

January 19, 2009

Kevin Stewart, P.E.
Urban Drainage and Flood Control District
Suite 156-B
2480 West 26th Avenue
Denver, CO 80211

Re: ALERT Gaging System Maintenance Program - FINAL End of Year Report

Dear Kevin,

OneRain is pleased to present you with the accompanying ALERT Gaging System 2008 End of Year Report. The purpose of the Report is to summarize the ALERT system maintenance activities completed by OneRain in 2008 on behalf of the Urban Drainage and Flood Control District (UDFCD) per our contract.

Although there was an increase in equipment failures from the previous year, we believe that maintenance for the 2008 season was successful, with no significant event going undetected. We are also excited about the continued implementation of the ALERT-2 protocol and the positive impact it may have on solving RF channel contention issues going forward.

The accompanying Report includes a description of the overall system performance and problems encountered, recommendations for the upcoming 2009 season, and copies of our last round of maintenance records.

We want to thank you for allowing us to be your maintenance service provider for 2008. It is truly a pleasure to work with an owner who appreciates and understands the value of their flood warning system; and especially your willingness to experiment with the new ALERT 2 protocol. We hope you are pleased with our service, and we look forward to our continued collaboration with the UDFCD. Please contact me with any questions.

Sincerely,



Mike Zucosky
Manager, Field Integrations



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UDFCD ALERT Gaging System Maintenance

**Annual Report
December 14, 2008**

**Presented To
Kevin Stewart
Urban Drainage and Flood Control District
Denver, Colorado**

**By
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EXECUTIVE SUMMARY

The purpose of this report is to summarize the ALERT system maintenance activities completed by OneRain in 2008 on behalf of the Urban Drainage and Flood Control District (UDFCD) under our current contract.

Although there was an increase in equipment failures from the previous year, we believe that maintenance for the 2008 season was successful, with no significant event going undetected. We are also excited about the continued implementation of the ALERT-2 protocol and the positive impact it may have on solving RF channel contention issues going forward.

OneRain and the District modified the maintenance schedule slightly from that conducted in 2007, including an interim trip to all rain gage sites. Table 1 below summarizes the maintenance activity over the course of the last six years. The “Service Rate” column is the ratio (%) of service calls to sites in the combined UDFCD/Boulder System.

There were significantly more failed pressure transducers in 2008 than in 2007. I do not believe this is due to any specific situation, but rather is due to an atypically low number of PT failures in 2007.

Table 1: Recent Maintenance Activity Statistics

Year	Total # of Visits	Service Calls OneRain/District	Number of Sites ¹	Service Rate
2001	701	66 (30/36)	152	43%
2002	723	59 (45/14)	161	37%
2003	794	110 (86/24)	171	64%
2004	790	78 (51/27)	173	45%
2005	810	97 (76/21)	174	56%
2006	696	97 (78/19)	182	53%
2007	653	58 (49/9)	183	32%
2008	715 ²	94(62/32)	194	48%

¹ This total number of sites includes repeaters and base stations.

² There have been 669 scheduled maintenance visits to date, with an additional 46 visits yet to be completed in Boulder County, with no problems anticipated.

SYSTEM PERFORMANCE

We had a total of seven hundred fifteen maintenance records; 669 scheduled visits to date, and an additional 46 visits to sites in Boulder County that are scheduled in the next few weeks, with no anticipated problems. There were sixty-two service calls initiated by OneRain, and thirty-two service calls requested by the District.

Service calls

Of the sixty-two service calls initiated by OneRain, they are broken down as follows:

- ◆ 28 Transmitter issues
- ◆ 13 Pressure Transducer issues
- ◆ 6 Pass List issues
- ◆ 4 Power issues
- ◆ 4 Bubbler issues
- ◆ 7 “Other” issues

Of the thirty-two service calls requested by the District, they are broken down as follows:

- ◆ 7 Tipping Bucket issues
- ◆ 5 Pressure Transducer issues
- ◆ 5 Erratic Reporting
- ◆ 4 Bubbler issues
- ◆ 3 Removals
- ◆ 3 ID Corrections
- ◆ 5 “Other” issues

Key factors resulting in almost 40% of the unscheduled visits can be attributed to the following:

CRX 10 Data logger – This data logger is no longer supported by the Manufacturer and has become an obsolete, difficult to maintain device. We’ve seen significant failure in this equipment not only at UDFCD, but at other client’s sites that utilize this specific data logger. The data logger/programming error resulted in five service visits to the Marston Site (1520) and three service visits to the DIA Site (1480).

