MHFD ALERT Gauging System Maintenance 2019 Annual Report

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Report Date: December 19, 2019

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Executive Summary

The purpose of this report is to summarize the ALERT system maintenance activities completed by OneRain in 2019 on behalf of the Mile-High Flood District (MHFD) under our current contract.

We believe that maintenance for the 2019 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.

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 course of the last seventeen 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	182	21%
2019[2]	667	38	182	21%

[1] Includes repeaters and base stations.
[2] In 2016 OneRain began using new Inventory Maintenance software.

System Performance

A total of 667 maintenance records were collected between January 1 – December 5, 2019, including 38 service calls initiated by OneRain.

Service Calls

The 38 total service calls included the following:

- 11 stage issues
- 7 power-related issues
- 7 tipping bucket issues
- 7 transmitter/RF issues
- 6 infrastructure 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, a number of batteries did not survive the interval between standard preventative maintenance visits. Batteries are subjected to a dynamic discharge testing at our office. If the battery underperforms it is scrapped and replaced.
- Stage issues – Out of the 11 stage service calls, 9 were due to pressure transducer failures/replacements. The other service call was for signal conditioning and calibration.
- Tipping bucket issues – Typically most issues for tipping buckets are due to clogging of the funnel by debris.
- Infrastructure issues – Most issues were due to damage to sites resulting from construction activities.

Pressure Transducer (PT) Failures and Replacements

There was an increase in the amount of PT failures compared to last year. Over the past few years, older Druck PTs have been replaced with Keller Acculevel PTs, as the originals have failed. This year 49 PT calibrations were performed. This number is significantly more than preceding years mainly contributed to older sensors being replaced. Specific PT replacements for 2019 are listed below.

- Leyden Confluence (210) – Replaced March 27
- Cherry Creek @ Steel (1720) – Replaced March 29
- Little Narrows (4470) – Replaced May 2
- Temple Pond (630) – Replaced May 13
- Evergreen Lake (2220) – Replaced July 25
- Havana Pond (10023) – Replaced August 14

- Lville DWY (1100) – Replaced August 20
- Horseshoe Park (710) – Replaced September 27
- Green Ditch (10048) – Replaced November 15

Damaged Equipment/Other Replacements

SPR @ Union (1640)

The tipping bucket top section was found dislodged from its base, it was re-secured and leveled. The Handar tipping bucket bearings were seizing, causing inaccurate reporting. A spare tipping bucket was installed in the top section.

Sand Creek Park (1800)

During take out of last year the PT conduit was found to be damaged, most likely from debris from a high flow event. Fortunately, the PT survived. On March 25 this site was visited for startup and conduit repair. The PT was removed and the broken section of conduit along the pedestrian bridge was replaced and re-secured. The PT was reinstalled and tested.

Figure 1: Damaged section of conduit at Sand Creek Park.

Niver Detention (1900)

The antenna mast at this site was found torn from the standpipe on August 20th, 2019. OneRain field technicians were able to re-secure the mast. The site continued to operate correctly for the duration of the season.

Figure 2: Niver Detentions antenna mast upon arrival (Left); Re-secured mast (Right).

Fourmile (4410)

This site was found not reporting in early June. A site visit revealed that all the equipment had been removed by construction workers fixing the stretch road along Fourmile canyon. Fortunately, the ALERT transmitter and pressure transducer were recovered intact. This site will need to be relocated and installed once construction is complete.

Bridge (4420)

On October 9th OneRain technicians met with a Boulder County CDOT contractor to discuss work being done to widen the channel where this site is located. The PT conduit was destroyed but the PT remained intact and was recovered. The enclosure mounted under the Bridge is still intact and reusable. After work is complete, the conduit will need to be reran. OneRain will stay in contact with the construction company to find out when work is complete.

ETG @ Hampden (10011)

In 2017, the standpipe was starting to lean and was not completely secure. The integrity of the site was compromised and was difficult to maintain safely. On March 19th the standpipe foundation was repaired.

