DEPARTMENT OF
ECOLOGY
State of Washington

# Acceptable Uses for Recycled Asphalt Roofing in Washington State

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For more information contact:

Waste 2 Resources Program
P.O. Box 47600
Olympia, WA  98504-7600

Phone:  360-407-6900

Washington State Department of Ecology - www.ecy.wa.gov

| | |
|---|---|
| o Headquarters, Olympia | 360-407-6000 |
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# Acceptable Uses for Recycled Asphalt Roofing in Washington State

*by*
*Marni Solheim*

Waste 2 Resources Program
Washington State Department of Ecology
Olympia, Washington

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# Acknowledgements

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- Waste 2 Resources Program:  Wayne Krafft, Chuck Matthews, Dawn Marie Maurer
- Water Quality Program:  Wayne Peterson, Jason Shira, Christopher Wheeler
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# Executive Summary

Recycling facilities that handle asphalt roofing shingles break the material into small pieces and market it for a range of uses. Ground-up roofing has been used in road construction as bedding under road surfaces, on gravel roads and as an additive to hot mix or cold patch asphalt. More uses have included horse arenas, unpaved home driveways, landscaping, animal bedding, trail construction and other purposes.

Concerns about potential contaminants in the roofing lead the Washington Department of Ecology (Ecology) to test ground asphalt-based roofing for chemical composition. Test results indicate that several metals (including arsenic) and polycyclic aromatic hydrocarbons (PAHs) are present at levels that may be harmful to human health and the environment. Arsenic and certain types of PAHs, including those present in the roofing, cause cancer in humans.

The use of recycled asphalt roofing in loose form may present risks. Humans may inhale, ingest or absorb asphalt roofing particles and its contaminants. Wind or precipitation may carry the material into water sources. As a result, Ecology expects a recycler of asphalt roofing to obtain either a solid waste permit or a Beneficial Use Determination (BUD) before distributing it for uses in the loose form. To obtain a permit or BUD, a recycler will need to show that any proposed use will prevent exposure to contaminants in the material.

Roofing materials bound in asphalt, as in hot mix or cold patch asphalt, are not mobile in the environment so present less of a risk. Ecology does not expect these uses to go through an approval process under solid waste regulations.

# Background

Ecology began researching recycled asphalt roofing in 2006 after a local health department suspected that asphalt roofing caused high levels of polycyclic aromatic hydrocarbons (PAHs) in soil after cleanup of a warehouse fire. At the time, Washington recyclers of asphalt roofing were marketing it for use in loose form for landscaping, trails, animal bedding, unpaved roadways, home driveways and erosion control.

Ecology's knowledge of contaminants in asphalt roofing was limited to asbestos content. Available data shows that shingles do not contain asbestos; however, asbestos often comes up as an issue. Ecology researched the issue of PAHs in roofing. The limited information available revealed that PAHs and other contaminants might be a concern.

- In March 2005, Ecology tested runoff from a pile of ground asphalt roofing at a Washington facility that recycled waste from a roofing manufacturer. Results showed dissolved solids in leachate exceeded groundwater quality standards. PAHs in leachate also exceeded standards for protection of human health for three types of PAHs that cause cancer (carcinogenic) in animals. PAHs in the stormwater pond exceeded groundwater quality standards for a probable human carcinogenic PAH. *(Jason Shira, Ecology Water Quality Program, March 16, 2005 Manchester Environmental Laboratory report)*

- Tests on ground asphalt shingles in the State of Maine showed levels of seven types of carcinogenic PAHs significantly exceeded Washington State cleanup standards. The tests also showed that levels of arsenic might be a concern. *(PowerPoint Presentation from Second Asphalt Shingle Recycling Forum, 2003, "How The Beneficial Use of Asphalt Shingles Got Licensed in Maine", Randy McMullin, ES II, Maine Department of Environmental Protection)*

- In 2004, the State of Oregon tested ground asphalt shingles used for mulch. The Oregon Department of Environmental Quality recommended against use of ground asphalt shingles in residential and commercial areas due to the presence of arsenic, zinc, lead and PAHs. *(Oregon Department of Environmental Quality, Staff Report: Reuse of Roofing Waste as Landscaping Mulch, Henning Larsen, R.G., Northwest Region Hydrogeologist)*

- Ecology's review of Maine and Oregon data reveal that ground asphalt shingles would potentially be a state-only dangerous waste in Washington due to levels of PAHs and copper. [Note: Chapter 173-303 WAC excludes roofing material from regulation as a dangerous waste unless it is also dangerous waste under federal requirements. However, excluded dangerous wastes are subject to cleanup laws, which could apply to areas where roofing material or leachate contaminates soils above federal limits.]

Carcinogenic PAHs are much higher in coal tar-based materials than petroleum-based asphalt. The source of the asphalt in shingles sold in Maine may be different from those sold in Washington, so they may have different concentrations of PAHs. The source of the asphalt for Oregon shingles may be the same as Washington shingles; however, Oregon tested only four samples. Ecology did not want to decide about use of the material based on limited or dissimilar data, so tested shingles at Washington recyclers.

Ecology tested materials from the three known asphalt-roofing recyclers in Washington. Ecology collected three samples from each facility on May 2, 2007. The lab used conventional methods to test for total metals, PAHs, toxicity and asbestos and the toxicity characteristic leaching procedure (TCLP) for arsenic, chromium and lead.

# Test Results and Evaluation

See Appendix A for a description of the standards Ecology used to evaluate test results. Ecology's comparison to multiple standards was not a comprehensive analysis of all factors related to each standard. The comparison was to get an idea of potential hazards. See appendices for lab reports and a summary of results and comparisons to standards.

## Total Metals in Asphalt Roofing Shingles

**Antimony** was present at levels unsafe if ingested by humans and toxic to plants.

**Arsenic** was present at levels that are a carcinogenic risk if ingested by humans, unsafe if ingested by humans, toxic to plants, toxic to soil invertebrates, toxic to soil microorganisms and microbial processes, toxic to avian and mammalian wildlife, above background soil levels and has the potential to pollute groundwater. Many samples exceeded standards by several orders of magnitude, including all nine samples for carcinogenic human ingestion levels.

**Beryllium** did not exceed any standard.

**Cadmium** was present at levels toxic to avian wildlife.

**Chromium** was present at levels toxic to plants, toxic to soil invertebrates, toxic to soil microorganisms and microbial processes, toxic to avian and mammalian wildlife and above background soil levels.

**Copper** was present at levels toxic to plants, toxic to soil invertebrates, toxic to soil microorganisms and microbial processes, toxic to avian wildlife and above background soil levels.

**Lead** was present at levels toxic to plants, toxic to avian and mammalian wildlife, above background soil levels and has the potential to pollute groundwater.

**Mercury** was present at levels toxic to soil invertebrates and above background soil levels.

**Nickel** was present at levels toxic to plants and above background soil levels.

**Selenium** did not exceed any standard.

**Silver** did not exceed any standard.

**Thallium** did not exceed any standard.

**Zinc** was present at levels toxic to plants, toxic to soil invertebrates, toxic to soil microorganisms, toxic to avian and mammalian wildlife and above background soil levels

## PAHs in Asphalt Roofing Shingles

PAHs were present at levels that are a carcinogenic risk if ingested or absorbed into the skin by humans and toxic to mammalian wildlife. Two of nine samples exceeded standards for carcinogenicity by several orders of magnitude.

When comparing results of individual, carcinogenic PAHs (cPAH) to values that account for increased impacts to children, cPAHs were present in several samples at carcinogenic levels if ingested, inhaled or dermally contacted by humans in residential and urban residential areas. Results also showed some samples contained cPAHs at carcinogenic levels if ingested, inhaled or dermally contacted by humans in occupational or construction worker settings.

## Asbestos in Asphalt Roofing Shingles

Asbestos was not detected in any of the samples.

## Dangerous Waste Characterization

Total metals results showing values that had the potential for dangerous waste designation were further tested using the Toxicity Characteristic Leaching Procedure (TCLP). These metals included arsenic, chromium and lead. Ecology assessed only samples with the highest metals levels using TCLP. Results show that ground asphalt shingles are not federal or state-only dangerous waste.

The laboratory also did fish bioassay tests on three samples. Fish bioassay tests determine if the presence of PAHs and other chemicals affect the dangerous waste designation for toxicity. Ecology chose three samples that appeared to have the smallest particles. No fish died during the test, so ground asphalt shingles are not federal or state-only dangerous waste for toxicity.

# Conclusions

Ground asphalt shingles used in loose form has the potential to harm humans and other animals. Due to the small particle size, inhalation, ingestion and dermal contact of harmful contaminants by humans and animals may occur in areas where recyclers have proposed to use recycled shingles in loose form. There is a likely potential for exposure in many proposed uses such as home driveways, landscaping, arenas, animal bedding, trails and on unpaved roads. For many of these proposed uses, cars and animals will continually break down material into smaller sizes. This would increase the exposed surface area of the material, which would further increase the potential for mobility and bioavailability of the hazardous components.

Ecology found contaminants in the ground asphalt roofing at levels high enough to harm plants, soil invertebrates and soil microbial processes.

Proposed uses have the potential to pollute waters of the state. Shingles may add contaminants to soil at levels that could leach into and negatively affect groundwater. Due to the small particle size of recycled shingles, stormwater and wind can carry contaminants in the ground shingles into surface waters where they could threaten aquatic life and pollute groundwater linked with surface water.

Ecology expects a recycler of asphalt roofing to obtain either a solid waste permit or a Beneficial Use Determination (BUD) before distributing it for uses in loose form. A recycler will need to show that any proposed use will prevent exposure to contaminants in the material. Use as part of hot mix asphalt or cold patch does not need to go through an approval process under state solid waste regulation.

# Appendices

**A. Standards for Evaluation**

**B. Table "Comprehensive Regulatory Standards and Test Result Comparison"**

**C. Table "Asphalt Roof Shingle Test Results Summary" and cPAH TEC Conversion**

**D. PowerPoint Presentation – "How the Beneficial Use of Asphalt Shingles Got Licensed in Maine"**

**E. ODEQ Staff Report - Reuse of Roofing Waste as Landscaping Mulch and Fact Sheet - Consumer Alert: Bark Mulches Made from Roofing Wastes May Be Unsafe to Use**

# Appendix A.  Standards for Evaluation

Due to the array of proposed uses of ground asphalt shingles, Ecology used several standards to assess test results.  The numbers below correspond to the numbered Regulatory Standards in the Table "Regulatory Standards and Test Result Comparison" in Appendix B.

1. Chapter 173-340 WAC, Model Toxics Control Act – Cleanup, CLARC Soil, Method B, Standard Formula Value, Direct Contact (ingestion only), unrestricted land use.  *Values here are concentrations of metal contaminants in soil that are protective of human health when ingested.*

   Chapter 173-340 WAC, Model Toxics Control Act – Cleanup, Equation 740-5, concurrent exposure for ingestion and dermal contact with soil.  *Values here are concentrations of carcinogenic PAHs in soil that are protective of human health when ingested or absorbed through skin.  Some carcinogens have a cleanup level based on exposure through multiple pathways into the body.  Some proposed uses of recycled asphalt shingles may result in contaminants entering the body through ingestion or through the skin.  This standard was used instead of Method B standards, which are for exposure through ingestion alone.*

2. Ecological Soil Screening Levels (Eco-SSLs), U.S. Environmental Protection Agency.  *Eco-SSLs are concentrations of contaminants in soils that are protective of organisms that often meet or eat other organisms that live in or on soil.  The EPA set Eco-SSLs for contaminants often found in soils at Superfund cleanup sites.  A group made up of federal, state, consulting, industry and academic participants helped establish the Eco-SSLs.  The Eco-SSLs were derived to limit the need for EPA and other risk assessors to perform duplicate literature searches and data assessments for the same contaminants at every site.*

3. Toxicological Benchmarks:
   - Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision.  Oak Ridge National Laboratory, ES/ER/TM-85/R3.
   - Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Processes: 1997 Revision.  Oak Ridge National Laboratory, ES/ER/TM-126/R2.
   - Toxicological Benchmarks for Wildlife: 1996 Revision.  Oak Ridge National Laboratory, ES/ER/TM-86/R3.

