WIDE-AREA AUGMENTATION SYSTEM PERFORMANCE ANALYSIS REPORT

Report #14

Reporting Period: July 1 to September 30, 2005

October 2005

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

Executive Summary

Since 1999 the WAAS Group at the William J. Hughes Technical Center has reported GPS performance as measured against the GPS Standard Positioning Service (SPS) Signal Specification. These quarterly reports are known as the PAN (Performance Analysis Network) Report. In addition to that report, the WAAS/NSTB Team reports on the performance of the Wide-Area Augmentation System (WAAS). This report is the fourteenth such WAAS quarterly report. This report covers WAAS performance during the period from July 1, 2005 to September 30, 2005.

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

Parameter	Site/Maximum	Site/Minimum
95% Horizontal Accuracy	Minneapolis 1.198 meters	Greenwood 0.58 meters
95% Vertical Accuracy	Minneapolis 1.937 meters	Chicago 1.141 meters
LPV Availability (HPL < 40 meters & VPL < 50 meters)	Salt Lake City 99.79%	Los Angeles 97.63%
95% HPL	San Angelo 29.189 meters	Atlanta 16.52 meters
95% VPL	San Angelo 43.73 meters	Kansas City 27.75 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 July 1, 2005 to September 30, 2005.

Table 1-1 PA Sites

	Number of Days Evaluated	Number of Samples
NSTB:		
Atlantic City	91	7845273
Greenwood	79	6838401
San Angelo	86	7429893
Oklahoma City	89	7710576
WAAS:		
Albuquerque	91	7841824
Anderson	80	6879842
Atlanta	89	7647616
Billings	92	7923190
Boston	91	7840858
Chicago	90	7738827
Cleveland	91	7903289
Dallas	92	7926352
Denver	92	7908028
Houston	91	7879786
Jacksonville	92	7917256
Kansas City	90	7738766
Los Angeles	92	7907518
Memphis	92	7914224
Miami	91	7840682
Minneapolis	73	6275495
New York	89	7734382
Oakland	87	7496523
Salt Lake City	92	7925657
Seattle	92	7931405
Washington DC	92	7922939

Table 1-2 NPA Sites

Location	Number of Days Evaluated	Number of Samples
Bangor	89	7771078
Mauna Loa	88	7668090
Kotzebue	85	7414184
Albuquerque	91	7920055
Anchorage	88	7682686
Atlanta	89	7729987
Billings	91	7941601
Boston	91	7913944
Cleveland	91	7919041
Cold Bay	91	7877440
Honolulu	90	7844997
Houston	91	7900408
Juneau	91	7879188
Kansas City	87	7536378
Los Angeles	91	7926371
Miami	91	7919424
Minneapolis	76	6643067
Oakland	83	7224618
Salt Lake City	91	7935360
San Juan	77	6712565
Seattle	91	7944241
Washington DC	91	7914810

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

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

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

Table 1-3 WAAS Performance Parameters

Performance Parameter	Expected WAAS Performance
PA Accuracy Horizontal	≤ 7.6m error 95% of the time
PA Accuracy Vertical	≤ 7.6m error 95% of the time
NPA Accuracy Horizontal	≤ 100m error 95% of the time ≤ 556m error 99.999% of the time
Availability LPV*	Not Defined for Current WAAS phase
Availability LNAV/VNAV*	Not Defined for Current WAAS phase
LPV and LNAV/VNAV Outages and outage rate	Not Defined for Current WAAS phase
LNAV Outages and outage rates	Not Defined for Current WAAS phase
Coverage LPV	Not Defined for Current WAAS phase For this report - 95% availability of 75% of CONUS
Coverage LNAV/VNAV	95% availability of 75% of CONUS
Coverage NPA	99.9% availability of 75% of service volume
LPV Availability	≥ 95% of the time within the service volume
LNAV/VNAV Availability	≥ 95% of the time within the service volume
Integrity	≤ 4 X 10e-8 HMI's per approach

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

1.1 Event Summary

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

Table 1.4 Test Events

GPS Week	Date	Sites	Events
1330 day 2 to 1331 day 2	7/5/05 to 7/12/05	All NSTB Sites except AC	Network outage.
1330 day 6	7/9/05	All WAAS Sites	WEI outage.
1333 day 1	7/25/05	All NSTB Sites except AC	Network outage.
1333 day 1 to 1334 day 5	7/25/05 to 8/5/05	Anderson	Anderson outage.
1333 day 3	7/27/05	Chicago	Installed new G2 receivers in Chicago WRS.
1333 day 4 to 1334 day 1	7/28/05 to 8/1/05	Minneapolis	Minneapolis outage.
1333 day 5	7/29/05	All WAAS Sites	WEI outage.
1333 day 5	7/29/05	Puerto Rico	Installed new G2 receivers in Puerto Rico WRS.
1334 day 1	8/1/05	Albuquerque	Installed new G2 receivers in Albuquerque WRS.
1334 day 3	8/3/05	Boston	Installed new G2 receivers in Boston WRS.
1334 day 5	8/5/05	Juneau	Installed new G2 receivers in Juneau WRS.
1335 day 1 to 1335 day 3	8/8/05 to 8/10/05	Atlanta	Installed new G2 receivers in Atlanta WRS.
1335 day 3	8/10/05	Los Angeles	Installed new G2 receivers in Los Angeles WRS.
1335 day 5 to 1336 day 2	8/12/05 to 8/16/05	New York	Installed new G2 receivers in New York WRS.
1336 day 0	8/14/05	All AORW Non-dual Sites	AORW SIS Gaps (120s, 5s, 4s, 1s).
1336 day 1	8/15/05	Honolulu	Installed new G2 receivers in Honolulu WRS.
1336 day 3	8/17/05	Jacksonville	Installed new G2 receivers in Jacksonville WRS.
1336 day 4 to 1336 day 5	8/18/05 to 8/19/05	Denver	Installed new G2 receivers in Denver WRS.
1336 day 4 to 1336 day 5	8/18/05 to 8/19/05	Houston	Installed new G2 receivers in Houston WRS.
1337 day 1	8/22/05	Cleveland	Installed new G2 receivers in Cleveland WRS.
1337 day 2	8/23/05	DC, Oakland, Anchorage	Switched from thread 1 to thread 2 on all three receivers.
1337 day 4	8/25/05	Miami	Installed new G2 receivers in Miami WRS.
1337 day 6 to 1338 day 3	8/27/05 to 8/31/05	Oakland	Oakland outage.
1338 day 1	8/29/05	Memphis	Installed new G2 receivers in Memphis WRS.
1338 day 1 to 1339 day 5	8/29/05 to 9/9/05	Greenwood	Greenwood outage.
1338 day 3	8/31/05	All Sites except Oakland	4 AORW SIS Gaps (1s, 7s, 7s, 6385s). 19 POR SIS Gaps (6781s, 240s, 2-40s).
1339 day 1	9/5/05	All Sites	AORW Switchover (10s). POR Switchover (10s). Low satellite PA availability. 10 SVs at 72% – 83% PA Availability. Same issue as described in Discrepancy Report #17.
1339 day 5 to 1341 day 2	9/9/05 to 9/20/05	Minneapolis	Minneapolis outage.
1340 day 2	9/13/05	All WAAS Sites	WEI outage. (220 sec lost.)
1341 day 1	9/19/05	All	PRN 14 maintenance caused C&V fault, which triggered SIS outage.

1.2 Report Overview

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

Section 3 summarizes the WAAS instantaneous availability performance, at each receiver, for three operational service levels during the reporting period. Daily availability is also plotted for each receiver evaluated. The number of outages and outage rate for each site is reported.

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

Section 5 summarizes the number of HMI's detected during the reporting period and presents a safety margin index for each receiver. The safety index reflects the amount of over bounding of position error by WAAS protection levels. This section also includes update rates of WAAS messages transmitted from AORW and POR.

Section 6 provides the UDRE and GIVE bounding percentage and the 95% index of the range and ionospheric accuracy for each satellite tracked by the WAAS receiver in Houston.

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

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

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

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

2.0 WAAS POSITION ACCURACY

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

Table 2-1 Operational Service Levels

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

Table 2.2 shows PA horizontal and vertical position accuracy maintained for 95% of the time at LPV and LNAV/VNAV operational service levels for the quarter. The table also includes 95% SPS accuracy for certain locations. Figures 2.1 to 2.4 show the daily horizontal and vertical 95% accuracy for LNAV/VNAV operational service level for the period. Note that WAAS accuracy statistics presented are compiled only

when all WAAS corrections (fast, long term, and ionospheric) for at least 4 satellites are available. This is referred to as PA navigation mode. The percentage of time that PA navigation mode was supported by WAAS at each receiver is also shown in Table 2.2. A user is considered to be in NPA navigation mode if only WAAS fast and long term corrections are available to a user (i.e. no ionospheric corrections). Table 2.3 shows NPA horizontal position accuracy for 95% and 99.999% of the time. This table also shows the maximum NPA horizontal position error for the quarter. Figures 2.5 shows the daily horizontal 95% accuracy for NPA.

During the evaluated period, the 95% horizontal and vertical accuracy at all evaluated sites were less than 2 meters for both WAAS operational service levels. The maximum 95% horizontal and vertical LPV errors are 1.198 meters and 1.937, both at Minneapolis. The minimum 95% horizontal and vertical LPV errors are 0.58 meters at Greenwood and 1.141 meters at Chicago. The maximum 95% and 99.999% NPA horizontal errors are 5.644 meters and 6.189 meters, both at Mauna Loa, respectively. The minimum 95% and 99.999% horizontal errors are 1.218 meters at Cleveland and 2.16 meters at Juneau, respectively.

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

Figures 2.6 to 2.15 show the distributions of the vertical and horizontal errors in triangle charts and 2-D histogram plots for the quarter at three locations, Kansas City, Washington DC and Seattle. The triangle charts show the distributions of vertical position errors (VPE) versus vertical protection levels (VPL) and horizontal position errors (HPE) versus horizontal protection levels (HPL). The horizontal axis is the position error and the vertical axis is the WAAS protection levels. Lower protection levels equate to better availability. The diagonal line shows the point where error equals protection level. Above and to the left of the diagonal line in the chart, errors are bounded (WAAS is providing integrity in the position domain); below and to the right, errors are not bounded (HMI could be present). The horizontal lines at various protection levels represent the various operational service levels as defined in Table 2.1. The 2-D histogram plots contain four histograms showing the distributions of vertical and horizontal position errors and normalized position errors. The left top and bottom histograms show the distributions of the actual vertical and horizontal errors. The horizontal axis is the position errors and the vertical axis is the total count of data samples (log scale) in each 0.1-meter bin. The right top and bottom histograms show the distributions of the actual vertical and horizontal errors normalized by one-sigma value of the protection level; vertical - (VPL/5.33) and horizontal - (HPL/6.0). The horizontal axis is the standard units and vertical axis is the observed distribution of normalized errors data samples in each 0.1-sigma bin. Narrowness of the normalized error distributions shows very good observed safety performance.

Table 2-2 PA 95% Horizontal and Vertical Accuracy

Location	Horizontal GLS/APV2/LPV (HAL=40m) (Meters)	Horizontal APV-1(LNAV) (HAL=556m) (Meters)	Vertical LPV/VNAV (VAL=50m) (Meters)	Percentage in PA mode (%)	SPS Accuracy	
					95% Horizontal (Meters)	95% Vertical (Meters)
Anderson	0.610	0.618	1.285	99.43467	*	*
Atlantic City	0.699	0.706	1.396	99.50704	*	*
Greenwood	0.580	0.586	1.508	99.74294	*	*
San Angelo	0.796	0.807	1.249	99.57241	*	*
Albuquerque	0.667	0.680	1.231	99.50021	2.463	4.156
Atlanta	0.610	0.620	1.211	99.48565	2.408	4.363
Billings	0.854	0.870	1.291	99.50343	2.293	4.238
Boston	0.784	0.795	1.298	99.49896	2.279	4.120
Chicago	0.662	0.672	1.141	99.49393	*	*
Cleveland	0.696	0.706	1.330	99.50681	2.278	4.217
Denver	0.745	0.759	1.515	99.50381	*	*
Houston	0.723	0.736	1.262	99.50213	2.696	4.248
Jacksonville	0.742	0.753	1.264	99.50365	*	*
Kansas City	0.776	0.788	1.196	99.49399	2.298	4.296
Los Angeles	0.934	0.939	1.321	99.80772	2.662	4.778
Memphis	0.648	0.658	1.303	99.50291	*	*
Miami	0.760	0.769	1.271	99.49859	2.931	4.431
Minneapolis	1.198	1.205	1.937	99.45029	2.236	3.904
New York	0.839	0.846	1.257	99.55595	*	*
Oakland	0.835	0.838	1.706	99.9368	2.552	4.960
Salt Lake City	0.694	0.699	1.344	99.80774	2.360	4.334
Seattle	0.874	0.877	1.368	99.80891	2.395	4.258
Washington DC	0.949	0.958	1.283	99.50291	2.259	4.419

* 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
Bangor	2.117	4.192	99.49	9.169
Mauna Loa	5.644	6.189	99.41	21.908
Kotzebue	2.170	4.368	99.38	6.114
Albuquerque	1.383	3.109	99.50	4.915
Anchorage	1.742	2.607	99.41	9.687
Atlanta	1.318	2.812	98.83	16.836
Billings	1.373	3.063	99.50	6.466
Boston	1.454	2.812	99.50	12.956
Cleveland	1.218	2.857	99.50	10.989
Cold Bay	1.404	3.120	99.41	8.182
Honolulu	3.087	4.304	99.41	13.954
Houston	1.790	2.733	99.50	14.736
Juneau	1.599	2.160	99.42	15.158
Kansas City	1.391	2.662	99.48	4.499
Los Angeles	1.710	3.094	99.80	5.019
Miami	1.682	2.799	99.50	4.867
Minneapolis	2.017	2.402	99.47	11.150
Oakland	1.463	3.523	99.31	6.263
Salt Lake City	1.270	3.829	99.80	4.066
San Juan	2.157	3.087	99.58	6.378
Seattle	1.460	3.695	99.80	4.812
Washington DC	1.797	2.872	99.50	15.152

Table 2-4 Maximum Error for LPV Service

Location	Horizontal Error (m)	Horizontal Error/HPL	Horizontal Maximum Ratio	Vertical Error (m)	Vertical Error/VPL	Vertical Maximum Ratio
Anderson	1.923	0.120	0.121	4.690	0.095	0.172
Atlantic City	3.490	0.201	0.237	4.114	0.131	0.140
Greenwood	2.291	0.128	0.132	4.861	0.164	0.184
Oklahoma City	2.314	0.084	0.129	3.628	0.114	0.114
San Angelo	2.375	0.067	0.113	4.559	0.139	0.139
Albuquerque	3.343	0.134	0.156	5.374	0.140	0.195
Atlanta	2.070	0.125	0.134	4.705	0.119	0.161
Billings	5.133	0.226	0.255	7.479	0.282	0.282
Boston	4.304	0.170	0.205	5.735	0.188	0.211
Chicago	2.821	0.212	0.212	6.161	0.172	0.183
Cleveland	3.569	0.163	0.220	5.380	0.270	0.270
Dallas	4.842	0.141	0.361	6.426	0.239	0.239
Denver	2.109	0.141	0.147	5.983	0.239	0.239
Houston	2.531	0.141	0.147	3.921	0.120	0.153
Jacksonville	2.563	0.138	0.159	4.926	0.100	0.138
Kansas City	2.168	0.149	0.163	3.695	0.126	0.165
Los Angeles	4.629	0.198	0.198	4.713	0.140	0.153
Memphis	2.601	0.113	0.150	4.204	0.169	0.169
Miami	2.823	0.173	0.175	6.503	0.167	0.181
Minneapolis	3.376	0.105	0.233	6.197	0.167	0.245
New York	2.907	0.157	0.157	5.564	0.190	0.190
Oakland	4.877	0.186	0.186	7.931	0.213	0.213
Salt Lake City	4.305	0.203	0.203	7.495	0.164	0.209
Seattle	4.239	0.112	0.192	5.828	0.245	0.248
Washington DC	2.875	0.110	0.197	6.598	0.134	0.205

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

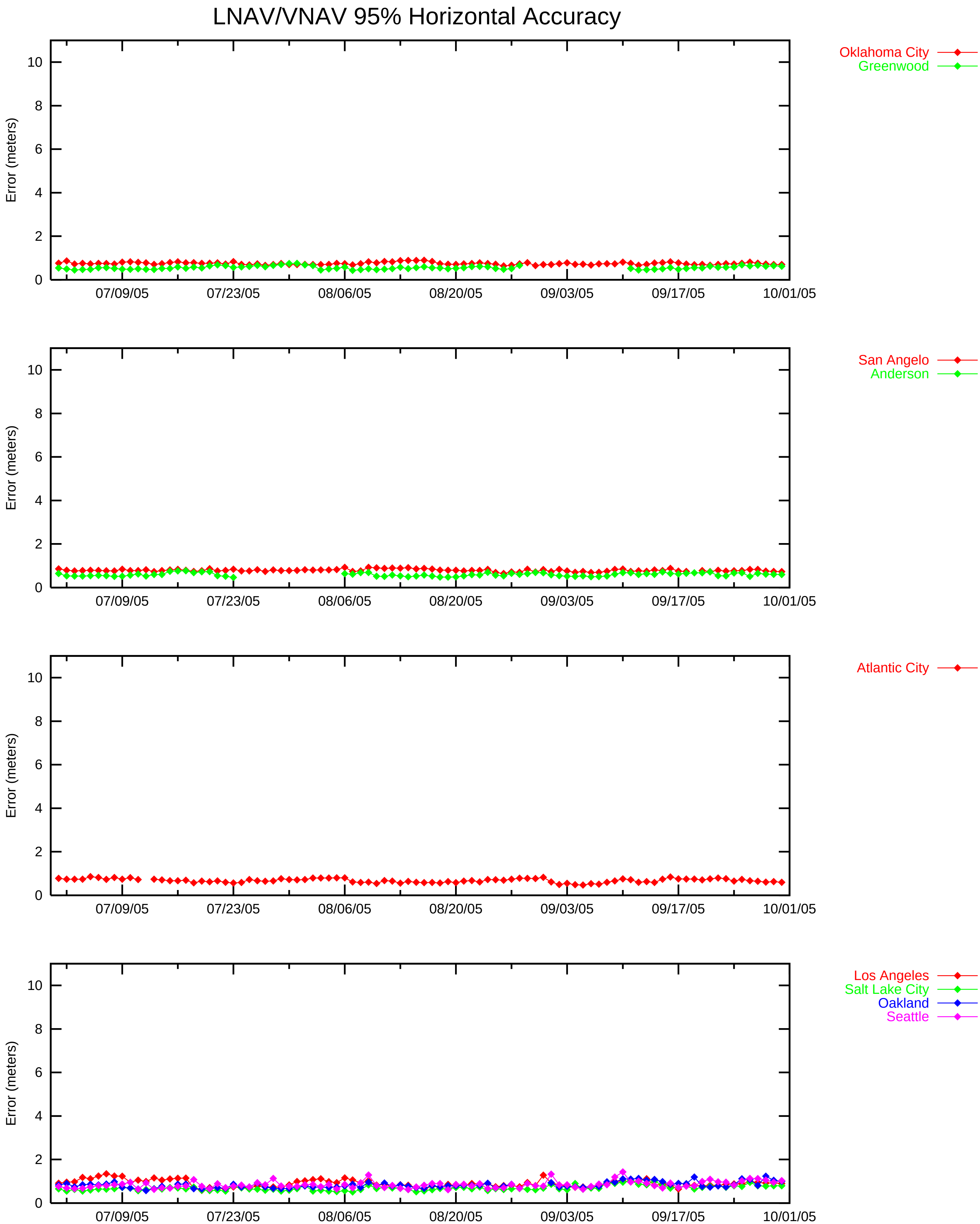


Figure 2-2 95% Horizontal Accuracy at LNAV/VNAV

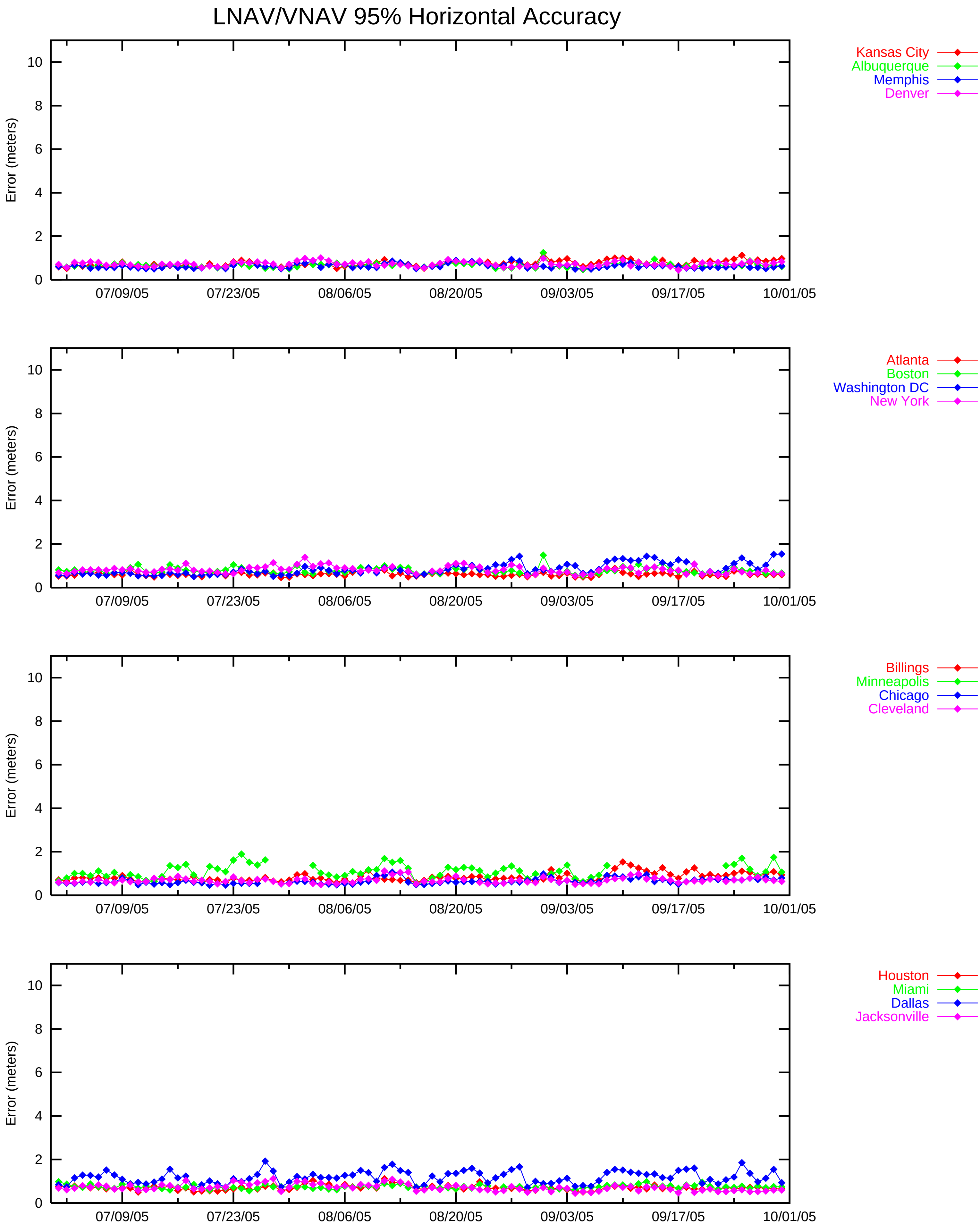


Figure 2-3 95% Vertical Accuracy at LNAV/VNAV

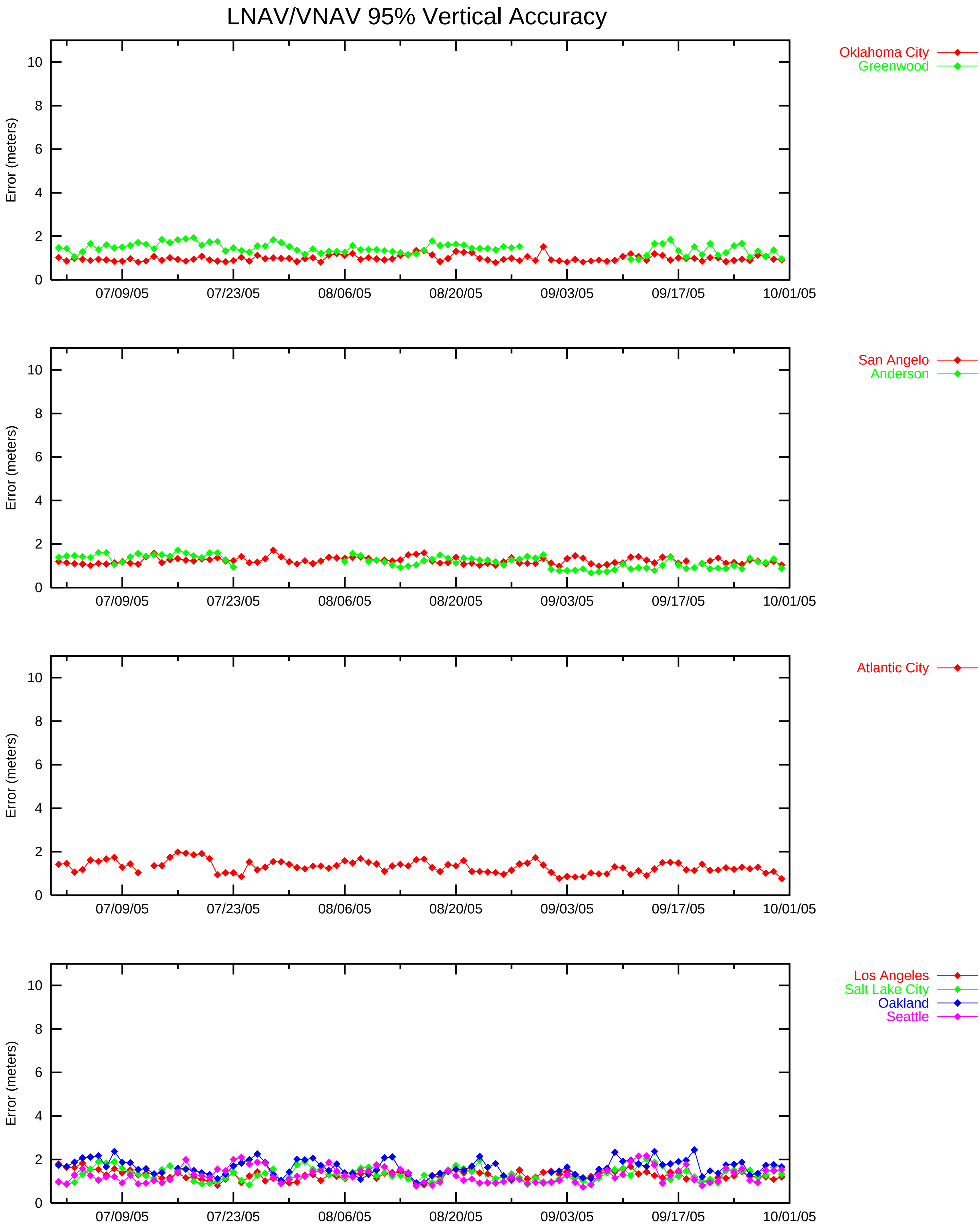


Figure 2-4 95% Vertical Accuracy at LNAV/VNAV

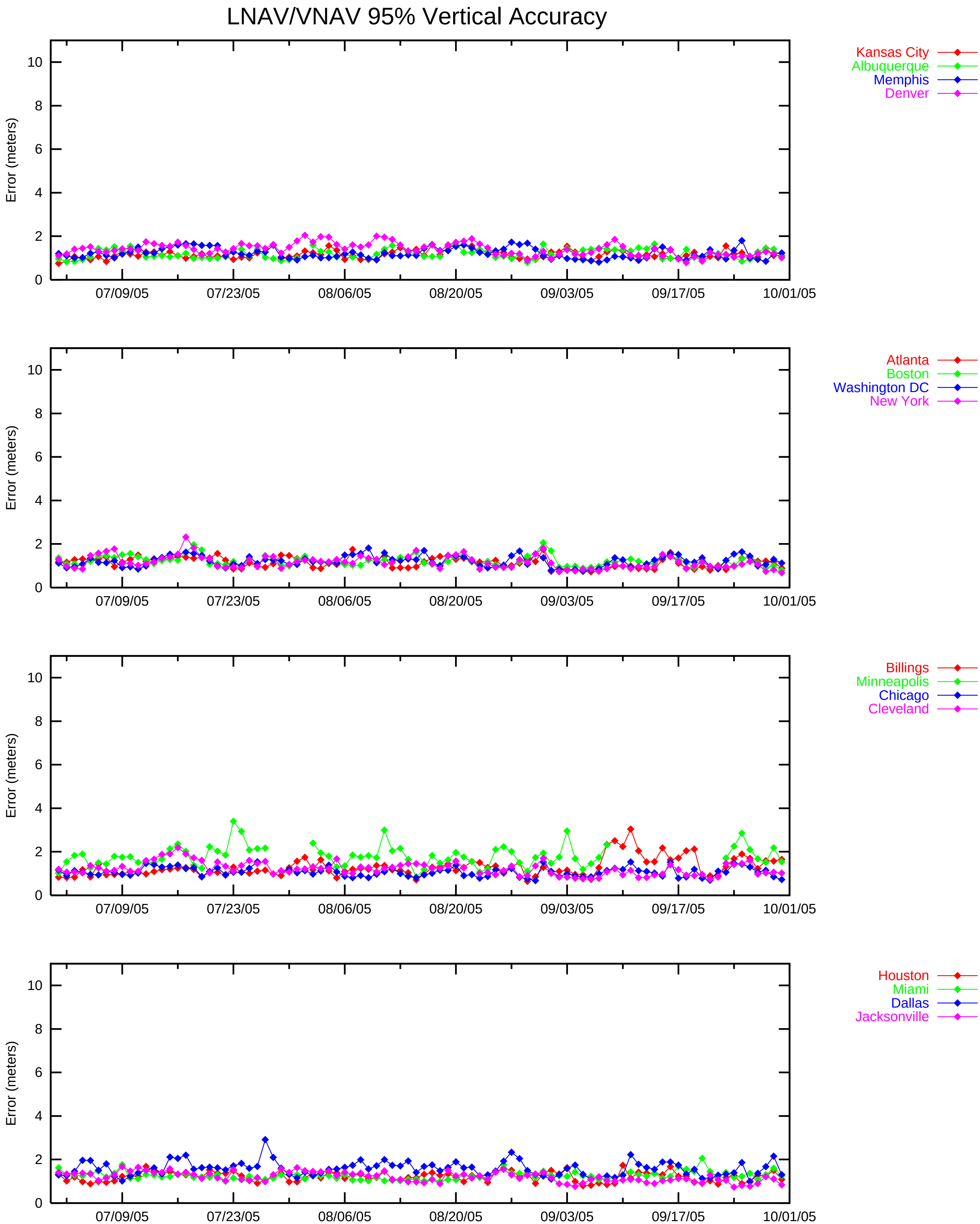


Figure 2-5 NPA 95% Horizontal Accuracy

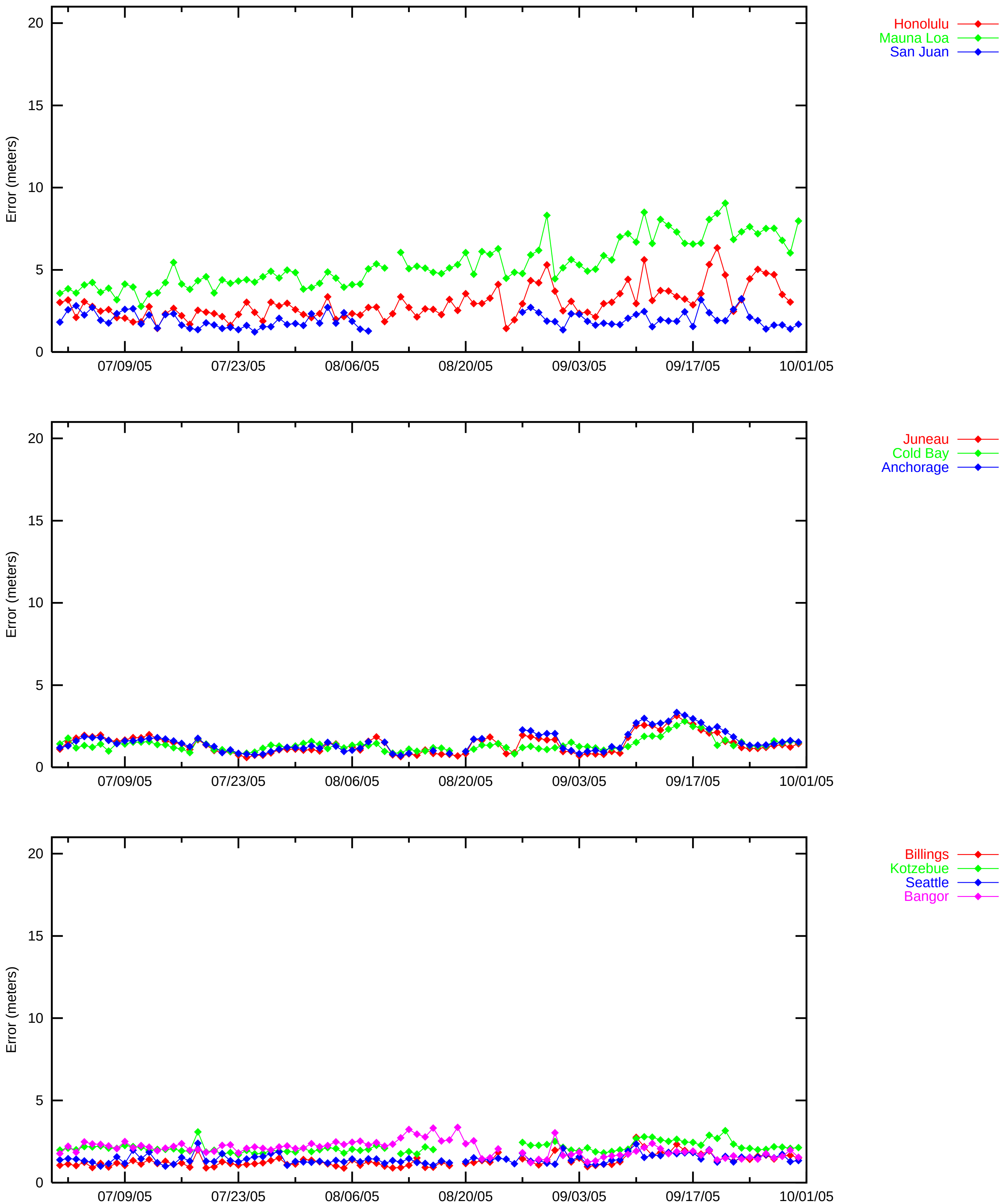
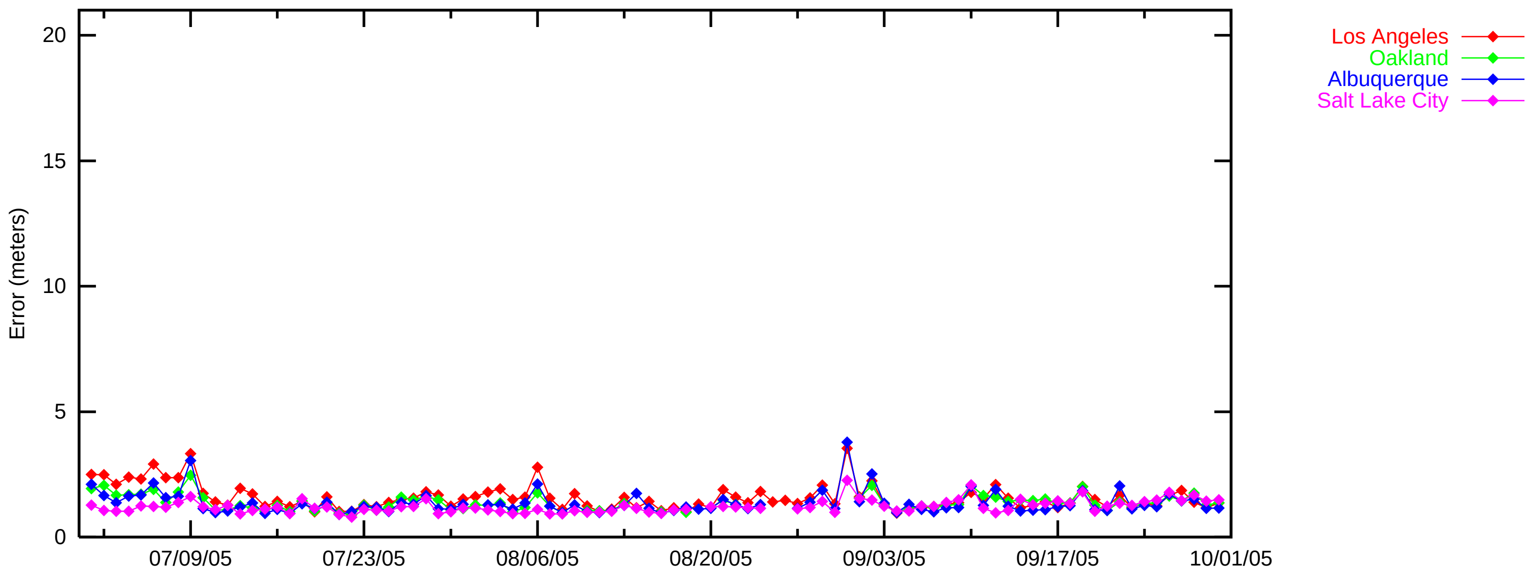
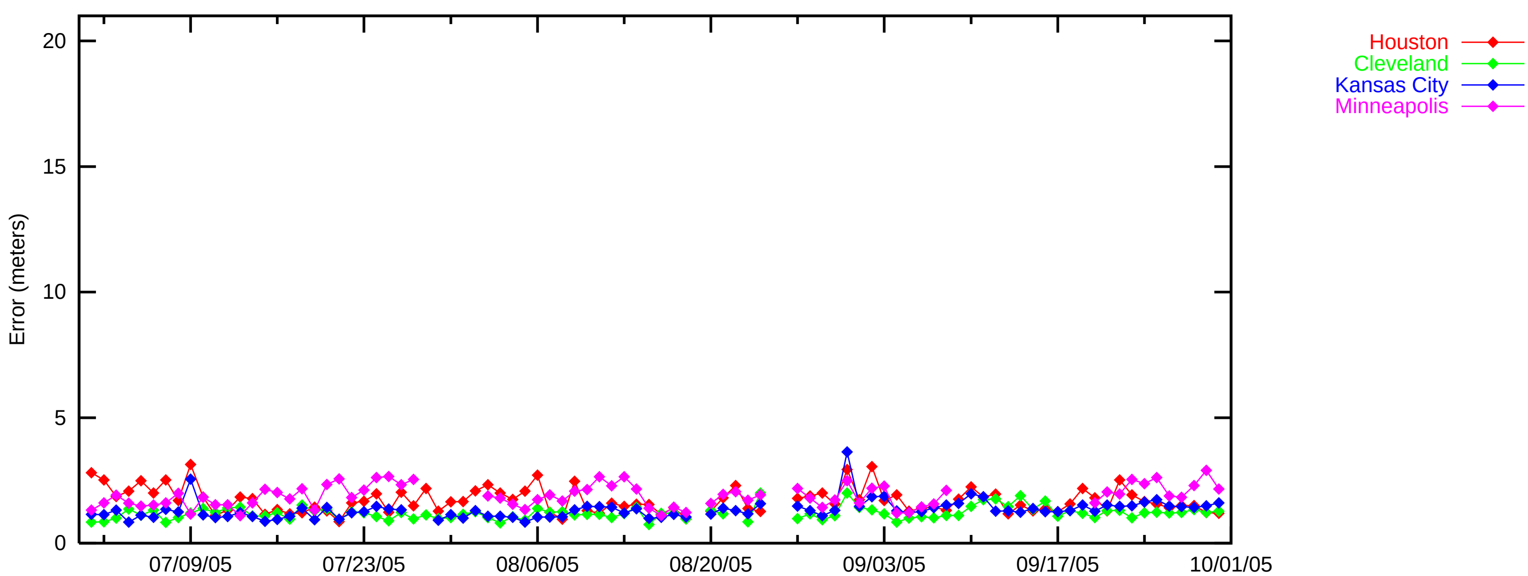


