WIDE-AREA AUGMENTATION SYSTEM PERFORMANCE ANALYSIS REPORT

Report #17

Reporting Period: April 1 to June 30, 2006

July 2006

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 sixteenth such WAAS quarterly report. This report covers WAAS performance during the period from April 1, 2006 to June 30 2006.

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 0.922 meters	Memphis 0.504meters
95% Vertical Accuracy	Miami 1.373 meters	Albuquerque 0.879 meters
LPV Availability (HPL < 40 meters & VPL < 50 meters)	Minneapolis 99.96%	Miami 96.23%
95% HPL	Los Angeles 31.805 meters	Atlanta 17.58 meters
95% VPL	Los Angeles 45.995 meters	Atlanta 27.858 meters

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1.0 INTRODUCTION

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

Objectives of this report are:

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

The WAAS data transmitted from GEO satellite PRN#122 (AORW) and PRN#134 (POR) were used in the evaluation. Table 1.1 and Table 1.2 list NSTB and WAAS reference station receivers used in Precision Approach (PA) and Non-Precision Approach (NPA) evaluation process, respectively. This report presents results from three months of data, collected from April 1, 2006 to June 30, 2006.

Table 1-1 PA Sites

	Number of Days Evaluated	Number of Samples
NSTB:		
Atlantic City	91	7857033
Greenwood	89	7668775
WAAS:		
Albuquerque	91	7833656
Atlanta	91	7823416
Billings	91	7841393
Boston	91	7837329
Chicago	91	7834796
Cleveland	91	7832892
Dallas	91	7838000
Denver	91	7824964
Houston	91	7829888
Jacksonville	91	7836084
Kansas City	91	7835306
Los Angeles	91	7827885
Memphis	90	7742073
Miami	91	7831803
Minneapolis	90	7794474
New York	91	7828030
Oakland	91	7840499
Salt Lake City	87	7486893
Seattle	88	7615989
Washington DC	91	7833072

Table 1-2 NPA Sites

Location	Number of Days Evaluated	Number of Samples
Albuquerque	90	7846435
Anchorage	90	7845835
Atlanta	90	7828842
Bethel	40	3486058
Billings	90	7844631
Boston	90	7846582
Cleveland	90	7839853
Cold Bay	90	7819702
Fairbanks	41	3548001
Honolulu	88	7623385
Houston	90	7843337
Juneau	78	6767632
Kansas City	90	7839111
Kotzebue	39	3441435
Los Angeles	90	7841332
Miami	90	7844912
Minneapolis	85	7406848
Oakland	90	7844223
Salt Lake City	89	7754167
San Juan	47	4110963
Seattle	90	7772806
Washington DC	90	7832665

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. Detailed analyses of particular events are documented in the Discrepancy Reports (DR). The DRs are posted on the website under 'WAAS Technical Reports' and can be accessed by via hyperlink from the Table 1.4.

Table 1-1 Test Events

GPS Week	Date	Sites	Events
1369 day 0 to 1369 day 1	4/2/06 to 4/3/06	Greenwood	Greenwood outage.
1369 day 4	4/6/06	All WAAS Sites	Added ZTL C&V to WAAS data collection.
1369 day 5	4/7/06	Denver	Denver Thread 1 receiver reset.
1373 day 4	5/4/06	All WAAS Sites	WEI outages.
1374 day 4	5/11/06	All WAAS Sites	WEI outage due to ZDC WMS cutover.
1375 day 4	5/18/06	Denver	Switch to Denver Thread 2.
1376 day 4	5/25/06	All AOR-W non-dual GEO Sites	See DR# 35, "Extended AORW Signal-in-Space Outage after equipment failure."
1376 day 5	5/26/2006	Midwest to Eastern CONUS Sites	See DR# 33, "Loss of Availability due to Satellite Maintenance on SV 13 (NANU 2006047)."
1377 day 2	5/30/06	All AOR-W Sites	See DR# 34, "Clarksburg GUS Failure."
1379 day 6 to 1380 day 1	6/17/06 to 6/19/06	All AOR-W non-dual GEO Sites	See DR# 36, "Multiple drops in AORW signal to noise ratio caused multiple missed messages and eventually an AORW GUS Switchover."
1380 day 1	6/19/06	Minneapolis	Switch to Minneapolis Thread 2.
1380 day 5	6/23/06	KC, Denver, Dallas, LA, Oakland, Seattle, Cold Bay	Release 4 upgrades caused network outages. Affected all sites connected to ZLA TCS Communications Node.
1380 day 6	6/24/06	All Sites	See DR# 37, "C&V failure at ZDC and ZLA."
1381 day 5	6/30/06	All WAAS Sites	WEI 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 0.922 meters at Los Angeles and 1.373 Miami. The minimum 95% horizontal and vertical LPV errors are 0.504 meters at Memphis and 0.879 meters at Albuquerque. The maximum 95% and 99.999% NPA horizontal errors are 3.095 meters and 7.734 both at Honolulu, respectively. The minimum 95% and 99.999% horizontal errors are 1.043 meters at Washington DC and 2.319 meters at Billings, 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)
Atlantic City	0.694	0.694	1.178	99.97505	*	*
Greenwood	0.629	0.629	1.012	99.97459	*	*
Albuquerque	0.659	0.659	0.879	99.97594	2.600	4.703
Atlanta	0.563	0.564	0.983	99.97508	2.562	5.013
Billings	0.693	0.694	0.907	99.97642	2.358	4.362
Boston	0.711	0.713	1.211	99.97622	2.522	4.660
Chicago	0.634	0.634	0.992	99.97519	*	*
Cleveland	0.638	0.639	1.049	99.97669	2.494	4.780
Dallas	0.743	0.743	1.202	99.97586	*	*
Denver	0.669	0.670	0.915	99.97605	*	*
Houston	0.652	0.652	1.077	99.97541	2.780	5.003
Jacksonville	0.613	0.614	1.058	99.97503	*	*
Kansas City	0.648	0.648	0.982	99.97525	2.413	4.839
Los Angeles	0.922	0.923	1.338	99.99865	2.815	5.247
Memphis	0.504	0.505	0.945	99.97489	*	*
Miami	0.834	0.835	1.373	99.97511	3.019	4.756
Minneapolis	0.745	0.745	1.065	99.97534	2.861	4.579
New York	0.592	0.593	1.094	99.97634	*	*
Oakland	0.814	0.815	1.273	99.99854	2.642	5.178
Salt Lake City	0.742	0.742	0.967	99.99893	2.433	4.752
Seattle	0.847	0.847	0.980	99.99873	2.468	4.514
Washington DC	0.571	0.571	1.047	99.97519	2.480	4.954

* SPS Data not available.

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

Location	95% Horizontal (meters)	99.999% Horizontal (meters)	Percentage in NPA mode (%)	Maximum Horizontal Error
Albuquerque	1.364	4.325	99.977	6.645
Anchorage	1.610	3.955	99.999	4.358
Atlanta	1.179	2.476	99.977	6.080
Bethel	1.483	3.068	99.994	3.589
Billings	1.150	2.319	99.978	4.346
Boston	1.137	3.491	99.977	3.769
Cleveland	1.096	3.323	99.977	4.620
Cold Bay	1.532	4.295	99.999	6.163
Fairbanks	1.389	3.114	99.998	3.883
Honolulu	3.095	7.734	99.991	8.147
Houston	1.703	4.793	99.977	5.021
Juneau	1.611	4.748	99.997	5.816
Kansas City	1.119	2.447	99.977	4.048
Kotzebue	1.729	4.963	99.998	5.342
Los Angeles	1.706	4.093	99.998	4.226
Miami	1.867	4.163	99.977	4.713
Minneapolis	1.216	2.885	99.978	4.764
Oakland	1.432	3.255	99.998	4.534
Salt Lake City	1.219	2.666	99.998	7.182
San Juan	2.614	6.900	52.507	5.107
Seattle	1.248	4.049	99.998	5.905
Washington DC	1.043	2.973	99.977	6.070

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

1.2.1 Location	Horizontal Error (m)	Horizontal Error/HPL	Horizontal Maximum Ratio	Vertical Error (m)	Vertical Error/VPL	Vertical Maximum Ratio
Atlantic City	2.968	0.087	0.107	4.391	0.093	0.129
Greenwood	2.594	0.115	0.124	4.927	0.134	0.137
Albuquerque	2.122	0.097	0.107	4.443	0.145	0.145
Atlanta	2.489	0.084	0.096	4.133	0.102	0.146
Billings	1.984	0.108	0.108	5.140	0.139	0.139
Boston	3.775	0.210	0.210	5.347	0.128	0.193
Chicago	1.704	0.044	0.098	2.891	0.099	0.121
Cleveland	3.197	0.190	0.190	5.727	0.234	0.234
Dallas	3.748	0.176	0.203	7.893	0.227	0.228
Denver	1.734	0.092	0.092	5.610	0.122	0.123
Houston	1.829	0.049	0.098	3.312	0.131	0.131
Jacksonville	1.841	0.046	0.103	3.504	0.082	0.132
Kansas City	2.419	0.081	0.130	2.970	0.147	0.147
Los Angeles	2.172	0.076	0.130	4.390	0.097	0.129
Memphis	2.047	0.056	0.092	3.043	0.105	0.116
Miami	2.433	0.099	0.131	4.739	0.146	0.225
Minneapolis	2.343	0.107	0.119	3.057	0.113	0.148
New York	1.452	0.042	0.081	4.037	0.099	0.123
Oakland	2.709	0.071	0.132	6.385	0.135	0.158
Salt Lake City	2.627	0.080	0.121	4.307	0.096	0.131
Seattle	2.447	0.084	0.133	4.613	0.101	0.149
Washington DC	1.580	0.080	0.096	3.382	0.128	0.128

