REPORT ON
PHASE II - COMPREHENSIVE SITE ASSESSMENT
PEPPERELL PAPER MILL
PEPPERELL, MASSACHUSETTS
DEP WAIVER SITE NO. 2-0447

VOLUME II OF II
RISK CHARACTERIZATION

by

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File No. 10768-043
February 1995

EXECUTIVE SUMMARY

This volume of the Phase II - Comprehensive Site Assessment (Phase II) of the Pepperell Paper Mill (the site) in Pepperell, Massachusetts presents results of the Phase II Risk Characterization (Risk Characterization). The Risk Characterization has been prepared in accordance with the requirements set forth in 310 CMR 40.0900 of the revised Massachusetts Contingency Plan (MCP). Because the site has been issued a waiver of approvals, the Risk Characterization is used to address requirements under the former MCP in support of a Waiver Completion Statement. The Risk Characterization evaluates the risk of harm to health, safety, public welfare and the environment from exposure to oil or hazardous materials (OHM) identified at the site. It concludes that under current conditions, there is "No Significant Risk" of harm to potential site receptors, but recommends that certain precautions be taken for excavation activities that could occur at the site.

The Risk Characterization for this site used a combined Method 2 and Method 3 approach, as defined in 310 CMR 40.0980 and 40.0995, respectively, based on the following observations:

- current or foreseeable future human exposures to site specific OHM are likely to occur predominantly through contact with the soil or groundwater;
- no Method 1 Soil Standards exist for the following OHMs: trichlorofluoromethane, copper, and carbon disulfide;
- the reporting in Volume I of no evidence of surface water and sediment OHM contamination above background; and
- the presence of OHM within two feet of the ground surface that are known to bioaccumulate.

Currently, the site is used for the operation of the Pepperell Paper Company paper mill. It also includes the Pepperell Power Company cogeneration plant (Cogen). The 19.49-acre site is located on the west bank of the Nashua River. The site is abutted to the east by the Nashua River, to the north by residential property, to the west by Mill Street and residential property, and to the south by Main Street. The property is fenced along the north, west, and south edges and the bank is steep along the river. Consequently, the presence of trespassers on-site is considered unlikely.

The paper mill consists of a number of interconnected, woodframe, one-story buildings. Human receptors associated with the current and anticipated use of the facility include employees working in the paper mill and Cogen plant. Given the industrial operations at the mill, the presence of children on the site now or in the future is considered extremely unlikely.

Greens Brook flows beneath Mill Street through a culvert passing between the mill and the Cogen plant. The Nashua River is a Class B, warm water body (314 CMR 4.06). As such, the Nashua River is defined as a potential habitat for fish, other aquatic life, and wildlife, and is considered suitable for primary and secondary contact recreation, including swimming and fishing. Adults or children may fish or play in the river below the site.

Environmental receptors associated with current and anticipated site use could include wildlife foraging in Greens Brook or the Nashua River, and fish and other aquatic organisms found in the brook and river. These receptors could be exposed to groundwater discharge or soil erosion from the site to the surface water bodies. It is unlikely that larger mammals not commonly associated with urban ecology

will commonly use the site for feeding, reproduction, or nesting. Birds may use the site for feeding or nesting along the banks of the Nashua.

As discussed in Volume I of this report, there are no private drinking water wells on Mill Street or in the vicinity of the site. The closest public drinking water well is 0.5 miles away, on the opposite side of the Nashua River. The area beneath the site is not located in a high or medium yield aquifer. The Nashua River is not used as a municipal drinking water supply along the stretch from Pepperell, Massachusetts, to and including Nashua, New Hampshire, approximately 4.2 miles downstream from the site.

The site has been operated as a paper mill for over 100 years, and the site owner has no plans to change or modify that use. Because the site buildings are suitable for continuing operation, significant demolition or reconstruction of existing buildings is not anticipated at this time. Thus, for the purposes of this risk assessment, the reasonably foreseeable future uses are assumed to be the current uses of the site, or analogous commercial or industrial purposes.

In the event that there is significant construction or demolition activities at the site, the exposures to surface and subsurface soils by construction or site workers could be different from the current exposures. Specifically, the use of outdoor areas could conceivably increase due to either expanded mill operations or construction activities. The latter could increase exposures to surficial and subsurface soils by construction workers as well as workers at the mill or Cogen plant. Potential exposures to groundwater could involve construction or utility workers involved in subsurface activities, down to the water table. Environmental receptors could include wildlife foraging in exposed excavations. Under future use conditions, the presence of children on the site is considered extremely unlikely.

To evaluate potential risk associated with current site conditions, soil samples collected within 3 ft. of the ground surface, with the exception of samples SS102, SS103, and SS109, are considered to be surface soils. Samples SS102, SS103, and SS109 were collected from locations beneath the paper mill's buildings which are not readily accessible. Surface soils are categorized as S-2 category for adult exposures under current site conditions of low frequency and possible high intensity use. Samples collected at depths greater than 3 ft., in addition to samples SS102, SS103 and SS109, are considered as subsurface soils and are classified as S-3 for adult exposure. Under current site conditions, the presence of a child is considered extremely unlikely. Groundwater at the site is categorized as both GW-2 and GW-3.

If the site retains its present use, or if the configuration of the site buildings does not change, future risks will be identical to present risks. However, to evaluate potential risk associated with site redevelopment for different commercial or industrial purposes involving demolition of existing buildings or construction of new buildup, soil samples collected within 3 ft. of the ground surface, regardless of current accessibility, are considered to be surface soils. Surface soils, under possible future site conditions, are categorized as S-2 for adult exposures. Samples collected at depths greater than 3 ft. are classified as subsurface soils and as S-3 soil category for adult exposures. Under future site conditions, the presence of a child is considered extremely unlikely. Groundwater at the site under future conditions is categorized as both GW-2 and GW-3.

Compounds of Potential Concern (COPC) identified from OHM detected at the site include volatile organic compounds (VOCs), total petroleum hydrocarbons (TPHs), and metals in surface soils, subsurface soils, and groundwater.

