messages

Data	**Associated Message Types**	**Maximum Update Interval** (seconds)	**En Route, Terminal, NPA Timeout** (seconds)	**Precision Approach Timeout** (seconds)
WAAS in Test Mode	0	6	N/A	N/A
PRN Mask	1	60	None	None
UDREI	2-6, 24	6	18	12
Fast Corrections	2-5, 24	See Table A-8 in RTCA DO-229C	See Table A-8 in RTCA DO-229C	See Table A-8 in RTCA DO-229C
Long Term Corrections	24, 25	120	360	240
GEO Nav. Data	9	120	360	240
Fast Correction Degradation	7	120	360	240
Weighting Factors	8	120	240	240
Degradation Parameters	10	120	360	240
Ionospheric Grid Mask	18	300	None	None
Ionospheric Corrections	26	300	600	600
UTC Timing Data	12	300	None	None
Almanac Data	17	300	None	None

Table 6-4 WAAS Fast Correction and Degradation Message Rates - AORW

Message Type	**On Time**	**Late**	**Max Late Length (seconds)**
1	139638	0	0
2	1310886	340	29
3	1310667	384	25
7	74538	139	144
9	92133	2	179
10	74566	112	145
17	29685	1	535
24	1310063	508	25

Table 6-5 WAAS Long Correction Message Rates (Type 24 and 25) - AORW

SV	On Time	Late	Max Late Length (seconds)
1	49908	0	0
2	34064	0	0
3	53616	0	0
4	58184	1	168
5	50420	0	0
6	39206	0	0
7	54397	0	0
8	49872	0	0
9	52150	0	0
10	57636	0	0
11	53405	0	0
13	50110	0	0
14	53342	1	185
15	50112	0	0
16	56698	0	0
17	53810	0	0
18	50700	0	0
20	49762	0	0
21	48435	0	0
22	40578	0	0
23	8540	0	0
24	56900	0	0
25	59102	1	167
26	52843	1	345
27	48215	0	0
28	46178	0	0
29	53666	0	0
30	51576	0	0

Table 6-6 WAAS Ephemeris Covariance Message Rates (Type 28) - AORW

SV	On Time	Late	Max Late Length (seconds)
1	42513	0	0
2	25433	1	192
3	44351	1	184
4	43250	0	0
5	43769	1	182
6	32387	0	0
7	43063	0	0
8	41474	0	0
9	44831	0	0
10	43735	0	0
11	45829	0	0
13	42238	0	0
14	41991	0	0
15	41354	0	0
16	43748	0	0
17	41772	0	0
18	41862	0	0
20	42356	0	0
21	35886	0	0
22	32115	0	0
23	6699	0	0
24	41696	1	121
25	41952	1	192
26	41350	0	0
27	34869	0	0
28	36698	1	161
29	42266	0	0
30	42946	0	0
31	40243	0	0
122	83425	0	0
134	83457	1	192

Table 6-7 WAAS Ionospheric Correction Message Rates (Type 26) - AORW

Band	Block	On Time	Late	Max Late Length (seconds)
0	0	27300	8	375
1	0	27302	7	334
1	1	27317	4	315
1	2	27306	3	511
1	3	27321	3	495
1	4	27308	4	504
2	0	27297	7	500
2	1	27312	4	487
2	2	27301	3	440
2	3	27288	4	420
2	4	27323	5	397
2	5	27310	2	350
3	0	27311	6	331

Table 6-8 WAAS Ionospheric Mask Message Rates (Type 18) - AORW

Band	On Time	Late	Max Late Length (seconds)
0	67541	0	0
1	67485	0	0
2	67516	0	0
3	67539	0	0

Table 6-9 WAAS Fast Correction and Degradation Message Rates - POR

Message Type	On Time	Late	Max Late Length (seconds)
1	138258	0	0
2	1310892	339	30
3	1310672	383	26
7	73836	106	189
9	92133	2	179
10	73809	106	139
17	29582	2	442
24	1310102	503	31

Table 6-10 WAAS Long Correction Message Rates (Type 24 and 25) - POR

SV	On Time	Late	Max Late Length (seconds)
1	51577	0	0
2	38638	1	186
3	55392	1	171
4	59831	0	0
5	52023	2	161
6	42118	0	0
7	56237	0	0
8	51487	0	0
9	53863	0	0
10	59558	1	176
11	55177	0	0
13	51796	0	0
14	55040	1	166
15	51746	0	0
16	58561	0	0
17	55547	0	0
18	52355	0	0
20	51404	1	164
21	50017	0	0
22	42077	0	0
23	10527	0	0
24	58786	0	0
25	61083	1	178
26	54764	0	0
27	49818	0	0
28	47686	0	0
29	55420	0	0
30	53234	1	172
31	53802	1	176

Table 6-11 WAAS Ephemeris Covariance Message Rates (Type 28) – POR

SV	On Time	Late	Max Late Length (seconds)
1	42511	1	194
2	25434	0	0
3	44349	2	191
4	43246	2	186
5	43771	0	0
6	32387	0	0
7	43061	1	192
8	41472	1	146
9	44829	1	193
10	43735	0	0
11	45827	0	0
13	42239	0	0
14	41989	1	168
15	41354	0	0
16	43745	0	0
17	41774	0	0
18	41860	0	0
20	42352	0	0
21	35884	0	0
22	32114	0	0
23	6698	0	0
24	41696	0	0
25	41954	0	0
26	41350	0	0
27	34868	1	193
28	36700	1	161
29	42264	1	193
30	42946	0	0
31	40241	1	192
122	83423	2	146
134	83452	2	192

Table 6-12 WAAS Ionospheric Correction Message Rates (Type 26) – POR

Band	Block	On Time	Late	Max Late Length (seconds)
0	0	27303	8	375
0	1	27318	6	576
0	2	27302	6	578
1	0	27312	9	316
1	1	27303	7	311
1	2	27310	8	309
1	3	27304	6	311
1	4	27314	4	304
2	0	27322	3	368
2	1	27299	2	319
2	2	27331	2	306
2	3	27301	4	311

Table 6-13 WAAS Ionospheric Mask Message Rates (Type 18) - POR

Band	On Time	Late	Max Late Length (seconds)
0	67154	0	0
1	67168	0	0
2	67192	0	0

7.0 SV RANGE ACCURACY

Range accuracy evaluation computes the probability that the WAAS User Differential Range Error (UDRE) and Grid Ionospheric Vertical Error (GIVE) statistically bound 99.9% of the range residuals for each satellite tracked by the receiver. A UDRE is broadcast by the WAAS for each satellite that is monitored by the system and the 99.9% bound (3.29 sigma) of the residual error on a pseudorange after application of fast and long-term corrections is checked. The pseudorange residual error is determined by taking the difference between the raw pseudorange and a calculated reference range. The reference range is equal to the true range between the corrected satellite position and surveyed user antenna plus all corrections (WAAS Fast Clock, WAAS Long-Term Clock, WAAS Ionospheric delay, Tropospheric delay, Receiver Clock Bias, and Multipath). Since the true ionospheric delay and multipath error are not precisely known, the estimated variance in these error sources are added to the UDRE before the comparing it to the residual error.

GPS satellite range residual errors were calculated for seven WAAS receivers during the quarter. Table 7.1 and 7.2 show the range error 95% index and 99.9% (3.29 sigma) bounding statistics for each SV at the selected locations. Last quarter 12 sites were evaluated but due processing issues the number of sites evaluated were reduced. During the evaluated period, all GPS satellite residual errors were less than 4.093 meters 95% of the time, and all satellites range errors were bounded 99.9% of the time by the UDRE except for PRN 25 at Minneapolis which was bounded 99.77%.

A GIVE is broadcast by the WAAS for each IGP that is monitored by the system and the 99.9% (3.29 sigma) bound of the ionospheric error is checked. The WAAS broadcasts the ionospheric model using IGP's at predefined geographic locations. Each IGP contains the vertical ionospheric delay and the error in that delay in the form of the GIVE. The ionospheric error is determined by taking the difference between the WAAS ionospheric delay interpolated from the IGP's and GPS dual frequency measurement at that GPS satellite.

GPS satellite ionospheric errors were calculated for seven WAAS receivers during the quarter. Table 7.3 and 7.4 show the ionospheric error 95% index and 99.9% (3.29 sigma) bounding statistics for each SV at the selected locations. All GPS satellite ionospheric errors were less than 3.095 meters 95% of the time and all satellites were bounded 100% of the time. Figures 7.1 to 7.4 show the daily trend of the 95% Range and Ionospheric Errors for Billings MT.

In this report seven sites are used for the range and ionosphere analysis. Due to data processing issues more sites could not be included in this report. Future reports will use more sites for this analysis.

Table 7-1 Range Error 95% Index and 3.29 Sigma Bounding

Site →	Billings		Washington DC		Salt Lake City		Miami	
SV ↓	95% Range Error	3.29 Sigma Bounding	95% Range Error	3.29 Sigma Bounding	95% Range Error	3.29 Sigma Bounding	95% Range Error	3.29 Sigma Bounding
1	1.959	100.00	1.591	100.00	1.367	100.00	1.485	100.00
2	1.843	100.00	1.176	100.00	1.840	100.00	1.522	100.00
3	1.836	100.00	2.111	100.00	1.988	100.00	1.570	100.00
4	2.332	100.00	1.776	100.00	2.286	100.00	1.625	100.00
5	1.602	100.00	1.228	100.00	1.885	100.00	1.962	100.00
6	1.843	99.9994	1.987	100.00	1.481	100.00	1.728	100.00
7	1.752	100.00	1.321	100.00	1.383	100.00	2.009	100.00
8	1.842	100.00	1.822	100.00	1.199	100.00	1.507	100.00
9	1.890	100.00	1.833	100.00	1.526	100.00	1.765	100.00
10	1.742	100.00	1.164	100.00	1.428	100.00	1.943	100.00
11	2.055	99.9769	1.424	100.00	1.242	100.00	1.990	100.00
12	-	-	-	-	-	-	-	-
13	2.032	100.00	1.470	100.00	1.141	100.00	1.802	100.00
14	1.725	99.9592	1.158	100.00	1.230	100.00	1.862	100.00
15	1.598	100.00	1.451	100.00	1.302	100.00	1.662	100.00
16	2.017	100.00	1.082	100.00	1.507	100.00	1.771	100.00
17	1.906	99.9928	1.137	100.00	1.291	100.00	1.481	100.00
18	1.585	100.00	1.005	100.00	1.291	100.00	2.463	100.00
19	-	-	-	-	-	-	-	-
20	2.123	99.9938	1.562	100.00	1.928	100.00	2.159	100.00
21	1.757	100.00	1.431	100.00	1.549	100.00	2.359	100.00
22	3.268	99.9318	3.016	100.00	2.823	99.9919	4.093	100.00
23	1.377	100.00	1.902	100.00	1.410	100.00	1.060	100.00
24	2.445	99.9977	1.572	100.00	1.961	100.00	1.523	100.00
25	2.268	99.9998	1.363	100.00	1.819	100.00	1.788	100.00
26	2.066	100.00	2.125	100.00	2.143	100.00	1.241	100.00
27	1.917	100.00	1.706	100.00	1.403	100.00	1.586	100.00
28	1.967	99.9895	1.279	100.00	1.431	100.00	1.987	100.00
29	1.765	100.00	2.036	100.00	1.389	100.00	1.670	100.00
30	2.196	99.9919	2.222	100.00	2.232	100.00	1.559	100.00
31	1.991	100.00	1.093	100.00	1.146	100.00	1.830	100.00
122	5.195	100.00	3.132	100.00	5.177	100.00	2.670	100.00
134	-	-	-	-	4.636	100.00	-	-

Table 7-2 Range Error 95% index and 3.29 Sigma Bounding

Site →	Minneapolis		Atlanta		Juneau	
SV ↓	95% Range Error	3.29 Sigma Bounding	95% Range Error	3.29 Sigma Bounding	95% Range Error	3.29 Sigma Bounding
1	2.723	99.9170	1.356	100.00	1.832	100.00
2	2.028	100.00	1.197	100.00	1.481	100.00
3	2.270	100.00	1.622	100.00	1.802	100.00
4	2.412	100.00	1.626	100.00	2.112	100.00
5	1.893	100.00	1.215	100.00	2.302	100.00
6	2.364	100.00	1.510	100.00	2.194	100.00
7	1.633	100.00	1.343	100.00	2.229	100.00
8	1.909	100.00	1.328	100.00	2.052	100.00
9	2.205	100.00	1.534	100.00	2.013	100.00
10	1.990	100.00	1.360	100.00	2.213	100.00
11	1.597	99.9999	1.209	100.00	2.273	100.00
12	-	-	-	-	-	-
13	2.170	100.00	1.383	100.00	1.806	100.00
14	1.479	99.9040	1.491	100.00	2.529	100.00
15	1.858	100.00	1.244	100.00	2.085	100.00
16	2.145	99.9555	1.441	100.00	2.198	100.00
17	1.985	100.00	1.118	100.00	1.976	100.00
18	1.381	100.00	1.469	100.00	2.532	100.00
19	-	-	-	-	-	-
20	1.597	99.9829	1.476	100.00	2.376	100.00
21	1.235	100.00	1.785	100.00	2.980	100.00
22	2.517	100.00	3.309	99.9231	3.422	100.00
23	1.729	100.00	0.984	100.00	1.428	100.00
24	2.508	99.9799	1.684	100.00	2.178	100.00
25	2.171	99.7682	1.292	100.00	2.073	100.00
26	3.130	100.00	1.992	100.00	2.105	100.00
27	1.981	100.00	1.459	100.00	1.981	100.00
28	1.479	100.00	1.249	100.00	2.500	100.00
29	2.170	100.00	1.645	100.00	1.838	100.00
30	2.261	99.9810	1.693	100.00	2.358	100.00
31	1.898	100.00	1.206	100.00	2.339	100.00
122	6.202	99.9995	3.590	100.00	-	-
134	-	-	-	-	3.372	100.00

