

Memo



Date: April 14, 2006
To: Kevin Stewart, Chad Kudym
From: Markus Ritsch, P.E.
Subject: March 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 March 1 through March 31, 2006.

II. General System Analysis Summary

A total of 175,112 individual data transmissions were analyzed. Meteorological sensors account for eighty (80) percent of the total transmissions. Wind reports account for forty-seven (47) percent or 82,608 records. In comparison, reports from precipitation sensors (10,461 reports) account for only six (6) percent of the total. March was again a windy month which is typical for the Colorado Front Range.

Ninety-eight (98) percent of the received data reports were flagged as "good" by the Nova Star validation process. Roughly twenty-seven hundred (2,762) reports were flagged as "bad". Of these "bad" reports, just under half (1,311) originated from the Wind Gust sensor (ID 2189) at Squaw Mountain. Another one hundred (110) "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 three months.

The system-wide radio traffic loading was approximately five thousand six hundred (5,648) reports per day with an average hourly load of two hundred and thirty five (235) reports. The peak hourly traffic load was just over four hundred (433) reports and occurred on March 26th between ten and eleven in the morning. A plot of monthly average and peak hourly traffic loading is provided.

The sensors reporting most frequently this month include:

1. Salisbury Park (sensor ID 2727) with 3,739 reports or one report every twelve to thirteen minutes, and
2. Diamond Hill (ID 1421) with 2,932 reports, one report every fifteen minutes, and
3. Urban Farm (ID 1464) with 2,915 reports.

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

III. Rain Sensor Timer Reporting Summary

March is a difficult month to compute the system-wide timer performance statistics because many of the District stations were placed back into service during the month. In February a total of seventy-five (75) rain sensors were operational. By the end of March, a total of one hundred and forty-eight (148) rain sensors were operational. Partial reporting for the month is evident and this skews the timer reporting statistics. In order to obtain a consistent comparison to January and February, only those stations that were operational during January and February are summarized in the timer performance table below. Beginning next month, the timer reporting will be quantified for all stations.

For those stations that were operational in February and March, the base station received eighty-five (85) percent of the non-incrementing timer reports. The following table summarizes those rain sensors with the worst non-incrementing timer reporting 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									
1460	1660	4820									
1640	4240	4570									

*Stapleton "Urban Farm" (1460), Doudy Draw (4820), St. Antons (4570)

IV. Rain Sensor Event Reporting Summary

A. District-Wide Total Tip/Count Statistics

The incrementing reports from one hundred and forty-five (145) individual 1-mm rain sensors were analyzed to quantify the District-wide statistical total monthly tip summary (Table 2).

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

Statistical Parameter	Value	Comments
Mean	18.39	Only the 1-mm rain sensors were included in the analysis
Median	17	Only the 1-mm rain sensors were included in the analysis
Standard deviation	12.357	Only the 1-mm rain sensors were included in the analysis
Mean plus three standard deviations	55.46	All sensor data for the month are within the Mean +/- 3 Std Dev
Minimum total count	1	A total of 3 sensors recorded only 1 tip
Maximum total count	49	This sensor was within 3 std deviations of the mean

A monthly summary 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	18.39									

B. Sensor-by-Sensor Incrementing Count Summary

The system-wide reception rate of incrementing rain/snow tip reports for the month was ninety-two (92) percent. A total of 2,447 incrementing reports were received and a total of 2,667 were expected. The total loss of incrementing reports was 8.25 percent. The following table summarizes those sensors with the worst rain transmission performance (Table 4).

Table 4. Monthly Summary of Sensors with the Most Missed Tips

Jan	Feb	Mar*	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
640	4010	4530									
1640	4080	4170									
4490	4170	4820									

*Winiger Ridge (4530), Pine Brook (4170), Doudy Draw (4820)

Several sensors were identified for further inspection. These sensors are West Metro FS13 (ID 1370), Slaughterhouse (ID 4190), and Winiger Ridge (ID 4530).

The rain sensor at West Metro FS13 (ID 1370) included a sequential transmission that jumped by more than six (6) counts. Further review of the time series showed that this sensor was activated on March 7 between 1:45 PM and

2:00 PM. A sequential transmission during this period was observed that jumped by twenty-two (22) counts. Because this jump occurred while the field crew was working at the station, the large jump is not considered erroneous rather an artifact of the installation work at the site.

The rain sensor at Slaughterhouse (ID 4190) recorded the highest number of incrementing reports with a total of forty-nine (49) tips for the month. A further visual inspection of the data from this sensor showed no anomalous data.

The rain sensor at Winiger Ridge (ID 4530) had the largest number of missed tips. A further visual inspection of the data from this sensor showed no anomalous data. The sequential incrementing reports included eight (8) double-tip reports with no hold-off transmissions and one (1) triple-tip report. The sequential reports for this sensor look reasonable.

V. Issues from Last Month

The following issues were identified last month. Follow-up comments after reviewing the March data are shown in blue.

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. [The same trend continues in the month of March.](#)
2. Continue to observe data transmissions from Twin Sisters (ID 4080) and Louisville Lake (ID 4750) for possible problems with their increment reporting. [The incrementing data reports from both of these sensors looks good in March. No problems were identified.](#)
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. [The Stapleton rain sensor \(ID 1460\) continues to exhibit poor timer performance. This could indicate a marginal radio path or the station’s radio/antenna system is not functioning properly. The maintenance records for this station should be reviewed and the standing wave ratio and radio output power should be verified. The incrementing and non-incrementing data from the SPR at Henderson \(1660\) gage looked reasonable in March. No problems identified with this sensor.](#)

VI. Issues Identified this Month

Further investigation into the following issues is recommended:

1. The Squaw Mountain sensors (ID 2189 and 2187) show a large amount of invalid or “bad” data in the NovaStar database.
2. Continue to observe the non-incrementing timer transmissions from Stapleton “Urban Farm” (1460), Doudy Draw (4820), St. Antons (4570), and Crescent (4010) for possible problems with their timer reporting.
3. Continue to observe rain transmissions from Winiger Ridge (4530), Pine Brook (4170), and Doudy Draw (4820) for possible problems with their increment reporting.