Under current site conditions, exposure point concentrations for surface soil COPC do not exceed the S-2/GW-2 and S-2/GW-3 standards. Under possible future site conditions, assuming site redevelopment, surface soil exposure point concentrations for lead and TPH exceed S-2/GW-2 and S-2/GW-3 Standards. Exceedance for lead is due to samples collected in the vicinity of the machine shop. Exceedance for TPH is associated with samples collected within the paper mill. The exposure point concentrations calculated for COPC in groundwater under current and foreseeable future site conditions do not exceed GW-2 and GW-3 standards. Based on these findings for a Method 2 Risk Characterization, a condition of "No Significant Risk" of harm to human health exists for this site under current conditions.

Ecological risk to aquatic and terrestrial receptors and habitats was evaluated using a Method 3 Stage I Environmental Screening. Comparison of COPC exposure point concentrations to Ambient Water Quality Criteria and Soil Threshold values, and evaluation of the completion of exposed pathways between habitats and COPC, indicated "No Significant Risk" of harm to the environment under current conditions. However, under potential future conditions, if buildings surrounding the courtyard adjacent to the machine shop are demolished such that the courtyard is no longer isolated from potential environmental receptors, the detected mercury level in soil in the courtyard could pose potential risk of harm to the environment.

Comparison of COPC soil and groundwater exposure concentrations to Upper Concentration Limits indicated that "No Significant Risk" of harm exists to natural resources and public welfare. Risk of harm to safety, evaluated in terms of a threat of physical harm or bodily injury to people, also indicated "No Significant Risk" at the site.

In summary, the Risk Characterization indicates that current site conditions pose "No Significant Risk" of harm to human health, public welfare, safety, and the environment. However, the Risk Characterization also indicates that soil category S-2/GW-2 and S-2/GW-3 standards for potential risk to human health would be exceeded under the unanticipated future site condition of redevelopment and demolition. Under this condition, soils which are currently isolated beneath buildings would become more accessible to on-site workers. Potential risk to on-site workers would be associated with excavation or high intensity contact with these soils.

Based on results of the Risk Characterization, it is recommended that, as a precautionary measure, the necessity of a health and safety plan be evaluated for on-site workers before performing intrusive activities that could lead to high intensity contact with soil. This evaluation would consist of a review of existing soil chemical analytical data for the proposed work area. Depending on results of this review, appropriate health and safety measures could be planned and executed as part of the work. In addition, it is also recommended that soil in the enclosed courtyard adjacent to the machine shop remain isolated from potential environmental receptors. Although unanticipated, if the surrounding buildings to this courtyard should be demolished, additional assessment of the soil in this area would be recommended.

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I. INTRODUCTION

This volume of the Phase II - Comprehensive Site Assessment (Phase II) of the Pepperell Paper Mill (the site) in Pepperell, Massachusetts presents results of the Phase II Risk Characterization (Risk Characterization). The Risk Characterization has been prepared based on criteria provided in 310 CMR 40.0900 of the revised Massachusetts Contingency Plan (MCP) [1]. Because the site has been issued a waiver of approvals, the Risk Characterization is used to address requirements under the former MCP in support of a Waiver Completion Statement. The Risk Characterization evaluates the risk of harm to health, safety, public welfare, and the environment from exposure to oil or hazardous materials (OHM) identified at the site. This Risk Characterization is not a stand-alone document, but should be read in conjunction with Volume I of this Phase II Report, the Phase I - Limited Site Investigation (Phase I) Report, and the Release Abatement Measure (RAM) Completion Report.

II. SELECTION OF RISK CHARACTERIZATION METHOD

Sections 40.0941 and 40.0942 of the revised MCP (310 CMR) set forth three methods (i.e., Methods 1, 2, and 3) by which to characterize the risk of harm to health, public welfare and the environment, and the selection of the method(s), respectively. Characterization of the risk to safety is to be evaluated according to 310 CMR 40.0960.

The risk characterization for this site uses a combined Method 2 and Method 3 approach, as defined in 310 CMR 40.0980 and 40.0995, respectively, based on the following observations:

- current or foreseeable future human exposures to site specific OHM are likely to occur predominantly through contact with the soil or groundwater;
- no Method 1 Soil Standards exist for the following OHMs: trichlorofluoromethane, copper, and carbon disulfide;
- no evidence of surface water and sediment OHM contamination above background; and
- the presence of OHM within 2 ft. of the ground surface that are known to bioaccumulate.

III. RISK CHARACTERIZATION APPROACH

For this site, Method 2 was used to the characterize the risk of harm to human health from exposures to OHM present in the soil and groundwater, and Method 3 was used to evaluate the risk of harm to public welfare and the environment. Characterization of the risk of harm to safety was evaluated separately.

In the absence of a revised Massachusetts Department of Environmental Protection (DEP) guidance document for risk characterization, the principles of the existing DEP Guidance for Disposal Site Risk Characterization and Related Phase II Activities - In Support of the MCP (DEP Guidance Document) [2] have been followed in this Risk Characterization.

For the Hazard Identification in this Risk Characterization, the chemical data were reviewed to assess the extent of contamination and to identify the compounds of potential concern (COPC) for both Method 2 and Method 3 (See Section VII).

In the characterization of risk for Method 2, exposure point concentrations were calculated for the COPC present in soil and groundwater. The exposure point concentrations were compared to the available Method 1 Numerical Standards identified in 310 CMR 40.0975(6)(a,b) and 40.0974(2) to evaluate whether a condition of "No Significant Risk" of harm to health exists at the site, as defined in 310 CMR 40.0973(7). In the case of trichlorofluoromethane, copper, and carbon disulfide, the exposure point concentration was compared to Method 2 Standards derived in accordance with 310 CMR 40.0984 and 40.0985.

Risk of harm to safety, as defined in 310 CMR 40.0960(2), was characterized through a comparison of conditions at the site with applicable or suitably analogous safety standards, and a level of "No Significant Risk" at the site, as defined in 310 CMR 40.0960(3), evaluated in terms of a threat of physical harm or bodily injury to people.

Under Method 3, "No Significant Risk" of harm to public welfare, as defined in 310 CMR 40.0994(4), and Natural Resources, as defined 310 CMR 40.0995(5), was characterized through evaluation of the impact of the COPC on public or private resources, and through comparison of the arithmetic mean level or concentration of the COPC in soil and groundwater, respectively, with the appropriate Upper Concentration Limit (UCL) listed in 310 CMR 40.0996(4).

