WIDE-AREA AUGMENTATION SYSTEM PERFORMANCE ANALYSIS REPORT

Report #13

Reporting Period: April 1 to June 30, 2005

July 2005

FAA/William J. Hughes Technical Center
NSTB/WAAS T&E Team
Atlantic City International Airport, NJ 08405

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 thirteenth such WAAS quarterly report. This report covers WAAS performance during the period from April 1, 2005 to June 30, 2005.

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, 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	Los Angeles 1.131 meters	Kansas City 0.694 meters
95% Vertical Accuracy	Oakland 1.787 meters	Kansas City 1.018 meters
LPV Availability (HPL < 40 meters & VPL < 50 meters)	Dallas 99.93%	Boston 97.05%
95% HPL	Grand Forks 29.684 meters	Atlanta 16.79 meters
95% VPL	Boston 45.529 meters	Kansas City 28.263 meters

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

APPENDIX

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 April 1, 2005 to June 30, 2005.

Table 1-1 PA Sites

	Number of Days Evaluated	Number of Samples
NSTB:		
Anderson	54	4641662
Atlantic City	93	8017919
Grand Forks	80	6923772
Greenwood	78	6732226
San Angelo	90	7801330
WAAS:		
Albuquerque	92	7939072
Atlanta	91	7847536
Billings	92	7940716
Boston	92	7931145
Chicago	89	7683251
Cleveland	90	7749228
Dallas	92	7939604
Denver	92	7940475
Houston	92	7940983
Jacksonville	92	7941661
Kansas City	92	7938818
Los Angeles	92	7933829
Memphis	78	6703836
Miami	92	7935069
Minneapolis	92	7907354
New York	92	7924726
Oakland	92	7939934
Salt Lake City	92	7938125
Seattle	92	7935077
Washington DC	92	7939238

Table 1-2 NPA Sites

Location	Number of Days Evaluated	Number of Samples
Bangor	85	7354866
Mauna Loa	85	7361867
Fairbanks	0	0
Bethel	0	0
Kotzebue	85	7373612
Albuquerque	92	7919701
Anchorage	84	7283991
Atlanta	91	7830510
Billings	92	7920610
Boston	85	7372496
Cleveland	90	7781190
Cold Bay	89	7666376
Honolulu	89	7708699
Houston	92	7922727
Juneau	92	7908397
Kansas City	85	7371116
Los Angeles	92	7920249
Miami	92	7921498
Minneapolis	91	7904418
Oakland	92	7923325
Salt Lake City	92	7920137
San Juan	89	7716058
Seattle	92	7920166
Washington DC	92	7924810

The report is divided in the performance categories listed below. This report also includes WAAS LPV Service Availability at Selected Airports, and WAAS Deterministic Code Noise and Multipath (CNMP) Bounding Analysis.

1. WAAS Position Accuracy
2. WAAS Operational Service Availability
3. Coverage
4. Integrity
5. WAAS Range Domain Accuracy
6. 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
LPV and LNAV/VNAV Outages and outage rate	Not Defined for Current WAAS phase
LNAV Outages and outage rates	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
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

GPS Week	Date	Sites	Events
1316 day 3	3/30/05	All WAAS Sites	WEI was switched from Ring 1 to Ring 2.
1316 day 6	4/2/05	All POR Sites	POR Signal in Space outage.
1316 day 6 to 1317 day 3	4/2/05/ to 4/6/05	All	WAAS solution broadcasts were inconsistent; issue apparent on both GEOs. LPV and LNAV/VNAV service availability were affected.
1317 day 2	4/5/05	Most of Northern CONUS	Ionospheric storm. Max Kp index = 7.
1317 day 3 to 1319 day 3	4/6/05 to 4/20/05	Memphis	Memphis outage.
1317 day 6 to 1321 day 3	4/9/05 to 5/4/05	Anderson	Anderson outage.
1319 day 2 to 1319 day 4	4/19/05 to 4/21/05	Chicago	Chicago outage.
1319 day 3	4/20/05	All WAAS Sites	WEI outage.
1319 day 5 to 1320 day 2	4/22/05/ to 4/26/05	Grand Forks	Grand Forks outage.
1320 day 5	4/29/05	All WAAS Sites	WEI outage.
1322 day 0	5/8/05	All WAAS Sites	WEI outage.
1322 day 0	5/8/05	NW CONUS Sites	Ionospheric storm. Max Kp index = 7. Loss of 95% LPV Coverage, NW CONUS.
1322 day 3 to 1324 day 3	5/11/05 to 5/25/05	Greenwood	Greenwood outage.
1322 day 4 to 1324 day 2	5/12/05 to 5/24/05	Anderson	Anderson outage.
1322 day 6 to 1325 day 2	5/14/05 to 5/31/05	Several Eastern and Central CONUS Sites	PRN 27 unscheduled outage. See NANUs 2005088, 2005089. Localized loss of 99% availability caused by PRN 27 being set to 'Do Not Use'.
1323 day 1	5/16/05	All WAAS Sites	WEI outage.
1324 day 2	5/24/05	All WAAS Sites	WEI outages.
1327 day 0	6/12/05	Many Northern CONUS Sites	Ionospheric storm. Max Kp index = 6.
1327 day 4	6/16/05	Several Central CONUS Sites	PRN 2 outage caused partial loss of PA Coverage at 99% Availability in Central CONUS.
1329 day 0	6/26/05	All POR Sites	POR Signal in Space outage.
1328 day 2 to 1329 day 0	6/21/05 to 6/26/05	Grand Forks	Grand Forks 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. The number of outages and outage rate for each site is reported.

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 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 6 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 7 provides the GEO ranging performance for AORW and POR.

Section 8 summarizes WAAS anomalies and problems identified during the reporting period, which adversely affect WAAS performance described in Table 1.3.

Section 9 provides WAAS LPV availability and outages at selected airports.

Section 10 provides the assessment of WAAS CNMP bounding for 75 WAAS receivers.

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 (i.e. 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 2 meters for both WAAS operational service levels. The maximum 95% horizontal and vertical LPV errors are 1.131 meters at Los Angeles and 1.787 meters at Oakland. The minimum 95% horizontal and vertical LPV errors are 0.694 meters and 1.018 meters, both at Kansas City. The maximum 95% and 99.999% NPA horizontal errors are 3.902 meters at Mauna Loa.and 10.969 meters at Honolulu, respectively. The minimum 95% and 99.999% horizontal errors are 1.394 meters at Kansas City and 4.149 meters at Juneau, respectively.

Table 2.4 shows the maximum horizontal and vertical position errors while the calculated HPL and VPL met the LPV service levels. The column marked ‘Horizontal (or Vertical) Error/HPL (or VPL)’ is the ratio of position error to protection level at the time the maximum error occurred. The column marked ‘Horizontal (or Vertical) Maximum Ratio’ is the maximum position error to protection level ratio for the quarter.

Figures 2.6 to 2.15 show the distributions of the vertical and horizontal errors in triangle charts and 2-D histogram plots for the quarter at three locations, Kansas 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 GLS/APV2/LPV (HAL=40m) (Meters)	Horizontal APV-1(LNAV) (HAL=556m) (Meters)	Vertical LPV/VNAV (VAL=50m) (Meters)	Percentage in PA mode (%)	SPS Accuracy	
					95% Horizontal (Meters)	95% Vertical (Meters)
Anderson	0.761	0.762	1.237	99.990456	*	*
Atlantic City	0.856	0.859	1.287	99.990845	*	*
Grand Forks	0.859	0.870	1.436	99.983421	*	*
Greenwood	0.731	0.731	1.229	99.987030	*	*
San Angelo	0.827	0.829	1.369	99.990730	*	*
Albuquerque	0.705	0.705	1.227	99.987633	2.842	5.326
Atlanta	0.734	0.735	1.192	99.990913	2.980	5.842
Billings	0.765	0.769	1.240	99.987450	2.640	5.008
Boston	0.939	0.943	1.436	99.990753	2.755	5.057
Chicago	0.704	0.707	1.135	99.991776	*	*
Cleveland	0.923	0.927	1.247	99.990723	2.826	5.371
Dallas	1.124	1.124	1.504	99.989304	*	*
Denver	0.774	0.776	1.368	99.987381	*	*
Houston	0.784	0.784	1.156	99.988945	3.230	5.489
Jacksonville	0.970	0.970	1.309	99.990845	*	*
Kansas City	0.694	0.695	1.018	99.986145	2.826	5.491
Los Angeles	1.131	1.131	1.730	99.998283	3.142	5.842
Memphis	0.736	0.736	1.209	99.990723	*	*
Miami	0.840	0.842	1.510	99.990837	3.500	5.582
Minneapolis	1.120	1.124	1.765	99.985382	2.662	4.893
New York	0.885	0.889	1.209	99.990738	*	*
Oakland	0.828	0.828	1.787	99.998459	2.912	5.761
Salt Lake City	0.717	0.719	1.447	99.995178	2.680	5.395
Seattle	0.848	0.850	1.646	99.997139	2.629	5.139
Washington DC	0.787	0.789	1.094	99.990906	2.817	5.632

* 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
Bangor	2.113	7.605	99.962	8.421
Mauna Loa	3.902	9.480	99.962	11.117
Fairbanks	-	-	-	-
Bethel	-	-	-	-
Kotzebue	2.133	5.330	99.961	14.225
Albuquerque	1.556	4.927	99.983	8.492
Anchorage	1.762	4.325	99.931	10.104
Atlanta	1.501	4.803	99.985	5.029
Billings	1.433	6.295	99.984	6.560
Boston	1.748	6.277	99.994	6.585
Cleveland	1.538	6.580	99.983	16.147
Cold Bay	1.507	4.939	99.934	10.521
Honolulu	3.451	10.969	99.933	11.870
Houston	2.088	6.872	99.983	12.497
Juneau	1.708	4.149	99.903	9.049
Kansas City	1.394	4.423	99.994	4.710
Los Angeles	2.108	5.556	99.993	14.619
Miami	2.009	4.736	99.983	13.548
Minneapolis	1.849	5.966	99.984	6.440
Oakland	1.611	4.584	99.993	16.147
Salt Lake City	1.466	4.377	99.993	5.943
San Juan	2.419	7.157	99.989	7.610
Seattle	1.686	4.946	99.992	6.333
Washington DC	1.531	5.250	99.983	6.430

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

Location	Horizontal Error (m)	Horizontal Error/HPL	Horizontal Maximum Ratio	Vertical Error (m)	Vertical Error/VPL	Vertical Maximum Ratio
Anderson	3.257	0.082	0.179	4.944	0.167	0.167
Atlantic City	5.235	0.203	0.203	6.891	0.175	0.201
Grand Forks	5.605	0.212	0.237	14.208	0.520	0.520
Greenwood	3.520	0.137	0.162	4.959	0.221	0.221
San Angelo	2.438	0.133	0.133	5.670	0.123	0.140
Albuquerque	2.405	0.174	0.174	4.947	0.119	0.189
Atlanta	3.180	0.193	0.193	5.441	0.146	0.183
Billings	5.262	0.139	0.271	5.005	0.151	0.216
Boston	4.626	0.283	0.283	7.614	0.170	0.254
Chicago	3.309	0.178	0.180	6.456	0.193	0.195
Cleveland	11.962	0.981	0.981	6.950	0.258	0.301
Dallas	5.459	0.322	0.324	9.457	0.333	0.333
Denver	5.778	0.154	0.190	5.494	0.246	0.246
Houston	2.277	0.058	0.120	6.851	0.262	0.263
Jacksonville	2.649	0.096	0.151	5.751	0.116	0.138
Kansas City	2.414	0.078	0.153	4.840	0.105	0.176
Los Angeles	3.050	0.101	0.147	5.828	0.144	0.170
Memphis	3.049	0.136	0.206	5.407	0.210	0.210
Miami	2.803	0.125	0.178	10.503	0.282	0.282
Minneapolis	4.858	0.178	0.217	12.756	0.285	0.285
New York	3.566	0.102	0.176	9.823	0.325	0.325
Oakland	3.070	0.084	0.110	7.628	0.204	0.222
Salt Lake City	3.717	0.094	0.198	6.111	0.173	0.187
Seattle	5.012	0.129	0.195	6.892	0.170	0.254
Washington DC	2.650	0.087	0.169	7.462	0.159	0.159

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

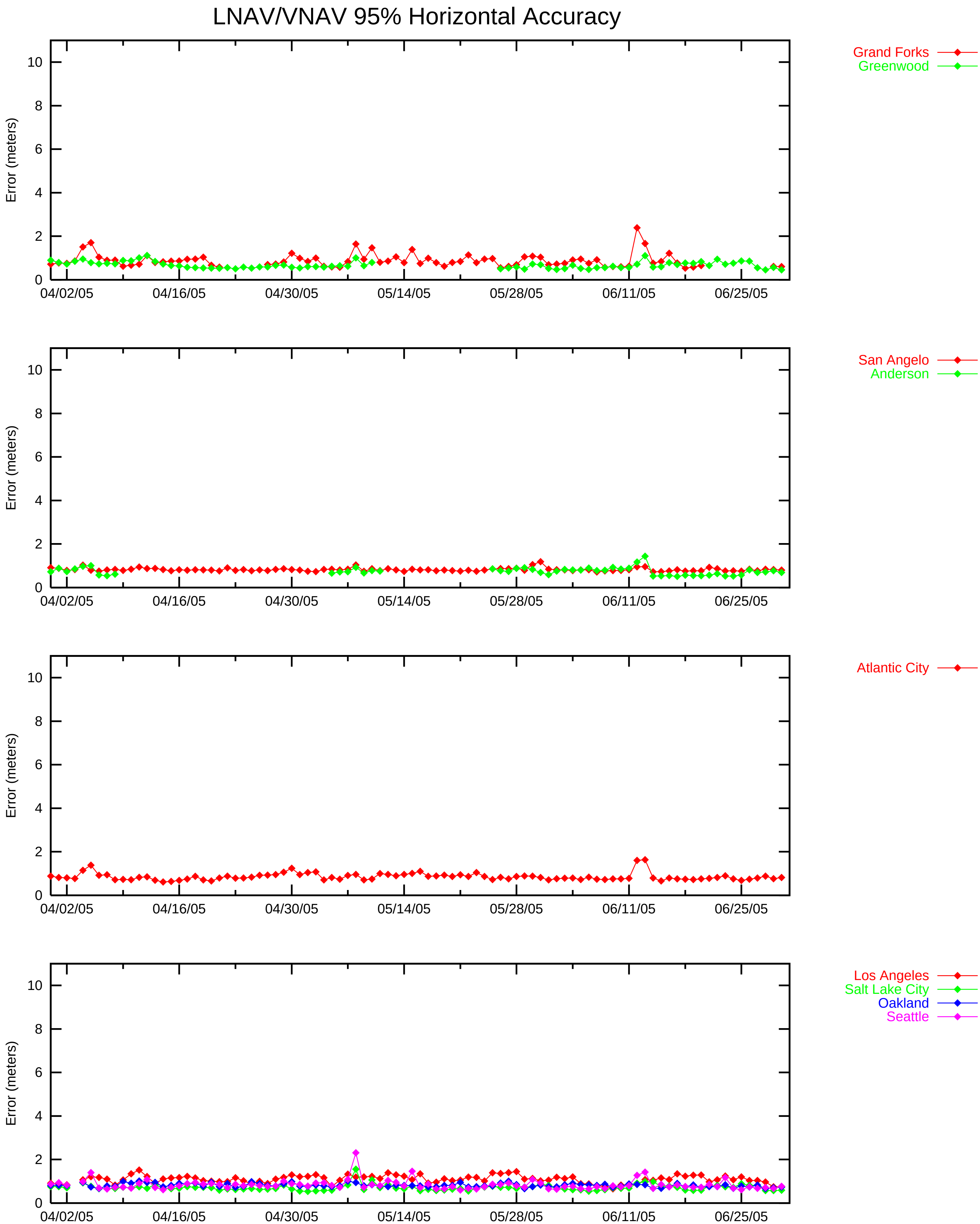


Figure 2_2 95% Horizontal Accuracy at LNAV/VNAV

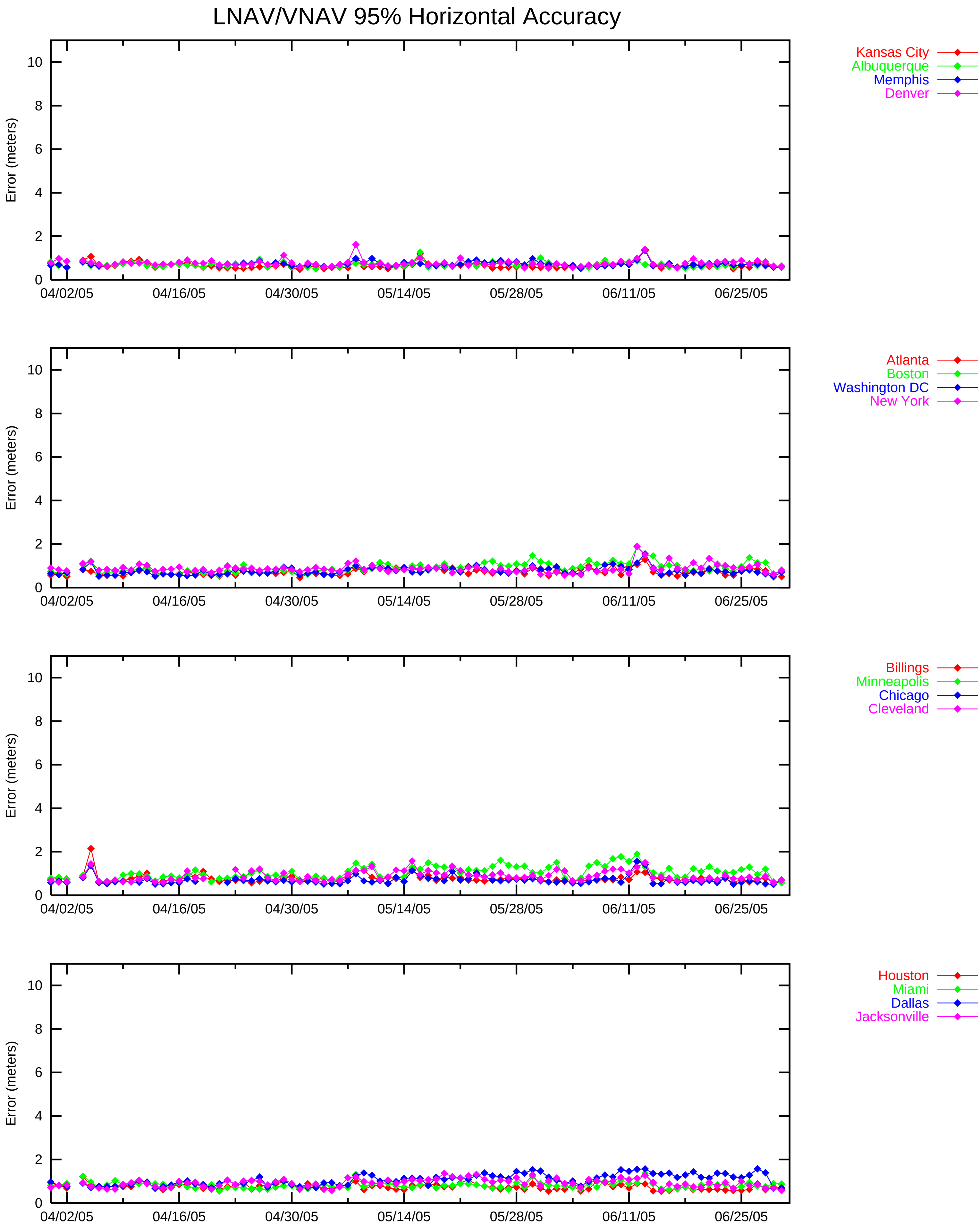


Figure 2_3 95% Vertical Accuracy at LNAV/VNAV

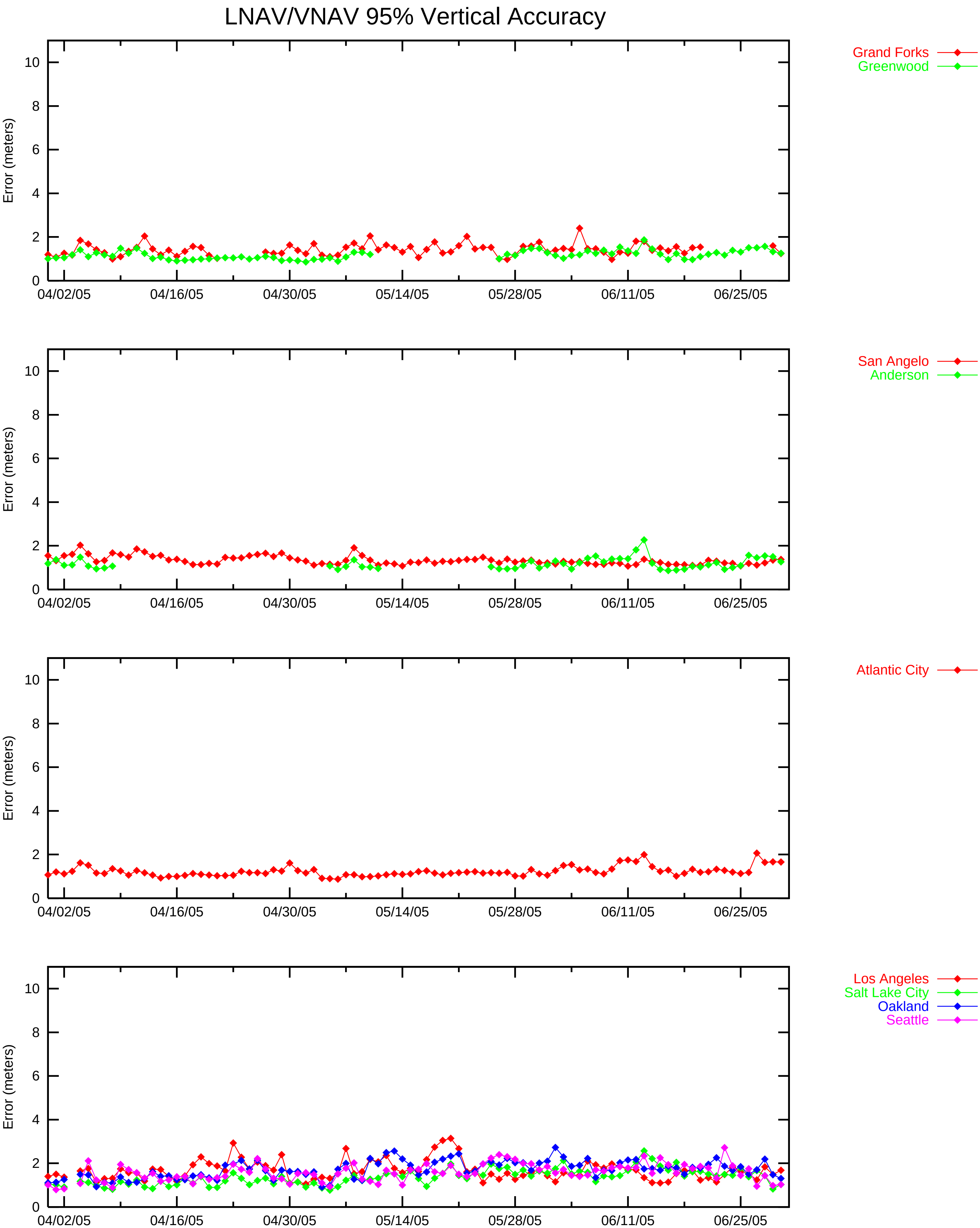


Figure 2_4 95% Vertical Accuracy at LNAV/VNAV

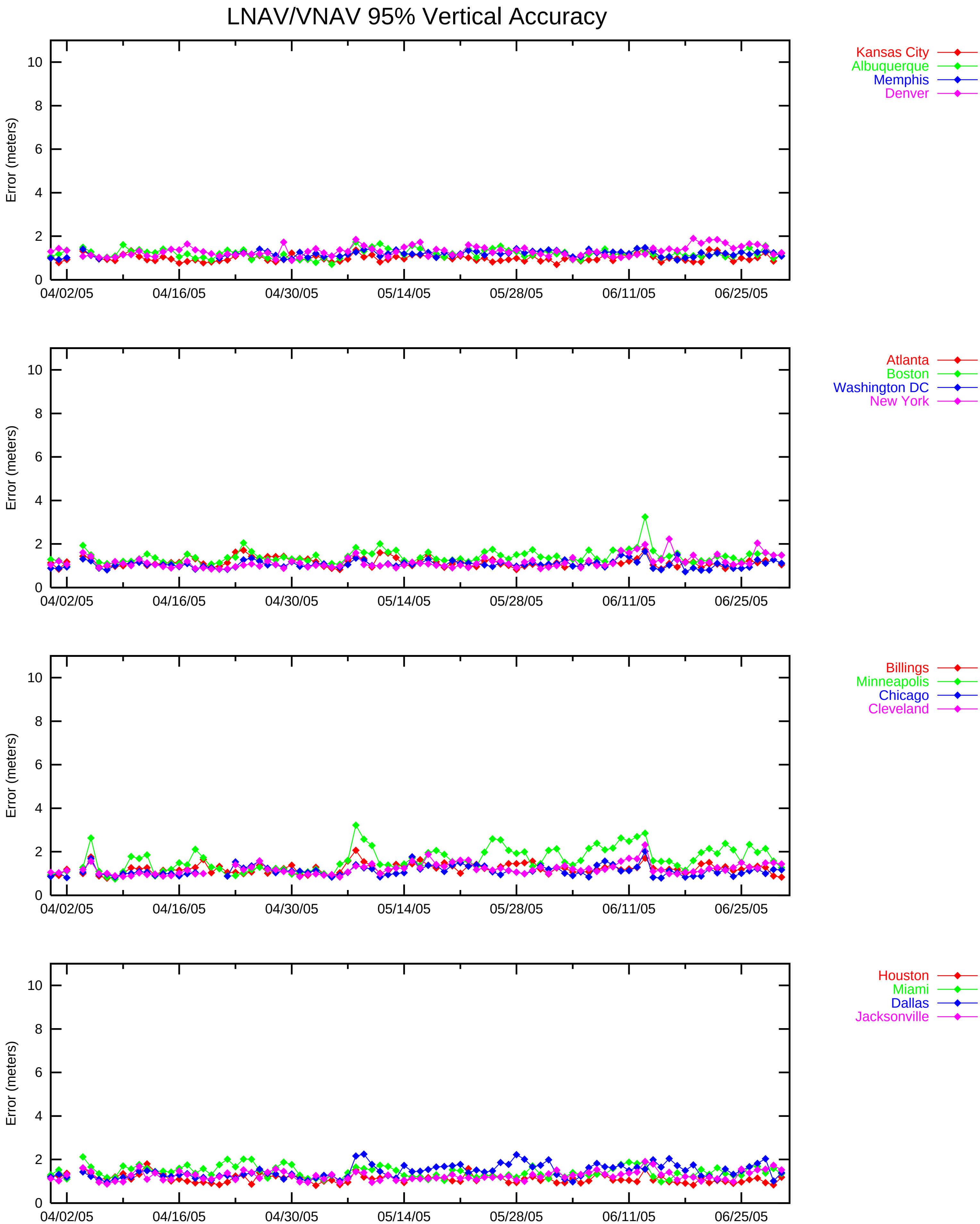
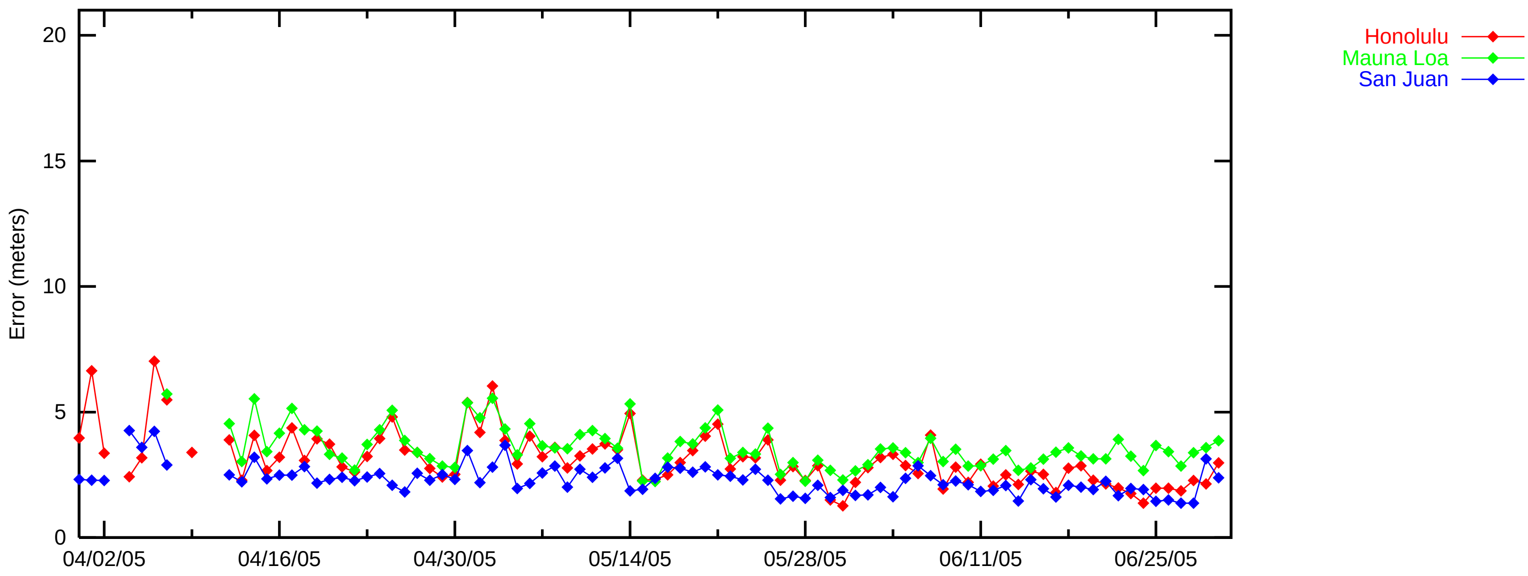
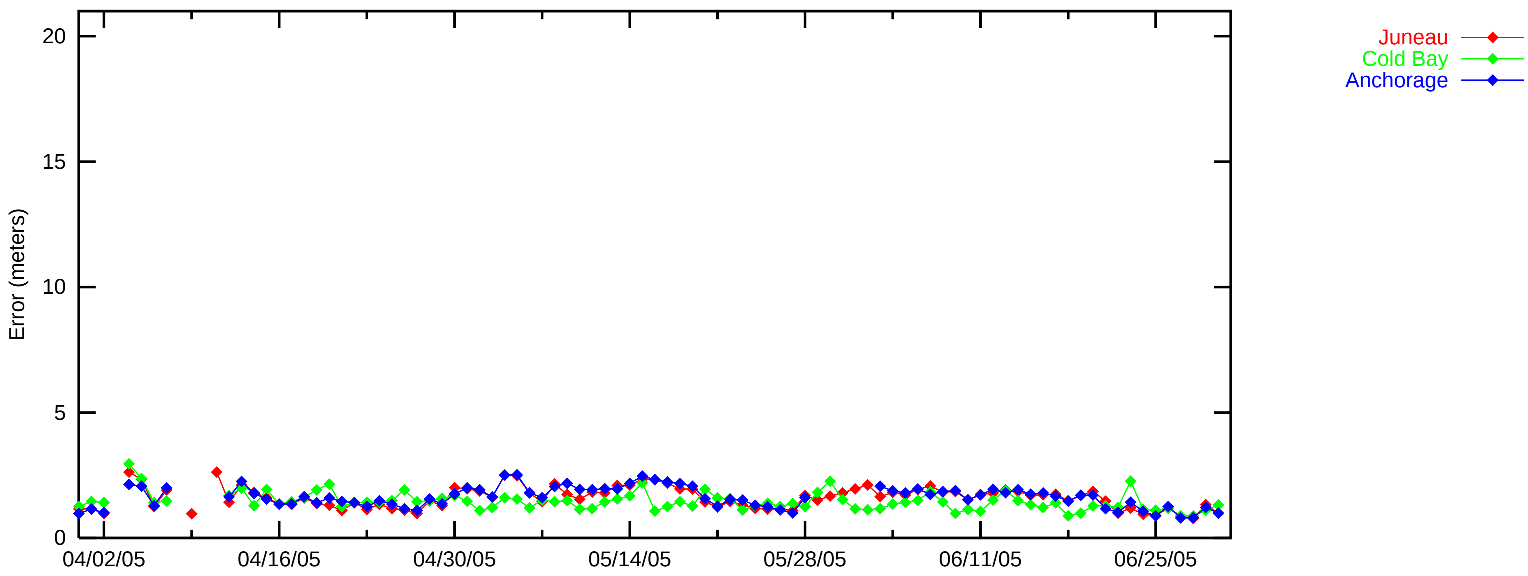