General System Analysis

Database Name P:\A207-UDFCD-Data-Analysis\data_extracts\Novastar_extract_200603.mdb

First Date in Database	3/1/06 12:00 AM	Total Days	31.0
Last Date in Database	3/31/06 11:59 PM	Total Hours	744.0

Total Records Analyzed	175112
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Records by Group

Wind Gust	33621	19%
Relative Humidity	26536	15%
Temperature	24052	14%
Wind Speed Average & Azimuth	21015	12%
Wind Direction	16855	10%
Wind Speed Average	11117	6%
Precipitation	10453	6%
Water Level PT-HSE	6309	4%
Battery Voltage Digital	5506	3%
Battery Voltage HSE	4311	2%
Solar Radiation	4147	2%
Barometric Pressure	2590	1%
Water Level Float	2023	1%
Fuel Moisture	1421	1%
Fuel Temperature	1393	1%
Water Level PT	1370	1%
Repeater Pass List	984	1%
Battery Voltage Analog	613	0%
Handar 585 ALARM Status	390	0%
12Hr Status Report	162	0%
Longmont Flow Gage	113	0%
Soil Moisture	62	0%
Longmont Water Level PT	56	0%
Precipitation-ASCII	8	0%
Solar Power	2	0%
Total	175109	

Records by Major Group

Meteorologic Sensors	139933	80%
Sensor Status Transmissions	11968	7%
Rain Sensors	10461	6%
Water Level Sensors	9871	6%
Soil and Fuel Sensors	2876	2%
Total	175109	

Records by Validation Type

Good	0	172350	98%
Questionable	1	2762	2%
Total		175112	

Sensors With Most Invalid Data

Description	Sensor	Reports
Squaw Mountain	2189	1311
Squaw Mountain	2187	110
Quincy Reservoir	753	100
Salisbury Park	2727	68
Elbert	1439	54

Traffic Loading Summary

Alert Reports	175112
Average Daily Traffic	5649
Average Hourly Traffic	235
Median Hourly Traffic	232
Peak Hourly Traffic	433

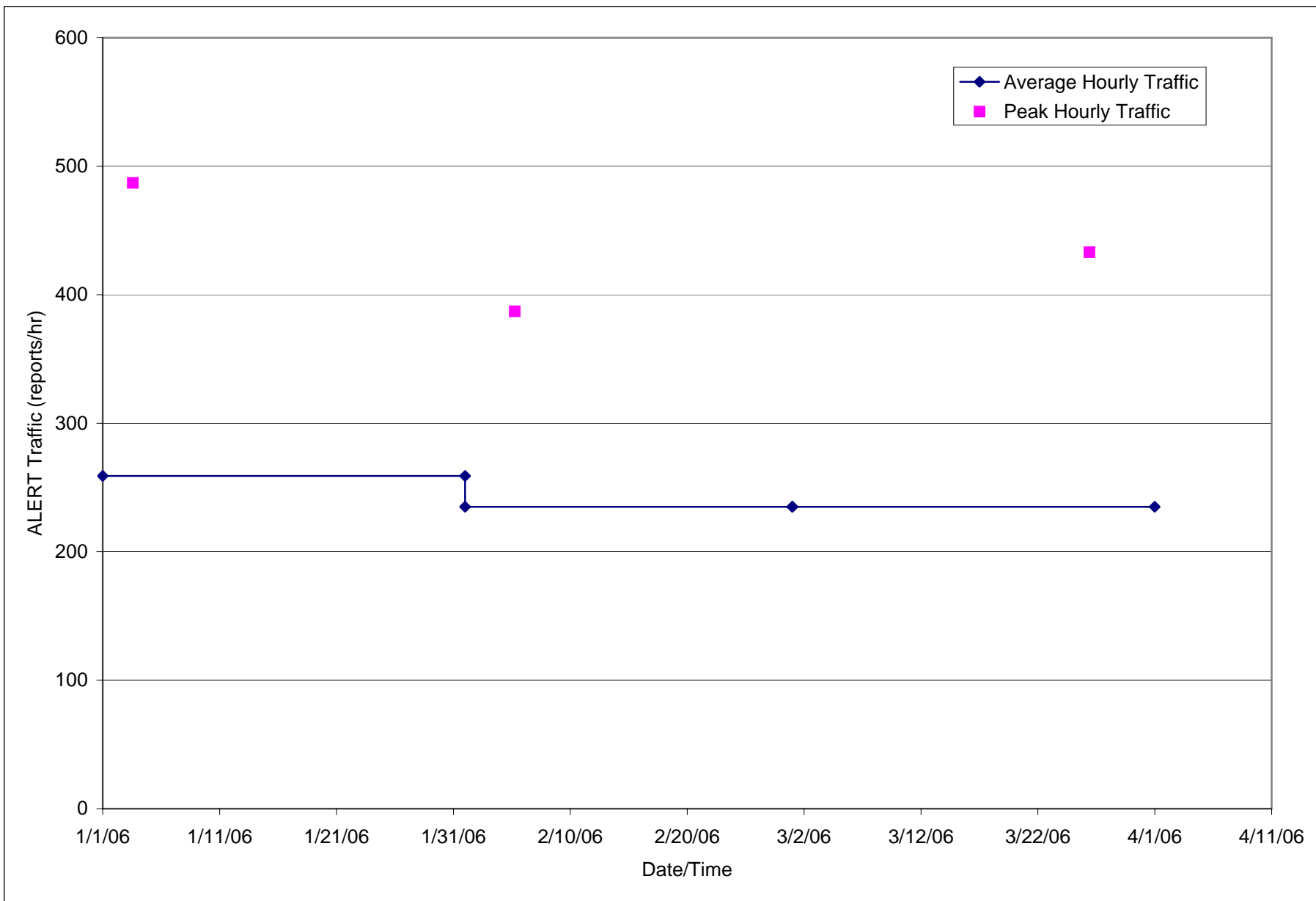
hour beginning
3/26/06 10:00 AM

Total Number of Sensors Defined 780 **Total Number of Sensors Reporting** 510

Reports per Sensor (highest)

