



MHFD ALERT Gauging System Maintenance 2021 Annual Report

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Executive Summary

The purpose of this report is to summarize the ALERT and ALERT2 system maintenance activities completed by OneRain in 2021 on behalf of the Mile-High Flood District (MHFD) under our current contract.

We believe that maintenance for the 2021 season was successful. We are excited about the continued implementation of the ALERT2™ protocol and the positive impact it will have on ensuring reliable data collection. Table 3 near the end of this report summarizes our site recommendations for the 2022 flood season and their respective costs.

Beginning in the 2008 maintenance season, OneRain and the District modified the maintenance schedule slightly from previous years by including an interim trip to all rain gauge sites. Table 1 below summarizes the maintenance activity over the last twenty years. The “Service Rate” column is the ratio (%) of service calls to sites in the combined MHFD/Boulder System.

Table 1: Recent maintenance activity statistics for MHFD & Boulder Co.

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	94 (62/32)	194	48%
2009	715	107 (93/14)	179	60%
2010	744	82 (81/1)	180	45%
2011	680	78 (69/9)	180	43%
2012	692	67 (53/14)	176	38%
2013	635	97(87/10)	177	55%
2014	624	64(64/0)	178	36%
2015	598	73(63/10)	175	42%
2016 ²	529	50	177	28%
2017 ²	634	44	178	25%
2018 ²	577	38	180	21%
2019 ²	667	38	180	21%
2020 ²	610	27(26/1)	180 ³	15%
2021 ²	604	12 (11/1)	180 ³	3%

¹ Includes repeaters and base stations.

² In 2016 OneRain began using new Inventory Maintenance software.

³ Both Fourmile and Bridge were out of service during the 2020 & 2021 flood seasons.

System Performance

A total of 604 maintenance records were collected between January 1 – December 14, 2021, including 12 service calls.

Service Calls

The 12 total service calls included the following:

- 4 stage issues
- 5 power-related issues
- 1 tipping bucket issues
- 2 transmitter/RF issues

The unscheduled visits can be attributed to the following:

- Transmitter/RF issues – Transmitter-related issues encompass a wide array of onsite issues including dead radios, program corruptions, transmitter failures, and antenna failures.
- Power issues – Due to an aging battery fleet, several batteries did not survive the interval between standard preventative maintenance visits. Batteries are subjected to dynamic discharge testing at our office. If the battery underperforms it is scrapped and replaced.
- Stage issues – Out of the 9 stage service calls, 7 were due to pressure transducer failures/replacements. The other calls were for pressure transducer signal conditioning.
- Tipping bucket issues – Typically most issues for tipping buckets are due to clogging of the funnel by debris.

Pressure Transducer (PT) Failures and Replacements

There were only 4 PT failures for the 2021 flood season, which is significantly less compared to previous years. Over the past few years, older Druck PTs have been replaced with Keller Acculevel PTs, as the originals have failed. This year 8 PT calibrations were performed. This number is significantly less than last year's, which is mainly attributed to older sensors being replaced. Specific PT replacements for 2021 are listed below.

- Ralston (110) – Replaced March 30
- Nolte Pond (10025) – Replaced May 26
- Harvard Jackson (610) – Replaced September 14
- Havana Park (500) – Replaced September 16

Damaged Equipment/Other Replacements

Cub Ck below Blue (2270)

After not reporting for over a week a site visit was made on June 2nd. During the site inspection moisture was found on the transmitter. All the potential spots for precipitation to enter the standpipe were sealed and a spare transmitter was installed. This site is a high priority for a replacement top section.

Genesee Village (2310)

This site's battery was found to be discharging rapidly after its round 3 visit. Upon further investigation it was found that the analog measurement LED was continuously staying on. A spare ALERT 3206 transmitter was installed on July 14th.

Cherry Creek @ Steele (10083)

This site's battery stopped charging and had lost GPS lock in early August. A site visit found that vandals had pulled on the GPS cable causing the SMS connector to separate from the cable and the solar panel wire was completely severed. A site visit on August 25th repaired the damage and the fixed cables were secured with metal tape to deter future damage.

Louisville WTP (10078)

The wind direction sensor at the Louisville WTP weather station has been centered around the northerly direction since early 2021. A site inspection revealed that the potentiometer had failed. The District's spare inventory does not currently include a wind sensor. OneRain is suggesting the District purchase 2 wind sensors in 2022 (Table 2); one to replace the failed sensor at this site, and the other to keep on-hand as a spare.