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

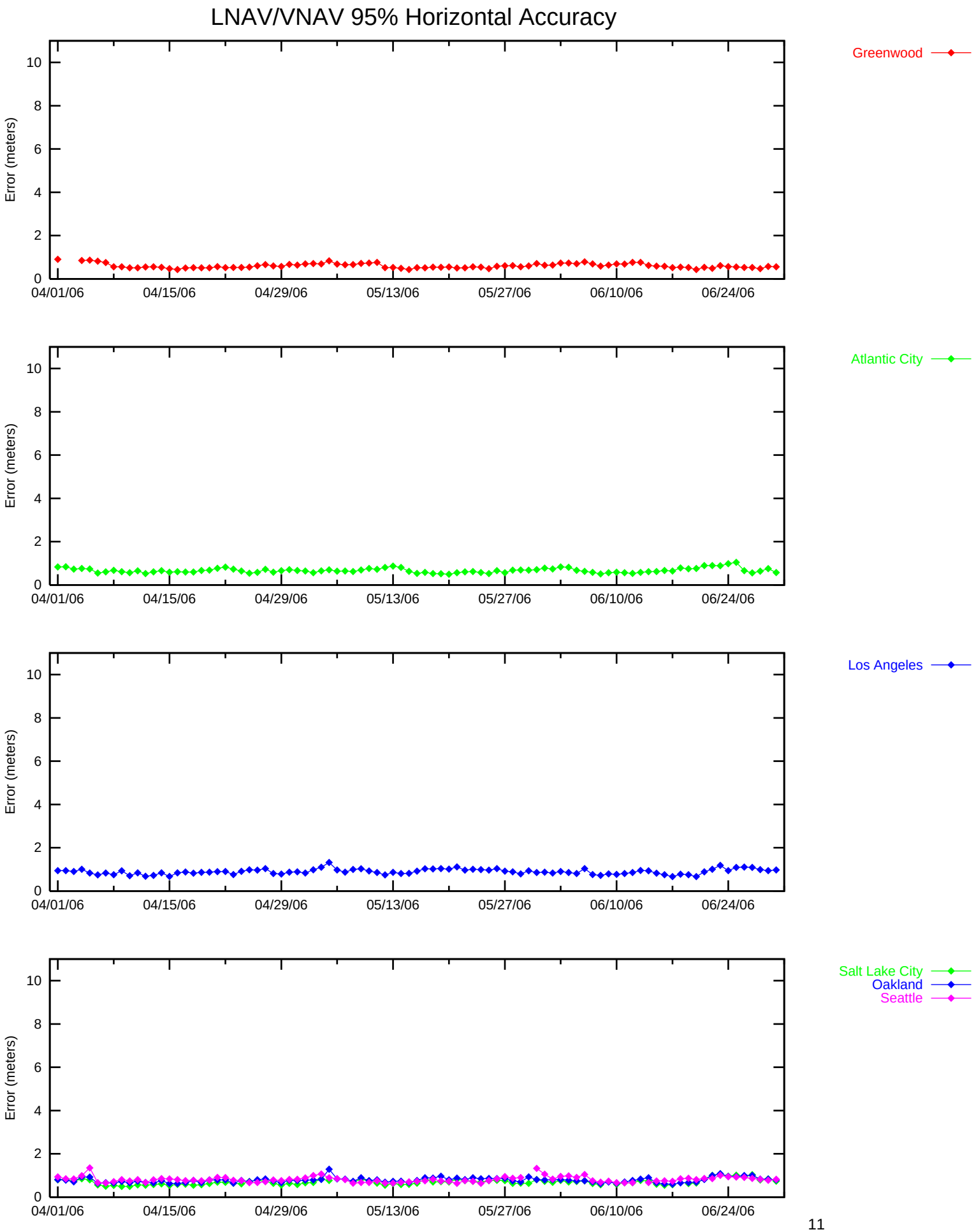


Figure 2-2 95% Horizontal Accuracy at LNAV/VNAV

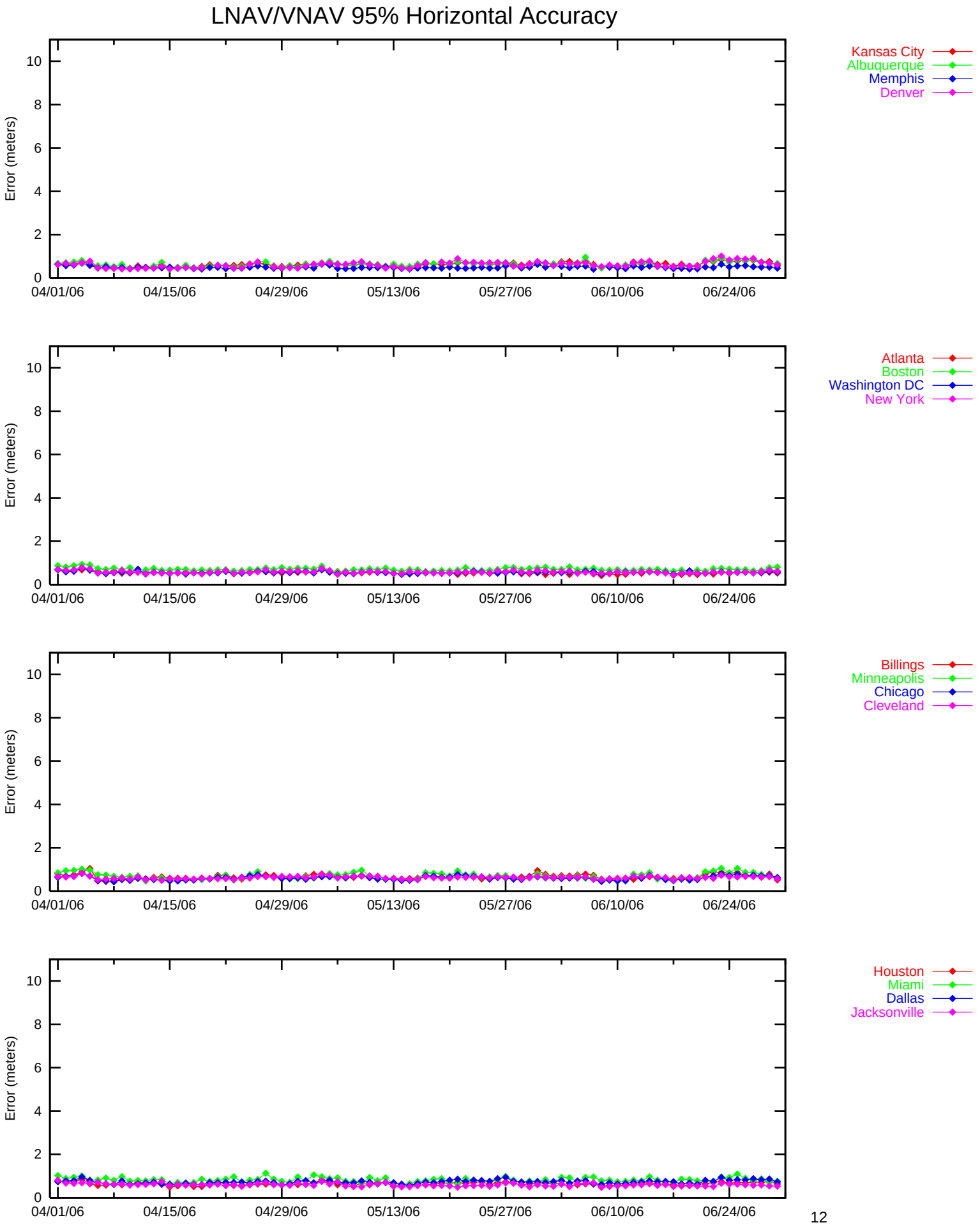


Figure 2-3 95% Vertical Accuracy at LNAV/VNAV

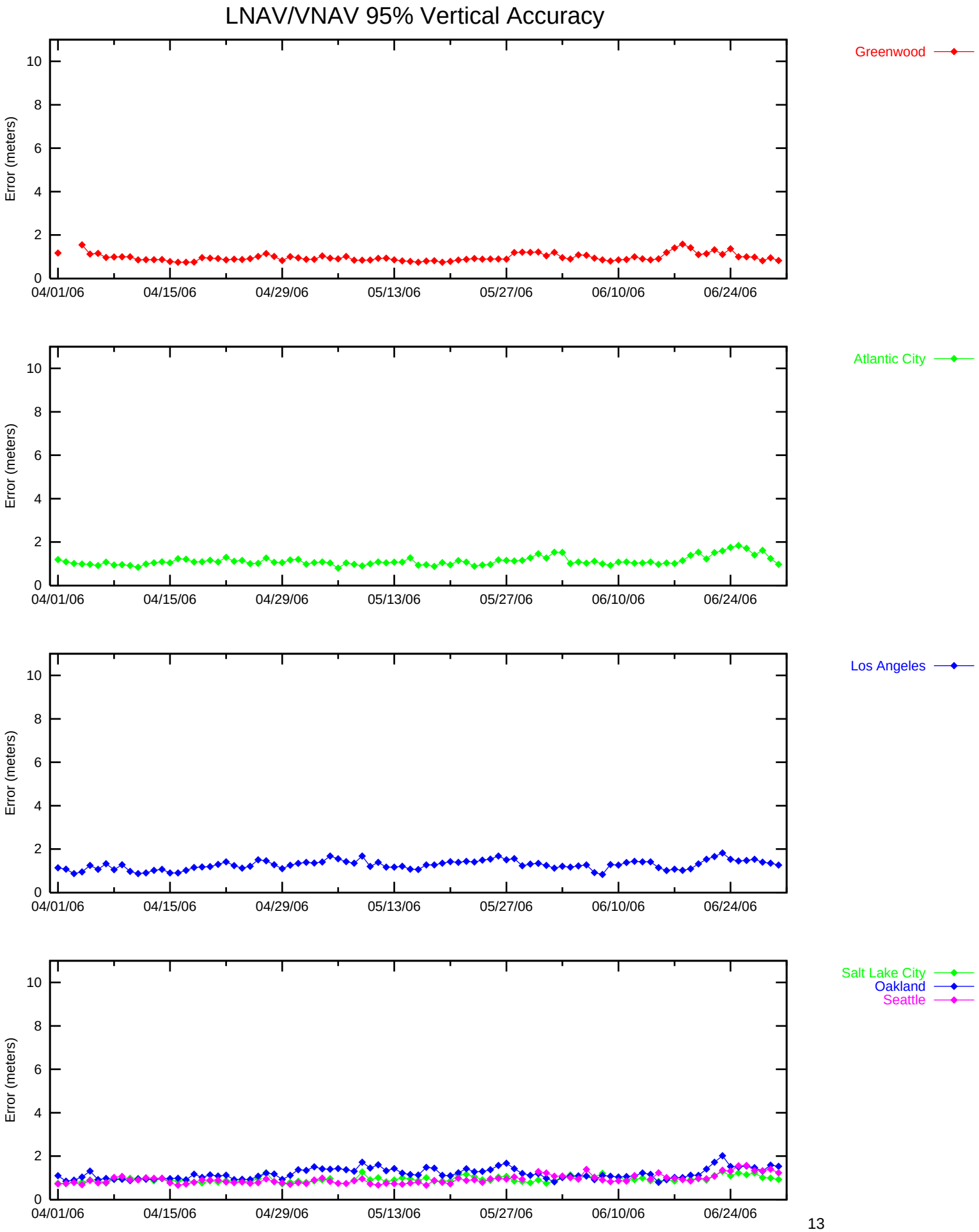


Figure 2-4 95% Vertical Accuracy at LNAV/VNAV

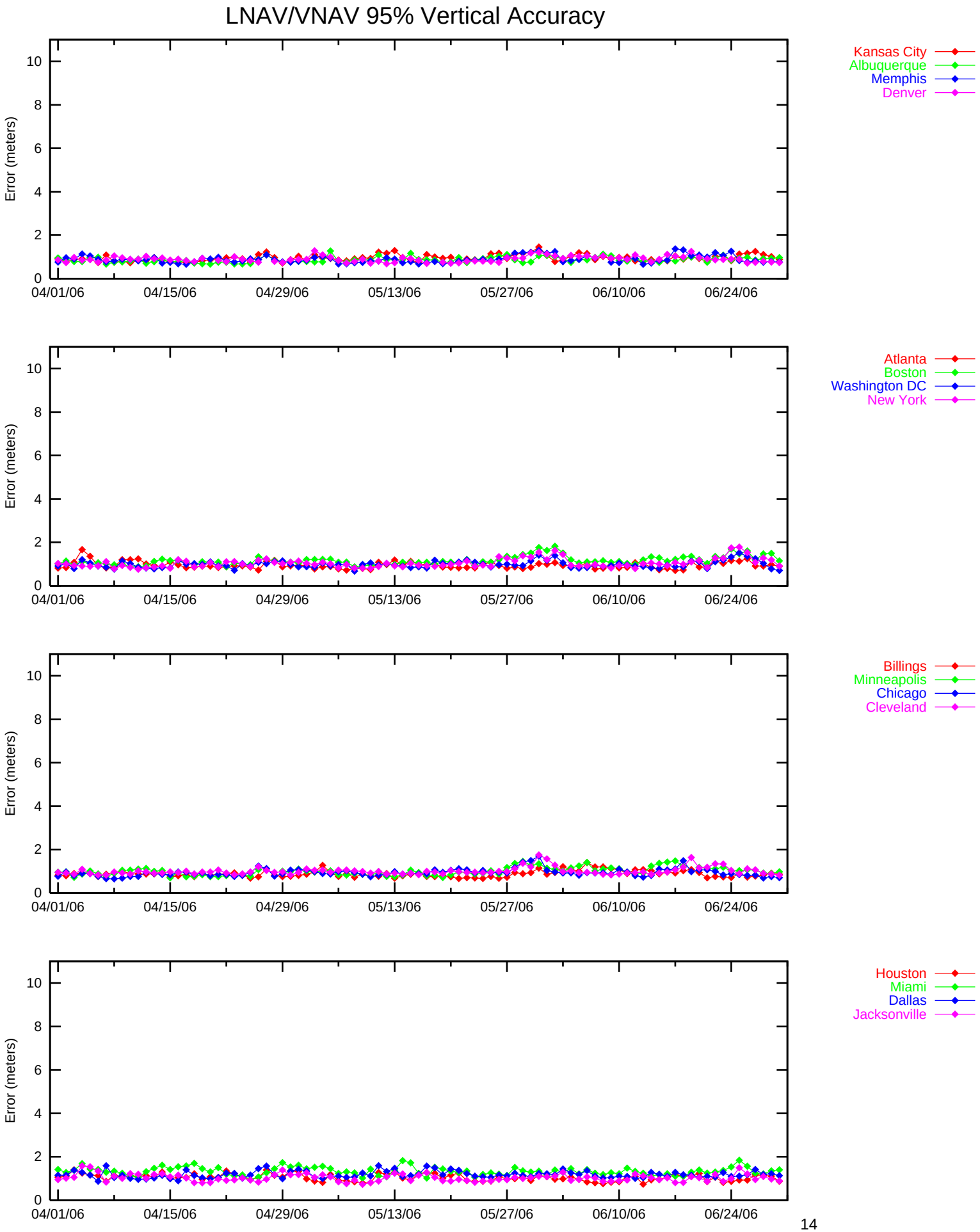


Figure 2-5 NPA 95% Horizontal Accuracy

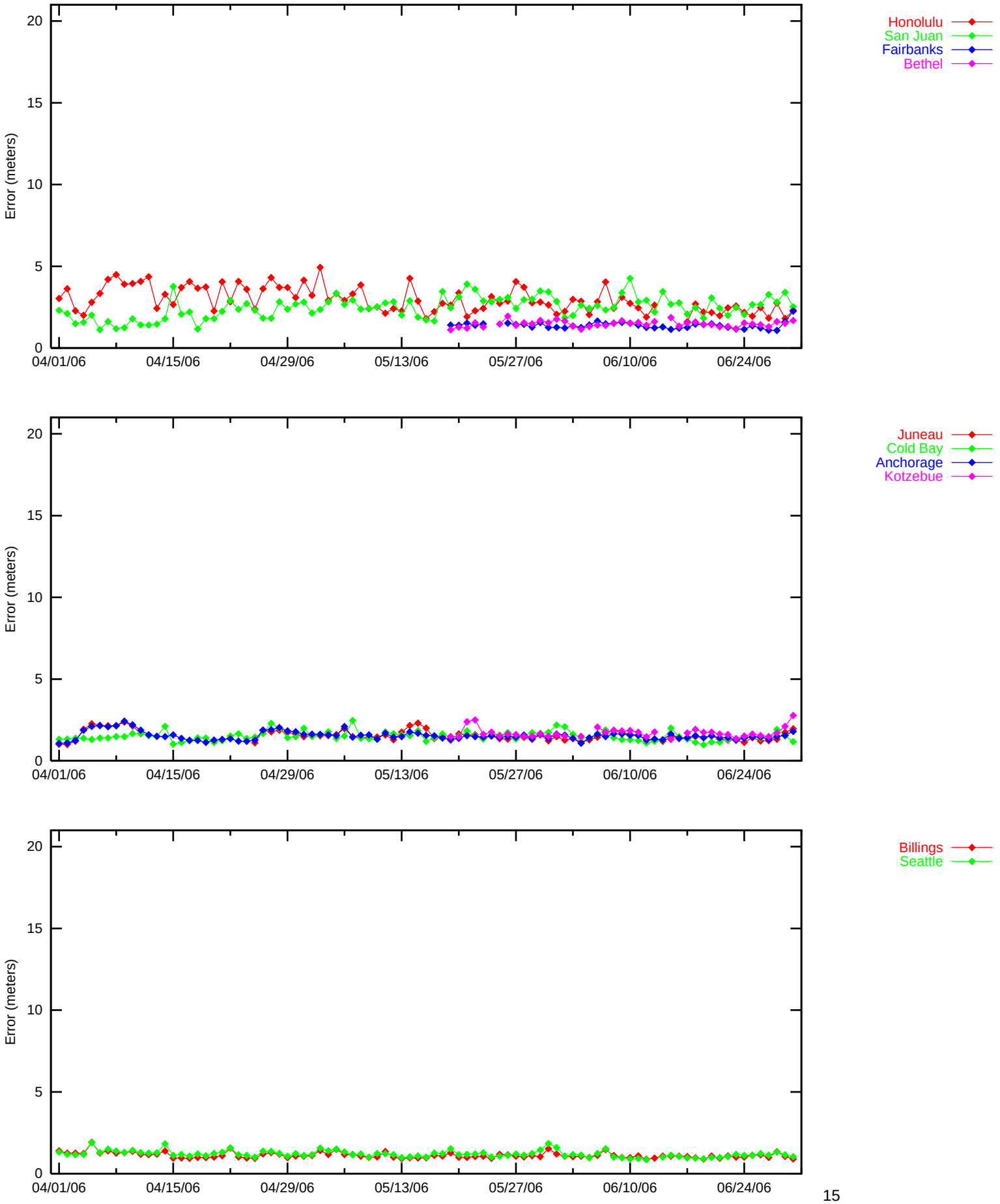


Figure 2-6 NPA 95% Horizontal Accuracy

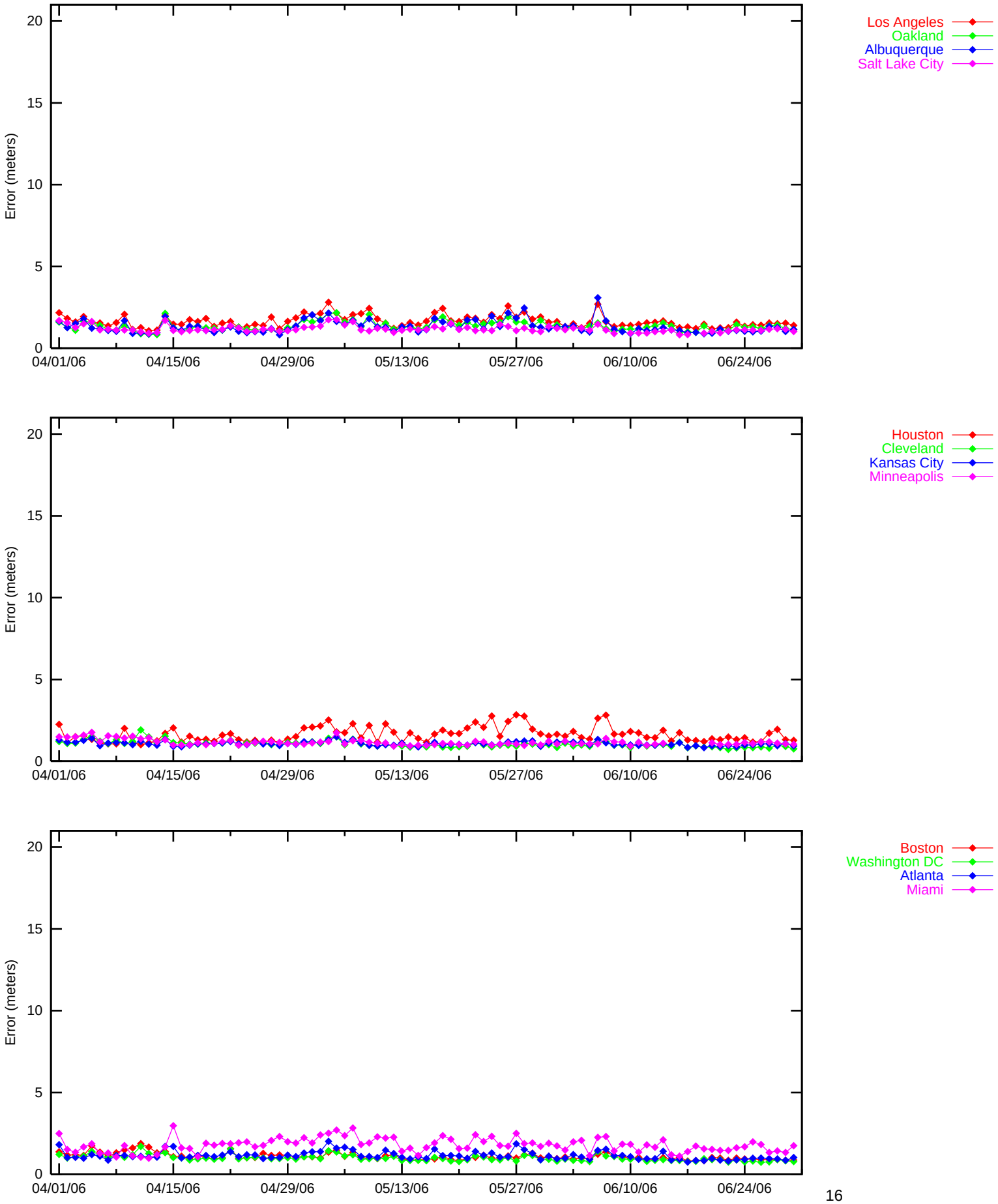


Figure 2-7 Horizontal Triangle Chart forKansas City

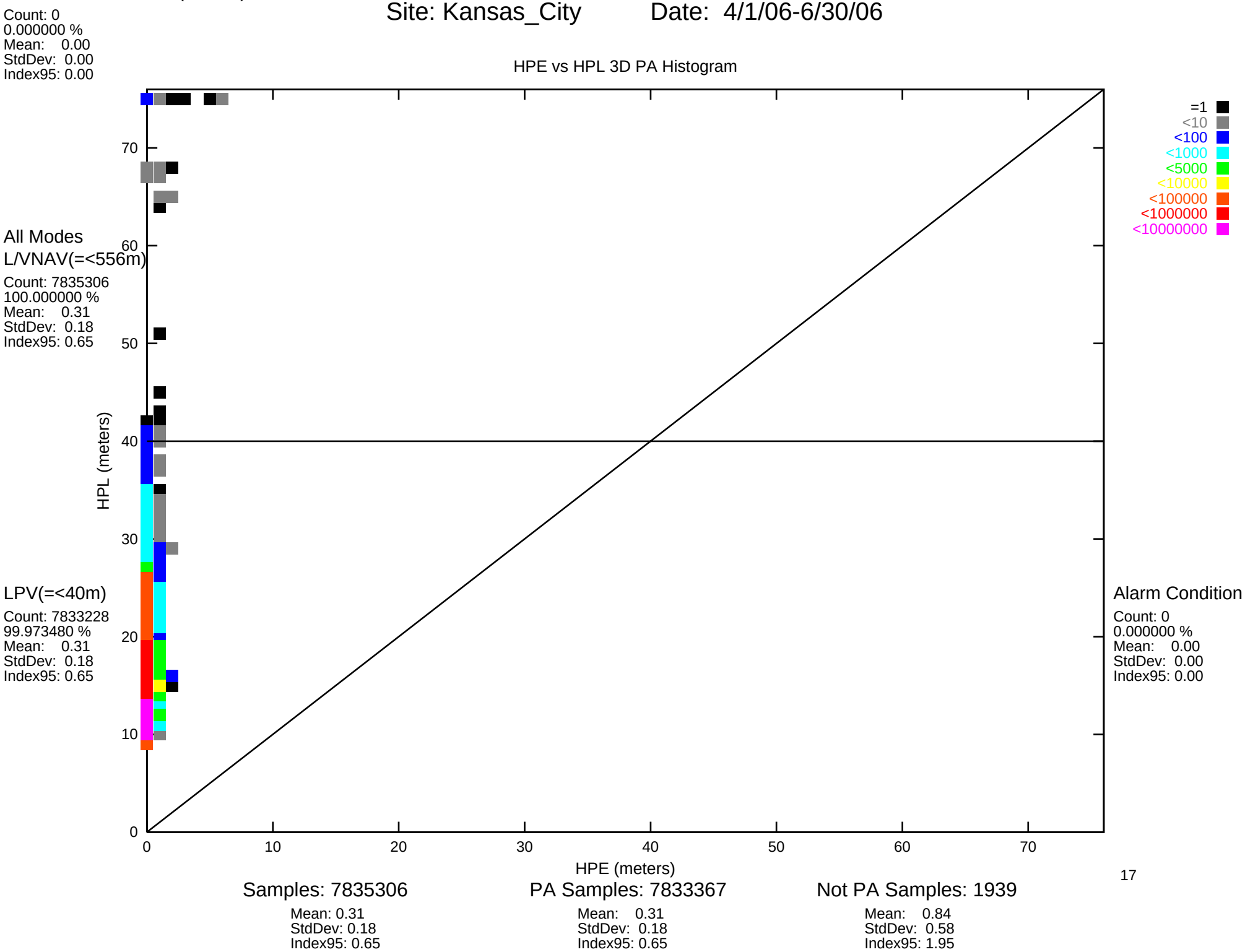


Figure 2-8 Vertical Triangle Chart for Kansas City

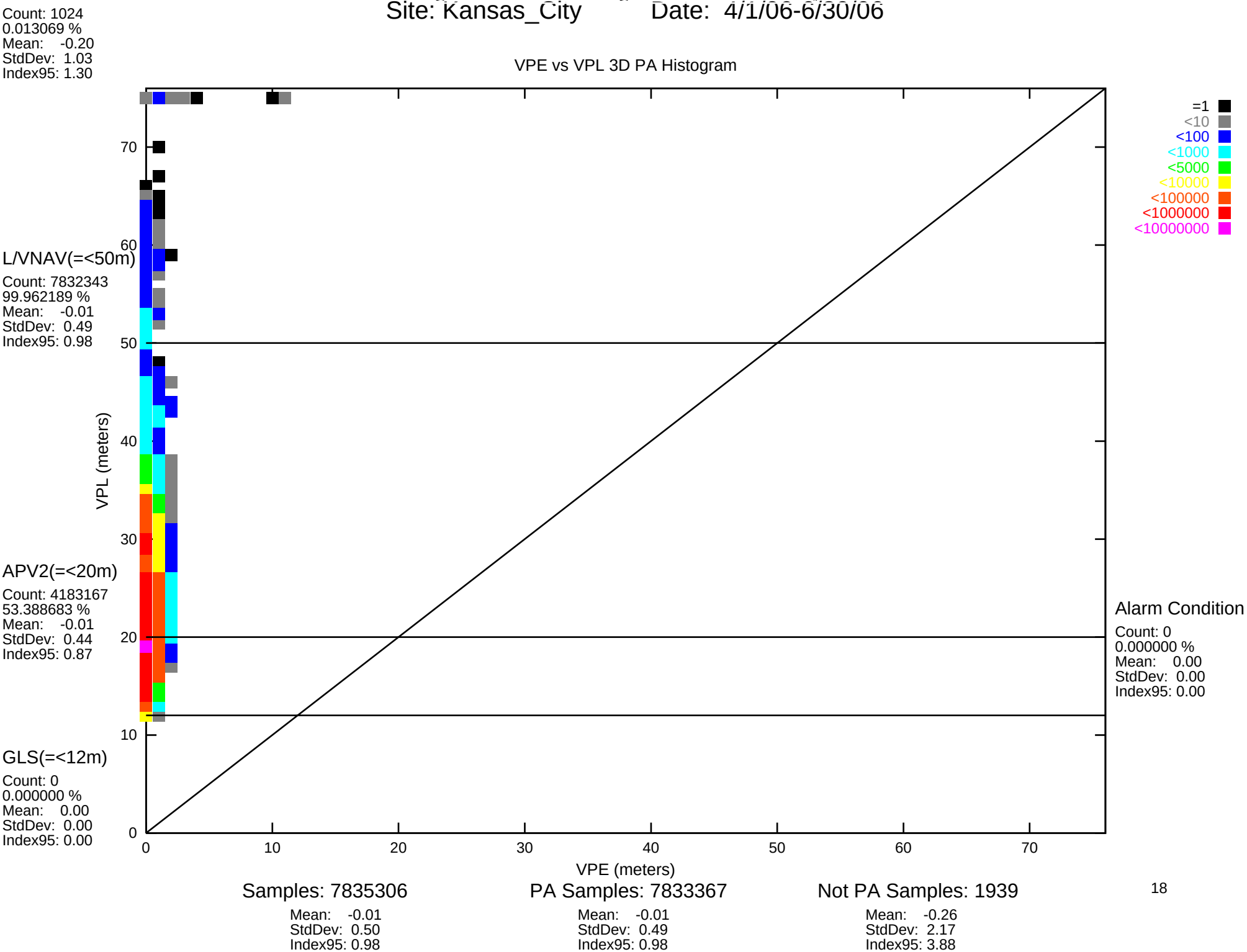


Figure 2-9 2-D Histogram for Kansas City

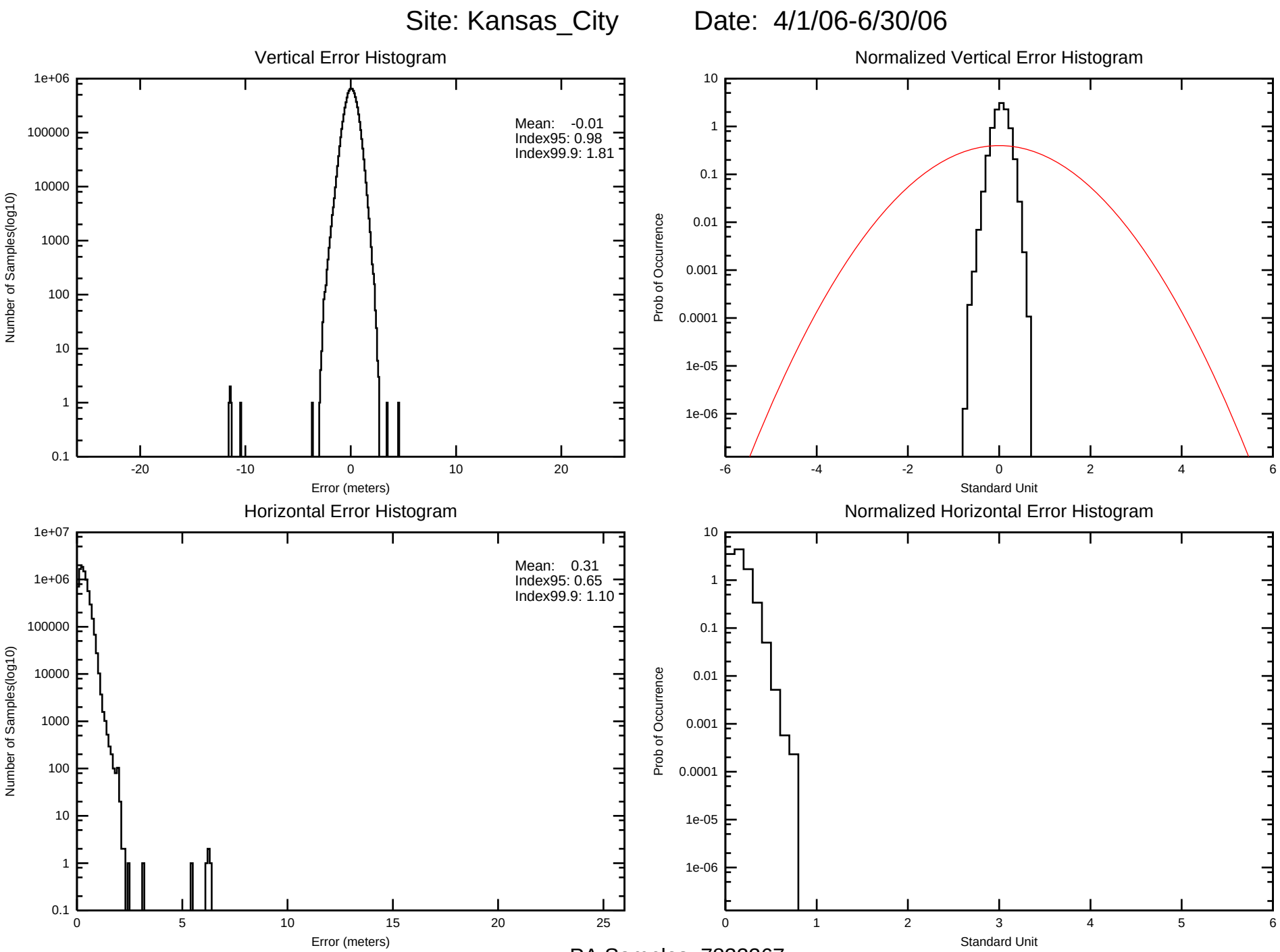


Figure 2-10 Horizontal Triangle Chart for Washington, DC

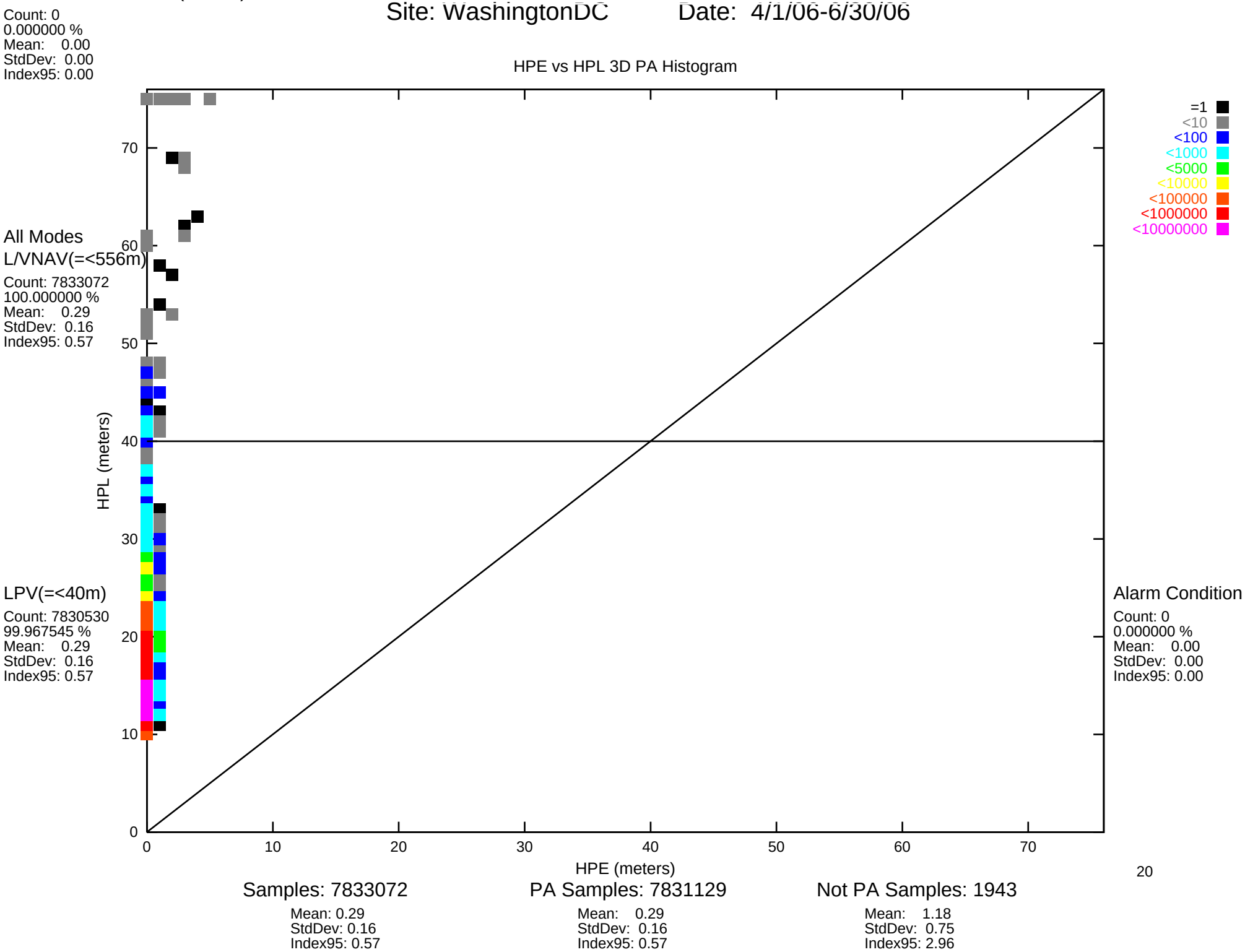
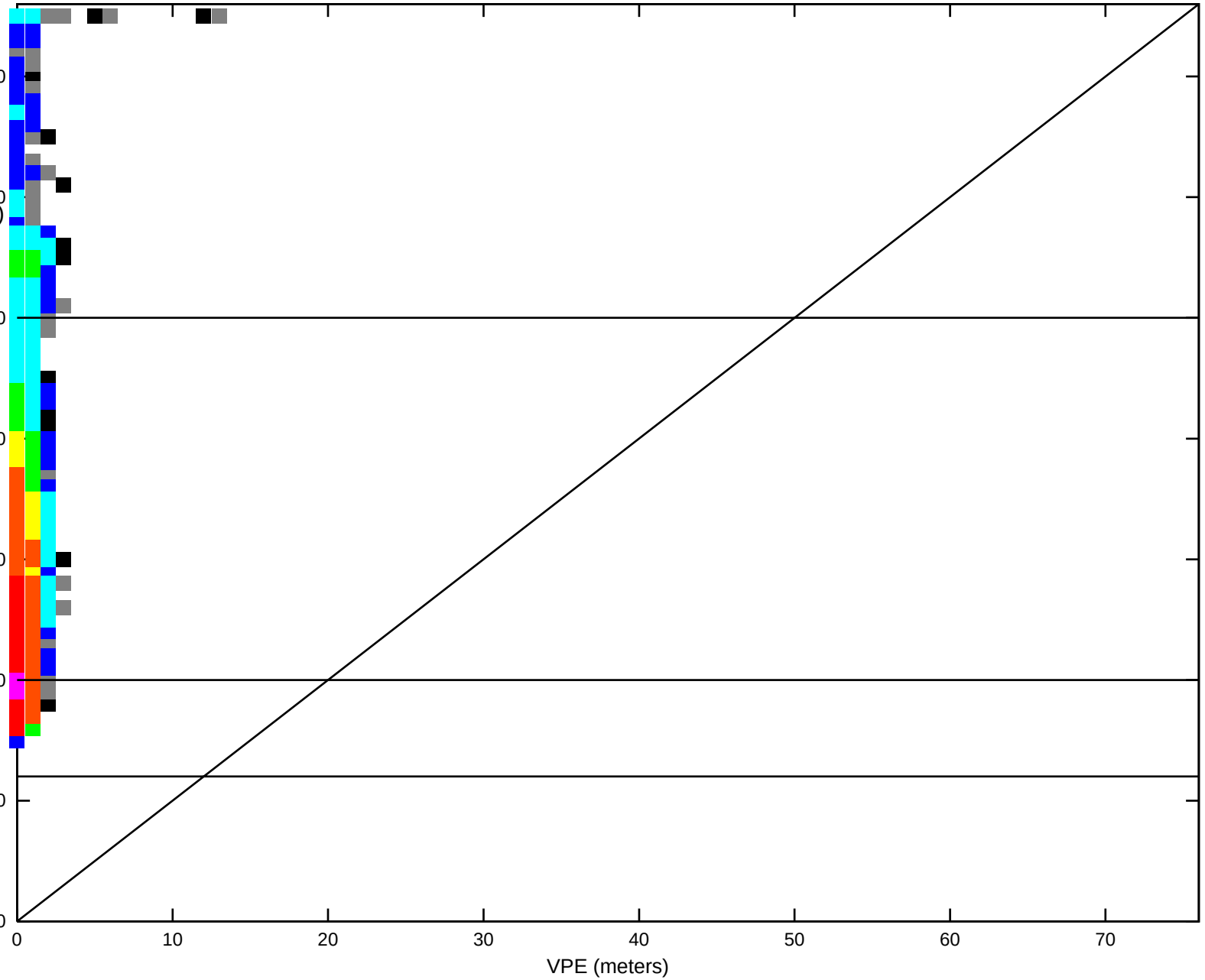


Figure 2-11 Vertical Triangle Chart for Washington, DC

Site: WashingtonDC Date: 4/1/06-6/30/06

PA mode Unavailable(>50m)
Count: 15104
0.192823 %
Mean: 0.93
StdDev: 0.71
Index95: 1.95

VPE vs VPL 3D PA Histogram



L/VNAV(=<50m)
Count: 7816025
99.782372 %
Mean: -0.02
StdDev: 0.53
Index95: 1.05

APV2(=<20m)
Count: 2191493
27.977440 %
Mean: -0.00
StdDev: 0.48
Index95: 0.94

GLS(=<12m)
Count: 0
0.000000 %
Mean: 0.00
StdDev: 0.00
Index95: 0.00

Alarm Condition
Count: 0
0.000000 %
Mean: 0.00
StdDev: 0.00
Index95: 0.00

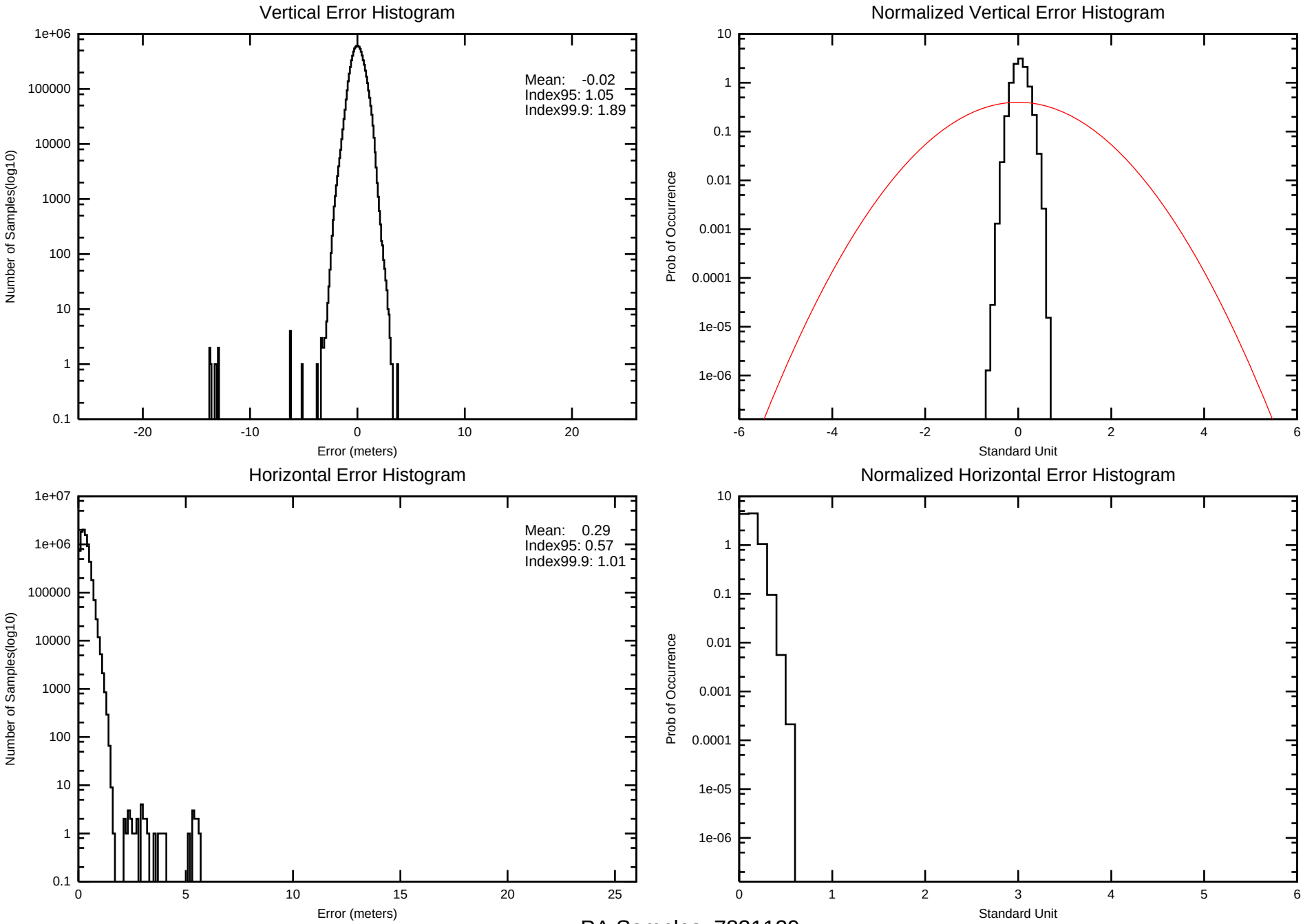
Samples: 7833072
Mean: -0.02
StdDev: 0.53
Index95: 1.05

PA Samples: 7831129
Mean: -0.02
StdDev: 0.53
Index95: 1.05

Not PA Samples: 1943
Mean: -1.04
StdDev: 1.72
Index95: 3.48

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

Site: WashingtonDC Date: 4/1/06-6/30/06



PA Samples: 7831129

Figure 2-13 Horizontal Triangle Chart for Seattle

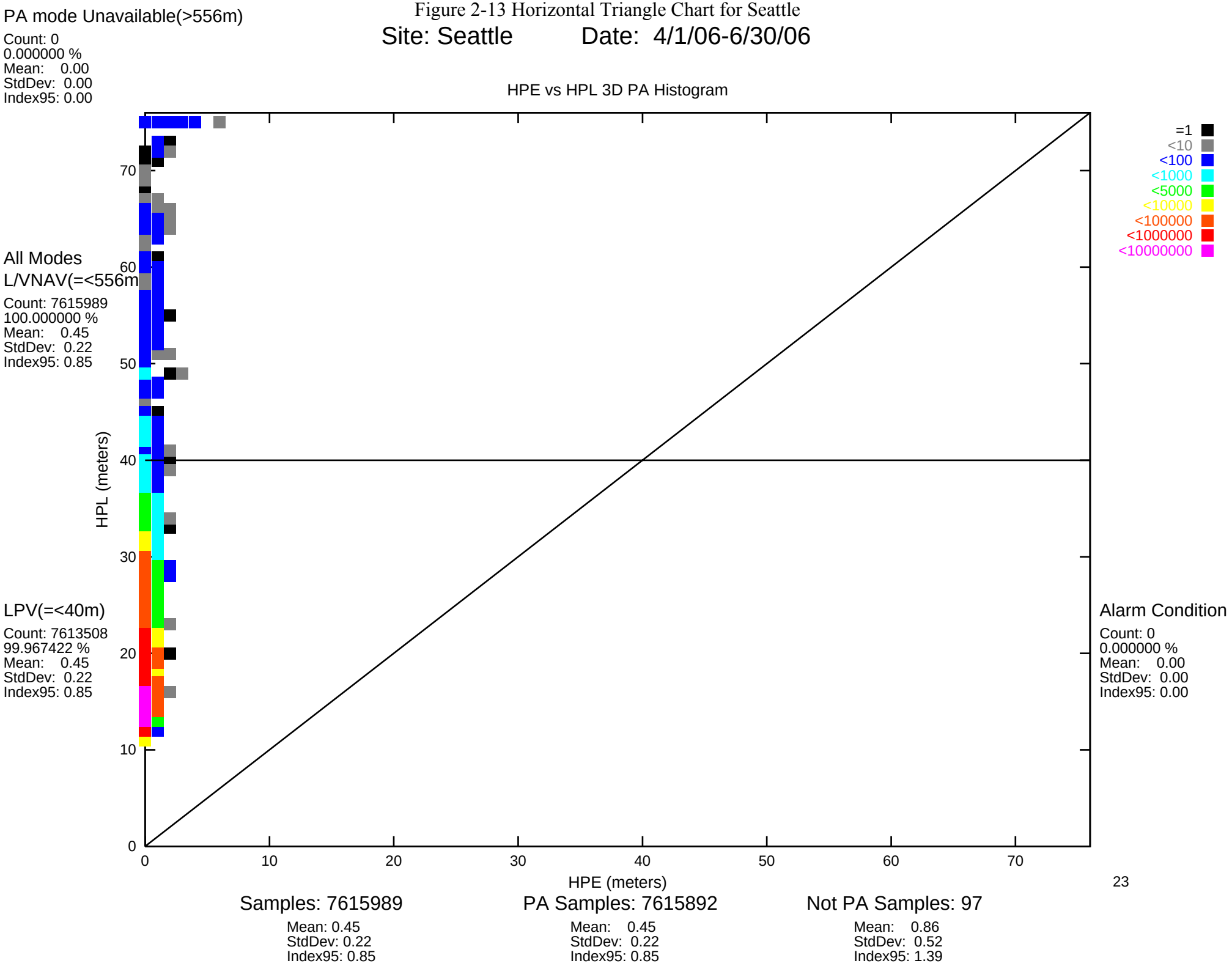
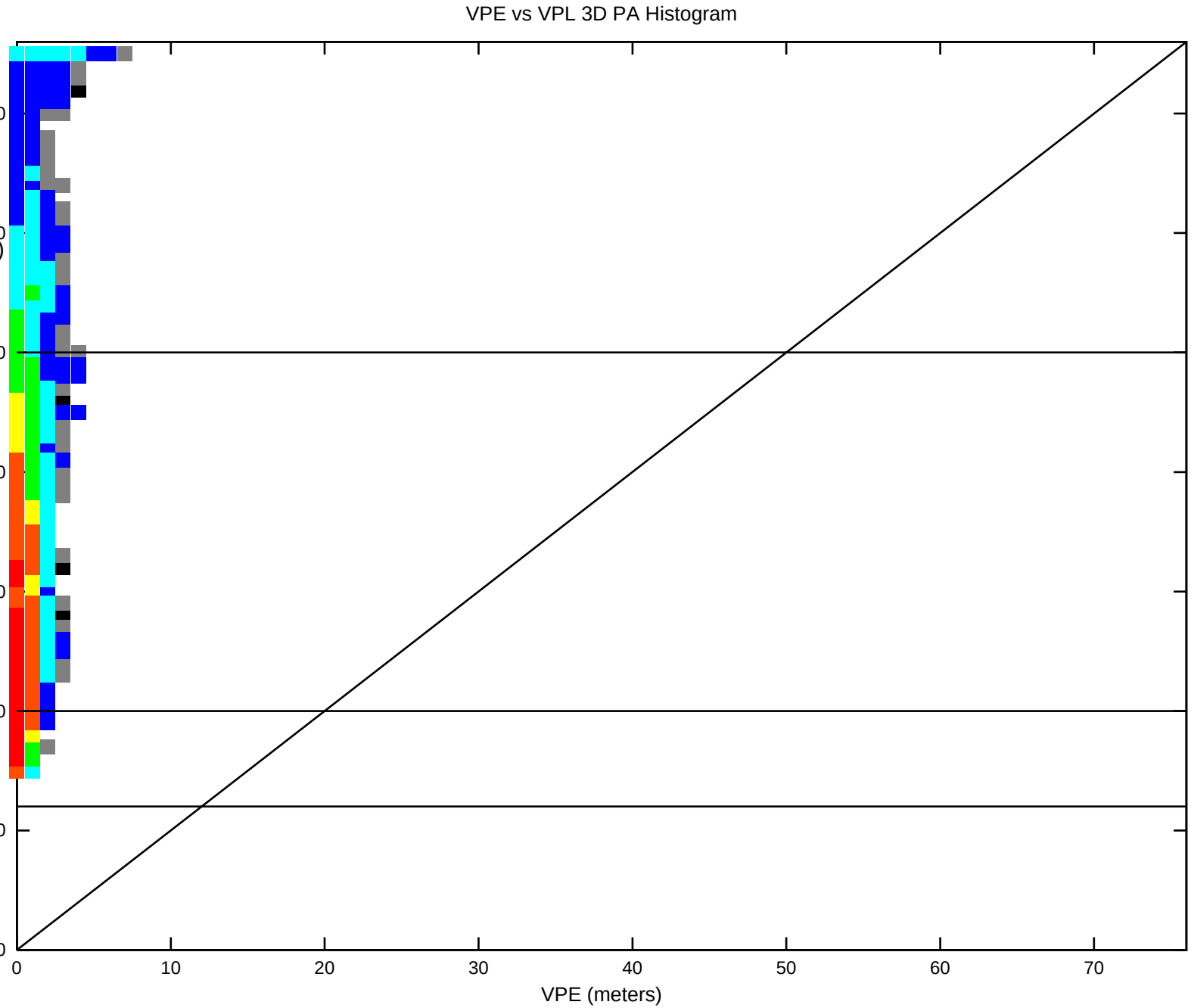


Figure 2-14 Vertical Triangle Chart for Seattle

Site: Seattle Date: 4/1/06-6/30/06

PA mode Unavailable(>50m)
Count: 23046
0.302600 %
Mean: 0.85
StdDev: 1.10
Index95: 2.65