Figure 2-6 NPA 95% Horizontal Accuracy





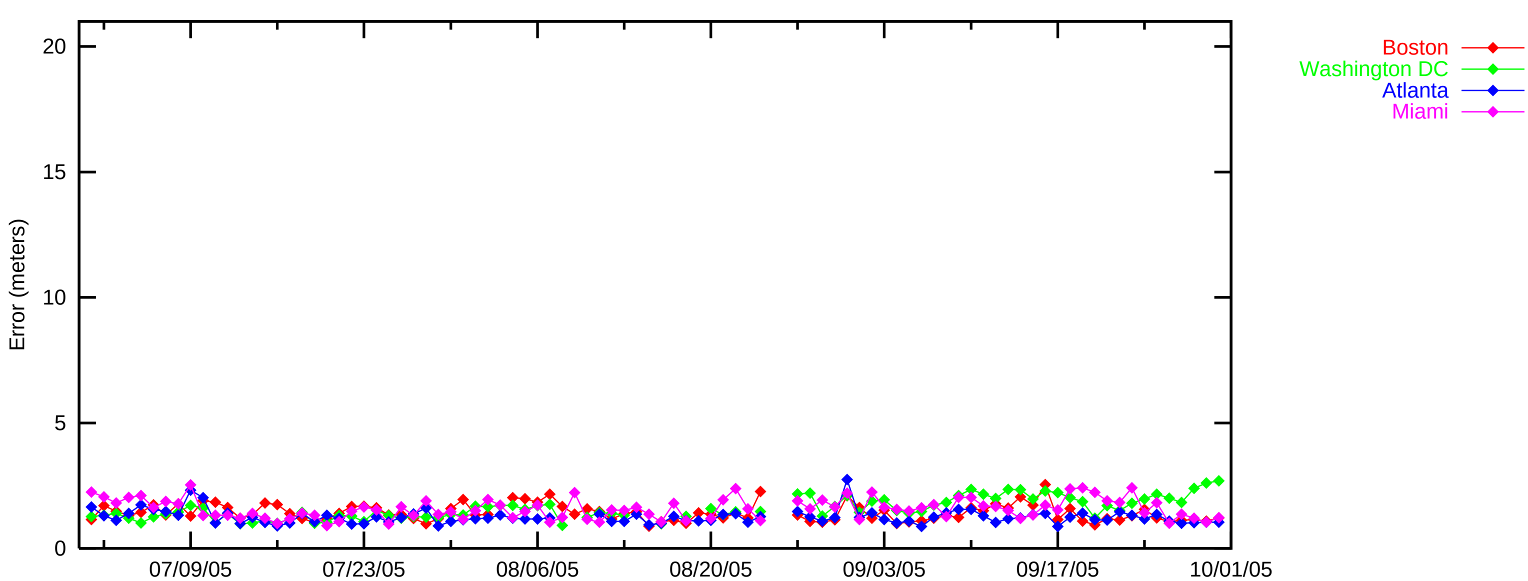


Figure 2-7 Horizontal Triangle Chart forKansas City

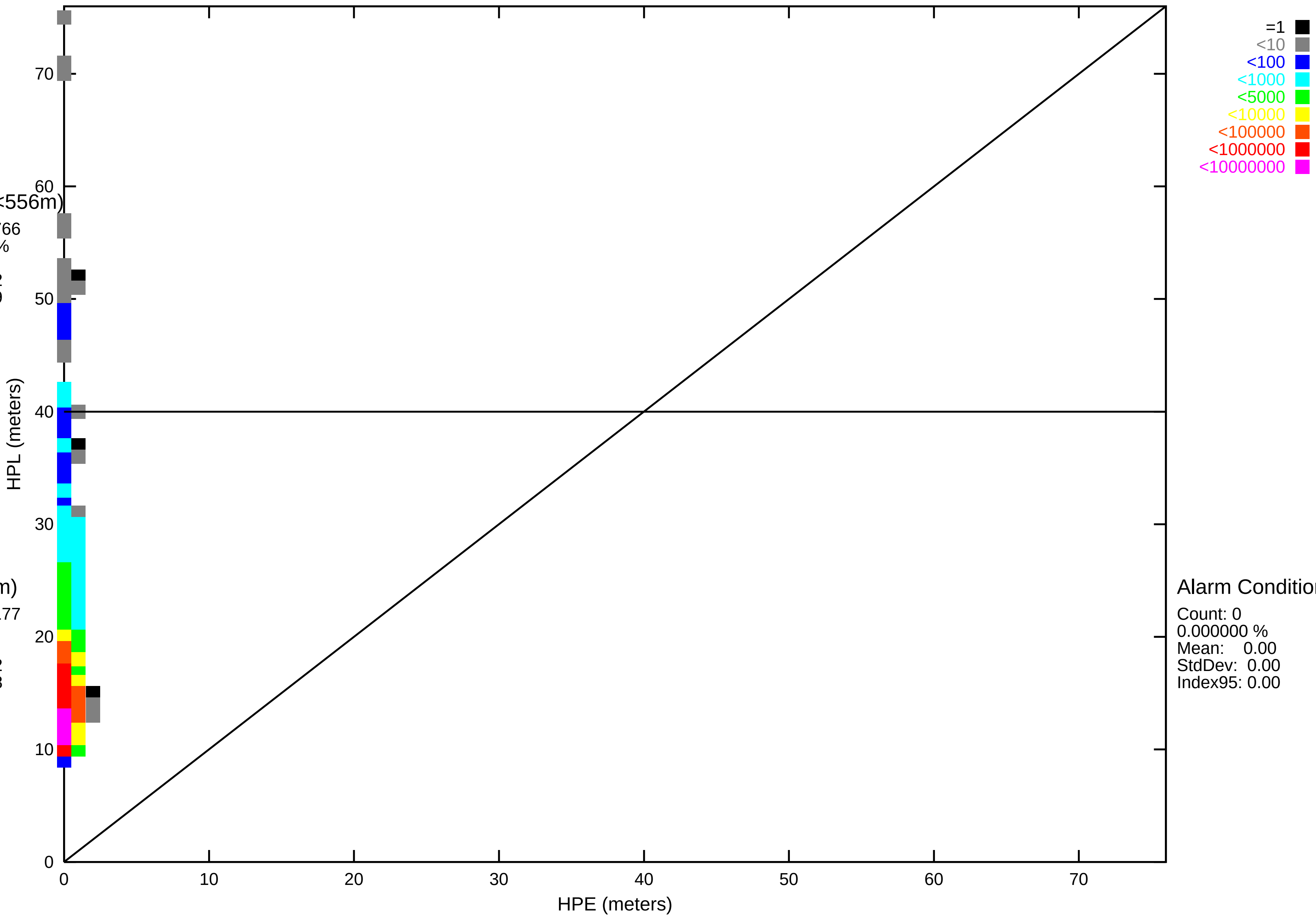
Site: Kansas_City Date: 7/1/05-9/30/05

PA mode Unavailable(>556m)
Count: 0
0.000000 %
Mean: 0.00
StdDev: 0.00
Index95: 0.00

All Modes
L/VNAV(=<556m)
Count: 7738766
100.000000 %
Mean: 0.36
StdDev: 0.22
Index95: 0.79

LPV(=<40m)
Count: 7699177
99.488434 %
Mean: 0.36
StdDev: 0.22
Index95: 0.78

HPE vs HPL 3D PA Histogram



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

Samples: 7738766
Mean: 0.36
StdDev: 0.22
Index95: 0.79

PA Samples: 7699607
Mean: 0.36
StdDev: 0.22
Index95: 0.78

Not PA Samples: 39159
Mean: 1.11
StdDev: 0.44
Index95: 1.79

Figure 2-8 Vertical Triangle Chart for Kansas City

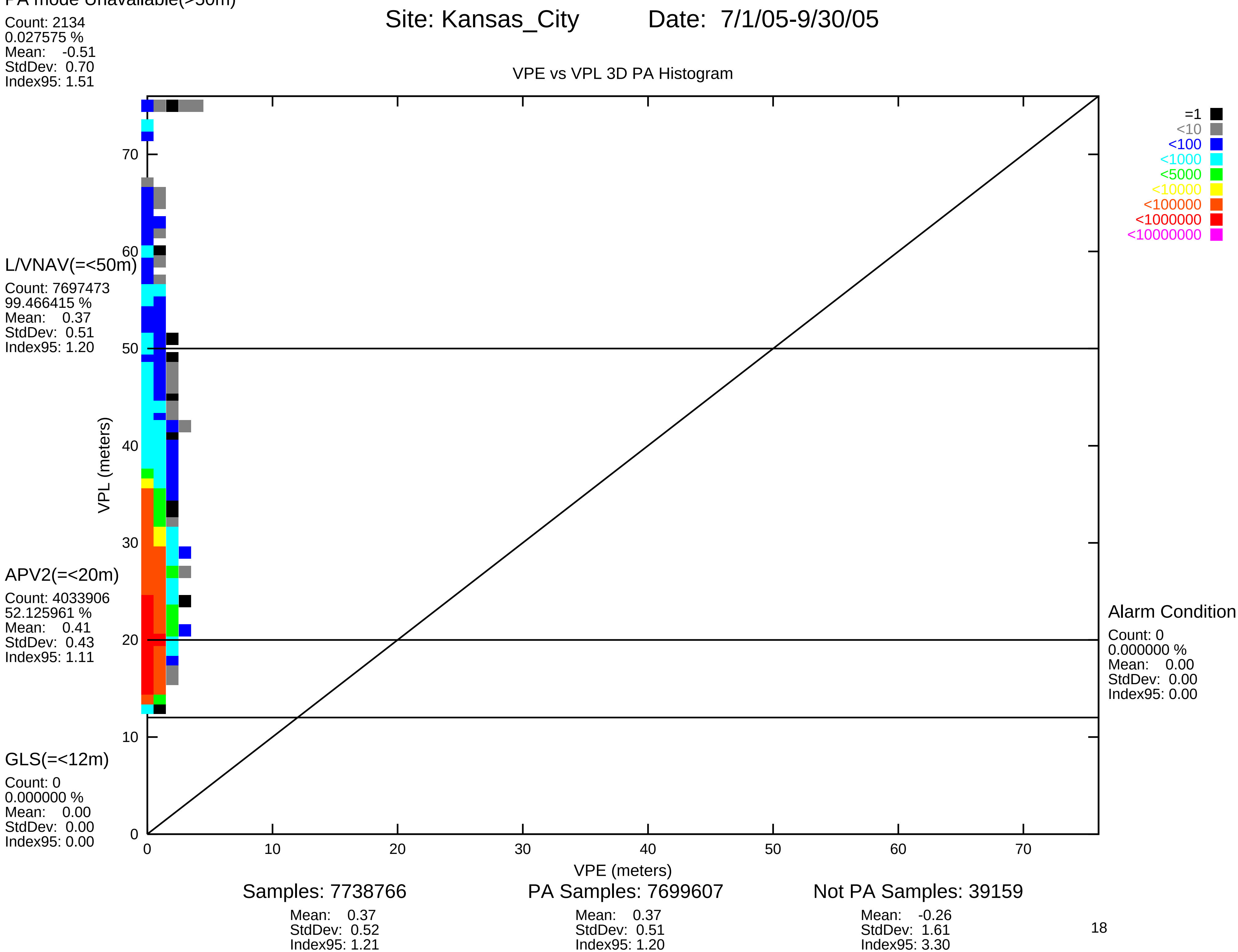


Figure 2-9 2-D Histogram for Kansas City

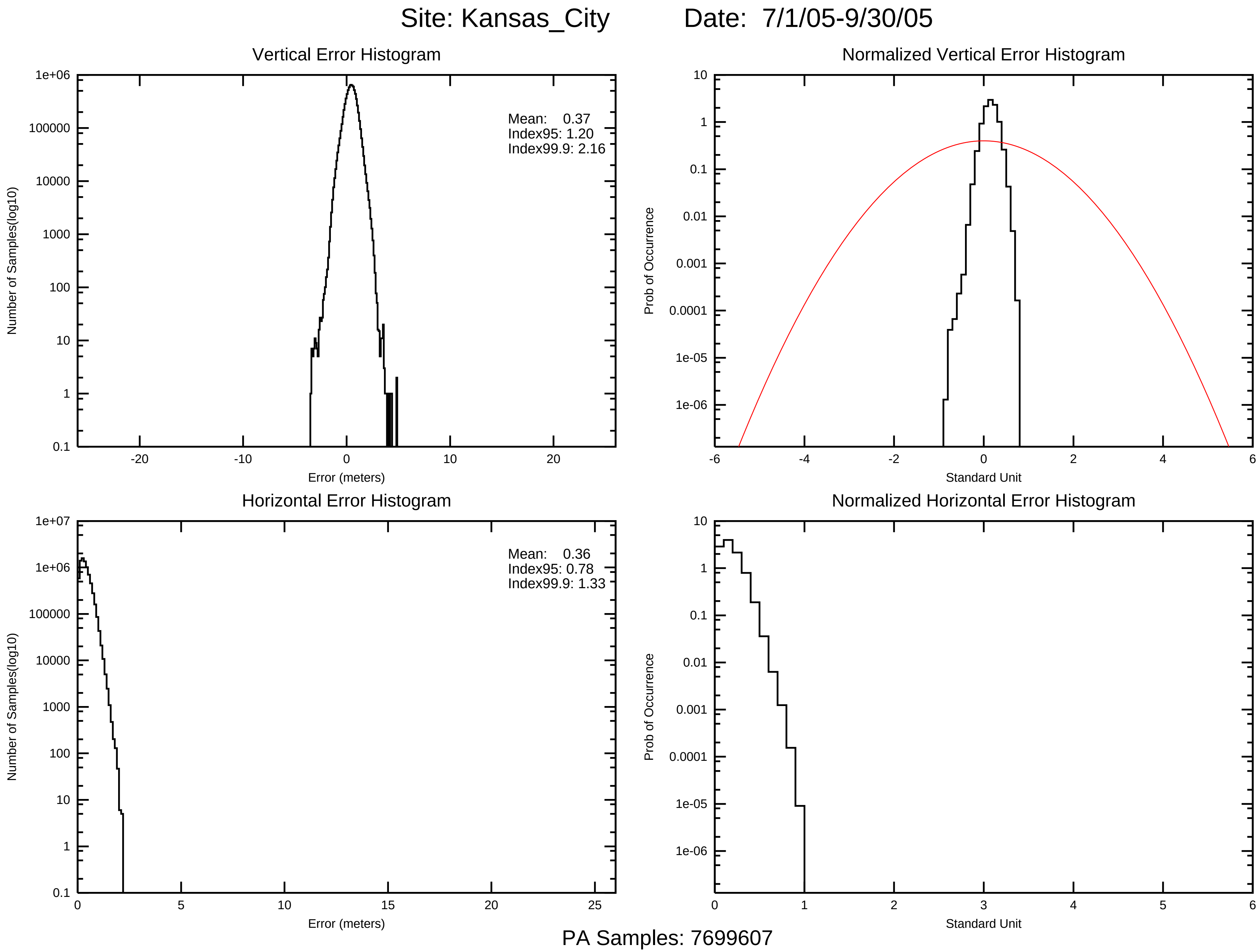


Figure 2-10 Horizontal Triangle Chart for Washington, DC

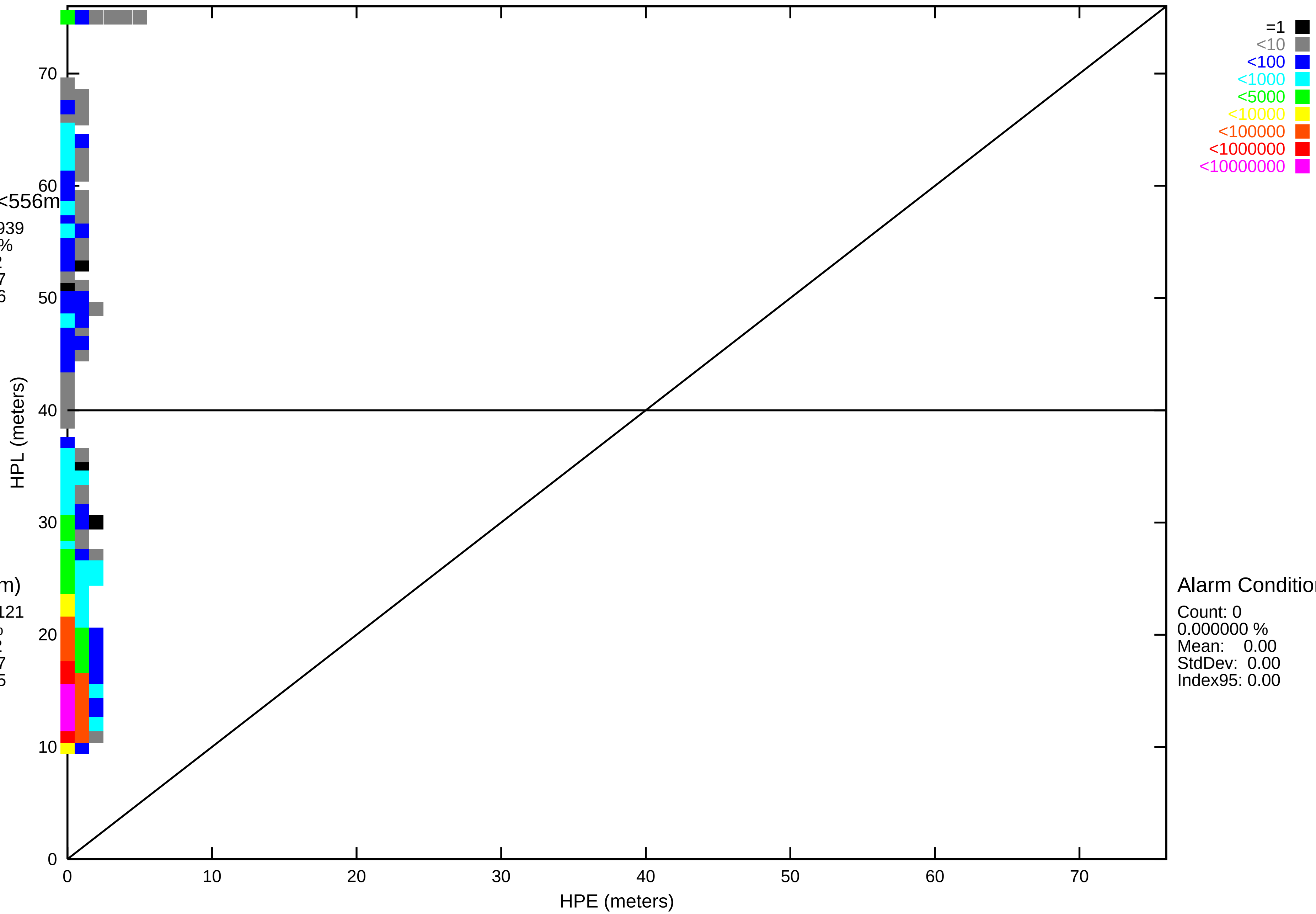
Site: WashingtonDC Date: 7/1/05-9/30/05

PA mode Unavailable(>556m)
Count: 0
0.000000 %
Mean: 0.00
StdDev: 0.00
Index95: 0.00

All Modes
L/VNAV(=<556m)
Count: 7922939
100.000000 %
Mean: 0.42
StdDev: 0.27
Index95: 0.96