Diamond Hill Base Station

On Dec 7th, OneRain visited the Diamond Hill server room to reestablish proper operation of the B2010 receive equipment. A prior power problem had caused the UPS in the wall cabinet to fail and the 12V battery for the equipment became depleted. A new fully charged 33AH battery was installed. The unused ALERT receiver/decoder was removed, as was the dead UPS. Derrick recommended connecting into the UPS in the server cabinet, as that was more reliable and still operating normally. Proper data feed to Contrail and Novastar servers was confirmed. During the outage the equipment at Westminster continued to feed the servers.

It is planned to move the ALERT2 receive equipment into the server rack, since space had been freed up and that will be more serviceable than the wall cabinet. Additionally, the cavity filter tuned to the ALERT frequency and the RF splitter will be removed since that is no longer needed, which will simplify and reduce the loss of the ALERT2 feed to the B2010. RF cabling and power distribution will be ordered, this update is planned for early 2022.

SPR @ Henderson

This site gets stage data via SDI-12 from the Colorado Division of Waters radar sensor. There has been no stage data transmitted via ALERT since March of 2021. OneRain will work on a solution to reestablish communication with the CDOW SDI12 sensor.

End of Season Pressure Transducer Failures

Havana Pond and Hidden Lake have failed pressure transducers which will be replaced before April 1st, 2022

2021 Site Installs, Reconstruction, Relocations, and Upgrades

Bridge (10095)

This ALERT site was decommissioned due to construction activities in 2020. Bridge was reinstalled as an ALERT2 site on November 16th. The original electronics enclosure (figure 1) and part of the pressure transducer conduit was reused. Additionally, an antenna mast was mounted on the side of the bridge and a well point was installed to house the PT. OneRain will install a solar panel and run RF cables before Spring 2022 start-up. This is a seasonal site and its ALERT2 source address is 10095.



Figure 1: Electronics housing reused at Bridge.

Niver Detention (10097)

Niver detention is was removed in June 2021 due to construction activities. It was out of service for most of the 2021 flood season. The reinstallation occurred on December 16th. The transmitter is now housed in a new telemetry cabinet. The PT conduiti is secured to the concrete outlet works. This new ALERT2 site is seasonal, and its source address is 10097.



Figure 2: Niver Detention cabinet enclosure.



Figure 3: PT well point for Niver Detention.

Boulder Falls (10098)

Boulder Falls is a stage only site located up Boulder Canyon. The original site was over 25 years old, and its conduit run was in disrepair. In late May the PT was found to have failed and it was impossible to run a new sensor in the existing conduit. A new standpipe was installed on December 22nd. A revisit will need to be made when the ice melts to finish installing the new PT conduit. This site is seasonal and its ALERT2 Source address is 10098.



Figure 4: Boulder Falls standpipe.

Door Retrofits

Doors retrofit kits were installed at the following 7 sites: St Antons, Temple Pond, Brighton, Sand Creek Park, Pinebrook, Mission Viejo and Fire Station 13. A door retrofit involves cutting a rectangular hole into the standpipe and riveting a shaped frame around the hole where a door is secured with a keyed locking mechanism. Typically, sites that are chosen for a door retrofit are ones located on uneven terrain which makes using a ladder to access the electronics unsafe. Doors also relieve strain on cabling, as it is easier to keep cables organized.

Solar Panel Installs

The following 7 sites were equipped with a solar panel: St. Antons, Dowdy Draw, Sunset, Sunshine, Logan Mill, Crescent Rain and Shanahan Ridge. All these sites are in Boulder County and are operated year-round. Most are quite remote and can be difficult to access, especially during the winter months. These solar panel installs will help ensure these gauges operate reliably throughout the year. Boulder Jail is the only remaining site without a solar panel that is operated year-round.

Cherry Creek MET Station (10091)

OneRain installed a weather station for The Cherry Creek Basin Water Quality Authority at Cherry Creek State Park. This site is included in this report because it shares the MHFD RF backbone.



Figure 5: Cherry Creek Met Station.

Marshall Fire

Three sites were in the burn area of the Marshall Fire which include Coal Creek at McCaslin, Louisville Dwy and Howard Berry WX. OneRain will inspect each site for damage prior to the start of the 2022 flood season.

Upcoming Work

OneRain plans to upgrade and reinstall the Fourmile gauge up Fourmile Canyon in early Spring. Additionally, the following 10 sites will be converted to ALERT 2 before April 1st: Utah Park, Iliff Pond, Confluence Pond, Piney Ck @ Liverpool, Denver West, Lena @ Hwy 6, Fairgrounds, Apex, Hidden Lake and Upper Sloan. As part of the upgrade, a solar panel and GPS antenna will be installed at each site. A subset of these sites will also be retrofitted with a door or a new top section.