Description	Sensor	Reports	Fraction of Total
Salisbury Park	2727	3739	2%
Diamond Hill	1421	2932	2%
Urban Farm	1464	2915	2%
Urban Farm	1466	2876	2%
Castle Rock	2747	2868	2%
Marston Lake North	1526	2808	2%
Elbert	1439	2793	2%
Urban Farm	1465	2788	2%
Urban Farm	1467	2766	2%
Quincy Reservoir	747	2722	2%

Average and Peak ALERT Traffic



Rain Timer Performance Analysis

Rain Timer Performance

Analyze Rain Sensors

systemwide average (days)
0.5443

Systemwide Average
70%

Rain Sensors	Description	Number of Received Timer Reports	Average Timer Interval	Number of expected Timer Reports	Performance
100	Carr Street	32	13:14	62.00	52%
110	Ralston Reservoir	45	13:16	62.00	73%
120	West Woods	31	12:46	62.00	50%
140	Blue Mountain	64	11:18	62.00	103%
150	Nott Creek	48	12:18	62.00	77%
200	Leyden Reservoir	45	13:03	62.00	73%
210	Leyden Confluence	25	13:44	62.00	40%
220	Upper Leyden	50	13:43	62.00	81%
300	Van Bibber Park	50	11:58	62.00	81%
310	Guy Hill Ranch	33	16:32	62.00	53%
330	Van Bibber @ Hwy 93	60	11:14	62.00	97%
400	Montview Park	25	13:51	62.00	40%
420	Expo Park	32	12:50	62.00	52%
430	Utah Park	30	12:54	62.00	48%
440	Fire Station #7	39	14:38	62.00	63%
500	Havana Park	40	14:54	62.00	65%
510	Virginia Court	42	12:38	62.00	68%
520	Jewell Detention	39	14:58	62.00	63%
530	Fire Station #19	45	12:59	62.00	73%
540	Parker/Mississippi	36	14:00	62.00	58%
600	Harvard Gulch Park	52	9:05	62.00	84%
610	Harvard @ Jackson	31	12:26	62.00	50%
620	Quincy/Highline	34	14:23	62.00	55%
630	Temple Pond at DTC	22	17:02	62.00	35%
640	Goldsmith @ Eastman	33	12:27	62.00	53%
650	liff Pond	29	13:26	62.00	47%
700	Toll Gate @ 6th	14	14:59	62.00	23%
710	Horseshoe Park Drop	16	13:40	62.00	26%
720	Confluence Pond	23	17:00	62.00	37%
730	No Name @ Quincy	25	14:12	62.00	40%
740	Smoky Hill	60	12:14	62.00	97%
750	Quincy Reservoir	57	12:30	62.00	92%
760	Mission Viejo Park	41	14:29	62.00	66%
800	Sable Ditch @ 18th	43	13:54	62.00	69%
810	Granby Ditch @ 6th	41	13:31	62.00	66%
820	ETG @ Buckley	40	15:00	62.00	65%
830	Side Creek Park	47	13:13	62.00	76%
840	Fire Station 12	44	13:49	62.00	71%
850	Flying J	24	16:15	62.00	39%
860	Sand Cr at Colfax	44	15:47	62.00	71%
870	Murphy Creek GC	25	16:25	62.00	40%
900	Aurora Reservoir	44	15:52	62.00	71%
910	H.G. @ Jackson/pre90	1		62.00	
1000	Maple Grove Resv.	63	11:02	62.00	102%
1010	Denver West	60	12:00	62.00	97%
1020	Lena @ Nolte Pond	32	12:46	62.00	52%
1030	NREL/S. Table Mtn.	55	13:30	62.00	89%
1040	Lena @ U.S. Hwy 6	57	12:48	62.00	92%
1050	Jeffco Fairgrounds	55	13:00	62.00	89%
1060	Heritage Square	56	11:56	62.00	90%
1100	Louisville Rec Ctr	35	14:41	62.00	56%
1110	Gunbarrel	40	13:34	62.00	65%
1200	Broomfield 3207	14	14:43	62.00	23%
1300	Hidden Lake	48	12:33	62.00	77%
1310	LDC at 64th	46	13:34	62.00	74%
1320	SPR at 3rd Ave	28	12:35	62.00	45%
1330	Roslyn	48	12:21	62.00	77%
1340	Sanderson at Xavier	32	12:28	62.00	52%
1350	Chatfield COE	39	14:14	62.00	63%
1360	Denver Zoo	44	13:03	62.00	71%
1370	West Metro FS13	34	16:49	62.00	55%
1400	Upper Sloan Det.	45	13:36	62.00	73%
1420	Diamond Hill	61	12:02	62.00	98%
1440	Elbert	50	15:01	62.00	81%
1460	Urban Farm	27	2:25	62.00	44%
1480	Third Creek at DIA	65	11:22	62.00	105%
1500	Powers Park	16	13:40	62.00	26%
1520	Marston Lake North	61	11:34	62.00	98%
1530	Bear Creek @ Lowell	30	13:02	62.00	48%
1620	Slaughterhouse Glch	16	12:49	62.00	26%
1640	SPR at Union Ave.	55	12:51	62.00	89%
1660	SPR at Henderson	54	13:11	62.00	87%
1700	Cherry Cr @ Champa	54	13:18	62.00	87%
1710	Shop Creek	38	15:25	62.00	61%
1720	Cherry Cr @ Steele	22	15:02	62.00	35%

