Health-based Guidelines for Air Management and Community Involvement During Former Manufactured Gas Plant Clean-ups

Wisconsin Bureau of Environmental and Occupational Health
Department of Health and Family Services

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Purpose and intended audience. The purpose of this guidance is to provide public health expectations and recommendations for managing air quality at the perimeter of manufactured gas plant (MGP) cleanup sites in order to minimize exposure to the public.

This guidance is intended for project managers, representing both environmental regulatory agencies and private consultants, who are working with MGP remediations. Environmental consultants and contractors having a range of experience with MGP work have undertaken MGP projects in Wisconsin. This experience ranges from MGP remediation specialists using state-of-the-art techniques to more generalized environmental consultants and contractors working on small MGP sites, perhaps as one component of a much larger construction project. Similarly, DNR project managers have a range of experiences. Most work on a variety of remediation projects, but because there are relatively few MGP sites in the state, may be involved in a MGP project for the first time.

This guidance is also intended to complement information on MGP remediation already available to the Energy and Environmental industries. *Management of Manufactured Gas Plant Sites* (GRI 1996), in limited circulation from the Gas Research Institute, is an extensive introduction to MGP technical issues. Much of the information in this guidance is at least topically referenced in the GRI text. This guidance expands on emerging technical and regulatory issues related to air quality and air management around MGP sites, with emphasis on public health.

Introduction

Manufactured gas plants in Wisconsin.
Manufactured gas plants operated in Wisconsin from the late 1800s to the mid-twentieth century. These facilities produced fuel gas comprised of methane, hydrogen, carbon monoxide, nitrogen, and other gases produced (Buckley 1983, GRI 1996) by heating coal, steam and coke, or steam and oil. In Wisconsin, some of these former manufactured gas plant (MGP) sites retain original buildings; others have since been converted to other uses but still have subsurface MGP wastes. Coal tars, light oils, and inorganic wastes typically found in soil, sediment, and groundwater near former MGPs are an environmental and public health concern.

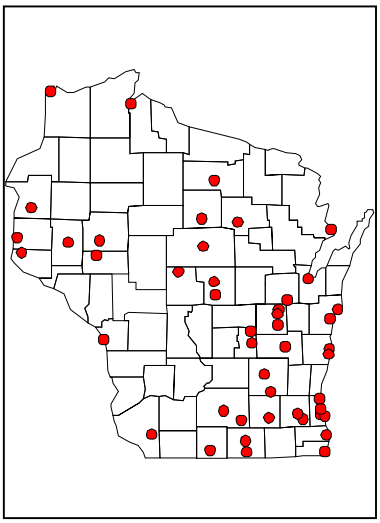


Figure 1. Former Manufactured Gas Plants are found throughout Wisconsin

DHFS role in evaluating former MGP sites. The Wisconsin Department of Health and Family Services (DHFS) supports the long-term public health and environmental benefits of MGP remediations, but recognizes the potential for short-term environmental health problems caused by the clean-up work. To prevent health problems, DHFS provides technical advice to the lead regulatory agency, usually the Wisconsin Department of Natural Resources (DNR), on public health issues related to MGP projects. DHFS also participates in statewide policy discussions conducted by the DNR manufactured gas plant team. The DNR has identified more than sixty sites in Wisconsin (Figure 1) for investigation and possible remediation. The type and extent of contamination, as well as the remediation challenges, vary with the size of the original operation, the gas manufacturing process used, and the physical geography of the remediation site. Most of these sites are in locations that are now urban areas or town centers. The proximity of residences and business to these sites presents the additional challenge of avoiding exposure hazards to the public during cleanup work.

Identification of air impacts as a key public health concern during MGP remedies. In Wisconsin, people have been exposed to MGP-related hydrocarbons through contact exposure to tar-contaminated surface water and sediment, through contact with subsurface tars by workers digging trenches, and by inhalation of volatile organic hydrocarbons (VOCs) released during excavation. In addition, the ingestion of well water contaminated with MGP wastes is a potential threat that is being monitored at some MGP sites in Wisconsin. Of the identified exposure pathways, the release of hydrocarbons to air during remediation work has the greatest potential to affect the general public. MGP-related contaminants may become airborne during removal, either through volatilization, or dispersed as soil dust. People who live or work nearby can be affected by air containing these substances. Nationwide, there has been increased emphasis on emissions control and air monitoring during MGP cleanups (Pluhar 2004). The recommendations proposed here seek to minimize the public's exposure to airborne contaminants from MGP sites.

Odor vs. safety: nuisance Vs measurable health effects. An important topic of this paper is its address of odor control at MGP sites as a public health issue. Air monitoring data from MGP sites in Wisconsin indicates that site managers have been generally successful at maintaining federal standards and guidelines for safe ambient air quality. Unfortunately, even at safe levels for VOCs and particulates, strong tar odors may still be evident. The gap between safe and "odor free" can affect public acceptance of an MGP project, especially when there are neighbors with either a real or perceived increased health risk from airborne exposure to MGP wastes. When MGP sites are excavated in sensitive public locations, it is advisable to extend air management of volatile compounds beyond existing health and environmental guidelines, and set air management targets that are closer to odor thresholds. DHFS recognizes that this is technically challenging and not always feasible. However, leading environmental consultants and utility companies conducting MGP projects in Wisconsin have been responsive to the goal and the challenges of controlling tar odors. This guidance does not advocate for specific air management targets beyond existing standards and guidelines. But, as a practical public

health and community relations' goal, DHFS believes that neighbors of MGP excavation and treatment projects should be able to escape tar odors within the refuge of their homes when doors and windows are closed. Meeting this practical goal will sometimes entail adopting stringent site management methods and increased emphasis on community outreach.

Developing an Air Management Plan.

