Declaration Owner

Bentley Mills, Inc.
4641 East Don Julian Rd
City of Industry, CA 91746
www.bentleymills.com | 800.423.4709

Product

Optimum Barrier™ II

This EPD represents delivery of product to North American customers

UNSPSC Code 30161709
CSI Code 09 68 13

Functional Unit

The functional unit is one square meter of floor covering over a 75-year period

EPD Number and Period of Validity

SCS-EPD-07714
EPD Valid March 7, 2022 through March 6, 2027

Product Category Rule

PCR Guidance for Building-Related Products and Services Part A: Life Cycle Assessment Calculation Rules and Report Requirements. Version 3.2. UL Environment. September 2018

PCR Guidance for Building-Related Products and Services Part B: Flooring EPD Requirements. Version 2. UL Environment. September 2018.

Program Operator

SCS Global Services
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Declaration Owner:	Bentley Mills, Inc.
Address:	14641 East Don Julian Rd, City of Industry, CA 91746
Declaration Number:	SCS-EPD-07714
Declaration Validity Period:	EPD Valid March 7, 2022 through March 6, 2027
Program Operator:	SCS Global Services
Declaration URL Link:	https://www.scsglobalservices.com/certified-green-products-guide
LCA Practitioner:	Gerard Mansell, SCS Global Services
LCA Software:	openLCA v1.10.3 and ecoinvent v3.7
Independent critical review of the LCA and data, according to ISO 14044 and ISO 14071	☐ internal ☒ external
LCA Reviewer:	Tom Gloria, Ph.D., Industrial Ecology Consultants
Part A Product Category Rule:	PCR Guidance for Building-Related Products and Services Part A: Life Cycle Assessment Calculation Rules and Report Requirements. Version 3.2. UL Environment. September 2018
Part A PCR Review conducted by:	Lindita Bushi, PhD (Chair); Hugues Imbeault-Tétreault, ing., M.Sc.A.; Jack Geibig
Part B Product Category Rule:	PCR Guidance for Building-Related Products and Services Part B: Flooring EPD Requirements. Version 2. UL Environment. September 2018.
Part B PCR Review conducted by:	Jack Geibig (Chair); Tom Gloria, PhD; and Thaddeus Owen
Independent verification of the declaration and data, according to ISO 14025 and the PCR	☐ internal ☒ external
EPD Verifier:	Tom Gloria, Ph.D., Industrial Ecology Consultants
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Disclaimers: *This EPD conforms to ISO 14025, 14040, 14044, and 21930.*

Scope of Results Reported: *The PCR requirements limit the scope of the LCA metrics such that the results exclude environmental and social performance benchmarks and thresholds, and exclude impacts from the depletion of natural resources, land use ecological impacts, ocean impacts related to greenhouse gas emissions, risks from hazardous wastes and impacts linked to hazardous chemical emissions.*

Accuracy of Results: *Due to PCR constraints, this EPD provides estimations of potential impacts that are inherently limited in terms of accuracy.*

Comparability: *The PCR this EPD was based on was not written to support comparative assertions. EPDs based on different PCRs, or different calculation models, may not be comparable. When attempting to compare EPDs or life cycle impacts of products from different companies, the user should be aware of the uncertainty in the final results, due to and not limited to, the practitioner's assumptions, the source of the data used in the study, and the specifics of the product modeled.*

In accordance with ISO 21930:2017, EPDs are comparable only if they comply with the core PCR, use the same sub-category PCR where applicable, include all relevant information modules and are based on equivalent scenarios with respect to the context of construction works.

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1. Bentley Mills

For more than 40 years, California-based Bentley Mills, Inc. has manufactured broadloom, carpet tile, and area rug products for interiors.

2. Product

2.1 PRODUCT DESCRIPTION

Bentley's Optimum Barrier™ II broadloom, is a moisture resistant broadloom containing recycled content. These products feature superior Texture Appearance Retention Rating's (TARR), as well as Green Label Plus and NSF® 140 certifications.

2.2 PRODUCT FLOW DIAGRAM

A flow diagram illustrating the production processes and life cycle phases included in the scope of the EPD is provided below.

2.3 APPLICATION

Bentley Mills flooring products in this EPD provide the primary function of floor covering for interior applications.

2.4 DECLARATION OF METHODOLOGICAL FRAMEWORK

The scope of the EPD is cradle-to-grave, including raw material extraction and processing, transportation, product manufacture, product delivery, installation and use, and product disposal. The life cycle phases included in the product system boundary are shown below.

Cut-off and allocation procedures are described below and conform to the PCR and ISO standards.

Table 1. *Life cycle phases included in the product system boundary.*

Product			Construction Process		Use							End-of-life				Benefits and loads beyond the system boundary
A1	A2	A3	A4	A5	B1	B1	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
Raw material extraction and processing	Transport to manufacturer	Manufacturing	Transport	Construction - installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	Deconstruction demolition	Transport	Waste processing	Disposal	Reuse, recovery and/or recycling potential
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	MND

X = Module Included | MND = Module Not Declared

2.5 TECHNICAL DATA

Technical specifications for Bentley Mills flooring products are summarized in Table 2.

Table 2. *Product specifications for Optimum Barrier™ II.*

Characteristic	Description	
Type of Manufacture	Tufted Carpet Broadloom	
Yarn Type	Nylon 6,6	
Additional characteristics according to NSF/ANSI 140	Gold	
Sustainable certifications	NSF 140, Declare Label, CRI Green Label Plus	
VOC emissions test method	CRI Green Label Plus, CDPH Section 01350	
CRI TARR rating	2.5 - 4.5 Moderate - Extreme Traffic	
Characteristic	**Nominal Value**	**Units**
Total thickness	5.8 (0.228)	mm (inch)
Product weight	2536 (74.80)	g/m^2 (oz/yd^2)
Surface pile thickness	2.3 (0.091)	mm (inch)
Number of tufts or loops $/dm^2$	8.2 (127.2)	Tufts per dm^2 (Tufts per in^2)
Surface pile weight	474.7 (14)	g/m^2 (oz/yd^2)
Pile fiber composition	100	%
Secondary backing	Polypropylene	NA

2.6 MARKET PLACEMENT/APPLICATION RULES

Technical specifications of the products are summarized below. Additional product performance specifications can be found on the manufacturer's website http://www.bentleymills.com.

