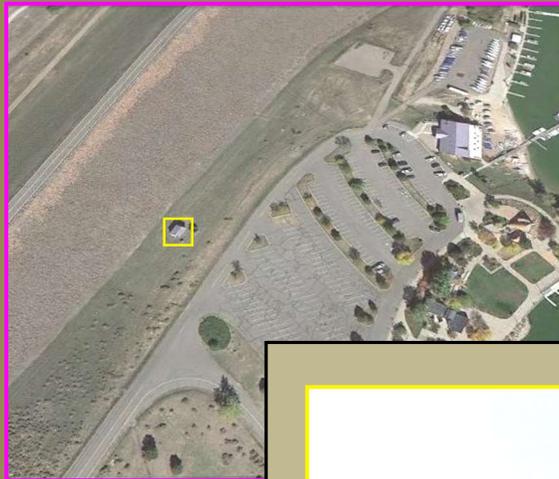

**CHERRY CREEK RESERVOIR
DESTRATIFICATION SYSTEM**

**OPERATION AND MAINTENANCE
ANNUAL REPORT
2022**



Submitted To:

Cherry Creek Basin Water Quality Authority



Prepared By:



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Richard "Rich" Borchardt

CHERRY CREEK BASIN WATER QUALITY AUTHORITY RESERVOIR DESTRATIFICATION SYSTEM OPERATION AND MAINTENANCE ANNUAL REPORT 2022

INTRODUCTION:

R2R Engineers is retained under the “Pollution Abatement Project Manager (PAPM)” agreement to operate and coordinate maintenance of the compressor and aeration system commonly referred to as the Cherry Creek Reservoir Destratification System (RDS). The RDS began operation in April 2008.

2022 RDS SEASON SUMMARY:

At their January 20, 2022 meeting, the CCBWQA Board of Directors (Board) adopted a restated amended Policy for the Operation of the RDS (Policy) by resolution 2022-1-2 included in **Appendix A** which:

- adopted the new operation season of about mid-April through about the end of September, and
- optimizes the water quality benefit of a reduced the summer chlorophyll-a average (historically reduced by 0.8 to 4.7 ug/l from 2008-2013¹).

In accordance with this Policy, R2R Engineers started the RDS on April 15, 2022 and shut it down on October 6, 2022.

2022 OPERATION DETAILS/REPAIRS/ MAINTENANCE:

The RDS test start and visual leak check was done on April 4, 2022 from 2:18 to 3:12 pm for 54 minutes with the pressure reducing valve set to a distribution system pressure of 40 psi. Ingersoll Rand replaced the top pressure regulating valve and performed their pre-season start inspection of the compressor on April 4, 2022. Prior to RDS test, leak check, and compressor inspection, an email was sent to CCBWQA representatives, Cherry Creek State Park representatives, and the Marina operator. The manholes were opened and the gage pressures for each of the 5 zones were observed (**Photo 1**). A visual observation was made from the shoreline



¹ Cherry Creek Reservoir Model Documentation - Section 5.2.1; April 2017, Hydros Consulting Inc.



with no leaks apparent; the surface of the reservoir included some waves that were visually masking some of the bubble plumes from the aerators (**Photo 2**).

The 2022 RDS Operations Log in **Appendix B** summarizes the operations and maintenance recorded during the 2022 season. Some of the key highlights are included below.

- The RDS was started for the season on April 15, 2022 at 8:56 am with the pressure reducing valve set to a distribution system pressure of 40 psi.
- The distribution system pressure was stepped up to 50 psi on April 25, 2022 at 2:55 pm.
- The distribution system pressure was stepped up to 55 psi on May 6, 2022 10:29 am.
- On May 10 at 9:55 am, the RDS was shut down at request of Colorado Parks and Wildlife to aid in the search and recovery efforts in the reservoir.
- On May 14, 2022 at 2:32 pm, the RDS was restarted.
- On June 6, 2022, Colorado Parks and Wildlife reported a potential leak in the reservoir.
- On June 7, 2022, LRE Water followed up on the leak report and observed a diffuser head that was creating a larger than normal bubble plume (**Photo 3**) and the other heads in the zone beyond the leak were still working so all zones were left operational.
- On June 14, 2022, Ingersoll Rand performed preventative maintenance which included cleaning of coolers.
- On June 21, 2022, B&RW replaced a blown regulator (**Photo 4**) in head 402 repairing the leak.
- On August 17, 2022, the louvers in both doors to the RDS Building were observed and found free from clogging and debris (**Photo 5**).
- On August 22-23, 2022, B&RW began annual maintenance of the in-lake distribution system.
- On September 6, 2022, Ingersoll Rand informed CCBWQA that they received a message stating temperatures were elevated and that there was a potential ventilation issue. R2R Engineers went out to the site and observed:
 - the louvers in both doors to the RDS Building and found no clogging, and
 - the compressor was shut down and had a warning of High Bearing Oil Temperature on September 2, 2022 at 16:03:46 (**Photo 6**).

Ingersoll Rand was informed of findings and they scheduled a technician for September 7, 2022.

- Ingersoll Rand performed preventative maintenance on September 7, 2022, which included cleaning of coolers, and the compressor was placed back into service.
- On September 14, 2022, the Marina reported a visible leak in the Reservoir.
- On September 15, 2022, LRE Water confirmed leak with large bubble plume and no heads beyond leak were running, they shut down Zone 1 so that remaining zones could still operate.

- On September 20, 2022, B&RW initiated repairs and found the line separated with a large gap between ends. B&RW tried unsuccessfully to pull lines closer together. B&RW capped the end of line so the first few heads in Zone 1 could operate until a larger repair could be made.
- On September 27, 2022, B&RW finished the repair of Zone 1 by disassembling the disconnected section, moving it back into place, and reassembling, thus reconnecting it. Zone 1 was fully returned to service.
- On October 4-5, 2022, B&RW finished annual maintenance of the in-lake distribution system.
- The RDS was shut down for the season on October 6, 2022 at 2:14 pm.