The Air Management Plan (AMP) lays out the key factors related to the project and surrounding area that influence the potential for air quality problems. The Air Management Plan can be considered in four parts. 1) Identify, and communicate with, the nearby population that could be affected by air quality from the site. 2) Establish measurable and protective air quality goals and action levels based on contaminant concentrations and distance from community members. 3) Identify the appropriate monitoring methods for the contaminants of concern. 4) Plan the overall project to minimize air quality impacts, and develop an action plan of responses to be taken when action levels are exceeded. Air management issues of this nature are inherently complex, making it important to have a contingency plan with feedback and response loops that detect and accommodate changing or unforeseen conditions.

Conceptual Air Management Plan. Responsible parties and their consultants are encouraged to contact state environmental and health agencies early in the project planning process to discuss a conceptual plan of the project. Contacting interested agencies at the conceptual stage allows ideas to be presented and concerns to be raised before investing effort in plans that might require extensive revision. This is especially true for unusual projects or for parties new to the State of Wisconsin. The development of cooperative, helpful relationships with agency staff is an added benefit in any remediation project.

Community Involvement

Informing neighborhoods and building public acceptance for MGP remedies. Most environmental consultants have a good deal of experience planning the logistics of a cleanup. Characterizing community interests that relate to air management can be a more complicated process. It is important to identify as much as possible where the nearest residents or workers will be with respect to the cleanup. Pay close attention to the locations of sensitive populations such as schools, hospitals, daycare centers, or nursing homes. The air management plan is designed to protect each of these populations from unhealthy exposures to contaminants from the cleanup project. The characteristics of the nearby population will play a role in decision-making when scheduling the project dates, operating times of day, planning truck routes, on- or off-site treatment, as well as the locations and types of perimeter air monitoring that would be conducted.

Public outreach is important *prior to* and *during* any MGP site remediation, both to avoid problems and alleviate concerns. Public meetings and literature should permit the public to anticipate odors and other air emissions, and their effects. Fact sheets and public meetings can be used to inform the public of site activities. Special efforts should also be made to identify and inform sensitive or less mobile people in the affected area.

Regulatory requirements for community involvement. In Wisconsin, parties responsible for contaminated soil sites, including former MGPs, have requirements, under DNR authority, to notify the public, government officials, and other interested parties, and to place informational signs at the work site, and to provide information when requested. These requirements are described in the Wisconsin Administrative Code ch. NR 714.07(1-6) (see http://www.legis.state.wi.us/rsb/code/nr/nr700.html). In addition, state and local officials such as DNR, DHFS, the local Health Department, and local government may choose to conduct public information activities. These activities might be conducted independently from, or in cooperation with, the activities required of responsible parties. Cooperative efforts between responsible parties and environmental, health, and government officials can be challenging, but ultimately builds credibility and accelerates community acceptance of the MGP remediation project.

Benefits of risk communication. Despite the long-term public health benefits of the remediation of former MGPs, there is often public concern over possible health effects from air releases during the clean-up work. Such concerns speak directly to public acceptance of MGP remediations, and sometimes results in organized resistance to particular projects. Risk communication efforts should anticipate community concerns, should seek to provide credible and authoritative information, and recognize the community as a stakeholder in local environmental quality with a right to community self-determination. State and local health departments are staffed with people trained in environmental risk communication who are available to assist, where appropriate, with public information activities. The responsible party may also choose to develop a local representative to serve as a credible point-of-contact and liaison to the public. For resources on risk communication, see bibliography.

Points of contact from public. A 24-hour phone number should be available to public and businesses so they can call with questions or complaints. To be most responsive to the community, the phone "hotline" should request specific information from callers, such as weather conditions, an odor description, and any health symptoms. The hotline should also tell the caller what would be done with the information they provide. Site managers need to immediately follow-up on air incidents and odor complaints in order to ensure that complaints have been appropriately treated and to avoid repeat events.

The point-of-contact representing remediation management should maintain, in the form of a phone log, a record of the public's phone inquiries and complaints. The phone log should note the contractor's response to each inquiry, and should be available to regulatory inspection, to be submitted at the project's completion along with the other permanent records of the work.

Identifying, accommodating, and communicating with individuals with special needs. One of the public health challenges associated with MGP remediation projects is to identify and accommodate neighbors who are extremely sensitive to the VOCs released from soil and groundwater. In Wisconsin, MGP site managers are usually quite successful in limiting air releases to within the safe levels agreed upon in air management plans. However, maintaining these safe levels may not preclude the presence of coal tar odors. These odors can be irritating, and people vary in their tolerance of odor and their perceived risk from exposure (Dalton *et al.* 1997, Dalton 1996). Other people may have conditions such as bronchitis, emphysema, or asthma (see DHFS 2001 for prevalence) that present additional unknowns from low level exposure. To address these unknowns, DHFS recommends first, that every effort be made to mitigate coal tar odors beyond established standards and guidelines such that nearby residents can not smell odors indoors when doors and windows are closed. Second, prior to the excavation, every individual within a close radius (approximately 200-400 yards, depending upon the site) of the excavation should be personally informed of the work by letter or phone call. This contact should inform neighbors that air quality will be maintained at safe levels, but if they have any preexisting health condition that is a concern, then they may contact the health department and/or their physician for advice. The information provided must be clear and sufficient to allow individuals to self-identify their need to seek additional advice. The points-of-contact representing both the responsible party and local health should be mutually aware of any individuals responding with advance concerns. Third, responsible parties should have advance agreement with local health officials over how they will accommodate individuals reporting actual health complaints ranging from a nuisance odor to acute respiratory effects. Such accommodation might range from simple advice and reassurance (close windows, dispatch technician with PID to home) to providing temporary relocation where necessary.

Accommodating individuals, particularly involving relocation, is a public risk perception challenge. People may become concerned unnecessarily because they want to be treated equally and may not recognize individual needs. Also, it is difficult to evaluate individual needs that may only manifest as a temporary discomfort or irritation to the evaluator, but may be intolerable to the complainant. For these reasons, health concerns and complaints raised after excavation commences should also be directed to a physician. Health departments and other stakeholders should be prepared to provide descriptions of the MGP project to physicians that will help them evaluate exposure. Stakeholders should have advance agreement of the accommodations that will be made following a physician's recommendation. Such agreements may require extended discussions among stakeholders of possible complaint scenarios, but at sensitive locations where complaints are expected, advance discussions and agreements will ultimately help the remediation to proceed smoothly.

