Memo

Water & Earth Technologies, Inc.
Water Resources and Environmental Consulting

Date: March 08, 2006

To: Kevin Stewart, P.E., Chad Kudym

From: Markus Ritsch, P.E.

Subject: **February 2006 ALERT Data Analysis**

I. ALERT Data Source

Raw ALERT data reports extracted from the Urban Drainage and Flood Control District's Nova Star 4.0 base station (ALERT 2) are analyzed for the period February 1 through February 28, 2006.

II. General System Analysis Summary

A total of 158,525 individual data transmissions were analyzed. Meteorological sensors accounted for eighty-six (86) percent of the total transmissions. Wind reports account for fifty-two (52) percent of the total traffic or 82,133 records. In comparison, reports from precipitation sensors (4,808 reports) account for only three (3) percent of the total transmissions. February was a dry and windy month which is typical for the Colorado Front Range.

Ninety-nine (99) percent of the received data reports were flagged as "good" by the Nova Star validation process. Roughly two thousand (2,314) reports were flagged as "bad". Of these "bad" reports, more than half (1,178) originated from the Wind Gust sensor (ID 2189) at Squaw Mountain. Another two hundred and fifty-four (254) "bad" reports originated from the Wind Speed Average sensor (ID 2187) at Squaw Mountain. The reception of "bad" data reports from the Squaw Mountain sensor ID's 2189 and 2187 has been a consistent theme for the past two months. The reason for these "bad" reports should be investigated and understood.

The system-wide radio traffic load was approximately five thousand six hundred (5,661) reports per day with an average hourly load of two hundred and thirty five (235) reports. The peak hourly traffic load was just under four hundred (387) reports and occurred on February 5th between six and seven in the morning. A plot of average and peak hourly traffic loading by month is provided.

The sensors that reported most frequently are Wind Speed Average and Azimuth sensors including:

1. Ward C-1 (sensor ID 4707) with 4,289 reports or one report every nine minutes, and

2. Salisbury Park (sensor ID 2727) with 3,209 reports or one report every twelve to thirteen minutes.

The reports from these sensors are distributed evenly over the entire month.

III. Rain Sensor Timer Reporting Summary

System-wide, the base station received eighty-seven (87) percent of the non-incrementing timer reports, which is very high. The following table summarizes those sensors with the worst timer transmission performance (Table 1).

Table 1. Monthly Summary of Sensors with Poor Timer Performance

Jan	Feb*	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1010	1460										
1460	1660										
1640	4240										

*-February sensors: Stapleton "Urban Farm" (1460), SPR at Henderson (1660), Sunset (4240)

IV. Rain Sensor Event Reporting Summary

A. District-Wide Total Tip/Count Statistics

The incrementing reports from individual 1-mm rain sensors were analyzed to quantify the District-wide total monthly tips (Table 2). A graphical map presentation of the total monthly tip/count by station is provided.

Table 2. District-Wide Total Tip/Count Statistical Summary

Statistical Parameter	Value	Comments
Mean	5.92	Only the 1-mm rain sensors were included in the analysis
Median	5.0	Only the 1-mm rain sensors were included in the analysis
Standard deviation	4.01	Only the 1-mm rain sensors were included in the analysis
Mean plus three standard deviations	17.95	All sensor data for the month are within the Mean +/- 3 Std Dev
Minimum total count	1	A total of 9 sensors recorded only 1 tip
Maximum total count	16	This sensor was within 3 std deviations of the mean

A summary by month of the District-wide mean total tip/count is presented (Table 3).

Table 3. Monthly Summary of District-Wide Mean Total 1-mm Tip/Count

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
4.62	5.92										

B. Sensor-by-Sensor Incrementing Count Summary

The system-wide reception of incrementing rain/snow tip reports was ninety-seven (97) percent, which is very high. Several sensors were identified for further inspection of their incrementing tip/count sequence. These sensors are Twin Sisters (ID 4080), Johnny Park (ID 4310), and Louisville Lake (ID 4750).

The rain sensor at Twin Sisters (ID 4080) included a sequential transmission that jumped by more than six (6) counts. Further review of the time series showed that erroneous transmissions were received on February 17th (raw count of 2013) and February 18th (raw count of 2015) that were programmatically flagged as valid data. These erroneous data transmissions resulted in two incremental tips that were counted as good reports when in fact they were not.

The rain sensor at Johnny Park (ID 4310) recorded the highest number of incrementing reports with a total of sixteen (16) tips for the month. A further visual inspection of the data from this sensor showed no anomalous data.