The four service visits to the SPR @ Henderson Site (1660) were related to reconfiguration during the transfer and transmitter and charger failures.

Reconfiguring the pressure transducer at the Tollgate @ 6th Site (700) resulted in four service visits. We rebuilt this sensor to transmit low flow data, but it does not seem to respond reliably. Site visits uncover no problems, but later it reports intermittently. We are currently seeking guidance from the USGS, who are most familiar with this type of installation.

Bubbler problems – Four service visits to the Ferril Lake Site (1380) were a direct result of the bubbler. A latent internal design flaw related to the firmware was acknowledged by the manufacturer and repaired by OneRain.

Pressure Transducers – PT failures were significantly higher this year than last. We believe that this years failure rate is typical, and that we had an uncharacteristically low volume of failures in 2007. PT failures resulted in almost 20% of the service calls for the year.

Pressure Transducer Failures or Replacements

As mentioned, PT failures were higher in 2008 than in the 2007 maintenance season. However, the number of failures is average for a maintenance year, with last year being an atypical number. As an example, in 2006 OneRain replaced fourteen pressure transducers, this year we replaced twelve, yet in 2007 we only replaced two. Specific details of pressure transducer activity are as follows:

We performed forty-six pressure transducer calibrations.

Pressure transducers were newly installed at the following three sites:

- ◆ Bayou Gulch (2833)
- ◆ Aurora Regional Pond (943)
- ◆ Piney Creek @ Liverpool (953)

Pressure transducers were replaced at the following twelve sites:

- ◆ Leyden Reservoir (203) replacement with 20psi unit
- ◆ Leyden Conf. (213) replacement after construction damage
- ◆ Montview Park (403) Druck (retired unit installed in September, 2005)
- ◆ Tollgate at 6th (713) KPSI (retired unit installed in May, 2007)
- ◆ ETG @ Buckley (823) KPSI (retired unit installed in May, 2007)
- ◆ Hidden Lake (1303) Druck (retired unit installed in March, 2004)
- ◆ Sanderson Gulch (1343) Druck (retired unit installed in April, 2003)
- ◆ Upper Sloan (1403) KPSI (retired unit installed in June 1996)
- ◆ Sand Creek Park (1803) Druck (retired unit installed in July, 2007)
- ◆ Eldorado Springs (4383) Druck (retired unit installed in March, 2002)
- ◆ Little Narrows (4473) Druck (retired unit installed in June, 2005)
- ◆ Lyons Diversion (4563) Druck (retired unit installed in November, 2003)

We previously experimented with other PTs to eliminate our sole source acquisition. In doing so, the new units purchased from KPSI did not perform as the manufacturer claimed. We insisted the company reconfigure their product to function as advertised, but they are still not as stable as we would like, resulting in multiple recalibrations. It should be noted that the company no longer produces this product. There were nine conversions from Handar to High Sierra Electronics at the following sites:

- ◆ Simms Street (133)
- ◆ Van Bibber @ SH 93 (333)
- ◆ Gunbarrel (1113)
- ◆ Cherry Creek/Steele (1723)
- ◆ Bear Creek @ Cub (2233)
- ◆ Cold Spring Gulch (2243)
- ◆ Rosedale (2253)
- ◆ Cub Creek below Blue (2273)
- ◆ Red Rocks (2373)

Multiple recalibrations of the pressure transducer were required at the following sites:

- ◆ Kelly Dam (413) KPSI (in service since September, 2005) – recommend replacement
- ◆ Maple Grove Reservoir (1003) KPSI (in service since April, 2006) – recommend replacement

The following three sites had pressure transducer failures that can not be repaired, and will have to be replaced at start-up with existing spares (and we will recommend replacement of existing spares accordingly):

- ◆ Ralston Reservoir (113) Druck (in service since September, 2004)
- ◆ Little Dry Creek @ 64th (1313) Druck (in service since September, 2001)
- ◆ Englewood Dam (1603) Druck (in service since April, 2003)

Damaged Equipment/Other Replacements

We replaced a total of eighteen ageing Handar 585 transmitters with High Sierra Electronics 3206 transmitters. These transmitters were in excess of 15 years old, and are no longer supported by any manufacturer. In replacing the transmitters, we also added signal conditioning circuits with desiccant vent boxes for the existing 4-20mA pressure transducers. We then had to recalibrate for the expanded range (0 – 2047 from the previous range of 0 - 255). We also rewired all the tipping buckets and shaft encoders at these sites accordingly. Table 2 summarizes these sites.

