Pavement Preservation Products Product Category Rule

Number 2011-01

1 June 2011

A Program of
Institute for Environmental Research and Education
PO Box 2449, Vashon WA 98070
iere.org/earthsure.aspx

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Pavement Preservation Products Product Category Rule

1. Identification of Product

1.1. UNSPSC Code: These products do not yet have a UNSPSC code, but could be used while performing these services under the noted UNSPSC codes.

1.1.1. 72103301 Parking lot or road maintenance or repairs or services
1.1.2. 72141003 Highway and road maintenance service
1.1.3. 72141104 Highway and road resurfacing service
1.1.4. 72141105 Sidewalk construction and repair service
1.1.5. 30222015 Runway [only maintenance or repair]
1.1.6. 72141101 Airport runway construction service
1.1.7. 95121613 Airfield [only maintenance or repair]

1.2. System Function: pavement preservation products restore the function of the existing pavement system and extend its service life, not increasing its capacity or strength[i].

a) Functional Unit: One square meter year of pavement preserved in average condition per ASTM D6433-09[ii] or ASTM 5340-10[iii]. In the United States, Federal Aviation Administration approvals P-626, P-630, P-631, P-632, EB-35, and EB-44, may also apply.

1.3. The scope of the PCR is Cradle to Grave.

1.4. The purpose of the PCR is to provide a detailed method for developing a business-to-business environmental product declaration to support comparable, informed, and objective sustainable purchasing.

1.5. Names and affiliations of the PCR Review Committee

Di Lu, independent, LCACP 2010-54
Ana Quiros, Eco-Global Advisors, Costa Rica
Vivik Khanna, PhD.,P.E., M.ASCE, Oklahoma Aeronautics Commission

The PCR committee recognizes and appreciates the reviewers for their contribution towards making this document stronger and clearer in both technical and editorial senses.

2. Administrative Details

2.1. Program operator: Institute for Environmental Research and Education (IERE)

2.2. A global search for pavement preservation PCRs identified no such document. This document appears to be the first.

2.3. Date of Publication: June 1, 2011

2.4. Expiration Date: May 31, 2016

Validity of any EPDs will be until the expiration date of the PCR, but any EPD must be updated in the case of substantial reformulation of the product. Substantial reformulation means any change affecting 10% of the mass of the product formulation or causing a 10% change in any impact category result.

3. Background

3.1. This PCR is developed in conformity with ISO 14040[iv], 14044[v], 14025[vi] and IERE's Earthsure Program[vii].

3.2. The PCR Development was funded by Asphalt Systems, Inc. (ASI)

3.3. Outreach was by phone and email, list of individuals contacted seen in Appendix A
Members of the PCR committee included:

Jim Roberts	ASI
Jim Aspin	Independent consultant to ASI
Kerry Nothnagel	Transystems
Kent Newman	Army Corps of Engineers
Alan James	Akzo Nobel
Brad Grose	ASI
Bob Young	ASI
Greg Cline	U.S. FAA, formerly US Navy
N. Mike Jackson	University of North Florida
Larry Galehouse	National Center for Pavement Preservation
Bruce Uhlman	BASF
Arlis A Kadrmas	BASF (Asphalt)

4. Definitions

4.1. AP 42: Air Pollution 42: a program of the U.S EPA for estimating air pollution emissions from industrial processes

4.2. CAS Number numerical identifier of chemicals provided by the Chemical Abstracts Service.

4.3. Competent Authority: an individual with a higher degree or at least five years experience in the relevant industry.

4.4. Consumptive Water Use: water removed from available supplies without return to a water resources system, e.g. water used in manufacturing, agriculture, and food preparation.

4.5. Ecosphere flows: raw materials taken from nature or returned to nature.

4.6. Foreground Data: data in processes under the direct control of the EPD owner.

4.7. Primary Data: raw data collected by the individuals in question, e.g., electricity invoices, stack test results, monthly monitoring data, etc.

4.8. Secondary Data: aggregated or modified data from a reputable source, e.g. descriptions of the local electric grid derived from the local utility, published peer reviewed articles, etc.

4.9. Semivolatiles: organic compounds typically having boiling points above 150 degrees Centigrade, and vapor pressures below 0.01 mm mercury.

4.10. Technosphere flows: all modified products and services. Technosphere flows are always accompanied by a financial exchange.
4.11. Tertiary data: data aggregated from many sources, e.g. in commercial LCI databases.
4.12. Unit Process: the lowest level at which life cycle inventory data is available.
4.13. Onsite formulation: changes in the product as applied to optimize for environmental conditions. For example more water or more sand or gravel may be added to the typical formulation.
4.14. First Tier Supplier: company selling product to the company seeking the EPD.
4.15. Foreground Data: data from processes under operational control of the EPD owner.
4.16. EPD Owner: the organization developing the EPD, usually the manufacturer
4.17. Background Data: data from processes not under operational control of the EPD Owner.

5. Acronyms

5.1. ASTM: American Society for Testing and Materials
5.2. BOD: Biological Oxygen Demand
5.3. COD: Chemical Oxygen Demand
5.4. EPA: Environmental Protection Agency
5.5. EPD: Environmental Product Declaration
5.6. ISO: international Association for Standardization
5.7. LCACP: Life Cycle Assessment Certified Professional.
5.8. LCA: Life Cycle Assessment
5.9. LCI: Life Cycle Inventory
5.10. LCIA: Life Cycle Impact Assessment
5.11. PM: Particulate matter (air)
5.12. PCR: Product Category Rule
5.13. TSS: Total suspended solids (water)
5.14. USGS: United States Geological Service
5.15. VOCs: Volatile Organic Substances

6. Standards Incorporated by Reference

6.1. Recommended Performance Guidelines for Emulsified Asphalt Slurry Seal Surfaces, 2010. International Slurry Surfacing Association A105
6.2. Recommended Performance Guidelines for Micro-Surfacing, 2010. International Slurry Surfacing Association A143
6.3. ASTM D6433 - 10 Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys
6.4. ASTM 5340-10 Standard Test Method for Airport Pavement Condition Index Surveys
6.5. ISO 14040: Environmental management — Life cycle assessment — Principles and framework
6.6. ISO 14044: Environmental management — Life cycle assessment — Requirements and guidelines

