Urban Drainage and Flood Control District 2002 ALERT maintenance summary report

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Overview

Maintenance activities on the ALERT Gauging Network for 2002 have been completed under Agreement 02-01.15. During the 2002 operating season, DIAD generated 713 maintenance reports for the combined UDFCD/Boulder County network. Of these, a total of 57 (8.0%) service calls were generated: 14 (24.5%) were unscheduled District service calls and 43 (75.5%) were unscheduled DIAD Incorporated service calls; the remainder documented standard maintenance activities. The overall percentage of service calls slightly decreased during the 2002 field season compared to the year 2001.

It is always noteworthy to examine sites that required multiple visits. Site 1700 (Cherry Creek @ Champa) required 8 unscheduled visits, site 4520 (Eagle Ridge) required 6, and sites 4030 (Red Garden Rain), 1660 (Henderson @ SPR) and 1810 (Sand Creek Mouth) required 4 apiece. The cumulative visits to these 5 sites accounted for 46% of all 2002 service calls; site 1700 alone accounted for 14.0%.

Two factors can explain the 15 of the 26 total service calls associated with these 5 "multiple visit" sites: 1) Continuance of the "handshaking" issue with sites 1810 and 1700, and 2) "phantom" problems associated with the performance (or lack thereof) of the new repeater network that was deployed for testing in late July, 2002 (see System-Wide Repeater Upgrade discussion below). The "phantom" problems produced bad data that appeared to be site specific, but in actuality were ultimately caused by the new repeaters. The handshaking issue actually decreased during 2002 relative to the 2001 season, but remains a significant annoyance. After accounting for the two factors above, the overall system performance was actually more robust than ever during the 2002 season, but the reliability of the new repeater network remains a potentially serious issue.

Damaged equipment and site reinstallations

During the 2002 season, the combined UDFCD/Boulder County network experienced the usual dose of damage resulting from vandalism or "unintended destruction". In April, a construction crew at site 1900 (Niver detention pond) severed the PT cable and conduit while sculpting the detention base for a bike/pedestrian path installation. The conduit was repaired and a new PT installed 2 weeks afterwards. On June 13, sensor 420 (Expo Park rain) reported over 300 tips. Aurora Parks disclosed that a stuck valve was causing continuous irrigation, contaminating the sensor data. In October, the PT at site 410 (Kelly Dam) was inaccessible due to construction on the culvert. As the housing was buried, it is still unclear whether the PT housing will require repair or replacement as a result. At the District's request, the pressure transducer and housing at site 1620 (Slaughterhouse) was removed in March prior to construction activity at the culvert; the sensor was reinstalled in June. Three sites were reinstalled after

temporary removal in 2001: site 1050 (Jefferson County Fairgrounds, rain only), site 200 (Leyden Reservoir, rain and stage, see Figure 1), and site 1010 (Denver West, rain only). Two other sites were reinstalled after incurring damage the previous year: site 1610 (Holly Dam, stage only) and site 1110 (Gunbarrel, rain and stage).

In a related vein, site 1700 (Cherry Creek @ Champa) was down for most of the 2002 flood season, at least as far as ALERT broadcasting was concerned. This was due to an unfortunate quirk in the co-dependent nature of equipment sharing at the site. The USGS needed GOES transmissions to occur from this site, so in June they swapped in another Sutron DCP that had a GOES radio. However, the "replacement" Sutron had downlevel firmware compared to the Sutron that was pulled. The downlevel firmware effectively disables the Tiny Basic program written to allow use of the Sutron DCP data for transmission of ALERT data using the 3210 serial interface. The USGS graciously offered to send the pulled unit to Sutron and have a GOES radio installed in it, with the intent of reinstalling it at the site to bring ALERT capability back up. Unfortunately, this did not occur until September, the end of the 2002 flood season.

At site 1630 (SPR @ Dartmouth), stage reports abruptly ended on September 3. Site inspection revealed that the tape was missing from the District's shaft encoder; the tape was found on the floor of the gauge station, along with the float and weight. CDWR Tech notes revealed that an attempt had been made to "muck out" the base of the stilling well to remove sediment. During this process the tape apparently broke and the equipment was pulled. The tape had severely rusted where it broke, so it would likely not have lasted long under normal circumstances in any event.

