

**TECHNICAL REVIEW OF THE
INTERIM REMEDIAL MEASURES SHUTDOWN PLAN
FOR THE BADGER ARMY AMMUNITION PLANT**

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EXECUTIVE SUMMARY

A review has been completed of the “Interim Remedial Measures Shutdown Plan – Badger Army Ammunition Plant” (BAAP), hereinafter referred to as the Interim Remedial Measures Report. As a result of this review, several concerns have been identified regarding the validity of the remedial plan as proposed by the Department of the Army (Army). Most significantly, the site investigation has not defined the degree and extent of soil or groundwater contamination, and the remedial options have not incorporated adequate groundwater monitoring data in order to effectively assess impacts emanating from the BAAP site.

The remedial plan does not provide sufficient evidence that natural attenuation as a final remedy is protective of human health and the environment in the vicinity of the former plant. The remedial cap does not sufficiently protect groundwater from soil contamination at the depths beneath the Propellant Burning Ground. In addition, a review of best practices from peer-reviewed journals indicates that most current remediation practices do not involve natural attenuation with contaminants of this type (DNT and VOCs) at the depths at which source contaminants are located without additional remediation measures within the source area.

The following provides a summary of the inconsistencies and concerns related to the investigative and remedial activities completed and the remedy currently proposed:

- **EXTENT OF SOIL AND GROUNDWATER CONTAMINATION EMANATING FROM THE PROPELLANT BURNING GROUND IS NOT ADEQUATELY DEFINED:** Determination of the degree and extent of soil and groundwater contamination is explicitly required in Wisconsin Administrative Code; these conditions required under current state law have not yet been met at the BAAP. Specifically, soil sampling has not included the full list of DNT isomers and the contaminant mass has not been adequately defined.
- **CONTAMINANT MASS CONTINUES TO IMPACT SOIL AND GROUNDWATER:** High levels of soil contamination continue to exist beneath the Propellant Burning Area, and the remedial cap does not provide a protective barrier to groundwater from contaminants that continue to be located at depth.
- **GROUNDWATER PLUME IS SHOWN TO BE NEITHER STABLE NOR RECEDING:** Natural attenuation is used as a final remedy for sites when the groundwater contaminant plume is proven to be stable or receding, and expected to “naturally degrade over time”; this has not been demonstrated at the site.
- **INTEGRITY AND APPLICATION OF MONITORING WELLS ARE QUESTIONABLE:** There is a lack of shallow groundwater monitoring wells screened across the water table interface, which has not allowed for an evaluation of the extent of DNT and other contaminants at this location. Consideration of groundwater quality data for monitoring wells completed with 100-foot screens provides for error given the potential for surficial contamination or dilution; samples collected from these wells cannot provide an accurate depiction of contaminants at the groundwater surface.
- **SIGNIFICANTLY HIGH LEVELS OF DNT PERSIST IN GROUNDWATER AFTER REMEDIATION:** DNT detections in groundwater in the vicinity of the Propellant Burning Ground indicate that contaminant

levels do not justify halting the operation of the remedial system. In addition to DNT, other volatile organics continue to be present at concentrations of concern within the aquifer.

- **ADDITIONAL MONITORING WELL LOCATIONS NEEDED:** The monitoring well network has not included enough data points at appropriate locations throughout the impacted area to accurately depict the hydrogeologic conditions at the site. Recommendations to turn off the system are based on this (incomplete) set of data. There are also significant voids in groundwater data, including the off-site areas directly east, south, and across the Wisconsin River.
- **ESTIMATED VELOCITY INDICATES POTENTIAL CONTAMINANT TRANSPORT OF GREATER THAN 5 MILES:** Multiple irrigation, commercial and residential wells have a zone of influence that extends to impacted soil and groundwater beneath the subsurface. Equations utilizing the average groundwater flow velocities provided by the Army have estimated that there may be potential receptors of groundwater contamination located at distances of as much as five miles from the contaminant sources.
- **HIGH CAPACITY WELLS NOT ACCOUNTED FOR IN EVALUATION OF GROUNDWATER FLOW:** The pumping of irrigation wells likely has a significant impact on groundwater flow in the vicinity of BAAP and has not yet been incorporated into the evaluation of contaminant transport. A more complete identification of the hydrogeologic impacts of pumping of high capacity wells in the area needs to be conducted. Contaminant contours have been drawn without full consideration of hydrogeologic conditions, resulting in an inaccurate depiction of the extent of groundwater contamination. This situation does not allow for an accurate evaluation of the impact of current remediation strategies, nor an adequate depiction of the risks to water supply wells.
- **POTENTIAL LONGTERM IMPACT TO PRAIRIE DU SAC MUNICIPAL WATER SUPPLY:** Hydrogeologic conditions have not been assessed sufficiently to assure no impending risk to the current water supply.
- **CONTAMINANT MASS CONTRIBUTING DIRECTLY TO SOURCE WATER CONTAMINATION IN LAKE WISCONSIN:** Source water concerns include contributions of contaminated groundwater in Weigand's Bay, Gruber's Grove, and directly into the Wisconsin River. The mitigation of this surface water issue has not been addressed at all in the proposed remediation plan.
- **BIOLOGICAL IMPACTS TO PLANTS AND ANIMALS NOT ASSESSED:** Biological impacts from the uptake of DNT-contaminated water has not been fully assessed, yet over 15 irrigation wells within a one mile distance of the contaminant plume (identified to be emanating from the Propellant Burning Ground) utilize the groundwater in this vicinity to irrigate fields and feed livestock.
- **CTET APPLICATION ESTIMATES DID NOT ACCOUNT FOR FULL NETWORK OF IRRIGATION WELLS:** The estimate of Carbon Tetrachloride (CTET) applied to fields did not take into account the additional irrigation wells that have been identified within, or near, the contaminant plume.

