BOTNIABANAN AB

EPD®

Passenger transport

Environmental Product Declaration for **passenger transport** on the Bothnia Line

Reg. no. S-P-00194 UN CPC 6421 Date 2010-03-19

Introduction

This environmental product declaration (EPD) describes, from a lifecycle perspective, the total environmental impact of passenger transport on the Bothnia Line.

Within the International EPD system based on ISO standard 14025, this EPD was drawn up in accordance with Product Category Rules (PCR) 2009:03 for Rail Transport and Railway Infrastructure (see www.environdec.com for further information about the EPD system).

The aim of this EPD is that it should provide transport buyers, stakeholders and decision makers with objective and reliable information on the environmental impact of rail transport. It takes both the infrastructure and the transport service aspects into account.

This EPD was developed by Botniabanan AB in cooperation with Banverket (the Swedish Rail Administration). It has been certified by Bureau Veritas Certification AB and the certification is valid for three years (after which it can be prolonged).

Botniabanan AB has been responsible for the financing, detailed planning and building of the Bothnia Line. On completion, Botniabanan AB will own the infrastructure and lease it to Banverket (the infrastructure manager). From 2050 onwards, infrastructure ownership will be transferred to Banverket. Botniabanan AB has ISO 9001:2000 (quality management), ISO 14001:2004 (environmental management) and AFS 2001:1 (work environment management) certification.

This EPD sets out the environmental performance of passenger transport on the Bothnia Line. The following EPDs are also available for other Bothnia Line systems:

- EPD for freight transport on the Bothnia Line.
- EPD for railway infrastructure on the Bothnia Line.
- EPD for railway tunnels on the Bothnia Line.
- EPD for railway track foundations on the Bothnia Line.
- EPD for railway bridges on the Bothnia Line.
- EPD for railway track on the Bothnia Line.
- EPD for power, signalling and telecom systems on the Bothnia Line.

As this EPD is based on data relating to Bothnia Line infrastructure and transport operations, the results might not be representative of railway passenger transport on other railway lines. In order to decide if the results can be representative for other railway lines, the most important areas that should be checked to be comparable with the Bothnia Line are:

- Railway functionality (type of traffic, axle load, etc.).
- Intensity of passenger and freight traffic operations.
- Topography (e.g. impact on share of bridges and tunnels).
- Mix of electricity for train operation and for construction, operation and maintenance of the infrastructure.
- Origin of materials (mainly steel and concrete).

Facts about infrastructure and transports on the Bothnia Line

TECHNICAL FACTS INFRASTRUCTURE

- Minimum radius of curvature: 3,200 m
- Maximum gradient: 10‰
- Track gauge: 1,435 mm
- Power supply voltage: 15 kV, 16 2/3 Hz, AT system
- Track: ballasted, concrete sleepers, UIC 60 rails (continuous welded)
- Signalling system: ERTMS level 2
- Maximum axle load: 25 tonnes (30 tonnes on bridges)

The Bothnia Line is a new Swedish railway running from Nyland (north of Kramfors) to Umeå. It is routed via Örnsköldsvik and comprises 190 km of new single-track railway with 22 sidings (each 1 km long) and 7 travel centres/stations. The latter have good connections for pedestrians, cyclists, local and regional bus traffic and private vehicles. There is a large freight terminal in Umeå and a smaller container terminal in Örnsköldsvik.

The line has 90 railway bridges (total length of 11 km) and 16 tunnels (25 km of main railway tunnels and 16 km of service and access tunnels). Designed for combined passenger and heavy freight traffic, the Bothnia Line offers maximum speeds of 250 km/h for passenger trains and 120 km/h for freight trains with a maximum axle load of 25 tonnes. The groundbreaking for the project took place on 14 August 1999 and the railway will become operational in autumn 2010.

Banverket's "Basprognos 2020" (developed using calculation methods common for the transport sector) provided the Bothnia Line traffic forecast on which this EPD is based. This forecast should be seen as a "medium scenario". The forecast rise in railway freight transport may become even higher as a result of increases in steel and ore transport and if taxes or similar economical instruments are used to limit road transport. Infrastructure's contribution to environmental impact results is in inverse proportion to forecast traffic volumes. If traffic volumes get 10 % higher than forecast, environmental impact from infrastructure gets 10 % lower per passenger km and vice versa. Forecast traffic volumes do not use the Bothnia Line's maximum capacity.