Boulder County Activity

There were no major issues in Boulder County this year. A separate report will be delivered to the county with additional recommendations and upgrades.

Button Rock Weather Station (4790)

The Button Rock weather station's performance has been degrading over the past several years. This site uses a Hydrolynx 5096 transmitter that is over 20 years old. The battery voltage has ceased to report in the last year. It is recommended that this site be upgraded to ALERT2 and the sensors be replaced.

Miscellaneous Activity

FCC Licensing

Currently, all sites are associated with an FCC license and are not due for renewal until 2025.

Alarming

Rainfall alarms were added to all sites in Contrail. Alarming is triggered by the following events:

- 0.5 Inches in 10 Minutes
- 1.0 inches in 1 hour
- 3.0 inches in 2 hours
- 5.0 Inches in 5 hours

Deliveries are set up for e-mail and/or text message. When a site is in the alarm state, the icon in the user interface will reflect this.

Inventory *plus*

All current and historical maintenance activities can be tracked in real-time at *inventory.onerain.com*. Here you will find current work orders, site issues, and historical activities.

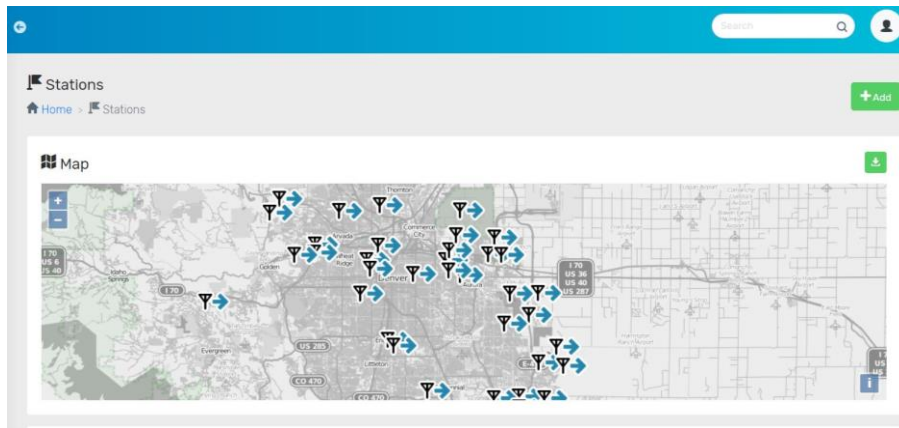
Contrail Branding

OneRain software engineers have updated the Mile High Flood Districts Contrail site with a new URL and logo to reflect the change in naming from UDFCD to MHFD. An additional subdomain was created: mhfd.onerain.com

TDMA

OneRain has been in charge of managing source addresses and TDMA information for WET and other agencies since 2013 when ALERT2 gauges had started to be deployed in the MHFD. This info is tracked under three separate websites: alert2.org, tdma.onerain.com, and mhfd.onerain.com.

Alert2.org provides the next available source address to be used, tdma.onerain.com tracks a site's ALERT2 parameters and the mhfd.onerain.com site tracks a site's location relative to its closest repeater to keep a site's slot or time to transmit as evenly dispersed as possible so that we can efficiently grow the system.