LPV(=<40m)
Count: 7878121
99.434326 %
Mean: 0.42
StdDev: 0.27
Index95: 0.95

HPE vs HPL 3D PA Histogram



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

Samples: 7922939
Mean: 0.42
StdDev: 0.27
Index95: 0.96

PA Samples: 7883559
Mean: 0.42
StdDev: 0.27
Index95: 0.95

Not PA Samples: 39380
Mean: 0.94
StdDev: 0.42
Index95: 1.63

Figure 2-11 Vertical Triangle Chart for Washington, DC

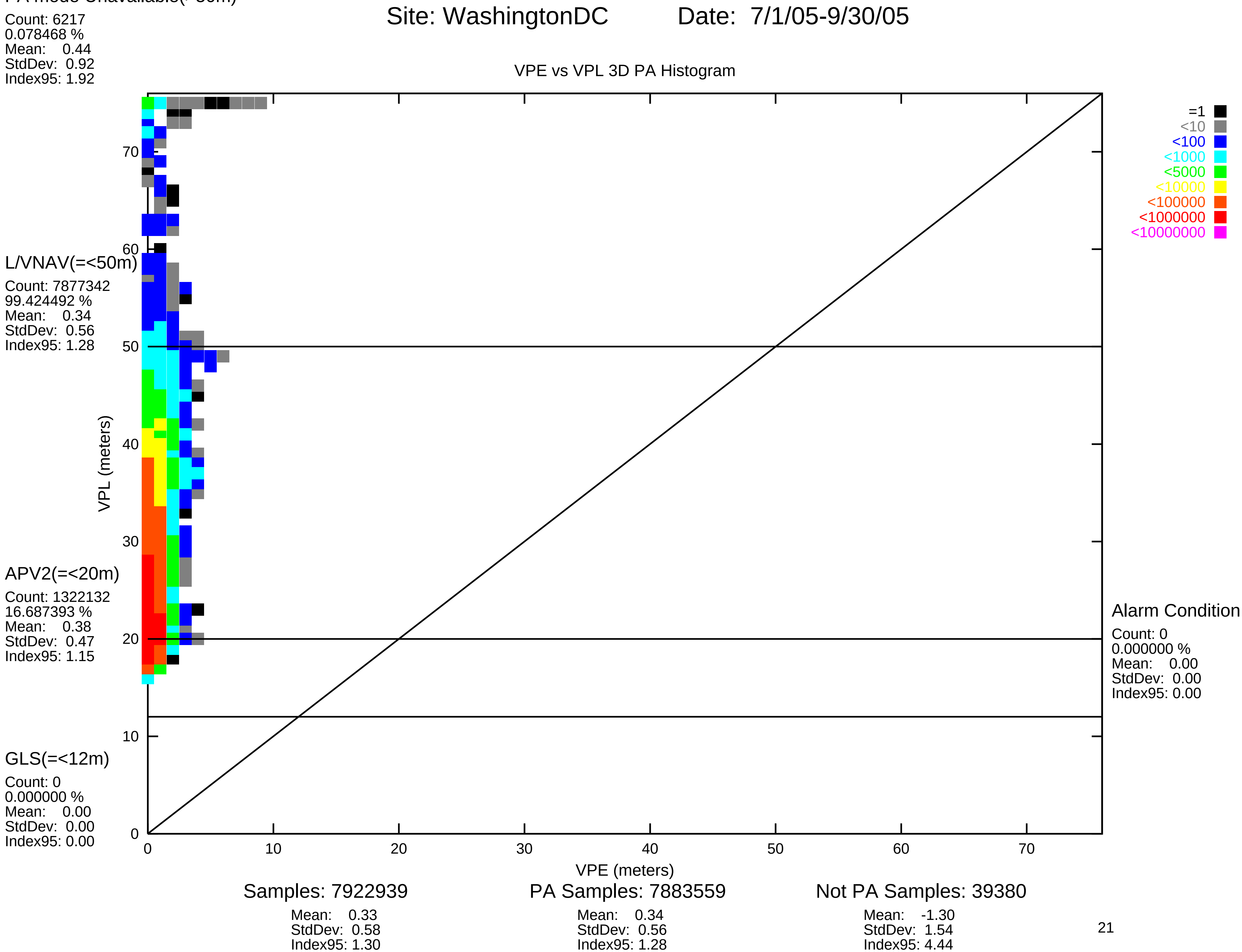


Figure 2-12 2-D Histogram for Washington, DC

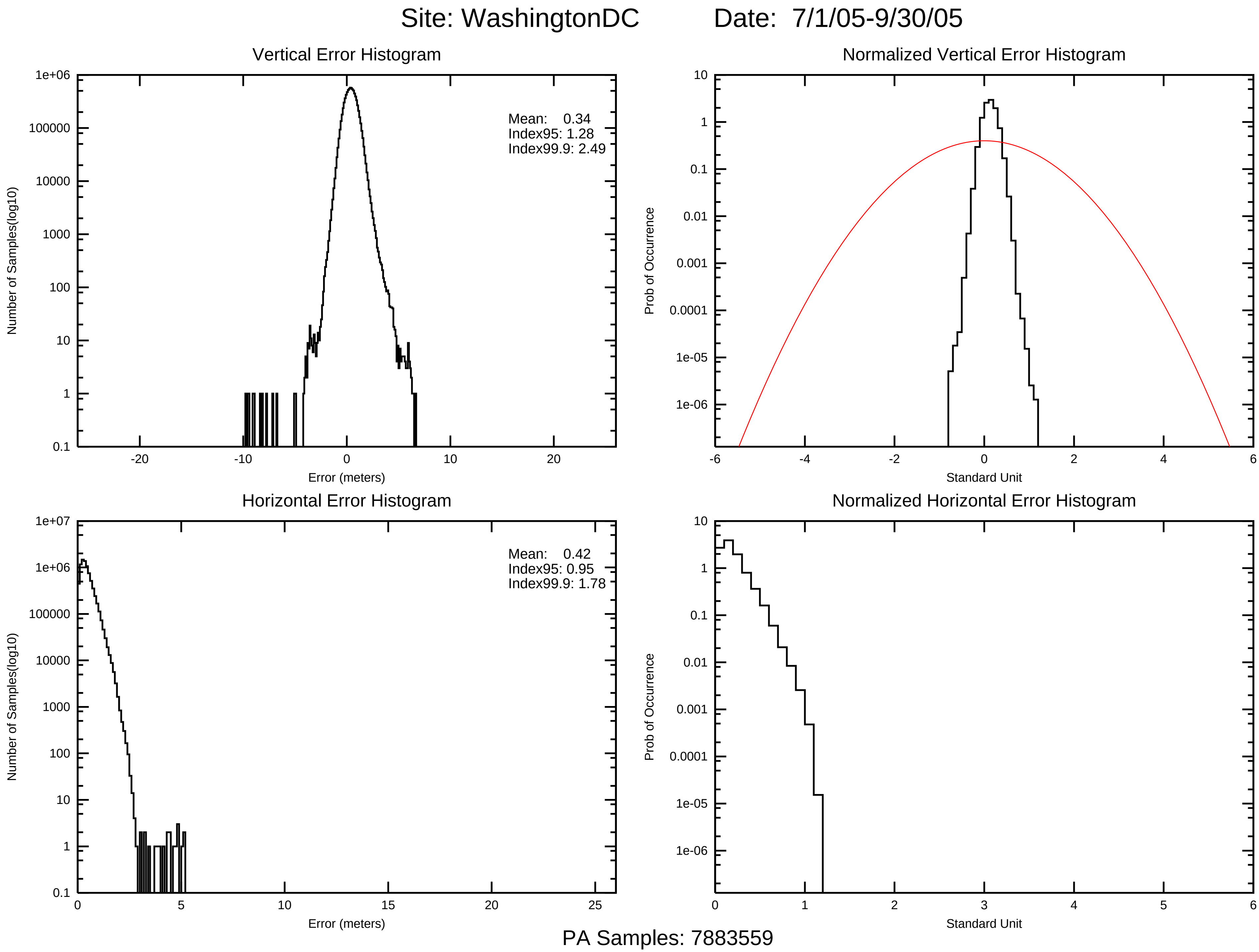


Figure 2-13 Horizontal Triangle Chart for Seattle

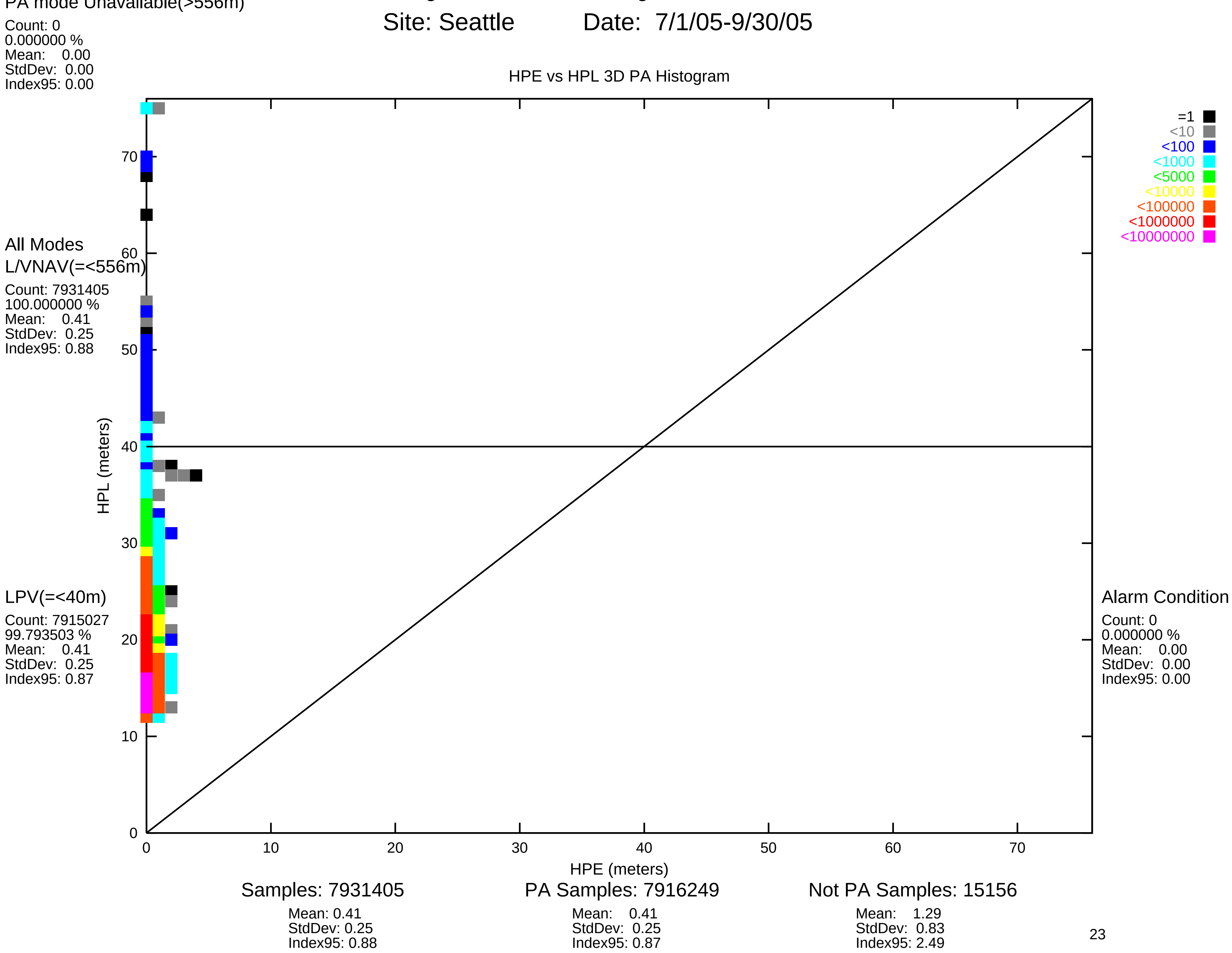


Figure 2-14 Vertical Triangle Chart for Seattle

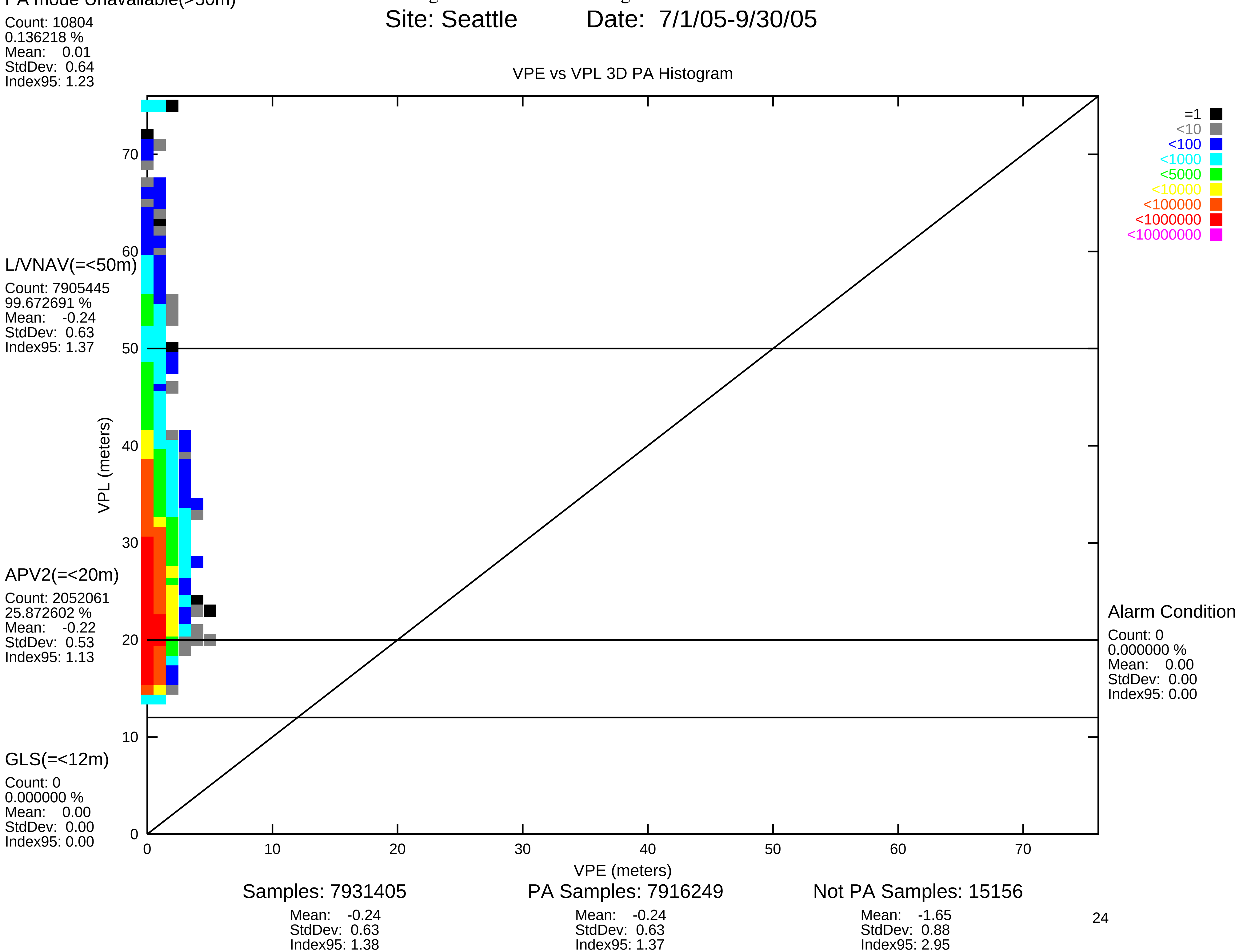
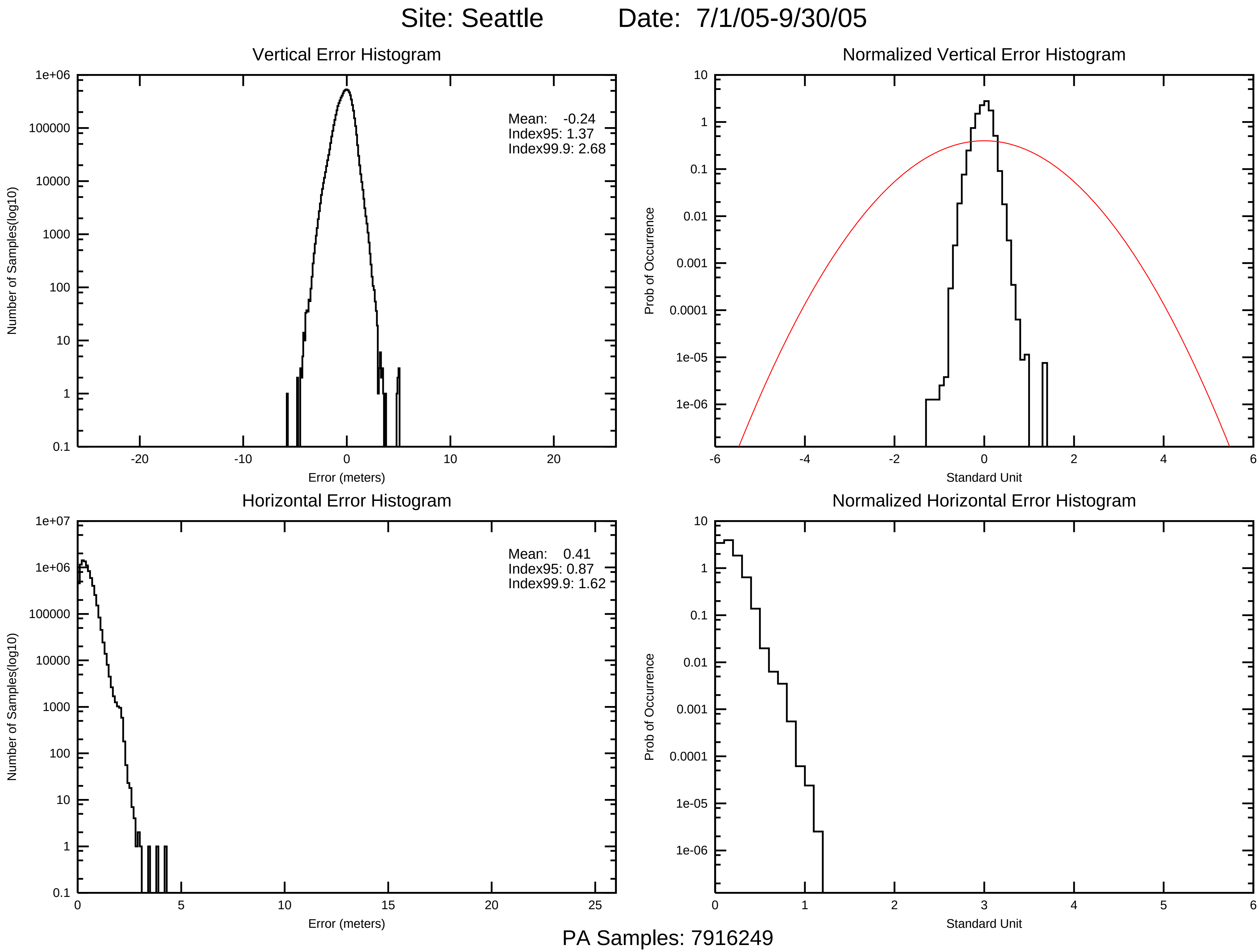


Figure 2-15 2-D Histogram for Seattle



3.0 AVAILABILITY

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

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

During the evaluated period, the maximum 95% HPL and VPL are 29.189 meters and 43.73 meters, both at San Angelo. The minimum 95% HPL and VPL are 16.52 meters at Atlanta and 27.75 meters at Kansas City.

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

Table 3-1 95% Protection Level

Location	95% HPL (meters)	95% VPL (meters)	Percentage in PA mode
Atlantic City	19.381	36.544	99.507042
Greenwood	17.906	30.551	99.742943
San Angelo	29.189	43.739	99.572411
Albuquerque	20.512	34.058	99.500206
Anderson	16.991	28.831	99.434669
Atlanta	16.522	29.044	99.485649
Billings	21.340	29.915	99.503433
Boston	25.229	43.370	99.498955
Chicago	16.660	31.244	99.493927
Cleveland	17.466	30.485	99.506805
Denver	18.566	28.543	99.503807
Houston	22.466	34.103	99.502129
Jacksonville	17.594	31.073	99.503654
Kansas City	16.660	27.753	99.493988
Los Angeles	27.414	43.218	99.807724
Memphis	16.788	30.162	99.502914
Miami	22.143	39.622	99.498589
Minneapolis	20.633	30.576	99.450287
New York	20.918	37.639	99.555954
Oakland	27.405	39.125	99.936798
Salt Lake City	19.414	30.936	99.807739
Seattle	21.101	30.551	99.808914
Washington DC	16.875	30.602	99.502907

Table 3.2 Quarterly Availability Statistics

Location	LPV *Average Availability Percentage of time*	LNAV/VNAV *Average Availability Percentage of time*	LPV WAAS *With 15 minute window*	LNAV/VNAV *With 15 minute window*
Anderson	0.99348795	0.99349141	0.99334951	0.99335303
Atlantic City	0.99210888	0.99220473	0.99138767	0.99156671
Greenwood	0.99687678	0.99687749	0.99644499	0.99644572
Oklahoma City	0.99208397	0.99230772	0.99162968	0.99185210
San Angelo	0.98143160	0.98334944	0.96230821	0.96673653
Albuquerque	0.99371791	0.99372721	0.99334814	0.99335745
Atlanta	0.99348795	0.99349141	0.99406298	0.99408744
Billings	0.99414915	0.99417347	0.99493941	0.99494661
Boston	0.99494785	0.99495554	0.97393903	0.97416370
Chicago	0.98233622	0.98254323	0.99442303	0.99459626
Cleveland	0.99432021	0.99448919	0.99451156	0.99459723
Denver	0.99445128	0.99453408	0.99489102	0.99489430
Houston	0.99491620	0.99493235	0.99456198	0.99461763
Jacksonville	0.99490023	0.99490404	0.99239064	0.99241239
Kansas City	0.99455506	0.99461025	0.99464087	0.99465327
Los Angeles	0.99339694	0.99341869	0.97059355	0.97230168
Memphis	0.99465120	0.99466413	0.99482893	0.99484169
Miami	0.97631902	0.97757667	0.98076534	0.98093990
Minneapolis	0.99483967	0.99485242	0.99397474	0.99408829
New York	0.98500246	0.98516840	0.99100524	0.99107803
Oakland	0.99374044	0.99384081	0.99091605	0.99147322
Salt Lake City	0.99221128	0.99228406	0.99790327	0.99790339
Seattle	0.99410260	0.99442530	0.99607535	0.99623220
Washington DC	0.99790329	0.99790341	0.99409342	0.99426080

Table 3.3 NPA Availability

Location	NPA Availability (Excluding RAIM/FDE)
Albuquerque	0.99496349
Anchorage	0.99713668
Atlanta	0.99482664
Bangor	0.99494120
Billings	0.99492891
Boston	0.99494398
Cleveland	0.99490678
Cold bay	0.99547177
Honolulu	0.99551025
Houston	0.99490597
Juneau	0.99552223
Kansas City	0.99490028
Kotzebue	0.99513920
Los Angeles	0.99809758
Mauna Loa	0.99552574
Miami	0.99492646
Minneapolis	0.99458490
Oakland	0.99998703
Puerto Rico	0.99582486
Salt Lake City	0.99804894
Seattle	0.99809012
Washington DC	0.99992743

Table 3.4 LPV and LNAV/VNAV Outage Rate

Location	LPV Outages	LPV Outage Rates	LNAV/VNAV Outages	LNAV/VNAV Outage Rates
Atlantic City	109	0.002102	101	0.001948
Anderson	25	0.000552	25	0.000552
Greenwood	40	0.000879	40	0.000879
Oklahoma City	157	0.003080	150	0.002942
San Angelo	308	0.006462	308	0.006432
Albuquerque	69	0.001329	68	0.001309
Atlanta	31	0.000612	29	0.000572
Billings	16	0.000304	15	0.000285
Boston	242	0.004755	234	0.004596
Chicago	18	0.000350	16	0.000311
Cleveland	23	0.000439	22	0.000420
Dallas	20	0.000380	18	0.000342
Denver	16	0.000305	15	0.000286
Houston	26	0.000497	20	0.000382
Jacksonville	63	0.001204	61	0.001166
Kansas City	15	0.000292	14	0.000273
Los Angeles	206	0.004026	194	0.003785
Memphis	20	0.000381	19	0.000362
Miami	237	0.004592	232	0.004494
Minneapolis	22	0.000508	19	0.000439
New York	82	0.001605	79	0.001546
Oakland	145	0.002862	131	0.002584
Salt Lake City	12	0.000228	11	0.000209
Seattle	36	0.000684	32	0.000607
Washington DC	27	0.000514	25	0.000476

Table 3.5 NPA Outage Rates

Location	NPA Outages	NPA Outage Rate
Albuquerque	12	0.00023357
Anchorage	9	0.00032623
Atlanta	12	0.00023944
Bangor	12	0.00023368
Billings	12	0.00023492
Boston	12	0.00023378
Cleveland	12	0.00023562
Cold bay	18	0.00034875
Honolulu	20	0.00038482
Houston	12	0.00023625
Juneau	18	0.00034499
Kansas City	11	0.00021708
Kotzebue	19	0.00039521
Los Angeles	6	0.00011380
Mauna_Loa	17	0.00032745
Miami	12	0.00023488
Minneapolis	11	0.00026012
Oakland	1	0.00003604
Puerto Rico	11	0.00026113
Salt Lake City	3	0.00005860
Seattle	7	0.00013357
Washington DC	7	0.00034074

Figure 3-1 LPV Instantaneous Availability

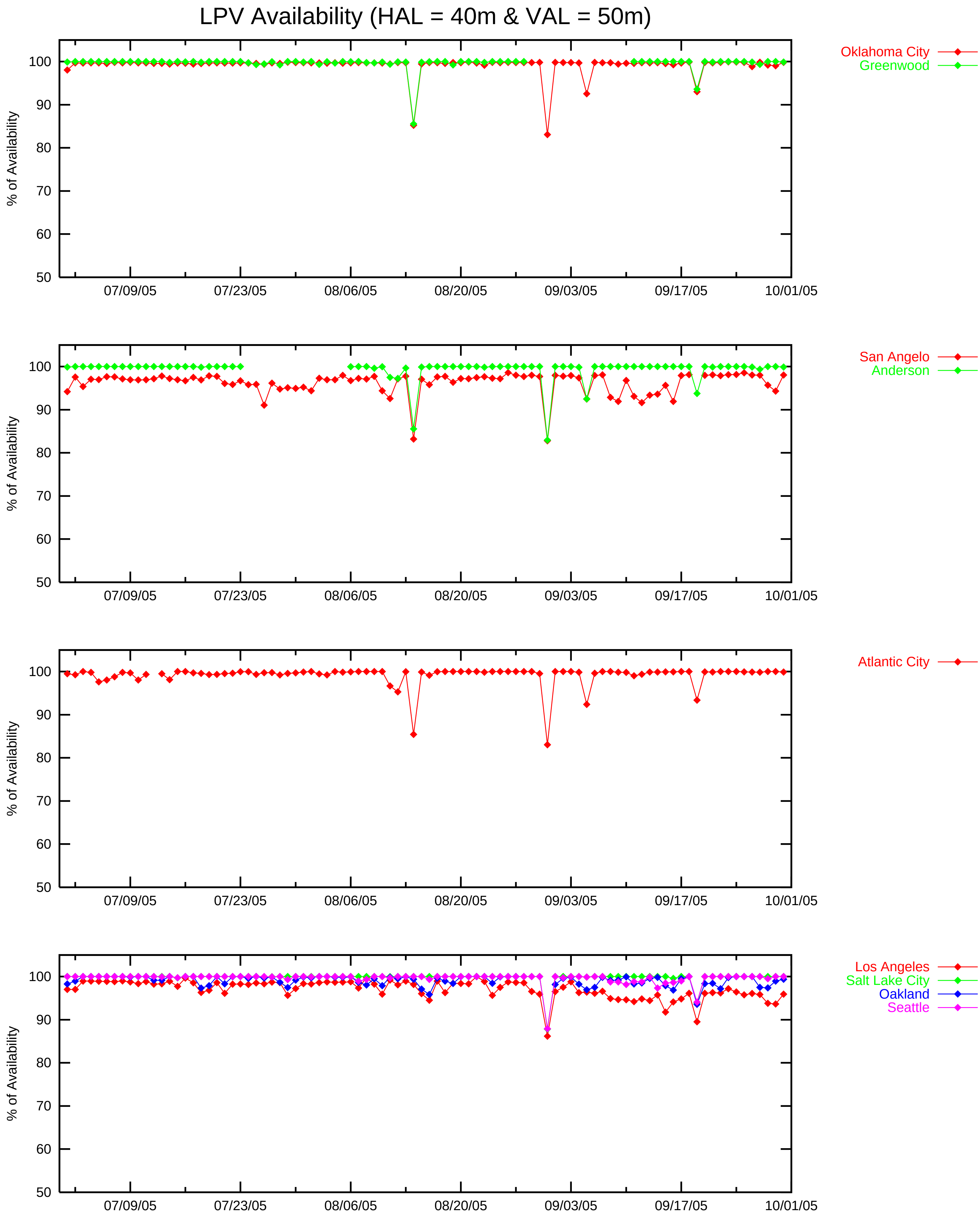
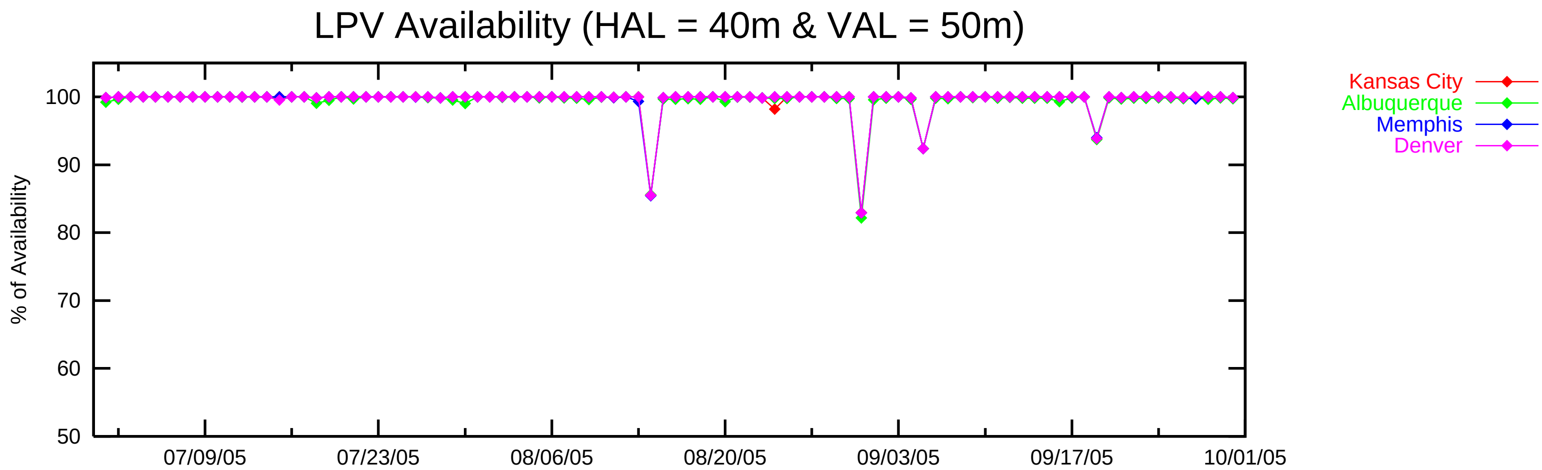
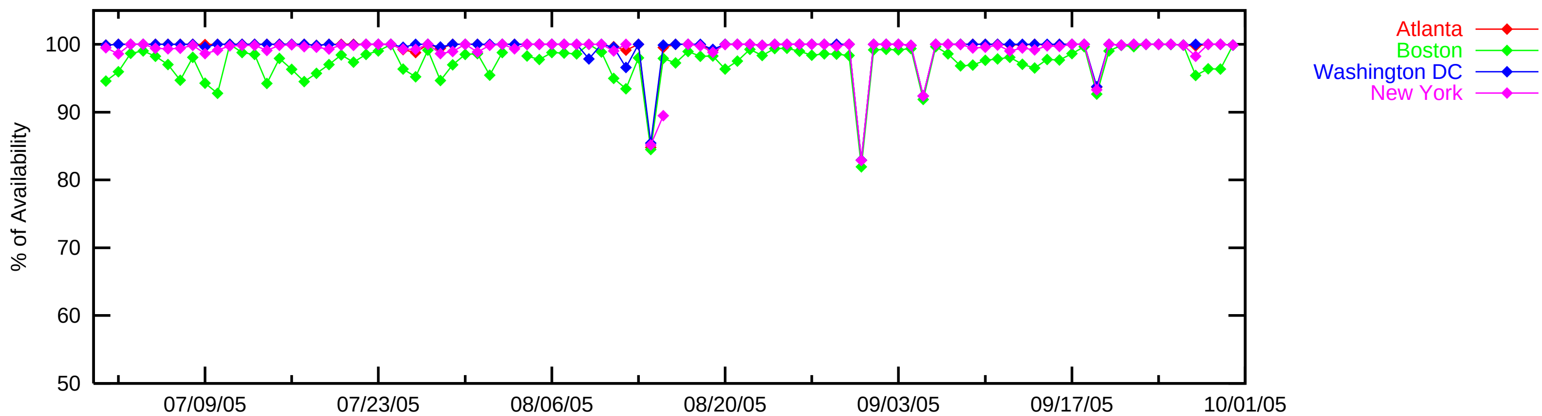
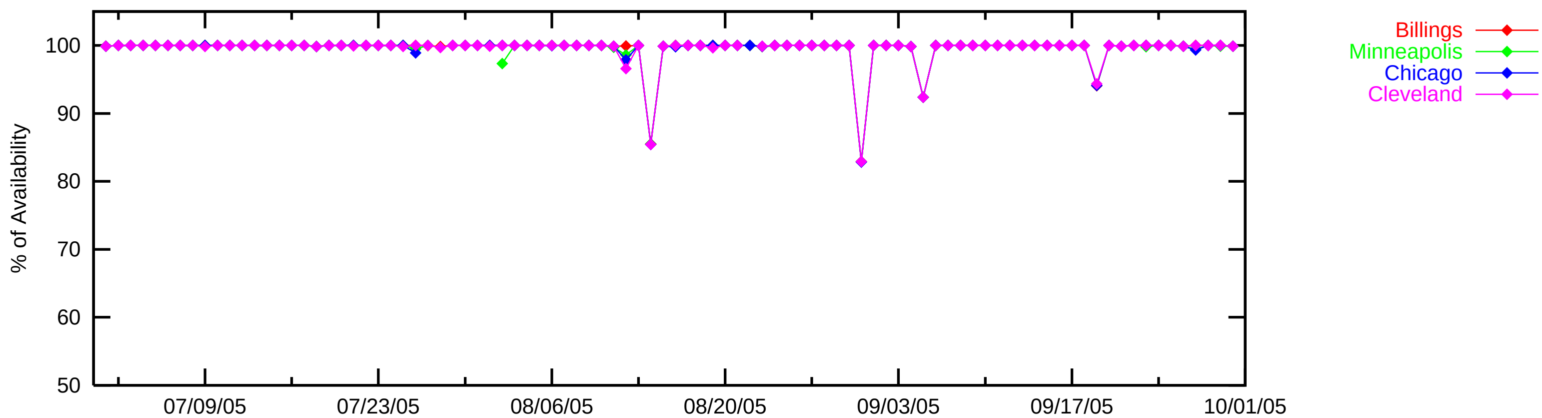


Figure 3-2 LPV Instantaneous Availability







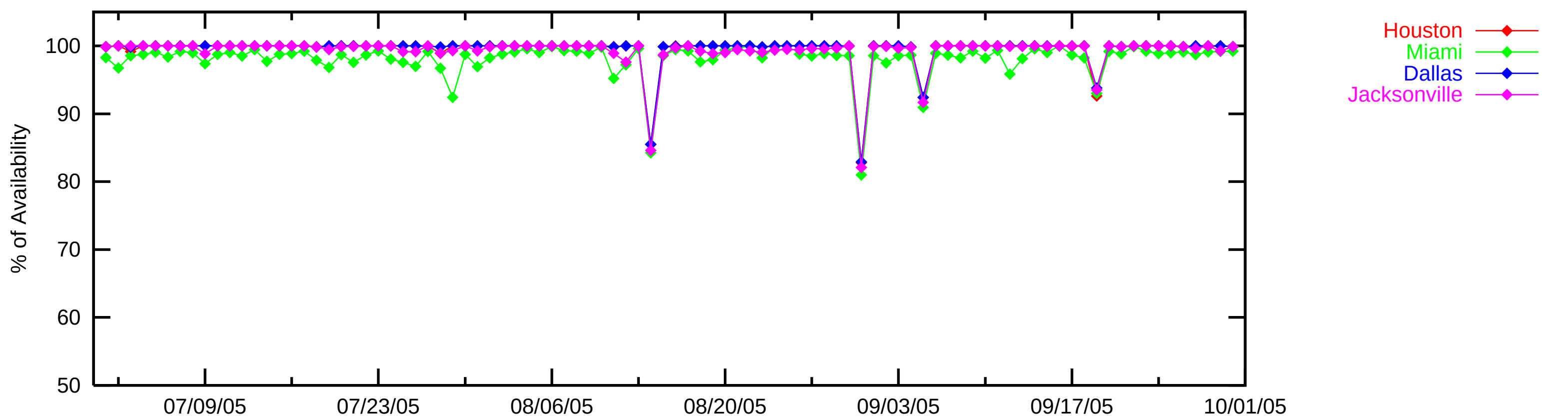


Figure 3-3 LNAV/VNAV Instantaneous Availability

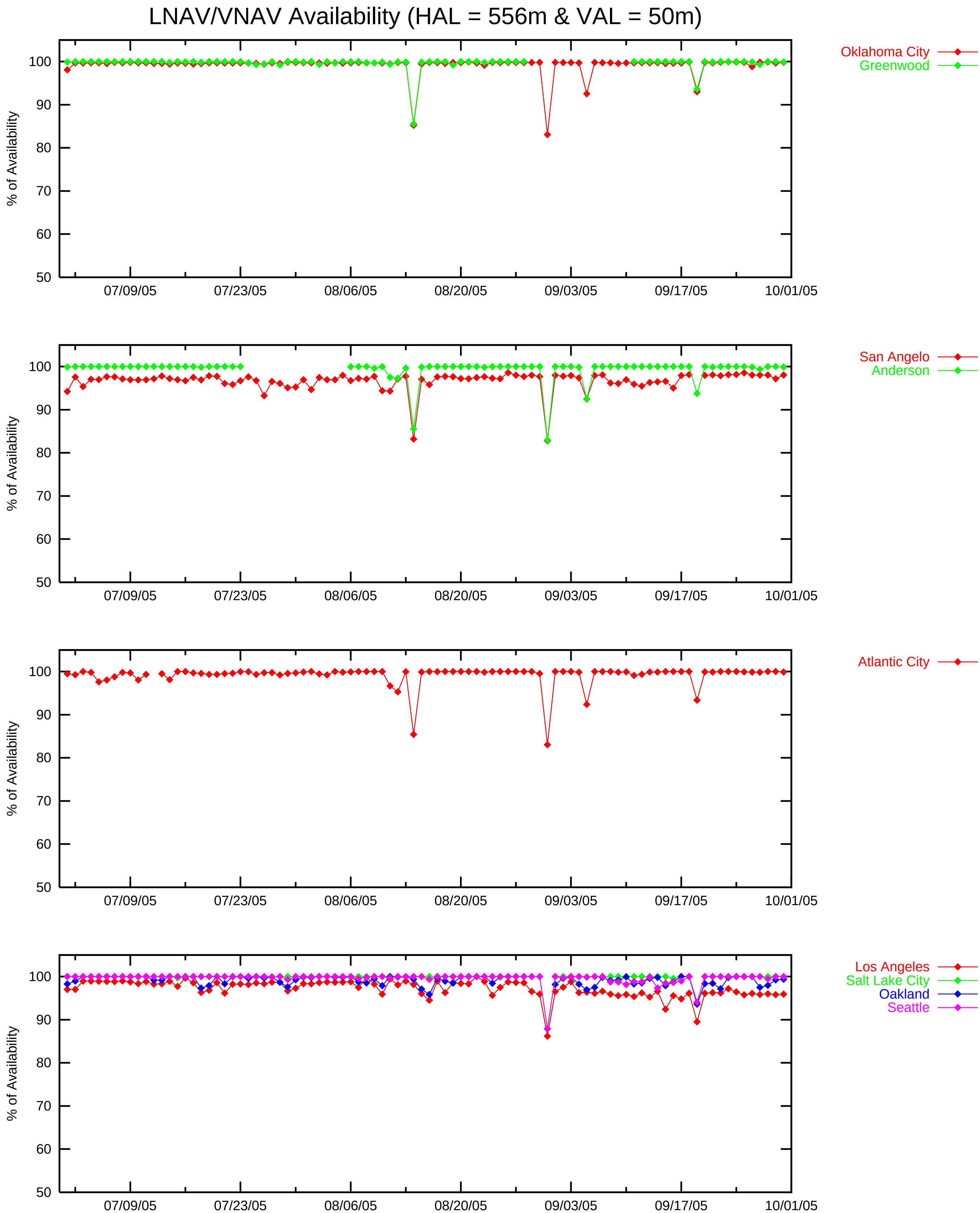
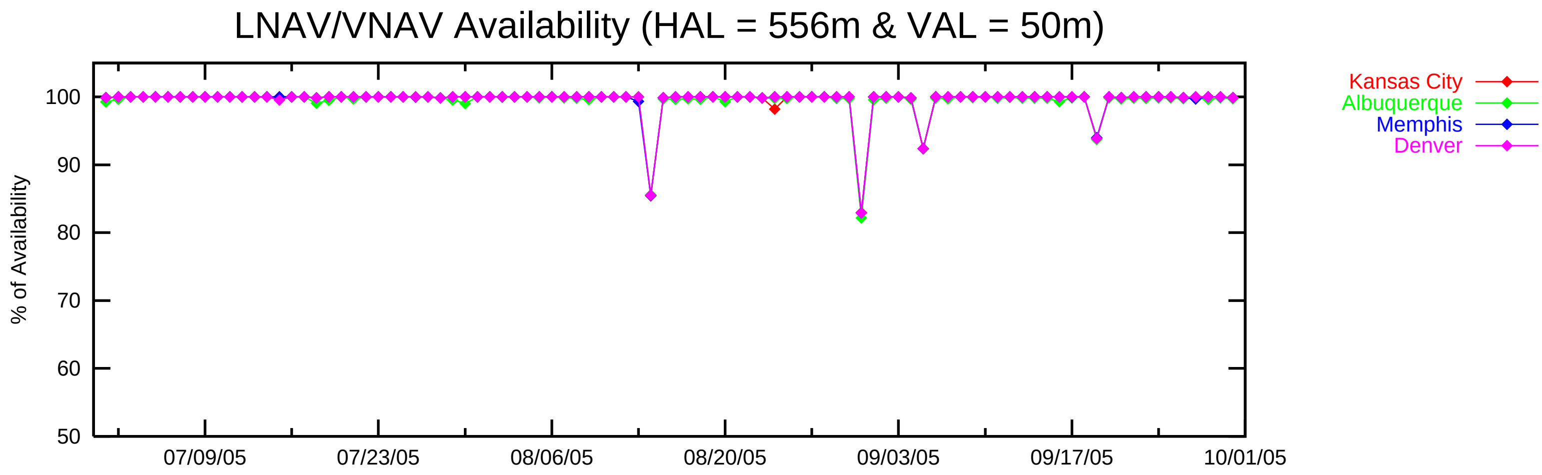
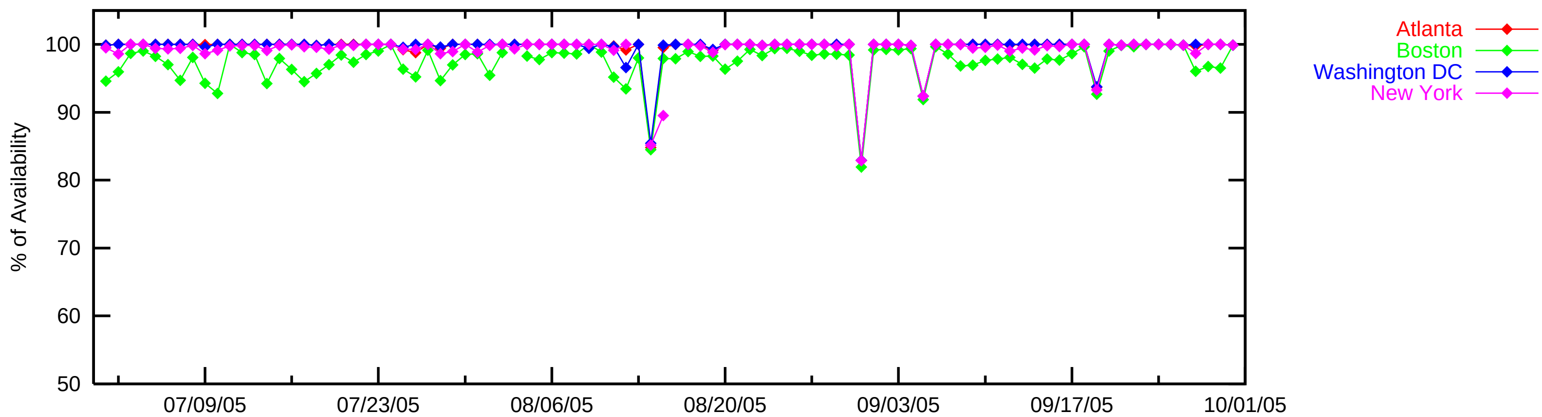
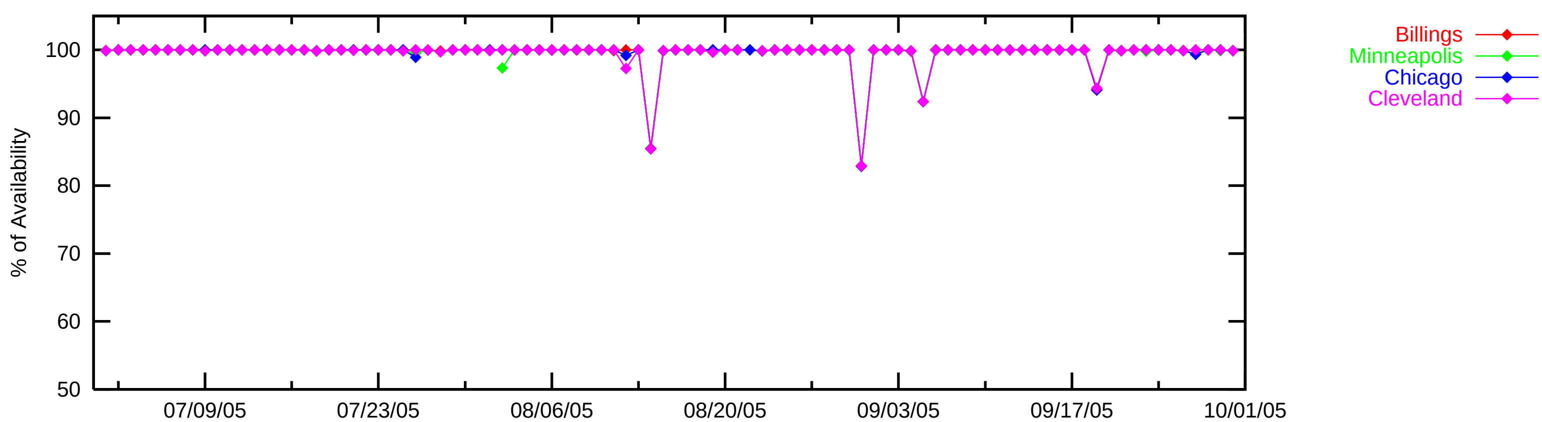