TECHNICAL EVALUATION

Upon review of the Interim Remedial Measures Report, the following provides a summary of the inconsistencies and concerns related with the activities completed and remedy proposed at the Propellant Burning Ground area of the Badger Army Ammunition Plant.

DEGREE AND EXTENT OF SOIL CONTAMINATION NOT ADEQUATELY DEFINED

The degree and extent of soil contamination is explicitly required in Wisconsin Administrative Code NR716.01 which specifically states, "site investigations (must) provide the information necessary to define the nature, degree and extent of contamination, define the source or sources of contamination, determine whether any interim actions, remedial actions, or both are necessary at the site or facility, and allow a interim or remedial action to be selected that complies with applicable environmental laws". This condition has not yet been met at the Propellant Burning Ground. Specifically, soil sampling has not included the full list of DNT isomers, regardless of the fact that the minor isomers have, at times, been the only DNT detected within groundwater monitoring wells.

High levels of soil contamination have been identified in source areas, although the current concentration of contaminants in soils has not been identified to the extent possible. This contaminant mass continues to negatively impact soil and groundwater beneath the Propellant Burning Ground. The full extent of soil contamination is unknown, although the technology exists to define such. Given that the concentration of these minor isomers should be adequately defined in order to understand the nature and extent of the impact to soil contamination and resultant groundwater contamination, this identification of minor isomers in source area soils is critical.

This soil methodology conflicts with the current Department of Natural Resources (Department) requirement for the analysis of DNT, including the minor isomers, in groundwater at the BAAP site. The Department had originally requested the sampling and analysis for all the isomers of DNT in soils beneath the BAAP facility in a letter to the Army on 15 September 2011; the Department has since retracted this request. However, the technical rationale originally provided by the Department for the sampling of soil parameters still exists; "This requirement is consistent with NR716, Wisconsin Administrative Code, which states that responsible parties must 'Determine the nature, degree and extent, both areal and vertical, of the hazardous substances or environmental pollution in all affected media'". The Department previously explains, "This additional testing requirement will aid in the evaluation of potential direct contact risks and possible sources for leaching of DNT to groundwater, and will test the idea that the ratios of DNT isomers in soil at the facility approximate those found in technical grade DNT". Perhaps of most significance, the correspondence states, "Remediation objectives should address the risks posed by all DNT isomers".

These technical issues remain and have yet to be addressed at the BAAP. Although the Department has backed away from this requirement, these actions remain very necessary and vital to the remedial progress at the

Propellant Burning Ground. The minor isotopes are commonly found at BAAP in groundwater monitoring wells and residential wells, and there are numerous sampling events in which only these minor isomers of DNT have been detected in groundwater. Understanding the degree, extent and transport of these contaminants is vital in evaluating continuing threats to water supplies and the Wisconsin River.