Figure 2-5 NPA 95% Horizontal Accuracy





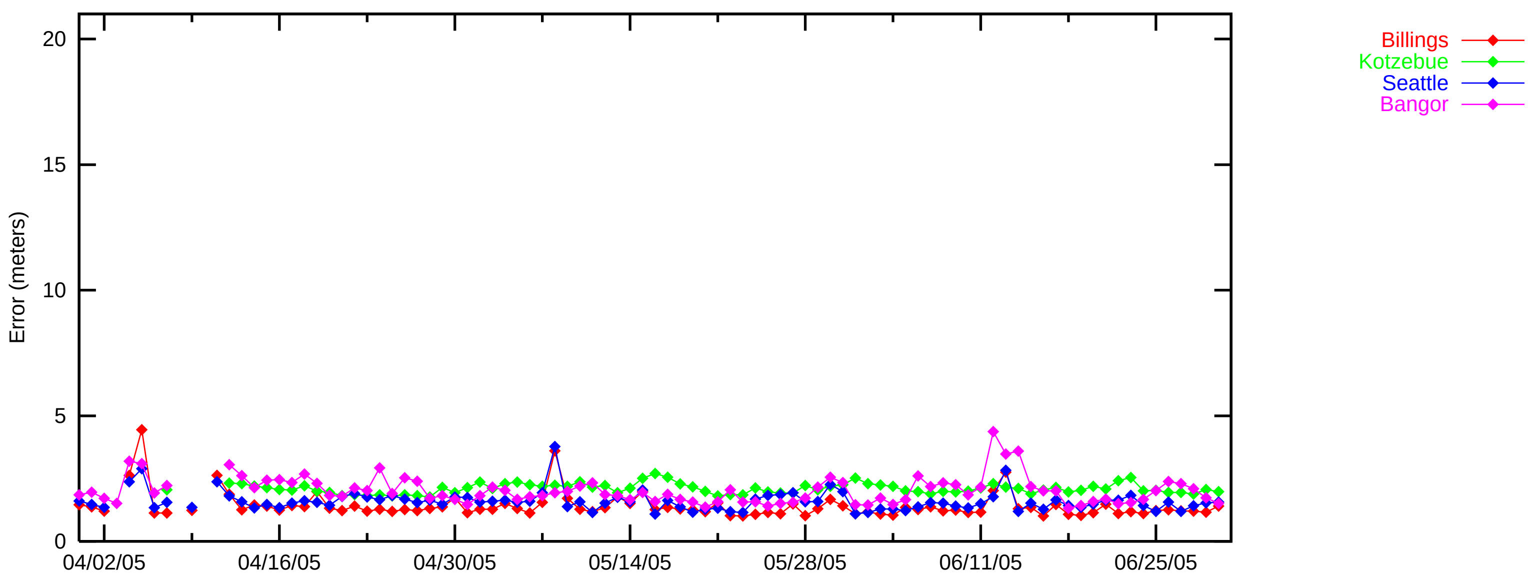


Figure 2-6 NPA 95% Horizontal Accuracy

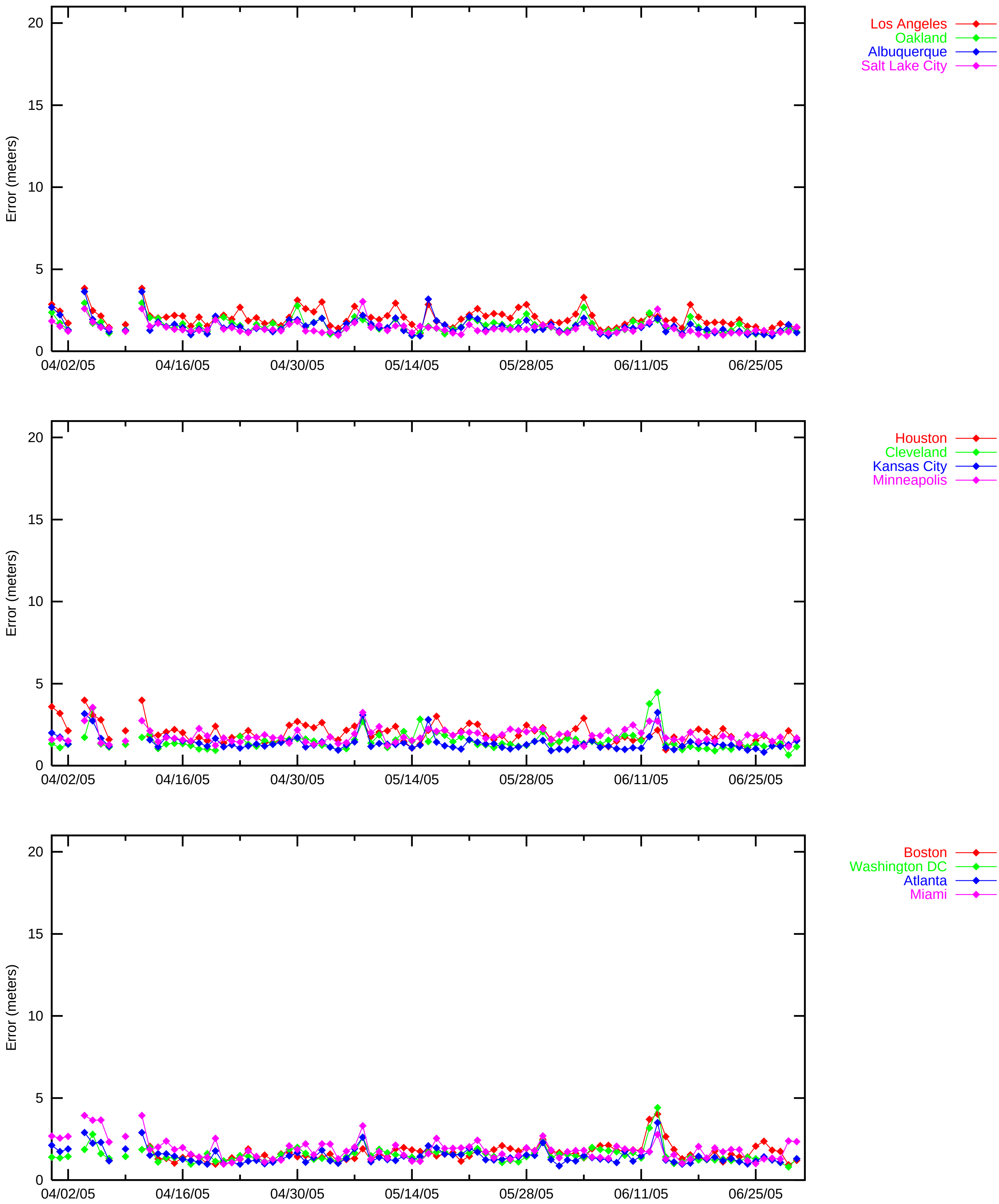


Figure 2-7 Horizontal Triangle Chart for Kansas City

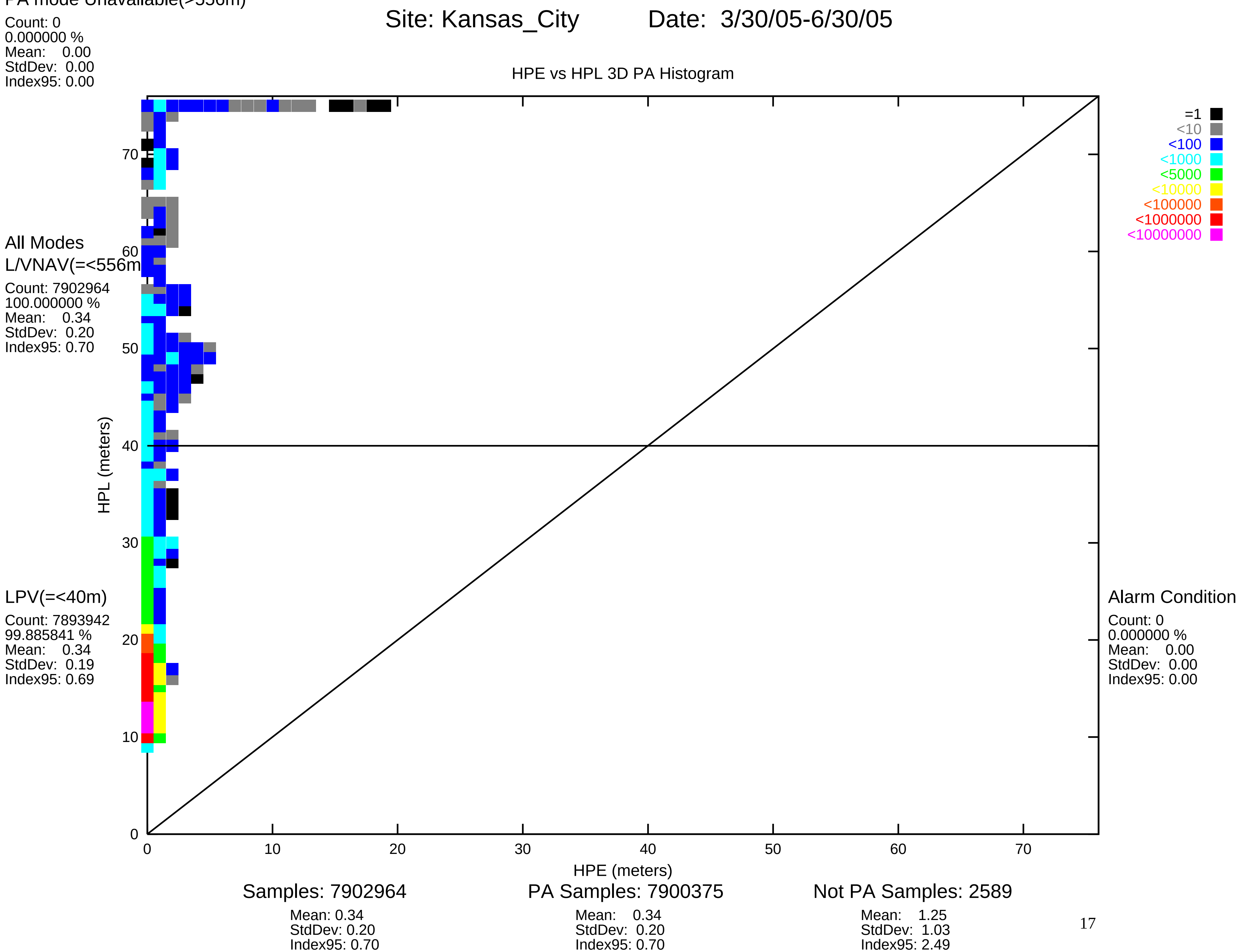


Figure 2-8 Vertical Triangle Chart for Kansas City

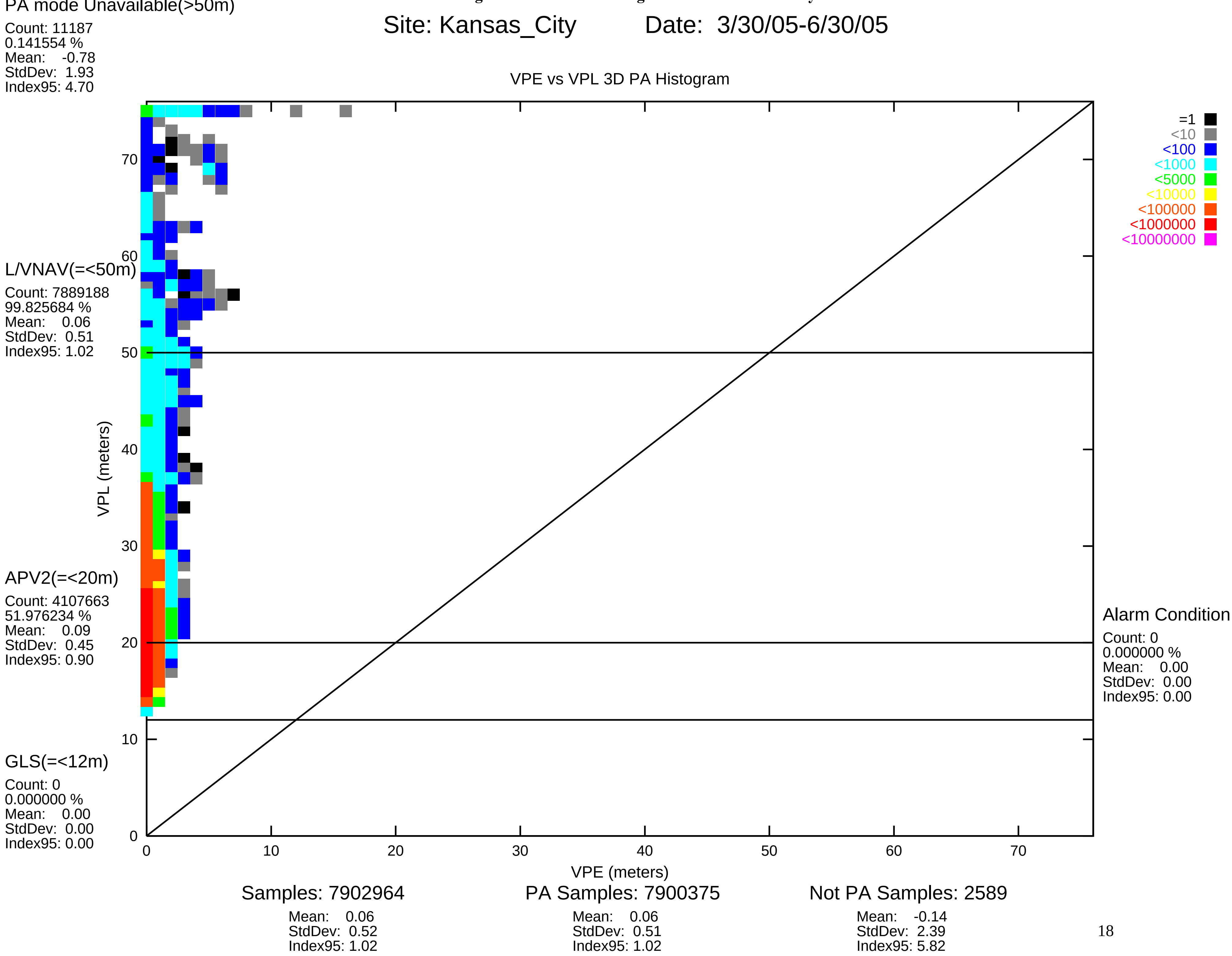


Figure 2-9 2-D Histogram for Kansas City

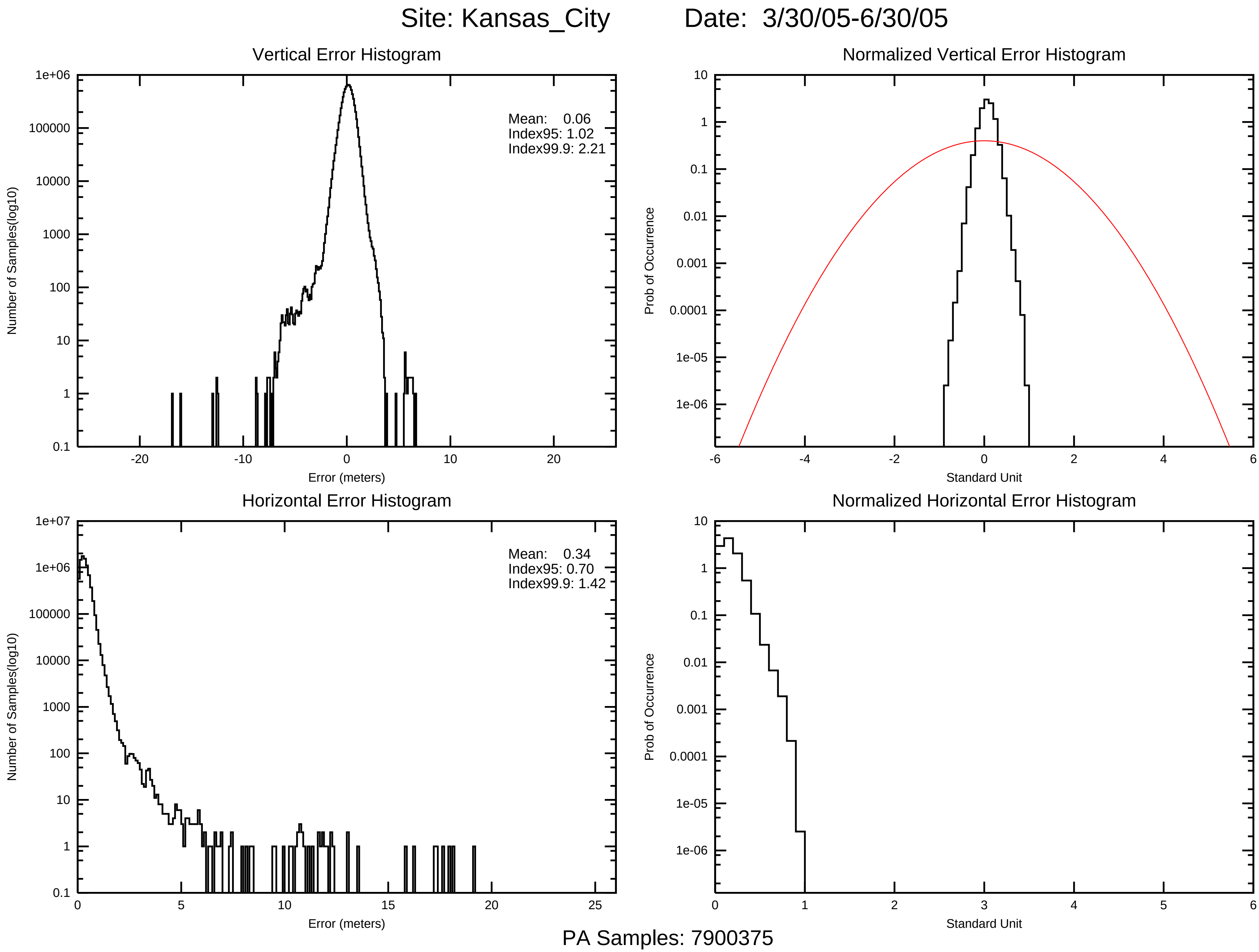


Figure 2-10 Horizontal Triangle Chart for Washington, DC

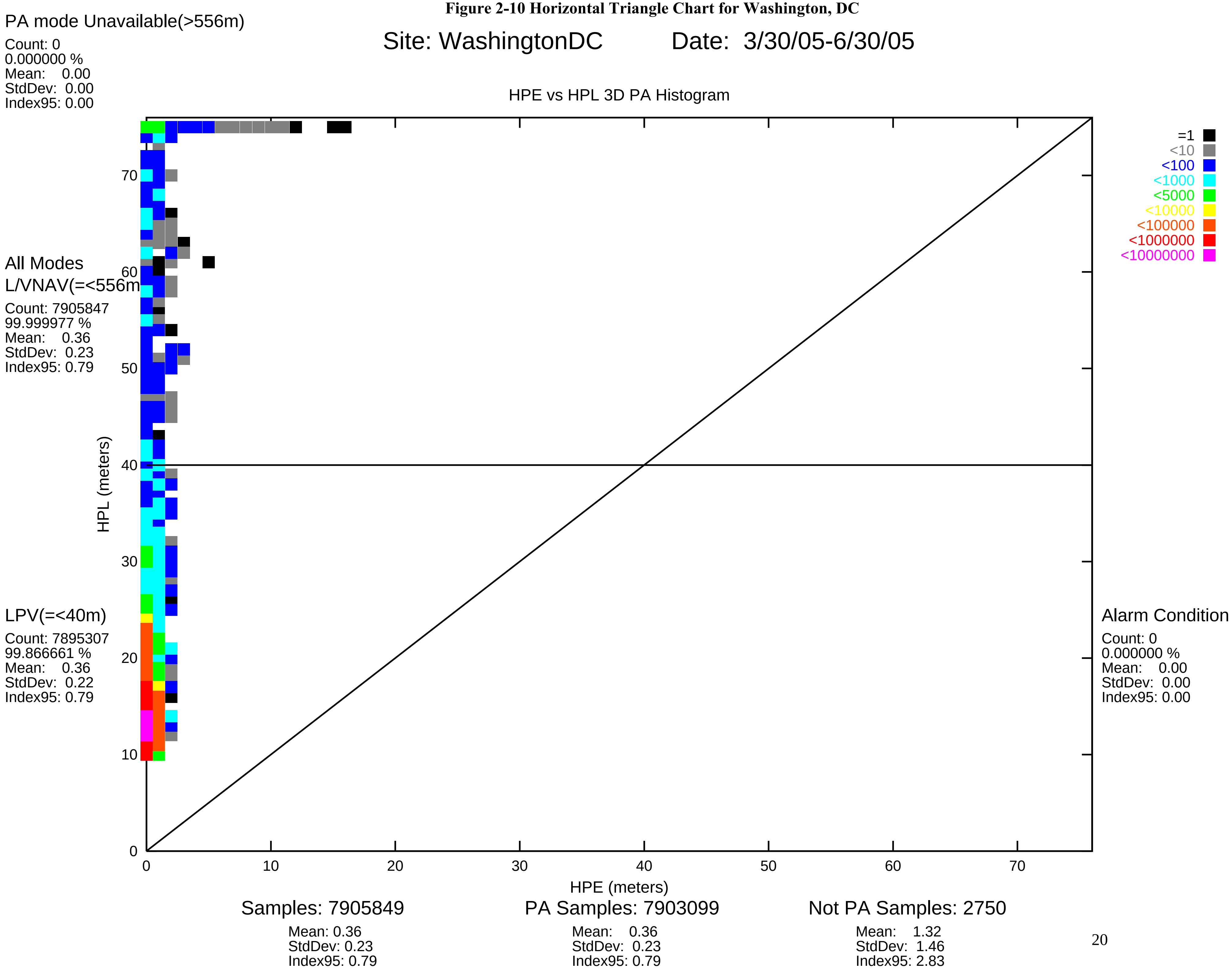


Figure 2-11 Vertical Triangle Chart for Washington, DC

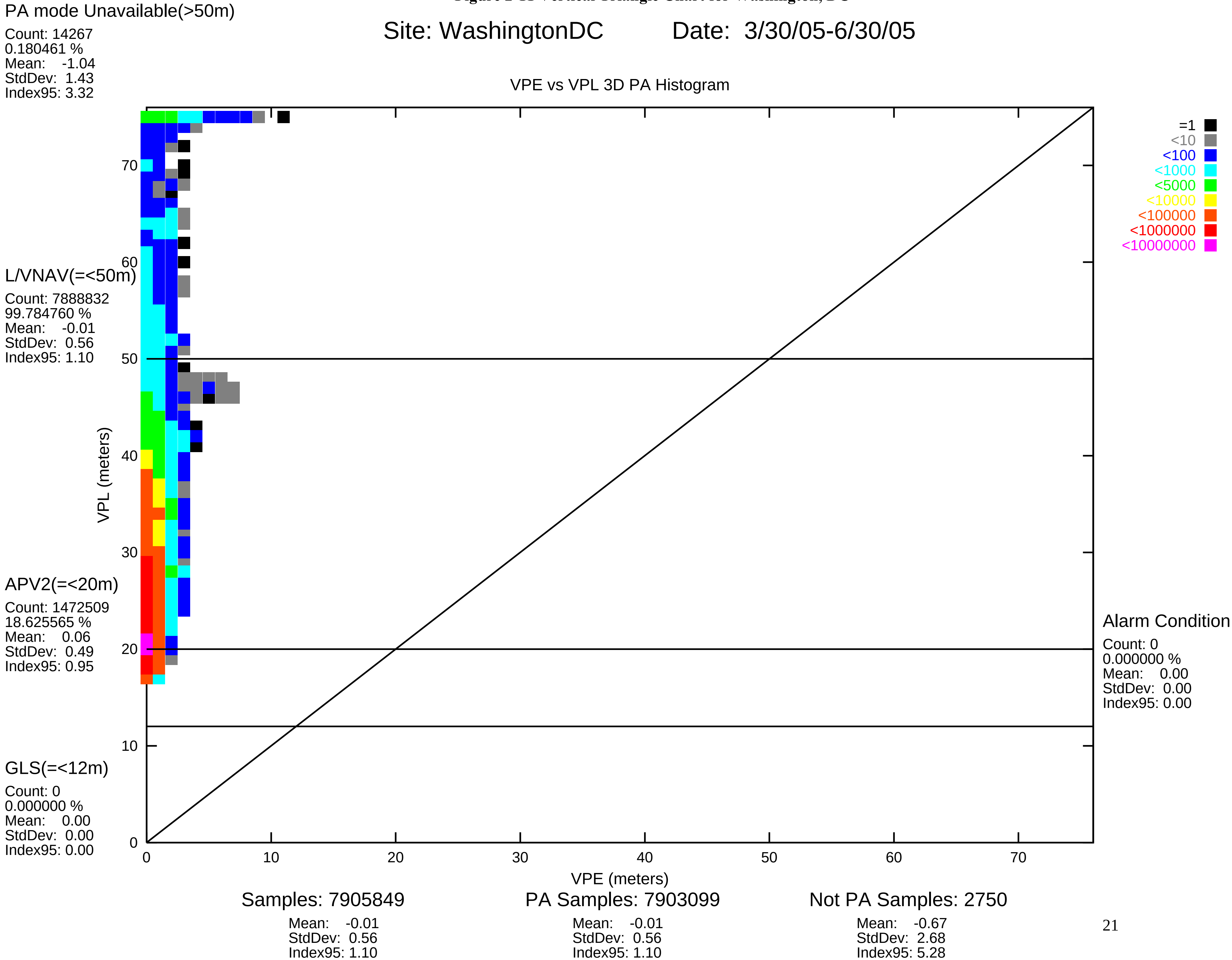


Figure 2-12 2-D Histogram for Washington, DC

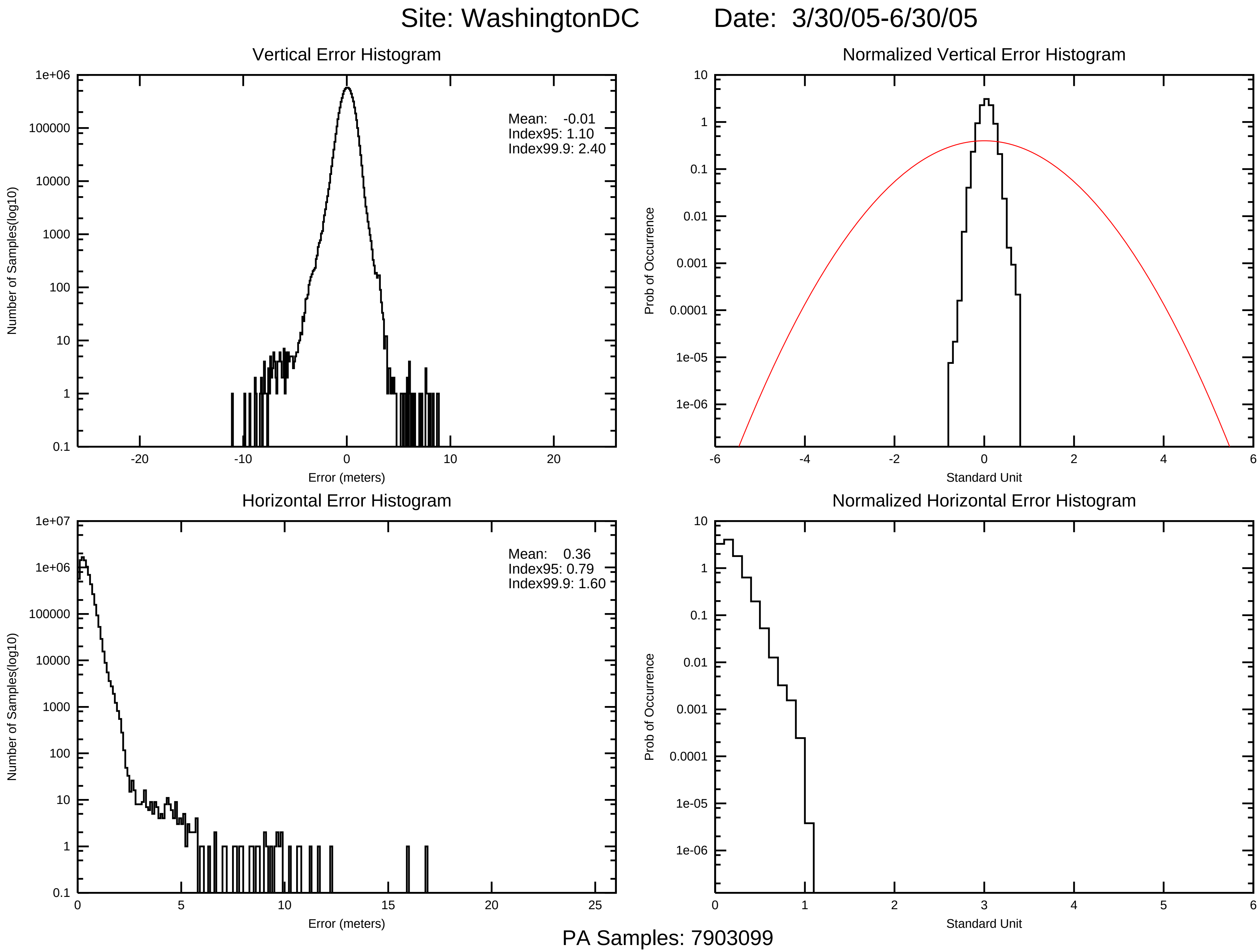


Figure 2-13 Horizontal Triangle Chart for Seattle

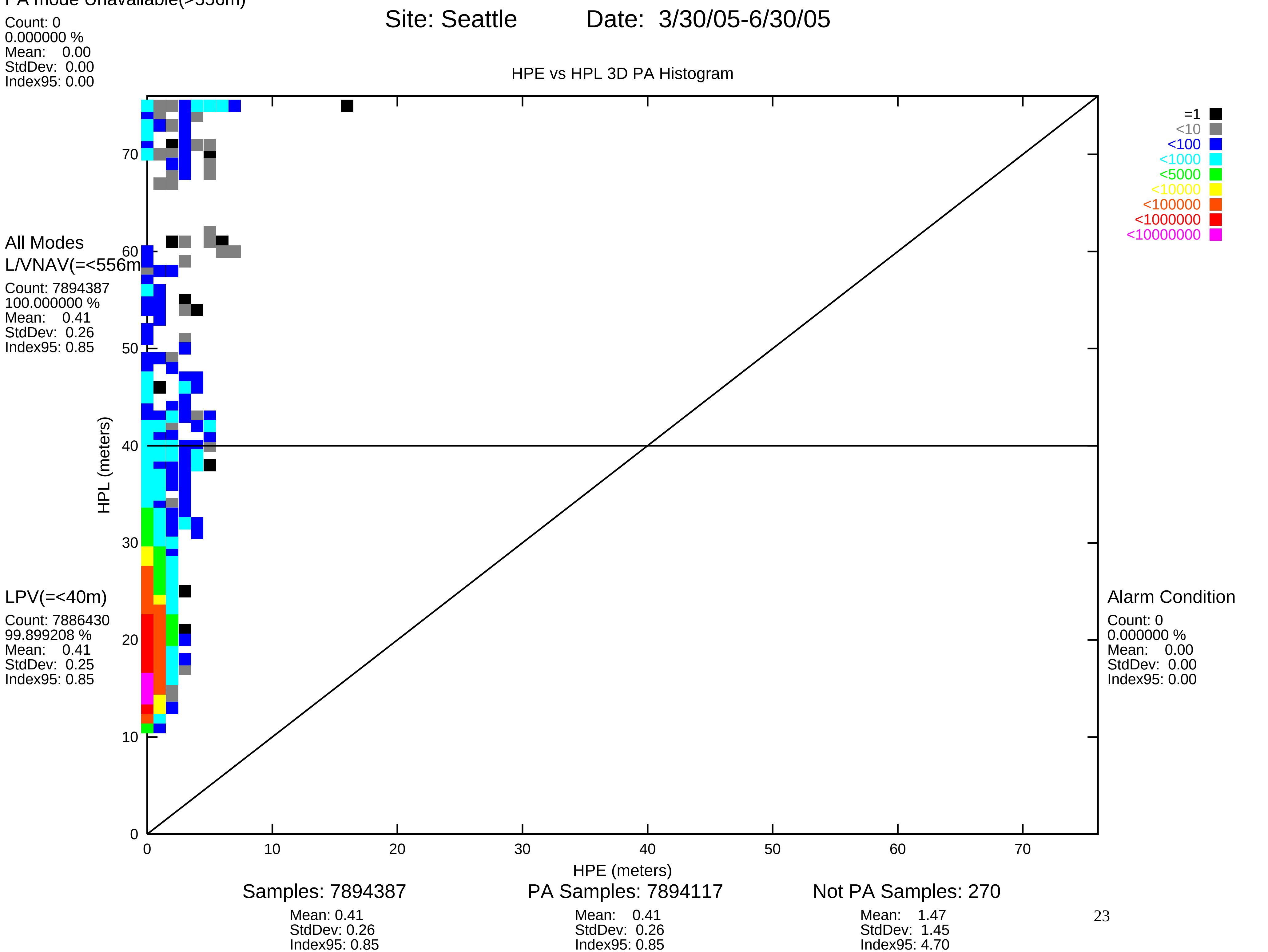


Figure 2-14 Vertical Triangle Chart for Seattle

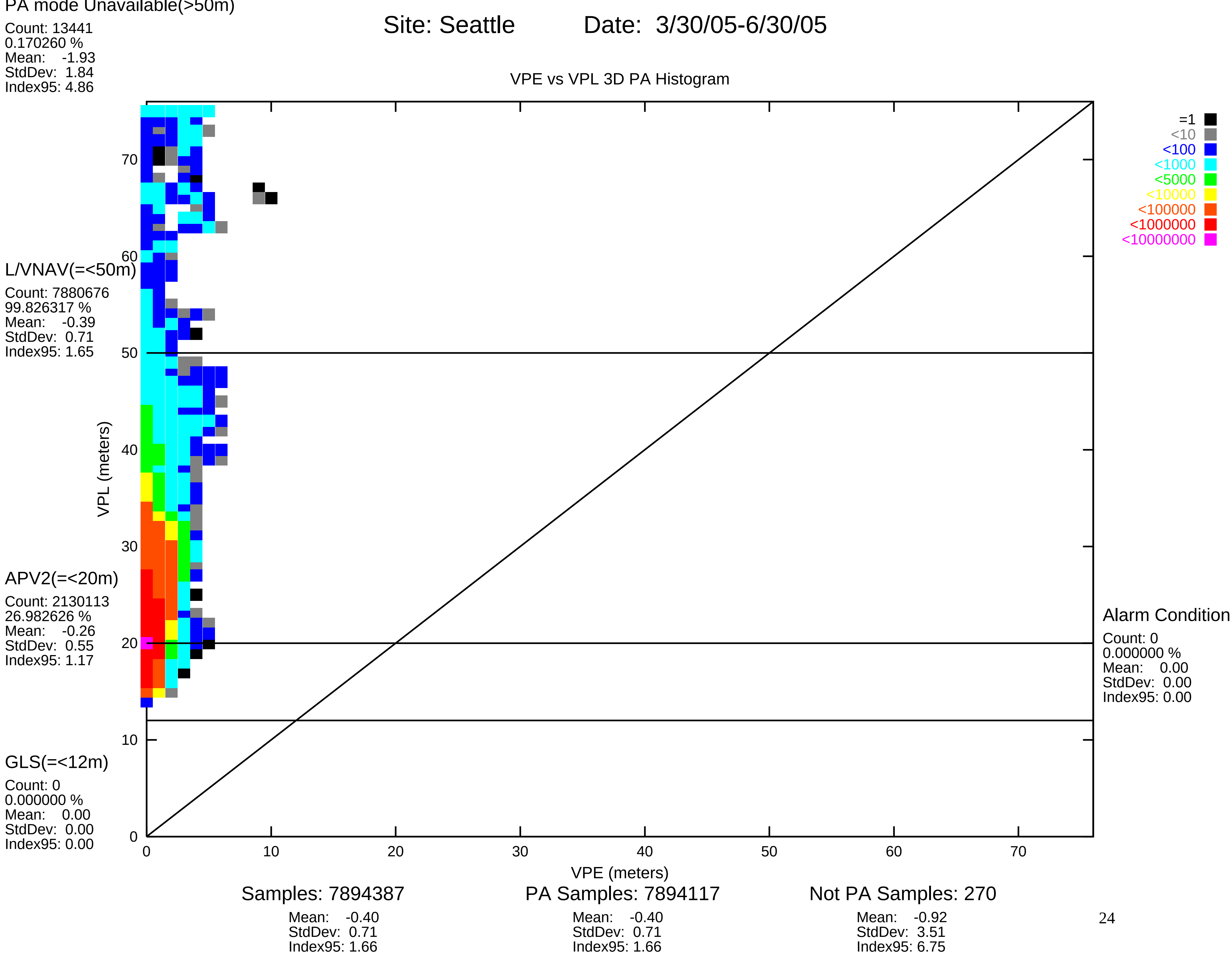
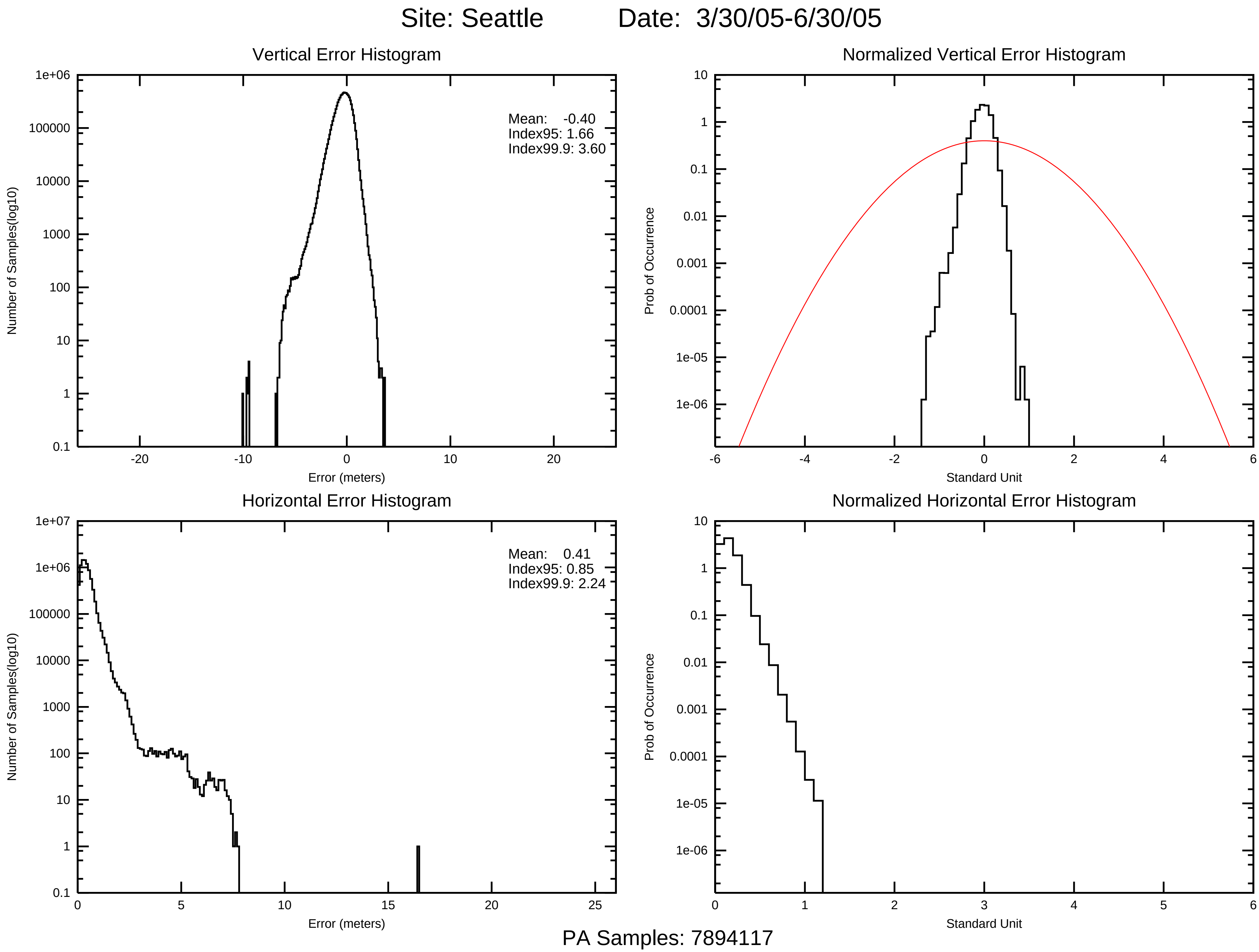


Figure 2-15 2-D Histogram for Seattle



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. The first two columns of Table 3.2 presents the average portion of time that WAAS operational service levels are available at each receiver location.

Availability of LPV and LNVA/VNAV service is evaluated by monitoring the WAAS protection levels at receiver locations throughout the test period. If both the vertical and horizontal protection levels are not greater than their respective alert limits (VAL and HAL) then the service is available. If either of the protection levels exceeds the required alert level then the operational service at that location is considered unavailable and an outage in service is recorded with its duration. The operational service is not considered available again until the protection levels are both within the alert limits for at least 15 minutes. Although this will reduce operational service availability minimally, it substantially reduces the number of service outages and prevents excessive switching in and out of service availability. The percent of time that LPV and LNVA/VNAV service is available using the fifteen-minute window criteria is presented in the last two columns in Table 3.2. The LPV and LNVA/VNAV service outages and associated outage rate for the test period is presented in Table 3.4. The outage rate is the percent of approaches that theoretically would be interrupted by a loss of operational service once the approach had started. Figures 3.1 through 3.4 show the daily availability of LNAV/VNAV and LPV service levels for the evaluated period. Figures 3.5 through 3.8 show the daily interruptions of LNAV/VNAV and LPV service levels for the evaluated period.

During the evaluated period, the maximum 95% HPL and VPL are 29.684 meters at Grand Forks and 45.680 meters at Boston, respectively. The minimum 95% HPL and VPL are 16.790 meters at Atlanta and 28.263 meters at Kansas City.

Availability of NPA service is evaluated by monitoring the WAAS horizontal protection level at receiver locations throughout the test period. If the horizontal protection level is not greater than the horizontal alert limit (HAL = 556m) then the service is available. If the horizontal protection level exceeds the required alert level or if WAAS navigation message is not received then the NPA service at that location is considered unavailable and an outage in service is recorded with its duration. The NPA service is not considered available again until the horizontal protection level is within the alert limit for at least 15 minutes. The percent of time that NPA service is available using the fifteen-minute window criteria is presented in Table 3.3. The NPA service outages and associated outage rate for the test period is presented in Table 3.5. The outage rate is the percent of NPA approaches that theoretically would be interrupted by a loss of operational service once the approach had started.

Table 3-1 95% Protection Level

Location	95% HPL (meters)	95% VPL (meters)	Percentage in PA mode
Anderson	17.420	29.371	99.990456
Atlantic City	20.885	37.881	99.990845
Grand Forks	29.684	38.600	99.983421
Greenwood	18.303	31.059	99.987030
San Angelo	29.296	45.501	99.990730
Albuquerque	20.157	33.728	99.987633
Atlanta	16.790	29.551	99.990913
Billings	20.506	30.220	99.987450
Boston	24.529	45.680	99.990753
Chicago	16.859	31.070	99.991776
Cleveland	17.830	31.124	99.990723
Dallas	18.878	31.009	99.989304
Denver	19.048	29.172	99.987381
Houston	22.611	35.442	99.988945
Jacksonville	17.718	32.122	99.990845
Kansas City	17.386	28.263	99.986145
Los Angeles	26.879	41.304	99.998283
Memphis	17.021	30.820	99.990723
Miami	22.489	40.686	99.990837
Minneapolis	20.353	30.300	99.985382
New York	20.688	38.515	99.990738
Oakland	27.887	38.701	99.998459
Salt Lake City	19.724	30.403	99.995178
Seattle	21.645	29.621	99.997139
Washington DC	17.193	31.458	99.990906

Table 3-2 Quarterly Availability Statistics

Location	LPV *Average Availability Percentage of time*	LNAV/VNAV *Average Availability Percentage of time*	LPV WAAS *With 15 minute window*	LNAV/VNAV *With 15 minute window*
Anderson	0.99787897	0.99788070	0.99687731	0.99687902
Atlantic City	0.99458760	0.99467367	0.99172315	0.99198086
Grand Forks	0.98161262	0.98187506	0.96985974	0.96999517
Greenwood	0.99844718	0.99875849	0.99803114	0.99833950
San Angelo	0.97609317	0.97685075	0.94556250	0.94642589
Albuquerque	0.99851257	0.99886084	0.99814568	0.99850396
Atlanta	0.99747258	0.99747372	0.99721020	0.99721135
Billings	0.99747062	0.99779481	0.99752482	0.99790882
Boston	0.97049427	0.97076577	0.95547535	0.95577212
Chicago	0.99650747	0.99650943	0.99625470	0.99625665
Cleveland	0.99773514	0.99775797	0.99726900	0.99742281
Dallas	0.99927956	0.99936044	0.99909246	0.99919091
Denver	0.99814624	0.99828637	0.99826145	0.99846348
Houston	0.99878114	0.99883795	0.99838899	0.99850001
Jacksonville	0.99856579	0.99858141	0.99831001	0.99834534
Kansas City	0.99860585	0.99865574	0.99830111	0.99831821
Los Angeles	0.99125028	0.99228156	0.98680138	0.98827719
Memphis	0.99898344	0.99901402	0.99878904	0.99881934
Miami	0.98992258	0.99012423	0.98531101	0.98552681
Minneapolis	0.99796188	0.99808002	0.99740632	0.99760395
New York	0.99469799	0.99489713	0.99239435	0.99268283
Oakland	0.99582720	0.99623609	0.99377348	0.99431229
Salt Lake City	0.99854362	0.99889964	0.99813218	0.99865560
Seattle	0.99823517	0.99835765	0.99713744	0.99749712
Washington DC	0.99830687	0.99830878	0.99811684	0.99811823

Table 3-3 NPA Availability

Location	NPA Availability (Excluding RAIM/FDE)
Albuquerque	0.99991054
Anchorage	0.99939743
Atlanta	0.99990854
Billings	0.99991029
Boston	0.99992648
Cleveland	0.99990781
Cold Bay	0.99942347
Honolulu	0.99941906
Houston	0.99990964
Juneau	0.99934227
Kansas City	0.99991079
Kotzebue	0.99968743
Los Angeles	0.99992890
Miami	0.99990870
Minneapolis	0.99991007
Oakland	0.99995390
Puerto Rico	0.99990233
Salt Lake City	0.99998854
Seattle	0.99995391
Washington DC	0.99990936

Table 3-4 LPV and LNAV/VNAV Outage Rate

Location	LPV Outages	LPV Outage Rates	LNAV/VNAV Outages	LNAV/VNAV Outage Rates
Anderson	26	0.000837	25	0.000805
AtlanticCity	171	0.003228	167	0.003151
Grand Forks	153	0.003380	145	0.003203
Greenwood	32	0.000708	29	0.000641
San Angelo	522	0.010620	477	0.009696
Albuquerque	46	0.000869	44	0.000831
Atlanta	35	0.000670	35	0.000670
Billings	18	0.000340	17	0.000321
Boston	263	0.005192	257	0.005072
Chicago	33	0.000643	33	0.000643
Cleveland	43	0.000827	37	0.000711
Dallas	26	0.000491	25	0.000472
Denver	21	0.000397	22	0.000416
Houston	32	0.000604	31	0.000585
Jacksonville	39	0.000737	38	0.000718
Kansas City	21	0.000397	21	0.000397
Los Angeles	200	0.003823	159	0.003035
Memphis	19	0.000422	18	0.000399
Miami	201	0.003850	200	0.003830
Minneapolis	39	0.000739	38	0.000720
New York	122	0.002320	121	0.002300
Oakland	105	0.001993	96	0.001821
Salt Lake City	37	0.000699	36	0.000680
Seattle	46	0.000871	45	0.000851
Washington DC	28	0.000529	28	0.000529

Table 3-5 NPA Outage Rates

Location	NPA Outages	NPA Outage Rate
Albuquerque	8	0.00015628
Anchorage	10	0.00021528
Atlanta	8	0.00015816
Bangor	15	0.00032034
Billings	8	0.00015625
Boston	6	0.00012750
Cleveland	8	0.00015896
Cold Bay	12	0.00024426
Honolulu	11	0.00022305
Houston	8	0.00015626
Juneau	19	0.00037151
Kansas City	8	0.00015629
Kotzebue	8	0.00017039
Los Angeles	11	0.00021487
Mauna Loa	8	0.00017067
Miami	8	0.00015630
Minneapolis	8	0.00015664
Oakland	11	0.00021487
Puerto Rico	8	0.00016213
Salt Lake City	3	0.00005861
Seattle	11	0.00021486
Washington DC	8	0.00015629