Table 7-3 Ionospheric Error 95% index and 3.29 Sigma Bounding

Site →	Billings		Washington DC		Salt Lake City		Miami	
SV ↓	95% Iono Error	3.29 Sigma Bounding	95% Iono Error	3.29 Sigma Bounding	95% Iono Error	3.29 Sigma Bounding	95% Iono Error	3.29 Sigma Bounding
1	0.780	100.00	0.729	100.00	0.554	100.00	0.967	100.00
2	0.716	100.00	0.681	100.00	0.876	100.00	0.886	100.00
3	0.696	100.00	1.000	100.00	0.920	100.00	0.807	100.00
4	1.141	100.00	1.260	100.00	1.470	100.00	0.929	100.00
5	0.654	100.00	0.589	100.00	0.661	100.00	0.901	100.00
6	0.813	100.00	1.170	100.00	1.013	100.00	1.240	100.00
7	0.984	100.00	0.641	100.00	0.671	100.00	1.069	100.00
8	0.691	100.00	0.817	100.00	0.547	100.00	0.665	100.00
9	0.672	100.00	0.979	100.00	0.681	100.00	0.709	100.00
10	0.898	100.00	0.566	100.00	0.475	100.00	0.981	100.00
11	0.779	100.00	0.537	100.00	0.436	100.00	1.002	100.00
12	-	-	-	-	-	-	-	-
13	0.758	100.00	0.849	100.00	0.498	100.00	0.978	100.00
14	0.994	100.00	0.638	100.00	0.558	100.00	0.967	100.00
15	0.627	100.00	0.952	100.00	0.597	100.00	0.967	100.00
16	0.791	100.00	0.548	100.00	0.585	100.00	0.639	100.00
17	1.075	100.00	0.835	100.00	0.849	100.00	0.881	100.00
18	0.891	100.00	0.457	100.00	0.587	100.00	1.332	100.00
19	-	-	-	-	-	-	-	-
20	0.994	100.00	0.540	100.00	0.618	100.00	1.241	100.00
21	1.204	100.00	0.770	100.00	0.791	100.00	1.410	100.00
22	2.715	100.00	2.314	100.00	2.152	100.00	2.923	100.00
23	0.415	100.00	0.966	100.00	0.700	100.00	0.845	100.00
24	1.483	100.00	1.078	100.00	1.357	100.00	1.068	100.00
25	1.023	100.00	0.920	100.00	1.045	100.00	1.294	100.00
26	0.947	100.00	1.246	100.00	1.140	100.00	0.902	100.00
27	0.745	100.00	0.779	100.00	0.762	100.00	0.857	100.00
28	0.933	100.00	0.650	100.00	0.557	100.00	1.079	100.00
29	0.726	100.00	1.114	100.00	0.729	100.00	0.761	100.00
30	0.855	100.00	1.082	100.00	1.036	100.00	0.865	100.00
31	0.780	100.00	0.605	100.00	0.577	100.00	0.710	100.00

Table 7-4 Ionospheric Error 95% index and 3.29 Sigma Bounding

Site →	Minneapolis		Atlanta		Juneau	
SV ↓	95% Iono Error	3.29 Sigma Bounding	95% Iono Error	3.29 Sigma Bounding	95% Iono Error	3.29 Sigma Bounding
1	0.998	100.00	0.767	100.00	1.197	100.00
2	0.931	100.00	0.669	100.00	0.842	100.00
3	0.874	100.00	1.035	100.00	1.182	100.00
4	1.217	100.00	1.141	100.00	1.135	100.00
5	0.661	100.00	0.728	100.00	1.300	100.00
6	1.222	100.00	1.045	100.00	1.140	100.00
7	0.695	100.00	0.660	100.00	1.500	100.00
8	0.690	100.00	0.764	100.00	1.389	100.00
9	0.913	100.00	0.880	100.00	1.222	100.00
10	0.767	100.00	0.697	100.00	1.438	100.00
11	0.544	100.00	0.622	100.00	1.302	100.00
12	-	-	-	-	-	-
13	0.962	100.00	0.760	100.00	1.331	100.00
14	0.576	100.00	0.769	100.00	1.835	100.00
15	0.794	100.00	0.723	100.00	1.448	100.00
16	0.712	100.00	0.558	100.00	1.554	100.00
17	1.054	100.00	0.736	100.00	1.354	100.00
18	0.510	100.00	0.813	100.00	2.083	100.00
19	-	-	-	-	-	-
20	0.798	100.00	0.778	100.00	1.515	100.00
21	0.712	100.00	1.100	100.00	2.048	100.00
22	2.277	100.00	2.460	100.00	3.095	100.00
23	0.818	100.00	0.713	100.00	0.679	100.00
24	1.441	100.00	1.153	100.00	1.361	100.00
25	0.885	100.00	0.873	100.00	1.434	100.00
26	1.355	100.00	1.341	100.00	1.081	100.00
27	0.757	100.00	0.928	100.00	1.366	100.00
28	0.639	100.00	0.636	100.00	1.850	100.00
29	0.912	100.00	1.068	100.00	1.109	100.00
30	0.979	100.00	0.992	100.00	1.101	100.00
31	0.660	100.00	0.623	100.00	1.387	100.00