Reporting. DHFS, DNR, and the Local Health Department should receive weekly reports by email or fax during MGP remediation work. These reports should include the status of site activities, perimeter air monitoring data & reports, daily exposure air monitoring reports, calls or contacts about odor or health questions or complaints from the public and

nearby businesses, and a copy of air monitoring logs from the portable air sampling program.

DNR, DHFS and the Local Health Department should be directly notified by phone or email if there are health or odor complaints, or if site activities result in air conditions that exceed agreed-upon "alarm" conditions. Also, someone with access to the air-monitoring log should be available at all times to address odor complaints from the public. The air management plan should include details for a 24-hour emergency telephone line to take calls from the public or from regulatory agencies. Records of these calls should be maintained to include who, what, why, and the response to each call. Part of the planned response to odor complaints should be to dispatch a portable instrument to the site of the complaint in order to verify there is a problem or to provide reassurance that odors are within safe levels. The log should include all readings collected during the perimeter monitoring, samples collected (when and where), and actions taken in response to any high values.

Other important avenues of communication. Environmental contractors should continually strive to improve site management. In particular, communication between contractors and subcontractors, via the site Health and Safety Officer, should ensure that defined protocols are followed.

DHFS recommends following completion of the site remedy, that DNR project managers debrief their regional member of the MGP team to discuss lessons learned with regard to air management.

Airborne contaminants of concern at MGP remediation sites.

Major components, of MGP wastes found in soil and groundwater. MGP soils are typically contaminated with a complex mixture of coal tars and inorganic wastes (Table 1; Figure 2). These residual process or coal tars are primarily represented by 500 to 3000 separate polycyclic aromatic hydrocarbons (PAHs) of three to six benzene rings, phenolics, volatile organic compounds (VOCs), and inorganic compounds of sulfur and nitrogen (Hatheway 2002). MGP production wastes also included large quantities of ammoniacal liquors (spent condensation waters of coal gas plants), and gas liquors (spent condensation waters of carburetted water gas plants). Also common were tar sludges removed from the sumps of the condensation devices. MGP oxide box wastes contain high concentrations of sulfur oxides and metal cyanides (Luthy *et al*. 1994). Groundwater contamination by light oils and tars is also common, depending upon the location and method of disposal of MGP wastes, and the depth and confinement of perched water and groundwater aquifers at individual sites. Many former MGPs were sited along waterways that now have public access. At a number of such sites in Wisconsin, DHFS has observed MGP exposed oxide box wastes in soils, and coal tar and oil sheens around soil, sediments, and surface water that are a direct-contact human health concern.

VOCs. A variety of volatile and semi-volatile hydrocarbons have been reported in soil and groundwater investigated at former MGP sites (Table 1). For example, total VOCs in groundwater have been observed to exceed 400 mg/L at Wisconsin MGP sites (Dames and Moore 2000). The VOCs typically found to exceed DNR groundwater standards (Wisconsin Administrative Code *ch*. NR 140) are benzene, ethylbenzene, naphthalene, xylenes, styrene, and toluene.

*Benzene and naphthalene are key VOC residuals***.** Of the VOCs found in airborne releases from excavation of MGP sites, benzene is the compound that typically drives public health concerns. The exposure limit of benzene is low enough to solely define the regulated toxicity of the MGP-related VOC mixture, and MGP air management decisions and action levels should focus on the potential for benzene release. Benzene, a by-product of coal coking or gas manufacturing processes, has both known human carcinogenicity (EPA class A) and high volatility (vapor pressure 75 mm Hg, 20ºC) (ATSDR 1997).

Naphthalene is another key compound of concern during MGP excavations. The volatility and toxicity of naphthalene are lower than benzene, although more similar to benzene than to other major VOCs (Table 2). The low odor threshold of naphthalene makes the presence of coal tar evident at low concentrations.

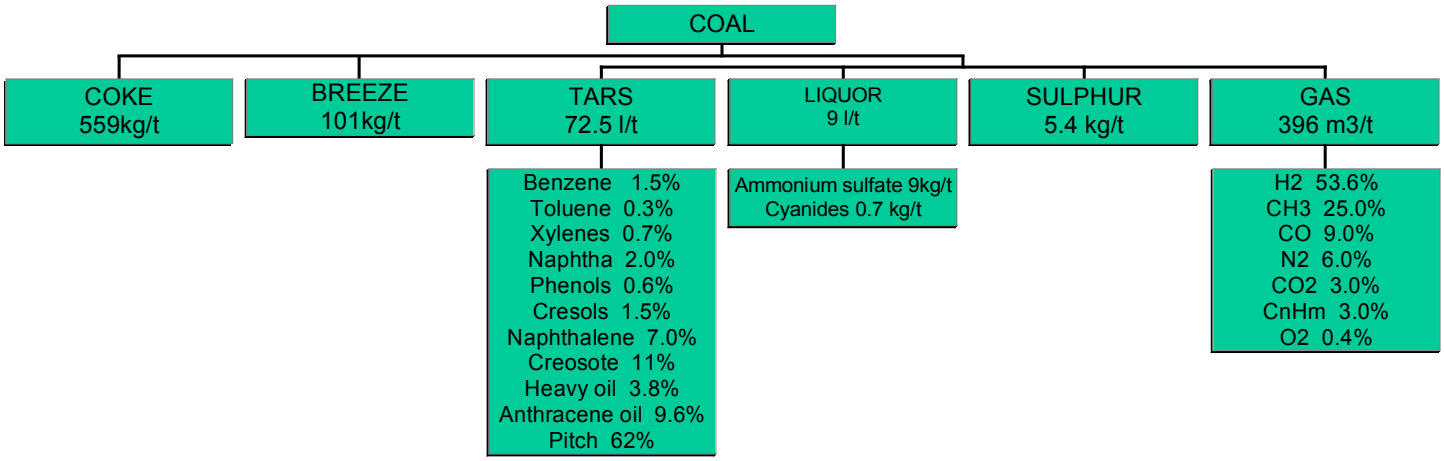
Monitoring naphthalene alongside VOCs requires additional work. Naphthalene is not detected quantitatively in EPA method TO-14/15 (SUMMA can samples; EPA 1999b), photo-ionization detectors (PID) calibrated for total VOCs, or particulate monitoring. In addition, losses during sampling render standard PUF plug sampling ineffective. Quantitative detection of naphthalene requires EPA method TO-13 (EPA 1999a) using a combination PUF/XAD2 collection medium or equivalent. Instantaneous readings of naphthalene can be made using a portable gas chromatograph with surface acoustic wave detector (GC/SAW) or another portable GC with a column suitable for naphthalene.