L/VNAV(=<50m)
Count: 7592846
99.696121 %
Mean: 0.03
StdDev: 0.49
Index95: 0.98

APV2(=<20m)
Count: 1788443
23.482742 %
Mean: 0.01
StdDev: 0.39
Index95: 0.76

GLS(=<12m)
Count: 0
0.000000 %
Mean: 0.00
StdDev: 0.00
Index95: 0.00

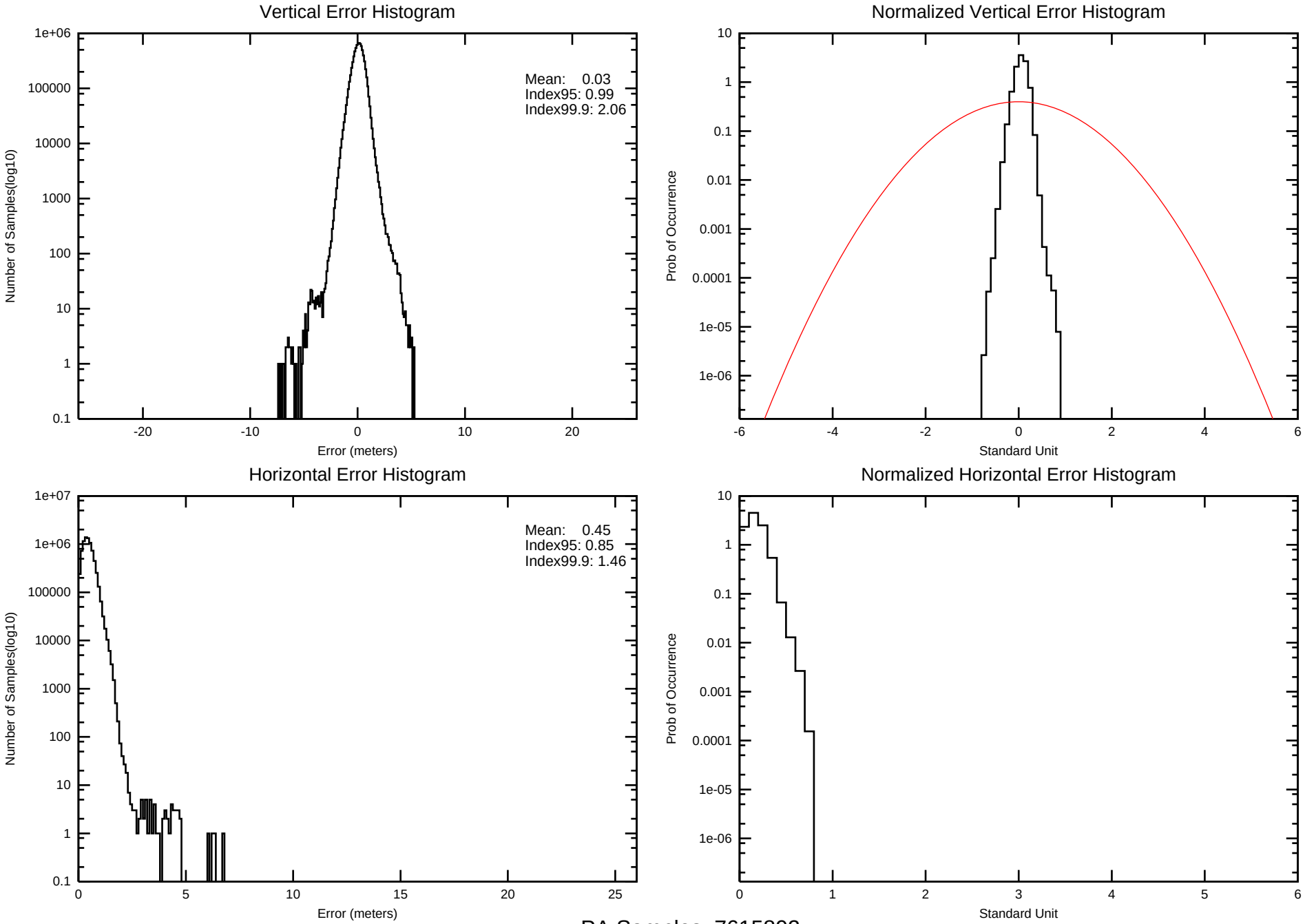
Alarm Condition
Count: 0
0.000000 %
Mean: 0.00
StdDev: 0.00
Index95: 0.00

Samples: 7615989
Mean: 0.03
StdDev: 0.50
Index95: 0.99

PA Samples: 7615892
Mean: 0.03
StdDev: 0.50
Index95: 0.99

Not PA Samples: 97
Mean: 0.82
StdDev: 1.37
Index95: 1.88

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 31.805 meters and 45.995 meters both at Los Angeles. The minimum 95% HPL and VPL are 17.58 meters at Atlanta and 27.858 meters both 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
Atlantic City	20.646	35.278	99.975052
Greenwood	19.834	30.735	99.974586
Albuquerque	23.542	34.153	99.975937
Atlanta	17.580	27.858	99.975075
Billings	22.771	31.606	99.976418
Boston	26.143	41.844	99.976219
Chicago	18.867	28.952	99.975189
Cleveland	19.465	29.426	99.976692
Dallas	21.728	32.997	99.975861
Denver	19.886	30.011	99.976051
Houston	25.639	35.736	99.975410
Jacksonville	18.611	30.722	99.975029
Kansas City	18.824	29.597	99.975250
Los Angeles	31.805	45.995	99.998650
Memphis	18.897	29.010	99.974892
Miami	22.832	40.157	99.975113
Minneapolis	21.527	31.164	99.975342
New York	22.151	36.920	99.976341
Oakland	31.227	44.865	99.998543
Salt Lake City	21.180	33.025	99.998932
Seattle	22.997	34.549	99.998726
Washington DC	19.094	29.931	99.975189

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*
Atlantic City	0.99683356	0.99708897	0.99604548	0.99647937
Greenwood	0.99883330	0.99883360	0.99838019	0.99838045
Albuquerque	0.99858546	0.99866080	0.99713145	0.99735320
Atlanta	0.99812818	0.99813890	0.99779421	0.99781187
Billings	0.99953222	0.99971396	0.99925139	0.99955221
Boston	0.98444635	0.98481321	0.97795002	0.97864279
Chicago	0.99953020	0.99953425	0.99913115	0.99913562
Cleveland	0.99865544	0.99867022	0.99814461	0.99817259
Dallas	0.99921471	0.99938262	0.99888116	0.99907006
Denver	0.99718094	0.99718493	0.99699869	0.99700097
Houston	0.99934560	0.99938339	0.99891005	0.99897180
Jacksonville	0.99785364	0.99785787	0.99752061	0.99753556
Kansas City	0.99961698	0.99962187	0.99946331	0.99946817
Los Angeles	0.96230412	0.96950120	0.95234365	0.96296958
Memphis	0.99943167	0.99943221	0.99911515	0.99911579
Miami	0.99412113	0.99416137	0.99234350	0.99239821
Minneapolis	0.99964732	0.99969298	0.99962456	0.99962950
New York	0.99501586	0.99534708	0.99393142	0.99424120
Oakland	0.97028404	0.97318131	0.96605527	0.96997817
Salt Lake City	0.99853384	0.99868238	0.99788741	0.99815468
Seattle	0.99667096	0.99696124	0.99358557	0.99509374
Washington DC	0.99777293	0.99782372	0.99736282	0.99745639

Table 3-3 NPA Availability

Location	NPA Availability (Excluding RAIM/FDE)
Albuquerque	0.99963899
Anchorage	0.99999286
Atlanta	0.99963447
Bethel	0.99998882
Billings	0.99964311
Boston	0.99963874
Cleveland	0.99963639
Cold Bay	0.99999271
Fairbanks	0.99998085
Honolulu	0.99997035
Houston	0.99963451
Juneau	0.99997917
Kansas City	0.99963571
Kotzebue	0.99998434
Los Angeles	0.99998750
Miami	0.99963662
Minneapolis	1.00000000
Oakland	0.99998751
Puerto Rico	0.99652932
Salt Lake City	0.99998801
Seattle	0.99998636
Washington DC	0.99963542

Table 3-4 LPV and LNAV/VNAV Outage Rate

Location	LPV Outages	LPV Outage Rates	LNAV/VNAV Outages	LNAV/VNAV Outage Rates
Atlantic City	58	0.001113	48	0.000921
Greenwood	34	0.000664	33	0.000645
Albuquerque	67	0.001288	63	0.001211
Atlanta	31	0.000596	29	0.000558
Billings	25	0.000479	18	0.000345
Boston	264	0.005174	264	0.005170
Chicago	22	0.000422	20	0.000384
Cleveland	30	0.000576	27	0.000518
Dallas	33	0.000633	21	0.000403
Denver	49	0.001908	49	0.001867
Houston	29	0.000557	23	0.000441
Jacksonville	33	0.000634	31	0.000596
Kansas City	18	0.000345	17	0.000326
Los Angeles	335	0.006749	243	0.004841
Memphis	22	0.000423	20	0.000384
Miami	110	0.002126	103	0.001990
Minneapolis	16	0.001110	13	0.000665
New York	83	0.001602	78	0.001505
Oakland	277	0.005492	195	0.003851
Salt Lake City	65	0.001262	61	0.001184
Seattle	97	0.001891	57	0.001110
Washington DC	32	0.000615	30	0.000577

Table 3-5 NPA Outage Rates

Location	NPA Outages	NPA Outage Rate
Albuquerque	15	0.00028683
Anchorage	3	0.00005736
Atlanta	15	0.00028747
Bethel	2	0.00008600
Billings	15	0.00028689
Boston	15	0.00028682
Cleveland	15	0.00028707
Cold Bay	3	0.00005755
Fairbanks	2	0.00008450
Honolulu	10	0.00019677
Houston	15	0.00028694
Juneau	8	0.00017726
Kansas City	15	0.00028709
Kotzebue	2	0.00008700
Los Angeles	7	0.00013392
Miami	15	0.00028688
Minneapolis	0	0.00000000
Oakland	7	0.00013387
Puerto Rico	9	0.00032863
Salt Lake City	7	0.00013543
Seattle	7	0.00013510
Washington DC	15	0.00028733