Figure 3-4 LNAV/VNAV Instantaneous Availability







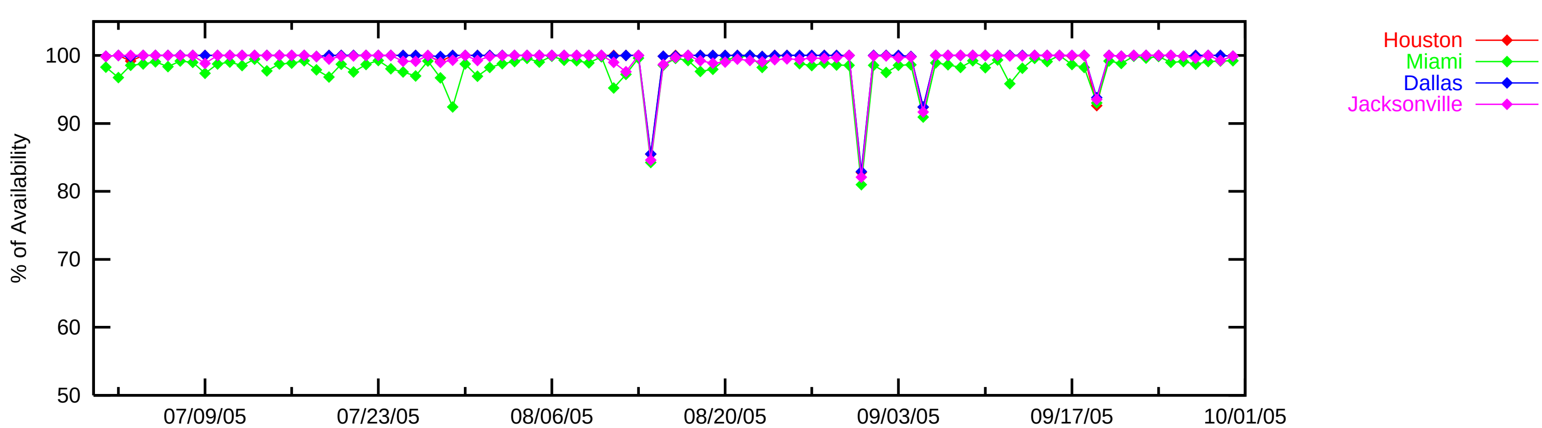


Figure 3-5 LPV Outages

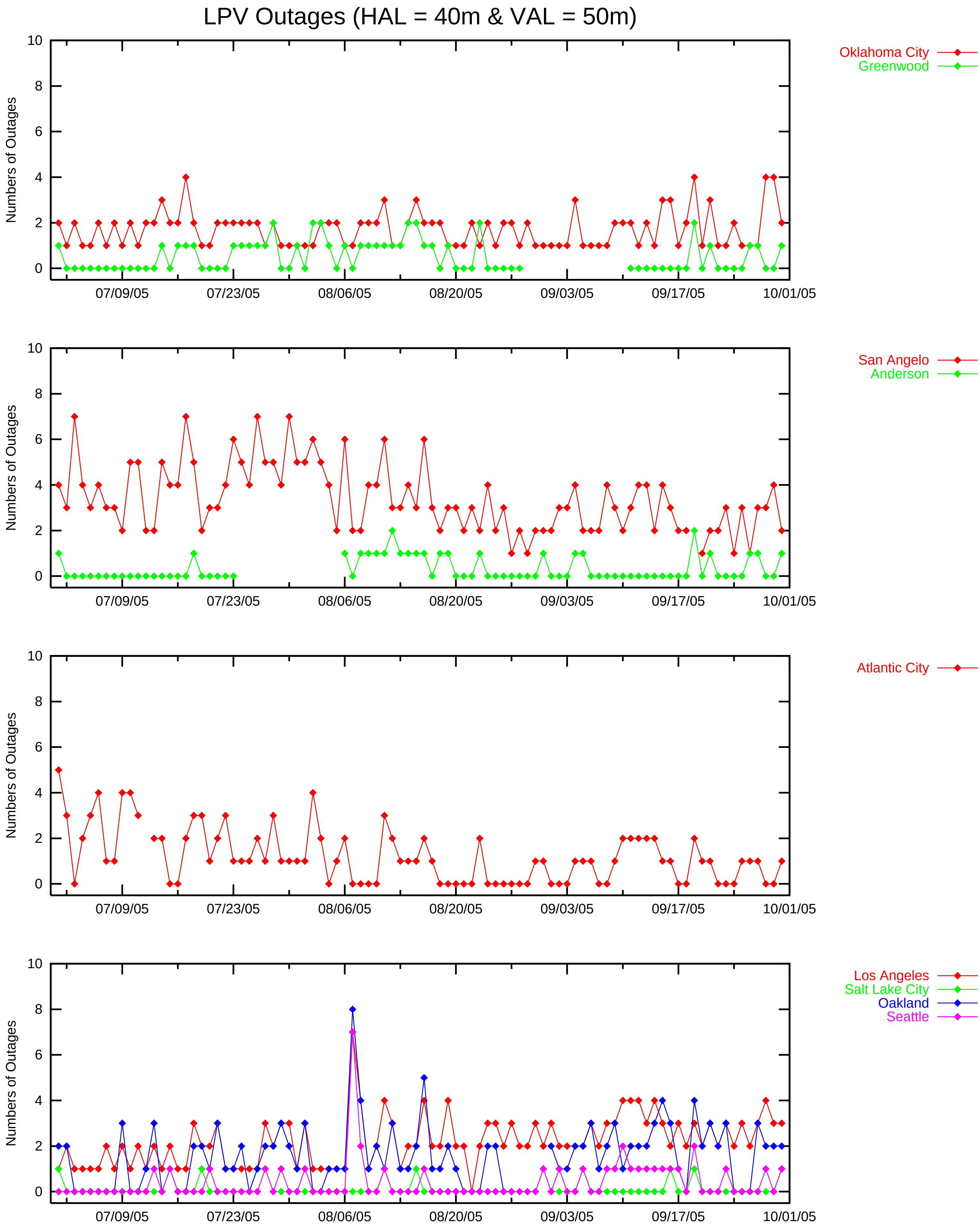
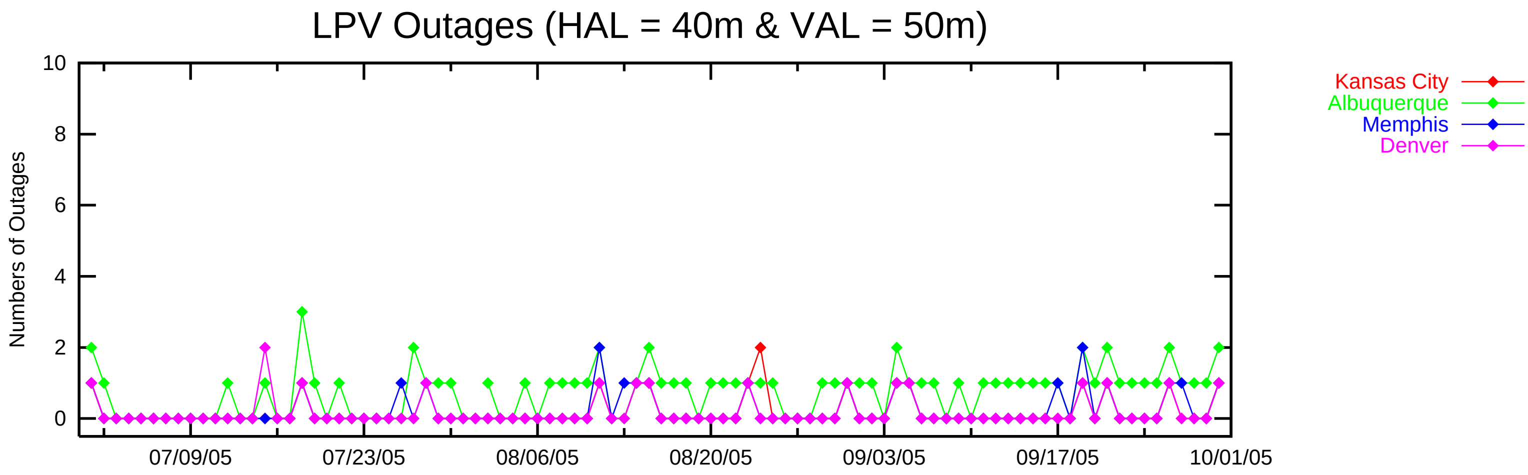
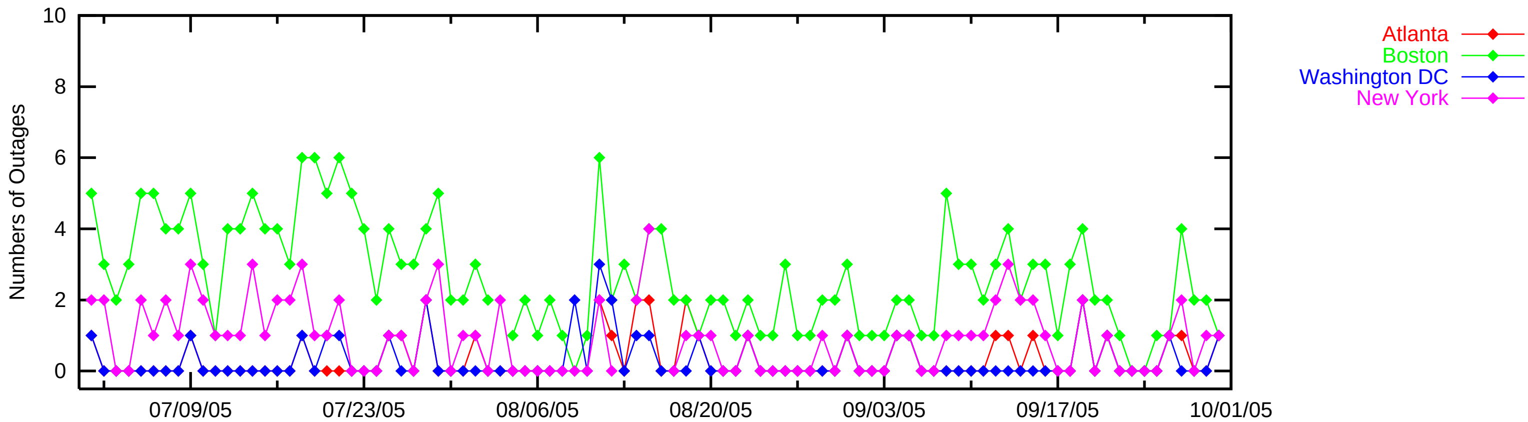
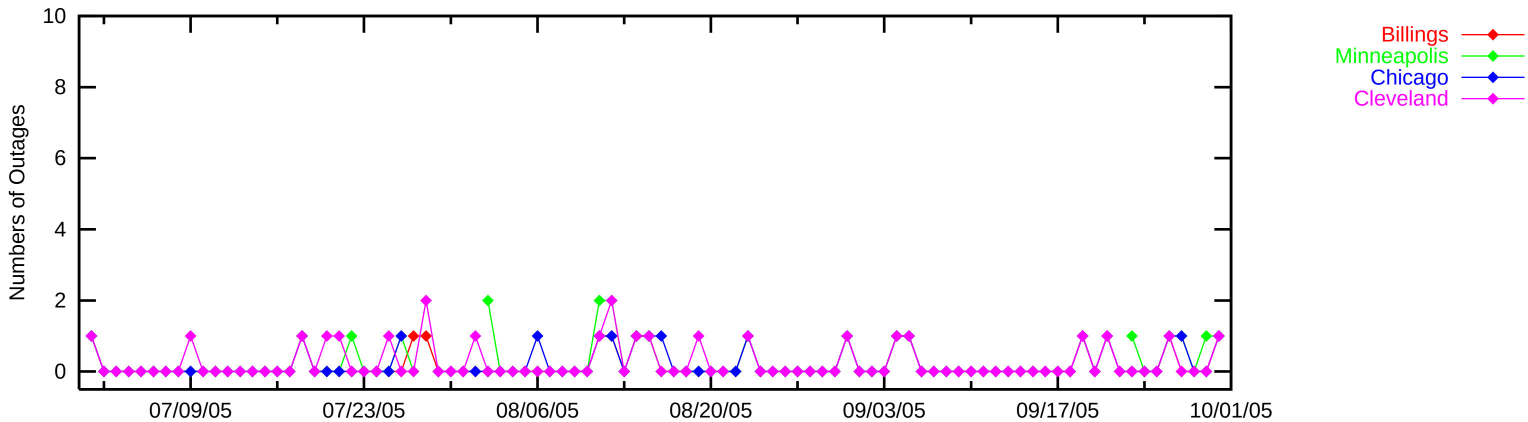


Figure 3-6 LPV Outages







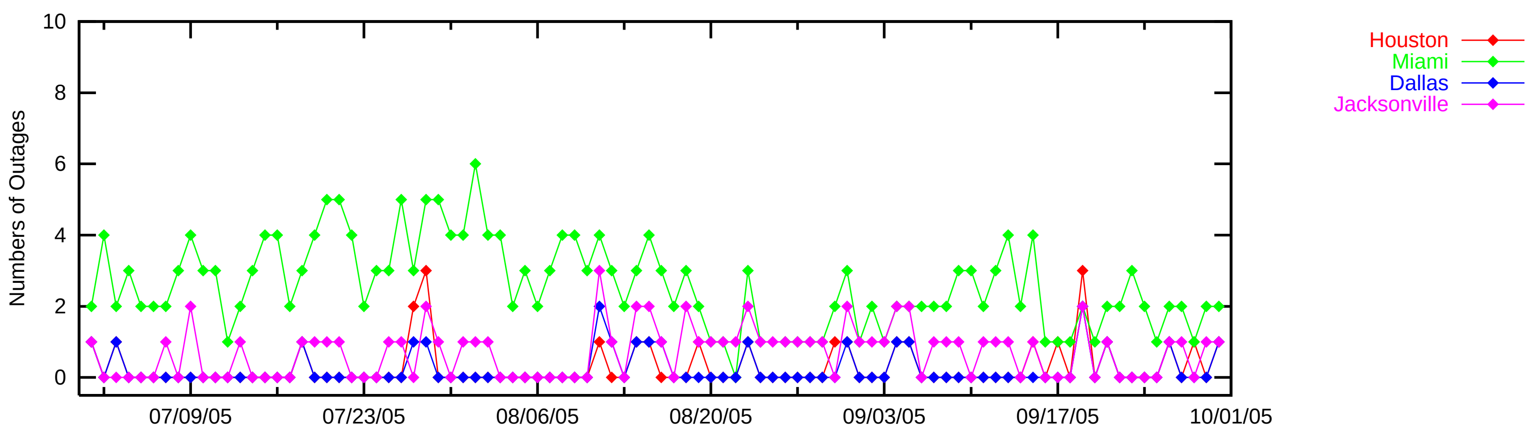


Figure 3-7 LNAV/VNAV Outages

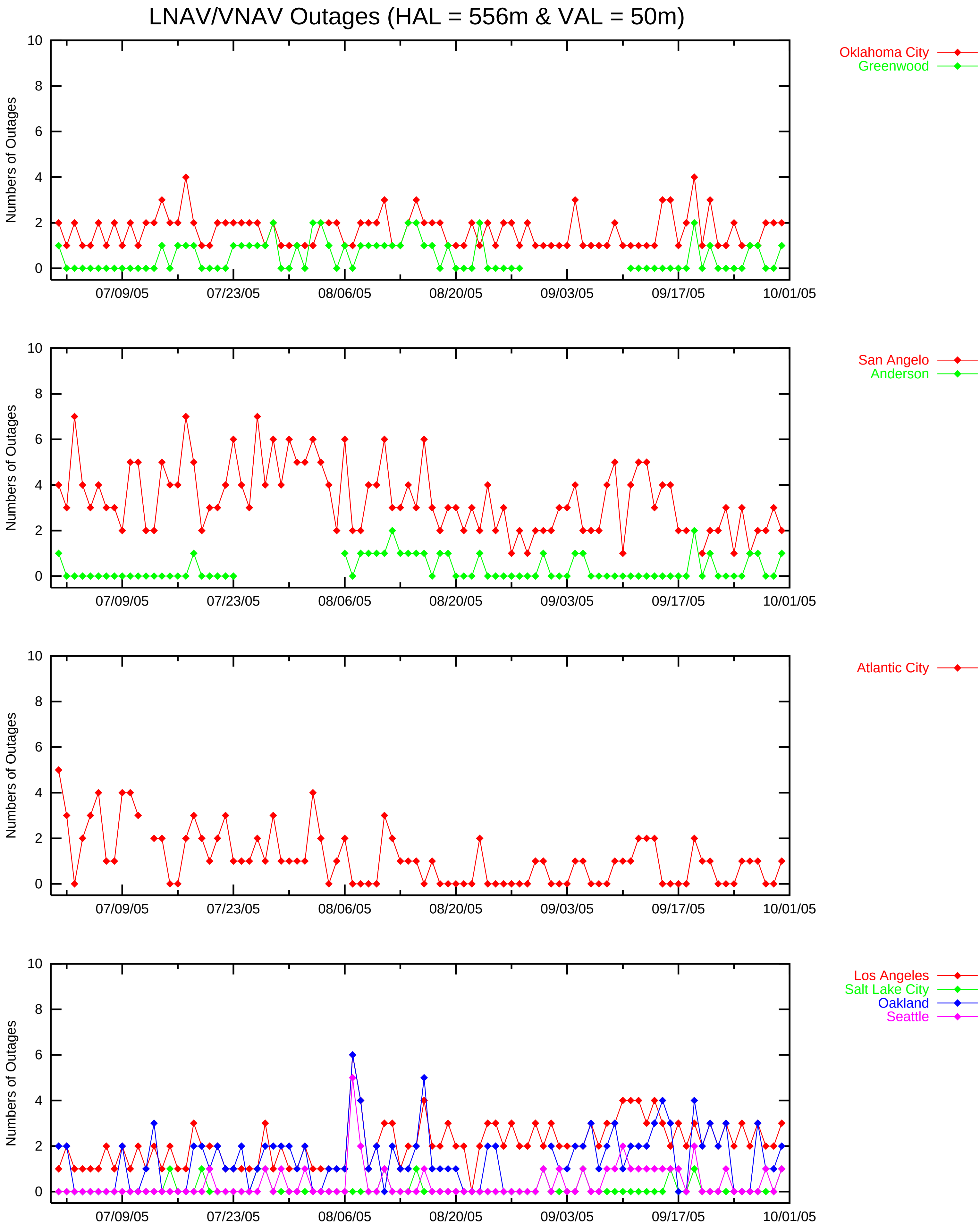
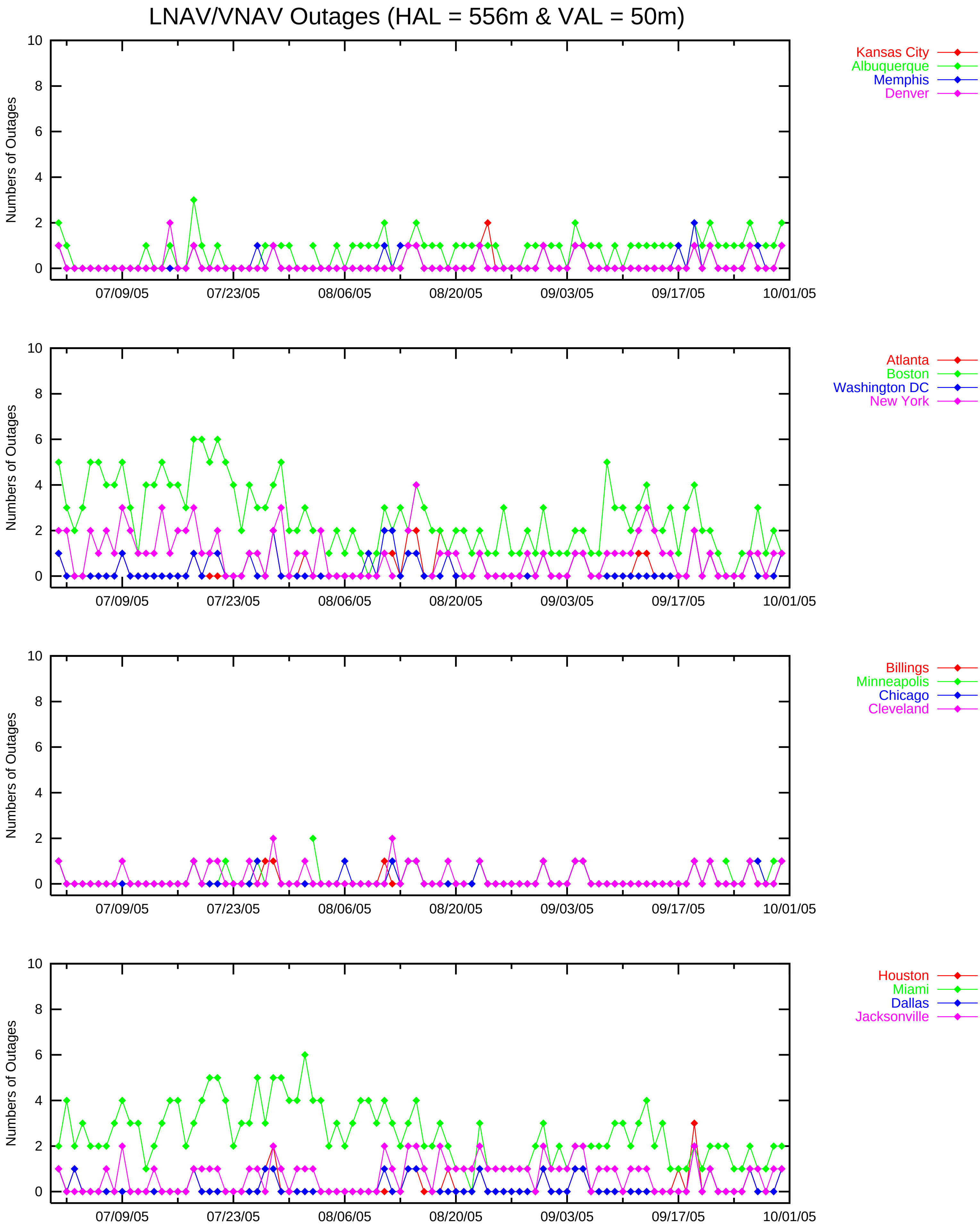


Figure 3-8 LNAV/VNAV Outages



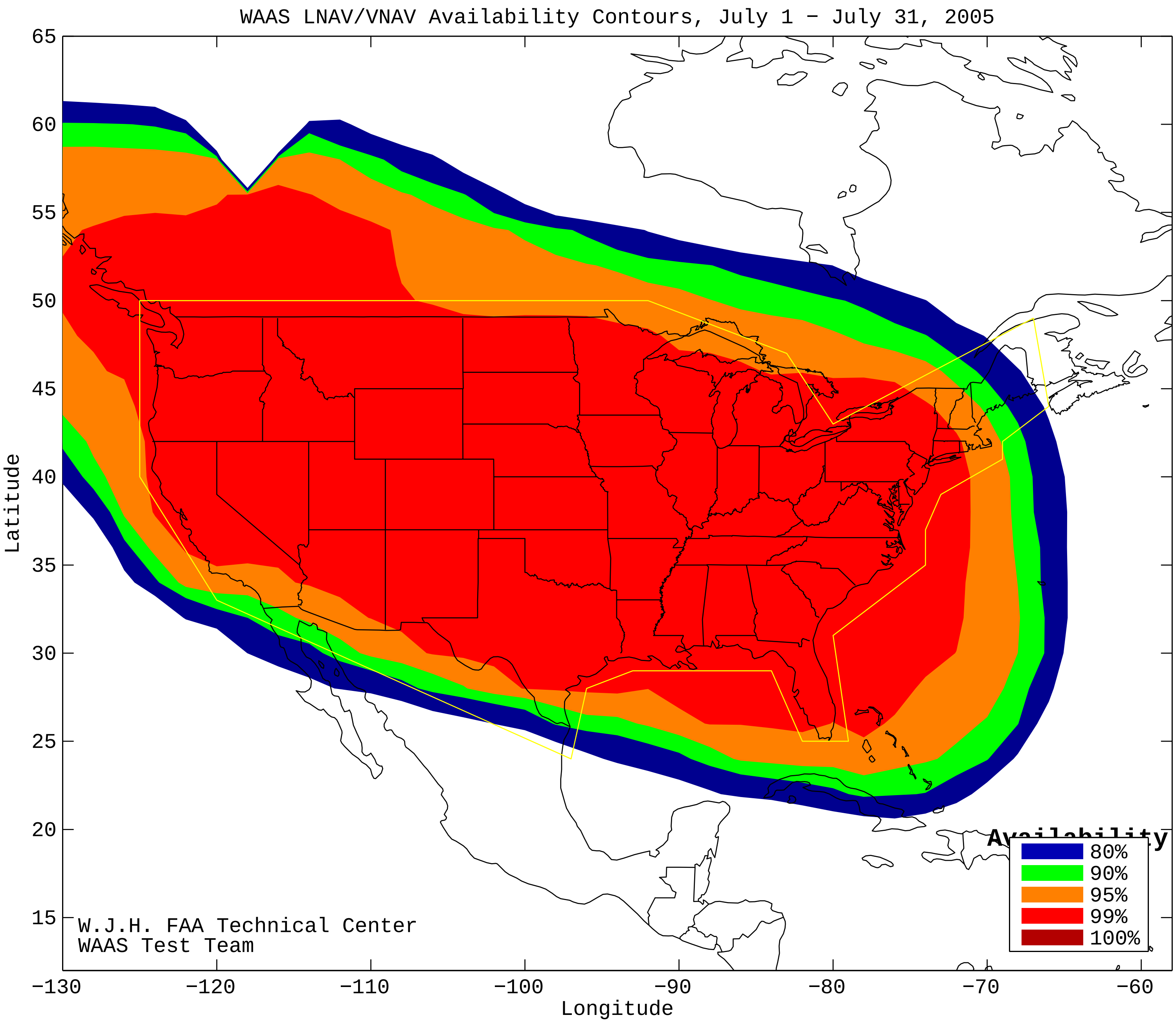
4.0 COVERAGE

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.

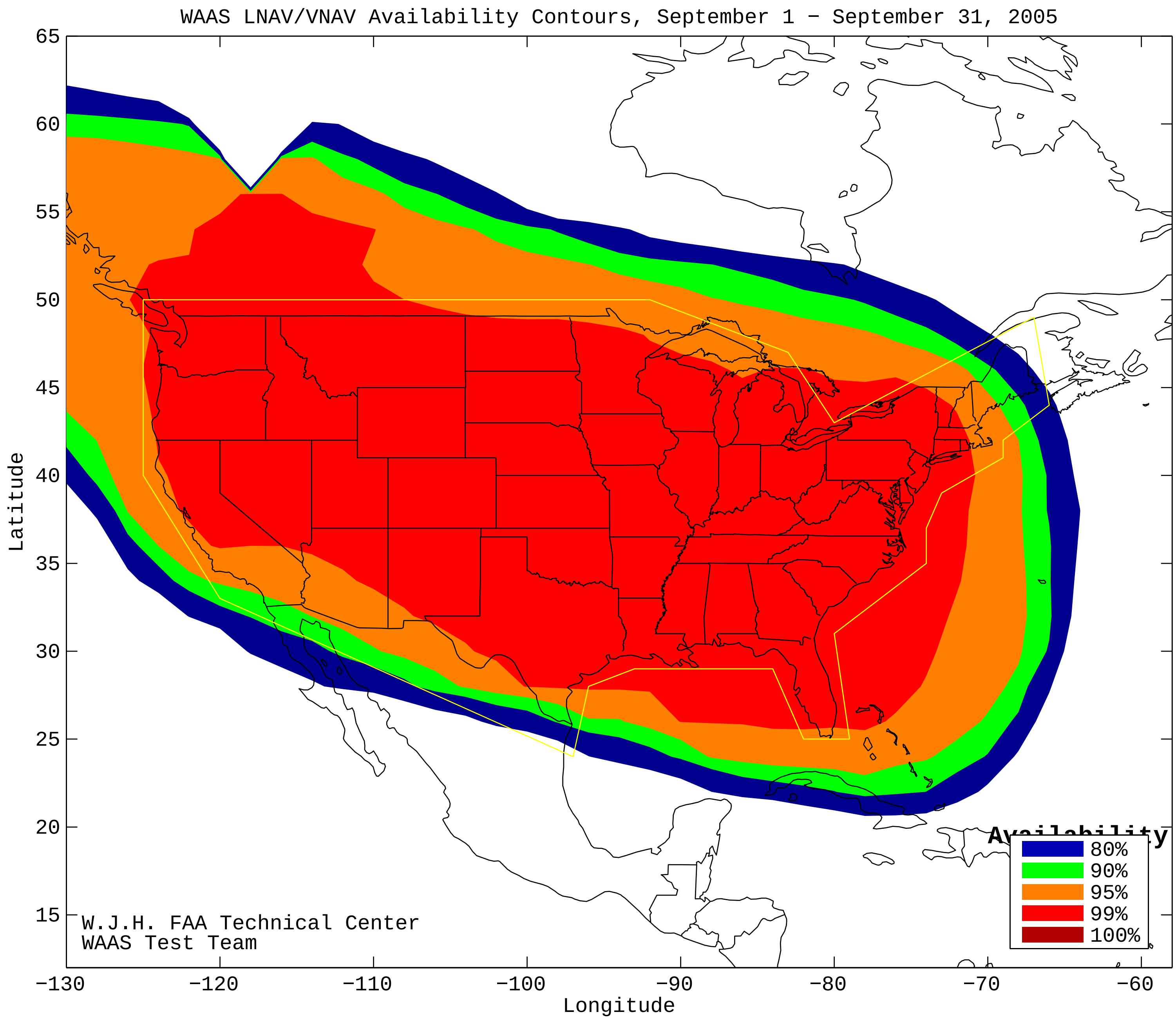
Figure 4-1 WAAS LNAV/VNAV Coverage -July



CONUS Coverage at 95% Availability = 94.74
CONUS Coverage at 99% Availability = 89.07
CONUS Coverage at 100% Availability = 0

SL = LNAV/VNAV

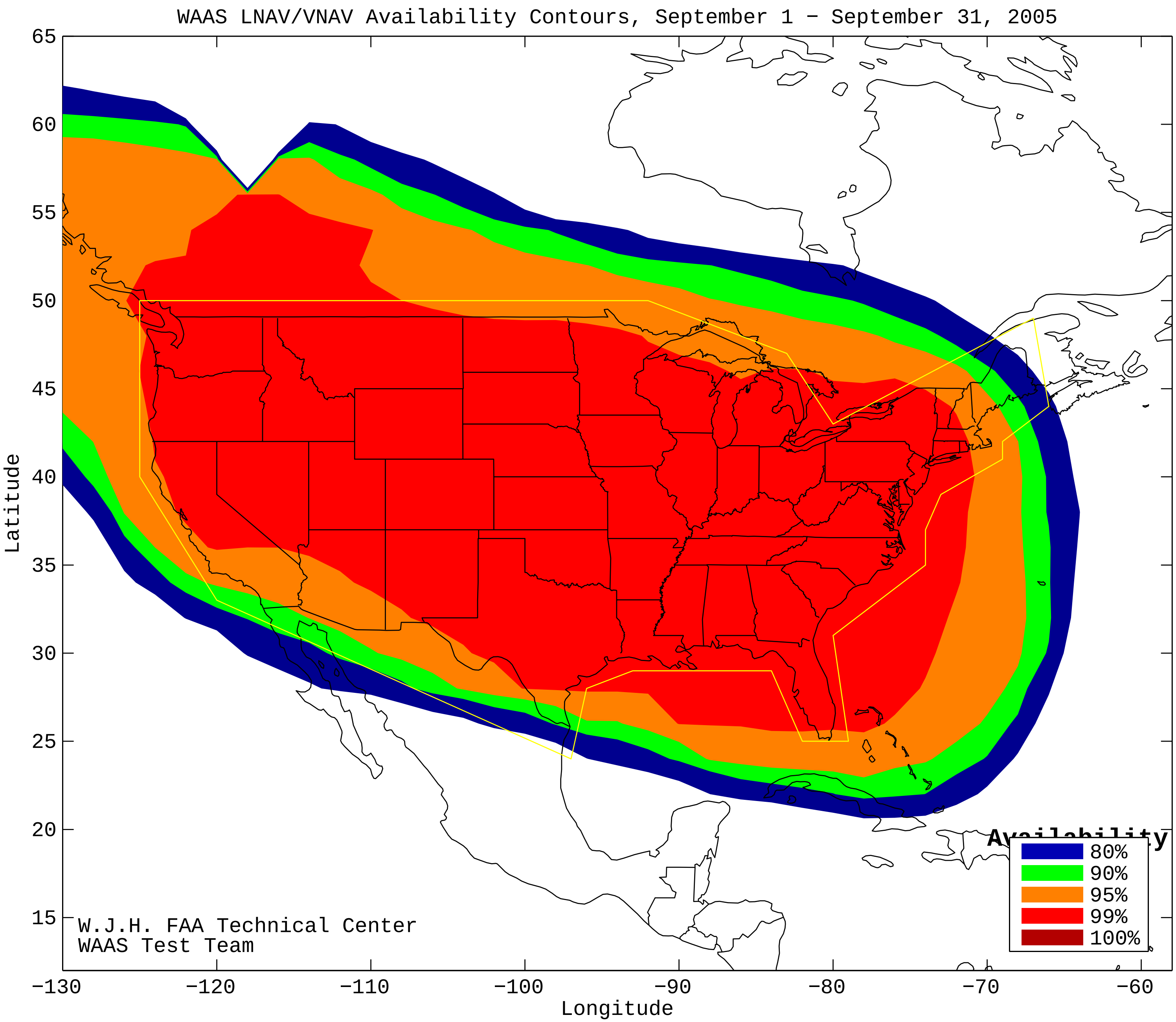
Figure 4-2 WAAS LNAV/VNAV Coverage -August



CONUS Coverage at 95% Availability = 95.55
CONUS Coverage at 99% Availability = 85.83
CONUS Coverage at 100% Availability = 0

SL = LNAV/VNAV

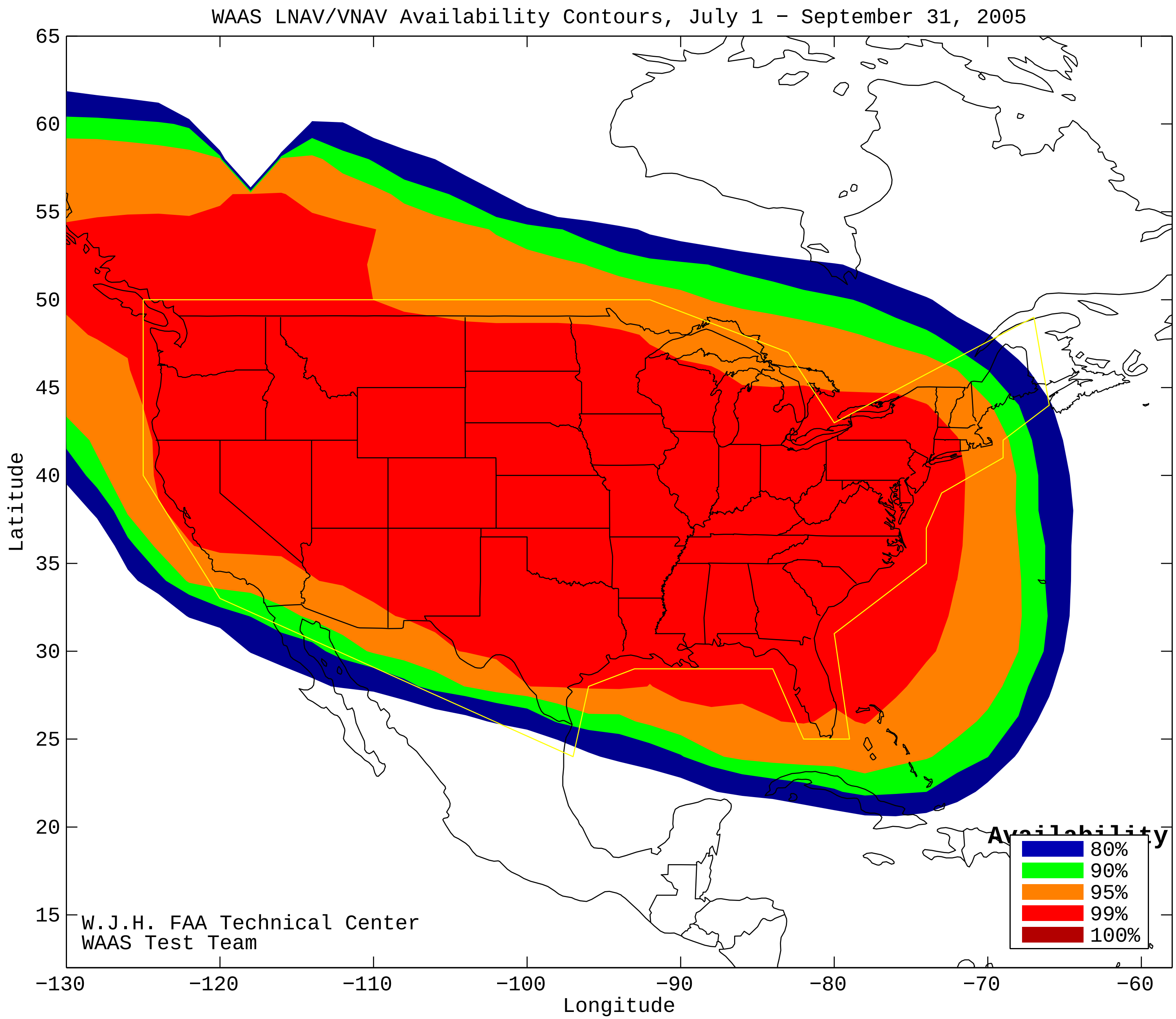
Figure 4-3 WAAS LNAV/VNAV Coverage -September



