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**REVIEW AND RECOMMENDATIONS
REPORT FOR THE
CABOT CARBON/KOPPERS
SUPERFUND SITE**

Prepared for:

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P.E. Certificate of Authorization #1841
P.G. Certificate of Authorization #133

February 2006

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EXECUTIVE SUMMARY

Contamination of the Floridan aquifer by creosote components was discovered in the summer of 2004 at a depth of 160 feet beneath the Cabot Carbon/Koppers Superfund site in Gainesville, Florida. Such components are directly related to the widespread and deep contamination of the overlying Hawthorn Group sediments by dense, non-aqueous phase liquids (DNAPLs) as documented since 2002 by Beazer and its consultants. The Floridan aquifer is Gainesville Regional Utilities' (GRU) sole source of potable water to supply approximately 170,000 people in the Gainesville-area of Alachua County, Florida. Consequently, the presence of this contamination in the Floridan aquifer, approximately 2 miles south of the Murphree Wellfield, prompted GRU to establish a team of independent consultants (DNAPL Consultant Team) to provide an independent review of existing data and findings presented by the primary responsible parties and regulatory agencies regarding the potential threat to the Murphree well field. The primary purpose of this report is to review previous work conducted at the Cabot/Koppers Superfund Site and to (1) establish working assumptions that should be applied in developing an effective Feasibility Study for the Koppers portion of the Superfund Site, and (2) provide recommendations for further site characterization that will allow a reliable analysis of the remedial options to be evaluated prior to the Feasibility Study.

Extensive contamination of the surficial sand aquifer beneath this Superfund site by arsenic, benzene, polynuclear-aromatic hydrocarbons, pentachlorophenol, and other phenols has resulted in the deep penetration of the Hawthorn Group sediments by these contaminants. The pathways followed by DNAPL and dissolved phases include fractures and bioturbation ("wormtube") structures in the clayey sediments. The conceptual model accepted during 1987-2004 was that the Upper Hawthorn Group clay was sufficiently impermeable to prevent creosote DNAPL present in the surficial aquifer from penetrating into the Hawthorn Group sediments; however, widespread contamination was discovered in the Lower Hawthorn Group during 2003 and 2004. Also in 2004, creosote contamination was detected in the Floridan aquifer at a depth of approximately 160 feet (Well FW-6), a short distance north of the Former North Lagoon, which received on the order of 75,000 to 200,000 gallons of waste creosote from 1940 to 1975. The fact that DNAPL creosote has been able to migrate down through the upper and middle Hawthorn clay units in several areas of the site and material balance calculations to assess the potential for dragdown of contamination at Well FW-6 indicate that this contamination of the Floridan aquifer was not 'dragged down' by drilling operations but had likely penetrated to the Floridan aquifer through the normal gravitational migration of a DNAPL.

The flow and transport of contaminants in the Floridan aquifer is facilitated primarily by dissolution features typical of a karstic aquifer (e.g., fractures and solution channels along former bedding planes) and the controlling contaminant-transport variables, in particular the effective porosity. A review of this parameter indicates that the value used to simulate the transport of dissolved contaminants in the Floridan aquifer should be approximately 1%, rather than the 15% used by Beazer's consultants. The consequence of this much smaller value, which is supported by tracer testing in carbonate rocks elsewhere in Florida and the USA, is that it produces a much shorter travel time through the Floridan aquifer from the Superfund site to the Murphree

Wellfield (i.e., <10 years). While the diffusion of contaminants from fractures (but not solution channels) into the porous limestone matrix may retard contaminant transport through the Floridan aquifer, sorption is unlikely to have a considerable retarding effect and attenuation by biodegradation will be substantial only if travel times are long in the groundwater flow system.

This report recommends further site characterization activities to support a reliable analysis of contaminant fate, transport, and remedial options that will be presented in the Feasibility Study. Most important among these actions is the need for a complete and spatially dense monitoring-well network in the Floridan aquifer that is now being attempted by Beazer. This network will make possible an estimation of the mass flux of contaminants leaving the site and subsequently migrating towards the Murphree Wellfield. In addition, a thorough, high-resolution geophysical reconnaissance of the site is required, likely using a combination of appropriate surface and downhole geophysical methods, to provide better characterization of the Hawthorn Group sediments and anomalies that may indicate solution channels and other karst phenomena in the Floridan.