Figure 3-1 LPV Instantaneous Availability

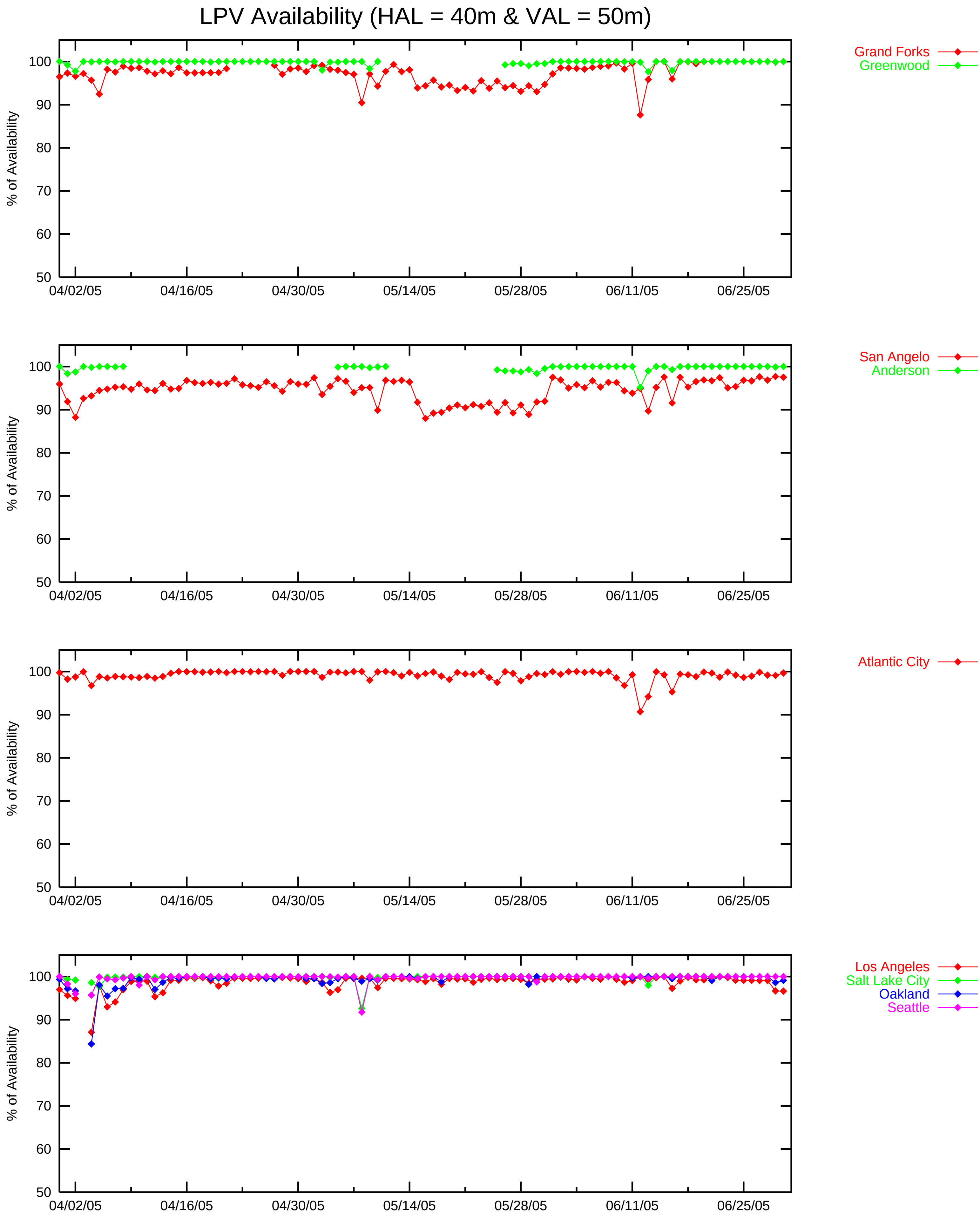


Figure 3-2 LPV Instantaneous Availability

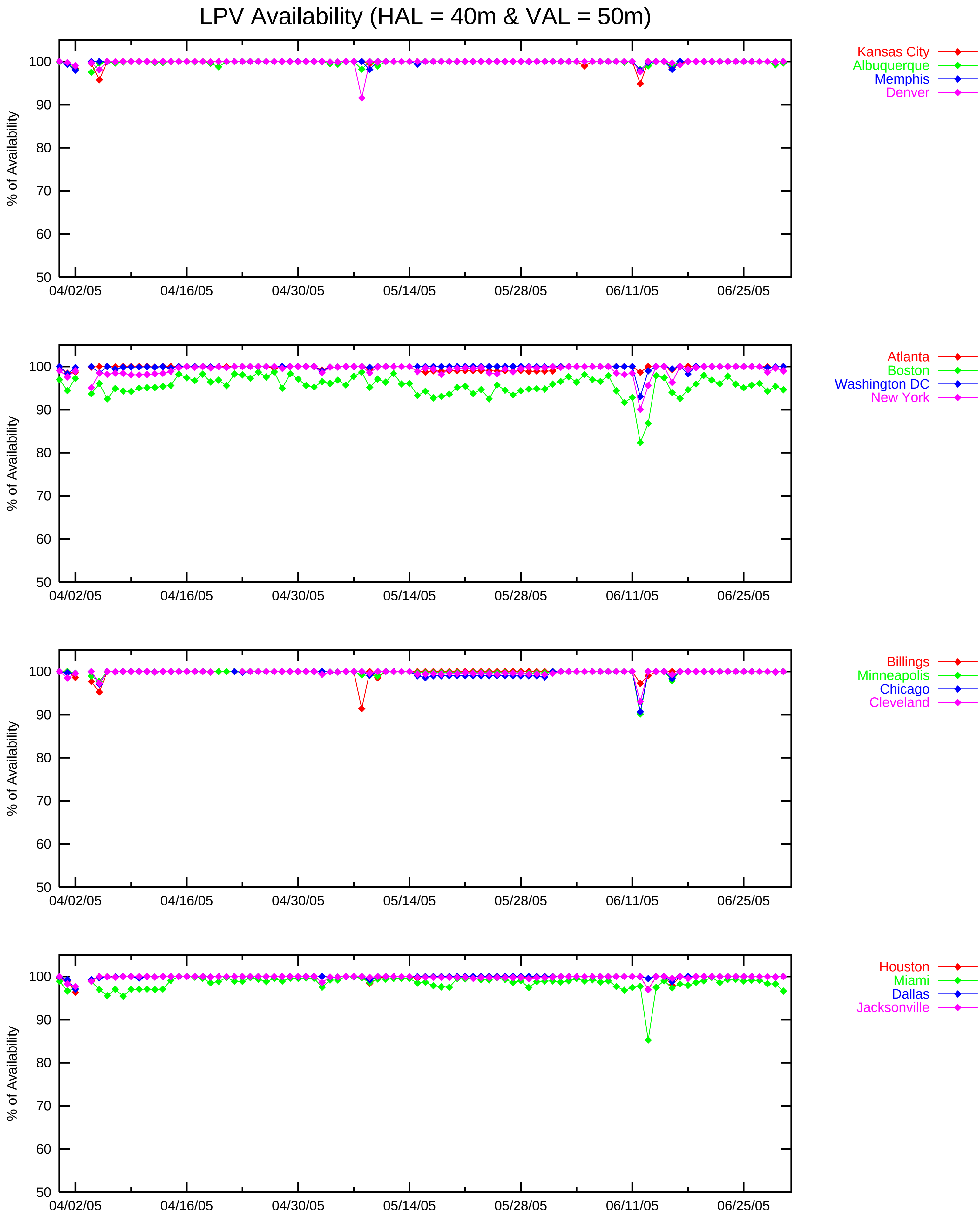


Figure 3-3 LNAV/VNAV Instantaneous Availability

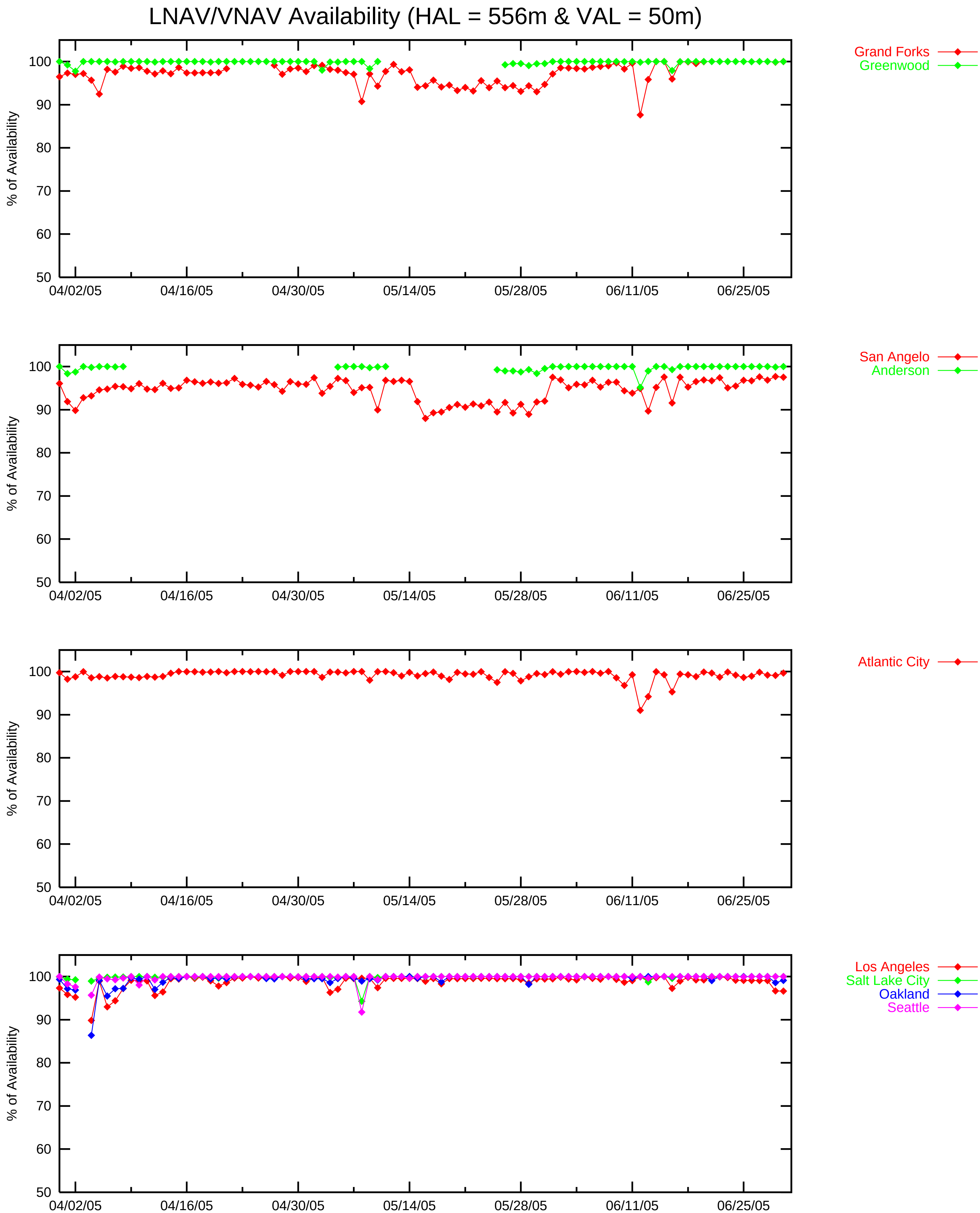


Figure 3_4 LNAV/VNAV Instantaneous Availability

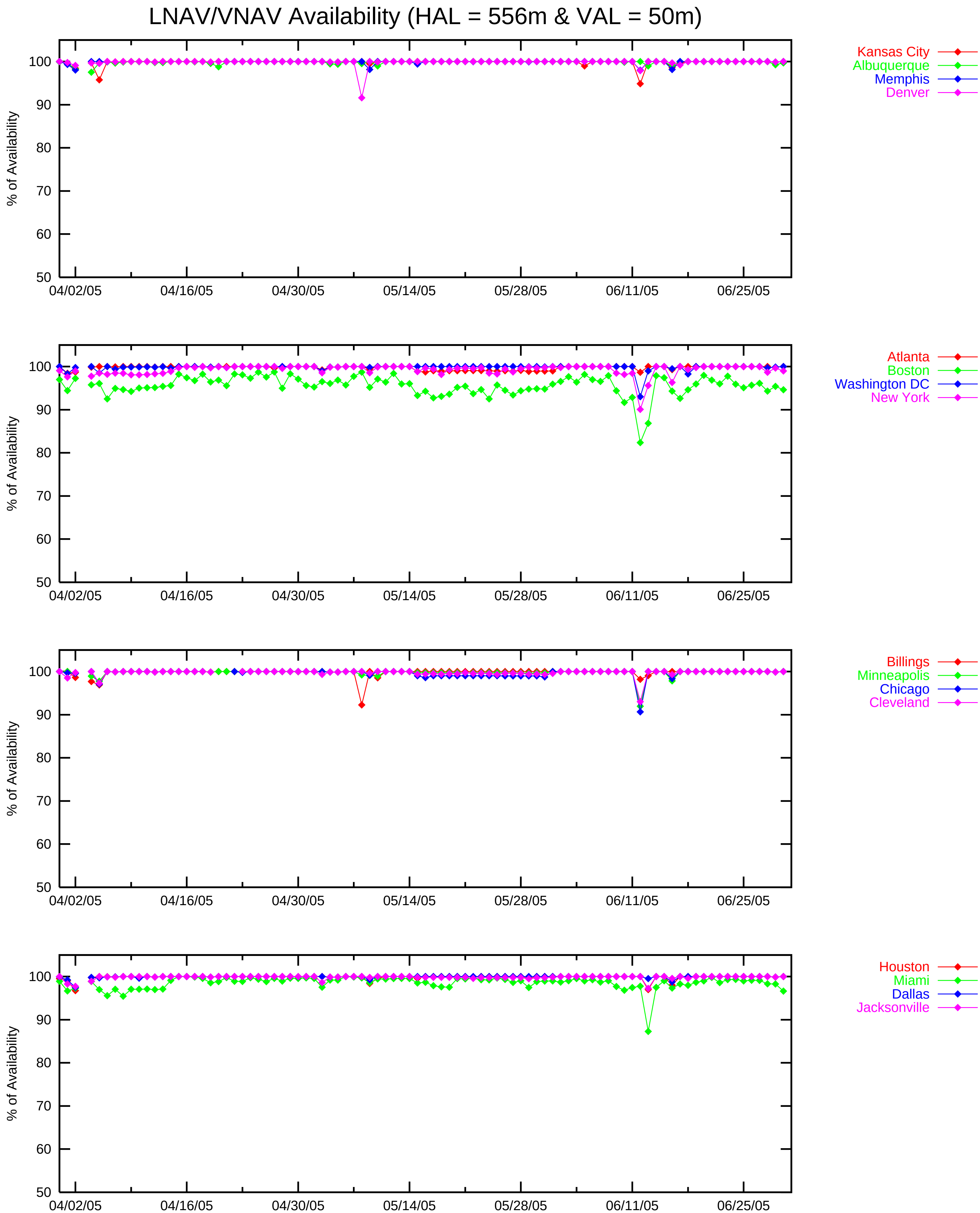


Figure 3-5 LPV Outages

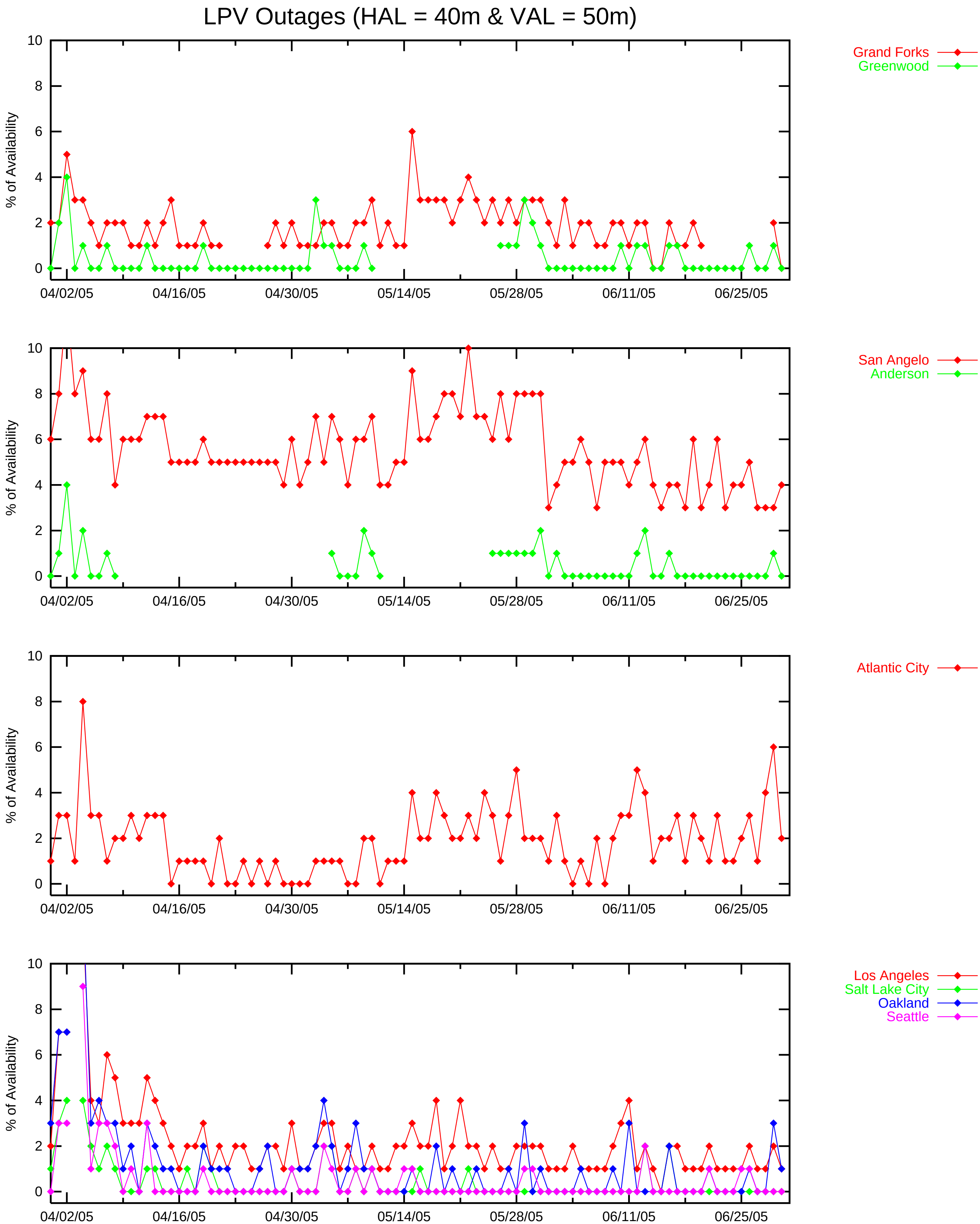


Figure 3-6 LPV Outages

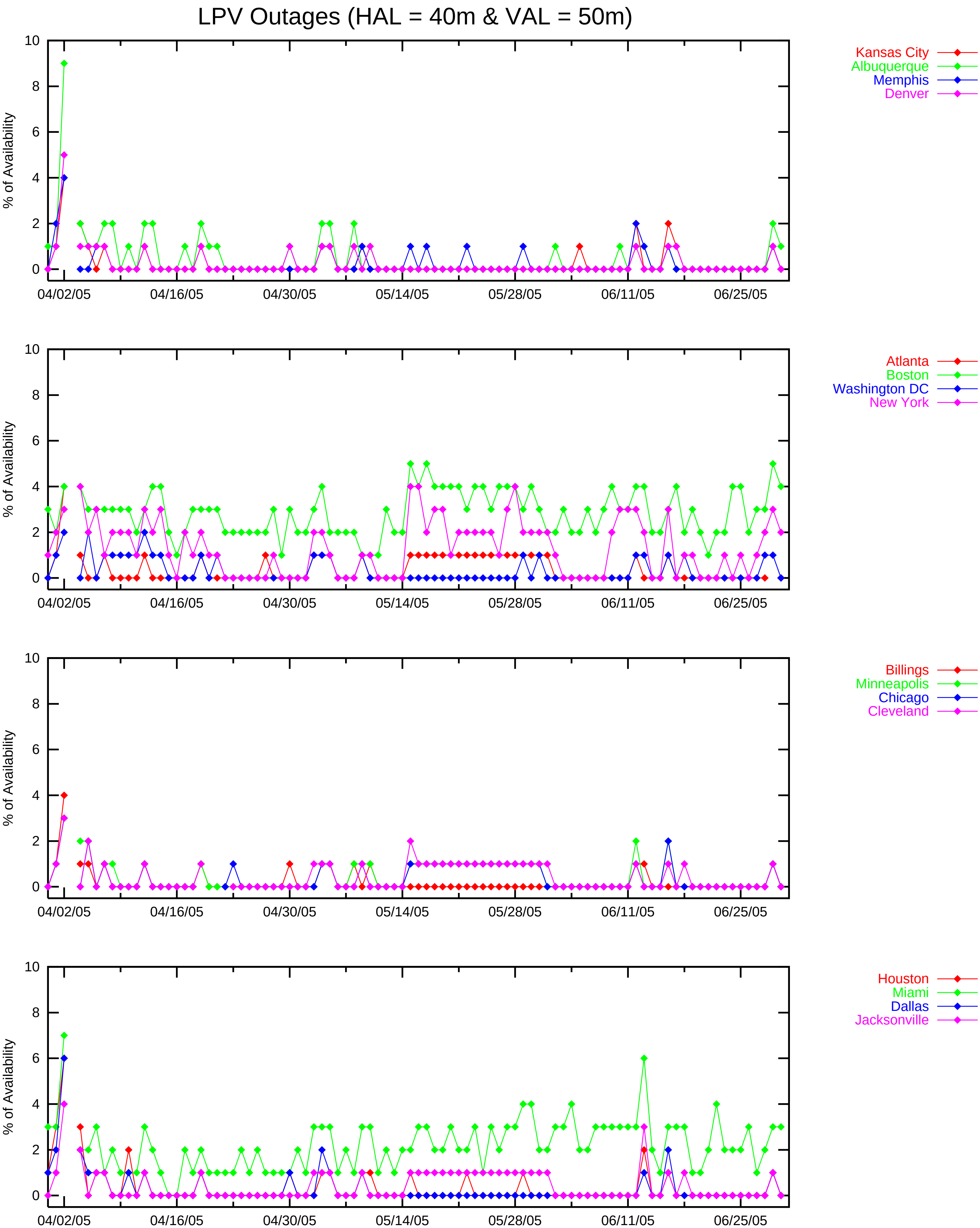


Figure 3-7 LNAV/VNAV Outages

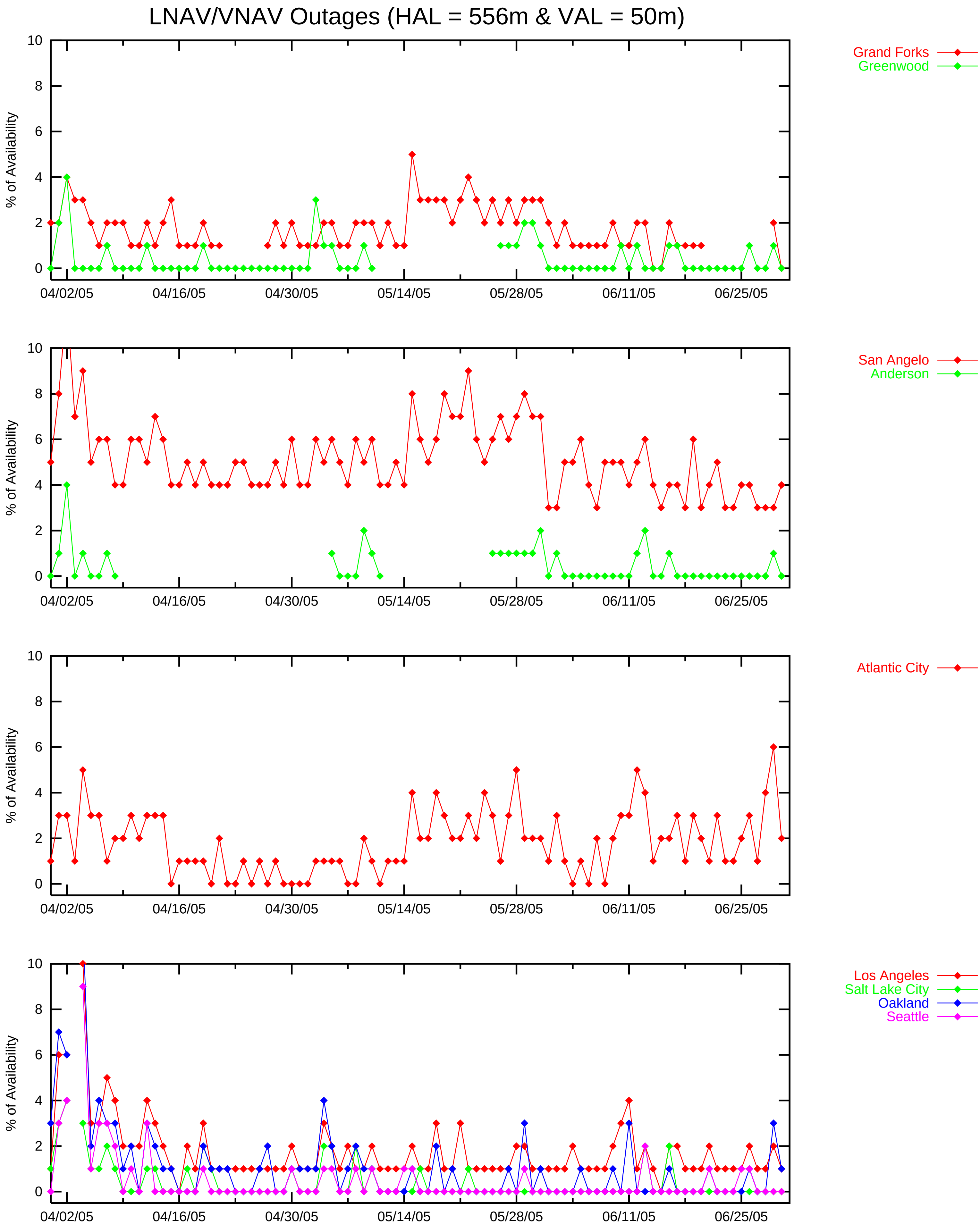
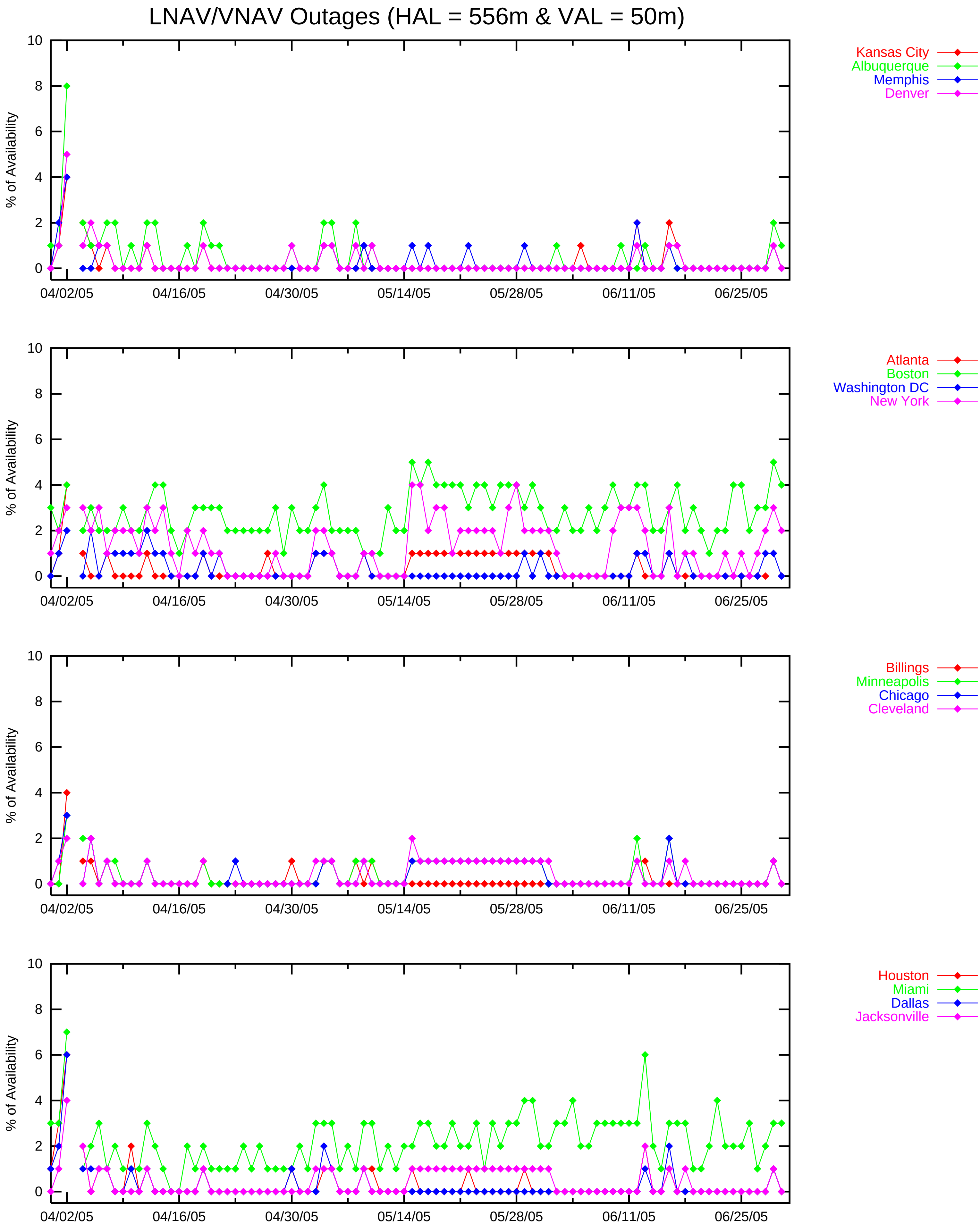


Figure 3-8 LNAV/VNAV Outages



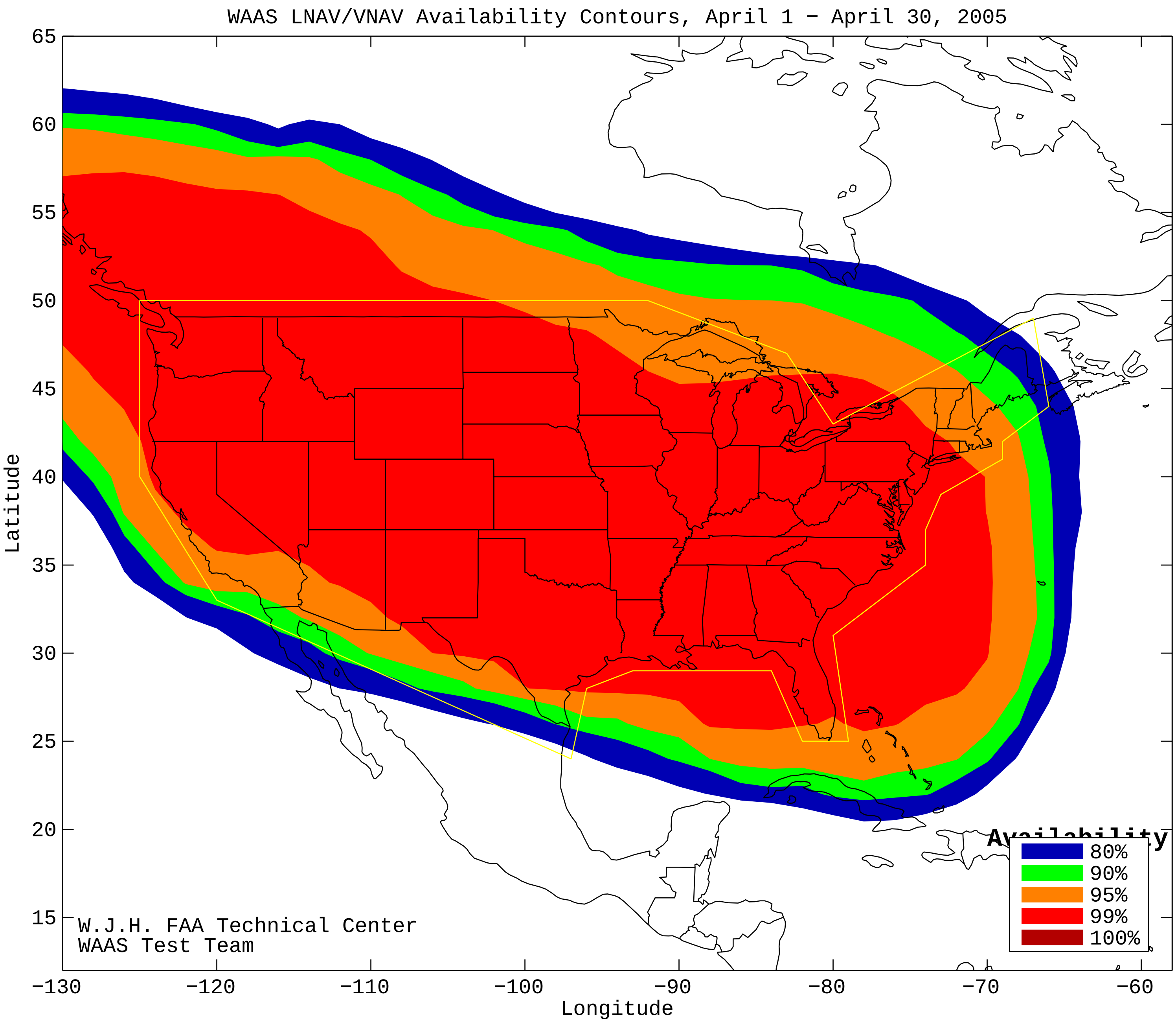
4.0 COVERAGE

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 the PA service volume, while NPA coverage was calculated at two-minute intervals and five degree spacing over the 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.