Figure 1. Site 200, Leyden Reservoir reinstallation

Site additions

Figure 2. Site 1520, Marston Lake Weather Suite

Three new monitoring sites were added to the District's ALERT system during 2002: site 1500 (Powers Park, rain and stage), site 1520 (Marston Lake, weather station and stage, see Figure 2), and site 1530 (Bear Creek @ Lowell, rain and stage). (The Powers Park site was originally assigned site ID 1670, but the signal was unreliable going though the Smoky Hill repeater. The ID was subsequently changed to 1500 to allow the signal to go through the Blue Mountain repeater, and performance has improved substantially.)

The Marston Lake site incorporates a structural design that was in part patterned after the "alternative" Urban Farm installation the previous year. The new structural differences are a new crossarm housing used on top of the mast and a smaller NEMA enclosure housing the DCP and sensor cable terminations. The DCP at Marston Lake is a Campbell Scientific CR10X datalogger. With the aid of a second-party consultant, DIAD has developed a new ALERT Serial Interface (ASI) board that can accept ALERT ID and data in a variety of serial data formats, including those provided by the CR-10X. The new interface has proven to be reliable since the site began broadcasting this summer.

The third new site is Bear Creek @ Lowell (a.k.a. "Bear Creek at Sheridan", as far as the Colorado Division of Water Resources is concerned). With the cooperation of one Bob Cooper, the District now shares the stilling well site maintained for many years by CDWR. The District's equipment is completely independent of the State's, so there will (make that "should") be no disturbance in terms of data collection by either entity upon the other.

The Bear Creek @ Lowell rain and stage site, as well as the Marston Lake weather suite site, are two of seven new (five more proposed) sites that are loosely defined as part of the "Southwest Denver Expansion Project". The District has been keenly aware of a blatant ALERT data collection gap in the rapidly developing SW corner of the metropolitan area, and the pieces needed to fill this void are rapidly falling into place. Current plans include adding three additional rain/stage sites in SW metro drainages, and two rain only sites, one near the Stapleton area and another near the Denver Zoo (hence the reference above to "loosely defined").

At long last, plans have also been recently set into motion for an expansion to the City of Aurora ALERT network. Proposed sites include a new weather suite at Aurora Reservoir, four new rain stage sites, and one rain only site. These sites will expand current coverage primarily to the east and north. This project will also include the reinstallation of the Shop Creek site, which was dismantled/abandoned during the 2000 flood season.

PT Replacements

Overall, PT performance might be classified as "in a holding pattern" compared with what occurred during 2001; there remains plenty of room for further improvement. Two PT's had to be replaced due to "inadvertent" damage: site 1900 (Niver detention pond) and site 1610 (Holly Dam). The original stage configuration at Holly Dam had to be reworked because of a combination of 1) excessive sediment filtering into the old conduit and 2) the weakened state of the old PT cable by electrical surge, which prevented it from being pulled out and removed without snapping in two. 100' of the old polypro conduit had to be excavated and removed. The conduit was replaced with ½" GRC.

New Druck PDCR 1830 pressure transducers were also installed at sites 120 (Croke Pump Station), 430 (Utah Park), 320 (Sports Complex), 600 (Harvard Gulch Park), 720 (Confluence Pond Canal), 1480 (DIA @ Third Creek), and 4470 (Little Narrows). These all replaced older, unstable Druck PDCR 1830's.

--The Druck at site 120 (Croke Pump Station) died shortly after it was installed in September of 2001. The PT was sent back to the manufacturer and was verified as defective, exhibiting the manufacturing defect that was described in detail in the UDFCD 2001 EOY Summary Report. Druck replaced the PT free of charge.

--The PT at site 320 (Sports Complex) was found to be severely drifting at startup and was immediately replaced after about 19 months of service. Druck denied any manufacturing defect and the District purchased a replacement; likewise for the PT at site 720 (the canal sensor at Confluence Pond), which failed after being installed 24 months earlier.

-- At site 430 (Utah Park), the pressure transducer exhibited excessive drift and was replaced with a District spare PT. The unit failed after 16 months in the field.

