Mining Webinar Series: Evaluation of Rotating Cylinder Treatment System™ at Elizabeth Mine, Vermont

Sponsored by: U.S. EPA, Office of Superfund Remediation and Technology Innovation, Technology Innovation and Field Services Division

Tuesday, March 16, 2021

https://clu-in.org/conf/tio/mining-elizabethmine_031621/

Closed Captioning Transcript

Please stand by for realtime captions >>

Well, good morning or good afternoon depending on your time zone. Welcome. You should be joining us for the CLU-IN webinar which is part of the ongoing mining webinar series. This is the evaluation of rotating cylinder treatment system at Elizabeth Mine in Vermont. My name is Jean Balent and I am the technical moderator for the upcoming session. The live broadcast will begin in just a few moments at 1:00 p.m. We have opened up the lines a few moments early, started a preliminary audio stream so the attendees can get connected and adjust settings locally and be prepared to start the broadcast at the scheduled time of 1:00 p.m. Eastern. If you have connected early, if you see a small Q&A box, please let me know how the audio and visuals are coming through by typing in a simple message into the empty space at the bottom of that window. And hitting the enter key or the arrow to submit your message. The Q&A window like all the sessions we host on CLU-IN is private so send in messages and let me know how the audio and visuals are coming through by using the Q&A window at any point. I appreciate and thank you

for everyone who has connected early and are sending in messages confirming that the audio and visuals are coming through okay. Again, if you're just getting connected, welcome. You should be joining us for the upcoming CLU-IN Internet seminar, and ongoing mining webinar series we've been hosting for some time. And the topic today is evaluation of rotating cylinder treatment system at Elizabeth Mine, Vermont. We are going to begin in just a few moments at 1:00 p.m. Eastern. But we have opened up the webinar environment and preliminary audio streams on the phones early. So the participants have time to hop on and get connected and adjust their settings locally, so you can begin the broadcast with us at 1:00

p.m. Eastern. For the session, audio defaults to your device or computer speakers and headphones. You should hear my voice coming through your device right now. If you're able to see the welcome side and hear my voice, please look in the lower right corner of the screen for a Q&A window which you can use

to privately submit comments and questions. If you are able to, I would love it if you can send in a quick message letting me know how the audio and visuals are coming through for you. If you have problems with the online audio, or simply cannot listen to your device, we do have a toll-free call in option. If you need the phone number to call in, you can request that using the Q&A window at any time. Again, we will begin the upcoming CLU-IN Internet seminar at 1:00 Eastern as part of the ongoing mining webinar series we've been hosting. And the topic today is evaluation of rotating cylinder treatment system at Elizabeth Mine in Vermont. I am Jean Balent and I am a technical moderator in the background for the broadcast for the live session will begin at 1:00 p.m. Eastern. We have opened up the environment just a few moments early so that attendees can get connected and adjust your settings locally and be prepared to start the broadcast with us at 1:00 p.m. I strongly encourage if you are connecting on a VPN or remote network, to disconnect now to improve the quality of the broadcast. Then I also encourage you to adjust your local volume settings. There are controls at the top of your screen which will allow you to send sound to different devices as well as adjust the volume.

Once you've made your you can see the welcome slide and you can hear my voice coming through your device, please feel free to send a message into the Q&A window that should be available in the lower right of your screen. Let me know how the audio and visuals are coming through. I do appreciate those participants who have sent messages and and although that is private, you can only see her own messages, I can see all them as they are coming in and we do appreciate the status indicators from the attendees come a confirming the audio and visual are working okay on your end. If you need a toll-free call in line to listen, please feel free to use the Q&A window to let me know and I will be happy to give you a calling lines you can listen on the telephone. All right we are getting very close to the scheduled start time so I wanted to check in with one of your sessions, the presenter, trying to see if we can get started so can I begin?

Yes please.

With that I will turn on the recording and officially welcome everyone to today's Internet seminar. The seminar is part of the ongoing mining webinar series and the topic today is evaluation of rotating cylinder treatment system, at Elizabeth Mine in Vermont. The session has been sponsored by the U.S. EPA and the office of Superfund remediation and technology innovation. My name is Jean Balent from the same office at EPA and I will be serving as a technical moderator in the background. I wanted to walk through just a few quick housekeeping items that everyone understands how to participate. And then turn it over to one of your speakers and session facilitators, Michele Mahoney, who is joining from the same office at EPA technology and field services position. With that, let's dive in.