Table 2: Sites w/Handar 585 Transmitter Replacements

Site ID	Site Name	Sensors ¹
130	Simms Street	S
150	Nott Creek	P
330	Van Bibber @ SH 93	PS
1110	Gunbarrel	PS
1630	S Platte @ Dartmouth	SE
1650	SPR @ 19 th Street	SE
1660	SPR @ Henderson	PSE
1720	Cherry Cr @ Steele	PS
2230	Bear Creek @ Cub	PS
2240	Cold Spring Gulch	PS
2250	Rosedale	PS
2260	Brook Forest	P
2270	Cub Ck below Blue	PS
2280	Kinney Peak	P
2310	Genesee Village	P
2350	Idledale	P
2360	Indian Hills	P
2370	Red Rocks	PS

¹S=Stage, P=Rain, PS=Rain/Stage, PSE = Rain/Shaft Encoder SE = Shaft Encoder

Site Additions

Six new sites were installed; five new sites at expanding metropolitan areas to enhance your flood warning system, and the sixth being a reinstallation of a site removed in 2004. Upon installation, we provided District staff the details on each site, as identified below, so they could immediately update their database. The new sites are as follows:

- ◆ Aurora Regional Pond. This site is identified as site #940, and consists of both rain and stage sensors. The site is located at Latitude 39.5831,

Longitude -104.709, Elevation 5931 feet. This site reports via the Smoky Hill Repeater. A site picture follows:



Figure 1: Aurora Regional Pond Rain/Stage Gages

- ◆ Piney Creek @ Liverpool. This site is identified as site # 950, and consists of both rain and stage sensors. The site is located at Latitude 39.595, Longitude -104.744, Elevation 5823 feet. This site reports via the Smoky Hill Repeater. A site picture follows:



Figure 2: Piney Creek @ Liverpool Rain/Stage Gages

- ◆ Ferril Lake. This site is identified as site # 1380, and consists of a stage only sensor. The site is located at Latitude 39.744, Longitude -104.946, Elevation 5271 Feet. This site reports via the Blue Mountain Repeater. A site picture follows:



Figure 3: Ferril Lake Stage Gage

- ◆ Lakewood Country Club. This site is identified as site # 1550, and consists of a rain only sensor. The site is located at Latitude 39.7276, Longitude -105.07, Elevation 5400 Feet. This site reports via the Blue Mountain Repeater. A site picture follows:



Figure 4: Lakewood County Club Rain Gage

- ◆ Bayou Gulch. This site replaces the prior site of Castle Oaks (2830) taken out of service in 2004. The site's new identifier is site #2850, and consists of both rain and stage sensors. The site is located at Latitude 39.4356, Longitude -104.77, Elevation 6016 Feet. This site reports via the Blue Mountain Repeater. A site picture follows:



Figure 5: Bayou Gulch Rain/Stage Gages

- ◆ Pump Station #3 (Aurora Airpark Weather Station). This site is identified as site #970, and is a full weather station. The site is located at Latitude 39.7364, Longitude -104.669, Elevation 5614 feet. This site reports via the Smoky Hill Repeater. Note that this site is not maintained by UDFCD, but by Aurora Water. A site picture follows:



Figure 6: Pump Station #3 (Aurora Airpark)

Smoky Hill Repeater Upgrade/Relocation

In August and September of this year the repeater at Smoky Hill was moved into the building of the East Cherry Creek Valley (ECCV) Water and Sanitation District. Additionally, new antennas were installed on ECCV's new tower. The repeater is located in the garage where ECCV has their other communication equipment (SCADA, amateur radio repeater, etc). Previously, the ALERT repeater was solar powered and installed in a standpipe on their grounds, which has subsequently been removed.

It is now enclosed in a new UDFCD supplied equipment rack, and supplied AC power with back-up battery. A cavity filter was installed in the receive path, to reduce interference from nearby transmitters. The receive antenna is a 4-bay omni, and the transmit antennas are directional yagis, aimed between UDFCD and OneRain. The antennas are installed at a higher elevation than the originals on the standpipe, and are expected to give equal or better performance. The tipping bucket that had been at that site was removed, and was not reinstalled on the building, as it was no longer considered necessary because of newly installed nearby precipitation gages at Sites 940 and 950 that give adequate coverage.

In addition to making numerous improvements to the existing ALERT repeater installation, this upgrade accomplished necessary preparations for the installation of the ALERT-2 concentrator (e.g. the second transmit yagi, power and space expansion, etc).

It should be noted that ECCV has been a most friendly and helpful host in allowing us to share in using their new tower and facility. They have provided us with instructions for obtaining emergency 24/7 access, should the situation arise.