Additional work must be undertaken at both the Koppers and Cabot Carbon parts of this Superfund site to evaluate and select appropriate remedial actions that will protect the Murphree Wellfield. Remedial actions in the Surficial aquifer at the Koppers site have been shown to be inadequate and need immediate attention to prevent further migration of contaminants off site. Remedial actions at the Koppers site are needed to prevent continued vertical migration of DNAPL through the Hawthorn Group. Migration of contaminants under the interceptor trench and drainage ditch at the Cabot site is suspected due to their volumetric capacities and relatively shallow vertical locations relative to the large volume of contaminated groundwater flowing in the surficial aquifer across the site. The potential for vertical migration of contaminants at the Cabot Carbon site, as has been demonstrated at the Koppers site, is also a concern in the case of the Koppers facility, and vertically into the Hawthorn formation beneath both facilities. Given the presence of phenolic and aromatic contamination in the Hawthorn Group sediments that was recorded in the 1989 Remedial Investigation report and recent changes in the site conceptual model, it is evident that this data should have been given more consideration in the initial evaluation and selection of remedial strategies implemented at both sites in the 1990s. It is critical that future site evaluations reconsider the effectiveness of existing site controls and their ability to protect the Floridan aquifer.

Finally, the presence of large amounts of phenolic compounds in the Hawthorn and the potential for migration of those contaminants to the Floridan aquifer is a major concern of GRU because very low (0.2 µg/L) phenol concentrations are known to produce taste and odor problems following chlorination (chlorination is used to prepare water for distribution at the Murphree Wellfield). Consequently, EPA must reevaluate remediation standards for these phenolic compounds that will apply during revision of the Feasibility Study.

The following conclusions should be used to establish working assumptions for developing the Feasibility Study:

It is now clear that the Lower Hawthorn sediments are heavily contaminated with dissolved-phase creosote compounds and creosote DNAPL that has seeped through approximately 100 feet of Hawthorn sediments at the Koppers site. The creosote DNAPL in the LHG appears to be mobile but its rate of migration is very slow because of its high viscosity, which is 40 to 50 times that of groundwater.

DNAPL beneath the Koppers site is potentially mobile in all of the geologic units—although at slow rates—and should be considered as such in evaluating site remedies. Contaminant concentrations in monitoring wells suggest that DNAPL is present in the Floridan aquifer.

Despite the large vertical gradients across the upper, middle and lower clay layers of the Hawthorn Group, these sediments should be considered to be leaky confining layers that are penetrated by numerous fractures and bioturbation, allowing them to transmit significant quantities of DNAPL and, therefore, contaminated groundwater. Consequently, they are neither permeability nor capillary pressure barriers and should be modeled with an effective porosity of ~1%.

The reliance on the electrical resistivity method to characterize the stratigraphic column beneath the Superfund site has resulted in considerable uncertainty about the structure of the Hawthorn Group and the underlying Ocala Limestone. Seismic reflection surveying may be a superior method for determining lithofacies changes in the Ocala Limestone and would likely improve the understanding of the structure of both the Hawthorn Group sediments and the Floridan aquifer. Data from high-resolution geophysical surveys should be collected and used in designing remediation strategies.

The performance assessment of the groundwater extraction system in the surficial aquifer conducted by Waterloo Hydrogeologic (2005b) has shown that the system is ineffective in controlling the migration of contaminated groundwater. Dissolved contamination from the base of the surficial aquifer beneath the Former North Lagoon—probably the most heavily contaminated part of the Koppers site—is shown to be unaffected by the extraction well system as this contamination migrates across the underlying upper Hawthorn clay layer a considerable distance before it can reach the influence of the extraction wells, eventually flowing downward to the Floridan aquifer and, ultimately, to the Murphree Wellfield.

Monitoring of groundwater quality in the surficial aquifer occurred sporadically during the early 1990s and less comprehensively as the decade progressed. Consequently, little is known about aqueous concentrations of contaminants in the surficial aquifer other than along the perimeter boundary where the extraction well network is situated. The available monitoring-well information points to the likelihood that creosote DNAPL has migrated down-dip to the northeast from the lagoons and from the Process Area underneath the railroad tracks and probably to the Cabot Carbon site.