Figure 7•1 95% Range Error (SV 1—SV 16) – Washington,

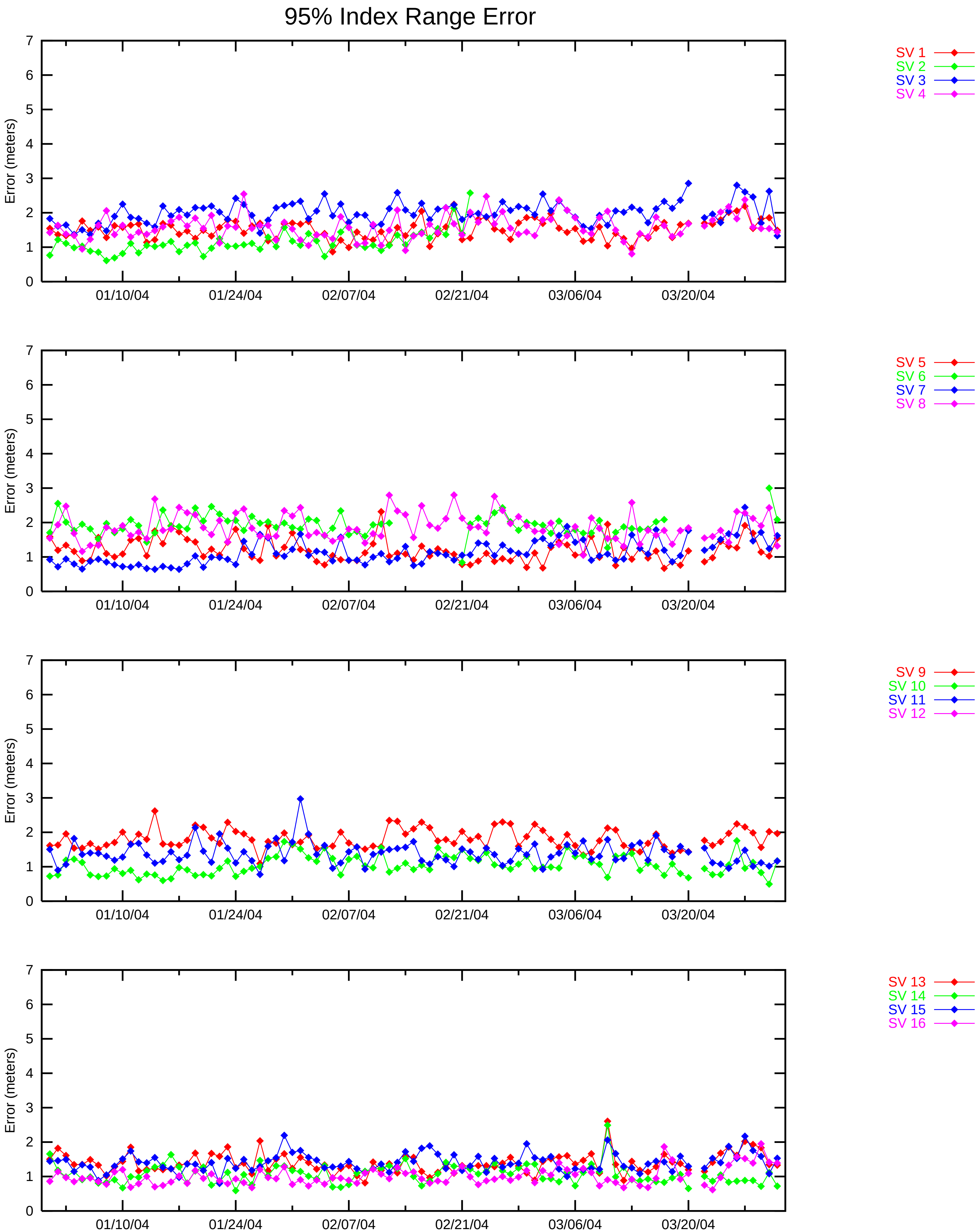


Figure 7•2 95% Range Error (SV 17—SV 31 and SV 122) – Washington, DC

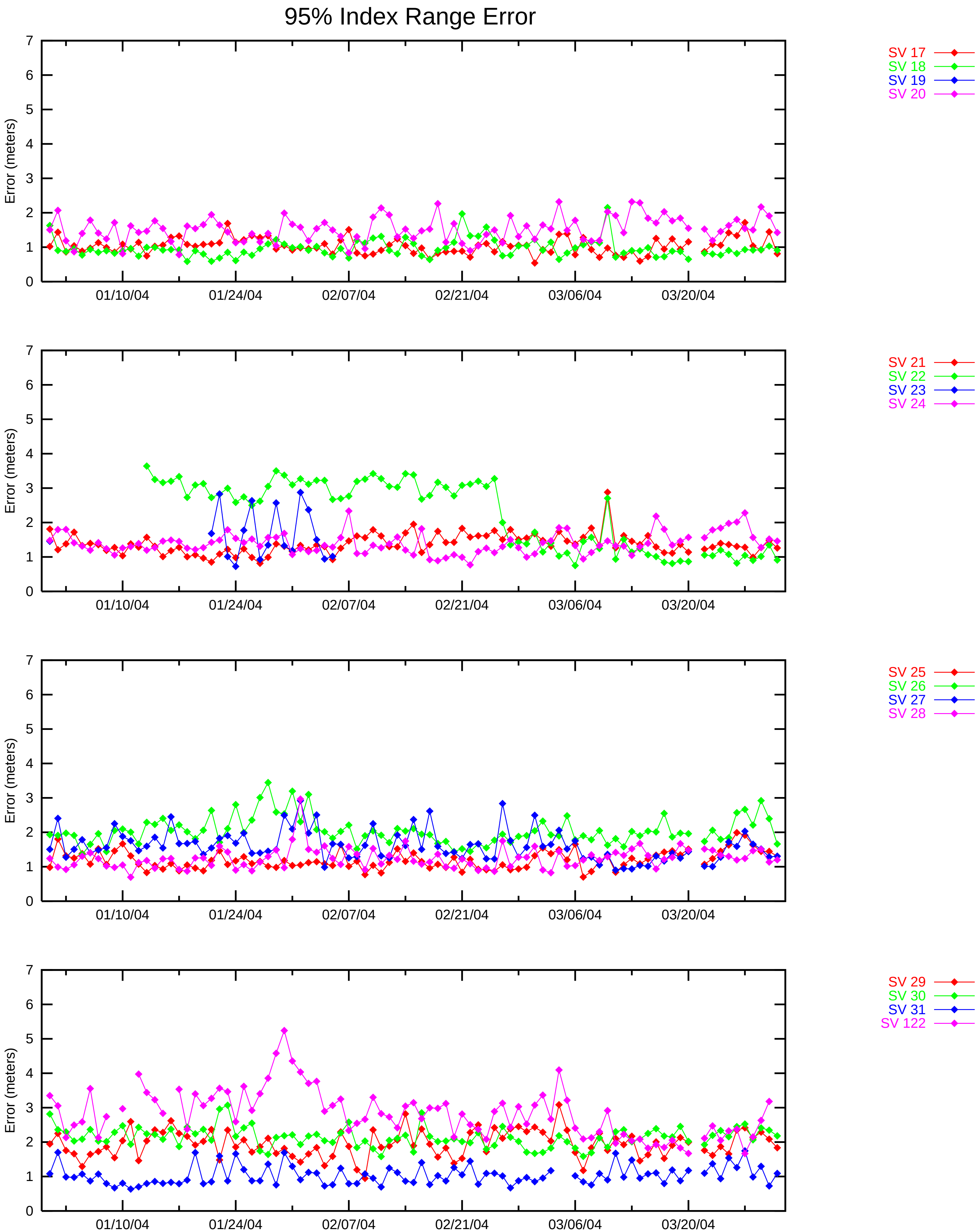


Figure 7•3 95% Ionospheric Error (SV 1—SV 16) – Washington, DC

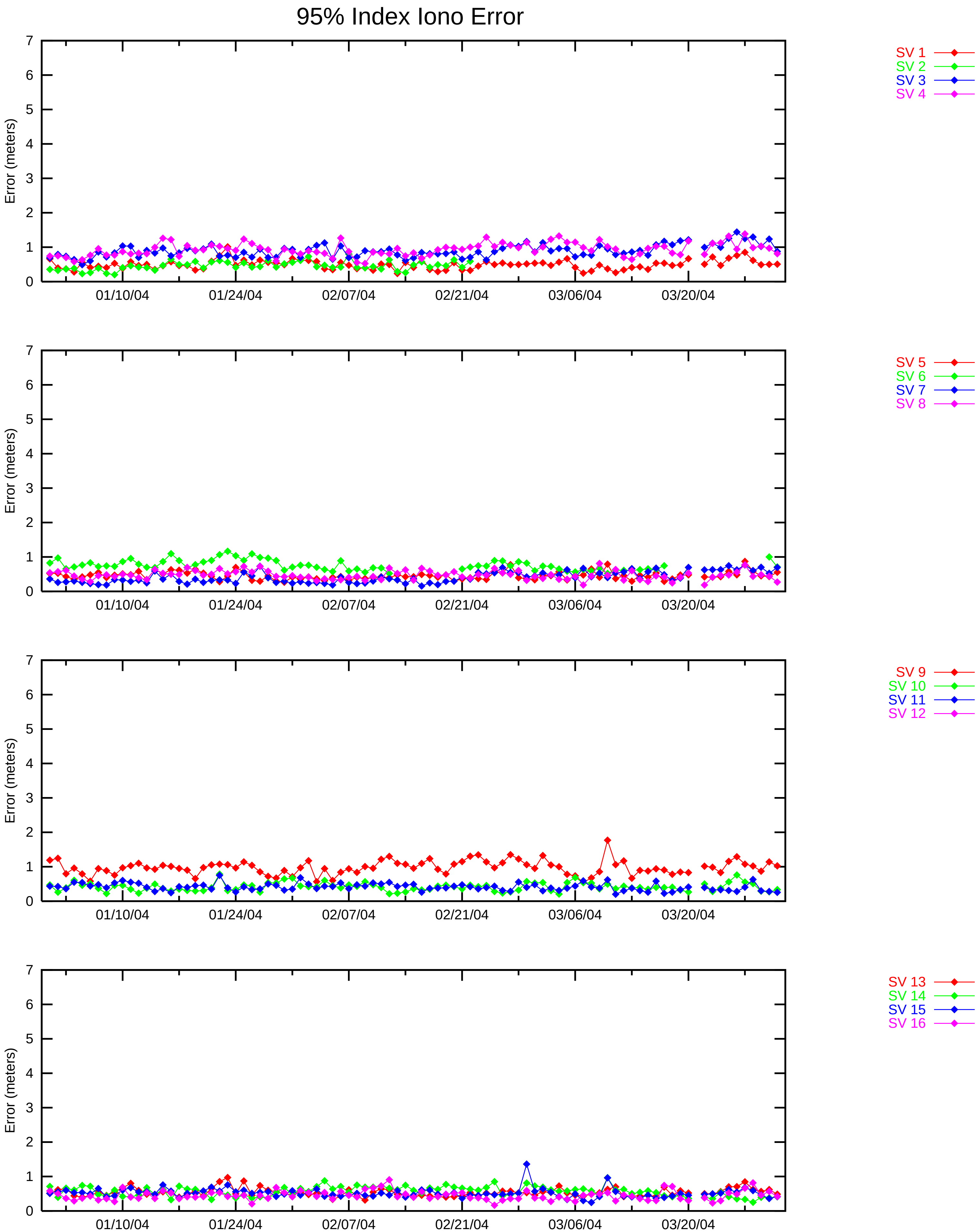
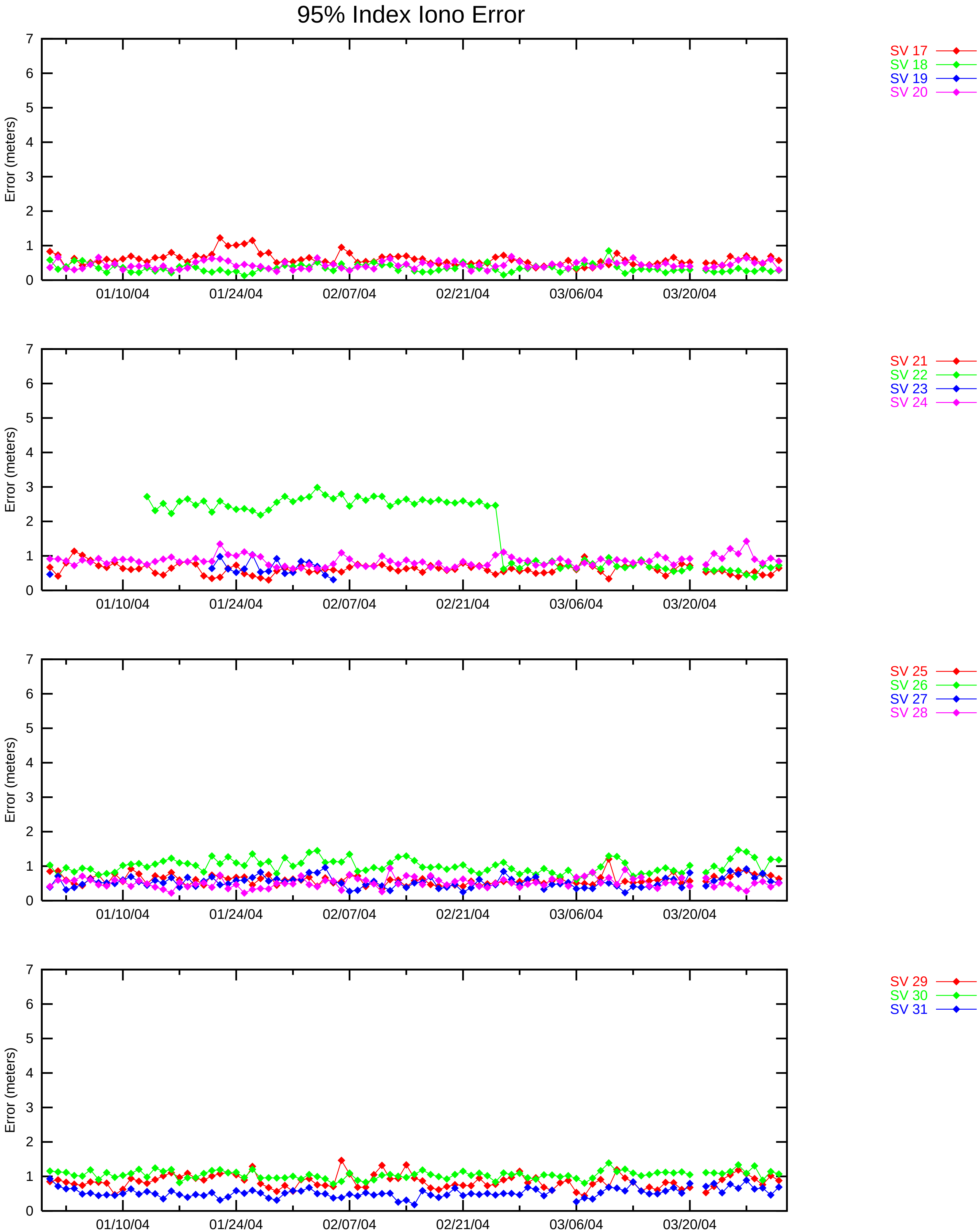


Figure 7•4 95% Ionospheric Error (SV 17—SV 31) – Washington, DC



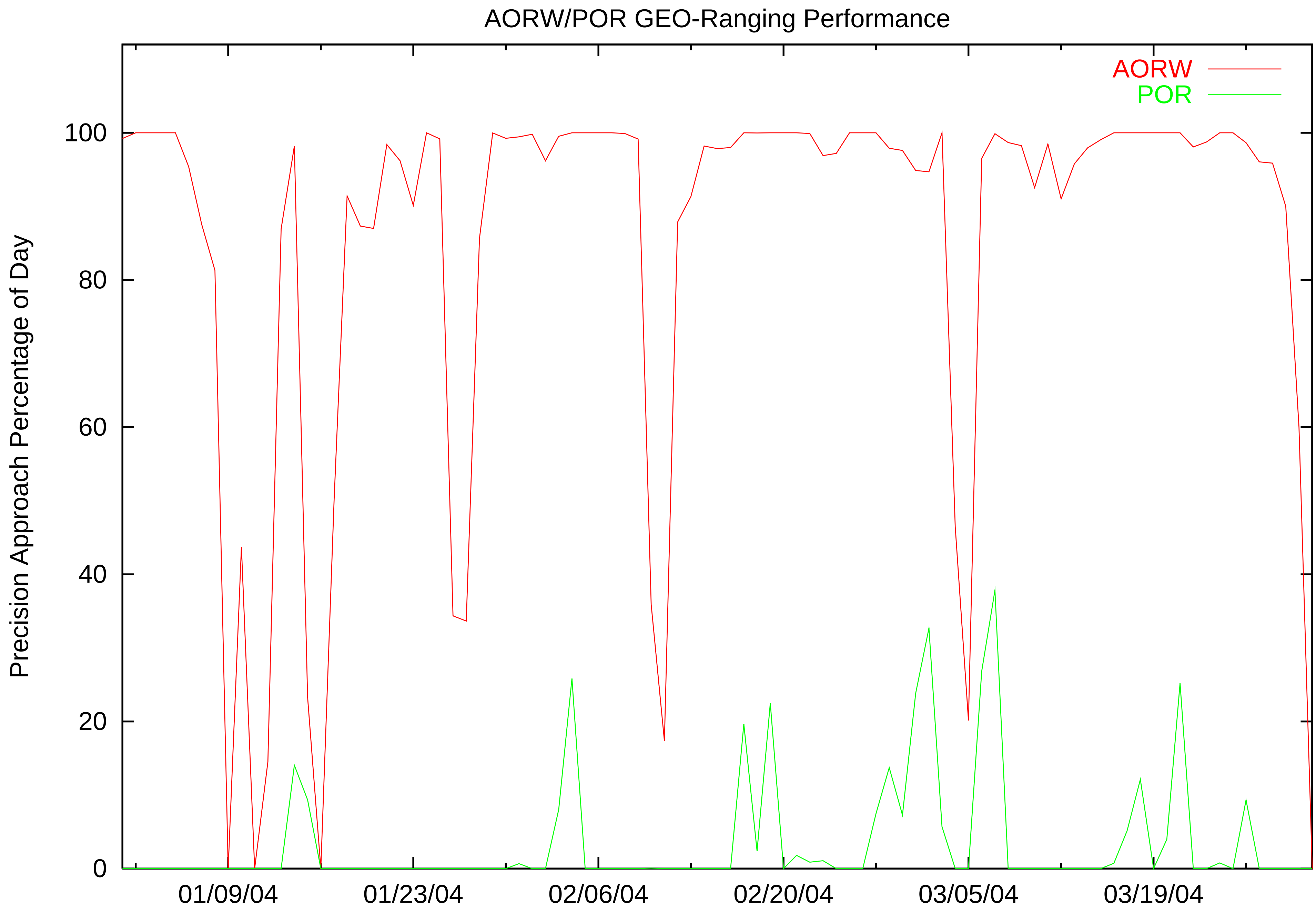
8.0 GEO RANGING PERFORMANCE

Table 8.1 shows the GEO-Ranging performance for AORW and POR satellites throughout the evaluated period. The percentage of PA ranging availability (i.e. the percentage of time a user receiver can use the GEO as a ranging source in a LNAV/VNAV or LPV position solution) for the AORW and POR is 85.21% and 3.5%, respectively. Figure 8.1 shows the trend of PA Ranging Availability for the AORW and POR satellite. The large drops in PA ranging availability for the AORW satellite is due to GUS switchovers. As in the past, the POR satellite as a ranging source has very low PA availability.

Table 8-1 GEO Ranging Availability

GEO	PA (%)	NPA (%)	Not Monitored (%)	Do Not Use (%)
AORW	85.21	13.40	0.40	0.99
POR	3.50	85.76	9.06	1.68

Figure 8•1 Daily PA GEO Ranging Availability Trend



9.0 WAAS PROBLEM SUMMARY

Title: WAAS IGP's in central CONUS were set to "Not Monitored" state during ionospheric storm.

Description: IGP's located between N40 latitude and N55 latitude and W95 longitude and W105 longitude were set to not monitored state on 3/10/04 (GPS week 1261 day 3) from GPS time of week 264395 to 264977. This caused WAAS users in north central CONUS to drop into NPA service. Before the IGP's were set to not monitored several IGP's in the same area were in ionospheric storm state (GIVE = 45 meters), which occurred due to increased ionospheric activity (KP = 6) during the beginning of the GPS day.

Title: Anomaly on WAAS POR GEO (PRN 134) set all GPS satellites to not monitored for approximately 600 seconds

Description: WAAS POR GEO (PRN 134) changed all satellite UDRE's to not monitored beginning at GPS time of week 264226 until 264820 on 3/10/04 (GPS week 1261 day 3). At the same time WAAS AORW GEO (PRN 122) broadcast UDRE's were set to normal values and did not change form being monitored. Users that only tracked WAAS POR GEO dropped from PA/NPA operation to SPS operation (GPS only) for the duration of the WAAS anomaly. This anomaly was due to the tripping of the WAAS User Position Monitor (UPM). The UPM is one of the monitors in WAAS that ensures integrity.

Title: WAAS Type 2 alert set 6 satellites to not monitored and do not use for 6 seconds

Description: A WAAS anomaly was found. On 2/2/04 Grand Fork, Greenwood, Prescott, San Angelo, Boston, Kansas City, Minneapolis and Oakland failed continuity at 132613-132628 GPS time of week. A WAAS Type 2 alert broadcasted during that time for 6sec caused the continuity failure. The UDREI for PRN 1, 2, 3 and 13 changed from 5 to 14 (not monitored), PRN 10 from 7 to 15(do not use) and PRN 8 from 6 to 15(do not use) by the WAAS alert. The UDREI was set back to normal when the next WAAS Type 2 was received.

Title: WAAS type 0 messages broadcast after a 1 second loss of signal in space

Description: On 3/8/04 there was a one second gap on AORW and a simultaneous two second gap on POR. These gaps occurred at GPS time 129022 and both were followed by a string of four T 0s starting at GPS time 129025. This anomaly caused a loss in the 99.9% NPA coverage availability.