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Table 3. *Product performance for the Bentley Mills flooring products.*

Test Method	Test Results
AATCC[1] Test Method 134 Electrostatic Propensity of Carpets	≤ 3.5 kV
AATCC[1] Test Method 16, Option 3 Colorfastness to Light	Passes 4 minimum
ASTM[2] E648 Standard Test Method for Critical Radiant Flux of Floor Covering Systems Using a Radiant Heat Energy Source	Pass Class 1, ≥ 0.45 W/cm^2
ASTM[2] E662 Standard test Method for Specific Optical Density of Smoke Generated by Solid Materials	< 450 dm Corrected
ASTM[2] D5252 Standard Practice for the Operation of the Hexapod Tumble Drum Tester	2.5 - 4.5 Moderate – Extreme Traffic, 12,000 Cycle 8.4 lb Heavy Ball

[1] American Association of Textile Chemists and Colorists. https://www.aatcc.org/
[2] ASTM International. https://www.astm.org/

2.7 PROPERTIES OF DECLARED PRODUCT AS DELIVERED

Optimum Barrier™ II products are delivered for installation in the form of broadloom carpet.

2.8 MATERIAL COMPOSITION

The primary component materials include nylon 6,6 face fiber, a secondary polypropylene backing and scrim containing some recycled materials, and various fillers, adhesives and binders.

Table 4. *Product material composition per 1 m^2 of Optimum Barrier™ II.*

Material	Amount (kg/m^2)	Percent of Total (%)
CaCO3	0.995	39%
Nylon	0.475	19%
Polypropylene	0.197	7.8%
Other	0.870	34%
TOTAL	**2.54**	**100%**

2.9 MANUFACTURING

Bentley Mills products in this EPD are manufactured at the City of Industry facility in California. The primary component materials include nylon 6,6 face fiber, a secondary polypropylene backing containing some recycled materials, and various fillers, adhesives and binders.

2.10 PACKAGING

Bentley Mills' products in this EPD are packaged for shipment using chipboard, corrugated board, wood pallets and packaging film.

Table 5. *Packaging composition per 1 m^2 of flooring product.*

Material	Amount (kg/m^2)	Percent of Total (%)
Packaging film (LDPE)	9.86×10^{-3}	2.3%
Corrugated board	0.176	40%
White-lined chipboard	0.104	24%
Wood pallet	0.145	33%
TOTAL	**0.435**	**100%**

2.11 PRODUCT INSTALLATION

Installation of the flooring products in this EPD requires application of acrylic polymer adhesive. It is assumed that the scrap generated during installation is negligible in this EPD. The impacts associated with packaging disposal are included with the installation phase as per PCR requirements.

2.12 USE CONDITIONS

No special conditions of use are noted.

2.13 REFERENCE SERVICE LIFE

The Reference Service Life (RSL) of the flooring product is 15 years.

2.14 RE-USE PHASE

The flooring products are not typically reused at end-of-life.

2.15 DISPOSAL

At end-of-life, the products can be reclaimed according to the guidelines of Bentley's FULFILL reclamation program. For modeling in the LCA, data for estimation of recycling rates for the product and packaging are taken from the Carpet America Recovery Effort's (CARE) 2019 Annual Report and the US Environmental Protection Agency's Municipal Solid Waste Report, respectively. For product materials, it is assumed that 5.5% are recycled, while recycling rates for packaging materials vary, depending on waste material type.

For disposal of product materials which are not recycled, it is assumed that 5.5% are incinerated and 89% go to a landfill. Similarly, for packaging materials not recycled, it is assumed that 20% are incinerated and 80% go to a landfill. Transportation of waste materials at end of life assumes a 20 mile average distance to disposal, consistent with assumptions used in the US EPA WARM model.

2.16 FURTHER INFORMATION

Further information on the product can be found on the manufacturers' website at http://www.bentleymills.com.

3. LCA: Calculation Rules

3.1 FUNCTIONAL UNIT

The functional unit used in the study is defined as 1 m^2 of floor covering installed for use over a 75-year period. The manufacturer warrants the products for a 15-year lifetime. For the present assessment, a reference service lifetime (RSL) of 15 years is assumed. The 15-year RSL leads to a total of five (5) product lifecycles during the 75-year period of the estimated service life (ESL).

The reference flows and number of product replacements based on a 15-year product lifetime for the product system are summarized below.

Table 6. *Functional unit and reference flow for the flooring products.*

Parameter	Optimum Barrier™ II	Unit
Functional Unit	1.0	m^2
Mass	2.54	kg/m^2
Replacements	4	# of Replacements

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3.2 SYSTEM BOUNDARY

The scope of the EPD is cradle-to-grave, including raw material extraction and processing, transportation, product manufacture, product delivery, installation and use, and product disposal. The life cycle phases included in the EPD scope are described in Table 7 and illustrated in Figure 1.

Table 7. *The modules and unit processes included in the scope for the flooring products.*

Module	Module description from the PCR	Unit Processes Included in Scope
A1	Extraction and processing of raw materials; any reuse of products or materials from previous product systems; processing of secondary materials; generation of electricity from primary energy resources; energy, or other, recovery processes from secondary fuels	Extraction and processing of raw materials for the flooring components.
A2	Transport (to the manufacturer)	Transport of component materials to the manufacturing facilities
A3	Manufacturing, including ancillary material production	Manufacturing of flooring products and packaging (incl. upstream unit processes)
A4	Transport (to the building site)	Transport of product (including packaging) to the building site
A5	Construction-installation process	The product is installed using the manufacturer's recommended, or similar, adhesives with negligible impacts. Only impacts from packaging disposal are included in this phase.
B1	Product use	Use of the flooring in a commercial building setting. There are no associated emissions or impacts from the use of the product
B2	Product maintenance	Maintenance of products over the 75-year ESL, including periodic cleaning.
B3	Product repair, replacement and refurbishment	The flooring is not expected to require repair over its lifetime.
B4	Product replacement	The materials and energy required for replacement of the product over the 75-year ESL of the assessment are included in this phase
B5	Product refurbishment	The flooring is not expected to require refurbishment over its lifetime.
B6	Operational energy use by technical building systems	There is no operational energy use associated with the use of the product
B7	Operational water use by technical building systems	There is no operational water use associated with the use of the product
C1	Deconstruction, demolition	Demolition of the product is accomplished using hand tools with no associated emissions and negligible impacts
C2	Transport (to waste processing)	Transport of flooring product to waste treatment at end-of-life
C3	Waste processing for reuse, recovery and/or recycling	The product is disposed of by incineration and/or landfilling which require no waste processing
C4	Disposal	Disposal of flooring product in municipal landfill or incineration
D	Reuse-recovery-recycling potential	Module Not Declared