   *Benchmarks are concentrations of contaminants in soils that the Oak Ridge National Laboratory (ORNL) found to be protective of organisms that often meet or eat organisms that live in or on soil.  The ORNL set benchmarks for contaminants often found in soils at U.S. Department of Energy sites.  ORNL used data from bibliographical databases (BIOSIS, POL TOX I, current contents), other agencies, such as the National Oceanographic Atmospheric Administration, a numeric database (PHYTOTOX), review articles, conventional literature searches and reports of toxicity tests of individual chemicals in laboratory, greenhouse, or field settings.*

4. Chapter 173-340 Washington Administrative Code, Table 749-3 (for wildlife only), Ecological Indicator Soil Concentrations for Protection of Terrestrial Plants and Animals. *These values for contaminants in soil are protective of wildlife.  Ecology has considered these values due to their connection to the Toxicological Benchmarks for Wildlife from Oak Ridge National Lab (ORNL).  ORNL benchmarks vary by species so are hard to use in*

*assessing potential impacts of ground asphalt roofing. In setting values for Table 749-3, Ecology developed a formula and used values from ORNL for a mammalian predator (shrew), avian predator (American robin) and mammalian herbivore (vole) to come up with a single value for each contaminant. The wildlife value is the lowest of the three chemical concentrations.*

5. Natural Background Soil Metals Concentrations in Washington State, October 1994, Publication #94-115. *Some soils in WA have naturally high levels of chemicals. Ecology compared test results to background levels to see if contaminants in ground asphalt shingles exceeded what WA soils may contain naturally.*

6. Chapter 173-303 Washington Administrative Code, Dangerous Waste Regulations, Sections 173-303-090 and 173-303-100, for arsenic, chromium, lead and toxicity. *These values are concentrations of contaminants that require special handling and disposal to protect human health and the environment.*

7. Chapter 173-200 Washington Administrative Code, Water Quality Standards For Ground Waters Of The State Of Washington, Section 173-200-040, Table 1 Ground Water Quality Criteria. *These values for contaminants in groundwater will maintain the highest quality of the state's groundwaters and protect existing and future uses of it. WAC 173-200 also addresses contaminants in soil and surface water because they have the potential to pollute groundwater, and establishes an antidegradation policy that requires prevention, control and treatment of contaminants that may affect groundwater. Ecology used toxicity characteristic leaching procedure (TCLP) results for arsenic, chromium and lead for comparison to this standard, though acknowledges other tests may better represent leaching of these metals in a natural environment.*

8. Oregon Department of Environmental Quality (ODEQ), Environmental Cleanup and Tanks Program, Risk-Based Concentrations for Individual Chemicals. *These values for carcinogenic PAHs in soils are protective of human health when exposed through ingestion, inhalation and dermal contact. The values were updated in 2007 and account for early-life exposure. Children have different exposure circumstances than do adults. They consume more of certain foods and water and have higher inhalation rates per unit of body weight than adults. Young children play close to the ground and come into contact with contaminated soil outdoors and with contaminated dust on surfaces and carpets indoors. Ingestion of breast milk is another pathway of exposure for infants and young children. ODEQ now requires the consideration of early-life exposure at all residential sites or other sites where childhood exposure is likely.*

Asbestos. Ecology referenced no standard since tests resulted in no detection of asbestos in any of the samples.

# Appendix B. Table “Comprehensive Regulatory Standards and Test Result Comparison”

# Appendix B

**Comprehensive Regulatory Standards and Test Result Comparison**

| Contaminant | Regulatory Standard (# of 9 total samples exceeding standard) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1. WAC 173-340:<br>Metals - CLARC, Soil, Method B, Standard Formula Value, Direct Contact (ingestion only), unrestricted land use<br>PAHs - Equation 740-5, concurrent exposure for ingestion and dermal contact with soil | | 2. Eco-SSLs (EPA)[h] | | | | 3. Toxicological Screening Benchmarks (ORNL) | | | | 4. WAC 173-340, Table 749-3 for Wildlife[c] | 5. WA Background Soil | 6. WAC 173-303, Dangerous Waste Criteria[c] | 7. WAC 173-200, Table 1 Ground Water Quality Criteria[d] |
| | Carcinogen | Non-carcinogen | Plants | Soil Invertebrates | Avian Wildlife | Mammalian Wildlife | Plants | Soil Invertebrate - earthworm | Soil Invertebrate - microorganisms and microbial processes | Avian and Mammalian Wildlife[b] | Wildlife | | | |
| | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/L | mg/L |
| Antimony | ---- | 32 (1 of 9) | ---- | 78 (0 of 9) | ---- | 0.27 (0 of 9) | 5 (3 of 9) | ---- | ---- | ---- | ---- | ---- | ---- | |
| Arsenic | 0.67 (9 of 9) | 24 (4 of 9) | 18 (4 of 9) | ---- | 43 (3 of 9) | 46 (0 of 9) | 10 (5 of 9) | 60 (2 of 9) | 100 (1 of 9) | ---- | 132 (1 of 9) | 7 (5 of 9) | 5 (0 of 1) | 0.00005 (1 of 1) |
| Beryllium | ---- | 16 (0 of 9) | ---- | 40 (0 of 9) | ---- | 21 (0 of 9) | 10 (0 of 9) | ---- | ---- | ---- | ---- | 2 (0 of 9) | ---- | |
| Cadmium | ---- | 80 (0 of 9) | 32 (0 of 9) | 140 (0 of 9) | 0.77 (2 of 9) | 0.36 (0 of 9) | 4 (0 of 9) | 20 (0 of 9) | 20 (0 of 9) | ---- | 14 (0 of 9) | 1 (0 of 9) | not considered | |
| Chromium | ---- | ---- | ---- | ---- | 34 (3 of 9) | 34 (3 of 9) | 1 (9 of 9) | 0.4 (9 of 9) | 10 (9 of 9) | ---- | 67 (1 of 9) | 42 (3 of 9) | 5 (0 of 1) | 0.05 (0 of 1) |
| Copper | ---- | 3000 (0 of 9) | 70 (7 of 9) | 80 (6 of 9) | 28 (8 of 9) | 49 (0 of 9) | 100 (5 of 9) | 50 (8 of 9) | 100 (5 of 9) | ---- | 217 (0 of 9) | 36 (8 of 9) | ---- | |
| Lead | ---- | ---- | 120 (3 of 9) | 1700 (0 of 9) | 11 (6 of 9) | 56 (0 of 9) | 50 (3 of 9) | 500 (0 of 9) | 900 (0 of 9) | ---- | 118 (3 of 9) | 17 (6 of 9) | 5 (0 of 3) | 0.05 (3 of 3) |
| Mercury | ---- | 24 (0 of 9) | ---- | ---- | ---- | ---- | 0.3 (0 of 9) | 0.1 (3 of 9) | 30 (0 of 9) | ---- | 5.5 (0 of 9) | 0.07 (3 of 9) | not considered | |
| Nickel | ---- | 1600 (0 of 9) | 38 (3 of 9) | 280 (0 of 9) | 210 (0 of 9) | 130 (0 of 9) | 30 (3 of 9) | 200 (0 of 9) | 90 (0 of 9) | ---- | 980 (0 of 9) | 38 (3 of 9) | ---- | |
| Selenium | ---- | 400 (0 of 9) | 0.52[a] (0 of 9) | 4.1 (0 of 9) | 1.2 (0 of 9) | 0.63 (0 of 9) | 1 (0 of 9) | 70 (0 of 9) | 100 (0 of 9) | ---- | 0.3 (0 of 9) | ---- | not considered | |
| Silver | ---- | 400 (0 of 9) | 560 (0 of 9) | ---- | 4.2 (0 of 9) | 14 (0 of 9) | 2 (0 of 9) | ---- | 50 (0 of 9) | ---- | ---- | ---- | not considered | |
| Thallium | ---- | 5.6 (0 of 9) | ---- | ---- | ---- | ---- | 1 (0 of 9) | ---- | ---- | ---- | ---- | ---- | ---- | |
| Zinc | ---- | 24,000 (0 of 9) | 160 (8 of 9) | 120 (9 of 9) | 46 (9 of 9) | 79 (0 of 9) | 50 (9 of 9) | 200 (8 of 9) | 100 (9 of 9) | ---- | 360 (8 of 9) | 86 (9 of 9) | ---- | |
| cPAH | 0.1 (6 of 9)[ef] | ---- | ---- | LMW 29 (0 of 9);<br>HMW 18 (0 of 9)[eg] | ---- | LMW 100 (0 of 9);<br>HMW 1.1 (9 of 9)[eg] | ---- | ---- | ---- | ---- | ---- | ---- | ---- | |
| Toxicity - fish LC50 | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | 10 (0 of 3); 100 (0 of 3) | |
| Asbestos (% present) | Asbestos was not detected in any sample. | | | | | | | | | | | | | |

| Contaminant | Regulatory Standard (# of 9 total samples exceeding standard) | | | | |
|---|---|---|---|---|---|
| | 8. Risk-Based Concentrations (ODEQ) - July 2009 | | | | |
| | Soil, Direct Contact (ingestion, dermal, inhalation) | | | | |
| | Residential | Urban Residential | Occupational | Construction Worker | Excavation Worker |
| cPAH: | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg |
| Benz[a]anthracene[i] | 0.15 (5 of 9) | 0.31 (2 of 9) | 2.7 (0 of 9) | 21 (0 of 9) | 590 (0 of 9) |
| Benzo[a]pyrene[i] | 0.015 (9 of 9) | 0.031 (9 of 9) | 0.27 (6 of 9) | 2.1 (0 of 9) | 59 (0 of 9) |
| Benzo[b]fluoranthene[i] | 0.15 (6 of 9) | 0.31 (3 of 9) | 2.7 (0 of 9) | 21 (0 of 9) | 590 (0 of 9) |
| Benzo[k]fluoranthene[i] | 1.5 (0 of 9) | 3.1 (0 of 9) | 27 (0 of 9) | 210 (0 of 9) | 5900 (0 of 9) |
| Chrysene | 15 (0 of 9) | 31 (0 of 9) | 270 (0 of 9) | 2100 (0 of 9) | 59000 (0 of 9) |
| Dibenz[a,h]anthracene | 0.015 (9 of 9) | 0.031 (9 of 9) | 0.27 (7 of 9) | 2.1 (1 of 9) | 59 (0 of 9) |
| Indeno[1,2,3-cd]pyrene | 0.15 (6 of 9) | 0.31 (3 of 9) | 2.7 (1 of 9) | 21 (0 of 9) | 590 (0 of 9) |

Shaded boxes indicate where one or more samples exceeded values.

Notes:

"----" means no value or no single value has been established.

"Eco-SSLs" mean ecological soil screening levels.

"EPA" means the United States Environmental Protection Agency.

"HMW" means high molecular weight.

"LMW" means low molecular weight.

"ODEQ" means Oregon Department of Environmental Quality

"ORNL" means Oak Ridge National Laboratory.

[a] Lab results show only that selenium was not detected at or above 1 mg/kg.

[b] Avian and mammalian values from ORNL vary by species. In setting values for WAC 173-340, Table 749-3, Ecology developed a formula and used data from ORNL for mammalian predator (shrew), avian predator (American robin) and

[c] All 9 samples were not evaluated for dangerous waste criteria. Only samples with the highest values in tests for total metals were evaluated for dangerous waste designation.

[d] Only TCLP results were used to compare to Table 1.

[e] Only carcinogenic PAHs (cPAH) results were used.

[f] Toxic equivalency quotient (TEQ) values were used for comparison. Non-detect values were calculated using one-half the detection limit.

[g] Lab results did not differentiate between HMW or LMW PAHs. Total cPAHs were used for comparison, regardless of this. Non-detect values were included in the total.

[h] Assumes 100% of contaminants are bioavailable.

[i] Non-detect values were compared at one-half the detection limit.