10.0 WAAS AIRPORT AVAILABILITY

The WAAS airport availability evaluation determines the number and length LVP service outages at selected airports from the transmitted WAAS navigation message. The navigation messages transmitted from both AORW and POR GEO satellites are processed simultaneously, and WAAS protection levels (VPL and HPL) are computed at each airport once a second in accordance with the WAAS MOPS. Once the protection levels have been produced at each airport an LPV service evaluation is conducted to identify outages in service (i.e. when protection levels exceed alert limits). WAAS LPV service is available for a user when the vertical protection level (VPL) is less than or equal to vertical alert limit (VAL) of 50 meters and the horizontal protection level (HPL) is less than or equal to horizontal alert limit (HAL) of 40 meters. If both conditions are met at a specified airport location then WAAS LPV service is available at that airport. If either one of the conditions are not met at a specified airport location then WAAS LPV service at that airport is unavailable and an outage in LPV service is recorded with its duration. When the LPV service becomes unavailable it is not considered available again until protection levels are below or equal to alert limits for at least 15 minutes. Although this will reduce LPV service availability minimally, it substantially reduces the number of service outages and prevents excessive switching in and out of service availability. When computing LPV service availability an extra two minutes of outage time was prefixed to each outage. The number of WAAS LPV service outages and the availability at selected airports for the period from 12/21/03 to 3/27/04 of WAAS operation is presented in Table 10.1. Figures 10.1 and 10.2 provide a graphical representation of WAAS LPV service availability and outage counts for the same period, respectively.

Table 10-1 WAAS LPV Outages and Availability

Airport ID	Airport Name	City	State	Outages	Availability
EET	SHELBY COUNTY	ALABASTER	AL	25	0.999106
79J	ANDALUSIA-OPP	ANDALUSIA/OP	AL	21	0.999072
KBHM	BIRMINGHAM INTL	BIRMINGHAM	AL	25	0.999073
KDHN	DOTHAN REGIONAL	DOTHAN	AL	19	0.999170
HSV	HUNTSVILLE INTL-CARL T JONES FIELD	HUNTSVILLE	AL	25	0.999098
MOB	MOBILE REGIONAL	MOBILE	AL	32	0.998732
KVBT	BENTONVILLE MUNICIPAL/ LM THADDEN FLD	BENTONVILLE	AR	14	0.999493
CDH	HARRELL FIELD	CAMDEN	AR	20	0.999421
KXNA	NORTHWEST ARKANSAS REGIONAL	FAYETTEVILLE/ SPRINGDALE/ROGERS	AR	14	0.999493
KFSM	FORT SMITH REGIONAL	FORT SMITH	AR	14	0.999485
LIT	ADAMS FIELD	LITTLE ROCK	AR	20	0.999379
SRC	SEARCY MUNICIPAL	SEARCY	AR	20	0.999313
ASG	SPRINGDALE MUNICIPAL	SPRINGDALE	AR	14	0.999492
KARG	WALNUT RIDGE REGIONAL	WALNUT RIDGE	AR	23	0.998964
IFP	LAUGHLIN/BULLHEAD INTL	BULLHEAD CITY	AZ	62	0.996984
KGCN	GRAND CANYON NATL PARK	GRAND CANYON	AZ	35	0.998661
KPHX	PHOENIX SKY HARBOR INTL	PHOENIX	AZ	123	0.992028
KPRC	ERNEST A LOVE FIELD	PRESCOTT	AZ	53	0.997066
KTUS	TUCSON INTL	TUCSON	AZ	164	0.983343
RQE	WINDOW ROCK	WINDOW ROCK	AZ	18	0.999466
KCRQ	MC CLELLAN-PALOMAR	CARLSBAD	CA	326	0.963353
O60	CLOVERDALE MUNICIPAL	CLOVERDALE	CA	127	0.991454
KDAG	BARSTOW-DAGGETT	DAGGETT	CA	118	0.990818
IYK	INYOKERN	INYOKERN	CA	94	0.993966
KLAX	LOS ANGELES INTL	LOS ANGELES	CA	310	0.968819
KOAK	METROPOLITAN OAKLAND INTL	OAKLAND	CA	136	0.990681
ONT	ONTARIO INTL	ONTARIO	CA	264	0.976225

Airport ID	Airport Name	City	State	Outages	Availability
KPMD	PALMDALE PROD FLT/ TEST INSTLN	PALMDALE	CA	222	0.981857
KMHR	SACRAMENTO MATHER	SACRAMENTO	CA	61	0.995863
KSMF	SACRAMENTO INTL	SACRAMENTO	CA	65	0.995531
SAN	SAN DIEGO INTL-LINDBERGH FIELD	SAN DIEGO	CA	417	0.951640
KSFO	SAN FRANCISCO INTL	SAN FRANCISCO	CA	157	0.988646
SJC	SAN JOSE INTL	SAN JOSE	CA	135	0.990786
SVE	SUSANVILLE MUNICIPAL	SUSANVILLE	CA	46	0.998000
TNP	TWENTYNINE PALMS	TWENTYNINE PALMS	CA	150	0.988514
AKO	AKRON-COLORADO PLAINS REGIONAL	AKRON	CO	17	0.999455
CEZ	CORTEZ MUNICIPAL	CORTEZ	CO	19	0.999541
KDEN	DENVER INTL	DENVER	CO	19	0.999435
HDN	YAMPA VALLEY	HAYDEN	CO	15	0.999575
LHX	LA JUNTA MUNICIPAL	LA JUNTA	CO	19	0.999485
LAA	LAMAR MUNICIPAL	LAMAR	CO	19	0.999501
2V2	VANCE BRAND	LONGMONT	CO	15	0.999571
EEO	MEEKER	MEEKER	CO	17	0.999544
TAD	PERRY STOKES	TRINIDAD	CO	21	0.999447
2V5	WRAY	WRAY	CO	17	0.999467
KBDL	BRADLEY INTL	WINDSOR LOCKS	CT	84	0.993543
KDCA	RONALD REAGAN WASHINGTON INTL	WASHINGTON	DC	26	0.998419
KIAD	WASHINGTON DULLES INTL	WASHINGTON	DC	28	0.998452
KFLL	FORT LAUDERDALE/ HOLLYWOOD INTL	FORT LAUDERDALE	FL	116	0.991924
KRSW	SOUTHWEST FLORIDA INTL	FORT MYERS	FL	71	0.995058
KGNV	GAINESVILLE REGIONAL	GAINESVILLE	FL	29	0.999016
KJAX	JACKSONVILLE INTL	JACKSONVILLE	FL	25	0.999425
KMIA	MIAMI INTL	MIAMI	FL	136	0.990130
KAPF	NAPLES MUNICIPAL	NAPLES	FL	99	0.993290
KOCF	OCALA INTL-JIM TAYLOR FLD	OCALA	FL	32	0.998646
KMCO	ORLANDO INTL	ORLANDO	FL	35	0.997977
KPFN	PANAMA CITY-BAY COUNTY INTL	PANAMA CITY	FL	20	0.999134
KPNS	PENSACOLA REGIONAL	PENSACOLA	FL	35	0.998616
SRQ	SARASOTA/BRADENTON INTL	SARASOTA/BRADENTON	FL	52	0.996804
KPIE	ST PETERSBURG-CLEARWATER INTL	ST PETERSBURG-CLEARWATER	FL	37	0.997739
KTLH	TALLAHASSEE REGIONAL	TALLAHASSEE	FL	20	0.999267
TPA	TAMPA INTL	TAMPA	FL	35	0.997777
KVRB	VERO BEACH MUNICIPAL	VERO BEACH	FL	48	0.996721
KPBI	PALM BEACH INTL	WEST PALM BEACH	FL	64	0.994961
KACJ	SOUTHER FIELD	AMERICUS	GA	19	0.999375
KATL	WILLIAM B HARTSFIELD ATLANTA INTL	ATLANTA	GA	19	0.999367
KSAV	SAVANNAH INTL	SAVANNAH	GA	15	0.999601
KTBR	STATESBORO-BULLOCH COUNTY	STATESBORO	GA	15	0.999606
KIKV	ANKENY REGIONAL	ANKENY	IA	21	0.998399
CID	THE EASTERN IOWA	CEDAR RAPIDS	IA	25	0.998160
DSM	DES MOINES INTL	DES MOINES	IA	20	0.998441

Airport ID	Airport Name	City	State	Outages	Availability
KMXO	MONTICELLO REGIONAL	MONTICELLO	IA	26	0.998084
KBOI	BOISE AIR TERMINAL/ GOWEN FIELD	BOISE	ID	22	0.999432
EUL	CALDWELL INDUSTRIAL	CALDWELL	ID	24	0.999393
SUN	FRIEDMAN MEMORIAL	HAILEY	ID	21	0.999495
SZT	SANDPOINT	SANDPOINT	ID	31	0.998123
KENL	CENTRALIA MUNICIPAL	CENTRALIA	IL	26	0.998511
KORD	CHICAGO-O'HARE INTL	CHICAGO	IL	30	0.997941
MDW	CHICAGO MIDWAY	CHICAGO	IL	29	0.997981
KARR	AURORA MUNICIPAL	CHICAGO/AURORA	IL	31	0.997969
KFOA	FLORA MUNICIPAL	FLORA	IL	27	0.998373
MLI	QUAD-CITY	MOLINE	IL	26	0.998102
KPIA	GREATER PEORIA REGIONAL	PEORIA	IL	28	0.998134
KPPQ	PITTSFIELD PENSTONE MUNI	PITTSFIELD	IL	22	0.998464
KTIP	RANTOUL NATL AVN CTR/ FRANK ELLIOT FLD	RANTOUL	IL	28	0.998158
KRFD	GREATER ROCKFORD	ROCKFORD	IL	31	0.998002
KSLO	SALEM-LECKRONE	SALEM	IL	26	0.998403
KANQ	TRI-STATE STEUBEN COUNTY	ANGOLA	IN	22	0.997970
KBMG	MONROE COUNTY	BLOOMINGTON	IN	26	0.998172
0I2	BRAZIL CLAY COUNTY	BRAZIL	IN	28	0.998134
FWA	FORT WAYNE INTL	FORT WAYNE	IN	22	0.998037
KIND	INDIANAPOLIS INTL	INDIANAPOLIS	IN	20	0.998187
SER	FREEMAN MUNICIPAL	SEYMOUR	IN	19	0.998265
SBN	MICHIANA REGIONAL TRANSPORTATION CTR	SOUTH BEND	IN	23	0.997989
KCBK	SHALTZ FIELD	COLBY	KS	20	0.999347
EHA	ELKHART-MORTON COUNTY	ELKHART	KS	13	0.999638
KHYS	HAYS RGNL	HAYS	KS	15	0.999496
KMHK	MANHATTAN REGIONAL	MANHATTAN	KS	19	0.999195
KOJC	JOHNSON COUNTY EXECUTIVE	OLATHE	KS	19	0.999160
TOP	PHILIP BILLARD MUNICIPAL	TOPEKA	KS	19	0.999165
KULS	ULYSSES	ULYSSES	KS	13	0.999632
ICT	WICHITA MID-CONTINENT	WICHITA	KS	15	0.999461
KWLD	STROTHER FIELD	WINFIELD/ARKANSAS CITY	KS	12	0.999613
KCVG	CINCINNATI/NORTHERN KY INTL	COVINGTON/CINCINNATI	KY	18	0.998373
KLEX	BLUE GRASS	LEXINGTON	KY	18	0.998510
SDF	LOUISVILLE INTERNATIONAL-STANDIFORD FLD	LOUISVILLE	KY	20	0.998295
KK22	BIG SANDY REGIONAL	PRESTONBURG	KY	18	0.998745
KAEX	ALEXANDRIA INTL	ALEXANDRIA	LA	29	0.999071
L39	LEESVILLE	LEESVILLE	LA	30	0.999076
MSY	NEW ORLEANS INTL/ MOISANT FIELD	NEW ORLEANS	LA	35	0.998628
SHV	SHREVEPORT REGIONAL	SHREVEPORT	LA	21	0.999364
KBOS	GEN EDWARD LAWRENCE LOGAN INTL	BOSTON	MA	175	0.987198
OWD	NORWOOD MEMORIAL	NORWOOD	MA	168	0.988327
KPVC	PROVINCETOWN MUNICIPAL	PROVINCETOWN	MA	227	0.982881
KBWI	BALTIMORE-WASHINGTON INTL	BALTIMORE	MD	27	0.998293
FDK	FREDERICK MUNICIPAL	FREDERICK	MD	28	0.998399