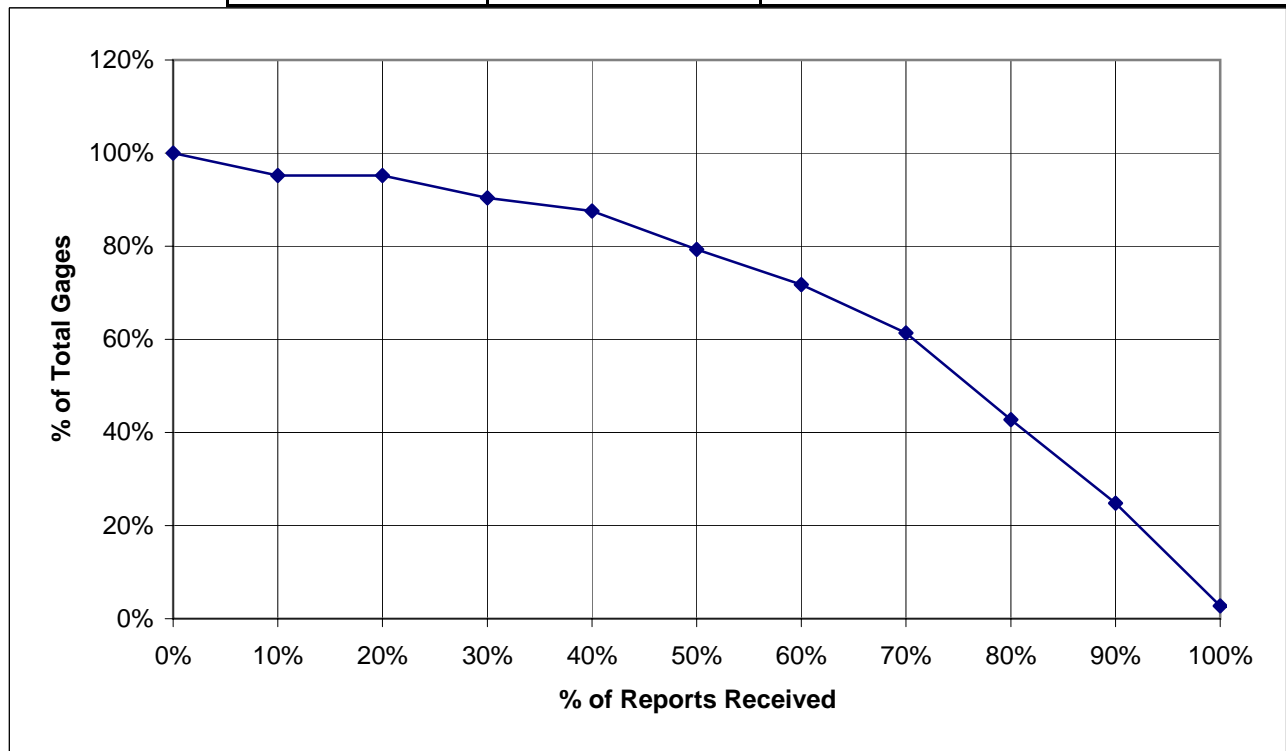
Rain Timer Performance Analysis - continued

Rain Sensors	Description	Number of Received Timer Reports	Average Timer Interval	Number of expected Timer Reports	Performance
1800	Sand Creek Park	31	12:53	62.00	50%
1810	Sand Creek at mouth	53	12:51	62.00	85%
1900	Niver Detention	38	16:04	62.00	61%
1920	Brighton	59	12:08	62.00	95%
2190	Squaw Mountain	51	14:20	62.00	82%
2210	Hiwan G.C.	50	14:26	62.00	81%
2220	Evergreen Lake	51	14:21	62.00	82%
2230	Bear Cr below Cub	6	0:00	62.00	10%
2240	Cold Sprg Glch conf	2		62.00	3%
2260	Brook Forest	2	0:00	62.00	3%
2270	Cub Cr below Blue	3	0:03	62.00	5%
2310	Genesee Village	2		62.00	3%
2320	Choke Cherry Resvr	213		62.00	
2330	Morrison	44	13:54	62.00	71%
2350	Idledale	2	0:00	62.00	3%
2360	Indian Hills	2	0:00	62.00	3%
2370	Red Rocks Park	1		62.00	
2710	Highlands Ranch WTP	59	12:13	62.00	95%
2730	Salisbury Park	45	15:09	62.00	73%
2750	Castle Rock	62	11:46	62.00	100%
2810	Pine Cliff Road	15	11:59	62.00	24%
2820	Haskins Gulch Conf	59	12:28	62.00	95%
2840	Sulphur Gulch	14	12:55	62.00	23%
4010	Crescent	39	16:49	62.00	63%
4020	Rio Grande	61	11:57	62.00	98%
4030	Red Garden	60	12:00	62.00	97%
4040	Martin Gulch	58	12:30	62.00	94%
4050	Walker Ranch	55	13:05	62.00	89%
4060	Lakeshore	47	15:01	62.00	76%
4070	Bear Peak	59	11:55	62.00	95%
4080	Twin Sisters	51	13:18	62.00	82%
4090	Magnolia	44	14:02	62.00	71%
4100	Filter Plant	60	11:57	62.00	97%
4110	Betasso	57	12:34	62.00	92%
4130	Swiss Peaks	45	16:23	62.00	73%
4140	Logan Mill	51	13:51	62.00	82%
4150	Gold Hill	45	13:57	62.00	73%
4160	Sunshine	60	12:11	62.00	97%
4170	Pine Brook	46	14:02	62.00	74%
4180	Gold Lake	47	13:51	62.00	76%
4190	Slaughterhouse	55	12:17	62.00	89%
4200	Lazy Acres	61	12:13	62.00	98%
4220	Fling's	51	13:43	62.00	82%
4230	Golden Age	60	12:27	62.00	97%
4240	Sunset	48	12:54	62.00	77%
4250	Geer Canyon	58	12:14	62.00	94%
4260	Taylor Mountain	54	13:01	62.00	87%
4270	Cannon Mountain	57	12:37	62.00	92%
4290	Red Hill	54	12:46	62.00	87%
4300	Big Elk Park	61	12:09	62.00	98%
4310	Johnny Park	58	12:27	62.00	94%
4330	Indian Ruins	57	12:11	62.00	92%
4340	Riverside	57	12:12	62.00	92%
4350	Conifer Hill	59	11:59	62.00	95%
4360	Justice Center	59	12:28	62.00	95%
4470	Little Narrows	55	13:00	62.00	89%
4490	Apple Valley	59	12:23	62.00	95%
4510	Pinewood Springs	62	12:49	62.00	84%
4520	Eagle Ridge	60	12:15	62.00	97%
4530	Winger Ridge	45	13:59	62.00	73%
4560	Lyons Diversion NSV	53	13:50	62.00	85%
4570	St. Antons	38	19:42	62.00	61%
4710	Ward C-1	53	13:37	62.00	85%
4730	Sugarloaf	45	15:03	62.00	73%
4750	Louisville Lake	52	13:52	62.00	84%
4770	Cal-Wood Ranch	56	12:58	62.00	90%
4790	Button Rock	60	11:59	62.00	97%
4810	Shanahan Ridge	44	14:35	62.00	71%
4820	Doudy Draw	32	14:21	62.00	52%
4830	SBC @ San Souci	45	14:21	62.00	73%
4840	SBC@S Boulder Ditch	46	14:03	62.00	74%
4850	Porphory Mtn	43	14:46	62.00	69%
4860	Fairview Peak	50	14:24	62.00	81%
8000	Test	244		62.00	
9100	Basin Avg-Bear Creek	465		62.00	
9101	Lena Basin Mean	493		62.00	