Just as with all the other women as we are hosting on CLU-IN, each event as a unique seminar homepage food when you registered today , you would have received a confirmation email and remind him of that will point you to the page and the page is active from today on you can feel free to bookmark it and reference it later. I encourage you to visit the home page because we have a lot of useful information including information about our speakers, their topics as well as links to download the presentation content and related resources and websites on today's session. There is also a form to fill out feedback based off of your participation in today's session. We will talk more about how to submit feedback to get a certificate at the end of the webinar today but I want to remind you the content and links have been posted on the homepage. To join us for the live broadcast, click the red button to join us but you will be invited into a very simple check in process and then that will present you with the screen of options for connecting to the live session. We are hosting it through Adobe connect so you can both watch and listen in real time through your device as the presenters give their talks. For those of you who are unable to join in the Adobe connect app , that is a free download and we strongly encourage the use of the app for the best experience. If you cannot come you can open up the Adobe connect environment and a simple web browser. If that also fails for you, we have posted sides and you can request the call in number and follow along by phone. Audio will default online so I encourage everyone to take a look at your local volume settings. You have a green speaker icon at the top and that speaker will have additional controls to decide which device it gets sent to. If you are watching in a browser you may have additional pop-ups you will need to access in order to further refine the audio settings. As noted, there is a toll-free call in line's of you connect about to work let me know in Q&A window and I will be happy to give a call in line. Everyone is automatically muted regardless of how you listen come on your computer or on your phone. We do ask you remain muted to cut back on other audio disruptions are unintended

audio disruptions for today's session. If you have a question or a comment or need to report technical difficulties can use the Q&A window which is visible in the lower right-hand corner of your screen throughout the broadcast. If you are comfortable with that, I would like to ask each of you to look for the Q&A window and to send in a quick greeting to our presenters. Please open up the Q&A window and click your cursor at the bottom box feel free to say hello or let them know how excited you are for the topic. When you're done typing the message, hit the enter key or click the arrow icon and that will privately submit your message. I see a number of messages coming in and I am talking to each and everyone of you. So we do encourage you to test that out and send in your greetings to the presenters today. Remember that's the same mechanism you will use to send in your questions or report any issues or complications that we will work with you to troubleshoot if you are having issues. The session is being recorded and you will automatically receive an email from me once the archive is available for on-demand playback. I do ask you to stay with us until the very end of the broadcast because it will cover some important reminders including how to access the recording as well as get a participation participate certificate. So visually on the screen, some of you may be using the old Adobe connect app and if you are I will point out the you have a button in the upper right hand corner that looks like four arrows pointing in opposite directions that will allow you to make the slide window larger. As pointed at you will have a Q&A window in the lower right where you can privately get those comments and questions at any time. For those of you that have been joining in an updated Adobe connect app or browser window you will see a very similar interface but the icons are different. For you to enlarge any window on the screen, look for a box of brackets around as you can feel free to go full screen as you need throughout today's broadcasts. You also have the Q&A window box in the lower corner. So I think that's the end of the technical reminders I have for today. I'm going to call up Michele Mahoney's materials and turn it over to Michele to get started with the broadcast today. Feel free to begin. >> Okay great, thank you, Jean. I wanted to share some resources that are available related to clean up sides we have all the archives and the webinars from the mining webinar series on this page which you can see here, at CLU-IN you have other information there is also want to make sure everyone was aware of that. And then getting into today as Jean mentioned, this is a mining webinar series, this is the direct link to access previous webinars. We've been doing these since 2012. You can go through and see if there's any other topics you would like to see. For today, we are very glad to be able to talk about the rotating cylinder treatment system at Elizabeth Mine and we have Barbara Butler who is a research environmental engineer with EPA's office of research and development could she focuses on understanding the transport and eco-toxicology of inorganics and surface water, groundwater and sediments and watersheds. She looks at the information in a number of different ways. We are excited to have Barb with us. And we also have Ed Hathaway, who is the remedial project manager for this site. He has on-site experience as well as Barb , and being the project manager and I would like to mention, that we have the pleasure of having Eric Hall on the call also his with the Novus group who is one of the operators for the treatment systems for use with us and will be available to answer any questions from that perspective. So keep that in mind as you are submitting questions. As Jean mentioned, type the questions in anytime throughout the presentation and we encourage you to do that so that when we do get to the questions, we are ready to go and starting to ask questions. So, thank you everyone, for attended. With that, I would like to turn it over to Barb and Ed for the presentation.

Thanks, Michele and thank you everyone for letting me present today. Next slide please. This is just the standard disclaimer that the views presenting today are mine and Ed's adult represent the views of the EPA. Today Ed is providing you with a history of the Elizabeth Mine and I will cover water treatment for ferrous iron briefly. Describe the RCTS system and previous literature report with conventional Lyme treatments. The performance of the RCTS at the Elizabeth Mine over nine your time and the lessons learned. And Ed will close us out with other remarks. Take it away. >> Thank you, Barb. I appreciate the opportunity to participate and help the audience finds this information useful. Let me present some Elizabeth Mine history for context of this has the Elizabeth Mine is one of six locations in New England where Superfund actions have taken place at a mining site located in East Central Vermont on Route 91 and 89. The Elizabeth mine operated for about 150 years for the early period, so they had copper, iron sulfate and responsible for 75% of the production. This generated 30,000 tons of copper and 200,000 cubic yards of waste material. This is limited since 8030 to 1942 when Elizabeth Mine was a beneficiary of a federal contract to support World War II and the Korean War which resulted in a 16 year period with 45,000 pounds of copper was produced that generated 3 million tons of waste. Operations ceased in 1958 in the property. These are just a few photos for perspective, the upper left is the 1898 at it. The bottom left does show the site turn operation and you can see the mill in the foreground. The lower right shows the after closure but you can see the condition of the department. The upper right shows the waste piles in the foreground and the tailing off in the distance. This is the photo of Elizabeth Mine,