Airport ID	Airport Name	City	State	Outages	Availability
GAI	MONTGOMERY COUNTY AIRPARK	GAITHERSBURG	MD	28	0.998404
W00	FREEWAY	MITCHELLVILLE	MD	26	0.998366
RJD	RIDGELY AIRPARK	RIDGELY	MD	28	0.997959
DMW	CARROLL CNTY REGIONAL/ JACK B. POAGE FLD	WESTMINSTER	MD	29	0.998319
PWM	PORTLAND INTL JETPORT	PORTLAND	ME	270	0.977217
KPQI	N MAINE REGIONAL AIRPORT AT PRESQUE	PRESQUE ISLE	ME	1005	0.829371
AMN	ALMA/GRATIOT COMMUNITY	ALMA	MI	24	0.997611
KARB	ANN ARBOR MUNICIPAL	ANN ARBOR	MI	22	0.997977
Y15	CHEBOYGAN COUNTY	CHEBOYGAN	MI	31	0.997335
KDTW	DETROIT METROPOLITAN WAYNE CTY	DETROIT	MI	22	0.998081
KFNT	BISHOP INTL	FLINT	MI	23	0.997770
KGRR	GERALD R FORD INTL	GRAND RAPIDS	MI	24	0.997667
KCMX	HOUGHTON COUNTY MEMORIAL	HANCOCK	MI	65	0.990153
BIV	TULIP CITY	HOLLAND	MI	23	0.997765
HTL	ROSCOMMON COUNTY	HOUGHTON LAKE	MI	24	0.997511
KMKG	MUSKEGON COUNTY	MUSKEGON	MI	25	0.997581
5D3	OWOSSO COMMUNITY	OWOSSO	MI	23	0.997689
KMBS	MBS INTL	SAGINAW	MI	23	0.997660
CIU	CHIPPEWA COUNTY INTL	SAULT STE. MARIE	MI	52	0.993896
KAXN	CHANDLER FIELD	ALEXANDRIA	MN	44	0.996073
KBDE	BAUDETTE INTL	BAUDETTE	MN	68	0.988425
KBRD	BRAINERD-CROW WING CO REGIONAL	BRAINERD	MN	49	0.992998
KDLH	DULUTH INTL	DULUTH	MN	55	0.991937
KMSP	MINNEAPOLIS-ST PAUL INTL/ WOLD CHAMBERLAIN	MINNEAPOLIS	MN	23	0.998272
KRGK	RED WING REGIONAL	RED WING	MN	26	0.998145
KRST	ROCHESTER INTL	ROCHESTER	MN	27	0.998188
KJYG	ST JAMES MUNICIPAL	ST JAMES	MN	22	0.998440
M05	CARUTHERSVILLE MEMORIAL	CARUTHERSVILLE	MO	26	0.998808
KMCI	KANSAS CITY INTL	KANSAS CITY	MO	18	0.999044
KLBO	FLOYD W JONES LEBANON	LEBANON	MO	19	0.999183
LXT	LEE'S SUMMIT MUNICIPAL	LEE'S SUMMIT	MO	17	0.999060
H41	MEXICO MEMORIAL	MEXICO	MO	20	0.998704
KDMO	SEDALIA MEMORIAL	SEDALIA	MO	18	0.998881
SGF	SPRINGFIELD-BRANSON REGIONAL	SPRINGFIELD	MO	15	0.999309
KSTL	LAMBERT-ST LOUIS INTL	ST LOUIS	MO	22	0.998453
KMO6	WASHINGTON MEMORIAL	WASHINGTON	MO	23	0.998602
0M6	PANOLA COUNTY	BATESVILLE	MS	25	0.999191
JAN	JACKSON INTL	JACKSON	MS	27	0.999127
MPE	PHILADELPHIA MUNICIPAL	PHILADELPHIA	MS	27	0.999068
KBIL	BILLINGS LOGAN INTL	BILLINGS	MT	23	0.998814
6S5	RAVALLI COUNTY	HAMILTON	MT	19	0.999031
KHLN	HELENA REGIONAL	HELENA	MT	21	0.998865
KLWT	LEWISTOWN MUNICIPAL	LEWISTOWN	MT	30	0.998411
KMLS	FRANK WILEY FIELD	MILES CITY	MT	33	0.997923
KHBI	ASHEBORO MUNICIPAL	ASHEBORO	NC	16	0.999059

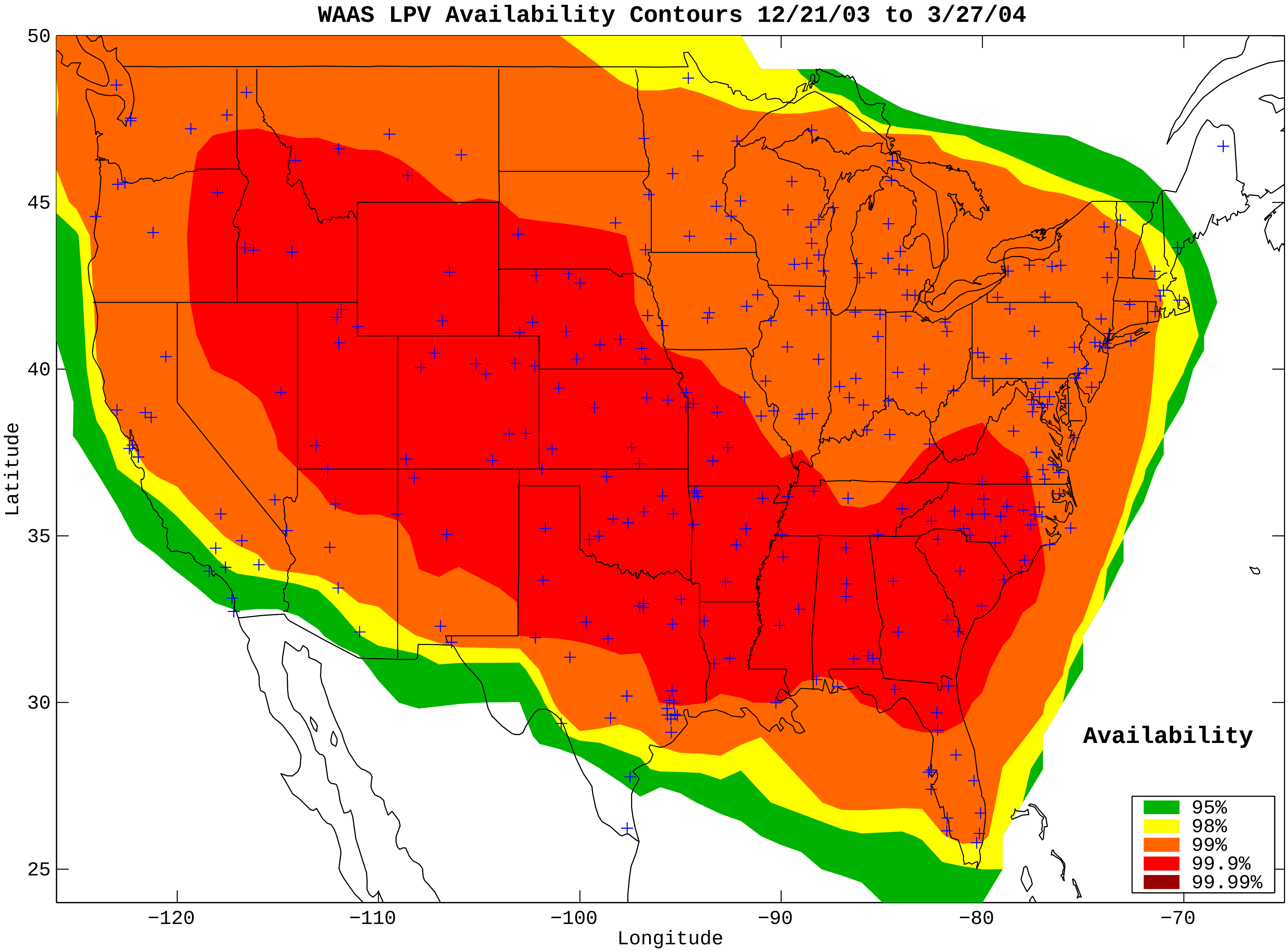
Airport ID	Airport Name	City	State	Outages	Availability
KAVL	ASHEVILLE REGIONAL	ASHEVILLE	NC	17	0.999202
MRH	MICHAEL J. SMITH FIELD	BEAUFORT	NC	22	0.998576
KCLT	CHARLOTTE/DOUGLAS INTL	CHARLOTTE	NC	16	0.999096
ECG	ELIZABETH CITY CGAS	ELIZABETH CITY	NC	24	0.998369
KFAY	FAYETTEVILLE REGIONAL/ GRANNIS FIELD	FAYETTEVILLE	NC	17	0.999079
GSO	PIEDMONT TRIAD INTL	GREENSBORO	NC	17	0.999040
PGV	PITT-GREENVILLE	GREENVILLE	NC	17	0.998706
HSE	BILLY MITCHELL	HATTERAS	NC	27	0.998162
HKY	HICKORY REGIONAL	HICKORY	NC	16	0.999066
KISO	KINSTON REGIONAL JETPORT AT STALLINGS FLD	KINSTON	NC	19	0.998867
MEB	LAURINBURG	MAXTON	NC	15	0.999120
KEQY	MONROE	MONROE	NC	16	0.999140
KRDU	RALEIGH-DURHAM INTL	RALEIGH/DURHAM	NC	17	0.999046
KRUQ	ROWAN COUNTY	SALISBURY	NC	16	0.999079
KTTA	SANFORD-LEE COUNTY RGNL	SANFORD	NC	17	0.999047
SUT	BRUNSWICK COUNTY	SOUTHPORT	NC	18	0.999295
OCW	WARREN FIELD	WASHINGTON	NC	20	0.998632
MCZ	MARTIN COUNTY	WILLIAMSTON	NC	17	0.998686
KILM	WILMINGTON INTL	WILMINGTON	NC	17	0.999122
W03	WILSON INDUSTRIAL AIR CENTER	WILSON	NC	19	0.998919
KFAR	HECTOR INTL	FARGO	ND	46	0.991709
MOT	MINOT INTL AIRPORT	MINOT	ND	44	0.991814
KANW	AINSWORTH MUNICIPAL	AINSWORTH	NE	18	0.999083
AUH	AURORA MUNICIPAL	AURORA	NE	21	0.999024
BIE	BEATRICE MUNICIPAL	BEATRICE	NE	22	0.999056
CSB	CAMBRIDGE MUNICIPAL	CAMBRIDGE	NE	20	0.999278
CEK	CRETE MUNICIPAL	CRETE	NE	22	0.998990
GRN	GORDON MUNICIPAL	GORDON	NE	15	0.999447
KEAR	KEARNEY MUNICIPAL	KEARNEY	NE	20	0.999046
KLBF	NORTH PLATTE REGIONAL LEE BIRD FLD	NORTH PLATTE	NE	20	0.999183
OMA	EPPLEY AIRFIELD	OMAHA	NE	20	0.998469
OKS	GARDEN COUNTY	OSHKOSH	NE	14	0.999613
SCB	SCRIBNER STATE	SCRIBNER	NE	20	0.998463
SNY	SIDNEY MUNICIPAL	SIDNEY	NE	16	0.999496
VTN	MILLER FIELD	VALENTINE	NE	18	0.999102
MHT	MANCHESTER	MANCHESTER	NH	170	0.988350
KACY	ATLANTIC CITY INTL	ATLANTIC CITY	NJ	36	0.997112
KMMU	MORRISTOWN MUNICIPAL	MORRISTOWN	NJ	44	0.996514
KEWR	NEWARK INTL	NEWARK	NJ	45	0.996162
7N7	SPITFIRE AERODROM	PEDRICTOWN	NJ	34	0.997428
K3NJ6	INDUCTOTHERM HELIPORT	RANCOCAS	NJ	37	0.996937
KABQ	ALBUQUERQUE INTL SUNPORT	ALBUQUERQUE	NM	28	0.999298
KFMN	FOUR CORNERS REGIONAL	FARMINGTON	NM	21	0.999510
KLRU	LAS CRUCES INTL	LAS CRUCES	NM	57	0.997453
ELY	ELY AIRPORT/YELLAND FELD	ELY	NV	27	0.999186
KLAS	MC CARRAN INTL	LAS VEGAS	NV	50	0.997822
ALB	ALBANY INTL	ALBANY	NY	65	0.994499
BUF	BUFFALO NIAGARA INTL	BUFFALO	NY	25	0.998057

Airport ID	Airport Name	City	State	Outages	Availability
KELM	ELMIRA/CORNING REGIONAL	ELMIRA	NY	32	0.997559
LGA	LA GUARDIA	FLUSHING	NY	49	0.995903
GFL	FLOYD BENNETT MEMORIAL	GLENS FALLS	NY	77	0.994082
KJHW	CHAUTAUQUA COUNTY/ JAMESTOWN	JAMESTOWN	NY	22	0.998265
LKP	LAKE PLACID	LAKE PLACID	NY	82	0.993844
KJFK	JOHN F KENNEDY INTL	NEW YORK	NY	48	0.995873
KSWF	STEWART INTL	NEWBURGH	NY	50	0.995777
PBG	PLATTSGURGH INTL	PLATTSGURGH	NY	105	0.992401
ROC	GREATER ROCHESTER INTL	ROCHESTER	NY	29	0.997633
KSYR	SYRACUSE HANCOCK INTL	SYRACUSE	NY	45	0.996876
B16	WHITFORDS	WEEDSPORT	NY	40	0.997310
FOK	THE FRANCIS S. GABRESKI	WESTHAMPTON BEACH	NY	69	0.994363
HPN	WESTCHESTER COUNTY	WHITE PLAINS	NY	50	0.995613
KRZT	ROSS COUNTY	CHILLICOTHE	OH	22	0.998423
KCLE	CLEVELAND-HOPKINS INTL	CLEVELAND	OH	23	0.998259
KCMH	PORT COLUMBUS INTL	COLUMBUS	OH	23	0.998373
KDAY	JAMES M COX DAYTON INTL	DAYTON	OH	22	0.998205
1G5	MEDINA MUNICIPAL	MEDINA	OH	24	0.998298
KTOL	TOLEDO EXPRESS	TOLEDO	OH	22	0.998026
KAVK	ALVA REGIONAL	ALVA	OK	13	0.999630
KCQB	CHANDLER MUNICIPAL	CHANDLER	OK	12	0.999613
2O8	HINTON MUNICPAL	HINTON	OK	13	0.999630
KHBR	HOBART MUNICIPAL	HOBART	OK	14	0.999617
K2K4	SCOTT FIELD	MANGUM	OK	14	0.999617
KMKO	DAVIS FIELD	MUSKOGEE	OK	13	0.999519
OKC	WILL ROGERS WORLD AIRPORT	OKLAHOMA CITY	OK	12	0.999645
KTUL	TULSA INTL	TULSA	OK	12	0.999613
S07	BEND MUNICIPAL	BEND	OR	37	0.998053
HIO	PORTLAND-HILLSBORO	HILLSBORO	OR	51	0.997429
LGD	UNION COUNTY	LA GRANDE	OR	35	0.998842
KONP	NEWPORT MUNICIPAL	NEWPORT	OR	77	0.995785
PDX	PORTLAND INTL	PORTLAND	OR	46	0.997581
S47	TILLAMOOK	TILLAMOOK	OR	75	0.995808
ABE	LEHIGH VALLEY INTL	ALLENTOWN	PA	38	0.997271
KBFD	BRADFORD REGIONAL	BRADFORD	PA	24	0.998228
MDT	HARRISBURG INTL	HARRISBURG	PA	28	0.998021
KJST	JOHN MURTHA JOHNSTOWN-CAMBRIA COUNTY	JOHNSTOWN	PA	22	0.998396
LHV	WILLIAM T. PIPER MEMORIAL	LOCK HAVEN	PA	29	0.998011
PHL	PHILADELPHIA INTL	PHILADELPHIA	PA	35	0.997252
KAGC	ALLEGHENY COUNTY	PITTSBURGH	PA	21	0.998504
KPIT	PITTSBURGH INTL	PITTSBURGH	PA	21	0.998444
PVD	THEODORE FRANCIS GREEN STATE	PROVIDENCE	RI	139	0.990187
AND	ANDERSON REGIONAL	ANDERSON	SC	18	0.999492
KCHS	CHARLESTON AFB/INTL	CHARLESTON	SC	14	0.999441
KCAE	COLUMBIA METROPOLITAN	COLUMBIA	SC	15	0.999422
KGSP	GREENVILLE-SPARTANBURG INTL	GREER	SC	15	0.999190
KMYR	MYRTLE BEACH INTL	MYRTLE BEACH	SC	16	0.999342
KHON	HURON REGIONAL	HURON	SD	20	0.998824