Figure 3: ETG @ Hampden standpipe after foundation repair.

2019 Site Installs, Reconstruction, Relocations, and Upgrades

Van Bibber (10064)

Van Bibber @ 93 (original Alert ID 330) was relocated downstream to Crestone Bridge on January 30th, 2019. This site uses a non-contact radar sensor to measure stage. This site was also upgraded to ALERT 2.

Figure 4: Van Bibber gauge relocation.

Kelly Dam (10070)

Kelly Dam was upgraded to ALERT2 on March 18th, 2019. OneRain installed a HSE 3306-02 transmitter, HSE 5301 solar panel, a GPS, and new top section. Its ALERT 2 source address is 10070.

Figure 5: Kelly Dam ALERT2 upgrade and infrastructure improvements.

Slaughterhouse (10071)

Slaughterhouse was upgraded to ALERT2 on March 28th, 2019. OneRain installed an HSE 3306-02 transmitter, HSE 5301 solar panel, and GPS. The PT riser was found damaged and was replaced as well. Its ALERT 2 source address is 10071.

Figure 6: Slaughterhouse ALERT2 upgrade.

Sable @ Colfax (10072)

Sable @ Colfax was upgraded to ALERT 2 on March 11, 2019. OneRain installed an HSE 3306-02 transmitter and a GPS. This site already had a solar panel. Its ALERT 2 source address is 10072.

Figure 7: Sable @ Colfax ALERT2 upgrade.

Aurora Regional Pond (10073)

This site was upgraded on March 19th, 2019 with an HSE 3306-02 transmitter and GPS. This site already had a solar panel. Its ALERT 2 Source address is 10073. (No picture was taken of the upgrade.)

Hiwan WX (10074)

Hiwan weather station was upgraded from ALERT (ID 2210) to ALERT2 (ID 10074) on March 12, 2019. All legacy hardware was removed including the old transmitter, temperature sensor, wind speed and direction gauges, and the old solar panel. OneRain installed an HSE 3306-02 ALERT2 transmitter, a GPS antenna, an HSE 5733 temperature and relative humidity sensor, an HSE 5730 barometric pressure sensor, an RM Young 05103 wind direction and velocity sensor, and an HSE 5301 solar panel with voltage regulator. The masts of the old wind sensors were sealed and left in place to prevent intrusion by insects or other pests.

Figure 8: Hiwan weather station ALERT2 and sensor upgrades

Brighton WX (10075)

Brighton weather station was upgraded from ALERT (ID 1920) to ALERT2 (ID 10075) on March 22, 2019. All legacy hardware was removed including the old transmitter, temperature sensor, and wind speed and direction gauges. OneRain installed an HSE 3306 ALERT2 transmitter, a GPS antenna, an HSE 5733 temperature and relative humidity sensor, an HSE 5730 barometric pressure sensor, and an RM Young 05103 wind direction and velocity sensor.

Figure 9: Brighton weather station ALERT2 and sensor upgrades.

Louisville WX (10078)

Louisville weather station was upgraded from ALERT (ID 4750) to ALERT2 (ID 1007) on August 6, 2019. OneRain removed the old transmitter, temperature sensor, and wind speed and direction gauges. OneRain installed a HSE 3306 ALERT2 transmitter, a GPS antenna, a HSE 5733 temperature and relative humidity sensor and a RM Young 05103 wind direction and velocity sensor. The masts of the old wind sensors were sealed and left in place to prevent intrusion by insects or other pests. This site still needs a barometric pressure sensor to be fully operational.

Figure 10: Louisville weather station ALERT2 and sensor upgrades.

Cherry Creek @ Steel (10083)

A non-contact radar sensor was installed on the pedestrian bridge at Cherry Creek @ Steel on November 8th, 2019. This site was also upgraded to ALERT 2. The site was also upgraded with a new top section, tipping bucket, a HSE 5301 solar panel, and permanent GPS antenna on December 18th, 2019, as well as retrofitted with a new door for safer maintenance.