started in 1999 when I started working on the site 22 years ago. It had been abandoned since 1958 and no maintenance or inspections performed on the dam, or the department. Next slide please. The photos on this page show the erosion on the face of the tailing band at the top left was taken after we started work could you can see some construction roads there and it gives you a bigger picture perspective on the tailing band and the other show the various states of erosion on the site when we started to work. An investigation and Elizabeth Mine was initiated in 2000 and identified the following issues of concern. The tailing dam for tailing pile one was unstable. There were five miles of aquatic impacts due to copper, iron, zinc and pH. Topper is Brooke had 100,000 micrograms per liter. The pH was low. The settlement was found to be toxic to organisms and we found led in the soil. And then groundwater

within the underground workings was considered unsuitable for human consumption due to the various metals, cadmium, cobalt, copper iron or manganese. The purple line on the map shows the extent of the aquatic impacts. So based on the identified issues, the EPA developed a cleanup strategy that focused on the following actions. First was to stabilize the tailing dam and second was to target control actions to minimize the generation of mine influence water. It consolidated waste rock and installing a barrier cover, it diverting water and we actually modify the strategy midterm to add an interactive treatment system. And the long-term goal was to have a passive treatment system to handle the residual. So next slide? We've got a few slides here to show the cleanup work. The site on the left shows working at the tailing dam with installing some drains. The slide on the right shows the lateral and the long version of the toe drain system. The site on the left here shows the construction of a 60,000 cubic yard compacted earth buttressed to re-fortify the tailing dam. On the right there is the area of the erosion control matching on the buttress installed. And they were cleaned back to reduce erosion. Next slide, this is the before slide further Copperas Brook factories. And the next slide is the after picture for the factories. We brought it down onto the tailing dam. Next slide. So one of the keys source control measures was the consolidate all the satellite waste areas, from the factories and 100,000 cubic yards of excavated tailing that had slumped off the tailing band and to achieve the final slope grades onto the 45 acres that we created it to be solar friendly. It required 150,000 cubic yards of soil to build a cover system at a two million-square-foot of Geo synthetics. There is a cartoon version on the left that shows the schematic for the closure which has the tailing down buttress in the way back of the slopes. The oranges the way struck based on top of the tailing and the green is the cover system which is the

incident to the right of it that shows the different layers of the cover system and how it was constructed. In the photo below, shows the shiny black material is the geomembrane. The brown is the copper soil placed over the drain. Next slide. This side even though it's more recent shows the solar facility that was developed on the department or the blue outline is the extent of the shallow groundwater and surface water diversion channels that were installed. So in 2000 after the dam stabilization were completed but before we have a chance to build the cover system under the waste relocation, and extreme drought area cause an unusually low dilution of the leachate on the West branch of the river having this visual effects. So next slide. So as a result we had to do five mile iron slick. Going down the river and you've got the map that shows you the whole extent of this from the site on the left-hand side of the photo over to the union village dam

in the right side of the photo. You can see inset photo showing the iron staining and the river at those locations. So the next slide., At that point, as a result of that condition, we sort of adopted the management we we had iron leachate was graded acidity smothering the men take environment be read very local stakeholders and state representatives really demanding that we do something. We had not yet implemented the actions that we knew they would take time before they could even affect something like this. So we sought to implement a treatment technology that could effectively provide an effective interim solution until we could get to the point where we could use passive treatment. In doing so, we knew we had several challenges. We have limited physical space by the picture on the right shows you it is hard to judge but the topography drops off very steeply, dropping down to the river. It is is about several hundred feet. From the tale of the dam to the river. It is Vermont will have to deal with extended periods of cold weather. We have high iron load that we had to deal with come up to 800 pounds a day. If we were going to do something that evolved open pond systems we had two significant precipitation events. But we did have electric power which was available. In addition, we were trying to balance the state of Vermont not having a lot of money to support operation and maintenance activities. So we turned to office of research and development from EPA and the consultant, to find a solution to this problem. So I will hand it off to Barb so she can introduce you to the overall construct and then right into the use of the RCTS at the Elizabeth Mine.

Thank you. The treatment of ferrous iron typically involves adding oxygen to oxidized ferrous iron to ferric iron and increasing the pH to above 3.5. Commonly with lime or slaked lime's use. And the equation shows ferrous iron to ferric and slinking with lime with water. And ferrous hydroxide using the line. There is hydroxide will precipitate with lime to become oxidized ferrous hydroxide when is oxygenated. That