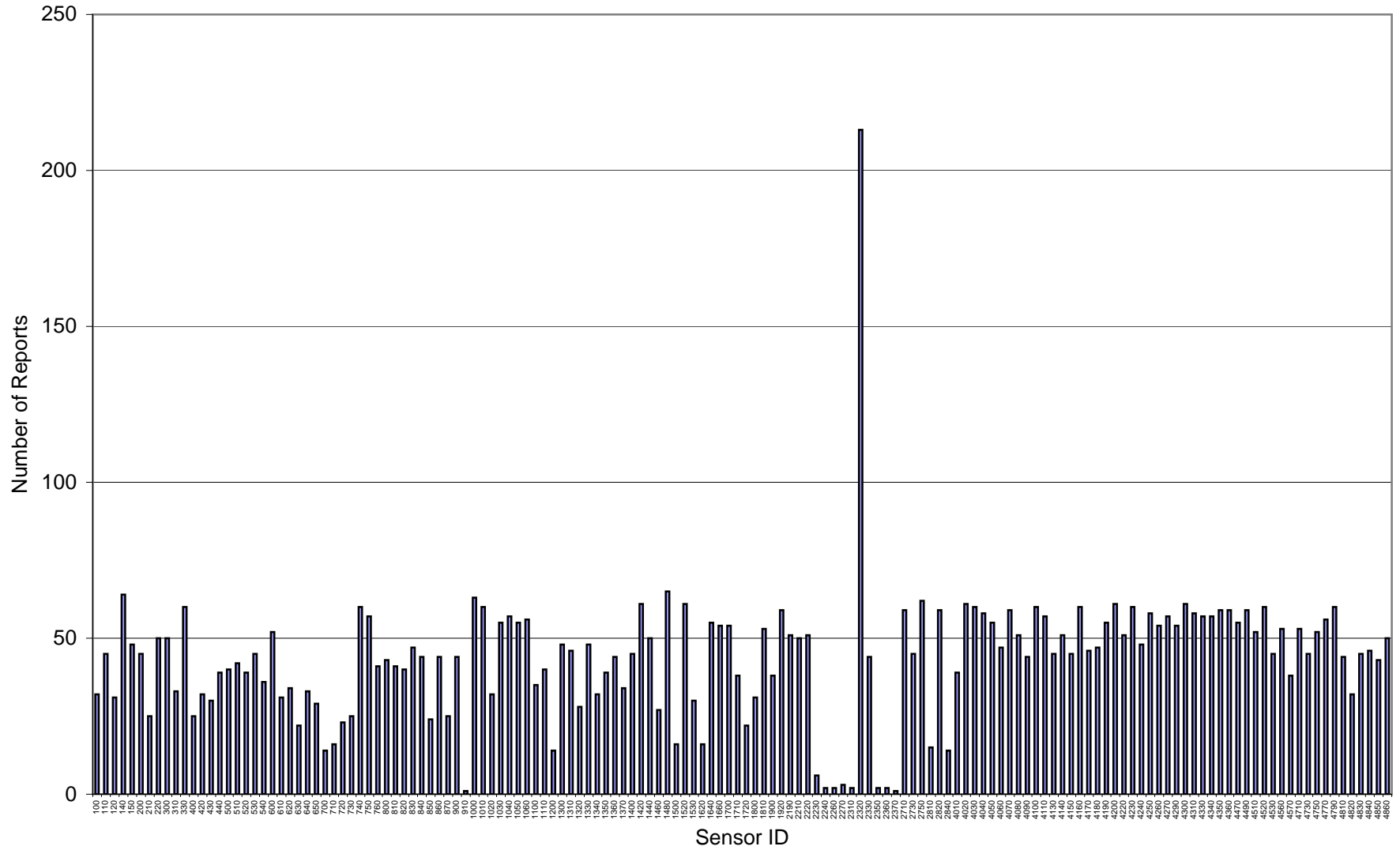
Rain Timer Performance Analysis

Rain Timer Performance

total number of gages 145		
% of reports received	frequency	% of gages receiving % or reports or greater
0%	0	100%
10%	7	95%
20%	0	95%
30%	7	90%
40%	4	88%
50%	12	79%
60%	11	72%
70%	15	61%
80%	27	43%
90%	26	25%
100%	32	3%



Number of Timer Reports Received



Rain Event Performance Analysis

Rain Event Performance

Systemwide Avg	92%	Reports Received	2447	Analyze Rain Sensors
		Total Tips	2667	
		Data Loss	8.25%	