6.7. ISO 14025: Environmental labels and declarations —Type III environmental declarations — Principles and procedures

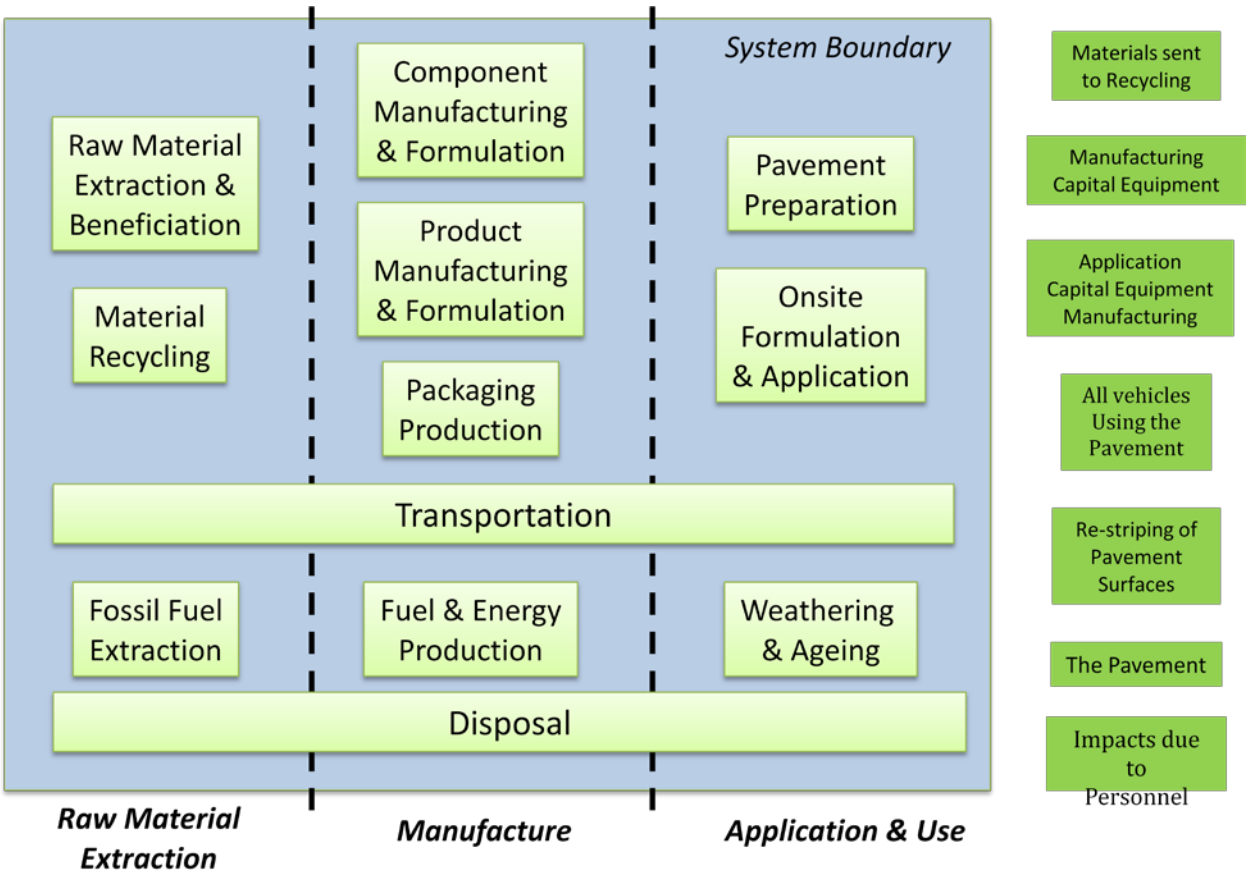
7. Inventory Analysis

The life cycle inventory is the input and output data collected at the unit process level. Combining the unit process data provides the entire life cycle inventory of the product system. The data is used to calculate the Life Cycle Impact Assessment and ultimately the Environmental Product Declaration.

7.1. This life cycle inventory covers all the stages of the life cycle from raw material extraction through the use phase. In the Earthsure system, waste treatment is modeled as an additional unit process rather than a life cycle stage. During use, some pavement products become worn away in use through chemical degradation or physical debridement, and imply no disposal unit process, while others contribute substantially to the pavement surface and their disposal or reuse must be accounted for at the time the road surface is removed.

7.2. The system boundary of the LCA study is illustrated in Figure 1. It excludes the production and disposal of capital equipment, but includes the operation of the equipment. The personnel impacts (travel to/from work; lunchroom operations and sanitary water treatment) are excluded. The office operations are excluded. The pavement itself is excluded, as is the operations of vehicles using the pavement. Where it is impossible to exclude office and personnel impacts (due to lack of sub-metering or measurement), these operations may be included, but a sensitivity analysis of this inclusion must be included in the study.

Figure 1 System Boundary for Pavement Preservation Products



7.3. The transportation model will ideally be based on actual information on fuel consumption and mode of transport. Where the transport is via common carrier, the following assumptions will be made:

7.3.1. All rail is assumed to have no empty haul-back. It is diesel powered.

7.3.2. Road transport is via diesel powered 20-ton tractor-trailers, with empty haul-back 50% of the time.

7.3.3.Ocean transport has no empty haul-back. It is diesel powered using bunker oil.

7.4. With the exception of energy producing processes, where unit operations have more than one product, the impact of the operations, including waste disposal is allocated according to the mass of the product. Where the mass of the product is not known, another unit may be used, but it must be converted to mass, and a sensitivity analysis performed on the potential range of the conversion. In the case of energy producing operations, the impacts are allocated according to energy production, on a useful energy equivalent basis.

7.5. Any wastes that are recycled (including those used for energy recovery) leave the system boundary, and are analyzed no further. When recycled materials are included in the product, they are considered raw materials, and the impact of their recycling is calculated from the point of discard, either at the discarding facility or at the waste management center.

7.6. Where waste disposal methods are known, they must be modeled for waste disposal. Where they are not known, the most recent waste inventory data from the U.S. EPA Office of Solid Waste or equivalent for the host country must be used.

7.7. No credit for bio-based greenhouse gases may be employed. However, sequestration of carbon into bio-based materials may be accounted for during raw material unit processes, which must include all the emissions created during growing, harvesting and transporting the biomass.

7.8. No carbon offset credits may be included in the calculation.

7.9. At least 95% of all mass and energy used in the system must be accounted for. No single flow that represents more than 1% of the total mass or energy flow may be excluded. All known toxic materials must be accounted for. At a minimum, all U.S. EPA Toxics Release Inventory Chemicals, or the equivalent for the host country must be evaluated.

7.10. At a minimum, the following ecosphere flows must be evaluated in the inventory, divided into releases to or removals from air, water and soil. If there is no flow, zeros should be noted. All Ecosphere inputs must be in units of in-nature amounts, e.g. nickel (in ground). A complete list can be found in Appendix C.

7.10.1. All greenhouse gases identified in the most recent IPCC technical report;

7.10.2. All fixed nitrogen; all phosphorus;

7.10.3. Categorical groups such as PM, TSS, VOCs, BOD and COD;

7.10.4. All substances on the US EPA Toxics Release Inventory or country equivalent;

7.10.5. All endocrine disrupters identified in the EU Annex 9 list;

7.10.6. All water withdrawal and release;

7.10.7. All minerals tracked by the U.S. Geological service in the Minerals Yearbook;

7.10.8. All removals of atmospheric components (O_2, N_2. etc.);

7.10.9. All fossil fuels extracted;

7.10.10. Land occupation (In units of area-years) and land use change (listing both the before and after use, following the satellite landcover naming conventions of the US Geological Service.

7.11. The entire inventory must be made available to the reviewer.

7.12. All foreground technosphere data must be primary data, collected over 12 months of operation. The month and year the data was gathered must be disclosed in the EPD.

7.13. Companies seeking the EPD must seek primary data from their first tier suppliers representing at least 80% of the mass of their technosphere inflows. Only when data is not available may they use secondary or tertiary data sources.

7.14. The electric grid for foreground operations should represent the local electric grid (as supplied by the local electric utility). Where unit operations are background data, or where the local utility will not provide the data, they should represent the most appropriate regional or national electric grid data as published by the U.S. LCI Database, the EU Database (ELCD) or other relevant national database.

7.15. Where the unit process is powered by renewable resources, e.g. wind or solar power, and no electricity leaves the facility (i.e. the system is not grid-linked), renewable electricity produced from wind or solar may be accounted for in the system.

7.16. All data must be in SI (metric) units.

7.17. The life cycle inventory must include information about the age of the data. All foreground data must be no more than two years old. All technosphere flows must be accompanied by the appropriate UNSPSC code. All Ecosphere flows must be accompanied by a CAS Number.

7.18. Where tertiary data is used, the most relevant data shall be used, in the following order of preference, from most to least desired: same locality> global> other locality. Where properly reviewed U.S. LCI database sets or EU ILCD or other national or regional datasets are available, they should be used for national data.

7.19. No data more than 10 years old may be used, unless it is affirmed by a competent authority that the processes they describe have not substantively changed.

Example Metadata: Extraction of Sand

Includes the removal of sand using heavy equipment and the sorting of the sand by size using a mechanical sieving machine.

Ecosphere inputs		
Sand in-ground	CAS # 99439-28-8	Primary data
Land occupation		Primary data
Technosphere inputs		
Diesel fuel	UNSPSC 15101505	Primary data
Lubricating oil	UNSPSC 15121520	Primary data
Electricity, single phase	UNSPSC 83101801	Primary data
Ecosphere outputs	(all calculated based on AP42)	
	Secondary data age 9 years	

7.20. Wherever possible, primary data should be calculated providing the mean, standard deviation and statistical distribution of the data. This data will support analysis of reproducibility and uncertainty of the data. Where these analyses are not possible, it will be assumed that the data are log-normally distributed with a relative standard deviation of 100%.

7.21. A flow chart showing the system boundaries must be included in the LCA study.

7.22. The unit process based Life cycle inventory must describe each of the unit processes as described above and as called out in ISO 14040 and 14044.

7.23. The inventory must disclose the percent of technosphere flow inventory that that are primary data, based on the number of technosphere flows.

7.24. All emissions factors used must be identified as primary (developed for the local unit process, or based on biological, chemical or physical constants such as stoichiometric equivalents), secondary (derived from studies of equivalent processes) or tertiary (derived from the aggregation of multiple similar processes).

7.25. The length of time of pavement life extension may be calculated using the default values shown below. These default figures represent the ***minimum*** life extension of the product, not the service life of the product. Most products will have life extension figures longer than found in Figure 2 below.