Particulates. Particulate matter, or PM, is the term for particles found in the air, including dust, dirt, soot, smoke, and liquid droplets (EPA, 2003a). Particulates, especially those from combustion sources, are solid mixtures of hydrocarbons, minerals, metals, and inorganics such as NOx and SOx. Particulates should be regarded not as inert dust but rather as chemical mixtures that have toxicological effects when inhaled. The high concentration of PAHs in MGP-contaminated soil makes the airborne dispersal of these waste soils a topic of interest and concern.

Potential sources of respirable (< 2.5μm: $PM_{2.5}$) and inhalable (< 10 μm: PM_{10}) particulates dispersed during MGP remediations include the handling of excavated PAH-contaminated soil, construction vehicle exhaust, construction road dust, PAH contaminated soil stockpiles, treated stockpiles, and potentially from malfunctioning thermal desorber stack emissions. Maintaining each of these sources to workplace and public health standards entails a combination of site management and air monitoring techniques. Perhaps most important is anticipating dry, windy conditions that disperse stockpiles. In Wisconsin, occasional problems have occurred around MGP sites where

winds have dispersed particles and odors from pretreated stockpiles awaiting thermal desorption. In these cases, irritating odors in nearby buildings were resolved using surfactant controls on stockpiles and closing building openings where necessary. With experience, site managers can anticipate and prevent such problems. For example, at a summer MGP excavation in an urban residential location in Wisconsin, site managers found it prudent to cease excavation work during hot or windy afternoons to avoid potential air releases that would generate complaints from the public.

Figure 2. Product yield from coal gasification. (Adapted from Buckley 1983)



PAHs. Polycyclic aromatic hydrocarbons are a diverse group of hydrocarbons that comprise a large proportion of MGP wastes (Figure 2). PAHs are also a focal component of the particles targeted in the NAAQS. The PAHs commonly studied in the environmental literature and included in environmental reports from MGP sites are 2-6 ringed, with molecular weights in the range of 128-300 (Boström *et al*. 2002). The actual breadth of PAH structures present in MGP wastes is probably much greater (Hathaway 2002) if included are little-studied larger molecular weight structures, PAHs with side-chain substituents, and PAHs with sulfur- or nitrogen-containing rings. The tendency of PAHs to disperse ranges from semi-volatile (e.g. naphthalene, vapor pressure 0.08 mm Hg;), to non-volatile structures that are dispersed via surface adsorption to particulate matter. A number of PAHs are toxic following their oxidation to a corresponding reactive structure (ATSDR 1995, Boström *et al*. 2002). Activation to a reactive structure can occur through photooxidation in the case of skin contact, or metabolically in the case of ingestion or inhalation. Benzo(a)pyrene (B(a)P) is one of several PAHs that form reactive, tumorigenic metabolites. B(a)P is the prototypical PAH in toxic equivalency comparisons, although several authors assign higher toxic equivalency factors (TEF) to

dibenzo[*a,h*]pyrene, dibenzo[*a,i*]pyrene, dibenzo[*a,l*]pyrene, and dibenze[*a,h*]anthracene (ATSDR 1995, Boström *et al*. 2002). Most of our lifetime exposure to PAHs occurs from ambient sources such as diesel exhaust; consequently PAHs are listed as one of the six major air pollutants targeted for reduction in ambient air by the national ambient air quality standards (NAAQS) of the clean air act (U.S. EPA 2003a). The current federal standard for particulate matter (PM_{10}) is 150 micrograms per cubic meter ($\mu g/m^3$) of air averaged over 24 hours and 50 $\mu g/m^3$ averaged over a one-year period. PAHs in excavated tars and tar-contaminated soils at MGP sites clearly have the potential to temporarily affect local air quality if allowed to disperse. All MGP remediation projects should include air management plans to control the dispersal of PAHs in excavated tars, tar-contaminated soil, and soil stockpiles awaiting treatment or transport.

Air standards for PAH particulates. Limiting the dispersion of PAHs is of primary concern during MGP remediation. However, as noted above, particulates released at MGP remediation sites are a mixture of substances representing the range of wastes and sources on site. The 150 $\mu g/m^3$ NAAQS is designed to address this variety of potential particulate sources. From a public health standpoint, the NAAQS is an appropriate air quality goal for the MGP site perimeter, and is more useful than, for example, a modification of the OSHA standards for carbon black, coal dust, or silica. A perimeter action level used to meet the NAAQS for particulates should be based on short-term exposure limit. A public health-based, short-term exposure limit for generic particulates is not widely used. Based on the ACGIH (2003) industrial recommendation of 10 mg/m^3 for inhalable particles and an uncertainty factor of 10 (for sensitive humans), a short term (15 minute) exposure limit of 1 mg/m^3 for inhalable (PM_{10}) particles is protective of public health. The action level for particulates that has been used at several MGP sites in Wisconsin is also 1 mg/m^3, although this action level was derived from standards for lead-contaminated soil (GZA, 2000). Although this action level for particulates has been empirically acceptable in most respects, it has the shortcoming of serving as a surrogate for monitoring naphthalene. Structurally, naphthalene is a PAH, but functionally is a VOC. Particulate measurements are not adequate to monitor naphthalene, a major component of MGP wastes, or other semi-volatile PAHs. See further discussion below under *Contaminants of Concern: VOCs.*

Metals. Metals, especially iron, are found in contaminated soils at MGP sites. Other metals found could include lead, arsenic, etc. The amount of these metals at MGP sites varies with the gas manufacturing process and with subsequent uses of these properties. These metals are nonvolatile but are potentially dispersed as inhalable and respirable particles. DHFS review of metal concentrations in soil data from MGP sites indicates that the public is adequately protected from metal exposure when dust control measures are followed and ambient air quality standards (PM_{10}) for particulates are met. Further public health review might be necessary at sites having extensive metal contamination from more recent activities.