For characterization of the risk of harm to the environment, a Method 3, Stage 1 Environmental Screening (as defined in 310 CMR 40.0995(3)) was used to evaluate potential exposure pathways through which COPC might impact biota and habitat(s) at and within the site. A condition of "No Significant Risk" of harm to the environment (310 CMR 40.0995(3)(a)(1,2)) was evaluated, based on the absence or presence of completed exposure pathways between the COPC and the environmental receptors identified, COPC exposure point concentrations which exceed Massachusetts Surface Water Quality Standards (314 CMR 4.00), Ambient Water Quality Criteria [3], or other environmental concentrations associated in the scientific literature with adverse environmental impacts, and the absence or presence of apparent significant environmental harm as described in 310 CMR 40.0995(3)(b)1.

IV. IDENTIFICATION OF SITE ACTIVITIES AND USES

4-01. INTRODUCTION

As part of the Risk Characterization, 310 CMR 40.0923 requires the identification of current and reasonable foreseeable activities and uses associated with a site and its surrounding environment, and a description of how these uses and activities could result in the exposure of human or environmental receptors to the OHM present. The site activities and uses of the groundwater must be determined independently of the activities and use of the land, and the site activities and uses of the land are to be identified regardless of whether the land is currently developed on not. In addition, the activities identified are to be used in conjunction with the criteria described in sections 40.0930 through 40.0939 of 310 CMR to identify applicable groundwater and soil categories for the estimation of the nature and magnitude of exposures to the OHM (See Section V).

4-02. CURRENT USES AND ACTIVITIES

Currently, the site is used for the commercial operation of the Pepperell Paper Company paper mill. It also includes the Pepperell Power Company cogeneration plant (Cogen). The 19.49-acre site is located on the west bank of the Nashua River. The site is abutted to the east by the Nashua River, to the north by residential property, to the west by Mill Street and residential property, and to the south by Main Street. The property is fenced along the north, west, and south edges and the bank is steep along the river. Consequently, the presence of trespassers on-site is considered unlikely.

The Cogen plant was built in 1989 and began supplying steam and electrical power to the mill in 1990. The rest of the site has been used as a paper mill since the 1800's. The paper mill consists of a number of interconnected, woodframe, one-story buildings. Human receptors associated with the current use of the facility primarily include employees working in the paper mill and Cogen plant. Under current site conditions, the presence of children on the site is considered extremely unlikely.

Although mostly paved or covered by buildings, the site has sections of exposed ground surface, mature trees, and weedy vegetation. The latter is commonly associated with disturbed and edge habitat communities. This condition is thought to be due to physical disturbances associated with paper mill activities (i.e. storage and movement of paper rolls). Current outdoor work activity at the site is minimal.

The topography of the site is for the most part level with a general slope from west to east toward the Nashua River. In the southern portion of the site, the river bank consists of a stone and concrete wall measuring approximately 8 feet high. The majority of the site is within the 500 year floodplain and a small portion is in the 100 year floodplain [4]. Under 310 CMR 10.57(1), areas subject to flooding may be critical habitats. Any area within the 10 year floodplain or within 100 feet of the river bank, whichever is greater and is still within the 100 year floodplain is considered to be an area of habitat deemed critical to protect. However, areas which have been previously developed to a point in which the ecological functioning of the flood zone has been eliminated, are excluded under 310 CMR 10.00. This is the case at this site.

Greens Brook flows beneath Mill Street through a culvert passing between the mill and the Cogen plant. The Nashua River is a Class B, warm water body (314 CMR 4.06). As such, the Nashua River is defined as a potential habitat for fish, other aquatic life, and wildlife, and is considered

suitable for primary and secondary contact recreation, including swimming and fishing. Potential human receptors are adults or children fishing or playing in the river below the site.

Environmental receptors associated with current site use could include wildlife foraging in Greens Brook or the Nashua River, and fish and other aquatic organisms found in the brook and river, that are impacted by groundwater discharge or soil erosion from the site to the surface water bodies. It is unlikely that larger mammals not commonly associated with urban ecology will commonly use the site for feeding, reproduction, or nesting. There may be several species of rodents commonly present on the site. It is not likely that the site would significantly contribute to the exposure of larger predators (hawks, owls, wildcats, etc.) to COPC since the site is developed and the available prey population is expected to be small relative to the overall prey availability in the larger feeding ranges of the larger predators. Birds may use the property for feeding or nesting along the banks of the Nashua.

The site is not used for the cultivation of fruits or vegetables destined for human consumption, or for the cultivation of ornamental plants. Recreational activities such as playing baseball, or leisure activities, such as picnicking, sunbathing or entertaining on the site are considered highly improbable.

As discussed in Volume I of this report, there are no private drinking water wells on Mill Street or in the vicinity of the site. The closest public drinking water well is 0.5 miles away, on the opposite side of the Nashua River. The area beneath the site is not located in a high or medium yield aquifer. The Nashua River is not used as a municipal drinking water supply along the stretch from Pepperell, Massachusetts, to and including Nashua, New Hampshire, approximately 4.2 miles downstream from the site.

4-03. POSSIBLE FUTURE USES AND ACTIVITIES

The site has been operated as a paper mill for over 100 years, and the site owner has no plans to change or modify that use. Because the site buildings are suitable for continuing operation, significant demolition or reconstruction of existing buildings is not anticipated at this time. Thus, for the purposes of this risk assessment, the reasonably foreseeable future uses are assumed to be the current uses of the site, or analogous commercial or industrial purposes.

In the event that there is significant construction or demolition activities at the site due to site redevelopment for a different commercial or industrial purpose, the use of outdoor areas may increase due to either expanded mill operations or construction activities. The latter could increase exposures to surficial and subsurface soils by construction workers as well as workers at the mill or Cogen plant. The potential exposures to groundwater could involve construction or utility workers involved in subsurface activities, down to the water table. Environmental receptors could include wildlife foraging in exposed excavations. Under future use conditions, the presence of children on the site is considered extremely unlikely.