Figure 3-1 LPV Instantaneous Availability

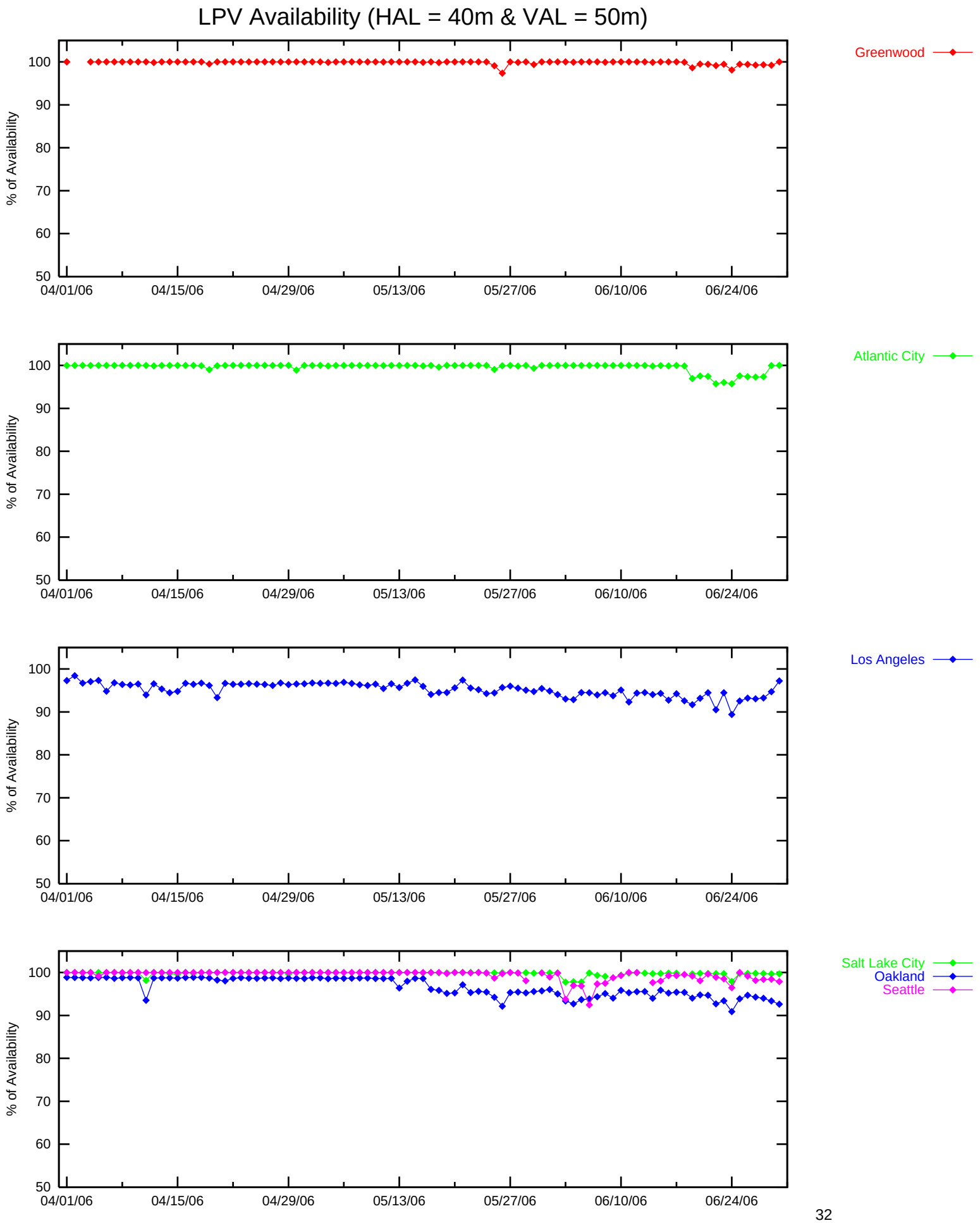


Figure 3-2 LPV Instantaneous Availability

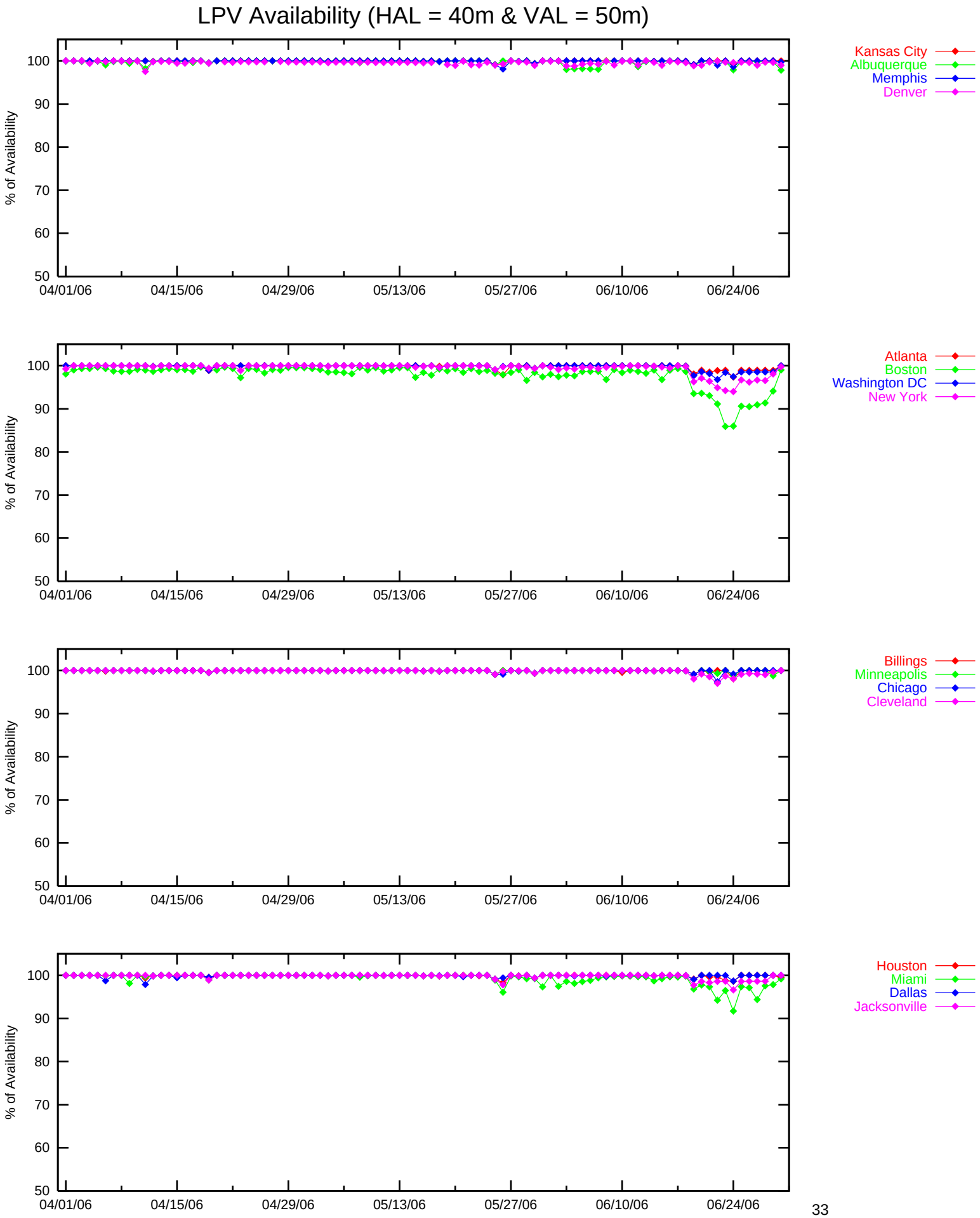


Figure 3-3 LNAV/VNAV Instantaneous Availability

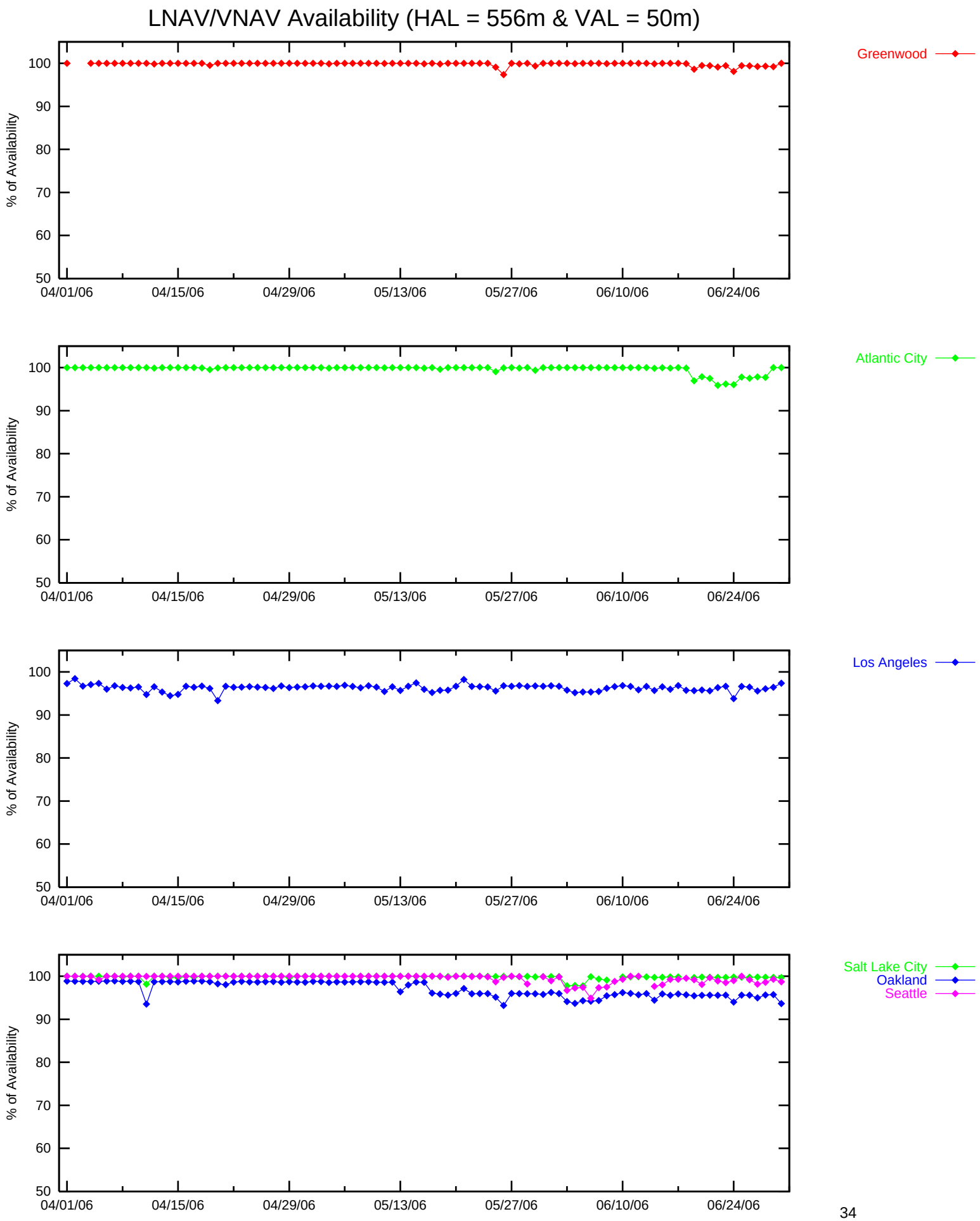


Figure 3-4 LNAV/VNAV Instantaneous Availability

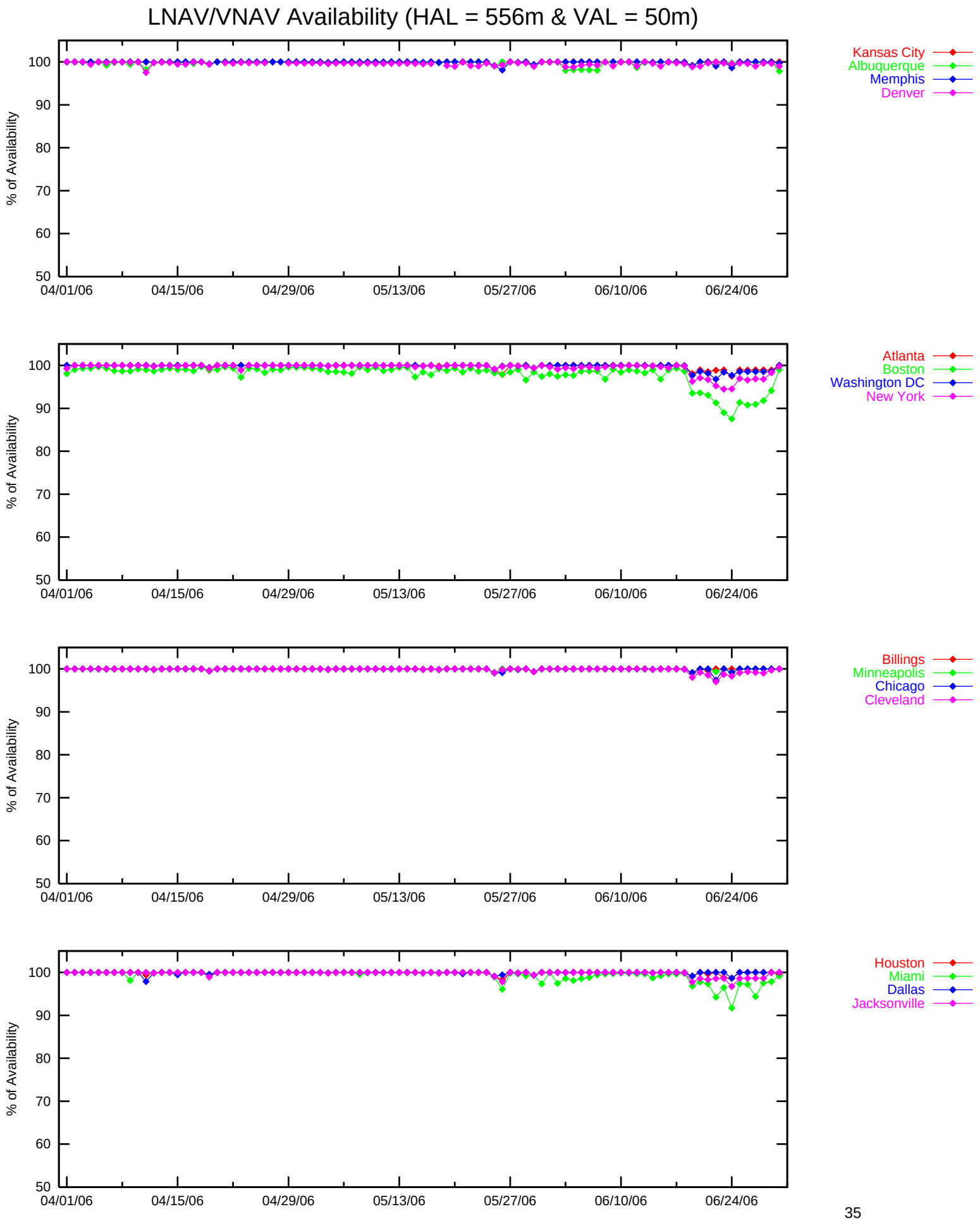


Figure 3-5 LPV Outages

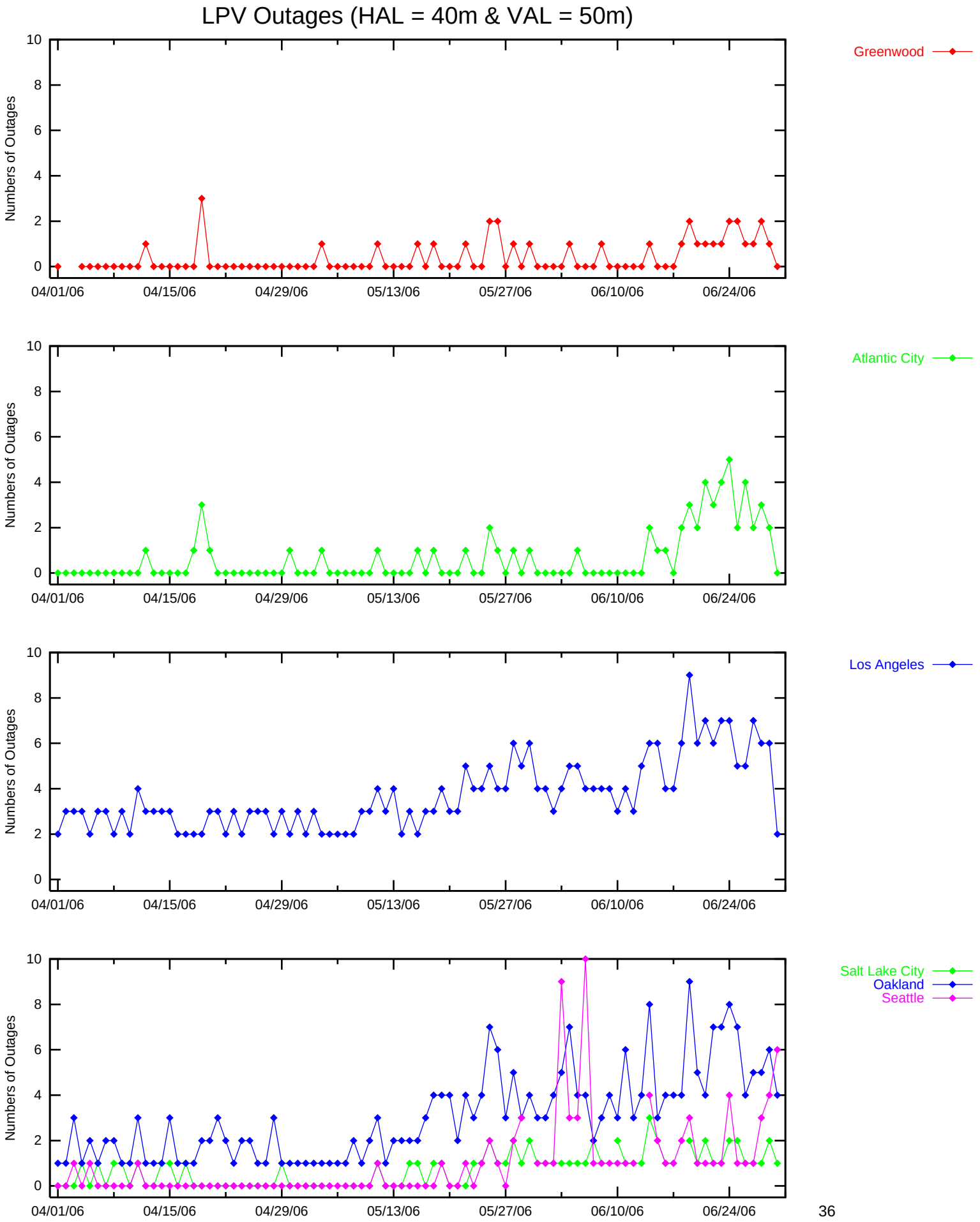


Figure 3-6 LPV Outages

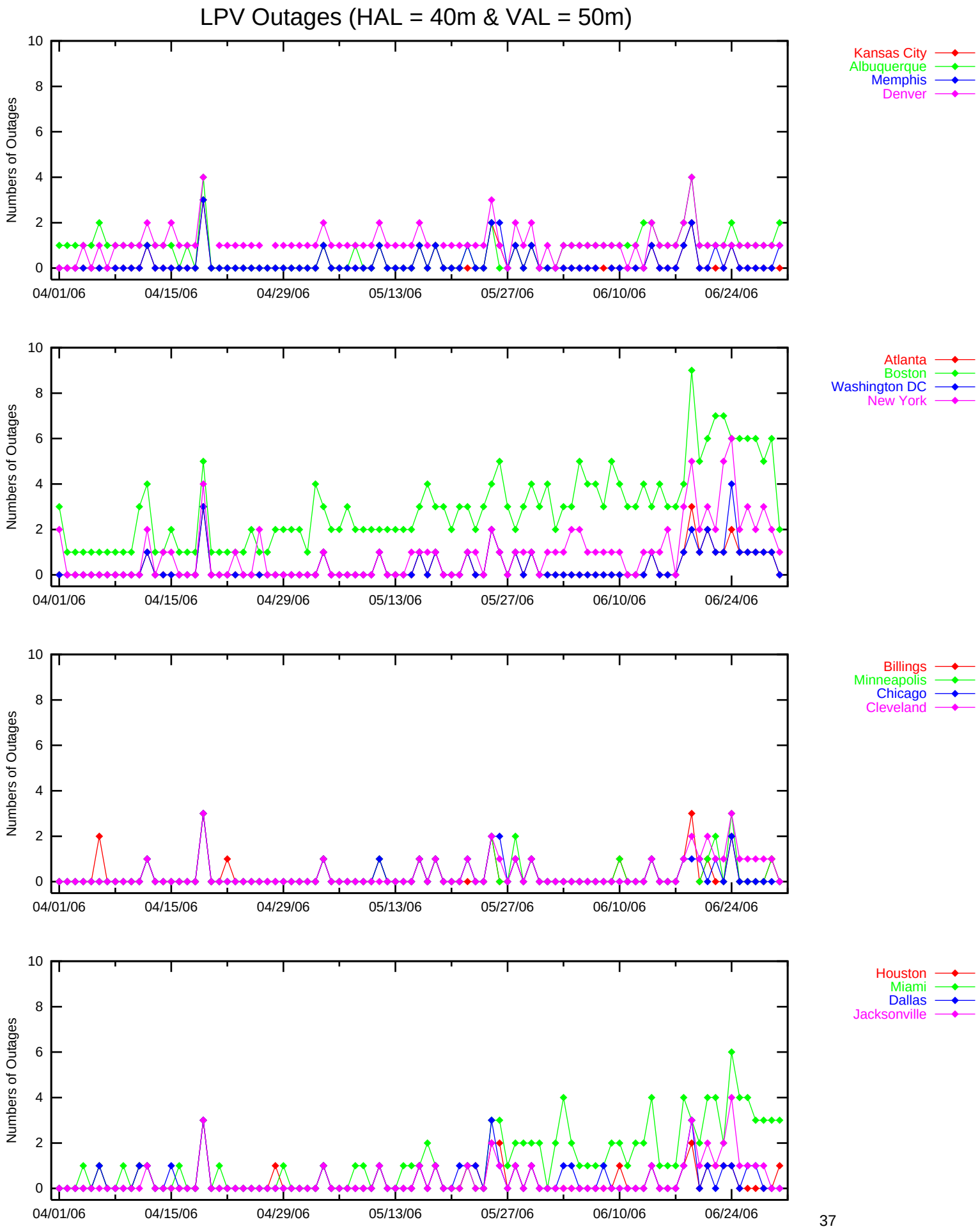


Figure 3-7 LNAV/VNAV Outages

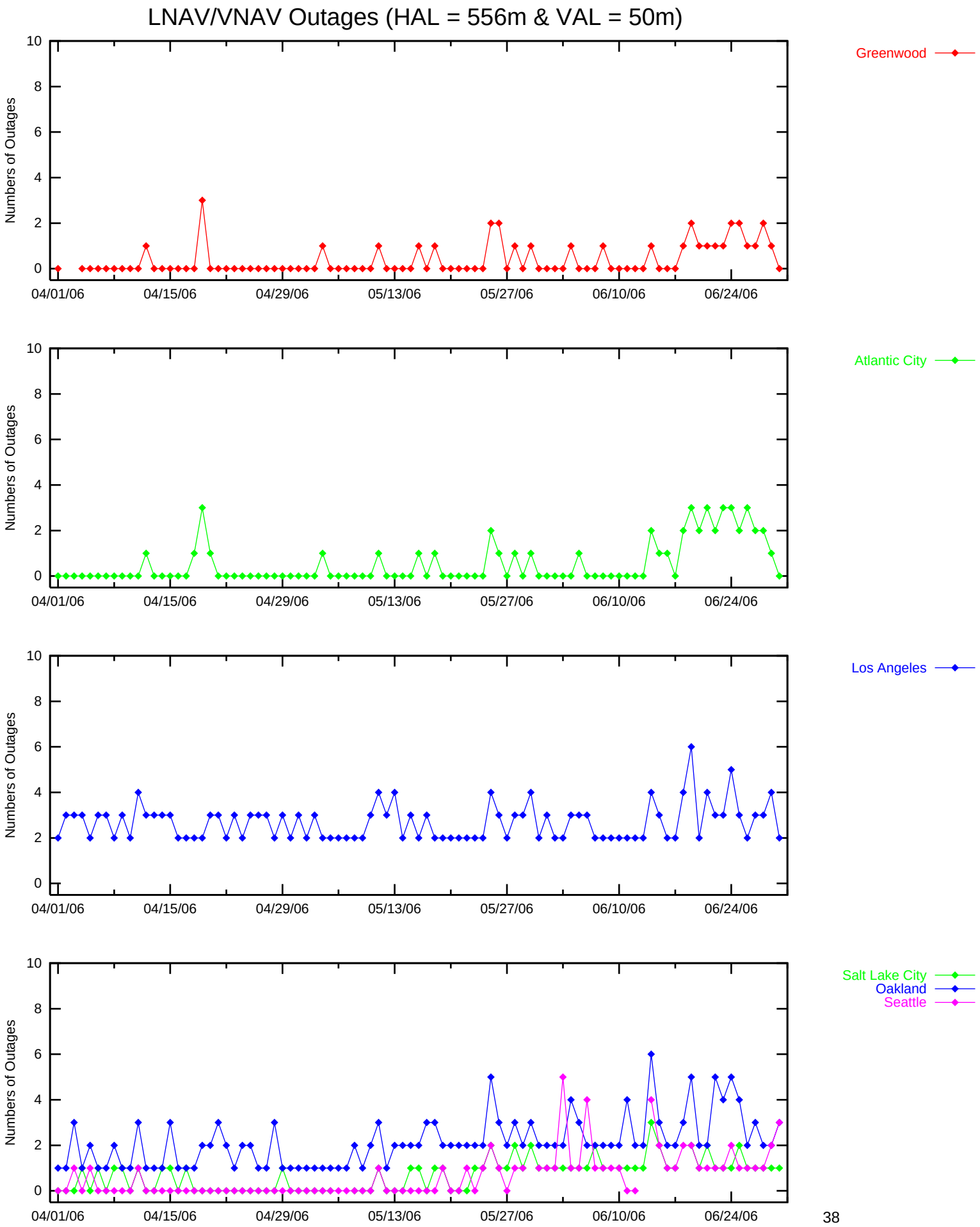
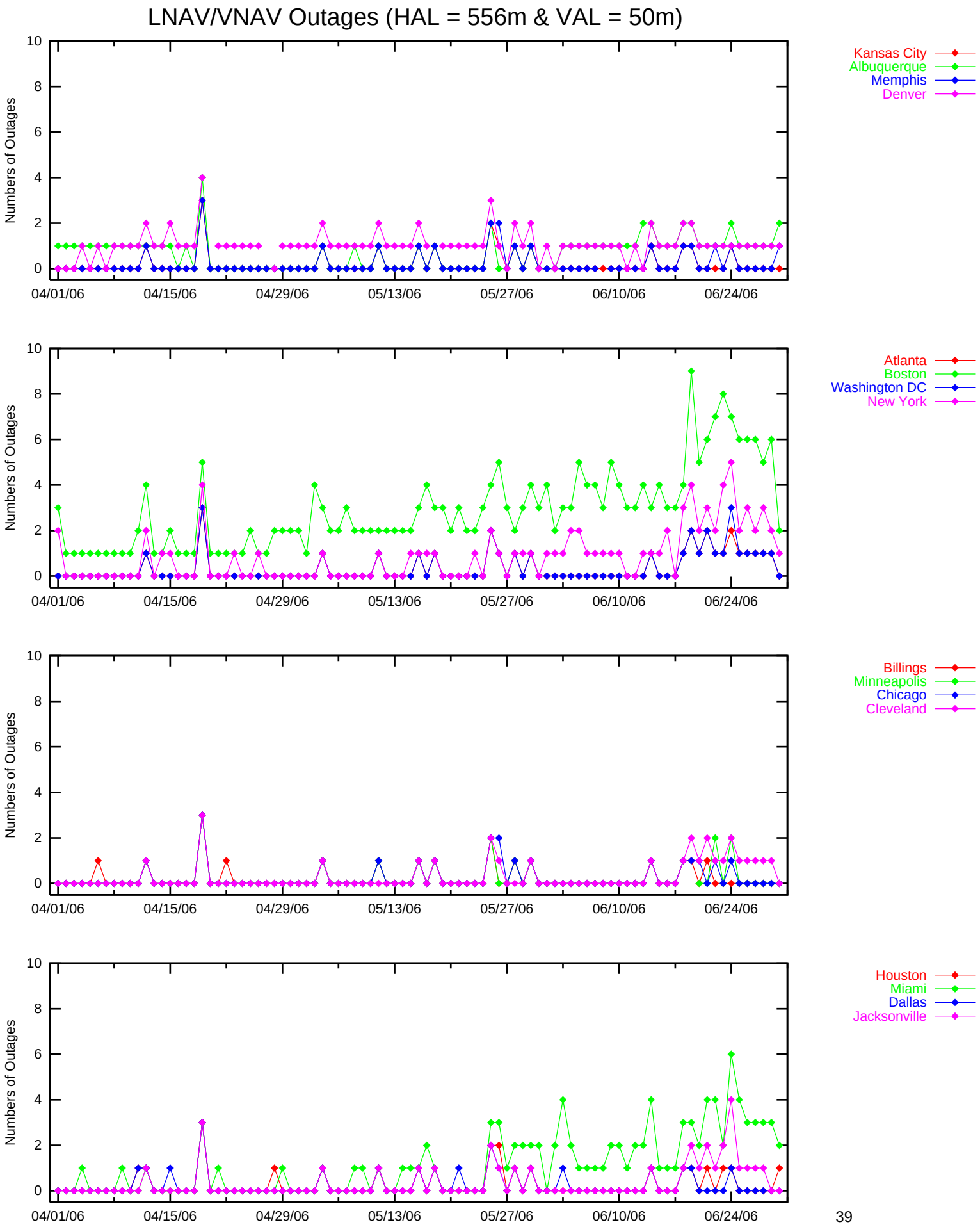


Figure 3-8 LNAV/VNAV Outages



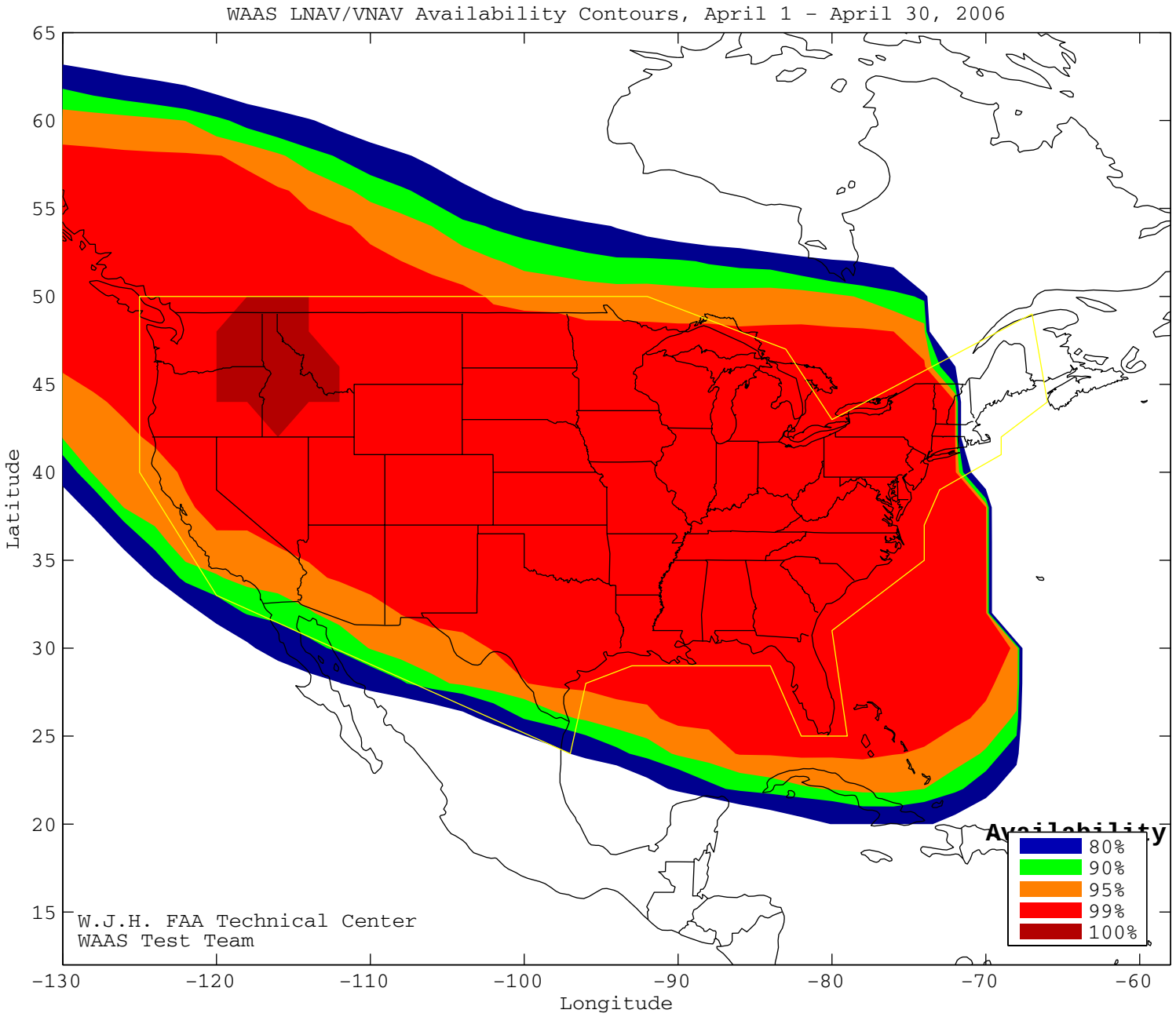
4.0 COVERAGE

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. Figures 4.15 to 4.17 show WAAS LNAV/VNAV, LPV, and NPA coverage since WAAS commissioning (July 2003). 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.

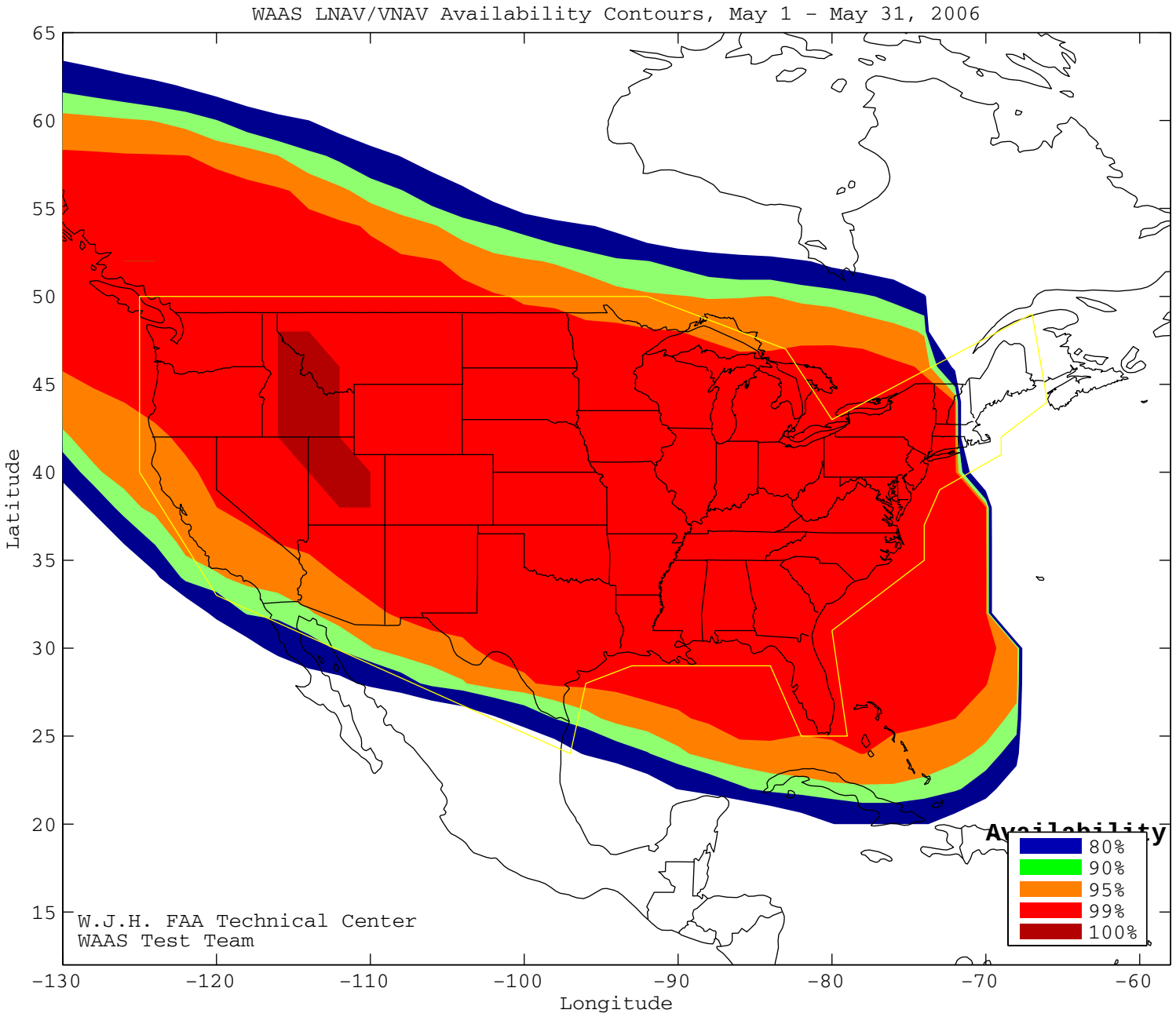
Figure 4-1 WAAS LNAV/VNAV Coverage - April



CONUS Coverage at 95% Availability = 93.93
CONUS Coverage at 99% Availability = 87.04
CONUS Coverage at 100% Availability = 6.073

SL = LNAV/VNAV

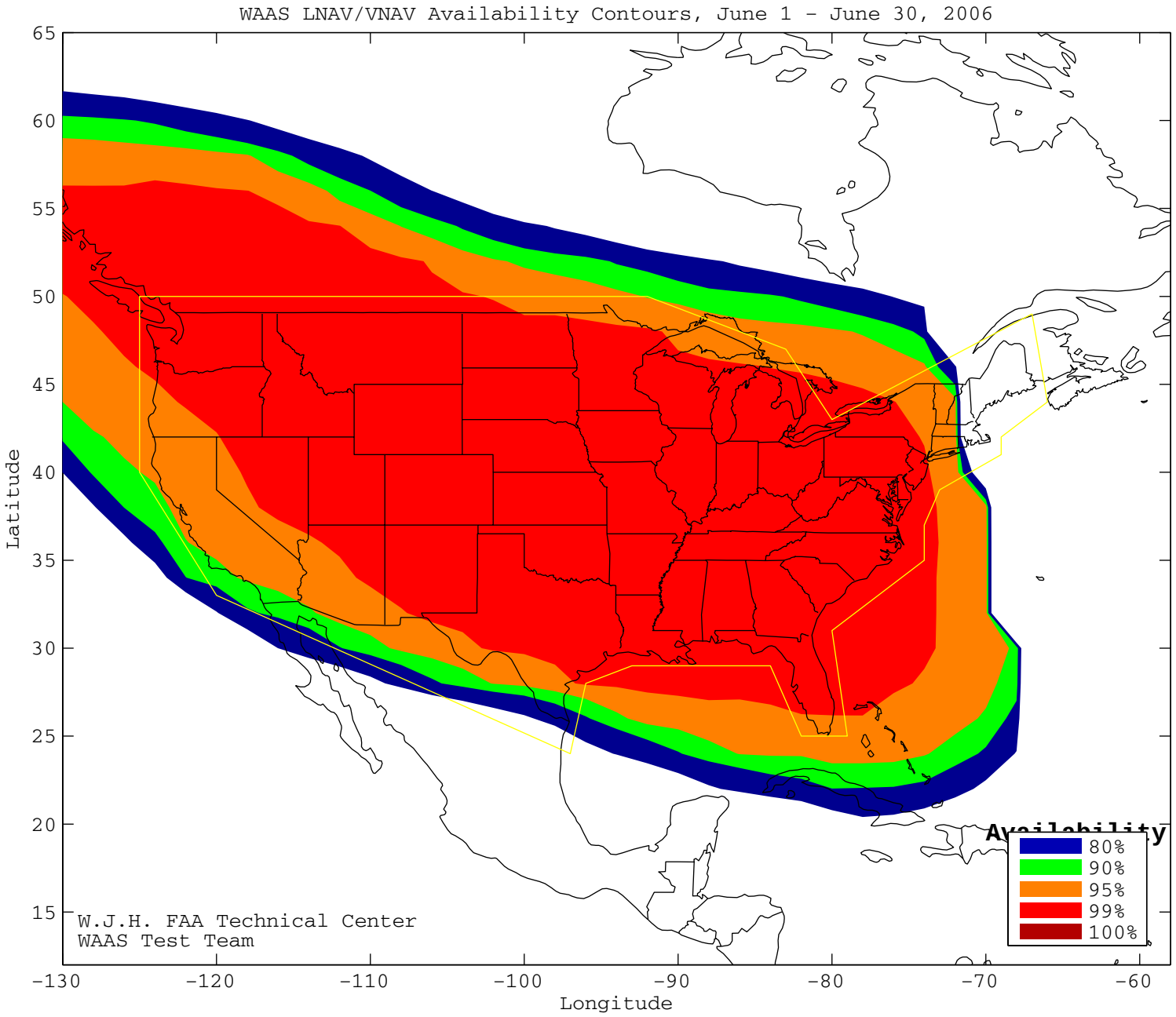
Figure 4-2 WAAS LNAV/VNAV Coverage - May



CONUS Coverage at 95% Availability = 93.12
CONUS Coverage at 99% Availability = 85.43
CONUS Coverage at 100% Availability = 6.478

SL = LNAV/VNAV

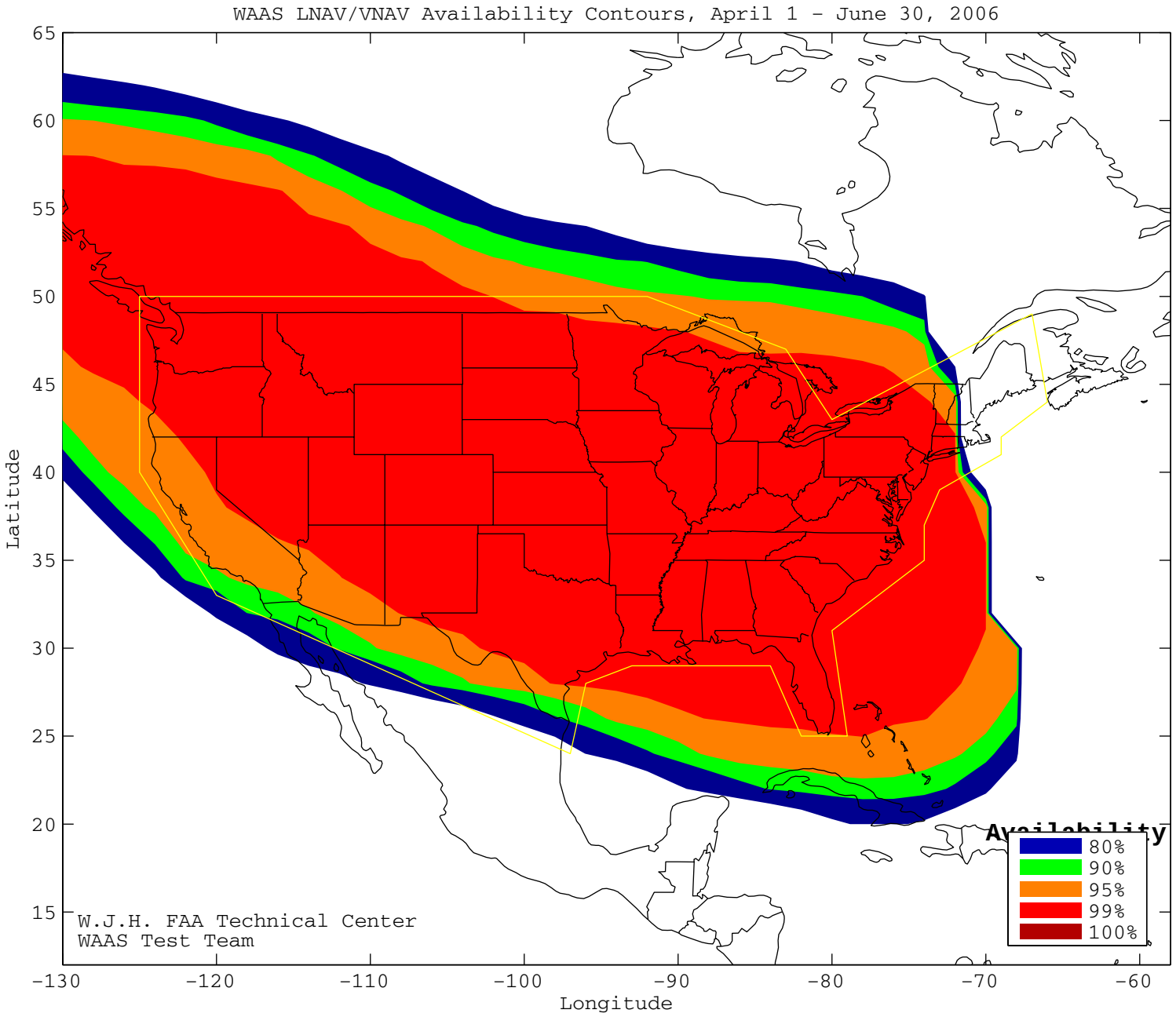
Figure 4-3 WAAS LNAV/VNAV Coverage - June



CONUS Coverage at 95% Availability = 92.71
CONUS Coverage at 99% Availability = 77.73
CONUS Coverage at 100% Availability = 0

SL = LNAV/VNAV

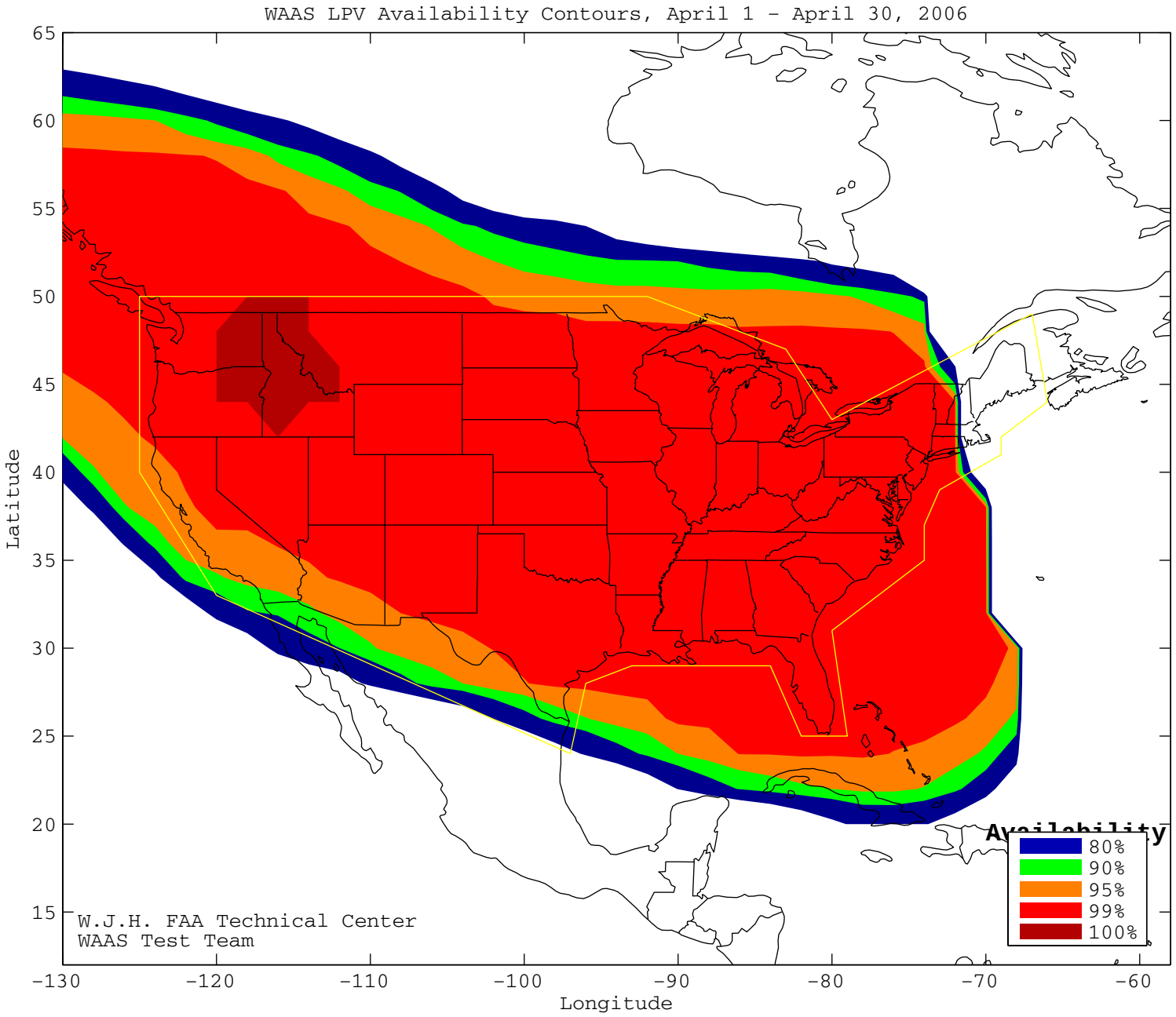
Figure 4-4 WAAS LNAV/VNAV Coverage for the Quarter



CONUS Coverage at 95% Availability = 93.12
CONUS Coverage at 99% Availability = 84.21
CONUS Coverage at 100% Availability = 0

SL = LNAV/VNAV

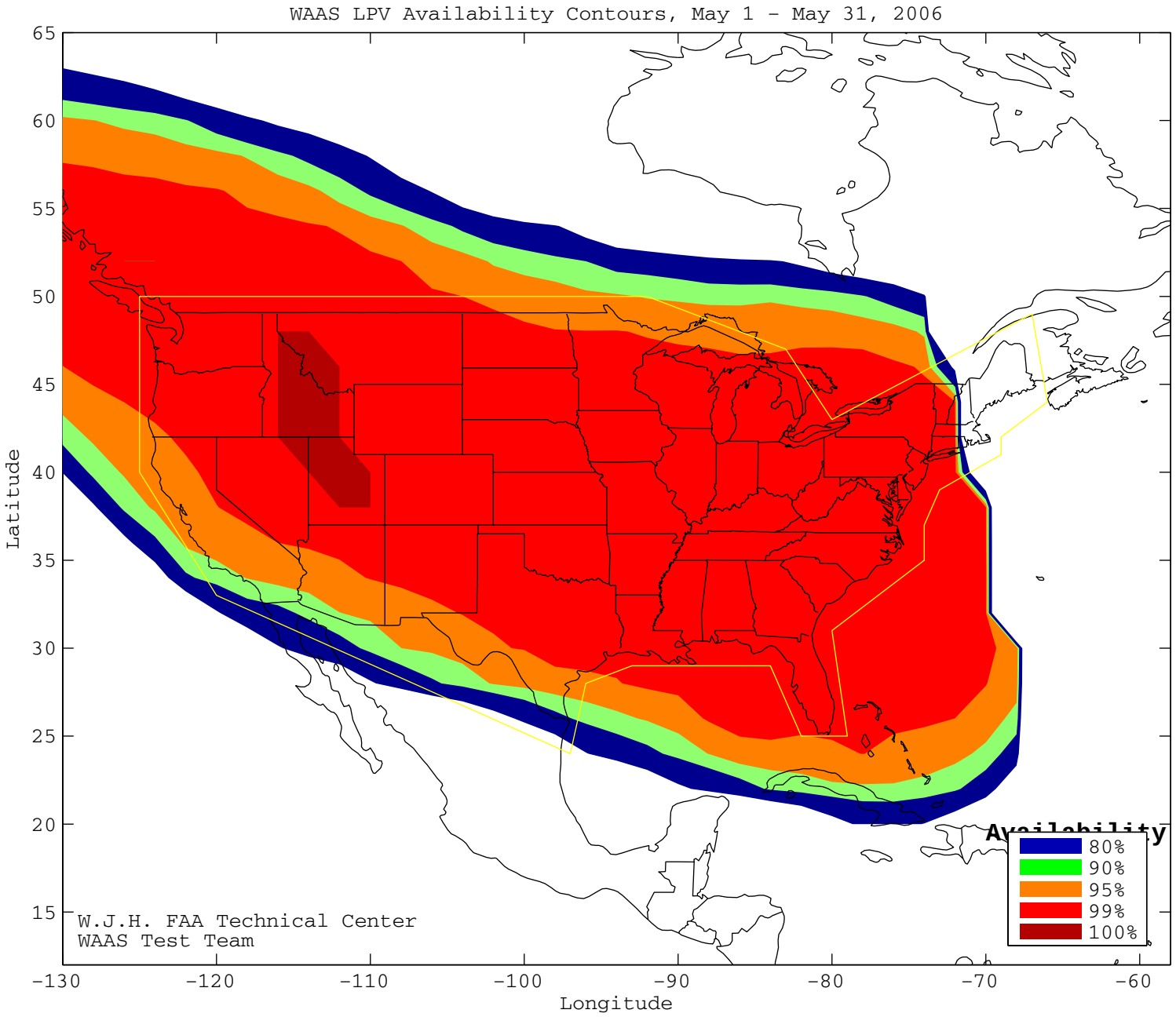
Figure 4-5 WAAS LPV Coverage - April



CONUS Coverage at 95% Availability = 93.12%
CONUS Coverage at 99% Availability = 87.04%
CONUS Coverage at 100% Availability = 6.073%

SL = LPV

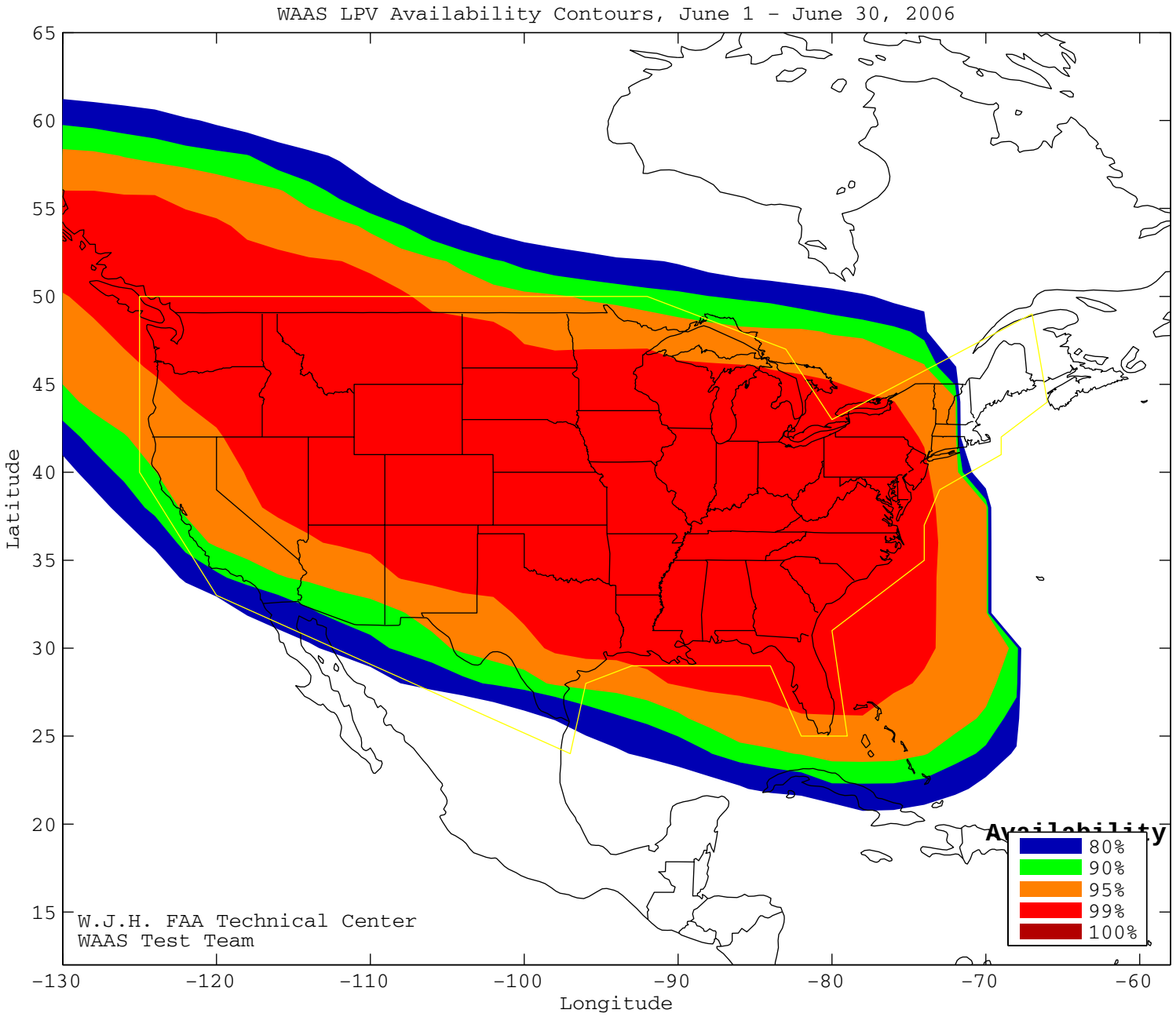
Figure 4-6 WAAS LPV Coverage - May



CONUS Coverage at 95% Availability = 92.31%
CONUS Coverage at 99% Availability = 82.19%
CONUS Coverage at 100% Availability = 6.478%