Frame

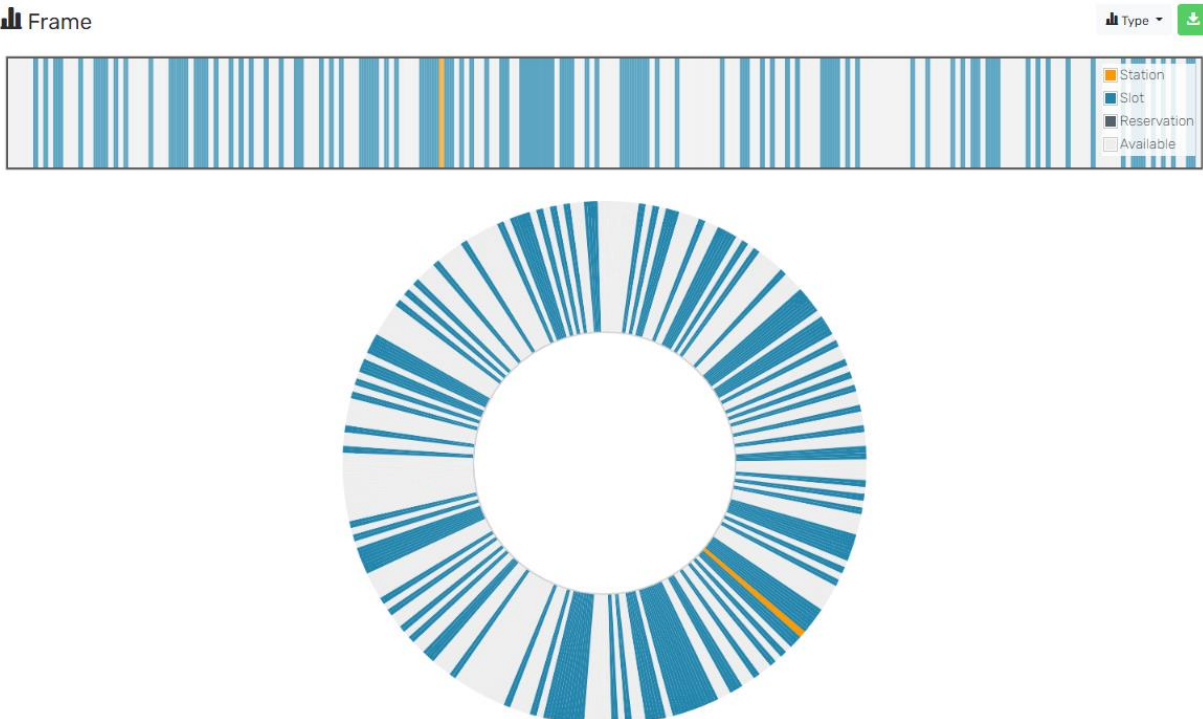


Figure 6: MHFD ALERT2 sites and TDMA timeslots.

Figure 6 was taken from tdma.onerain.com and highlights the ALERT2 sites in Denver (top) and all the slots currently used in the MHFD system (bottom). There are currently 96 ALERT2 sites in total which puts the system at 43% capacity.

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 worthy of note.

ALERT2™ Upgrade

Below is a complete list of sites using the ALERT2 protocol, maintained by OneRain (59 total):

- Carr Street
- Maple Grove Reservoir
- East Toll Gate at Hampden
- Blackstone
- Havana Pond
- James Creek at Jamestown
- Lower Lefthand
- Murphy Creek
- Nolte Pond
- South St. Vrain at Berry
- Quincy Reservoir Wx
- Flying J
- Broomfield
- Aurora Reservoir Wx
- Green Ditch
- Van Bibber @ 93
- Kelly Dam
- Sable @ Colfax
- Hiwan
- Urban Farm
- Cherry Creek @ Steel
- Powers Park
- Leyden Reservoir
- Boulder Falls
- Iliff Pond*
- Piney Ck @ Liverpool*
- Upper Sloan*
- Confluence Pond*
- Hidden Lake*
- Fairgrounds*
- Sand Creek at Colfax
- Westerly Creek Dam
- Coal Creek at McCaslin
- Diamond Hill Wx
- Sanderson Gulch
- Side Creek Park
- Little Dry Creek @ 64th
- Broadway
- Porphyry
- Montview
- Filter Plant
- NREL
- Lakewood Gulch
- Walker Mountain
- Maple Grove res Gates
- Fairview Peak
- Slaughterhouse
- Aurora Regional Pond
- Brighton
- Louisville WTP
- Expo Park
- Bear Creek @ Lowell
- Niver Detention
- Bridge
- Utah Park*
- Fourmile*
- Lena @ Hwy 6*
- Apex*
- Denver West*