Figure 2 Default Minimum Pavement Life Extension Times

Asphalt Pavements	Minimum Pavement Life Extension (years)
Rejuvenators	1
Fog Seals	1
Crack Filling	1
Crack Sealing	2
Slurry Seals	4
Micro Surfacing	5
Chip Seals	5
Ultra-Thin Bonded Wearing Course	5
Ultra-Thin HMA Overlays	4
Thin HMA Overlays	5

Concrete Pavements	Minimum Pavement Life Extension (years)
Crack Sealing	1
Spall Repair	1
Diamond Grinding	3
Partial Depth Repair	5[viii]
Full Depth Repair	3
Dowel Bar Retrofit	2
Bonded Overlays	15[ix]

If default values are not used, the EPD owner must provide documentation of the expected pavement extension value, either through statistical analysis of existing use, or through engineering calculations. Calculations must be based on the range of anticipated application environments and conditions, and the calculated value for pavement extension must represent an arithmetic mean of the measured or calculated scenarios. Calculated scenarios should consider climate, weather during application and initial pavement condition.

During the use phase, there are losses due to volatilization, UV degradation, and physical debridement. These must be estimated based on the average scenario described above. Where the losses in runoff or in volatilization are not measured, the total bulk amount of the volatiles and semivolatiles in the virgin material must be assumed to be released. Semivolatiles must be characterized using US EPA method 8270 of SW846[x] or equivalent. Non-volatile components must be assumed to be landfilled as part of the next life cycle of pavement preservation product, unless it can be shown that the material is recycled into the next use of the product (e.g. through in-place asphalt recycling).

8. Life Cycle Impact Assessment

The impact assessment for methodology is based on expected impacts from the production, application and use of pavement preservation products. Stratospheric ozone depletion is an effect that is driven

largely by the release of refrigerants, which are not used in the pavement preservation product value chain, so this impact will be ignored. Impact assessment will be performed using the following methods

8.1. Climate change is the result of the anthropogenic addition of greenhouse gases into the atmosphere. These gases trap heat in the atmosphere, leading to a wide diversity of effects, including sea level rise and acidification, extreme weather events such as hurricane and tornadoes and droughts and floods. Greenhouse gases are released primarily through combustion processes. Ruminant enteric fermentation and other biological processes also contribute to these emissions. Climate change ultimately yields effects such as crop failure and increased incidence of disease leading to human mortality and losses of species and ecosystems. The majority of greenhouse gases are derived from combustion, and all products include combustion in their value chains, even if only for the purpose of transportation.

The midpoint indicator of climate change is the CO_2 equivalents is a measure of infrared radiative forcing, using the most common and important (in terms of fraction of the greenhouse effect) gas, CO_2. The lifetime of CO_2 in the atmosphere is very variable, but a weighted average is near 100 years, and thus the 100 year time horizon is selected. The characterization factors are derived from the Intergovernmental Panel on Climate Change's most recent 100-year horizon global warming potentials. In addition to CO_2, N_2O, and CH_4 are major drivers of climate change. Minor drivers of climate change include many refrigerants and some industrial chemicals. All of them must be accounted for in estimating the climate change impact.

8.2. Acidification causes the destruction of aquatic and terrestrial ecosystems through the wet and dry deposition of strong acids and ammonia. The acidification of soils mobilizes the aluminum in the soils and this has direct toxic effects on fish and other species, as well as an indirect effect through inhibition of uptake of potassium by plants, leading to loss of forest ecosystems. Acidification also affects the built environment, causing the slow dissolution of buildings. We have chosen the stoichiometric gram equivalents of hydrogen ion for emissions of oxides of sulfur and nitrogen, ammonia, HCL, HF, H_2SO_4, H_3PO_4

8.3. Eutrophication is the overgrowth of biomass caused by the anthropogenic release of nutrients, particularly fixed nitrogen and phosphorus. Eutrophied water bodies show early effects in terms of species distribution and toxic algal blooms, and ultimately as algae decompose eutrophication causes oxygen depletion leading to fish kills. Large portions of the world's water bodies are subject to eutrophication seasonally. Most causes of excess nutrient releases are agriculture, human and animal wastes, and combustion processes.

In the 1930's A.C. Redfield discovered that the ratio of carbon to nitrogen to phosphorus uptake into marine ecosytems was constant (C:N:P = 106:16:1, on an atom basis) and subsequently this ratio was confirmed to be the same in freshwater systems. The Redfield ratio

is the basis of all life cycle impact models. Report the nitrogen mass equivalents of carbon, nitrogen and phosphorus compounds released, using the Redfield Ratio.

8.4. Human and ecotoxicity represent direct effects of releases of toxic materials on humans and other organisms. It is anticipated that toxic materials will be emitted during the production and application of pavement preservation products, and they may also be emitted during the use phase. These shall be evaluated using the Usetox method, latest version.

8.5. Photochemical smog is produced when oxides of nitrogen and volatile organic substances are present in the atmosphere in the presence of sunlight. Ozone is formed, and this form of oxygen causes many direct effects, reducing crop yields, asthma and other respiratory effects in humans and animals. The production of ozone has been shown to be more related to the existence of oxides of nitrogen (NOx) than to the release of volatile organic substances.

Measurement of smog shall use the most recent U.S. EPA TRACI method, expressed in mass of ozone equivalents.

8.6. Non-renewable energy is expected to be used during the production, transportation and application of pavement preservation. The most recent Impact 2002+ method[xi] shall be used to evaluate this impact.

8.7. Resource Depletion: Listing of all uses of minerals with less than 100 years reserves as calculated by the ratio of extraction/proven reserves, and published by the most recent USGS Minerals Yearbook.

8.8. Some pavement preservation products include water, while others use water at various stages of the life cycle. There is currently no consensus on how to measure water resource depletion, so at this time, consumptive freshwater use shall be the indicator. Consumptive water use includes all the use of freshwater resources.

Figure 1 Life Cycle Impact Assessment Models

Impact Category	Category Indicator	Model Source
Climate Change	Mass of CO_2 Equivalents	Intergovernmental Panel on Climate Change[xii], most recent publication
Acidification	Mass Hydrogen Ion Equivalents	Stoichiometric equivalents
Eutrophication	Mass Nitrogen equivalents	Redfield Ratio[xiii,xiv]
Human Toxicity	CTUh	Use-Tox
Ecological toxicity	CTUe	Use-tox
Photochemical Smog	Mass O_3 equivalents	TRACI

Non-renewable Energy	MJ primary	Impact 2002+
Mineral Resource Depletion	Mass of minerals with less than 200 years reserves	USGS (listed in appendix)
Water Use	Volume of Water consumed	N/A

9. Sensitivity analyses

Sensitivity analyses must be performed on the following assumptions:

9.1. The composition of the product, taking into account the reasonable range of its composition at application;

9.2. Any allocation that could not be performed directly using mass or energy data;

9.3. Unless default minimum values are used, the range of road lifetime extension of the product.

10. Other measures to be disclosed

10.1. All toxic materials in the product as required by the U.S. Occupation and Health Administration (OSHA) requirements for Material Safety Data Sheets shall be disclosed on the EPD. Documentation for this disclosure shall include the MSDSs of components of the product and the formulation of the product.

10.2. The business or business unit manager must sign a declaration that affirms that the information disclosed in the EPD is true and correct to the best of his/her knowledge.

11. Format of the EPD

An example of the format is shown in Appendix A, and the EPDs should be substantively similar to the example.

11.1. The format of the EPD shall be as follows:

11.1.1. The name of the product, with any numerical identifier

11.1.2. A description of the use of the product (e.g. as fog seal on asphalt, as sealer on cement)

11.1.3. Any specifications or consensus standards the product meets

11.1.4. A photograph of the product either in the container (for packaged shipment) or during application or use (for bulk shipments).

11.1.5. The name of the producer of the product

11.1.6. The name of the PCR and the Program Operator

11.1.7. The date of expiry of the EPD

11.1.8. The table of the impact indicator results, shown by life cycle stage

11.1.9. List of MSDS toxic materials, with percent content

11.1.10. Signature by business unit manager that the EPD is true and correct to the best of his/her knowledge

11.1.11. Validation by third party LCACP that the EPD conforms with this PCR.

11.1.12. Contact information for the validator.

Appendix A: Mockup of EPD

Product Declaration
For XYZ Product, ABC Pavement Preservers

Product Information

XYZ product covers all kinds of asphalt pavements and extends their life four years on average. It is applied by spraying onto surfaces either by hand spray for small areas or by truck spray applicator for larger applications.