SL = LPV

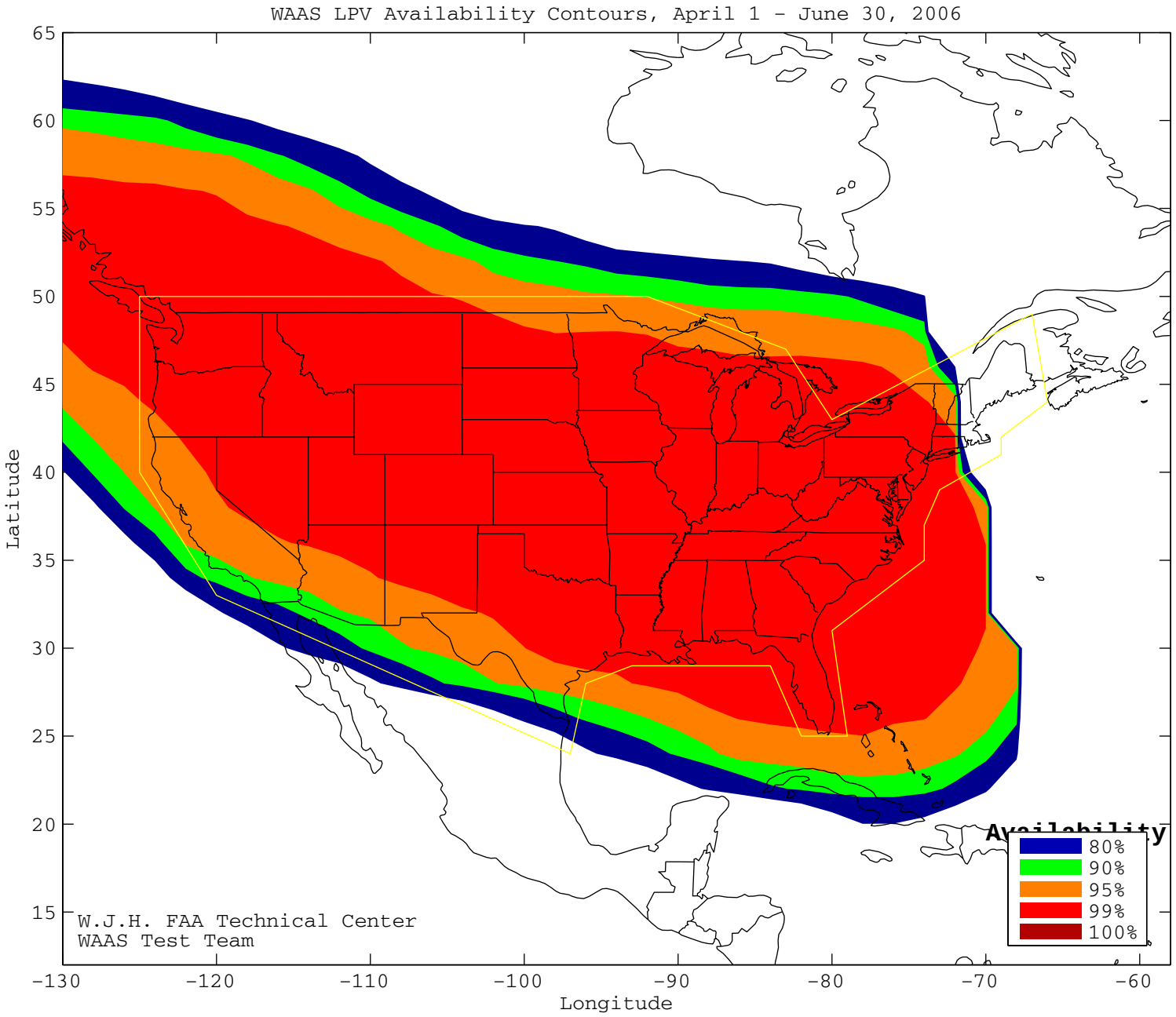
Figure 4-7 WAAS LPV Coverage - June



CONUS Coverage at 95% Availability = 88.66%
CONUS Coverage at 99% Availability = 72.87%
CONUS Coverage at 100% Availability = 0%

SL = LPV

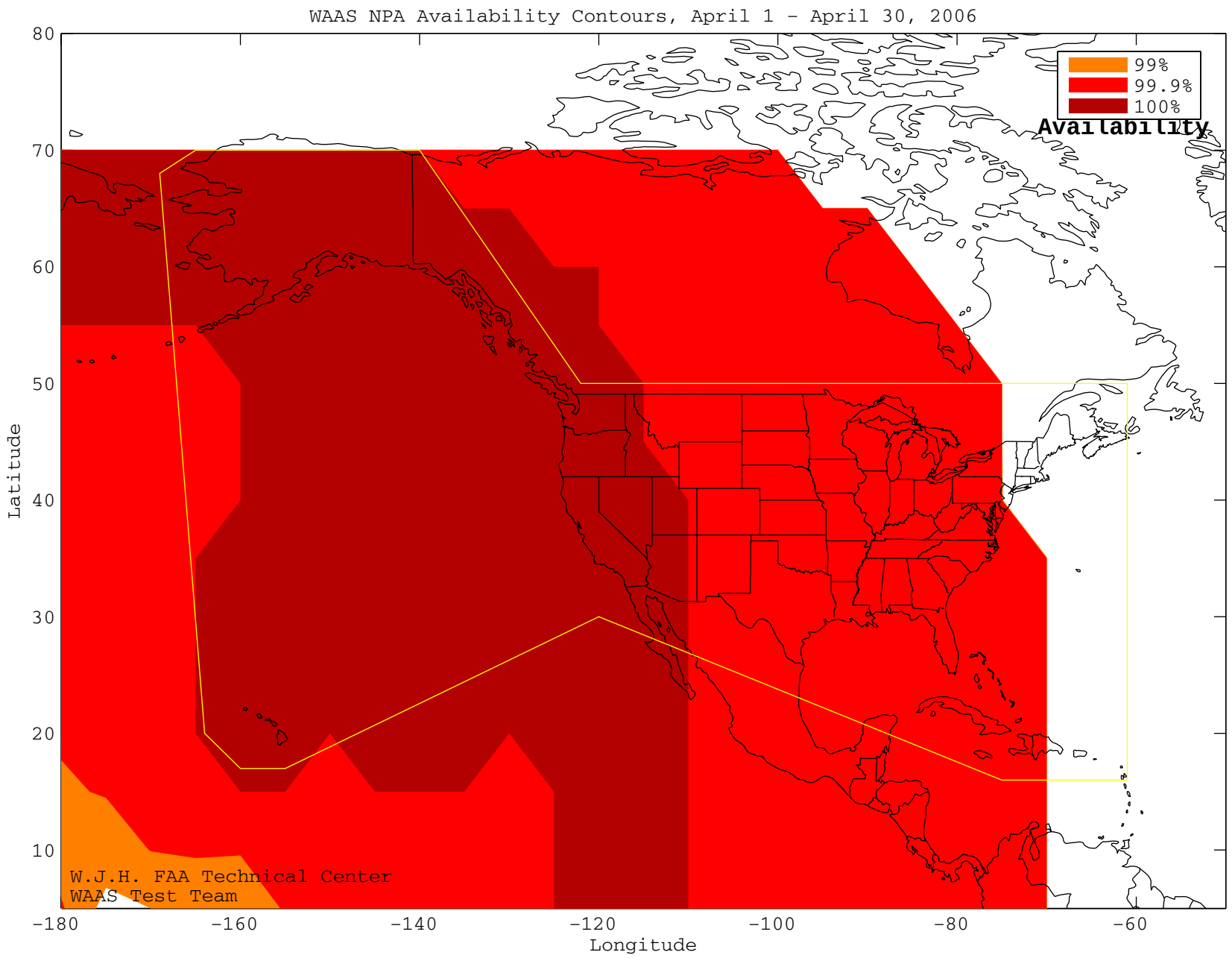
Figure 4-8 WAAS LPV Coverage for the Quarter



CONUS Coverage at 95% Availability = 91.5%
CONUS Coverage at 99% Availability = 79.35%
CONUS Coverage at 100% Availability = 0%

SL = LPV

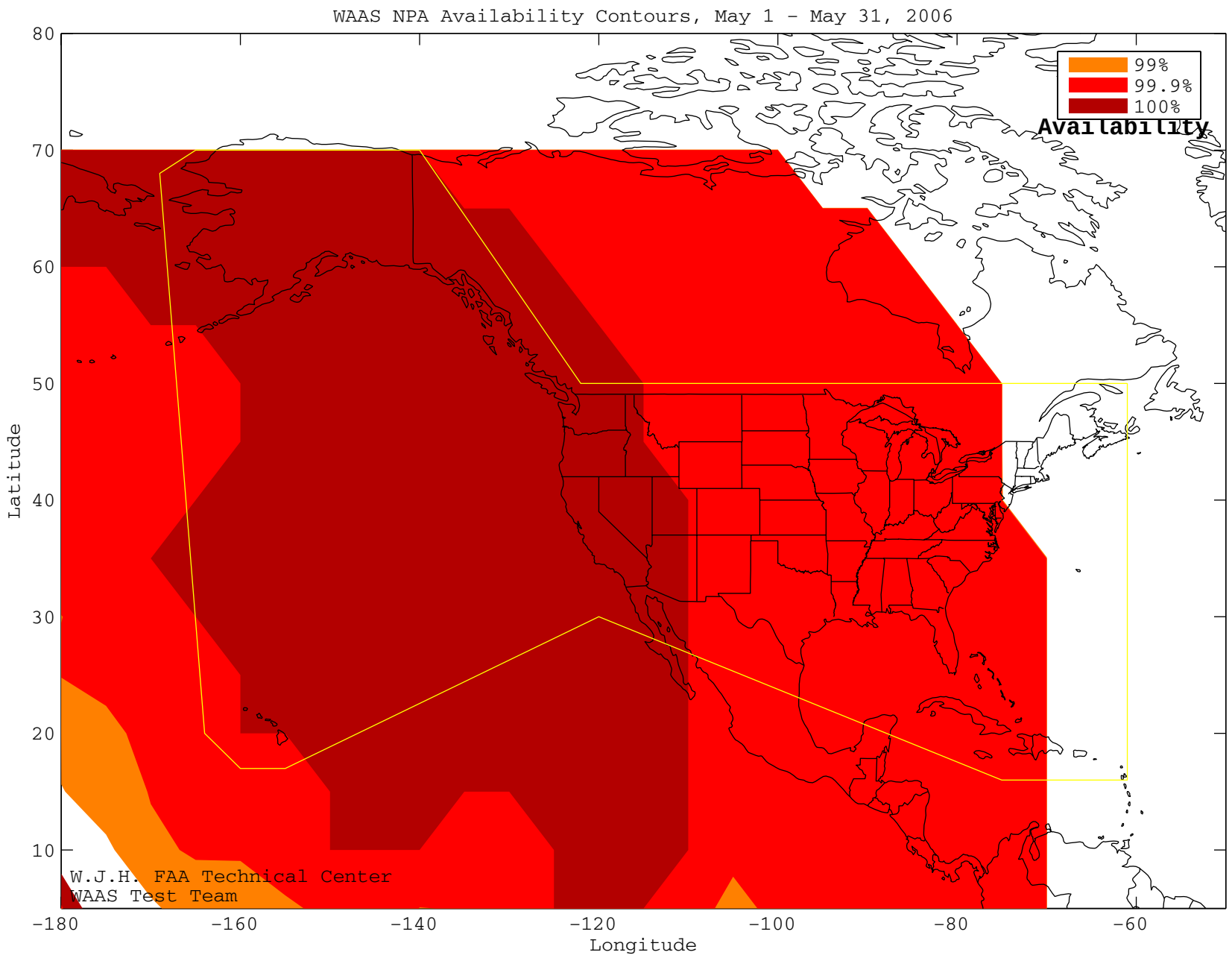
Figure 4-9 WAAS NPA Coverage - April



WAAS Coverage at 99% Availability = 94.12%
WAAS Coverage at 99.9% Availability = 94.12%
WAAS Coverage at 100% Availability = 61.03%

SL = NPA

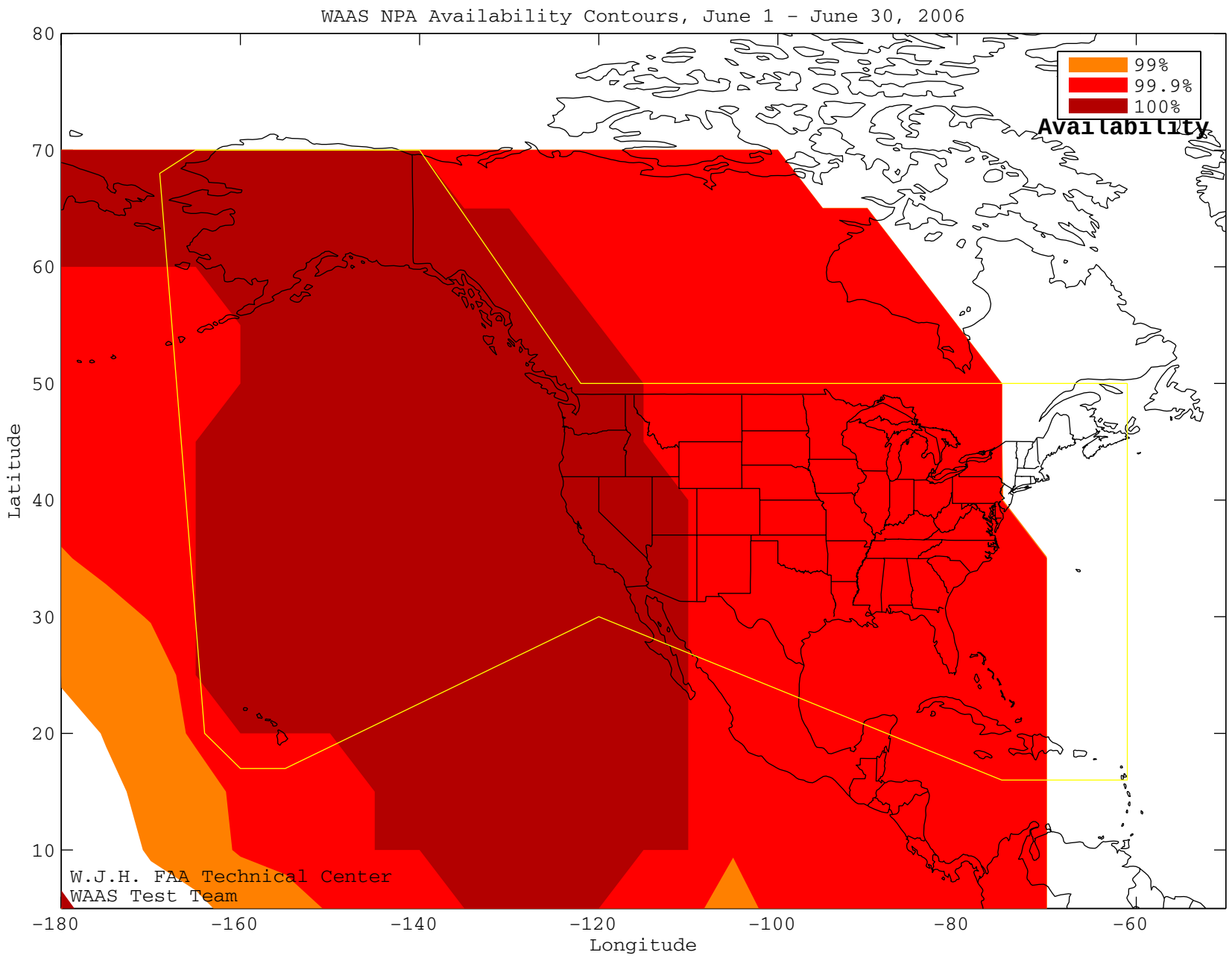
Figure 4-10 WAAS NPA Coverage - May



WAAS Coverage at 99% Availability = 94.12%
WAAS Coverage at 99.9% Availability = 94.12%
WAAS Coverage at 100% Availability = 61.76%

SL = NPA

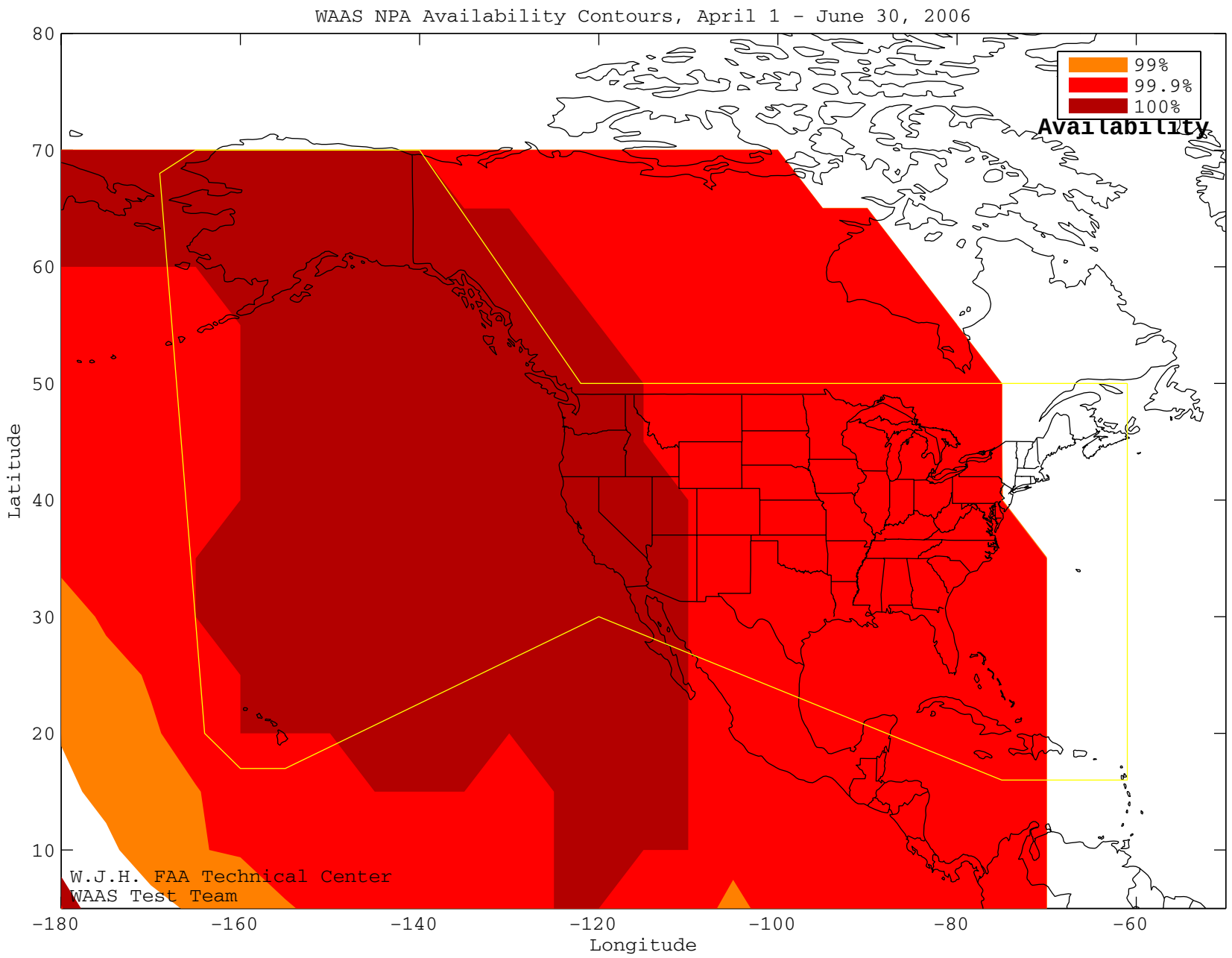
Figure 4-11 WAAS NPA Coverage - June



WAAS Coverage at 99% Availability = 94.12%
WAAS Coverage at 99.9% Availability = 94.12%
WAAS Coverage at 100% Availability = 61.76%

SL = NPA

Figure 4-12 WAAS NPA Coverage for the Quarter



WAAS Coverage at 99% Availability = 94.12%
WAAS Coverage at 99.9% Availability = 94.12%
WAAS Coverage at 100% Availability = 60.29%

SL = NPA

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

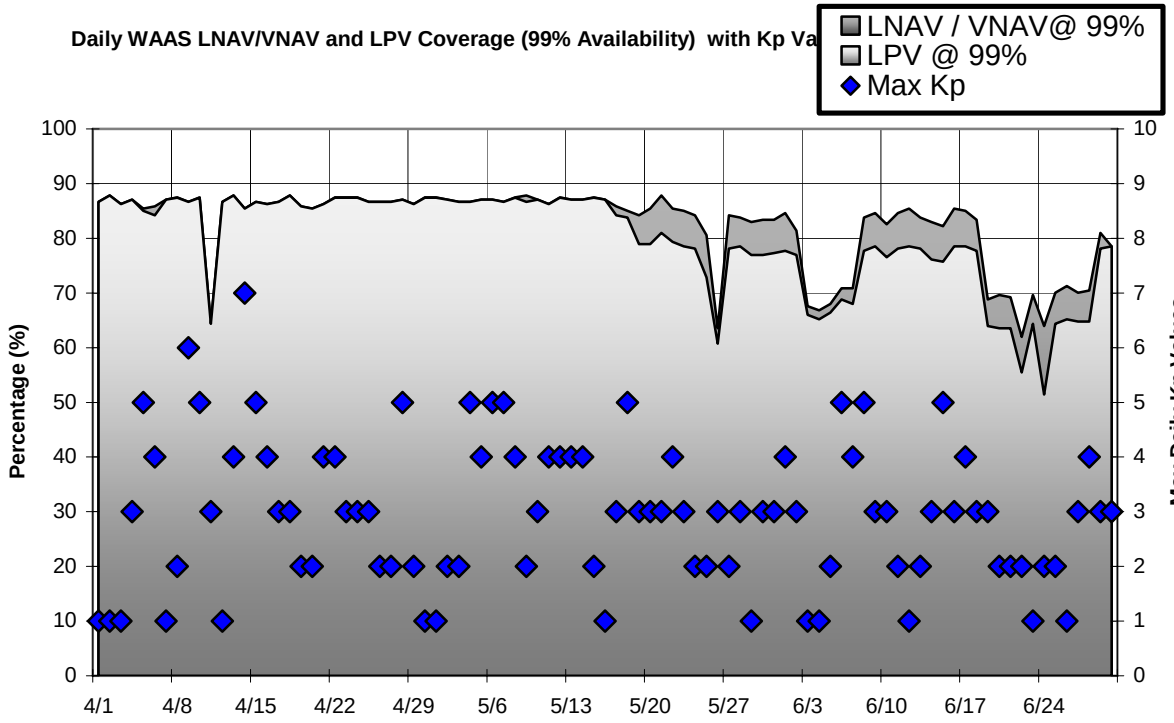


Figure 4-14 Daily NPA Coverage

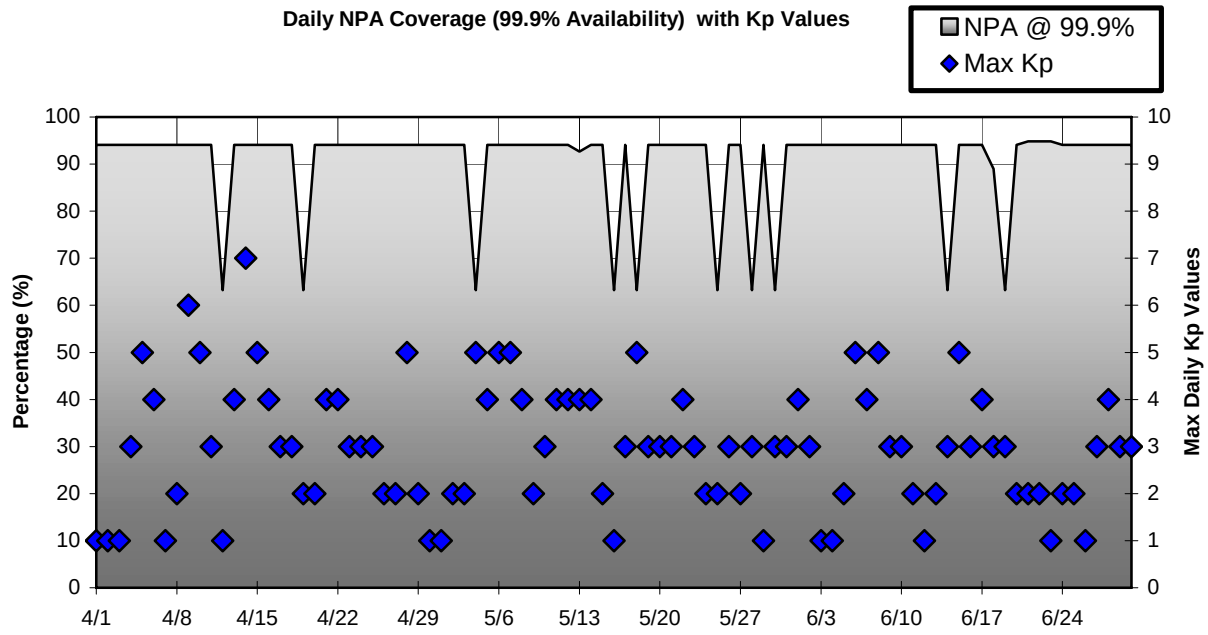
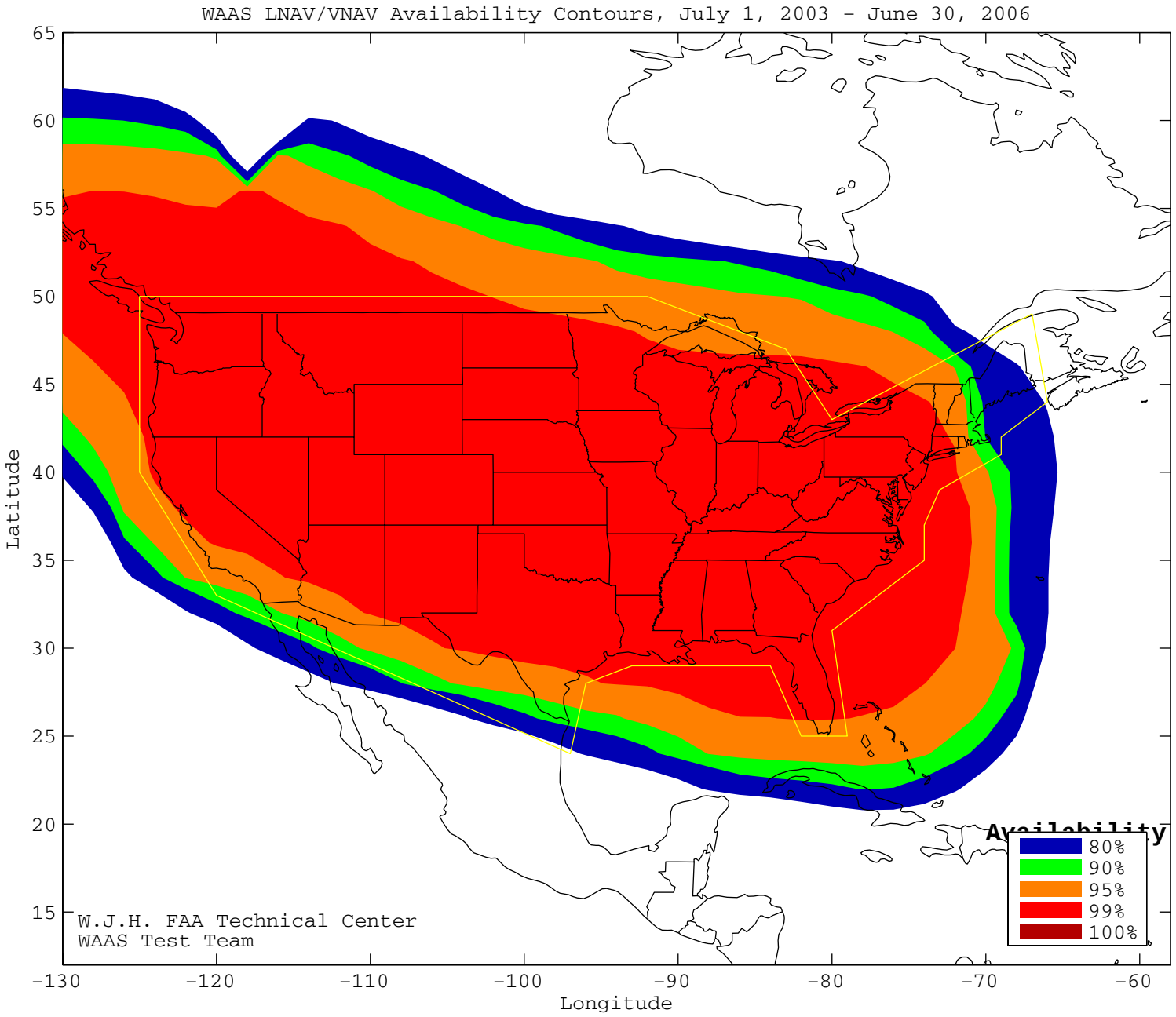