*Denotes sites to be upgraded to A2 by 2022 Start-up

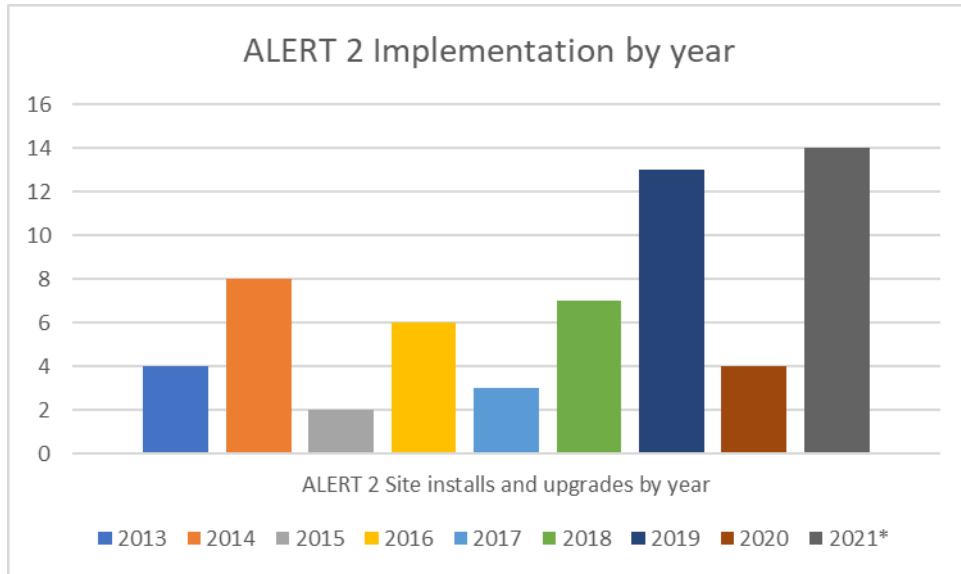


Figure 7: : ALERT2 sites added to the MHFD system by year. *Note that 11 of the sites for 2021 will be completed by start-up of 2022

Metadata Consistency

OneRain will continue to work with WET and other agencies to integrate database metadata ensuring accuracy and consistency. This includes sharing sensor calibration data, updating rating tables, and E19 levels.

Spare Equipment Recommendations for the 2022 Season

Table 2: Spare equipment recommendations

Manufacturer	Model	Cost	Purchase	Total	Notes
Keller	Acculevel	\$1,333	1	\$1,333	50 ft PT
Keller	Acculevel	\$1,483	3	\$4,449	100 ft PT
Keller	Acculevel	\$1,633	1	\$1,633	150ft PT
Vaisala	HMP110	\$830	1	\$830	Temp / RH Sensor
RM Young	5103	\$1339	2	\$2678	Wind Monitor
HSE	5730-03	\$724	1	\$724	Barometer
			TOTAL	\$11,647	

Additional Site Recommendations

The following are additional site recommendations not associated with spare equipment. The approximate cost for these recommendations is summarized in Table 3 and explained below. A detailed proposal can be provided upon request.

Table 3 Approximate cost of additional site recommendations.

Site / Activity	Approximate Cost (per site)
Standpipe Door Retrofit	\$671
Top Section Replacement	\$587 / \$1012

Standpipe Door Retrofit Implementation

In previous seasons OneRain has been retrofitting old standpipes with doors using the High Sierra door kit. There are still many sites that lack a door and are therefore difficult to access the electronics inside. We propose purchasing at least 5 retrofit kits for installation during the Spring of 2022. The installation of doors improves both maintenance safety, hardware wear and tear, and efficiency. The cost of **\$671** per retrofit includes hardware and labor. The list below contains sites that would benefit most greatly from the upgrade:

- Cub Ck below Blue
- Parker @ Mississippi
- Bear Ck @ Cub
- Sports Complex
- Shanahan Ridge

Replacement Top Sections

In addition to adding doors to standpipes, several sites would benefit from having their top sections replaced due to old age and damage. High Sierras newer style top sections use a key locking mechanism that makes maintenance safer and more efficient. Sites with these new top sections and door retrofits improve safety and reduce potential damage to electronics or pinched wires by not having to remove the transmitter from the top of the standpipe. Sites chosen to have a new top section installed should already have a door or have a door installed. The cost for a new top section is **\$587** without a tipping bucket mechanism and **\$1,012** for a top section that includes a tipping bucket mechanism. Six of the listed sites would need a top section and a new tipping bucket mechanism since currently they have an older style mechanism that is not compatible with the new top sections (sites denoted below with an *). The following 12 would benefit most from this upgrade:

- Cub Ck below Blue*
- Bear Ck @ Cub*
- Brighton*
- Fire Station 13*
- SPR @ Third*
- Denver Zoo*

- Sand Creek Park
- Pinebrook
- Mission Viejo
- Sports Complex
- Temple Pond
- Parker @ Mississippi

MHFD Comm Engine Sites / HydroLynx 5096 Legacy Transmitters

There are 12 Comm Engine and 4 Hydrolynx 5096 Transmitter sites left in the MHFD system that are over 20 years old. This equipment is outdated, and no longer supported by the original vendors. The following table lists sites that would most benefit from being updated to ALERT2.

Table 4 Legacy hardware recommended site upgrades

Site	Legacy Equipment	Cost
Calwood Ranch WX	5096	\$10,066
Sugarloaf WX	5096	\$10,066
Hills Mills WX	5096	\$9,691 (currently has a door)
Elbert WX	CE	\$10,066

Weather station upgrades should include an ALERT2 transmitter, new weather sensors (air temperature / relative humidity, wind speed / direction and barometric pressure) as well as a door, top section, and solar panel. While all sites in Table 4 would benefit from an equipment upgrade, Calwood Ranch would benefit most.

Appendix A: Spares on Hand

Per separate PDF accompanying this document