Figure 11: Cherry Creek @ Steel radar sensor (left); ALERT2 and infrastructure upgrades (right).

Powers Park (10084)

Powers Park was upgraded to ALERT 2 on December 12th, 2019. The original site (Alert ID 1500) began to accumulate water in the base of the standpipe. The upgraded site infrastructure incorporates the mounted cabinet style electronics enclosure and the keyed top section. This style prevents groundwater seepage into the enclosure while ensuring site security and maintainability.

Figure 12: Powers Park ALERT2 and infrastructure upgrades.

Expo Park (10085)

Expo Park (legacy Alert ID 420), like Powers Park, also had issues with water seeping into the original standpipe. This site now utilizes the mounted cabinet style enclosure to prevent future seepage problems. This site was also upgraded to ALERT2 which was completed on December 12, 2019. Both Powers and Expo Parks are seasonal sites. Test transmissions were sent at the time of installation but electronics were removed for the winter.

Figure 13: Expo Park ALERT2 and infrastructure upgrades.

Gold Hill Repeater

On April 6th, 2019 the GPS week rolled over, which happens every 19.7 years. ALERT2 encoders that did not handle this correctly would exhibit problems between then and the beginning of the next month (they reacquire the leap second correction on reboot or at the beginning of each month). After working on the Gold Hill repeater in April and having it shift to the wrong time slot after reboot it was determined that it had been built with a prototype GPS module that did not handle the roll-over correctly. To keep it from consistently interfering with another single repeater, we disconnected the GPS so that it would transmit randomly, limiting its transmission collisions. OneRain staff visited all the other repeater sites that we maintain and confirmed that only Gold Hill had the prototype GPS, and all the other repeaters maintained their correct time slots. MHFD's spare repeater also uses the newer GPS. It was not installed at Gold Hill, so that it would remain available in case one of the larger critical repeaters went down during the flood season.

OneRain became aware of safety stock of G2012 encoders that HSE had manufactured at the end of production by BWD. On Oct 23rd OneRain replaced the G2012 encoder at the Gold Hill ALERT2 repeater. The new board correctly sync'd on GPS, locked on its assigned time slot, and correct operation was verified.

It should be noted that repeater logs show when individual gauge sites transmitted, and are used to determine if they are in their time slots and for other diagnostics. Messages received at the base receivers (Diamond Hill and Westminster) do not have that information about the gauge sites, only the times the repeater transmitted. Accordingly, especially for the sites that can be difficult to access in severe weather, it would be valuable to add cell modems to their IP ports for maintenance and troubleshooting. This can also be used as a failover redundant path to feed Contrail (only the ALERT2 reports) in the case that the repeater's transmitter or antenna fails. Typically, it is only enabled when needed, or used with a Concentrator to minimize data costs.

Blue Mountain Upgrade

A new repeater is to be installed at Blue Mountain. The new repeater will be replacing 3 existing pieces of equipment (ALERT Repeater, ALERT2 Repeater, ALERT Weather Station) with a single unit. The existing sensors at the Blue Mountain site will be integrated into the new repeater to maintain its present functionality. At the time of this report the repeater had just arrived at OneRain's office. The repeater will be tested and configured over the coming weeks. Installation is expected to occur sometime in January 2020.

Door Upgrades

The following sites were retrofitted with a door. The existing infrastructure is quite old and did not have the door option. Adding a door increases efficiency and safety while maintaining sites.

Red Garden (4030)

Installed on March 27, 2019.

Iliff Pond (650)

Installed on March 11, 2019.

Hidden Lake (1300)

Installed on February 12th, 2019.

Louisville (1100)

OneRain retrofitted the standpipe with a door on March 7th, 2019. (No picture was taken.)