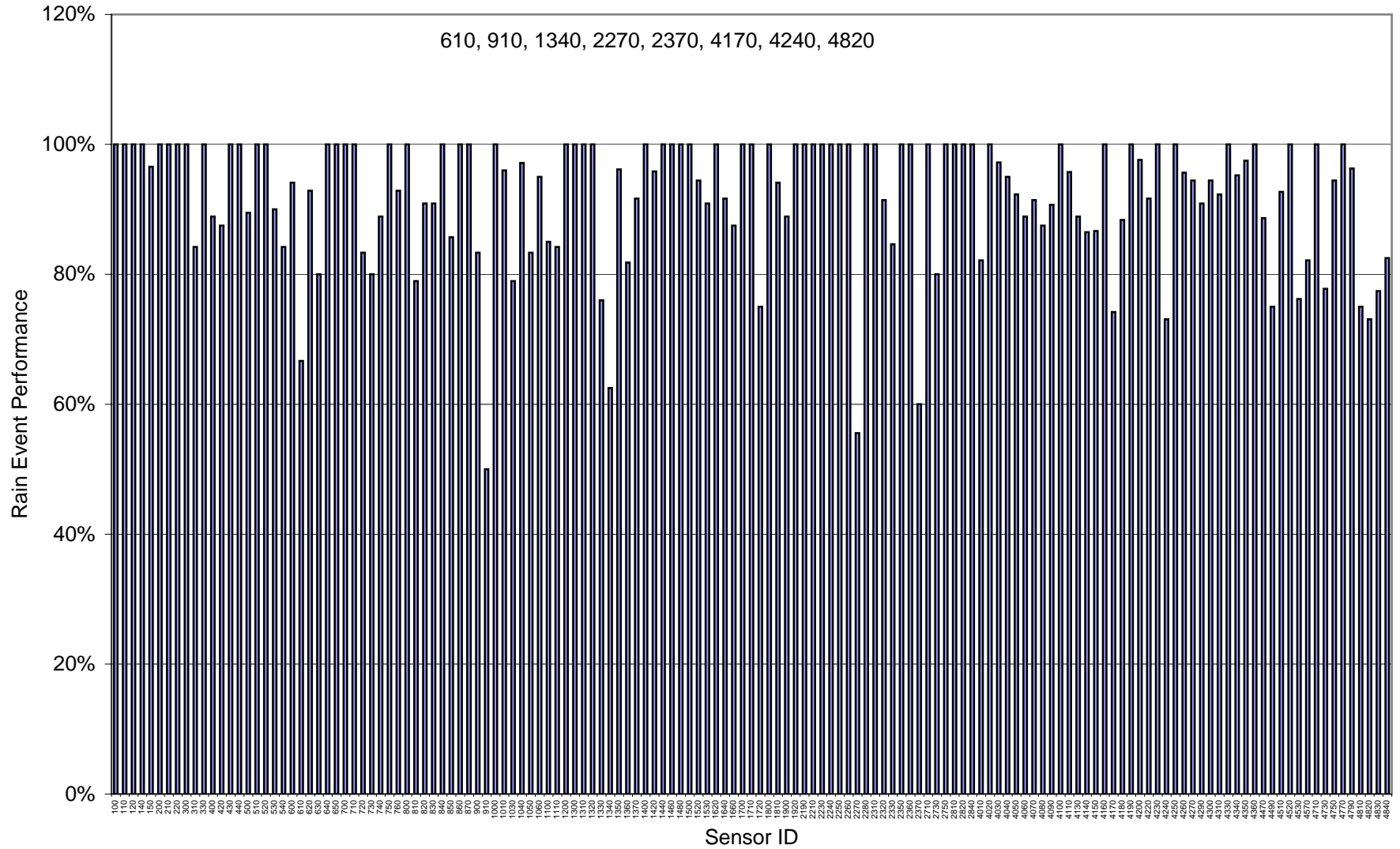
Rain Sensor	Total Performance	Number of 1-tips	Number of 2-tips	Number of 3-tips	Number of 4-tips	Number of 5-tips	Number of 6-tips	Number of >6-tips	Number of actual tips	Number of expected tips	Number of missed tips	Number of hold-off transmissions	Bucket size from Sensordef
100	100%	7	0	0	0	0	0	0	7	7	0	0	0.0393701
110	100%	15	0	0	0	0	0	0	15	15	0	0	0.0393701
120	100%	10	0	0	0	0	0	0	10	10	0	0	0.0393701
140	100%	14	0	0	0	0	0	0	14	14	0	0	0.0393701
150	97%	27	1	0	0	0	0	0	28	29	1	1	0.0393701
200	100%	24	0	0	0	0	0	0	24	24	0	0	0.0393701
210	100%	4	0	0	0	0	0	0	4	4	0	0	0.0393701
220	100%	18	0	0	0	0	0	0	18	18	0	1	0.0393701
300	100%	15	0	0	0	0	0	0	15	15	0	0	0.0393701
310	84%	13	3	0	0	0	0	0	16	19	3	0	0.0393701
330	100%	24	0	0	0	0	0	0	24	24	0	1	0.0393701
400	89%	7	1	0	0	0	0	0	8	9	1	0	0.0393701
420	86%	6	1	0	0	0	0	0	7	8	1	0	0.0393701
430	100%	7	0	0	0	0	0	0	7	7	0	0	0.0393701
440	100%	20	0	0	0	0	0	0	20	20	0	0	0.0393701
500	89%	15	2	0	0	0	0	0	17	19	2	0	0.0393701
510	100%	17	0	0	0	0	0	0	17	17	0	0	0.0393701
520	100%	16	0	0	0	0	0	0	16	16	0	0	0.0393701
530	90%	16	2	0	0	0	0	0	18	20	2	0	0.0393701
540	84%	14	1	1	0	0	0	0	16	19	3	0	0.0393701
600	94%	15	1	0	0	0	0	0	16	17	1	0	0.0393701
610	67%	8	1	0	0	1	0	0	10	15	5	0	0.0393701
620	93%	12	1	0	0	0	0	0	13	14	1	0	0.0393701
630	80%	6	2	0	0	0	0	0	8	10	2	0	0.0393701
640	100%	9	0	0	0	0	0	0	9	9	0	0	0.0393701
650	100%	8	0	0	0	0	0	0	8	8	0	0	0.0393701
700	100%	2	0	0	0	0	0	0	2	2	0	0	0.0393701
710	100%	3	0	0	0	0	0	0	3	3	0	0	0.0393701
720	83%	4	1	0	0	0	0	0	5	6	1	0	0.0393701
730	80%	6	2	0	0	0	0	0	8	10	2	0	0.0393701
740	89%	7	1	0	0	0	0	0	8	9	1	0	0.0393701
750	100%	9	0	0	0	0	0	0	9	9	0	0	0.0393701
760	93%	12	1	0	0	0	0	0	13	14	1	0	0.0393701
800	100%	7	0	0	0	0	0	0	7	7	0	0	0.0393701