Photo 3



Photo 4

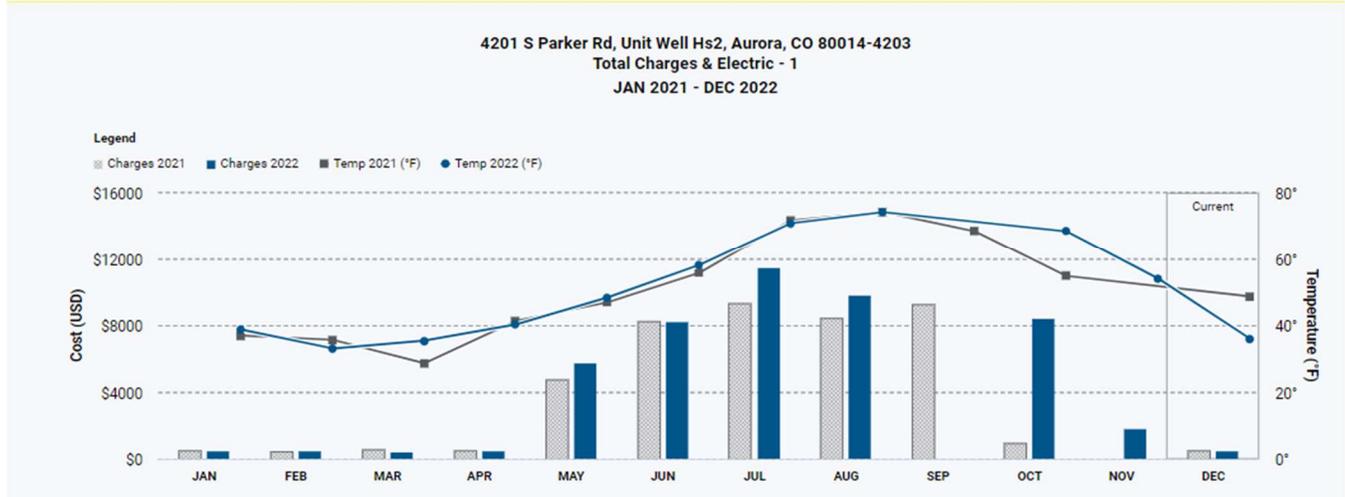
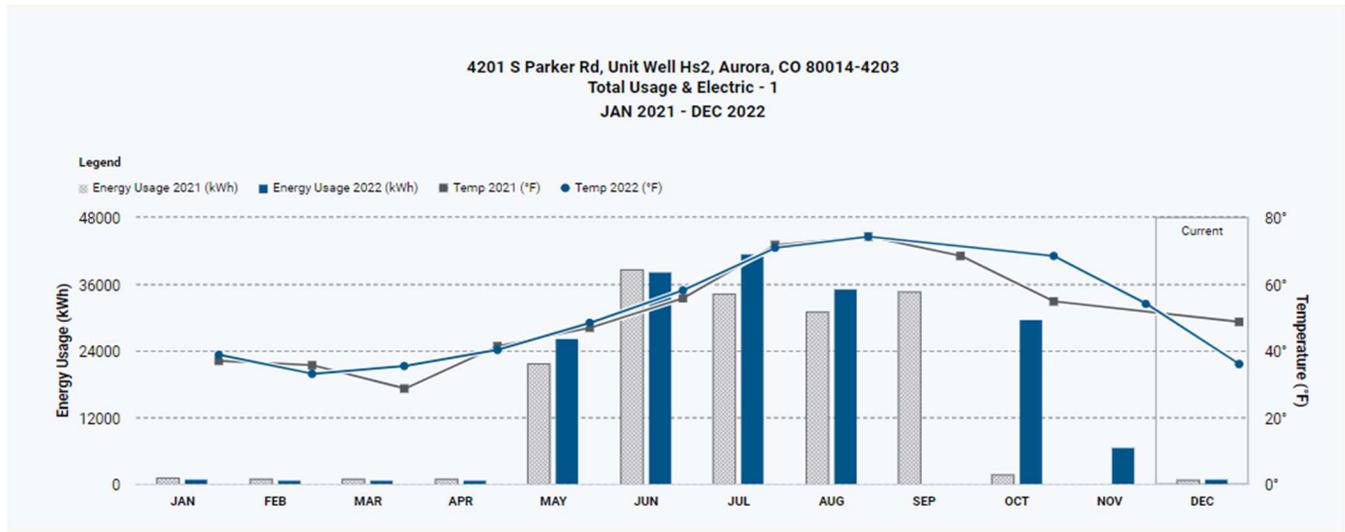


Photo 5



Photo 6

2022 ELECTRICAL USAGE AND CHARGES:



Xcel Energy changed its reporting this year² and now provides two graphs and corresponding monthly data for the 2022 electrical usage and charges (see graphs above and corresponding monthly data in **Appendix C**). These graphs show the previous year for comparison as well. Note that there is information missing for November 2021 and September 2022, which is likely a result of the meter not being read. The charges are actual dollars billed and have not been adjusted for inflation. When the corresponding data is summarized, the total electrical usage for 2022 was 181720 kWh at a cost of \$48,088.50 compared with 2021 that used 166880 kWh at a cost of \$43,623.15. The energy use of the RDS increased in 2022, while the 2022 season was longer (comparing stop dates of 10/6/22 versus 10/1/22) there were other shut down periods in 2022 (for 4 days May 10-14, 2022 and 5 days September 2-7, 2022) that would offset the longer season operation of 5 days. There isn't a readily apparent reason for this 8.8% increase, and it may be a result of different weather patterns and reservoir conditions (i.e., depth and temperature of water). It is recommended that the energy use be monitored going forward to determine whether there are any developing performance issues with the RDS.