# Appendix C. Table “Asphalt Roof Shingle Test Results Summary” and cPAH TEC Conversion

# Appendix C

**Asphalt Roof Shingle Test Results Summary**
sampling event 5/02/07

**Violet= the analyte was not detected at or above the reported result=U**
**Blue= the analyte was positively identified. The associated numerical result is an estimate=J**
**Orange= the analyte was not detected at or above the reported result. However, the reported result is approximate and may or may not represent the actual limit of quantitation necessary and precisely measure the analyte sample.=UJ**

| **Contaminant** | **Sample Results** | | | | | | | | | **Levels** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Metals concentration (mg/Kg or ppm)** | **1A** | **1B** | **1C** | **2A** | **2B** | **2C** | **3A** | **3B** | **3C** | **median** | **average** | **min** | **max** |
| Antimony | 13.90 | 26.00 | 35.90 | 0.28 | 0.32 | 0.21 | 2.00 | 1.60 | 0.24 | 1.60 | 8.21 | 0.21 | 35.90 |
| Arsenic | 43.30 | 61.30 | 132.00 | 1.95 | 2.06 | 2.31 | 29.30 | 16.00 | 6.76 | 16.00 | 31.10 | 1.95 | 132 |
| Beryllium | 0.19 | 0.17 | 0.20 | 0.15 | 0.15 | 0.17 | 0.11 | 0.12 | 0.10 | 0.15 | 0.15 | 0.10 | 0.20 |
| Cadmium | 0.79 | 0.50 | 0.79 | 0.13 | 0.14 | 0.12 | 0.37 | 0.21 | 0.20 | 0.21 | 0.35 | 0.12 | 0.79 |
| Chromium | 32.30 | 23.80 | 45.90 | 14.70 | 11.80 | 14.30 | 28.10 | 54.90 | 100.00 | 28.10 | 35.39 | 11.80 | 100 |
| Copper | 92.60 | 61.40 | 117.00 | 295.00 | 267.00 | 306.00 | 184.00 | 78.70 | 13.20 | 117.00 | 153.19 | 13.20 | 306 |
| Lead | 199.00 | 205.00 | 287.00 | 9.83 | 7.94 | 6.74 | 26.60 | 21.00 | 39.70 | 26.60 | 82.94 | 6.74 | 287 |
| Mercury | 0.13 | 0.16 | 0.14 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.05 | 0.01 | 0.16 |
| Nickel | 29.30 | 24.60 | 38.90 | 11.30 | 8.88 | 10.50 | 26.70 | 59.30 | 65.20 | 26.70 | 30.14 | 8.88 | 65.20 |
| Selenium | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Silver | 0.41 | 0.34 | 0.23 | 0.26 | 0.26 | 0.15 | 0.23 | 0.42 | 0.10 | 0.26 | 0.27 | 0.10 | 0.42 |
| Thallium | 0.21 | 0.16 | 0.16 | 0.22 | 0.21 | 0.18 | 0.15 | 0.20 | 0.10 | 0.18 | 0.18 | 0.10 | 0.22 |
| Zinc | 681.00 | 511.00 | 814.00 | 1,000.00 | 1,100.00 | 845.00 | 392.00 | 369.00 | 150.00 | 681.00 | 654.30 | 150.00 | 1100 |
| total metals (mg/Kg or ppm) | 1,094.13 | 915.43 | 1,473.22 | 1,334.83 | 1,399.78 | 1,186.69 | 690.57 | 602.46 | 376.61 | 1,094.13 | 1,016.78 | 376.61 | 1,473.22 |
| **TCLP (mg/L or ppm)** | | | | | | | | | | | | | |
| Arsenic | | | 0.011 | | | | | | | | | | |
| Chromium | | | | | | | | | 0.0050 | | | | |
| Lead | 0.16 | 0.21 | 0.14 | | | | | | | | | | |
| **Fish Bioassay** | | | | | | | | | | | | | |
| % mortality 10 mg/L | | | 0 | | | 0 | 0 | | | | | | |
| % mortality 100 mg/L | | | 0 | | | 0 | 0 | | | | | | |
| **Asbestos (% present)** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | |
| **cPAH (ug/Kg or ppb)** | | | | | | | | | | | | | |
| Benzo(a)anthracene | 550 | 512 | 662 | 247 | 275 | 230 | 259 | 400 | 500 | 400 | 404 | 230 | 662 |
| Chrysene | 1,080 | 1,870 | 2,940 | 701 | 752 | 336 | 365 | 1,170 | 1,450 | 1,080 | 1,174 | 336 | 2,940 |
| Benzo(b)fluoranthene | 550 | 442 | 1,640 | 224 | 275 | 230 | 259 | 390 | 500 | 390 | 490 | 224 | 1,640 |
| Benzo(k)fluoranthene | 550 | 525 | 1,540 | 247 | 275 | 230 | 267 | 390 | 500 | 390 | 491 | 230 | 1,540 |
| Benzo(a)pyrene | 898 | 977 | 1,460 | 504 | 584 | 341 | 259 | 622 | 721 | 622 | 699 | 259 | 1,460 |
| Ideno(1,2,3-cd)pyrene | 2,850 | 1,170 | 1,230 | 247 | 534 | 230 | 259 | 400 | 500 | 500 | 792 | 230 | 2,850 |
| Dibenzo(a,h)anthracene | 3,180 | 1,220 | 1,280 | 542 | 607 | 460 | 518 | 800 | 999 | 800 | 1,041 | 460 | 3,180 |
| total cPAHs (ug/Kg) | 9,658 | 6,716 | 10,752 | 2,712 | 3,302 | 2,057 | 2,186 | 4,172 | 5,170 | 4,172 | 5,090 | 2,057 | 10,752 |

Conversion of cPAHs to Toxic Equivalent Concentrations:

| **Contaminant** | **Non-detect for all samples?** | **TEF** | **Sample Results** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1A | | | 1B | | | 1C | | | 2A | | |
| cPAH: | | | [µg/kg] | qual | TEQ | [µg/kg] | qual | TEQ | [µg/kg] | qual | TEQ | [µg/kg] | qual | TEQ |
| Benzo(a)anthracene | FALSE | 0.1 | 550 | UJ | 28 | 512 | J | 51 | 662 | J | 66 | 247 | UJ | 12 |
| Chrysene | FALSE | 0.01 | 1,080 | J | 11 | 1,870 | J | 19 | 2,940 | J | 29 | 701 | J | 7 |
| Benzo(b)fluoranthene | FALSE | 0.1 | 550 | UJ | 28 | 442 | J | 44 | 1,640 | J | 164 | 224 | J | 22 |
| Benzo(k)fluoranthene | FALSE | 0.1 | 550 | UJ | 28 | 525 | UJ | 26 | 1,540 | UJ | 77 | 247 | UJ | 12 |
| Benzo(a)pyrene[a] | TRUE | 1 | 898 | UJ | 0 | 977 | UJ | 0 | 1,460 | UJ | 0 | 504 | UJ | 0 |
| Ideno(1,2,3-cd)pyrene | FALSE | 0.1 | 2,850 | J | 285 | 1,170 | UJ | 59 | 1,230 | UJ | 62 | 247 | UJ | 12 |
| Dibenzo(a,h)anthracene | FALSE | 0.1 | 3,180 | J | 318 | 1,220 | UJ | 61 | 1,280 | J | 128 | 542 | UJ | 27 |
| Toxic equivalent concentration [µg/kg] | | | | | 696 | | | 260 | | | 526 | | | 94 |
| Toxic equivalent concentration [mg/kg] | | | | | 0.696 | | | 0.26 | | | 0.526 | | | 0.094 |

| **Contaminant** | **Non-detect for all samples?** | **TEF** | **Sample Results** | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 2B | | | 2C | | | 3A | | | 3B | | | 3C | | | |
| cPAH | | TEF | [µg/kg] | qual | TEQ | [µg/kg] | qual | TEQ | [µg/kg] | qual | TEQ | [µg/kg] | qual | TEQ | [µg/kg] | qual | TEQ | |
| Benzo(a)anthracene | FALSE | 0.1 | 275 | UJ | 14 | 230 | UJ | 12 | 259 | UJ | 13 | 400 | UJ | 20 | 500 | UJ | 25 | |
| Chrysene | FALSE | 0.01 | 752 | J | 8 | 336 | J | 3 | 365 | UJ | 2 | 1,170 | J | 12 | 1,450 | J | 15 | |
| Benzo(b)fluoranthene | FALSE | 0.1 | 275 | UJ | 14 | 230 | UJ | 12 | 259 | UJ | 13 | 390 | J | 39 | 500 | UJ | 25 | |
| Benzo(k)fluoranthene | FALSE | 0.1 | 275 | UJ | 14 | 230 | UJ | 12 | 267 | J | 27 | 390 | J | 39 | 500 | UJ | 25 | |
| Benzo(a)pyrene[a] | TRUE | 1 | 584 | UJ | 0 | 341 | UJ | 0 | 259 | UJ | 0 | 622 | UJ | 0 | 721 | UJ | 0 | |
| Ideno(1,2,3-cd)pyrene | FALSE | 0.1 | 534 | UJ | 27 | 230 | UJ | 12 | 259 | UJ | 13 | 400 | UJ | 20 | 500 | UJ | 25 | |
| Dibenzo(a,h)anthracene | FALSE | 0.1 | 607 | UJ | 30 | 460 | UJ | 23 | 518 | UJ | 26 | 800 | UJ | 40 | 999 | UJ | 50 | |
| Toxic equivalent concentration [µg/kg] | | | | | 106 | | | 72 | | | 93 | | | 170 | | | 164 | |
| Toxic equivalent concentration [mg/kg] | | | | | 0.106 | | | 0.072 | | | 0.093 | | | 0.17 | | | 0.164 | |

"TEF" means toxic equivalent factor.

"TEQ" means toxic equivalent quotient.

[a] Benzo(a)pyrene had a non detect value in all samples in the dataset, therefore a value of zero was assigned as its TEQ, consistent with the approach to dioxins in "CONCISE EXPLANATORY STATEMENT AND RESPONSIVENESS SUMMARY

# Appendix D. PowerPoint Presentation – “How the Beneficial Use of Asphalt Shingles Got Licensed in Maine”

## Second Asphalt Shingles Recycling Forum

How “The Beneficial Use of Asphalt Shingles” Got Licensed in Maine

Randy McMullin, ES III
Maine Department of Environmental Protection

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06-096
Department of Environmental Protection

Maine Solid Waste Management Rules:
Chapter 418 (effective date 1998)

Beneficial Use of Solid Wastes
www.state.me.us/dep/rwm/rules

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From This…….

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To this……

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**Maine**

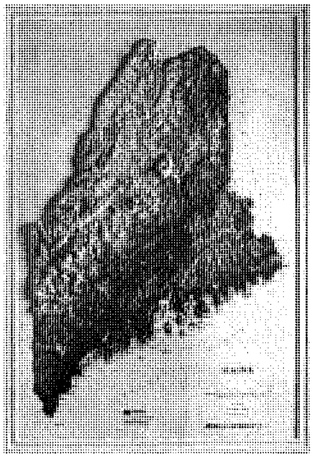
1.3 million people (40th)

30,995 square miles (39th)

2 commercial landfills

Tipping fee

$85+ ton



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## Exemptions

- Exempted numerous beneficial use of materials which pose little, if any, risk from all licensing by the Department
- Landscaping materials
- inert fill
- processed oil contaminated soil in and under pavement
- some clean ash materials
- some clean dredge materials
- most paper products

## Additional Exemptions

- Also:
  - Recycled and processed asphalt pavement and concrete
  - some whole tire uses
  - some materials which are reused in a manufacturing process

## Beneficial Use General Standards

A. If intended to be used as a raw material substitute in manufacturing, the beneficially used secondary material must perform as an acceptable substitute for the material it is replacing.

B. If the secondary material is intended to be beneficially used as a product, it must meet or exceed the applicable generally accepted product specifications and standards for that product.

C. The beneficial use will not pollute any waters of the state, contaminate the ambient air, constitute a hazard to health or welfare or create a nuisance.

Also the use must be kept out of the water..

A beneficial use activity may not be located in, on, or over any protected natural resource or be located adjacent to and operated in such a manner that material or soil may be washed into any protected natural resource unless approved pursuant to 38 M.R.S.A. Section 480-A *et seq.*

*From Chapter 418.3.E "General Standards for Beneficial Use"*

## Permit By Rule Uses

- Easy to license
- 20 day turnaround
- Public notice
- Very limited risk
- Licensed the usage site

- Examples
- Tire Chips as a drainage material
- Tire Chips in lightweight fill applications

## Reduced Procedure Licensing

- More concerns about total risk usually by means of exposure for the usage
- Public notice required
- Still a relatively easy license to get

- Examples
- Additional dredge materials
- Some ash materials in road construction materials
- Some ash in flowable fills

## Full Beneficial Use License

- If the constituents of concern meet the de minimus risk standards of Appendix A, no risk assessment required
- Public notice required
- More involved review

- Examples
- C&D as a bio-mass boiler fuel
- uses of ground sheetrock
- uses for foundry sands, various ashes, dredged materials, etc.

## Beneficial Use with Risk Assessment

- Exceed the concentration levels allowed as a *de minimus* risk in Appendix A
- Public notice required
- Risk management required to minimize total risk
- Shingles
- Other ashes
- Other uses of oil contaminated soils
- Other fuels

## *De Minimus* Risk Standards

- ILCR of 5 x $10^{-6}$
- HI < 1/2
- Units are in mg/kg or parts per million
- Most restrictive pathway of exposure used (dermal, ingestion, inhalation, etc.)
- Based on 1/2 of the Clean Up Standard for the Department's Hazardous Waste Sites ILCR of 1 x $10^{-5}$ and HI< 1, Residential Use
- Based on EPA 3 Risk Based Concentrations adjusted for typical Maine exposure.

## So just what is in asphalt shingles to worry about?

- Asbestos?
- Metals?
- Carcinogenic PAHs?
- Pathways of exposure?

## Asbestos

- Sampled during the first year of operation from 1994-1995. $25 +/- per sample.
- In residential samples, 0 hits of 118 samples
- EPA approved methodology, 600/M4-82-020 Polarized Light Microscopy.
- During the grinding process, air monitoring [utilizing EPA Level II method] utilized with no hits.
- Commercial rolled roofing still being tested.