CONUS Coverage at 95% Availability = 95.55
CONUS Coverage at 99% Availability = 85.83
CONUS Coverage at 100% Availability = 0

SL = LNAV/VNAV

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



CONUS Coverage at 95% Availability = 95.95
CONUS Coverage at 99% Availability = 86.23
CONUS Coverage at 100% Availability = 0

SL = LNAV/VNAV

Figure 4-5 WAAS LPV Coverage -July

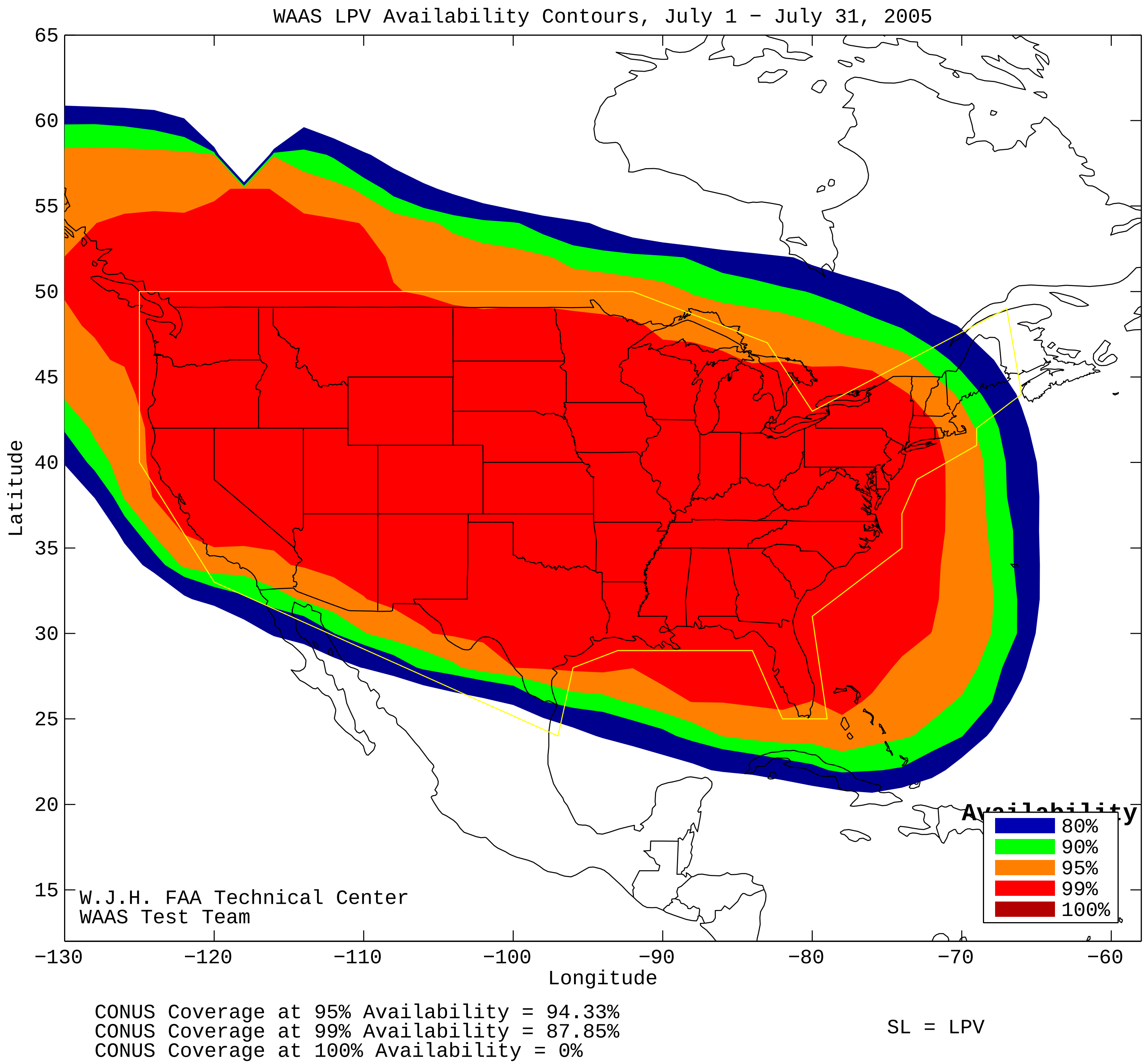
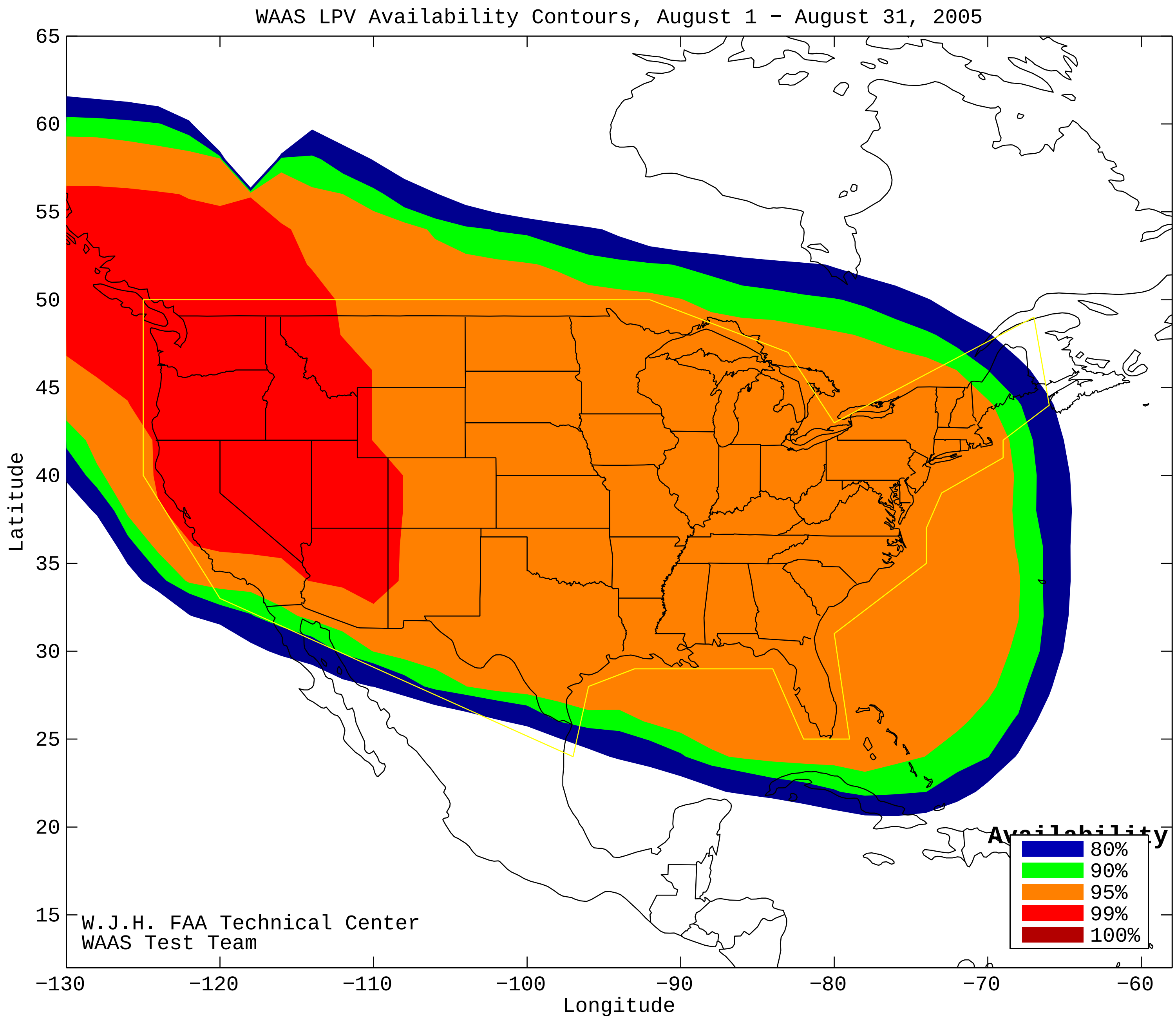


Figure 4-6 WAAS LPV Coverage -August



CONUS Coverage at 95% Availability = 95.14%
CONUS Coverage at 99% Availability = 20.65%
CONUS Coverage at 100% Availability = 0%

SL = LPV

Figure 4-7 WAAS LPV Coverage -September

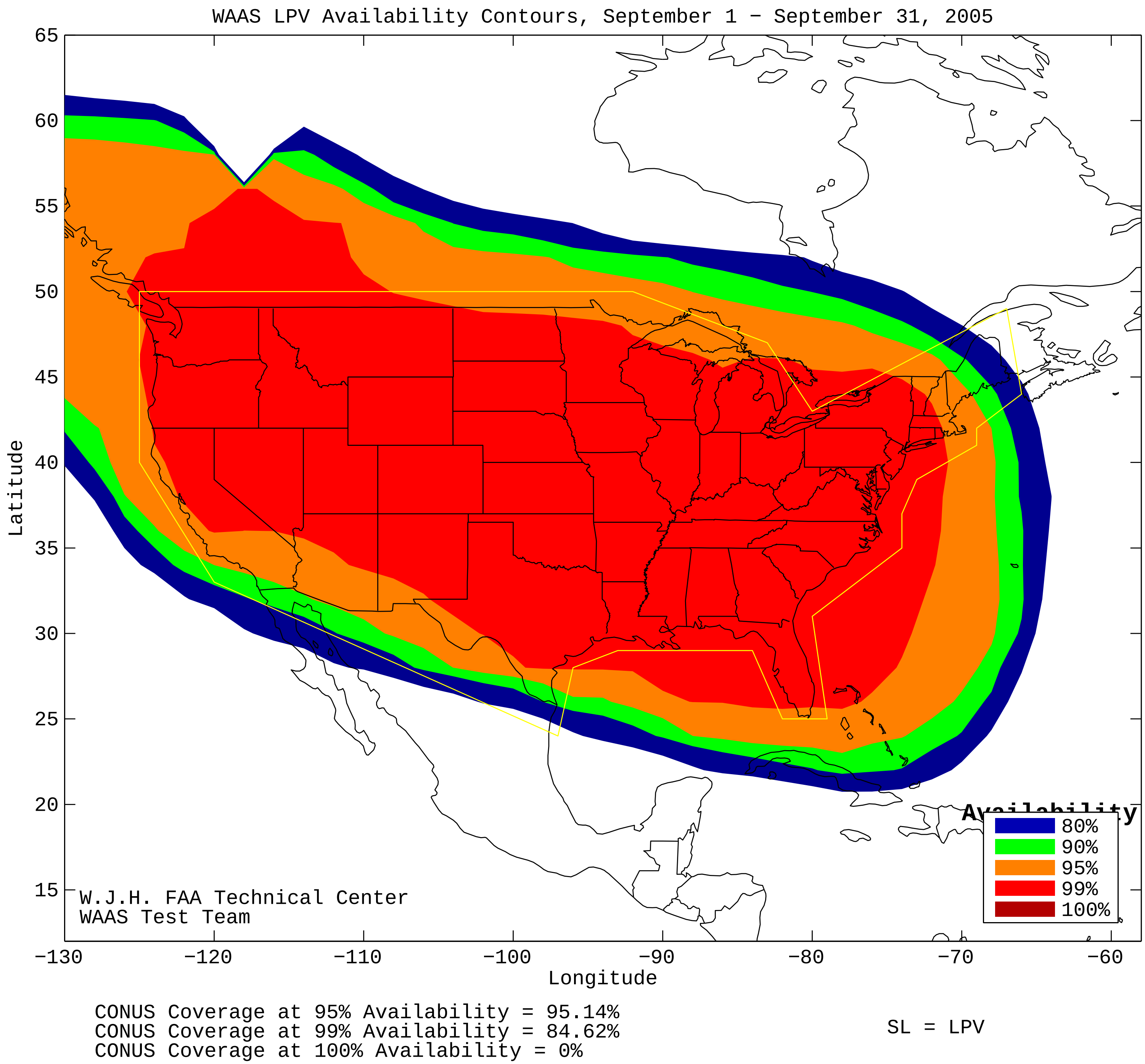
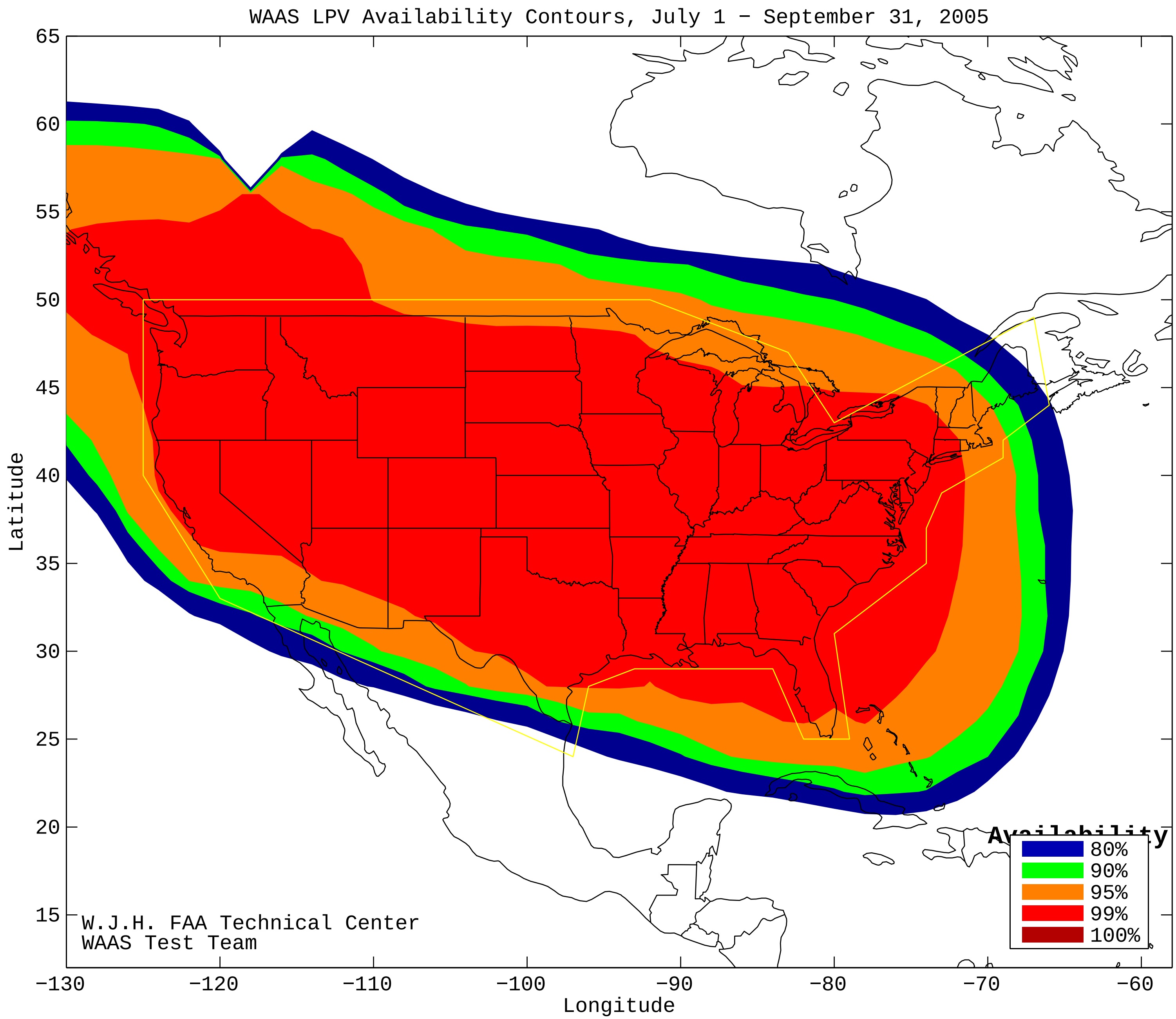


Figure 4-8 WAAS LPV Coverage for the Quarter



CONUS Coverage at 95% Availability = 94.74%
CONUS Coverage at 99% Availability = 85.43%
CONUS Coverage at 100% Availability = 0%

SL = LPV

Figure 4-9 WAAS NPA Coverage -July

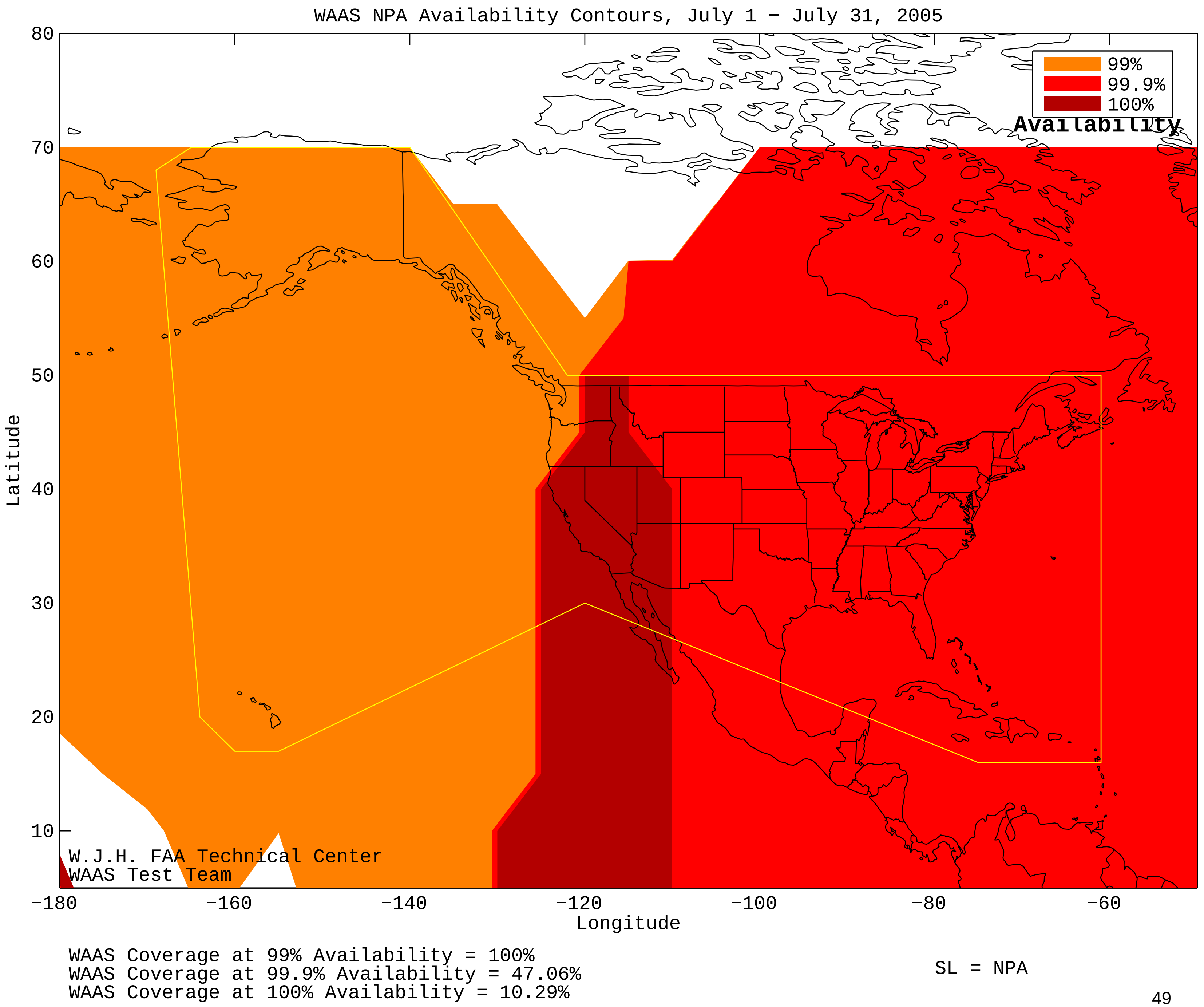
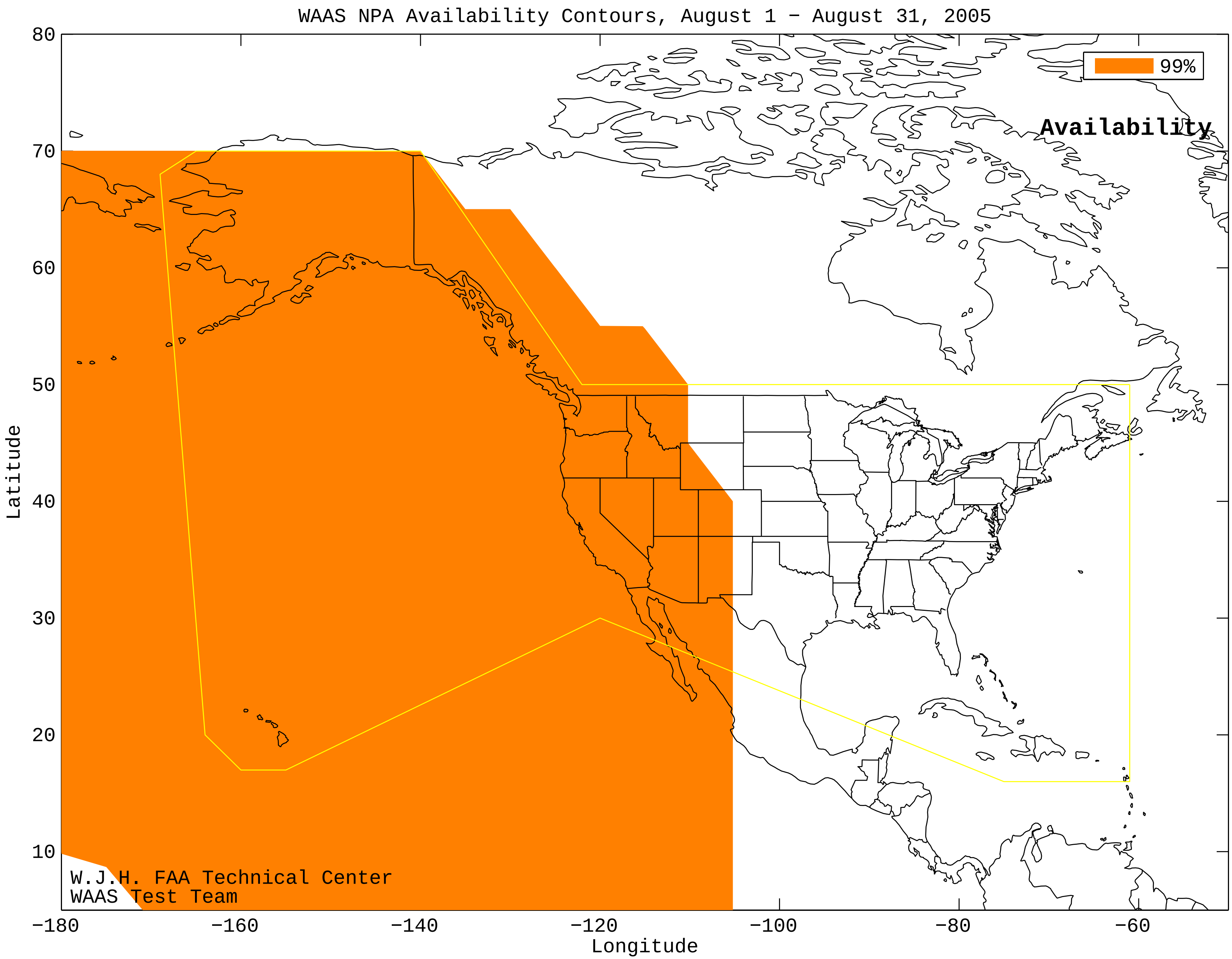


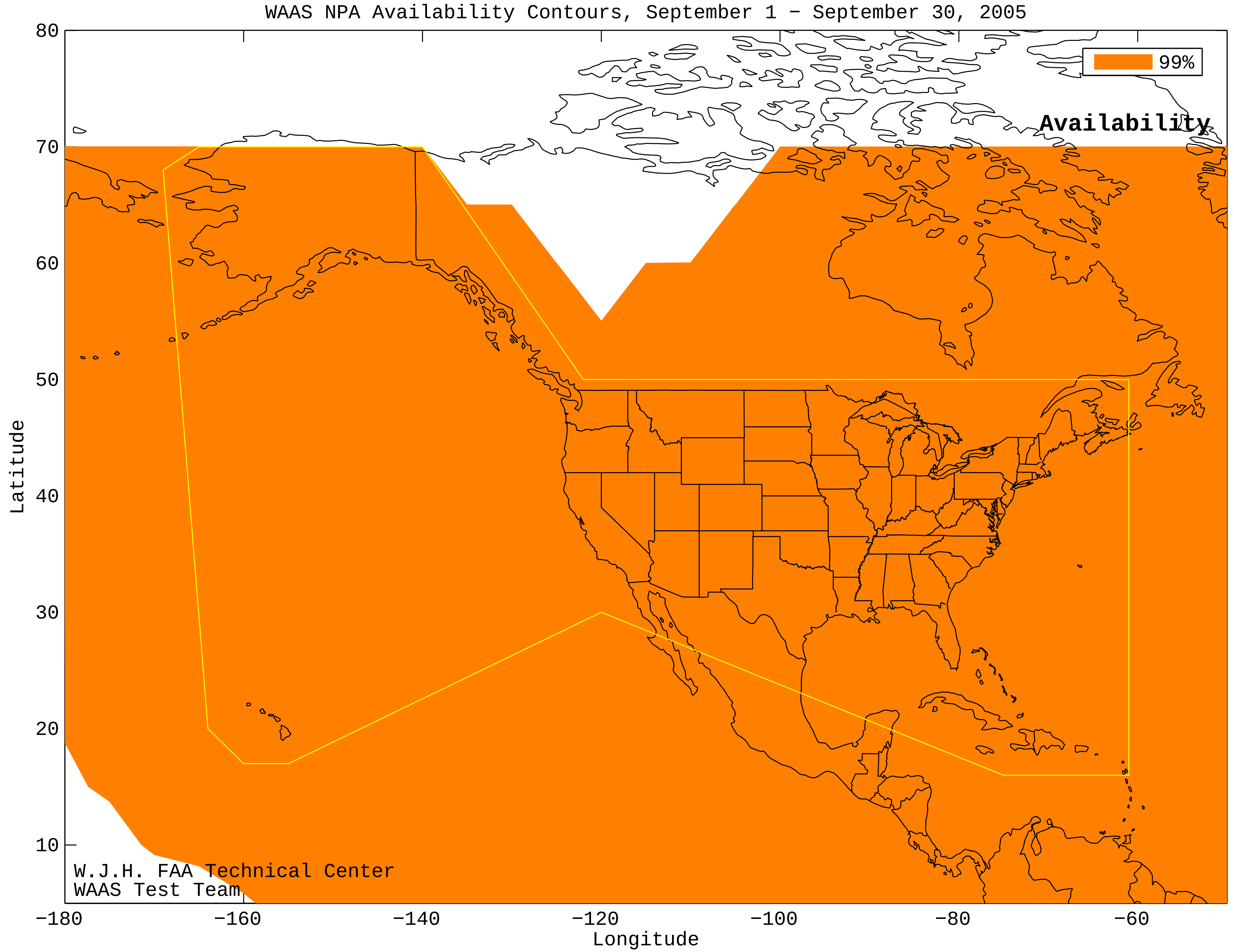
Figure 4-10 WAAS NPA Coverage -August



WAAS Coverage at 99% Availability = 63.24%
WAAS Coverage at 99.9% Availability = 0%
WAAS Coverage at 100% Availability = 0%

SL = NPA

Figure 4-11 WAAS NPA Coverage -September



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

SL = NPA

Figure 4-12 WAAS NPA Coverage for the Quarter

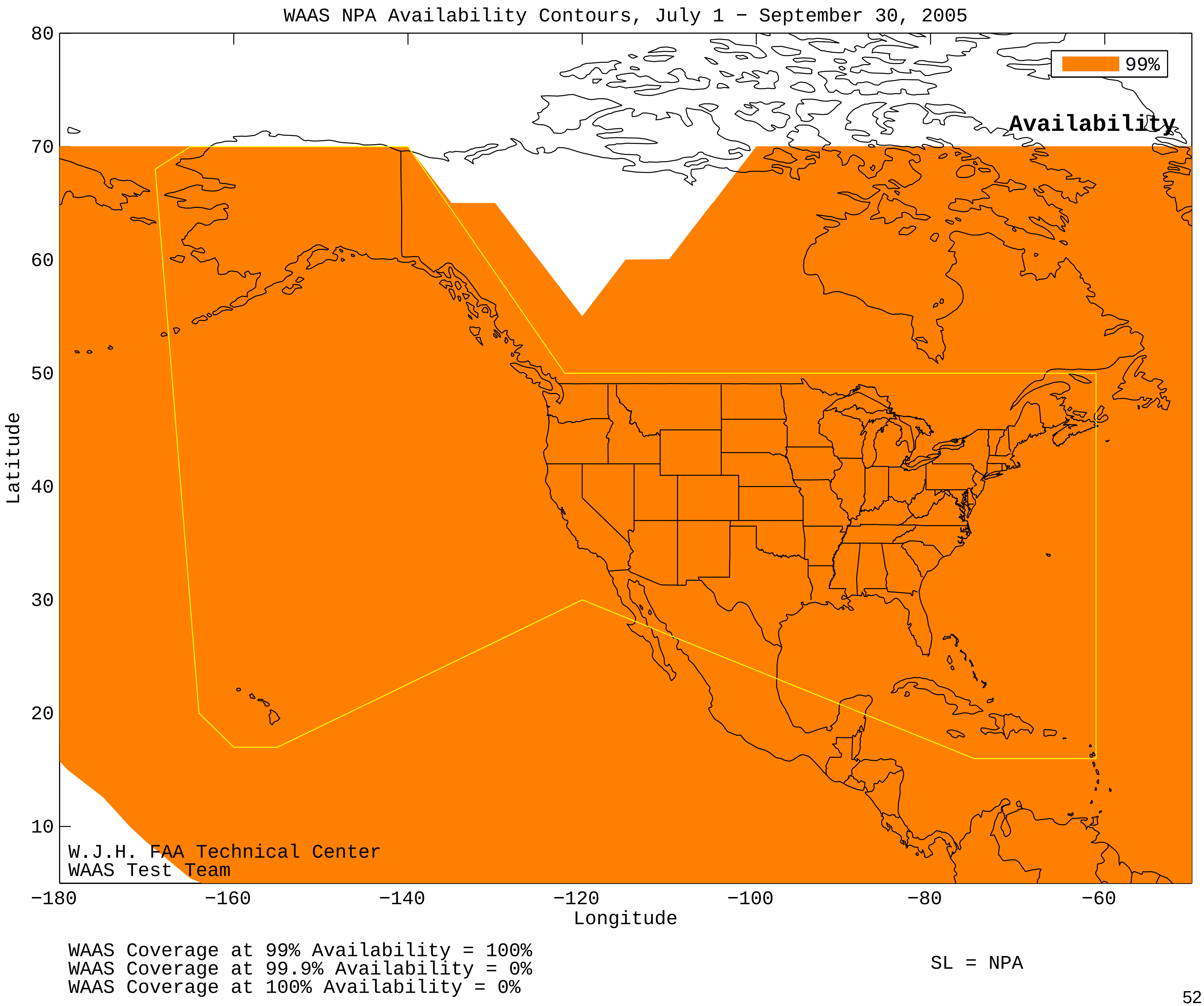


Figure 4-13 Daily WAAS LNAV/VNAV and LPV Coverage

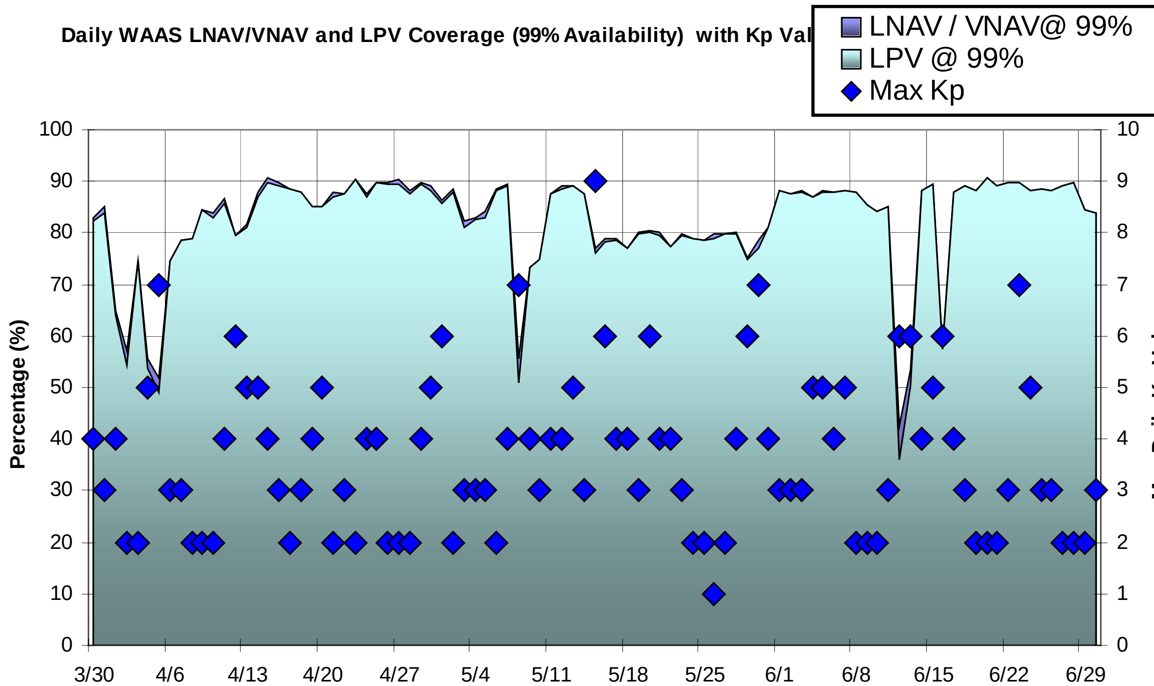


Figure 4-14 Daily NPA Coverage

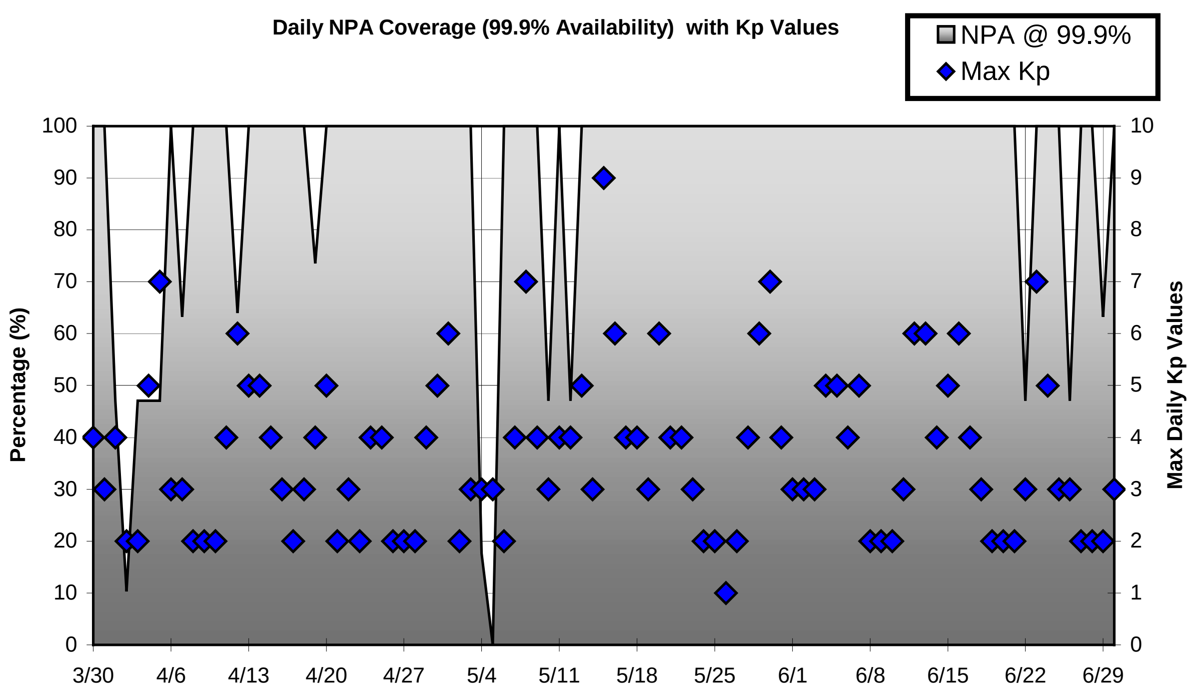
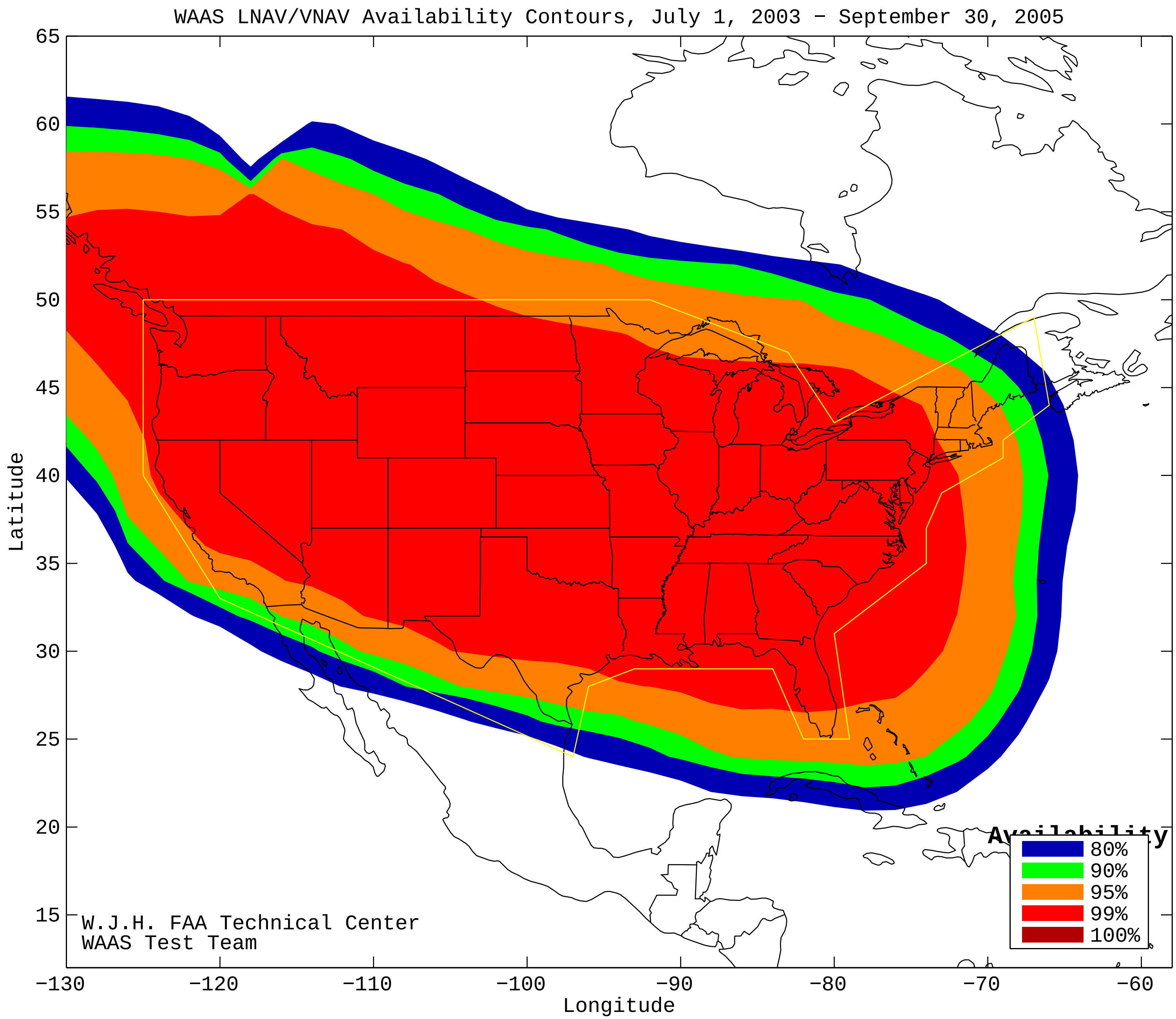