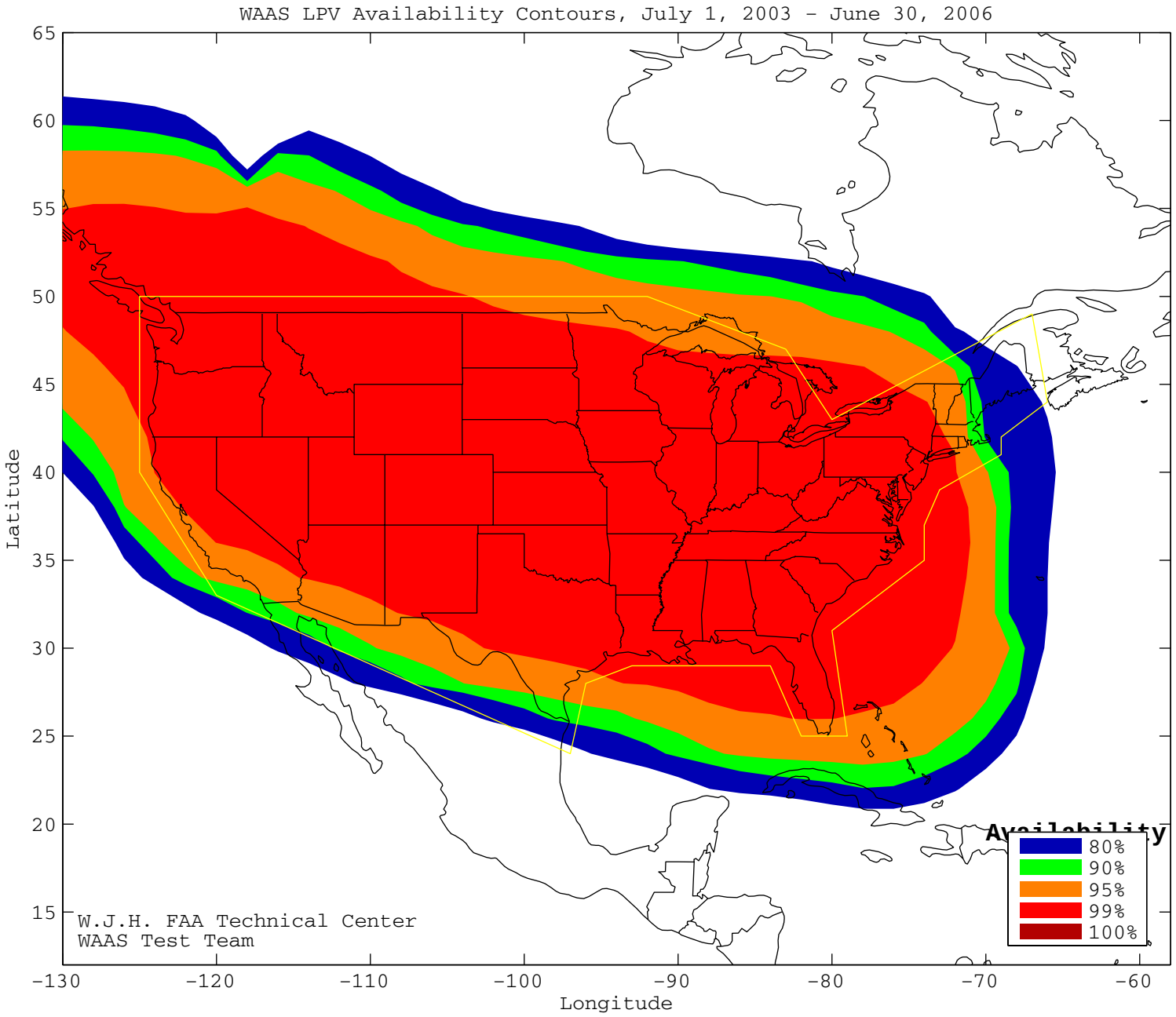
Figure 4-15 WAAS LNAV/VNAV Coverage Since Commissioning



CONUS Coverage at 95% Availability = 94.74
CONUS Coverage at 99% Availability = 87.04
CONUS Coverage at 100% Availability = 0

SL = LNAV/VNAV

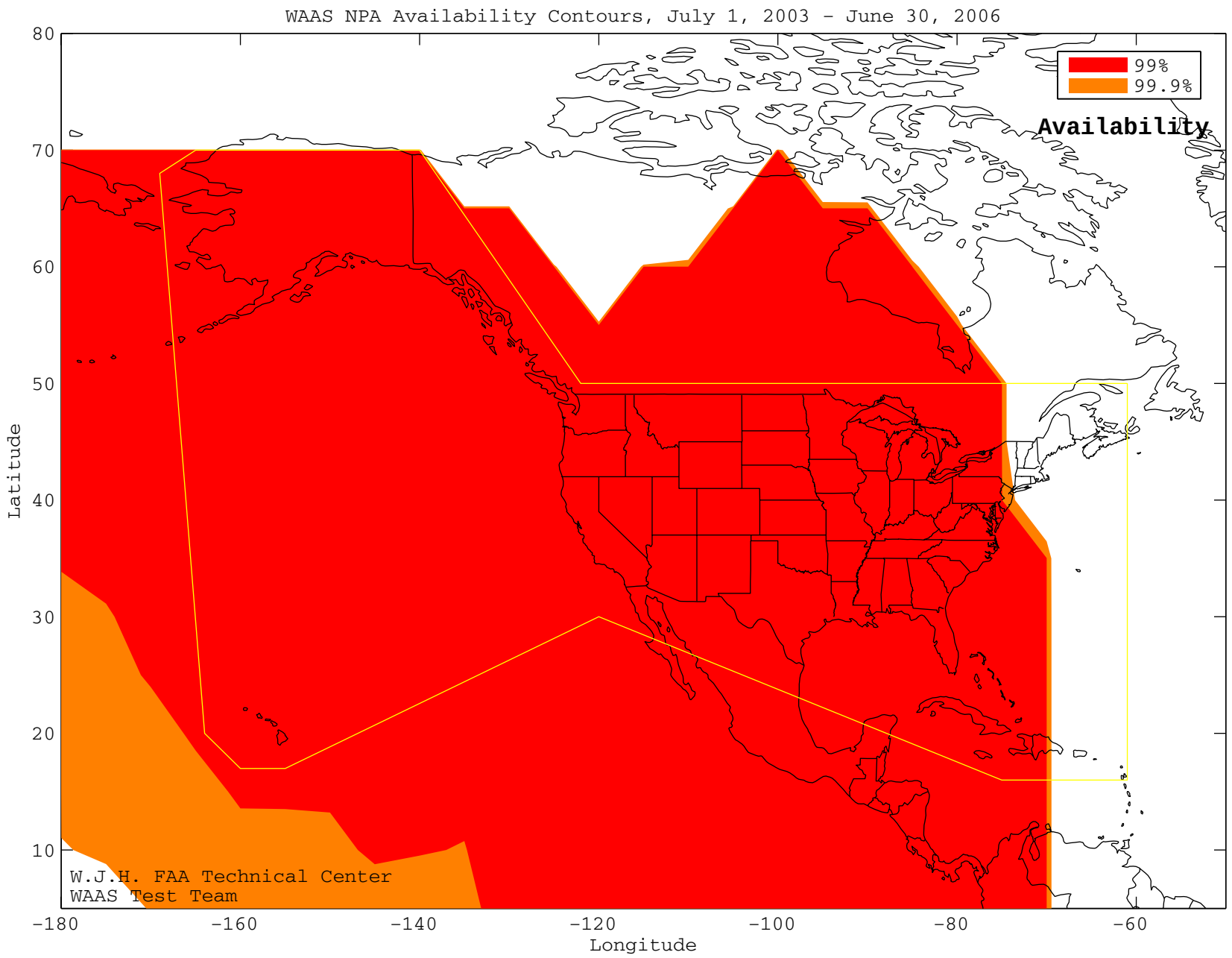
Figure 4-16 WAAS LPV Coverage Since Commissioning



CONUS Coverage at 95% Availability = 93.93%
CONUS Coverage at 99% Availability = 86.23%
CONUS Coverage at 100% Availability = 0%

SL = LPV

Figure 4-17 NPA Coverage Since Commissioning



WAAS Coverage at 99% Availability = 94.12
WAAS Coverage at 99.9% Availability = 94.12
WAAS Coverage at 100% Availability = 0

SL = NPA

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	
Atlantic City	10.00	7.61	0
Greenwood	8.57	7.61	0
Albuquerque	10.00	6.66	0
Atlanta	12.00	6.66	0
Billings	10.00	7.61	0
Boston	5.00	5.33	0
Chicago	12.00	8.88	0
Cleveland	5.45	4.44	0
Dallas	5.00	4.44	0
Denver	8.57	5.33	0
Houston	12.00	7.61	0
Jacksonville	10.00	7.61	0
Kansas City	8.57	6.66	0
Los Angeles	8.57	7.61	0
Memphis	12.00	8.88	0
Miami	8.57	4.44	0
Minneapolis	8.57	6.66	0
New York	15.00	7.61	0
Oakland	8.57	6.66	0
Salt Lake City	8.57	7.61	0
Seattle	8.57	6.66	0
Washington DC	12.00	7.61	0

An observed safety margin index of greater than one indicates safe bounding of the greatest observed error, less than one indicates that the maximum error was not bounded, and a result equal to one means that the error was equal to the protection level. As evidenced by the statistics in the above table, the lowest safety margin index is 4.44 at Cleveland. 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.

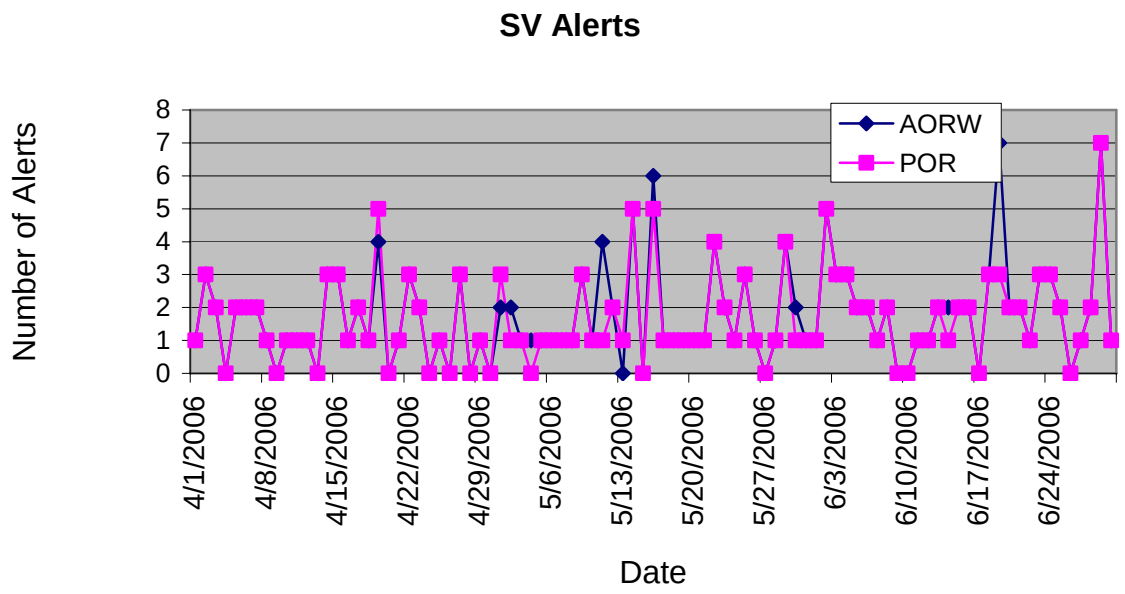
5.2 Broadcast Alerts

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	59	64	0.6483	0.7032
3	63	69	0.6923	0.7582
6	7	0	0.0769	0
24	53	48	0.5824	0.5274
26	0	0	0	0
Total Alerts	182	181	2	1.9890

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	139597	0	0
2	1310247	117	36
3	1310278	114	32
7	74645	101	217
9	92129	1	158
10	74622	128	208
17	29698	16	506
24	1310251	114	34

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

SV	On Time	Late	Max Late Length (seconds)
1	41314	2	172
2	44729	1	172
3	39857	2	171
4	44947	1	168
5	46081	1	164
6	42725	0	0
7	46759	5	187
8	42267	0	0
9	45990	1	168
10	45519	1	166
11	46845	1	175
13	42874	1	176
14	44525	2	176
15	41810	2	173
16	46320	1	168
17	45164	1	170
18	43323	2	177
19	45151	0	0
20	46205	3	177
21	35992	1	168
22	38903	4	178
23	42888	1	177
24	46609	2	176
25	24742	0	0
26	43692	1	165
27	39945	5	187
28	38795	2	170
29	44234	1	182
30	44305	0	0

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

SV	On Time	Late	Max Late Length (seconds)
1	39494	2	187
2	42417	1	158
3	37676	2	153
4	42579	2	182
5	43820	3	243
6	40444	0	0
7	44201	6	179
8	40060	3	128
9	43792	1	138
10	42991	4	195
11	44541	2	180
13	40356	2	149
14	41941	0	0
15	39326	3	304
16	42704	3	168
17	41866	0	0
18	40183	2	190
19	41301	3	186
20	41866	1	167
21	32994	5	269
22	35482	1	185
23	38730	4	192
24	42204	0	0
25	22376	2	128
26	39773	4	192
27	36610	5	192
28	35380	2	172
29	40298	5	194
30	40079	2	192
134	76814	3	189

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

Band	Block	On Time	Late	Max Late Length (seconds)
0	0	27315	15	579
1	0	27294	15	577
1	1	27314	17	671
1	2	27295	13	670
1	3	27299	11	659
1	4	27309	14	640
2	0	27283	18	616
2	1	27290	15	592
2	2	27291	13	509
2	3	27308	14	576
2	4	27309	16	512
2	5	27283	20	551
3	0	27317	16	580

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

Band	On Time	Late	Max Late Length (seconds)
0	67475	0	0
1	67460	0	0
2	67451	0	0
3	67462	0	0

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

Message Type	On Time	Late	Max Late Length (seconds)
1	138196	0	0
2	1310389	94	39
3	1310435	82	35
7	73876	120	194
9	92128	3	337
10	73878	102	180
17	29594	6	494
24	1310374	95	34

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

SV	On Time	Late	Max Late Length (seconds)
1	41313	0	0
2	44737	1	174
3	39866	0	0
4	44954	0	0
5	46087	1	170
6	42726	0	0
7	46779	0	0
8	42261	1	164
9	45989	1	168
10	45520	1	172
11	46857	0	0
13	42860	0	0
14	44531	0	0
15	41818	2	178
16	46333	1	166
17	45160	1	168
18	43333	0	0
19	45148	1	181
20	46204	1	176
21	35997	0	0
22	38916	0	0
23	42905	1	177
24	46605	0	0
25	24737	1	173
26	43702	0	0
27	39984	2	170
28	38808	0	0
29	44253	0	0
30	44305	2	172

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

SV	On Time	Late	Max Late Length (seconds)
1	39491	0	0
2	42429	0	0
3	37679	2	133
4	42578	0	0
5	43816	1	178
6	40448	0	0
7	44225	1	144
8	40060	3	167
9	43799	0	0
10	42996	3	168
11	44546	1	175
13	40346	5	179
14	41941	0	0
15	39335	5	304
16	42712	2	143
17	41859	2	171
18	40182	1	192
19	41308	2	139
20	41874	0	0
21	33000	2	136
22	35491	0	0
23	38734	0	0
24	42202	2	179
25	22370	0	0
26	39788	0	0
27	36610	2	144
28	35381	3	158
29	40317	2	144
30	40093	1	192
134	76823	0	0

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

Band	Block	On Time	Late	Max Late Length (seconds)
0	0	27334	12	532
0	1	27308	9	535
0	2	27309	10	539
1	0	27311	11	544
1	1	27302	12	528
1	2	27312	8	532
1	3	27315	10	504
1	4	27294	11	451
2	0	27294	10	483
2	1	27311	13	462
2	2	27306	7	427
2	3	27352	7	445

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

Band	On Time	Late	Max Late Length (seconds)
0	67087	0	0
1	67105	0	0
2	67123	0	0

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	1.293	100.00	1.231	100.00	1.459	100.00	1.087	100.00	0.972	100.00	1.300	100.00
2	2.232	100.00	1.712	100.00	1.243	100.00	1.583	100.00	1.705	100.00	1.947	100.00
3	1.129	100.00	1.015	100.00	1.821	100.00	1.804	100.00	1.330	100.00	1.183	100.00
4	1.747	100.00	1.519	100.00	1.825	100.00	1.968	100.00	1.983	100.00	1.295	100.00
5	1.369	100.00	1.082	100.00	1.311	100.00	1.146	100.00	1.149	100.00	1.176	100.00
6	1.464	100.00	1.328	100.00	1.711	100.00	1.982	100.00	1.357	100.00	1.470	100.00
7	1.257	100.00	1.181	100.00	1.356	100.00	1.563	100.00	1.586	100.00	1.417	100.00
8	1.468	100.00	0.949	100.00	1.243	100.00	1.433	100.00	1.008	100.00	0.917	100.00
9	1.282	100.00	1.214	100.00	1.597	100.00	1.498	100.00	1.565	100.00	1.338	100.00
10	1.804	100.00	1.325	100.00	1.006	100.00	1.249	100.00	1.199	100.00	1.846	100.00
11	1.676	100.00	1.256	100.00	1.324	100.00	1.381	100.00	2.406	100.00	1.651	100.00
12	-	-	-	-	-	-	-	-	-	-	-	-
13	1.177	100.00	1.323	100.00	1.351	100.00	1.602	100.00	1.088	100.00	1.285	100.00
14	1.835	100.00	0.864	100.00	1.256	100.00	1.189	100.00	1.265	100.00	1.715	100.00
15	1.613	100.00	1.033	100.00	1.537	100.00	1.690	100.00	1.104	100.00	1.468	100.00
16	1.525	100.00	1.219	100.00	0.943	100.00	1.243	100.00	1.153	100.00	1.735	100.00
17	1.206	100.00	1.242	100.00	1.629	100.00	1.513	100.00	1.489	100.00	0.872	100.00
18	1.730	100.00	1.033	100.00	1.326	100.00	1.410	100.00	1.010	100.00	2.016	100.00
19	3.145	100.00	2.619	100.00	2.571	100.00	2.512	100.00	2.465	100.00	3.192	99.9355
20	1.611	100.00	1.030	100.00	1.158	100.00	1.073	100.00	1.631	100.00	1.785	100.00
21	2.355	100.00	1.669	100.00	1.760	100.00	1.426	100.00	1.484	100.00	1.818	100.00
22	1.766	100.00	1.270	100.00	1.587	100.00	1.330	100.00	1.456	100.00	1.913	100.00
23	3.149	99.7009	2.070	100.00	2.269	100.00	2.486	100.00	2.779	100.00	3.314	99.6508
24	1.676	100.00	1.361	100.00	1.594	100.00	2.294	100.00	1.886	100.00	1.452	100.00
25	1.137	100.00	1.325	100.00	1.159	100.00	1.395	100.00	1.373	100.00	1.114	100.00
26	1.426	100.00	1.454	100.00	1.725	100.00	1.931	100.00	1.522	100.00	1.309	100.00
27	1.237	100.00	1.056	100.00	1.226	100.00	1.597	100.00	1.177	100.00	1.085	100.00
28	1.657	100.00	1.117	100.00	0.995	100.00	1.006	100.00	1.055	100.00	1.715	100.00
29	1.151	100.00	1.847	100.00	2.125	100.00	1.952	100.00	1.794	100.00	1.122	100.00
30	1.380	100.00	1.569	100.00	1.455	100.00	1.737	100.00	1.731	100.00	1.110	100.00
31	-	-	-	-	-	-	-	-	-	-	-	-
122	-	-	-	-	-	-	-	-	-	-	-	-
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	1.356	100.00	1.652	100.00	1.241	100.00	1.441	100.00	0.913	100.00	1.443	100.00
2	2.017	100.00	1.846	100.00	1.303	100.00	2.045	100.00	1.356	100.00	1.223	100.00
3	1.497	100.00	1.722	100.00	1.274	100.00	1.527	100.00	1.058	100.00	1.155	100.00
4	1.851	100.00	2.671	100.00	1.760	100.00	2.021	100.00	1.365	100.00	1.786	100.00
5	1.648	100.00	1.443	100.00	1.391	100.00	1.621	100.00	0.861	100.00	1.081	100.00
6	1.625	100.00	2.146	100.00	2.167	100.00	1.574	100.00	1.406	100.00	1.525	100.00
7	1.781	100.00	2.055	100.00	1.306	100.00	1.443	100.00	0.958	100.00	1.228	100.00
8	1.294	100.00	1.635	100.00	1.234	100.00	1.826	99.1466	0.811	100.00	1.110	100.00
9	1.893	100.00	2.126	100.00	1.477	100.00	1.718	100.00	1.229	100.00	1.718	100.00
10	1.605	100.00	1.601	100.00	0.996	100.00	1.862	100.00	0.826	100.00	0.881	100.00
11	1.593	100.00	1.663	100.00	2.347	100.00	1.938	100.00	1.104	100.00	1.202	100.00
12	-	-	-	-	-	-	-	-	-	-	-	-
13	1.530	100.00	1.353	100.00	1.710	100.00	1.473	100.00	0.981	100.00	1.600	100.00
14	1.653	100.00	1.310	100.00	1.826	100.00	1.456	100.00	1.151	100.00	1.060	100.00
15	1.778	100.00	1.697	100.00	1.308	100.00	1.766	100.00	1.162	100.00	0.973	100.00
16	1.594	100.00	1.358	100.00	1.501	100.00	1.828	100.00	1.074	100.00	0.853	100.00
17	1.451	100.00	2.158	100.00	1.754	100.00	1.601	100.00	0.955	100.00	1.615	100.00
18	1.353	100.00	1.680	100.00	1.025	100.00	1.879	100.00	1.190	100.00	1.065	100.00
19	2.977	100.00	2.612	100.00	2.338	100.00	3.226	100.00	2.396	100.00	2.132	100.00
20	2.026	100.00	1.435	100.00	1.143	100.00	1.733	100.00	1.206	100.00	1.004	100.00
21	2.119	100.00	1.633	100.00	1.779	100.00	1.921	100.00	1.493	100.00	1.285	100.00
22	2.066	100.00	1.376	100.00	2.982	100.00	1.501	100.00	1.476	100.00	1.034	100.00
23	2.843	100.00	2.688	100.00	2.567	100.00	2.905	100.00	2.221	100.00	1.684	100.00
24	1.769	100.00	2.472	100.00	1.734	100.00	2.380	100.00	1.271	100.00	1.898	100.00
25	1.607	100.00	2.030	100.00	1.318	100.00	1.400	100.00	0.863	100.00	1.321	100.00
26	1.899	100.00	2.272	100.00	1.768	100.00	2.076	100.00	1.604	100.00	1.801	100.00
27	1.359	100.00	1.850	100.00	1.168	100.00	1.690	100.00	0.806	100.00	1.370	100.00
28	1.519	100.00	1.316	100.00	1.414	100.00	1.434	100.00	1.052	100.00	1.123	100.00
29	1.461	100.00	1.927	100.00	1.754	100.00	1.797	100.00	1.297	100.00	1.403	100.00
30	2.076	100.00	2.182	100.00	1.847	100.00	1.799	100.00	1.509	100.00	1.977	100.00
31	-	-	-	-	-	-	-	-	-	-	-	-
122	-	-	-	-	-	-	-	-	-	-	-	-
134	-	-	-	-	-	-	-	-	-	-	6.223	100.00

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	0.850	100.00	0.629	100.00	0.732	100.00	0.789	100.00	0.654	100.00	0.628	100.00
2	1.788	100.00	1.227	100.00	0.893	100.00	1.166	100.00	1.135	100.00	1.464	100.00
3	0.593	100.00	0.448	100.00	0.562	100.00	0.950	100.00	0.814	100.00	0.473	100.00
4	1.064	100.00	1.031	100.00	1.090	100.00	1.315	100.00	1.616	100.00	0.888	100.00
5	0.799	100.00	0.553	100.00	0.631	100.00	0.462	100.00	0.503	100.00	0.526	100.00
6	0.876	100.00	0.781	100.00	0.785	100.00	1.159	100.00	0.911	100.00	0.702	100.00
7	0.623	100.00	0.548	100.00	0.507	100.00	0.662	100.00	0.580	100.00	0.497	100.00
8	0.867	100.00	0.546	100.00	0.525	100.00	0.814	100.00	0.706	100.00	0.504	100.00
9	0.675	100.00	0.571	100.00	0.590	100.00	0.651	100.00	0.639	100.00	0.556	100.00
10	1.212	100.00	0.756	100.00	0.389	100.00	0.751	100.00	0.638	100.00	1.087	100.00
11	0.991	100.00	0.610	100.00	0.458	100.00	0.564	100.00	1.263	100.00	0.904	100.00
12	-	-	-	-	-	-	-	-	-	-	-	-
13	0.729	100.00	0.720	100.00	0.598	100.00	0.926	100.00	0.737	100.00	0.588	100.00
14	1.313	100.00	0.430	100.00	0.416	100.00	0.545	100.00	0.594	100.00	1.153	100.00
15	0.815	100.00	0.561	100.00	0.587	100.00	0.692	100.00	0.515	100.00	0.636	100.00
16	0.920	100.00	0.719	100.00	0.325	100.00	0.603	100.00	0.598	100.00	0.953	100.00
17	0.809	100.00	0.877	100.00	0.947	100.00	1.003	100.00	1.105	100.00	0.490	100.00
18	1.310	100.00	0.546	100.00	0.676	100.00	0.835	100.00	0.728	100.00	1.365	100.00
19	2.165	100.00	1.594	100.00	1.575	100.00	1.663	100.00	1.784	100.00	2.235	100.00
20	0.964	100.00	0.535	100.00	0.545	100.00	0.494	100.00	0.833	100.00	0.914	100.00
21	1.642	100.00	1.114	100.00	0.778	100.00	0.840	100.00	0.934	100.00	1.352	100.00
22	1.336	100.00	0.822	100.00	0.719	100.00	0.757	100.00	0.969	100.00	1.456	100.00
23	2.166	100.00	1.560	100.00	1.703	100.00	1.810	100.00	2.201	100.00	2.377	100.00
24	0.927	100.00	0.777	100.00	0.789	100.00	1.461	100.00	1.340	100.00	0.907	100.00
25	0.745	100.00	0.848	100.00	0.712	100.00	1.092	100.00	1.168	100.00	0.592	100.00
26	0.732	100.00	0.719	100.00	0.529	100.00	0.989	100.00	0.916	100.00	0.620	100.00
27	0.856	100.00	0.658	100.00	0.644	100.00	0.996	100.00	0.873	100.00	0.604	100.00
28	1.280	100.00	0.600	100.00	0.589	100.00	0.562	100.00	0.607	100.00	1.100	100.00
29	0.650	100.00	0.857	100.00	0.635	100.00	0.853	100.00	0.822	100.00	0.504	100.00
30	0.780	100.00	0.856	100.00	0.757	100.00	0.951	100.00	0.799	100.00	0.464	100.00
31	-	-	-	-	-	-	-	-	-	-	-	-

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	0.817	100.00	1.108	100.00	0.671	100.00	0.837	100.00	0.482	100.00	0.620	100.00
2	0.977	100.00	0.983	100.00	0.656	100.00	1.859	100.00	0.884	100.00	0.893	100.00
3	0.636	100.00	0.878	100.00	0.786	100.00	0.674	100.00	0.424	100.00	0.557	100.00
4	1.226	100.00	1.706	100.00	1.275	100.00	1.226	100.00	0.921	100.00	0.947	100.00
5	0.651	100.00	0.836	100.00	0.736	100.00	0.743	100.00	0.346	100.00	0.493	100.00
6	1.051	100.00	1.584	100.00	1.190	100.00	1.001	100.00	0.786	100.00	0.708	100.00
7	0.850	100.00	1.175	100.00	0.592	100.00	0.679	100.00	0.348	100.00	0.515	100.00
8	0.676	100.00	1.196	100.00	0.933	100.00	0.968	100.00	0.525	100.00	0.538	100.00
9	0.746	100.00	1.081	100.00	0.619	100.00	0.804	100.00	0.557	100.00	0.859	100.00
10	0.796	100.00	0.834	100.00	0.526	100.00	1.381	100.00	0.322	100.00	0.462	100.00
11	0.747	100.00	0.680	100.00	1.130	100.00	1.052	100.00	0.449	100.00	0.504	100.00
12	-	-	-	-	-	-	-	-	-	-	-	-
13	0.969	100.00	0.988	100.00	1.188	100.00	0.869	100.00	0.644	100.00	0.728	100.00
14	0.578	100.00	0.666	100.00	0.827	100.00	1.067	100.00	0.491	100.00	0.656	100.00
15	0.584	100.00	1.100	100.00	0.666	100.00	0.925	100.00	0.339	100.00	0.375	100.00
16	0.759	100.00	0.750	100.00	0.414	100.00	1.090	100.00	0.419	100.00	0.437	100.00
17	1.162	100.00	1.521	100.00	1.185	100.00	0.922	100.00	0.645	100.00	0.765	100.00
18	0.570	100.00	0.780	100.00	0.549	100.00	1.576	100.00	0.570	100.00	0.537	100.00
19	1.542	100.00	1.541	100.00	1.161	100.00	2.207	100.00	1.486	100.00	1.581	100.00
20	0.983	100.00	0.709	100.00	0.520	100.00	0.949	100.00	0.600	100.00	0.528	100.00
21	0.926	100.00	0.909	100.00	1.311	100.00	1.626	100.00	0.914	100.00	0.877	100.00
22	0.873	100.00	0.779	100.00	1.672	100.00	1.365	100.00	0.858	100.00	0.724	100.00
23	1.761	100.00	1.700	100.00	1.798	100.00	2.371	100.00	1.625	100.00	1.447	100.00
24	1.031	100.00	1.516	100.00	1.131	100.00	1.425	100.00	0.839	100.00	0.957	100.00
25	1.139	100.00	1.386	100.00	1.054	100.00	0.695	100.00	0.699	100.00	0.771	100.00
26	0.868	100.00	1.387	100.00	0.737	100.00	1.287	100.00	0.765	100.00	0.911	100.00
27	1.075	100.00	1.465	100.00	0.975	100.00	1.140	100.00	0.581	100.00	0.726	100.00
28	0.683	100.00	0.839	100.00	0.760	100.00	1.192	100.00	0.495	100.00	0.638	100.00
29	0.657	100.00	1.125	100.00	0.831	100.00	1.013	100.00	0.515	100.00	0.626	100.00
30	1.147	100.00	1.354	100.00	1.036	100.00	0.829	100.00	0.796	100.00	0.875	100.00
31	-	-	-	-	-	-	-	-	-	-	-	-