--The pressure transducer at site 600 (Harvard Gulch Park) was in service for just over 21 months before failing. At the request of the District, the PT housing was moved to the south wingwall of the culvert upstream of the trash grate. A flood event during the summer of 2001 at this site was not captured appropriately by the stage sensor with the old configuration measuring stage inside the grate at the base of the channel. Hydraulic characteristics at the old point of measurement were such that stage reports were severely underestimating actual hydraulic head at flood discharges. The new configuration will miss low flow data, but will now reliably capture stage data at high discharges.

--The PT at DIA was originally installed at site 810 (Grandby Ditch) in November of 2000, pulled out in July of 2001, and then was reinstalled at DIA in November of 2001. The PT was one of those units that was always "on the edge" in terms of stability, but not so marginal that it demanded replacement. In October, it demanded replacement as its output went bonkers. The PT will be replaced as soon as a replacement can be procured.

--At site 4470 (Little Narrows) the pressure transducer was determined to be defective in July, less than 4 months after it had been installed. Plans are to return the unit to Druck for failure analysis, as it is exhibits the manufacturing defect associated with the product.

--Finally, the pressure transducer at Button Rock (not a Druck) was diagnosed as failing after looking at some very random data output from the sensor. The City of Longmont verified the failure and eventually replaced the sensor. This sensor is the property of the City, not the District.

Discussion of PT problems

It is impossible to determine whether the PT fallout that continued in 2002 is simply a result of older Druck PT "dropouts" that were manufactured and installed prior to Druck's admission of having a manufacturing problem, or if the product itself is wanting in other unknown aspects. Lacking any solid evidence to the latter hypothesis, we are hopeful that PT fallout will slowly fade with time as the newer (presumably superior quality) sensors make their way into the system and gradually populate more and more of the District's stage sites.

Druck PT's that failed during 2002 continued to exhibit the basic modus operandi of failing after less than 2 years of service. When a Druck PT fails, we immediately check the unit for the manufacturing defect that causes failure. This year, three PT's clearly exhibited the defect in question and were sent back to the manufacturer for Failure Analysis. Only one was verified as having the manufacturing defect (and was replaced free of charge), the other two were deemed as having faults that Druck chooses to term "customer-induced". Although we are incredibly dubious that we are inducing any problems ourselves, we continue to take great care in our handling of the "delicate Druck PDCR 1830 pressure transducers" during installation and subsequent inspections (as well as removals, which we are unfortunately getting quite proficient at).

System-wide repeater upgrade

The repeater related problems experienced after deployment in late July may be succinctly encapsulated in two sentences. The first problem was that the repeater would intermittently "lockup"; the lockup state required manual intervention to correct. The second problem was that the repeater would intermittently garble the sensor ID and/or the sensor data bits contained in the ALERT message.

The lockup issue was found with two of the new repeaters that were deployed (Blue Mountain and Gold Hill). This problem was discovered to be software related. The microprocessor is supposed to set a "sleep" mode flag if it does not receive certain instructions in a specific time frame. The microprocessor would always successfully enter sleep mode, but would intermittently fail to properly set its "sleep" flag on when doing so. The PIC (Processing Interface Circuit), after receiving data from a remote ALERT station, would first examine the microprocessor "sleep" flag status. If it saw the flag "on", it would then send an instruction to reset the flag to the "off" condition, then proceed to send the appropriate instructions. If it saw the flag "off", it immediately sent its instructions to the microprocessor. The problem was that the PIC would test the flag "sleep" mode and see an "off" condition, when in actuality the microprocessor was asleep but had failed to set the flag to its true state. "Sleeping Beauty", indeed.

After the problem was verified, a series of software updates were forwarded from the manufacturer. Additionally, the microprocessors and PICs in each repeater have been upgraded/replaced (as there is no reason to believe that the remaining repeaters that had not yet exhibited the lockup condition were any less susceptible to the problem).

The garbling of ALERT sensor ID/data from the repeater was attributed to a poorly sensitized modem that was incapable of properly dealing with weaker radio signals. (This helps explain the observed propensity of only select sites to exhibit the majority of deviant data transmissions.) A newer, more sensitive modem has been forwarded and tested at DIAD Incorporated; the short-term test results have so far been encouraging.

Although there is promise that the identified problems have been resolved, the fact of the matter is that the repeater performance cannot be reproduced in a test environment that guarantees acceptable reliability in the field, particularly with a system that encompasses the size and scope of the one the District administers. With this in mind, DIAD Incorporated has adopted an alternative-vendor strategy that can be pursued, if necessary, to attempt to ensure that the reliability of the District's ALERT network continues to perform at acceptable levels. In the very worst-case scenario, the original repeaters will remain available for duty next spring if resolution of the problem(s) at hand cannot be resolved to everyone's satisfaction.