The rain sensor at Louisville Lake (ID 4750) included sequential transmissions that jumped by more than six (6) counts. Further review of the time series showed that during the period February 24th through February 28th the raw count values jumped between two different sequential series. The first series is the original series that was consistently propagated throughout the month ending at 274. A second series developed on the 24th in the range of 286. The base station software has a difficult time trying to programmatically determine which series is correct. Erroneous tip/count values resulted in the validated data for this station.

V. Issues Requiring Follow-Up Work

Further investigation into the following issues is recommended:

1. As with January, the Squaw Mountain sensors (ID 2189 and 2187) show a large amount of invalid or "bad" data in the NovaStar database. Are the validation parameters correctly defined within NovaStar?

2. Continue to observe data transmissions from Twin Sisters (ID 4080) and Louisville Lake (ID 4750) for possible problems with their increment reporting.

3. Continue to observe the non-incrementing timer transmissions from Stapleton "Urban Farm" (1460) and SPR at Henderson (1660) for possible problems with their timer reporting.

General System Analysis

Database Name	P:\A207-UDFCD Data Analysis\data_extracts\Novastar_extract_200602.mdb

First Date in Database	2/1/06 12:00 AM	**Total Days**	28.0
Last Date in Database	2/28/06 11:59 PM	**Total Hours**	672.0

Total Records Analyzed	158525

Records by Group

Group	Count	Percent
Wind Gust	33494	21%
Relative Humidity	24726	16%
Temperature	22799	14%
Wind Speed Average & Azimuth	22575	14%
Wind Direction	15455	10%
Wind Speed Average	10609	7%
Battery Voltage Digital	4873	3%
Precipitation	4808	3%
Water Level PT-HSE	4362	3%
Solar Radiation	3620	2%
Barometric Pressure	2386	2%
Battery Voltage HSE	2298	1%
Water Level Float	1900	1%
Fuel Moisture	1282	1%
Fuel Temperature	1271	1%
Repeater Pass List	854	1%
Battery Voltage Analog	613	0%
Water Level PT	179	0%
Longmont Flow Gage	110	0%
12Hr Status Report	103	0%
Handar 585 ALARM Status	65	0%
Soil Moisture	61	0%
Longmont Water Level PT	47	0%
Precipitation-ASCII	26	0%
Repeater ON Count	5	0%
Repeater Battery Check	1	0%
Repeater Status Report	1	0%
Snow (water equiv.)	1	0%
Solar Power	1	0%
Total	158525	

Records by Major Group

Group	Count	Percent
Meteorologic Sensors	135664	86%
Sensor Status Transmissions	8808	6%
Water Level Sensors	6598	4%
Rain Sensors	4834	3%
Soil and Fuel Sensors	2614	2%
Total	158518	

Records by Validation Type

Type	Code	Count	Percent
Good	0	156211	99%
Questionable	1	2314	1%
	Total	158525	

Sensors With Most Invalid Data

Description	Sensor	Reports
Squaw Mountain	2189	1178
Squaw Mountain	2187	254
Maple Grove Resv.	1003	55
Quincy Reservoir	753	44
Blue Mountain	139	37

Traffic Loading Summary

Alert Reports	158525	
Average Daily Traffic	5661	
Average Hourly Traffic	235	
Median Hourly Traffic	240	hour beginning
Peak Hourly Traffic	387	2/5/06 6:00 AM

Total Number of Sensors Defined	**Total Number of Sensors Reporting**
780	367

Reports per Sensor (highest)

Description	Sensor	Reports	Fraction of Total
Ward C-1	4707	4289	3%
Salisbury Park	2727	3209	2%
Urban Farm	1465	3173	2%
Urban Farm	1467	3108	2%
Squaw Mountain	2189	2565	2%
Urban Farm	1464	2556	2%
Diamond Hill	1421	2540	2%
Louisville Lake	4747	2496	2%
Urban Farm	1466	2488	2%
Castle Rock	2744	2441	2%