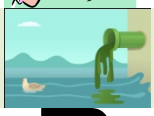
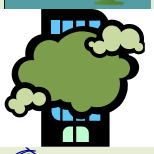
The analysis shown here was performed in accordance with the Earthsure Environmental Product Declaration Program, using the product category rule for pavement preservation products. The analysis is based on a life cycle assessment of XYZ Product, using data collected from January to December, 2012. Environmental Product Declarations from other sources using different Product Category Rules may not be comparable to this one.

Picture of the products covered by the EPD

Measurement Certification

Product Name	XYZ Product
Product ID number(s)	12345, 12345b, 12346
Meets quality specification	California technical specification ABC123, ISSI Standards 143 and ARRA standard 987.
Product Category Rule	Earthsure 2011-01 Pavement Preservation Products
Product Category Rule Operator	Earthsure program, IERE PO Box 2449, Vashon WA 98070 earthsure.org 206-463-7430
This EPD is valid until	May 31, 2016
Validator Name	John Smith
Validator Signature	
LCACP Registration Number	LCACP 2008-22
Date	25 January 2013

The Life Cycle Environmental Impact of preserving one square meter of pavement for one year using XYZ Product

	Raw Materials	Transport	Manu-facturing	Application and Use	Equivalent Units
 Climate Change	400	50	40	150	Grams CO_2
 Acidification	1	.01	.05	.6	Grams H+
 Eutrophication	.01	.01	.02	.3	Grams N
 Human Toxicity	.0005	.0008	.00001	.0005	CTUh
 Ecotoxicity	5	1	.5	1	CTUe
 Photochemical Smog	.005	.01	.001	.2	Grams O_3
 Non-renewable Energy	150	30	20	75	MJ primary
 Mineral Resource	2	0	0	0	Grams minerals
 Water Resource	5	.01	.5	2	Liters water

More information on XYZ Product

XYZ Product contains these hazardous materials	
CAS Number	Name
1310-73-2	Sodium Hydroxide
8002-05-9	Petroleum distillates
8012-56-4	Sodium dodecyl sulfate
To the best of our knowledge, XYZ Product contains no endocrine disrupters as defined by the European Commission.	
Percentage of primary technosphere data	62%
Dates of data collection	January-December 2012

Product Owner Certification

I have personally examined the conditions and the individuals performing this analysis and to the best of my knowledge, these representations are true and accurate.	
Name	Jane Doe, CEO
Date	30 January, 2013
Signature	Jane Doe

Disclaimers

The analyses presented here were performed with all due care, but the user should realize that they represent the average results measured under standardized conditions and the actual environmental performance will vary depending on the particular application, the climate, the traffic type and intensity and other factors beyond the control of ABC Pavement Preservers.

The results shown here pertain only to the referenced product category rule. They should not be compared directly to results using a different product category rule.

For more information, contact

ABC Pavement Preservers
123 Main Street
Smallsville, Ohio 23435
www.ABCPavementPreservers.com
info@ABC PavementPreservers.com
712-222-2222

Appendix B: List of invited interested parties

The following individuals were contacted via email and invited to participate in developing this PCR.

Name	Affiliation
Nancy Albright, P. E.	Director, Division of Maintenance, Kentucky DOT
John Andreae	Idaho Pavement
David Andrewski	Pavement Engineer, Indiana DOT
Paul Annarummo	Administrator, Bridge and highway Maintenance, RIDOT
Jim Aspin	Consultant to ASI
Thadd Buzan	Office of Deputy Undersecretary of Defense for Installations and Environment
Francois Chaignon	COLAS, Inc
German Claros	Research and Technology Implementation Office, Texas DOT
Greg Cline	Federal Aviation Administration, formerly U.S. Navy
Caleb Dobbins	Administrator, Bureau of Highway Maintenance, NH DOT
Dale Doughty	Director Bureau of Maintenance and operations Maine DOT
R. Gary Fore	National Asphalt Pavement Association
Larry Galehouse	National Pavement Preservation Center, Michigan State University
John Garrity	Bituminous Engineer, Minnesota DOT
Brad Grose	Asphalt Systems, Inc.
Steve Guy, P.E.	Florida, DOT
Bob Humer	Asphalt Institute
N. Mike Jackson	University of South Florida
Alan James	Akzo Nobel
Arlis Kadrmas	BASF
Richard Lewis	National Center for Asphalt Technology
George Lukes	Utah DOT
Kent Newman	Army Corps of Engineers
Ron Newsome	Alabama DOT
Kent Nicholson	IOWA DOT
Terry Nothnagel	Transystems
Angela Parsons, P.E.	Alaska DOT
Dave Ray, P.E., P.S.	Maintenance Administrator, Ohio DOT
Jim Roberts	ASI
Delmar Salomon	Pavement Preservation Systems
Tom Sands	Operations Division Manager, Nebraska DOT
Shakir Shatnawi	California DOT, Pavement
Peter Stephanos	US DOT
Jon Swartz	Administrator, Montana DOT
Bruce Uhlman	BASF
Joe Wright	Director, Maintenance & Operation, Delaware DOT
Megan White	Washington DOT

In addition, individuals working for the U.S. EPA and environmental non-governmental organizations Greenseal and World Resources Institute were invited to participate. Some of the invitees declined to be listed here.

Appendix C: List of *de minimus* information for life cycle inventory

(ecosphere flows) Compilation of the flows outlined in section 7.10.

Raw materials

Aluminum
Antimony
Arsenic
Asbestos
Barite
Bauxite and Alumina
Beryllium
Bismuth
Boron
Bromine
Cadmium
Chromium
Clays
Coal
Cobalt
Construction Sand and Gravel
Columbium (Niobium) and Tantalum
Copper
Diatomite
Feldspar and Nepheline Syenite
Ferroalloys
Fluorspar
Gallium
Garnet
Germanium
Gold
Graphite
Gypsum
Helium
Indium
Industrial Diamond
Iodine
Iron and Steel
Iron Ore
Land Occupation
Land Use Change
Lead
Lithium
Magnesium
Manganese
Mercury
Mica
Molybdenum
Natural Gas
Nickel
Nitrogen
Oxygen
Peat
Perlite
Phosphate Rock
Petroleum
Platinum-Group Metals
Potash
Pumice and Pumicite
Rare Earths
Rhenium
Selenium and Tellurium
Silica
Silicon
Silver
Soda Ash
Stone, Crushed
Stone, Dimension
Strontium
Sulfur
Talc
Thorium
Tin
Titanium
Tungsten
Uranium
Vanadium
Vermiculite
Fresh Water
Wollastonite
Zeolites
Zinc
Zirconium and Hafnium

Emissions to air water and soil

CAS Number	Name
4080-31-3	1-(3-Chloroallyl)-3,5,7-triaza- 1-azoniaadamantane chloride
354-11-0	1,1,1,2-Tetrachloro-2-fluoroethane
630-20-6	1,1,1,2-Tetrachloroethane
71-55-6	1,1,1-Trichloroethane
354-14-3	1,1,2,2-Tetrachloro-1-fluoroethane
79-34-5	1,1,2,2-Tetrachloroethane
79-00-5	1,1,2-Trichloroethane
13474-88-9	1,1-Dichloro-1,2,2,3,3-pentafluoropropane
812-04-4	1,1-Dichloro-1,2,2-trifluoroethane
111512-56-2	1,1-Dichloro-1,2,3,3,3-pentafluoropropane
1717-00-6	1,1-Dichloro-1-fluoroethane
57-14-7	1,1-Dimethyl hydrazine
96-18-4	1,2,3-Trichloropropane
120-82-1	1,2,4-Trichlorobenzene
95-63-6	1,2,4-Trimethylbenzene
106-88-7	1,2-Butylene oxide
96-12-8	1,2-Dibromo-3-chloropropane
106-93-4	1,2-Dibromoethane
1649-08-7	1,2-Dichloro-1,1- difluoroethane
354-23-4	1,2-Dichloro-1,1,2- trifluoroethane
422-44-6	1,2-Dichloro-1,1,2,3,3- pentafluoropropane
431-86-7	1,2-Dichloro-1,1,3,3,3- pentafluoropropane
95-50-1	1,2-Dichlorobenzene
107-06-2	1,2-Dichloroethane
540-59-0	1,2-Dichloroethylene
78-87-5	1,2-Dichloropropane
122-66-7	1,2-Diphenylhydrazine
95-54-5	1,2-Phenylenediamine
615-28-1	1,2-Phenylenediamine dihydro-chloride
106-99-0	1,3-Butadiene
507-55-1	1,3-Dichloro-1,1,2,2,3- pentafluoropropane
136013-79-1	1,3-Dichloro-1,1,2,3,3- pentafluoropropane
541-73-1	1,3-Dichlorobenzene