Figure 6: Smoky Hill Antenna



Figures 7/8: Equipment housing

Site Removals

The following three sites were removed at your request:

- ◆ Denver Zoo (1360) To be relocated in the Spring, 2009 pending construction activities at the Zoo
- ◆ Marshall (1540) Unknown future relocation
- ◆ Indian Ruins (4330) Removed at homeowners request, to be relocated in the Fall, 2009 (Note that this station is maintained by Boulder County as part of the St. Vrain/Left Hand Canyon Creek network)


Changes Requested by Aurora

- ◆ Quincy Weather Station (750) - Replaced obsolete equipment at existing weather station with High Sierra Electronics equipment, and added a barometer (there was a Solar Radiation sensor at this site, which we now are using as a spare)
- ◆ Aurora Reservoir (900) - Added a barometer and solar radiation sensor
- ◆ Pump Station #3 (Aurora Airpark) (970) – New site with full weather station (Note that this weather station is not maintained by UDFCD, but by Aurora Water)

Miscellaneous Activity of Note

FCC Licensing

To date, OneRain has received confirmation for renewed or extended licensing on all sites and call signs. As new sites are installed OneRain will keep the licenses up to date.

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ALERT-2

2008 Summary

During 2008, it was planned to install ALERT-2 concentrators at the Blue Mountain and Smoky Hill repeater sites, in addition to moving half of the gages that report through each of those sites to a second RF frequency (to reduce contention during a storm event). The output from the two receivers at each repeater site was to be combined into a single ALERT transmit signal (using arbitration functionality to be added by the ALERT repeater vendors). This combined ALERT signal would allow reception at both UDFCD and OneRain. Additionally, ALERT-2 concentrators were installed at each site, with receivers at OneRain and Blue Water Design for the purpose of data comparison with the ALERT feed.


Funding delay resulted in a late start in implementing the dual frequency ALERT repeaters, which are necessary for the frequency splitting. Difficulties by one of the equipment vendors (High Sierra Electronics) in implementing the arbitration functionality caused an additional delay. As a result, no input frequency splitting was able to be done for the 2008 storm season. Feeding the data via ALERT-2 has been successful at both receiving sites. Additionally, GPS-based Time Division Multiple Access has been implemented to prevent collisions between the transmissions from the two repeater sites. The comparison of data received via ALERT-2 to that of the ALERT feeds is ongoing, and has been yielding positive results. Comparison of the two will continue through the winter (several dozen gages and weather stations remain in operation throughout the year).

2009 Plans

During the spring install, approximately half the gages routing through Blue Mountain and Smoky Hill will have their transmit frequency shifted to the alternative frequency. ALERT transmission from the repeaters will be accomplished using the new arbitration functionality available for HydroLynx repeaters. Each ALERT-2 concentrator already allows two input data feeds. The 2009 season will allow parallel operation of ALERT and ALERT-2, initially from Smoky Hill and Blue Mountain, and then (after building additional concentrators) through the other repeaters: Gold Hill, Lee Hill, and West Creek (contingent on receiving approval for that site). ALERT-2 receive capability will also be installed at UDFCD. This will allow comparison of data throughout the year, for the purpose of qualifying ALERT-2 as the production feed from the repeaters to the base stations in the future.

FUTURE AREAS OF INTEREST

The sections below outline areas that the District and OneRain have been tracking through our monthly meetings, or areas of future concern we want to make you aware of.

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Shared USGS Sites

The USGS change to Sutron "Satlink" (SDI) equipment will impact two sites: Cherry Creek @ Champa (1700) and SPR @ Union (1640). Cherry Creek has an old High Sierra Electronics serial transmitter and SPR @ Union has a Com engine for the transmitter. Both sites have rain and stage gages. We will need to evaluate equipment compatibility and what modifications are needed to continue to receive data from these sites.

Sand Creek Mouth

You have discussed previously your desire to discontinue your alliance with USGS for the stage sensor at the Sand Creek Mouth Site (1810). This will require us to install a pressure transducer in the existing stilling well with a transmitter in the existing shed and use the existing tipping bucket on the shed. The stilling well is nearby and as a result, some maintenance and/or flushing may be required on a regular basis. We will need to evaluate and submit a proposal for this work when you are ready to proceed.

Utah Park

This site was taken out of service due to major construction activity at the Park. We will need to reinstall the rain/stage gages upon completion of the park construction. We recommend installation at the new outfall similar to the past configuration.