The Cabot Carbon site appears to be a major source of contaminant (phenols and aromatic hydrocarbons) infiltration to the Hawthorn Group sediments that may ultimately reach the Floridan aquifer. NAPL was detected beneath the site as recently as June 2005 and, similar to the Koppers site, strong downward gradients exist from the surficial aquifer across the Upper Hawthorn Group clay, indicating that contaminant infiltration is likely occurring.

Dissolved-phase arsenic concentrations in the Surficial aquifer have been measured at 5.3 ppm—530 times the Federal drinking water standard. At this time, very little is known about the extent of this contamination and its migration into the Hawthorn Group and the Floridan aquifer.

Phenolic compounds are a major concern of GRU because phenol concentrations well below health-based standards are known to produce taste and odor problems following chlorination.

Recommendations of this report are summarized below with detail presented in Section 5 and in the body of this report.

✓ 1. Complete work described in the present Floridan Aquifer Monitoring Work Plan with transect wells and source zone wells including all relevant geophysics, groundwater elevation monitoring, and groundwater quality monitoring. ✓

at Hawthorne well design

2. If any of the 12 transect and source-area wells currently being installed indicate the presence of contaminants in the Floridan aquifer above action levels, then the horizontal and vertical limits of the plume as well as the distribution of contaminants within the plume must be identified. See also Recommendation #18. *yes*

3. Continue monitoring of wells completed in the Floridan aquifer. ✓

?? 4. Determine whether the rotosonic drilling method has caused disaggregation of the cores in recent drilling.

not 4

maybe 5. Conduct aquifer pumping tests in the Floridan aquifer to determine hydraulic conductivity and to support the evaluation of contaminant fate and transport and remedial actions employing hydraulic containment. *estinks*

?? 6. Evaluate further, if necessary, the nature and extent of the possible unconsolidated areas of the Floridan aquifer.

maybe 7. Design a groundwater pump-and-treat system to contain contaminant migration in the Floridan aquifer in the vicinity of FW-6 and other affected areas (pending results from the multilevel monitoring wells presently under construction).

pump #6 + 12

71 8. Evaluate migration pathways and attenuation mechanisms in the Floridan aquifer between the Koppers Site and the Murphree Wellfield.

22 9. Complete a series of high-resolution geophysical profiles across the site in order to better characterize the stratigraphy of the Cabot Carbon/Koppers Superfund Site including the Floridan aquifer. Goals of the survey should be to:

- a. Establish the structure/topography of, and discontinuities in, the Upper, Middle, and Lower Hawthorn Clays.
- b. Establish the stratigraphy of Hawthorn Group sediments, between the Upper, Middle, and Lower Hawthorn clays so a sound Feasibility Study can be written that addresses remediation of the Hawthorn Group.
- c. This geophysical survey should also establish the horizontal and vertical bounds of the "unconsolidated" Ocala Limestone and assist in identifying flow paths within the UTZ of the Floridan aquifer—see Recommendations #6 and #8.

22 sample 10. Using information developed in Recommendation #9 and well/boring logs, reevaluate the interpretation of the Upper Hawthorn Group clay surface because of the likelihood of lateral migration of DNAPL along the top of the Upper Hawthorn Group clay.

yes on redump
push on AS 11. Redevelop the network of monitoring wells established during 1984-1995 in the surficial aquifer to remove fines in advance of conducting tests for hydraulic conductivity and quarterly sampling. [Special attention should be paid to determining the horizontal and vertical distribution of arsenic contamination and to identifying the sources of arsenic.] This recommendation equally applies to the Cabot Carbon site. } ??

yes when 12. Conduct direct-push groundwater sampling at the base of the surficial aquifer on the Koppers site to provide additional information regarding the extent of creosote migration from the four DNAPL source zones.

OK 13. Conduct direct-push sampling at the top, middle, and base of the Surficial Aquifer at a sufficient number of locations on the former Cabot Carbon plant property to determine the fate of contamination that has not been captured by the Koppers extraction well system.