Cyanides. Cyanide wastes at MGP sites exist mostly as stable iron cyanide complexes, such as ferric ferrocyanide, which are associated with oxide box wastes common to coal gas sites. A small percentage (< 5%; Luthy *et al.* 1994) of the total cyanide-containing

waste is in the form of less stable metallo-cyanides and cyanide salts. The potential for free cyanides to be released from these materials into groundwater is a topic that has received both scientific and regulatory attention (Ghosh, *et al.* 1999a, 1999b; EPA 2003d). The release of cyanide to air at MGP sites is theoretically possible, but because such releases would occur from very slow dissociation of iron cyanides followed by rapid volatilization and dissipation, this is unlikely to be an exposure issue. DHFS has identified no public health concern from cyanide exposure to the general public at the site perimeter. Still, prudent

Table 1. Composition of MGP wastes (From Gas Research Institute 1996). Chemicals in bold have been found to be an environmental or public health concern in soil, sediment, and groundwater at MGP sites in WI.

Inorganics	Metals	VOCs	Phenolics	PAHs
Ammonia	Aluminum	**Benzene**	Phenol	Acenaphthene
Cyanide	Antimony	**Ethyl**	Methyl	Acenaphthylene
Nitrate	Arsenic	**Benzene**	phenol	Anthracene
Sulfate	Barium	**Toluene**	Dimethyl	**Benzo(a)anthracene**
Sulfide	Cadmium	**Xylenes**	Phenol	**Benzo(a)pyrene**
Thiocyanates	Chromium	**Styrene**		**Benzo(b)fluoranthene**
	Copper			Benzo(g,h,i)perylene
	Iron			Benzo(k)fluoranthene
	Lead			**Chrysene**
	Manganese			**Dibenzo(a,h)anthracene**
	Mercury			Dibenzofuran
	Nickel			**Fluoranthene**
	Selenium			Fluorene
	Silver			**Indeno(1,2,3-cd)pyrene**
	Vanadium			**Naphthalene**
	Zinc			Phenanthrene
				Pyrene
				2-Methylnaphthalene

management of worker safety at MGP sites suggests that cyanide should be monitored in air within the work zone when Prussian Blue soils are encountered.

Sulfur compounds. Sulfur-containing compounds, produced by pyrolysis or combustion of coal, are common in soil and groundwater at MGP sites. This is especially true in oxide box wastes, which may contain 40% sulfur oxides (Luthy *et al.* 1994). Pulmonary damage from sulfur-containing materials, particularly sulfur dioxide (ATSDR MRL=10ppb), are well known (Kleinman 2003) but have not been well addressed as an

air issue during MGP remediations. Sulfides (S^{2-} ; metal-sulfur compounds), sulfates (SO_4^{2-} ; compounds of oxygen and sulphur combined with one or more metals), and sulfites, where present, are predictably dispersed with soil and dust particles during MGP excavations. At this time, DHFS recommends that non-volatile sulfur compounds be managed in the context of NAAQS for particles discussed above.

Table 2. Toxicity, odor, volatility, and relative prevalence of major volatile compounds in air at MGP sites.

				Prevalence in air at one example MGP site[c]	
	Toxicity RBC ppb[a]	Odor threshold ppb [b]	Vapor pressure mmHg, 68F	Excavation (total volatiles= 4103 µg/m^3)	Perimeter (total volatiles = 1117 µg/m^3)
Benzene	**10**	**61,000**	**75**	**21.7%**	**7.7%**
Naphthalene	**0.6**	**40**	**0.08**	**46.3%**	**6.3%**
Xylenes	**23**	**20,000**	**7**	**11.5%**	**56.4%**
Toluene	**106**	**1,600**	**21**	**8.3%**	**17%**
Styrene	**235**	**140**	**5**	**Not reported**	**Not reported**
Ethylbenzene	**230**	**100-600**	**7**	**11.9%**	**12.5%**

[a]EPA, *Integrated Risk Information System, 2004.* Reference concentration chronic inhalation.
[b]AIHA 1989
[c]Collins *et al.* 1999

Developing Air Quality Goals and Action Levels

Recommended sentinel compounds. Many different volatile chemicals are present in MGP wastes, but on-site air management decisions are usually based on the monitoring of just a few of these (Collins *et al.* 1999). The choice of representative sentinel compounds in an air management plan should be based both on the risk imparted by a compound's prevalence and toxicity, as well as the analytical ability to detect these compounds. The odor threshold of particular VOCs also factors into their inclusion as a sentinel compound, since tar odors around MGP excavations speaks directly to public risk perception surrounding the remediation work. MGP projects often extrapolate from the fuel spill model, choosing the BTEX group (benzene, toluene, ethylbenzene, xylenes) as representative VOCs. Other candidate sentinel compounds should be considered, based on environmental assessment. For example, groundwater from an MGP test well in Wisconsin having 23,000 µg/L total VOCs included, as prevalent compounds, benzene (29%), naphthalene (31%), xylenes (17%), styrene (6%), and toluene (12%) (Dames and

Moore 2000). Other PAHs, including acenaphthene, fluorene, anthracene, fluoranthene, and pyrene comprise a small percentage of volatile chemicals detectable in air (Collins *et al.*1999). DHFS recommends choosing sentinel compounds at each remediation based on prior environmental assessment. However, based on prevalence, toxicity, volatility, and odor, benzene and naphthalene tend to define the volatile mixture around MGP sites (Table 2). Notably, the proportion of each of the major volatiles may not be the same in the excavation zone as at the perimeter (Table 2), indicating the need for separate air monitoring in the work zone and the perimeter. The minimum perimeter air monitoring recommended by DHFS would include total VOCs and benzene, using instruments sensitive to intermediate and maximum action levels defined in the site air management plan.