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Average and Peak ALERT Traffic
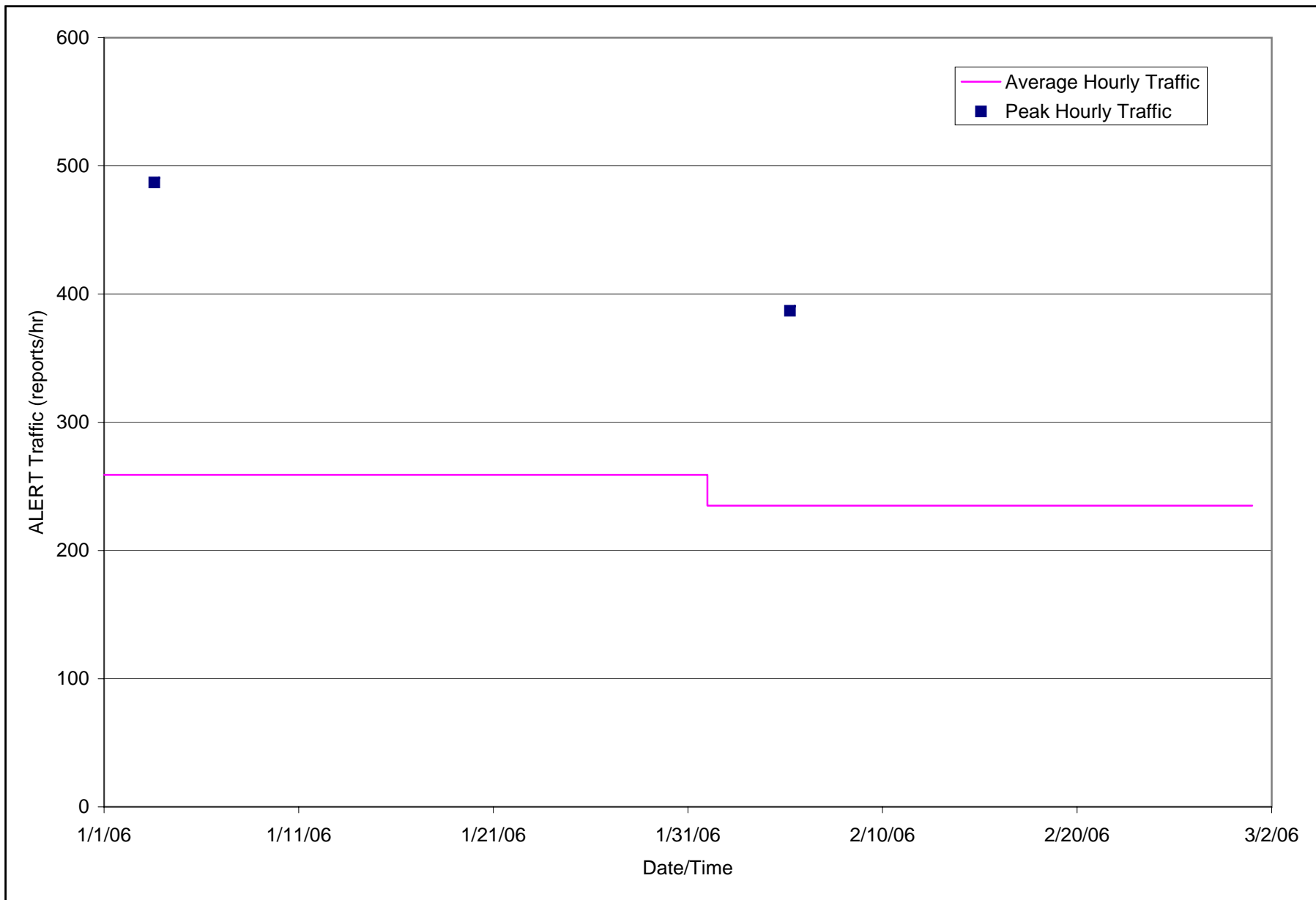
Chart showing ALERT Traffic (reports/hr) on the y-axis (0 to 600) versus Date/Time on the x-axis (1/1/06 to 3/2/06). The legend indicates a pink line for "Average Hourly Traffic" and dark blue squares for "Peak Hourly Traffic".