14. Immediately undertake a re-appraisal of the Koppers extraction-well network and add boundary wells, sufficient in number and location assure 100% containment and, as an interim measure, add wells in each of the DNAPL source zones and the arsenic plume to capture dissolved contamination before it has the opportunity move vertically into the Hawthorn Group. The pumping of contaminated groundwater from source areas is an interim measure only and is intended to

control vertical migration of contaminants until source-removal can be accomplished.

15. Conduct additional characterization of Hawthorn Group sediments at each source area in sufficient detail to support remedial actions. *(offsite to the west)*

16. Immediately undertake a re-appraisal of the existing interceptor trench system at the Cabot Carbon site. This evaluation should include collecting groundwater samples at multiple depths through the entire vertical saturated section of the Surficial Aquifer along a transect east of, and along the entire length of, the existing interceptor trench and along the northern boundary of the site.

17. Install extraction system components at the Cabot site sufficient to prevent contaminant migration both laterally offsite and vertically into the Hawthorn formation.

18. Install additional monitoring wells in the Hawthorn formation adjacent to the former Cabot Carbon lagoon areas to evaluate the potential for vertical migration of DNAPL or dissolved contaminants vertically from the Surficial Aquifer or laterally from the Koppers site. If contamination is confirmed in the Lower Hawthorn Group, then Floridan monitoring wells, preferably multiport wells, must be installed and sampled to evaluate vertical and lateral plume dimensions in the Floridan.

19. Revise the groundwater cleanup goal for phenolic compounds beneath the Cabot Carbon site. The goal for phenols must prevent nuisance odors when groundwater from the Murphree Wellfield is chlorinated prior to distribution.

20. Reassess the nature and extent of LNAPL and DNAPL beneath the Cabot Site based on what we now understand regarding DNAPL mobility and migration at the Koppers Site. Develop plans for its removal as necessary.

1.0 INTRODUCTION

In the summer of 2004, creosote contamination was discovered in a new well drilled to a depth of 160 feet and penetrating 18 feet into the Floridan Aquifer beneath the Cabot Carbon/Koppers Superfund Site. On account of the presence of this contamination in the same aquifer from which GRU produces finished water for the City of Gainesville, GRU established a team of independent consultants (DNAPL Consultant Team, referred to as the *Team*) to protect its groundwater supply, which is produced from the Floridan aquifer 2 miles northeast of the site at GRU's Murphree Wellfield. This wellfield is GRU's sole source of potable water for approximately 170,000 people in the Gainesville area.

GRU directed the Team to focus its efforts on protecting the Murphree Wellfield and provide timely advice so that the public retains confidence in the safety of the water supply provided by GRU. The objectives of the Team, as stated in its Preliminary Report (GRU, 2005), are as follows:

- Perform a comprehensive review of the Koppers site data and reports.
- Review the approach being used to characterize and remediate the site.
- Recommend further actions needed to ensure that the site is appropriately cleaned up and that the water supply is protected.
- Help GRU to work with USEPA and other agencies and Beazer to ensure the site is cleaned up and the water supply protected.

Because of concerns that grew during 2005 about the eastern part of this Superfund site, the responsibility for which rests with Cabot Carbon, a fifth objective developed:

- Consider what additional characterization should be undertaken at the Cabot Carbon site and whether Cabot Carbon's current remedial actions are protecting the Murphree Wellfield.

The Team has reviewed documents presenting the characterization and remediation activities being conducted by GeoTrans, TRC, and other contractors and laboratories on behalf of Beazer, which retains environmental liability for the Koppers part of the Cabot/Koppers Superfund Site. The Koppers site has been a wood treatment facility since approximately 1916. Creosote was used to treat wood from 1916 until the late 1960s. Wolman salts (i.e., chromated copper arsenate (CCA)), were used at the site beginning in 1936 and the current plant was constructed in the late 1960s (USACE, 2000). Pentachlorophenol (PCP) was used for an uncertain period beginning in 1969 (Hunter/ESE, 1989). Koppers switched from creosote to CCA in the late 1960s and wood-

treating operations continue today using only CCA. An unknown volume of creosote, PCP, and CCA was released into the surficial aquifer at Koppers. Constituents of all three treating compounds were detected in shallow groundwater at the site in the 1980s, while creosote compounds were first observed in the Floridan aquifer in 2004.