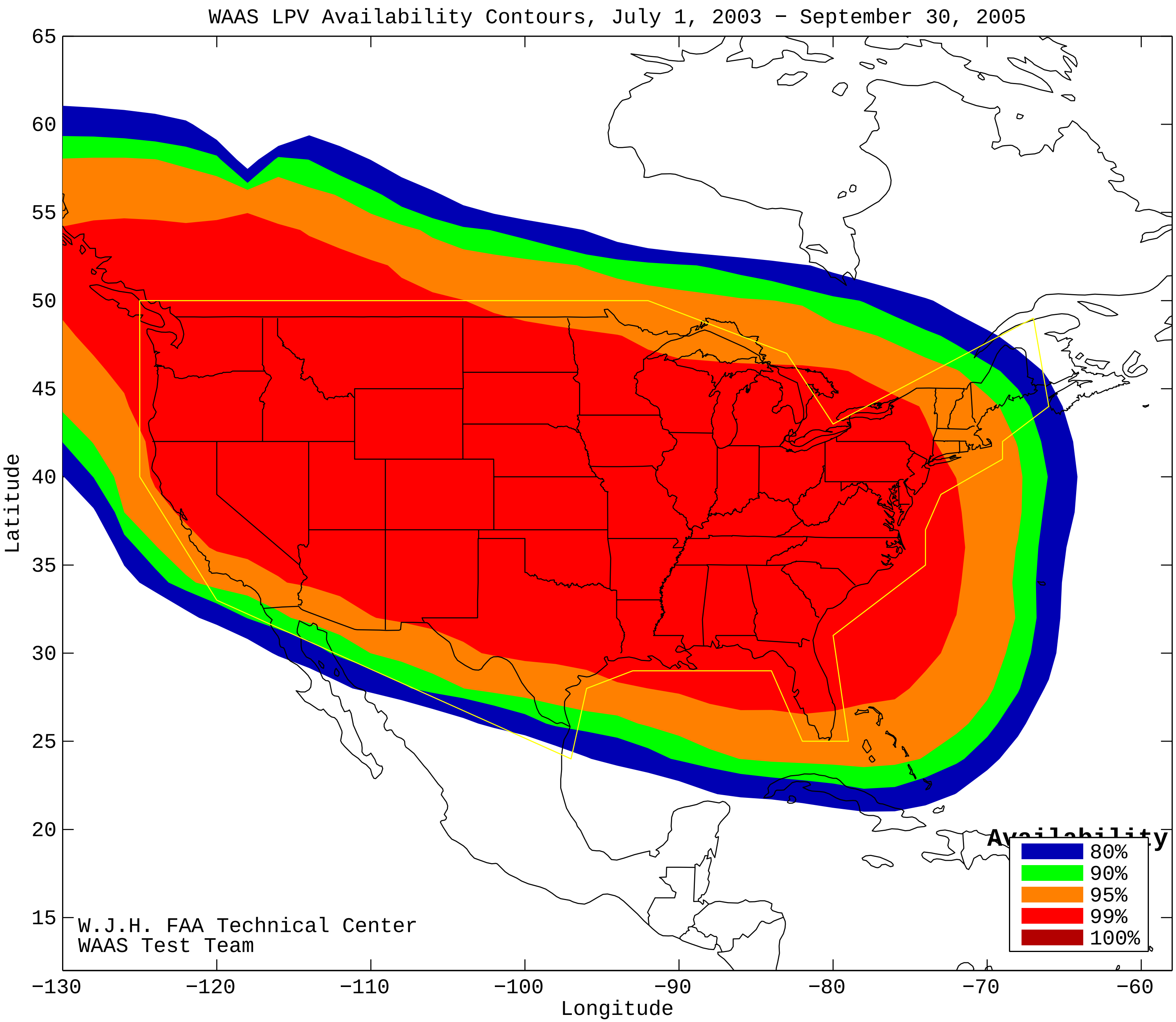
Figure 4-15 WAAS LNAV/VNAV Coverage Since Commissioning



CONUS Coverage at 95% Availability = 96.36
CONUS Coverage at 99% Availability = 85.83
CONUS Coverage at 100% Availability = 0

SL = LNAV/VNAV

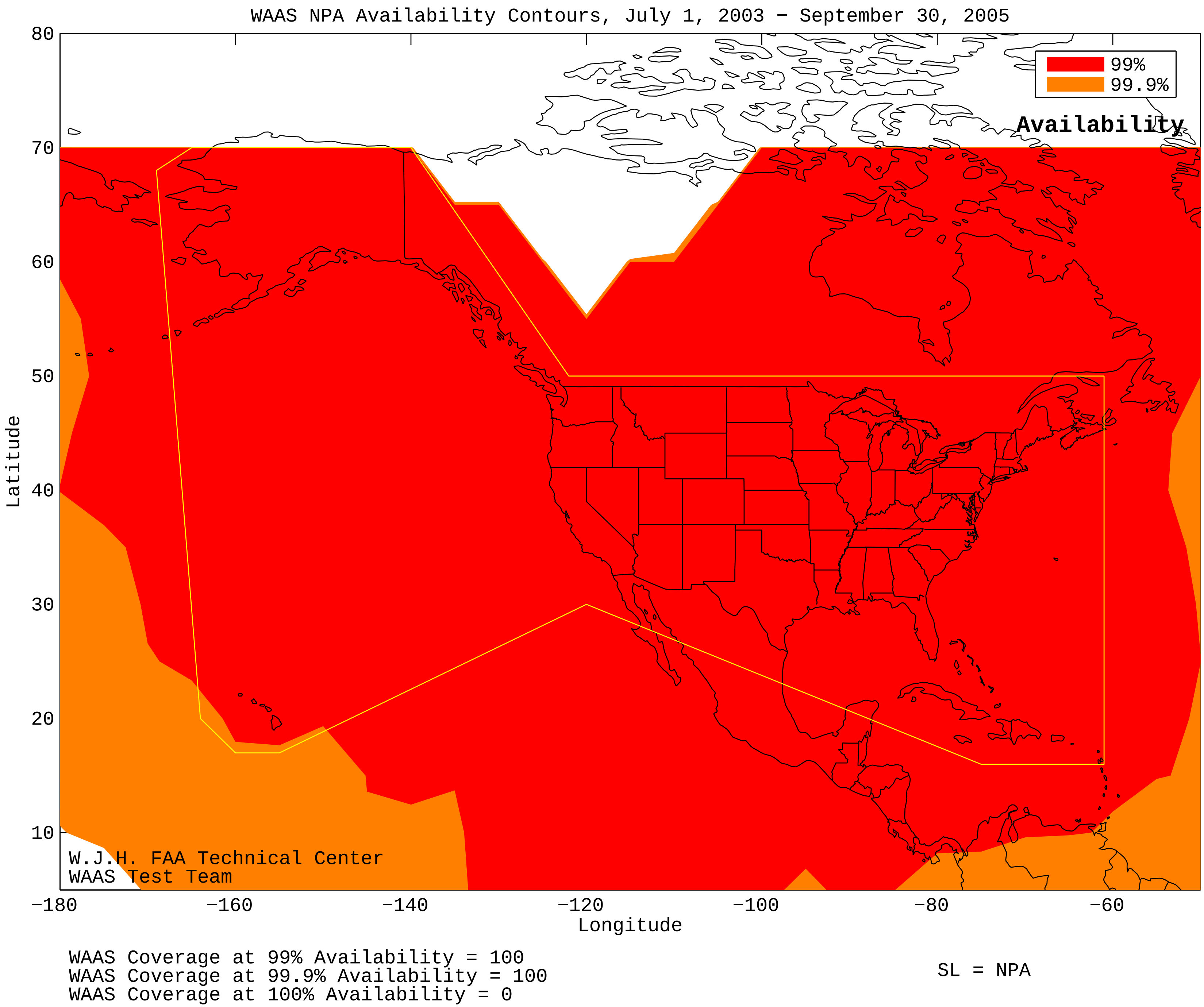
Figure 4-16 WAAS LPV Coverage Since Commissioning



CONUS Coverage at 95% Availability = 95.55%
CONUS Coverage at 99% Availability = 84.62%
CONUS Coverage at 100% Availability = 0%

SL = LPV

Figure 4-17 NPA Coverage Since Commissioning



5.0 INTEGRITY

5.1 HMI Analysis

Analysis of integrity includes the identification and evaluation of HMI (hazardously misleading information), as well as the generation of a safety index to illustrate the margin of safety that WAAS protection levels are providing. The safety margin index (shown in Table 5.1) is a metric that shows how well the protection levels are bounding the maximum observed error. The process for determining this index involves normalizing the largest error observed at a site. This is accomplished by dividing this maximum observed error by the WAAS estimated standard deviation of the error. The safety margin requirement, 5.33 standard units for vertical and 6 standard units for horizontal, is then divided by this maximum normalized error.

Table 5-1 Safety Margin Index and HMI Statistics

Location	Safety Index		Number of HMIs
	Horizontal	Vertical	
Anderson	4.29	7.61	0
Atlantic City	7.50	1.52	0
Greenwood	8.57	5.33	0
San Angelo	10.00	7.61	0
Albuquerque	6.00	4.85	0
Atlanta	7.50	5.92	0
Billings	4.00	3.55	0
Boston	5.00	1.52	0
Chicago	5.00	5.33	0
Cleveland	3.53	3.14	0
Denver	7.50	4.10	0
Houston	7.50	6.66	0
Jacksonville	6.67	2.22	0
Kansas City	6.67	5.92	0
Los Angeles	5.45	6.66	0
Memphis	7.50	5.92	0
Miami	6.00	2.42	0
Minneapolis	4.29	4.10	0
New York	5.45	3.55	0
Oakland	1.20	1.07	0
Salt Lake City	5.00	4.85	0
Seattle	1.36	2.05	0
Washington DC	5.45	4.85	0

An observed safety margin index of greater than one indicates safe bounding of the greatest observed error, less than one indicates that the maximum error was not bounded, and a result equal to one means that the error was equal to the protection level. As evidenced by the statistics in the above table, the lowest safety margin index is 3.53 at Seattle. Also, Table 5.1 shows the number of HMIs that occurred during the quarter, of which there were none. An HMI occurs if the position error exceeds the protection level in the vertical or horizontal dimensions at any time and 6.2 seconds or more passes before this event is corrected by WAAS. Since WAAS was made available to the public in August 2000 there has not been an HMI event. Note that the FAA commissioned WAAS for safety of life services in July 2003.

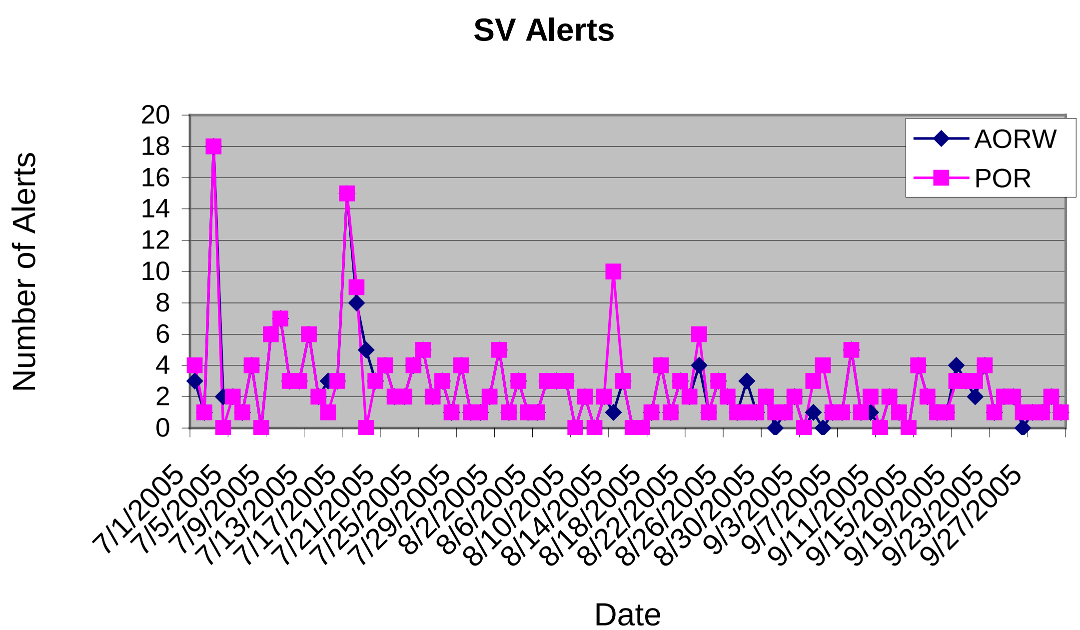
5.2 Broadcast Alerts

The WAAS transmits alert messages to protect the users from satellite degradation or severe ionospheric activity, both of which can cause unsafe conditions for a user. Space Vehicle (SV) alerts increase the User Differential Range Error (UDRE) of satellites, which can reduce the weighting of the satellite in the navigation solution, or completely exclude it from the navigation solution. An increase in UDRE's after an alert effectively increases the user protection levels (HPL and VPL), which affect the availability. Additionally, if an alert message sequence lasts for more than 12 seconds, WAAS fast corrections can time out, causing a loss of continuity. Table 5.2 shows the total number of alerts and the average number of alerts per day. Figure 5.1 shows the number of SV alerts that occurred daily during the reporting period. Often the number of alerts on one GEO is the same as the number of alerts on the other GEO. Therefore, lines tend to overlap in most points on this plot.

Table 5-2 WAAS SV Alert

	Number of Alerts		Average Alerts Per Day	
Message Type	**AORW**	**POR**	**AORW**	**POR**
2	99	99	1.0760	1.0760
3	104	105	1.1304	1.1413
6	1	1	0.0108	0.0108
24	59	78	0.6413	0.8478
26	0	0	0	0
Total Alerts	263	283	2.8586	3.0760

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)
0	94	11	348951
1	140864	1	180
2	1323010	119	127
3	1323051	114	121
7	75178	131	222
9	93016	2	169
10	75183	108	276
17	29955	5	421
24	1322867	155	127

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

SV	On Time	Late	Max Late Length (seconds)
1	36450	1	173
2	44715	0	0
3	45683	0	0
4	45055	0	0
5	41424	1	179
6	43947	0	0
7	44778	0	0
8	43014	1	165
9	46050	1	174
10	45689	0	0
11	47024	2	169
13	43826	0	0
14	43905	0	0
15	41665	1	172
16	46071	0	0
18	43283	0	0
19	45522	1	173
20	46043	0	0
21	35647	1	177
22	39077	0	0
23	43202	0	0
24	46871	1	150
25	45152	1	164
26	44150	1	169
27	38314	0	0
28	38942	2	254
29	44296	1	175
30	46607	1	178

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

SV	On Time	Late	Max Late Length (seconds)
1	34937	6	240
2	42526	0	0
3	43366	4	304
4	42610	2	190
5	39245	2	187
6	41409	1	184
7	42540	3	192
8	40590	0	0
9	43465	4	184
10	42883	1	150
11	44527	4	258
13	41294	1	130
14	41260	5	209
15	39166	2	254
16	42788	0	0
18	40264	1	185
19	41615	1	191
20	41955	3	240
21	32861	3	264
22	35631	4	278
23	39180	1	163
24	42614	1	168
25	40879	2	194
26	40222	0	0
27	35304	4	264
28	35952	3	328
29	40519	1	240
30	42392	3	192
122	82748	3	184
134	76764	1	193

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

Band	Block	On Time	Late	Max Late Length (seconds)
0	0	27562	8	606
1	0	27559	8	579
1	1	27563	8	576
1	2	27561	7	551
1	3	27561	10	556
1	4	27557	7	544
2	0	27558	9	576
2	1	27572	4	504
2	2	27565	6	519
2	3	27586	5	473
2	4	27563	8	473
2	5	27564	6	576
3	0	27613	9	608

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

Band	On Time	Late	Max Late Length (seconds)
0	68077	1	301
1	68087	0	0
2	68050	1	353
3	68130	0	0

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

Message Type	On Time	Late	Max Late Length (seconds)
0	126	18	419446
1	139466	3	276
2	1322696	161	246
3	1322752	149	246
7	74455	94	287
9	92710	2	331
10	74449	113	308
17	29841	1	313
24	1322621	179	246

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

SV	On Time	Late	Max Late Length (seconds)
1	36421	0	0
2	44621	2	178
3	45546	0	0
4	44945	0	0
5	41604	0	0
6	43928	2	175
7	44775	1	170
8	42898	0	0
9	46131	0	0
10	45597	1	177
11	46983	0	0
13	43567	0	0
14	43936	0	0
15	41731	0	0
16	45932	0	0
18	43475	0	0
19	45446	0	0
20	45948	0	0
21	35748	3	174
22	39239	0	0
23	42963	0	0
24	46752	0	0
25	45134	1	169
26	44219	1	166
27	38130	0	0
28	38842	0	0
29	44334	0	0
30	46724	0	0

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

SV	On Time	Late	Max Late Length (seconds)
1	34930	4	179
2	42425	3	169
3	43240	1	121
4	42523	1	182
5	39404	1	160
6	41385	3	159
7	42549	0	0
8	40481	1	195
9	43544	4	168
10	42795	1	129
11	44510	2	258
13	41051	0	0
14	41266	3	161
15	39208	2	185
16	42650	0	0
18	40426	5	187
19	41519	3	192
20	41872	1	174
21	32975	2	168
22	35785	4	278
23	38978	2	194
24	42510	0	0
25	40869	2	153
26	40272	1	257
27	35092	3	282
28	35848	1	328
29	40538	2	182
30	42497	4	128
122	82684	2	128
134	76905	1	126

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

Band	Block	On Time	Late	Max Late Length (seconds)
0	0	27587	8	576
0	1	27563	9	444
0	2	27544	9	437
1	0	27557	11	577
1	1	27551	12	576
1	2	27553	15	576
1	3	27541	13	587
1	4	27564	12	521
2	0	27539	9	515
2	1	27568	11	584
2	2	27564	8	502
2	3	27631	9	504

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

Band	On Time	Late	Max Late Length (seconds)
0	67714	1	368
1	67718	1	368
2	67709	1	368

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	1.572	100.00	1.380	100.00	1.485	100.00	1.791	100.00	1.781	100.00	1.429	100.00
2	2.486	99.9999	2.186	100.00	2.053	100.00	2.034	100.00	2.904	100.00	1.768	100.00
3	1.502	100.00	1.340	100.00	1.776	100.00	1.817	100.00	2.093	100.00	1.232	100.00
4	2.509	99.9323	1.753	100.00	1.707	100.00	2.581	100.00	1.895	100.00	2.036	100.00
5	1.865	100.00	1.531	100.00	1.589	100.00	1.587	100.00	2.301	100.00	1.127	100.00
6	2.196	100.00	1.576	100.00	1.490	100.00	2.251	100.00	1.782	100.00	1.644	100.00
7	1.942	99.8958	1.321	100.00	1.288	100.00	1.823	100.00	1.987	100.00	1.042	100.00
8	1.707	100.00	1.228	100.00	1.604	100.00	2.260	100.00	1.660	100.00	1.283	100.00
9	2.242	99.8738	1.411	100.00	1.630	100.00	2.116	100.00	1.881	100.00	1.306	100.00
10	1.811	100.00	1.859	100.00	1.456	100.00	1.361	100.00	1.733	100.00	1.887	100.00
11	1.835	100.00	1.482	100.00	1.465	100.00	1.772	100.00	2.638	100.00	1.638	100.00
12	-	-	-	-	-	-	-	-	-	-	-	-
13	1.578	100.00	1.543	100.00	1.494	100.00	1.811	100.00	1.825	100.00	1.363	100.00
14	1.826	100.00	1.540	100.00	1.652	100.00	1.573	100.00	2.059	100.00	1.195	100.00
15	1.695	100.00	1.087	100.00	1.444	100.00	1.908	100.00	1.834	100.00	1.353	100.00
16	1.644	100.00	2.356	100.00	1.265	100.00	1.868	100.00	2.033	100.00	1.394	100.00
17	-	-	-	-	-	-	-	-	-	-	-	-
18	1.691	100.00	1.337	100.00	1.434	100.00	1.349	100.00	2.152	100.00	1.354	100.00
19	3.196	100.00	2.585	100.00	2.737	100.00	2.761	99.7540	3.330	100.00	2.863	99.9997
20	1.952	100.00	1.443	100.00	1.522	100.00	1.508	100.00	2.685	100.00	1.090	100.00
21	2.049	100.00	2.316	100.00	1.644	100.00	1.985	100.00	2.783	100.00	1.358	100.00
22	1.930	100.00	1.535	100.00	1.533	100.00	1.614	100.00	2.469	100.00	1.365	100.00
23	3.449	99.9055	2.637	100.00	2.831	100.00	3.036	100.00	4.205	99.0854	2.856	99.9419
24	2.674	99.8617	1.803	100.00	1.879	100.00	2.415	100.00	2.251	100.00	1.893	100.00
25	1.605	100.00	1.270	100.00	1.428	100.00	1.939	100.00	2.267	100.00	1.481	100.00
26	2.122	100.00	2.548	100.00	1.967	100.00	2.337	100.00	2.606	100.00	1.599	100.00
27	1.667	100.00	1.280	100.00	1.564	100.00	2.094	100.00	1.682	100.00	1.217	100.00
28	1.949	100.00	1.209	100.00	1.244	100.00	1.567	100.00	2.333	100.00	1.126	100.00
29	1.807	100.00	2.062	100.00	1.595	100.00	2.086	100.00	1.820	100.00	1.412	100.00
30	2.198	100.00	1.530	100.00	1.695	100.00	2.264	100.00	1.972	100.00	1.691	100.00
31	-	-	-	-	-	-	-	-	-	-	-	-
122	3.768	100.00	3.829	100.00	3.769	100.00	3.584	100.00	2.316	100.00	2.604	100.00
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	1.386	100.00	1.559	100.00	1.663	100.00	2.085	100.00	1.537	100.00	1.573	100.00
2	2.294	99.9958	2.861	99.9826	2.105	100.00	1.470	100.00	1.342	100.00	1.551	99.9995
3	1.343	100.00	1.439	100.00	1.242	100.00	1.732	100.00	1.292	100.00	1.087	100.00
4	1.859	99.9995	2.205	100.00	1.787	100.00	2.493	99.9994	1.610	100.00	1.770	99.9996
5	1.538	100.00	2.335	99.9755	1.489	100.00	2.156	100.00	1.103	100.00	1.106	100.00
6	1.735	100.00	1.534	100.00	1.984	100.00	2.408	99.9799	1.694	100.00	1.582	100.00
7	1.498	100.00	1.589	100.00	1.316	100.00	1.765	100.00	0.954	100.00	1.011	100.00
8	1.237	100.00	1.416	100.00	1.302	100.00	2.360	100.00	1.435	100.00	1.077	100.00
9	1.493	100.00	1.652	100.00	1.477	100.00	2.093	100.00	1.762	100.00	1.664	100.00
10	1.583	100.00	2.159	100.00	1.615	100.00	1.636	100.00	0.892	100.00	0.966	100.00
11	1.445	100.00	2.076	100.00	2.090	100.00	1.306	100.00	1.060	100.00	1.047	100.00
12	-	-	-	-	-	-	-	-	-	-	-	-
13	1.316	100.00	1.435	100.00	1.384	100.00	2.093	100.00	1.454	100.00	1.407	100.00
14	1.606	100.00	2.082	100.00	1.622	100.00	1.424	100.00	0.981	100.00	1.040	100.00
15	1.333	100.00	1.533	100.00	1.352	100.00	1.795	100.00	1.380	100.00	1.164	100.00
16	1.776	100.00	1.745	100.00	1.693	100.00	1.732	100.00	1.051	100.00	0.909	100.00
17	-	-	-	-	-	-	-	-	-	-	-	-
18	1.539	99.9998	2.197	100.00	1.509	100.00	1.313	100.00	0.946	100.00	1.201	100.00
19	2.759	100.00	3.207	100.00	2.982	100.00	2.532	99.9980	2.151	100.00	2.032	100.00
20	1.910	100.00	1.850	100.00	1.783	100.00	1.486	100.00	1.327	100.00	1.047	100.00
21	2.118	100.00	2.345	100.00	2.542	100.00	1.408	100.00	1.270	100.00	1.321	99.9999
22	1.834	100.00	2.167	100.00	2.215	100.00	1.202	100.00	1.210	100.00	1.080	100.00
23	2.787	100.00	3.298	99.3233	3.121	100.00	2.478	100.00	2.339	100.00	2.108	100.00
24	1.886	100.00	1.914	100.00	1.317	100.00	2.552	99.9840	1.803	100.00	1.902	100.00
25	1.432	100.00	1.805	100.00	1.467	100.00	1.851	99.9831	1.429	100.00	1.473	100.00
26	1.729	100.00	1.982	100.00	1.786	100.00	2.591	99.9951	1.833	100.00	1.776	100.00
27	1.347	99.9996	1.549	100.00	1.361	100.00	1.978	100.00	1.385	100.00	1.251	100.00
28	1.634	100.00	1.942	100.00	1.554	100.00	1.545	100.00	0.923	100.00	0.893	100.00
29	1.394	100.00	1.410	100.00	1.511	100.00	2.302	99.9754	1.581	100.00	1.310	100.00
30	2.330	100.00	2.127	100.00	1.799	100.00	1.903	100.00	1.806	100.00	1.916	100.00
31	-	-	-	-	-	-	-	-	-	-	-	-
122	3.636	100.00	4.161	99.9963	2.569	100.00	5.049	100.00	2.855	100.00	-	-
134	6.618	100.00	5.110	100.00	-	-	-	-	-	-	2.445	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	1.142	100.00	0.517	100.00	0.743	100.00	0.960	100.00	1.215	100.00	0.712	100.00
2	1.774	100.00	1.401	100.00	1.474	100.00	1.665	100.00	2.099	100.00	1.373	100.00
3	0.832	100.00	0.550	100.00	0.775	100.00	0.753	100.00	1.189	100.00	0.508	100.00
4	1.304	100.00	1.011	100.00	1.056	100.00	1.492	100.00	1.268	100.00	1.080	100.00
5	0.845	100.00	0.568	100.00	0.885	100.00	0.688	100.00	1.183	100.00	0.416	100.00
6	1.088	100.00	0.731	100.00	0.774	100.00	1.089	100.00	1.007	100.00	0.770	100.00
7	1.100	100.00	0.666	100.00	0.768	100.00	0.977	100.00	1.326	100.00	0.478	100.00
8	0.945	100.00	0.494	100.00	0.802	100.00	1.284	100.00	1.261	100.00	0.499	100.00
9	0.978	100.00	0.582	100.00	0.727	100.00	0.854	100.00	0.866	100.00	0.513	100.00
10	1.182	100.00	0.938	100.00	0.891	100.00	1.057	100.00	1.155	100.00	0.988	100.00
11	1.028	100.00	0.694	99.9944	0.628	100.00	0.775	100.00	1.482	100.00	0.821	100.00
12	-	-	-	-	-	-	-	-	-	-	-	-
13	0.926	100.00	0.721	100.00	0.739	100.00	0.899	100.00	0.951	100.00	0.475	100.00
14	1.281	100.00	0.887	100.00	1.021	100.00	1.271	100.00	1.682	100.00	0.986	100.00
15	0.997	100.00	0.481	100.00	0.798	100.00	0.924	100.00	1.149	100.00	0.440	100.00
16	1.065	100.00	1.106	100.00	0.657	100.00	0.999	100.00	1.615	100.00	0.887	100.00
17	-	-	-	-	-	-	-	-	-	-	-	-
18	1.286	100.00	0.875	100.00	1.027	100.00	1.135	100.00	1.703	100.00	1.053	100.00
19	2.026	100.00	1.592	100.00	1.669	100.00	1.971	100.00	2.275	100.00	1.976	100.00
20	1.004	100.00	0.710	100.00	0.936	100.00	0.830	100.00	1.575	100.00	0.695	100.00
21	1.640	100.00	1.359	100.00	1.100	100.00	1.750	100.00	2.181	100.00	0.988	100.00
22	1.518	100.00	1.038	100.00	1.130	100.00	1.384	100.00	1.948	100.00	1.147	100.00
23	2.477	100.00	1.857	100.00	1.963	100.00	2.302	100.00	3.164	100.00	2.282	100.00
24	1.368	100.00	0.877	99.9875	0.915	99.9996	1.243	100.00	1.255	100.00	1.029	100.00
25	1.089	100.00	0.475	100.00	0.762	100.00	1.075	100.00	1.468	100.00	0.594	100.00
26	1.088	100.00	1.260	100.00	0.925	100.00	1.262	100.00	1.398	100.00	0.764	100.00
27	1.135	100.00	0.556	100.00	0.831	100.00	1.109	100.00	1.316	100.00	0.579	100.00
28	1.303	100.00	0.585	100.00	0.871	100.00	1.176	100.00	1.824	100.00	0.906	100.00
29	0.938	100.00	1.075	100.00	0.716	100.00	0.968	100.00	1.061	100.00	0.604	100.00
30	1.151	100.00	0.787	100.00	0.843	100.00	1.007	100.00	0.863	100.00	0.743	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	0.829	100.00	0.853	100.00	0.622	100.00	0.774	100.00	0.498	100.00	0.782	100.00
2	1.081	100.00	1.790	100.00	1.197	100.00	1.156	100.00	0.955	100.00	1.275	100.00
3	0.566	100.00	0.741	100.00	0.510	100.00	0.606	100.00	0.494	100.00	0.575	99.9979
4	0.985	100.00	1.356	100.00	1.000	100.00	1.027	100.00	0.895	100.00	0.855	99.9998
5	0.471	100.00	1.188	100.00	0.815	100.00	0.615	100.00	0.477	100.00	0.485	100.00
6	0.937	100.00	0.945	100.00	0.841	100.00	1.005	100.00	0.823	100.00	0.708	100.00
7	0.826	100.00	1.015	100.00	0.613	100.00	0.551	100.00	0.390	100.00	0.567	100.00
8	0.388	100.00	0.905	100.00	0.602	100.00	0.867	100.00	0.524	100.00	0.542	100.00
9	0.558	100.00	0.818	100.00	0.629	100.00	0.651	100.00	0.702	100.00	0.756	99.9999
10	0.849	100.00	0.990	100.00	0.716	100.00	0.720	100.00	0.386	100.00	0.652	100.00
11	0.633	100.00	0.953	100.00	0.910	100.00	0.814	100.00	0.471	100.00	0.534	100.00
12	-	-	-	-	-	-	-	-	-	-	-	-
13	0.566	100.00	0.779	100.00	0.631	100.00	0.792	100.00	0.590	100.00	0.620	100.00
14	0.699	100.00	1.244	100.00	1.092	100.00	0.660	100.00	0.532	100.00	0.742	100.00
15	0.489	100.00	0.867	100.00	0.540	100.00	0.538	100.00	0.378	100.00	0.384	100.00
16	0.894	100.00	0.822	100.00	0.942	100.00	0.713	100.00	0.416	100.00	0.680	99.9999
17	-	-	-	-	-	-	-	-	-	-	-	-
18	0.703	100.00	1.360	100.00	1.007	100.00	0.780	100.00	0.661	100.00	0.778	100.00
19	1.598	100.00	1.790	100.00	1.786	100.00	1.836	100.00	1.457	100.00	1.510	99.9998
20	0.752	100.00	0.818	100.00	1.060	100.00	0.852	100.00	0.852	100.00	0.722	100.00
21	1.062	100.00	1.409	100.00	1.844	100.00	1.185	100.00	1.015	100.00	1.036	100.00
22	0.897	100.00	1.355	100.00	1.438	100.00	0.991	100.00	0.853	100.00	0.823	100.00
23	1.970	100.00	2.292	100.00	2.363	100.00	2.021	100.00	1.703	100.00	1.590	100.00
24	0.821	100.00	0.999	100.00	0.725	100.00	1.160	100.00	0.917	100.00	0.966	99.9998
25	0.706	100.00	0.939	100.00	0.643	100.00	0.702	100.00	0.507	100.00	0.753	100.00
26	0.768	100.00	1.148	100.00	0.835	100.00	1.000	100.00	0.922	100.00	0.928	100.00
27	0.632	100.00	1.014	100.00	0.822	100.00	0.846	100.00	0.495	100.00	0.655	100.00
28	0.752	100.00	1.228	100.00	1.194	100.00	0.717	100.00	0.576	100.00	0.651	100.00
29	0.531	100.00	0.791	100.00	0.659	100.00	0.808	100.00	0.645	99.9959	0.666	100.00
30	1.125	100.00	1.131	100.00	0.725	100.00	0.743	100.00	0.821	100.00	0.886	100.00
31	-	-	-	-	-	-	-	-	-	-	-	-