Rain Timer Performance

			systemwide average (days) 0.5408	Analyze Rain Sensors	Systemwide Average 87%
Rain Sensors	**Description**	**Number of Received Timer Reports**	**Average Timer Interval**	**Number of expected Timer Reports**	**Performance**
140	Blue Mountain	50	13:02	56.00	89%
740	Smoky Hill	54	12:13	56.00	96%
750	Quincy Reservoir	53	12:27	56.00	95%
860	Sand Cr at Colfax	22	2:54	56.00	39%
900	Aurora Reservoir	54	12:13	56.00	96%
1000	Maple Grove Resv.	52	12:28	56.00	93%
1420	Diamond Hill	51	13:00	56.00	91%
1440	Elbert	51	12:57	56.00	91%
1460	Urban Farm	24	3:16	56.00	43%
1480	Third Creek at DIA	49	13:30	56.00	88%
1520	Marston Lake North	53	12:28	56.00	95%
1640	SPR at Union Ave.	49	13:16	56.00	88%
1660	SPR at Henderson	37	18:00	56.00	66%
1700	Cherry Cr @ Champa	49	13:31	56.00	88%
1810	Sand Creek at mouth	49	13:01	56.00	88%
1920	Brighton	52	12:43	56.00	93%
2190	Squaw Mountain	49	13:30	56.00	88%
2210	Hiwan G.C.	52	12:43	56.00	93%
2220	Evergreen Lake	54	12:11	56.00	96%
2320	Choke Cherry Resvr	179		56.00	
2330	Morrison	46	14:11	56.00	82%
2710	Highlands Ranch WTP	51	12:58	56.00	91%
2730	Salisbury Park	52	12:42	56.00	93%
2750	Castle Rock	51	12:57	56.00	91%
2820	Haskins Gulch Conf	54	12:13	56.00	96%
4010	Cresent	47	12:33	56.00	84%
4020	Rio Grande	53	12:27	56.00	95%
4030	Red Garden	52	12:44	56.00	93%
4040	Martin Gulch	52	12:13	56.00	93%
4050	Walker Ranch	51	12:59	56.00	91%
4060	Lakeshore	43	14:25	56.00	77%
4070	Bear Peak	53	12:42	56.00	95%
4080	Twin Sisters	48	12:45	56.00	86%
4090	Magnolia	48	13:35	56.00	86%
4100	Filter Plant	54	12:13	56.00	96%
4110	Betasso	53	12:15	56.00	95%
4130	Swiss Peaks	44	15:09	56.00	79%
4140	Logan Mill	45	14:25	56.00	80%
4150	Gold Hill	47	13:38	56.00	84%
4160	Sunshine	55	11:58	56.00	98%
4170	Pine Brook	46	13:09	56.00	82%
4180	Gold Lake	45	13:35	56.00	80%
4190	Slaughterhouse	46	13:57	56.00	82%
4200	Lazy Acres	50	13:19	56.00	89%
4220	Fling's	47	14:11	56.00	84%
4230	Golden Age	53	12:26	56.00	95%
4240	Sunset	41	14:48	56.00	73%
4250	Geer Canyon	50	12:48	56.00	89%
4260	Taylor Mountain	54	12:12	56.00	96%
4270	Cannon Mountain	54	12:11	56.00	96%
4290	Red Hill	55	11:58	56.00	98%
4300	Big Elk Park	50	12:43	56.00	89%
4310	Johnny Park	50	13:43	56.00	89%
4330	Indian Ruins	52	12:27	56.00	93%
4340	Riverside	53	12:27	56.00	95%
4350	Conifer Hill	51	12:45	56.00	91%
4360	Justice Center	51	12:59	56.00	91%
4470	Little Narrows	46	12:31	56.00	82%
4490	Apple Valley	52	12:40	56.00	93%
4510	Pinewood Springs	44	15:08	56.00	79%
4520	Eagle Ridge	51	12:48	56.00	91%
4530	Winiger Ridge	46	14:18	56.00	82%
4560	Lyons Diversion NSV	46	14:07	56.00	82%
4570	St. Antons	48	13:42	56.00	86%
4710	Ward C-1	51	12:58	56.00	91%
4730	Sugarloaf	48	13:52	56.00	86%
4750	Louisville Lake	44	12:18	56.00	79%
4770	Cal-Wood Ranch	48	13:57	56.00	86%
4790	Button Rock	52	12:29	56.00	93%
4810	Shanahan Ridge	46	14:11	56.00	82%
4820	Doudy Draw	46	14:31	56.00	82%
4830	SBC @ San Souci	44	14:29	56.00	79%
4840	SBC@S Boulder Ditch	47	13:40	56.00	84%
4850	Porphory Mtn	46	12:33	56.00	82%
4860	Fairview Peak	48	13:40	56.00	86%

