NOVEMBER - DECEMBER TECHNICAL REPORT
AMERICAN CYANAMID SUPERFUND SITE

CRISIS, Inc.
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I have elected to devote this Technical Report to the subject of Ground Water Treatment, one of the major technical issues at the American Cyanamid site in Bridgewater, N.J., and at many highly contaminated former industrial sites.

I have touched on ground water issues in previous Technical Reports, but with little emphasis on treatment because the proposed treatment plant is the product of a long period of technical development and design which is nearing completion, so that the details of how the ground water will be treated are now known.

Previous Technical Reports by me relating to ground water have looked at:

- August 2013 - Ground water Remediation and Raritan River Seeps
- October/November 2013 – Ground Water Treatment and Ground Water Extraction
- January/February 2014 – Site Wide Ground Water
- December 2015 – Ground Water (Update on Progress)

Ground water remediation is a key to completing the remediation of the American Cyanamid Site, along with soil remediation and remediation of the contents of numerous impoundments that have been reported on in many of my Technical Reports.

In our September 19, 2016 conference call with Pfizer and EPA, Pfizer reported that they expect to complete the detailed design of their ground water treatment facility in December 2016 Arrangements are presently being made for the securing of permits and permit equivalents for the ground water treatment facility, and access agreements with utilities are being completed in order to provide electric power and fresh water to the building that will house the ground water treatment plant and will serve as a permanent administration facility on the site. In short, Pfizer anticipates embarking on construction of the treatment facility shortly, and has engaged a contractor to be the construction manager of this building and treatment plant.

1.0 FIVE KEY ELEMENTS IN GROUND WATER REMEDIATION

The five key elements in ground water remediation at the American Cyanamid site are:

- **Extraction.** Getting the water from the bedrock and the overburden soil
- **Conveyance.** Getting the water from the extraction wells, through the site and across barriers, to a treatment facility

- **Hydraulic Barrier Walls**. Preventing contaminated ground water from escaping untreated from the property
- **Treatment**. Removing contaminants and cleaning the water to acceptable standards and concentrations
- **Bedrock Injection**. Discharging the water back into the ground to maintain a hydraulic equilibrium at the site

2.0 CONTAMINANTS AND SOURCES OF INFLUENT

2.1 Contaminants of Concern:

Given the diversity of manufacturing operations on this site over many years, it is not surprising that there is a wide diversity of contaminants in ground water with concentrations that exceed the New Jersey Water Quality Standards for ground water. The following organic chemicals were given to me by Pfizer as the "top 5" contaminants that the treatment facility is designed to remediate.

- Benzene. Of all contaminants on site, both in ground water and in residence in the most highly contaminated Impoundments, 1 & 2, benzene is the most significant, and is a "driver" of much of the on-site remediation. Benzene is a product of one of the major industrial processes conducted at the American Cyanamid property, the fractional distillation of coal tar. Benzene is of concern in the Raritan River and Cuckel's Brook as well as in ground water extracted from both the bedrock and from the overburden layer of soil.
- Chlorobenzene. This chemical was often used as an intermediate in the production of other chemicals including solvents and aniline.
- Aniline. This colorless, oily liquid was the "parent" substance for many dyes and drugs produced over the years on this site.
- Naphthalene. Known as "tar camphor", naphthalene is derived from boiling coal tar oils and from petroleum fractions following catalytic processing
- N-nitrosodyphenylamine. This yellow liquid was used in rocket fuels, solvents and rubber accelerators.

The primary metals to be treated at the new ground water treatment facility include the very common metals iron, nickel, zinc and manganese. Removal of metals from water requires entirely different treatment approaches than removal of complex organic compounds.

2.2 Incoming Waste Streams:

Ground water extraction wells have already been installed to capture the two most significant on-site waste streams; shallow ground water from the overburden layer of soil covering the property, and deeper ground water to be removed from the cracks and fissures inherent in the bedrock that underlies the entire site. Significant field testing has been conducted within the bedrock to determine where deep extraction wells can be located in order to intercept the openings in the bedrock to exert significant hydraulic control over the entire mass of ground water occupying the bedrock structure beneath the property.

Other sources of influent waste flows to be captured for the treatment facility include surface storm water, and water that may be the by-product of remediation of areas of concern on the property including impoundments and areas of soil contamination. Although I have no specifics at this time, the design engineers for the treatment processes indicate that inflow will also include leachate from above - ground encapsulated waste disposal areas, located largely at Area 8 in proximity to the treatment facility.