An additional repeater in the Boulder County portion of the system (Gold Hill, see Figure 3) will now provide backup to the Lee Hill repeater in the same fashion that the two Denver area ALERT repeaters back each other up. An additional benefit to the Gold Hill backup repeater in Boulder County is that the ALERT radio traffic can be redistributed over two repeaters instead of one. This will decrease the traffic load on the Lee Hill repeater and either allow for expansion of the system, or improved performance under the existing traffic demand. The combination of 1) the new Gold Hill repeater and 2) having all primary repeaters be PC programmable and remotely controllable improves the reliability of the entire system and help ensure that real time ALERT data is available to emergency managers at all times. This will provide for faster, automatic switching of repeater function if or when one of the primary repeaters fails.

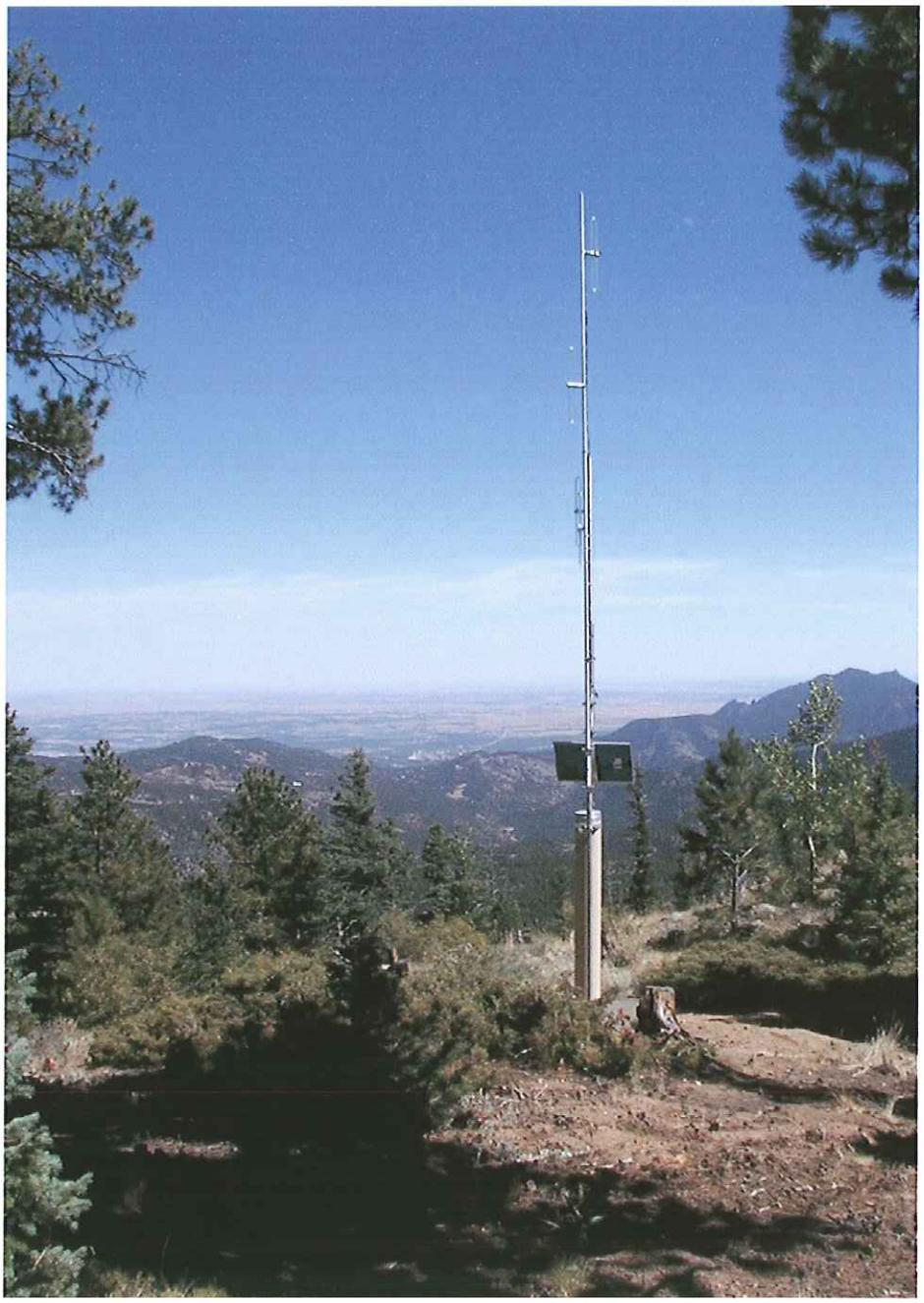

Figure 3. Site 8015, Gold Hill Repeater

Miscellaneous activity of note

--Several problems occurred at Eagle Ridge (site 4520) that were related to an aging power system. The voltage regulator was found to be loading down the solar input voltage from 18.8 V to 5.9 V. A new regulator was installed shortly thereafter. Later in the season, more battery problems revealed an open circuit on the solar panel positive terminal; this was repaired temporarily until a new solar panel could be acquired. The new panel was installed in September.

--Parker and Mississippi (site 540) continued its wicked ways in terms of reliability. The omnidirectional antenna and antenna cable were replaced in April in an attempt to improve RF performance at the site, which has historically been marginal. Despite a significant improvement in the measured VSWR, the reliability of the site remains inconsistent. The next logical step is to install a directional antenna here.

--At Red Garden (site 4030) the old antenna and cable were also replaced as the omnidirectional was missing 2 ground planes and had sustained damage, apparently from rock throwers.

--Squaw Mountain (site 2190) has also displayed inconsistent reliability since its install. The problem has been vexing, as there are no line-of-sight issues, the radio puts out 7+ watts, and VSWR has always looked good. However, the tower is loaded and the equipment is in a very noisy environment. Reliability became particularly poor in August. A service visit required the 555 transmitter to be reprogrammed, which fixed the random rain data problem noted at the base. A 3-element YAGI was also installed on the E face of tower in an effort to improve reliability. During the process, the original antenna connector simply fell apart after applying slight pressure when removing it from the omni. A new cable was assembled on site. Reliability has been much improved since then.

