Northwest Plume Groundwater System
Greensand Media Removal and Waste Packaging
Paducah Gaseous Diffusion Plant, Paducah, Kentucky

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ABSTRACT

The Northwest Plume Groundwater System (NWPGS) was temporarily shut down due to high differential pressures across the greensand filters. Increased levels of suspended solids were introduced into the system from monitoring well development water, equipment decontamination water, and secondary containment water. These waters were treated for suspended solids through a groundwater pretreatment system but were suspected of causing the high differential pressures in the greensand filters. Prior to the system being shutdown, the NWPGS had been experiencing increasingly shorter run times between filter backwashes indicating that the normal backwash cycle was not adequately removing the fines. This condition led to the removal and replacement of greensand media from two filter vessels. Discussions include problems with the removal process, waste packaging specifications, requirements for the disposition of greensand media, and lessons learned.

INTRODUCTION

The NWPGS is a groundwater treatment facility located at the Paducah Gaseous Diffusion Plant (PGDP) near Paducah, Kentucky. The NWPGS is designed to recover and treat groundwater contaminated with trichloroethylene (TCE) and Technetium-99 (Tc-99) using air stripping and ion exchange technologies, respectively. The system also includes filtration for iron and manganese removal via greensand filtration. The treated groundwater is discharged to a permitted outfall. Typically, influent sources for the treatment system are supplied from four extractions wells. However, additional water from other plume sources was accepted that contained similar contaminants of concern. Over time, the differential pressure across the greensand filters began to increase. Backwashing operations were only partially successful in lowering these pressures as run times became shorter and shorter until the system had to be shut down. This condition led to an evaluation of and subsequent replacement of the greensand filter media.

GREENSAND MEDIA DEGRADATION

The original media installation (from bottom to top) consisted of (4) 4-inch layers of varying sized gravel, an 18-inch layer of manganese greensand, and an 18-inch layer of anthracite coal. The primary purpose of the greensand filters was to remove high levels of iron, manganese, and suspended solids that could potentially foul and/or plug downstream process equipment. The greensand media was regenerated using potassium permanganate with a metering pump and tank system. However, high levels of iron and manganese were never detected in influent groundwater sample results. Therefore, the greensand media regeneration process was terminated early in the life of the treatment system and the greensand filters began serving as particulate filters only.

Typical life of greensand filter media is usually 5-7 years although some systems may use the media for longer periods of time. Normal media attrition occurs over time causing the filter material to slowly fracture and the fine material to be washed from the filters due to its lower specific gravity. Normal attrition is typically 1-3% per year[1]. When a filter bed needs replacement, it is usually prompted by short filter runs due to physical softening and breakdown of the manganese greensand.

One NWPGS greensand filter vessel was opened and visually inspected revealing an approximate 2-3 millimeter layer of clay-like fines covering the top of the filter media as shown in Fig. 1 and Fig. 2 below. A 1-inch copper tube was used to collect core samples of the filter media down to the top of the gravel bed. The total depth of the filter media remaining after 6½ years was observed to be approximately 18-20 inches compared to the installed depth of 36 inches. All of the material was black in color although the material retrieved from near the gravel (8-10 inch layer on top of the gravel) appeared to be greensand. There was no noticeable odor or slime observed, therefore microbiological activity was not considered.

Fig. 1. Top layer of media

Fig. 2. Anthracite with clay layer

The second greensand filter vessel was also opened for inspection and waste characterization sampling. The bed surface and filter media condition was consistent with what was observed in the first filter.

A greensand media manufacturer was consulted regarding the condition of the spent filter media. After review of digital photographs, the media manufacturer stated that the filter bed was in poor shape and had an appearance consistent with that of improper cleaning and backwashing. They also indicated that the media loss during routine backwashing could have been expedited due to deterioration of the greensand media. The specific gravity of the greensand may have been altered due to the lack of regeneration, thus allowing more of the media to be removed during backwashing.

SAMPLING AND CHARACTERIZATION

Sampling of the spent greensand media was performed to help characterize the greensand waste for final disposition. A sampling and analysis plan was developed that required four core samples to be collected in each vessel. A one-inch copper tube was used to collect the core samples, which were composited and sent to a Utah-Certified fixed-base laboratory for analysis. Sampling results indicated that contaminant levels for Tc-99 and TCE were relatively low with the highest values being 61.8 pCi/g and 1,100 µg/L, respectively. The result for TCE did not meet the standard in the Code of Federal Regulations 40CFR261.24 of being hazardous for TCE (D040 waste code). However, based on process knowledge of the waste, waste codes F001, F002, and U228 were applied. The waste did not exceed the LDR listed in 40CFR268, which is 6 mg/kg for TCE. The spent media was characterized as mixed waste meeting LDR requirements.