## Asbestos Conclusion

- Not likely to occur in Residential Shingles
- More likely to be found in rolled roofing for commercial uses

- All loads to be visually inspected
- Commercial materials tested
- Monitoring and random sampling

## Metals mg/kg

| In Ground Shingles | | Appendix A Standards |
|---|---|---|
| **Arsenic** | **5.6** | **5.375** |
| Barium | 63.4 | 2000 |
| Cadmium | < 1.09 | 10 |
| Chromium | 26.7 | 47.5 |
| Lead | 81.4 | 375 |
| Mercury | 0.17 | 1.2 |
| Selenium | <1.1 | 6.25 |
| Silver | <1.63 | 42.5 |

## cPAHs ug/kg or ppb

| | Shingles | Appendix A |
|---|---|---|
| Benz[a] anthracene | 42,500 | **11,000** |
| Benzo[b]fluoranthene | 48,000 | **11,000** |
| Benzo[k]fluoranthene | 10,000 | 110,000 |
| →**Benzo[a]pyrene** | **33,500** | **1,100** |
| Chrysene | 29,000 | 110,0000 |
| →**Dibenz[ah]anthracene** | **5,800** | **1,100** |
| Indeno[1,2,3-cd]pyrene | 25,000 | **11,000** |

## cPAHs

- The combined toxicity of the cPAHs is driven by the ratio of Benzo[a]pyrene to the toxicity of all of the other cPAHs by a factor of 5/7.6 = 0.66
- Therefore, a factor of 0.66 [BaP/cPAHs] x the BaP concentration was used to limit the total combined toxicity of all of the cPAHs.

## Pathways of Exposure

- No Leaching
- Inhalation at the processing facility
- Ingestion

**To Reduce Risk**

- Hard Surface which includes hot asphalt mix and cold patch
- Spray bars at the processing facility
- 50% shingles as a maximum concentration
- Limit the shingle fines
- Limit the max area in a residential setting

## What is Driving the Ingestion Risk?

| | |
|---|---|
| **Benzo[a]pyrene** | **30 times** the risk standard |
| Arsenic | **High Cancer Slope Factor** |
| all other cPAHs | Adds **1/3 to total toxicity** |
| Amount of **fines** | Limit fines to **15% max** |
| Total **area of the use** in a residential setting | Assumed to be **25%** of total yard available for ingestion |
| **% of shingles** in the final mix | **50/50** mix is maximum |

## Critical Pathway of Exposure

- Residential Use as a not hard surface
- Ingestion by children [200 mg/day x 6 years]
- Ingestion by adults [100 mg/day x 30 years]
- Amount of material in a yard = Ac= 25%
- Fc = fraction contaminated = 50% x 15%
- 143 days per year of exposure
- 15% fines (passing a #100 screen, 150 *um*)

## Secondary Road

## Residential Driveway

## Subdivision Roads

## Risk Calculation

- **Risk** = constituents of concern x toxicity x dose
- **EPC** = maximum exposure point concentration within final product
- **Fraction Contaminated** = Fc = % of shingles x the % of fines = **50%** ground shingles x **15%** fines
- **Ac** = area contaminated = **25%** of "yard"

These are the license limit CRS has to meet on an annual reporting basis:

- Max EPC [BaP] = 38.7 mg/kg = $\frac{0.66 \times 1.1 \text{ mg/kg}}{(50\% \text{ shingles} \times 15\% \text{ fines} \times 25\% \text{ of yard})}$
- Max EPC [As] = **71.6 mg/kg**

$$\frac{\text{Appendix A Std.}}{\text{Ac} \times \text{Fc}} = \frac{5.375 \text{ mg/kg}}{0.25 \times 0.075}$$

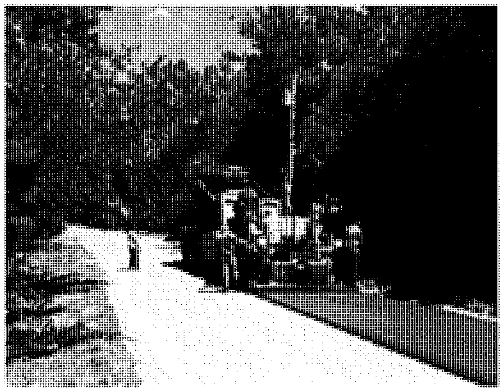
## Condition of Approval:

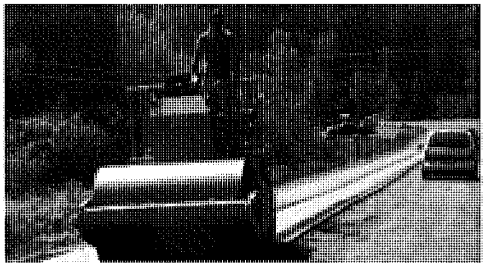
- As part of the facility annual report, the applicant continues to annually monitor the concentrations of Benzo[a]pyrene and of the RCRA 8 metals in the final mixtures within products for Beneficial Use to ensure the concentration are at or less than levels evaluated within the assessment of risk. The maximum concentration level for Benzo[a]pyrene is 38.7 mg/kg.

## Commercial Recycling Inc.
## Solid Waste Processing Facility
## #S-021243-WK-A-N

- Virgin Oil Petroleum Contaminated Soils and Non-Virgin Petroleum Contaminated Soils
- Various Inert Fill Material
- Recycled Asphalt Pavement
- Various Non Haz Bottom Ash
- Shingles/Drywall/Porcelain/Glass/Coal Flyash
- 15-20,000 tons per year of shingles
- In compliance with all permits, no NOVs

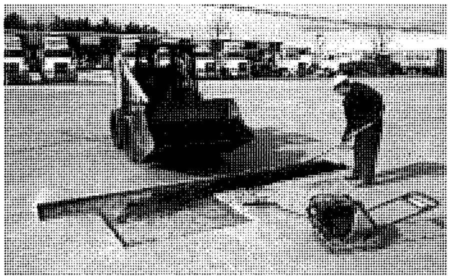
## Hard Surface Paving



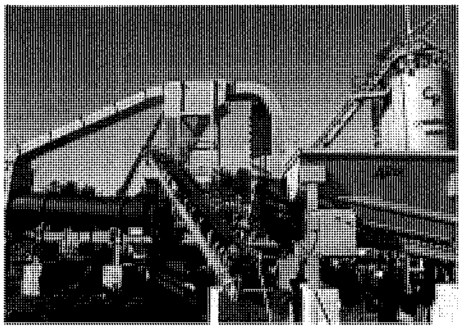


## Cold Patch
## jack's patch™

## Applying Recycled Shingle Cold Patch



## Hot Batch Asphalt



## Parking Lot

# Appendix E. ODEQ Staff Report - Reuse of Roofing Waste as Landscaping Mulch and Fact Sheet - Consumer Alert: Bark Mulches Made from Roofing Wastes May Be Unsafe to Use

Oregon Department of Environmental Quality

# Staff Report: Reuse of Roofing Waste as Landscaping Mulch

*Henning Larsen, R.G., Northwest Region Hydrogeologist*

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**August 2004**

## Table of Contents

## Executive Summary

Several years ago some recycling facilities in Western Oregon began selling an alternative to wood-derived bark mulch that's produced by grinding mixed asphalt shingle waste. Markets for the "mulch", sold under the names "No Spark Bark" and "Budget Bark", include residential and commercial landscaping, and use on embankments, shoulders and landscaped areas maintained within ODOT right-of-ways. The total volume of mulch sold statewide is unknown, but one Portland area company, Pacific Land Clearing, reportedly ground-up 24,000 tons of the material in 2003 while another company Roofgone, based out of Springfield, Oregon estimated their production at 10,000 tons. . Based on concerns regarding the concentration of hazardous constituents in roofing waste, the DEQ collected and analyzed four samples of the Budget Bark. The laboratory analyses detected significant levels of heavy metals and polynuclear aromatic hydrocarbons (PAHs). Several of the contaminants including arsenic, lead, and benzo(a)pyrene are classified by the Environmental Protection Agency as persistent, bioaccumulative and toxic (PBT) chemicals and their concentrations in the mulch greatly exceed relevant human health and ecological standards. Based on the nature, toxicity, and concentration of contaminants in the roofing waste, reuse of the material as landscaping mulch violates DEQ policies and standards related to the protection of human health and the environment and conflicts with Executive Order EO-99-013 pertaining to PBTs. The DEQ has consulted with the Department of Justice and confirmed that the Agency has the authority to regulate application of the material under the Solid Waste, Water Quality, and the Hazardous Substance Remedial Action rules.

It is recommended that the DEQ pursue a course that includes: 1) meeting with mulch producers and ODOT to discuss our findings and concerns, 2) developing guidance through the Solid Waste Program on appropriate reuses of the mixed roofing waste, 3) requiring and/or modifying Solid Waste permits for material recycling facilities that limits reuse options for the waste, 4) collecting and evaluating additional information regarding product use on residential and commercial properties and within transportation right-of-ways.

## Background

- Historically in Oregon, most roofing waste has been disposed of at landfills. Since the mid 1990s, several reuses for the waste have been developed by companies operating material recycling facilities in the Willamette Valley. About eight years ago, Woodwaste Reclamation of Aumsville began receiving source separated asphalt shingles and selling them for "top dressing" on gravel roads. They found the larger pieces, when applied in a layer 1"-2" thick, made an asphalt-like surface and a good dust suppressant. In recent years facilities have sending well-sorted stockpiles of the waste shingles to asphalt batch plants to be recycled into road building material.

- Several years ago, the Roofgone Company of Springfield, Oregon began grinding mixed roofing waste (composed of asphalt shingles, wood, and felt paper) and selling the product as landscaping mulch under the name "No Spark Bark". The coarsely ground product is used by ODOT within their right-of-ways, while a more finely ground version is applied to residential and commercial properties. The manufacturers of this product did not consult with the DEQ on this reuse of the roofing waste. Several DEQ solid waste staff were concerned about this material being applied as mulch but had no evidence at the time that it posed environmental and human health threats.

- The DEQ is aware of two companies in the Willamette Valley manufacturing the landscaping product. Roofgone, a Springfield based company, produces the mulch and has also patented the product. Roofgone also licenses Pacific Land Clearing, Incorporated to manufacture the bark alternative. Pacific Land Clearing reported that they ground and sold 24,000 tons[1] of the material last year, while Roofgone estimated their production at 10,000 tons[2]. At this time, they are the only known producers in Oregon of the roofing waste-derived bark mulch.

- Asphalt has been used on roads and roofs for decades, however, what is different in this case is that the asphalt and associated metals are ground finely and spread in sensitive environments. The grinding process greatly increases the surface to volume ratio of the particles which in turn significantly increases the mobility and bioavailability of the hazardous constituents.

## Bark Mulch Use

The bark is applied primarily to control weed germination and growth, to prevent soil erosion, and for its aesthetic qualities; when finely ground it has the appearance of a rich compost-bark dust. ODOT also values its relative inflammability. For several years ODOT has been applying the bark mulch on embankments, shoulders and landscaped areas within their right-of-ways (Photo #1). The manufacturers also indicate the product is being purchased by landscapers for use at commercial and residential properties (Photo #2).

Suppression of weed germination and growth by the bark is accomplished primarily through physical shielding of the underlying soil from heat and light. The hazardous constituents found in the bark are not known to provide any beneficial use.

### Coverage

Assuming: an application thickness of 2.5 inches, product bulk density of 1017 lbs/yd$^3$ (3), and an annual production of 35,000 tons; there is enough material produced to cover approximately 205 acres on an annual basis.

## "Bark Mulch" Composition

The "bark mulch' is approximately 50% wood waste and 50% asphalt shingle waste with incidental heavy metal contamination resulting from the grinding of nails and flashing, and from chemical treatment of the roofing shingles. The asphalt shingles themselves are composed of 30%-40% asphalt cement/binder, 40%-60% rock granules and mineral fillers, and 1-12% fiber (fiberglass or cellulose)[4].

**Photo #1: Promoting Residential Applications of "No Spark Bark"**
**Source: Roofgone Inc. website,**
wwwroofgone@roofgone.net

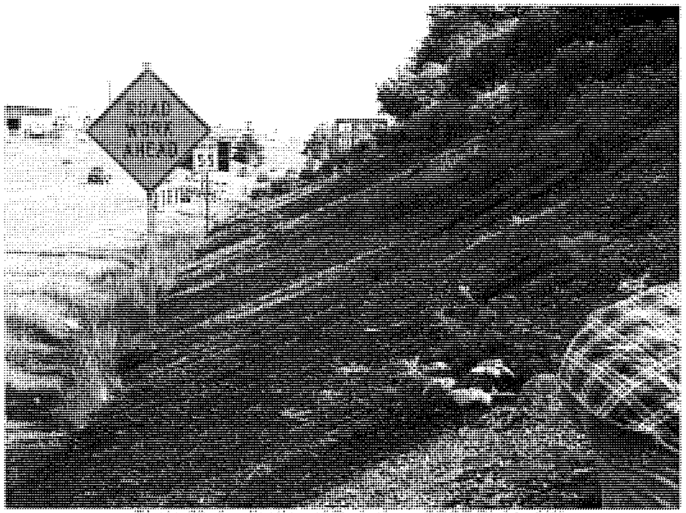


**Photo #2: Application of Bark along ODOT Right-of-Way**

Hazardous Constituents of the "Bark"

Numerous hazardous constituents were detected in laboratory analyses of the bark, raising concerns about its use and the impact on public health and the environment. Contaminants found in the "bark" can be divided into three primary groups: metals, petroleum hydrocarbons, and petroleum derived polynuclear aromatic hydrocarbons (PAHs). Many are highly toxic to both humans and aquatic organisms and are classified by the EPA as PBTs.