V. DETERMINATION OF SOIL AND GROUNDWATER CATEGORIES

5-01. INTRODUCTION

Under a Method 1 and Method 2 Risk Characterization, soil and groundwater categories (310 CMR 40.0930) have been established for use in the characterization of risk posed by the site. The soil categories consider the frequency and intensity of use and the accessibility of soils. The groundwater categories consider the location of the groundwater relative to actual or potential drinking water sources, the location of structures likely to be affected by the migration of vapors from groundwater, and the discharge of groundwater to surface water.

5-02. CURRENT SITE CONDITIONS

To evaluate potential risk associated with current site conditions discussed in Section 4-02, soil samples collected within 3 ft. of the ground surface, with the exception of samples SS102, SS103 and SS109, are considered to be surface soils. Surface soils are categorized as S-2 category for adult exposures under current site conditions of low frequency and possible high intensity use.

Sample SS102 is located in an abandoned cellar with limited access and sample SS109 is located deep within a crawl space under one of the buildings. Although, both samples were collected within 3 ft. of the ground surface, both represent locations which have low frequency of visitation and a low intensity of use, defining S-3 category soils for adult exposure. Sample SS103 is located under the floor slab of a building and is also considered as an S-3 category for adult exposure under current conditions. Samples collected at depths greater than 3 ft. are considered as subsurface and classified as S-3 for adult exposure. Under current site conditions the presence of a child is considered unlikely.

Groundwater on the site is categorized as both GW-2 and GW-3. GW-2 is based on the presence of volatile organic compounds (VOCs) in the groundwater and occupied structures within 30 ft. of the OHM. GW-3 is based on the potential discharge of on-site groundwater to the Nashua River.

5-03. FUTURE SITE CONDITIONS

The current use of the site is expected to continue for the foreseeable future. However, it is conceivable, but not expected, that there could be building demolition or construction if the site is redeveloped for other commercial or industrial purposes. If there is unexpected major demolition and reconstruction involving the removal of buildings, soil samples SS102, SS103, and SS109 could conceivably be uncovered and disturbed. If demolition were to occur, soil samples SS102, SS103, and SS109 could then be considered surface soils, if exposed. Under such a scenario, all surface soils within 3 ft. of ground surface would be classified as S-2 soils for adult exposure of low frequency and possible high intensity use. Samples collected at depths greater than 3 ft. would be considered as subsurface and are classified as S-3 soil category for adult exposure under future conditions.

Groundwater on the site would remain as GW-2 and GW-3.

VI. EXPOSURE POINTS AND EXPOSURE POINT CONCENTRATIONS

The chemical data reported in Volume I of this Phase II Report were reviewed for each environmental medium affected (i.e., soil, groundwater, surface water, and sediments), and a list of COPC for evaluation in the Risk Characterization was developed from the OHM detected. The Method 2 Risk Characterization takes into account human exposure points in the determination of the soil and groundwater categories. The following is a brief discussion of site conditions and exposure point concentrations.

Soil, groundwater, surface water and sediment data obtained during the Phase I and Phase II assessments were used to evaluate the extent of release of OHM at the site. Samples were analyzed for VOCs, total petroleum hydrocarbons (TPH), priority pollutant metals (metals), pesticides, and polychlorinated biphenyls (PCBs).

For surface soils, several VOCs, metals, TPH, and PCBs were detected with varying frequencies. For subsurface soils, several VOCs, metals and TPH were detected. In groundwater, VOCs, dissolved metals and TPH were detected in several of the monitoring wells around the site.

Sampling data were reviewed, and values considered representative of potential exposure points were tabulated. Table I presents a summary of surface soil quality data collected across the site from 1991 to the present. Based on the successful completion of a RAM at the site, the data for sampling points SS108 and SS125 were eliminated from consideration in the assessment. Refer to the Release Abatement Measure Completion Report previously filed with the DEP under a separate cover for a description of response actions undertaken. Table I provides information on the frequency of detection of the OHM, analytical limits of detection, arithmetic average and maximum levels detected, the sample with the maximum level, and the range of levels detected. The arithmetic average of the soil levels detected is considered representative of the more likely exposure point concentration for potential exposures involving surface activities around the site under future foreseeable uses and activities, and was used under Method 2 to evaluate the risk of harm to human health.

Table II presents a summary of subsurface soil quality data collected across the site from 1991 to the present. The arithmetic average of the soil levels detected is considered representative of the more-likely exposure point concentration for potential exposures involving subsurface activities around the site under future foreseeable uses and activities, and was used under Method 2 to evaluate the risk of harm to human health.

Table III presents a summary of groundwater quality data collected across the site during the most recent round of sampling. The average concentrations of the OHMs detected in the monitoring wells are considered representative of the exposure point concentrations for evaluation of the risk of harm to human health under Method 2.

Tables IV and V present the frequency of detection, detection limits, arithmetic average and maximum levels, sample with maximum level, and range of levels of OHM detected in the surface water and sediments of the Nashua River, respectively.

For the purposes of averaging, in accordance with existing risk assessment guidance, analytical values reported as "Not Detected" (ND) were assigned a value of zero and "Trace" (TR) values were assigned a value of one half the detection limit. Duplicate samples were averaged and treated as one sample.

Additionally, individual samples were compared to Method 1/Method 2 standards to evaluate possible localized exposures and to further define possible remedial actions.

VII. IDENTIFICATION OF COMPOUNDS OF POTENTIAL CONCERN

7-01. INTRODUCTION

The chemical data discussed above were reviewed in order to identify the compounds of potential concern (COPC) for both the Method 2 and Method 3 Risk Characterizations. COPC are defined as those chemicals that are potentially site-related and whose data are of sufficient quality for use in a quantitative Risk Characterization.

Table VI summarizes the COPC evaluated in this risk characterization under Methods 2 and 3.

7-02. SOILS

The arithmetic average of the levels of metals detected in surface and subsurface soils were compared to the available DEP established background values (Table VII and VIII). In the absence of DEP values for soil, the average levels were compared to the arithmetic average background and range of levels for metals in eastern U.S. soils and other surficial materials (Table VII and VIII). The arithmetic average of arsenic and chromium levels in both the surface and subsurface soils did not exceed the DEP established background levels. Additionally, the arithmetic average of beryllium levels in surface and subsurface soils did not exceed the average background levels in the eastern U.S. Consequently, these metals were not quantitatively evaluated in the Risk Characterization.