Apache Plume

Pending approval from the City of Parker, we will need to install rain/stage gages at this site.

Stroh Road

A site has been selected that will minimize landscape disturbance with the installation of the conduit and underground utilities. Pending funding, we will proceed with installation of this site.

Tollgate @ 6th

The bubbler at the Tollgate @ 6th Site (700) has been experiencing problems. The USGS suggested installing a "muffler" to buffer the orifice. We provided UDFCD a sketch, which consisted of a nested set of PVC pipes with marbles between, holding the bubbler tube orifice inside and isolated from the sediment. At your direction, we are available to help install and adjust offset accordingly.

CR 10X Data Logger Sites


The CR 10X is obsolete, and no longer supported by the manufacturer. We will continue to make recommendations to upgrade the remaining sites where the 10X is still in use. There are six that remain in the system to date, two with noted failures that will need to be addressed before Spring deployment.

SPARE EQUIPMENT RECOMMENDATIONS FOR UPCOMING SEASON

1. Signal Conditioning Module
 - a. High Sierra Electronics 100mV to analog signal conditioning modules. Have four on hand, recommend purchasing five additional spares
Cost at (5) x \$100 each = \$500
 - b. High Sierra Electronics 4-20 mA. Have none on hand, and six in the system. Recommend purchasing one for a spare
Cost = \$100
 - c. Hydrolynx. The High Sierra Electronics module is not compatible with the Hydrolynx transmitter. We have two modules in the system. Recommend obsoleting the Hydrolynx signal conditioning module upon failure (Replacing the transmitter to a High Sierra Electronics)
2. Transmitter
 - a. One Weather Transmitter to back up the Handar replacement units
Cost = \$3,900
 - b. High Sierra 3206 – recommend purchasing 5
Cost at (5) x \$2,225 each = \$8,900
3. Wind Sensor
 - a. Spare sonic wind sensor
Cost = \$1,700
4. Radio
 - a. Spare Maxon Radio currently needed for repair, and recommend five for spares.
Cost at (6) x \$155 each = \$930
5. Top Section at Red Garden Site (4030)
 - a. Need to repair/replace top section.
Cost = \$500
6. Pressure Transducer
 - a. Druck PDCR 1830 100mV, 10psi
1 @ 50', 2 @ 100', 1 @ 160'
Cost = \$3,050

Note: Two spare transmitters were used in the Handar replacement effort. One spare transmitter and two signal conditioning modules will be needed in the replacement of the CR10X at DIA.

Total cost = \$ 19,580

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CONCLUSION

We enjoyed performing your maintenance for the 2008 season. We believe it was a successful year, with no significant event going undetected. We are excited about the ALERT-2 protocol and how it might address the very serious RF channel contention issues.

Compared to 2007, in 2008 there were a high number of PT failures, but as explained, that was to be expected given the low number of failures the prior year,. The positive aspect of this is that these problems were caught by preventive maintenance.

For the upcoming 2009 season, our goals are to continue to improve methods to calibrate and validate weather sensor data and to establish more meaningful statistics on the useful life of a piece of equipment.

APPENDIX A: SPARES ON HAND

Sensors

RH/AT Sensors – Vaisala HMP 45A	5 each
Anemometer – Wind Speed Hydrolynx	1 each
Wind Vane – Wind Direction Hydrolynx	1 each
Handar sensors (removed from Quincy (used)	1 each
Wind Speed	1 each
Wind Direction	1 each
Air Temperature and Humidity	1 each

Solar Panels

110mA	3 each
5W	1 each

Pressure Transducers

Druck PDCR 1830 10psi 100mV 100 feet	3 each
Druck PDCR 1830 10psi 100mV 160 feet	1 each
Druck PDCR 1830 10psi 100mV 180 feet	1 each
KPSI 4-20mA (Sand Cr @ Colfax) 180 feet	1 each

Repeaters


Hydrolynx 50386 dual frequency	1 each
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Transmitters

Hydrolynx 5096	2 each
Hydrolynx 5096-81 Wx	1 each
High Sierra 3206 (combined UDFCD/BoCo)	5 each

Antennae

Omni (BoCo)	1 each
Yagi (BoCo)	1 each

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APPENDIX B: MAINTENANCE RECORDS (PER SEPARATE PDF ACCOMPANYING THIS DOCUMENT)

APPENDIX C: PT CALIBRATION LOG (PER SEPERATE PDF ACCOMPANYING THIS DOCUMENT)

APPENDIX D: INVENTORY (PER SEPARATE PDF ACCOMPANYING THIS DOCUMENT)