GREENSAND REMOVAL

Various removal techniques were evaluated to determine the most practical, cost-efficient, and safest way to remove the greensand from the filter columns. The three methods evaluated were as follows:

- Sluicing
- Vacuuming
- Shoveling

The sluicing method would have required water to flush the media out of the vessels by using pumps, hoses, and other equipment to set up a recirculating and containment system. This method was discounted for several reasons. The flushing process would have been inhibited due to the location of access ports and by the formation of the media itself. It would have been difficult to control the sluicing of unwanted media (greensand and anthracite) while leaving the needed gravel layers of the support bed in the vessel. With all things considered, this method was not used. Pros and cons are summarized below.

Pros: minimal personnel contact with contaminated waste
Cons: additional equipment needed with associated costs; filter design not conducive to sluicing; difficult to control media removal; elevated work required

The vacuuming method included a tornado vacuum with a high efficiency purified air filtration system. A similar method had been used routinely with vapor-phase activated carbon. The greensand media was relatively dry since the vessels had been drained for approximately one year. Equipment needed was a high-powered tornado vacuum, heavy gauge drums to withstand the vacuum pressures, and associated ancillary equipment. An additional concern that arose was airborne radiological contamination. Though radiological levels were low, the potential for airborne radioactivity was a possibility. Therefore, respirators would be required if using this method. Pros and cons of this method are summarized below:

Pros: reduced contact from personnel, personnel were experienced with vacuum operations
Cons: slight potential for airborne radiological contamination; some equipment costs; elevated work required; respirators required

Lastly, the shoveling method would require shovels, rakes, and other types of hand tools to remove the media from the vessel opening and place it into drums. All tools would have to be made of plastic or other non-metal or abrasive material to preserve the glass-lined vessels. The media could be emptied out of the side man-way opening and would not require personnel to work on top of the vessel. Pros and cons of this method were as follows:

Pros: simple approach, no special or expensive equipment needed, no elevated work
Cons: increased risk of back injury; workers in close contact with contaminated media; may be difficult to control release of material out of side man-way hatch; increased risk of personnel contamination

Initially, the method chosen was vacuuming. Vacuuming would keep workers out of close contact with the media and was a method that had been performed before on another spent media. The risk for airborne contamination was very low and the equipment costs were not excessive.

Problems Encountered

The vacuuming method was unsuccessful due to compaction of the media in the vacuum hoses. Though the media was relatively dry, the slight moisture in the media was enough to cause the compaction problems. Compaction was something discussed with the Tornado vacuum manufacturer prior to purchase, but was not anticipated to be a problem with the described moisture content of the media. The removal activities were postponed until a new approach was developed.

After evaluating the two previously considered alternate methods, it was decided to remove the media manually. Removing the media by manual shoveling would eliminate potential problems with sluicing. Access to the vessels was obtained by a 24-inch opening located on the side of the vessel approximately 4-ft high. The main concern with this removal method was preventing an uncontrolled spill of media. The media was approximately 3-ft above the top of the opening of the filter vessel. Therefore the potential of a substantial release of media was a concern. To eliminate this potential hazard, a loading strap was placed around the entire vessel and man-way opening and was released gradually with a ratcheting mechanism. This not only controlled the release of media, but also helped control the filling of 55-gallon drums that were placed just below the man-way opening. Each drum was filled slowly until the level of the media reached the bottom of the opening where the media could be accessed and removed by shovels and rakes.

WASTE PACKAGING, STORAGE, AND DISPOSITION

Once the greensand media was removed from the vessels, the waste material had to be properly stored until transportation to an off-site treatment, storage, and disposal facility. The waste was also containerized and labeled to meet Department of Transportation (DOT) regulations.

There were (29) 55-gallon drums of greensand media, PPE, and associated materials generated from the removal task. Sampling results and process knowledge indicated that the waste would be classified as a mixed waste. The hazardous constituents in the waste forced the material to be handled and stored in accordance with all applicable Resource Conservation and Recovery Act (RCRA) regulations. The volume of the waste (greater than 55 gallons) did not allow for storage in a satellite accumulation area. A 90-day storage area was established in the NWPGS facility to store the waste since the waste was planned for disposal in a time frame that would meet the 90-day storage requirement. All appropriate training was conducted for the individuals responsible for the containerization, handling, and inspections of the waste generated. This decision was made prior to containerization of the waste allowing personnel adequate time to make all required notifications and perform required training. The storage area for the waste was a decision that had to be made prior to greensand removal to stay in compliance with all site and regulatory requirements.