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.

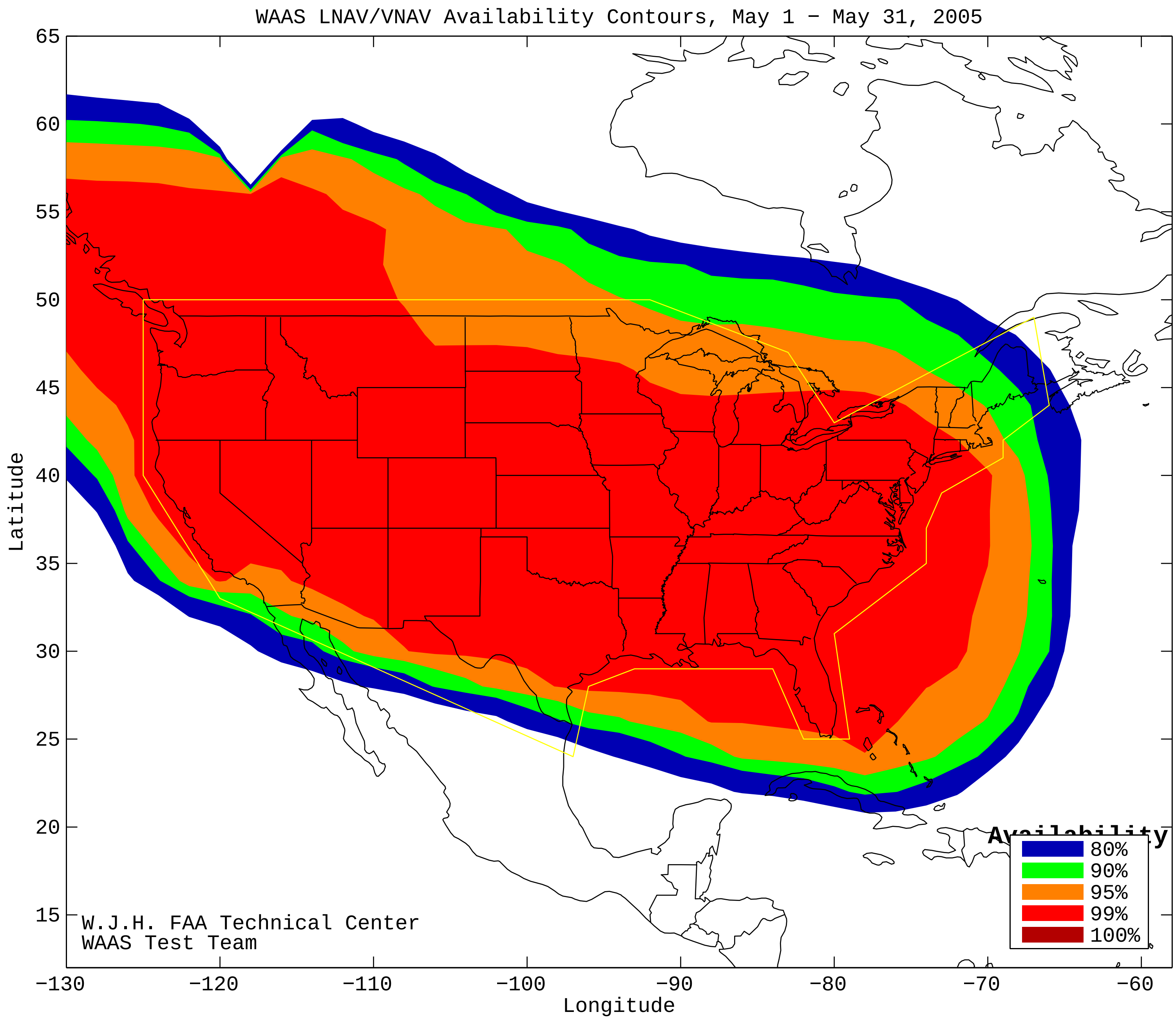
Figure 4-1 WAAS LNAV/VNAV Coverage -April



CONUS Coverage at 95% Availability = 95.55
CONUS Coverage at 99% Availability = 84.21
CONUS Coverage at 100% Availability = 0

SL = LNAV/VNAV

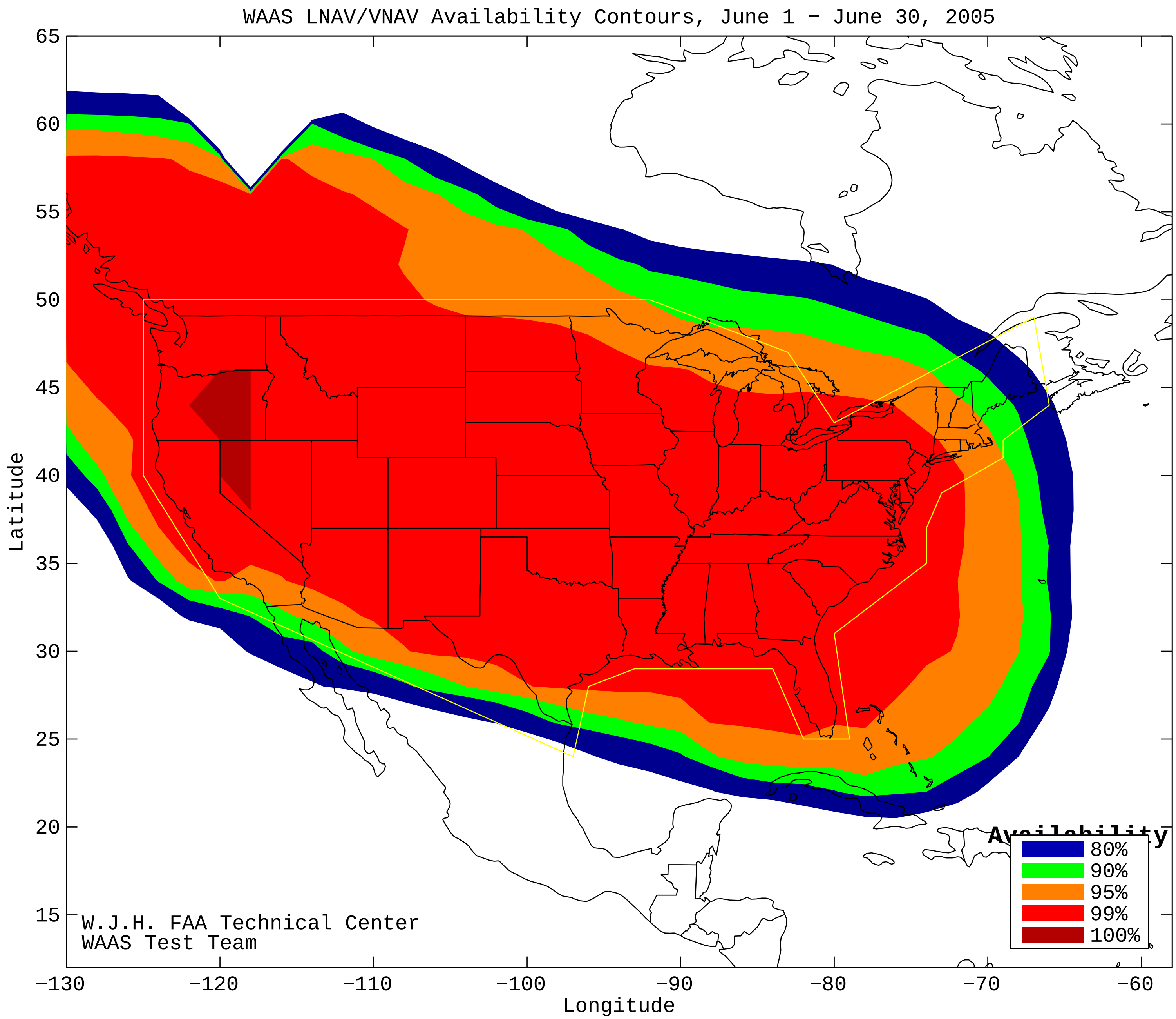
Figure 4-2 WAAS LNAV/VNAV Coverage -May



CONUS Coverage at 95% Availability = 94.74
CONUS Coverage at 99% Availability = 84.21
CONUS Coverage at 100% Availability = 0

SL = LNAV/VNAV

Figure 4-3 WAAS LNAV/VNAV Coverage - June



CONUS Coverage at 95% Availability = 94.74
CONUS Coverage at 99% Availability = 86.23
CONUS Coverage at 100% Availability = 4.049

SL = LNAV/VNAV

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

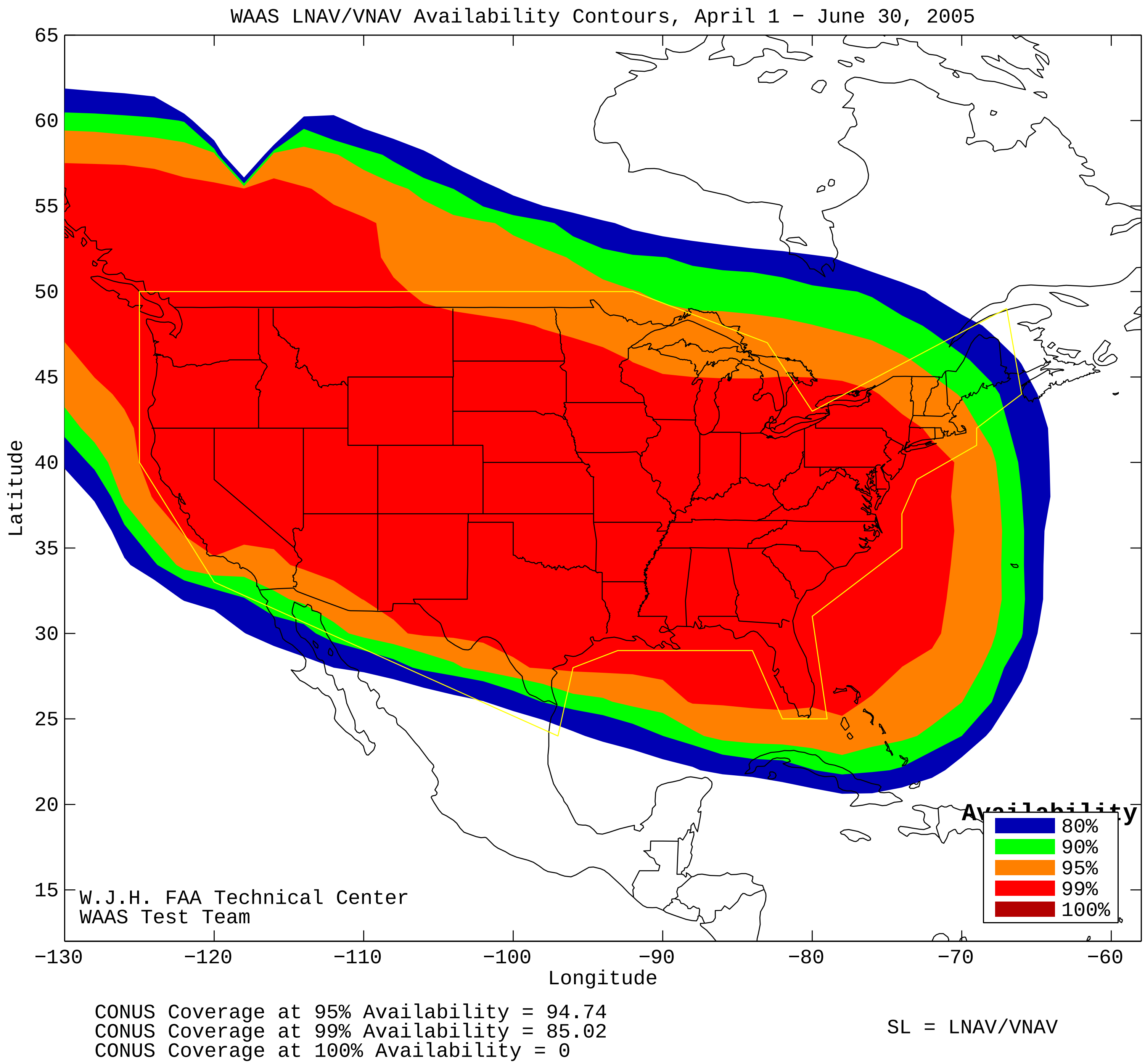
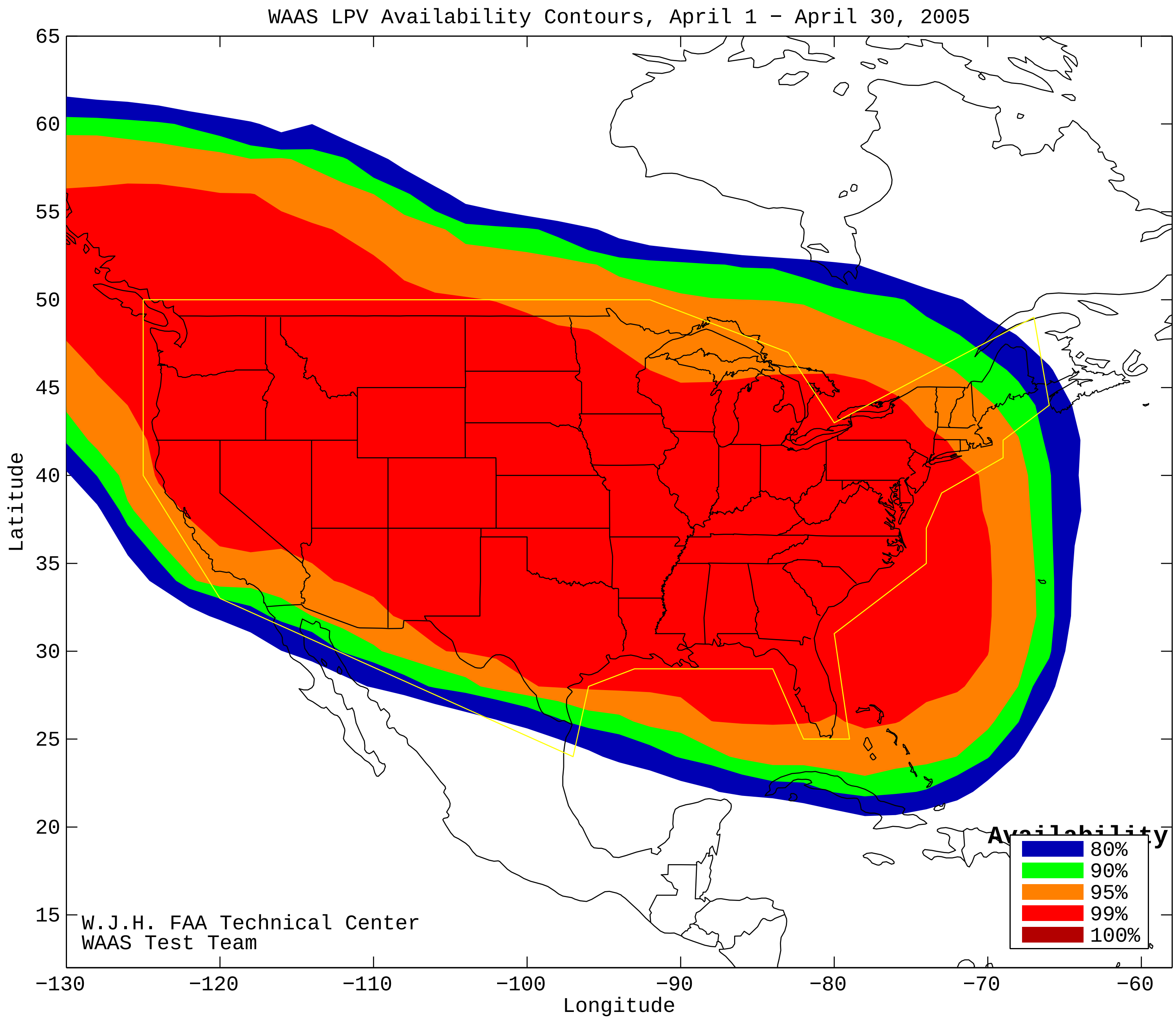