Airport ID	Airport Name	City	State	Outages	Availability
1D1	MILBANK MUNICIPAL	MILBANK	SD	34	0.997905
KRAP	RAPID CITY REGIONAL	RAPID CITY	SD	17	0.999474
FSD	JOE FOSS FIELD	SIOUX FALLS	SD	18	0.998565
CHA	LOVELL FIELD	CHATTANOOGA	TN	19	0.999163
TYS	MC GHEE TYSON	KNOXVILLE	TN	19	0.998859
KMEM	MEMPHIS INTL	MEMPHIS	TN	24	0.999196
KBNA	NASHVILLE INTL	NASHVILLE	TN	26	0.998466
PHT	HENRY COUNTY	PARIS	TN	27	0.998788
KABI	ABILENE REGIONAL	ABILENE	TX	35	0.998973
AMA	AMARILLO INTL	AMARILLO	TX	16	0.999594
KLBX	BRAZORIA COUNTY	ANGLETON/LAKE JACKSON	TX	74	0.996590
AUS	AUSTIN-BERGSTROM INTL	AUSTIN	TX	59	0.997137
7F9	COMANCHE	COMANCHE	TX	28	0.999127
KCXO	MONTGOMERY COUNTY	CONROE	TX	33	0.998979
CRP	CORPUS CHRISTI INTL	CORPUS CHRISTI	TX	228	0.964864
KDAL	DALLAS LOVE FIELD	DALLAS	TX	19	0.999477
ADS	ADDISON	DALLAS	TX	18	0.999495
KDFW	DALLAS-FT WORTH INTL	DALLAS-FT WORTH	TX	18	0.999495
KDRT	DEL RIO INTL	DEL RIO	TX	127	0.993563
ELP	EL PASO INTL	EL PASO	TX	82	0.995775
KHRL	VALLEY INTL	HARLINGEN	TX	532	0.906648
KAXH	HOUSTON-SOUTHWEST	HOUSTON	TX	51	0.998253
KDWH	DAVID WAYNE HOOKS MEMORIAL	HOUSTON	TX	36	0.998861
KEFD	ELLINGTON FIELD	HOUSTON	TX	44	0.998455
KHOU	WILLIAM P HOBBY	HOUSTON	TX	44	0.998472
KIAH	GEORGE BUSH INTERCONTINENTAL/HOUSTON	HOUSTON	TX	37	0.998848
KIWS	WEST HOUSTON	HOUSTON	TX	45	0.998614
KSGR	SUGAR LAND MUNI/HULL FLD	HOUSTON	TX	50	0.998292
KLBB	LUBBOCK INTL	LUBBOCK	TX	19	0.999525
MAF	MIDLAND INTL	MIDLAND	TX	35	0.999024
OSA	MOUNT PLEASANT MUNICIPAL	MOUNT PLEASANT	TX	19	0.999475
KSJT	SAN ANGELO RGNL/MATHIS FLD	SAN ANGELO	TX	59	0.997906
KSAT	SAN ANTONIO INTL	SAN ANTONIO	TX	90	0.994579
KTYR	TYLER POUNDS REGIONAL	TYLER	TX	21	0.999411
BMC	BRIGHAM CITY	BRIGHAM CITY	UT	17	0.999576
KCDC	CEDAR CITY REGIONAL	CEDAR CITY	UT	28	0.998969
KKNB	KANAB MUNICIPAL	KANAB	UT	27	0.998982
LGU	LOGAN-CACHE	LOGAN	UT	15	0.999604
SLC	SALT LAKE CITY INTL	SALT LAKE CITY	UT	20	0.999507
KCHO	CHARLOTTESVILLE-ALBEMARLE	CHARLOTTESVILLE	VA	18	0.998628
FKN	FRANKLIN MUNICIPAL-JOHN BEVERLY ROSE	FRANKLIN	VA	20	0.998576
LVL	BRUNSWICK MUNICIPAL	LAWRENCEVILLE	VA	18	0.998843
JYO	LEESBURG MUNICIPAL/ GODFREY FIELD	LEESBURG	VA	28	0.998445
HEF	MANASSAS REGIONAL/ HARRY P. DAVIS FIELD	MANASSAS	VA	27	0.998486
MTV	BLUE RIDGE	MARTINSVILLE	VA	17	0.998975
KPHF	NEWPORT NEWS/ WILLIAMSBURG INTL	NEWPORT NEWS	VA	24	0.998446

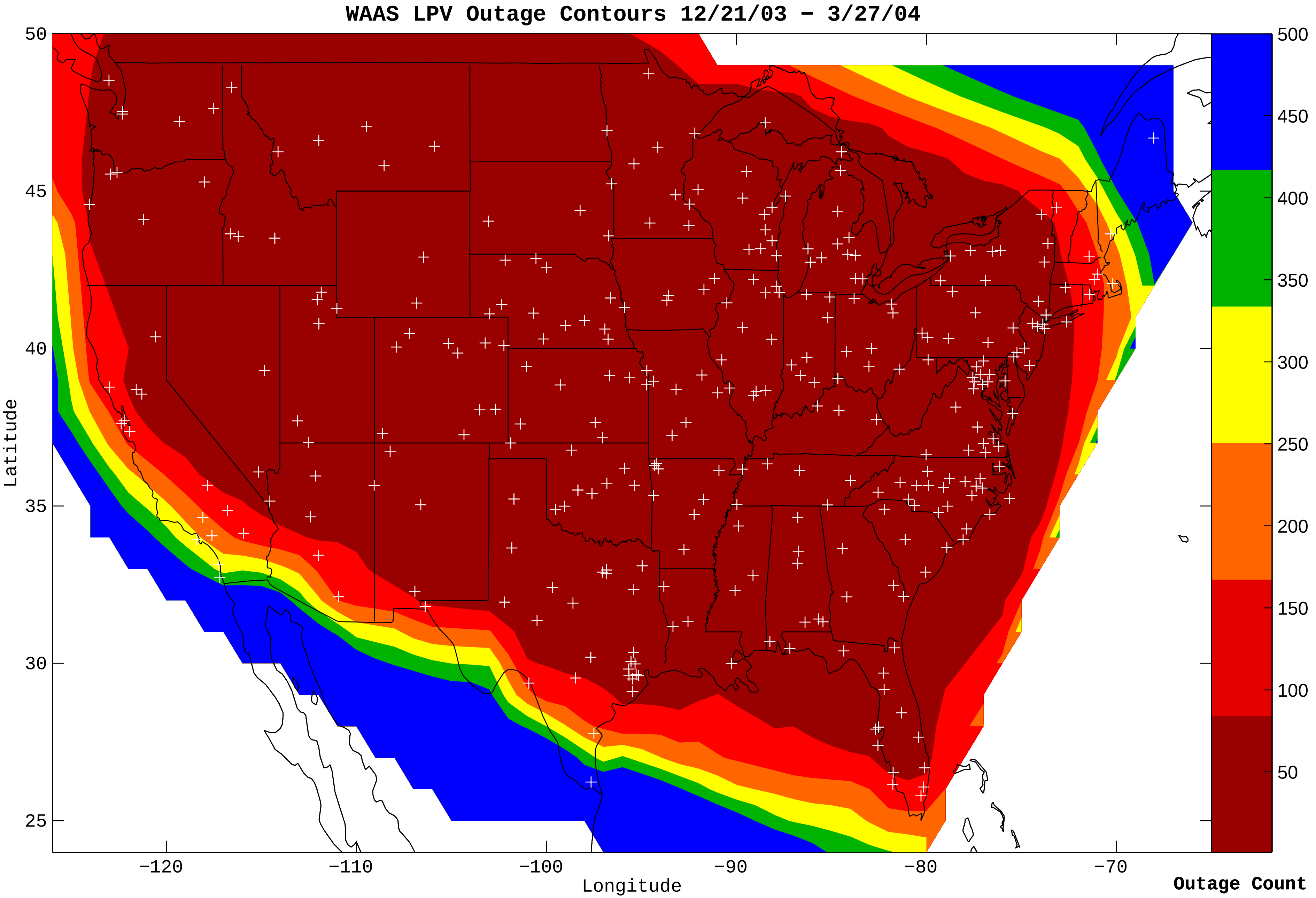
Airport ID	Airport Name	City	State	Outages	Availability
KORF	NORFOLK INTL	NORFOLK	VA	26	0.998307
RIC	RICHMOND INTL	RICHMOND	VA	19	0.998564
AKQ	WAKEFIELD MUNICIPAL	WAKEFIELD	VA	22	0.998543
WAL	WALLOPS FLIGHT FACILITY	WALLOPS ISLAND	VA	29	0.997871
BTV	BURLINGTON INTL	BURLINGTON	VT	104	0.992183
FHR	FRIDAY HARBOR	FRIDAY HARBOR	WA	65	0.996288
KMWH	GRANT COUNTY INTL	MOSES LAKE	WA	34	0.998415
KSEA	SEATTLE-TACOMA INTL	SEATTLE	WA	54	0.997323
BFI	BOEING FIELD/ KING COUNTY INTL	SEATTLE	WA	53	0.997291
KGEG	SPOKANE INTL	SPOKANE	WA	30	0.998500
KATW	OUTAGAMIE COUNTY REGIONAL	APPLETON	WI	32	0.997663
3T3	BOYCEVILLE MUNICIPAL	BOYCEVILLE	WI	30	0.998057
FLD	FOND DU LAC COUNTY	FOND DU LAC	WI	31	0.997703
KGRB	AUTIN STRAUBEL INTL	GREEN BAY	WI	32	0.997656
MSN	DANE COUNTY REGIONAL-TRUAX FIELD	MADISON	WI	30	0.997909
MKE	GENERAL MITCHELL INTL	MILWAUKEE	WI	30	0.997892
KCWA	CENTRAL WISCONSIN	MOSINEE	WI	33	0.997600
RHI	RHINELANDER-ONEIDA COUNTY	RHINELANDER	WI	43	0.997130
SUE	DOOR COUNTY CHERRYLAND	STURGEON BAY	WI	34	0.997492
RYV	WATERTOWN MUNICIPAL	WATERTOWN	WI	30	0.997899
ETB	WEST BEND MUNICIPAL	WEST BEND	WI	31	0.997844
KMGW	MORGANTOWN MUNICIPAL-WLB HART FLD	MORGANTOWN	WV	22	0.998539
KPKB	WOOD CO-GILL ROBB WILSON FLD	PARKERSBURG	WV	20	0.998572
KCPR	NATRONA COUNTY INTL	CASPER	WY	16	0.999572
EVW	EVANSTON-UNITA CNTY-BURNS FLD	EVANSTON	WY	18	0.999536
SAA	SHIVELY FIELD	SARATOGA	WY	15	0.999573

Figure 10•1 WAAS LPV Availability



W.J.H. FAA Technical Center
WAAS Test Team
04/14/04

Figure 10•2 WAAS LPV Outage



W.J.H. FAA Technical Center
WAAS Test Team
04/14/04

11.0 WAAS DETERMINISTIC CODE NOISE AND MULTIPATH BOUNDING ANALYSIS

WAAS utilizes a deterministic model to estimate the residual CNMP noise after the application of standard dual frequency carrier smoothing techniques to minimize the effects of multipath and code noise. This analysis performs an assessment of how well that deterministic model bounds the actual errors. This analysis is periodically performed as part of the WAAS Test Team's off-line monitoring to ensure that there are no drastic detrimental changes to the multipath environment at the WAAS Reference Stations (WRSs). This analysis also ensures that WAAS system is not indefinitely exposed to conspiring receiver failure symptoms that would invalidate the CNMP bounding estimate in a manner that would exceed the assumption that no more than one receiver is conspiring to deceive the WAAS monitors at any time by underestimating the residual measurement noise the safety monitors. Although some failures mechanisms that cause CNMP bounding issues are occasionally seen, no "conspiring" errors have ever been detected. That is, data has caused the safety monitors to trip unnecessarily versus missing a necessary trip.

The analysis post processes measurement data to estimate the pseudorange code to carrier ambiguity for each entire arc of measurements for each satellite pass. The ambiguity estimate is then used to level the carrier measurement. The leveled carrier is then used as a multipath free truth estimate. The WAAS real time deterministic CNMP smoothing algorithm is then applied to the original measurements. The difference between the smoothed measurements and the leveled truth measurements is compared to the deterministic noise estimates. Only arcs with continuous carrier phase greater in length than 7200 seconds are utilized for this analysis to minimize the impacts of non-zero mean multipath biasing the truth estimates. The WAAS dual frequency cycle slip detector algorithm is used to detect any discontinuities in the carrier phase.

Statistics are calculated on how well the 0.1 multiples of the deterministically estimated standard deviation bounds the difference between the leveled truth and the real time smoothed measurements. Those statistics are then compared to a theoretical gaussian distribution and an extensive set of plots are generated and manually reviewed. Table 11.1 recaps the results of that manual analysis.