Development of action levels.

Action levels vs. ambient air standards. During the review of air management plans (AMP) at MGP sites in Wisconsin, there has been discussion over the term "Action Level." There has also been much discussion of whether action levels should be created as policy benchmarks for MGP work. Some of this discussion is clarified by defining action levels as distinct from an air quality standard or guideline. For the purposes of public health, action levels proposed within an air management plan are a site management tool used to maintain existing air quality standards and guidelines at the unsecured perimeter. These ambient (daily and annual) air quality standards and guidelines already exist for common VOCs and particulates.

There is no single set of ambient air quality rules for compounds of concern at MGP sites. The ambient air goals recommended by DHFS are a combination of enforceable standards (*e.g.* National Ambient Air Quality Standards; NR 445 Ambient Air Standards) and non-enforceable guidelines (*e.g.* ATSDR Minimal Risk Level; EPA Risk-Based Concentration). The NAAQS for total particulates (PM_{10}, 24 hour average) is 0.150 mg/m^3. The guideline numbers for VOCs (Table 4) are presented where federal or state standards are absent. These guidelines are health-based environmental concentrations below which no harm is expected to the general public.

DHFS relies on existing ambient air standards and guidelines when asked to evaluate air monitoring plans and air monitoring data for MGP projects. The efficacy of action levels proposed in the AMP is ultimately defined by their ability to meet established standards and guidelines at the site perimeter. The action levels needed to protect public health could vary with the distance from the unsecured perimeter to the excavation, with the distance from the perimeter to stationary receptors such as residences or businesses unrelated to the MGP, with the time of year, and with the sensitivity and frequency of the monitoring program. Table 3 lists action levels that have been used successfully to maintain ambient air quality at several sites in Wisconsin. These action levels were used at sites using minimal air monitoring and sampling, and having low population density at the site perimeter. DHFS recommends that these action levels be used as a starting point in developing the site AMP. However, higher concentration action levels have been used

(GZA 2003) to maintain air quality in urban residential settings, but using sophisticated real-time air monitoring techniques. In either case, DHFS would make the same recommendation: maintain 24-hour ambient air quality within existing health-based standards and guidelines, and further reduce nuisance odors as needed to meet community health needs and avoid odor complaints.

Two other points to consider in developing the AMP are first, that air management performance must be verified with time-weighted (8 or 24 hour) air sampling. Second, it is likely that during the excavation of coal tars, air quality will intermittently exceed the ambient air goals for periods that are brief enough to still maintain ambient air quality over the 24-hour cycle. Assuming the site will be managed to keep peak releases brief, these brief releases should still be held within some "maximum." Occupationally, this maximum would correspond to either a ceiling value or a 15-minute time-weighted average (TWA). But, no formal brief exposure standards exist for the general public that would correspond to the 15-minute occupational TWA. However, using a standard uncertainty factor of 10 for extrapolating from "normal" to "sensitive" humans, intermittent releases should not exceed, at the perimeter, one-tenth of the 15-minute time weighted average for either specific compounds or total VOCs. Table 4 contains recommended 15-minute maximum concentrations for perimeter air quality.

Air management plan action levels should provide immediate feedback needed to minimize air releases from the site. A prescribed set of site-specific responses should be proposed to accompany each action level. Table 3 lists a simple set of responses. Many AMPs use a more detailed decision tree or flow chart that integrates the various factors that enter into site management decisions (*e.g.* Lingle *et al.* 2000, Symonik *et al.* 1999) Environmental consultants and site managers are encouraged to develop and employ action levels that focus on achieving odor control rather than merely staying within short-term and 24-hour air standards.

DHFS recommends that air management plans use both intermediate and maximum action levels (Table 3). The response to exceeding an intermediate action level would be to monitor continuously and begin steps to mitigate air releases. Exceeding a maximum action level should result in immediately ceasing work until the air release is controlled. Continuing the excavation or material handling might require a shift in work strategy, such as more stringent air management techniques, or working on another part of the project until cooler or less windy conditions prevail. The use of intermediate action levels can be used to more closely anticipate releases and establish protocol for intermediate air management responses that will help avoid work stoppages.

Background exposure to VOCs. The development of action levels should consider that many MGP components have a background presence in ambient air. Background monitoring should be conducted prior to any excavation. The development of action levels should consider that public exposure VOC and PAH releases during excavation of MGP sites will rarely be zero due to the background presence of VOCs and PAHs. For example, in St. Paul, Minnesota (Sexton *et al*. 2004), personal air samplers placed on 71

non-smoking adults revealed that during normal daily activities, these adults were exposed to benzene (7.6 µg/m^3), toluene (30.3 µg/m^3), and xylenes (27.8 µg/m^3).

Occupational guidelines are inappropriate air quality goals at the MGP site perimeter. Another point occasionally requiring clarification is the gap between occupational and public health standards. Occupational standards are designed for exposures of workday duration to healthy, non-pregnant adults. Public health standards account for sensitive individuals and longer exposure duration. In some cases public health standards are extrapolated from occupational standards; in other cases they are based upon separate experimental models. Perimeter action levels should trigger steps to maintain public ambient air quality while occupational standards should be used for air management decisions in the worker breathing zone. Unadjusted TLVs for ambient air at or beyond the perimeter of any site are not sufficiently protective of public health, whether the site is in a residential or commercial setting.

Table 3. Recommended range of action levels and interventions for perimeter air quality at former manufactured gas plant excavations.

