

# Health Consultation

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Evaluation of Health Concerns Associated with Outdoor Wood  
Boiler Use in a Rural Subdivision in Kenosha County, Wisconsin

**Prepared by the  
Wisconsin Department of Health Services**

MAY 21, 2010

Prepared under a Cooperative Agreement with the  
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES  
Agency for Toxic Substances and Disease Registry  
Division of Health Assessment and Consultation  
Atlanta, Georgia 30333

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In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR or ATSDR's Cooperative Agreement Partner which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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## HEALTH CONSULTATION

Evaluation of Health Concerns Associated with Outdoor Wood  
Boiler Use in a Rural Subdivision in Kenosha County, Wisconsin

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### Summary and Statement of Issues

In the Fall of 2008 and Winter of 2009, the Wisconsin Department of Health Services (DHS) and the Kenosha County Health Department (KCHD) received a series of complaints from a homeowner in Kenosha County, Wisconsin, regarding health concerns stemming from the operation of an outdoor wood boiler (OWB) unit by another resident of their rural subdivision. The OWB was installed in October of 2008, and is in operation year-round. The complainant, and members of the complainant's family, claimed that emissions from the OWB were causing or exacerbating a number of health conditions, including asthma, cardiovascular illness, cancer and seizures. The main public health concern and exposure pathway associated with operation of this OWB is the inhalation of particulates and other toxic chemicals released from the combustion of wood smoke.

On January 5, 2010, DHS and KCHD performed a joint investigation of particulate levels in the vicinity of the residential OWB in Kenosha County, WI, and DHS has reached the following conclusions in this health consultation report:

*Conclusion 1. DHS concludes that under typical conditions, brief, occasional smoke exposure can be expected to people living directly downwind of the operating OWB. Based on limited available exposure information, this exposure is not expected to have harmed the health of non-sensitive nearby residents.*

*Basis of decision. Nearby homeowners are likely exposed intermittently to PM<sub>2.5</sub> concentrations considered mildly to moderately elevated. However, due to the distance to neighboring homes and variations in atmospheric conditions, it is unlikely that prolonged exposures to harmful levels of PM<sub>2.5</sub> occur as a result of OWB usage in this subdivision. The worsening of existing respiratory and cardiovascular conditions is possible from occasional elevations in fine particulate levels. In contrast, there is a lack of evidence supporting a link between OWB use in this neighborhood and the *causation* of cardiovascular illness or cancer.*

*Conclusion 2. Under certain unusual atmospheric conditions, the emission of wood smoke from OWB operation and other sources may harm the health of individuals with pre-existing respiratory and cardiovascular sensitivities.*

*Basis of decision. Unusual atmospheric conditions that prevent the dispersion of locally produced smoke particulates could contribute to poor air quality lasting more than 24 hours.*

*Next Steps: DHS will continue to encourage the local regulation of open or outdoor burning, including OWBs. DHS is available to assist village, township, city and/or county officials to develop an OWB/Open Burning Ordinance, in an effort to reduce the likelihood of citizens being exposed to OWB emissions, and provide the basis to resolve conflicts when complaints arise. In addition, DHS will make available particulate monitoring equipment and technical guidance to the KCDH, should additional complaints of wood smoke arise in this, or other, neighborhoods in Kenosha County.*

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## **Background**

### ***OWB basics***

OWBs, or outdoor hydronic heaters, are free-standing wood furnaces consisting of a firebox surrounded by an insulated water jacket (Appendix A). Insulated pipes transport cool water to the water jacket, where it is heated and returned to the home to provide hot water for various uses. OWBs are designed to require little maintenance, having large fireboxes capable of accommodating large wood loads that can burn for many hours without tending. The burn rate is controlled by a thermostat in the home that alters the amount of air supplied to the firebox for wood combustion. When the thermostat reaches its desired temperature setting, the firebox is deprived of oxygen, causing the wood to smolder until more heat is needed.