7-03. GROUNDWATER

In the case of groundwater, the arithmetic average of the concentrations of arsenic, cadmium, lead, and mercury did not exceed the DEP background concentrations (Table IX). Consequently, these metals were not quantitatively evaluated in the Risk Characterization.

Groundwater data for nickel from monitoring well B104-MW is not considered to be representative of groundwater conditions and was not used in this Risk Characterization. Monitoring well B104-MW was the only well in which nickel was detected out of 17 groundwater samples tested for metals. The monitoring well was inadvertently destroyed shortly after sampling. Groundwater from a replacement well (B206-MW) in the same area did not contain nickel.

7-04. SEDIMENT AND SURFACE WATER

A comparison of OHM levels in surface water and sediment samples taken from the Nashua River upstream and downstream of the site suggests that the site has not measurably impacted sediment or surface water quality, and that the levels detected represent background for the river. Compounds detected adjacent to or downstream of the site are present at similar or greater levels upstream, with the exception of Aroclor-1254 in sediment. Consequently, these OHM, other than Aroclor-1254, were dropped from further consideration in the Risk Characterization. The Aroclor-1254 in sediment is addressed in the Stage I Environmental Screening (Section 9-04).

VIII. METHOD 2: RISK TO HUMAN HEALTH

8-01. DEVELOPMENT OF SOIL AND GROUNDWATER STANDARDS

Soil standards for trichlorofluoromethane, copper, and carbon disulfide and groundwater standards for trichlorofluoromethane and copper were developed in accordance with 310 CMR 40.0985 and 40.0984.

8-02. COMPARISON OF EXPOSURE POINT CONCENTRATIONS TO STANDARDS

The exposure point concentrations and individual samples from surface and subsurface soils were compared to appropriate Method 1 and Method 2 category standards, as discussed in Sections 5-02 and 5-03, respectively.

8-03. CURRENT SITE CONDITIONS

A. Soils

Under current site conditions, no average exposure point concentration for surface soil COPC exceed the S-2/GW-2 or S-2/GW-3 standards (Table X). The exposure point concentration for subsurface soil COPC do not exceed S-3/GW-2 and S-3/GW-3 standards (Table XI). Individual COPC levels exceed the standards in selected locations. In surface soils the lead level exceeds S-2/GW-2 and S-2/GW-3 standards in sample SS104. In subsurface soils the lead level exceeds S-3/GW-2 and S-3/GW-3 standards in samples B204-S7 and SS109. In surface soils the TPH level exceeds S-2/GW-2 and S-2/GW-3 standards in samples SS101 and SS104. In subsurface soils the TPH level exceeds S-3/GW-2 and S-3/GW-3 standards in samples SS102 and SS109. It is considered unlikely under current site conditions that exposure would occur exclusively and continuously from a single location and average values are more appropriate for long term risk assessment.

B. Groundwater

The average exposure point concentration for groundwater COPC did not exceed GW-2 or GW-3 standards (Table XII). However, individual samples B108-MW, B204-MW and B207-MW exceed the Method 2 GW-3 standards for copper. The Method 2 standard developed for copper is driven by the marine acute Ambient Water Quality Criteria (AWQC)(2.9 ug/l * 10) [3]. However, copper toxicity is inversely related to hardness in freshwater systems. The freshwater AWQC values, based on a hardness of 100 mg/l $CaCO_3$, are 12 ug/l for chronic and 18 ug/l for acute compared to the 2.9 ug/l for marine acute. Site groundwater discharges into the Nashua River, a freshwater system. Thus, the use of 12 ug/l in calculating the site specific GW-3 groundwater standards for copper would change the standard from 30 ug/l (groundwater) to 120 ug/l (groundwater). This is three times the highest groundwater concentration of copper detected and still represents a protective concentration for the biota of the Nashua River.

8-04. FUTURE SITE CONDITIONS

A. Soil

If the current footprint of the existing buildings remains unchanged, the future risk associated with soil exposures at the site will be identical to the present risk at the site. Under the site redevelopment scenario identified in Section 5.03, surface soil average exposure point concentrations (Table XIII and XIV) for lead and TPH exceed S-2/GW-2 and S-2/GW-3 standards (Table XV). Exceedance for the S-2/GW-2 and S-2/GW-2 standard of 600 mg/kg for lead results from an average exposure point concentration of 792 mg/kg, which is due to two samples (SS104 at 1,415 mg/kg and SS109 at 1,650 mg/kg) collected in the vicinity of the paper mill's machine shop. Sample SS104 was collected from an enclosed courtyard adjacent to the machine shop. Sample SS109 was collected from within a crawl space beneath the floor of the machine shop. Metals were analyzed in two other surface soil samples (B104-S1 and B203-S2) collected from the site. At these locations, lead was detected in both samples at significantly lower concentrations (B104-S1 at 52 mg/kg and B203-S2 at 53 mg/kg) than in those samples collected near the machine shop. For TPH, the S-2/GW-2 and S-2/GW-3 standard of 2,500 mg/kg was exceeded by an average exposure point concentration of 2,529 mg/kg resulting from the analysis of twelve surface soil samples for TPH. A total of four surface soil samples exceeded this criteria (SS101 at 3,500 mg/kg, SS102 at 8,900 mg/kg, SS104 at 4,800 mg/kg, and SS109 at 8,200 mg/kg).

No exposure point concentration (Table XVI and XVII) for subsurface soil COPC exceed S-3/GW-2 and S-3/GW-3 standards (Table XVIII). For subsurface soil, individual COPC levels exceed the S-3/GW-2 and S-3/GW-3 standard for lead in sample B204-S7. This sample was collected from a depth of 13.0 to 13.5 ft. As with current site conditions, it is considered unlikely that future exposure would occur exclusively and continuously from a single location. Therefore, the average values are more appropriate for long term risk assessment.