--Unfortunately, both Powers Park (site 1500) and Expo Park (site 420) suffer from significant irrigation contamination. Ironically, particular effort was made at both these sites to avoid this problem by meeting with respective Parks and Rec staff and discussing where the standpipes would least likely be contaminated before the installs took place. No more meetings with Parks staff are likely to occur.

--At Cub Creek Below Blue (site 2270), a runaway Handar 585 transmitter had to be replaced in early August. The transmitter was reporting every 2 minutes. Subsequent bench testing proved fruitless as the problem could not be replicated.

--The Boulder County narrowbanding upgrade effort again stalled in 2002. Two sites in the shared portion of the UDFCD/Boulder County network do not currently have a 3206 transmitter: Magnolia, site 4090, and the Justice Center,

site 4360. Six sites in the "unshared" portion of the network remain ASCII protocol sites: Johnny Park (4310), Big Elk Park (4300), Red Hill (4290), Cannon Mountain (4270), Taylor Mountain (4260) and Indian Ruins (4330). Boulder County narrowbanding upgrades should take precedence over all other transmitter upgrades in the District's system. If budgets allow, District stage sites should then be next in line for transmitter replacement. A total of 12 District stage sites are still using Sierra-Misco 5050 transmitters. After Boulder County, these sites should take the highest priority in terms of continuing narrowband upgrades. Fourteen more S-M 5050's are still employed at rain only sites, leaving a total of 26 S-M 5050's that will require replacement with 3206's.

--Two more solar panels (sites 4180 and 4510) were replaced with brand new smaller units that better fit the power budget requirements associated with the new Boulder County site configurations using 3206 transmitters and their associated smaller batteries. Five more sites (4070, 4290, 4030, 4330 and 4530) require solar panel retrofits. Three of the remaining five sites still have power-sucking ASCII transmitters that require the large solar panels to maintain battery charge and stay alive over the winter. When these transmitters are replaced, the retrofits can proceed.

DIAD Incorporated would like to thank the District's ALERT administrator, Kevin Stewart, for his continued guidance, and we hope to again have the opportunity to support the UDFCD during the next flood season.