### ***Public health concerns surrounding OWB use in residential settings***

OWBs can create air quality problems for neighbors, due to high smoke output and poor smoke dispersal. Because OWBs smolder when the homeowners require less heat, they generate greater smoke emissions than most other wood furnaces. According to EPA studies, OWBs produce roughly 12 times more particulate smoke than an EPA-certified indoor wood stove (Houck and Tiegs 1998). OWB operators should only burn dry seasoned wood. Burning wet, damp, or green wood reduces the efficiency and heat output of the OWB, and increases particulate emissions. For example, green wood can have a moisture content as high as 50% (NY EPB 2005). The excess moisture in freshly cut or damp wood must be expelled as steam before the wood can burn properly, resulting in a large reduction in energy generation for the home. Additionally, when energy is diverted to heat water into steam, the fire temperature is decreased, leading to incomplete wood combustion and an increase in the emission of unburned particulates.

Improper installation of OWBs in residential areas is another potential cause of public health concern. OWBs are often operated with smoke stacks much shorter than conventional fireplaces and wood stoves, and at locations too close to neighboring homes. The least stringent recommendations suggest a separation distance between OWBs and neighboring homes of at least 100-300 feet, and if between 100-300 feet, the smoke stack should be at least 2 feet above the neighbor's roof line.

### ***Health concerns associated with wood smoke exposure***

Wood smoke is comprised of a long list of chemicals including water vapor, carbon dioxide, various hydrocarbons, organic acids, aldehydes, and oxides of sulfur and nitrogen. These chemicals are emitted as both volatile gases and particulates (Larson 1993). Particulates are condensed mixtures of chemicals and solid aerosols produced during the incomplete combustion of biomass. The fraction of particles less than 2.5 $\mu$ m in size, known as PM<sub>2.5</sub>, are small enough to be inhaled into the deepest part of the lungs, where they can enter the blood stream and contribute to inflammation of tissues in the lungs, heart, and vasculature. Although the precise composition of wood smoke is influenced by variables such as the fuel source, the combustion temperature, and the combustion appliance, it is estimated that 93% of the particulate emissions from wood combustion are in the PM<sub>2.5</sub> range (Houck and Tiegs 1998). In the case of wood smoke from OWBs, an important feature influencing exposure is the common use of short smokestacks that release emissions close to the ground.

### *Conflicts over OWB use in residential settings*

Due in large part to increasing energy costs, there has been a surge in OWB sales in the US in recent years, especially in rural and semi-rural areas of the Northeastern and upper Midwestern states. It is estimated that over 27,000 OWBs were purchased in Wisconsin from 1990 to 2006, second in the US behind only Michigan (NESCAUM 2006). The increasing popularity of residential OWBs in Wisconsin in recent years has resulted in a corresponding increase in air quality complaints from neighbors of OWB operators. Concerns are focused on the potential health impact of regular or occasional wood smoke inhalation and a reduction in the enjoyment of one's property. These complaints are directed toward DHS, WDNR, local health departments, and other local officials.

Although a few states have instituted statewide regulations on the operation of OWBs, Wisconsin does not currently have a similar statewide ordinance. A handful of local municipalities in Wisconsin have adopted ordinances requiring minimum setback distances and stack heights for OWBs, but in the vast majority of the state they are unregulated. In the unregulated portions of Wisconsin, the recourse of OWB complainants is limited to:

- 1) The initiation of private litigation against the operator.
- 2) Requesting assistance from one's local and/or state health department to investigate the OWB as a potential human health hazard.
- 3) Lobbying local officials to adopt an ordinance regulating OWB usage in their jurisdiction.

## **Discussion**

### *Exposure Pathway Analysis*

With regard to operation of the OWB in Kenosha County, WI, the main exposure pathway identified and investigated by DHS was the emission of combustion particulates from the OWB, and their potential for inhalation.

### *Description of OWB in Kenosha County, WI*

On January 5, 2010, representatives from DHS and the Kenosha County Health Department made an unannounced, mid-morning visit of the area and observed the OWB operating under approximate conditions of 18°F and a west or northwest 10-mph wind. The OWB was manufactured by Johnson Furnaces (model: Big John), and is fitted with an eight-foot stack that places the stack height 16 feet above ground. The unit is not an EPA phase I or phase II model. A hand-held DustTrak particle meter was used to measure particulate matter (PM<sub>2.5</sub>) levels both upwind and downwind of the operating OWB. There were no houses downwind on that day, but the distances measured were chosen to simulate distances to 7 houses located within 550 feet (*Appendix C; locations A-G*).