The National Risk Management Research Laboratory, Ground Water and Ecosystems Restoration Division, concurs with the fact that the additional isomers of DNT should be included in monitoring of groundwater conditions at sites where DNT was processed. As stated in the NRMRL Status Report for the week of 23 July 2012:

DNT has been released into the environment at some sites where explosives manufacture and handling have been conducted. Historically, it appears that the focus of environmental monitoring of DNT has been on the 2,4- and 2,6-isomers, which are considered the “major isomers” in commerce and military use. However, recently, there has been concern that the other isomers, the “minor isomers”, could be of environmental and public health importance, and so it has been suggested they should be included in monitoring activities. Toxicological studies have evaluated other DNT isomers, but such studies are of limited use for evaluating DNT fate and transport in the environment. However, some general comments on the transport and fate of the minor isomers can be made, based on extrapolation from transport and fate of the major isomers, and the similarities in chemical properties between all the DNT isomers.

Recently, a Provisional Peer-Reviewed Toxicity Value (PPRTV) was derived for technical grade DNT, including all isomers. These Tier II values are developed by the EPA Office of Research and Development/ National Center for Environmental Assessment/ Superfund Health Risk Technical Support Center for risk assessments at Superfund sites and other hazardous waste sites utilizing current information and methodologies. The appropriate use of these risk assessment values has been cited by EPA as appropriate for Superfund sites and other hazardous waste sites where Integrated Risk Information System (IRIS) values have not been developed. PPRTV values for DNT were published in April 2013, and requests have been made to the Department to utilize these values for the assessment of soil contamination at the BAAP site. It is a concern that the Department may not apply these risk values to source soils which are contributing to current and future groundwater contamination.

It is concerning that the Army was directed to sample soils for the minor isomers of DNT by the Department and were subsequently allowed a reprieve from this requirement, coupled by the Department's refusal to apply recently developed risk values to source soils which continue to contribute contaminants to groundwater and source waters beneath BAAP. Minor isomers have been significant in groundwater sampling events, at times being the only DNT isomers detected. It is appropriate to conduct soil sampling to define the degree and extent of each of the isomers within the source area; especially the soils which remain at depths nearing 100 feet below land surface (bls).

The Department's Approval of Alternative Feasibility Study (28 June 2012) lists Conditions of Approval, including the requirement (#9 of 14) that the Army conduct “adequate saturated and unsaturated soil sampling, for all appropriate parameters, within the PBG, the DBG and central plumes to determine the nature and extent of site contaminants adsorbed onto the soil”. The requirement goes on to explain, “Because back-diffusion of adsorbed waste constituents appears to be a major contributor to the groundwater plumes' stability, fully

characterizing the adsorbed waste mass is necessary to evaluate natural attenuation as a possible remedial alternative". This is understood to include the requirement to evaluate all contaminants within the soil that are contributing to groundwater contamination, including all six isomers of DNT.

As stated in the Department's June 20, 2013 guidance document, Soil Residual Contaminant Level Determinations Using the U.S. EPA Regional Screening Level Web Calculator, the guidance is "intended for Department of Natural Resources staff and for the public, for use in understanding and applying the administrative rules that are applicable to the cleanup of soil contamination." Because these Department's NR720 revisions now direct the user to use the EPA's online calculator to determine generic residual contaminant levels, it is logical to apply the values within the EPA calculator for DNT mixed isomers at the BAAP site in sampling soil at the source area.

It is recommended that soil in the source area be analyzed for all DNT isomers, as provided for in the EPA online web calculator, and the extent of soil contamination be adequately defined prior to permanently shutting down the current remediation system.

DEGREE AND EXTENT OF GROUNDWATER CONTAMINATION NOT ADEQUATELY DEFINED

Although definition of the degree and extent of groundwater contamination is explicitly required in Wisconsin Administrative Code, contaminant contours have been defined without full consideration of hydrogeologic conditions at the site. Without consideration of the pumping of irrigation wells, additional residential and commercial wells, and a better understanding of the contaminant mass (concentrations of the major and minor isomers of DNT), the contaminant plumes drawn in the former reports are likely inaccurately depicted, not allowing for the necessary and appropriate remediation strategies.

The Department's Response to Public Comments on the Army's Alternative Feasibility Study for Groundwater states the following:

Per s. NR716.11 (9), Wis. Adm. Code, the Army is required to make a good faith effort to sample public or private water supply wells as part of a regular monitoring program and/or to determine the extent of groundwater contamination. Private and public water supply wells to be sampled include those wells that are known or suspected to be affected by groundwater contamination and other wells that the Department determines have the potential to be affected by groundwater contamination.

Groundwater conditions have not been adequately assessed as required by the Department to determine the extent of contamination. There are areas of the site where no monitoring has been conducted; these include the area directly east of the Propellant Burning Ground, and the area southeast of the facility along both the west and east sides of the Wisconsin River. There are numerous private residential water supply wells and irrigation wells that have not been analyzed. In addition, seeps contributing groundwater to the surface water of the Wisconsin River have not been analyzed, and would provide valuable information regarding the detection of contaminants into the river below the dam.