abiotic oxidation rate of ferrous iron is shown by this equation. It has a first depend on the concentrations of ferric iron and oxygen meaning that a doubling of either the ferric concentration or the oxygen concentration will double the rate of oxidation. The second order of dependence on the concentration and with pH being a log unit and an increase of one unit is a tenfold increase in hydroxide concentration. This would increase the rate of the reaction by 100 times, 10 raised to the power of two and the plot on the right shows the half-life of ferrous iron as a function of pH. You can see with the blue line drawn here that the pH of 7, the oxidation takes only minutes. Next slide please. So active treatment system there is a general preference to treat iron with lime over sodium hydroxide because it creates a denser sludge and has a higher neutralization capacity. Sodium hydroxide has more careful storage and caustic liquid and is a potential to freeze. Lime also as a floor change in pH with each incremental dose and depending on the site there may be concerns with discharging large quantities of sodium. So I will be talking about the comparison of RCTS and the RCTS in general. Next slide please. The RCTS was designed by water technologies Inc. to be more compact and mobilize a bowl. It replaces conventional agitators, compressors, diffusers and reaction tanks that are used in conventional lime treatment plans. With a perforated cylinder that rotates through a trough containing a lime slurry and water to be treated. In the RCTS, the water adheres to the inner and outer services of the cylinder as it rotates to facilitate oxygen exchange. Agitation by impact of perforation with the water enhances the lime mixing and dissolution as well as oxygen transfer to the water. In 2009, they presented data from a direct comparison of the conventional lime treatment plant with the RCTS that was conducted at the leviathan mine in California. They show the RCTS had comparably lower lime consumption rate, higher dissolved oxygen concentration in effluent and a shorter residence time was required and also less energy was consumed. Next slide please. The RCTS system was chosen at the Elizabeth mine because it has a small footprint and it can handle a very high iron load. It would've been difficult and expensive to keep the water from freezing both before and after treatment and the building would have required installation and heating in very cool climate. It was operated during the months of April through November. It was designed to handle an average flow of 30 gallons per minute at a maximum flow of 40 gallons per minute as well as to obtain an effluent iron Constitution maximum of 50 milligrams per liter. With an average influence of 900 milligrams per liter. The system is anticipated to have an operational life of five years but operated for 10. Next slide please. This picture shows an aerial view of the sites treatment components. Following the red arrows, the water is collected from the drain, goes to the RCTS in white building . The treated water goes to the sedimentation basement. Next slide please. The flow into the system from the CLU-IN and was

told by floats. The pump operated at a higher rate than the leachate flow rate and a wet well level needed to be capped. This resulted in the typical sump operation nine or 10 hours a day. Next slide please.

From the wet well, the leachate was pumped into a neutralization mixing tank shown here at the bottom right. Some of the leachate went through a final and was mixed with quicklime from a silo in a grinder pump. This is the image on the top right. The slurry was recirculated back into the neutralization and mixing tank. The reason this was done is to increase the residence time for neutralization. One of the checks to see whether the neutralization is occurring properly is to observe the color of the water in the tank. Although it's hard to tell in this photo, if it is a dark bluish green, that's from the formation of small particles of ferrous hydroxide. Next slide please. The neutralization tank, water flowed by gravity to the RCTS unit where it was aerated as a thin layer of water around inside the rotating cylinders. The image on the bottom left shows the trough that held two of the rotating cylinders and the picture on the top right is one of the cylinders. The image on the bottom right shows the location of the neutralization tank, the funnel and grinder back at a distance. And the electrical panels in connection on the side. These images provide a sense of the small size of the enclosure needed for the system. Next slide please. Once aerated and neutralized with the water was gravity fed from the RCTS to the sedimentation basin. The visual check on the oxidation of the water in the RCTS is the brown color that is at the end here, at the bottom of the photo on the left. This indicates the small present particles of ferric oxide. Maintenance and operation needs is to operate in accordance with manufacturer's construction bid maintain accurate records of data from operations. Process operation monitoring using field analytical methods. Removing precipitates from parts component parts and system parts when necessary. Troubleshooting and repairing or replacing any faulty equipment. And seasonal operation at the site required commissioning and decommissioning every year. Next slide please. It included in this case of the from 2009 to 2017. It included at least one sample from each month of operation. This schematic on the right shows the performance monitoring locations in the yellow circles. The performance he used was total iron which includes ferrous and ferric iron species and ferrous iron. The last bullet on the slide has an error, where should read the total measurements were conducted on both filtered and unfiltered samples. Several unfiltered at ideal -01, that neutralization tank and 5 which was the sedimentation basin, and filtered at ITO three. This is the RCTS. PH from all three locations was examined in the case study. Next slide please. This shows a load of iron in the brown circles on the primary why access and flow in the blue squares on the secondary axis . Both as a function of time from 2005 to 2018. The early average iron concentrations were marked by yellow triangles and the yellow diamonds Mark the yearly average flow. The main thing to note in this graph is that after each activity, that is what about earlier, the average yearly flows and the low decrease. And the continued to decrease over time after the cover was completed in 2012. Next slide please. This shows the concentration of the total iron on the Y axis versus time with the unfiltered effluent to the RCTS shown as blue circles and the on filtered effluent shows as a light blue*. I was get teed up on that word. *. This is shown by the green diamonds. The flow is shown on the secondary Y axis with the solid black line. Comparing the results between the sampling location, shows the concentration decreases with the treatment. You could see the concentration and the influent water could be decreased by time. Concentration from the sediment basin and the light blue stars were generally near to or less than one milligram per liter. One milligram per liter is important because of the water quality criteria for iron in Vermont. This is later at the previous slide and it shows the decreases in concentrations of unfiltered ferrous iron overtime of the influent and sedimentation and the filtered ferrous concentration from the RCTS. Concentrations from the sedimentation basin are generally less than one with only a few exceptions. Next slide please. This spot shows pH overtime for the same location. Combined influence pH, the blue circles remain within the range of about 5 1/2 to 6.8 of the nine years of data analyzed. There is more variability in pH in the RCTS , effluent and the green diamond and the sedimentation basin effluent with maximum pH in RCTS effluent. Based on the data from