² Xcel CCBWQA Account Data, Public Service Company of Colorado, 2022

RECOMMENDATIONS:

The following recommendations are provided for consideration to improve system operation.

- The compressor coolers were cleaned on June 14, 2022; however, the compressor had a temperature warning and shutdown on September 2, 2022. For this reason, it is recommended to have Ingersoll Rand (IR) clean compressor coolers at a frequency of about every 2 months during the operating season to minimize the chances of another high temperature shutdown like what happened from September 2-7, 2022. This cleaning can be requested by contacting IR's Technician Supervisor, currently Daniel Ortiz at DOrtiz@irco.com or on his mobile phone 303.598.7069.
- Since there was a delay in knowing that the compressor wasn't running (CCBWQA had to wait until the after the holiday weekend to be contacted by IR of a potential issue), it is recommended that CCBWQA evaluate options to improve communication with IR and consider other options to monitor RDS operations to minimize the length of future lengths shutdowns.
 - IR was contacted to start this evaluation, and they are beta testing providing their Remote Monitoring System (RMS) to their customers. The RMS provides e-mail and notifications and an online platform to IR that identifies maintenance needs of the compressor. The RMS beta test would be included in CCBWQA's PackageCare so there wouldn't be any additional cost; a request to add CCBWQA has been made to IR's Account Manager, currently Jeff Handley at Jeff.Handley@irco.com or on his mobile phone 303.345.4407). If CCBWQA notices an issue through the RMS or site visit, then a call can be placed to 1-800-223-1911 option 1 to IR to request maintenance on the compressor. The standard work hours are Monday through Friday 7:30 am to 4:00 pm (Mountain Time); if maintenance is needed outside of those hours, a recorded message gives instructions for a 24-hour call service that will reach out to the on-call technician. Maintenance during standard work hours is covered under CCBWQA's PackageCare plan, but after-hours work is not covered and is charged at an hourly rate with a 4-hour minimum.
 - If the RMS doesn't meet the information and communication needs of CCBWQA, CCBWQA can look at possibly reviving the previous notification system (SCADA and Mission Control software used with the old compressor) or a new one that provides a call out to a list (consultant staff and manager) and remote monitoring/control option. This option would likely need further evaluation to determine the scope of work and identification of costs.
- Since there was an 8.8% increase in energy consumption from 2021 to 2022, it is recommended to continue monitoring the annual energy consumption and look for any trends that may point to developing issues or concerns.

RDS POLICY and HISTORY

For the 2009-2013 operating seasons, the Cherry Creek Basin Water Quality Authority (CCBWQA) annually reviewed the prior year's Reservoir Destratification System operating policies and procedures in light of reservoir data collected from system operations to determine the system start-up date.

In 2014, data collected during the time period of 2008 through 2013 was further analyzed. The data identified that the destratification system provided two primary benefits. One is the reduction in the dominance of blue-green algae as part of the whole algal assemblage, and the second is the reduction in the periods when the reservoir is thermally stratified during the summer.³

The data further suggested that operating the aeration system in early spring did not significantly affect blue-green algae (i.e. cyanobacteria) growth, since the primary cyanobacteria growth period is from June through September when water temperatures are warmer.⁴ Additionally, the aeration system supports destratification of the reservoir, thereby reducing the tendency for the reservoir to "turn over," bringing up

³ CCBWQA January 28, 2013. *Compressor Design Basis - Daily Operation*, William P. Ruzzo, P.E., Craig Wolf, GEI.

⁴ GEI, Consultants, Inc. January 2014. *Cherry Creek Reservoir 2013 Water Year Aquatic Biological Nutrient Monitoring Study and Cottonwood Creek Pollutant Reduction Facilities Monitoring*.

anoxic water and higher concentrations of nutrients from the reservoir floor. The data from 2008 through 2013 suggested that the reservoir begins to stratify in late-April to mid-May.

After review of the data, it was concluded that operation of the destratification system, beginning in 2014, shall be modified as follows:

- a. System start-up shall occur between the dates of May 1st and May 10th.
- b. System shutdown shall occur between the dates of November 1st and November 15th.

Additionally, operation of the destratification system shall be limited to those times when ice is not present on the reservoir, except under specific scenarios. This information resulted in "Operation Policy Regarding Ice" policy adopted by the CCBWQA's Board on February 20, 2014 and the "Destratification System Compressor Start-up Procedure" approved by the CCBWQA's Technical Advisory Committee on April 3, 2014 (mentioned here for historical purposes since it has subsequently been updated when the RDS Operations Policy was adopted via resolution 2022-1-2 at the January 20, 2022 Board meeting, see **Appendix A**).

Prior to the start of the 2014 operation of the destratification season, the question surfaced regarding whether the system should be started to allow for reservoir data to be collected with the destratification system in non-operational mode. This would provide additional water quality data to be collected for the in-progress reservoir modeling effort that was underway. The CCBWQA's Technical Advisory Committee took this question under advisement and recommended to the CCBWQA's Board that the system not operate during the 2014 season. The CCBWQA's Board approved this change in the Destratification Operating Policy such that the system did not operate for the entire 2014 aeration season.

Then in 2015 and again in 2016, the CCBWQA's Technical Advisory Committee (TAC) took the question of whether the destratification system should operate under advisement and in each year recommended to the CCBWQA's Board that the system not operate during the 2015 and 2016 aeration seasons in order to collect additional water quality data with the system turned off. The CCBWQA's Board approved the TAC's recommendation each year.