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

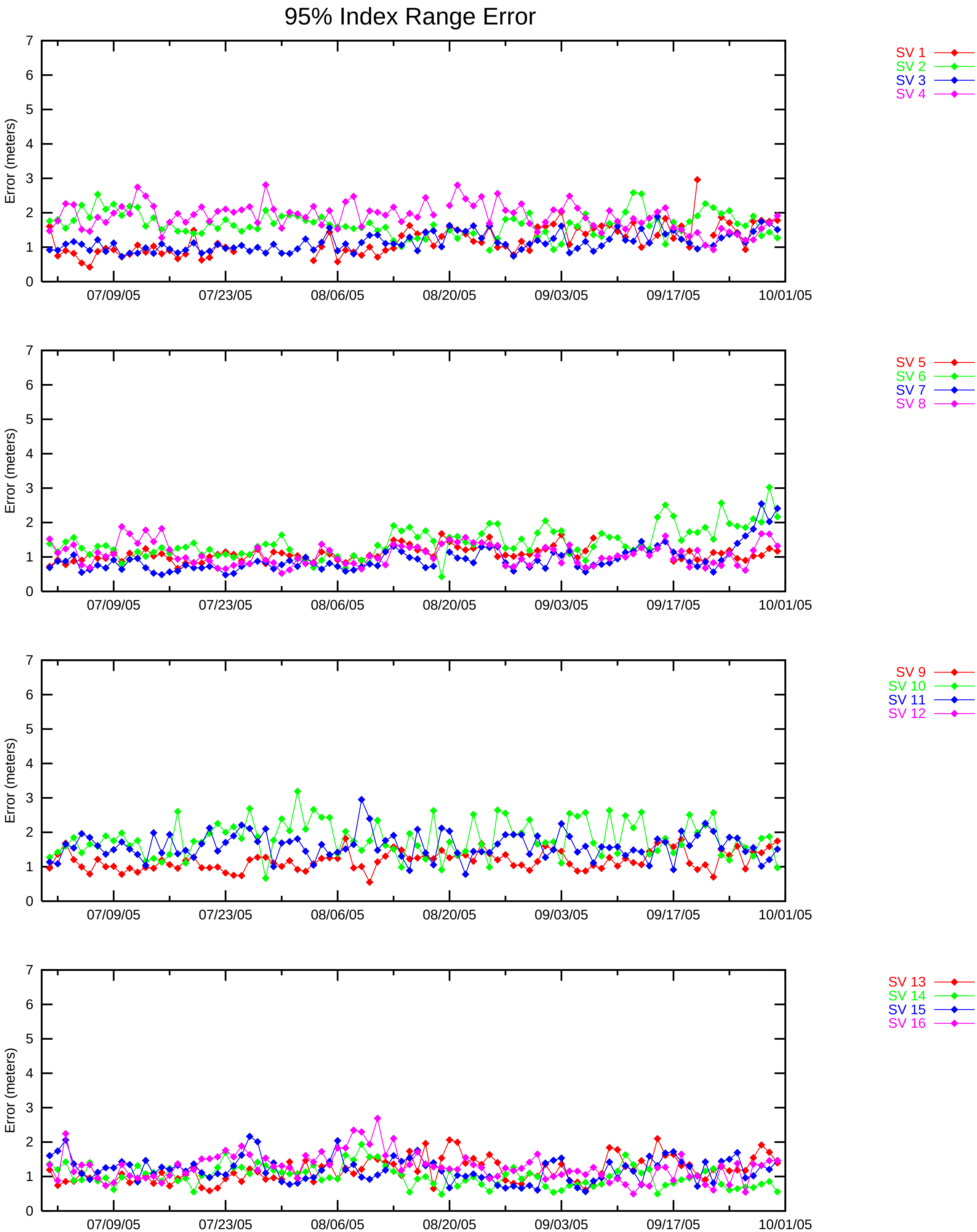


Figure 6-2 95% Range Error (SV 17 --SV 31 and SV 122) - Washington, DC

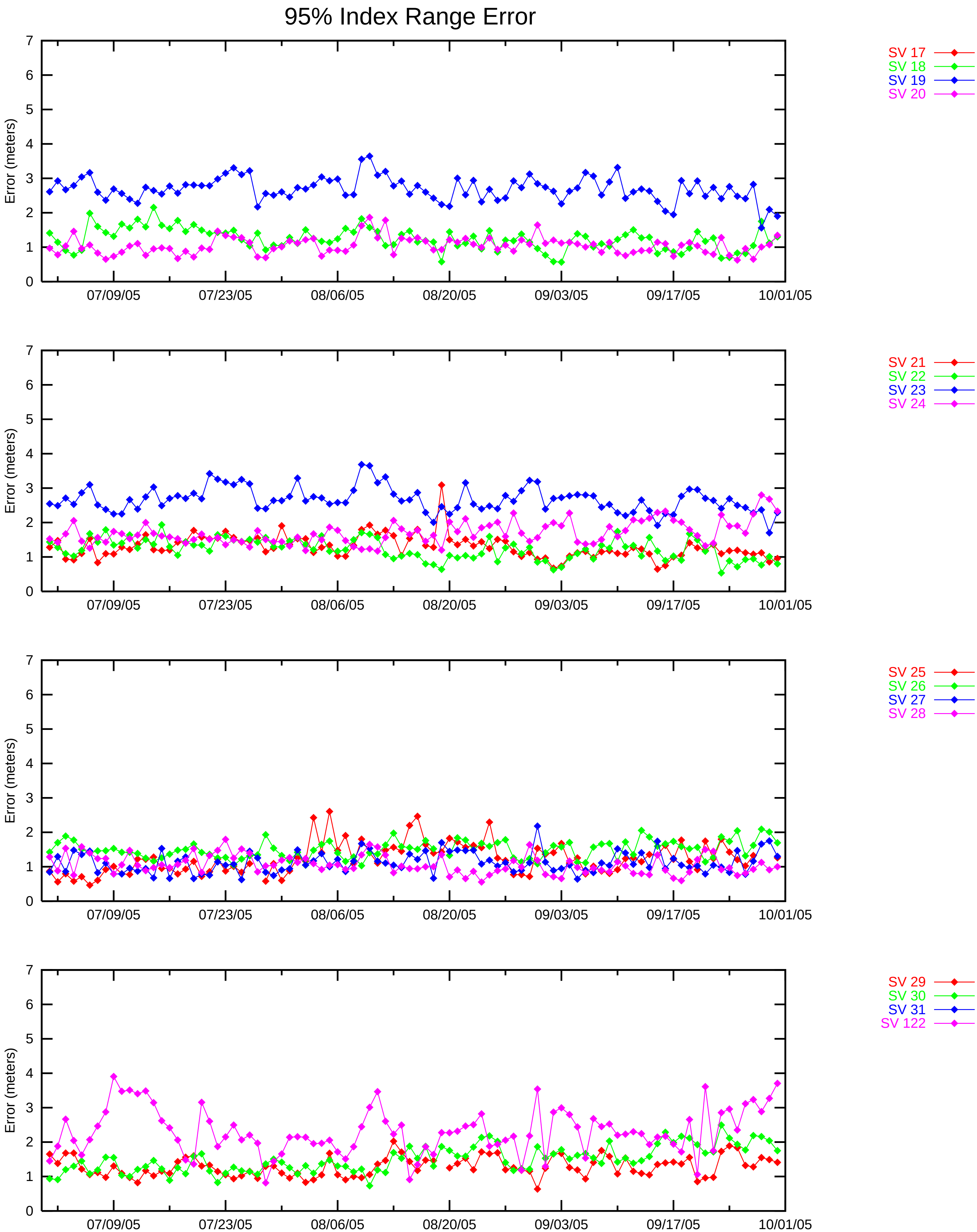
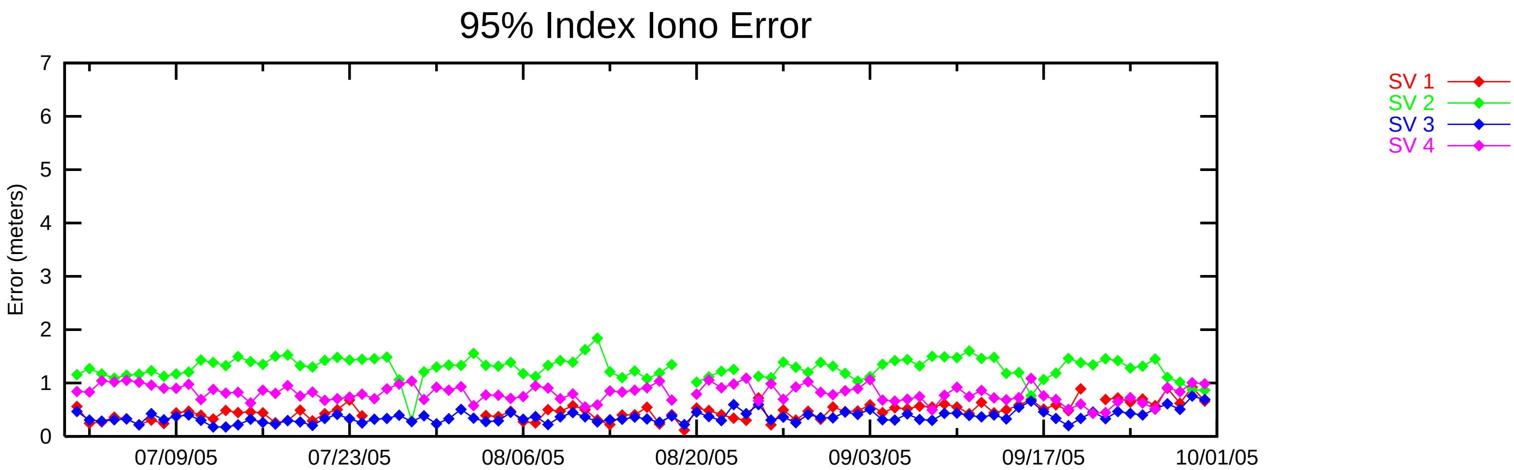
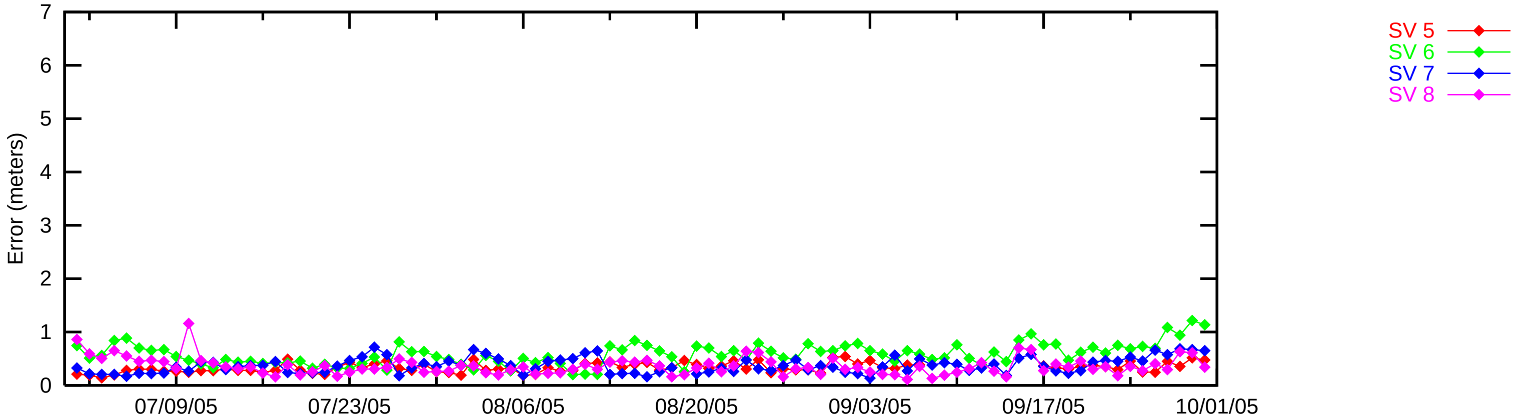
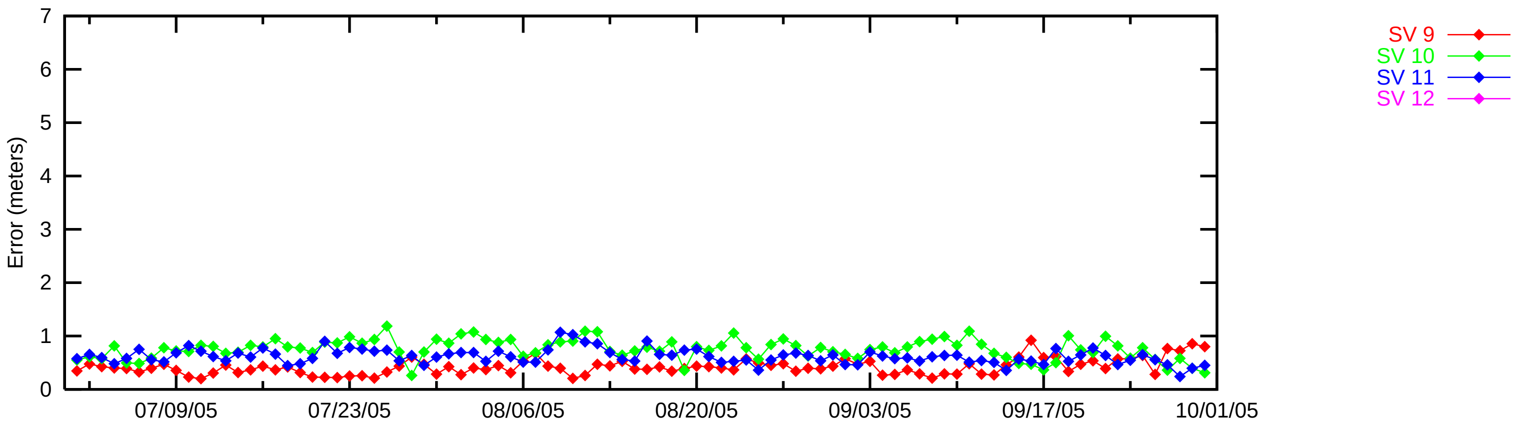


Figure 6-3 95% Ionospheric Error (SV 1 --SV 16) - Washington, DC







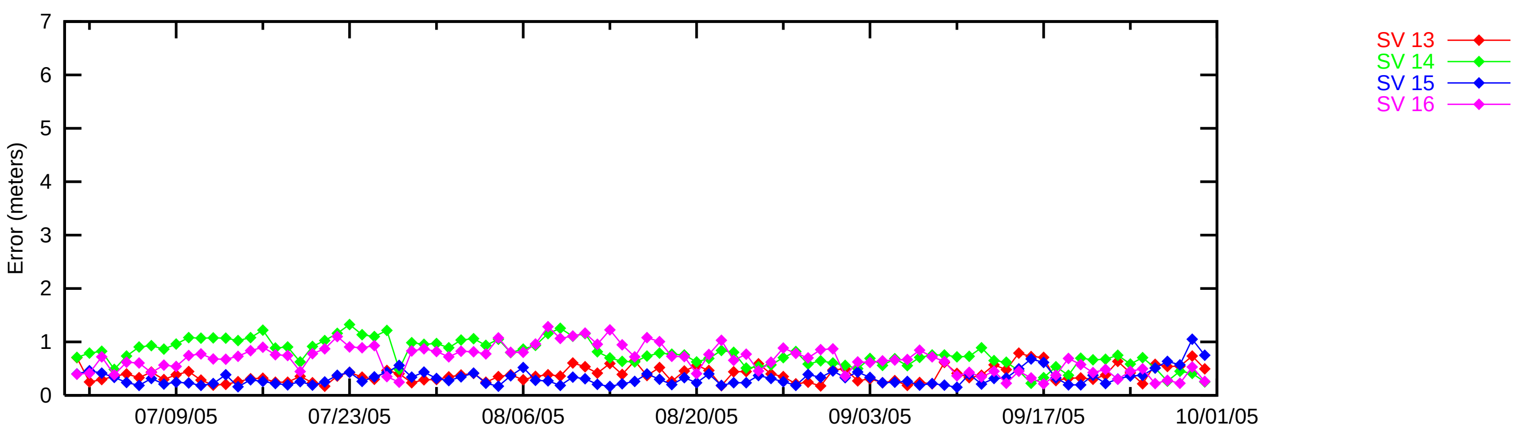
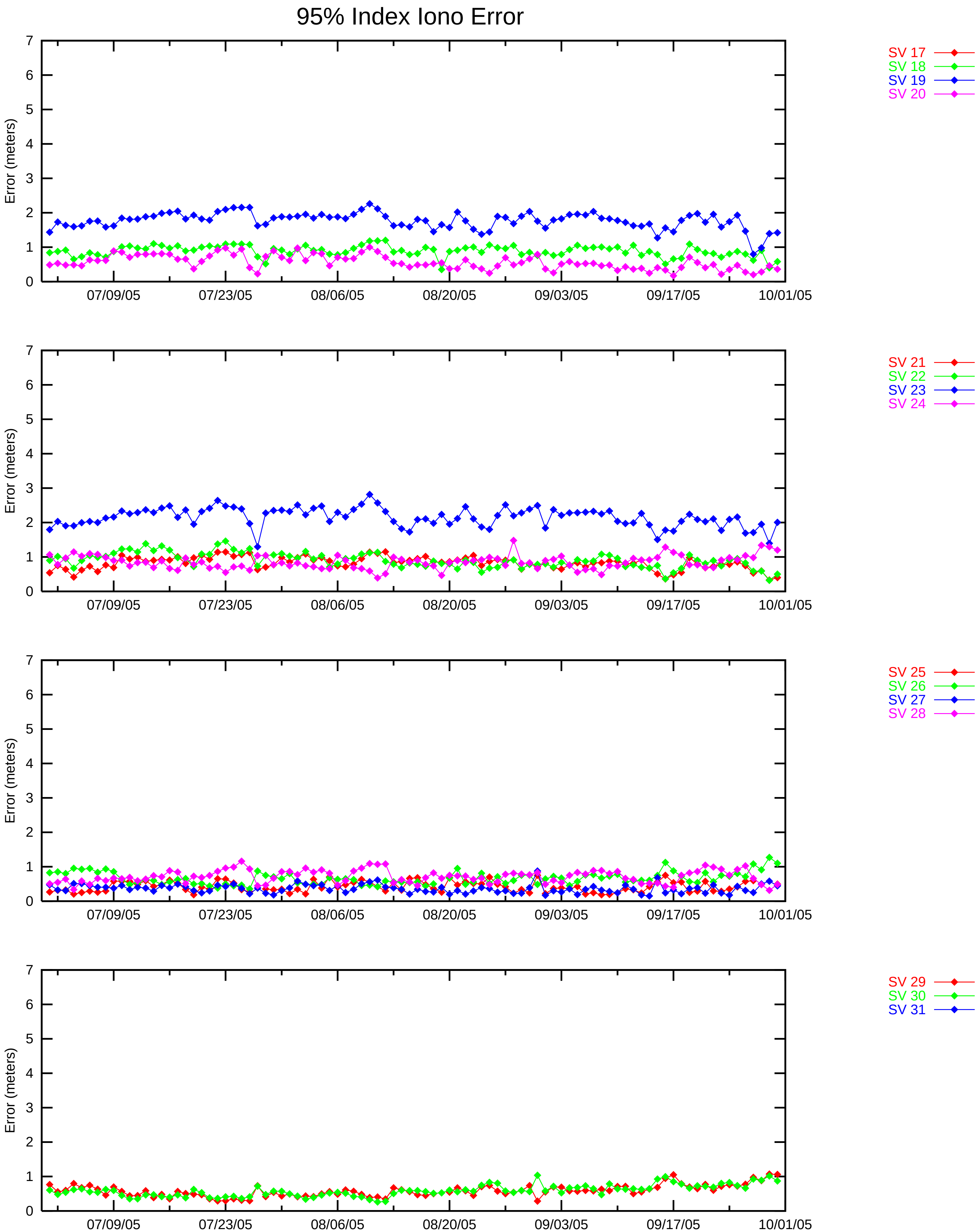


Figure 6-4 95% Ionospheric Error (SV 17 --SV 31) - Washington, DC



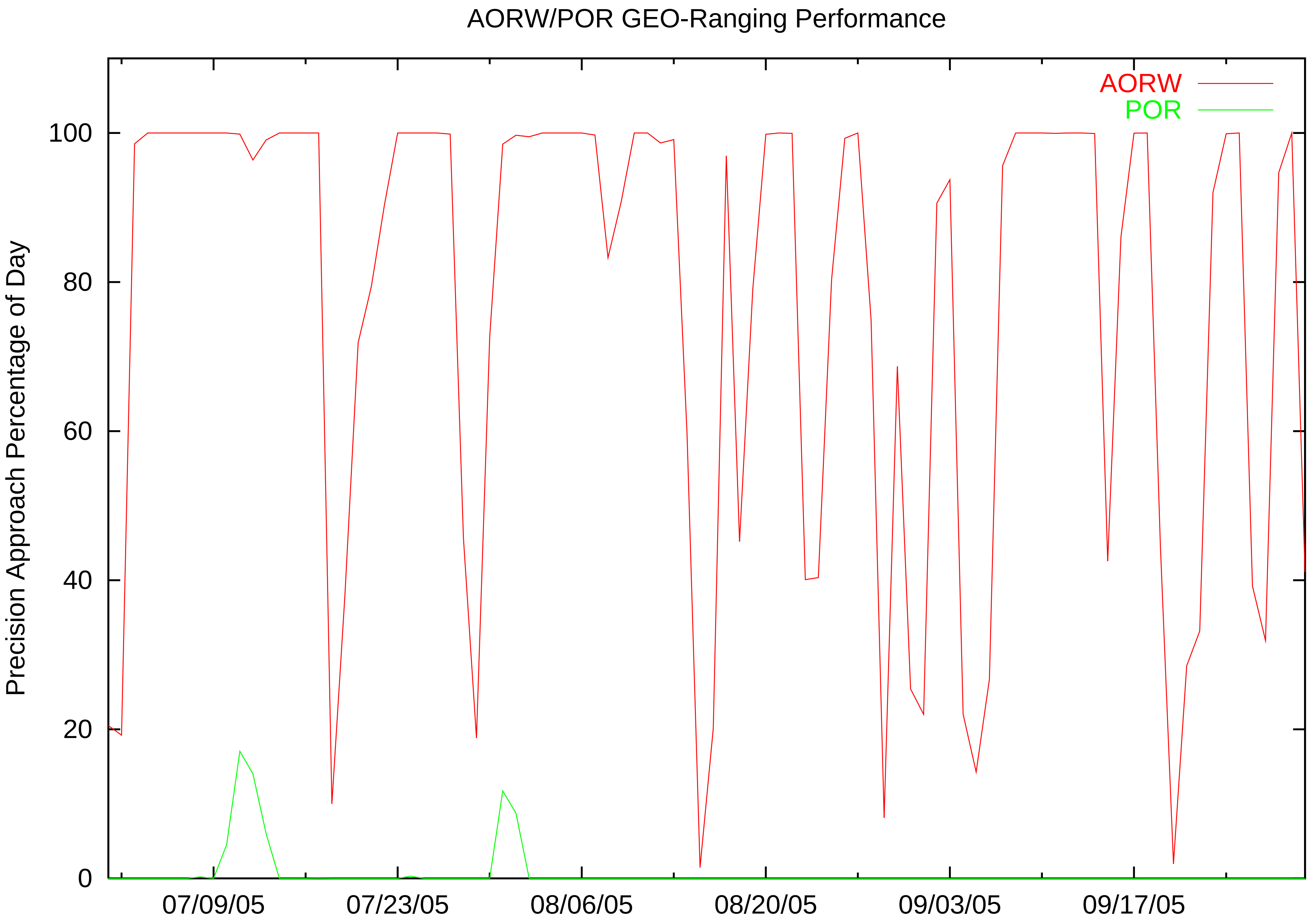
7.0 GEO RANGING PERFORMANCE

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 85.670% and 0.779%, respectively. Figure 7.1 shows the trend of PA Ranging Availability for the AORW and POR satellite. The percentage of time the AOR-W GEO was available for PA ranging is lower this quarter than expected. The reason is thread switching by key WRSs and poor WRS receiver performance. The large drops in PA ranging availability for the AORW satellite is due to GUS switchovers. As in the past, the POR satellite as a ranging source has very low PA availability.

Table 7-1 GEO Ranging Availability

GEO	PA (%)	NPA (%)	Not Monitored (%)	Do Not Use (%)
AORW	76.834	20.936	1.729	0.358
POR	0.681	89.947	8.899	0.332

Figure 7-1 Daily PA GEO Ranging Availability Trend



8.0 WAAS PROBLEM SUMMARY

During this quarter there were several outages of the WAAS service. Some of these outages were related to the upgrade of the WAAS receivers at certain reference stations. Other outages were not related to this upgrade. Details of each of the outages were documented in WAAS Discrepancy Reports. This quarterly report lists each outage and a short description of why the outage occurred.

A common theme to several of the outages was the upgrade of WAAS receivers at reference stations. This was a planned upgrade for the WAAS. Receivers at 15 of the 25 reference stations received the upgraded receivers. However, the processing of WAAS messages by the new receivers, in certain situations, was different and caused processing errors at the WAAS master stations. These processing errors were the catalyst for several of the outages listed. During the latter part of this quarter the problem with new receivers was fixed.

August 14, 2005 – Service outage in the AOR service region. This region includes all of the contiguous United States (CONUS). There is redundancy with the POR satellite in the western part of CONUS so WAAS service was not lost there. Service was lost for three hours and was caused by the issue with the new WAAS receivers.

August 28, 2005 - Service outage in the POR GEO service region (includes western CONUS, Hawaii, and Alaska). This region has redundant coverage in the western CONUS so only redundancy in that part of the POR service region was lost. Service was lost for one hour and was caused by the issue with the new WAAS receivers.

August 31, 2005 – Service was lost for the AOR and POR service regions. Several conditions occurred at the same time to cause this outage. The conditions included the issue with the new WAAS receivers, terrestrial communications loss at the Brewster GUS, and eventually the faulting of both WAAS master stations. POR service was lost for three hours and AOR service was lost for four hours.

September 5, 2005 - Service outage in the AOR service region. This region includes all of the contiguous United States (CONUS). There is redundancy with the POR satellite in the western part of CONUS so WAAS service was not lost there. Service was lost for three hours and was caused by the issue with the new WAAS receivers.

September 19, 2005 - Service was lost for the AOR and POR service regions. Both WAAS master stations faulted causing the outage. The reason for the fault was related to a GPS satellite being set to unhealthy. This is a normal occurrence that has happened over a hundred times since WAAS was commissioned. However, the timing of the satellite being set to unhealthy caused an error condition in the orbit determination software of the WAAS master stations. Service was lost for approximately 70 minutes.

September 21, 2005 - Service outage in the POR GEO service region (includes western CONUS, Hawaii, and Alaska). This region has redundant coverage in the western CONUS so only redundancy in that part of the POR service region was lost. The cause of the outage was internal WAAS processing related to time to alarm. Only vertical navigation service was lost during this outage; WAAS set all satellites to not monitored on the POR data stream. Enroute and non-precision approach users can still use satellites that are declared ‘not monitored’ by WAAS. The service outage lasted approximately one hour.

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 7/3/05 to 10/1/05 of WAAS operation is presented in Table 9.1. Figures 9.1 and 9.2 provide a graphical representation of WAAS LPV service availability and outage counts for the same period, respectively.

Table 9-1 WAAS LPV Outages and Availability

Airport Id	Airport Name	City	State	Outages	Availability
YEG	EDMONTON INTL	EDMONTON	AB	86	0.990910
CGA	CRAIG	CRAIG	AK	181	0.982133
HYD	HKDER	HKDER	AK	183	0.982828
JNU	JUNEAU INTL AIRPORT	JUNEAU	AK	535	0.939589
KTN	KETCHIKAN AIRPORT	KETCHIKAN	AK	166	0.983690
PEC	PELICAN	PELICAN	AK	508	0.941431
PSG	PETERSBURG MUNICIPAL	PETERSBURG	AK	259	0.976253
SIT	SITKA AIRPORT	SITKA	AK	344	0.966952
79J	ANDALUSIA-OPP	ANDALUSIA/OP	AL	31	0.994966
KBHM	BIRMINGHAM INTL	BIRMINGHAM	AL	19	0.995706
KDHN	DOTHAN REGIONAL	DOTHAN	AL	31	0.994753
HSV	HUNTSVILLE INTL – CARL T JONES FIELD	HUNTSVILLE	AL	16	0.995796
MOB	MOBILE REGIONAL	MOBILE	AL	32	0.995324
MGM	MONTGOMERY REGIONAL/ DANNELLY FIELD	MONTGOMERY	AL	26	0.995400
MSL	MUSCLE SHOALS NORTHWEST ALABAMA REGIONAL	SHEFFIELD	AL	16	0.995800
EET	SHELBY COUNTY	ALABASTER	AL	20	0.995645
LIT	ADAMS FIELD	LITTLE ROCK	AR	13	0.996078
M73	ALMYRA	ALMYRA	AR	13	0.996079
KVBT	BENTONVILLE MUNICIPAL/ LM THADDEN FIELD	BENTONVILLE	AR	13	0.996079
BYH	BLYTHEVILLE	BLYTHEVILLE	AR	15	0.995906
HRO	BOONE COUNTY AIRPORT	HARRISON	AR	13	0.996079
KFSM	FORT SMITH REGIONAL	FORT SMITH	AR	13	0.996080
CDH	HARRELL FIELD	CAMDEN	AR	13	0.996078
KXNA	NORTHWEST ARKANSAS REGIONAL	FAYETTEVILLE/ SPRINGDALE/ROGERS	AR	13	0.996081
SRC	SEARCY MUNICIPAL	SEARCY	AR	13	0.996078
ASG	SPRINGDALE MUNICIPAL	SPRINGDALE	AR	13	0.996079

KARG	WALNUT RIDGE REGIONAL	WALNUT RIDGE	AR	14	0.996044
KPRC	ERNEST A LOVE FIELD	PRESCOTT	AZ	54	0.993078
KGCN	GRAND CANYON NATL PARK	GRAND CANYON	AZ	45	0.995052
IFP	LAUGHLIN/BULLHEAD INTL	BULLHEAD CITY	AZ	57	0.991399
KPHX	PHOENIX SKY HARBOR INTL	PHOENIX	AZ	66	0.990559
KTUS	TUCSON INTL	TUCSON	AZ	162	0.977808
RQE	WINDOW ROCK	WINDOW ROCK	AZ	42	0.997170
BFL	BAKERSFIELD/MEADOWS FIELD	BAKERSFIELD	CA	190	0.987702
KDAG	BARSTOW-DAGGETT	DAGGETT	CA	104	0.987554
O60	CLOVERDALE MUNICIPAL	CLOVERDALE	CA	130	0.991962
IYK	INYOKERN	INYOKERN	CA	101	0.989831
KLAX	LOS ANGELES INTL	LOS ANGELES	CA	262	0.962057
KCRQ	MC CLELLAN-PALOMAR	CARLSBAD	CA	245	0.942767
KOAK	METROPOLITAN OAKLAND INTL	OAKLAND	CA	156	0.990423
ONT	ONTARIO INTL	ONTARIO	CA	166	0.972262
KPMD	PALMDALE PROD FLT/ TEST INSTLN	PALMDALE	CA	208	0.976527
KSMF	SACRAMENTO INTL	SACRAMENTO	CA	99	0.994105
KMHR	SACRAMENTO MATHER	SACRAMENTO	CA	97	0.994334
SAN	SAN DIEGO INTL-LINDBERGH FIELD	SAN DIEGO	CA	279	0.929656
KSFO	SAN FRANCISCO INTL	SAN FRANCISCO	CA	166	0.989826
SJC	SAN JOSE INTL	SAN JOSE	CA	169	0.989939
SVE	SUSANVILLE MUNICIPAL	SUSANVILLE	CA	57	0.997042
TNP	TWENTYNINE PALMS	TWENTYNINE PALMS	CA	105	0.983883
AKO	AKRON-COLORADO PLAINS REGIONAL	AKRON	CO	13	0.996086
COS	COLORADO SPRINGS	COLORADO SPRINGS	CO	15	0.996025
CEZ	CORTEZ MUNICIPAL	CORTEZ	CO	29	0.995666
KDEN	DENVER INTL	DENVER	CO	15	0.996008
LHX	LA JUNTA MUNICIPAL	LA JUNTA	CO	15	0.996053
LAA	LAMAR MUNICIPAL	LAMAR	CO	13	0.996087
EEO	MEEKER	MEEKER	CO	15	0.996008
TAD	PERRY STOKES	TRINIDAD	CO	15	0.996040
2V2	VANCE BRAND	LONGMONT	CO	15	0.996004
2V5	WRAY	WRAY	CO	13	0.996076
HDN	YAMPA VALLEY	HAYDEN	CO	13	0.996056
KBDL	BRADLEY INTL	WINDSOR LOCKS	CT	83	0.990780
KDCA	RONALD REAGAN WASHINGTON INTL	WASHINGTON	DC	18	0.995431
KIAD	WASHINGTON DULLES INTL	WASHINGTON	DC	18	0.995440
FXE	FORT LAUDERDALE EXECUTIVE AIRPORT	FORT LAUDERDALE	FL	144	0.985658
KFLL	FORT LAUDERDALE/ HOLLYWOOD INTL	FORT LAUDERDALE	FL	147	0.984905
KGNV	GAINESVILLE REGIONAL	GAINESVILLE	FL	36	0.993990
KJAX	JACKSONVILLE INTL	JACKSONVILLE	FL	34	0.994214
KMIA	MIAMI INTL	MIAMI	FL	159	0.983461
KAPF	NAPLES MUNICIPAL	NAPLES	FL	77	0.990419
KOCF	OCALA INTL-JIM TAYLOR FLD	OCALA	FL	37	0.993823
KMCO	ORLANDO INTL	ORLANDO	FL	41	0.993475
KPBI	PALM BEACH INTL	WEST PALM BEACH	FL	125	0.987779
KPFN	PANAMA CITY-BAY COUNTY INTL	PANAMA CITY	FL	30	0.994824
KPNS	PENSACOLA REGIONAL	PENSACOLA	FL	34	0.994836