Figure 4-5 WAAS LPV Coverage -April



CONUS Coverage at 95% Availability = 94.74
CONUS Coverage at 99% Availability = 83.81
CONUS Coverage at 100% Availability = 0

SL = LPV

Figure 4-6 WAAS LPV Coverage -May

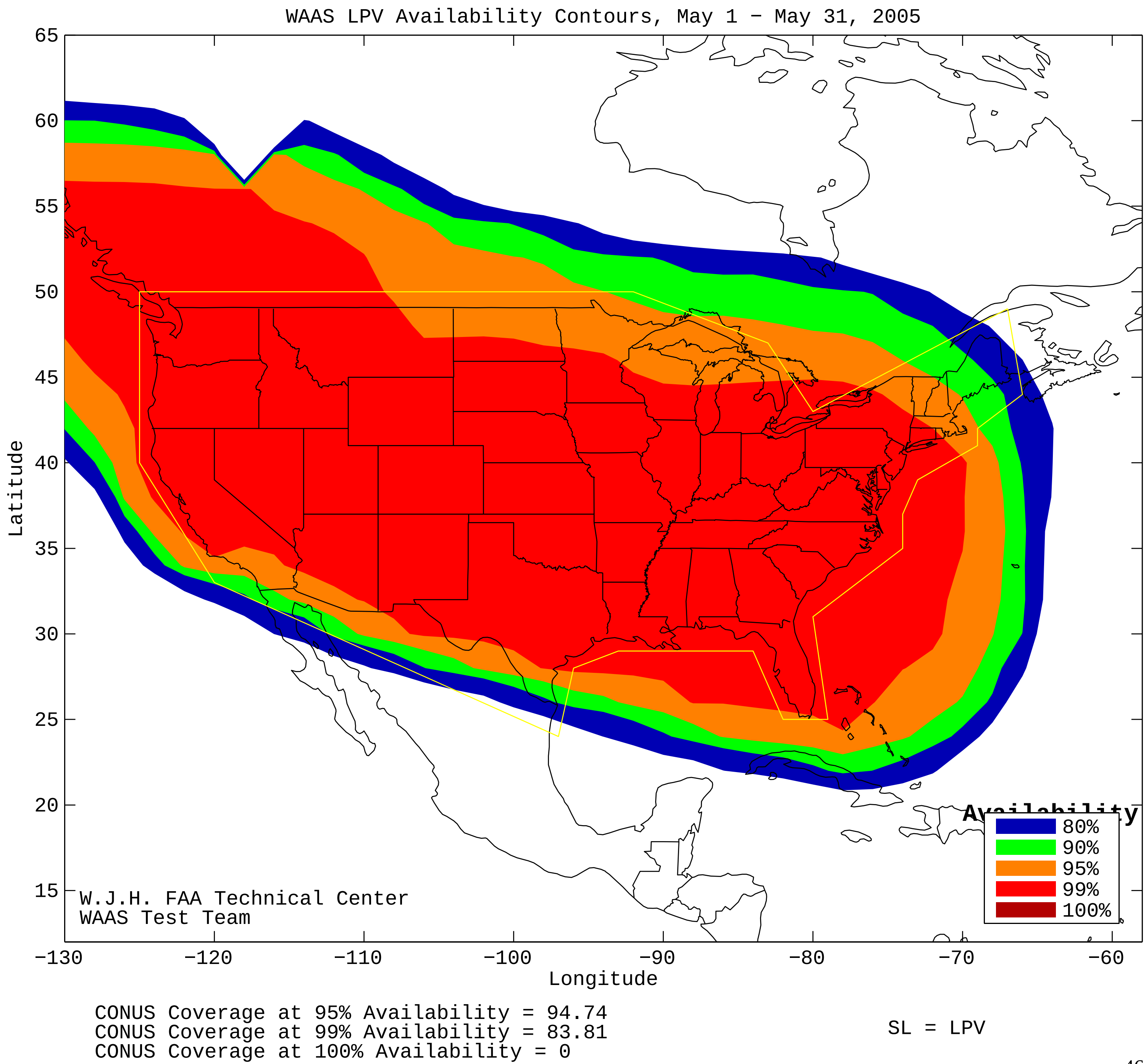
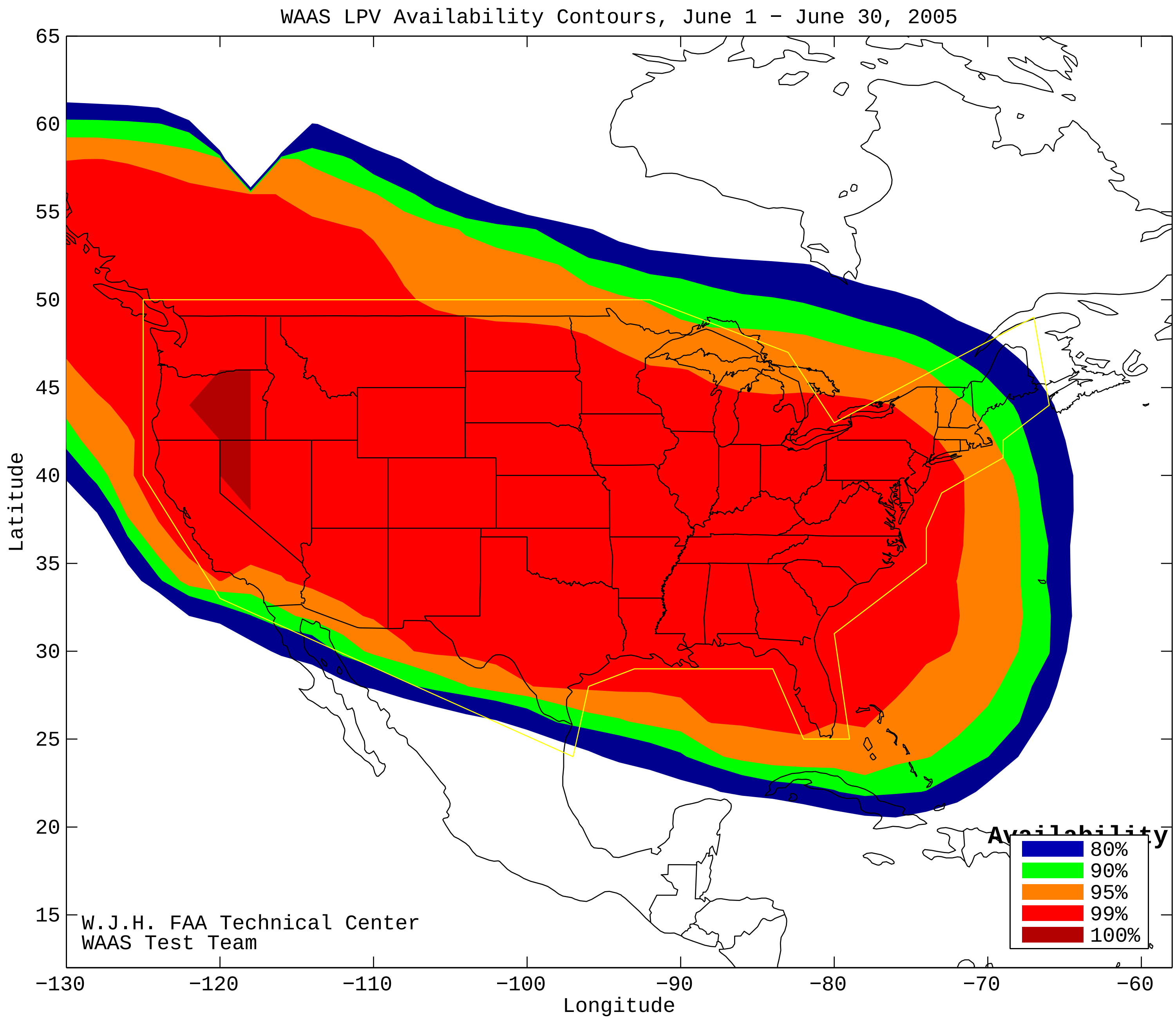


Figure 4-7 WAAS LPV Coverage -June



CONUS Coverage at 95% Availability = 94.74
CONUS Coverage at 99% Availability = 86.23
CONUS Coverage at 100% Availability = 4.049

SL = LPV

Figure 4-8 WAAS LPV Coverage for the Quarter

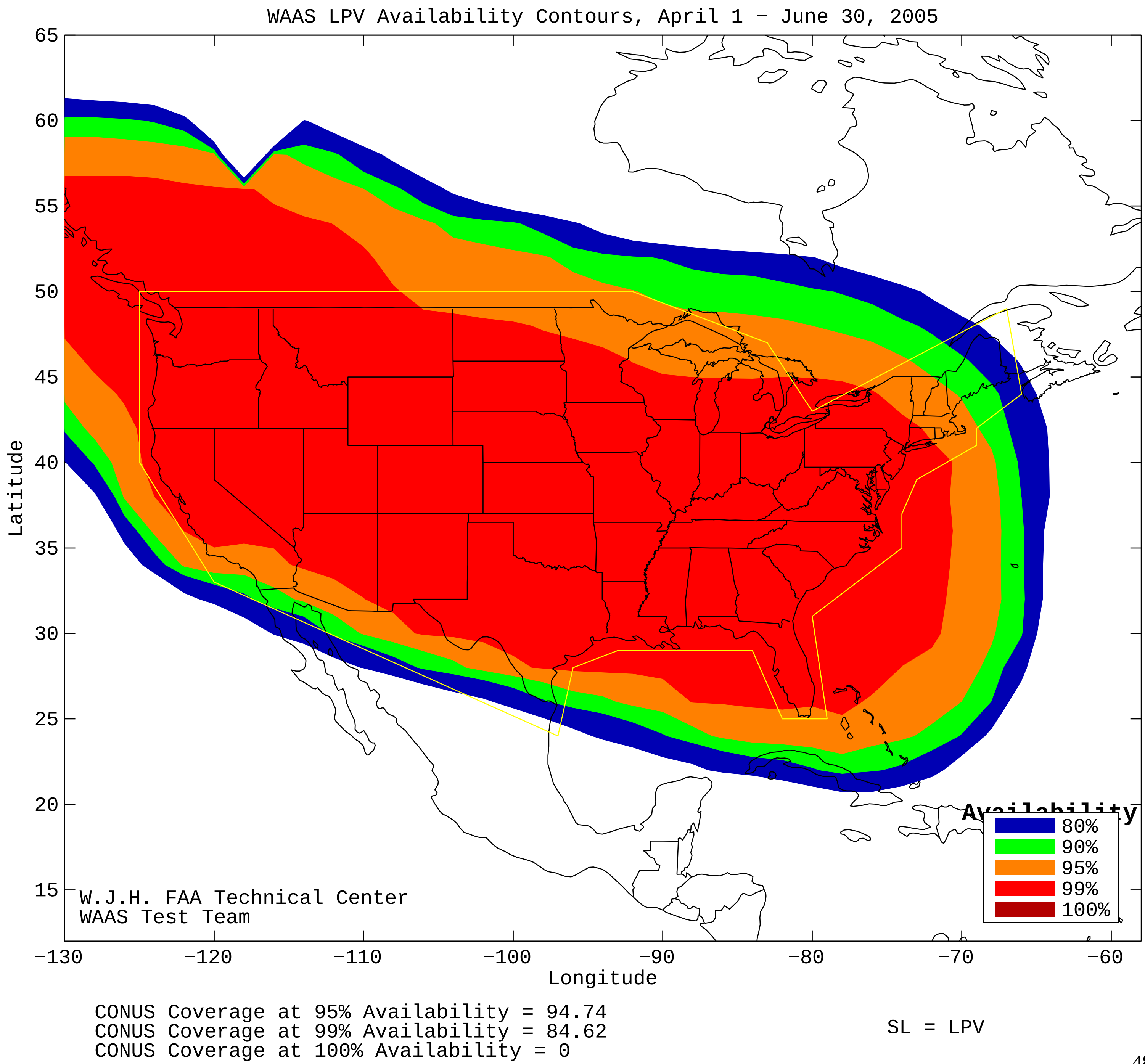
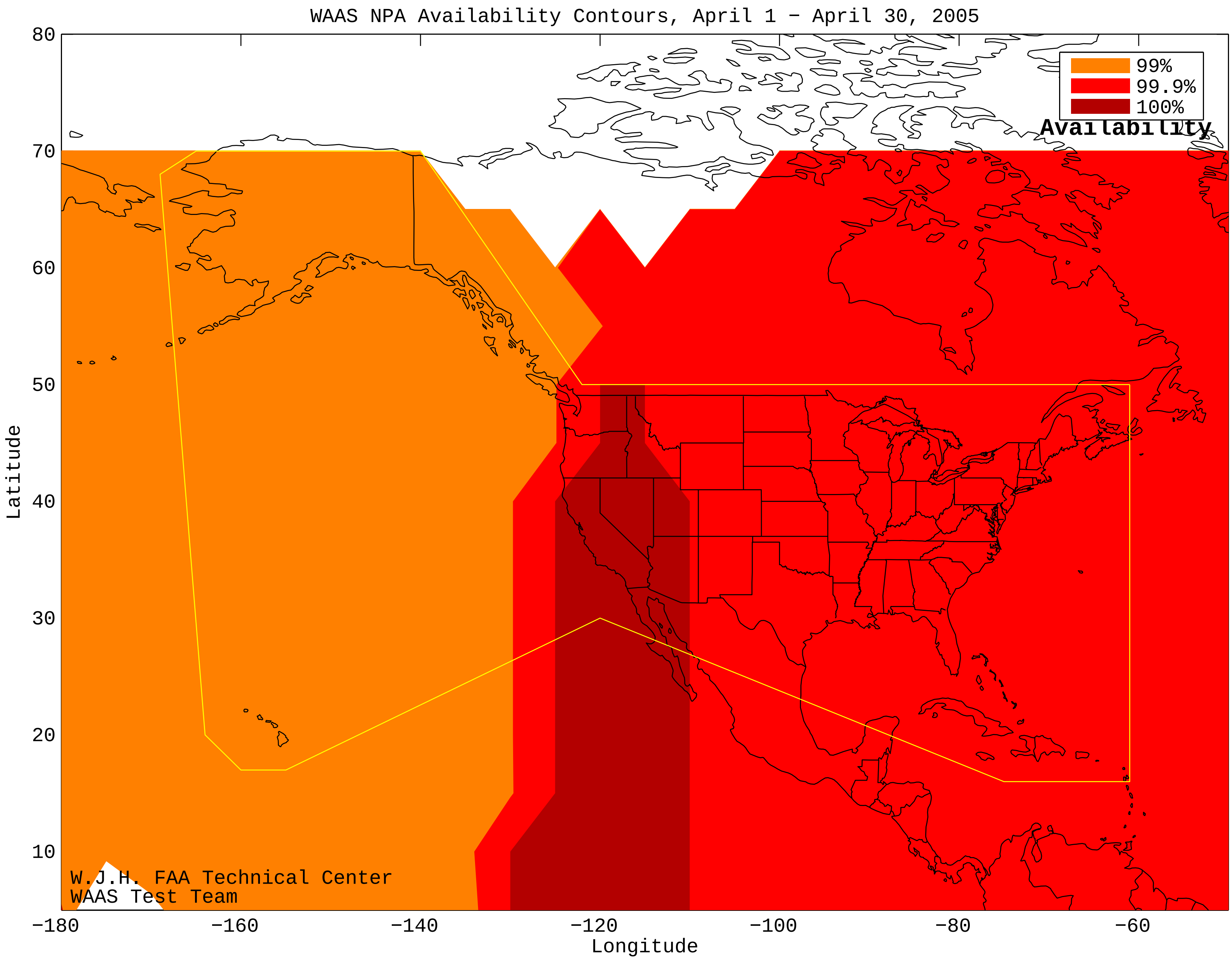


Figure 4-9 WAAS NPA Coverage -April



WAAS Coverage at 99% Availability = 100
WAAS Coverage at 99.9% Availability = 47.06
WAAS Coverage at 100% Availability = 10.29

SL = NPA

Figure 4-10 WAAS NPA Coverage -May

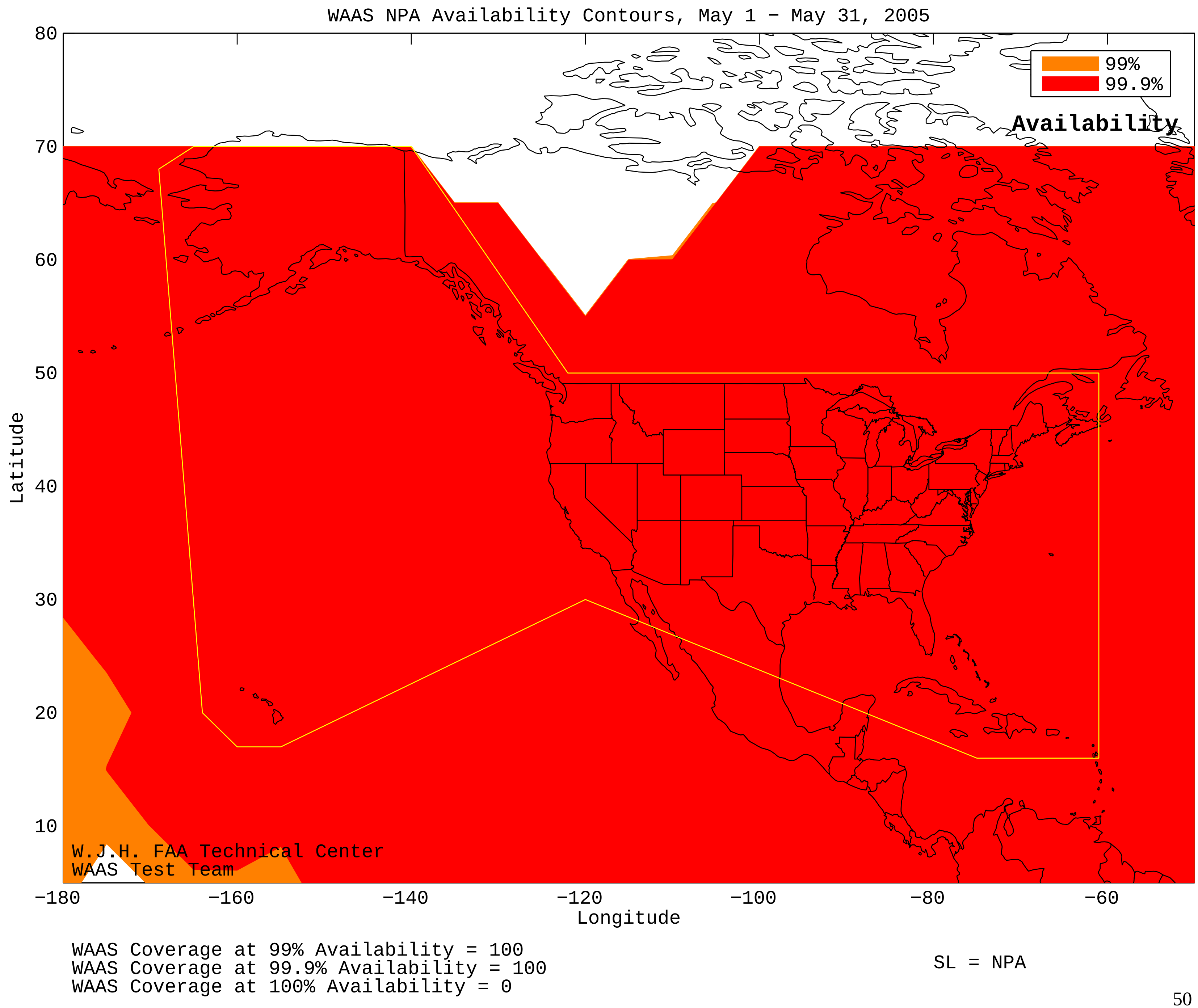


Figure 4-11 WAAS NPA Coverage -June

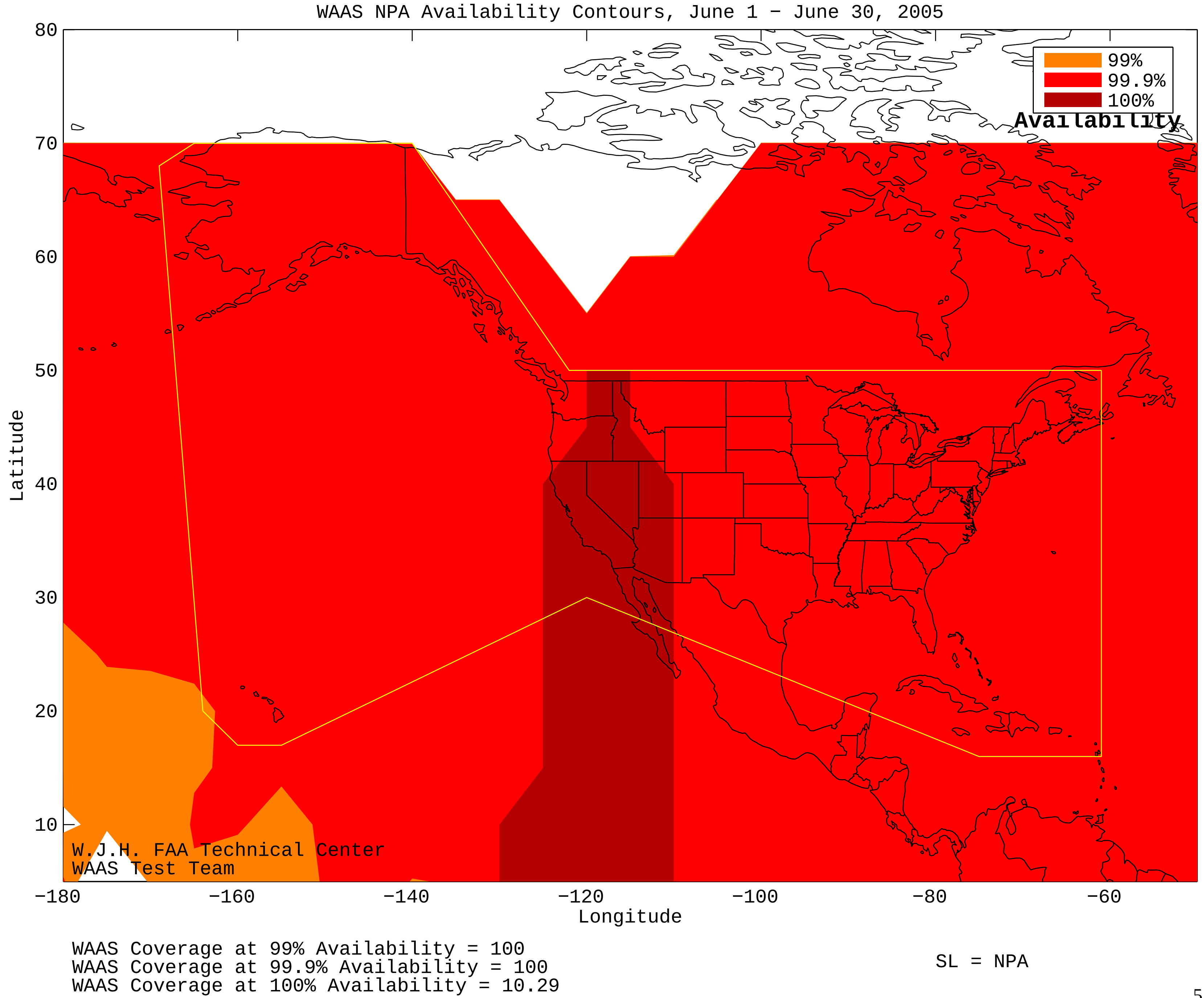
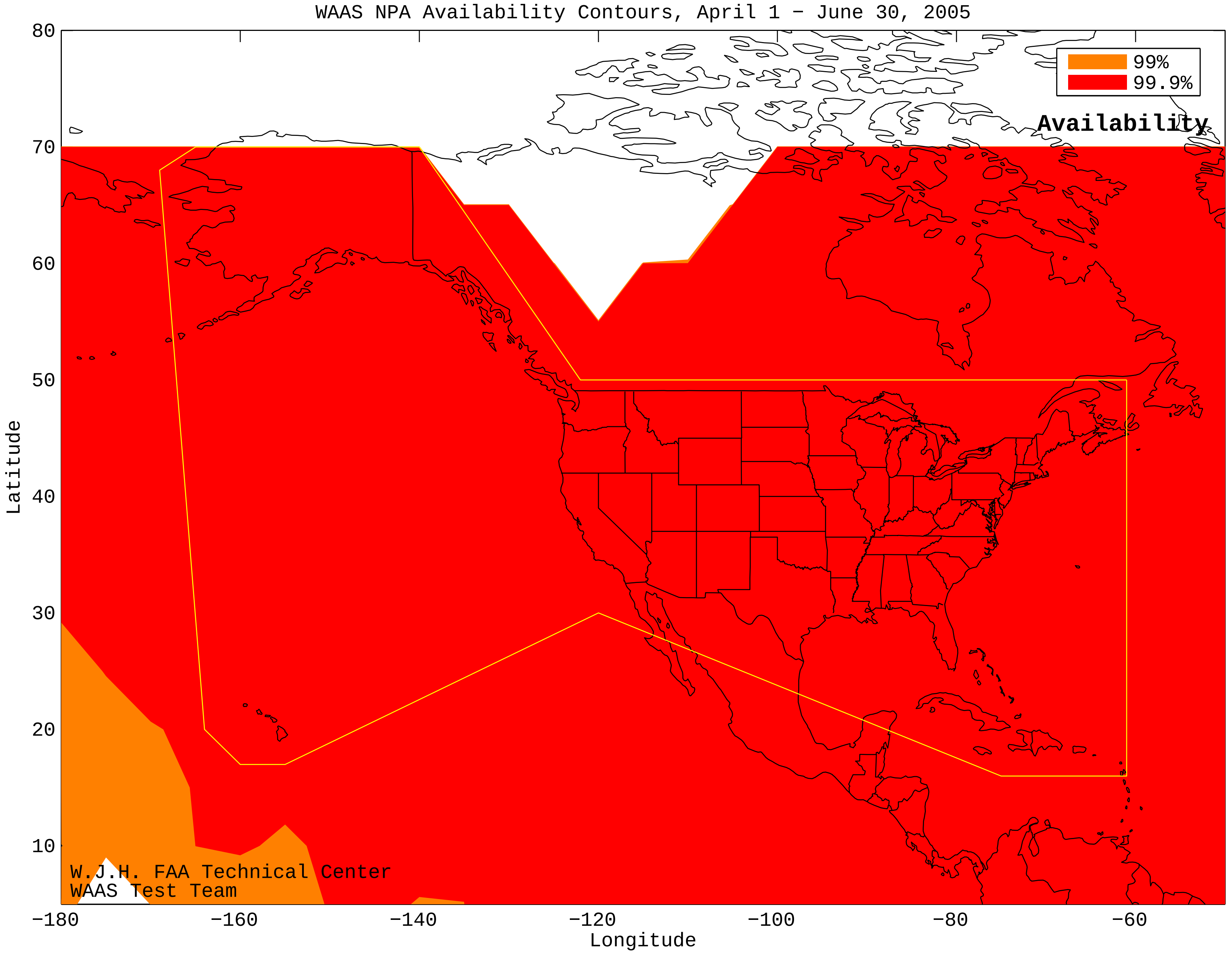


Figure 4-12 WAAS NPA Coverage for the Quarter



WAAS Coverage at 99% Availability = 100
WAAS Coverage at 99.9% Availability = 100
WAAS Coverage at 100% Availability = 0

SL = NPA

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

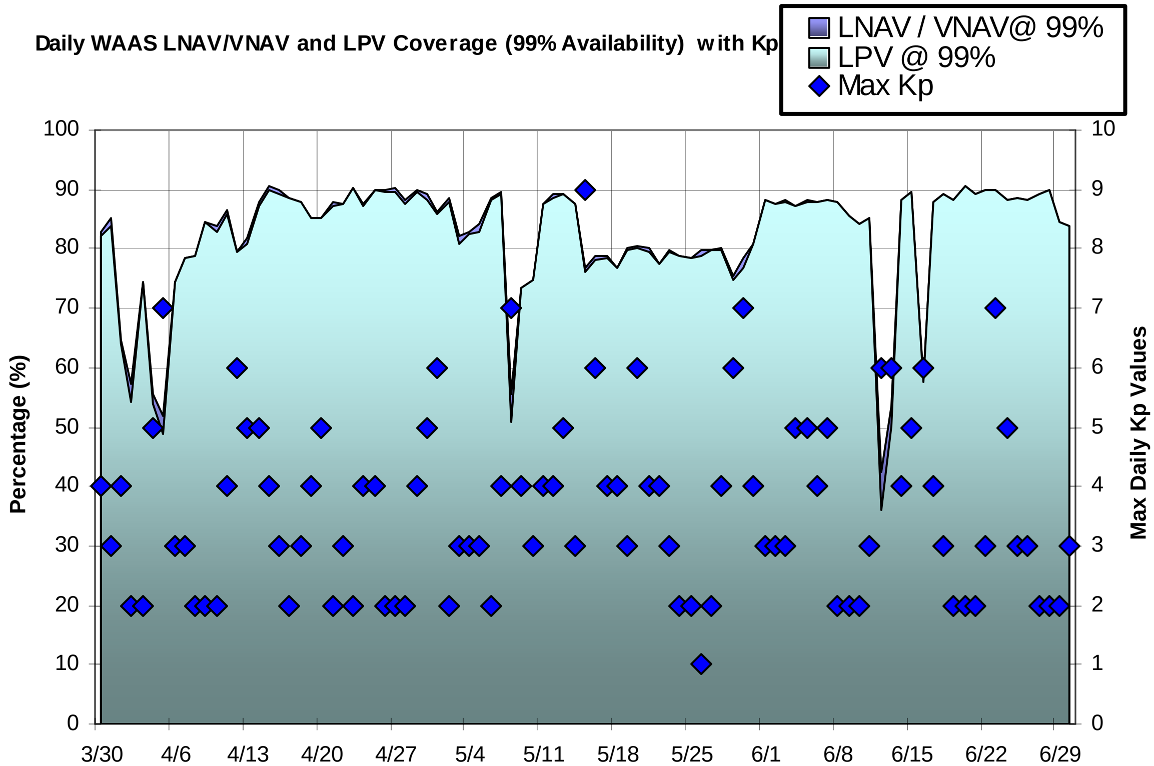
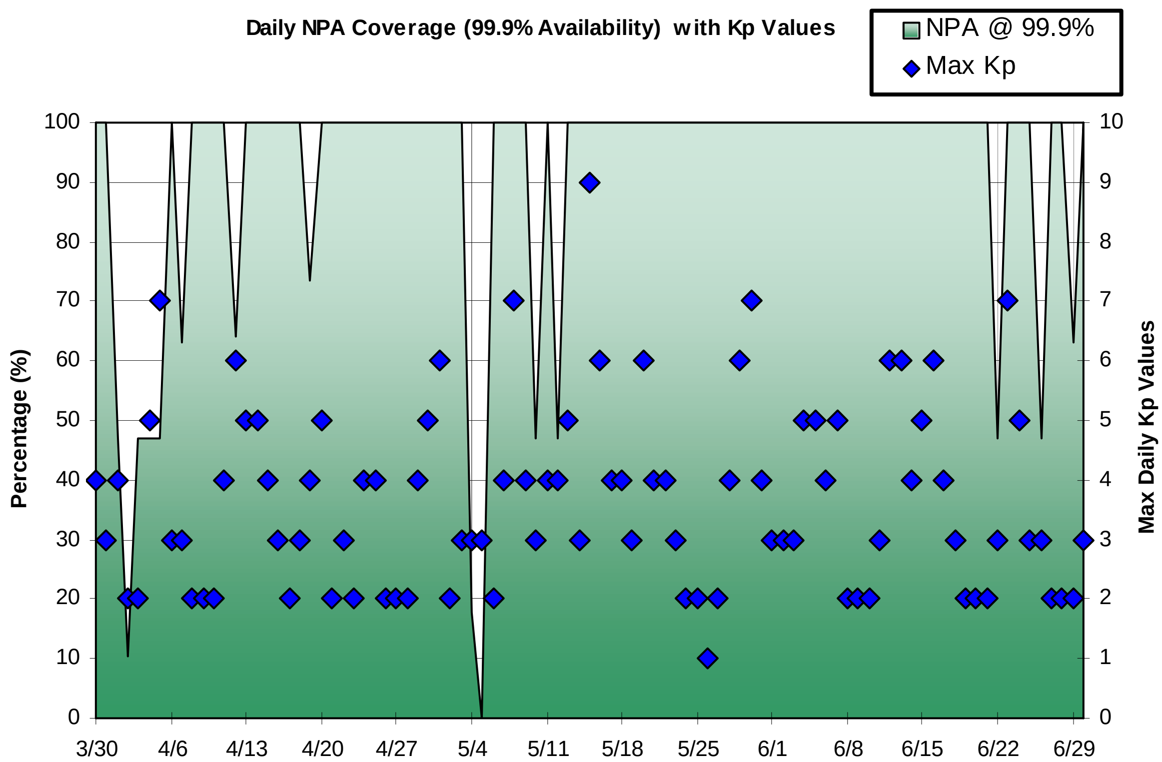


Figure 4-14 Daily NPA Coverage



5.0 INTEGRITY

5.1 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 5.1) 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 5-1 Safety Margin Index and HMI Statistics

Location	Safety Index		Number of HMIs
	Horizontal	Vertical	
Anderson	6.00	5.92	0
Atlantic City	5.00	4.85	0
Grand Forks	4.29	1.90	0
Greenwood	6.67	4.44	0
San Angelo	8.57	7.61	0
Albuquerque	6.00	5.33	0
Atlanta	5.45	5.33	0
Billings	3.75	4.44	0
Boston	3.75	3.81	0
Chicago	6.00	5.33	0
Cleveland	4.29	3.81	0
Dallas	4.29	3.33	0
Denver	5.45	4.10	0
Houston	8.57	3.81	0
Jacksonville	6.67	7.61	0
Kansas City	6.67	5.92	0
Los Angeles	7.50	5.92	0
Memphis	5.00	4.85	0
Miami	6.00	4.44	0
Minneapolis	4.62	4.44	0
New York	6.00	4.10	0
Oakland	10.00	4.44	0
Salt Lake City	5.45	5.33	0
Seattle	5.45	3.81	0
Washington DC	6.00	6.66	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 lowest safety margin index is 3.53 at Seattle. Also, Table 5.1 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. Since WAAS was made available to the public in August 2000 there has not been an HMI event. Note that the FAA commissioned WAAS for safety of life services in July 2003.