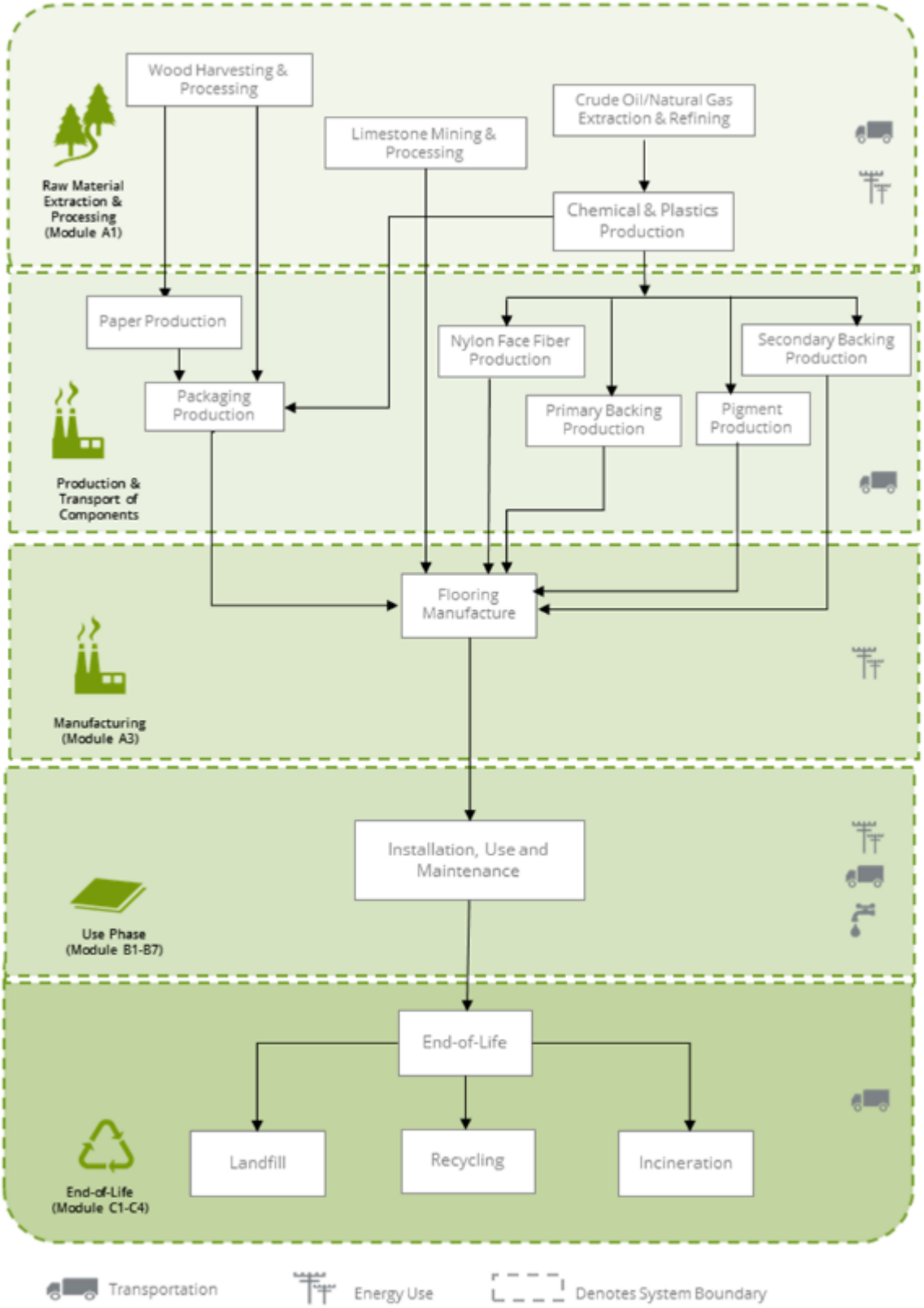

Figure 1. *Flow Diagram for the life cycle of the Bentley Mills flooring product system.*

3.3 PRODUCT SPECIFIC CALCULATION FOR USE PHASE

The recommended cleaning regime is highly dependent on the use of the premises where the floor covering is installed. In high traffic areas more frequent cleaning will be needed compared to areas where there is low traffic. For the purposes of this EPD, light maintenance (low traffic levels) is presented.

3.4 UNITS

All data and results are presented using SI units.

3.5 ESTIMATES AND ASSUMPTIONS

- The Bentley City of Industry, California facility is located in the CAMX eGRID EPA NERC subregion. An Ecoinvent inventory dataset representing CAMX eGRID energy mix is used to estimate resource use and emissions from electricity use at the Bentley manufacturing facility.
- Electricity and resource use (natural gas and water) at the City of Industry facility was allocated to the flooring products based on product mass.
- The Reference Service Life (RSL) of the products was modeled based on information provided by the manufacturer assuming their products are installed and maintained as recommended and used for the specific application noted.
- Inventory data for some material components were unavailable and modeled using proxy datasets from the Ecoinvent LCI databases.
- Specific data regarding the dyeing process of the carpet fiber was not available from the manufacturer. Both the solution and continuous carpet dyeing processes were modeled using representative data from CRI.
- Product maintenance involves regular vacuuming and periodic surface steam cleaning, as well as restorative steam cleaning, based on the level of wear conditions and foot traffic. The present assessment was based on a light traffic level; sensitivity analyses were conducted to evaluate the impacts of different assumptions regarding product maintenance.
- For the product end-of-life, excluding product packaging, recycling rates (Section 4.2) are assumed based on industry survey data collected by the Carpet America Recovery Effort (CARE) and documented in their 2019 annual report. Disposal of carpet fiber, exclusive of carpet backing, was modeled for three disposal scenarios: inert materials landfill, incineration, and recycling.
- Disposal of product packaging, composed of white-lined chipboard, corrugated cardboard and plastic film stacked on wooden pallets, is modeled based on 2018 statistics for municipal solid waste generation and disposal in the United States, from the US Environmental Protection Agency. This data supplies recycling rates for durable goods, as well as for packaging and containers.
- For final disposal of the packaging material and carpet tiles at end-of-life, all materials are assumed to be transported 20 miles by diesel truck to either a landfill, incineration facility, or material reclamation facility (for recycling). Datasets representing disposal in a landfill and waste incineration are from Ecoinvent.
- Modeling of recycled materials follows the recycled content method (also known as 100-0 method or cut-off method) whereby only the burdens of reprocessing the waste material are allocated to the system from the use of the recycled material.

It should also be noted that LCIA results are relative expressions and do not predict impacts on category endpoints, the exceeding of thresholds, safety margins or risks.

The PCR requires the results for several inventory flows related to construction products to be reported including energy and resource use and waste and outflows. These are aggregated inventory flows, and do not characterize any potential impact; results should be interpreted taking into account this limitation.

3.6 CUT-OFF RULES

According to the PCR, processes contributing greater than 1% of the total environmental impact indicator for each impact are included in the inventory. No data gaps were allowed which were expected to significantly affect the outcome of the indicator results. No known flows are deliberately excluded from this EPD.

3.7 DATA SOURCES

Primary data were provided by Bentley Mills for their manufacturing facilities. The sources of secondary LCI data are the Ecoinvent database.