During each of the three years that the destratification system didn't operate, one or more cyanobacteria blooms were observed within the reservoir. Prior to the start of the 2017 aeration season, the CCBWQA's Technical Advisory Committee (TAC) again took the question of whether the destratification system should operate in 2017. Since the reservoir modeling was complete, TAC recommended the destratification system operate from the first of May through the July 4th weekend to determine if this abbreviated aeration season would prevent a cyanobacteria bloom. The CCBWQA's Board approved TAC's recommendation and the destratification system was started on May 1, 2017. Following the system shutdown on July 1, 2017, the aeration system was operated (exercised) periodically to maintain it in a "ready state".

Again in 2018, TAC reviewed and recommended the same operational procedure for the destratification system, which was approved by the CCBWQA's Board.

In 2019, the TAC and Board approved a similar operation season to 2017 and 2018, with the following modifications:

1. Test runs and startup begin in April to assess and prepare for system operations; and
2. If the system is inoperative for longer than 1 day, a restart procedure be established; and
3. Automated controls be evaluated at a cost of less than \$7,500.

A restart procedure of contacting a group⁵ to review available water quality monitoring data and length of operation to establish a restart protocol.

In 2020, the compressor was replaced in July, see compressor replacement summary in **Appendix D**. The RDS was operated from May 1 through November 16, 2020 to capture the full water quality benefits from the RDS. The compressor operated even through the hottest months of July and August. There were several

⁵ Cherry Creek State Park Manager (Jason Trujillo), Colorado Parks and Wildlife Water Quality Coordinator (Mindi May), Solitude Lake Management Regional Manager (Erin Stewart) and the CCBWQA's Pollution Abatement Project Manager (Rich Borchardt)

algae blooms. One of the worst was a blue-green algae bloom from July 9 to July 14, 2020 resulting in the Marina and Swim Beaches being closed to water contact and warning signs posted. It was recommended that the RDS operation season and policy be updated to include additional data that has been gathered since 2014 (when previous RDS Operations Policy) and the ability of new compressor to operate for a longer season.⁶

In 2021, it was noted in the 2021 RDS Operations and Maintenance Annual Report⁷ to add observation and cleaning, if needed, of louvers in the building doors.

In 2022, the CCBWQA Board of Directors (Board) adopted a restated amended Policy for the Operation of the RDS (Policy) by resolution 2022-1-2 included in **Appendix A** which:

- adopted the new operation season of about mid-April through about the end of September; and
- optimizes the water quality benefit of a reduced the summer chlorophyll-a average (historically reduced by 0.8 to 4.7 ug/l from 2008-2013⁸).

⁶ CCBWQA 2020 RDS Operations and Maintenance Annual Report, R2R Engineers.

⁷ CCBWQA 2021 RDS Operations and Maintenance Annual Report, R2R Engineers

⁸ Cherry Creek Reservoir Model Documentation - Section 5.2.1; April 2017, Hydros Consulting Inc.

APPENDIX A – Resolution 2022-1-2 RDS Operations Season and Policy

CHERRY CREEK BASIN WATER QUALITY AUTHORITY

RESOLUTION 2022-1-2

ARAPAHOE AND DOUGLAS COUNTIES, COLORADO

A RESOLUTION ADOPTING A RESTATED AND AMENDED POLICY FOR THE OPERATION OF THE CHERRY CREEK RESERVOIR DESTRATIFICATION SYSTEM

WHEREAS, the Cherry Creek Basin Water Quality Authority (“Authority”) is authorized by the provisions of Section 25-8.5-110(1)(a), C.R.S., to adopt policies to facilitate the governance and management of the affairs of the Authority and for the execution of the powers vested in the Authority, and for carrying out the provisions of Article 8.5 of Title 25 of the Colorado Revised Statutes; and

WHEREAS, the Authority is statutorily charged with protecting, preserving, and enhancing the water quality of Cherry Creek, the Cherry Creek Reservoir and related Watershed; and

WHEREAS, the Authority has installed and currently operates an aeration system in the Reservoir (“Destratification System”) for the purpose of mixing the water column to reduce the occurrence of thermal stratification; and

WHEREAS, on February 20, 2014, the Authority adopted a Destratification System Operating Policy (“Policy”) which the Authority desires to restate and amend; and

WHEREAS, the Authority’s Technical Advisory Committee has reviewed the proposed Restated and Amended Destratification System Operating Policy and recommends the Board adopt the same.

NOW THEREFORE, BE IT RESOLVED BY the Board of Directors of the Cherry Creek Basin Water Quality Authority, Arapahoe and Douglas Counties, Colorado that:

Section 1. Adoption of Restated and Amended Policy. The Restated and Amended Destratification System Operating Policy attached hereto as **Exhibit A** is hereby adopted.

Section 2. Prior Policies Superseded. The Restated and Amended Policy supersedes all policies previously adopted by the Board that pertain to the operation of the Destratification System including, but not limited to, the Policy adopted on February 20, 2014.

Section 3. No Assumed Duty. The Authority is afforded certain immunities, defenses, and protections from and against tort liability under the Colorado Governmental Immunity Act, Section 24-10-101, *et. seq.*, C.R.S., which the Authority, by the adoption of this Policy, does not waive in whole or in part. The adoption of this Policy and its subsequent implementation shall not give rise to a duty of care on the part of the Authority where none otherwise existed, nor shall the enforcement of or failure to enforce the Policy or any provision contained therein give rise to a duty of care when none otherwise existed.

Section 4. Severability. Should any one or more sections or provisions of this Resolution be judicially declared invalid or unenforceable, such determination shall not affect, impair, or invalidate the remaining provisions of this Resolution, the intention being that the various sections and provisions hereof are severable.