B. Groundwater

The exposure point concentrations for groundwater COPC do not exceed GW-2 or GW-3 standards (Table XII). Comparison of individual groundwater samples to standards were discussed in Section 8-03 and are not expected to change under future conditions.

IX. SAFETY, PUBLIC WELFARE, NATURAL RESOURCES, AND ENVIRONMENTAL RISK CHARACTERIZATION

9-01. INTRODUCTION

Under current and future uses of the site, the evaluation of risk to safety, public welfare, natural resources, and the environment is focused on COPC detected in the soil, groundwater, surface water, and sediments, and the potential impact on human and environmental receptors from exposure to these compounds both on and off the site.

9-02. SAFETY

Risk of harm to safety was characterized in accordance with 310 CMR 40.0960(3). Under current site activities and uses, no rusted or corroded drums or containers, open pits, lagoons, or other dangerous structures exist at the site, neither is there any apparent threat of fire or explosion, including the presence of explosive vapors resulting from the release of COPC.

COPC, which in their native state (i.e., prior to a release or spill) could exhibit the characteristics of corrosivity, reactivity, or flammability, as defined in 310 CMR 40.0347, are not considered to be present at the site in an "uncontained manner," such that their presence could pose a risk to safety.

Employee activities within the structures are regulated under OSHA, which should protect worker safety when in compliance.

Based on these observations, a condition of "No Significant Risk" of harm to safety is considered to exist, as defined in 310 CMR 40.0960(3).

9-03. PUBLIC WELFARE AND NATURAL RESOURCES

Risk of harm to public welfare and natural resources from COPC in the soil and groundwater at the site is characterized through comparison of the arithmetic mean of the levels or concentrations detected to the respective UCLs listed in 310 CMR 40.0996(4). The arithmetic average of OHM levels and individual sample OHM levels detected in soils and groundwater across the site do not exceed their respective UCLs (Table XIX). The site is not considered to pose a nuisance condition, unilateral restrictions on the use of other properties, or degrade public or private drinking water resources. Thus, a condition of "No Significant Risk" to public welfare and natural resources is considered to exist.

9-04. STAGE I ENVIRONMENTAL SCREENING

A. Introduction

Risk of harm to the environment may be characterized through the identification of environmental receptors that may be impacted by the COPC either directly or indirectly through off-site migration. Environmental receptors include habitats of special concern and

biota, such as Areas of Critical Environmental Concern (ACEC) and threatened and/or endangered species, plants, and wildlife.

Based on a review of available information, the following observations about the site may be made:

- There is no visible evidence of sheens or nonaqueous phase liquids on surface waters;
- There is no evidence of recent fish kills;
- The site is not located within or adjacent to an Area of Critical Environmental Concern (ACEC). There are no inland ACECs listed for the town of Pepperell [5].
- The U.S.G.S. topographic plan does not indicate the presence of wetlands at or in the immediate vicinity of the site. The closest wetland is Reedy Meadow, approximately 2.8 miles southeast of the site [6].
- The EPA Region 1 list of Priority Wetlands in New England does not indicate the presence of priority waterbodies/wetlands in the Nashua River basin in Pepperell [7].
- The Property is not located within or adjacent to a Priority Habitat or Expected Habitat of State-Listed Rare Wetland Wildlife. The nearest Priority Habitat is located approximately 600 feet north and approximately 0.6 river miles downstream on the Nashua River. The Priority Habitat is identified as both a Natural Community and Habitat of State Listed Rare Species [8] and as an Expected Habitat of State-Listed Rare Wetland Wildlife [9]. The site is generally topographically upgradient and upstream of the habitat. The closest linear distance (600 feet) is separated by a small knoll. The habitat area is defined around the confluence of the Nissitissit and Nashua Rivers [8,9].
- A Natural Resource Map from the Division of Environmental Protection does not indicate the presence of protected open space, salt marsh forests, or ACECs within 500 feet of the site [10].
- The majority of the site is within the 500 year floodplain and a small portion is in the 100 year floodplain. Under 310 CMR 10.57(1) [4], areas subject to flooding may be critical habitat. Any area within the 10 year floodplain or within 100 feet of the river bank, whichever is greater and is still within the 100 year floodplain is considered to be a resource area and critical to protect under 310 CMR 10.00. However, areas which have been previously developed to a point in which the ecological functioning of the flood zone has been eliminated are excluded as an area subject to flooding. The sections within the 100 year floodplain include a small section of the relatively undisturbed bank and a small area where Greens Brook meets the Nashua River. These areas are not expected to be impacted by site activities.
- The bank of the Nashua River is relatively undisturbed and contains mature growth along much of the site boundary.
- There are contaminants located within 2 feet of the ground surface which may bioaccumulate: cadmium, mercury, and Aroclor-1254.

Based on the above observations, a current exposure or potential for exposure of compounds known to bioaccumulate to environmental receptors exists. To evaluate the potential risk associated with environmental receptor exposure to mercury, cadmium, and PCBs, acceptable soil levels were calculated using several exposure pathways, toxicity information, and bioaccumulation factors (BAFs). The use of the Nashua River by wildlife is not considered to be a concern due to the absence of site-specific contamination present in the water column. The presence of Aroclor-1254 in the sediment is addressed below in Section 9-05(C).

Data and information from Toxicological Profiles [11,12], a study of a PCB contaminated wetland [13], and Contaminant Hazard Review of mercury [14] were used to estimate acceptable levels of dietary intake for environmental receptors. Acceptable soil levels were calculated as follows:

$$\text{Acceptable Soil Level} = \frac{\text{No Observable Effects Level}}{(BAF_{fs} * FR * D)}$$

Where BAF_{fs} is the bioaccumulation factor of the food source (Body Burden of food source divided by soil level of contaminant), FR is the proportion of the site used by the final receptor as a feeding range, and D is the proportion of the diet composed by the food source. It is conservatively assumed that 100 percent of the receptors' diet is from the potentially contaminated food source and that the site comprises 90% of the receptors' feeding range.