Influent water will be conveyed to the treatment facility by several miles of piping, with the water flowing under pressure provided by the pumps that will lift the water from the shallower overburden and the deeper bedrock. The conveyance pipes will be installed accompanied by subsurface fiber optic and electrical conduit, flood protection towers and above ground valve vaults in the Raritan River flood plain.

Ground water will be fed into the conveyance system by 7 bedrock ground water extraction wells (up to 250 feet deep) and 16 overburden ground water extraction wells (up to 25 feet deep).

3.0 GROUND WATER TREATMENT FACILITY

The ground water treatment facility will be housed in a new permanent 16,000 square foot pre-fab metal building that will be built in the upland Impoundment 8 area of the property, where for years the two office trailers serving as Pfizer's on-site headquarters were located, and recently removed. Within this new building there will be situated:

- Treatment process equipment, detailed in Section 4.0
- 1300 KW emergency electric generator
- Utility services including electric power, gas, water and sewer.
- Administrative offices
- Meeting space

On the outside of the facility will be located 11 outdoor tanks of up to 350,000 gallons for flow equalization.

4.0 GROUND WATER TREATMENT PROCESSES

There are eight primary steps in the ground water treatment process train, and two steps in the processing of solid material (sludge) removed from the ground water during treatment. The ground water being treated generally has a much more complex chemical makeup than municipal wastewater (sewage) but a far smaller presence of solids that can be filtered. The natural ground water found in the bedrock generally has a larger concentration of metals and minerals than would most domestic or industrial wastes being treated. Generally, water treatment processes fall into one of three technical categories, although some processes can be combinations of more than one category. The primary treatment process types are:

- Physical – where contaminants can be removed by settling or filtration
- Chemical – where the addition of one or more chemicals brings about a chemical reaction that triggers the removal of contaminants, usually as a solid material (precipitate)
- Biological – where organic chemicals are broken down biologically into less harmful substances, sometimes upon the addition of an agent to facilitate the process

4.1 Water Treatment Processes

Pfizer will be employing these processes to treat the ground water with contaminants dissolved into the waste stream.

- Flow Equalization. Ground water conveyed to the treatment facility will be stored and mixed in equalization tanks so that there is a relatively constant volume of flow into the treatment system.
- Fenton's Oxidation. Pre-oxidation of organic contaminants in highly polluted pharmaceutical wastewater is frequently accomplished through a process originally discovered by H.J.H. Fenton in 1894. In the Fenton process, iron catalyzed hydrogen peroxide is used to oxidize waste streams containing phenols, formaldehyde, petroleum derived BTEX (Benzene, Ethylbenzene, Toluene and Xylenes) compounds, pesticides, etc – many of which are in the ground water beneath the American Cyanamid site.
- Metals Precipitation. Some of the metals within the wastewater stream will be removed as solids precipitated out through the addition of chemical agents creating the appropriate chemical reactions. Some of the metal sludge from this process will be recirculated back into the liquid waste stream, and some of it will be collected in a sludge storage tank.
- Biological Treatment. The actual form of biological treatment has not been specified in the information I have, but usually wastewater is introduced into some form of biological reactor, along with some biological reaction agents, and possibly with heat, to bring about the desired biological breakdown of organic compounds.
- Membrane Filtration Systems. Membrane filters are used to concentrate the breakdown products from the biological treatment process just upstream. Some of the solids from this process are recirculated back into the biological treatment reactor, and some are taken out of the process stream and sent into the sludge storage tank.
- Granular Activated Carbon (GAC). GAC is a very common ground water treatment process, and for some less contaminated ground water influents may be the only treatment process used. In other situations, including at American Cyanamid, GAC is used to "polish" the otherwise treated effluent. When the carbon is "spent" it must be removed and regenerated for reuse, making the use of GAC a relatively expensive process. From the GAC units, some of the treated water will be recirculated back into the influent tanks, and some of it will move on to the next process. Some treated water from the final treatment process will be recirculated back into the GAC units. GAC works by the process of Adsorption (not ABsorption)

which is a physical process whereby certain organic compounds are attracted to the surface of the carbon.