The US Environmental Protection Agency (EPA) listed the site on the National Priority List of Superfund sites in 1983 and published the Record of Decision (ROD) in 1990. The ROD led to the excavation, treatment and backfilling of shallow (4 feet deep) contaminated soils from the former North and South Lagoons (referred to herein as FNL and FSL). Further details of source-area remediation activities are described by TRC (1999). Groundwater remediation involved the establishment, in 1995, of an extraction and treatment system within the shallow aquifer along the northeast and eastern perimeter of the Koppers site.

In September 2000, the first 5-year review of the site was submitted to the EPA by the U.S. Army Corps of Engineers (USACE, 2000). It raised no concerns about threats to Gainesville's groundwater supply. However, the Corps did note that "the groundwater treatment system has not accomplished the groundwater remediation objectives," although it did not point out the fact that the extraction system was functioning well below its design rate. These objectives, originally stated in the 1990 ROD, include the following groundwater cleanup criteria:

- Arsenic = 50 µg/L
- Phenol = 2630 µg/L
- Naphthalene = 18 µg/L
- Benzene = 1 µg/L

The USACE review concluded that "groundwater contamination does not appear to pose any threat to the environment or to human health at present" (USACE, 2000, p.32).

In May 2001, a Proposed Plan (of remedial actions) was published by EPA Region IV (US EPA, 2001), which identified remedial action goals for site clean-up and recommended the implementation of a proposed course of action identified as Alternative 7F. Alternative 7F specified actions that were clearly intended to prevent the migration of contamination from the shallow aquifer, which was known to be heavily contaminated with wood-preserving fluids, to areas off-site. When the Proposed Plan was released in 2001, EPA believed (2001, p.11) that the Hawthorn Group sediments provided an impermeable "confining unit," protecting the Floridan Aquifer. This conclusion was reached by McLaren/Hart (1993a) in their Site Characterization Report. Although evidence from the 1984 Remedial Investigation Study (Hunter/ESE, 1989) had previously indicated that phenolic contamination had penetrated the Hawthorn Group sediments beneath the shallow aquifer, Beazer's consultants in their Site Characterization Report (McLaren/Hart, 1993a) strongly supported the concept that the Hawthorn Group was impermeable to vertical migration of creosote. With respect to the creosote contamination, EPA made clear in their account of Alternative 7F that:

Limited pump and treat should be maintained to assure that any flow occurring across the low permeability barrier is directed inward, and no contaminants escape the sources areas (US EPA, 2001, p.11).

By contrast with the Koppers site, the Cabot Carbon Company site attracted little regulatory attention. Cabot Carbon had produced naval stores and charcoal by destructive distillation of pine stumps from the mid-1940s until 1966 (Hunter/ESE, 1989). Liquid products of the retorts were light and heavy pine oils and pitch, some of which are considered by the regulatory community as LNAPL (lighter-than-water non-aqueous phase liquid) and some as DNAPL. Process water containing these NAPLs was discharged to lined and unlined ponds from which light and heavy components were recovered. Some remediation has been conducted at the Cabot site; however, no characterization of the Hawthorn Group has been conducted since the 1989 Remedial Investigation report (Hunter/ESE, 1989) and monitoring wells have not been installed into the Floridan aquifer at the Cabot Carbon portion of the Superfund site.

The DNAPL Consultant Team issued a report in January, 2005 titled *Preliminary Report of the GRU DNAPL Consultant Team on Creosote Contamination beneath the Koppers Superfund Site, Gainesville, Florida*. In that report, the Team concluded the following:

- It was improbable that the naphthalene and other creosote-related compounds detected in the groundwater in the Floridan aquifer in 2004 were dragged down into the aquifer by the drilling process.
- Consequently, the Team concluded that the Hawthorn Group, including the lower Hawthorn clay unit, was transmitting creosote DNAPL to the Floridan aquifer.
- The existing nine Floridan monitoring wells were inadequate to characterize the vertical and horizontal extent of creosote contamination in the bedrock aquifer due to their limited number and their shallow depth.
- A significant amount of DNAPL was present in the surficial aquifer and the Hawthorn Group sediments.
- A significant fraction of the creosote DNAPL was likely to be still mobile.
- Mobile DNAPL in both the surficial aquifer and the Hawthorn group sediments will continue to move into the Floridan aquifer unless appropriate remedial actions are taken.