The Department's Approval of Alternative Feasibility Study (28 June 2012) lists Conditions of Approval, including the requirement (#3 of 14) that the Army "shall prepare a comprehensive written report evaluating the effectiveness of the MIRM and IRM systems in preventing offsite groundwater contaminant migration". This requirement should clearly include a continued, more detailed delineation of groundwater contaminant plumes offsite, in order to address current and future contaminant migration.

It is recommended that the extent of groundwater contamination be adequately defined prior to permanently shutting down the current remediation system.

CONTAMINANT MASS CONTINUES TO IMPACT SOIL AND GROUNDWATER

The Wisconsin Groundwater Law (Wisconsin Act 410, Wisconsin's Comprehensive Groundwater Protection Act) protects each aquifer regardless of its potential use, value or vulnerability. Allowing the BAAP to shut down the current remediation system, without further remediation measures in place to reduce the continued migration of contaminants from the source area to the deep aquifer, does not provide adequate protection to the alluvial sand and gravel aquifer. Further, installation of a municipal water supply system in lieu of additional remediation equates that of the aquifer classification utilized throughout the remainder of the nation.

Additional remediation measures are necessary at the source in order to reduce the continued loading of contamination into the local groundwater aquifer; the engineered RCRA cap at the surface is not sufficient to mitigate impacts from soil contamination confined at depth (reported to be as much as 100 feet bls). Because soil contamination remains within the soil column that at times may be below the water table, these soils will continue to contribute to groundwater contamination into the future unless the contamination is removed. Remedial caps are commonly installed for contamination located near the surface in order to minimize the potential for precipitation to leach contaminants into the groundwater. Installation of a barrier (cap) eighty feet above the contaminated zone at the Propellant Burning Ground will not negate the movement of groundwater through this area (regional flow being from the bluffs north of the site toward the southeast), nor protect these soils from leaching contaminants into the aquifer.

Several significant studies evaluating the appropriate use of natural attenuation as a viable remedial remedy have been conducted; three peer-reviewed research projects are summarized below.

- A survey of the use of "monitored natural attenuation" at sites contaminated with chlorinated compounds was been conducted, and the results published in Remediation Journal (McGuire et al, "Historical Analysis of Monitored Natural Attenuation: A Survey of 191 Chlorinated Solvent Sites and 45 Solvent Plumes", Remediation Journal, Volume 15, Issue 1, Winter 2004, pp. 99-112). Experienced environmental consultants were surveyed regarding use of natural attenuation and effectiveness. The report documents the success of natural attenuation as a remedial remedy at one third of the sites, where the remedial strategy was implemented in conjunction with source control. Approximately one third of the sites reviewed required another remediation strategy such as plume remediation or containment. A third of the sites utilized natural attenuation as the sole remedy where contaminant plumes were shown to be reducing prior to approval of this strategy. The conclusion reached by the

authors of the survey is that natural attenuation is not considered an appropriate remedy in the presence of expanding contaminant plumes, or where the time frame is determined to be “unreasonably long.”

- The specific natural attenuation properties of DNT and TNT are discussed in detail within a PhD dissertation (Sungsoo Han, “In Situ Bioremediation and Natural Attenuation of Dinitrotoluenes and Trinitrotoluene”, Dissertation for PhD in Environmental Engineering, School of Civil and Environmental Engineering, Georgia Institute of Technology, August 2008). Specifically, the mineralization of 2,6-DNT was determined to be “very low.” Toxic characteristics of the degradation compounds were identified and described as having low soil adsorption. For these reasons, natural attenuation of DNT was identified as having a high potential for not being appropriate at a similar former ammunition site.
- Results of a literature search, survey, and workshop are published in an international journal, Science of the Total Environment (Declercq, I. et al, “Monitored Natural Attenuation (MNA) of Contaminated Soils: State of the Art in Europe – a Critical Evaluation”, Science of the Total Environment, Volume 426, 1 June 2012, pp. 393-405). This report discusses a lengthy study of the evaluation of the effectiveness of natural attenuation, significant source removal, and the need for a thorough understanding of the specific biodegradation processes of the contaminants of concern.