Rain Timer Performance

	total number of gages	
	74	
% of reports received	frequency	% of gages receiving % or reports or greater
0%	0	100%
10%	0	100%
20%	0	100%
30%	0	100%
40%	1	99%
50%	1	97%
60%	0	97%
70%	1	96%
80%	6	88%
90%	31	46%
100%	34	0%
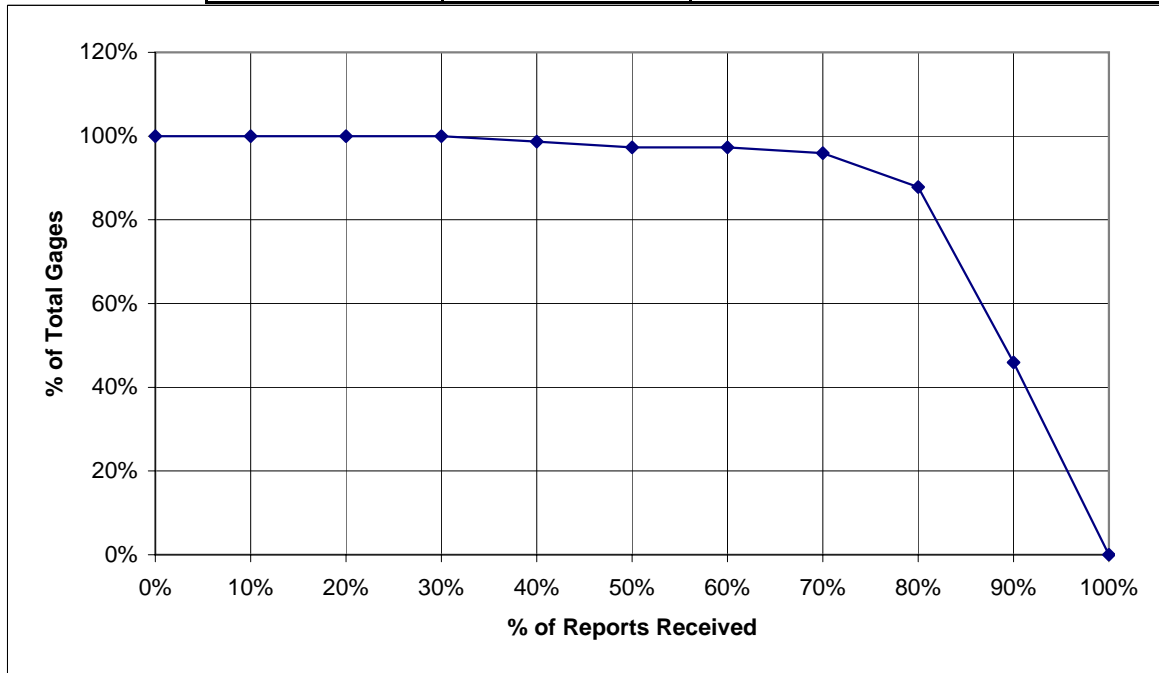
Number of Timer Reports Received