The Review and Recommendations report was commissioned by GRU in mid 2005 when it became apparent that the Team had different interpretations of the available data and had drawn different conclusions from these interpretations than those presented by Beazer and its consultants to the regulatory community (i.e., EPA, the Florida Department of Environmental Protection and the Alachua County Environmental Protection Department). Therefore, this

report addresses unresolved issues stemming from the conclusions stated above and additional issues that have been identified during the Team's study of conditions at the Superfund site including the potential continued downward migration of creosote and the lack of actions to prevent that migration.

2.0 OBJECTIVES OF THE REVIEW AND RECOMMENDATIONS REPORT

The specific objectives for this report were established by GRU in June 2005 and can be summarized as follows:

- A review of the outstanding technical issues that threaten the protection of the Murphree Wellfield to establish working assumptions that should be applied during development of Feasibility Studies.
- The preparation of recommendations concerning further site characterization that will be necessary to support a meaningful evaluation of remedial strategies in future feasibility studies.

Recommendations concerning proposed remedial activities (i.e., feasibility studies) are not addressed in this report and would be premature without further characterization of the site. Section 3 of this report reviews what is known about contamination in and the hydrogeology of the Floridan Aquifer, which is the source of GRU's Murphree Wellfield. Section 4 reviews the contamination in and the hydrogeology of the Surficial Aquifer and Hawthorn Group sediments that overlie the Floridan aquifer. Section 5 summarizes the recommendations made in Sections 3 and 4. Section 6 is a list of references.

3.0 THE FLORIDAN AQUIFER: CONTAMINANT FATE AND TRANSPORT AND RECOMMENDED FURTHER WORK

3.1 CONTAMINANTS OF POTENTIAL CONCERN

The contaminants of potential concern in the groundwater of the Floridan aquifer associated with the Koppers site include a wide variety of organic compounds and inorganic chemicals derived from the wood preservation chemicals. Organic compounds from creosote include benzene, toluene, ethyl benzene and xylenes (BTEX), phenolic compounds, and polycyclic aromatic hydrocarbons (PAHs). Organic compounds from pentachlorophenol (PCP) include PCP and various chlorophenols and petroleum hydrocarbons. Inorganic chemicals include arsenic, chromium, and copper.

These contaminants of potential concern are listed in Table 3-1 together with their maximum concentrations measured to date in groundwater in the surficial aquifer or Hawthorn sediments and the Floridan aquifer.

3.2 POTENTIAL EFFECTS ON MURPHREE WELLFIELD

3.2.1 Numerical Criteria

Several contaminants of potential concern at the Koppers site have been found in the Floridan aquifer beneath the site at concentrations that exceed Florida drinking water standards (DWS), or Florida groundwater cleanup target levels (GCTL). These chemicals are noted in Table 3-1 together with their maximum concentrations in groundwater and their respective Florida standards. Some of the regulatory standards for drinking water were established on the basis of risk to human health while others were established on the basis of taste and odor effects in a drinking water supply, in particular the phenolic compounds.

The compounds and chemicals in the Floridan aquifer beneath the Koppers site that have been found at concentrations that have exceeded their respective regulatory standards include the following:

- Arsenic
- Benzene
- 2-methyl phenol
- 3- and 4-methyl phenol
- 2,4-dimethyl phenol
- Acenaphthene
- Benzo(a)anthracene
- Carbazole
- Dibenzofuran
- 2-methyl naphthalene
- Naphthalene