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

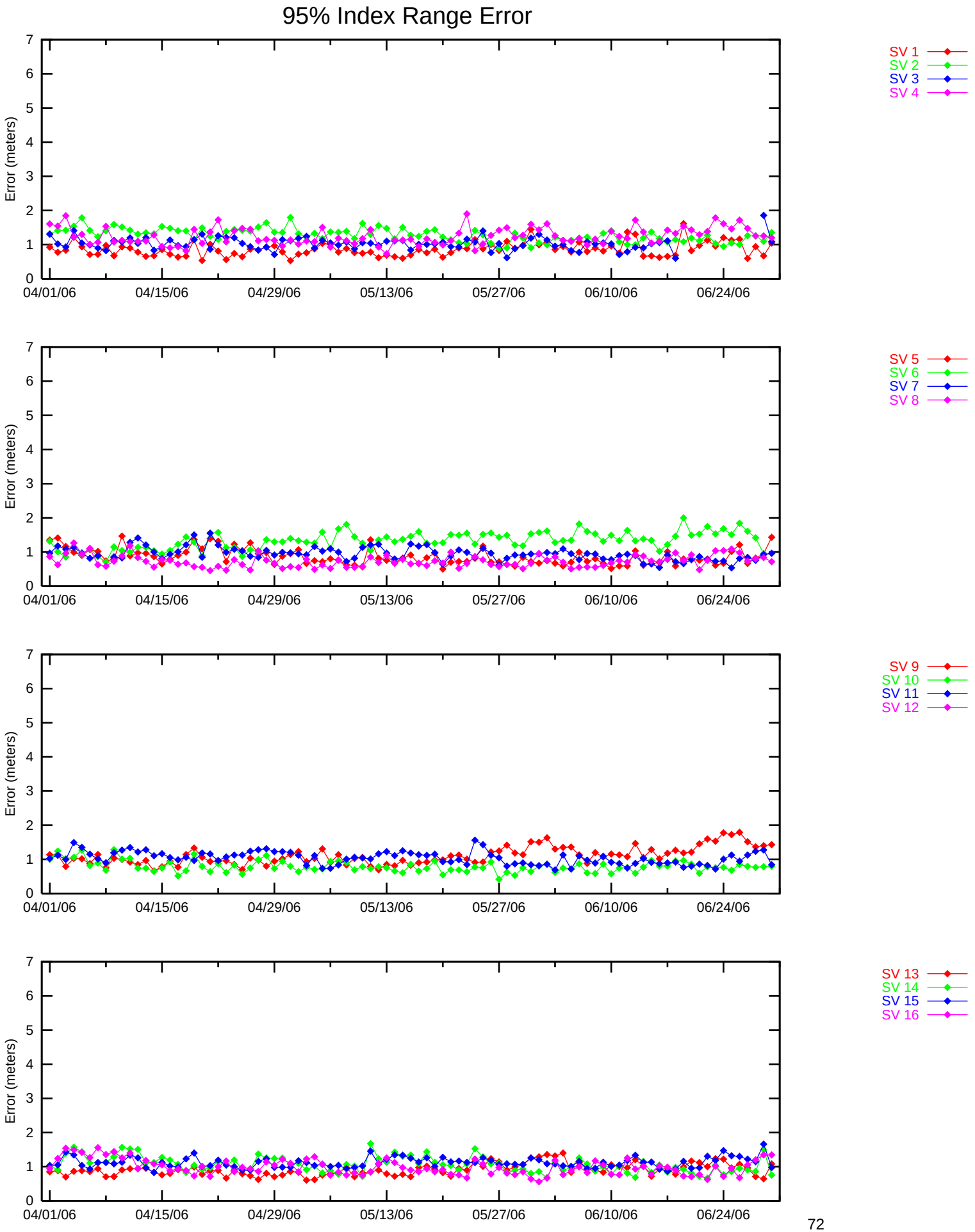


Figure 6-2 95% Range Error (SV 17 --SV 31 and SV 122) - Washington, DC

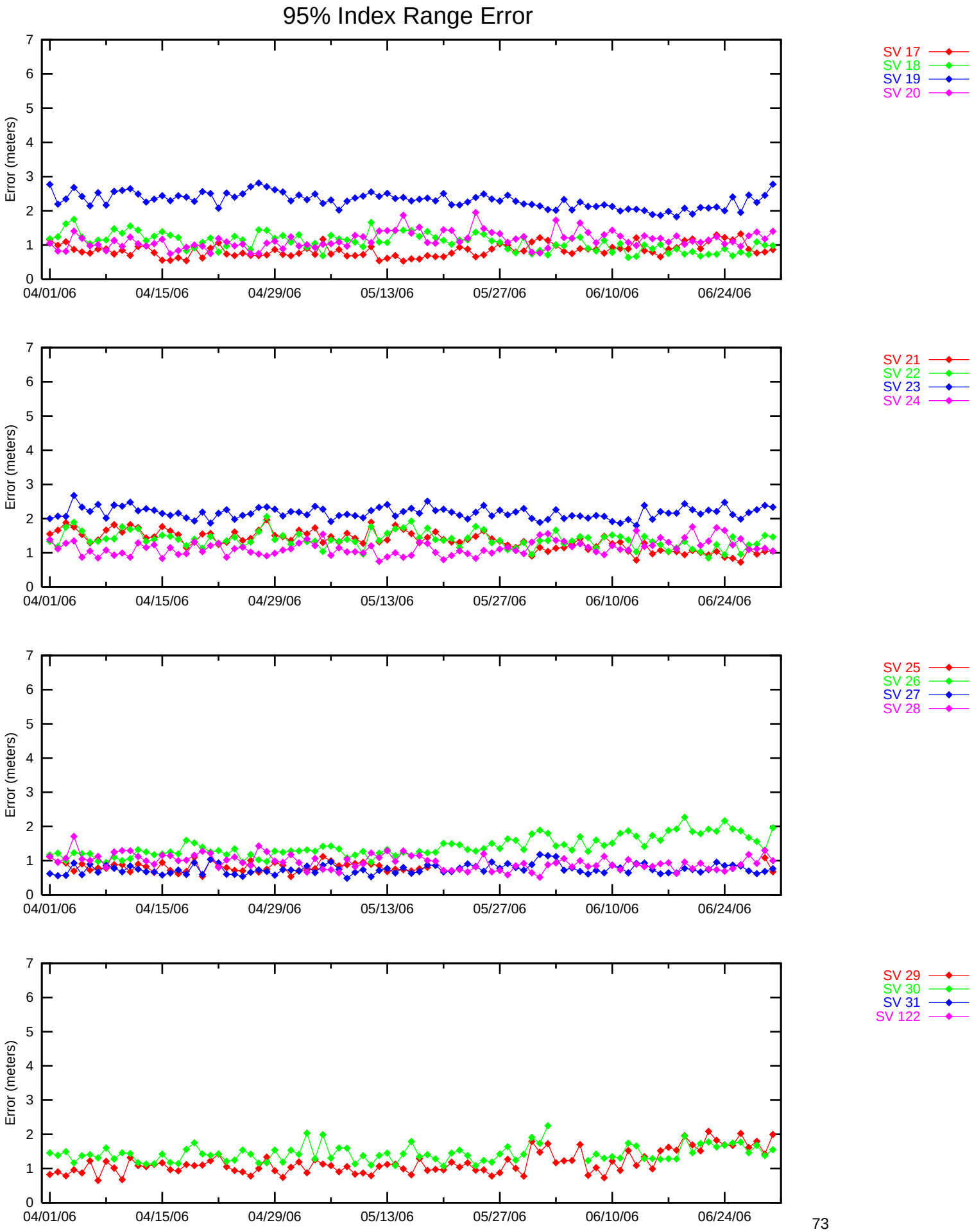


Figure 6-3 95% Ionospheric Error (SV 1 --SV 16) - Washington, DC

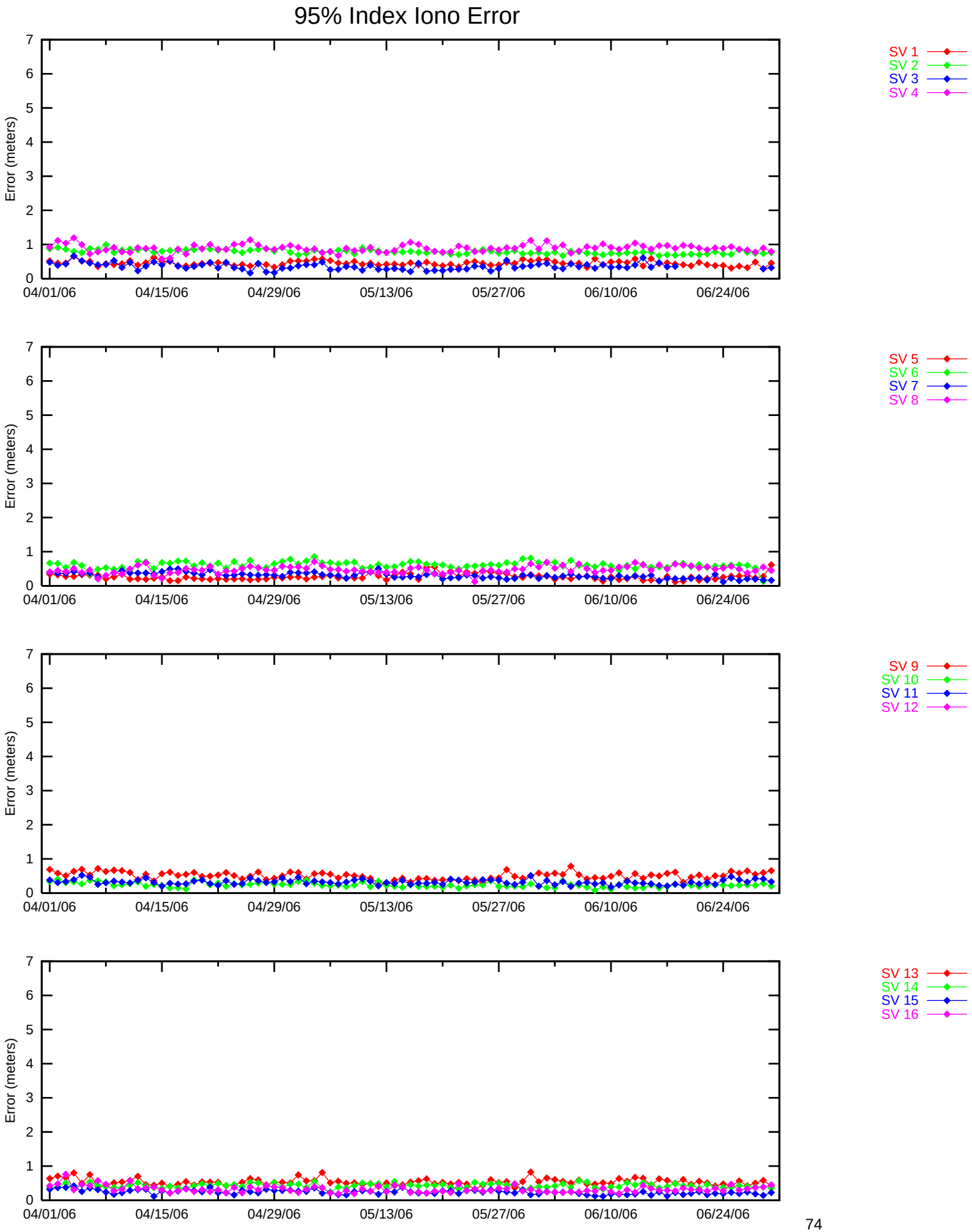
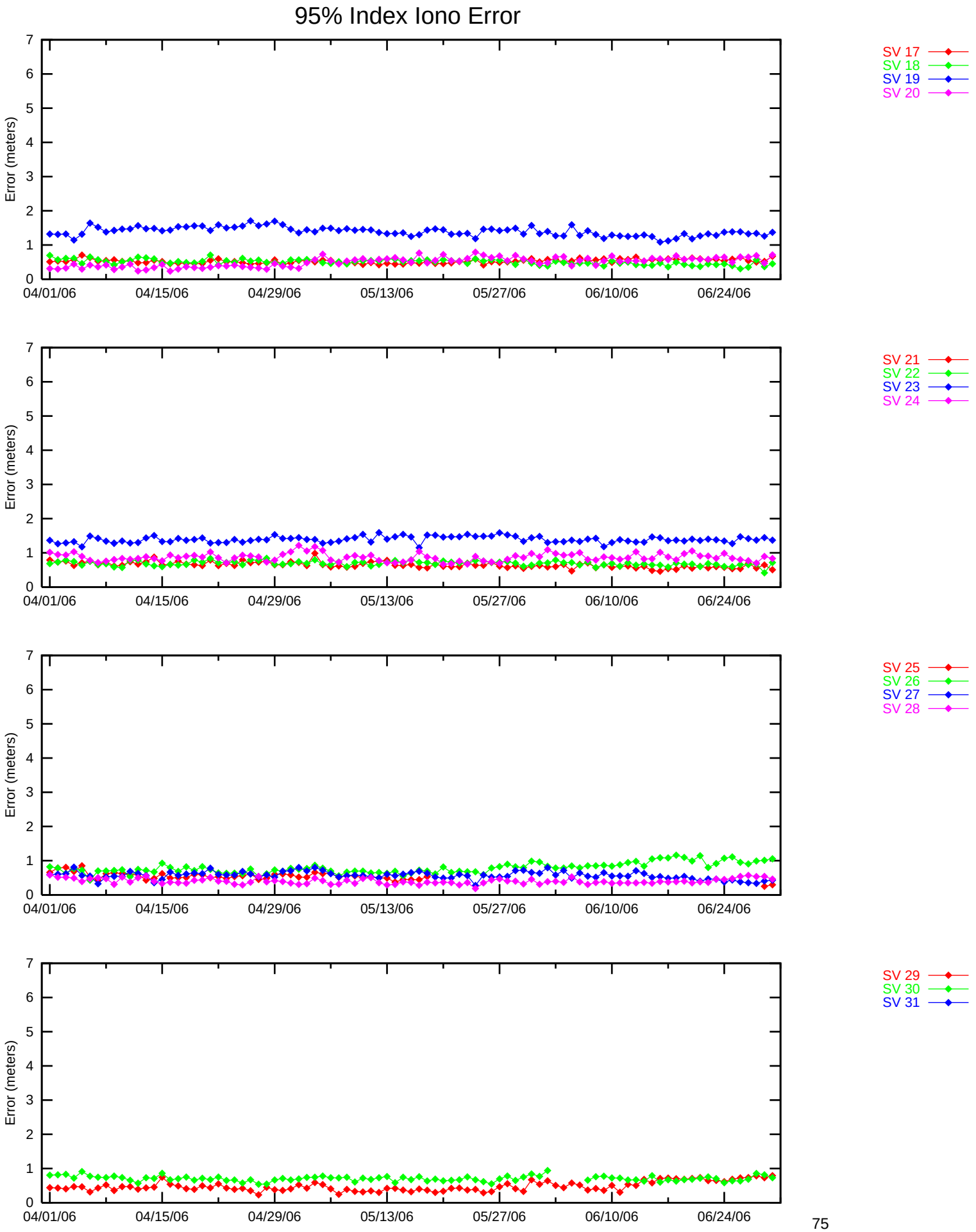


Figure 6-4 95% Ionospheric Error (SV 17 --SV 31) - Washington, DC



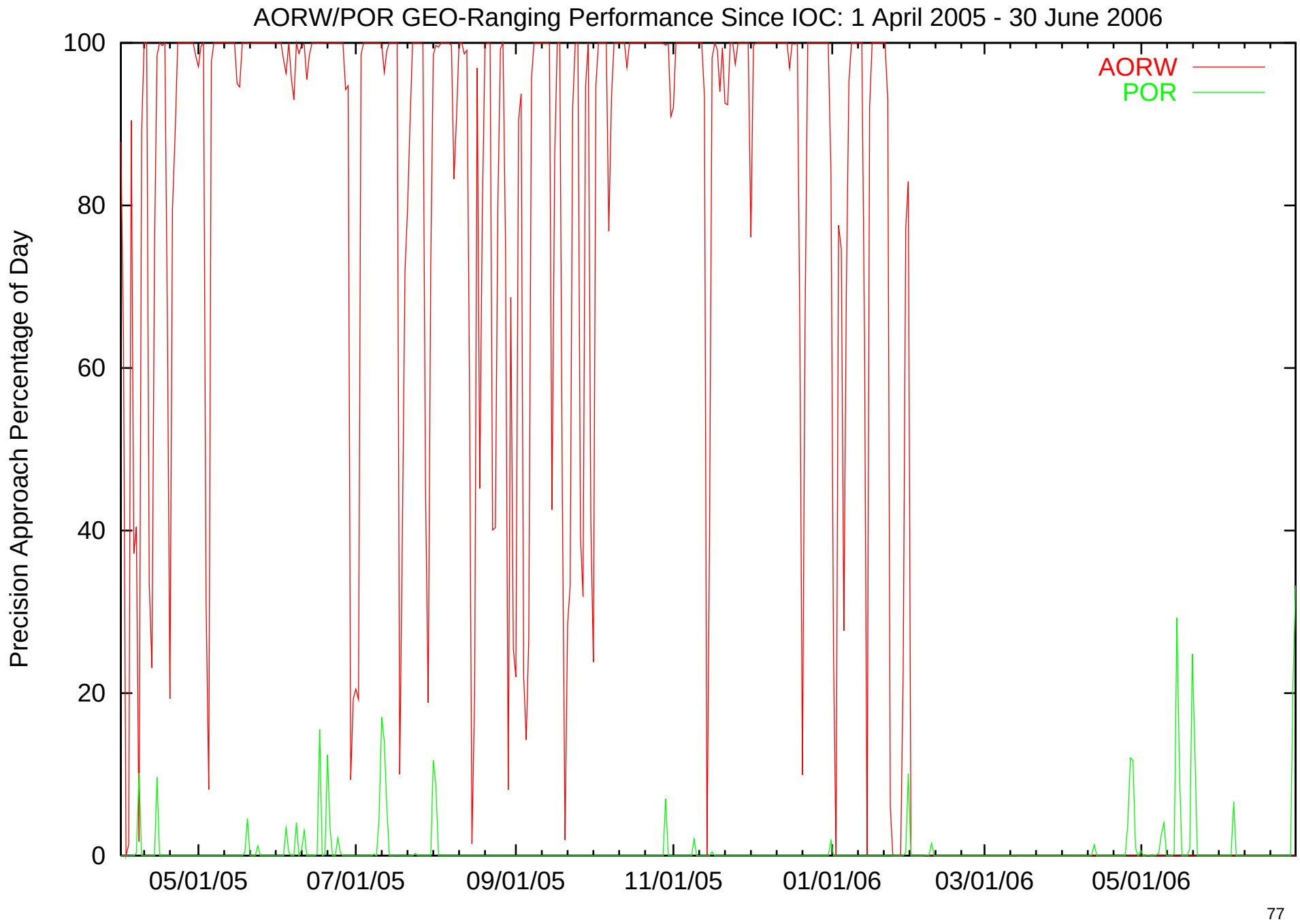
7.0 GEO RANGING PERFORMANCE

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 0% and 1.957%, respectively. Figure 7.1 shows the trend of PA Ranging Availability for the AORW and POR satellite. The AOR-W GEO was unavailable for PA ranging this quarter as expected. The reason is the AOR-W GEO was repositioning to its new location and was not available during the transitional period. 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	0	0	99.081	0.908
POR	1.957	89.927	7.112	0.993

Figure 7-1 Daily PA GEO Ranging Availability Trend



8.0 WAAS PROBLEM SUMMARY

During this period, there are several events that affected WAAS service. Details of each of the events are documented in the WAAS Discrepancy Report (DR). The DRs are posted on the website under 'WAAS Technical Reports' and can be accessed via hyperlink below.

May 25, 2006 - See DR# 35, "Extended AORW Signal-in-Space Outage after equipment failure."

May 26, 2006 - See DR# 33, "Loss of Availability due to Satellite Maintenance on SV 13 (NANU 2006047)."

May 30, 2006 - See DR# 34, "Clarksburg GUS Failure."

June 17, 2006 - See DR# 36, "Multiple drops in AORW signal to noise ratio caused multiple missed messages and eventually an AORW GUS Switchover."

June 24, 2006 - See DR# 37, "C&V failure at ZDC and ZLA."

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 4/1/2006 to 6/30/2006 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	141	0.985916
CGA	CRAIG	CRAIG	AK	96	0.992575
HYD	HKDER	HKDER	AK	90	0.99223
JNU	JUNEAU INTL AIRPORT	JUNEAU	AK	379	0.963991
KTN	KETCHIKAN AIRPORT	KETCHIKAN	AK	77	0.992173
PEC	PELICAN	PELICAN	AK	320	0.967678
PSG	PETERSBURG MUNICIPAL	PETERSBURG	AK	204	0.985014
SIT	SITKA AIRPORT	SITKA	AK	222	0.979752
EET	SHELBY COUNTY	ALABASTER	AL	30	0.998034
79J	ANDALUSIA-OPP	ANDALUSIA/OP	AL	30	0.997861
KBHM	BIRMINGHAM INTL	BIRMINGHAM	AL	30	0.998114
KDHN	DOTHAN REGIONAL	DOTHAN	AL	30	0.997595
HSV	HUNTSVILLE INTL-CARL T JONES FIELD	HUNTSVILLE	AL	30	0.99839
MOB	MOBILE REGIONAL	MOBILE	AL	24	0.998566
MGM	MONTGOMERY REGIONAL/ DANNELLY FIELD	MONTGOMERY	AL	31	0.997807
MSL	MUSCLE SHOALS NORTWEST ALABAMA REGIONAL	SHEFFIELD	AL	29	0.998604
M73	ALMYRA	ALMYRA	AR	20	0.998811
KVBT	BENTONVILLE MUNICIPAL/ LM THADDEN FIELD	BENTONVILLE	AR	19	0.999077
BYH	BLYTHEVILLE	BLYTHEVILLE	AR	21	0.998741
CDH	HARRELL FIELD	CAMDEN	AR	20	0.999012
KXNA	NORTHWEST ARKANSAS REGIONAL	FAYETTEVILLE/SPRINGDALE /ROGERS	AR	19	0.999079
KFSM	FORT SMITH REGIONAL	FORT SMITH	AR	19	0.999075
HRO	BOONE COUNTY AIRPORT	HARRISON	AR	19	0.999059
LIT	ADAMS FIELD	LITTLE ROCK	AR	20	0.998843
SRC	SEARCY MUNICIPAL	SEARCY	AR	20	0.99884

ASG	SPRINGDALE MUNICIPAL	SPRINGDALE	AR	19	0.999073
KARG	WALNUT RIDGE REGIONAL	WALNUT RIDGE	AR	20	0.998811
IFP	LAUGHLIN/BULLHEAD INTL	BULLHEAD CITY	AZ	161	0.975901
KGCN	GRAND CANYON NATL PARK	GRAND CANYON	AZ	115	0.991758
KPHX	PHOENIX SKY HARBOR INTL	PHOENIX	AZ	209	0.959147
KPRC	ERNEST A LOVE FIELD	PRESCOTT	AZ	196	0.977763
KTUS	TUCSON INTL	TUCSON	AZ	265	0.939614
RQE	WINDOW ROCK	WINDOW ROCK	AZ	43	0.998127
BFL	BAKERSFIELD/MEADOWS FIELD	BAKERSFIELD	CA	304	0.954713
KCRQ	MC CLELLAN-PALOMAR	CARLSBAD	CA	426	0.895438
O60	CLOVERDALE MUNICIPAL	CLOVERDALE	CA	219	0.961732
KDAG	BARSTOW-DAGGETT	DAGGETT	CA	197	0.962838
IYK	INYOKERN	INYOKERN	CA	242	0.968063
KLAX	LOS ANGELES INTL	LOS ANGELES	CA	393	0.916684
KOAK	METROPOLITAN OAKLAND INTL	OAKLAND	CA	239	0.963541
ONT	ONTARIO INTL	ONTARIO	CA	361	0.934528
KPMD	PALMDALE PROD FLT/ TEST INSTLN	PALMDALE	CA	336	0.947724
KMHR	SACRAMENTO MATHER	SACRAMENTO	CA	184	0.975364
KSMF	SACRAMENTO INTL	SACRAMENTO	CA	192	0.973806
SAN	SAN DIEGO INTL- LINDBERGH FIELD	SAN DIEGO	CA	445	0.873702
KSFO	SAN FRANCISCO INTL	SAN FRANCISCO	CA	249	0.961105
SJC	SAN JOSE INTL	SAN JOSE	CA	242	0.963346
SVE	SUSANVILLE MUNICIPAL	SUSANVILLE	CA	137	0.988268
TNP	TWENTYNINE PALMS	TWENTYNINE PALMS	CA	214	0.953468
AKO	AKRON-COLORADO PLAINS REGIONAL	AKRON	CO	17	0.999247
COS	COLORADO SPRINGS	COLORADO SPRINGS	CO	22	0.998985
CEZ	CORTEZ MUNICIPAL	CORTEZ	CO	25	0.998211
KDEN	DENVER INTL	DENVER	CO	21	0.999009
HDN	YAMPA VALLEY	HAYDEN	CO	22	0.998705
LHX	LA JUNTA MUNICIPAL	LA JUNTA	CO	21	0.999017
LAA	LAMAR MUNICIPAL	LAMAR	CO	20	0.999035
2V2	VANCE BRAND	LONGMONT	CO	21	0.999008
EEO	MEEKER	MEEKER	CO	21	0.998748
TAD	PERRY STOKES	TRINIDAD	CO	24	0.99878
2V5	WRAY	WRAY	CO	17	0.999225
KBDL	BRADLEY INTL	WINDSOR LOCKS	CT	163	0.987817
KDCA	RONALD REAGAN WASHINGTON INTL	WASHINGTON	DC	32	0.996836
KIAD	WASHINGTON DULLES INTL	WASHINGTON	DC	32	0.996956
KFLL	FORT LAUDERDALE/ HOLLYWOOD INTL	FORT LAUDERDALE	FL	83	0.992825
FXE	FORT LAUDERDALE EXECUTIVE AIRPORT	FORT LAUDERDALE	FL	73	0.993245
KRSW	SOUTHWEST FLORIDA INTL	FORT MYERS	FL	76	0.994177
KGNV	GAINESVILLE REGIONAL	GAINESVILLE	FL	32	0.997101
KJAX	JACKSONVILLE INTL	JACKSONVILLE	FL	32	0.997034
KMIA	MIAMI INTL	MIAMI	FL	114	0.991447
KAPF	NAPLES MUNICIPAL	NAPLES	FL	83	0.993044
KOCF	OCALA INTL-JIM TAYLOR FIELD	OCALA	FL	33	0.99708
KMCO	ORLANDO INTL	ORLANDO	FL	34	0.996851
KPFN	PANAMA CITY-BAY COUNTY INTL	PANAMA CITY	FL	30	0.997654

KPNS	PENSACOLA REGIONAL	PENSACOLA	FL	30	0.998088
SRQ	SARASOTA/BRADENTON INTL	SARASOTA/BRADENTON	FL	63	0.995326
KPIE	ST PETERSBURG-CLEARWATER INTL	ST PETERSBURG-CLEARWATER	FL	41	0.996732
KTLH	TALLAHASSEE REGIONAL	TALLAHASSEE	FL	30	0.997396
TPA	TAMPA INTL	TAMPA	FL	36	0.996879
KVRB	VERO BEACH MUNICIPAL	VERO BEACH	FL	42	0.995965
KPBI	PALM BEACH INTL	WEST PALM BEACH	FL	58	0.994632
KACJ	SOUTHER FIELD	AMERICUS	GA	30	0.99718
KATL	WILLIAM B HARTSFIELD ATLANTA INTL	ATLANTA	GA	30	0.997485
KSAV	SAVANNAH INTL	SAVANNAH	GA	31	0.996875
KTBR	STATESBORO-BULLOCH COUNTY	STATESBORO	GA	31	0.996931
KIKV	ANKENY REGIONAL	ANKENY	IA	21	0.999009
CID	THE EASTERN IOWA	CEDAR RAPIDS	IA	22	0.998921
DSM	DES MOINES INTL	DES MOINES	IA	21	0.999008
KMXO	MONTICELLO REGIONAL	MONTICELLO	IA	21	0.998876
KBOI	BOISE AIR TERMINAL/ GOWEN FLD	BOISE	ID	24	0.998599
EUL	CALDWELL INDUSTRIAL	CALDWELL	ID	26	0.998184
SUN	FRIEDMAN MEMORIAL	HAILEY	ID	13	0.999265
PIH	POCATELLO REGIONAL	POCATELLO	ID	14	0.999176
SZT	SANDPOINT	SANDPOINT	ID	11	0.999455
KENL	CENTRALIA MUNICIPAL	CENTRALIA	IL	21	0.998742
KORD	CHICAGO-O'HARE INTL	CHICAGO	IL	22	0.99871
MDW	CHICAGO MIDWAY	CHICAGO	IL	22	0.998708
KARR	AURORA MUNICIPAL	CHICAGO/AURORA	IL	22	0.998724
KFOA	FLORA MUNICIPAL	FLORA	IL	21	0.998733
MLI	QUAD-CITY	MOLINE	IL	21	0.998791
KPIA	GREATER PEORIA REGIONAL	PEORIA	IL	22	0.99875
KPPQ	PITTSFIELD PENSTONE MUNICIPAL	PITTSFIELD	IL	21	0.998772
KTIP	RANTOUL NATL AVN CTR/FRANK ELLIOT FLD	RANTOUL	IL	22	0.998716
KRFD	GREATER ROCKFORD	ROCKFORD	IL	22	0.998746
KSLO	SALEM-LECKRONE	SALEM	IL	21	0.998741
3CK	LAKE IN THE HILLS	UNKNOWN	IL	22	0.998723
KANQ	TRI-STATE STEUBEN COUNTY	ANGOLA	IN	29	0.998564
KBMG	MONROE COUNTY	BLOOMINGTON	IN	20	0.99877
0I2	BRAZIL CLAY COUNTY	BRAZIL	IN	20	0.998763
CEV	METTEL FIELD	CONNERSVILLE	IN	29	0.998509
FWA	FORT WAYNE INTL	FORT WAYNE	IN	28	0.998601
KIND	INDIANAPOLIS INTL	INDIANAPOLIS	IN	20	0.99877
SER	FREEMAN MUNICIPAL	SEYMOUR	IN	24	0.998704
SBN	MICHIANA REGIONAL TRANSPORTATION CTR	SOUTH BEND	IN	22	0.998662
KCBK	SHALTZ FIELD	COLBY	KS	17	0.999233
EHA	ELKHART-MORTON COUNTY	ELKHART	KS	19	0.999033
GLD	RENNER FIELD/GOODLAND MUNICIPAL	GOODLAND	KS	17	0.999229
KHYS	HAYS REGIONAL	HAYS	KS	17	0.999259
LWC	LAWRENCE MUNICIPAL	LAWRENCE	KS	18	0.999122
KMHK	MANHATTAN REGIONAL	MANHATTAN	KS	18	0.999147

KOJC	JOHNSON COUNTY EXECUTIVE	OLATHE	KS	18	0.999113
TOP	PHILIP BILLARD MUNICIPAL	TOPEKA	KS	18	0.99913
KULS	ULYSSES	ULYSSES	KS	18	0.999217
ICT	WICHITA MID-CONTINENT	WICHITA	KS	18	0.99919
KWLD	STROTHER FIELD	WINFIELD/ARKANSAS CITY	KS	18	0.999175
KCVG	CINCINNATI/NORTHERN KY INTL	COVINGTON/CINCINNATI	KY	29	0.998341
KLEX	BLUE GRASS	LEXINGTON	KY	29	0.998238
LOZ	LONDON	LONDON	KY	30	0.997974
SDF	LOUISVILLE INTL-STANDIFORD FIELD	LOUISVILLE	KY	29	0.998526
KK22	BIG SANDY REGIONAL	PRESTONBURG	KY	30	0.997787
SME	SOMERSET-PULASKI COUNTY	SOMERSET	KY	30	0.998132
KAEX	ALEXANDRIA INTL	ALEXANDRIA	LA	20	0.998844
DRI	DE RIDDER/ BEAUREGARD PAIRISH APT	BEAUREGARD	LA	20	0.998856
LCH	LAKE CHARLES REGIONAL	LAKE CHARLES	LA	20	0.998831
L39	LEESVILLE	LEESVILLE	LA	20	0.998863
MSY	NEW ORLEANS INTL/ MOISANT FIELD	NEW ORLEANS	LA	20	0.998697
SHV	SHREVEPORT REGIONAL	SHREVEPORT	LA	20	0.998927
KBOS	GEN EDWARD LAWRENCE LOGAN INTL	BOSTON	MA	229	0.974403
MVY	VINEYARD HAVEN	MARTHA'S VINEYARD	MA	219	0.980236
OWD	NORWOOD MEMORIAL	NORWOOD	MA	234	0.975977
KPVC	PROVINCETOWN MUNICIPAL	PROVINCETOWN	MA	354	0.244482
YWG	WINNIPEG AIRPORT	WINNIPEG	MB	320	0.95559
KBWI	BALTIMORE-WASHINGTON INTL	BALTIMORE	MD	32	0.996819
FDK	FREDERICK MUNICIPAL	FREDERICK	MD	32	0.997027
GAI	MONTGOMERY COUNTY AIRPARK	GAITHERSBURG	MD	32	0.99693
W00	FREEWAY	MITCHELLVILLE	MD	32	0.996798
RJD	RIDGELY AIRPARK	RIDGELY	MD	32	0.996636
DMW	CARROLL CNTY REGIONAL/ JACK B. POAGE FIELD	WESTMINSTER	MD	32	0.997002
PWM	PORTLAND INTL JETPORT	PORTLAND	ME	332	0.233426
KPQI	N MAINE REGIONAL ARPT AT PRESQUE I	PRESQUE ISLE	ME	380	0.18193
AMN	ALMA/GRATIOT COMMUNITY	ALMA	MI	25	0.998605
KARB	ANN ARBOR MUNI	ANN ARBOR	MI	24	0.998687
Y15	CHEBOYGAN COUNTY	CHEBOYGAN	MI	43	0.996076
KDTW	DETROIT METROPOLITAN WAYNE CTY	DETROIT	MI	30	0.998541
KFNT	BISHOP INTL	FLINT	MI	27	0.99859
KGRR	GERALD R FORD INTL	GRAND RAPIDS	MI	22	0.998677
KCMX	HOUGHTON COUNTY MEMORIAL	HANCOCK	MI	157	0.987381
BIV	TULIP CITY	HOLLAND	MI	22	0.998677
HTL	ROSCOMMON COUNTY	HOUGHTON LAKE	MI	24	0.998554
KMKG	MUSKEGON COUNTY	MUSKEGON	MI	22	0.998673
5D3	OWOSSO COMMUNITY	OWOSSO	MI	24	0.998636
KMBS	MBS INTL	SAGINAW	MI	23	0.99862
CIU	CHIPPEWA COUNTY INTL	SAULT STE. MARIE	MI	53	0.994079
HAI	THREE RIVERS MUNICIPAL DR. HAINES	UNKNOWN	MI	22	0.998665
HYX	SAGINAW CO H.W. BROWNE	UNKNOWN	MI	25	0.998593