CAS Number	Name
542-75-6	1,3-Dichloropropylene
108-45-2	1,3-Phenylenediamine
764-41-0	1,4-Dichloro-2-butene
106-46-7	1,4-Dichlorobenzene
123-91-1	1,4-Dioxane
624-18-0	1,4-Phenylenediamine dihydro- chloride
82-28-0	1-Amino-2-methylanthraquinone
35691-65-7	1-Bromo-1-(bromomethyl)- 1,3-propanedicarbonitrile
354-25-6	1-Chloro-1,1,2,2- tetrafluoroethane
75-68-3	1-Chloro-1,1-difluoroethane
306-83-2	2,2-Dichloro-1,1,1- trifluoroethane
128903-21-9	2,2-Dichloro-1,1,1,3,3- pentafluoropropane
2655-15-4	2,3,5-Trimethylphenyl methylcarbamate
422-48-0	2,3-Dichloro-1,1,1,2,3-
78-88-6	2,3-Dichloropropene
95-95-4	2,4,5-Trichlorophenol
88-06-2	2,4,6-Trichlorophenol
94-75-7	2,4-D
53404-37-8	2,4-D 2-ethyl-4- methylpentyl ester
1928-43-4	2,4-D 2-ethylhexyl ester
1929-73-3	2,4-D butoxyethyl ester
94-80-4	2,4-D butyl ester
2971-38-2	2,4-D chlorocrotyl ester
94-11-1	2,4-D isopropyl ester
1320-18-9	2,4-D propylene glycol butyl ether ester
2702-72-9	2,4-D sodium salt
94-82-6	2,4-DB
615-05-4	2,4-Diaminoanisole
39156-41-7	2,4-Diaminoanisole sulfate
95-80-7	2,4-Diaminotoluene
120-83-2	2,4-Dichlorophenol
105-67-9	2,4-Dimethylphenol
51-28-5	2,4-Dinitrophenol
121-14-2	2,4-Dinitrotoluene
541-53-7	2,4-Dithiobiuret
120-36-5	2,4-DP
606-20-2	2,6-Dinitrotoluene
87-62-7	2,6-Xylidine
53-96-3	2-Acetylaminofluorene
117-79-3	2-Aminoanthraquinone
75-88-7	2-Chloro-1,1,1- trifluoroethane
2837-89-0	2-Chloro-1,1,1,2- tetrafluoroethane
532-27-4	2-Chloroacetophenone
110-80-5	2-Ethoxyethanol
149-30-4	2-Mercaptobenzothiazole (MBT)
109-86-4	2-Methoxyethanol
75-86-5	2-Methyllactonitrile
109-06-8	2-Methylpyridine
88-75-5	2-Nitrophenol
79-46-9	2-Nitropropane
90-43-7	2-Phenylphenol
422-56-0	3,3-Dichloro-1,1,1,2,2- pentafluoropropane
91-94-1	3,3'-Dichlorobenzidine
612-83-9	3,3'-Dichlorobenzidine dihydrochloride
64969-34-2	3,3'-Dichlorobenzidine sulfate
119-90-4	3,3'-Dimethoxybenzidine
20325-40-0	3,3'-Dimethoxybenzidine dihydrochloride
111984-09-9	3,3'-Dimethoxybenzidine hydrochloride
119-93-7	3,3'-Dimethylbenzidine
41766-75-0	3,3'-Dimethylbenzidine dihydrofluoride
612-82-8	3,3'-Dimethylbenzidine dihydrochloride
460-35-5	3-Chloro-1,1,1- trifluoropropane
563-47-3	3-Chloro-2-methyl-1-propene
542-76-7	3-Chloropropionitrile
55406-53-6	3-Iodo-2-propynyl
101-80-4	4,4'-Diaminodiphenyl ether
80-05-7	4,4'-Isopropylidenediphenol
101-14-4	4,4'-Methylenebis(2-chloroaniline)
101-61-1	4,4'-Methylenebis(N,N-dimethyl) benzenamine
101-77-9	4,4'-Methylenedianiline
139-65-1	4,4'-Thiodianiline
534-52-1	4,6-Dinitro-o-cresol
60-09-3	4-Aminoazobenzene
92-67-1	4-Aminobiphenyl
60-11-7	4-Dimethylaminoazobenzene
92-93-3	4-Nitrobiphenyl
100-02-7	4-Nitrophenol
99-59-2	5-Nitro-o-anisidine
99-55-8	5-Nitro-o-toluidine
71751-41-2	Abamectin
30560-19-1	Acephate
75-07-0	Acetaldehyde
60-35-5	Acetamide
75-05-8	Acetonitrile
98-86-2	Acetophenone
62476-59-9	Acifluorfen, sodium salt
107-02-8	Acrolein
79-06-1	Acrylamide
79-10-7	Acrylic acid
107-13-1	Acrylonitrile
15972-60-8	Alachlor
116-06-3	Aldicarb
309-00-2	Aldrin
107-18-6	Allyl alcohol
107-05-1	Allyl chloride
107-11-9	Allylamine
319-84-6	alpha-Hexachlorocyclohexane
134-32-7	alpha-Naphthylamine
7429-90-5	Aluminum (fume or dust)
1344-28-1	Aluminum oxide (fibrous forms)
20859-73-8	Aluminum phosphide
834-12-8	Ametryn
33089-61-1	Amitraz
61-82-5	Amitrole
7664-41-7	Ammonia
101-05-3	Anilazine
62-53-3	Aniline
120-12-7	Anthracene
7440-36-0	Antimony
7440-38-2	Arsenic
1332-21-4	Asbestos (friable)
1912-24-9	Atrazine
7440-39-3	Barium
22781-23-3	Bendiocarb
1861-40-1	Benfluralin
17804-35-2	Benomyl
98-87-3	Benzal chloride
55-21-0	Benzamide
71-43-2	Benzene
92-87-5	Benzidine
191-24-2	Benzo(g,h,i)perylene
98-07-7	Benzoic trichloride
98-88-4	Benzoyl chloride
94-36-0	Benzoyl peroxide
100-44-7	Benzyl chloride
7440-41-7	Beryllium
91-59-8	beta-Naphthylamine
57-57-8	beta-Propiolactone
82657-04-3	Bifenthrin
	biological oxygen demand
92-52-4	Biphenyl
108-60-1	Bis(2-chloro-1-methylethyl)ether