2015, the former pH range from the treasure from the neutralization tank and the RCTS was 8 1/2 to 11. And from 8 1/2 tonight at half with the sedimentation basin effluent Butte over the tenures of the system demonstrated the operated the RCTS at pH less than 8 led to high amounts of ferrous iron in the sedimentation basin effluent and operation of both pH 9.5, led to an increase in just the formation and scaling of the rotating cylinder. In this figure, it shows the pH of the RCTS effluent in the grain, is generally exceeding 9 1/2. Next slide please. These show the percentage removal between the effluent from RCTS and the sedimentation basis for unfiltered ferrous iron overtime on the left and unfiltered total iron overtime on the right. As well as the monthly averages and the variability for the sedimentation basin pH on the secondary Y axis. The removal was 98% for unfiltered samples of total iron. Next slide please. These graphs show concentrations for laboratory data collected on the base. The total recoverable iron has solid orange triangles and alterable on the y-axis and the dates that they were sampled on the X axis. The figure on the left is the influence for the risk mix tank and the decreasing trend in concentration over time. Most evident starting with 2013 samples which was after the cover system had been completed. The concentration of total recoverable iron from the RCTS is in the middle graph and that's essentially the same as it is for the combined influence. They filtered iron concentration is much lower in RCTS effluent compared to the bottom left it in fact only the October 2009

was identified as being above the laboratory detection limit. So this suggests the RCTS effectively removed all ferrous iron. The rough on the right shows the total recoverable iron has decreased less than six milligrams per liter from more than 200 milligrams per liter that was shown in the middle graph. Unfiltered iron was generally left or less than .2 milligrams per liter which is a detection limit. This indicates the settling of precipitated iron hydroxide. Next slide please. This shows percentage removal total recoverable iron and filtered iron from lab results on the Y axis and on the X axis. The total recoverable iron removed from the RCTS effluent of the treatment system effluent shown by the blue circles was less than 10%. This result would be expected because the neutralization and aeration step change the oxidation state of iron and the solubility and is expected the settling of precipitants will occur in the sedimentation basin as the water moves from the RCTS to the basin to keep those precipitants formed with the small amount moved over by the RCTS has a mixing tank or the rotating cylinder, both of which did occur over time and was periodically cleaned up along with the scale. The laboratory data also showed high removal percentages for both total recoverable and filtered iron. With the lowest removal of 97% for total recoverable iron and 98%

for iron. Dissolved oxygen in the to be one varied widely from 2001 to 2010. It was not monitored with the system but data collected in 2009 indicated the average dissolved oxygen in the RCTS effluent was four point I'm sorry, influent was 4.3 on the average effluent from the RCTS was 6.4. Which indicates that RCTS added an average of two milligrams per liter of dissolved oxygen to the water. Next slide. These show the comparison of the treatment on the left, I picture you saw earlier. And then after the treatment had been started on the right which is a dramatic difference in the Ompompanoosuc River. I will be presenting some lessons learned. Next slide. Calcium from the lime solution will react with sulfate to perform and become gypsum. It is two grams per liter. Total sulfate concentration in tv one RCTS range from one and have the 4.2 grams per liter with an average of 3.2 . The image on the top right shows a piece of the scale and the image on the bottom right shows one clean cylinder and one cylinder still coated with gypsum and iron precipitate. This affected all components of the system and some of the things that happen, the system had clogged pipes and outlets, cracked seams and the drums. Failed bearings from scale buildup which caused an unbalanced rotation and blocking of sedimentation basin effluent pipe . One instance the reaction of lime or the line with water is exothermic and a clogged pipe actually melted from the line. Next slide please. Some other things learned are to make life a little easier, let me know and equip it should be as accessible as possible for maintenance tasks. The design to consider potential future upgrades and pumps should be configured to allow for use of universal motors. Any factors need to be considered to optimize both the efficiency and the costs. Such as identifying and understand required specifications for piping and components with contact in the lime. And identifying ways to minimize complications of gypsum formation. Next slide please. Also important to monitor pH to assure sufficient neutralization followed by effective aeration with minimal scaling. As I mentioned earlier, operational experience show the optimal pH for water at the site from the RCTS was between 8 and 9.5. Monitoring ferrous iron allows assessment of oxidizing performance, monitoring the D.O. may be helpful in assuring sufficient oxidation occurring in the RCTS to minimize any reliance on the sedimentation basin for oxygenation. And sludge storage can be a challenge for some of the things to consider or there is a potential for anyone to trespass since the consistency of the sludge does not support walking on it. And whether there are any hazard components that will have off-site disposal as whether if there is is sufficient land disposal. And lastly sufficient funds should be available to allow replacement of components to avoid the loss of treatment capability. Although the system lasted twice as long as it was designed to cover the RCTS drums and the neutralization tank were approaching the end of their useful lives. And now I will pass it over to Ed for final remarks.