Table 8. *Data sources for the Bentley Mills product system.*

Material	Material Dataset	Data Source	Publication Date
PRODUCT MATREIALS			
Nylon 6,6	Ascend, Thrive, Prisma nylon 6,6 face fiber	Primary data	2021
Calcium Carbonate (Limestone)	market for limestone, crushed, washed | limestone, crushed, washed | Cutoff, S	EI v3.7	2020
Polypropylene	polypropylene production, granulate | polypropylene, granulate | Cutoff, S/RoW	EI v3.7	2020
Other (dispersants, stabilizer, additives)	chemical production, organic | chemical, organic | Cutoff, S/GL styrene-acrylonitrile copolymer production | styrene-acrylonitrile copolymer | Cutoff, S/RoW; market for fatty acid | fatty acid | Cutoff, S/GLO; carbon black production | carbon black | Cutoff, S/GLO; zinc oxide production | zinc oxide | Cutoff, S/RoW; acrylic binder production, product in 34% solution state | acrylic binder, without water, in 34% solution state | Cutoff, S/RoW; vinyl acetate production | vinyl acetate | Cutoff, S/RoW	EI v3.7	2020
PACKAGING MATERIALS			
Chipboard	white lined chipboard carton production | white lined chipboard carton | Cutoff, S/RoW	EI v3.7	2020
Corrugated board	containerboard production, linerboard, testliner | containerboard, linerboard | Cutoff, S/RoW	EI v3.7	2020
Packaging film	packaging film production, low density polyethylene | packaging film, low density polyethylene | Cutoff, S/RoW	EI v3.7	2020
Pallet	EUR-flat pallet production | EUR-flat pallet | Cutoff, S/RoW	EI v3.7	2020
TRANSPORT			
Truck	transport, freight, lorry 16-32 metric ton, EURO4 | transport, freight, lorry 16-32 metric ton, EURO4 | Cutoff, S/RoW	EI v3.7	2020
Ship	transport, freight, sea, container ship | transport, freight, sea, container ship | Cutoff, S/GLO	EI v3.7	2020
RESOURCES			
Grid electricity	Electricity, medium voltage, per kWh - CAMX/CAMX	eGRID 2018; EI v3.7	2018; 2020
Natural gas	heat production, natural gas, at boiler modulating >100kW | heat, district or industrial, natural gas | Cutoff, S/RoW	EI v3.7	2020

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3.8 DATA QUALITY

The data quality assessment addressed the following parameters: time-related coverage, geographical coverage, technological coverage, precision, completeness, representativeness, consistency, reproducibility, sources of data, and uncertainty.

Table 9. *Data quality assessment for the product system.*

Data Quality Parameter	Data Quality Discussion
Time-Related Coverage: Age of data and the minimum length of time over which data is collected	The most recent available data are used, based on other considerations such as data quality and similarity to the actual operations. Typically, these data are less than 5 years old (typically 2016). All of the data used represented an average of at least one year's worth of data collection, and up to three years in some cases. Manufacturer-supplied data (primary data) are based on annualized production for 2020.
Geographical Coverage: Geographical area from which data for unit processes is collected to satisfy the goal of the study	The data used in the analysis provide the best possible representation available with current data. Electricity use for product manufacture is modeled using representative data for the EPA NERC CAMX sub-region. Surrogate data used in the assessment are representative of global or North American operations. Data representative of global operations are considered sufficiently similar to actual processes. Data representing product disposal are based on US statistics.
Technology Coverage: Specific technology or technology mix	For the most part, data are representative of the actual technologies used for processing, transportation, and manufacturing operations. Representative datasets, specific to the type of material, are used to represent the actual processes, as appropriate.
Precision: Measure of the variability of the data values for each data expressed	Precision of results are not quantified due to a lack of data. Data collected for operations were typically averaged for one or more years and over multiple operations, which is expected to reduce the variability of results.
Completeness: Percentage of flow that is measured or estimated	The LCA model included all known mass and energy flows for production of the flooring products. In some instances, surrogate data used to represent upstream and downstream operations may be missing some data which is propagated in the model. No known processes or activities contributing to more than 1% of the total environmental impact for each indicator are excluded.
Representativeness: Qualitative assessment of the degree to which the data set reflects the true population of interest	Data used in the assessment represent typical or average processes as currently reported from multiple data sources and are therefore generally representative of the range of actual processes and technologies for production of these materials. Considerable deviation may exist among actual processes on a site-specific basis; however, such a determination would require detailed data collection throughout the supply chain back to resource extraction.
Consistency: Qualitative assessment of whether the study methodology is applied uniformly to the various components of the analysis	The consistency of the assessment is considered to be high. Data sources of similar quality and age are used; with a bias towards Ecoinvent v3.7 data where available. Different portions of the product life cycle are equally considered.
Reproducibility: Qualitative assessment of the extent to which information about the methodology and data values would allow an independent practitioner to reproduce the results reported in the study	Based on the description of data and assumptions used, this assessment would be reproducible by other practitioners. All assumptions, models, and data sources are documented.
Sources of the Data: Description of all primary and secondary data sources	Data representing energy use at Bentley's manufacturing facility represents an annual average and are considered of high quality due to the length of time over which these data are collected, as compared to a snapshot that may not accurately reflect fluctuations in production. For secondary LCI data, Ecoinvent v3.7 LCI data are used.
Uncertainty of the Information: Uncertainty related to data, models, and assumptions	Uncertainty related to materials in the products and packaging is low. Actual supplier data for all upstream operations were not available and the study relied upon the use of existing representative datasets. These datasets contained relatively recent data (<10 years) but lacked geographical representativeness. Uncertainty related to the impact assessment methods used in the study are high. The impact assessment method required by the PCR includes impact potentials, which lack characterization of providing and receiving environments or tipping points.

3.9 PERIOD UNDER REVIEW

The period of review is calendar year 2020.

3.10 ALLOCATION

Manufacturing resource use was allocated to the products based on product area as a fraction of total facility production. Impacts from transportation were allocated based on the mass of material and distance transported.

3.11 COMPARABILITY

The PCR this EPD was based on was not written to support comparative assertions. EPDs based on different PCRs, or different calculation models, may not be comparable. When attempting to compare EPDs or life cycle impacts of products from different companies, the user should be aware of the uncertainty in the final results, due to and not limited to, the practitioner's assumptions, the source of the data used in the study, and the specifics of the product modeled.

4. LCA: Scenarios and Additional Technical Information

Delivery and Installation stage (A4 - A5)

Distribution of the flooring products to the point of installation is included in the assessment. Transportation parameters for modeling transport to product distribution centers are summarized in Table 10. A total distance of 500 miles (805 km) is assumed for transport by diesel truck from the distribution center to point of installation.