Top Section Upgrades

The following top sections were old and out of round. New top sections were installed which included the new “locking” mechanism for ease of access.

Lena @ Hwy 6 (1040)

Installed March 6th, 2019.

Iliff Pond (650)

Installed March 11th, 2019.

Englewood (1600)

Installed March 8th, 2019.

Upper Sloan (1400)

Installed March 6th, 2019.

Niver Detention (1900)

Installed March 6th, 2019.

Kelly Dam (10070)

Installed March 18th, 2019.

Confluence Pond (720)

A new top section was installed on March 25th, 2019. The PT riser was replaced and secured to the concrete channel.

Horseshoe Park (710)

A new top section was installed on March 11th 2019. (No picture was taken.)

Solar Panel Installs

The following sites did not have a solar panel. To increase site up-time, solar panels were added to these locations.

Betasso (4110)

Installed on March 26, 2019.

Red Garden (4030)

Installed on March 27, 2019.

Pine Brook (4170)

Installed on March 26, 2019.

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.

James Creek (10017)

The original site was removed in June of 2018 because the bridge was being rebuilt. The site was relocated to the downstream side of the creek and is now monitored with a non-contact radar sensor which was installed March 17th, 2019.

Figure 14: James Creek radar gauge

Fairview Peak ALERT2 Upgrade

Fairview Peak is the most remote rain gauge in the MHFD. It was upgraded to ALERT 2 on March 27th, 2019. Its ALERT2 source address is 10069. A solar panel was also installed on a separate visit in April.

Figure 15: Fairview Peak ALERT2 upgrade.

Button Rock Weather Station (4790)

The Button Rock weather station's performance has been degrading over the past year. This site uses a Hydrolynx 5096 transmitter that is over 20 years old. The battery voltage has ceased to report for the last 5 months and rain tips have started to count backwards. It is recommended that this site be upgraded to ALERT2 with new sensors.

Door / Solar Panel Installs

Door retrofit kits and solar panels were installed at Flings, Golden Age, Lee Hill Rain, Whispering Pines, and Lazy Acres. These sites were some of the few remaining year-round sites in the Boulder area that did not have a solar panel.

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

Since ALERT2 gauges have started been deployed in the MHFD starting in 2013, OneRain has been in charge of managing source addresses and TDMA information for WET and other agencies deploying these gauges in the region. 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 sites ALERT2 parameters and the mhfd.onerain.com site tracks a sites location relative to its closest repeater as to keep a sites slot or time to transmit as evenly dispersed as possible so that we can efficiently grow the system.