CAS Number	Name	CAS Number	Name	CAS Number	Name
111-91-1	Bis(2-chloroethoxy) methane	5234-68-4	Carboxin	68085-85-8	Cyhalothrin
111-44-4	Bis(2-chloroethyl) ether	120-80-9	Catechol	533-74-4	Dazomet
542-88-1	Bis(chloromethyl) ether	75-69-4	CFC-11	53404-60-7	Dazomet, sodium salt
56-35-9	Bis(tributyltin) oxide	76-13-1	CFC-113	1163-19-5	Decabromodiphenyl oxide
10294-34-5	Boron trichloride	76-14-2	CFC-114	13684-56-5	Desmedipham
7637-07-2	Boron trifluoride	76-15-3	CFC-115	117-81-7	Di(2-ethylhexyl) phthalate
314-40-9	Bromacil	75-71-8	CFC-12	2303-16-4	Diallate
53404-19-6	Bromacil, lithium salt	75-72-9	CFC-13	25376-45-8	Diaminotoluene (mixed isomers)
7726-95-6	Bromine	2439-01-2	Chinomethionat	333-41-5	Diazinon
353-59-3	Bromochlorodifluoromethane	133-90-4	Chloramben	334-88-3	Diazomethane
75-25-2	Bromoform	57-74-9	Chlordane	132-64-9	Dibenzofuran
74-83-9	Bromomethane	115-28-6	Chlorendic acid	124-73-2	Dibromotetrafluoroethane
75-63-8	Bromotrifluoromethane	90982-32-4	Chlorimuron ethyl	84-74-2	Dibutyl phthalate
1689-84-5	Bromoxynil	7782-50-5	Chlorine	1918-00-9	Dicamba
1689-99-2	Bromoxynil octanoate	10049-04-4	Chlorine dioxide	99-30-9	Dichloran
357-57-3	Brucine	79-11-8	Chloroacetic acid	90454-18-5	Dichloro-1,1,2-trifluoroethane
141-32-2	Butyl acrylate	108-90-7	Chlorobenzene	25321-22-6	Dichlorobenzene (mixed isomers)
123-72-8	Butyraldehyde	510-15-6	Chlorobenzilate	75-27-4	Dichlorobromomethane
4680-78-8	C.I. Acid Green 3	75-45-6	Chlorodifluoromethane	75-71-8	Dichlorodifluoromethane
6459-94-5	C.I. Acid Red 114	75-00-3	Chloroethane	75-43-4	Dichlorofluoromethane
569-64-2	C.I. Basic Green 4	67-66-3	Chloroform	75-09-2	Dichloromethane
989-38-8	C.I. Basic Red 1	74-87-3	Chloromethane	127564-92-5	Dichloropentafluoropropane
1937-37-7	C.I. Direct Black 38	107-30-2	Chloromethyl methyl ether	97-23-4	Dichlorophene
28407-37-6	C.I. Direct Blue 218	76-06-2	Chloropicrin	76-14-2	Dichlorotetrafluoroethane
2602-46-2	C.I. Direct Blue 6	126-99-8	Chloroprene	34077-87-7	Dichlorotrifluoroethane
16071-86-6	C.I. Direct Brown 95	63938-10-3	Chlorotetrafluoroethane	62-73-7	Dichlorvos
2832-40-8	C.I. Disperse Yellow 3	1897-45-6	Chlorothalonil	51338-27-3	Diclofop methyl
81-88-9	C.I. Food Red 15	75-72-9	Chlorotrifluoromethane	115-32-2	Dicofol
3761-53-3	C.I. Food Red 5	5598-13-0	Chlorpyrifos methyl	77-73-6	Dicyclopentadiene
3118-97-6	C.I. Solvent Orange 7	64902-72-3	Chlorsulfuron	1464-53-5	Diepoxybutane
842-07-9	C.I. Solvent Yellow 14	7440-47-3	Chromium	111-42-2	Diethanolamine
97-56-3	C.I. Solvent Yellow 3	7440-48-4	Cobalt	38727-55-8	Diethatyl ethyl
492-80-8	C.I. Solvent Yellow 34	7440-50-8	Copper	64-67-5	Diethyl sulfate
128-66-5	C.I. Vat Yellow 4	8001-58-9	Creosote	35367-38-5	Diflubenzuron
7440-43-9	Cadmium	1319-77-3	Cresol (mixed isomers)	101-90-6	Diglycidyl resorcinol ether
156-62-7	Calcium cyanamide	4170-30-3	Crotonaldehyde	94-58-6	Dihydrosafrole
133-06-2	Captan	98-82-8	Cumene	55290-64-7	Dimethipin
63-25-2	Carbaryl	80-15-9	Cumene hydroperoxide	60-51-5	Dimethoate
1563-66-2	Carbofuran	135-20-6	Cupferron	2524-03-0	Dimethyl chlorothiophosphate
124-38-9	Carbon dioxide	21725-46-2	Cyanazine	131-11-3	Dimethyl phthalate
75-15-0	Carbon disulfide	1134-23-2	Cycloate	77-78-1	Dimethyl sulfate
56-23-5	Carbon tetrachloride	110-82-7	Cyclohexane	124-40-3	Dimethylamine
124-73-2	Carbon tetrachloride	108-93-0	Cyclohexanol	2300-66-5	Dimethylamine dicamba
463-58-1	Carbonyl sulfide	68359-37-5	Cyfluthrin	79-44-7	Dimethylcarbamyl chloride

CAS Number	Name
115-10-6	Dimethylether
88-85-7	Dinitrobutyl phenol (Dinoseb)
25321-14-6	Dinitrotoluene (mixed isomers)
39300-45-3	Dinocap
957-51-7	Diphenamid
122-39-4	Diphenylamine
2164-07-0	Dipotassium endothall
136-45-8	Dipropyl isocinchomeronate
138-93-2	Disodium cyanodithioimidocarbonate
330-54-1	Diuron
2439-10-3	Dodine
28057-48-9	d-trans-Allethrin
106-89-8	Epichlorohydrin
13194-48-4	Ethoprop
140-88-5	Ethyl acrylate
541-41-3	Ethyl chloroformate
759-94-4	Ethyl dipropylthiocarbamate
100-41-4	Ethylbenzene
74-85-1	Ethylene
107-21-1	Ethylene glycol
75-21-8	Ethylene oxide
96-45-7	Ethylene thiourea
151-56-4	Ethyleneimine (Aziridine)
75-34-3	Ethylidene dichloride
52-85-7	Famphur
60168-88-9	Fenarimol
13356-08-6	Fenbutatin oxide
66441-23-4	Fenoxaprop ethyl
72490-01-8	Fenoxycarb
39515-41-8	Fenpropathrin
55-38-9	Fenthion
51630-58-1	Fenvalerate
14484-64-1	Ferbam
69806-50-4	Fluazifop butyl
2164-17-2	Fluometuron
7782-41-4	Fluorine
51-21-8	Fluorouracil (5-Fluorouracil)
69409-94-5	Fluvalinate
133-07-3	Folpet
72178-02-0	Fomesafen
50-00-0	Formaldehyde
64-18-6	Formic acid
76-13-1	Freon 113
353-59-3	Halon-1211
75-63-8	Halon-1301
124-73-2	Halon-2402
354-14-3	HCFC-121
354-21-2	HCFC-122
306-83-2	HCFC-123
306-83-2	HCFC-123
2837-89-0	HCFC-124
2837-89-0	HCFC-124
359-28-4	HCFC-131)
	HCFC-132)
	HCFC-133)
	HCFC-141)
1717-00-6	HCFC-141b
1717-00-6	HCFC-141b**
	HCFC-142
75-68-3	HCFC-142b
75-68-3	HCFC-142b**
	HCFC-151
75-43-4	HCFC-21**
75-45-6	HCFC-22
75-45-6	HCFC-22**
422-26-4	HCFC-221
422-49-1	HCFC-222
422-52-6	HCFC-223
422-54-8	HCFC-224
	HCFC-225
422-56-0	HCFC-225ca
422-56-0	HCFC-225ca**
507-55-1	HCFC-225cb
507-55-1	HCFC-225cb**
431-87-8	HCFC-226
421-94-3	HCFC-231
460-89-9	HCFC-232
7125-84-0	HCFC-233
425-94-5	HCFC-234
460-92-4	HCFC-235
666-27-3	HCFC-241
460-63-9	HCFC-242
460-69-5	HCFC-243
	HCFC-244
421-41-0	HCFC-251
819-00-1	HCFC-252
460-35-5	HCFC-253
420-97-3	HCFC-261
421-02-03	HCFC-262
430-55-7	HCFC-271
593-70-4	HCFC-31
	HCFE-235da2
76-44-8	Heptachlor
87-68-3	Hexachloro-1,3-butadiene
118-74-1	Hexachlorobenzene
77-47-4	Hexachlorocyclopentadiene
67-72-1	Hexachloroethane
1335-87-1	Hexachloronaphthalene
70-30-4	Hexachlorophene
680-31-9	Hexamethylphosphoramide
51235-04-2	Hexazinone
306-83-2	HFC-125
811-97-2	HFC-134a
420-46-2	HFC-143a
75-37-6	HFC-152a
431-89-0	HFC-227ea
75-46-7	HFC-23
690-39-1	HFC-236fa
460-73-1	HFC-245fa
75-10-5	HFC-32
406 58 6	HFC-365mfc
138495-42-8	HFC-43-10mee
3822-68-2	HFE-125
1691-17-4	HFE-134
420-46-2	HFE-143a
78522-47-1	HFE-236ca12 (HG-10)
22410-44-2	HFE-245c2
1885-48-9	HFE-245fa2
425-88-7	HFE-254cb2
188690-78-0	HFE-338pcc13 (HG-01)
28523-86-6	HFE-347mcc3
406-78-0	HFE-347pcf2
160620-20-2	HFE-356pcc3
	HFE-43-10pccc124(H-Galden 1040x)
163702-07-6	HFE-449sl (HFE 7100)
163702-08-7 163702-05-4 163702-06-5	HFE-569sf2 (HFE-7200)
163702-08-7	HFE-7100
67485-29-4	Hydramethylnon
302-01-2	Hydrazine
10034-93-2	Hydrazine sulfate
7647-01-0	Hydrochloric acid