810	79%	12	2	1	0	0	0	0	15	19	4	0	0.0393701
820	91%	9	1	0	0	0	0	0	10	11	1	0	0.0393701
830	91%	9	1	0	0	0	0	0	10	11	1	0	0.0393701
840	100%	17	0	0	0	0	0	0	17	17	0	1	0.0393701
850	86%	5	1	0	0	0	0	0	6	7	1	0	0.0393701
860	100%	8	0	0	0	0	0	0	8	8	0	2	0.0393701
870	100%	8	0	0	0	0	0	0	8	8	0	0	0.0393701
900	83%	4	1	0	0	0	0	0	5	6	1	0	0.0393699
910	50%	0	1	0	0	0	0	0	1	2	1	0	0.03937
1000	100%	31	0	0	0	0	0	0	31	31	0	0	0.0393701
1010	96%	23	1	0	0	0	0	0	24	25	1	0	0.0393701
1030	79%	11	4	0	0	0	0	0	15	19	4	0	0.0393701
1040	97%	33	1	0	0	0	0	0	34	35	1	0	0.0393701
1050	83%	12	3	0	0	0	0	0	15	18	3	0	0.0393701
1060	95%	18	1	0	0	0	0	0	19	20	1	0	0.0393701
1100	85%	14	3	0	0	0	0	0	17	20	3	0	0.0393701
1110	84%	13	3	0	0	0	0	0	16	19	3	0	0.0393701
1200	100%	1	0	0	0	0	0	0	1	1	0	0	0.0393701
1300	100%	14	0	0	0	0	0	0	14	14	0	0	0.0393701
1310	100%	14	0	0	0	0	0	0	14	14	0	0	0.0393701
1320	100%	8	0	0	0	0	0	0	8	8	0	0	0.0393701
1330	76%	17	1	0	0	0	1	0	19	25	6	0	0.0393701
1340	83%	6	2	0	0	0	0	0	10	16	6	0	0.0393701
1350	96%	24	1	0	0	0	0	0	25	26	1	0	0.0393701
1360	82%	25	1	0	0	0	1	0	27	33	6	0	0.0393701
1370	92%	20	2	0	0	0	1	0	22	24	2	0	0.0393701
1400	100%	20	0	0	0	0	0	0	20	20	0	0	0.0393701
1420	96%	22	1	0	0	0	0	0	23	24	1	0	0.0393701
1440	100%	11	0	0	0	0	0	0	11	11	0	0	0.0393701
1460	100%	13	0	0	0	0	0	0	13	13	0	0	0.0393701
1480	100%	7	0	0	0	0	0	0	7	7	0	0	0.0393701
1500	100%	4	0	0	0	0	0	0	4	4	0	0	0.0393701
1520	94%	16	1	0	0	0	0	0	17	18	1	0	0.0393701
1530	91%	9	1	0	0	0	0	0	10	11	1	0	0.0393701
1620	100%	2	0	0	0	0	0	0	2	2	0	0	0.0393701
1640	82%	10	1	0	0	0	0	0	11	12	1	0	0.0393701
1660	86%	6	1	0	0	0	0	0	7	8	1	0	0.0393701
1700	100%	11	0	0	0	0	0	0	11	11	0	0	0.0393701
1710	100%	2	0	0	0	0	0	0	2	2	0	0	0.0393701
1720	75%	4	2	0	0	0	0	0	6	8	2	0	0.0393701
1800	100%	10	0	0	0	0	0	0	10	10	0	0	0.0393701