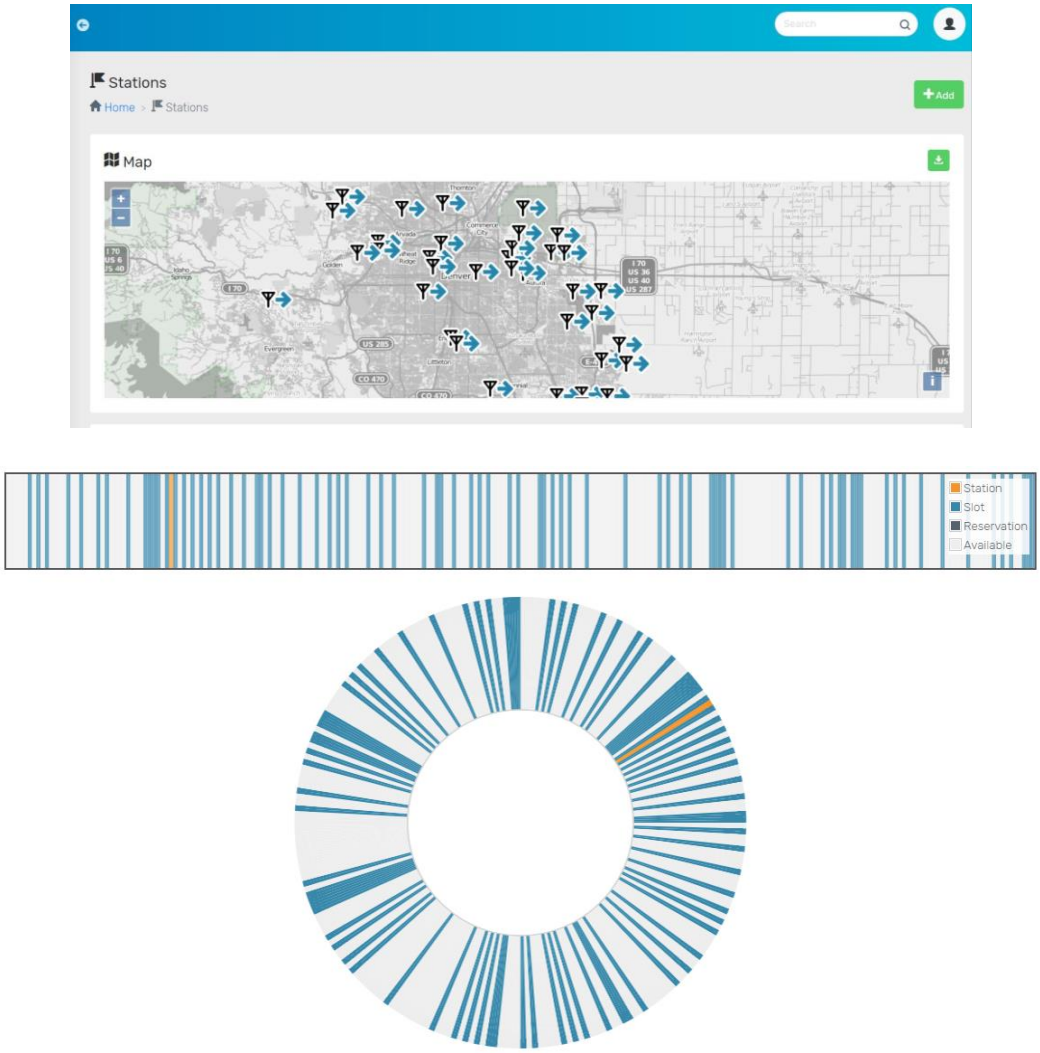

Figure 16: MHFD ALERT2 sites and TDMA timeslots, December 2019.

Figure 16 was taken from tdma.onerain.com and highlight ALERT2 sites in Denver (above) and all the slots currently used in the MHFD system (below). There are currently 75 ALERT2 sites total which puts the system at 33.3% 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 (43 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
- 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