Air Monitoring Location	Recommended DHFS Action Level (ppm)	Recommended Interventions When Action Levels are Reached or Exceeded
VOCs at Site Perimeter	0.1 to 1.0 total VOCs	-worker breathing protection -test for benzene
Benzene at Site Perimeter	0.1 to 0.5 benzene	-halt site activities
Particulates at Site Perimeter	0.150 to 1.0 mg/m^3 total particulates	-initiate dust control measures

Air monitoring methods

Perimeter air monitoring should be a part of the work plan at every MGP remediation site. The site workplan should include an air sampling protocol including: 1) location of sampling stations, 2) the sampling interval, 3) target substances (or surrogate), 4)

detection limit of target substances, 5) the action level and planned response for each target substance, 6) meteorologic conditions concurrent with sampling.

Air monitoring techniques for the MGP site perimeter. Although perimeter air monitoring should be a part of the work plan at every MGP remediation site, there is no single air monitoring approach best suited or appropriate for all sites. A number of methods are available, ranging from automated real-time gas chromatography to hand-held devices such as photoionization detectors. Automated gas chromatography has been used effectively to measure sentinel compounds around MGP sites and provide results in continuous 15 minute cycles. This feedback effectively teaches project officers how to manage their sites to avoid air emissions that affect both site workers and the off-site public. Real time air monitoring is particularly useful at sites that are technically complex and densely populated. Because of the cost and complexity of such a system, hand-held instruments may be appropriate at sites that are small, isolated, or where the duration of the excavation is relatively brief. To be useful for air monitoring at the site perimeter, the detection limit of the method used should be less than the intermediate action level agreed upon in the site Air Monitoring Plan. Alternatively the detection limit should be 2.4% of the occupational 8-hour time-weighted average for the substance being monitored, where 2.4% extrapolates from work week to full time exposure and incorporates a 10-fold uncertainty factor (40 hr/160 hr x 1/10 = 2.4%).

Table 4. DHFS-recommended 24-hour and short-term perimeter air quality values for MGP remediation sites.

	Acceptable 24-hour average concentration (ppb)	DHFS-Recommended Maximum	
		15 minute (ppb) [d]	Peak (ppb) [f]
Benzene	10 [a]	500	2,500
Naphthalene	20 [b]	15,000	*
Xylenes	23 [a]	15,000	*
Toluene	94 [a]	30,000	50,000
Styrene	235 [a]	10,000	20,000
Ethylbenzene	230 [a]	12,000	*
PM_{10}	0.150 $\mu g/m^3$ [c]	1.0 $\mu g/m^3$ [e]	*

[a] U.S. EPA reference concentration (RfC) for lifetime exposure.
[b] DHFS-derived 14-day acute exposure.
[c] National ambient air-quality standard for PM_{10} (particulate matter < 10 um).
[d] One-tenth of corresponding U.S. Occupational Safety and Health Adminstration value except where specified.
[e] ACGIH
[f] One-tenth of corresponding American Conference of Governmental Industrial Hygienists value.
*Occupational value not available.
ppb: parts per million

Instrumentation

Drager tubes. Drager tubes and similar single-use chemical detection tubes have limited application for perimeter air monitoring at MGP sites. Because of limited sensitivity, short shelf life, and high variability, they are best used semi-quantitatively, such as to determine if a specific contaminant is present. They are not recommended to measure the air contaminant concentrations at the site perimeter needed for making action level decisions (GRI 1996). Additional analysis is needed for any positive contaminant hit on a Draeger Tube. Detection limits published for compound-specific Draeger Tubes are: benzene (0.5 ppm), toluene (50 ppm), xylenes (10 ppm), styrene (1 ppm) (AFC International Inc. 2003. http://www.afcintl.com/tubeac.htm)

Photo-Ionization Detector. Hand-held photo-ionization dectectors (PID) capable of detecting 1 ppb total organic vapors or 100 ppb benzene are commercially available, and are more sensitive and easier to use that gas detection tubes. Of particular note are benzene-specific PIDs. Because benzene at low concentrations (50 ppb; Table 3) often defines the toxicity of the MGP-related VOC mixture, low-concentration field screening for both benzene and total VOCs is recommended

Laboratory analysis using SUMMA canister samples. Up-wind and down-wind ambient air sampling for VOCs using EPA Method TO-14 or TO-15 from SUMMA canisters samples at locations where site perimeter monitoring with a PID detects greater than 0.5 total VOCs. In most cases, an up-wind and down-wind sample should be collected for VOCs at least once every three days regardless of the PID measurements.

Particle monitoring. Consistent with monitoring VOCs, monitoring particulates should employ a combination of real-time techniques for making action level decisions and time weighted techniques to verify compliance with NAAQS. A variety of separation and capture techniques are available for time-weighted sampling, including cyclonic separators, cascade impactors, and filters. Portable and semi-portable particle meters are available for instantaneous readings. An issue responsible parties should be aware of is the current shift from PM_{10} to $PM_{2.5}$ as the NAAQS. At this time, DHFS and DNR recommend continued use of the Federal Reference Method (FRPS 1287-065 or equivalent; U.S. EPA 2003c) for PM_{10} as more appropriate for construction-phase activities at MGP sites, and continued use of the 1 mg/m^3 action level.

Portable GC/MS. Gas chromatography/mass spectroscopy (GC/MS) has seen increasing use during MGP remediations. Semi-portable automated GC/MS systems have been developed that send results, over a 15 minute cycle, to a central monitoring location (GZA, 2000). Several GC/MS stations, placed around the perimeter of an MGP remediation, are used to simultaneously monitor an entire site, and to provide real-time feedback for making air management decisions. This system is expensive to employ, and the overall air mitigation performance is less than that of an enclosure. However, for sites where stringent air management is needed, but an enclosure is not possible, this is a useful method. GC/MS is also available in portable suitcase-sized units. A useful application of portable GC/MS is to provide sensitive field screening for VOCs in neighborhoods where there have been odor complaints. At some sites, local vagaries in

wind patterns raise the possibility that air releases are carried to locations not predicted by perimeter air monitoring. Portable VOC detection using GC/MS is a sensitive means to provide verification and reassurance to the public.