Section 5. Repeal. Any and all resolutions, or part thereof, in conflict or inconsistent herewith, or to the extent of such conflict or inconsistency are hereby repealed; provided, however, that the repeal of any such resolution or part thereof shall not revive any other resolution or part thereof heretofore repealed or superseded.

Section 6. Effective Date. The provisions of this Resolution memorialize the actions taken by the Board at its December 16, 2021, regular meeting and accordingly, shall take effect as of said date.

ADOPTED on the 16th day of December 2021 and **EXECUTED** this 20th day of January, 2022.

**CHERRY CREEK BASIN WATER
QUALITY AUTHORITY**

By: **Joshua Rivero**

Joshua Rivero, Chair

Attest:

John A McCarty

John A. McCarty, Secretary/Treasurer

EXHIBIT A

CHERRY CREEK BASIN WATER QUALITY AUTHORITY

CHERRY CREEK RESERVOIR RESTATED AND AMENDED DESTRATIFICATION SYSTEM OPERATING POLICY

July 19, 2021

(TAC reviewed September 2, 2021; Board reviewed January 20, 2022)

Recommended Operating Season and Start-up Criteria:

In 2020, the Cherry Creek Basin Water Quality Authority (CCBWQA) replaced the compressor to improve the operation of the Reservoir Destratification System (RDS) and to allow for operation from March 1 through November 30. In July 2020; the compressor was replaced, and operation was tested through November 16, 2020.¹ With the new compressor, it appears that the RDS has the capability of operating from ice off through ice on the reservoir.

In 2021, CCBWQA wanted to optimize the water quality benefits of the RDS. CCBWQA reviewed the water quality data from the water quality sampling and thermistor set in the reservoir to evaluate the optimal operating season. For the period of 2016 – 2020²:

- the earliest start of thermal stratification was April 20, 2020 (without RDS Operating); and,
- the latest finish of thermal stratification was October 17, 2020 (RDS was operating) or September 27, 2018 (without RDS Operating).

Considering this information, CCBWQA's Technical Advisory Committee at its September 2, 2021, meeting proposed amending the RDS Operations Policy to include, among other things that the RDS should be operated:

- from about mid-April through at least the end of September; and
- before startup, CCBWQA's System Operator will need to visually verify that ice should be off the reservoir³ and the temperature in the building 38 degrees Fahrenheit; and,
- CCBWQA's System Operator shall then log the detail of the start-up and shut-down procedure in the Cherry Creek Reservoir Destratification Facilities Operation and Maintenance Annual Report.

Start-up Procedure:

CCBWQA's System Operator should perform a leak check after ice off and ahead of Operating Season start date. CCBWQA's System Operator will perform test by:

¹ Cherry Creek Reservoir Destratification System – 2020 Operation and Maintenance Annual Report, R2R Engineers.

² E-mails from Solitude Lake Management on March 25, 2021, and April 14, 2021.

³ Destratification System - Operation Policy Regarding Ice; adopted by the CCBWQA Board on February 20, 2014

1. Notifying Cherry Creek State Park Staff (manager and operations manager), Marina Operator, and Ingersoll Rand's client manager for CCBWQA of leak test and season start date.
2. At distribution manholes, check that valves are configured to send air to all zones.
3. Set Pressure Reducing Valve to 40 psi.
4. Review Compressor discharge pressure is set to a range between 100-110 psi.
5. Start compressor following instructions in compressor manual.
6. Monitor gages on Pressure Reducing Valve and Compressor. Compressor delivers 100-110 psi and Pressure Reducing Valve regulates it to 40 psi going to distribution system.
7. Shutdown compressor if compressor delivers more than 110 psi or output on Pressure Reduction Valve exceeds 40 psi.
8. Check pressure gages at distribution manholes.
9. Visually look for leaks by driving dam road and using binoculars from dam and shoreline or by boat.
10. After test, shut-down RDS and report any leaks.
11. Record leak test date and time.

For season start-up, CCBWQA's System Operator:

1. Follow instructions 2-8 from leak test.
2. Step up of pressure in 2 phases (50 and 55 psi) at least 4 hours apart,
 - a. Check Pressure Reducing Valve output doesn't exceed phase pressure.
 - b. Check pressure gages at distribution manholes.
3. Record start-up date and time.

Shut-down Procedure:

1. Notifying Cherry Creek State Park Staff (manager and operations manager), Marina Operator, and Ingersoll Rand's client manager for CCBWQA of season end date.
2. Turn off Compressor.
3. Monitor gages on Pressure Reducing Valve and Compressor. Pressures should drop.
4. Record shut-down date and time.

CHERRY CREEK BASIN WATER QUALITY AUTHORITY
CHERRY CREEK RESERVOIR DESTRATIFICATION SYSTEM
OPERATIONS POLICY

July 19, 2021 (TAC reviewed September 2, 2021; Board reviewed
January 20, 2022)

Recommended Operating Season and Start-up Criteria:

In 2020, the Cherry Creek Basin Water Quality Authority (CCBWQA) replaced the compressor to improve the operation of the Reservoir Destratification System (RDS) and to allow for operation from March 1 through November 30. In July 2020; the compressor was replaced, and operation was tested through November 16, 2020.¹ With the new compressor, it appears that the RDS has the capability of operating from ice off through ice on the reservoir.

In 2021, CCBWQA wanted to optimize the water quality benefits of the RDS. CCBWQA reviewed the water quality data from the water quality sampling and thermistor set in the reservoir to evaluate the optimal operating season. For the period of 2016 – 2020²:

- the earliest start of thermal stratification was April 20, 2020 (without RDS Operating); and,
- the latest finish of thermal stratification was October 17, 2020 (RDS was operating) or September 27, 2018 (without RDS Operating).