Thank you. Next slide. So in some areas, the temperature went system provided effective treatment for 10 years but we routinely met the one part per million or leader standard should
over the entire time we treated almost 51 million gallons of leachate. And, we were able to effectively help transition where the source control could affect both the flow and the concentration of the leachate so that we went from a situation where we started with 800 pounds of day of iron being discharged and at the end of the useful life were down to 24 pounds a day of iron discharge. So in the big picture you know we had stabilized the dam and we had seen iron and copper concentration loads reduced to the West branch which was a 99% of copper concentration as part of the source control actions. 95% reduction in iron concentration for the source control actions. We have a four unit pH shipped from the surface water and we continue to see a decline in the leachate flow levels. Next slide. And, you know, as a plug for the benefit of the treatment system and the source control actions, the West branch of the Ompompanoosuc River was on the federal and state impaired waters list in 2014 it was officially removed from the impaired waters list and had been impaired water since the early

1800s. And it was document to be impaired since 1960s. Next slide. And so, that RCTS really helped us walk the transition from the source control action to get to where we really wanted to be which was a passive treatment system that we were able to install in 2019 and is now fully operational. And that is the subject of a discussion on another day. So, I appreciate the opportunity to present. I believe the opening for questions now?

Yes we received some questions coming in as you both were speaking and I want to encourage people to continue to type in any questions as we are going through them now. Someone had asked about, you are mentioning that the system operated only from April through November. So how are you managing leachate during the rest of the year, in the winter months?

Well, candidly, is that was a compromise we had to make. From an economic perspective where we didn't want to have to build a formal building facility and have everything heated and freeze protected. But we also found, for reasons I cannot explain that the iron impacts dropped off dramatically as the temperature dropped. So we didn't see the iron plume downstream in the winter. It was not visual. But it came back every spring and it stayed through the summer. So because this was an interim treatment, it wasn't the final action. It was not really designed to be a final achievement of cleanup standards. We struck that compromise which allowed us to build a more cost-effective system and operate in conditions from an accessibility and functionality perspective, to get it to work. So that's the reason.

Okay, thank you. I think Barb come you might have mentioned this but I'm going to ask you just in case there's any clarification needed. This question came up a couple times. Around the slide 40, it showed that the concentrations were increasing between 2016 and 2017. So there were a couple questions that came in about it and I think you try to explain it as it seemed to coincide with your effort not to overline. But where there ever any other operational factors that changed during that time period? Or any other explanations?

Yes, good question. So we really don't know the reason why that jump was observed. One of the things that did change in that period of time was there is a change in the operator, at the site. So the message, the field methods used could be sometimes could be interpretation or it could be the methodology that was followed. We don't know the actual answer to that question. We actually did call that out of the report, too. As being something that we don't know exactly what caused that. We have some hypotheses but no firm answer.

To add to that, we were comfortable in that the set basin concentration was within our target levels. But you are right, we did have a change in operators. The flow was dropping dramatically at that time and we actually started to see color changes and neutralization tank and the low flow may have been causing more agitation and oxidation from the pump station into the neutralization tank. But we don't have a good explanation for it.

This is Eric. Although I was not involved with the operation during that time., 2016 to 2017, looking at the data I think it just may be that they didn't filter the sample prior to it going to the basin like doing prior to simulate settling is what I think the difference is when you see the higher total iron concentrate . I don't have that graph but I believe that's the difference. Again, I was not involved with the operation at that point.

Yes I'm a let me just pause for a second to say I apologize for not properly introducing Eric Hall with Novus group is one of the engineers that have supported the EPA at this project for over 10 years. He was part of the group that identified the use of the a CTS system and contracted it and was a component of the operation and assessment over the 10 year period. As a matter of introduction.

Great, thank you all. The next question is, is there any limitations from Vermont for discharge to surface water at high pH? They noticed there were many data points where the pH is greater than 10 and maybe even up to 11?

Yes. Once again this is from the long-term perspective, they have a plus or minus so to speak on the amount of pH you can have with the West branch itself is actually a fairly alkaline system that has a pH of around 8. But they do have a pH and I don't have it off the top of my head. Had we maintained the system as a long-term solution, then we may have had a consider that for Copperas Brook which is a smaller water body that flows -- the West branch has tens and hundreds and thousands of CMS at time. It is tremendous. It is quickly assimilated but Copperas Brook is your typical high gradient mountain stream and there are times when the flow is very low it as a matter fact there were times when the flow was almost entirely the leachate. So from the long-term perspective, that is something we would have had to address once again, the stakeholders were all accepting of the fact that in the short term, even though it turned out to be 10 years, that moving the iron and achieving the water quality standards for the chemical constituents was a higher priority. And that we would just continue to monitor and we did not see any pH issues in the West branch. A little quarter-mile section of Copperas Brook, the pH -- it went very quickly but I don't have the data for that. If we had made that a permit system we would have had to address that.

Okay. I guess related to the pH there has been a couple questions coming in, wondering if you had any scale observed downstream. If there was any scaling in streams.