Table 11-1 CNMP Bounding Statistics

WAAS Site	WRE	Jul 03	Aug 03	Sep 03	Oct 03	Nov 03	Dec 03	Jan 04	Feb 04	Mar 04
Albuquerque	A	green	orange	blue	green	blue	green	blue	blue	green
	B	blue	blue	blue	orange	green	blue	blue	blue	blue
	C	blue	green	blue	blue	blue	blue	green	blue	blue
Anchorage	A	green	green	orange	orange	orange	blue	green	green	yellow
	B	green	green	red	red	orange	green	blue	blue	blue
	C	blue	green	green	green	orange	green	blue	blue	blue
Atlanta	A	blue	blue	blue	blue	blue	blue	blue	blue	blue
	B	orange	blue	blue	green	green	blue	blue	blue	blue
	C	blue	blue	blue	orange	blue	blue	blue	blue	green
Billings	A	blue	blue	blue	blue	green	blue	blue	blue	blue
	B	blue	blue	blue	blue	blue	blue	blue	blue	blue
	C	blue	blue	blue	green	blue	blue	blue	blue	blue
Boston	A	blue	blue	green	green	blue	green	blue	green	blue
	B	blue	blue	orange	blue	blue	blue	blue	blue	blue
	C	green	green	blue	blue	blue	blue	blue	blue	blue
Chicago	A	blue	blue	green	blue	green	blue	orange	orange	blue
	B	green	blue	orange	blue	green	blue	blue	blue	blue
	C	orange	blue	orange	blue	blue	orange	blue	blue	yellow
Cleveland	A	green	orange	green	orange	orange	green	green	green	green
	B	blue	green	blue	green	orange	green	blue	blue	yellow
	C	blue	blue	blue	green	green	blue	green	blue	blue
Cold Bay	A	blue	blue	blue	blue	blue	blue	blue	blue	red
	B	green	orange	blue	blue	orange	blue	green	blue	blue
	C	blue	blue	blue	blue	blue	blue	blue	blue	blue
Dallas	A	blue	blue	blue	green	green	green	blue	green	green
	B	red	green	green	blue	blue	green	blue	blue	blue
	C	blue	green	blue	blue	blue	blue	blue	blue	blue
Denver	A	blue	blue	blue	green	blue	green	green	blue	green
	B	blue	blue	blue	blue	blue	blue	blue	blue	blue
	C	blue	blue	blue	blue	blue	blue	blue	blue	blue
Honolulu	A	orange	orange	orange	orange	green	orange	orange	orange	red
	B	green	blue	green	blue	orange	blue	blue	blue	blue
	C	orange	red	green	blue	green	blue	blue	green	blue
Houston	A	red	orange	red	red	red	red	orange	red	red
	B	red	red	red	red	red	red	red	orange	red
	C	red	red	red	red	orange	red	red	red	red
Jacksonville	A	blue	blue	blue	blue	blue	blue	blue	blue	blue
	B	green	blue	blue	blue	blue	blue	blue	green	blue
	C	blue	blue	blue	blue	blue	green	blue	blue	blue
Juneau	A	blue	blue	orange	blue	blue	green	blue	blue	yellow
	B	blue	blue	blue	blue	orange	orange	blue	blue	yellow
	C	blue	orange	blue	blue	blue	blue	blue	green	green
Kansas City	A	blue	blue	blue	green	orange	blue	blue	orange	yellow
	B	red	green	green	blue	green	blue	blue	orange	green
	C	blue	blue	red	blue	red	green	blue	blue	green
Los Angeles	A	blue	blue	green	blue	green	blue	blue	blue	blue
	B	blue	blue	blue	blue	orange	blue	blue	blue	blue
	C	green	blue	blue	orange	green	blue	orange	blue	blue
Memphis	A	green	blue	green	orange	blue	blue	blue	green	blue
	B	blue	orange	green	blue	orange	orange	blue	blue	blue
	C	blue	blue	blue	blue	blue	blue	blue	blue	blue
Miami	A	green	blue	blue	orange	green	blue	green	green	green
	B	blue	blue	green	orange	orange	green	green	green	green
	C	red	red	green	red	red	green	orange	orange	red
Minneapolis	A	blue	orange	green	blue	green	blue	blue	blue	yellow
	B	blue	blue	green	green	orange	orange	blue	green	blue
	C	blue	blue	green	blue	orange	blue	blue	blue	blue
New York	A	blue	green	blue	blue	blue	blue	blue	green	blue
	B	blue	blue	blue	green	blue	blue	blue	green	green
	C	green	green	orange	orange	green	green	green	green	green

WAAS Site	**WRE**	**Jul 03**	**Aug 03**	**Sep 03**	**Oct 03**	**Nov 03**	**Dec 03**	**Jan 04**	**Feb 04**	**Mar 04**
Oakland	A	● orange	● blue	● blue	● green	● blue	● blue	● blue	● orange	● blue
	B	● blue	● green	● blue	● red	● orange	● orange	● blue	● blue	● blue
	C	● red	● green	● blue	● green	● orange	● red	● blue	● green	● green
Salt Lake City	A	● blue	● green	● blue	● blue	● blue	● blue	● green	● blue	● blue
	B	● blue	● blue	● green	● red	● green	● blue	● green	● blue	● blue
	C	● orange	● blue	● green	● blue	● blue	● green	● blue	● blue	● blue
San Juan	A	● orange	● green	● blue	● green	● green	● blue	● blue	● blue	● yellow
	B	● blue	● orange	● blue	● orange	● orange	● blue	● green	● blue	● yellow
	C	● blue	● green	● blue	● orange	● green	● orange	● green	● blue	● blue
Seattle	A	● blue	● orange	● blue	● blue	● blue	● blue	● blue	● blue	● blue
	B	● blue	● blue	● blue	● blue	● orange	● blue	● blue	● blue	● blue
	C	● blue	● blue	● blue	● blue	● blue	● blue	● blue	● blue	● blue
Washington, DC	A	● blue	● blue	● blue	● blue	● blue	● blue	● blue	● blue	● blue
	B	● blue	● blue	● blue	● blue	● blue	● blue	● blue	● blue	● blue
	C	● blue	● blue	● blue	● blue	● blue	● green	● red	● green	● blue

Δ (blue) **Excellent** - 3.29σ bounded 100%

Δ (green) **Good** - 4σ bounded 100%

Δ (orange) **Fair** - 4σ bounded 100% with one worst satellite excluded (Requires manual review)

Δ (red) **Poor** – Requires manual review

12.0 WAAS EQUIPMENT OUTAGE

To determine if outages of any WAAS assets affects the SIS performance, failures to WAAS equipment is tracked. Some events, such as a GUS switchover, definitely affect SIS performance. Other events, like multiple WRE outages at a single WRS, may or may not affect SIS performance. During this quarter none of the WRS outages negatively affected SIS performance.

Data was collected from all WAAS sites to determine if any failures occurred. This data is made available through the WAAS External Interface (WEI). ACB-430 developed software parses the data so it is available for analysis. Any equipment failures are confirmed with AOS-240 and/or WAAS operations personnel.

During this reporting period there were a total of seventeen GUS switchovers. The dates and times of the switchovers are shown in Table 12.1. The reasons for the switchovers include maintenance action, preventative maintenance, and operations policy. The operations policy refers to the policy that two GUSs cannot be in primary at the same site, in this case Santa Paula. To further explain, each GEO satellite for the WAAS has two uplink locations. The AORW satellite's uplinks are located at Clarksburg MD and Santa Paula CA. The POR satellite's uplinks are located at Brewster WA and Santa Paula CA (note that this uplink is physically independent from the AORW Santa Paula uplink, they are just located at the same facility). An uplink is normally in one of two modes: primary or backup. The primary uplink transmits the WAAS information to the respective GEO satellite. The backup uplink is a hot standby. When a switchover occurs there is a loss of the WAAS signal, for that particular GEO satellite, for approximately 10 seconds while the backup GUS locks in the GEO signal. The number of switchovers continues to be a concern due to the negative impact on WAAS users. The WAAS Operations organizations have been informed on the negative impacts of GUS switchovers. Policies have been implemented to help prevent the large number of switchovers that have occurred since WAAS commissioning.

There were also a large number of WRE outages during this quarter. Once again this quarter, the primary reason for WRE outages was the so called three card reset. This event occurs when the WAAS receiver ceases to send data to the WRE processor. This causes the WRE to fault. This problem continues to be investigated by second level engineering. Table 12.2 lists all the outages that affected reference stations.

There were several outages at the National Operations Command Center (NOCC) and Pacific Operations Command Center (POCC). None of these outages affected the WAAS SIS or WAAS operations. Table 12.3 lists all the outages at the NOCC and POCC for this reporting period.

During this quarter the FAA installed the first changes to the WAAS since commissioning. The software and hardware upgrades occurred March 2 – March 4 (NSTB Week 1260, GPS days 2 through 4). Several problems occurred during this upgrade that caused the ZLA C&V to fault. That is the reason for most of the C&V faults during this quarter. The C&V failures during the upgrade did not affect system performance. The other outage of the ZLA C&V was due to maintenance and this also did not affect system performance.

NOTE: The tables below show dates and times according to GPS nomenclature. This quarter began on Week 1251, Day 4 (January 1, 2004) and ended Week 1264, Day 3 (March 31, 2004). Here is an explanation for the related column headings in all the following tables:

- *NSTB Week #: The GPS week begins 12:00:00 AM Sunday and ends 11:59:59 PM Saturday. The NSTB week is equal to the GPS week plus 1024.*
- *GPS Day: The first GPS day is Day 0 (Sunday) and Day 6 is Saturday.*
- *GPS Time: Number of seconds into the week since 12:00:00 AM Sunday.*

Table 12-1 WAAS GUS Switchovers from January 1, 2004 to March 31, 2004

NSTB Week	GPS Day	Satellite	GPS Time (Seconds)
1264	2	AOR-W	244464
1259	2	POR	202631
1259	3	POR	288512
1254	5	POR	501910
1252	5	AOR-W	453766
1253	0	AOR-W	40327
1255	1	AOR-W	116918
1253	4	AOR-W	359821
1252	4	AOR-W	428828
1264	3	POR	289120
1255	1	POR	96710
1257	2	AOR-W	203824
1253	4	AOR-W	421216
1253	4	POR	374489
1257	3	POR	289995
1253	0	AOR-W	15185
1253	5	AOR-W	464566

Table 12-2 WRE Outages from January 1, 2004 to March 31, 2004

NSTB Week	GPS Day	Site	Start Time (GPS Seconds)	End Time (GPS Seconds)	Duration (Seconds)
1251	6	BIL-C	555323	558535	3212
1252	0	ZMP-B	13424	16922	3498
1252	2	ZMP-A	257794	264370	6576
1252	3	ZJX-C	328572	333411	4839
1252	4	ZMP-B	431219	436686	5467
1252	6	JNU-B	530639	534145	3506
1252	6	HNL-A	560595	600382	39787
1252	6	JNU-A	579858	583955	4097
1253	0	ZAB-B	15292	17674	2382
1253	0	ZLC-A	82791	85408	2617
1253	1	ZAB-C	141464	338491	197027
1253	1	ZOA-B	157565	161668	4103
1253	2	HNL-A	226351	330103	103752
1253	2	ZSE-C	230984	237121	6137
1253	2	CDB-C	233976	249234	15258
1253	5	ZOA-A	482084	486326	4242
1253	6	ZKC-B	526498	529250	2752
1253	6	ZAN-C	563974	566954	2980
1254	0	ZLA-C	34903	36379	1476

NSTB Week	GPS Day	Site	Start Time (GPS Seconds)	End Time (GPS Seconds)	Duration (Seconds)
1254	2	ZSE-B	194435	374689	180254
1254	2	ZSU-C	207388	210228	2840
1254	4	ZOB-B	402888	405627	2739
1254	4	HNL-C	410902	415811	4909
1254	4	ZBW-C	416840	421726	4886
1254	6	ZTL-B	553988	557181	3193
1254	6	CDB-C	556946	587793	30847
1254	6	ZTL-C	588138	591775	3637
1254	6	ZLA-B	589029	593080	4051
1255	0	ZTL-A	4096	6986	2890
1255	0	ZBW-C	80610	83727	3117
1255	1	ZBW-A	120668	123439	2771
1255	3	ZOB-B	325745	332755	7010
1255	5	HNL-B	507216	511243	4027
1256	3	ZJX-C	314307	318957	4650
1256	3	ZJX-C	329690	333249	3559
1256	3	ZSE-B	339387	342777	3390
1256	4	ZBW-B	371425	375599	4174
1256	4	ZHU-B	372880	376743	3863
1256	4	ZLC-C	408338	420844	12506
1257	3	ZME-B	302978	306257	3279
1257	4	ZMP-C	398397	403838	5441
1257	5	ZOB-C	488634	493025	4391
1257	5	ZDV-C	488846	491862	3016
1258	0	ZNY-C	37739	41041	3302
1258	1	JNU-A	97978	101160	3182
1258	1	JNU-B	102229	106267	4038
1258	1	JNU-A	153254	155834	2580
1258	1	JNU-B	*	*	*
1258	2	ZKC-C	*	*	*
1258	2	ZME-A	*	*	*
1258	3	JNU	*	*	*
1258	4	JNU-A	354360	432660	78300
1258	4	ZJX-C	416820	419417	2597
1258	4	ZAB-A	422902	427502	4600
1258	5	JNU-B	501002	507323	6321
1258	6	ZKC-A	521963	346417	429254
1258	6	ZAN-C	599375	600133	758
1259	3	ZNY-C	311092	314113	3021
1259	3	ZKC-B	339801	342759	2958
1259	4	ZMP-C	428119	435593	7474
1259	5	ZSU-A	468017	483148	15131