B. Potential Bioaccumulation: Cadmium in Soil

Cadmium at 100 ppm in food was reported to progressively decrease the number of rat litters produced per dam [11]. A conservative 50 ppm was used as a no observable effects level (NOEL) for small rodents. BAFs for plants were calculated based on the average soil levels of cadmium (60 ppb) [13] and the maximum reported levels of cadmium in leafy plants (450 ug/kg) and grains (130 ug/kg) from non-polluted soils [11]. The BAFs were 7.5 and 2.2 for leafy plants and grains, respectively. Based on these assumptions, the calculated acceptable soil level for cadmium is 7,410 ug/kg soil for the protection of small herbivorous mammals feeding on leafy plants. The average surface soil cadmium level at the site is 1,675 ug/kg and the maximum level is 2,300 ug/kg. Both are below the 7,410 ug cadmium/kg soil, calculated to be protective of small mammals feeding on leafy plants. Large predators or sensitive receptors feeding on small mammals will generally require a larger feeding range than offered by the site and the potential contaminated prey. Therefore, for modelled receptors, the presence of cadmium does not present a significant risk at the site.

C. Potential Bioaccumulation: PCBs in Soil

Based on the ecological exposure assessment of PCB-contaminated wetlands [15], sediment/soil criterion of 45,900 ug/kg and 14,000 ug/kg of PCBs were calculated for the protection of raccoons and mink at a 13-acre wetland. The Pepperell Paper Mill site is 19.5-acres, but unlike the wetland in the above referenced study, it is developed with permanent structures and is unlikely to compose a significant portion of the natural feeding ranges of mink or raccoons.

Acceptable soil levels to protect avian species feeding on worms and insects on the site is calculated based on BAFs of 0.29 and 0.19 for worms and insects [15], respectively, and a protective dietary allowance of 5 ppm [15]. The protective soil concentration for a bird

feeding on worms is 19,150 ug PCB/kg soil. Because the site average and maximum surface soil PCB level of 393 ug/kg soil and 1,400 ug/kg soil, respectively, are below the protective concentrations for mink, raccoons, and birds, no significant risk of harm to these receptors is anticipated.

D. Potential Bioaccumulation: PCBs in Sediment

Aroclor-1254 was detected in sediments in the Nashua River. The maximum level of 120 ug/kg sediment was detected downstream of the site. Aroclor-1232 was detected upstream but not downstream of the site. Additionally, the detection limits of Aroclor-1254 ranged from a low of 7 ug/kg to a high of 200 ug/kg. Because 200 ug/kg is greater than the detected concentration of 120 ug/kg, Aroclor-1254 may be present at upstream and downstream locations at concentrations below the detection limits. The Aroclor-1254 is conservatively assumed to be a COPC and evaluated for the potential to bioaccumulate.

An average sediment level of 19.5 ug PCB/g carbon is predicted to protect pore water concentrations from becoming greater than the ambient water quality criteria of 0.014 ug/l [15]. With a conservative assumption of 1% carbon present in the sediment, the protective average sediment concentration would be 0.195 ug/g, which is greater than the maximum detected sediment concentration. The presence of Arochlor-1254 in the sediment is therefore not considered to present risk to mink and potentially sensitive aquatic species from chronic PCB exposure.

E. Potential Bioaccumulation: Mercury in Soil

Mercury often displays toxic effects at levels just above background. The form of the mercury dictates its bioavailability, toxicity, and ultimate fate in the environment. Methylmercury is considered the more toxic and more likely to biomagnify in the foodchain. A majority of the available information on the fate, transport, and ecotoxicology of mercury is from the aquatic systems, where it is considered a high concern due to the biological methylation of mercury, the bioaccumulation in fish and other aquatic organisms, and the potential for human exposure through the consumption of contaminated fish. The ecotoxicology of mercury in terrestrial systems is not as well documented.

The LD_{50} (60-day exposure) for inorganic mercury was reported at 790 ug/kg for earthworms [14]. The site average soil concentration is 708 ug/kg. However, this average level includes the maximum level of mercury (1,700 ug/kg) located in a completely enclosed courtyard (sample SS104). Based on qualitative comparison, it may be expected that the earthworm population and other sensitive receptors at this location on the site are impacted by the levels of mercury present. However, the current and anticipated continued isolation of the courtyard reduces the likelihood of the presence of normal ecological functioning, multiple environmental receptor exposure, and foodchain magnification. Removal of the courtyard from the ecological exposure level lowers the average surface soil exposure level of mercury to 377 ug/kg, which is below the DEP Background level of mercury in soil (500 ug/kg) [16]. If there is unanticipated demolition of the buildings such that the courtyard is no longer isolated, there may be potential adverse effects on sensitive environmental receptors due to the mercury level detected in soil at this location.

F. Assessment of Results

Based on the above considerations, current conditions at the site do not present a significant risk of harm to the biota or habitats identified with the exception of the courtyard area. Although demolition of the surrounding buildings is not anticipated, this area would require further assessment if it was no longer isolated from potential environmental receptors.

X. UNCERTAINTY ANALYSIS

10-01. GENERAL UNCERTAINTY

This Risk Characterization is subject to a number of uncertainties. As a result, risk estimates derived from the equations and assumptions in this Risk Characterization should not be interpreted as absolute estimates of the risks of harm to health, safety, welfare or the environment from the site. General sources of uncertainty include:

- o sampling of the environmental media.
- o modeling of exposure point concentrations or levels.
- o development of toxicity data including the chemical specific soil and groundwater standards, discussed below.

10-02. UNCERTAINTY ASSOCIATED WITH HAZARD IDENTIFICATION

The assumption that all compounds detected, even if detected only once, are characteristic of conditions at the site contributes significantly to the uncertainty of the Risk Characterization. In the case of metals in soils and groundwater, where the arithmetic average level detected did not exceed available DEP background levels, or in the absence of DEP soil values, did not exceed the arithmetic average background values for eastern U.S. soils, the metal was dropped from the evaluation.

As discussed earlier, the following compounds were not quantitatively evaluated in the Risk Characterization: arsenic, beryllium, and chromium in soils and arsenic, cadmium, lead, mercury, and nickel in groundwater.

10-03. UNCERTAINTY ASSOCIATED WITH DEVELOPMENT OF METHOD 1 AND 2 STANDARDS

The development of Method 1 and Method 2 Standards include the use of dose-response values (RfDs, RfCs, CSFs, & Unit Risk).