SRQ	SARASOTA/BRADENTON INTL	SARASOTA/BRADENTON	FL	59	0.992505
KRSW	SOUTHWEST FLORIDA INTL	FORT MYERS	FL	63	0.991593
KPIE	ST PETERSBURG-CLEARWATER INTL	ST PETERSBURG-CLEARWATER	FL	56	0.992764
KTLH	TALLAHASSEE REGIONAL	TALLAHASSEE	FL	34	0.994451
TPA	TAMPA INTL	TAMPA	FL	56	0.992814
KVRB	VERO BEACH MUNICIPAL	VERO BEACH	FL	70	0.991728
KSAV	SAVANNAH INTL	SAVANNAH	GA	22	0.995497
KACJ	SOUTHER FIELD	AMERICUS	GA	25	0.995223
KTBR	STATESBORO-BULLOCH COUNTY	STATESBORO	GA	23	0.995422
KATL	WILLIAM B HARTSFIELD ATLANTA INTL	ATLANTA	GA	19	0.995670
KIKV	ANKENY REGIONAL	ANKENY	IA	17	0.995937
DSM	DES MOINES INTL	DES MOINES	IA	17	0.995963
KMXO	MONTICELLO REGIONAL	MONTICELLO	IA	17	0.995843
CID	THE EASTERN IOWA	CEDAR RAPIDS	IA	17	0.995887
KBOI	BOISE AIR TERMINAL/GOWEN FLD	BOISE	ID	13	0.999058
EUL	CALDWELL INDUSTRIAL	CALDWELL	ID	13	0.999058
SUN	FRIEDMAN MEMORIAL	HAILEY	ID	12	0.999087
PIH	POCATELLO REGIONAL	POCATELLO	ID	11	0.999113
SZT	SANDPOINT	SANDPOINT	ID	12	0.999087
KARR	AURORA MUNICIPAL	CHICAGO/AURORA	IL	15	0.995667
KENL	CENTRALIA MUNICIPAL	CENTRALIA	IL	15	0.995809
MDW	CHICAGO MIDWAY	CHICAGO	IL	15	0.995623
KORD	CHICAGO-O'HARE INTL	CHICAGO	IL	15	0.995630
KFOA	FLORA MUNICIPAL	FLORA	IL	15	0.995810
KPIA	GREATER PEORIA REGIONAL	PEORIA	IL	15	0.995895
KRFD	GREATER ROCKFORD	ROCKFORD	IL	15	0.995684
3CK	LAKE IN THE HILLS	UNKNOWN	IL	15	0.995671
KPPQ	PITTSFIELD PENSTONE MUNICIPAL	PITTSFIELD	IL	14	0.996041
MLI	QUAD-CITY	MOLINE	IL	15	0.995879
KTIP	RANTOUL NATL AVN CTR/FRANK ELLIOT FLD	RANTOUL	IL	15	0.995652
KSLO	SALEM-LECKRONE	SALEM	IL	15	0.995809
0I2	BRAZIL CLAY COUNTY	BRAZIL	IN	15	0.995640
FWA	FORT WAYNE INTL	FORT WAYNE	IN	15	0.995661
SER	FREEMAN MUNICIPAL	SEYMOUR	IN	16	0.995625
KIND	INDIANAPOLIS INTL	INDIANAPOLIS	IN	15	0.995653
CEV	METTEL FIELD	CONNERSVILLE	IN	16	0.995627
SBN	MICHIANA REGIONAL TRANSPORTATION CTR	SOUTH BEND	IN	15	0.995636
KBMG	MONROE COUNTY	BLOOMINGTON	IN	15	0.995651
KANQ	TRI-STATE STEUBEN COUNTY	ANGOLA	IN	15	0.995657
EHA	ELKHART-MORTON COUNTY	ELKHART	KS	14	0.996061
KHYS	HAYS REGIONAL	HAYS	KS	13	0.996077
KOJC	JOHNSON COUNTY EXECUTIVE	OLATHE	KS	13	0.996080
LWC	LAWRENCE MUNICIPAL	LAWRENCE	KS	13	0.996080
KMHK	MANHATTAN REGIONAL	MANHATTAN	KS	13	0.996079
TOP	PHILIP BILLARD MUNICIPAL	TOPEKA	KS	13	0.996079
GLD	RENNER FIELD/GOODLAND MUNICIPAL	GOODLAND	KS	13	0.996076

KCBK	SHALTZ FIELD	COLBY	KS	13	0.996076
KWLD	STROTHER FIELD	WINFIELD/ARKANSAS CITY	KS	13	0.996080
KULS	ULYSSES	ULYSSES	KS	13	0.996076
ICT	WICHITA MID-CONTINENT	WICHITA	KS	13	0.996080
KK22	BIG SANDY REGIONAL	PRESTONBURG	KY	14	0.995695
KLEX	BLUE GRASS	LEXINGTON	KY	16	0.995623
KCVG	CINCINNATI/NORTHERN KY INTL	COVINGTON/CINCINNATI	KY	16	0.995625
LOZ	LONDON	LONDON	KY	15	0.995643
SDF	LOUISVILLE INTL-STANDIFORD FLD	LOUISVILLE	KY	16	0.995623
SME	SOMERSET-PULASKI COUNTY	SOMERSET	KY	15	0.995633
KAEX	ALEXANDRIA INTL	ALEXANDRIA	LA	16	0.996019
DRI	DE RIDDER/ BEAUREGARD PAIRISH APT	BEAUREGARD	LA	18	0.995882
LCH	LAKE CHARLES REGIONAL	LAKE CHARLES	LA	19	0.995722
L39	LEESVILLE	LEESVILLE	LA	17	0.995945
MSY	NEW ORLEANS INTL/ MOISANT FIELD	NEW ORLEANS	LA	21	0.995747
SHV	SHREVEPORT REGIONAL	SHREVEPORT	LA	14	0.996062
KBOS	GEN EDWARD LAWRENCE LOGAN INTL	BOSTON	MA	171	0.980420
OWD	NORWOOD MEMORIAL	NORWOOD	MA	138	0.983523
KPVC	PROVINCETOWN MUNICIPAL	PROVINCETOWN	MA	243	0.970497
MVY	VINEYARD HAVEN	MARTHA'S VINEYARD	MA	151	0.982210
YWG	WINNIPEG AIRPORT	WINNIPEG	MB	171	0.967254
KBWI	BALTIMORE-WASHINGTON INTL	BALTIMORE	MD	19	0.995375
DMW	CARROLL CNTY REGIONAL/ JACK B. POAGE FLD	WESTMINSTER	MD	19	0.995383
FDK	FREDERICK MUNICIPAL	FREDERICK	MD	19	0.995432
W00	FREEWAY	MITCHELLVILLE	MD	18	0.995426
GAI	MONTGOMERY COUNTY AIRPARK	GAITHERSBURG	MD	18	0.995430
RJD	RIDGELY AIRPARK	RIDGELY	MD	20	0.995277
KPQI	N MAINE REGIONAL ARPT AT PRESQUE I	PRESQUE ISLE	ME	832	0.756174
PWM	PORTLAND INTL JETPORT	PORTLAND	ME	316	0.949973
AMN	ALMA/GRATIOT COMMUNITY	ALMA	MI	24	0.995298
KARB	ANN ARBOR MUNICIPAL	ANN ARBOR	MI	17	0.995649
KFNT	BISHOP INTL	FLINT	MI	17	0.995617
Y15	CHEBOYGAN COUNTY	CHEBOYGAN	MI	117	0.985661
CIU	CHIPPEWA COUNTY INTL	SAULT STE. MARIE	MI	123	0.984137
KDTW	DETROIT METROPOLITAN WAYNE CTY	DETROIT	MI	17	0.995643
KGRR	GERALD R FORD INTL	GRAND RAPIDS	MI	15	0.995640
KCMX	HOUGHTON COUNTY MEMORIAL	HANCOCK	MI	182	0.980932
KMBS	MBS INTL	SAGINAW	MI	30	0.995087
KMKG	MUSKEGON COUNTY	MUSKEGON	MI	15	0.995628
5D3	OWOSSO COMMUNITY	OWOSSO	MI	16	0.995631
HTL	ROSCOMMON COUNTY	HOUGHTON LAKE	MI	90	0.991497
HYX	SAGINAW CO H.W. BROWNE	UNKNOWN	MI	28	0.995252
HAI	THREE RIVERS MUNICIPAL DR. HAINES	UNKNOWN	MI	15	0.995646
BIV	TULIP CITY	HOLLAND	MI	15	0.995634
KBDE	BAUDETTE INTL	BAUDETTE	MN	120	0.989554

KBRD	BRAINERD-CROW WING CO REGIONAL	BRAINERD	MN	23	0.995492
KAXN	CHANDLER FIELD	ALEXANDRIA	MN	19	0.995890
KDLH	DULUTH INTL	DULUTH	MN	58	0.993520
KMSP	MINNEAPOLIS-ST PAUL INTL/ WOLD CHAMBERLAIN	MINNEAPOLIS	MN	21	0.995596
KRGK	RED WING RGNL	RED WING	MN	21	0.995553
KRST	ROCHESTER INTL	ROCHESTER	MN	18	0.995623
KJYG	ST JAMES MUNICIPAL	ST JAMES	MN	19	0.995878
STC	ST. CLOUD	SAINT CLOUD	MN	20	0.995703
M05	CARUTHERSVILLE MEMORIAL	CARUTHERSVILLE	MO	15	0.995891
KLBO	FLOYD W JONES LEBANON	LEBANON	MO	13	0.996080
KMCI	KANSAS CITY INTL	KANSAS CITY	MO	13	0.996080
KSTL	LAMBERT-ST LOUIS INTL	ST LOUIS	MO	15	0.995939
LXT	LEE'S SUMMIT MUNICIPAL	LEE'S SUMMIT	MO	13	0.996080
H41	MEXICO MEMORIAL	MEXICO	MO	14	0.996056
MYJ	MEXICO MEMORIAL	MEXICO	MO	14	0.996056
STJ	ROSECRANS MEMORIAL	ROSECRANS	MO	13	0.996080
KDMO	SEDALIA MEMORIAL	SEDALIA	MO	13	0.996098
SGF	SPRINGFIELD-BRANSON REGIONAL	SPRINGFIELD	MO	13	0.996079
KMO6	WASHINGTON MEMORIAL	WASHINGTON	MO	14	0.996036
GWO	GREENWOOD-LEFLORE	GREENWOOD	MS	13	0.996078
JAN	JACKSON INTL	JACKSON	MS	14	0.995957
0M6	PANOLA COUNTY	BATESVILLE	MS	15	0.996021
MPE	PHILADELPHIA MUNICIPAL	PHILADELPHIA	MS	16	0.995909
CRX	ROSCOE TURNER	UNKNOWN	MS	15	0.995912
KBIL	BILLINGS LOGAN INTL	BILLINGS	MT	14	0.996076
KMLS	FRANK WILEY FIELD	MILES CITY	MT	13	0.996096
KHLN	HELENA RGNL	HELENA	MT	14	0.996743
KLWT	LEWISTOWN MUNICIPAL	LEWISTOWN	MT	14	0.996075
6S5	RAVALLI COUNTY	HAMILTON	MT	11	0.999104
KHBI	ASHEBORO MUNICIPAL	ASHEBORO	NC	16	0.995644
KAVL	ASHEVILLE RGNL	ASHEVILLE	NC	15	0.995678
HSE	BILLY MITCHELL	HATTERAS	NC	25	0.995019
SUT	BRUNSWICK COUNTY	SOUTHPORT	NC	20	0.995375
KCLT	CHARLOTTE/DOUGLAS INTL	CHARLOTTE	NC	15	0.995662
ECG	ELIZABETH CITY CGAS	ELIZABETH CITY	NC	23	0.995206
KFAY	FAYETTEVILLE RGNL/ GRANNIS FIELD	FAYETTEVILLE	NC	17	0.995601
HKY	HICKORY REGIONAL	HICKORY	NC	15	0.995668
KISO	KINSTON RGNL JETPORT AT STALLINGS FLD	KINSTON	NC	20	0.995406
MEB	LAURINBURG	MAXTON	NC	17	0.995605
MCZ	MARTIN COUNTY	WILLIAMSTON	NC	20	0.995402
MRH	MICHAEL J. SMITH FIELD	BEAUFORT	NC	22	0.995232
KEQY	MONROE	MONROE	NC	16	0.995646
GSO	PIEDMONT TRIAD INTL	GREENSBORO	NC	15	0.995671
PGV	PITT-GREENVILLE	GREENVILLE	NC	20	0.995400
KRDU	RALEIGH-DURHAM INTL	RALEIGH/DURHAM	NC	17	0.995510
RWI	ROCKY MOUNT-WILSON RGNL	ROCKY MOUNT	NC	20	0.995441
KRUQ	ROWAN COUNTY	SALISBURY	NC	15	0.995666
KTTA	SANFORD-LEE COUNTY RGNL	SANFORD	NC	17	0.995609
OCW	WARREN FIELD	WASHINGTON	NC	20	0.995370

KILM	WILMINGTON INTL	WILMINGTON	NC	19	0.995333
W03	WILSON INDUSTRIAL AIR CENTER	WILSON	NC	20	0.995441
KFAR	HECTOR INTL	FARGO	ND	18	0.995628
MOT	MINOT INTL AIRPORT	MINOT	ND	25	0.994834
KANW	AINSWORTH MUNICIPAL	AINSWORTH	NE	13	0.996077
AUH	AURORA MUNICIPAL	AURORA	NE	13	0.996077
BIE	BEATRICE MUNICIPAL	BEATRICE	NE	13	0.996080
CSB	CAMBRIDGE MUNICIPAL	CAMBRIDGE	NE	13	0.996076
CEK	CRETE MUNICIPAL	CRETE	NE	13	0.996079
OMA	EPPLEY AIRFIELD	OMAHA	NE	13	0.996093
OKS	GARDEN COUNTY	OSHKOSH	NE	13	0.996077
GRN	GORDON MUNICIPAL	GORDON	NE	13	0.996098
KEAR	KEARNEY MUNICIPAL	KEARNEY	NE	13	0.996077
VTN	MILLER FIELD	VALENTINE	NE	13	0.996089
KLBF	NORTH PLATTE RGNL LEE BIRD FLD	NORTH PLATTE	NE	13	0.996076
SCB	SCRIBNER STATE	SCRIBNER	NE	13	0.996080
SNY	SIDNEY MUNICIPAL	SIDNEY	NE	13	0.996077
MHT	MANCHESTER	MANCHESTER	NH	199	0.978155
KACY	ATLANTIC CITY INTL	ATLANTIC CITY	NJ	31	0.994687
K3NJ6	INDUCTOTHERM HELIPORT	RANCOCAS	NJ	22	0.995057
KMMU	MORRISTOWN MUNICIPAL	MORRISTOWN	NJ	34	0.994665
KEWR	NEWARK INTL	NEWARK	NJ	34	0.994629
7N7	SPITFIRE AERODROM	PEDRICTOWN	NJ	22	0.995111
KABQ	ALBUQUERQUE INTL SUNPORT	ALBUQUERQUE	NM	21	0.995868
KFMN	FOUR CORNERS RGNL	FARMINGTON	NM	42	0.995106
KLRU	LAS CRUCES INTL	LAS CRUCES	NM	66	0.991117
ELY	ELY AIRPORT/YELLAND FELD	ELY	NV	18	0.998909
KLAS	MC CARRAN INTL	LAS VEGAS	NV	54	0.993225
ALB	ALBANY INTL	ALBANY	NY	69	0.992147
BUF	BUFFALO NIAGARA INTL	BUFFALO	NY	23	0.995022
KJHW	CHAUTAUQUA COUNTY/ JAMESTOWN	JAMESTOWN	NY	18	0.995330
KELM	ELMIRA/CORNING RGNL	ELMIRA	NY	22	0.995052
GFL	FLOYD BENNETT MEMORIAL	GLENS FALLS	NY	90	0.990249
ROC	GREATER ROCHESTER INTL	ROCHESTER	NY	31	0.994568
KJFK	JOHN F KENNEDY INTL	NEW YORK	NY	38	0.994340
LGA	LA GUARDIA	FLUSHING	NY	37	0.994370
LKP	LAKE PLACID	LAKE PLACID	NY	110	0.987844
PBG	PLATTSGURGH INTL	PLATTSGURGH	NY	154	0.981659
KSWF	STEWART INTL	NEWBURGH	NY	34	0.994384
KSYR	SYRACUSE HANCOCK INTL	SYRACUSE	NY	40	0.994069
FOK	THE FRANCIS S. GABRESKI	WESTHAMPTON BEACH	NY	64	0.992366
HPN	WESTCHESTER COUNTY	WHITE PLAINS	NY	40	0.994196
B16	WHITFORDS	WEEDSPORT	NY	35	0.994295
4F5	BELLEFONTAINE MUNICIPAL AIRPORT	BELLEFONTAINE	OH	16	0.995664
KCLE	CLEVELAND-HOPKINS INTL	CLEVELAND	OH	17	0.995527
KDAY	JAMES M COX DAYTON INTL	DAYTON	OH	16	0.995650
I68	LEBANON-WARREN COUNTY	UNKNOWN	OH	16	0.995645
1G5	MEDINA MUNICIPAL	MEDINA	OH	17	0.995540
OSU	OHIO STATE UNIVERSITY	COLUMBUS	OH	15	0.995678
KCMH	PORT COLUMBUS INTL	COLUMBUS	OH	15	0.995679

KRZT	ROSS COUNTY	CHILLICOTHE	OH	15	0.995691
KTOL	TOLEDO EXPRESS	TOLEDO	OH	16	0.995665
KAVK	ALVA RGNL	ALVA	OK	13	0.996077
KCQB	CHANDLER MUNICIPAL	CHANDLER	OK	13	0.996080
CHK	CHICKASHA	CHICKASHA	OK	13	0.996080
GCM	CLAREMORE REGIONAL	CLAREMORE	OK	13	0.996082
1K4	DAVID J PERRY	UNKNOWN	OK	13	0.996080
KMKO	DAVIS FIELD	MUSKOGEE	OK	13	0.996079
DUA	EAKER FIELD AIRPORT	EAKER	OK	13	0.996079
2O8	HINTON MUNICPAL	HINTON	OK	13	0.996080
KHBR	HOBART MUNICIPAL	HOBART	OK	13	0.996077
MIO	MIAMI	MIAMI	OK	13	0.996079
MDF	MORELAND MUNICIPAL	MORELAND	OK	13	0.996077
PVJ	PAULS VALLEY MUNICIPAL AIRPORT	PAULS VALLEY	OK	13	0.996080
PNC	PONCA CITY	PONCA CITY	OK	13	0.996082
K2K4	SCOTT FIELD	MANGUM	OK	13	0.996076
SNL	SHAWNEE	SHAWNEE	OK	13	0.996080
TQH	TAHLEQUAH	TAHLEQUAH	OK	13	0.996082
KTUL	TULSA INTL	TULSA	OK	13	0.996081
OKC	WILL ROGERS WORLD AIRPORT	OKLAHOMA CITY	OK	13	0.996080
YOW	OTTAWA AIRPORT	OTTAWA	ON	111	0.986311
S07	BEND MUNICIPAL	BEND	OR	33	0.998653
SLE	MCNARY FIELD	SALEM	OR	37	0.998406
KONP	NEWPORT MUNICIPAL	NEWPORT	OR	55	0.997059
PDX	PORTLAND INTL	PORTLAND	OR	35	0.998613
HIO	PORTLAND-HILLSBORO	HILLSBORO	OR	38	0.998537
S47	TILLAMOOK	TILLAMOOK	OR	46	0.997707
LGD	UNION COUNTY	LA GRANDE	OR	19	0.998959
KAGC	ALLEGHENY COUNTY	PITTSBURGH	PA	18	0.995492
KBFD	BRADFORD RGNL	BRADFORD	PA	19	0.995302
MDT	HARRISBURG INTL	HARRISBURG	PA	19	0.995306
KJST	JOHN MURTHA JOHNSTOWN-CAMBRIA COUNTY	JOHNSTOWN	PA	19	0.995461
LNS	LANCASTER	LANCASTER	PA	19	0.995250
ABE	LEHIGH VALLEY INTL	ALLENTOWN	PA	20	0.995057
PHL	PHILADELPHIA INTL	PHILADELPHIA	PA	22	0.995101
KPIT	PITTSBURGH INTL	PITTSBURGH	PA	18	0.995489
LHV	WILLIAM T. PIPER MEMORIAL	LOCK HAVEN	PA	19	0.995229
PVD	THEODORE FRANCIS GREEN STATE	PROVIDENCE	RI	117	0.987145
AND	ANDERSON REGIONAL	ANDERSON	SC	15	0.995651
KCHS	CHARLESTON AFB/INTL	CHARLESTON	SC	17	0.995577
KCAE	COLUMBIA METROPOLITAN	COLUMBIA	SC	17	0.995626
KGSP	GREENVILLE-SPARTANBURG INTL	GREER	SC	15	0.995674
KMYR	MYRTLE BEACH INTL	MYRTLE BEACH	SC	17	0.995576
KHON	HURON REGIONAL	HURON	SD	13	0.996099
FSD	JOE FOSS FIELD	SIOUX FALLS	SD	13	0.996098
1D1	MILBANK MUNICIPAL	MILBANK	SD	14	0.996065
KRAP	RAPID CITY REGIONAL	RAPID CITY	SD	13	0.996097
YXE	SASKATOON AIRPORT	SASKATOON	SK	132	0.977854
PHT	HENRY COUNTY	PARIS	TN	15	0.995865
CHA	LOVELL FIELD	CHATTANOOGA	TN	15	0.995802

TYS	MC GHEE TYSON	KNOXVILLE	TN	15	0.995645
KMEM	MEMPHIS INTL	MEMPHIS	TN	15	0.995966
KBNA	NASHVILLE INTL	NASHVILLE	TN	16	0.995801
TRI	TRI-CITIES REGIONAL TN/ VA AIRPORT	UNKNOWN	TN	14	0.995695
KABI	ABILENE REGIONAL	ABILENE	TX	16	0.995903
ADS	ADDISON	DALLAS	TX	15	0.996024
ALI	ALICE	ALICE	TX	121	0.987122
AMA	AMARILLO INTL	AMARILLO	TX	14	0.996057
AUS	AUSTIN-BERGSTROM INTL	AUSTIN	TX	22	0.995196
KLBX	BRAZORIA COUNTY	ANGLETON/LAKE JACKSON	TX	24	0.995068
7F9	COMANCHE	COMANCHE	TX	17	0.995847
CRP	CORPUS CHRISTI INTL	CORPUS CHRISTI	TX	107	0.988355
KDAL	DALLAS LOVE FIELD	DALLAS	TX	15	0.996024
KDFW	DALLAS-FT WORTH INTL	DALLAS-FT WORTH	TX	15	0.996028
KDWH	DAVID WAYNE HOOKS MEMORIAL	HOUSTON	TX	21	0.995624
KDRT	DEL RIO INTL	DEL RIO	TX	51	0.991792
ELP	EL PASO INTL	EL PASO	TX	76	0.989796
KEFD	ELLINGTON FIELD	HOUSTON	TX	22	0.995572
KIAH	GEORGE BUSH INTERCONTINENTAL/HOUSTON	HOUSTON	TX	21	0.995614
KAXH	HOUSTON-SOUTHWEST	HOUSTON	TX	23	0.995462
KLBB	LUBBOCK INTL	LUBBOCK	TX	15	0.995998
MAF	MIDLAND INTL	MIDLAND	TX	22	0.995350
KCXO	MONTGOMERY COUNTY	CONROE	TX	20	0.995689
OSA	MOUNT PLEASANT MUNICIPAL	MOUNT PLEASANT	TX	13	0.996077
KSJT	SAN ANGELO RGNL/MATHIS FLD	SAN ANGELO	TX	22	0.995388
KSAT	SAN ANTONIO INTL	SAN ANTONIO	TX	33	0.994012
KSGR	SUGAR LAND MUNI/HULL FLD	HOUSTON	TX	23	0.995459
SGR	SUGARLAND MUNI/HULL FIELD	SUGAR LAND	TX	23	0.995459
KTYR	TYLER POUNDS RGNL	TYLER	TX	14	0.996060
KHRL	VALLEY INTL	HARLINGEN	TX	641	0.898914
KIWS	WEST HOUSTON	HOUSTON	TX	22	0.995532
KHOU	WILLIAM P HOBBY	HOUSTON	TX	22	0.995547
BMC	BRIGHAM CITY	BRIGHAM CITY	UT	13	0.998992
KCDC	CEDAR CITY RGNL	CEDAR CITY	UT	42	0.997762
KKNB	KANAB MUNICIPAL	KANAB	UT	43	0.996807
LGU	LOGAN-CACHE	LOGAN	UT	13	0.999029
SLC	SALT LAKE CITY INTL	SALT LAKE CITY	UT	13	0.998980
MTV	BLUE RIDGE	MARTINSVILLE	VA	14	0.995585
LVL	BRUNSWICK MUNICIPAL	LAWRENCEVILLE	VA	17	0.995513
KCHO	CHARLOTTESVILLE-ALBEMARLE	CHARLOTTESVILLE	VA	17	0.995532
FKN	FRANKLIN MUNICIPAL-JOHN BEVERLY ROSE	FRANKLIN	VA	20	0.995374
JYO	LEESBURG MUNICIPAL/ GODFREY FIELD	LEESBURG	VA	18	0.995458
HEF	MANASSAS REGIONAL/ HARRY P. DAVIS FIELD	MANASSAS	VA	18	0.995460
KPHF	NEWPORT NEWS/ WILLIAMSBURG INTL	NEWPORT NEWS	VA	21	0.995339
KORF	NORFOLK INTL	NORFOLK	VA	22	0.995311
RIC	RICHMOND INTL	RICHMOND	VA	18	0.995495
AKQ	WAKEFIELD MUNICIPAL	WAKEFIELD	VA	20	0.995372

WAL	WALLOPS FLIGHT FACILITY	WALLOPS ISLAND	VA	30	0.995035
BTV	BURLINGTON INTL	BURLINGTON	VT	162	0.980835
BFI	BOEING FIELD/ KING COUNTY INTL	SEATTLE	WA	37	0.998518
FHR	FRIDAY HARBOR	FRIDAY HARBOR	WA	41	0.996556
KMWH	GRANT COUNTY INTL	MOSES LAKE	WA	32	0.998719
KSEA	SEATTLE-TACOMA INTL	SEATTLE	WA	37	0.998517
KGEG	SPOKANE INTL	SPOKANE	WA	13	0.999078
KGRB	AUTIN STRAUBEL INTL	GREEN BAY	WI	22	0.995409
3T3	BOYCEVILLE MUNICIPAL	BOYCEVILLE	WI	21	0.995381
KCWA	CENTRAL WISCONSIN	MOSINEE	WI	25	0.995350
MSN	DANE COUNTY REGIONAL- TRUAX FIELD	MADISON	WI	17	0.995597
SUE	DOOR COUNTY CHERRYLAND	STURGEON BAY	WI	50	0.994120
FLD	FOND DU LAC COUNTY	FOND DU LAC	WI	17	0.995551
MKE	GENERAL MITCHELL INTL	MILWAUKEE	WI	15	0.995638
MTW	MANITOWOC COUNTY	MANITOWOC	WI	17	0.995552
KATW	OUTAGAMIE COUNTY RGNL	APPLETON	WI	18	0.995502
RHI	RHINELANDER-ONEIDA COUNTY	RHINELANDER	WI	70	0.993466
JVL	SOUTHERN WISCONSIN REGIONAL AIRPORT	JANESVILLE	WI	15	0.995687
RYV	WATERTOWN MUNICIPAL	WATERTOWN	WI	17	0.995619
ETB	WEST BEND MUNICIPAL	WEST BEND	WI	17	0.995605
OSH	WITTMAN REGIONAL	OSHKOSH	WI	17	0.995537
KMGW	MORGANTOWN MUNI- WLB HART FLD	MORGANTOWN	WV	17	0.995528
KPKB	WOOD CO- GILL ROBB WILSON FLD	PARKERSBURG	WV	15	0.995642
EVW	EVANSTON-UNITA CNTY- BURNS FLD	EVANSTON	WY	13	0.999028
KCPR	NATRONA COUNTY INTL	CASPER	WY	14	0.996063
SAA	SHIVELY FIELD	SARATOGA	WY	13	0.996069

Figure 9-1 WAAS LPV Availability

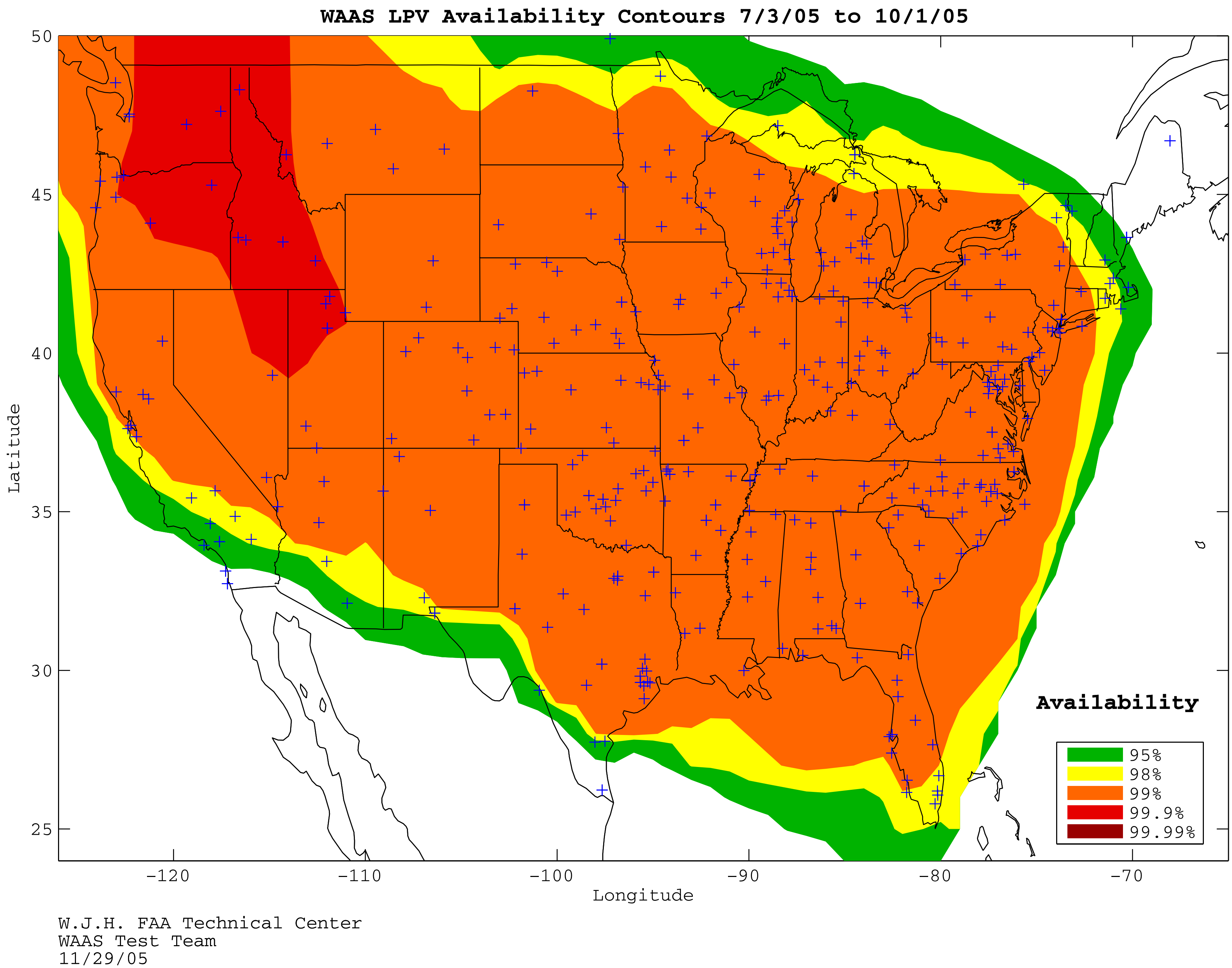
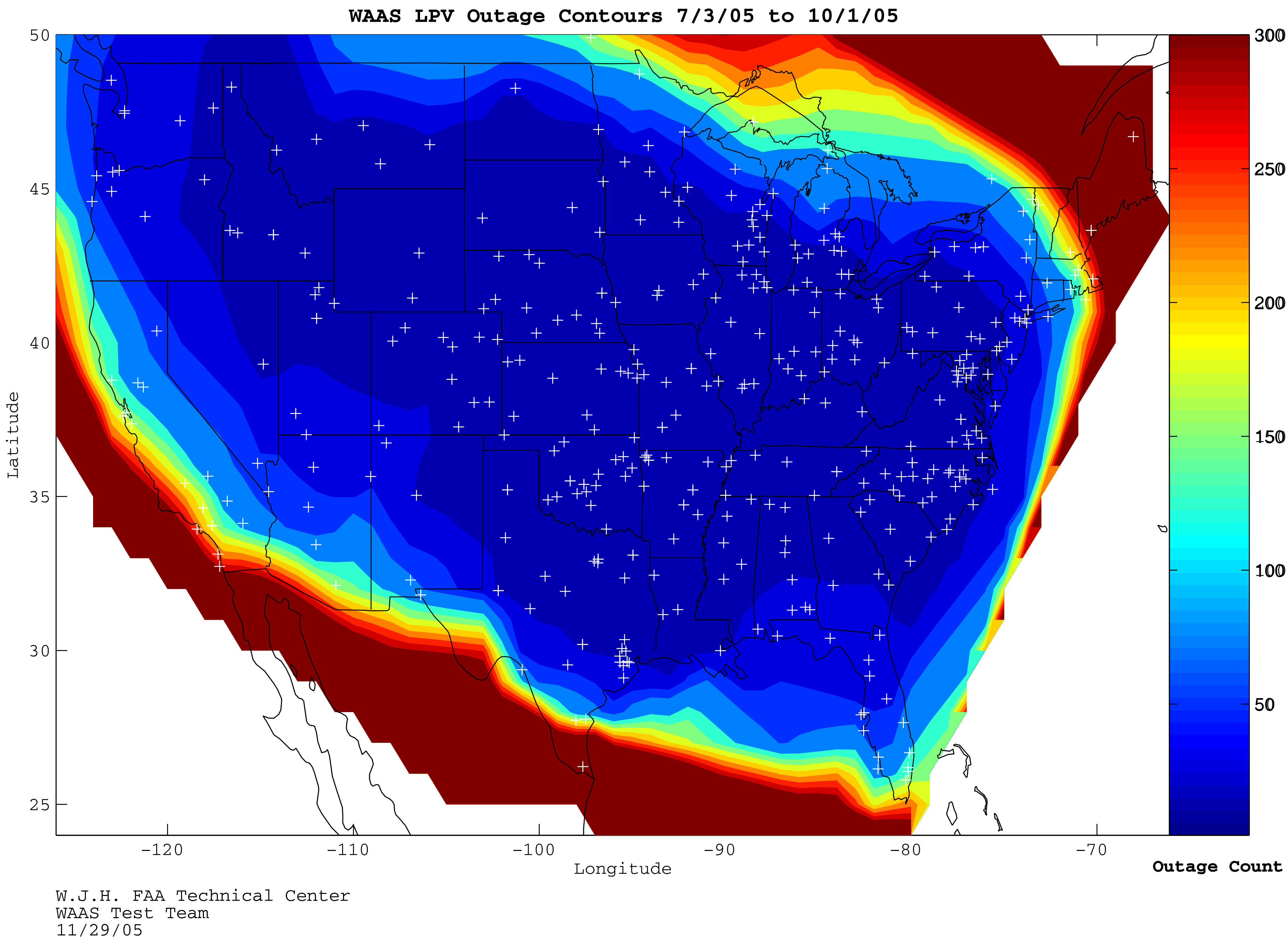


Figure 9-2 WAAS LPV Outage



10.0 WAAS DETERMINISTIC CODE NOISE AND MULTIPATH BOUNDING ANALYSIS

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

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

Statistics are calculated on how well the 0.1 multiples of the deterministically estimated standard deviation bounds the difference between the leveled truth and the real time smoothed measurements. Those statistics are then compared to a theoretical gaussian distribution and an extensive set of plots are generated and manually reviewed. Table 10.1 recaps the results of that manual analysis.

Table 10-1 CNMP Bounding Statistics

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

New York	A	green	blue	blue	blue	blue	green	yellow	blue	blue	yellow	blue	blue
	B	yellow	blue	blue	blue	blue	green	blue	blue	blue	blue	yellow	red
	C	blue	green	blue	blue	blue	blue	green	blue	blue	blue	yellow	yellow
Oakland	A	green	red	yellow	blue	red	blue	blue	green	blue	blue	yellow	blue
	B	yellow	yellow	blue	blue	blue	blue	green	yellow	green	blue	blue	blue
	C	yellow	yellow	red	blue	green	green	blue	blue	yellow	green	red	green
Salt Lake City	A	blue	blue	blue	blue	blue	green	blue	blue	blue	green	green	blue
	B	blue	blue	blue	blue	blue	blue	blue	blue	blue	blue	green	blue
	C	blue	blue	green	blue	blue	blue	green	blue	blue	blue	green	blue
San Juan	A	blue	green	green	blue	green	blue	green	yellow	blue	blue	yellow	green
	B	red	blue	blue	yellow	blue	yellow	blue	blue	blue	green	blue	yellow
	C	green	red	blue	yellow	green	green	green	red	yellow	yellow	green	yellow
Seattle	A	blue	green	blue	blue	blue	blue	blue	blue	blue	blue	blue	green
	B	blue	blue	green	blue	blue	green	blue	blue	blue	blue	blue	blue
	C	blue	blue	blue	blue	blue	blue	blue	red	blue	green	blue	blue
Washington, DC	A	blue	blue	blue	blue	blue	blue	blue	blue	green	blue	blue	blue
	B	blue	blue	blue	blue	blue	blue	blue	blue	blue	blue	blue	blue
	C	blue	blue	blue	green	blue	blue	blue	blue	blue	blue	blue	yellow

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

Appendix A: Glossary

General Terms and Definitions

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

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

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

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

CONUS. Continental United States.

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

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

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

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

GEO. Geostationary Satellite.

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

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

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

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

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

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

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

LNAV. Lateral Navigation.

MOPS. Minimum Operational Performance Standards.

Navigation Message. Message structure designed to carry navigation data.

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

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

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

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

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

SV. Satellite Vehicle.

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

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

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

VNAV. Vertical Navigation.

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