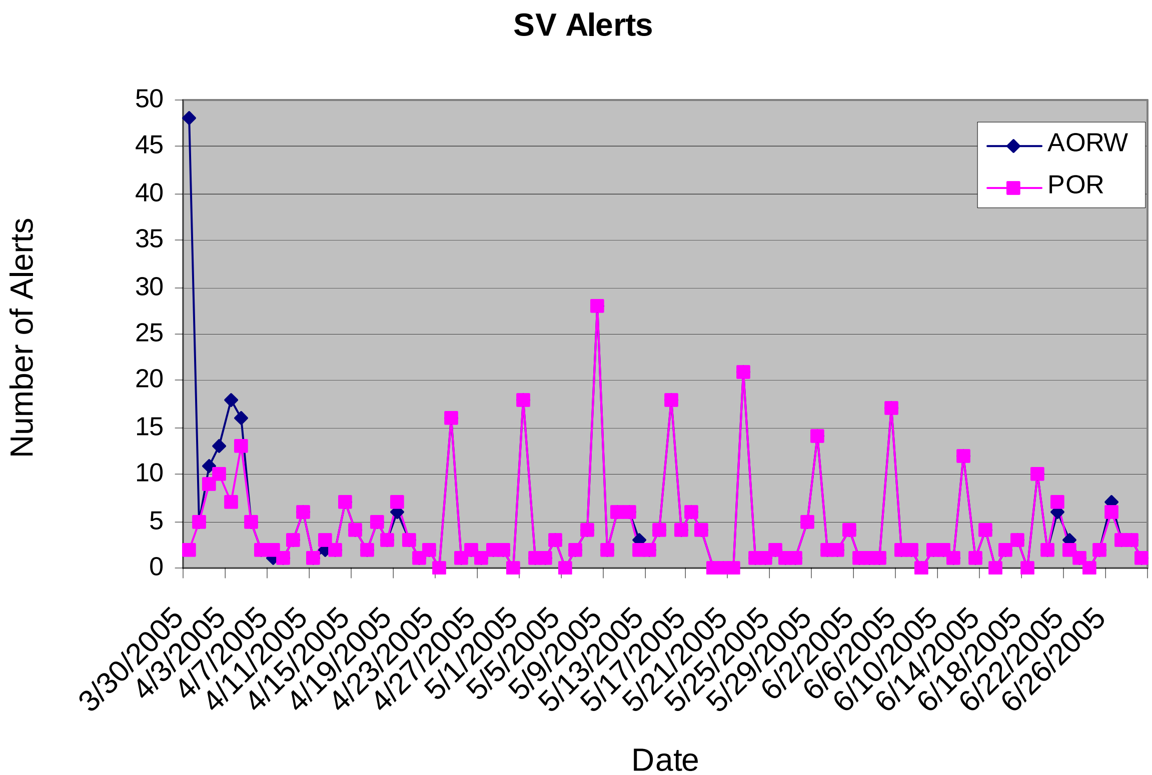
5.2 Broadcast Alerts

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. An increase in UDRE'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 a loss of continuity. Table 5.2 shows the total number of alerts and the average number of alerts per day. Figure 5.1 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.

Table 5-2 WAAS SV Alert

	Number of Alerts		Average Alerts Per Day	
Message Type	**AORW**	**POR**	**AORW**	**POR**
2	198	176	2.1290	1.8924
3	160	158	1.7204	1.6989
6	8	11	0.0860	0.1182
24	135	110	1.4516	1.1827
26	0	0	0	0
Total Alerts	501	455	5.3870	4.8924

Figure 5-1 SV Daily Alert Trends



5.3 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 5.3 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 5.4 to 5.8 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 5.9 to 5.13.

Table 5-3 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 5-4 WAAS Fast Correction and Degradation Message Rates - AORW

Message Type	**On Time**	**Late**	**Max Late Length (seconds)**
1	142327	0	0
2	1339366	232	30
3	1339273	238	25
7	75998	125	146
9	94160	1	171
10	76024	133	144
17	30315	4	485
24	1339177	247	28

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

SV	On Time	Late	Max Late Length (seconds)
1	41587	0	0
2	45176	0	0
3	46241	1	157
4	46013	0	0
5	46736	0	0
6	44578	1	178
7	40021	0	0
8	43247	0	0
9	47169	0	0
10	46308	0	0
11	48405	0	0
13	44494	0	0
14	45392	0	0
15	43292	0	0
16	47312	0	0
18	43601	1	170
19	46422	0	0
20	47120	0	0
21	37465	0	0
22	40389	0	0
23	44132	1	169
24	47577	0	0
25	47224	0	0
26	42920	0	0
27	32464	0	0
28	39657	0	0
29	45074	1	174
30	47790	0	0
31	4979	0	0

Table 5-6 WAAS Ephemeris Covariance Message Rates (Type 28) - AORW

SV	On Time	Late	Max Late Length (seconds)
1	39748	1	126
2	43046	0	0
3	44082	1	168
4	43531	1	175
5	44383	1	128
6	42029	0	0
7	37939	1	192
8	41321	0	0
9	44536	1	127
10	43792	0	0
11	45910	3	247
13	41895	3	163
14	42571	0	0
15	40907	0	0
16	44130	0	0
18	40860	1	121
19	42558	0	0
20	42887	3	192
21	34692	2	126
22	36841	1	122
23	39987	1	180
24	43222	2	154
25	42820	1	192
26	38986	6	176
27	30004	2	185
28	36595	3	217
29	41217	1	127
30	43438	0	0
31	4521	0	0
122	84855	0	0
134	73280	0	0

Table 5-7 WAAS Ionospheric Correction Message Rates (Type 26) - AORW

Band	Block	On Time	Late	Max Late Length (seconds)
0	0	27926	6	377
1	0	27916	4	369
1	1	27914	5	368
1	2	27919	4	356
1	3	27898	5	576
1	4	27899	5	339
2	0	27905	8	576
2	1	27916	6	456
2	2	27920	7	443
2	3	27929	5	434
2	4	27909	8	565
2	5	27912	6	372
3	0	27913	2	374

Table 5-8 WAAS Ionospheric Mask Message Rates (Type 18) - AORW

Band	On Time	Late	Max Late Length (seconds)
0	68896	0	0
1	68868	0	0
2	68869	0	0
3	68816	0	0

Table 5-9 WAAS Fast Correction and Degradation Message Rates - POR

Message Type	On Time	Late	Max Late Length (seconds)
1	141034	2	283
2	1338828	208	150
3	1338801	207	108
7	75371	120	295
9	94109	5	342
10	75414	96	213
17	30210	6	438
24	1338552	256	138

Table 5-10 WAAS Long Correction Message Rates (Type 24 and 25) - POR

SV	On Time	Late	Max Late Length (seconds)
1	41584	1	171
2	45127	2	174
3	46227	3	168
4	46006	0	0
5	46724	2	170
6	44538	2	256
7	40037	0	0
8	43213	1	341
9	47136	1	168
10	46284	2	258
11	48431	0	0
13	44474	1	157
14	45389	0	0
15	43241	2	258
16	47256	2	177
18	43563	1	174
19	46432	0	0
20	47126	2	166
21	37438	1	256
22	40328	2	340
23	44140	0	0
24	47565	0	0
25	47160	2	169
26	42875	3	341
27	32439	0	0
28	39654	0	0
29	45040	2	333
30	47746	2	258
31	4978	0	0

Table 5-11 WAAS Ephemeris Covariance Message Rates (Type 28) – POR

SV	On Time	Late	Max Late Length (seconds)
1	39747	2	192
2	43013	1	192
3	44061	0	0
4	43517	1	121
5	44380	0	0
6	41985	3	311
7	37918	4	185
8	41286	3	275
9	44523	1	150
10	43763	2	336
11	45907	2	147
13	41886	1	126
14	42565	1	192
15	40877	1	140
16	44072	4	349
18	40859	1	151
19	42573	1	155
20	42884	3	194
21	34666	4	384
22	36828	2	386
23	39999	1	192
24	43199	0	0
25	42788	3	193
26	38942	4	344
27	29981	1	205
28	36600	2	239
29	41164	2	288
30	43403	1	192
31	4514	0	0
122	84469	5	298
134	74153	1	177

Table 5-12 WAAS Ionospheric Correction Message Rates (Type 26) – POR

Band	Block	On Time	Late	Max Late Length (seconds)
0	0	27907	10	420
0	1	27913	6	576
0	2	27905	8	465
1	0	27900	10	499
1	1	27891	8	495
1	2	27894	9	499
1	3	27885	13	580
1	4	27890	13	576
2	0	27923	9	586
2	1	27874	11	544
2	2	27885	8	435
2	3	27916	8	576

Table 5-13 WAAS Ionospheric Mask Message Rates (Type 18) - POR

Band	On Time	Late	Max Late Length (seconds)
0	68493	0	0
1	68555	1	398
2	68608	1	355

6.0 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 twelve WAAS receivers during the quarter. Table 6.1 and 6.2 show the range error 95% index and 99.9% (3.29 sigma) bounding statistics for each SV at the selected locations. Figures 6.1 and 6.2 show the range error for each SV as measured by the WAAS receivers at the Washington DC reference station.

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 vertical ionospheric delay interpolated from the IGP's and GPS dual frequency measurement at that GPS satellite.

GPS satellite ionospheric errors were calculated for twelve WAAS receivers during the quarter. Table 6.3 and 6.4 show the ionospheric error 95% index and 99.9% (3.29 sigma) bounding statistics for each SV at the selected locations. Figures 6.3 and 6.4 show the ionospheric error for each SV as measured by the WAAS receiver at the Washington DC reference station.

Table 6-1 Range Error 95% index and 3.29 Sigma Bounding

Site →	Billings		Albuquerque		Boston		Washington DC		Houston		Kansas City	
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	95% Range Error	3.29 Sigma Bounding	95% Range Error	3.29 Sigma Bounding
1	1.450	100	1.487	100	1.262	100	1.772	100	1.267	100	2.000	100
2	2.653	100	3.756	99.8859	2.901	100	2.850	100	3.524	100	3.525	99.9561
3	1.442	100	1.201	100	1.570	100	1.896	100	1.684	100	1.978	100
4	2.056	100	1.805	100	1.899	100	2.157	100	2.051	100	2.011	100
5	1.417	100	1.301	99.9829	1.451	100	1.510	100	1.790	99.9065	1.731	100
6	2.084	100	2.068	100	1.890	100	2.301	100	1.428	100	2.531	100
7	1.221	100	1.159	100	1.426	100	1.449	100	1.463	100	1.535	100
8	1.523	100	1.160	100	1.674	100	1.755	100	1.325	100	1.998	100
9	1.601	100	1.502	100	1.580	100	1.988	100	1.733	100	1.803	100
10	1.348	100	1.888	99.9974	1.325	100	1.314	100	1.516	100	1.452	100
11	1.520	100	1.993	100	1.604	100	1.749	100	1.459	100	1.251	100
12	-	-	-	-	-	-	-	-	-	-	-	-
13	1.373	100	1.334	100	1.339	100	1.762	100	1.332	100	1.639	100
14	1.495	100	1.627	100	1.223	100	1.404	100	1.684	100	1.218	100
15	1.573	100	1.398	100	1.383	100	1.500	100	1.228	100	1.891	100
16	1.493	100	1.891	100	1.179	100	1.365	100	1.279	100	1.402	100
17	1.584	100	1.746	100	1.250	100	1.620	100	1.631	100	1.804	100
18	1.364	100	1.780	100	1.196	100	1.216	100	1.714	100	1.512	100
19	2.904	100	3.463	100	2.994	99.9899	2.713	99.9963	2.973	100	2.666	99.9999
20	1.657	99.9998	1.472	100	1.547	100	1.539	100	2.007	100	1.355	100
21	1.672	100	2.117	100	1.380	100	1.568	100	1.967	100	1.178	100
22	1.751	99.9999	1.613	100	1.425	100	1.530	100	2.033	100	1.381	100
23	3.176	99.6282	3.025	100	3.477	100	2.878	100	3.026	100	2.487	99.9999
24	2.187	100	1.695	100	1.651	100	2.155	100	2.194	100	2.242	100
25	1.303	100	1.352	100	1.228	100	1.554	100	1.827	100	1.941	100
26	2.029	100	2.108	100	1.889	100	2.426	100	2.425	100	2.082	100
27	1.610	100	1.221	100	1.364	100	1.637	100	1.269	100	1.849	100
28	1.496	100	1.652	100	1.630	100	1.706	100	1.734	100	1.291	100
29	1.566	100	2.131	100	1.510	100	2.158	100	1.408	100	1.952	100
30	2.098	100	1.504	99.9955	1.648	100	2.592	100	1.870	100	2.255	100
31	1.277	100	1.223	100	1.239	100	1.472	100	1.865	100	1.391	100
122	4.977	100	3.024	100	3.424	100	2.318	100	2.456	100	3.038	100
134	-	-	-	-	-	-	-	-	-	-	-	-

Table 6-2 Range Error 95% index and 3.29 Sigma Bounding

Site →	Los Angeles		Salt Lake City		Miami		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	95% Range Error	3.29 Sigma Bounding	95% Range Error	3.29 Sigma Bounding	95% Range Error	3.29 Sigma Bounding
1	1.629	100	1.383	100	1.349	100	1.892	99.9320	2.399	99.9388	1.611	100
2	2.529	100	3.414	99.9044	4.126	100	2.938	99.8416	3.705	99.4545	2.845	100
3	2.051	100	1.408	100	1.328	100	1.519	100	2.334	100	1.553	100
4	3.154	100	2.154	100	1.712	100	1.987	100	2.424	100	2.097	100
5	2.012	99.9594	1.717	100	1.699	100	1.504	100	1.927	100	1.252	100
6	3.195	99.9300	1.400	100	1.661	100	2.239	100	2.589	100	1.963	100
7	2.249	100	1.184	100	1.729	100	1.197	100	1.761	100	1.538	100
8	1.803	100	1.061	100	1.264	100	2.098	100	1.959	100	1.388	100
9	3.322	99.9546	1.668	100	1.151	100	1.634	100	2.326	99.9448	1.967	100
10	1.699	100	1.471	100	1.696	100	1.484	100	1.762	100	1.320	100
11	1.529	100	1.248	100	1.929	100	1.456	99.9982	2.051	100	1.467	100
12	-	-	-	-	-	-	-	-	-	-	-	-
13	1.611	100	1.111	100	1.532	100	1.882	100	1.936	100	1.487	100
14	1.426	100	1.056	100	1.666	100	1.209	100	1.853	100	1.247	100
15	1.639	100	0.911	100	1.485	100	1.937	100	1.916	100	1.420	100
16	1.613	100	1.350	100	1.959	100	1.743	99.9802	1.950	100	1.192	100
17	2.744	100	1.317	100	1.491	100	1.490	100	1.939	99.9779	1.520	100
18	1.386	100	1.235	100	2.083	100	1.096	100	1.722	100	1.473	100
19	2.485	100	2.413	100	3.192	100	2.431	100	3.094	99.9997	2.560	100
20	1.577	100	1.587	100	2.149	100	1.684	99.9935	1.846	100	1.508	100
21	1.601	100	1.461	100	2.138	100	1.154	100	1.829	100	1.710	100
22	1.658	100	1.410	100	2.283	100	1.155	100	1.843	100	1.352	100
23	2.709	100	2.463	100	3.070	100	2.422	100	3.062	99.9479	2.719	100
24	3.380	100	1.862	100	1.433	100	1.999	100	2.553	99.9554	1.949	100
25	1.647	100	1.501	100	1.230	100	1.683	99.8706	2.213	99.9851	1.672	100
26	2.183	100	2.224	100	1.221	100	2.443	100	2.567	99.9935	2.152	100
27	1.972	100	1.650	100	1.459	100	1.739	100	2.243	100	1.532	100
28	1.593	100	1.244	100	1.996	100	1.169	99.9999	1.854	100	1.436	100
29	2.263	100	1.662	100	1.100	100	2.077	100	2.449	99.9947	1.972	100
30	2.481	99.7897	2.047	100	1.509	100	2.325	100	2.674	99.9477	2.095	100
31	1.946	100	1.386	100	2.087	100	1.369	99.9979	1.842	100	1.476	100
122	4.002	100	4.126	100	2.945	100	4.987	100	3.991	100	-	-
134	5.241	100	5.532	100	-	-	-	-	-	-	3.754	100

Table 6-3 Ionospheric Error 95% index and 3.29 Sigma Bounding

Site →	Billings		Albuquerque		Boston		Washington DC		Houston		Kansas City	
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	95% Iono Error	3.29 Sigma Bounding	95% Iono Error	3.29 Sigma Bounding
1	0.707	100	0.722	100	0.692	100	1.158	100	0.643	100	1.189	100
2	2.657	100	3.003	100	2.395	100	2.290	100	2.498	100	2.575	100
3	0.560	100	0.586	100	0.729	100	1.034	100	0.873	100	1.121	100
4	0.992	100	1.096	100	1.215	100	1.636	100	1.415	100	1.423	100
5	0.505	100	0.609	100	0.762	100	0.810	100	0.852	100	0.844	100
6	0.747	100	0.987	100	0.978	100	1.354	100	0.873	100	1.579	100
7	0.593	100	0.665	100	0.625	100	0.969	100	0.893	100	0.940	100
8	0.708	100	0.586	100	0.722	100	1.092	100	0.829	100	1.298	100
9	0.653	100	0.667	100	0.851	100	1.127	100	0.869	100	0.988	100
10	0.742	100	1.189	100	0.891	100	0.959	100	1.094	100	0.709	100
11	0.750	100	1.061	100	0.566	100	0.756	100	0.746	100	0.571	100
12	-	-	-	-	-	-	-	-	-	-	-	-
13	0.495	100	0.535	100	0.626	100	1.088	100	0.626	100	0.896	100
14	0.912	100	1.274	100	0.806	100	0.953	100	1.038	100	0.675	100
15	0.456	100	0.877	100	0.704	100	0.997	100	0.550	100	1.112	100
16	0.589	100	1.186	100	0.534	100	0.882	100	0.809	100	0.765	100
17	0.752	100	0.975	100	0.772	100	1.081	100	1.144	100	1.106	100
18	0.818	100	1.308	100	0.936	100	0.895	100	0.964	100	0.881	100
19	1.864	100	2.234	100	1.755	100	1.695	100	2.114	100	1.598	100
20	0.814	100	0.935	100	0.910	100	0.782	100	1.123	100	0.598	100
21	1.137	100	1.399	100	1.070	100	1.154	100	1.407	100	0.849	100
22	1.131	100	1.320	100	1.028	100	1.038	100	1.311	100	0.803	100
23	2.119	100	2.458	100	2.481	100	2.190	100	2.417	100	1.651	100
24	1.257	100	1.027	100	1.302	100	1.562	100	1.422	100	1.596	100
25	0.671	100	0.681	100	0.670	100	1.059	100	1.153	100	1.126	100
26	0.885	100	1.151	100	1.020	100	1.445	100	1.397	100	1.338	100
27	0.966	100	0.601	100	0.630	100	1.027	100	0.701	100	1.204	100
28	0.823	100	0.971	100	0.826	100	1.040	100	1.364	100	0.688	100
29	0.596	100	1.015	100	0.784	100	1.219	100	0.665	100	1.230	100
30	0.864	100	0.667	100	0.871	100	1.335	100	0.776	100	1.129	100
31	0.619	100	0.650	100	0.668	100	0.923	100	1.223	100	0.739	100

Table 6-4 Ionospheric Error 95% index and 3.29 Sigma Bounding

Site →	Los Angeles		Salt Lake City		Miami		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	95% Iono Error	3.29 Sigma Bounding	95% Iono Error	3.29 Sigma Bounding	95% Iono Error	3.29 Sigma Bounding
1	1.236	100	0.711	100	0.863	100	0.786	100	1.590	100	0.785	100
2	1.941	100	2.365	100	2.554	100	2.404	100	2.416	100	2.266	100
3	0.993	100	0.620	100	0.683	100	0.593	100	1.351	100	0.924	100
4	1.738	100	1.270	100	0.974	100	1.024	100	1.654	100	1.151	100
5	0.648	100	0.671	100	0.748	100	0.556	100	1.167	100	0.648	100
6	1.541	100	0.824	100	0.895	100	1.190	100	1.587	100	1.089	100
7	1.306	100	0.595	100	0.766	100	0.585	100	1.015	100	0.888	100
8	0.973	100	0.579	100	0.679	100	0.872	100	1.301	100	0.736	100
9	1.197	100	0.726	100	0.698	100	0.742	100	1.459	100	0.937	100
10	0.650	100	0.605	100	0.771	100	0.782	100	1.033	100	0.834	100
11	0.596	100	0.457	100	0.899	100	0.785	100	1.012	100	0.948	100
12	-	-	-	-	-	-	-	-	-	-	-	-
13	1.000	100	0.406	100	0.782	100	0.698	100	1.107	100	0.835	100
14	0.597	100	0.602	100	0.885	100	0.778	100	1.236	100	1.055	100
15	0.931	100	0.397	100	0.619	100	0.716	100	1.283	100	0.824	100
16	0.705	100	0.588	100	0.948	100	0.629	100	1.131	100	0.735	100
17	1.338	100	0.765	100	0.750	100	0.836	100	1.452	100	1.006	100
18	0.625	100	0.634	100	1.046	100	0.809	100	1.124	100	1.112	100
19	1.176	100	1.554	100	1.882	100	1.762	100	1.890	100	1.888	100
20	0.586	100	0.860	100	1.211	100	0.803	100	1.038	100	1.060	100
21	0.516	100	0.832	100	1.347	100	1.040	100	1.297	100	1.313	100
22	0.529	100	0.835	100	1.374	100	0.997	100	1.252	100	1.309	100
23	1.555	100	1.912	100	2.335	100	2.022	100	2.257	100	2.188	100
24	1.792	100	1.189	100	1.101	100	1.222	100	1.854	100	1.190	100
25	1.137	100	0.761	100	0.901	100	0.623	100	1.447	100	0.993	100
26	1.035	100	1.093	100	0.848	100	1.054	100	1.680	100	1.046	100
27	1.279	100	0.949	100	0.798	100	0.579	100	1.535	100	0.812	100
28	0.616	100	0.596	100	1.104	100	0.747	100	1.081	100	0.934	100
29	0.955	100	0.841	100	0.665	100	0.841	100	1.490	100	0.930	100
30	1.199	100	1.008	100	0.825	100	1.077	100	1.515	100	1.041	100
31	0.957	100	0.665	100	1.133	100	0.671	100	0.979	100	0.842	100