It is recommended that the Department reconsider natural attenuation as an alternative to contamination emanating from the BAAP unless additional source area remediation is conducted. The current plan constitutes a precedent with regard to allowing contamination to continue to migrate deeper into the aquifer affecting water supply wells and a major waterway, resulting in the eventual inability to utilize groundwater resources for any purpose; this closely resembles aquifer classification, which is not allowed under the State’s Groundwater Law. The alluvial sand and gravel aquifer of the Wisconsin River Basin, as well as underlying aquifers, should be protected to the extent possible in order to provide adequate water supply for current use as well as into the future.

GROUNDWATER CONTAMINANT PLUME IS NEITHER STABLE NOR RECEDING

Natural attenuation is used as a final remedy for sites when the groundwater contaminant plume is proven to be stable or receding, and is expected to “naturally degrade over time”. The groundwater contaminant plume beneath the Propellant Burning Ground is not stable, nor receding. In addition, the contaminant plume(s) located off site are not stable nor receding, and will not be until the source of the contamination is removed.

The Department’s Template for Notification of Residual Contamination and Continuing Obligations (PUB-RR-919) provides the following wording for notification of property owners and right-of-way holders affected by off-site residual contamination, when natural attenuation is the chosen remedy. This wording defines the situations where natural attenuation is deemed an appropriate remedial option by the Department:

“...The environmental consultants who have investigated this contamination have informed me that this groundwater contaminant plume is stable or receding and will naturally degrade over time. I believe

that allowing natural attenuation to complete the cleanup at this site will meet the requirements for case closure that are found in chapter NR726, Wisconsin Administrative Code...

In the DNR Response to Public Comments on the Army's Alternative Feasibility Study for Groundwater, the Department indicated the following:

"Monitoring of natural attenuation processes will be needed to assure that the contaminant plumes are stable or receding".

It is important to note that, if contaminant levels are not stable or receding at the termination of the remedial activity, and the contaminant source remains in place, the levels of contamination will not become stable or receding without further source removal or treatment. The current contaminant plume at the BAAP facility, as well as the plume(s) offsite, are not stable nor receding. These plumes will require further source control in order to naturally degrade over time.

The current remediation system has been unsuccessful in remediating contaminants in the source area. The fact that this system did not provide a complete remediation does not preclude the potential for additional remedial options to be implemented, which could significantly reduce the release of contaminants into groundwater.

It is recommended that additional source control options be evaluated and implemented in order to reduce the release of contaminants into the groundwater, and to allow the potential for natural attenuation to occur.

INTEGRITY AND APPLICABILITY OF MONITORING WELLS QUESTIONABLE

Groundwater monitoring wells utilized for evaluation of site conditions are not screened at the levels appropriate for adequate identification of contaminant presence and extent.

Wisconsin Administrative Code NR141.05 defines a water table observation well as "any groundwater monitoring well, in which the screen or open borehole intersects a water table, which is installed for the specific purpose of determining either the elevation of the water table or the physical, chemical, biological or radiological properties of groundwater at the water table or both". Monitoring wells measured and sampled for groundwater levels and water quality parameters in the area of the Propellant Burning Ground do not meet this requirement.

Several wells utilized for water quality assessment consist of screens that are a hundred feet in length, which provide a strong likelihood of cross contamination from soils closer to the surface, potential for dilution from precipitation seeping in along the screen length, an inability to collect representative groundwater samples at the water table interface, and questionable construction. In addition, these wells were described as being installed for the purposes of remediation, and not for the purpose of water table observation which is explicitly required in the definition provided. Any groundwater measurements and groundwater samples collected from these wells are questionable.

In addition, it appears that contour maps were prepared utilizing wells screened from different areas, which puts the contaminant plumes, as previously drawn, in question.

It is recommended that additional monitoring wells be installed to assess transport of contaminants from the Propellant Burning Ground, and should be constructed according to Department guidelines; specifically, water table observation wells. The Army should provide a listing of all monitoring wells indicating screen lengths, sampled intervals, and water level measurements, and provide new isocontour maps utilizing appropriate data from consistent screened intervals.

SIGNIFICANTLY HIGH LEVELS OF DNT PERSIST IN GROUNDWATER AFTER REMEDIATION

Groundwater data provided by the Army to justify discontinuation of the remediation system indicates that there continues to be consistent levels of DNT in groundwater in the Propellant Burning Ground, at concentrations greater than NR140 Preventative Action Limits and Enforcement Standards, indicating that groundwater and source water continue to be impacted. Contaminant plumes identified by the Army in 2010 indicate significant offsite contamination identified south of the BAAP, continuing to impact the aquifer and the Wisconsin River. These existing contaminant concentrations indicate that the remediation system has not reduced contaminant levels enough, if at all, to justify halting remediation. This situation is likely to continue as long as high levels of soil contamination exist in the source area. As stated previously, although an engineered barrier at the surface may successfully reduce contribution of surface and shallow contaminants to the groundwater, it is unlikely to reduce contribution of contaminants to the groundwater from source soils that are located at depth.