CAS Number	Name
7647-01-0	hydrochloric acid
7664-39-3	hydrofluoric acid
74-90-8	Hydrogen cyanide
7664-39-3	Hydrogen fluoride
7783-06-4	Hydrogen sulfide
123-31-9	Hydroquinone
35554-44-0	Imazalil
13463-40-6	Iron pentacarbonyl
78-84-2	Isobutyraldehyde
465-73-6	Isodrin
25311-71-1	Isofenphos
67-63-0	Isopropyl alcohol
120-58-1	Isosafrole
77501-63-4	Lactofen
7439-92-1	Lead
58-89-9	Lindane
330-55-2	Linuron
554-13-2	Lithium carbonate
121-75-5	Malathion
108-31-6	Maleic anhydride
109-77-3	Malononitrile
12427-38-2	Maneb
7439-96-5	Manganese
108-39-4	m-Cresol
99-65-0	m-Dinitrobenzene
93-65-2	Mecoprop
7439-97-6	Mercury
150-50-5	Merphos
126-98-7	Methacrylonitrile
137-42-8	Metham sodium
74-82-8	Methane
74-82-8	Methane
67-56-1	Methanol
20354-26-1	Methazole
2032-65-7	Methiocarb
94-74-6	Methoxone
3653-48-3	Methoxone sodium salt
72-43-5	Methoxychlor
96-33-3	Methyl acrylate
74-83-9	Methyl bromide
79-22-1	Methyl chlorocarbonate
71-55-6	Methyl chloroform
60-34-4	Methyl hydrazine
74-88-4	Methyl iodide
108-10-1	Methyl isobutyl ketone
624-83-9	Methyl isocyanate
556-61-6	Methyl isothiocyanate
80-62-6	Methyl methacrylate
298-00-0	Methyl parathion
1634-04-4	Methyl tert-butyl ether
74-95-3	Methylene bromide
9006-42-2	Metiram
21087-64-9	Metribuzin
7786-34-7	Mevinphos
90-94-8	Michler's ketone
2212-67-1	Molinate
1313-27-5	Molybdenum trioxide
76-15-3	Monochloropentafluoroethane
150-68-5	Monuron
505-60-2	Mustard gas
108-38-3	m-Xylene
88671-89-0	Myclobutanil
121-69-7	N,N-Dimethylaniline
68-12-2	N,N-Dimethylformamide
142-59-6	Nabam
300-76-5	Naled
91-20-3	Naphthalene
71-36-3	n-Butyl alcohol
110-54-3	n-Hexane
7440-02-0	Nickel
1929-82-4	Nitrapyrin
7697-37-2	Nitric acid
10102-43-9	nitric oxide
139-13-9	Nitrilotriacetic acid
98-95-3	Nitrobenzene
1836-75-5	Nitrofen
10102-44-0	nitrogen dioxide
51-75-2	Nitrogen mustard
55-63-0	Nitroglycerin
10024-97-2	Nitrous oxide
10024-97-2	Nitrous oxide
872-50-4	N-Methyl-2-pyrrolidone
924-42-5	N-Methylolacrylamide
55-18-5	N-Nitrosodiethylamine
62-75-9	N-Nitrosodimethylamine
924-16-3	N-Nitrosodi-n-butylamine
621-64-7	N-Nitrosodi-n-propylamine
86-30-6	N-Nitrosodiphenylamine
4549-40-0	N-Nitrosomethylvinylamine
59-89-2	N-Nitrosomorpholine
759-73-9	N-Nitroso-N-ethylurea
684-93-5	N-Nitroso-N-methylurea
16543-55-8	N-Nitrosonornicotine
100-75-4	N-Nitrosopiperidine
27314-13-2	Norflurazon
90-04-0	o-Anisidine
134-29-2	o-Anisidine hydrochloride
95-48-7	o-Cresol
2234-13-1	Octachloronaphthalene
29082-74-4	Octachlorostyrene
528-29-0	o-Dinitrobenzene
19044-88-3	Oryzalin
20816-12-0	Osmium tetroxide
95-53-4	o-Toluidine
636-21-5	o-Toluidine hydrochloride
301-12-2	Oxydemeton methyl
19666-30-9	Oxydiazon
42874-03-3	Oxyfluorfen
95-47-6	o-Xylene
10028-15-6	Ozone
104-94-9	p-Anisidine
123-63-7	Paraldehyde
1910-42-5	Paraquat dichloride
56-38-2	Parathion
	particulate matter
106-47-8	p-Chloroaniline
95-69-2	p-Chloro-o-toluidine
104-12-1	p-Chlorophenyl isocyanate
120-71-8	p-Cresidine
106-44-5	p-Cresol
100-25-4	p-Dinitrobenzene
1114-71-2	Pebulate
40487-42-1	Pendimethalin
608-93-5	Pentachlorobenzene
76-01-7	Pentachloroethane
87-86-5	Pentachlorophenol (PCP)
57-33-0	Pentobarbital sodium
79-21-0	Peracetic acid
594-42-3	Perchloromethyl mercaptan
52645-53-1	Permethrin
76-19-7	PFC-218
355-25-9	PFC-3-1-10

CAS Number	Name
115-25-3	PFC-318
678-26-2	PFC-4-1-12
355-42-0	PFC-5-1-14
306-94-5	PFC-9-1-18
	PFPMIE
85-01-8	Phenanthrene
108-95-2	Phenol
26002-80-2	Phenothrin
57-41-0	Phenytoin
75-44-5	Phosgene
7803-51-2	Phosphine
7723-14-0	Phosphorus (yellow or white)
85-44-9	Phthalic anhydride
1918-02-1	Picloram
88-89-1	Picric acid
51-03-6	Piperonyl butoxide
29232-93-7	Pirimiphos methyl
100-01-6	p-Nitroaniline
156-10-5	p-Nitrosodiphenylamine
1336-36-3	Polychlorinated biphenyls
7758-01-2	Potassium bromate
128-03-0	Potassium dimethyldithio-carbamate
137-41-7	Potassium N-methyldithio- carbamate
106-50-3	p-Phenylenediamine
41198-08-7	Profenofos
7287-19-6	Prometryn
23950-58-5	Pronamide
1918-16-7	Propachlor
1120-71-4	Propane sultone
709-98-8	Propanil
2312-35-8	Propargite
107-19-7	Propargyl alcohol
31218-83-4	Propetamphos
60207-90-1	Propiconazole
123-38-6	Propionaldehyde
114-26-1	Propoxur
115-07-1	Propylene (Propene)
75-56-9	Propylene oxide
106-42-3	p-Xylene
110-86-1	Pyridine
91-22-5	Quinoline
106-51-4	Quinone
82-68-8	Quintozene
76578-14-8	Quizalofop-ethyl
10453-86-8	Resmethrin
78-48-8	S,S,S-Tributyltrithiophosphate
81-07-2	Saccharin
94-59-7	Safrole
78-92-2	sec-Butyl alcohol
7782-49-2	Selenium
74051-80-2	Sethoxydim
7440-22-4	Silver
122-34-9	Simazine
26628-22-8	Sodium azide
1982-69-0	Sodium dicamba
128-04-1	Sodium dimethyldithiocarbamate
62-74-8	Sodium fluoroacetate
7632-00-0	Sodium nitrite
132-27-4	Sodium o-phenylphenoxide
131-52-2	Sodium pentachlorophenate
100-42-5	Styrene
96-09-3	Styrene oxide
7446-09-5	Sulfur Dioxide
7446-09-5	sulfur dioxide
2551-62-4	Sulfur hexafluoride
13827-32-2	sulfur monoxide
7446-11-9	sulfur trioxide
7664-93-9	Sulfuric acid
2699-79-8	Sulfuryl fluoride (Vikane)
35400-43-2	Sulprofos
	suspended solids
34014-18-1	Tebuthiuron
3383-96-8	Temephos
5902-51-2	Terbacil
75-65-0	tert-Butyl alcohol
79-94-7	Tetrabromobisphenol A
127-18-4	Tetrachloroethylene
961-11-5	Tetrachlorvinphos
64-75-5	Tetracycline hydrochloride
7696-12-0	Tetramethrin
7440-28-0	Thallium
148-79-8	Thiabendazole
62-55-5	Thioacetamide
28249-77-6	Thiobencarb
59669-26-0	Thiodicarb
23564-06-9	Thiophanate ethyl
23564-05-8	Thiophanate methyl
79-19-6	Thiosemicarbazide
62-56-6	Thiourea
137-26-8	Thiram
1314-20-1	Thorium dioxide
7550-45-0	Titanium tetrachloride
108-88-3	Toluene
26471-62-5	Toluene diisocyanate (mixed isomers)
584-84-9	Toluene-2,4-diisocyanate
91-08-7	Toluene-2,6-diisocyanate
8001-35-2	Toxaphene
10061-02-6	trans-1,3-Dichloropropene
110-57-6	trans-1,4-Dichloro-2-butene
43121-43-3	Triadimefon
2303-17-5	Triallate
68-76-8	Triaziquone
101200-48-0	Tribenuron methyl
1983-10-4	Tributyltin fluoride
2155-70-6	Tributyltin methacrylate
52-68-6	Trichlorfon
76-02-8	Trichloroacetyl chloride
79-01-6	Trichloroethylene
75-69-4	Trichlorofluoromethane
57213-69-1	Triclopyr triethylammonium salt
121-44-8	Triethylamine
	trifluoromethyl sulphur pentafluoride
1582-09-8	Trifluralin
26644-46-2	Triforine
639-58-7	Triphenyltin chloride
76-87-9	Triphenyltin hydroxide
126-72-7	Tris(2,3-dibromopropyl) phosphate
72-57-1	Trypan blue
51-79-6	Urethane (Ethyl carbamate)
7440-62-2	Vanadium
50471-44-8	Vinclozolin
108-05-4	Vinyl acetate
593-60-2	Vinyl bromide
75-01-4	Vinyl chloride
75-35-4	Vinylidene chloride
	volatile organic compounds
1330-20-7	Xylene (mixed isomers)
7440-66-6	Zinc (fume or dust)
12122-67-7	Zineb