Considering this information, CCBWQA's Technical Advisory Committee at their September 2, 2021 accepted the update the RDS Operations Policy and the RDS should be operated:

- from about mid-April through at least the end of September; and
- before startup, CCBWQA's System Operator will need to visually verify that ice should be off the reservoir³ and the temperature in the building 38 degrees Fahrenheit; and,
- CCBWQA's System Operator shall then log the detail of the start-up and shut-down procedure in the Cherry Creek Reservoir Destratification Facilities Operation and Maintenance Annual Report.

Start-up Procedure:

CCBWQA's System Operator should perform a leak check after ice off and ahead of Operating Season start date. CCBWQA's System Operator will perform test by:

1. Notifying Cherry Creek State Park Staff (manager and operations manager), Marina Operator, and Ingersoll Rand's client manager for CCBWQA of leak test and season start date.
2. At distribution manholes, check that valves are configured to send air to all zones.
3. Set Pressure Reducing Valve to 40 psi.
4. Review Compressor discharge pressure is set to a range between 100-110 psi.
5. Start compressor following instructions in compressor manual.
6. Monitor gages on Pressure Reducing Valve and Compressor. Compressor delivers 100-110 psi and Pressure Reducing Valve regulates it to 40 psi going to distribution system.
7. Shutdown compressor if compressor delivers more than 110 psi or output on Pressure Reduction Valve exceeds 40 psi.
8. Check pressure gages at distribution manholes.
9. Visually look for leaks by driving dam road and using binoculars from dam and shoreline or by boat.
10. After test, shut-down RDS and report any leaks.
11. Record leak test date and time.

For season start-up, CCBWQA's System Operator:

1. Follow instructions 2-8 from leak test.

¹ Cherry Creek Reservoir Destratification System – 2020 Operation and Maintenance Annual Report, R2R Engineers.

² E-mails from Solitude Lake Management on March 25, 2021 and April 14, 2021.

³ Destratification System - Operation Policy Regarding Ice; adopted by the CCBWQA Board on February 20, 2014

2. Step up of pressure in 2 phases (50 and 55 psi) at least 4 hours apart,
 - a. Check Pressure Reducing Valve output doesn't exceed phase pressure.
 - b. Check pressure gages at distribution manholes.
3. Record start-up date and time.

Shut-down Procedure:

1. Notifying Cherry Creek State Park Staff (manager and operations manager), Marina Operator, and Ingersoll Rand's client manager for CCBWQA of season end date.
2. Turn off Compressor.
3. Monitor gages on Pressure Reducing Valve and Compressor. Pressures should drop.
4. Record shut-down date and time.

Signature: 

Email: jrivero@parkeronline.org

Signature: 
John A. McCarty (Jan 30, 2022 16:21 MST)

Email: johnmccarty1972@gmail.com

APPENDIX B - 2022 RDS OPERATIONS LOG

Cherry Creek Basin Water Quality Authority
 2022 Reservoir Destratification System (RDS) Operational Log
 December 23, 2022

Date	Day	Time		Runtime Minutes	System Pressure psi	Comments
		Start	Shutdown			
4/4/2022	Monday					Ingersoll Rand replaced top pressure regulating valve and performed pre-season start inspection
4/4/2022	Monday	2:18 PM	3:12 PM	54	40	No leaks or problems observed
4/15/22	Friday	8:56 AM			40	Season Start
4/25/22	Monday	2:55 PM			50	Stepped up system pressure to 50 psi
5/6/22	Friday	10:29 AM			55	Stepped up system pressure to 55 psi
5/10/22	Tuesday		9:55 AM		55	RDS was shutdown at request of CPW for search and recovery
5/14/22	Saturday	2:32 PM			55	Notified by CPW that RDS could be started
6/6/22	Monday				55	CPW reported possible leak
6/7/22	Tuesday				55	LRE Water confirmed leak and provided coordinates. Other heads still working.
6/14/22	Tuesday				55	Ingersoll Rand performed preventative maintenance which included cleaning of coolers
6/21/22	Tuesday				55	B&RW replaced blown regulator in head 402
8/17/22	Wednesday				55	Observed louvers in both doors were clear
8/22/22	Monday				55	B&RW performed in lake maintenance
8/23/22	Tuesday				55	B&RW performed in lake maintenance
9/2/22	Friday		4:03 PM		55	High Bearing Oil Temperature
9/6/22	Tuesday				55	Ingersoll Rand received message stating temperatures were elevated and that there was a potential ventilation issue. Observed louvers in both doors were clear, noted Compressor Warning of High Bearing Oil Temperature on 9/2/22 at 16:03:46. Informed Ingersoll Rand which scheduled a technician for 9/7/22.
9/7/22	Wednesday				55	Ingersoll Rand performed preventative maintenance which included cleaning of coolers
9/14/22	Wednesday				55	Marina reported possible leak
9/15/22	Thursday				55	LRE Water confirmed leak with large bubble plume and no heads beyond leak were running, they shut down Zone 1 so that remaining zones could still operate
9/20/22	Tuesday				55	B&RW initiated repairs found line separated with large gap between ends. Tried unsuccessfully to pull lines closer together. Capped end of line so the first few heads in Zone 1 could operate until larger repair could be made
9/20/22	Tuesday				55	B&RW initiated repairs and found the line separated with large gap. B&RW tried unsuccessfully to pull lines closer together. B&RW capped the end of line so first few heads in Zone 1 could operate until a larger repair could be made
9/27/22	Tuesday				55	B&RW repaired the gap by disassembling the disconnected section, moving it back into place, and reassembling thus reconnecting it.
10/4/22	Tuesday				55	B&RW performed in lake maintenance
10/5/22	Wednesday				55	B&RW performed in lake maintenance
10/6/22	Thursday		2:14 PM			Season stop