Specifically, contaminant concentrations in the interim remedial measures (IRM) influent were identified as higher in December 2010 than any months previous (0.24 ppb in December, with detections ranging from 0.10 ppb to 0.22 ppb in the five months previous). TCE fluctuated throughout the period, from a high of 3.0 ppb (July) to a low of 1.5 ppb (December). In addition, 1,1,1-TCA decreased slightly, from 0.14 ppb (July) to 0.10 ppb (August through December). Four isomers of DNT (2,3-DNT, 2,4-DNT, 2,5-DNT and 3,5-DNT) were detected consistently at 0.50 ppb for all six months (July through December). The 2,6-DNT isomer decreased slightly, from 0.8 ppb in July to 0.5 ppb for the remaining months (August through December). The 3,4-DNT isomer increased from 0.50 ppb (July through October) to 1.3 ppb (November and December). These results do not indicate a significant reduction in contaminant concentrations.

Comparison of 2008 IRM groundwater concentrations with 2011 concentrations indicate a slight increase in the overall detects of TCA in the influent. Other than the contaminant 2,3-DNT which decreased slightly (1.0 ppb to less than 0.05 ppb), the remaining contaminants had no change in concentrations within the three year period.

Overall comparisons of Source Area Monitoring Well Concentration Over Time Graphs indicate the presence of total DNT over the Enforcement Standard for ten years from 2002 through March of 2012. Total DNT in PBM-002 fluctuated from less than 1 ppb in 2001, to a high concentration of almost 10 ppm in 2002, then to over 1,000 ppb total DNT from 2009-2011, and 500 ppb in 2012. This level of DNT indicates that there continues to

be a source impacting the groundwater, and system shutoff will most certainly result in additional contribution of these contaminants into the aquifer.

It is recommended that the Department require continued monitoring of the site, including the installation of additional monitoring wells, and reconsider natural attenuation as an alternative to contamination emanating from the BAAP unless additional remediation of soils in the source area is conducted.

ADDITIONAL MONITORING LOCATIONS NEEDED

The “Interim Remedial Measures Shutdown Plan” recommends the addition of three monitoring wells located south-southeast of PBM-002 at a distance of 30 feet and approximate depth of 120 feet bgs. The recommendation includes sampling at installation and 30 days after, as well as 30, 45, 60, and 75 days after the system is shut down. There is no information regarding groundwater contaminant impacts to the southeast of the waste pits; namely, east of the PBN-891 cluster. The DNT isocontour map defines the contaminant plume with a void of monitoring information along the east side of the depicted plume, toward Landfill #1. A comparison of the DNT and CTET plumes also indicates that DNT has been detected further north than the CTET, and deeper in the aquifer than the CTET.

The Department’s Approval of Alternative Feasibility Study (28 June 2012) lists Conditions of Approval, including the requirement (#5 of 14) that the Army “shall propose an investigation and monitoring program to define the degree and extent to which contaminated groundwater is entering the Wisconsin River, Lake Wisconsin, and/or other surface waters. This shall include, but not be limited to, installation of additional groundwater monitoring wells in addition to those already being used to monitor the plume(s) and may include the sampling of surface water”. Although the locations of additional wells are not designated, it could be understood that additional definition of contaminant movement is needed in the locations as specified above; north of the Propellant Burning Ground, both east and west of the current contaminant plumes as identified by the Army (2010), as well as south and southwest of the currently identified plume. Monitoring wells are also necessary at locations east of the Wisconsin River (technical rationale described in further detail below).

The groundwater monitoring plan should extend through several years, to allow for seasonal fluctuations and to achieve a complete steady state. Increases in concentrations should trigger a startup response for the remediation system.

It is recommended that additional monitoring be conducted prior to shutdown of the current remediation system, including sampling of the full monitoring well network, addition of sampling points located west, southwest, east, and south of the current BAAP monitoring network, sampling of residential and irrigation wells within several miles of the currently defined contaminant plume, and sampling of high capacity wells located downgradient and east of the Wisconsin River.