The State of Maine Department of Environmental Protection (MDEP) evaluated potential beneficial uses of ground asphalt shingles including use as a component of paving material for use on rural roads[5]. The MDEP evaluation included a risk assessment based on exposure to PAHs and metals found in the shingles. As part of this evaluation they analyzed two samples of ground asphalt shingles to determine PAH and metals content.

| PAHs | 1040-1 (ug/kg) | 1040-1DL (ug/kg) | Region 9 Res. PRGs (ug/kg) |
|---|---|---|---|
| Benz(a)anthracene | **46000** | **39000** | 620 |
| Benz(b)fluoranthene | **44000** | **48000** | 620 |
| Benz(k)fluoranthene | **10000** | <42000 | 6200 |
| Benzo(a)pyrene | **33000** | **34000** | 62 |
| Chrysene | 28000 | 30000 | 62000 |
| Dibenz(ah)anthracene | **5800** | **<42000** | 62 |
| Ideno(1,2,3-cd)pyrene | **25000** | **<42000** | 620 |
| **Metals** | (mg/kg) | (mg/kg) | (mg/kg) |
| Arsenic | 2.2 | 5.6 | 0.39 |
| Lead | 6.8 | 81.4 | 400 |
| Mercury | 0.04 | 0.17 | 1 |

**Table 1: Results of Ground Shingle Analyses, Maine Department of Environmental Protection**

In April 2004, DEQ staff collected 4 samples of the "Budget Bark" produced by PLC at their North Suttle Road facility in Portland, Oregon. A fifth analysis was run on piece of pure asphalt shingle.

The results of the analyses indicate the samples of asphalt shingles analyzed by MDEP contained considerably higher PAH levels than those analyzed by the ODEQ (factor of 10 higher, approximately). This is in part due to the fact that the ODEQ analyzed samples of the bark mulch which contains only 50% asphalt shingle material (and 50% wood waste), while MDEP analyzed samples of pure asphalt shingle. However, comparing the results for ODEQ #5 (pure shingle sample) to the Maine data, by weight the Maine samples contain significantly higher PAH levels.

Asphalt shingle composition can vary with respect to the proportion of asphalt to mineral filler, and the Maine data may represent shingles with proportionally higher asphalt content.

| Sample No.<br>PAHs | #1<br>(ug/kg) | #2<br>(ug/kg) | #3<br>(ug/kg) | #4<br>(ug/kg) | #5 Pure Shingle<br>(ug/kg) |
|---|---|---|---|---|---|
| Phenanthrene | 1500 | 1500 | 3400 | 1400 | <970 |
| Fluoranthene | 2700 | 2500 | 4000 | 3100 | <970 |
| Pyrene | 3300 | 3100 | 4700 | 3600 | <970 |
| Benz(a)anthracene | 2300 | 2200 | 3500 | 2800 | <970 |
| Benz(b)fluoranthene | 3000 | 3100 | 4400 | 2900 | <970 |
| Benz(k)fluoranthene | <250 | <250 | <250 | 300 | <970 |
| Benzo(a)pyrene | 3700 | 3700 | 4900 | 3200 | 5040 |
| Chrysene | 2900 | 1200 | 4000 | 2700 | <970 |
| Dibenz(ah)anthracene | 460 | 360 | 530 | 440 | <970 |
| Benzo(ghi)perylene | 1400 | 1400 | 2000 | 1200 | <970 |
| Ideno(1,2,3-cd)pyrene | 890 | 940 | 1200 | 840 | <970 |
| **Metals** | (mg/kg) | (mg/kg) | (mg/kg) | (mg/kg) | (mg/kg) |
| Arsenic | 25 | 20 | <20 | 28 | <50 |
| Barium | 70 | 120 | 102 | 86 | <100 |
| Copper | 76.4 | 60 | 51.9 | 49.1 | 1230 |
| Lead | 130 | 137 | 220 | 141 | <25 |
| Mercury | 0.133 | 0.202 | 0.177 | 0.13 | 0.0059 |
| Zinc | 334 | 352 | 498 | 384 | 0.17 |

**Table 2: ODEQ Bark Mulch Product Sample Results**

Significant differences were also observed in the metal concentrations. The concentrations detected in the ODEQ analyses were considerably higher than the results reported by MDEP. This is attributed to the fact that the bark mulch analyzed by DEQ contained incidental metal contamination resulting from grinding up of nails and flashing along with the shingle and wood waste; whereas, the Maine data represents shingle material only.

Other sources of metals in the roofing waste appear to be chemically treated shingles. Copper and zinc are commonly used to control moss growth on roofs. ODEQ sample #5 (pure shingle) contained 1230 ppm copper. This anomalously high value for a single piece of asphalt shingle, in the absence of any obvious metal content, suggests the source is a chemical treatment of the roofing material.

In the past, asbestos had been a component of some asphalt shingles, and has been infrequently detected in shingle waste in other states. Use of asbestos in asphalt shingles was discontinued in 1973. A study conducted by the Texas Transportation Institute estimated that 1 in 200 roofs have asbestos in the shingles[4]. The frequency of asbestos occurring in the roofing waste is expected to decline as time goes on.

**Environmental Fate and Transport of Contaminants**

Blending
It is expected that over the course of several years the bark mulch as a whole will blend with surface soils, initially reducing concentrations of hazardous substances present in the product. However, based on their concentrations in the product, contaminant levels in the soil are expected to remain well above applicable reference levels (e.g. risk-based concentrations) even after blending has occurred. In addition, if used like other mulches, repeated applications of the "bark" is expected as the wood waste component biodegrades and asphalt particles break apart and become incorporated into the underlying the soil matrix. Over time this would further concentrate metals and refractory PAHs in surface soils.

Biodegradation
The wood waste (50% by volume) is the most biodegradable component of the bark and it is anticipated to break down relatively quickly. Lower weight hydrocarbons will be the first components of the asphalt to degrade, while asphaltenes, carcinogenic PAHs, and other long chained hydrocarbons are less degradable and are expected to persist for many years. Heavy metals such as lead, mercury, copper and zinc are not biodegradable and will remain in the environment in perpetuity.

Sorption/Leaching
PAHs and metals generally have low aqueous solubilities, while also having a strong affinity to soil particles and organic matter in most environments. Because of these characteristics, the contaminants have low leaching to groundwater potential and will tend to remain in shallow soils. Low redox conditions and acidic pH can enhance metal mobility, where as high pH, humus content, clay content, and the presence of metal oxides all retard metals mobility[6].

Analyses of bark samples using the Toxicity Leaching Characteristic Procedure (TCLP) detected 150 and 220 ppb lead, and 490 and 420 ppb barium, in the leachate. Leached contaminants are much more mobile in the environment then their adsorbed counterparts and are available for transport to groundwater and surface waters.

Particulate Transport
The primary mechanism for contaminant migration in the environment is particulate transport, with stormwater and wind being the primary transport agents. Precipitation falling directly on the bark mulch and erosion of the application surfaces will tend to move contaminants into drainage swales and ditches where it can be more directly transported by stormwater into surface waters.

Wind-blown transport may also be significant for contaminant migration. Small particle size and the relatively low density of the asphaltic material (.95-1.13 gr/cm$^3$)[7] as compared to the specific gravity of mineral derived dust (2-3 gr/cm$^3$) increases the potential for wind-blown transport.

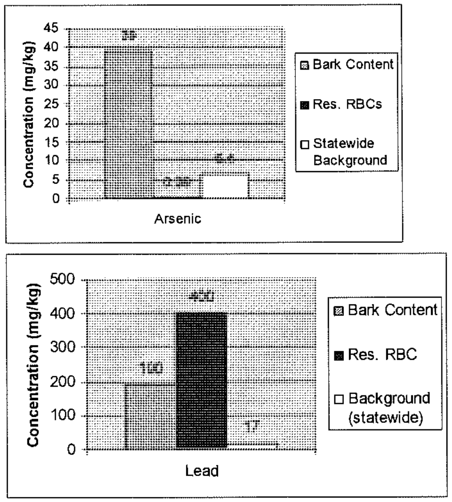
Summary of Fate and Transport

- Generally low aqueous solubilities and high affinity for soil particles and organic matter
- PAHs and Metals will tend to stay in surface soils
- TCLP results and predictive modeling indicates that there is potential for leaching of lead, barium and benzo(a)pyrene to groundwater and into surface water.
- Wind blown dust, and colloidal or sediment transport are the primary transport mechanisms

**Exposure Risks**

Human Health
DEQ analyses of the "bark mulch" detected several hazardous constituents at levels greatly exceeding their respective residential and commercial risk-based concentrations for surface soil. Comparison of constituent levels in the bark to surface soil risk-based concentrations is appropriate since the material is being used as mulch and essentially becomes the surface soil after application.

Exposure to the hazardous constituents in the mulch chiefly occurs through incidental oral ingestion, inhalation of dust, and absorption from dermal contact. Increased exposure is expected at residential sites due to the direct contact with soils in gardens and landscaped areas. Relatively high soil ingestion rates of children make them a particularly vulnerable sub-population



**Figures 1 and 2: Average Concentrations of Arsenic and Lead in Bark Mulch Based on ODEQ Product Analyses and Field Data, April-May, 2004 ***

*Metals concentrations in the mulch were averaged based on both product and field data. This approach was taken
because: 1) the metals levels in the field samples were significantly higher than those measured in the product samples, 2) metals are conservative contaminants, and 3) field data indicates the mulch is the source of the elevated arsenic and lead levels.

There are also human health concerns associated with ODOT's use along rural roads and highways. This material has a lower density than mineral-derived dust and may blow or migrate onto properties adjacent to the road ways. (Note: MDEP did a risk assessment for a similar scenario when they considered reuses of shingle material in paving applications).

*<u>Carcinogens detected above residential soil standards</u>*:

**benzo(a)pyrene, benz(a)anthracene, dibenzo(a,h)anthracene, benzo(k)fluoranthene, ideno(1,2,3,-cd)pyrene, and arsenic.**

Based on the results of product analyses and field sampling, arsenic and benzo(a)pyrene found in the bark mulch contribute the largest proportion of carcinogenic risk. Arsenic was detected in 5 of 6 samples at concentrations ranging from 20-92 ppm, with an average of 39 ppm. These values greatly exceed the threshold risk-based concentration (RBC) of .39 ppm, commercial RBC of 1.6 ppm, and the estimated statewide soil background concentration of 6.4 ppm. In addition, the great range in arsenic concentrations observed within the limited number of samples (6), suggests that maximum arsenic concentrations occurring in the mulch likely exceed the maximum measured concentration of 92 ppm. Arsenic is considered a class A human carcinogen by the EPA[8].

Benzo(a)pyrene was detected in all four product samples at concentrations ranging from 3.2-4.9 ppm, averaging 3.875 ppm. These values greatly exceed the residential RBC of .062 ppm and the commercial RBC of .27 ppm. Benzo(a)pyrene is considered a class B2 human carcinogen by the EPA[8].

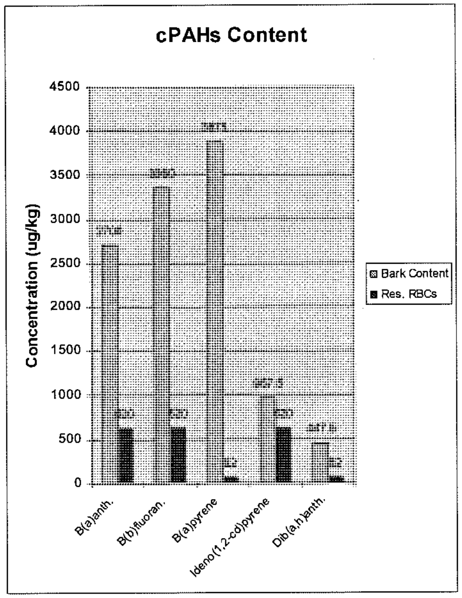


**Figure 3: Average Concentrations Based on Results from ODEQ Product Analyses, April 2004 with Comparison to Residential Risk-Based Concentrations**

Benz(a)anthracene, dibenzo(a,h)anthracene, benzo(k)fluoranthene, ideno(1,2,3,-cd)pyrene constitute the remainder of the carcinogenic risk. Theses contaminants are all considered class B2 human carcinogens[8].