At the time of completion of this EPD, it was not known which traffic operators would be providing passenger and freight services on the Bothnia Line. The passenger and freight services will be provisional and limited during the first year of operation. From autumn 2011, regional passenger traffic will use new Coradia Nordic X 62 trains and the operator will be decided by a Norrtåg AB procurement at the beginning of 2010. Interregional passenger traffic in Sweden is largely provided by SJ AB, which has a monopoly for such services. However, this monopoly ends in 2010 and interregional traffic will then also be open to competition via procurement. Freight traffic has long been deregulated and is procured by the individual transport buyers.

Location of the Bothnia Line.

Traffic forecast (based on Banverket's "Basprognos 2020") for the Bothnia Line in 2020.

Train type	No of trains per day	Annual transport in passenger km (pkm) and tonne km (tkm)
Passenger	28	343 800 000 pkm
Freight	21	506 400 000 tkm

Environmental performance

Resource use and emissions

The environmental performance section of the declaration is based on a lifecycle assessment (LCA) carried out by IVL Swedish Environmental Research Institute in 2009. An overview of system boundaries and included processes is given in the text, figures and tables below.

Extraction and production of raw materials, transport of materials and manufacturing of products were included in the LCA calculations. The data in respect of infrastructure-related processes and quantities of materials was collected from the building of the Bothnia Line. As regards steel for rails, specific data for material production was used. For other materials, selected generic data was used according to the calculation rules in PCR 2009:03. The electricity used in construction processes and for production of materials was calculated as the average electricity mix for the countries hosting the processes. Calculation of the environmental impact of building railway tunnels, bridges and track foundations was based on data from three selected "typical" contracts for each of the three structures. As regards soil and rock excavation quantities, fuel and electricity consumption, etc., specific data was collected from these contracts and used as a basis for calculating the environmental impact of the entire Bothnia Line.

Existing EPDs were used as sources of data on the construction, operation, maintenance and decommissioning of railway passenger vehicles (Alstom) and for some electrical system components (Bombardier). However, these had not been certified as per the international EPD system. Consequently, they were checked for compliance with rules for e.g. system boundaries in PCR 2009:03.

The emissions from electricity used for train operation were calculated using the specific electricity mix bought by Banverket. In 2008, this was almost 100% hydropower.

The LCA calculations are based on a calculation period of 60 years. This means that they include all construction, operation and maintenance processes assumed to take place in that time. All results are presented per passenger km (pkm).

All processes and elements needed to provide rail transport were included in the LCA. The figure shows some of the most important structural elements.

Overview of processes and elements included in the LCA for the different infrastructure subsystems.

Infrastructure construction						Infrastructure operation	Infrastructure maintenance
Railway Substructure	**Track**	**Power supply system**	**Signalling and telecom systems**	**Station installations**	**Other installations**		
Tunnels	Rail	Catenary system	Balises	Railway stations/travel centers	Noise barriers	Rail grinding	Reinvestment determined by lifetimes of components and constructions
Bridges	Concrete sleepers	Catenary posts	Interlocking system	Freight terminals	Fences	Switch heating	
Track foundations	Ballast	Cables	Radio towers		Wildlife culverts	Illumination of tunnels and depots	
Deforestation	Switches and drivers	Substations	Cables			Frost protection for firefighting water in tunnels	
Service roads	Rail grinding	Transformers	UPS systems			Operation of railway stations and freight terminals	
Ducting (cable ducts and manholes)		UPS systems	Service buildings			Operation of electrical and electronic systems	
Drainage and surface water piping		Service buildings					

Overview of processes included in the LCA for the different transport service subsystems.

Vehicles	Train operation
Production	Production of electricity
Maintenance	Losses in the electrical grid

Processes and system elements that were excluded from the LCA as, under the rules in PCR 2009:03, they make a negligible contribution to environmental impact categories (<1 %). For processes excluded by default, see PCR 2009:03.