Group	Contaminant	Maximum in Surficial or Hawthorn (µg/L)	Maximum in Floridan (µg/L)	Florida DWS	Florida GCTL
Aesthetics	Odor	-	-	3 (Threshold Odor Number)	-
Inorganic	Arsenic	5,300	170	10	-
BTEX	Benzene	1,900	14	1.0	-
	Toluene	1,500	7.7	1,000	-
	Ethyl Benzene	380	7.6	700	-
	Xylenes	1,200	17	10,000	-
Phenols	Phenol	570	6.7	-	10
	2-Methyl Phenol	3,300	72	-	35
	3-Methyl Phenol	NM	NM	-	35
	4-Methyl Phenol	NM	NM	-	3.5
	3+4-Methyl Phenol	4,700	100	-	33.5*
	2,4-Dimethyl Phenol	18,000	170	-	140
Chlorophenols	Pentachlorophenol	3,700	0.53	1	-
PAHs	Acenaphthene	1,200	230	-	20
	Acenaphthylene	54	3.8	-	210
	Anthracene	230	16	-	2,100
	Benzo(a)anthracene	170	1	-	0.05
	Benzo(a)pyrene	67	<	-	0.2
	Benzo(b)fluoranthene	75	<	-	0.05
	Benzo(k)fluoranthene	68	<	-	0.5
	Carbazole	810	89	-	1.8
	Chrysene	160	1	-	4.8
	Dibenzofuran	920	140	-	28
	Fluoranthene	970	33	-	280
	Fluorene	1,000	140	-	280
	2-Methyl Naphthalene	1,700	310	-	28
	Naphthalene	20,000	2,600	-	14
	Phenanthrene	2,300	170	-	210
	Pyrene	650	18	-	210

Groundwater concentrations rounded to 2 significant figures

DWS- Drinking Water Standard

GCTL- Groundwater Cleanup Target Level

NM- Not measured separately

- No standard specified

* Standard is sum of standards for 3-Methyl Phenol and 4-Methyl Phenol

Some of these compounds (2-methyl phenol, 2,4-dimethyl phenol) exceeded their respective regulatory standards by a small margin. Arsenic, benzene, 3- and 4-methyl phenol, acenaphthene, benzo(a)anthracene, dibenzofuran and 2-methyl naphthalene exceeded their respective standards by about 10 times. Carbazole exceeded its standard by about 50 times. Naphthalene exceeded its standard by about 185 times.

No tests have been performed on the groundwater from the Floridan aquifer to determine the threshold odor number, for which there is an established regulatory standard.

As a result of these findings, the evaluation of groundwater contamination in the Floridan aquifer should consider, at a minimum, naphthalene, carbazole, arsenic, benzene, 2-methyl phenol, 3- and 4-methyl phenol, 2,4-dimethyl phenol, acenaphthene, benzo(a)anthracene, dibenzofuran, 2-methyl naphthalene, and compounds which could contribute to odor impacts in the groundwater.

3.2.2 Taste and Odor Impacts

Table 3-2 summarizes the phenolic compounds that have been found in the Floridan aquifer beneath the Koppers site and their respective Florida GCTLs. The phenolic compound found at the highest concentration is typically 2,4-dimethyl phenol. The maximum concentrations of phenolic compounds in the Floridan exceeded their respective Florida GCTLs by a small margin. Many individual groundwater samples had detectable concentrations of phenolics but at concentrations below GCTLs. The detection limits for these phenolic compounds have ranged typically from 1 to 5 µg/L.

Table 3-2 Phenolic Compounds Found in the Floridan Aquifer Beneath the Koppers Site (Concentrations in µg/L)			
Compound	Max in Surficial or Hawthorn	Max in Floridan Aquifer	FLDEP GCTL
Phenol	570	6.7	10
2-Methyl Phenol	3,300	72	35
3-Methyl + 4-Methyl Phenol	4,700	100	3-Methyl = 35 4-Methyl = 3.5
2,4-Dimethyl Phenol	18,000	170	140
Total Phenolics	22,900	336	-

The Florida GCTL for phenol is based on its potential to cause taste and odor effects (i.e., organoleptic concerns, in untreated or non-chlorinated drinking water), while the Florida GCTLs for methyl and dimethyl phenol compounds are based on their potential human health effects (62-777, F.A.C., Table 1). However, in the case of groundwater that is extracted and disinfected for a municipal water supply using chlorine, as is the case with the Murphree Wellfield, the presence of phenolics may be of concern at much lower concentrations than the GCTLs. This is because the phenolics react with the chlorine to form odorous compounds that cause unpleasant tastes and odors in the treated water. This phenomenon has been recognized in the water supply

engineering literature for more than 60 years. It is believed that chlorination of drinking water containing phenolic compounds and other reactions in water distribution systems may cause the formation of chlorophenols and chlorinated anisoles, which have taste thresholds of 0.1 µg/L or lower (WHO, 2004, p. 214)