860, 1460, 1660   4240, 4060, 4130, 4510, 4750, 4830

Number of Reports
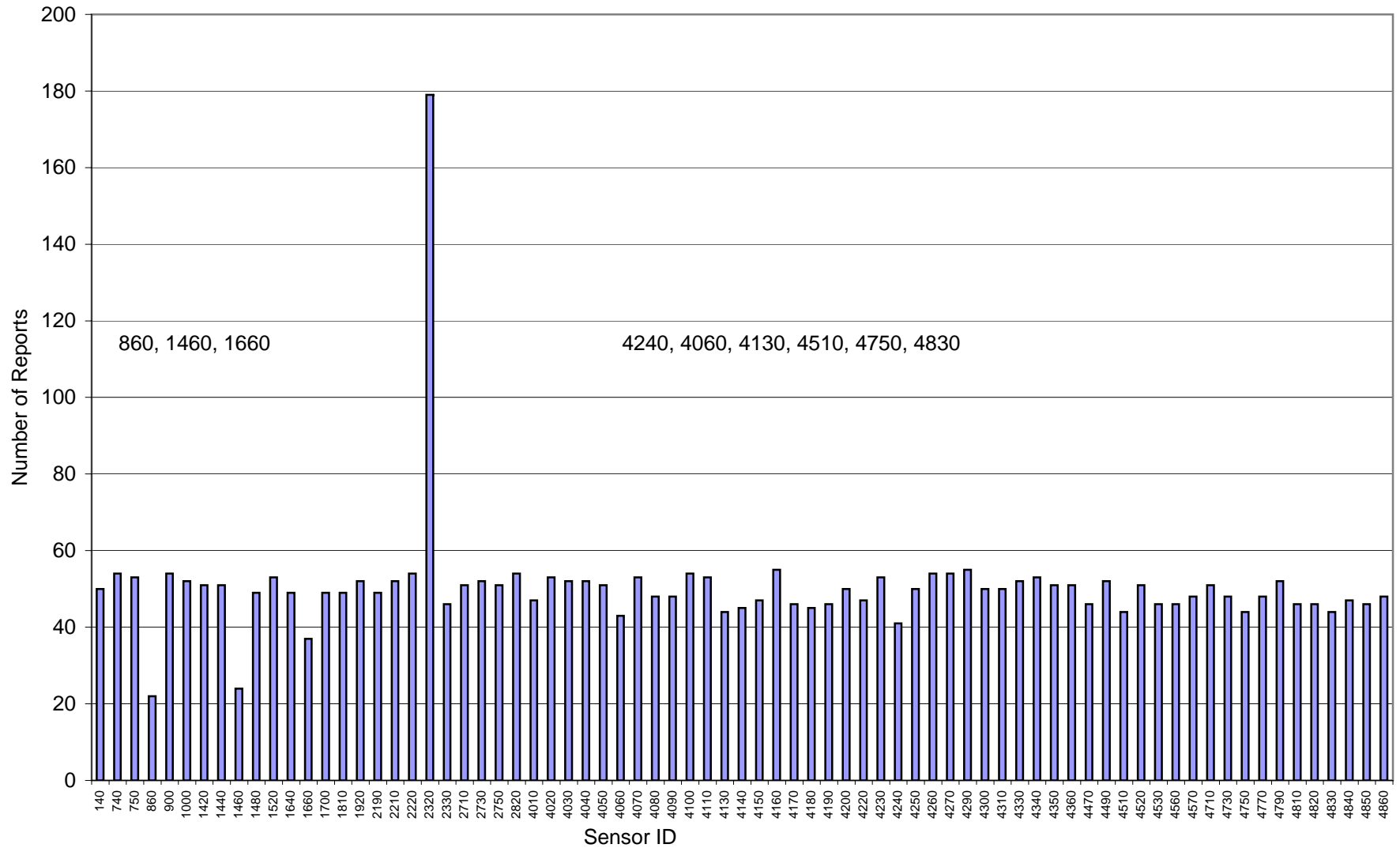
Sensor ID

Sensors with performance <80% noted

Rain Event Performance				
		Reports Received	356	Analyze Rain Sensors
	Systemwide Avg	Total Tips	370	
	97%	Data Loss	3.78%	