- Arsenic Adsorption System. The metal Arsenic is naturally present in ground water beneath the American Cyanamid site, and some Arsenic waste has been discharged into the ground water. The final treatment step will be to remove arsenic by utilizing an adsorption agent to attract the dissolved metal out of the waste water flow. Some of the effluent from this process will be recirculated back to the influent equalization tanks, some will be recirculated back to the GAC units, and some will be discharged into a final effluent storage tank.
- Effluent Storage. The final step, effluent storage, is designed to enable the treatment plant operators to discharge a uniform flow into the network of pipes that will convey the treated wastewater into the injection wells which will convey the treated product into the bedrock.

A note on the process flow diagram that I relied on for this information indicates that a sand filtration system will be added to the process train if needed following the startup and optimization of the waste treatment process facility which was designed for Pfizer by the engineering consulting firm of Brown and Caldwell of Upper Saddle River, New Jersey.

4.2 Solids Treatment

Several of the processes described above generate solids in the form of residues or precipitates. Solid residuals from the water treatment will be conveyed to a sludge storage tank, which is the first step of the solids processing or treatment. The other steps include:

- Dewatering. There are several processes available to dewater sludge, and it is not clear as to whether one single process will be employed, or if it would be a multi-step process, but on the process diagram it is described as Dewatering Systems.
- Sludge Cake Disposal. Dewatering consolidates the sludge, but does not entirely remove all of the liquid content. The residual product, known as “Sludge Cake” will be removed for disposal, possibly on-site. Prior to disposal it will have to be tested to determine whether it will be classified “hazardous” or “non-hazardous” under federal waste management rules.
- Centrate Recirculation. The liquid component of the sludge that is removed during the dewatering process will get recirculated back to the front end of the water treatment process and will come back through the multiple treatment processes described above in 4.1.

4.3 Monitoring

Operation of a sophisticated wastewater treatment system, such as the one that has been designed for Pfizer at the American Cyanamid site, requires skilled operators who will be licensed by the state of New Jersey. Several forms of monitoring will be necessary, including:

- Start-up Monitoring. There will be a start-up period where the objective will be to optimize the treatment processes in conjunction with one another, given that there is some overlap in function from one process to another, and given the design which calls for the recirculation of flow from several processes back to earlier stages in the treatment. The operators of the plant will have a lot of flexibility, but that comes with a challenge to find the most effective combination of operations for each component of the plant.

- Flow Monitoring. Flows into and out of the front-end equalization tank and the back end effluent storage tank will be monitored, along with the internal flows created by the recirculation of some volume of the partially treated water.
- Chemical Monitoring. The chemical composition of the output from each stage of treatment has to be monitored to determine the effectiveness of that step in the treatment train.
- Effluent Monitoring. The Discharge to Groundwater Permit Equivalent for the Pfizer facility was issued by NJDEP on November 17, 2016. The permit contains a long list of effluent limits placed on the output of the treatment plant prior to discharging to the injection wells that will but the water back into the bedrock. These limits fall under the categories of Inorganics, Total Metals, Semi-Volatiles and Volatile Organics. The plant operators will be obligated to monitor the effluent on the following basis:
  - Twice per month for the first quarter
  - Monthly for the next 6 months
  - Quarterly thereafter until the cessation of plant operation
    Beyond the first 2 years of operation, if results are below anti-degradation limits, the operator may petition EPA/NJDEP for reduced future monitoring, such as semi-anniual.

5.0 SCHEDULE MOVING FORWARD

Bid packages for the construction of the Ground Water Treatment Facility are going out this month, and construction is scheduled to begin in March or April 2017. Completion of the facility is scheduled for the second quarter of 2018. This will be followed by several weeks of startup for both the treatment system and the conveyance system. Pfizer expects to attain complete startup in June or July 2018. This is one portion of the remediation schedule that has had an aggressive schedule; and the schedule has been largely adhered to.

CRISIS is looking forward to the construction of this facility, and is hoping we have a chance to do an on-site inspection during the facility construction. We are looking even more forward to the time approximately 1 ½ years from now when the treatment facility with its contaminant removal processes is fully operational and meeting the ground water effluent standards that have been prescribed by EPA and NJDEP for the remediation of ground water at the property.

If you have any questions or comments, please contact CRISIS' Technical Advisor by e-mail at iwhitman@whitmanco.com.

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