ESTIMATED VELOCITY INDICATES CONTAMINANT TRANSPORT DISTANCES OF GREATER THAN 5 MILES

The “Revised Alternative Feasibility Study” indicates an average groundwater flow velocity of 263 feet per year, and estimates the transport of DNT at less than 0.72 feet per day; “slower than CTET and TCE in the groundwater beneath BAAP.”

Utilizing the estimated rate provided previously, and the deposition of contaminants during World War II (1945), and factoring in a conservative reduction of 20%, DNT and other VOCs in groundwater have potentially traveled several miles from the source.

$$68 \text{ years} \times 263 \text{ feet/year} \times \text{mile}/5280 \text{ feet} = 3.4 \text{ miles}$$

Factoring in a conservative reduction of 20%, the potential contaminant transport of DNT is estimated at approximately 3 miles from the source.

$$68 \text{ years} \times 263 \text{ feet/year} \times 0.80 \times \text{mile}/5280 \text{ feet} = 2.7 \text{ miles}$$

However, the Army’s “Remedial Investigation Report” calculated the average linear flow velocity for the “off-post area” south of the BAAP at 680 feet per year. This indicates that contamination at the southern portion of the impacted area could have been transported distances greater than 6 miles from the southern boundary.

$$68 \text{ years} \times 608 \text{ feet/year} \times 0.80 \times \text{mile}/5280 \text{ feet} = 6.3 \text{ miles}$$

Regional groundwater flow is from the west/northwest to the southeast. As groundwater contamination in the deep aquifer is likely not entirely affected by the presence of the Wisconsin River, there are multiple potential receptors for DNT and VOC contamination on the east side of the river. These potential sources have not yet been assessed, and/or may not yet be impacted, but could be in the future. Specifically, several irrigation wells are located less than 1.5 miles directly southeast from the southern boundary of the BAAP; these wells are screened at the same interval as the recovery wells, are permitted to pump over 500,000 gallons per day, and likely have a zone of influence that extends to subsurface areas known to be impacted by DNT and VOC contamination from BAAP.

It is recommended that the Department require continued monitoring of the site, including the installation of additional monitoring wells, and reconsider natural attenuation as an alternative to contamination emanating from the BAAP unless additional remediation of soils in the source area is conducted.

HIGH CAPACITY WELLS NOT ACCOUNTED FOR IN EVALUATION OF GROUNDWATER FLOW

The pumping of irrigation wells likely has a significant impact on groundwater flow in the vicinity of BAAP. This has a direct effect on the contaminant plume, but has not yet been incorporated into the evaluation of contaminant transport nor included in preparation of estimated isocontour maps. The Army concluded that the remediation wells caused significant drawdown; irrigation wells in the vicinity are permitted to pump as much or more than the remediation wells, creating additional drawdowns that should be included in the assessment.

It is recommended that a more complete identification of the hydrogeologic impacts of high capacity wells in the area be conducted, and that isocontour maps be redrawn to incorporate this information.

POTENTIAL LONG-TERM IMPACT TO PRAIRIE DU SAC MUNICIPAL WATER SUPPLY

Potential risk to the Prairie du Sac municipal water supply should be evaluated more closely. The contaminant transport (described above) indicates that decades of contamination could potentially reach the municipal water supply wells. As pumping of private residential water supply wells within the municipality have not been evaluated in the depiction of ground water flow maps, these should also be assessed.

A high detection of arsenic in one of the Prairie du Sac municipal water supply wells may indicate the likelihood of intrusion of river water during high levels, which could distort the groundwater flow, causing contamination to flow to the south toward the existing water supply network. As the increase in arsenic can also be an indicator of reducing conditions, indicating the likelihood of contamination, the water supply system could be at risk from future contamination.

It is recommended that Prairie du Sac municipal wells be sampled and analyzed for contaminants including DNT breakdown products. In addition, given the transport of contaminants in the deep aquifer and the possibility that municipal wells may see impacts in the future, it is suggested that reimbursement for future maintenance and treatment if contaminants are detected in the water supply be taken into consideration.

CONTAMINANT MASS CONTRIBUTING DIRECTLY TO SOURCE WATER CONTAMINATION IN LAKE WISCONSIN

Source water concerns include contributions of contaminated groundwater in Weigand's Bay, Gruber's Grove, and directly into the Wisconsin River. Without further remediation of the contaminant mass at the source, the source area soils will continue to contribute contamination into surface waters. The mitigation of this surface water issue has not been addressed at all in the proposed remediation plan.

It is recommended that source removal be conducted, and that the current contribution of contaminants into the waters of the Wisconsin River be fully assessed, including soil sampling, surface water sampling, and sampling of seeps occurring along the sides of the river at locations both south of and at the dam.