### *Data summary*

The highest levels of PM<sub>2.5</sub> (96 – 120 µg/m<sup>3</sup>) were found roughly 200 feet from the operating OWB, with concentrations dissipating beyond that distance. We detected PM<sub>2.5</sub> of 30-40 µg/m<sup>3</sup> at a distance of approximately 400 feet downwind of the operating OWB. Beyond 550 feet, particulate measurements dropped to background levels. Downwind detections of elevated

particulates were found within a narrow plume; PM<sub>2.5</sub> was at background levels when measured approximately 30° off the direction of the visible smoke stack plume (*Appendix C; location H*).

*Table 1.* Particulate monitoring results from January 5, 2010 investigation in Kenosha County.

Location	A	B	C	D	E	F	G	H
Direction	↑ wind	↓ wind	↓ wind	↓ wind	↓ wind	↓ wind	↓ wind	30° offwind
Distance from OWB (feet)	50	50	200	300	400	500	650	500
PM <sub>2.5</sub> Level (µg/m <sup>3</sup> )	12	13	96 - 120	30 - 40	30 - 40	19 - 28	12	12

↑ wind= up wind location; ↓ wind= downwind location

Measuring air quality at an outdoor location on a single day has limitations due to the variable nature of weather, and its effect on smoke dispersion. Additional work would be required to ensure strict accuracy of the instrument under the field conditions around this OWB. That said, the atmospheric conditions on January 5, 2010, and the observed patterns of smoke dispersion, appeared to be within the range of typical conditions as judged by county health department field staff.

### ***Exposure assessment***

It is expected that on any given day, one or more nearby houses could lie downwind of the OWB in this rural Kenosha County, WI neighborhood. Outdoor wood-fired boilers emit smoke that ends up concentrated at near-ground-level; eleven nearby houses are located at a GIS-estimated distance of 250 to 750 feet. Of these, the complainant’s residence, located northwest of the OWB operator’s residence, is most distant. Most or all of the neighboring houses lie at a slightly higher elevation than the OWB. For these reasons, residential spacing is critical in order to avoid the creation of health hazards and/or smoke nuisance complaints. There is no minimum spacing that works in all conditions, but the WDNR Model Open Burning Ordinance suggests 300-500 feet (WDNR 2004). At this Kenosha County, WI site, the houses are spaced at approximately the maximum density at which the WDNR would recommend unregulated OWB use. Under unusually stagnant weather conditions, emissions from the OWB could occasionally cause unhealthy air quality for the residence of the OWB owner or for downwind residences. Under more typical wind conditions reported here, it appears the OWB may affect one or more houses in the range of the plume occasionally, but no single house continuously.

Under the conditions of low concentration and intermittent exposure observed near the operator’s OWB, those most likely affected with symptoms would be individuals with preexisting lung conditions or sensitivities. It is noteworthy that smoke from wood burning and other combustion sources contain carcinogens. However, reports of cancer in the vicinity of this subdivision in Kenosha County, WI would not be expected to result from recent operation of an OWB. Cancer does not develop immediately, even after chronic and concentrated exposure to a cancer-causing agent. There is a typical period of 15 to 30 years between exposure to a carcinogen and medical diagnosis of cancer (WDHS 2002). Similarly, reports to the KCHD of neurological seizures following exposure to wood smoke would not be expected.

### Public Health Implications

Although it is well known that combustion particulates contain harmful chemicals, the potential for harm from exposure to particulates depends upon their concentration and the duration of exposure. PM<sub>2.5</sub> levels are currently used as the best single indicator of the health impacts of most combustion sources (Naeher 2007). The National Ambient Air Quality Standard (NAAQS) for atmospheric particulate matter averaged over a 24-hour period is 35 micrograms of PM<sub>2.5</sub> per cubic meter of air (35 µg/m<sup>3</sup>) (EPA 2010). When particulate concentrations exceed this standard, there is an increased potential for harm, especially to those who are most sensitive. The increased sensitivity may be due to preexisting conditions such as asthma, chronic bronchitis, or cardiovascular disease. The PM<sub>2.5</sub> NAAQS is designed for application to regional air quality. There is not a corresponding standard for local air quality such as might be found in the neighborhood of an operating OWB. It is DHS practice, when measuring local air quality, to state that if the concentration of PM<sub>2.5</sub> is sustained at levels greater than 35 µg/m<sup>3</sup> over 24 hours, it is consistent with regional conditions under which the DNR would issue an Air Quality Advisory (WDNR 2010). Under the Advisory, citizens are asked to limit burning, driving, lawnmower use, *etc.*, and sensitive individuals would be asked to avoid exercise and other activities that would increase their respiratory stress and exposure.