NSTB Week	GPS Day	Site	Start Time (GPS Seconds)	End Time (GPS Seconds)	Duration (Seconds)
1259	5	ZLC-C	496069	497776	1707
1259	5	ZLC-B	498592	506472	7880
1259	5	JNU-C	499289	502022	2733
1259	6	ZSE-A	523753	526779	3026
1259	6	HNL-A	548878	550474	1596
1260	3	ZDC-C	314266	321242	6976
1261	2	JNU-A	236453	239279	2826
1261	2	JNU-B	237655	255270	17615
1261	3	JNU-A	260457	321917	61460
1261	3	HNL-A	317656	320454	2798
1261	3	ZHU-A	318180	508812	190632
1261	3	ZOA-C	334581	347262	12681
1261	3	ZDC-B	*	*	*
1261	5	JNU-A	443428	446139	2711
1261	5	JNU-B	443439	463900	20461
1261	5	ZJX-B	507244	510779	3535
1261	6	ZME-C	542995	547111	4116
1262	0	ZJX-A	55309	60631	5322
1262	1	ZNY-C	115668	119452	3784
1262	2	HNL-C	220781	220927	146
1262	2	ZJX-C	222525	223827	1302
1262	2	ZAU-B	235887	239378	3491
1262	3	ZAU-C	279880	309765	29885
1262	3	ZAU-A	303130	306557	3427
1262	3	ZBW-C	310446	311859	1413
1262	3	ZBW-C	314538	323836	9298
1262	3	BIL-A	543947	262968	885779
1262	4	ZLA-A	383311	387478	4167
1262	5	ZHU-C	498523	501529	3006
1262	6	ZFW-C	527787	531080	3293
1263	0	ZDC-A	69113	71474	2361
1263	1	ZNY-C	145393	151963	6570
1263	1	ZOA-C	147419	152024	4605
1263	3	ZLC-C	336343	344377	8034
1263	3	ZNY-A	341384	346246	4862
1263	4	ZNY-B	397212	400260	3048
1263	4	CDB-B	401257	404450	3193
1263	4	ZNY-C	412979	418418	5439
1263	4	ZNY-B	414839	418118	3279
1263	5	ZFW-B	465741	468613	2872
1263	5	ZOA-C	482978	485569	2591
1263	5	ZMA-A	494398	497359	2961

NSTB Week	GPS Day	Site	Start Time (GPS Seconds)	End Time (GPS Seconds)	Duration (Seconds)
1263	6	ZMA-B	525832	528798	2966
1263	6	CDB-A	539820	10298	75278
1263	6	ZFW-A	597604	601053	3449
1263	6	ZAN-C	598279	601031	2752
1264	0	ZDV-C	76327	79483	3156
1264	1	ZDV-A	95342	98813	3471
1264	1	ZKC-A	149549	156811	7262
1264	1	ZMA-C	149985	153582	3597
1264	2	ZAN-A	197598	200534	2936
1264	2	ZAN-B	242283	245771	3488
1264	2	ZBW-C	242532	245073	2541
1264	3	ZLA-B	279983	283412	3429
1264	3	BIL-A	292762	295622	2860

* - There was a WEI outage for the Technical Center for these days. No times for the outages are available for these days.

Table 12-3 O&M Outages from January 1, 2004 to March 31, 2004

NSTB Week	GPS Day	Site	Start Time (GPS Seconds)	End Time (GPS Seconds)	Duration (Seconds)
1252	1	POCC	119460	123637	4177
1255	5	NOCC	481991	483259	1268
1260	3	POCC	261165	268734	7569
1260	3	NOCC	311921	320741	8820
1264	2	POCC	192932	199955	7023

Table 12-4 C&V Outages from January 1, 2004 to March 31, 2004

NSTB Week	GPS Day	Site	Start Time (GPS Seconds)	End Time (GPS Seconds)	Duration (Seconds)
1253	4	ZLA-CP1	376608	380271	3663
1260	2	ZLA-CP1	248574	253803	5229
1260	2	ZLA-CP2	248574	253803	5229
1260	3	ZLA-CP1	261907	273171	11264
1260	3	ZLA-CP1	320437	322215	1778
1260	3	ZLA-CP1	324304	344339	20035

13.0 GPS Broadcast Orbit vs. IGS Precise Orbits Analysis

As part of the WAAS off-line monitoring process, the accuracy of the GPS broadcast ephemeris is periodically compared to the IGS precise orbit information to monitor the validity of an a priori assumption concerning the accuracy of the GPS broadcast ephemeris information that is part of a brute force computer simulation analysis utilized as part of the safety proof of the WAAS MT-28 functionality. That brute force analysis searches a simulated error sphere around a GPS satellite for a worst case projection of post correction ephemeris error to any user. A pessimistic extrapolation of historical data was used as an a priori to limit the radius of the searched sphere to a finite distance. This periodic off-line monitoring verifies that the original logic of the a priori assumption remains sound. The assumption being validated is:

Height Error:	+/- 15 meters,
Along Track Error:	+/- 65 meters,
Cross Track Error:	+/- 30 meters.

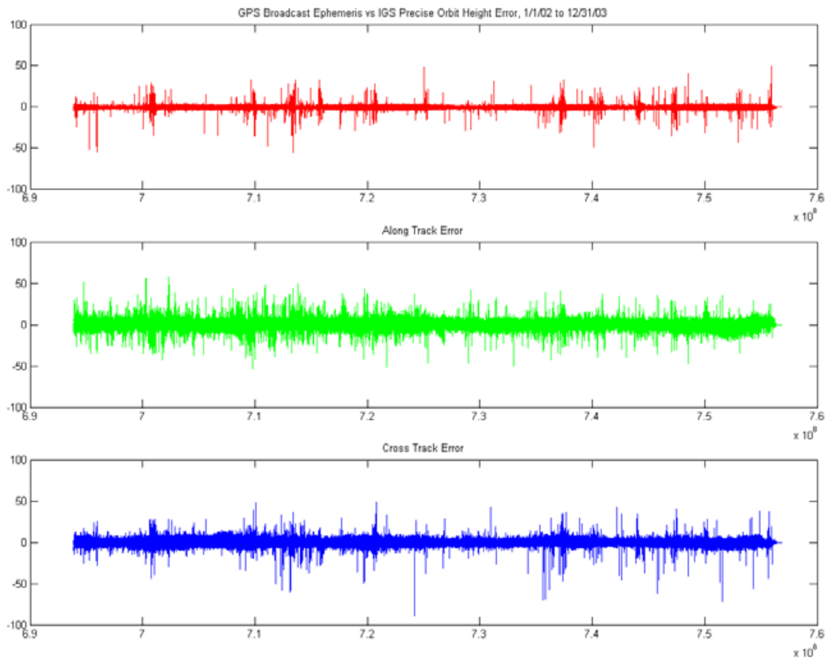
24 hour global GPB broadcast ephemeris information files and IGS precise orbit files are downloaded from the National Geodetic Survey (NGS). GPS satellite positions are computed every 15 minutes and differenced with the precise orbits. The resulting error information is then segregated into the Height, Along Track, Cross Track (HAC) error data. The standard deviation of the error is then computed for each dimension for each satellite. The assumption if valid if a 5.33 scaling of the standard deviation across all satellites is within the a priori. Only data points where GPS is healthy and valid IGS data is available are considered.

Two years of data from 1/1/02 to 12/31/03 (GPS week 1147 day 2 to week 1251 day 3) is presented. Figure 13-1 is a plot of the standard deviations. The worst case standard deviations meet the criteria (PRN 6 Height, PRN 17 Along Track, PRN 6 Cross Track), therefore the assumption is validated.

Figure 13-2 is provided for information. It contains a plot of the errors versus time for all satellites. The occasional "spikiness" is the result of missing data problems in the NGS broadcast ephemeris files which results in the prior ephemeris being utilized longer than would actually have been observed. For this analysis, a time window of 4 hours from the time of ephemeris was allowed. The NGS broadcast files contain a fair number of "false lock" ephemeris records that result in astronomical errors and what appear to be occasional bit errors. In particular, records repeated 16 seconds later with only the time of ephemeris changed by 16 seconds were a particular problem. These errors have been removed by a validation screen that requires consensus agreement across all the records for a particular PRN for that day and enforces the IODE and IODC update rules.

Figure 13-1 Standard Deviations for Height, Along Track, and Cross Track

Figure 13-2 Broadcast vs. Precise Orbit Errors – All Satellites



Appendix A: Glossary

General Terms and Definitions

Alert. An alert is an indication provided by the GPS/WAAS equipment to inform the user when the positioning performance achieved by the equipment does not meet the integrity requirements.

APV-ILNAV/VNAV. APV-I is a WAAS operational service level with an HAL equal to 556 meters and a VAL equal to 50 meters.

Availability. The availability of a navigation system is the ability of the system to provide the required function and performance at the initiation of the intended operation. Availability is an indication of the ability of the system to provide usable service within the specified coverage area.

AVP-II. APV-II is a WAAS operational service level with an HAL equal to 40 meters and a VAL equal to 20 meters.

CONUS. Continental United States.

Continuity. The continuity of a system is the ability of the total system (comprising all elements necessary to maintain aircraft position within the defined airspace) to perform its function without interruption during the intended operation. More specifically, continuity is the probability that the specified system performance will be maintained for the duration of a phase of operation, presuming that the system was available at the beginning of that phase of operation.

Coverage. The coverage provided by a radio navigation system is that surface area or space volume in which the signals are adequate to permit the user to determine position to a specified level of accuracy. Coverage is influenced by system geometry, signal power levels, receiver sensitivity, atmospheric noise conditions, and other factors that affect signal availability.

Dilution of Precision (DOP). The magnifying effect on GPS position error induced by mapping GPS ranging errors into position through the position solution. The DOP may be represented in any user local coordinate desired. Examples are HDOP for local horizontal, VDOP for local vertical, PDOP for all three coordinates, and TDOP for time.

Fault Detection and Exclusion (FDE). Fault detection and exclusion is a receiver processing scheme that autonomously provides integrity monitoring for the position solution, using redundant range measurements. The FDE consists of two distinct parts: fault detection and fault exclusion. The fault detection part detects the presence of an unacceptably large position error for a given mode of flight. Upon the detection, fault exclusion follows and excludes the source of the unacceptably large position error, thereby allowing navigation to return to normal performance without an interruption in service.

GEO. Geostationary Satellite.

Global Positioning System (GPS). A space-based positioning, velocity, and time system composed of space, control, and user segments. The space segment, when fully operational, will be composed of 24 satellites in six orbital planes. The control segment consists of five monitor stations, three ground antennas, and a master control station. The user segment consists of antennas and receiver-processors that provide positioning, velocity, and precise timing to the user.

GLS. GLS is a WAAS operational service level with HAL equal to 40 meters and VAL equal to 12 meters.

Grid Ionospheric Vertical Error (GIVE). GIVEs indicate the accuracy of ionospheric vertical delay correction at a geographically defined ionospheric grid point (IGP). WAAS transmits one GIVE for each IGP in the mask.

Hazardous Misleading Information (HMI). Hazardous misleading information is any position data, that is output, that has an error larger than the current protection level (HPL/VPL), without any indication of the error (e.g., alert message sequence).

Horizontal Alert Limit (HAL). The Horizontal Alert Limit (HAL) is the radius of a circle in the horizontal plane (the local plane tangent to the WGS-84 ellipsoid), with its center being at the true position, which describes the region that is required to contain the indicated horizontal position with a probability of $1\text{-}10^{-7}$ per flight hour, for a particular navigation mode, assuming the probability of a GPS satellite integrity failure being included in the position solution is less than or equal to 10^{-4} per hour.

Horizontal Protection Level (HPL). The Horizontal Protection Level is the radius of a circle in the horizontal plane (the plane tangent to the WGS-84 ellipsoid), with its center being at the true position, which describes the region that is assured to contain the indicated horizontal position. It is based upon the error estimates provided by WAAS.

Ionospheric Grid Point (IGP). IGP is a geographically defined point for which the WAAS provides the vertical ionospheric delay.

LNAV. Lateral Navigation.

MOPS. Minimum Operational Performance Standards.

Navigation Message. Message structure designed to carry navigation data.

Non-Precision Approach (NPA) Navigation Mode. The Non-Precision Approach navigation mode refers to the navigation solution operating with a minimum of four satellites with fast and long term WAAS corrections (no WAAS ionospheric corrections) available.

Position Solution. The use of ranging signal measurements and navigation data from at least four satellites to solve for three position coordinates and a time offset.

Precision Approach (PA) Navigation Mode. The Precision Approach navigation mode refers to the navigation solution operating with a minimum of four satellites with all WAAS corrections (fast, long term, and ionospheric) available.

Selective Availability. Protection technique employed by the DOD to deny full system accuracy to unauthorized users.

Standard Positioning Service (SPS). Three-dimensional position and time determination capability provided to a user equipped with a minimum capability GPS SPS receiver in accordance with GPS national policy and the performance specifications.

SV. Satellite Vehicle.

User Differential Range Error (UDRE). UDRE's indicate the accuracy of combined fast and slow error corrections. WAAS transmits one UDRE for each satellite in the mask.

Vertical Alert Limit (VAL). The Vertical Alert Limit is half the length of a segment on the vertical axis (perpendicular to the horizontal plane of WGS-84 ellipsoid), with its center being at the true position, which describes the region that is required to contain the indicated vertical position with a probability of $1\text{-}10^{-7}$ per flight hour, for a particular navigation mode, assuming the probability of a GPS satellite integrity failure being included in the position solution is less than or equal to 10^{-4} per hour.

Vertical Protection Level (VPL). The Vertical Protection Level is half the length of a segment on the vertical axis (perpendicular to the horizontal plane of WGS-84 ellipsoid), with its center being at the true position, which describes the region that is assured to contain the indicated vertical position. It is based upon the error estimates provided by WAAS.

VNAV. Vertical Navigation.

Wide Area Augmentation System (WAAS). The WAAS is made up of an integrity reference monitoring network, processing facilities, geostationary satellites, and control facilities. Wide area reference stations and integrity monitors are widely dispersed data collection sites that contain GPS/WAAS ranging receivers that monitor all signals from the GPS, as well as the WAAS geostationary satellites. The reference stations collect measurements from the GPS and WAAS satellites so that differential corrections, ionospheric delay information, GPS/WAAS accuracy, WAAS network time, GPS time, and UTC can be determined. The wide area reference station and integrity monitor data are forwarded to the central data processing sites. These sites process the data in order to determine differential corrections, ionospheric delay information, and GPS/WAAS accuracy, as well as verify residual error bounds for each monitored satellite. The central data processing sites also generate navigation messages for the geostationary satellites and WAAS messages. This information is modulated on the GPS-like signal and broadcast to the users from geostationary satellites.