Table 10. *Transport parameters, per 1 m^2.*

Parameter	Value	Unit
Liters of fuel	18.7	l/100 km
Transport distance	805	km
Capacity utilization (including empty runs)	76	%
Weight of final packaged product transported - *Optimum Barrier™ II*	2.83	kg/m^2

Installation of the Bentley Mills products included in this EPD requires the application of an adhesive. The recommended adhesive is an acrylic base polymer with an application rate of 0.03 gallons lb per ft^2 (0.11 kg/m^2). It is assumed that the scrap generated during installation is negligible.

The impacts associated with packaging disposal are included with the installation phase, as per PCR requirements. Recycling rates for packaging are used to estimate packaging weights disposed. A summary of waste disposed and biogenic carbon uptake and emissions for product packaging is provided in Table 11.

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Table 11. *Installation parameters for the Bentley flooring products, per 1 m^2.*

Parameter	Value
Ancillary materials - Adhesive (kg)	0.11
Net freshwater consumption (m^3)	-
Electricity consumption (kWh)	-
Product loss per functional unit (kg)	negligible
Waste materials generated by product installation (kg)	negligible
Output materials resulting from on-site waste processing (kg)	na
Direct emissions (kg)	-
Packaging Material	**Mass of packaging waste (kg)**
Plastic	9.86×10^{-3}
Corrugated	0.176
Chipboard	0.104
Wood	0.145
Biogenic carbon in packaging (kg CO_2)	0.748

Use stage (B1)

No impacts are associated with the use of the product over the Reference Service Lifetime.

Maintenance stage (B2)

According to the manufacturer, typical maintenance involves regular vacuuming and periodic surface steam cleaning, as well as restorative steam cleaning. The present assessment is based on a recommended cleaning schedule for light traffic levels.

Table 12. *Maintenance parameters for the flooring products, per 1 m^2*

Parameter	Value	Unit
Maintenance process	Vacuuming	-
Maintenance cycle	Twice weekly	Cycles / RSL
Maintenance cycle	7,800	Cycles / ESL
Electricity	0.433	kWh/m^2/yr
Maintenance process	Extraction Cleaning	-
Maintenance cycle	Twice annually	Cycles / RSL (twice annually)
Maintenance cycle	150	Cycles / ESL
Electricity	0.067	kWh/m^2/yr
Water	1.372	kg/m^2/yr
Further assumptions	Light traffic	-

Repair/Refurbishment stage (B3; B5)

Product repair and refurbishment are not relevant during the lifetime of the product.

Replacement stage (B4)

The materials and energy required for replacement of the product over the 75-year ESL of the assessment are included in this stage.

Table 13. *Reference Service Life and replacement cycle for the Optimum Barrier™ II products, per m^2*

Parameter	Value	Unit
Reference Service Life (RSL)	15	years
Replacement Cycle (ESL/RSL-1)	4	-

Building operation stage (B6 – B7)

There is no operational energy or water use associated with the use of the product.

Disposal stage (C1 - C4)

The disposal stage includes demolition of the products (*C1*); transport of the flooring products to waste treatment facilities (*C2*); waste processing (*C3*); and associated emissions as the product degrades in a landfill or is burned in an incinerator (*C4*). For the flooring products, no emissions are generated during demolition (*C1*) while no waste processing (*C3*) is required for incineration or landfill disposal. Transportation of waste materials at end-of-life (*C2*) assumes a 20 mile (~32 km) average distance to disposal, consistent with assumptions used in the US EPA WARM model.

Data for estimation of recycling rates for the product and packaging are taken from the Carpet America Recovery Effort's (CARE) 2019 Annual Report and the US Environmental Protection Agency's Municipal Solid Waste Report, respectively. For product materials, it is assumed that 5.5% are recycled, while recycling rates for packaging materials vary, depending on waste material type.

For disposal of product materials which are not recycled, it is assumed that 5.5% are incinerated and 89% go to a landfill. Similarly, for packaging materials not recycled, it is assumed that 20% are incinerated and 80% go to a landfill. Transportation of waste materials at end of life assumes a 20 mile (32 km) average distance to disposal, consistent with assumptions used in the US EPA WARM model

The relevant disposal statistics used for the packaging are summarized in Table 14.

Table 14. *Recycling rates for packaging materials at end-of-life.*

Material	Recycling Rate
Paper & Pulp	78.2%
Plastics	14.6%
Wood	26.1%

5. LCA: Results

Results of the Life Cycle Assessment are presented below. It is noted that LCA results are relative expressions and do not predict impacts on category endpoints, the exceeding of thresholds, safety margins or risks.

The following environmental impact category indicators are reported using characterization factors based on the U.S. EPA's Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts – TRACI 2.1 and CML-IA.

CML-IA Impact Category	Unit	TRACI 2.1 Impact Category	Unit
Global Warming Potential (GWP)	kg CO_2 eq	Global Warming Potential (GWP)	kg CO_2 eq
Depletion potential of the stratospheric ozone layer (ODP)	kg CFC 11 eq	Ozone Depletion Potential (ODP)	kg CFC 11 eq
Acidification Potential of soil and water (AP)	kg SO_2 eq	Acidification Potential (AP)	kg SO_2 eq
Eutrophication Potential (EP)	kg PO_4^{3-} eq	Eutrophication Potential (EP)	kg N eq
Photochemical Oxidant Creation Potential (POCP)	kg C_2H_4 eq	Smog Formation Potential (SFP)	kg O_3 eq
Abiotic depletion potential (ADP-elements) for non-fossil resources	kg Sb eq	Fossil Fuel Depletion Potential (ADP_{fossil})	MJ Surplus, LHV
Abiotic depletion potential (ADP-fossil fuels) for fossil resources	MJ, LHV		

The following key life cycle inventory data parameters are taken from the PCR, which include resource use, output flows, and waste categories.

Key Life Cycle Inventory Parameter	Acronym	Reporting Unit
Use of renewable primary energy excluding renewable primary energy resources used as raw materials	RPR_E	MJ, LHV
Use of renewable primary energy resources used as raw materials	RPR_M	MJ, LHV
Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials	$NRPR_E$	MJ, LHV
Use of non-renewable primary energy resources used as raw materials	$NRPR_M$	MJ, LHV
Use of secondary material	SM	kg
Use of renewable secondary fuels	RSF	MJ, LHV
Use of non-renewable secondary fuels	NRSF	MJ, LHV
Use of net fresh water	FW	m^3
Hazardous waste disposed	HWD	kg
Non-hazardous waste disposed	NHWD	kg
High-level radioactive waste disposed	HLRW	kg
Intermediate- and low-level radioactive waste disposed	ILLRW	kg
Components for re-use	CRU	kg
Materials for recycling	MR	kg
Materials for energy recovery	MER	kg
Exported energy	EE	MJ, LHV

Modules B1, B3, B5, B6, and B7 are not associated with any impact and are therefore declared as zero. In addition, module C1 and C3 are likewise not associated with any impact as the products are expected to be manually deconstructed. Additionally, as the flooring products do not contain significant amounts of bio-based materials, biogenic carbon emissions and removals are not declared. Module D is not declared. In the interest of space and table readability, these modules are not included in the results presented below.