Gas Chromatography with Surface Acoustic Wave detector (GC/SAW) is a portable GC method that is sensitive to naphthalene and larger molecular weight volatiles and semi-volatiles. Field-portable GC/SAW instruments (e.g. zNose, Electronic Sensor Technology, Newbury Park, CA) have being promoted for use during MGP remediations (GEI 2004).

Mitigation techniques.

Seasonal timing. Seasonal timing of an MGP excavation can have an important effect on air management strategies. In Wisconsin, as in other temperate regions, excavating MGP sites during cold weather simplifies many of the public health issues related to the remediation work. During cold weather, exposed hydrocarbons are less volatile, neighbors keep windows and doors closed, and there is generally less foot traffic. Direct benefits to site managers include fewer odor complaints and less need for foam and surfactants for odor control. DHFS recognizes there are problems with extreme cold weather work, including machinery failure, work stoppages, and ice-fouled water lines. Odor control techniques become more complicated when overspray from surfactants or misting systems create icy roads, and when plastic sheeting becomes stiff and brittle. Of all of these factors, DHFS believes that the simple fact that doors and windows are closed in winter has the greatest effect on minimizing public perception of the odor issue, thereby increasing public acceptance of MGP remediation projects.

Dust and odor control methods. The use of dust and odor control methods at MGP sites is commonplace and includes some combination of water, physical barriers such as plastic sheeting, wind screens, surfactants, and other chemical coatings such as foams (GEI 1996, sec. 12.4.2; U.S. EPA. 2003b). Perimeter misting systems supplemented with odor-masking perfumes have recently been used in Wisconsin. Scents added to the mist masks low concentrations of objectionable VOCs, but does not remove these VOCs from air. The mist does prevent dispersion of particulates, but only to the extent that precipitation follows interception. During hot or windy conditions, dispersion may still occur. Control of releases from source areas is still the primary mitigation technique. These various techniques and systems vary in cost and applicability. Ultimately, their effective use depends on the experience and judgement of on-site managers.

Excavation methods are another technique for reducing dust and odors. Most often cited is minimizing the excavation face combined with odor-encapsulating foam. A special form of excavation is Cassion-drilling, in which large-diameter drills (6 feet or more) bring up contaminated soil which can be immediately stabilized with cement and replaced in the drill hole. In terms of causing air releases, this technique presents the contrast of vigorously churned material, which enhances release, combined with a

minimal and intermittent excavation face that limits air releases. At this time it is unclear how much air monitoring and dust and odor control is needed to ensure public safety when Cassion drilling is used.

Enclosure methods. Many former MGPs were located on sites that now see urban-density commercial or residential uses. Public acceptance of excavation work at such sites may require the most stringent methods to control air emissions. A temporary structure, combined with an air purification system, is often the most effective way to control emissions. Temporary structures can also effectively enclose certain operations, such as the on-site oxidative treatment of coal tar, that would not otherwise be possible. Temporary structures have several disadvantages, such as rental and installation costs, scheduling constraints, limited interior space, and requirements for respiratory protection (Pluhar 2004). During the limited use of enclosures at MGP sites in Wisconsin, DHFS has seen that air releases of VOCs and particulates have been controlled to within public health guidelines, but that coal tar odors can still be irritating to adjacent residents (DHFS 2002). Although the aim of using enclosures is to preclude the displacement of sensitive residents, project managers are advised to carefully evaluate whether a proposed enclosure will actually meet community needs. More recent developments in enclosure methods include "air lock" doorways that address a key weakness in enclosure design (Pluhar 2004). DHFS will review field performance reports of improved enclosure designs as they become available.

Establishing the on-site decision making process.

Action Level response plan. Where MGP work is in close proximity to residences, odor and health complaints from the public should be anticipated. The health and safety plan or air management plan for each MGP remediation project should include contingency plans of actions that can be taken to intervene and prevent inhalation exposures to the public.

Contingency plan. MGP remediation consultants should anticipate that on certain days, it may not be possible to maintain ambient air quality with the tools they have available. In addition to stated actions when intermediate and maximum action levels are exceeded, the air monitoring plan for each site should include discussion of such contingencies. Contingencies might range from rescheduling site actions to offering temporary relocation of residents.

Summary.

This guidance was developed both to protect public health around MGP remediation projects and to help those projects proceed smoothly. One key to effective air management and public outreach at MGP remediation sites is collaboration among public health, environmental agencies, and responsible parties. DHFS experience at MGP sites in Wisconsin was used to illustrate how to anticipate community health needs and to create partnerships with state and local health agencies during the course of the remediation. Because the amount of air management and public outreach needed varies with each site, this guidance avoids being overly prescriptive. However, in order for

health departments to approach the community with credibility, some minimum air management and community health goals are recommended.

Conclusions

- Air management plans at MGP remediations in WI have been largely successful in meeting 24-hour air standards and guidelines for ambient air.
- Even where 24-hour health-based standards and guidelines are met, tar odors are typically evident.
- The control of tar odors plays an important role in the public's acceptance of the MGP remediation project.
- At sensitive locations, building public acceptance for an MGP project entails a combination of public outreach efforts and a stringent air management plan.

Recommendations

- Air quality at the unsecured perimeter of MGP remediation sites should meet existing public health-based 24-hour standards and guidelines for ambient air.
- Site air management plans, including monitoring and mitigation methods, and action levels, should be designed to protect perimeter air quality.
- Neighbors of MGP excavations should be able to avoid tar odors within their homes with doors and windows closed. Meeting this goal should focus on site management, but might also entail special accommodations for neighbors.
- At locations when MGP work will affect the public, detailed plans should be developed for risk communication, accepting and responding to complaints from the public, and accommodating individuals with special needs. Developing these plans usually entails discussion and advance agreement among major stakeholders.

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Abbreviations used. VOC: volatile organic carbon. PAH: polycyclic aromatic hydrocarbon. ATSDR: Federal Agency for Toxic Substances and Disease Registry. MCL: ATSDR's Maximum contaminant Level. NAAQS: National Ambient Air Quality Standard. GC/MS: gas chromatography/mass spectroscopy. PM: particulate matter.