PM<sub>2.5</sub> in the environment is not unique to smoke from outdoor wood boilers. Particulates are emitted from many combustion sources including vehicle exhaust, cigarette smoke, gas furnaces, indoor fireplaces and wood stoves, and industrial smoke stacks. The effects of exposure to wood smoke can be both short-term and long-term and are related to pulmonary and cardiovascular inflammation caused by irritating and oxidizing substances found in smoke, or to substances in smoke that are metabolized to forms that damage cells.

### Child Health Considerations

Children are a primary concern when evaluating the risk posed by toxic substance exposure in a community. The comparison values used in evaluating exposures should consider the entire community, including children, when possible. Children play outdoors and sometimes engage in hand-to-mouth behaviors that increase exposure potential. Children have increased relative respiration rates and surface areas, predisposing them to greater relative exposures. If children are exposed to higher levels of contaminants during critical growth stages, their developing body systems can sustain permanent damage. Therefore, it is important to impose exposure guidelines that carefully consider the enhanced susceptibility of children to toxic insults. Of note, the guidance value used by DHS in OWB cases is the EPA NAAQS for fine particulates (PM<sub>2.5</sub>), which is protective of sensitive populations such as asthmatics, children, and the elderly.

### Conclusions

DHS reached the following conclusions regarding the operation of an OWB in a rural subdivision of Kenosha County, WI:

- *Under typical conditions, brief, occasional smoke exposure can be expected to people living directly downwind of the operating OWB. Based on limited available exposure information, this exposure is not expected to have harmed the health of non-sensitive nearby residents. Under the variable atmospheric conditions most commonly present*



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regionally, wood smoke particulates from the operation of the OWB described here are emitted in a narrow plume. The narrow and variable nature of the plume, combined with the existing spacing of the residences in the area, is the basis of the conclusion that wood smoke from the OWB typically does not create conditions that continuously affect the health of those living nearby.

- *Unusual atmospheric conditions such as thermal inversion and low wind dispersion the emission of wood smoke from OWB operation and other sources can contribute to high concentrations of combustion-related particulates lasting more than 24 hours. These atmospheric conditions may harm the health of individuals with pre-existing respiratory and cardiovascular sensitivities.*

## **Recommendations**

In follow-up to the investigation of particulate levels in the vicinity of an OWB in Kenosha County, WI, DHS recommends the following actions:

- Given the marginally sufficient residential spacing at this location, regulation of open or outdoor burning, including outdoor boilers, is warranted to avoid future conflicts over smoke emissions. *Examples of possible regulatory measures might include establishing minimum setback distances to neighboring property, ensuring that only clean, dry firewood is used as fuel, and limiting or banning OWB use during the warm seasons when windows are open, or when the region is under an air quality advisory.*

## **Public Health Action Plan**

The public health action plan (PHAP) identifies actions that have been or may be taken to protect the health of homeowners living near an OWB in a rural subdivision in Kenosha County, WI. The PHAP ensures that public health hazards have been identified and that a plan of action is established to halt or prevent unsafe exposures to hazardous substances in the environment.

### Actions that have been taken by agencies for this case include:

- DHS assisted KCDH in an environmental investigation to assess the health concerns associated with operation of the OWB in question.
- The results of the DHS/KCHD investigation were shared with the OWB operator, the complainant neighbor, and the Town chairman.

### Current and future actions to be implemented by agencies involved in this case include:

- DHS will make available particulate monitoring equipment and technical guidance to the KCDH, should additional complaints of wood smoke arise in this, or other, neighborhoods in Kenosha County.
- DHS is available to provide education to the citizens and officials of Kenosha County on proper OWB usage and the health concerns associated with regular exposure to wood smoke.
- DHS is available to assist village, township, city and/or county officials to develop an OWB/Open Burning Ordinance, in an effort to reduce the likelihood of citizens being exposed to OWB emissions, and provide the basis to resolve conflicts when complaints arise.