Rain Sensor	Total Performance	Number of 1-tips	Number of 2-tips	Number of 3-tips	Number of 4-tips	Number of 5-tips	Number of 6-tips	Number of >6-tips	Number of actual tips	Number of expected tips	Number of missed tips	Number of hold-off transmissions	Bucket size from Sensordef
140	100%	3	0	0	0	0	0	0	3	3	0	0	0.0393701
860	100%	1	0	0	0	0	0	0	1	1	0	0	0.0393701
1000	100%	7	0	0	0	0	0	0	7	7	0	0	0.0393701
1420	100%	5	0	0	0	0	0	0	5	5	0	0	0.0393701
1460	100%	1	0	0	0	0	0	0	1	1	0	0	0.0393701
1520	100%	2	0	0	0	0	0	0	2	2	0	0	0.0393701
1640	100%	1	0	0	0	0	0	0	1	1	0	0	0.0393701
1700	100%	1	0	0	0	0	0	0	1	1	0	0	0.0393701
1810	100%	1	0	0	0	0	0	0	1	1	0	0	0.0393701
1920	100%	1	0	0	0	0	0	0	1	1	0	0	0.0393701
2210	100%	1	0	0	0	0	0	0	1	1	0	0	0.0393701
2320	100%	4	0	0	0	0	0	0	4	4	0	0	0.0393701
2330	100%	2	0	0	0	0	0	0	2	2	0	0	0.0393701
2710	100%	1	0	0	0	0	0	0	1	1	0	0	0.0393701
2820	100%	2	0	0	0	0	0	0	2	2	0	0	0.0393701
4010	86%	5	1	0	0	0	0	0	6	7	1	0	0.0393701
4020	100%	3	0	0	0	0	0	0	3	3	0	0	0.0393701
4030	88%	6	1	0	0	0	0	0	7	8	1	0	0.0393701
4040	100%	11	0	0	0	0	0	0	11	11	0	0	0.0393701
4050	100%	5	0	0	0	0	0	0	5	5	0	0	0.0393701
4060	100%	4	0	0	0	0	0	0	4	4	0	0	0.0393701
4070	100%	9	0	0	0	0	0	0	9	9	0	0	0.0393701
4080	75%	2	1	0	0	0	0	1	3	4	1	0	0.0393701
4090	100%	11	0	0	0	0	0	0	11	11	0	0	0.0393701
4110	100%	11	0	0	0	0	0	0	11	11	0	0	0.0393701
4130	100%	6	0	0	0	0	0	0	6	6	0	0	0.0393701
4140	100%	8	0	0	0	0	0	0	8	8	0	0	0.0393701
4150	88%	6	1	0	0	0	0	0	7	8	1	0	0.0393701
4160	93%	12	1	0	0	0	0	0	13	14	1	0	0.0393701
4170	80%	3	1	0	0	0	0	0	4	5	1	0	0.0393701
4180	92%	10	1	0	0	0	0	0	11	12	1	0	0.0393701
4190	100%	12	0	0	0	0	0	0	12	12	0	0	0.0393701
4200	100%	12	0	0	0	0	0	0	12	12	0	0	0.0393701
4220	100%	5	0	0	0	0	0	0	5	5	0	0	0.0393701
4230	100%	3	0	0	0	0	0	0	3	3	0	0	0.0393701
4240	100%	4	0	0	0	0	0	0	4	4	0	0	0.0393701
4250	100%	10	0	0	0	0	0	0	10	10	0	0	0.0393701
4260	100%	4	0	0	0	0	0	0	4	4	0	0	0.0393701
4270	100%	3	0	0	0	0	0	0	3	3	0	0	0.0393701
4290	100%	14	0	0	0	0	0	0	14	14	0	0	0.0393701
4300	100%	2	0	0	0	0	0	0	2	2	0	0	0.0393701
4310	100%	16	0	0	0	0	0	0	16	16	0	0	0.0393701
4330	100%	4	0	0	0	0	0	0	4	4	0	0	0.0393701
4340	88%	6	1	0	0	0	0	0	7	8	1	0	0.0393701
4350	88%	6	1	0	0	0	0	0	7	8	1	0	0.0393701
4360	100%	10	0	0	0	0	0	0	10	10	0	0	0.0393701
4470	100%	10	0	0	0	0	0	0	10	10	0	0	0.0393701
4510	92%	11	1	0	0	0	0	0	12	13	1	0	0.0393701
4520	100%	5	0	0	0	0	0	0	5	5	0	0	0.0393701
4530	100%	6	0	0	0	0	0	0	6	6	0	0	0.0393701
4570	100%	5	0	0	0	0	0	0	5	5	0	0	0.0393701
4710	100%	1	0	0	0	0	0	0	1	1	0	0	0.0393701
4730	100%	2	0	0	0	0	0	0	2	2	0	0	0.0393701
4750	100%	6	0	0	0	0	0	1	6	6	0	0	0.0393701
4770	100%	7	0	0	0	0	0	0	7	7	0	0	0.0393701
4790	100%	2	0	0	0	0	0	0	2	2	0	0	0.0393701
4810	100%	4	0	0	0	0	0	0	4	4	0	0	0.0393701
4820	100%	5	0	0	0	0	0	0	5	5	0	0	0.0393701
4830	100%	5	0	0	0	0	0	0	5	5	0	0	0.0393701
4840	100%	10	0	0	0	0	0	0	10	10	0	0	0.0393701
4850	50%	2	0	0	1	0	0	1	3	6	3	0	0.01
4860	89%	7	1	0	0	0	0	0	8	9	1	0	0.01
	Total Tips	344	11	0	1	0	0						