Rain Event Performance Analysis - continued

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 Sensor/def
1810	94%	15	1	0	0	0	0	0	16	17	1	0	0.0393701
1900	89%	7	1	0	0	0	0	0	8	9	1	0	0.0393701
1920	100%	15	0	0	0	0	0	0	15	15	0	0	0.0393701
2190	100%	7	0	0	0	0	0	0	7	7	0	0	0.0393701
2210	100%	21	0	0	0	0	0	0	21	21	0	0	0.0393701
2230	100%	3	0	0	0	0	0	0	3	3	0	1	0.0393701
2240	100%	2	0	0	0	0	0	0	2	2	0	1	0.0393701
2250	100%	1	0	0	0	0	0	0	1	1	0	0	0.0393701
2260	100%	2	0	0	1	0	0	0	2	2	0	1	0.0393701
2270	96%	3	1	0	1	0	0	0	5	4	0	2	0.0393701
2280	100%	1	0	0	0	0	0	0	1	1	0	0	0.0393701
2310	100%	2	0	0	0	0	0	0	2	2	0	1	0.0393701
2320	91%	30	1	1	0	0	0	0	32	35	3	0	0.0393701
2330	85%	20	0	2	0	0	0	0	22	26	4	0	0.0393701
2350	100%	2	0	0	0	0	0	0	2	2	0	0	0.0393701
2360	100%	2	0	0	0	0	0	0	2	2	0	0	0.0393701
2370	89%	2	0	1	0	0	0	0	3	2	1	1	0.0393701
2710	100%	8	0	0	0	0	0	0	8	8	0	0	0.0393701
2730	80%	6	2	0	0	0	0	0	8	10	2	0	0.0393701
2750	100%	9	0	0	0	0	0	0	9	9	0	0	0.0393701
2810	100%	2	0	0	0	0	0	0	2	2	0	0	0.0393701
2820	100%	14	0	0	0	0	0	0	14	14	0	0	0.0393701
2840	100%	2	0	0	0	0	0	0	2	2	0	0	0.0393701
4010	82%	19	3	1	0	0	0	0	23	28	5	0	0.0393701
4020	100%	26	0	0	0	0	0	0	26	26	0	0	0.0393701
4030	97%	34	1	0	0	0	0	0	35	36	1	0	0.0393701
4040	95%	36	2	0	0	0	0	0	38	40	2	0	0.0393701
4050	92%	22	2	0	0	0	0	0	24	26	2	0	0.0393701
4060	89%	21	3	0	0	0	0	0	24	27	3	0	0.0393701
4070	91%	30	1	1	0	0	0	0	32	35	3	0	0.0393701
4080	88%	12	2	0	0	0	0	0	14	16	2	0	0.0393701
4090	91%	36	2	1	0	0	0	0	39	43	4	1	0.0393701
4100	100%	17	0	0	0	0	0	0	17	17	0	0	0.0393701
4110	96%	43	2	0	0	0	0	0	45	47	2	0	0.0393701
4130	89%	21	3	0	0	0	0	0	24	27	3	0	0.0393701
4140	86%	27	5	0	0	0	0	0	32	37	5	0	0.0393701
4150	87%	22	4	0	0	0	0	0	26	30	4	0	0.0393701
4160	100%	40	0	0	0	0	0	0	40	40	0	0	0.0393701
4170	74%	17	4	2	0	0	0	0	23	31	8	0	0.0393701
4180	88%	34	3	1	0	0	0	0	38	43	5	0	0.0393701
4190	100%	49	0	0	0	0	0	0	49	49	0	0	0.0393701
4200	98%	40	1	0	0	0	0	0	41	42	1	0	0.0393701
4220	92%	20	2	0	0	0	0	0	22	24	2	0	0.0393701
4230	100%	27	0	0	0	0	0	0	27	27	0	0	0.0393701
4240	73%	14	3	2	0	0	0	0	19	26	7	0	0.0393701
4250	100%	41	0	0	0	0	0	0	41	41	0	0	0.0393701
4260	96%	21	1	0	0	0	0	0	22	23	1	0	0.0393701
4270	94%	16	1	0	0	0	0	0	17	18	1	0	0.0393701
4290	91%	37	2	1	0	0	0	0	40	44	4	0	0.0393701
4300	94%	16	1	0	0	0	0	0	17	18	1	0	0.0393701
4310	92%	33	3	0	0	0	0	0	36	39	3	0	0.0393701
4330	100%	28	0	0	0	0	0	0	28	28	0	0	0.0393701
4340	95%	19	1	0	0	0	0	0	20	21	1	0	0.0393701
4350	98%	38	1	0	0	0	0	0	39	40	1	0	0.0393701
4360	100%	47	0	0	0	0	0	0	47	47	0	0	0.0393701
4470	89%	35	3	1	0	0	0	0	39	44	5	0	0.0393701
4490	75%	2	1	0	0	0	0	0	3	4	1	0	0.0393701
4510	93%	35	3	0	0	0	0	0	38	41	3	0	0.0393701
4520	100%	23	0	0	0	0	0	0	23	23	0	0	0.0393701
4530	76%	23	8	1	0	0	0	0	32	42	10	0	0.0393701
4570	82%	18	5	0	0	0	0	0	23	28	5	0	0.0393701
4710	100%	16	0	0	0	0	0	0	16	16	0	0	0.0393701
4730	78%	10	4	0	0	0	0	0	14	18	4	0	0.0393701
4750	94%	16	1	0	0	0	0	0	17	18	1	0	0.0393701
4770	100%	20	0	0	0	0	0	0	20	20	0	0	0.0393701
4790	96%	25	1	0	0	0	0	0	26	27	1	0	0.0393701
4810	75%	2	1	0	0	0	0	0	3	4	1	0	0.0393701
4820	73%	14	4	0	1	0	0	0	19	26	7	0	0.0393701
4830	77%	18	5	1	0	0	0	0	24	31	7	0	0.0393701
4840	83%	27	5	1	0	0	0	0	33	40	7	0	0.0393701
Total Tips		2263	158	21	2	1	2						

Rain Event Performance

Sensors with performance <75% noted



Measured Rain Event Analysis

Rain Sensor	(mm of rain measured)	Outliers Removed
	Measured Bucket Tips	(mm of rain measured) Measured Bucket Tips
100	7	7
110	15	15
120	10	10
140	14	14
150	29	29
200	24	24
210	4	4
220	18	18
300	15	15
310	19	19
330	24	24
400	9	9
420	8	8
430	7	7
440	20	20
500	19	19
510	17	17
520	16	16
530	20	20
540	19	19
600	17	17
610	15	15
620	14	14
630	10	10
640	9	9
650	8	8
700	2	2
710	3	3
720	6	6
730	10	10
740	9	9
750	9	9
760	14	14
800	7	7
810	19	19
820	11	11
830	11	11
840	17	17
850	7	7
860	8	8
870	8	8
900	6	6
910	2	2
1000	31	31
1010	25	25
1030	19	19
1040	35	35
1050	18	18
1060	20	20
1100	20	20
1110	19	19
1200	1	1
1300	14	14
1310	14	14
1320	8	8
1330	25	25
1340	16	16
1350	26	26
1360	33	33
1370	24	24
1400	20	20
1420	24	24
1440	11	11
1460	13	13
1480	7	7
1500	4	4
1520	18	18
1530	11	11
1620	2	2
1640	12	12
1660	8	8
1700	11	11
1710	2	2
1720	8	8
1800	10	10

Rain Sensor	(mm of rain measured)	Outliers Removed
	Measured Bucket Tips	(mm of rain measured) Measured Bucket Tips
1810	17	17
1900	9	9
1920	15	15
2190	7	7
2210	21	21
2230	3	3
2240	2	2
2250	1	1
2260	2	2
2270	9	9
2280	1	1
2310	2	2
2320	35	35
2330	26	26
2350	2	2
2360	2	2
2370	5	5
2710	8	8
2730	10	10
2750	9	9
2810	2	2
2820	14	14
2840	2	2
4010	28	28
4020	26	26
4030	36	36
4040	40	40
4050	26	26
4060	27	27
4070	35	35
4080	16	16
4090	43	43
4100	17	17
4110	47	47
4130	27	27
4140	37	37
4150	30	30
4160	40	40
4170	31	31
4180	43	43
4190	49	49
4200	42	42
4220	24	24
4230	27	27
4240	26	26
4250	41	41
4260	23	23
4270	18	18
4290	44	44
4300	18	18
4310	39	39
4330	28	28
4340	21	21
4350	40	40
4360	47	47
4470	44	44
4490	4	4
4510	41	41
4520	23	23
4530	42	42
4570	28	28
4710	16	16
4730	18	18
4750	18	18
4770	20	20
4790	27	27
4810	4	4
4820	26	26
4830	31	31
4840	40	40

Expected Tip Data Analysis	
Mean	18.39
Median	17.00
Std Deviation	12.36
Mean + 3 st dev	55.46
Mean - 3 st dev	-18.68
Min	1
Max	49