Table 15. *Life Cycle Impact Assessment (LCIA) results for the **Optimum Barrier™ II** flooring products over a 75-yr time horizon. Results reported in MJ are calculated using lower heating values. All values are rounded to three significant digits. (Solution dyed)*

Impact Category	A1	A2	A3	A4	A5	B2	B4	C2	C4
CML-IA									
GWP (kg CO_2 eq)	6.66	1.59	0.926	0.387	0.645	6.04	46.5	0.103	1.31
	10%	2.5%	1.4%	0.6%	1%	9.4%	72%	0.16%	2%
AP (kg SO_2 eq)	8.90×10^{-3}	6.14×10^{-3}	1.88×10^{-3}	1.49×10^{-3}	2.76×10^{-3}	3.30×10^{-2}	8.79×10^{-2}	4.81×10^{-4}	3.26×10^{-4}
	6.2%	4.3%	1.3%	1%	1.9%	23%	62%	0.34%	0.23%
EP (kg $(PO_4)^{3-}$ eq)	2.11×10^{-3}	1.45×10^{-3}	4.14×10^{-3}	3.52×10^{-4}	1.58×10^{-3}	1.03×10^{-2}	6.83×10^{-2}	1.03×10^{-4}	7.35×10^{-3}
	2.2%	1.5%	4.3%	0.37%	1.6%	11%	71%	0.11%	7.7%
POCP (kg C_2H_4 eq)	7.90×10^{-4}	2.05×10^{-4}	1.46×10^{-4}	4.99×10^{-5}	3.83×10^{-4}	1.29×10^{-3}	7.35×10^{-3}	1.57×10^{-5}	2.49×10^{-4}
	7.5%	2%	1.4%	0.48%	3.7%	12%	70%	0.15%	2.4%
ODP (kg CFC-11 eq)	7.98×10^{-8}	2.78×10^{-7}	5.13×10^{-8}	6.76×10^{-8}	7.77×10^{-8}	1.68×10^{-7}	2.32×10^{-6}	1.80×10^{-8}	6.94×10^{-9}
	2.6%	9.1%	1.7%	2.2%	2.5%	5.5%	76%	0.59%	0.23%
ADPE (kg Sb eq)	46.3	23.5	12.8	5.73	10.8	78.8	405	1.41	0.751
	7.9%	4%	2.2%	0.98%	1.8%	13%	69%	0.24%	0.13%
ADPF (MJ eq)	4.41×10^{-6}	5.65×10^{-6}	3.55×10^{-6}	1.38×10^{-6}	6.49×10^{-6}	1.07×10^{-4}	8.69×10^{-5}	9.27×10^{-8}	1.61×10^{-7}
	2%	2.6%	1.6%	0.64%	3%	50%	40%	0.043%	0.075%
TRACI 2.1									
GWP (kg CO_2 eq)	6.64	1.59	0.904	0.386	0.633	6.02	45.4	0.103	1.09
	11%	2.5%	1.4%	0.62%	1%	9.6%	72%	0.16%	1.7%
AP (kg SO_2 eq)	8.64×10^{-3}	7.20×10^{-3}	2.05×10^{-3}	1.75×10^{-3}	2.79×10^{-3}	3.26×10^{-2}	9.38×10^{-2}	5.95×10^{-4}	4.09×10^{-4}
	5.8%	4.8%	1.4%	1.2%	1.9%	22%	63%	0.4%	0.27%
EP (kg N eq)	2.97×10^{-3}	1.77×10^{-3}	9.20×10^{-3}	4.30×10^{-4}	3.49×10^{-3}	2.11×10^{-2}	0.151	7.66×10^{-5}	1.97×10^{-2}
	1.4%	0.84%	4.4%	0.21%	1.7%	10%	72%	0.037%	9.4%
SFP (kg O_3 eq)	8.10×10^{-2}	0.174	3.90×10^{-2}	4.24×10^{-2}	4.36×10^{-2}	0.348	1.62	1.69×10^{-2}	7.27×10^{-3}
	3.4%	7.4%	1.6%	1.8%	1.8%	15%	68%	0.71%	0.31%
ODP (kg CFC-11 eq)	9.62×10^{-8}	3.70×10^{-7}	6.51×10^{-8}	9.00×10^{-8}	8.57×10^{-8}	2.26×10^{-7}	2.96×10^{-6}	2.40×10^{-8}	9.21×10^{-9}
	2.4%	9.4%	1.7%	2.3%	2.2%	5.8%	75%	0.61%	0.23%
FFD (MJ eq)	6.91	3.36	1.92	0.818	1.35	8.09	58.7	0.213	9.55×10^{-2}
	8.5%	4.1%	2.4%	1%	1.7%	9.9%	72%	0.26%	0.12%

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Table 16. *Resource use and waste flows for the **Optimum Barrier™ II** flooring products over a 75-yr time horizon. Results reported in MJ are calculated using lower heating values. All values are rounded to three significant digits. (Solution dyed)*

Parameter	A1	A2	A3	A4	A5	B2	B4	C2	C4
Resources									
RPR_E (MJ)	2.78	0.265	5.97	$6.46x10^{-2}$	0.541	10.2	38.6	$5.30x10^{-3}$	$3.04x10^{-2}$
	4.8%	0.45%	10%	0.11%	0.93%	17%	66%	0.0091%	0.052%
RPR_M (MJ)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0%	0%	0%	0%	0%	0%	0%	0%	0%
$NRPR_E$ (MJ)	INA	INA	INA	INA	INA	INA	INA	INA	INA
$NRPR_M$ (MJ)	INA	INA	INA	INA	INA	INA	INA	INA	INA
SM (kg)	0.905	0.00	0.00	0.00	0.00	0.00	3.62	0.00	0.00
	20%	0%	0%	0%	0%	0%	80%	0%	0%
RSF/NRSF (MJ)	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
RE (MJ)	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
FW (m^3)	$6.75x10^{-2}$	$1.67x10^{-2}$	$5.96x10^{-2}$	$4.07x10^{-3}$	$4.58x10^{-2}$	0.590	0.00	$4.55x10^{-4}$	$1.99x10^{-3}$
	8.6%	2.1%	7.6%	0.52%	5.8%	75%	0%	0.058%	0.25%
Wastes									
HWD (kg)	$8.23x10^{-6}$	$6.26x10^{-5}$	$1.48x10^{-5}$	$1.52x10^{-5}$	$8.79x10^{-6}$	$6.70x10^{-5}$	0.00	$3.84x10^{-6}$	$2.36x10^{-6}$
	4.5%	34%	8.1%	8.3%	4.8%	37%	0%	2.1%	1.3%
NHWD (kg)	1.73	1.13	0.185	0.275	0.230	0.283	0.00	$6.72x10^{-3}$	2.37
	28%	18%	3%	4.4%	3.7%	4.6%	0%	0.11%	38%
HLRW (kg)	$1.28x10^{-6}$	$1.25x10^{-6}$	$5.12x10^{-6}$	$3.04x10^{-7}$	$1.77x10^{-6}$	$9.28x10^{-5}$	0.00	$2.35x10^{-8}$	$1.66x10^{-7}$
	1.2%	1.2%	5%	0.3%	1.7%	90%	0%	0.023%	0.16%
ILLRW (kg)	$1.51x10^{-5}$	$1.56x10^{-4}$	$2.90x10^{-5}$	$3.79x10^{-5}$	$1.44x10^{-5}$	$4.91x10^{-4}$	0.00	$1.01x10^{-5}$	$3.95x10^{-6}$
	2%	21%	3.8%	5%	1.9%	65%	0%	1.3%	0.52%
CRU (kg)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MR (kg)	0.00	0.00	0.00	0.00	$6.67x10^{-2}$	0.00	0.409	0.00	$3.56x10^{-2}$
	0%	0%	0%	0%	13%	0%	80%	0%	7%
MER (kg)	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
EE (MJ)	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.