## Calculation of Cumulative Carcinogenic Risk Based on Mulch Composition

$$\text{Risk} = \left[\left(\frac{\text{conc}_x}{\text{RBC}_x}\right) + \left(\frac{\text{conc}_y}{\text{RBC}_y}\right) + \left(\frac{\text{conc}_z}{\text{RBC}_z}\right)\right] \cdot 10^{-6}$$

$$Risk = \left[\left(\frac{B(a)P}{RBC}\right) + \left(\frac{Arsenic}{RBC}\right) + \left(\frac{B(a)An}{RBC}\right) + \left(\frac{DiB(a)An}{RBC}\right) + \left(\frac{B(b)Fl}{RBC_z}\right) + \left(\frac{Ideno}{RBC_z}\right)\right] \cdot 10^{-6}$$

$$Risk = \left[\left(\frac{3875}{62}\right) + \left(\frac{39000}{390}\right) + \left(\frac{2700}{620}\right) + \left(\frac{447}{62}\right) + \left(\frac{3350}{620}\right) + \left(\frac{968}{620}\right)\right] \cdot 10^{-6}$$

Carcinogenic Risk = $1.8 \times 10^{-4}$

### *Non-carcinogens detected above residential standards:*

DEQ samples of the bark dust were not analyzed for total petroleum hydrocarbons (TPH), however, based on the asphalt content in the waste, concentrations in excess of 100,000 ppm are expected. Depending on the composition of the TPH and the proportion of aliphatic to aromatic hydrocarbons, applicable risk-based concentrations range between 8,000-100,000 ppm range[19].

Based on the analyses of product and field samples lead levels in the mulch ranged from 130 -296 ppm. The average lead level measured in the material was 190 ppm, approximately 48% of the residential standard and significantly elevated with respect to the statewide background level of 17 ppm. Repeated applications of the bark would likely further concentrate lead levels in surface soils.

As in the case of arsenic, the range of lead levels measured in the mulch was large given the relatively small number of samples analyzed. This data suggests that some of the mulch sold likely contains lead levels greater than the 400 ppm surface soil residential standard.

Mercury was also detected at an average concentration of .16 ppm, below health-based screening levels.

### *Leaching to Groundwater*

TCLP tests detected lead in the leachate at 150 and 220 ppb. This exceeds the 15 ppb federal drinking water action level for lead. In addition, DEQ totals analyses of the bark detected benzo(a)pyrene at an average concentration of 3.875 ppm, exceeding the DEQ RBC of 2.4 ppm protective of the leaching pathway. Based on these results there is some potential to adversely impact groundwater.

### Ecological Risk

The bark mulch contains numerous chemicals that are highly toxic to aquatic organisms, elevated above background levels, and detected above the DEQ's Freshwater Sediment Standards[18]. In addition, a subset of these contaminants has been designated as persistent bioaccumulative toxins (PBTs) by the EPA because they are known to significantly bioaccumulate in the tissue of fish, birds, and mammels.

Contaminants above the Freshwater Sediment Screening Level Values include:

**benzo(a)pyrene**, benz(a)anthracene*, dibenzo(a,h)anthracene*, benzo(k)fluoranthene*, benzo(g,h)perylene*, pyrene*, fluoranthene*, phenanthrene*, chrysene*, arsenic*, barium, copper, lead*, mercury**, and zinc*.**

* denotes PBT
** denotes Priority PBT

Concerns regarding ecological risk and comparisons to aquatic sediment standards are based on use of the mulch along drainage ditches, swales, and other stormwater structures that discharge to surface waters. Stormwater transport of particulates, and leaching of barium and lead are the primary mechanisms for discharge to waters of the state.

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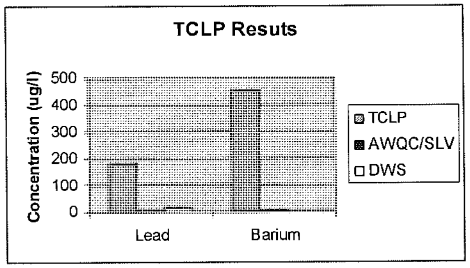

**Figure 4:** Results of the Toxicity Characteristic Leaching Procedure (TCLP) Analyses with Comparison to Ambient Water Quality Concentrations (AWQC) and Drinking Water Standards (DWS)

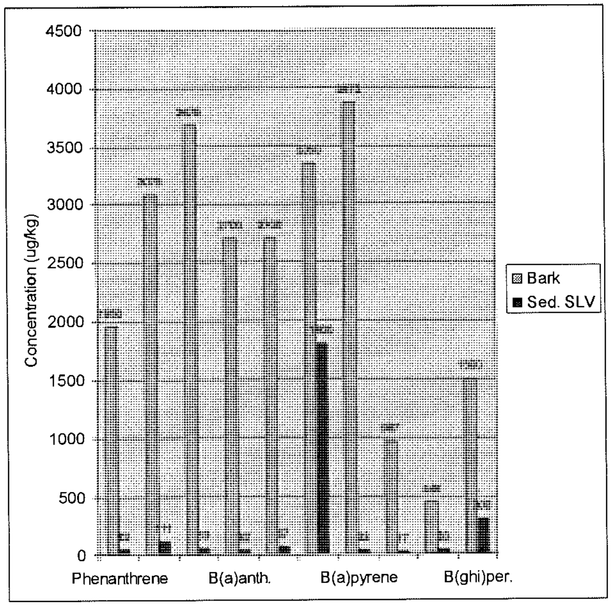

**Figure 5:** Average PAH Concentrations Based on Results from ODEQ Product Analyses, April 2004 with Comparison to Freshwater Sediment Screening Level Values[18]

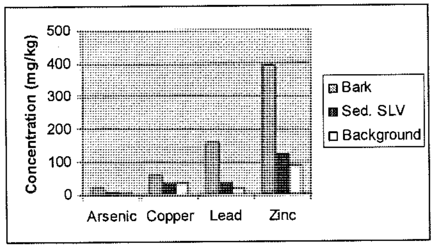

**Figure 6:** Average Metals Concentrations Based on Results from ODEQ Product Analyses, April 2004 with Comparison to Freshwater Sediment Screening Level Values[18] and Statewide Background levels in soil[10]

## Field Sampling Along ODOT Right-of-Way

On two separate occasions in May and June 2004, ODOT and DEQ staff visited two sites where the "No Spark Bark" had been applied. The first site was adjacent to Clackamas Community College near the intersection of Highway 213 and South Molalla Avenue. The second site sampled is located at 7373 Southeast Milwaukee Expressway. The primary goals of the sampling were: 1) to characterize contaminant levels in the mulch covered areas as compared to other areas within the right-of-way, and 2) to determine if hazardous constituents in the bark mulch were migrating into stormwater drainage systems and accumulating in surface water sediments, and 3) to determine whether the bark was increasing the load of contaminants transported by stormwater. The objectives of the sampling were to collect representative samples of: 1) the mulch material, 2) soil immediately beneath the mulch, 3) sediment in the adjacent drainage ditches, 4) background (unimpacted soil), and 5) sediment from a drainage ditch located along the same road, but where the bark material had not been used (Control).

### Observations

As can be seen in the photo below, bark had been applied to an embankment along Highway 213. Picking up a handful of the mulch, 1/4-1/2 inch pieces of asphalt shingles and wood were of observed, along with granules of asphalt and frit. On the surface the bark was somewhat bleached looking while beneath the surface the material was dark and looked relatively fresh. There were obvious signs that the material was being shed from the embankment into the drainage ditch.

Small pieces of asphalt could be seen mixed in with the sediment at the bottom of the ditch (photo #4), and accumulations of ground asphalt and shredded wood could be seen on the grating covering the inlet to the storm sewer the ditch drained to (photo #5).

**Photo #3: Highway 213/Clackamas Community College (CCC) Site. Photo shows mulch shedding off the embankment into the drainage ditch. Water can be seen flowing in the bottom of the ditch to a storm sewer.**

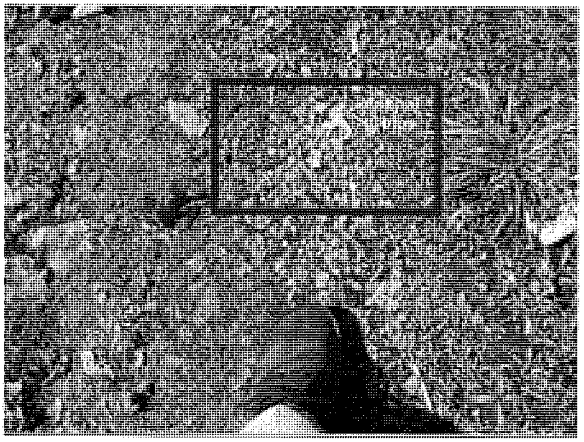

**Photo #4: Asphalt Chips Accumulating in the Drainage Ditch Sediments at the CCC Site.**

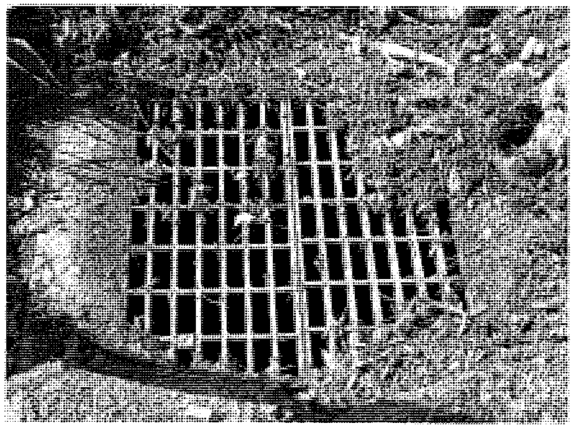

**Photo #5: Mulch Material Collecting on the Grating of the Storm Sewer Inlet at the CCC Site.**

## Sampling Results

PAH Analyses

*Bark Mulch:* The results presented in Table 3 indicate that PAH levels in the bark mulch sampled in the field were elevated with respect to background, although they were considerably lower than the concentrations measured in the bark stockpiled at the PLC production facility. On average, total PAH levels of the bark sampled in the field were 25% of the levels measured in the freshly ground material stockpiled at the PLC production facility. In addition, the most toxic PAHs, benzo(a)pyrene and dibenz(a,h)anthracene were not detected in the field samples.

*Soil:* Samples of soil located directly beneath the mulch were also analyzed for PAHs. The analyses detected the presence of PAHs at levels 5-10% of what was found in the bark mulch. No PAHs were detected in either sample at levels exceeding risk-based cleanup values, although benzo(a)pyrene was detected at the Clark site at a concentration of 41.6 ppb.

*Ditch Sediments*: Total PAH levels at the CCC site averaged 3900 ppb (roughly 67% of mulch levels), while concentrations averaged 520 ppb (approximately10% of the mulch levels) at the Clark site. Benzo (a) pyrene, benzo (b) fluoranthene, benzo (g,h,i) perylene, chrysene, fluoranthene, ideno (1,2,3-cd) pyrene, and pyrene exceeded freshwater aquatic sediment screening values at the CCC site, while benzo (b) fluoranthene, chrysene, and pyrene exceeded at the Clark site. Cumulative exceedence of SLVs (sum of: measured levels/SLVs) at CCC site was approximately 96, where at the control site it was 48.

*Background*: At the CCC site, three background soil samples was collected, composited, and analyzed for the PAHs. Chrysene, at a concentration of 43.9 ppb, was the only PAH detected. No contaminants were detected above health-based screening levels.

*Control:* Total PAH levels in ditch sediments at the control site averaged 2500 ppb. Benzo (b) fluoranthene, benzo (g,h,i) perylene, chrysene, fluoranthene, and pyrene exceeded freshwater aquatic sediment screening values. A greater percentage of the PAHs detected in the sediments at the control site were non-carcinogenic as compared to those detected at the CCC site where the bark mulch had been used.

Metals

*Bark Mulch*: Arsenic levels in the bark mulch sampled in the field were significantly higher (58 ppm at the CCC site and at 91.7 ppm at the Clark

location), then the average concentration of 23.4 ppm detected in the bark sampled at the PLC facility. Lead was detected at 220 ppm and 296 ppm at the CCC and Clark sites, respectively. This again was significantly higher than the average concentration of 157 ppm detected in the PLC samples. Mercury was detected in the mulch at both sites at .13 ppm, below the freshwater sediment SLV of .2 ppm. Copper was detected at the CCC site at 207 ppm and at the Clark site at 61.8 ppm. Zinc was detected at 365 ppm and 389 ppm at the CCC and Clark sites, respectively.

*Soil:* At the CCC site, metals concentrations in soil directly beneath the bark were consistent with naturally occurring background levels. At the Clark site, a background sample was not collected, thus the impact of the bark on metals concentrations in underlying soils could not be assessed. However, based on all of the data collected it appears that arsenic levels may have increased as a result of placement of the bark mulch, and that lead levels were slightly elevated.