These toxicity values and their application have the following uncertainties:

- o the use of dose-response information from effects observed at high doses to predict the adverse health effects that may occur following exposure to the low levels expected from human contact with the compound in the environment;
- o the use of dose-response information from short-term exposure studies to predict the effects of long-term exposures, and vice-versa;
- o the use of dose-response information from animal studies to predict adverse health effects in humans;

- o the use of dose-response information from homogeneous animal populations or healthy human populations to predict the adverse health effects likely to be observed in the general population consisting of individuals with a wide range of sensitivities;
- o the use of oral RfD and CSF values as surrogate toxicity values for the dermal and inhalation routes of exposure;
- o the use of surrogate RfD, RfC, CSF, and Unit Risk values for those compounds without assigned values;
- o the assumption that the compound of concern exerts the same toxic effect regardless of the route of exposure;
- o the application of a bioavailability factor (BAF) of 1 for compounds without an assigned BAF. This assumes that the entire amount of the compound inhaled, ingested or in contact with the skin was absorbed (i.e., 100 percent absorption) and available to exert its toxic action;
- o the use of default values for daily ingestion rates, breathing rates, average body weights, surface areas, and permeability constants, etc;
- o the use of "average site-specific" assumptions for SESOIL leaching potential calculations (e.g. porosity, Ksa, etc.);
- o the uses of attenuation factors based on radon and the applied dilution factor used in the model for calculating the indoor air concentrations from volatilization from groundwater.

10-04. UNCERTAINTIES ASSOCIATED WITH STAGE I ENVIRONMENTAL SCREENING

Uncertainties associated with the Stage I Environmental Screening are as follows:

- o the use of laboratory derived toxicity values for use in complex environmental situations;
- o the use of laboratory animal toxicity data for other possible more or less sensitive organisms;
- o the use of BAFs derived from other sites;
- o the determination of potential receptors without either qualitative or quantitative site surveys of biota and habitats.

XI. DISCUSSION AND CONCLUSIONS

11-01. INTRODUCTION

A Risk Characterization has been performed for the Pepperell Paper Mill located in Pepperell, Massachusetts, using a combined Method 2 and 3, in accordance with the requirements set forth in 310 CMR 40.0900 of the MCP and the DEP Guidance for Disposal Site Risk Characterization and Related Phase II Activities.

The general classes of chemicals detected at the site are VOCs, metals, TPHs, and PCBs.

Media evaluated included soil (surface and subsurface), groundwater, surface water, and sediment. Evidence from chemical analysis of surface water and sediments suggest that the contaminants are a result of upstream contamination and transport, and not a result of off-site migration of OHM from soils or groundwater to the Nashua River.

11-02. SOILS UNDER CURRENT SITE CONDITIONS

Under current conditions, exposure point concentrations for surface soils COPC do not exceed the S-2/GW-2 and S-2/GW-3 standards (Table X).

Individual samples noted in Section 8-03 do exceed standards, but due to their physical location it is unlikely that exposure would occur exclusively and continuously from one of these locations. Therefore, under current conditions, as discussed in Section 5-02, there is "No Significant Risk" of harm to human health.

11-03. SOILS UNDER POSSIBLE FUTURE SITE CONDITIONS

As noted, risk from soils under expected future site conditions is predicted to be the same as the risk under present site conditions. Although not anticipated, under a redevelopment scenario involving removal of the paper mill's buildings, surface soil exposure point concentrations for lead and TPH would exceed S-2/GW-2 and S-2/GW-3 standards (Table XV). Exceedance for lead is associated with two soil samples collected in the vicinity of the machine shop. Exceedance for TPH is associated with four samples collected from selected locations within the paper mill, two of which contribute to lead exceedance. Under this scenario, the potential risk of harm to human health would be associated with excavation or other high intensity contact with the site's soil by adult workers.

11-04. GROUNDWATER UNDER CURRENT AND POSSIBLE FUTURE SITE CONDITIONS

The exposure point concentrations calculated for COPC in groundwater under current and foreseeable future site conditions do not exceed GW-2 and GW-3 standards, and therefore, indicate the presence of "No Significant Risk" for human health.

11-05. LEVEL OF RISK

A condition of "No Significant Risk" of harm to human health has been achieved for this site under current conditions. For future conditions, soil category S-2/GW-2 and S-2/GW-3 standards for potential risk to human health are exceeded under the unanticipated future site condition of redevelopment and demolition. Under this condition, soils which are currently isolated beneath buildings would become more accessible to on-site workers. Potential risk to on-site workers would be associated with excavation or high intensity contact with these soils.

A condition of "No Significant Risk" to public welfare, natural resources, safety, and the environment has been achieved for this site. However, under potential future conditions, if buildings surrounding the courtyard adjacent to the machine shop are demolished such that the courtyard is no longer isolated from potential environmental receptors, the detected mercury level in soil in the courtyard could pose potential risk of harm to the environment.

XII. RECOMMENDATIONS

Based on the Risk Characterization's analysis, exposure point concentrations for lead and TPH exceed S-2/GW-2 and S-2/GW-3 standards for potential risk to human health under those future site conditions which would include redevelopment and building demolition on the site. The potential for risk to human health under this scenario would be associated with excavation into contaminated soil by adult workers. Some soils which could contribute to this potential risk are currently in isolated locations in crawl spaces and unused cellars beneath the mill's buildings. As discussed, demolition and redevelopment, which would make these soils more accessible, is not anticipated for the site. However, despite the various levels of accessibility to the site's surface soil, it is recommended as a precautionary measure that the necessity of a health and safety plan be evaluated for on-site workers before performing intrusive activities that could lead to high intensity contact with soil. This evaluation would consist of a review of existing soil chemical analytical data for the proposed work area. Depending on results of this review, appropriate health and safety measures could be planned and executed as part of the work.

Based on the mercury level detected in a soil sample collected from the courtyard adjacent to the machine shop, it is recommended that the soil in this area remain isolated from potential environmental receptors. Although unanticipated, if the surrounding buildings to this courtyard should be demolished, additional assessment of the soil in this area would be recommended.

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