RDS all zones operating with leak in a single head with other heads in zone beyond leak still operating
 RDS operating with one zone shutdown as leak took numerous heads out of service; other zones still operating
 RDS completely shut down

APPENDIX C – XCEL ENERGY INFORMATION

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Annual Total
Energy Usage 2021 (kWh)	1080	920	1000	920	21720	38640	34240	31000	34760	1760		840	166880
Energy Usage 2022 (kWh)	880	800	760	800	26200	38240	41600	35160		29760	6640	880	181720
Temp 2021 (°F)	36.97059	35.63793	28.63333	41.36207	46.90323	55.77419	71.78571	74.31035	68.46667	54.81035		48.65152	
Temp 2022 (°F)	38.76471	33.06667	35.39655	40.25806	48.39655	58.13334	70.9138	74.25		68.46774	54.06452	36	

Missing Informaiton likely due to meter not being read

Increase in Energy Usage (2022 kWh/2021 kWh)= 1.088926174

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Annual Total
Charges 2021	498.99	471.01	572.57	533.73	4759.94	8285.34	9341.35	8468.24	9249.96	952.58		489.44	43623.15
Charges 2022	497.28	481.62	473.83	486.83	5802.56	8276.05	11497.55	9826.91		8420.9	1820.2	504.77	48088.5
Temp 2021 (°F)	36.97059	35.63793	28.63333	41.36207	46.90323	55.77419	71.78571	74.31035	68.46667	54.81035		48.65152	
Temp 2022 (°F)	38.76471	33.06667	35.39655	40.25806	48.39655	58.13334	70.9138	74.25		68.46774	54.06452	36	

Missing Informaiton likely due to meter not being read

APPENDIX D - COMPRESSOR REPLACEMENT SUMMARY

DATE: January 12, 2021

TO: Chuck Reid, CCBWQA Manager

CC: Jacob James, CCBWQA TAC Chairman

FROM: Richard Borchardt, PE & CFM

SUBJECT: Reservoir Destratification System – 2020 Compressor Replacement Project Summary



Background and Purpose:

In April 2008, the Cherry Creek Basin Water Quality Authority (CCBWQA) placed the Reservoir Destratification System (RDS) in service. Shortly after startup the air compressor began shutting down through internal overheating protection. **Figure 1** shows the location of the RDS Compressor Building where the compressor is located.

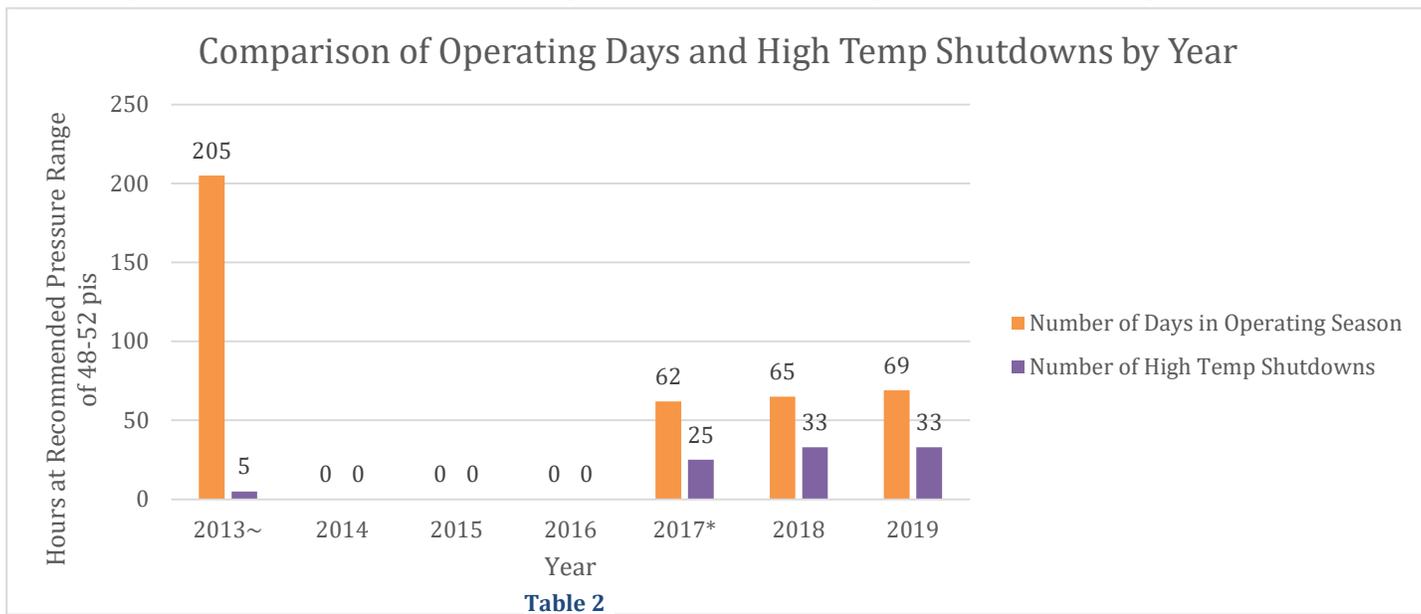
In September 2013, Eaton Energy Solutions (EES) prepared a report evaluating the RDS and providing options to improve operation of the RDS¹. EES provided several options and ultimately concluded that the compressor needed to be replaced to obtain full operation (24 hours a day, 7 days a week, through the operating season of

March 1 to November 30) at the appropriate volume of air 287 cubic feet per minute (cfm) at a pressure of 58 pounds per square inch (psi) on-site. Between 2013 and 2019, certain of EES's recommendations were implemented: replacing the above ground piping and upgrading controls to minimize manual restarts.