*Ditch Sediments*: At the CCC site, copper, lead, and zinc were detected at concentrations exceeding those found at the background and control sites and also exceeded freshwater sediment SLVs. Copper levels were approximately twice those observed at the control site, while zinc was elevated by a factor of 2.5, and lead by a factor of 3. At the Clark site lead, copper, and zinc were detected at concentrations exceeding freshwater sediment SLVs, while mercury was detected at .1 ppm. With no background or control samples to compare to, contributions from the bark mulch to the metals contamination in the ditch sediments can't be assessed. However, at 134 ppm, lead was approximately 4 times background levels and 5.5 times greater than levels found at the control site. Mercury was also found in the sediments (and in the bark mulch), whereas it was not detected in underlying soils, or at the background and control sites.

*Control:* At the control sampling site chromium exceeded its freshwater sediment SLV by a factor of 2 and the zinc exceeded its SLV by a factor 1.1. All other metals were detected at levels below their respective SLVs.

*Background*: None of the metals analyzed for exceeded their respective freshwater sediment SLVs.

| Site | | CCC | | | | | Clark | | | Fresh. |
|---|---|---|---|---|---|---|---|---|---|---|
| Sampling Location | | Mulch | Soil | Ditch | Back. | Control | Mulch | Soil | Ditch | Sed. SLV |
| Contaminant | **PAHs (ug/kg)** | | | | | | | | | |
| | Fluorene | ND | ND | ND | ND | **153** | ND | ND | ND | 77 |
| | Phenanthrene | ND | ND | ND | ND | **417** | ND | ND | ND | 42 |
| | Fluoranthene | ND | ND | **309** | ND | **393** | ND | ND | 84.5 | 111 |
| | Pyrene | **2460** | **101** | **740** | ND | **715** | **1370** | **66.1** | **107** | 53 |
| | Benz(a)anthracene | ND | ND | ND | ND | ND | ND | ND | ND | 32 |
| | Chrysene | **2180** | **167** | **773** | 43.9 | **359** | **1250** | ND | **121** | 57 |
| | Benzo(b)fluoranthene | **1930** | **126** | **816** | ND | **205** | **1400** | **71.9** | **108** | 27 |
| | Benzo(a)pyrene | ND | ND | **279** | ND | ND | ND | **41.6** | ND | 32 |
| | Ideno(1,2l,3,-cd)pyrene | ND | ND | **318** | ND | ND | ND | ND | ND | 17 |
| | Dibenz(a,h)anthracene | ND | ND | ND | ND | ND | ND | ND | ND | 33 |
| | Benzo(ghi)perylene | ND | 98 | **670** | ND | 241 | **971** | 51.2 | 108 | 300 |
| | Total PAHs | **6570** | 492 | **3905** | 43.9 | **2483** | **4991** | 230.8 | 528.5 | 1610 |
| | **Metals (mg/kg)** | | | | | | | | | |
| | Arsenic | **58** | 2.51 | 3.09 | 2.17 | 3.19 | **91.7** | 5.98 | **4.57** | 6 |
| | Barium | 128 | 261 | 213 | 248 | 216 | 118 | 185 | 228 | NS |
| | Copper | **207** | 30.1 | **63.9** | 34.7 | 33.4 | **61.8** | 25.9 | **40.1** | 36 |
| | Chromium | **44.5** | **86.3** | **46.2** | 29.6 | **75.4** | **41.6** | 22.4 | 25.8 | 37 |
| | Lead | **220** | 23.4 | **79.3** | 34.7 | **24.8** | **296** | **44.2** | **134** | 35 |
| | Mercury | 0.132 | ND | ND | ND | ND | 0.139 | ND | 0.102 | 0.2 |
| | Zinc | **365** | 72.2 | **306** | 80.5 | **137** | **389** | 100 | **202** | 123 |
| | **Metals TCLP (mg/l)** | | | | | | | | | |
| | Arsenic | ND | ND | ND | ND | ND | ND | ND | ND | N/A |
| | Barium | **1.2** | **1.28** | **1.29** | ND | **0.943** | ND | **1.01** | ND | N/A |
| | Copper | ND | ND | ND | ND | ND | ND | ND | ND | N/A |
| | Lead | ND | ND | ND | ND | ND | ND | ND | ND | N/A |
| | Mercury | ND | ND | ND | ND | ND | ND | ND | ND | N/A |
| | Zinc | **1.29** | ND | **1.43** | ND | **0.929** | **1.58** | ND | ND | N/A |

Table 3: Results of ODEQ/ODOT Right-of-Way Sampling

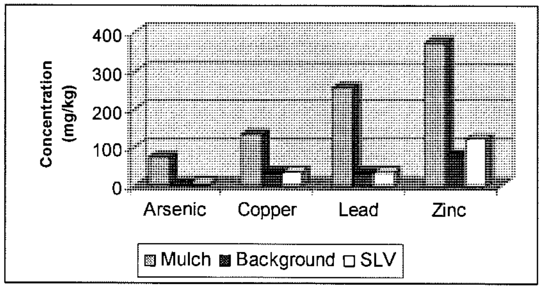

**Figure 7:** Results of Right-of-Way sampling Comparing Metals Concentrations in Mulch with Background Levels and Freshwater Sediment Screening Level Values (SLV)

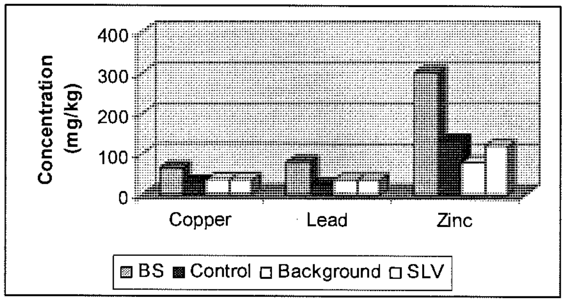

**Figure 8:** Metals Concentrations in Ditch Sediments for the Barked Site (BS) and Non-Barked (Control) Site, as Compared to Background Levels Measured at the CCC Site and Freshwater Sediment SLVs.

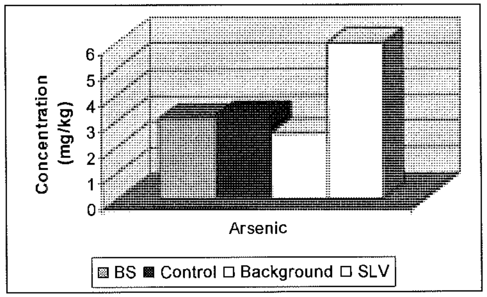

Figure 9: Arsenic Levels in Ditch Sediments at Barked (BS) and Non-Barked (Control) Sites as Compared to Background at CCC Site and Freshwater Sediment SLVs.

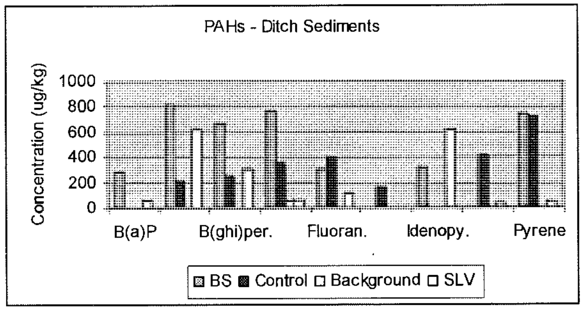

Figure 10: PAH Levels in Ditch Sediments at Barked Site (BS) and Non-Barked Site (Control) as Compared to Background Measured at CCC site and Freshwater Sediment SLVs.

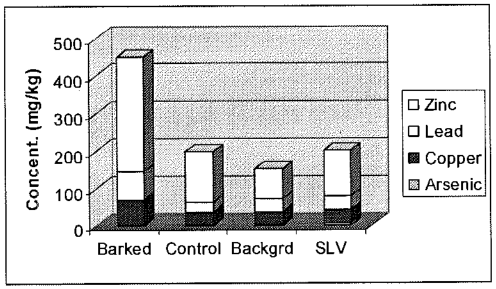

Figure 11: Cumulative Concentration of Select Metals in Drainage Ditches [Barked (CCC) vs Non–Barked (Control)] as Compared to Background Levels and Corresponding SLVs.

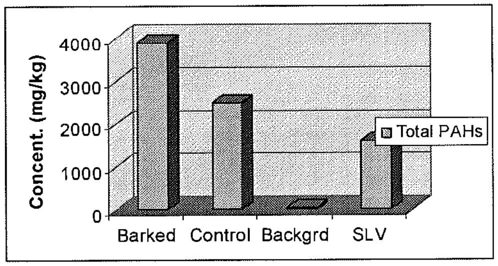

Figure 12: Total PAHs at Barked (CCC) and Non-Barked (Control) Sites as Compared to Background and SLV

Interpretation of Results

1. *Sediment in the drainage ditches exceed freshwater sediment SLVs.* This was true of all three sites. However, in comparison to the control location, sediments at the CCC site had approximately 60 % higher total PAH levels, on average 250% higher levels of lead, copper and zinc, and twice the cumulative ecological risk.

2. *Substantially lower PAH values were measured in the bark mulch in the field than in the fresh material sampled at the production facility.* Possible explanations: 1) degradation (biological, UV radiation), 2) variability in product composition.

3. *Higher concentration of carcinogenic PAHs where bark mulch was used as compared to control.* This may reflect different sources of the PAHs at

the CCC and Control sampling locations. The ground-up asphalt shingles in the bark mulch carry a high load of carcinogenic PAHs which may be affecting the distribution of PAHs in the drainage ditch sediments.

4. *High levels of arsenic and lead in the bark mulch tested in the field as compared to fresh samples collected at the facility.* Variability in product composition.

5. *Variability in ratios of metals content in bark mulch to concentrations in sediments.* Mobility of different metals in the environment vary. Based on previous research of metals mobility, it was anticipated that arsenic would be more mobile than either lead or copper. Field data on the distribution of metals at the CCC and Clark sites indicate there has been greater transport of lead and copper than arsenic.

6. *Higher level of PAHs at bark mulch site than at control.* 1) Application of bark mulch is resulting in buildup of PAHs in drainage ditch sediments 2) Within variability of sediment contaminant levels.

Field Investigation Conclusions

- The bark mulch has significantly higher levels of PBT contaminants than any other soil media sampled within the right-of-ways

- Field observations at both the CCC and Clark sites indicate the bark material is shedding from landscaped areas directly into drainage ditches with transport to the storm sewer system

- Data suggests that use of the bark mulch is exacerbating contaminant levels including several PBTs within right-of-way areas. Evidence for this conclusion is much stronger for metals than PAHs.

- Based on metals data, hazardous constituent levels in the bark mulch vary significantly

Sources of Uncertainty

1. Limited number of sampling points
2. Data distribution characteristics are unknown
3. Drainage characteristics of Control site differ some from the CCC site
4. Samples collected at Control site were taken under different antecedent conditions

### Regulation of Bark Mulch Contaminants and Applications by Cleanup Program

As indicated by Oregon Assistant Attorney General Larry Edelman, the application of the bark mulch and the hazardous substances it contains falls within the definition of "release" as defined in Oregon Revised Statute 465.200 (21). As such, it is subject to the Hazardous Substance Remedial Action Rules, commonly referred to as the Environmental Cleanup Rules. Amongst other requirements, these rules specify maximum allowable human health risks at residential and commercial properties from exposure to hazardous substances. For carcinogens the maximum allowable risk level is an excess cancer risk of 1 x $10^{-6}$, while "hot spots" of contamination are defined as areas with carcinogenic risks in excess of 1 x$10^{-4}$. Based on product analyses and field data, residential areas where the bark mulch is applied would exceed allowable risk levels for several contaminants and on average be considered "hot spots'. For hot spots in general, there is a preference for cleanup, while residential properties with hot spots would likely be considered high priority cleanup sites.

### How these Contaminants are Regulated by the DEQ Biosolids Program

CFR 40 Part 503 lists maximum pollutant contaminant levels in soil receiving biosolid applications. There are four hazardous constituents of the bark mulch that have maximum levels established for biosolids applications. Under Part 503, the maximum amount of arsenic, lead, mercury and benzo(a)pyrene allowed in the biosolids are 41 ppm, 300 ppm, 17 ppm, and 15 ppm, respectively. To arrive at this value the EPA performed a risk assessment that evaluated 14 exposure pathways. The limiting pathway for all four contaminants was direct ingestion of biosolids by children. The EPA risk assessment assumed an allowable risk level of 1 x $10^{-4}$ excess cancer risk for carcinogens and a hazard quotient of 1 for non-carcinogens. In comparison, DEQ cleanup standards for these contaminants are .39 ppm, 400 ppm, 1 ppm, and .062 ppm for arsenic, lead, mercury and B(a)P, respectively. The greatest disparity in standards is with the carcinogens, and is primarily due to DEQ cleanup levels being based on a maximum allowable risk of $10^{-6}$.

In discussions with Mark Cullington, DEQ Manager of the Biosolids Program, he cautioned that these values should not be taken out of context. The standards are based on the assumption that the contaminants are part of an organic-rich biosolids matrix and that this matrix affects and often significantly retards both the mobility and bioavailability of the contaminants. In addition, Mr. Cullington emphasized the 503 standards are maximums, and that in practice contaminant levels in the biosolids are typically a fraction of these values.