Infrastructure	Transport service
Platform equipment	Emissions from abrasion of wheels, brakes and contact lines
Train heating posts	Ticket sales and similar services
Shunting towers	Vehicle decommissioning
Waste handling processes	
Train control centre	

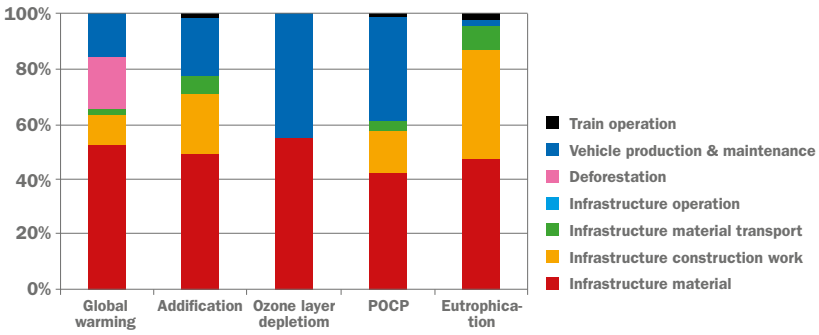
Environmental impact of 1 passenger travelling 1 km (1 pkm) on the Bothnia Line. All construction, operation and maintenance activities over 60 years are included for both railway infrastructure and transport service.

Impact category	Unit	Railway Infrastructure			Transport Service		Total
		Infrastructure construction	Infrastructure operation	Infrastructure maintenance	Vehicles (production & maintenance)	Train operation	
Resource use							
Non-renewable materials	kg	0.35	$7.2 \cdot 10^{-6}$	0.021	0.00017	$4.6 \cdot 10^{-5}$	0.37
Renewable materials	kg	$9.9 \cdot 10^{-5}$	0	$8.3 \cdot 10^{-5}$	0	0	0.00018
Non-renewable energy	MJ	0.066	0.0073	0.033	0.038	0.00062	0.15
Renewabe energy	MJ	0.0032	0.041	0.0019	0	0.33	0.38
Recycled resources	kg	0.00072	0	0.00024	0	0	0.00096
Water	kg	0.026	0	0.018	0	0	0.044
Land use	m^2	0.00015	$8.5 \cdot 10^{-5}$	$9.3 \cdot 10^{-6}$	0	0.00051	0.00076
Emissions							
Global warming	kg CO_2 equivalents	0.0080	$3.7 \cdot 10^{-5}$	0.0029	0.0021	$7.9 \cdot 10^{-5}$	0.013
Acidification	kg SO_2 equivalents	$2.4 \cdot 10^{-5}$	$1.1 \cdot 10^{-7}$	$1.1 \cdot 10^{-5}$	$9.8 \cdot 10^{-6}$	$5.9 \cdot 10^{-7}$	$4.6 \cdot 10^{-5}$
Ozone depletion	kg CFC-11 equivalents	$2.0 \cdot 10^{-12}$	0	$2.2 \cdot 10^{-12}$	$3.3 \cdot 10^{-12}$	0	$7.6 \cdot 10^{-12}$
POCP (Photochemical oxidant formation)	kg ethene equivalents	$1.9 \cdot 10^{-6}$	$1.2 \cdot 10^{-8}$	$8.6 \cdot 10^{-7}$	$1.7 \cdot 10^{-6}$	$5.0 \cdot 10^{-8}$	$4.6 \cdot 10^{-6}$
Eutrophication	kg PO_4^{3-} equivalents	$5.3 \cdot 10^{-6}$	$2.0 \cdot 10^{-8}$	$1.4 \cdot 10^{-6}$	$7.5 \cdot 10^{-8}$	$1.1 \cdot 10^{-7}$	$6.8 \cdot 10^{-6}$
Other							
Ouput of materials for recycling	kg	$1.1 \cdot 10^{-6}$	0	0.00087	0	0	0.00087
Waste. hazardous	kg	$1.3 \cdot 10^{-5}$	$1.6 \cdot 10^{-5}$	$3.4 \cdot 10^{-6}$	0	0	$3.2 \cdot 10^{-5}$
Waste. excess soil	kg	0.25	0	0	0	0	0.25
Waste. other	kg	0.011	$1.3 \cdot 10^{-5}$	0.0056	0	$4.9 \cdot 10^{-6}$	0.017

Specification of resources making the largest contributions to the different resource use categories