I think as many of you may realize, the Copperas Brook itself was essentially at a fair Creek base. So after 150 years of mining and discharge, I'm not sure we would have been able to differentiate very well could we did not see, as a matter fact, the West branch , the rocks and the bed once we show in that picture were very well. Had to complete that recovery and the inspections with the water Molineux train group . They didn't report any issues there. So you know, we tended to meet our target of one milligram per liter good as I said if you're trying to differentiate it's hard when you get down there and you tip into the settlement and see six or eight inches of the deposit.

Okay. That makes sense.

If someone wants to know how you can explain again what is happening in the frontal operation? Is that for the dosing of Lyman how is it transferred to the drum?

Do you want me to take that one? Sure. I don't have the slide up in front of me but the water came up from the wet well and as the water came up from the wet well it was split into the neutralization tank. And to the frontal. The line came over and was fed into the funnel off the silo. And in order, we needed water to circulate alignment down to the pump. So that's what the purpose of the funnel was. And then the water would go in the final, final down to the grinder pump which would grind up the lime and feet over to the neutralization tank. And just put additional water, we would feedwater back from the neutralization tank to help move the lime around.

If it wasn't obvious, we had a dry lime feeds of the water was for transport of the lime.

Okay great. We have a couple questions on this and people are wondering, do analyzer do have any other heavy metals or other contaminants or constituents in the effluent ? If so, how did the treatment effect those?

We were very fortunate that that leachate discharge was almost exclusively iron and we have sampled the effluent with the metals analysis and we even idolize the sludge on occasion. It may be different for different sites in different circumstances it had we use this treatment technology for the Copperas Brook we may have clearly been wrestling with levels of copper, zinc, cobalt and cadmium. But the tailing department, loosing this even in the monitoring wells we've sampled from the tailing department, just where essentially almost exclusively iron and sulfate.

Okay great. We have another question about the system. What cause the blockage of the sedimentation pond effluent plate? Was a hair ferrous hydroxide or how was it solved?

We had several blockages and Eric can add better detail but we had an initial blockage of the lime feed, the lime solidified and created a backup that created the milk. And then the darn gypsum anytime we had a pipe, we had created the gypsum in it. And I will point Eric probably had to clean the pipe out or unplug it.

Yes, Ed. Initially where would come down from the final initially, everything was hard piped in the whole system could we thought that would be better but it turns out that they created more maintenance so if you were able to rebuild the system. We did this as we optimized the time. We found that having flexible hoses made things so much easier between the whole system. So what it was the frontal to the neutralization tank. Anywhere we could put flexible hoses. We did have a couple of blockages in the sediment basin come initially, it had under drain where you saw this long stick taken out , the sludge in the picture that was the first time we drained the tank and got rid of the sludge. Over time, the gypsum unfortunately plugged the drain. So the way around it was we had to build something on the side of the sedimentation mission so when I got up to the elevation it would fall over not go up the pipe, that's the way to solve that problem.

Okay, thank you. Let's see. Let's ask another question we have about the piping. Did you have a protocol for unclogging? Or did you replace the pipes, what was the procedure for that?

Yes -- we had a consistent drop we try to solve the problem by either changing the type of piping or in the case of the effluent discharge we eliminated the piping and went to the system. Besides that I will let Eric take on as a took a lot of time cleaning both drums and different pipes at times.

And mentioned and I said before, we figure out the flexible hosing was the key and then to preventative maintenance that we would try to change other hoses about every two weeks but as we would change them out we would clean them without acid and banging out any of the gypsum that would accumulate on the hoses. About once a week to every two weeks, we would flush the neutralization tank had a pipe where we were able to discharge that directly to the sediment basin and that would get out any sludge that was in the tank. And then,

as it was optimized, I won't talk about the whole beginning but we were able to put a crane system inside the building that could take off the cover. We were able to probably , towards the end when it was optimized, but twice year take the cover off and bang out the holes in the RCTS as you saw that one picture where one was scaled over and one was white . That was in the middle of a cleaning process. And the other thing we did was we added wash ports on the side of the RCTS to be able to flush out any Lyme build up in the RCTS gypsum.

Okay, thank you.

Can you share information about the cost of the system? What it cost to install it and the annual operation maintenance?

Yes. Sort of. The installation our site this specific so the question of the cost to the treatment system versus all the earth work that was done to make room for the sediment basin and install it, I don't have those numbers. I don't have them handy. But I can tell you it was about $200,000 a year or $250,000 year to operate the system. And the total installation cost, oh, I think it might have approached $1 million. But I don't know -- it's been a while since I looked at the numbers that we had to do a fair amount of earthwork as we showed in that one photo. There was not good topography available. I just to get the sediment basin income went to dig that out and get that all set up.

With a question about the sludge. Is any of it hazardous to wildlife gimmick is there any practical way to solidify the upper layers of it or put a cover on the sludge?