**Oregon Executive Order No. EO-99-13**

In 1999 Govenor Kitzhaber signed an executive order calling for the elimination of persistent, bioaccumulative, and toxic pollutants (PBTs). The order identifies the DEQ as the lead agency in a state-wide effort to eliminate releases of PBTs into the environment. Initial goals of the order are: 1) outline a range of approaches for to identify, track and eliminate the release of PBTs into the environment by year 2020; 2) evaluate state, national and international efforts to eliminate PBTs;
3) determine what activities generate PBTs, estimate the amounts being generated, and identify missing data; and 4) identify ways to utilize education technical assistance, pollution prevention, economic incentives, government procurement policies, compliance and permitting activities to eliminate PBT releases.

Mass of PBTs Released to the Environment from application of "No Spark Bark" and Similar Products

Est. mass of bark mulch produced annually x (PBT concentration[a]) = Mass of PBT released annually

35,000 tons X 2000 lbs/ton x (PBT conc. (PPM)) x 1 x $10^{-6}$

Assuming the following concentrations of PBTs in the Bark Mulch

B(a)P = 3.95 ppm
Total PAHs = 23.8 ppm
Arsenic = 39 ppm
Lead = 190 ppm
Mercury = .15 ppm

a = based on DEQ product test results for organics, product and field sampling test results for metals

This yields the following estimates:

B(a)P = 276.5 lbs/yr
Total PAHs = 1666 lbs/yr
Arsenic = 2739 lbs/yr
Lead = 13,275 lbs/yr
Mercury = 10.48 lbs/yr

**Authority of Other Agencies to Regulate this Product**

Health Division- Call into Ken Kaufman (Toxicologist) – Indicated it was out of their purview to regulate consumer products. Mr. Kaufman did say that his agency can issue public health advisories and would be willing to assist if asked to do so.

Oregon Department of Agriculture (Frank Prantl, Pesticide/Fertilizer Division) – Regulated if: 1) product claims to enhance soil/crop productivity (considered a soil amendment or fertilizer), or 2) it contains chemicals that suppress plant (weed) growth (herbicide) or kill pests (pesticide). Growth suppression by mechanical means (physically blocking light/heat) is specifically exempt. Based on these criteria, ODA does not have the authority to regulate No Spark Bark.

OSHA – MSDS Sheet - Prepared by, or for, manufacturing company (preparation by company owner is acceptable). They do not need to indicate the presence of hazardous constituents if they are less than 1% by weight or .1% by weight if the toxic constituent is a carcinogen. Lab analyses indicate PAHs are less than 1% by weight, and individual carcinogens are less than .1%.

**DEQ Authority to Regulate this Product**

Cleanup Rules

Hazardous Substance Remedial Action Rules Division 122

> *(1) These rules establish the standards and procedures to be used under ORS 465.200 through 465.455 and 465.900 for the determination of removal and remedial action necessary to assure protection of the present and future public health, safety and welfare, and the environment in the event of a release or threat of a release of a hazardous substance.*

Question: Does placement of the "bark" in residential and commercial properties, or areas within or adjacent to waters of the state constitute a "release" or "threat of a release" as defined in Division 122? ORS 465.200 (21) defines release as '*any spilling, leaking pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping or disposing into the environment including the abandonment or discarding of barrels, containers and other closed receptacles…."*

Noted Exclusion: (21)(d) The normal application of fertilizer.

Department of Justice attorney Larry Edelman confirmed the DEQ "*has authority to investigate and respond under ORS 465 and Div 122 to releases or threats of* *releases to the environment of hazardous substances from no spark bark on a case by case basis in the same manner DEQ would respond to other releases."*

Water Quality

340-041-0004 Antidegradation – *Purpose. The purpose of the Antidegradation policy is to guide decisions that affect water quality such that unnecessary further degradation from new or increased point and nonpoint sources of pollution is prevented, and to protect, maintain, enhance existing surface water quality to ensure full protection of all existing beneficial uses.*

340-041-0007 Statewide Narrative Criteria

*(1) Nothwithstanding the water quality standards contained in this Division, the highest and best practicable treatment and/or control of wastes, activities, and flows must in every case be provided do as to maintain dissolved oxygen and overall water quality at the highest possible levels and water temperatures, coliform bacteria concentrations, dissolved chemical substances, toxic materials ...... and other deleterious factors at the lowest possible levels.*

340-041-0033 Toxic Substances

*(1) Toxic substances may not be introduced above natural background levels in the waters of the State in amounts, concentrations, or combination that may be harmful , may chemically change to harmful forms in the environment, or may accumulate in sediments or bioaccumulate in aquatic life or wildlife to levels that adversely affect public health, safety or welfare, aquatic life, wildlife, or other designated beneficial uses.*

Definition of "waters of the state" are interpreted to include drainage ditches maintained by ODOT that drain to streams, rivers and lakes (ORS 468b.005).

(10) "Water" or "the waters of the state" include lakes, bays, ponds, impounding reservoirs, springs, wells, rivers, streams, creeks, estuaries, marshes, inlets, canals, the Pacific Ocean within the territorial limits of the State of Oregon and all other bodies of surface or underground waters, natural or artificial, inland or coastal, fresh or salt, public or private (except those private waters which do not combine or effect a junction with natural surface or underground waters), which are wholly or partially within or bordering the state or within its jurisdiction. [Formerly 449.075 and then 468.700; 2003 c.469 §1]

ODOT is issued a statewide MS4 stormwater permit by the DEQ under Division 45 rules (340-045-015) pertaining to NPDES permits. The permit requires ODOT to comply with narrative criteria excerpted above.

This material is being used by ODOT for landscaping, erosion and dust control. These are key management activities within the maintained areas covered by their MS4 permit. The Department interprets our regulatory authority to cover key management activities that have the potential to affect water quality and aquatic habitats.

Mr. Edelman confirmed this interpretation is accurate: *"that pollution of waters of the state caused by application of the "bark " could violate water quality provisions of state law, and that DEQ may have authority through applicable general permits to regulate placement of the material in or near highway culverts and drains"*

Solid Waste Rules

340-096-0040 pertains to transfer stations and material recovery facilities such as Roofgone that are permitted by the Department.

In regards to authority under the solid waste rules Mr. Edelman indicated *"that DEQ probably has authority to regulate processing and, thereby production, of the bark through MRF permits and the operations plans under Div 96 .I indicated it might be useful to develop some internal guidance for allowable constituent levels and uses of the material. Although DEQ does not have specific authority to regulate beneficial uses of solid waste materials, it has, from time to time, made determinations of acceptable applications of waste such as glass for roadbeds and approval of landfill cover materials."*

Mr. Edelman added: *"If DEQ has serious concerns about environmental and human exposure risks from certain uses of this material, it should make those concerns known to the producers, who could face liability .It may be possible to get voluntary cooperation to identify acceptable uses and those that are not acceptable. The acceptable uses could be identified in permits.*

**Conclusions**

- Ground up roofing waste contains numerous hazardous constituents that potentially pose significant health and environmental risks.
- The EPA has designated several of the contaminants found in the waste as PBTs and priority PBTs based on their human health and ecological risks and persistence in the environment.
- Use of the bark mulch product in sensitive environments such as gardens, landscaped areas and along right-of-way drainage structures can significantly increase human health and ecological exposures to the hazardous constituents it contains.

- Based on the average concentrations of contaminants found in the mulch, bark applications on residential properties would be considered "Hot Spots" of contamination. These sites would typically be remediated in the cleanup programs (Cleanup and Tanks), and likely considered high priority sites.
- Contaminants in the mulch do not serve a beneficial purpose and their placement in the environment could be construed as disposal.
- The bark mulch derived from the roofing waste does not serve a unique function but is simply a substitute for wood derived mulch, which is not known to have adverse human health or environmental impacts.
- The use of the bark mulch is exacerbating contamination along ODOT managed right-of-ways and constitutes additional and unnecessary loading of contaminants within state's watersheds.
- The use of the bark mulch by ODOT conflicts with Executive Order 99-013 on PBTs which requires that efforts be made to minimize, or eliminate where possible, the discharge of PBTs into the environment (DEQ was designated as the lead State agency). The use of this product likely also conflicts with Executive Order 03-03 on Sustainability.
- Review of our regulations and DOJ opinion indicates the DEQ has the authority to regulate production and use of the bark under DEQ solid waste rules and can regulate "after the fact" on a case-by-case basis under the cleanup rules. Authority under the water quality regulations can also be invoked in regards to ODOT's MS4 permit.
- The DEQ appears to be the only regulatory agency with authority over the production and use of this product.
- Given: the nature and uses of the product, its derivation from a solid waste, DEQ's charge of environmental protection and its permitting authority; the Agency is uniquely qualified to regulate the use of the product.

**Recommendations**

1. Share with ODOT and the manufacturers our findings and conclusions
2. Meet with ODOT and manufacturers to discuss our findings and their responses to them

3. Collect information on its application at residential properties
4. Collect information on ODOT's use of the product including geographic areas of use, sensitivity of application areas, periods of application.
5. Develop guidance specifying appropriate reuses of shingle waste.
6. Develop solid waste permits and operations plans reflecting this guidance.
7. Coordinate with the Health Division to issue a public health advisory.
8. If necessary, develop monitoring plans with ODOT to evaluate quality of stormwater runoff from areas of application.
9. Develop rules for requiring beneficial use analyses of new reuses of solid waste

Fact Sheet

# Consumer Alert: Bark Mulches Made from Roofing Wastes May Be Unsafe to Use

State of Oregon
**Department of Environmental Quality**

**Land Quality Division**
**Western Region**
1102 Lincoln St, Ste 210
Eugene, OR 97401
Phone: ( 541) 686-7838
( 800) 844-8467
Fax: ( 541) 686-7551
Contact: Bob Barrows
*www.oregon.gov/DEQ/*

## Background

Since late 2000, bark mulches composed of old asphalt roofing wastes have been produced and sold in the Portland and Eugene/Springfield areas. The material was called “Budget Bark” in the Portland area and “No Spark Bark” in Eugene/Springfield. The low-cost mulch was promoted as a bark mulch substitute for its low flammability and weed control properties.

In 2004, DEQ became concerned about soil and groundwater contamination from application of these mulches, and analyzed samples of the products. Results showed levels of contaminants in quantities of concern for human health and aquatic life.

DEQ analyses of the bark mulches detected several chemical constituents, including polynuclear aromatic hydrocarbons (PAHs) and arsenic, at levels exceeding those considered “safe” for soils located in residential and commercial settings. The chemicals of primary concern are arsenic and five petroleum-derived PAHs. Arsenic and several of the PAHs are considered probable human carcinogens by the US Environmental Protection Agency (EPA).

## Health and Ecological Risks

The mulches are not immediately hazardous to human health or aquatic life, but people should avoid repeated exposure by getting it in their mouths or by breathing the dust. The contaminants in the material are not very soluble, so they would not be expected to contaminate groundwater when thinly spread as landscaping mulch.

Human exposure to the toxics in the mulch can occur primarily through skin contact or oral ingestion from unwashed hands, and inhalation of dust. Gardening and landscaping activities will increase the possibility of exposure.

Children are especially at risk by ingesting the mulch or breathing its dust. Children are likely to play close to the ground and often put their fingers and hands in their mouths, which adds to their exposure risk. Because young bodies grow and develop rapidly, toxins have the ability to cause lasting harm if children are repeatedly exposed to these substances.

## Advice for use of mulch products

DEQ advises that homeowners and commercial property owners who use landscaping mulch avoid these two products and any mulch product containing asphalt roofing wastes. Many other safe mulch products are available for use as weed control.

If asphalt roofing mulch has already been used, DEQ recommends removal if the material has been placed in residential areas or commercial areas with frequent human activity.

## Should I have the mulch tested for toxics?

Testing is not needed to identify the material. The material is ground up asphalt roofing and should be fairly easy to visually identify. The asphalt will appear as dark black bits or chunks, often speckled with colored sand-sized particles. Individuals wanting to have their material tested should contact an analytical laboratory. Chemical constituents to be tested for include: 1) total metals and 2) polynuclear aromatic hydrocarbons.

## How do I remove the material from my property?

As with any potentially toxic material, property owners may want to consider hiring a professional cleanup company to remove this material. Homeowners can remove this material themselves. If you decide to do your own work, make sure you minimize your contact with the material by wearing a long sleeved shirt or jacket, long pants, and closed-toed shoes, and be sure to moisten the material to minimize generating dust that you could inhale. Any suspected bark mulch material can be raked or shoveled into sealed plastic bags and disposed with other garbage.

If mulch particles have been tracked into your home, remove them using a wet mop or equivalent. We recommend having your carpet cleaned if soiled by this material.

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By: Bob Barrows
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