Rain Event Performance
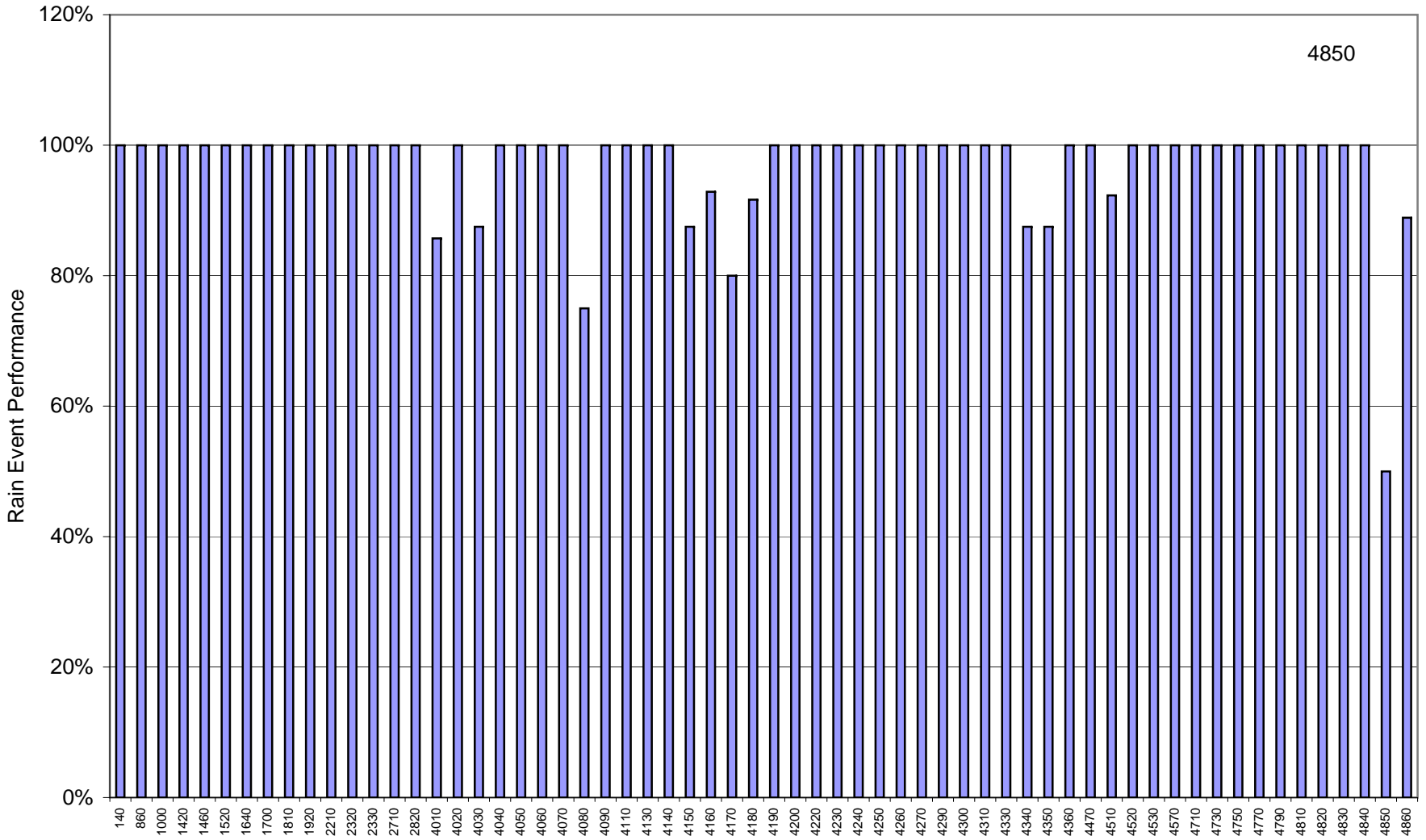
Measured Rain Event Analysis

Rain Sensor	(mm of rain measured) Measured Bucket Tips	Outliers Removed (mm of rain measured) Measured Bucket Tips		Expected Tip Data Analysis	
140	3	3		Mean	5.92
860	1	1		Median	5
1000	7	7		Std Deviation	4.01
1420	5	5		Mean - 3 st dev	-6.11
1460	1	1		Mean + 3 st dev	17.95
1520	2	2		Minimum	1
1640	1	1		Maximum	16
1700	1	1			
1810	1	1			
1920	1	1			
2210	1	1			
2320	4	4			
2330	2	2			
2710	1	1			
2820	2	2			
4010	7	7			
4020	3	3			
4030	8	8			
4040	11	11			
4050	5	5			
4060	4	4			
4070	9	9			
4080	4	4			
4090	11	11			
4110	11	11			
4130	6	6			
4140	8	8			
4150	8	8			
4160	14	14			
4170	5	5			
4180	12	12			
4190	12	12			
4200	12	12			
4220	5	5			
4230	3	3			
4240	4	4			
4250	10	10			
4260	4	4			
4270	3	3			
4290	14	14			
4300	2	2			
4310	16	16			
4330	4	4			
4340	8	8			
4350	8	8			
4360	10	10			
4470	10	10			
4510	13	13			
4520	5	5			
4530	6	6			
4570	5	5			
4710	1	1			
4730	2	2			
4750	6	6			
4770	7	7			
4790	2	2			
4810	4	4			
4820	5	5			
4830	5	5			
4840	10	10			

Total Bucket Tips
February 2006

- ○ 1 - 3
- ○ 4 - 6
- ● 7 - 9
- ● 10 - 12
- ● 13 - 16