The sludge is another one of the challenges we had the advantage for the first several years to be able to put it on top of the site and put under the covers system. Another advantage, we experienced a rapid drop in load after the cover system that we actually accumulated it in basin for the final five up plus years. The we mixed it with cement and consolidated it at one end of the basin. We put a soil cover over it. We wanted to make sure it has a consistency that wouldn't be a hazard from sinking in it. And that we wanted to cover it. One of our consultants who works in Pennsylvania specializes in looking at the reuse of iron sludge is for pigments and others. But unfortunately, the site location was such that even though it was in the east, it is far enough from anywhere, that who would want to use it to make the cost practical? When we analyze the sludge, it's pretty much iron and turbinate. But we couldn't find anyone but if it gets more used, then we have some opportunities for it. If you have a similar situation where we didn't really have any hazardous constituents. Once again, if we were going to operate this in perpetuity, we would have to have a mechanism to probably pull it out and dry it out and form a dry cake or something. And find a landfill or something else where we can dispose it and get rid of it from a bulk perspective. That's one of the challenges.

And I add something to the question? For those interested there is a little bit about this in the EPA report and I just pulled it up for a generalized statement for treating one gallon of water it was about seven since per gallon and that was based on some numbers that were averages. But that information is in the report.

Thanks, I think we have a link to that report in the related URLs that are associated with this webinar. If you go to that part of the Adobe connect screen you will be able to find that pretty easily. Thank you.

I guess we have time for one last question I see here but we know this isn't interim treatment system put in at the site and I guess there is some interest, if there is any information or details you can share about the new system if you will, that is being used at Elizabeth Mine.

I will start and Barb if you want to add onto that. So as I mentioned in my the sides, the long-term goal from the beginning was passive treatment. But we just never had , we did not have the load that really allowed it to be practical. From the space perspective. Once the loads dropped enough, we work with consultants only work with Barb and other experts, and they provide some good input and we develop the passive treatment system that collects the drain system that used to go to the RCTS. We now have it plumbed into a limestone drain. From there he goes into a settling pond and then a goes into a vertical flow pond with a compost top and limestone base. It comes out there and goes into another wet one and then drops into the stream. It is effectively removing the iron and we have been monitoring that carefully and as Barb alluded to we hope to do a webinar on that in the future. There are some challenges that we certainly encountered. With other factors. But it is working well and that goes year-round. Even actually monitoring it monthly for the past couple of years. So far, so good. I think one of our big pictures is the combination of aggressive source control with it the opportunity to handle the problem as an interim measure without having to build a permanent expensive system, and being able to transition to a much more cost-effective passive system in this case worked well for us. We are happy with the outcome.

Did you want to add anything, Barb?

No. Thank you I thought that was a great nation and I look forward to presenting data on the passive treatment system in the future webinars.

Great. Great I did see one last question come in but I will ask quickly. What flows are you treating through the passive system?

Right now we are looking at around 69 gallons a minute. In the iron concentration is an average of 150 milligrams per liter.

Great, thank you. Well we did get to all the questions and I want to thank all the participants, these are very engaging and good questions so I'm glad for your participation. I will let Barb and Ed and Eric all know that we are getting a lot of thank youse from the participants in the chat box now. They really appreciate your presentation. You for taking the time and we look forward to having you talk about this site again in the future. Thank you. We really appreciate it.

Thank you.

Thank you.

Great. I will turn over to Jean to wrap up the session for us.

Thank you very much, with that, I will go ahead and walk through some final reminders as we close things out today. I do encourage those of you who are interested in learning more about online training opportunities, technical publications and technologies, for cleanup sites, visit us at cluin.org or sign up for the free monthly newsletter, tech direct. If you're looking for copies of the presentation materials, they have been posted to download from the seminar homepage. As I highlighted at the start, if you visit the home page there are tabs that will allow you to access information about the speakers or their sides and related resources including the EPA report which was highlighted at the end of the session today.

We have all that information bookmarked on the seminar homepage. I will ask each of you to fill out a brief online feedback form to let us know what you thought of the delivery today both in the content that was covered along with the technology we used to host it. Please know I do read each and every one of these submissions on the help us continue to offer technical presentations like this through the cleanup information network. I'm often asked if we issued CEU or PDH. While we don't provide those types of credit hours, we can give you a participation certificate after you fill out the feedback form. Note that there is a box at the bottom of the form that you must check along with including a valid email address. As soon as you submit feedback and you've checked the box on the form and you send it and will immediately have access to a participation certificate that looks like this which will have information about the session included the date, time and length. You can download the presentation materials and often times the attendees are able to earn credit for sitting in with participation certificates and the materials and the registration email. If you happen to share your connection with others, if there were people connecting with you each person can fill out the online feedback form to get their own certificate even if they didn't register for the session. If you are one of the lucky ones replaying the recorded session as I noted, it was recorded. You will get an email with a link to playback the archive. Texas about one week or so to produce that and you're welcome to share that with others you think this is viable. If you are watching the recorded version, you can follow the links over to the seminar feedback form. There are available to you in the middle right under related URLs. I've pasted them directly into the Q&A pot as well. I want to echo what everybody says, thanks to the presenters and organizers who took time out of their days to share their expertise and help host the session. As well as the support staff on in the background. With that, we will normally conclude the live broadcast. Thank you so very much for joining us. [Event Concluded]