BIOLOGICAL IMPACTS TO PLANTS AND ANIMALS NOT ASSESSED

Biological impacts from the uptake of DNT-contaminated water has not been fully assessed, yet there are multiple irrigation wells within a three mile radius of the BAAP site. Specifically, over 15 irrigation wells within a one mile distance of the contaminant plume (identified to be emanating from the Propellant Burning Ground) utilize the groundwater in this vicinity to irrigate fields and feed livestock. Crops include corn, alfalfa and soybeans on both sides of the river, as well as squash, melons, sweet corn and garden vegetables on the east side. Animals raised within a mile of Lake Wisconsin include beef cattle, chickens, donkeys, ducks, goats, horses, lamas, milk cows and sheep. Additional potential receptors include residential and commercial water supplies.

It is recommended that the risk assessment, previously initiated and not completed, be required to evaluate the impact to humans and livestock from ingesting plants irrigated by contaminated groundwater.

CARBON TETRACHLORIDE APPLICATION ESTIMATES DID NOT ACCOUNT FOR NETWORK OF IRRIGATION WELLS

In the DNR Response to Public Comments on the Army's Alternative Feasibility Study for Groundwater, the Department estimated the following application of Carbon Tetrachloride (CTET) to fields utilizing contaminated irrigation water:

One inch of irrigation water would account for less than one pound of CTC (sic) per application. This amount of contamination appears to be below levels of regulatory concern and is not thought to represent a threat to human health or the environment.

This estimate does not take into account the additional irrigation wells that have been identified within, or near, the contaminant plume. Given the dry period experienced last year and the additional wells that need to be accounted for, the likely amount of CTET released into the atmosphere through irrigation is estimated to be much greater than that previously stated by the Department.

It is recommended that the full extent of high capacity wells be evaluated to better determine the amount of contamination applied to fields in, and within the vicinity of, the contaminant plume.

RECOMMENDATIONS

Based on the review of the Interim Remedial Measures Report, the following recommendations are provided:

- soil in the source area be analyzed for all DNT isomers, and the extent of soil contamination be adequately defined prior to permanently shutting down the current remediation system.
- the extent of groundwater contamination be adequately defined prior to permanently shutting down the current remediation system.
- the Department of Natural Resources (Department) reconsider natural attenuation as an alternative to contamination emanating from the BAAP unless additional source area remediation is conducted. The current plan constitutes a precedent with regard to allowing contamination to continue to migrate deeper into the aquifer affecting water supply wells and a major waterway, resulting in the eventual inability to utilize groundwater resources for any purpose; this closely resembles aquifer classification, which is not allowed under the State's Groundwater Law. The alluvial sand and gravel aquifer of the Wisconsin River Basin, as well as underlying aquifers, should be protected to the extent possible in order to provide adequate water supply for current use as well as into the future.
- additional source control options be evaluated and implemented in order to reduce the release of contaminants into the groundwater, and to allow the potential for natural attenuation to occur.
- additional monitoring wells be installed to assess transport of contaminants from the BAAP, and constructed according to Department guidelines; specifically, water table observation wells. The Army should provide a listing of all monitoring wells indicating screen lengths, sampled intervals, and water level measurements, and provide new isocontour maps utilizing appropriate data from consistent screened intervals.
- the Department require continued monitoring of the site, including the installation of additional monitoring wells, and reconsider natural attenuation as an alternative to contamination emanating from the BAAP unless additional remediation of soils in the source area is conducted.
- a more complete identification of the hydrogeologic impacts of high capacity wells in the area be conducted, and that isocontour maps be redrawn to incorporate this information.
- Prairie du Sac municipal wells be sampled and analyzed for contaminants including DNT breakdown products. In addition, given the transport of contaminants in the deep aquifer and the possibility that municipal wells may see impacts in the future, it is suggested that reimbursement for future maintenance and treatment if contaminants are detected in the water supply be taken into consideration.

- source removal be conducted, and that the current contribution of contaminants into the waters of the Wisconsin River be fully assessed, including soil sampling, surface water sampling, and sampling of seeps occurring along the sides of the Wisconsin River at locations both south of and at the dam.
- the risk assessment, previously initiated and not completed, be required to evaluate the impact to humans and livestock from ingesting plants irrigated by contaminated groundwater, as well as animal products from livestock grazing on these impacted plants.
- the full extent of high capacity wells be evaluated to better determine the amount of contamination applied to fields in, and within the vicinity of, the contaminant plume.

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