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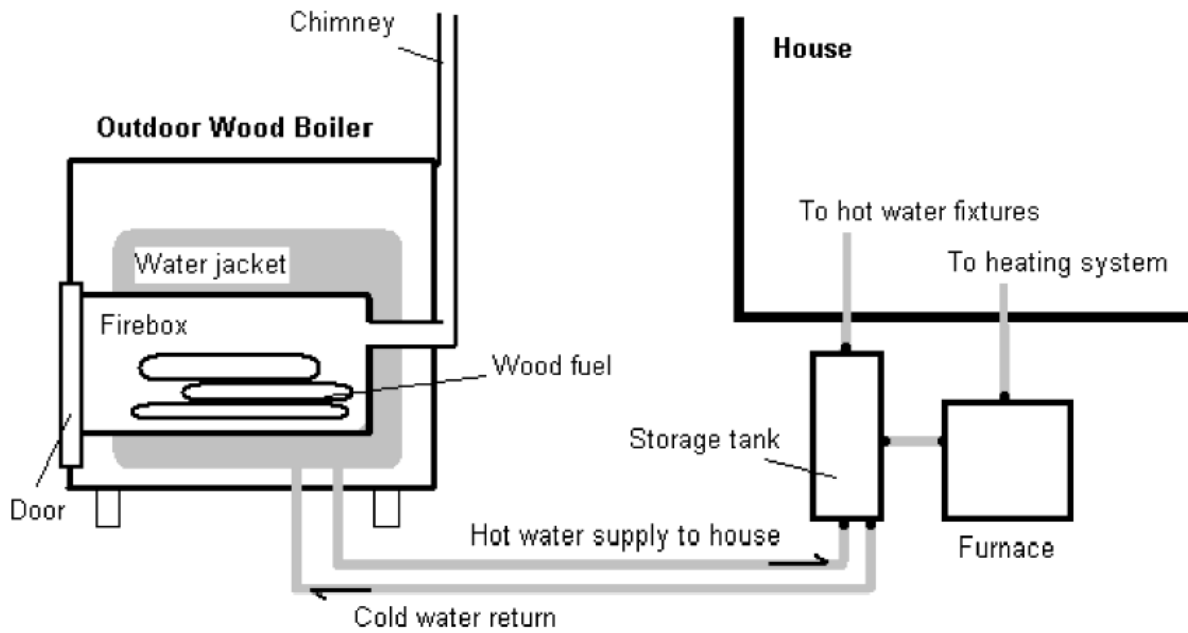
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## Appendices

Appendix A. Diagram illustrating the components and set-up of a typical OWB.



Source: (Johnson PRS 2006)

*Appendix B.* Views of neighborhood spacing surrounding Wheatland subdivision residential outdoor wood boiler. A: View to the west of OWB operator's house. Houses in the background are approximately 300 feet from the OWB; B: View northeast from OWB operator's residence to residence approximately 450 feet from OWB in background. The complainant's residence is additional 300 feet beyond house in background; C: View from OWB operator's residence to OWB and neighboring houses to the west; D: View southeast from OWB, where air monitoring took place on January 5, 2010. No nearby homes currently reside in this direction.



## Kenosha County Outdoor Wood Boiler Investigation

*Appendix C.* Aerial view of Kenosha County rural subdivision and vicinity. The approximate location of the OWB is shown in relation to the residence of the complainant. Also shown (in yellow letters) are the approximate sites of particulate monitoring from January 5, 2010.



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## CERTIFICATION


This Health Consultation for an Evaluation of the Health Concerns Associated with the Kenosha County Outdoor Wood Boiler Investigation was prepared by the Wisconsin Department of Health Services under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with the approved methodology and procedures existing at the time the Health Consultation was begun. Editorial review was completed by the Cooperative Agreement partner.



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The Division of Health Assessment and Consultation (DHAC), ATSDR, has reviewed this Health Consultation and concurs with the findings.



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