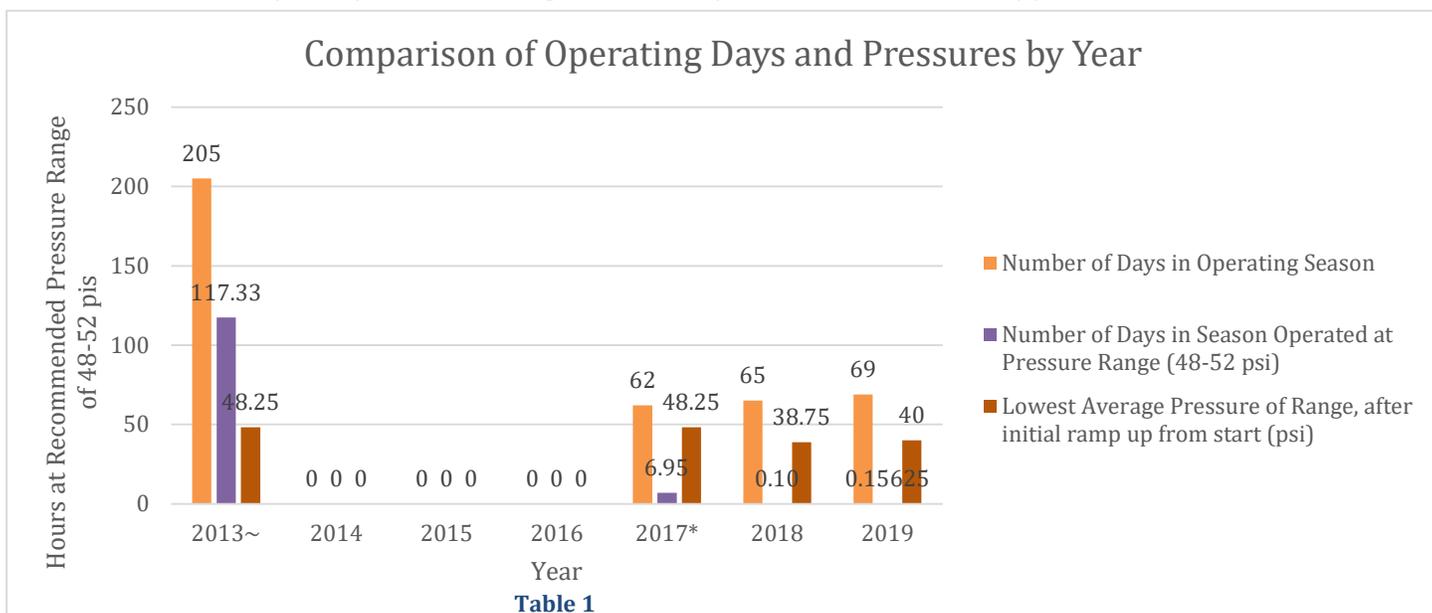
¹ Destratification System Evaluation for Cherry Creek Reservoir in Cherry Creek State Park, Co. Eaton Energy Solutions, Inc. September 27, 2013

Existing Conditions:

After the 2019 operating season, R2R Engineers prepared comparison of operating metrics from 2013 through 2019 (RDS was not operated in 2014 and 2015). These comparisons showed the continual decline operation time and pressure of the RDS. **Table 1** compares the number of days that the RDS was operated and the



corresponding number of high temperature shutdowns that occurred during that period. **Table 2** compares the number of days that the RDS was operated, with the number of days that it was operated at the best achievable pressure range (48-52 psi) with aging compressor, and the lowest average pressure range (pressure that was used to keep compressor running as much as possible). There is an apparent trend from 2018- 2019



of an increased number of high temperature shutdowns (33) with lower than ideal operating pressures (average of pressure ranges of 38.75 in 2018 and 40 in 2019).

Reservoir Destratification System – 2020 Compressor Replacement

January 12, 2021

Page | 3 of 3

R2R Engineers Memorandum

Procurement and Installation:

In 2020, CCBWQA replaced the compressor through a design-build procurement process. The selected bidder, Ingersoll Rand, installed a 100 Horsepower motor compressor capable of delivering 317 cfm at 100 psi on-site (exceeds performance specification), and a variable speed drive. CCBWQA added a receiver tank in the bid alternate to lower the pressure changes and extend the life of the compressor. Pressure regulators were included to allow CCBWQA to adjust pressure to the 58 psi.

Photo 2 shows the old compressor being removed, and **Photo 3** shows the new compressor installed. ²



Photo 2

Water Quality Benefits:

The RDS' water quality benefits include:

- Reduction of approximately 810 pounds of Phosphorus per year³
- Disrupting blue-green algae life cycles as part of the whole algal assemblage, and
- Decreasing periods when the reservoir is thermally stratified during the summer⁴.

The decline in operating time and pressure (over time) has likely impacted these benefits. The compressor replacement restores the original operation parameters and associated water quality benefits.

Summary:

Water Quality Benefit of reduction of ≈ 810 pounds of Phosphorus per season

Total Project Cost = \$314,241⁵

Authority's Share = \$314,241

Engineer/Contractor: Ingersoll Rand



Photo 3

² Full Installation and Inspection Report by RG and Associates available from CCBWQA Manager.

³ CCBWQA 2020 Capital Improvement Program Supporting Data, Board Adopted Version November 21, 2019.

⁴ CCBWQA January 28, 2013. Compressor Design Basis - Daily Operation, William P. Ruzzo, P.E., Craig Wolf, GEI.

⁵ Includes 10-year maintenance plan.