Figure 6-1 95% Range Error (SV 1 --SV 16) - Washington, DC

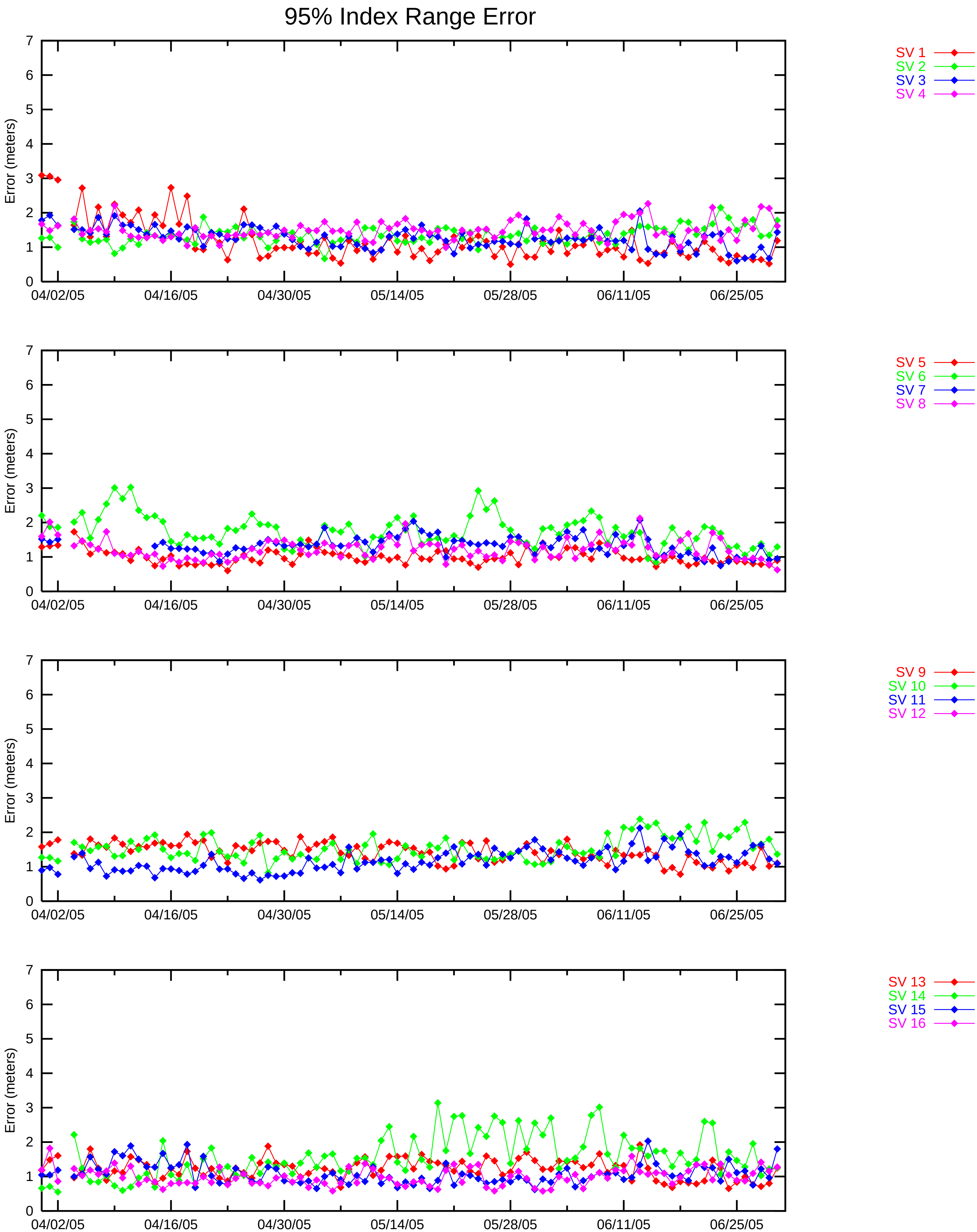


Figure 6-2 95% Range Error (SV 17 --SV 31 and SV 122) - Washington, DC

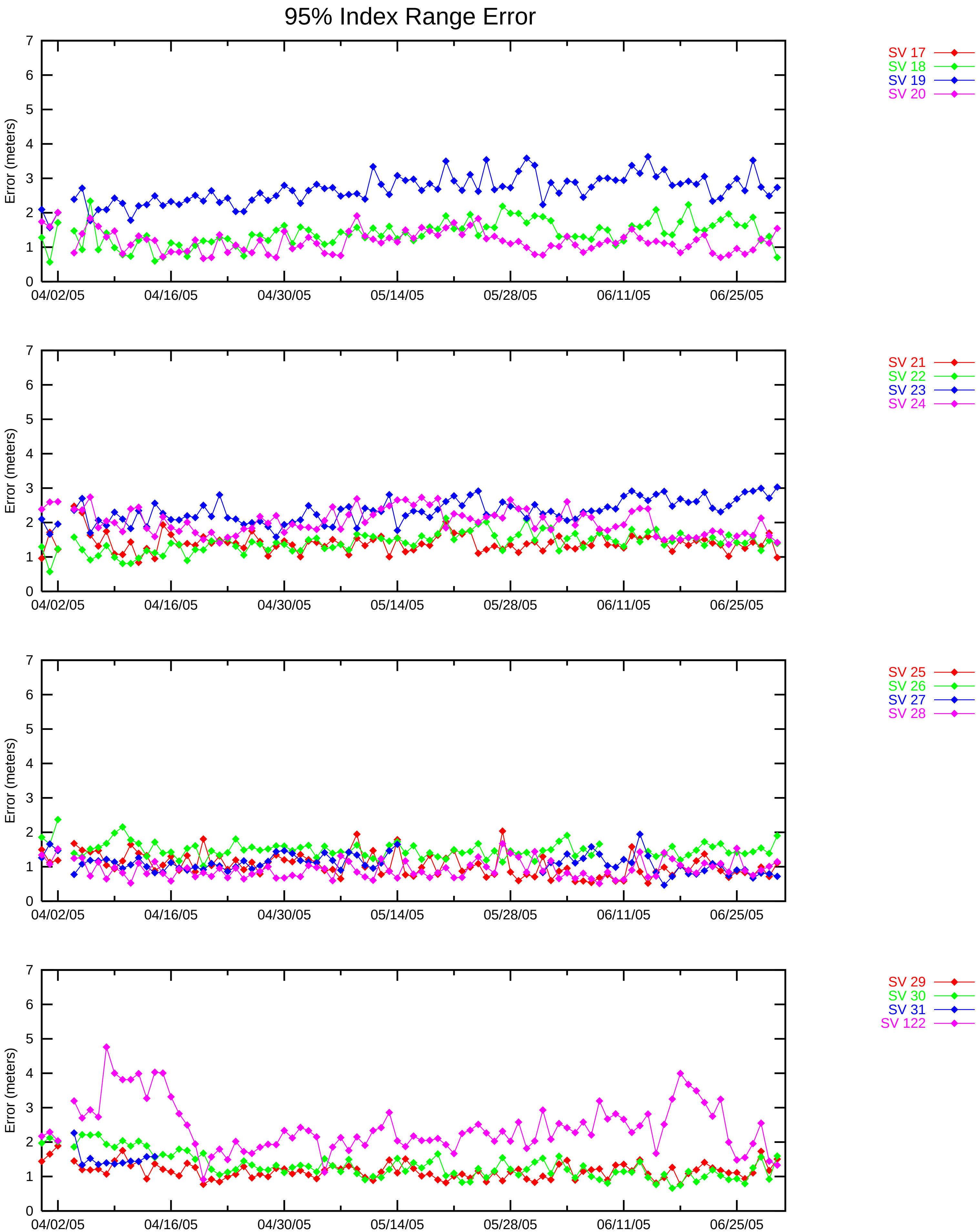


Figure 6-3 95% Ionospheric Error (SV 1 --SV 16) - Washington, DC

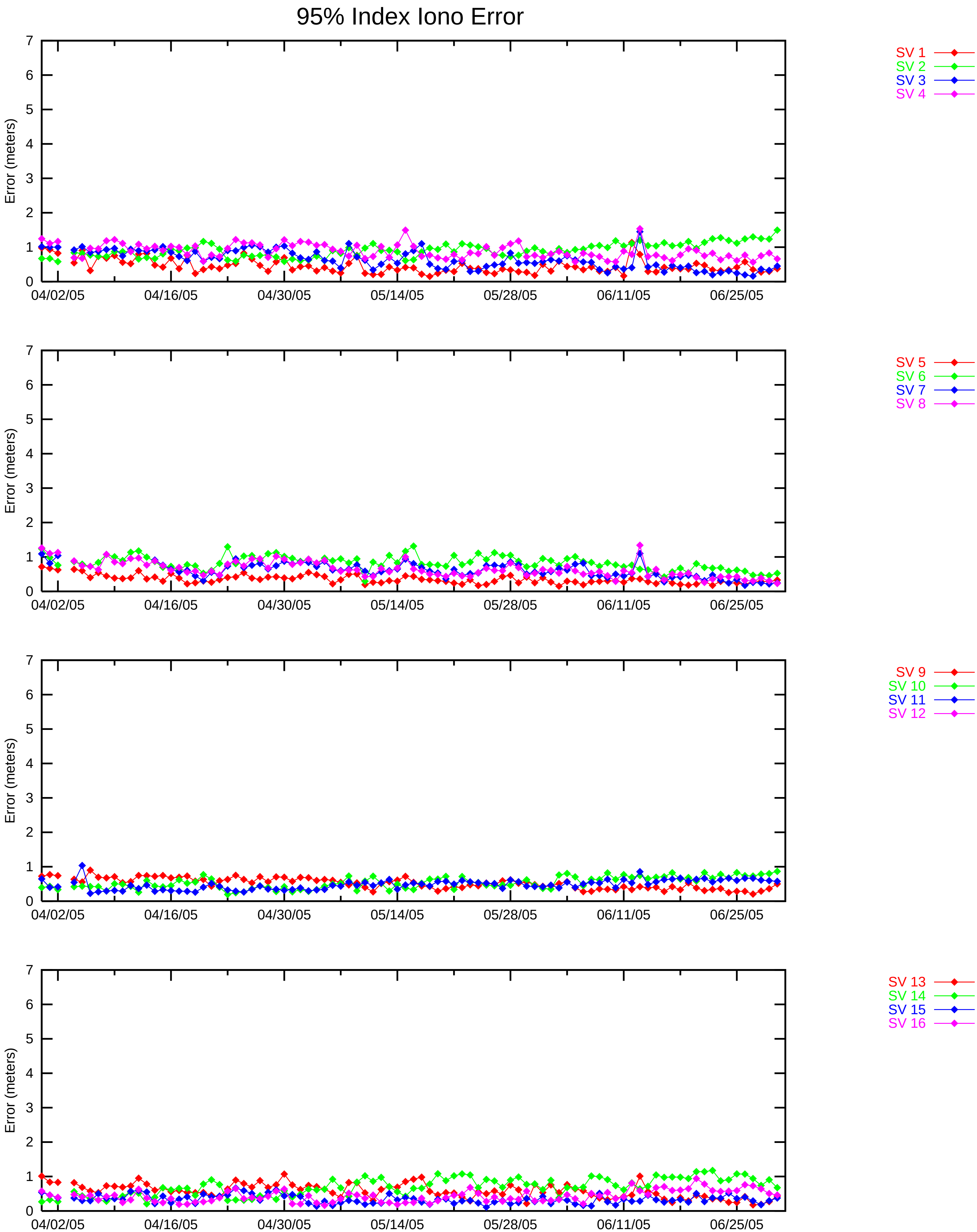
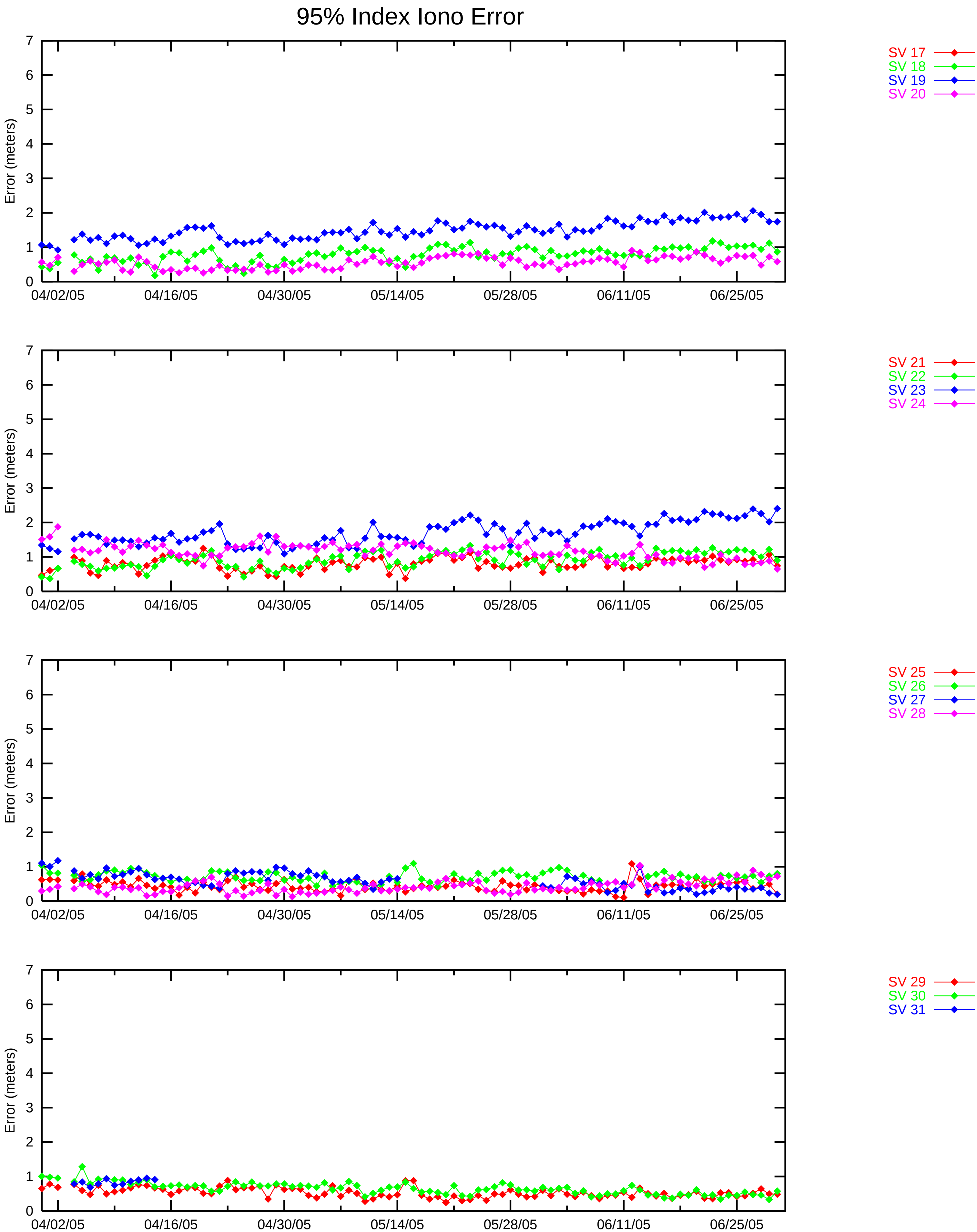


Figure 6-4 95% Ionospheric Error (SV 17 --SV 31) - Washington, DC



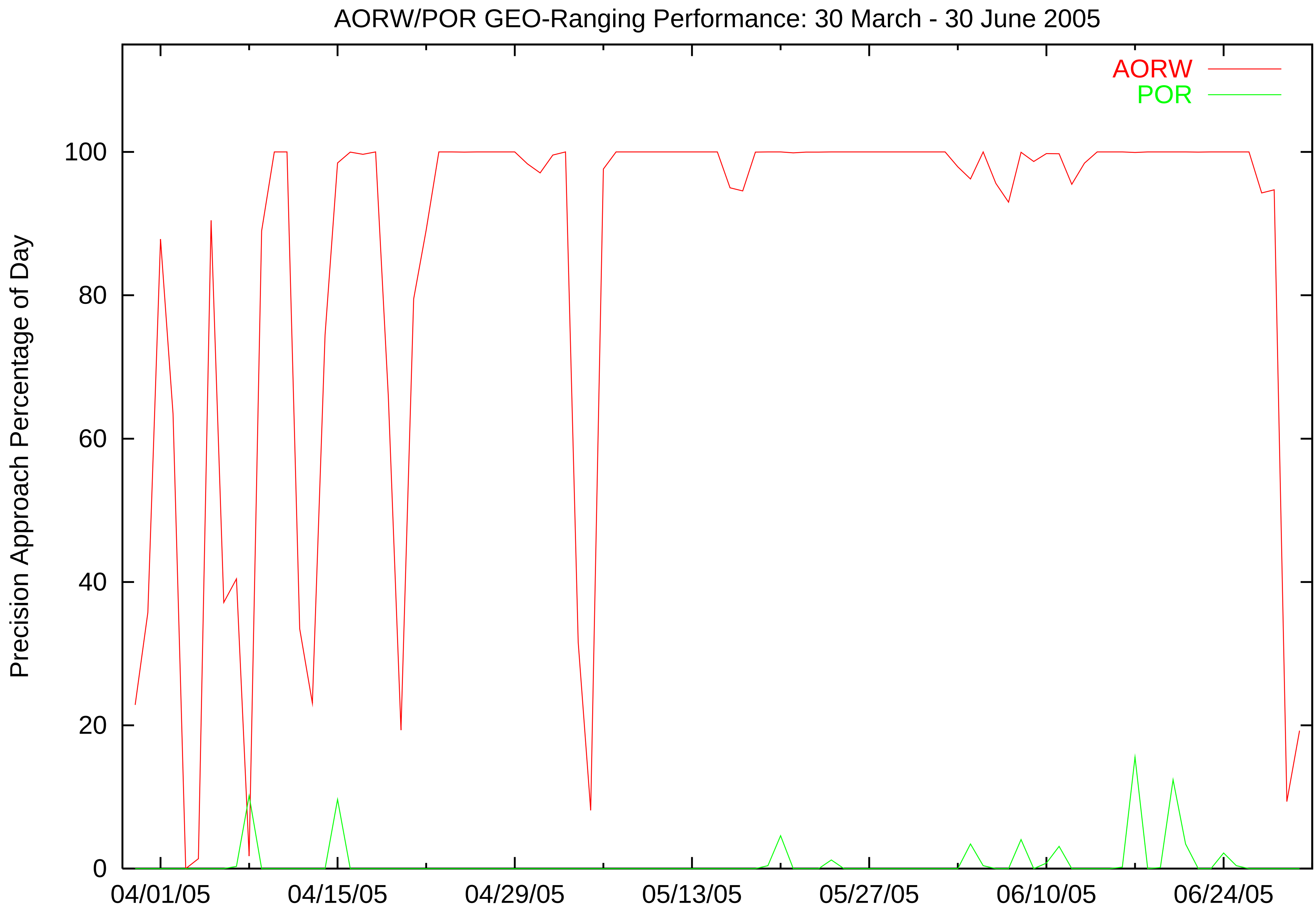
7.0 GEO RANGING PERFORMANCE

Table 7.1 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 85.670% and 0.779%, respectively. Figure 7.1 shows the trend of PA Ranging Availability for the AORW and POR satellite. The percentage of time the AOR-W GEO was available for PA ranging is lower this quarter than expected. The reason is thread switching by key WRSs and poor WRS receiver performance. 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 7-1 GEO Ranging Availability

GEO	PA (%)	NPA (%)	Not Monitored (%)	Do Not Use (%)
AORW	85.670	13.496	0.253	0.579
POR	0.779	85.041	10.828	3.350

Figure 7-1 Daily PA GEO Ranging Availability Trend



8.0 WAAS PROBLEM SUMMARY

Test events for this quarter are summarized in Table 1.4.

9.0 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 10/3/04 to 1/1/05 of WAAS operation is presented in Table 9.1. Figures 9.1 and 9.2 provide a graphical representation of WAAS LPV service availability and outage counts for the same period, respectively.

Table 9-1 WAAS LPV Outages and Availability

Airport Id	Airport Name	City	State	Outages	Availability
YEG	EDMONTON INTL	EDMONTON	AB	183	0.984854
CGA	CRAIG	CRAIG	AK	328	0.977397
HYD	HKDER	HKDER	AK	285	0.980448
JNU	JUNEAU INTL AIRPORT	JUNEAU	AK	761	0.919707
KTN	KETCHIKAN AIRPORT	KETCHIKAN	AK	273	0.980819
PEC	PELICAN	PELICAN	AK	752	0.919035
PSG	PETERSBURG MUNICIPAL	PETERSBURG	AK	442	0.970146
SIT	SITKA AIRPORT	SITKA	AK	600	0.954419
EET	SHELBY COUNTY	ALABASTER	AL	36	0.997821
79J	ANDALUSIA-OPP	ANDALUSIA/OP	AL	38	0.997716
KBHM	BIRMINGHAM INTL	BIRMINGHAM	AL	36	0.997897
KDHN	DOTHAN REGIONAL	DOTHAN	AL	38	0.997382
HSV	HUNTSVILLE INTL – CARL T JONES FIELD	HUNTSVILLE	AL	35	0.997681
MOB	MOBILE REGIONAL	MOBILE	AL	30	0.998276
MGM	MONTGOMERY REGIONAL/ DANNELLY FIELD	MONTGOMERY	AL	37	0.997774
MSL	MUSCLE SHOALS NORTWEST ALABAMA REG	SHEFFIELD	AL	34	0.997974
M73	ALMYRA	ALMYRA	AR	20	0.998833
KVBT	BENTONVILLE MUNICIPAL/ LM THADDEN FLD	BENTONVILLE	AR	25	0.998728
BYH	BLYTHEVILLE	BLYTHEVILLE	AR	22	0.998567
CDH	HARRELL FIELD	CAMDEN	AR	22	0.998797
KXNA	NORTHWEST ARKANSAS RGNL	FAYETTEVILLE/ SPRINGDALE/ROGERS	AR	24	0.998747
KFSM	FORT SMITH REGIONAL	FORT SMITH	AR	23	0.998999
HRO	BOONE COUNTY AIRPORT	HARRISON	AR	21	0.998907
LIT	ADAMS FIELD	LITTLE ROCK	AR	21	0.998929
SRC	SEARCY MUNICIPAL	SEARCY	AR	19	0.998919
ASG	SPRINGDALE MUNICIPAL	SPRINGDALE	AR	24	0.998821

KARG	WALNUT RIDGE REGIONAL	WALNUT RIDGE	AR	23	0.998667
IFP	LAUGHLIN/BULLHEAD INTL	BULLHEAD CITY	AZ	65	0.993139
KGCN	GRAND CANYON NATL PARK	GRAND CANYON	AZ	59	0.995737
KPHX	PHOENIX SKY HARBOR INTL	PHOENIX	AZ	103	0.989588
KPRC	ERNEST A LOVE FIELD	PRESCOTT	AZ	61	0.994446
KTUS	TUCSON INTL	TUCSON	AZ	161	0.978325
RQE	WINDOW ROCK	WINDOW ROCK	AZ	48	0.998052
BFL	BAKERSFIELD/MEADOWS FIELD	BAKERSFIELD	CA	149	0.990963
KCRQ	MC CLELLAN-PALOMAR	CARLSBAD	CA	339	0.941788
O60	CLOVERDALE MUNICIPAL	CLOVERDALE	CA	110	0.992143
KDAG	BARSTOW-DAGGETT	DAGGETT	CA	127	0.988911
IYK	INYOKERN	INYOKERN	CA	62	0.995846
KLAX	LOS ANGELES INTL	LOS ANGELES	CA	283	0.965261
KOAK	METROPOLITAN OAKLAND INTL	OAKLAND	CA	121	0.991025
ONT	ONTARIO INTL	ONTARIO	CA	224	0.969798
KPMD	PALMDALE PROD FLT/ TEST INSTLN	PALMDALE	CA	244	0.982691
KMHR	SACRAMENTO MATHER	SACRAMENTO	CA	69	0.995254
KSMF	SACRAMENTO INTL	SACRAMENTO	CA	75	0.995026
SAN	SAN DIEGO INTL – LINDBERGH FIELD	SAN DIEGO	CA	351	0.928547
KSFO	SAN FRANCISCO INTL	SAN FRANCISCO	CA	135	0.990389
SJC	SAN JOSE INTL	SAN JOSE	CA	124	0.991075
SVE	SUSANVILLE MUNICIPAL	SUSANVILLE	CA	49	0.997149
TNP	TWENTYNINE PALMS	TWENTYNINE PALMS	CA	152	0.978797
AKO	AKRON- COLORADO PLAINS REGIONAL	AKRON	CO	23	0.998005
COS	COLORADO SPRINGS	COLORADO SPRINGS	CO	25	0.998004
CEZ	CORTEZ MUNICIPAL	CORTEZ	CO	48	0.998264
KDEN	DENVER INTL	DENVER	CO	23	0.997642
HDN	YAMPA VALLEY	HAYDEN	CO	23	0.997625
LHX	LA JUNTA MUNICIPAL	LA JUNTA	CO	24	0.998120
LAA	LAMAR MUNICIPAL	LAMAR	CO	22	0.998349
2V2	VANCE BRAND	LONGMONT	CO	23	0.997603
EEO	MEEKER	MEEKER	CO	24	0.997688
TAD	PERRY STOKES	TRINIDAD	CO	25	0.998345
2V5	WRAY	WRAY	CO	21	0.998376
KBDL	BRADLEY INTL	WINDSOR LOCKS	CT	197	0.984122
KDCA	RONALD REAGAN WASHINGTON INTL	WASHINGTON	DC	29	0.997938
KIAD	WASHINGTON DULLES INTL	WASHINGTON	DC	28	0.997978
KFLL	FORT LAUDERDALE/ HOLLYWOOD INTL	FORT LAUDERDALE	FL	175	0.986654
FXE	FORT LAUDERDALE EXECUTIVE AIRPORT	FORT LAUDERDALE	FL	169	0.987096
KRSW	SOUTHWEST FLORIDA INTL	FORT MYERS	FL	74	0.993444
KGNV	GAINESVILLE REGIONAL	GAINESVILLE	FL	41	0.997398
KJAX	JACKSONVILLE INTL	JACKSONVILLE	FL	40	0.997993
KMIA	MIAMI INTL	MIAMI	FL	185	0.985295
KAPF	NAPLES MUNICIPAL	NAPLES	FL	87	0.992347
KOCF	OCALA INTL-JIM TAYLOR FLD	OCALA	FL	45	0.997084
KMCO	ORLANDO INTL	ORLANDO	FL	48	0.996811
KPFN	PANAMA CITY-BAY COUNTY INTL	PANAMA CITY	FL	38	0.997472
KPNS	PENSACOLA REGIONAL	PENSACOLA	FL	39	0.997854

SRQ	SARASOTA/BRADENTON INTL	SARASOTA/BRADENTON	FL	73	0.994552
KPIE	ST PETERSBURG – CLEARWATER INTL	ST. PETERSBURG-CLEARWATER	FL	64	0.995550
KTLH	TALLAHASSEE REGIONAL	TALLAHASSEE	FL	39	0.997440
TPA	TAMPA INTL	TAMPA	FL	62	0.995687
KVRB	VERO BEACH MUNICIPAL	VERO BEACH	FL	82	0.993800
KPBI	PALM BEACH INTL	WEST PALM BEACH	FL	146	0.989057
KACJ	SOUTHER FIELD	AMERICUS	GA	35	0.997245
KATL	WILLIAM B HARTSFIELD ATLANTA INTL	ATLANTA	GA	35	0.997044
KSAV	SAVANNAH INTL	SAVANNAH	GA	29	0.998897
KTBR	STATESBORO-BULLOCH COUNTY	STATESBORO	GA	34	0.998639
KIKV	ANKENY REGIONAL	ANKENY	IA	22	0.998040
CID	THE EASTERN IOWA	CEDAR RAPIDS	IA	38	0.997382
DSM	DES MOINES INTL	DES MOINES	IA	21	0.998088
KMXO	MONTICELLO REGIONAL	MONTICELLO	IA	38	0.997097
KBOI	BOISE AIR TERMINAL/ GOWEN FLD	BOISE	ID	24	0.998309
EUL	CALDWELL INDUSTRIAL	CALDWELL	ID	24	0.998295
SUN	FRIEDMAN MEMORIAL	HAILEY	ID	17	0.998256
PIH	POCATELLO REGIONAL	POCATELLO	ID	16	0.998331
SZT	SANDPOINT	SANDPOINT	ID	21	0.997515
KENL	CENTRALIA MUNICIPAL	CENTRALIA	IL	33	0.997460
KORD	CHICAGO-O'HARE INTL	CHICAGO	IL	35	0.996011
MDW	CHICAGO MIDWAY	CHICAGO	IL	35	0.995982
KARR	AURORA MUNICIPAL	CHICAGO/AURORA	IL	35	0.996206
KFOA	FLORA MUNICIPAL	FLORA	IL	34	0.997147
MLI	QUAD-CITY	MOLINE	IL	37	0.997021
KPIA	GREATER PEORIA REGIONAL	PEORIA	IL	37	0.997071
KPPQ	PITTSFIELD PENSTONE MUNICIPAL	PITTSFIELD	IL	35	0.997985
KTIP	RANTOUL NATL AVN CTR/ FRANK ELLIOT FLD	RANTOUL	IL	34	0.996456
KRFD	GREATER ROCKFORD	ROCKFORD	IL	37	0.996297
KSLO	SALEM-LECKRONE	SALEM	IL	33	0.997395
3CK	LAKE IN THE HILLS	UNKNOWN	IL	35	0.996051
KANQ	TRI-STATE STEUBEN COUNTY	ANGOLA	IN	33	0.995996
KBMG	MONROE COUNTY	BLOOMINGTON	IN	33	0.996278
0I2	BRAZIL CLAY COUNTY	BRAZIL	IN	33	0.996404
CEV	METTEL FIELD	CONNERSVILLE	IN	34	0.996064
FWA	FORT WAYNE INTL	FORT WAYNE	IN	33	0.996061
KIND	INDIANAPOLIS INTL	INDIANAPOLIS	IN	34	0.996146
SER	FREEMAN MUNICIPAL	SEYMOUR	IN	33	0.996258
SBN	MICHIANA REGIONAL TRANSPORTATION CENTER	SOUTH BEND	IN	33	0.995952
KCBK	SHALTZ FIELD	COLBY	KS	24	0.998413
EHA	ELKHART-MORTON COUNTY	ELKHART	KS	22	0.998391
GLD	RENNER FIELD/ GOODLAND MUNICIPAL	GOODLAND	KS	23	0.998517
KHYS	HAYS REGIONAL	HAYS	KS	24	0.998150
LWC	LAWRENCE MUNICIPAL	LAWRENCE	KS	23	0.998076
KMHK	MANHATTAN REGIONAL	MANHATTAN	KS	22	0.998260
KOJC	JOHNSON COUNTY EXECUTIVE	OLATHE	KS	23	0.998223
TOP	PHILIP BILLARD MUNICIPAL	TOPEKA	KS	23	0.998079

KULS	ULYSSES	ULYSSES	KS	21	0.998440
ICT	WICHITA MID-CONTINENT	WICHITA	KS	24	0.998228
KWLD	STROTHER FIELD	WINFIELD/ARKANSAS CITY	KS	24	0.998397
KCVG	CINCINNATI/NORTHERN KY INTL	COVINGTON/CINCINNATI	KY	35	0.996052
KLEX	BLUE GRASS	LEXINGTON	KY	34	0.996200
LOZ	LONDON	LONDON	KY	34	0.996532
SDF	LOUISVILLE INTL – STANDIFORD FLD	LOUISVILLE	KY	33	0.996259
KK22	BIG SANDY REGIONAL	PRESTONBURG	KY	36	0.997543
SME	SOMERSET-PULASKI COUNTY	SOMERSET	KY	34	0.996368
KAEX	ALEXANDRIA INTL	ALEXANDRIA	LA	25	0.998559
DRI	DE RIDDER/ BEAUREGARD PAIRISH APT	BEAUREGARD	LA	26	0.998527
LCH	LAKE CHARLES REGIONAL	LAKE CHARLES	LA	30	0.998334
L39	LEESVILLE	LEESVILLE	LA	25	0.998551
MSY	NEW ORLEANS INTL/ MOISANT FIELD	NEW ORLEANS	LA	29	0.998291
SHV	SHREVEPORT REGIONAL	SHREVEPORT	LA	24	0.998754
KBOS	GEN EDWARD LAWRENCE LOGAN INTL	BOSTON	MA	282	0.954794
MVY	VINEYARD HAVEN	MARTHA'S VINEYARD	MA	276	0.969111
OWD	NORWOOD MEMORIAL	NORWOOD	MA	282	0.962356
KPVC	PROVINCETOWN MUNICIPAL	PROVINCETOWN	MA	296	0.948662
YWG	WINNIPEG AIRPORT	WINNIPEG	MB	195	0.962365
KBWI	BALTIMORE-WASHINGTON INTL	BALTIMORE	MD	30	0.997627
FDK	FREDERICK MUNICIPAL	FREDERICK	MD	29	0.997865
GAI	MONTGOMERY COUNTY AIRPARK	GAITHERSBURG	MD	30	0.997861
W00	FREEWAY	MITCHELLVILLE	MD	29	0.997815
RJD	RIDGELY AIRPARK	RIDGELY	MD	31	0.997540
DMW	CARROLL CNTY REGIONAL/ JACK B. POAGE FLD	WESTMINSTER	MD	29	0.997832
PWM	PORTLAND INTL JETPORT	PORTLAND	ME	301	0.936079
KPQI	N MAINE REGIONAL ARPT AT PRESQUE I	PRESQUE ISLE	ME	786	0.805061
AMN	ALMA/GRATIOT COMMUNITY	ALMA	MI	36	0.996072
KARB	ANN ARBOR MUNICIPAL	ANN ARBOR	MI	35	0.996351
Y15	CHEBOYGAN COUNTY	CHEBOYGAN	MI	166	0.982621
KDTW	DETROIT METROPOLITAN WAYNE CTY	DETROIT	MI	35	0.996613
KFNT	BISHOP INTL	FLINT	MI	35	0.996244
KGRR	GERALD R FORD INTL	GRAND RAPIDS	MI	35	0.996081
KCMX	HOUGHTON COUNTY MEMORIAL	HANCOCK	MI	244	0.967154
BIV	TULIP CITY	HOLLAND	MI	36	0.996066
HTL	ROSCOMMON COUNTY	HOUGHTON LAKE	MI	53	0.995640
KMKG	MUSKEGON COUNTY	MUSKEGON	MI	37	0.996163
5D3	OWOSSO COMMUNITY	OWOSSO	MI	35	0.996150
KMBS	MBS INTL	SAGINAW	MI	39	0.995943
CIU	CHIPPEWA COUNTY INTL	SAULT STE. MARIE	MI	178	0.977255
HAI	THREE RIVERS MUNICIPAL DR. HAINES	UNKNOWN	MI	33	0.995964
HYX	SAGINAW CO H.W. BROWNE	UNKNOWN	MI	38	0.996016
KAXN	CHANDLER FIELD	ALEXANDRIA	MN	67	0.994435
KBDE	BAUDETTE INTL	BAUDETTE	MN	185	0.970220

KBRD	BRAINERD – CROW WING CO REGIONAL	BRAINERD	MN	119	0.989368
KDLH	DULUTH INTL	DULUTH	MN	141	0.981748
KMSP	MINNEAPOLIS-ST PAUL INTL/ WOLD CHAMBERLAIN	MINNEAPOLIS	MN	44	0.996713
KRGK	RED WING REGIONAL	RED WING	MN	40	0.996844
KRST	ROCHESTER INTL	ROCHESTER	MN	37	0.997351
STC	ST. CLOUD	SAINT CLOUD	MN	59	0.996376
KJYG	ST JAMES MUNICIPAL	ST JAMES	MN	25	0.998051
M05	CARUTHERSVILLE MEMORIAL	CARUTHERSVILLE	MO	29	0.998360
KMCI	KANSAS CITY INTL	KANSAS CITY	MO	21	0.997982
KLBO	FLOYD W JONES LEBANON	LEBANON	MO	24	0.998313
LXT	LEE'S SUMMIT MUNICIPAL	LEE'S SUMMIT	MO	24	0.998068
H41	MEXICO MEMORIAL	MEXICO	MO	21	0.998374
MYJ	MEXICO MEMORIAL	MEXICO	MO	21	0.998374
STJ	ROSECRANS MEMORIAL	ROSECRANS	MO	22	0.997955
KDMO	SEDALIA MEMORIAL	SEDALIA	MO	26	0.998153
SGF	SPRINGFIELD- BRANSON REGIONAL	SPRINGFIELD	MO	25	0.998533
KSTL	LAMBERT-ST LOUIS INTL	ST LOUIS	MO	34	0.998081
KMO6	WASHINGTON MEMORIAL	WASHINGTON	MO	21	0.998605
0M6	PANOLA COUNTY	BATESVILLE	MS	21	0.998727
GWO	GREENWOOD-LEFLORE	GREENWOOD	MS	21	0.998689
JAN	JACKSON INTL	JACKSON	MS	21	0.998646
MPE	PHILADELPHIA MUNICIPAL	PHILADELPHIA	MS	22	0.998675
CRX	ROSCOE TURNER	UNKNOWN	MS	36	0.998289
KBIL	BILLINGS LOGAN INTL	BILLINGS	MT	19	0.997024
6S5	RAVALLI COUNTY	HAMILTON	MT	15	0.997951
KHLN	HELENA REGIONAL	HELENA	MT	20	0.997453
KLWT	LEWISTOWN MUNICIPAL	LEWISTOWN	MT	25	0.996630
KMLS	FRANK WILEY FIELD	MILES CITY	MT	22	0.996655
KHBI	ASHEBORO MUNICIPAL	ASHEBORO	NC	18	0.998648
KAVL	ASHEVILLE REGIONAL	ASHEVILLE	NC	36	0.997830
MRH	MICHAEL J. SMITH FIELD	BEAUFORT	NC	32	0.997855
KCLT	CHARLOTTE/DOUGLAS INTL	CHARLOTTE	NC	20	0.998487
ECG	ELIZABETH CITY CGAS	ELIZABETH CITY	NC	32	0.997689
KFAY	FAYETTEVILLE REGIONAL/ GRANNIS FIELD	FAYETTEVILLE	NC	24	0.998688
GSO	PIEDMONT TRIAD INTL	GREENSBORO	NC	18	0.998658
PGV	PITT-GREENVILLE	GREENVILLE	NC	26	0.998025
HSE	BILLY MITCHELL	HATTERAS	NC	34	0.997462
HKY	HICKORY REGIONAL	HICKORY	NC	19	0.998503
KISO	KINSTON REGIONAL JETPORT AT STALLINGS FLD	KINSTON	NC	26	0.998121
MEB	LAURINBURG	MAXTON	NC	26	0.998682
KEQY	MONROE	MONROE	NC	20	0.998772
KRDU	RALEIGH-DURHAM INTL	RALEIGH/DURHAM	NC	20	0.998353
RWI	ROCKY MOUNT – WILSON REGIONAL	ROCKY MOUNT	NC	25	0.998233
KRUQ	ROWAN COUNTY	SALISBURY	NC	19	0.998478
KTTA	SANFORD – LEE COUNTY REGIONAL	SANFORD	NC	22	0.998490
SUT	BRUNSWICK COUNTY	SOUTHPORT	NC	31	0.998533
OCW	WARREN FIELD	WASHINGTON	NC	29	0.997935