Appendix D: Example data gathering spreadsheets

Spreadsheets for primary data gathering should be sent to the producer and to the first tier suppliers to the producer. See examples below.

Contact information

Name	
Address	
Phone #	
Email	

Information needed: Composition of Product

Component	Amount	units of amount	Location from which component came	transport method	packaging type	composition of package	weight of package	Package Disposal method	Distance to disposal site, miles

In facility information

Monthly production data	Total Production of facility (mass/ month)	units	Total production of GSB88 (mass/month)	units	Total electricity use, kWh	Total Natural Gas Use, Therms	Total Diesel/ heating oil use, gallons	Total Water use, gallons	Total Propane use, gallons	Total gasoline use, gallons	Total lubricant use, mass/ month	Mass Unit	Total ancillary chemical use, Mass/ month	Mass unit	Total Solid Waste Produced , Mass/ month	Mass Unit	Total Hazardous Waste Produced/ month	Mass unit
Nov-09																		
1-Dec																		
Jan-10																		
Feb-10																		
Mar-10																		
Apr-10																		
May-10																		
Jun-10																		
Jul-10																		
Aug-10																		
Sep-10																		
Oct-10																		
Nov-10																		

Waste Disposal Practices					Air Emissions Information	
Waste Stream	Disposal Method	Distance to disposal	Transport type		Pollutant	emission, lb/lb product
					PM	
					VOC	

Product Shipping

Monthly shipping data	Rail Shipped		Truck Shipped		Other (specify)	
	short tons	average distance, miles	tons	average distance, miles	tons	average distance, miles
Nov-09						
1-Dec						
Jan-10						
Feb-10						
Mar-10						
Apr-10						
May-10						
Jun-10						
Jul-10						
Aug-10						
Sep-10						
Oct-10						
Nov-10						

Appendix E: Report of the PCR review committee

The Review committee made the following statements.

Overall, I would say that this product category rule was performed to ISO standards in both execution and in the documentation. The documentation is thorough and clear. They've taken care to hit the key points in section 6.7.1 of ISO 14025. The PCR fufill the general programme instructions.

section 2.2 claims " no other PCR document currently exists…" Is this a statement for USA? For the whole world? Who keeps a "registrar" of current existing PCRs. On another issue: why 5 years for expiration? (is there a logic behind this period?)

some references to data sources are better stated than others.

Better mention of reproducibility and uncertainty

General comment: tables and diagrams should be named and referenced in text (see 7.24). Other comments: 7.3.1 and 7.3.2: only "diesel powered"? For section 7.4 as it relates to "sensitivity analysis": refer to section 9 and enlarge scope and writing of this section 9

Please note section 7.6 has wording ("…or equivalent for the host country") which could be applied in other sections, for example 7.10.10 for land use. For 7.17 indicate in addition to CAS or UNSPSC, the "data level" (primary…) -as per example in 7.21 (incude in 7.21 example, the "age").

7.5 for recycling allocation is not clear. Need more explanation.7.15 specifically "wind or solar"?

General comment: tables should be named and referenced in text (see 8.9). In section 8, why are these impact categories are selected? Why Ozone Depletion is not included? Need to reference each impact category and model sources.

"The characterisation factor for human toxicity (human toxicity potential) is expressed in comparative toxic units (CTUh), providing the estimated increase in morbidity in the total human population per unit mass of a chemical emitted (cases per kilogram), assuming equal weighting between cancer and non-cancer due to a lack of more precise insights into this issue. " Need to explain why the characaterization factor for human toxicity is DALYs instead of CTUh when using USEtox.

The standards incorporated by reference (page 3 of PCR) include the performance guidelines published by the slurry seal association. I presume that this document will pertain to airport pavements too and therefore should also include FAA approved materials (P-626, P-630, P-631, P-632, EB-35, and EB-44,). The Standards incorporated include ASTM D6433-09 – Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys. Since this is also intended for airport pavement, it should also include ASTM 5340-10 Standard Test Method for Airport Pavement Condition Index Surveys.

While I like the idea of including and requiring the minimum pavement life extensions, I could not understand:

> Minimum Extension in life with rejuvenation and Fog seals was expected to be the same. Rejuvenation is a much costlier treatment and in our experience produces an extension of about 2-3yrs in the life of the pavement at least, unless applied incorrectly or to pavements not suited to the treatment due to the nature and extent of distresses.

Again the expectation of minimum life extension is the same for slurry seals and Micro surfacing. This is also counter intuitive since, micro surfacing is expected to last longer.

I feel that the life extensions should be linked to pavement condition prior to the application to give the user a better expectation of the results. I have attached a table in word format with this email for your consideration.

Appendix F: Descriptions of the response to the review

All the recommendations of the reviewers were accepted and addressed, with exception of the final one to put in another table describing pavement extension times under different conditions. The purpose of the minimum time table is to create a level playing field and minimize the potential for misrepresentation of the effectiveness of the product. We have strengthened the language to ensure a broader understanding of the default values and how to provide product-specific information.

References

[i] Definition paraphrased from the Federal Highway Administration Pavement Preservations Definitions Memo, September 12, 2005, Signed by David R. Geiger, Director of Asset Management.

[ii] ASTM D6433-09 – Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys

[iii] ASTM 5340-10 Standard Test Method for Airport Pavement Condition Index Surveys.

[iv] ISO 14040: Environmental management — Life cycle assessment — Principles and framework

[v] ISO 14044. Environmental management — Life cycle assessment — Requirements and guidelines

[vi] ISO 14025: Environmental labels and declarations —Type III environmental declarations —Principles and procedures

[vii] Earth sure® Environmental Product Declarations General Program http://iere.org/Data/Sites/1/SharedFiles/earthsure/Earthsure%20General%20Program.pdf

[viii] American Concrete Pavement Association. 2006. *Concrete Pavement Field Reference Preservation and Repair.*

[ix] National Concrete Pavement technology Center. 2008. *Guide to Concrete Overlays Sustainable Solutions to Resurfacing and Rehabilitating Existing pavements*. Second Edition.

[xx] METHOD 8270D SEMIVOLATILE ORGANIC COMPOUNDS BY GAS CHROMATOGRAPHY/MASS SPECTROMETRY (GC/MS). http://www.epa.gov/osw/hazard/testmethods/sw846/pdfs/8270d.pdf

[xi] Jolliet, O.; Margni, M.; Charles, R.; Humbert, S.; Payet, J.; Rebitzer, G.; Rosenbaum, R. 2003. IMPACT 2002+: A new life cycle impact assessment methodology. International Journal of Life Cycle Assessment 10(6), pp. 324– 330.

[xii] Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 2007 Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.) Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. (Note: updates anticipated in 2012)

[xiii] Redfield, A.C. 1934. On the proportions of organic derivatives in seawater and their relation to the composition of plankton. In Daniel, R.J [Ed] *James Johnstone Memorial Volume.* University Press of Liverpool pp.177-192.

[xiv] Redfield, A.C. 1958. The biological control of chemical factors in the environment. *Am. Sci.* 46:205-21.