KAXN	CHANDLER FIELD	ALEXANDRIA	MN	23	0.998931
KBDE	BAUDETTE INTL	BAUDETTE	MN	157	0.981592
KBRD	BRAINERD-CROW WING CO REGIONAL	BRAINERD	MN	30	0.99855
KDLH	DULUTH INTL	DULUTH	MN	79	0.996282
KMSP	MINNEAPOLIS-ST PAUL INTL/WOLD CHAMBERLAIN	MINNEAPOLIS	MN	22	0.999013
KRGK	RED WING REGIONAL	RED WING	MN	22	0.999033
KRST	ROCHESTER INTL	ROCHESTER	MN	20	0.999062
STC	ST. CLOUD	SAINT CLOUD	MN	22	0.998923
KJYG	ST JAMES MUNICIPAL	ST JAMES	MN	20	0.99912
M05	CARUTHERSVILLE MEMORIAL	CARUTHERSVILLE	MO	21	0.998737
KMCI	KANSAS CITY INTL	KANSAS CITY	MO	18	0.999113
KLBO	FLOYD W JONES LEBANON	LEBANON	MO	19	0.998969
LXT	LEE'S SUMMIT MUNICIPAL	LEE'S SUMMIT	MO	18	0.999105
H41	MEXICO MEMORIAL	MEXICO	MO	21	0.998859
MYJ	MEXICO MEMORIAL	MEXICO	MO	21	0.998859
STJ	ROSECRANS MEMORIAL	ROSECRANS	MO	18	0.999117
KDMO	SEDALIA MEMORIAL	SEDALIA	MO	19	0.998981
SGF	SPRINGFIELD-BRANSON REGIONAL	SPRINGFIELD	MO	19	0.999067
KSTL	LAMBERT-ST LOUIS INTL	ST LOUIS	MO	20	0.998777
KMO6	WASHINGTON MEMORIAL	WASHINGTON	MO	20	0.998766
0M6	PANOLA COUNTY	BATESVILLE	MS	21	0.998729
GWO	GREENWOOD-LEFLORE	GREENWOOD	MS	21	0.998755
JAN	JACKSON INTL	JACKSON	MS	21	0.998825
MPE	PHILADELPHIA MUNICIPAL	PHILADELPHIA	MS	22	0.998668
CRX	ROSCOE TURNER	UNKNOWN	MS	20	0.99876
KBIL	BILLINGS LOGAN INTL	BILLINGS	MT	21	0.998912
6S5	RAVALLI COUNTY	HAMILTON	MT	9	0.99956
KHLN	HELENA REGIONAL	HELENA	MT	12	0.999121
KLWT	LEWISTOWN MUNICIPAL	LEWISTOWN	MT	22	0.998827
KMLS	FRANK WILEY FIELD	MILES CITY	MT	23	0.998818
KHBI	ASHEBORO MUNICIPAL	ASHEBORO	NC	30	0.997391
KAVL	ASHEVILLE REGIONAL	ASHEVILLE	NC	30	0.997382
MRH	MICHAEL J. SMITH FIELD	BEAUFORT	NC	31	0.996809
KCLT	CHARLOTTE/DOUGLAS INTL	CHARLOTTE	NC	30	0.997459
ECG	ELIZABETH CITY CGAS	ELIZABETH CITY	NC	32	0.99676
KFAY	FAYETTEVILLE REGIONAL/GRANNIS FIELD	FAYETTEVILLE	NC	31	0.997151
GSO	PIEDMONT TRIAD INTL	GREENSBORO	NC	30	0.997402
PGV	PITT-GREENVILLE	GREENVILLE	NC	31	0.996926
HSE	BILLY MITCHELL	HATTERAS	NC	32	0.996716
HKY	HICKORY REGIONAL	HICKORY	NC	30	0.997437
KISO	KINSTON REGIONAL JETPORT AT STALLINGS FIELD	KINSTON	NC	31	0.996956
MEB	LAURINBURG	MAXTON	NC	31	0.997236
KEQY	MONROE	MONROE	NC	30	0.997399
KRDU	RALEIGH-DURHAM INTL	RALEIGH/DURHAM	NC	31	0.997143
RWI	ROCKY MOUNT-WILSON REGIONAL	ROCKY MOUNT	NC	31	0.996991
KRUQ	ROWAN COUNTY	SALISBURY	NC	30	0.997412
KTTA	SANFORD-LEE COUNTY REGIONAL	SANFORD	NC	31	0.997202

SUT	BRUNSWICK COUNTY	SOUTHPORT	NC	31	0.99702
OCW	WARREN FIELD	WASHINGTON	NC	31	0.996867
MCZ	MARTIN COUNTY	WILLIAMSTON	NC	31	0.996883
KILM	WILMINGTON INTL	WILMINGTON	NC	31	0.996998
W03	WILSON INDUSTRIAL AIR CENTER	WILSON	NC	31	0.997003
KFAR	HECTOR INTL	FARGO	ND	71	0.994971
MOT	MINOT INTL AIRPORT	MINOT	ND	98	0.993413
KANW	AINSWORTH MUNICIPAL	AINSWORTH	NE	18	0.999224
AUH	AURORA MUNICIPAL	AURORA	NE	18	0.999187
BIE	BEATRICE MUNICIPAL	BEATRICE	NE	18	0.999151
CSB	CAMBRIDGE MUNICIPAL	CAMBRIDGE	NE	16	0.999281
CEK	CRETE MUNICIPAL	CRETE	NE	18	0.999154
GRN	GORDON MUNICIPAL	GORDON	NE	18	0.999066
KEAR	KEARNEY MUNICIPAL	KEARNEY	NE	17	0.999239
KLBF	NORTH PLATTE REGIONAL LEE BIRD FIELD	NORTH PLATTE	NE	16	0.999281
OMA	EPPLEY AIRFIELD	OMAHA	NE	18	0.999142
OKS	GARDEN COUNTY	OSHKOSH	NE	17	0.999222
SCB	SCRIBNER STATE	SCRIBNER	NE	18	0.999153
SNY	SIDNEY MUNICIPAL	SIDNEY	NE	17	0.999236
VTN	MILLER FIELD	VALENTINE	NE	18	0.999223
MHT	MANCHESTER	MANCHESTER	NH	231	0.974799
KACY	ATLANTIC CITY INTL	ATLANTIC CITY	NJ	33	0.996369
KMMU	MORRISTOWN MUNICIPAL	MORRISTOWN	NJ	53	0.995366
KEWR	NEWARK INTL	NEWARK	NJ	62	0.995018
7N7	SPITFIRE AERODROM	PEDRICTOWN	NJ	33	0.99663
K3NJ6	INDUCTOTHERM HELIPORT	RANCOCAS	NJ	43	0.996099
KABQ	ALBUQUERQUE INTL SUNPORT	ALBUQUERQUE	NM	39	0.997546
KFMN	FOUR CORNERS REGIONAL	FARMINGTON	NM	30	0.998119
KLRU	LAS CRUCES INTL	LAS CRUCES	NM	202	0.97188
ELY	ELY AIRPORT/YELLAND FELD	ELY	NV	28	0.997455
KLAS	MC CARRAN INTL	LAS VEGAS	NV	126	0.985478
ALB	ALBANY INTL	ALBANY	NY	162	0.99075
BUF	BUFFALO NIAGARA INTL	BUFFALO	NY	31	0.997627
KELM	ELMIRA/CORNING REGIONAL	ELMIRA	NY	42	0.996407
LGA	LA GUARDIA	FLUSHING	NY	70	0.994457
GFL	FLOYD BENNETT MEMORIAL	GLENS FALLS	NY	190	0.986818
KJHW	CHAUTAUQUA COUNTY/ JAMESTOWN	JAMESTOWN	NY	31	0.997715
LKP	LAKE PLACID	LAKE PLACID	NY	201	0.984165
KJFK	JOHN F KENNEDY INTL	NEW YORK	NY	70	0.994398
KSWF	STEWART INTL	NEWBURGH	NY	56	0.994998
PBG	PLATTSGURGH INTL	PLATTSGURGH	NY	252	0.977051
ROC	GREATER ROCHESTER INTL	ROCHESTER	NY	43	0.99677
KSYR	SYRACUSE HANCOCK INTL	SYRACUSE	NY	59	0.995783
B16	WHITFORDS	WEEDSPORT	NY	51	0.996077
FOK	THE FRANCIS S. GABRESKI	WESTHAMPTON BEACH	NY	83	0.991857
HPN	WESTCHESTER COUNTY	WHITE PLAINS	NY	72	0.994157
4F5	BELLEFONTAINE MUNICIPAL AIRPORT	BELLEFONTAINE	OH	31	0.998332
KRZT	ROSS COUNTY	CHILLICOTHE	OH	30	0.998241
KCLE	CLEVELAND-HOPKINS INTL	CLEVELAND	OH	31	0.998384
KCMH	PORT COLUMBUS INTL	COLUMBUS	OH	30	0.998468

OSU	OHIO STATE UNIVERSITY	COLUMBUS	OH	31	0.998302
KDAY	JAMES M COX DAYTON INTL	DAYTON	OH	31	0.998287
1G5	MEDINA MUNICIPAL	MEDINA	OH	31	0.998415
KTOL	TOLEDO EXPRESS	TOLEDO	OH	28	0.998634
I68	LEBANON-WARREN COUNTY	UNKNOWN	OH	30	0.998273
KAVK	ALVA REGIONAL	ALVA	OK	17	0.99926
KCQB	CHANDLER MUNICIPAL	CHANDLER	OK	19	0.999159
CHK	CHICKASHA	CHICKASHA	OK	19	0.999197
GCM	CLAREMORE REGIONAL	CLAREMORE	OK	19	0.999103
DUA	EAKER FIELD AIRPORT	EAKER	OK	20	0.998968
2O8	HINTON MUNICPAL	HINTON	OK	19	0.999205
KHBR	HOBART MUNICIPAL	HOBART	OK	21	0.99888
K2K4	SCOTT FIELD	MANGUM	OK	20	0.998879
MIO	MIAMI	MIAMI	OK	19	0.999092
MDF	MORELAND MUNICIPAL	MORELAND	OK	18	0.999229
KMKO	DAVIS FIELD	MUSKOGEE	OK	19	0.999099
OKC	WILL ROGERS WORLD AIRPORT	OKLAHOMA CITY	OK	20	0.999175
PVJ	PAULS VALLEY MUNICIPAL AIRPORT	PAULS VALLEY	OK	21	0.999129
PNC	PONCA CITY	PONCA CITY	OK	19	0.999165
SNL	SHAWNEE	SHAWNEE	OK	19	0.999162
TQH	TAHLEQUAH	TAHLEQUAH	OK	19	0.999092
KTUL	TULSA INTL	TULSA	OK	19	0.999111
1K4	DAVID J PERRY	UNKNOWN	OK	20	0.999168
YOW	OTTAWA AIRPORT	OTTAWA	ON	147	0.986686
S07	BEND MUNICIPAL	BEND	OR	52	0.995433
HIO	PORTLAND-HILLSBORO	HILLSBORO	OR	52	0.99475
LGD	UNION COUNTY	LA GRANDE	OR	28	0.998059
KONP	NEWPORT MUNICIPAL	NEWPORT	OR	68	0.991873
PDX	PORTLAND INTL	PORTLAND	OR	50	0.994984
SLE	MCNARY FIELD	SALEM	OR	55	0.994259
S47	TILLAMOOK	TILLAMOOK	OR	59	0.993789
ABE	LEHIGH VALLEY INTL	ALLENTOWN	PA	42	0.996006
KBFD	BRADFORD REGIONAL	BRADFORD	PA	31	0.997584
MDT	HARRISBURG INTL	HARRISBURG	PA	32	0.997021
KJST	JOHN MURTHA JOHNSTOWN-CAMBRIA COUNTY	JOHNSTOWN	PA	31	0.997509
LNS	LANCASTER	LANCASTER	PA	32	0.996915
LHV	WILLIAM T. PIPER MEMORIAL	LOCK HAVEN	PA	32	0.997251
PHL	PHILADELPHIA INTL	PHILADELPHIA	PA	40	0.996465
KAGC	ALLEGHENY COUNTY	PITTSBURGH	PA	31	0.997756
KPIT	PITTSBURGH INTL	PITTSBURGH	PA	31	0.997853
PVD	THEODORE FRANCIS GREEN STATE	PROVIDENCE	RI	189	0.982697
AND	ANDERSON REGIONAL	ANDERSON	SC	30	0.99729
KCHS	CHARLESTON AFB/INTL	CHARLESTON	SC	31	0.997151
KCAE	COLUMBIA METROPOLITAN	COLUMBIA	SC	31	0.997409
KGSP	GREENVILLE-SPARTANBURG INTL	GREER	SC	30	0.997227
KMYR	MYRTLE BEACH INTL	MYRTLE BEACH	SC	31	0.997146
KHON	HURON REGIONAL	HURON	SD	20	0.999065
1D1	MILBANK MUNICIPAL	MILBANK	SD	21	0.998996
KRAP	RAPID CITY REGIONAL	RAPID CITY	SD	20	0.999142
FSD	JOE FOSS FIELD	SIOUX FALLS	SD	19	0.999079

YXE	SASKATOON AIRPORT	SASKATOON	SK	263	0.962939
CHA	LOVELL FIELD	CHATTANOOGA	TN	30	0.997986
TYS	MC GHEE TYSON	KNOXVILLE	TN	30	0.997737
KMEM	MEMPHIS INTL	MEMPHIS	TN	21	0.998752
KBNA	NASHVILLE INTL	NASHVILLE	TN	29	0.998583
PHT	HENRY COUNTY	PARIS	TN	20	0.998744
TRI	TRI-CITIES REGIONAL TN/ VA AIRPORT	UNKNOWN	TN	30	0.997531
KABI	ABILENE REGIONAL	ABILENE	TX	33	0.997824
ALI	ALICE	ALICE	TX	288	0.960206
AMA	AMARILLO INTL	AMARILLO	TX	24	0.99881
KLBX	BRAZORIA COUNTY	ANGLETON/LAKE JACKSON	TX	84	0.992794
AUS	AUSTIN-BERGSTROM INTL	AUSTIN	TX	44	0.996954
7F9	COMANCHE	COMANCHE	TX	35	0.997877
KCXO	MONTGOMERY COUNTY	CONROE	TX	26	0.998581
CRP	CORPUS CHRISTI INTL	CORPUS CHRISTI	TX	261	0.964416
KDAL	DALLAS LOVE FIELD	DALLAS	TX	21	0.998708
ADS	ADDISON	DALLAS	TX	21	0.998744
KDFW	DALLAS-FT WORTH INTL	DALLAS-FT WORTH	TX	21	0.998705
KDRT	DEL RIO INTL	DEL RIO	TX	196	0.97572
ELP	EL PASO INTL	EL PASO	TX	205	0.968933
KHRL	VALLEY INTL	HARLINGEN	TX	589	0.872288
KAXH	HOUSTON-SOUTHWEST	HOUSTON	TX	46	0.997568
KDWH	DAVID WAYNE HOOKS MEMORIAL	HOUSTON	TX	28	0.998465
KEFD	ELLINGTON FIELD	HOUSTON	TX	38	0.998012
KHOU	WILLIAM P HOBBY	HOUSTON	TX	37	0.99802
KIAH	GEORGE BUSH INTERCONTINENTAL/HOUSTON	HOUSTON	TX	28	0.998381
KIWS	WEST HOUSTON	HOUSTON	TX	32	0.998314
KSGR	SUGAR LAND MUNICIPAL/ HULL FIELD	HOUSTON	TX	38	0.997897
KLBB	LUBBOCK INTL	LUBBOCK	TX	33	0.998116
MAF	MIDLAND INTL	MIDLAND	TX	74	0.987377
OSA	MOUNT PLEASANT MUNICIPAL	MOUNT PLEASANT	TX	20	0.99893
KSJT	SAN ANGELO REGIONAL/ MATHIS FIELD	SAN ANGELO	TX	73	0.990355
KSAT	SAN ANTONIO INTL	SAN ANTONIO	TX	81	0.99013
SGR	SUGARLAND MUNICIPAL/ HULL FIELD	SUGAR LAND	TX	38	0.997897
KTYR	TYLER POUNDS REGIONAL	TYLER	TX	21	0.998887
BMC	BRIGHAM CITY	BRIGHAM CITY	UT	15	0.998918
KCDC	CEDAR CITY REGIONAL	CEDAR CITY	UT	37	0.997679
KKNB	KANAB MUNICIPAL	KANAB	UT	63	0.996724
LGU	LOGAN-CACHE	LOGAN	UT	13	0.998943
SLC	SALT LAKE CITY INTL	SALT LAKE CITY	UT	14	0.998932
KCHO	CHARLOTTESVILLE-ALBEMARLE	CHARLOTTESVILLE	VA	30	0.997108
FKN	FRANKLIN MUNICIPAL- JOHN BEVERLY ROSE	FRANKLIN	VA	31	0.996826
LVL	BRUNSWICK MUNICIPAL	LAWRENCEVILLE	VA	31	0.996954
JYO	LEESBURG MUNICIPAL/ GODFREY FIELD	LEESBURG	VA	32	0.997005
HEF	MANASSAS REGIONAL/ HARRY P. DAVIS FIELD	MANASSAS	VA	32	0.996942

MTV	BLUE RIDGE	MARTINSVILLE	VA	30	0.997397
KPHF	NEWPORT NEWS/ WILLIAMSBURG INTL	NEWPORT NEWS	VA	32	0.996762
KORF	NORFOLK INTL	NORFOLK	VA	32	0.996733
RIC	RICHMOND INTL	RICHMOND	VA	32	0.996865
AKQ	WAKEFIELD MUNICIPAL	WAKEFIELD	VA	31	0.996834
WAL	WALLOPS FLIGHT FACILITY	WALLOPS ISLAND	VA	32	0.996592
BTV	BURLINGTON INTL	BURLINGTON	VT	245	0.977265
FHR	FRIDAY HARBOR	FRIDAY HARBOR	WA	41	0.996525
KMWH	GRANT COUNTY INTL	MOSES LAKE	WA	27	0.997913
KSEA	SEATTLE-TACOMA INTL	SEATTLE	WA	45	0.996265
BFI	BOEING FIELD/ KING COUNTY INTL	SEATTLE	WA	46	0.996292
KGEG	SPOKANE INTL	SPOKANE	WA	14	0.998978
KATW	OUTAGAMIE COUNTY REGIONAL	APPLETON	WI	23	0.99871
3T3	BOYCEVILLE MUNICIPAL	BOYCEVILLE	WI	23	0.998917
FLD	FOND DU LAC COUNTY	FOND DU LAC	WI	22	0.998731
KGRB	AUTIN STRAUBEL INTL	GREEN BAY	WI	23	0.998652
JVL	SOUTHERN WISCONSIN REGIONAL AIRPORT	JANESVILLE	WI	22	0.998755
MSN	DANE COUNTY REGIONAL-TRUAX FIELD	MADISON	WI	22	0.998815
MTW	MANITOWOC COUNTY	MANITOWOC	WI	23	0.998694
MKE	GENERAL MITCHELL INTL	MILWAUKEE	WI	22	0.998714
KCWA	CENTRAL WISCONSIN	MOSINEE	WI	23	0.998748
OSH	WITTMAN REGIONAL	OSHKOSH	WI	23	0.998713
RHI	RHINELANDER-ONEIDA COUNTY	RHINELANDER	WI	34	0.99806
SUE	DOOR COUNTY CHERRYLAND	STURGEON BAY	WI	23	0.998607
RYV	WATERTOWN MUNICIPAL	WATERTOWN	WI	22	0.998731
ETB	WEST BEND MUNICIPAL	WEST BEND	WI	22	0.998723
KMGW	MORGANTOWN MUNICIPAL-WLB HART FIELD	MORGANTOWN	WV	31	0.997659
KPKB	WOOD CO-GILL ROBB WILSON FIELD	PARKERSBURG	WV	30	0.998108
KCPR	NATRONA COUNTY INTL	CASPER	WY	20	0.999065
EVW	EVANSTON-UNITA CNTY-BURNS FIELD	EVANSTON	WY	13	0.999025
SAA	SHIVELY FIELD	SARATOGA	WY	22	0.998996

Figure 9-1 WAAS LPV Availability

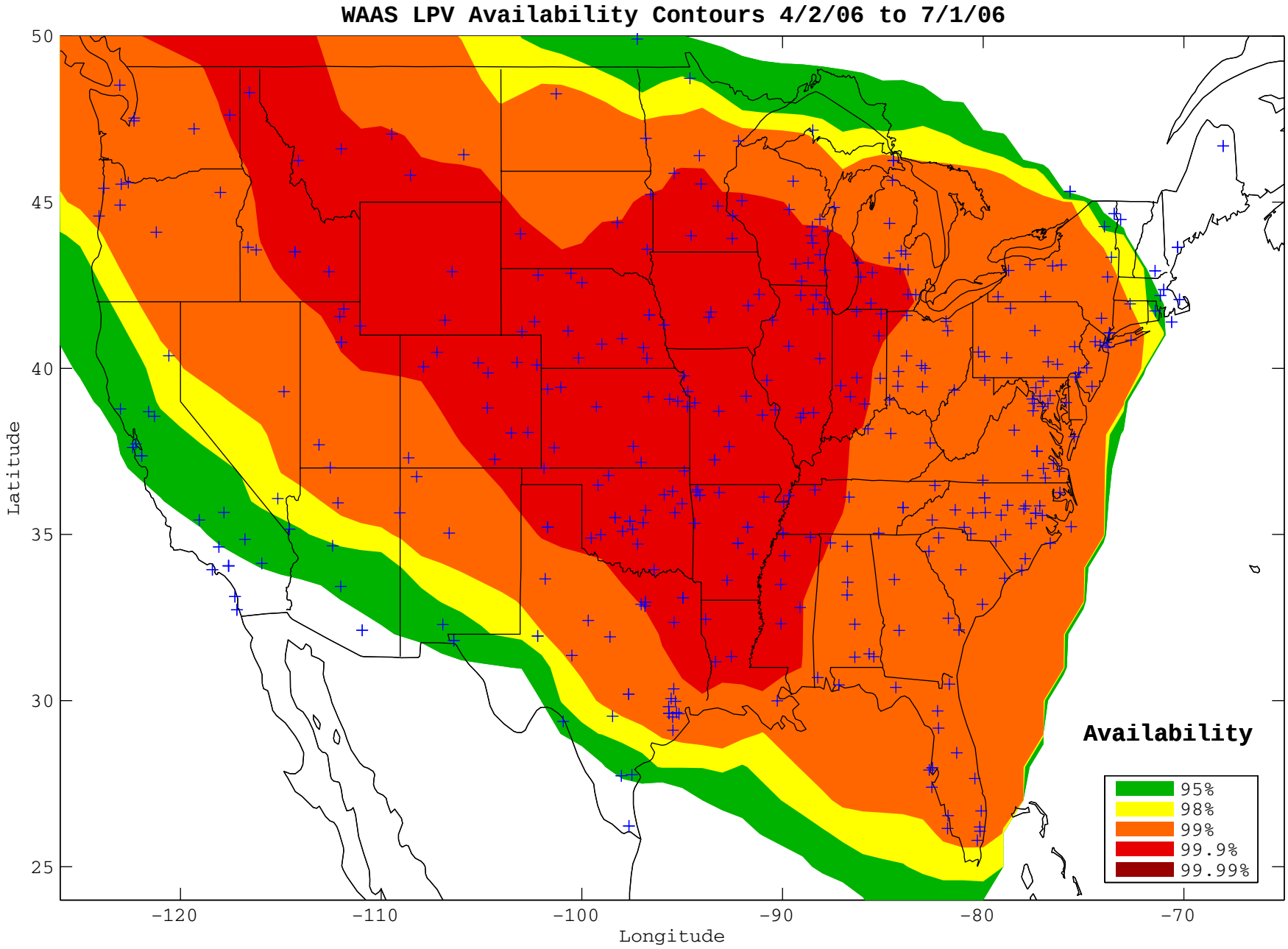
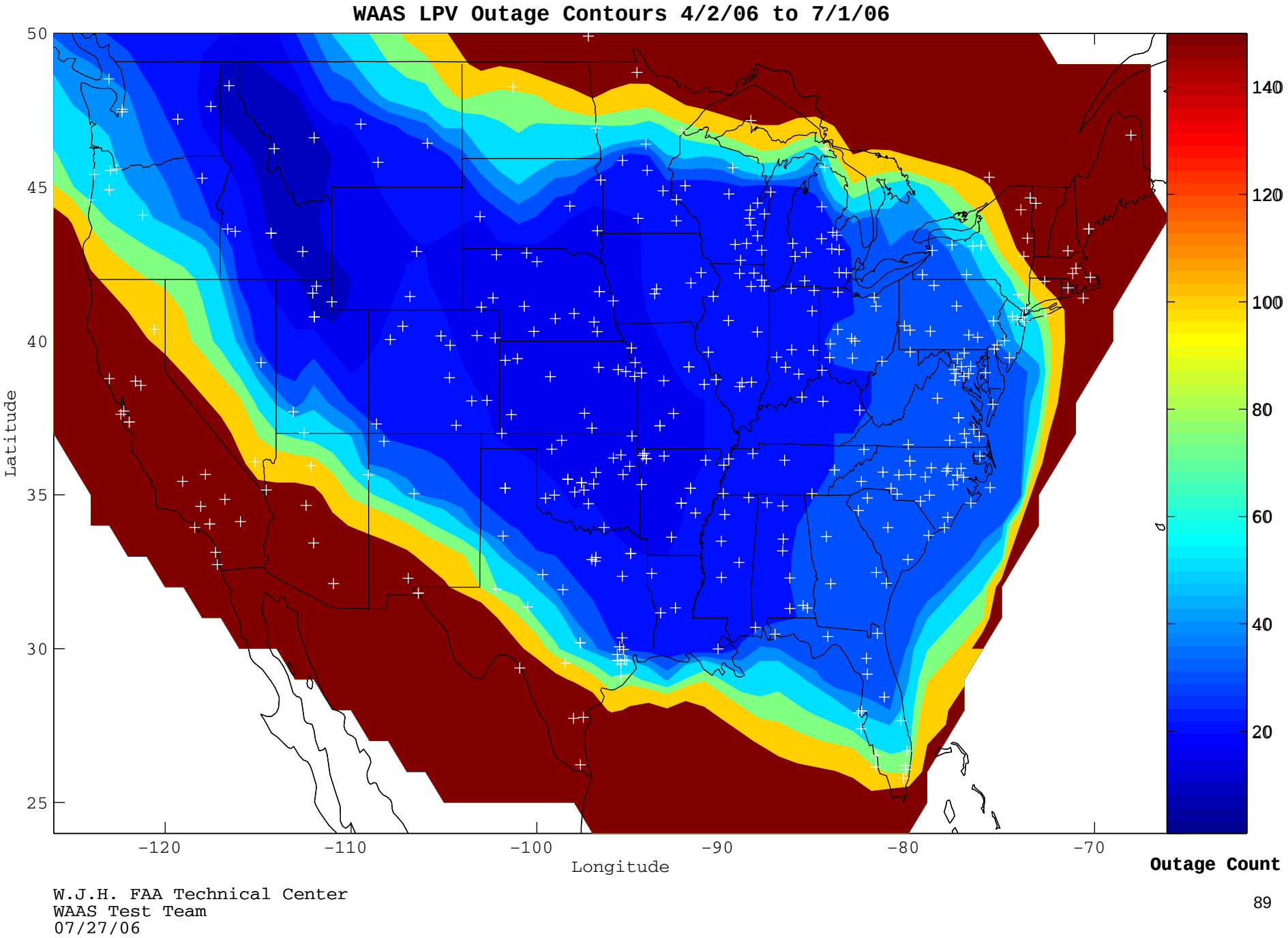


Figure 9-2 WAAS LPV Outage



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.

During this evaluated period, the legacy receivers (non-G2) are predominantly the trouble receivers, with over 95% of their failures occurring on the L2 frequency.

Table 10-1 CNMP Bounding Statistics

WAAS Site	WRE	Jul 05	Aug 05	Sep 05	Oct 05	Nov 05	Dec 05	Jan 06	Feb 06	Mar 06	Apr 06	May 06	Jun 06
Albuquerque	A	●	●	●	●	●	●	●	●	●	●	●	●
	B	●	●	●	●	●	●	●	●	●	●	●	●
	C	●	●	●	●	●	●	●	●	●	●	●	●
Anchorage	A	●	●	●	●	●	●	●	●	●	●	●	●
	B	●	●	●	●	●	●	●	●	●	●	●	●
	C	●	●	●	●	●	●	●	●	●	●	●	●
Atlanta	A	●	●	●	●	●	●	●	●	●	●	●	●
	B	●	●	●	●	●	●	●	●	●	●	●	●
	C	●	●	●	●	●	●	●	●	●	●	●	●
Billings	A	●	●	●	●	●	●	●	●	●	●	●	●
	B	●	●	●	●	●	●	●	●	●	●	●	●
	C	●	●	●	●	●	●	●	●	●	●	●	●
Boston	A	●	●	●	●	●	●	●	●	●	●	●	●
	B	●	●	●	●	●	●	●	●	●	●	●	●
	C	●	●	●	●	●	●	●	●	●	●	●	●
Chicago	A	●	●	●	●	●	●	●	●	●	●	●	●
	B	●	●	●	●	●	●	●	●	●	●	●	●
	C	●	●	●	●	●	●	●	●	●	●	●	●
Cleveland	A	●	●	●	●	●	●	●	●	●	●	●	●
	B	●	●	●	●	●	●	●	●	●	●	●	●
	C	●	●	●	●	●	●	●	●	●	●	●	●
Cold Bay	A	●	●	●	●	●	●	●	●	●	●	●	●
	B	●	●	●	●	●	●	●	●	●	●	●	●
	C	●	●	●	●	●	●	●	●	●	●	●	●
Dallas	A	●	●	●	●	●	●	●	●	●	●	●	●
	B	●	●	●	●	●	●	●	●	●	●	●	●
	C	●	●	●	●	●	●	●	●	●	●	●	●
Denver	A	●	●	●	●	●	●	●	●	●	●	●	●
	B	●	●	●	●	●	●	●	●	●	●	●	●
	C	●	●	●	●	●	●	●	●	●	●	●	●
Honolulu	A	●	●	●	●	●	●	●	●	●	●	●	●
	B	●	●	●	●	●	●	●	●	●	●	●	●
	C	●	●	●	●	●	●	●	●	●	●	●	●
Houston	A	●	●	●	●	●	●	●	●	●	●	●	●
	B	●	●	●	●	●	●	●	●	●	●	●	●
	C	●	●	●	●	●	●	●	●	●	●	●	●
Jacksonville	A	●	●	●	●	●	●	●	●	●	●	●	●
	B	●	●	●	●	●	●	●	●	●	●	●	●
	C	●	●	●	●	●	●	●	●	●	●	●	●
Juneau	A	●	●	●	●	●	●	●	●	●	●	●	●
	B	●	●	●	●	●	●	●	●	●	●	●	●
	C	●	●	●	●	●	●	●	●	●	●	●	●
Kansas City	A	●	●	●	●	●	●	●	●	●	●	●	●
	B	●	●	●	●	●	●	●	●	●	●	●	●
	C	●	●	●	●	●	●	●	●	●	●	●	●
Los Angeles	A	●	●	●	●	●	●	●	●	●	●	●	●
	B	●	●	●	●	●	●	●	●	●	●	●	●
	C	●	●	●	●	●	●	●	●	●	●	●	●

Memphis	A	●	●	●	●	●	●	●	●	●	●	●	●
	B	●	●	●	●	●	●	●	●	●	●	●	●
	C	●	●	●	●	●	●	●	●	●	●	●	●
Miami	A	●	●	●	●	●	●	●	●	●	●	●	●
	B	●	●	●	●	●	●	●	●	●	●	●	●
	C	●	●	●	●	●	●	●	●	●	●	●	●
Minneapolis	A	●	●	●	●	●	●	●	●	●	●	●	●
	B	●	●	●	●	●	●	●	●	●	●	●	●
	C	●	●	●	●	●	●	●	●	●	●	●	●
New York	A	●	●	●	●	●	●	●	●	●	●	●	●
	B	●	●	●	●	●	●	●	●	●	●	●	●
	C	●	●	●	●	●	●	●	●	●	●	●	●
Oakland	A	●	●	●	●	●	●	●	●	●	●	●	●
	B	●	●	●	●	●	●	●	●	●	●	●	●
	C	●	●	●	●	●	●	●	●	●	●	●	●
Salt Lake City	A	●	●	●	●	●	●	●	●	●	●	●	●
	B	●	●	●	●	●	●	●	●	●	●	●	●
	C	●	●	●	●	●	●	●	●	●	●	●	●
San Juan	A	●	●	●	●	●	●	●	●	●	●	●	●
	B	●	●	●	●	●	●	●	●	●	●	●	●
	C	●	●	●	●	●	●	●	●	●	●	●	●
Seattle	A	●	●	●	●	●	●	●	●	●	●	●	●
	B	●	●	●	●	●	●	●	●	●	●	●	●
	C	●	●	●	●	●	●	●	●	●	●	●	●
Washington, DC	A	●	●	●	●	●	●	●	●	●	●	●	●
	B	●	●	●	●	●	●	●	●	●	●	●	●
	C	●	●	●	●	●	●	●	●	●	●	●	●

- **Excellent** - 3.29σ bounded 100%
- **Good** - 4σ bounded 100%
- **Fair** - 4σ bounded 100% with one worst satellite excluded (Requires manual review if symptoms repeat from month to month)
- **Poor** – Requires manual review

Shaded receivers represent legacy receivers (non-G2). These receivers are predominantly the trouble receivers, with over 95% of their failures occurring on the L2 frequency.

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.

DR. Discrepancy Report

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.