The waste containers and associated materials used in packaging were chosen prior to media removal. The container selection was made after thorough process knowledge of the waste was developed. The physical properties of the waste were considered to determine the appropriate container. The Paducah site also has several requirements concerning container pedigree that helps to ensure that containers are manufactured in accordance with appropriate quality control measures. Many of these requirements were put in place after the initial planning phases of the project. Prior to any future media change-out or other waste packaging for off-site disposal, these requirements will be reviewed to determine if approved manufacturers/vendors of waste containers exist. Use of these vendors/manufacturers would help to ensure the waste container used is of sound quality and design. It also allows all site requirements for off-site shipments to be addressed in the planning stages of the waste shipment, rather than trying to incorporate additional requirements after the work has began. Proper selection of waste containers based on site requirements would have avoided future overpacking/repackaging of the waste. Using approved vendors/manufacturers also reduces the potential for any suspect or counterfeit items to be used in the manufacturing process.

Once the waste had been containerized, additional actions were still required. The weights of the containers had to be determined. A NIST-traceable scale was used to weigh each container. The use of the NIST-traceable scale reduced the potential for inaccurate weight measurements. Inaccurate weight measurements could have lead to inaccurate data thus leading to errors listed on hazardous waste manifests or other shipping documents. The reliability of data is also important to ensure that waste meets the requirements of the receiving facilities. The waste was destined for disposal at Envirocare of Utah, which like all disposal facilities, has limits for the concentrations of contaminants that can be accepted under their operating permit. Accurate container weights also ensure that problems are not encountered once the waste arrives at the disposal facility.

Waste Profile

During initial sampling activities of the waste, the waste acceptance criteria (WAC) for the receiving facility was reviewed to ensure that all required parameters were sampled. The correct method should also be determined prior to sampling activities. If an LDR determination is needed, the sampling results should be reported in “Totals” with units of mg/kg instead of Toxic Characteristic Leaching Procedure (TCLP) results with units of mg/L. The analytical results for the greensand media indicated it to be a mixed waste. The RCRA constituent was TCE and the radiological component was Tc-99. Subsequently, the waste was stored onsite as mixed waste. However, the level of Tc-99 in the waste was below the DOT regulatory limit for radiological materials. Therefore, the waste would not be shipped as a Class 7 radiological waste under DOT, but a Class 9 miscellaneous waste. The waste would still be disposed of as a mixed waste, but would be shipped as a hazardous waste.

For transportation, a waste broker was used to arrange for the transporter. The waste broker possessed the required Generator Site Access Permit that is required to dispose of waste at Envirocare of Utah. The broker was also responsible for preparing the shipping documents. This allowed for an additional review of all the shipping documents prior to the actual shipment. The additional review reduced the chance of an error to occur on the shipping documents. For all shipments of hazardous or radiological waste from DOE sites, the transporter of the waste must be approved by the Department of Energy (DOE) motor carrier evaluation program (MCEP). The MCEP provides a list of transporters that have been evaluated by the DOE transportation department. The MCEP constantly evaluates transporters safety and performance to ensure that transporters strive to maintain a safe and compliant transportation record. By using a transporter on the MCEP list, the shipper is assured that the transporter has a favorable history of safely transporting waste.

CONCLUSION

In summary, the greensand filter media was nearing or had already reached the typical filter bed life of media that is routinely regenerated. The greensand media had not been regenerated since late 1995 or early 1996. The very short greensand filter run times and high differential pressures that eventually shut down the NWPGS were most likely due to increased solids loading on deteriorated filter media.

The lessons learned acquired from this task dealt primarily with the initial removal method. Though the greensand media was relatively dry, compaction in the vacuum hose prevented the method from being successful. More research should have been done to ensure the method would work for this particular application. Research may have included testing for moisture content, compaction characteristics, and/or trial runs with similar vacuum devices to test the application.

Another lessons learned involved the characterization process. The initial sampling plan met the requirements for characterization required by Envirocare, however the incorrect analytical method was identified. To determine LDR compliance, analytical results for volatiles must be “totals” in units of mg/kg rather than mg/L as generated by TCLP. This oversight led to an additional sampling event to ascertain LDR compliance.

Lastly, a lesson was learned in the groundwater treatment realm itself. Much of the water being accepted from outside sources consisted of water collected from secondary containment of mobile tanks stationed in outside areas (surface impoundment water). Though this water was considered “clean” since it was only rainwater, surface impoundment water can contain environmental contaminants such as mold, algae, and other constituents that can lead to biological problems. Though these types of contaminants were not suspected of causing the filter plugging, the potential problems of treating these waters were not considered.

REFERENCES

1. Water Control Associates, Inc., Job No. 1029, MMES Subcontract No. 39P-FTM10V, Item No. 003, Northwest Plume Manganese Greensand Filters.