INA = Indicator not assessed | Neg. = Negligible

Table 17. *Life Cycle Impact Assessment (LCIA) results for the **Optimum Barrier™ II** flooring products over a 75-yr time horizon. Results reported in MJ are calculated using lower heating values. All values are rounded to three significant digits. (Piece dyed)*

Impact Category	A1	A2	A3	A4	A5	B2	B4	C2	C4
CML-IA									
GWP (kg CO_2 eq)	6.66	1.59	3.01	0.387	0.645	6.04	54.8	0.103	1.31
	8.9%	2.1%	4%	0.52%	0.87%	8.1%	74%	0.14%	1.8%
AP (kg SO_2 eq)	8.90×10^{-3}	6.14×10^{-3}	3.82×10^{-3}	1.49×10^{-3}	2.76×10^{-3}	3.30×10^{-2}	9.57×10^{-2}	4.81×10^{-4}	3.26×10^{-4}
	5.8%	4%	2.5%	0.98%	1.8%	22%	63%	0.32%	0.21%
EP (kg $(PO_4)^{3-}$ eq)	2.11×10^{-3}	1.45×10^{-3}	4.44×10^{-3}	3.52×10^{-4}	1.58×10^{-3}	1.03×10^{-2}	6.95×10^{-2}	1.03×10^{-4}	7.35×10^{-3}
	2.2%	1.5%	4.6%	0.36%	1.6%	11%	72%	0.11%	7.6%
POCP (kg C_2H_4 eq)	7.90×10^{-4}	2.05×10^{-4}	3.28×10^{-4}	4.99×10^{-5}	3.83×10^{-4}	1.29×10^{-3}	8.08×10^{-3}	1.57×10^{-5}	2.49×10^{-4}
	6.9%	1.8%	2.9%	0.44%	3.4%	11%	71%	0.14%	2.2%
ODP (kg CFC-11 eq)	7.98×10^{-8}	2.78×10^{-7}	2.14×10^{-7}	6.76×10^{-8}	7.77×10^{-8}	1.68×10^{-7}	2.97×10^{-6}	1.80×10^{-8}	6.94×10^{-9}
	2.1%	7.2%	5.5%	1.7%	2%	4.3%	77%	0.46%	0.18%
ADPE (kg Sb eq)	46.3	23.5	43.7	5.73	10.8	78.8	529	1.41	0.751
	6.3%	3.2%	5.9%	0.77%	1.5%	11%	71%	0.19%	0.1%
ADPF (MJ eq)	4.41×10^{-6}	5.65×10^{-6}	4.04×10^{-6}	1.38×10^{-6}	6.49×10^{-6}	1.07×10^{-4}	8.89×10^{-5}	9.27×10^{-8}	1.61×10^{-7}
	2%	2.6%	1.9%	0.63%	3%	49%	41%	0.043%	0.074%
TRACI 2.1									
GWP (kg CO_2 eq)	6.64	1.59	2.97	0.386	0.633	6.02	53.6	0.103	1.09
	9.1%	2.2%	4.1%	0.53%	0.87%	8.2%	73%	0.14%	1.5%
AP (kg SO_2 eq)	8.64×10^{-3}	7.20×10^{-3}	4.03×10^{-3}	1.75×10^{-3}	2.79×10^{-3}	3.26×10^{-2}	0.102	5.95×10^{-4}	4.09×10^{-4}
	5.4%	4.5%	2.5%	1.1%	1.7%	20%	64%	0.37%	0.26%
EP (kg N eq)	2.97×10^{-3}	1.77×10^{-3}	9.63×10^{-3}	4.30×10^{-4}	3.49×10^{-3}	2.11×10^{-2}	0.152	7.66×10^{-5}	1.97×10^{-2}
	1.4%	0.84%	4.6%	0.2%	1.7%	10%	72%	0.036%	9.3%
SFP (kg O_3 eq)	8.10×10^{-2}	0.174	6.73×10^{-2}	4.24×10^{-2}	4.36×10^{-2}	0.348	1.73	1.69×10^{-2}	7.27×10^{-3}
	3.2%	6.9%	2.7%	1.7%	1.7%	14%	69%	0.67%	0.29%
ODP (kg CFC-11 eq)	9.62×10^{-8}	3.70×10^{-7}	2.77×10^{-7}	9.00×10^{-8}	8.57×10^{-8}	2.26×10^{-7}	3.81×10^{-6}	2.40×10^{-8}	9.21×10^{-9}
	1.9%	7.4%	5.5%	1.8%	1.7%	4.5%	76%	0.48%	0.18%
FFD (MJ eq)	6.91	3.36	6.98	0.818	1.35	8.09	78.9	0.213	9.55×10^{-2}
	6.5%	3.1%	6.5%	0.77%	1.3%	7.6%	74%	0.2%	0.09%

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Table 18. *Resource use and waste flows for the **Optimum Barrier™ II** flooring products over a 75-yr time horizon. Results reported in MJ are calculated using lower heating values. All values are rounded to three significant digits. (Piece dyed)*