According to the United States Public Health Service in 1962: *“Both the International Drinking Water Standards and those of the U.S. Public Health Service of 1946 recommended a limit of 1 µg/L of phenol in water (Note: the analytical test method used in this era quantified the concentration of total phenolic compounds, not just phenol). This limit is set because of the undesirable taste often resulting from chlorination of waters containing extremely low concentrations of phenol.”*

Salvato (1992), in his discussion of drinking water quality in the 4th Edition of his textbook on Environmental Engineering and Sanitation, noted that *“Phenols in concentrations of 0.2 ppb in combination with chlorine will impart phenolic or medicinal taste to drinking water”* and that *“The WHO [World Health Organization] guideline for individual phenols, chlorophenols, and 2,4,6-trichlorophenol is not greater than 0.1 µg/L (0.1 ppb), as the taste and odor can be detected at or above that level after chlorination....The AWWA [American Water Works Association] advises that phenol concentrations be less than 2.0 µg/L at the point of chlorination.”*

The concentrations of these phenolic compounds in the Floridan aquifer beneath the Koppers Site are higher, by factors of 10 to 1,000 times, than the 0.1 µg/L to 2 µg/L concentrations that have been reported to potentially cause taste and odor problems in chlorinated drinking water supplies. The migration of even low concentrations of phenolic compounds to the Murphree Wellfield could have undesirable effects on the drinking water quality.

As a result of these findings, EPA’s evaluation of groundwater contamination, in the Floridan aquifer and elsewhere, should rigorously consider the fate and transport of phenolic compounds.

3.3 CURRENT DELINEATION OF GROUNDWATER CONTAMINATION

3.3.1 Creosote Compounds

As described in Section 3.2, a variety of aromatic and phenolic compounds have been found in the groundwater of the Floridan aquifer beneath the Koppers site at concentrations that have exceeded regulatory limits. The spatial distributions of the groundwater contamination by aromatic and phenolic compounds are illustrated in Figures 3-1 and 3-2, respectively. The values shown in these figures are the maximum concentrations found by Beazer during 2003 through 2005. The existing monitoring wells in the Floridan aquifer have relatively short intakes (i.e., 10 to 15 feet) in the upper part of the aquifer that is believed to be about 100 feet in thickness (see further discussion in Section 3.4). The general direction of groundwater flow in the Floridan aquifer beneath the site is believed to be toward the northeast toward the Murphree Wellfield.



FW-7

Naph	4.6
Carb	1.6
Ace	0.53
DBzF	<
2MNaph	<
Bz	0.98

FW-2

Naph	1.7
Carb	<
Ace	13
DBzF	0.71
2MNaph	<
Bz	<

KII SITE BOUNDARY

FW-6

Naph	2,560
Carb	89
Ace	233
DBzF	141
2MNaph	309
Bz	14

FW-4

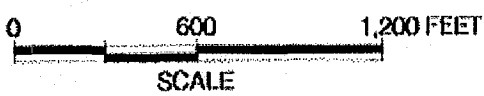
Naph	<
Carb	<
Ace	<
DBzF	<
2MNaph	<
Bz	0.65

FW-3

Naph	16
Carb	2.0
Ace	1.4
DBzF	<
2MNaph	<
Bz	1.8

Florida GCTLs

Naph	14
Carb	1.8
Ace	20
DBzF	28
2MNaph	28
Bz MCL	1.0



LEGEND

FLORIDIAN AQUIFER MONITORING WELLS

Aromatic compounds in groundwater in the Floridan aquifer (maximum conc. µg/L).

Naph- naphthalene, Carb- carbazole, Ace- acenaphthene, DBzF- dibenzofuran, 2MNaph- 2-methyl naphthalene, Bz- benzene
< Not detected

Base map from: **TRC**

Figure 3-1