MCZ	MARTIN COUNTY	WILLIAMSTON	NC	27	0.997972
KILM	WILMINGTON INTL	WILMINGTON	NC	28	0.998452
W03	WILSON INDUSTRIAL AIR CENTER	WILSON	NC	25	0.998262
KFAR	HECTOR INTL	FARGO	ND	82	0.992280
MOT	MINOT INTL AIRPORT	MINOT	ND	104	0.987702
KANW	AINSWORTH MUNICIPAL	AINSWORTH	NE	22	0.997734
AUH	AURORA MUNICIPAL	AURORA	NE	21	0.997868
BIE	BEATRICE MUNICIPAL	BEATRICE	NE	20	0.998014
CSB	CAMBRIDGE MUNICIPAL	CAMBRIDGE	NE	22	0.997912
CEK	CRETE MUNICIPAL	CRETE	NE	20	0.998009
GRN	GORDON MUNICIPAL	GORDON	NE	21	0.997896
KEAR	KEARNEY MUNICIPAL	KEARNEY	NE	20	0.997868
KLBF	NORTH PLATTE REGIONAL LEE BIRD FLD	NORTH PLATTE	NE	21	0.997877
OMA	EPPLEY AIRFIELD	OMAHA	NE	23	0.998066
OKS	GARDEN COUNTY	OSHKOSH	NE	24	0.997898
SCB	SCRIBNER STATE	SCRIBNER	NE	21	0.998029
SNY	SIDNEY MUNICIPAL	SIDNEY	NE	20	0.997700
VTN	MILLER FIELD	VALENTINE	NE	21	0.997729
MHT	MANCHESTER	MANCHESTER	NH	269	0.952547
KACY	ATLANTIC CITY INTL	ATLANTIC CITY	NJ	59	0.995970
KMMU	MORRISTOWN MUNICIPAL	MORRISTOWN	NJ	68	0.994870
KEWR	NEWARK INTL	NEWARK	NJ	74	0.994653
7N7	SPITFIRE AERODROM	PEDRICTOWN	NJ	42	0.996962
K3NJ6	INDUCTOTHERM HELIPORT	RANCOCAS	NJ	53	0.996203
KABQ	ALBUQUERQUE INTL SUNPORT	ALBUQUERQUE	NM	37	0.998328
KFMN	FOUR CORNERS REGIONAL	FARMINGTON	NM	48	0.998255
KLRU	LAS CRUCES INTL	LAS CRUCES	NM	58	0.996435
ELY	ELY AIRPORT/YELLAND FELD	ELY	NV	24	0.998847
KLAS	MC CARRAN INTL	LAS VEGAS	NV	59	0.994412
ALB	ALBANY INTL	ALBANY	NY	180	0.984795
BUF	BUFFALO NIAGARA INTL	BUFFALO	NY	40	0.997142
KELM	ELMIRA/CORNING REGIONAL	ELMIRA	NY	52	0.996775
LGA	LA GUARDIA	FLUSHING	NY	90	0.993902
GFL	FLOYD BENNETT MEMORIAL	GLENS FALLS	NY	216	0.975043
KJHW	CHAUTAUQUA COUNTY/ JAMESTOWN	JAMESTOWN	NY	30	0.998138
LKP	LAKE PLACID	LAKE PLACID	NY	212	0.968594
KJFK	JOHN F KENNEDY INTL	NEW YORK	NY	93	0.993836
KSWF	STEWART INTL	NEWBURGH	NY	100	0.993025
PBG	PLATTSGURGH INTL	PLATTSGURGH	NY	231	0.957713
ROC	GREATER ROCHESTER INTL	ROCHESTER	NY	66	0.996100
KSYR	SYRACUSE HANCOCK INTL	SYRACUSE	NY	102	0.993115
B16	WHITFORDS	WEEDSPORT	NY	83	0.994402
FOK	THE FRANCIS S. GABRESKI	WESTHAMPTON BEACH	NY	132	0.989169
HPN	WESTCHESTER COUNTY	WHITE PLAINS	NY	102	0.992832
4F5	BELLEFONTAINE MUNICIPAL AIRPORT	BELLEFONTAINE	OH	34	0.996348
KRZT	ROSS COUNTY	CHILLICOTHE	OH	34	0.997028
KCLE	CLEVELAND-HOPKINS INTL	CLEVELAND	OH	34	0.997887
KCMH	PORT COLUMBUS INTL	COLUMBUS	OH	33	0.997076
OSU	OHIO STATE UNIVERSITY	COLUMBUS	OH	33	0.996924
KDAY	JAMES M COX DAYTON INTL	DAYTON	OH	35	0.996065

1G5	MEDINA MUNICIPAL	MEDINA	OH	34	0.997995
KTOL	TOLEDO EXPRESS	TOLEDO	OH	34	0.996480
I68	LEBANON-WARREN COUNTY	UNKNOWN	OH	35	0.996052
KAVK	ALVA REGIONAL	ALVA	OK	25	0.998378
KCQB	CHANDLER MUNICIPAL	CHANDLER	OK	23	0.998576
CHK	CHICKASHA	CHICKASHA	OK	24	0.998539
GCM	CLAREMORE REGIONAL	CLAREMORE	OK	23	0.998722
DUA	EAKER FIELD AIRPORT	EAKER	OK	21	0.998901
2O8	HINTON MUNICPAL	HINTON	OK	24	0.998425
KHBR	HOBART MUNICIPAL	HOBART	OK	25	0.998600
K2K4	SCOTT FIELD	MANGUM	OK	27	0.998510
MIO	MIAMI	MIAMI	OK	26	0.998511
MDF	MORELAND MUNICIPAL	MORELAND	OK	24	0.998622
KMKO	DAVIS FIELD	MUSKOGEE	OK	25	0.998869
OKC	WILL ROGERS WORLD AIRPORT	OKLAHOMA CITY	OK	24	0.998441
PVJ	PAULS VALLEY MUNICIPAL AIRPORT	PAULS VALLEY	OK	23	0.998789
PNC	PONCA CITY	PONCA CITY	OK	25	0.998369
SNL	SHAWNEE	SHAWNEE	OK	23	0.998593
TQH	TAHLEQUAH	TAHLEQUAH	OK	24	0.998768
KTUL	TULSA INTL	TULSA	OK	24	0.998697
1K4	DAVID J PERRY	UNKNOWN	OK	24	0.998530
YOW	OTTAWA AIRPORT	OTTAWA	ON	203	0.968181
S07	BEND MUNICIPAL	BEND	OR	36	0.997683
HIO	PORTLAND-HILLSBORO	HILLSBORO	OR	36	0.997465
LGD	UNION COUNTY	LA GRANDE	OR	24	0.998253
KONP	NEWPORT MUNICIPAL	NEWPORT	OR	51	0.996756
PDX	PORTLAND INTL	PORTLAND	OR	36	0.997415
SLE	MCNARY FIELD	SALEM	OR	42	0.997340
S47	TILLAMOOK	TILLAMOOK	OR	45	0.996987
ABE	LEHIGH VALLEY INTL	ALLENTOWN	PA	50	0.996299
KBFD	BRADFORD REGIONAL	BRADFORD	PA	24	0.998325
MDT	HARRISBURG INTL	HARRISBURG	PA	35	0.997612
KJST	JOHN MURTHA JOHNSTOWN-CAMBRIA COUNTY	JOHNSTOWN	PA	18	0.998419
LNS	LANCASTER	LANCASTER	PA	39	0.997220
LHV	WILLIAM T. PIPER MEMORIAL	LOCK HAVEN	PA	36	0.997719
PHL	PHILADELPHIA INTL	PHILADELPHIA	PA	47	0.996759
KAGC	ALLEGHENY COUNTY	PITTSBURGH	PA	18	0.998420
KPIT	PITTSBURGH INTL	PITTSBURGH	PA	19	0.998407
PVD	THEODORE FRANCIS GREEN STATE	PROVIDENCE	RI	258	0.973170
AND	ANDERSON REGIONAL	ANDERSON	SC	38	0.997931
KCHS	CHARLESTON AFB/INTL	CHARLESTON	SC	31	0.998567
KCAE	COLUMBIA METROPOLITAN	COLUMBIA	SC	21	0.998886
KGSP	GREENVILLE – SPARTANBURG INTL	GREER	SC	37	0.998213
KMYR	MYRTLE BEACH INTL	MYRTLE BEACH	SC	35	0.998508
KHON	HURON REGIONAL	HURON	SD	23	0.997668
1D1	MILBANK MUNICIPAL	MILBANK	SD	29	0.997094
KRAP	RAPID CITY REGIONAL	RAPID CITY	SD	19	0.997501
FSD	JOE FOSS FIELD	SIOUX FALLS	SD	21	0.997836
YXE	SASKATOON AIRPORT	SASKATOON	SK	225	0.966800
CHA	LOVELL FIELD	CHATTANOOGA	TN	35	0.996857

TYS	MC GHEE TYSON	KNOXVILLE	TN	33	0.996599
KMEM	MEMPHIS INTL	MEMPHIS	TN	21	0.998765
KBNA	NASHVILLE INTL	NASHVILLE	TN	35	0.997276
PHT	HENRY COUNTY	PARIS	TN	36	0.997675
TRI	TRI-CITIES REGIONAL TN/ VA AIRPORT	UNKNOWN	TN	36	0.997804
KABI	ABILENE REGIONAL	ABILENE	TX	35	0.998399
ALI	ALICE	ALICE	TX	225	0.978230
AMA	AMARILLO INTL	AMARILLO	TX	24	0.998519
KLBX	BRAZORIA COUNTY	ANGLETON/LAKE JACKSON	TX	45	0.997467
AUS	AUSTIN-BERGSTROM INTL	AUSTIN	TX	39	0.997798
7F9	COMANCHE	COMANCHE	TX	36	0.998272
KCXO	MONTGOMERY COUNTY	CONROE	TX	35	0.997957
CRP	CORPUS CHRISTI INTL	CORPUS CHRISTI	TX	210	0.981622
KDAL	DALLAS LOVE FIELD	DALLAS	TX	27	0.998749
ADS	ADDISON	DALLAS	TX	25	0.998827
KDFW	DALLAS-FT WORTH INTL	DALLAS-FT WORTH	TX	26	0.998777
KDRT	DEL RIO INTL	DEL RIO	TX	73	0.995715
ELP	EL PASO INTL	EL PASO	TX	68	0.995848
KHRL	VALLEY INTL	HARLINGEN	TX	696	0.879783
KAXH	HOUSTON-SOUTHWEST	HOUSTON	TX	42	0.997609
KDWH	DAVID WAYNE HOOKS MEMORIAL	HOUSTON	TX	38	0.997844
KEFD	ELLINGTON FIELD	HOUSTON	TX	41	0.997684
KHOU	WILLIAM P HOBBY	HOUSTON	TX	39	0.997718
KIAH	GEORGE BUSH INTERCONTINENTAL/HOUSTON	HOUSTON	TX	38	0.997833
KIWS	WEST HOUSTON	HOUSTON	TX	39	0.997711
KSGR	SUGAR LAND MUNICIPAL/ HULL FLD	HOUSTON	TX	40	0.997661
KLBB	LUBBOCK INTL	LUBBOCK	TX	28	0.998392
MAF	MIDLAND INTL	MIDLAND	TX	35	0.998220
OSA	MOUNT PLEASANT MUNICIPAL	MOUNT PLEASANT	TX	23	0.998938
KSJT	SAN ANGELO RGNL/MATHIS FLD	SAN ANGELO	TX	41	0.997838
KSAT	SAN ANTONIO INTL	SAN ANTONIO	TX	44	0.997354
SGR	SUGARLAND MUNICIPAL/ HULL FIELD	SUGAR LAND	TX	40	0.997661
KTYR	TYLER POUNDS REGIONAL	TYLER	TX	27	0.998734
BMC	BRIGHAM CITY	BRIGHAM CITY	UT	17	0.998320
KCDC	CEDAR CITY REGIONAL	CEDAR CITY	UT	51	0.997652
KKNB	KANAB MUNICIPAL	KANAB	UT	53	0.996954
LGU	LOGAN-CACHE	LOGAN	UT	16	0.998243
SLC	SALT LAKE CITY INTL	SALT LAKE CITY	UT	19	0.998387
KCHO	CHARLOTTESVILLE-ALBEMARLE	CHARLOTTESVILLE	VA	21	0.998174
FKN	FRANKLIN MUNICIPAL – JOHN BEVERLY ROSE	FRANKLIN	VA	29	0.997939
LVL	BRUNSWICK MUNICIPAL	LAWRENCEVILLE	VA	21	0.998244
JYO	LEESBURG MUNICIPAL/ GODFREY FIELD	LEESBURG	VA	28	0.998027
HEF	MANASSAS REGIONAL/ HARRY P. DAVIS FIELD	MANASSAS	VA	28	0.997956
MTV	BLUE RIDGE	MARTINSVILLE	VA	19	0.998618
KPHF	NEWPORT NEWS/ WILLIAMSBURG INTL	NEWPORT NEWS	VA	33	0.997723

KORF	NORFOLK INTL	NORFOLK	VA	32	0.997674
RIC	RICHMOND INTL	RICHMOND	VA	25	0.998109
AKQ	WAKEFIELD MUNICIPAL	WAKEFIELD	VA	28	0.997943
WAL	WALLOPS FLIGHT FACILITY	WALLOPS ISLAND	VA	40	0.997231
BTV	BURLINGTON INTL	BURLINGTON	VT	240	0.957133
FHR	FRIDAY HARBOR	FRIDAY HARBOR	WA	39	0.997406
KMWH	GRANT COUNTY INTL	MOSES LAKE	WA	29	0.997797
KSEA	SEATTLE-TACOMA INTL	SEATTLE	WA	38	0.997400
BFI	BOEING FIELD/ KING COUNTY INTL	SEATTLE	WA	37	0.997407
KGEG	SPOKANE INTL	SPOKANE	WA	22	0.997784
KATW	OUTAGAMIE COUNTY REGIONAL	APPLETON	WI	42	0.995781
3T3	BOYCEVILLE MUNICIPAL	BOYCEVILLE	WI	46	0.996170
FLD	FOND DU LAC COUNTY	FOND DU LAC	WI	40	0.995937
KGRB	AUTIN STRAUBEL INTL	GREEN BAY	WI	42	0.995672
JVL	SOUTHERN WISCONSIN REGIONAL AIRPORT	JANESVILLE	WI	38	0.996136
MSN	DANE COUNTY REGIONAL-TRUAX FIELD	MADISON	WI	38	0.996173
MTW	MANITOWOC COUNTY	MANITOWOC	WI	41	0.995837
MKE	GENERAL MITCHELL INTL	MILWAUKEE	WI	36	0.996006
KCWA	CENTRAL WISCONSIN	MOSINEE	WI	43	0.995622
OSH	WITTMAN REGIONAL	OSHKOSH	WI	40	0.995843
RHI	RHINELANDER-ONEIDA COUNTY	RHINELANDER	WI	126	0.986820
SUE	DOOR COUNTY CHERRYLAND	STURGEON BAY	WI	47	0.995592
RYV	WATERTOWN MUNICIPAL	WATERTOWN	WI	37	0.995944
ETB	WEST BEND MUNICIPAL	WEST BEND	WI	36	0.995991
KMGW	MORGANTOWN MUNICIPAL – WLB HART FLD	MORGANTOWN	WV	17	0.998435
KPKB	WOOD CO – GILL ROBB WILSON FLD	PARKERSBURG	WV	18	0.998406
KCPR	NATRONA COUNTY INTL	CASPER	WY	20	0.997459
EVW	EVANSTON-UNITA CNTY-BURNS FLD	EVANSTON	WY	15	0.998120
SAA	SHIVELY FIELD	SARATOGA	WY	21	0.997679

Figure 9-1 WAAS LPV Availability

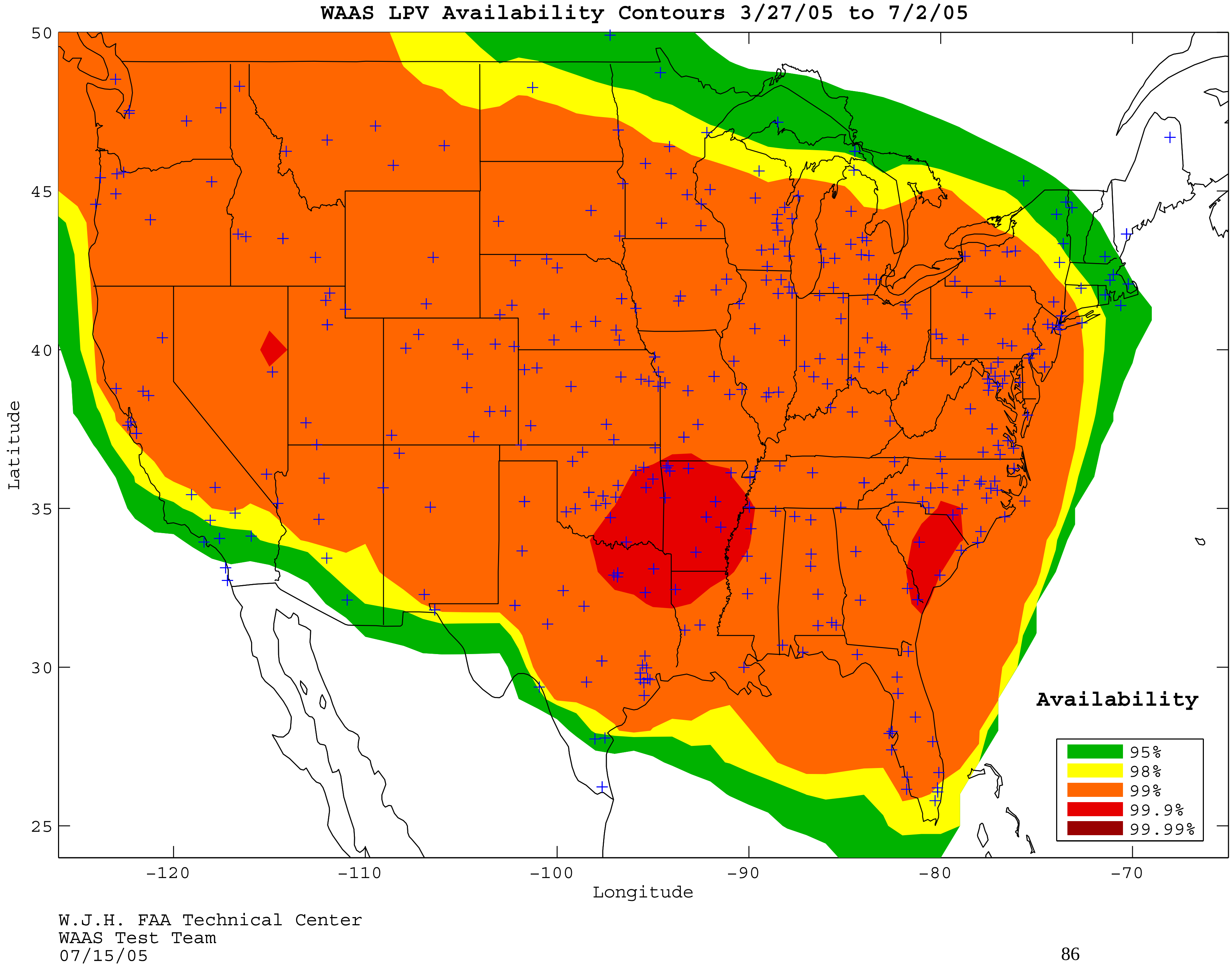
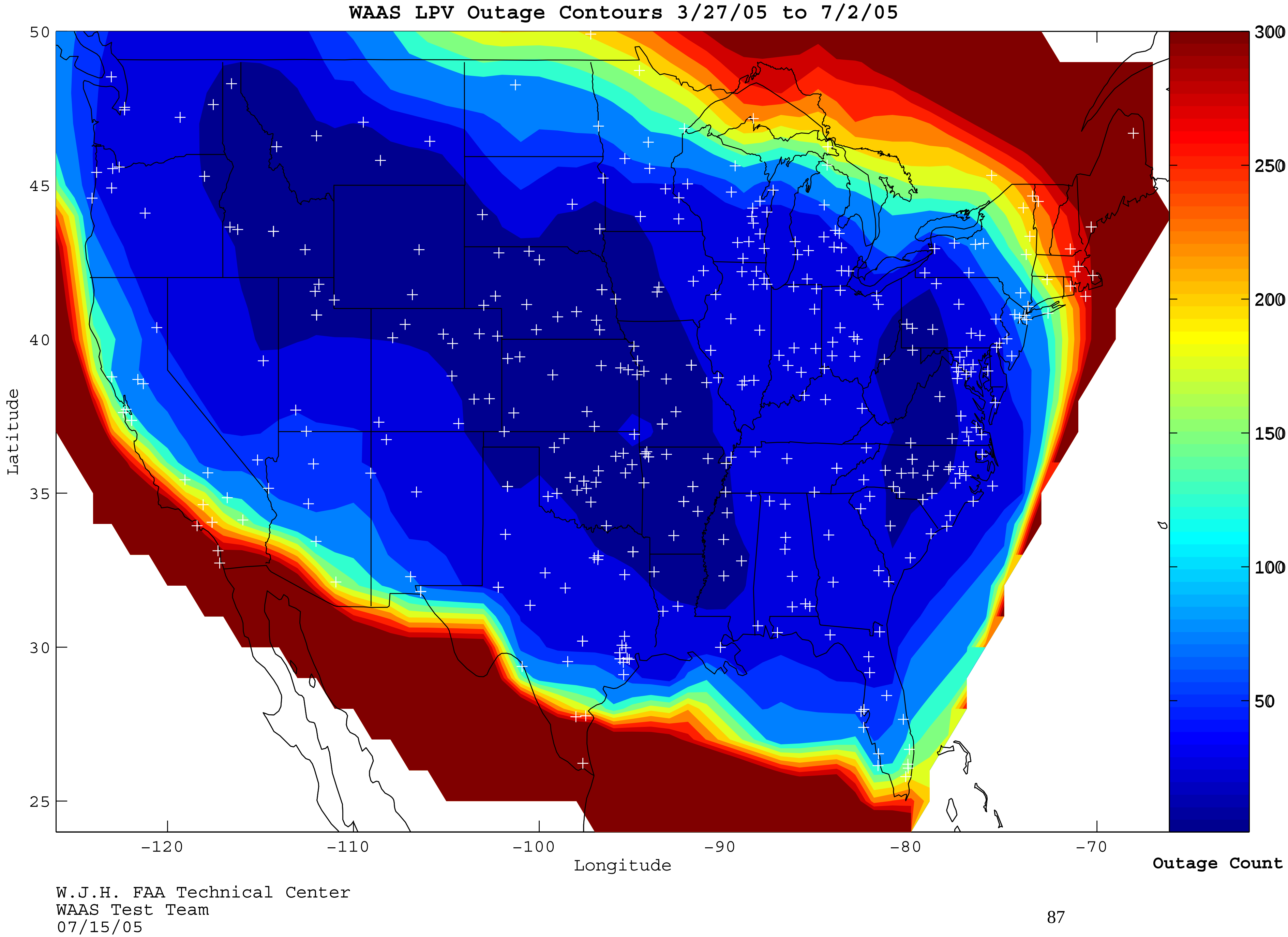


Figure 9-2 WAAS LPV Outage



10.0 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 10.1 recaps the results of that manual analysis.

Table 10-1 CNMP Bounding Statistics

WAAS Site	WRE	Jul 04	Aug 04	Sep 04	Oct 04	Nov 04	Dec 04	Jan 05	Feb 05	Mar 05	Apr 05	May 05	Jun 05
Albuquerque	A	blue	blue	blue	yellow	blue	green	blue	yellow	green	yellow	blue	green
	B	blue	blue	blue	blue	green	blue	blue	blue	blue	blue	blue	blue
	C	blue	blue	blue	blue	blue	blue	blue	blue	blue	green	blue	blue
Anchorage	A	blue	yellow	green	green	blue	blue	green	blue	green	green	yellow	yellow
	B	blue	green	blue	green	green	blue	blue	blue	blue	blue	green	yellow
	C	yellow	blue	yellow	yellow	blue	blue	yellow	blue	blue	yellow	green	green
Atlanta	A	blue	green	green	blue	blue	blue	blue	blue	blue	blue	blue	blue
	B	green	blue	blue	blue	blue	blue	blue	blue	green	green	red	red
	C	blue	blue	blue	blue	blue	blue	yellow	green	blue	blue	blue	blue
Billings	A	blue	blue	green	blue	blue	blue	blue	blue	blue	blue	blue	blue
	B	blue	blue	blue	blue	blue	blue	blue	blue	blue	blue	blue	blue
	C	green	blue	blue	blue	blue	blue	blue	blue	blue	blue	blue	blue
Boston	A	blue	blue	blue	green	blue	yellow	blue	blue	yellow	blue	blue	yellow
	B	green	blue	blue	green	blue	blue	blue	blue	blue	blue	blue	blue
	C	yellow	blue	green	blue	blue	blue	blue	blue	blue	blue	blue	blue
Chicago	A	blue	blue	blue	blue	blue	green	green	blue	blue	blue	blue	blue
	B	blue	blue	blue	blue	green	blue	blue	blue	green	blue	blue	green
	C	blue	green	yellow	yellow	blue	green	blue	blue	yellow	green	blue	blue
Cleveland	A	blue	blue	green	blue	blue	blue	blue	green	blue	yellow	green	blue
	B	blue	blue	blue	blue	yellow	blue	blue	yellow	blue	yellow	yellow	green
	C	blue	green	yellow	yellow	blue	blue	blue	blue	green	blue	blue	blue
Cold Bay	A	blue	blue	blue	blue	blue	blue	blue	blue	blue	blue	blue	yellow
	B	blue	blue	blue	blue	blue	green	blue	blue	blue	yellow	green	green
	C	blue	yellow	blue	blue	blue	blue	blue	blue	blue	yellow	green	green
Dallas	A	green	green	blue	green	blue	blue	blue	blue	blue	blue	blue	blue
	B	blue	blue	green	yellow	yellow	yellow	blue	blue	yellow	yellow	yellow	green
	C	blue	blue	blue	blue	blue	blue	blue	green	blue	green	blue	green
Denver	A	blue	blue	blue	blue	blue	blue	blue	blue	blue	blue	blue	blue
	B	blue	blue	green	blue	blue	blue	blue	green	blue	blue	green	blue
	C	green	blue	blue	green	blue	red	blue	blue	blue	green	green	green
Honolulu	A	yellow	red	green	red	red	yellow	green	yellow	yellow	blue	yellow	red
	B	blue	blue	yellow	green	green	blue	blue	blue	blue	blue	blue	blue
	C	blue	blue	blue	yellow	red	blue	yellow	blue	blue	yellow	blue	blue
Houston	A	red	yellow	red	red	yellow	blue	green	red	green	blue	green	blue
	B	red	red	yellow	green	green	red	green	red	red	green	green	green
	C	red	green	yellow	green	yellow	yellow	yellow	yellow	yellow	yellow	yellow	green
Jacksonville	A	green	blue	blue	blue	blue	blue	blue	blue	blue	blue	blue	blue
	B	blue	blue	green	green	yellow	blue	green	yellow	blue	blue	blue	blue
	C	blue	blue	blue	blue	blue	blue	green	blue	blue	blue	blue	blue
Juneau	A	blue	blue	blue	blue	blue	blue	green	green	blue	green	blue	yellow
	B	green	yellow	blue	blue	blue	blue	red	blue	blue	yellow	green	green
	C	green	blue	yellow	yellow	blue	blue	green	green	blue	red	yellow	blue
Kansas City	A	green	blue	blue	blue	blue	blue	blue	blue	blue	blue	blue	blue
	B	blue	blue	blue	blue	yellow	blue	blue	yellow	blue	blue	blue	blue
	C	blue	blue	blue	blue	blue	blue	blue	blue	blue	blue	blue	yellow
Los Angeles	A	green	blue	blue	yellow	blue	blue	blue	blue	blue	blue	blue	green
	B	blue	blue	green	blue	blue	blue	blue	green	blue	blue	blue	blue
	C	blue	blue	green	blue	green	yellow	blue	yellow	blue	blue	blue	blue
Memphis	A	blue	yellow	blue	green	blue	yellow	blue	blue	blue	blue	blue	green
	B	blue	green	green	blue	blue	yellow	green	blue	blue	yellow	blue	blue
	C	blue	blue	blue	blue	green	blue	blue	blue	blue	blue	blue	blue
Miami	A	blue	blue	green	green	green	green	green	blue	blue	blue	blue	blue
	B	blue	blue	green	blue	green	blue	blue	green	blue	blue	green	green
	C	blue	blue	yellow	blue	yellow	blue	green	green	green	yellow	yellow	yellow
Minneapolis	A	blue	blue	blue	blue	blue	blue	blue	blue	blue	blue	blue	blue
	B	green	blue	blue	blue	blue	blue	blue	blue	blue	blue	yellow	blue
	C	blue	blue	blue	yellow	blue	blue	green	blue	blue	green	blue	blue

WAAS Site	WRE	Jul 04	Aug 04	Sep 04	Oct 04	Nov 04	Dec 04	Jan 05	Feb 05	Mar 05	Apr 05	May 05	Jun 05
New York	A	• (blue)	• (green)	• (blue)	• (green)	• (blue)	• (blue)	• (blue)	• (blue)	• (green)	• (yellow)	• (blue)	• (blue)
	B	• (green)	• (green)	• (blue)	• (yellow)	• (blue)	• (blue)	• (blue)	• (blue)	• (green)	• (blue)	• (blue)	• (blue)
	C	• (blue)	• (yellow)	• (blue)	• (blue)	• (green)	• (blue)	• (blue)	• (blue)	• (blue)	• (green)	• (blue)	• (blue)
Oakland	A	• (yellow)	• (yellow)	• (blue)	• (green)	• (red)	• (yellow)	• (blue)	• (red)	• (blue)	• (blue)	• (green)	• (blue)
	B	• (blue)	• (blue)	• (blue)	• (yellow)	• (yellow)	• (blue)	• (blue)	• (blue)	• (blue)	• (green)	• (yellow)	• (green)
	C	• (yellow)	• (yellow)	• (yellow)	• (yellow)	• (yellow)	• (red)	• (blue)	• (green)	• (green)	• (blue)	• (blue)	• (yellow)
Salt Lake City	A	• (blue)	• (blue)	• (green)	• (blue)	• (blue)	• (blue)	• (blue)	• (blue)	• (green)	• (blue)	• (blue)	• (blue)
	B	• (blue)	• (blue)	• (blue)	• (blue)	• (blue)	• (blue)	• (blue)	• (blue)	• (blue)	• (blue)	• (blue)	• (blue)
	C	• (blue)	• (green)	• (blue)	• (blue)	• (blue)	• (green)	• (blue)	• (blue)	• (blue)	• (green)	• (blue)	• (blue)
San Juan	A	• (green)	• (blue)	• (blue)	• (blue)	• (green)	• (green)	• (blue)	• (green)	• (blue)	• (green)	• (yellow)	• (blue)
	B	• (blue)	• (blue)	• (yellow)	• (red)	• (blue)	• (blue)	• (yellow)	• (blue)	• (yellow)	• (blue)	• (blue)	• (blue)
	C	• (green)	• (blue)	• (yellow)	• (green)	• (red)	• (blue)	• (yellow)	• (green)	• (green)	• (green)	• (red)	• (yellow)
Seattle	A	• (blue)	• (green)	• (blue)	• (blue)	• (green)	• (blue)	• (blue)	• (blue)	• (blue)	• (blue)	• (blue)	• (blue)
	B	• (blue)	• (blue)	• (blue)	• (blue)	• (blue)	• (green)	• (blue)	• (blue)	• (green)	• (blue)	• (blue)	• (blue)
	C	• (green)	• (blue)	• (blue)	• (blue)	• (blue)	• (blue)	• (blue)	• (blue)	• (blue)	• (blue)	• (red)	• (blue)
Washington, DC	A	• (yellow)	• (blue)	• (blue)	• (blue)	• (blue)	• (blue)	• (blue)	• (blue)	• (blue)	• (blue)	• (blue)	• (green)
	B	• (blue)	• (blue)	• (blue)	• (blue)	• (blue)	• (blue)	• (blue)	• (blue)	• (blue)	• (blue)	• (blue)	• (blue)
	C	• (blue)	• (red)	• (blue)	• (blue)	• (blue)	• (blue)	• (green)	• (blue)	• (blue)	• (blue)	• (blue)	• (blue)

Δ **Excellent** - 3.29σ bounded 100%
Δ **Good** - 4σ bounded 100%
Δ **Fair** - 4σ bounded 100% with one worst satellite excluded (Requires manual review)
Δ **Poor** – Requires manual review

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.