Parameter	A1	A2	A3	A4	A5	B2	B4	C2	C4
Resources									
RPR_E (MJ)	2.78	0.265	6.07	$6.46x10^{-2}$	0.541	10.2	39.0	$5.30x10^{-3}$	$3.04x10^{-2}$
	4.7%	0.45%	10%	0.11%	0.92%	17%	66%	0.009%	0.052%
RPR_M (MJ)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0%	0%	0%	0%	0%	0%	0%	0%	0%
$NRPR_E$ (MJ)	INA	INA	INA	INA	INA	INA	INA	INA	INA
$NRPR_M$ (MJ)	INA	INA	INA	INA	INA	INA	INA	INA	INA
SM (kg)	0.905	0.00	0.00	0.00	0.00	0.00	3.62	0.00	0.00
	20%	0%	0%	0%	0%	0%	80%	0%	0%
RSF/NRSF (MJ)	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
RE (MJ)	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
FW (m^3)	$6.75x10^{-2}$	$1.67x10^{-2}$	0.105	$4.07x10^{-3}$	$4.58x10^{-2}$	0.590	0.00	$4.55x10^{-4}$	$1.99x10^{-3}$
	8.1%	2%	13%	0.49%	5.5%	71%	0%	0.055%	0.24%
Wastes									
HWD (kg)	$8.23x10^{-6}$	$6.26x10^{-5}$	$3.69x10^{-5}$	$1.52x10^{-5}$	$8.79x10^{-6}$	$6.70x10^{-5}$	0.00	$3.84x10^{-6}$	$2.36x10^{-6}$
	4%	31%	18%	7.4%	4.3%	33%	0%	1.9%	1.2%
NHWD (kg)	1.73	1.13	0.209	0.275	0.230	0.283	0.00	$6.72x10^{-3}$	2.37
	28%	18%	3.4%	4.4%	3.7%	4.5%	0%	0.11%	38%
HLRW (kg)	$1.28x10^{-6}$	$1.25x10^{-6}$	$5.78x10^{-6}$	$3.04x10^{-7}$	$1.77x10^{-6}$	$9.28x10^{-5}$	0.00	$2.35x10^{-8}$	$1.66x10^{-7}$
	1.2%	1.2%	5.6%	0.29%	1.7%	90%	0%	0.023%	0.16%
ILLRW (kg)	$1.51x10^{-5}$	$1.56x10^{-4}$	$3.33x10^{-5}$	$3.79x10^{-5}$	$1.44x10^{-5}$	$4.91x10^{-4}$	0.00	$1.01x10^{-5}$	$3.95x10^{-6}$
	2%	20%	4.4%	5%	1.9%	65%	0%	1.3%	0.52%
CRU (kg)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MR (kg)	0.00	0.00	0.00	0.00	$6.67x10^{-2}$	0.00	0.409	0.00	$3.56x10^{-2}$
	0%	0%	0%	0%	13%	0%	80%	0%	7%
MER (kg)	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
EE (MJ)	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.

INA = Indicator not assessed | Neg. = Negligible

6. LCA: Interpretation

The contributions to total impact indicator results are dominated by the product replacement phase of the assessment. With the exception of the Eutrophication Potential impacts, the raw material extraction and processing and product maintenance phases are the next largest contributors to indicator impact results followed by upstream material transport and product distribution.

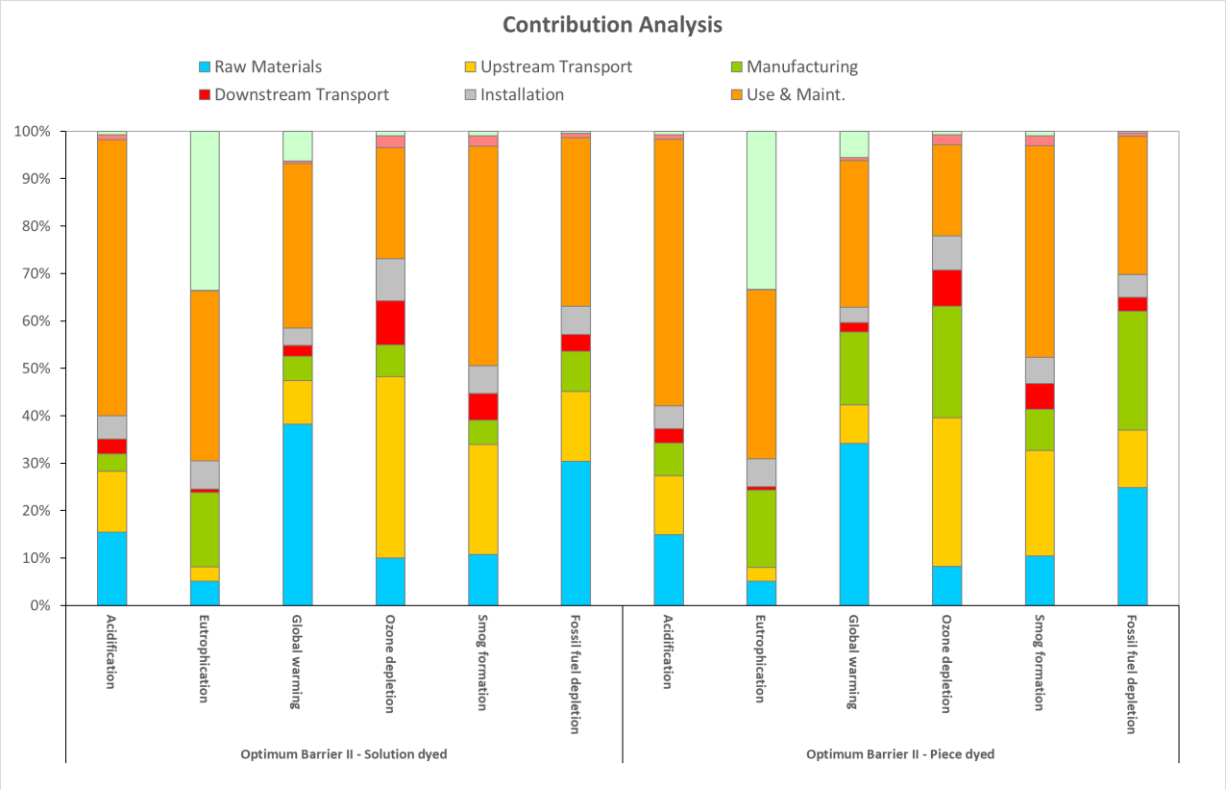

Figure 2. *Contribution analysis for the Optimum Barrier™ II product system – TRACI*

7. Additional Environmental Information

7.1 ENVIRONMENT AND HEALTH DURING MANUFACTURING

The Bentley Mills manufacturing facility operates under a Quality Management System and an Environmental Management System. The testing laboratory is NVLAP certified to ISO 17025.

7.2 ENVIRONMENT AND HEALTH DURING INSTALLATION

The Bentley Mills flooring products meet the requirements of the following:

1. CRI Green Label Plus
2. CDPH/EHLB Standard Method v1.2-2017 (California Section 01350)

7.3 ENVIRONMENTAL ACTIVITIES AND CERTIFICATIONS

For more information on Bentley Mills' certifications and environmental initiatives please view our website at http://www.bentleymills.com.

8. References

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