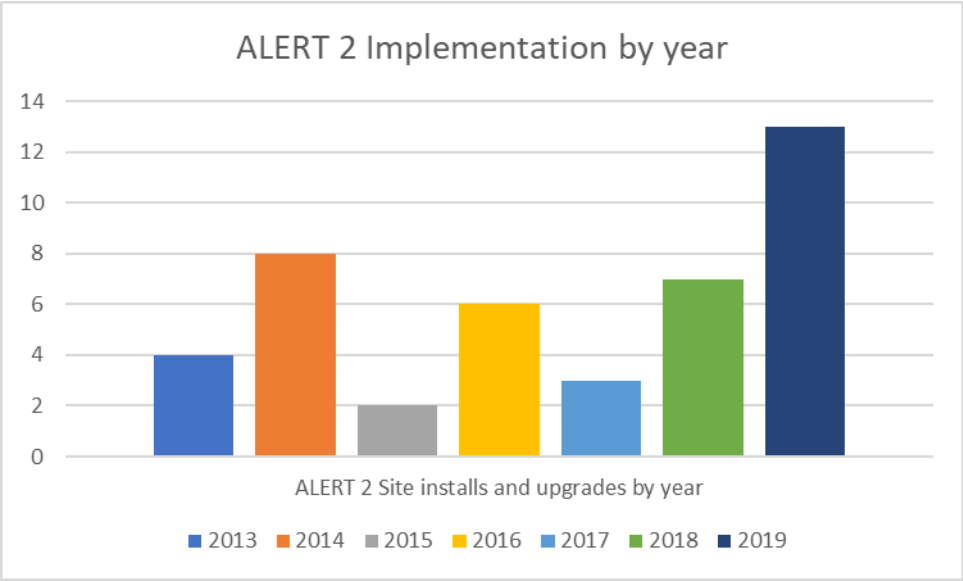

Figure 17: ALERT2 sites added to the MHFD system by year.

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 Upcoming Season

Currently the spare stock of pressure transducers is dangerously low and consist of only older Druck units that had been removed from now defunct sites. It is of high priority to replenish PT stock to keep current stage sites fully operational in case of future PT failures.

Table 2: Spare Equipment Recommendations

Manufacturer	Model	Cost	Purchase	Total	Notes
High Sierra	7135-11	$423	2	$846	GPS Antenna / Cable
High Sierra	5730-03	$650	1	$650	Barometric Pressure Sensor (Louisville WX)
Keller	Acculevel	$1,312.5	4	$5,250	100 ft. PT
Keller	Acculevel	$1,362.5	2	$2,725	120 ft. PT
Keller	Acculevel	$1,462.5	2	$2,925	160 ft. PT
Keller	Acculevel	$1,512.5	2	$3,025	180 ft. PT
Keller	Acculevel	$1,562.5	2	$3,125	200 ft. PT
			TOTAL	**$18,546**	

Additional Site Recommendations

The following are additional site recommendations not associated with spares. A detailed proposal can be provided upon request.

Standpipe Door Retrofit Implementation

On 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 7 retrofit kits for installation during the spring of 2019. The installation of doors improves both maintenance safety, hardware wear and tear, and efficiency. The cost of **$565** per retrofit includes hardware and labor. The list below contains sites that would benefit most greatly from the upgrade:

- Parker @ Mississippi
- Temple Pond
- Brighton
- Sand Creek Park
- Cub Creek below Blue
- Pinebrook
- Mission Viejo

Replacement Top Sections

In addition to adding doors to standpipes, there are a number of sites that 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 coupled with these new top sections and door retrofits limit the amount of time spent on a ladder and reduce potential damage to electronics or pinched wires by not having to remove the transmitter out 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 **$796.** The following sites would greatly benefit from this:

- Parker @ Mississippi
- Temple Pond
- Brighton
- Sand Creek Park
- Cub Creek below Blue
- Pinebrook
- Mission Viejo

Solar Panel Campaign

There are 6 sites that are year-round, located in the canyons of Boulder that currently do not have solar panels. To alleviate unnecessary site visits due to failing batteries it is recommended solar is installed. This campaign could be spread out over multiple seasons. The cost of a new solar panel and labor is **$498**. The 6 sites owned by MHFD are as follows:

- St. Antons
- Dowdy Draw
- Sunset
- Logan Mill
- Crescent Rain
- Shanahan Ridge

MHFD Comm Engine Sites / HydroLynx 5096 Legacy Transmitters.

There are 12 Comm Engine and 4 Hydrolynx 5096Transmitter 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 being updated to ALERT 2.

Table 3: Recommended Site Upgrades

Site	Legacy Equipment
Calwood Ranch WX	5096
Sugarloaf WX	5096
Hills Mills WX	5096
Chatfield Dam rain only	5096
Elbert WX	CE
Shop Creek rain only	CE
Upper Leyden rain only	CE

The cost to upgrade these sites varies from approximately $3000 to $10,000. Weather station upgrades includes upgraded ALERT2 telemetry, new sensors as well as door and top section installs if applicable. We propose upgrading 1 or 2 a year starting with Calwood Ranch and Shop Creek.

Appendix A: Spares on Hand

Per separate PDF accompanying this document