Resource use category	Largest contributors
Non-renewable materials	Solid rock: 96.5% Sand and gravel: 1.7% Limestone: 1.3% Iron: 0.5%
Renewable materials	Wood: 100.0 %
Non-renewable energy	Crude oil: 45.7% Coal: 32.0% Nuclear: 12.4% Natural gas: 9.8%
Renewabe energy	Hydro power: 98.2% Biomass fuel: 1.7%
Recycled resources	Ferrous scraps: 98.9% Steel scrap: 0.6% Copper scrap: 0.4% Stainless steel scrap: 0.1%

Dominance analysis



Emissions impact categories and the relative contributions (in %) made by different process groups. The process groups include all activities during the calculation period of 60 years. For example, “Infrastructure material” covers all materials used during construction, maintenance and reinvestment.

Infrastructure material = Emissions from raw material acquisition and production of materials such as steel, concrete, etc.

Infrastructure construction work = Emissions from machines (excavators, trucks, drilling rigs, etc.) used in constructing the infrastructure. This also includes transport of excavated soil and rock.

Infrastructure material transport = Emissions from vehicles (e.g. trucks and trains) used for transporting infrastructure material (e.g. sleepers and cables) from suppliers to the construction site.

Infrastructure operation = Emissions from production of electricity used for operation of the infrastructure (e.g. tunnel illumination and switch heating).

Deforestation = Net emissions of CO2 resulting from forest land being permanently changed to railway land.

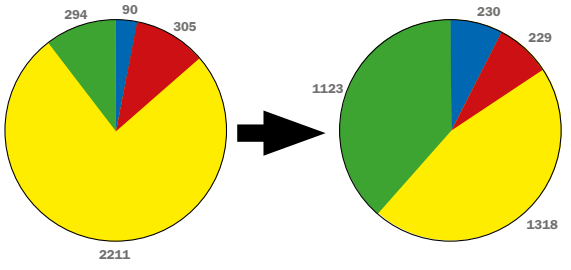
Vehicle production and maintenance = Emissions from production of vehicle components and from manufacturing and maintenance of railway vehicles.

Train operation = Emissions from the production of the electricity needed for the propulsion of trains (the Bothnia Line uses electric trains only).

Land use and impacts on biodiversity

The Biotope Method® (developed by Vattenfall) was used to quantify the impact that land use in building the railway infrastructure has had on biodiversity. All land areas that have been affected by the building of the railway have been placed in one of the following categories: critical biotope, rare biotope, general biotope and technotope.

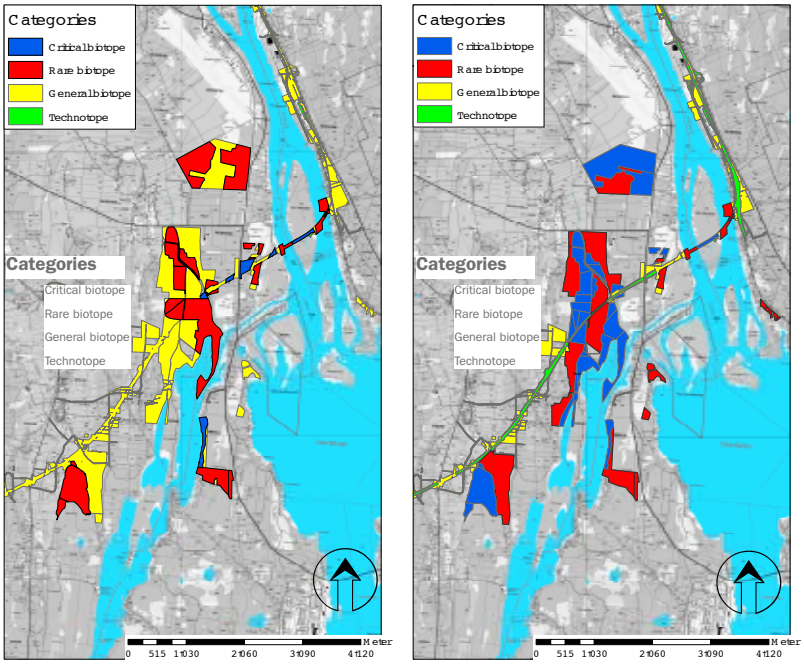
The figures and table below shows the identified changes in the above-mentioned categories. Change per pkm was calculated using the allocation rules in PCR 2009:03.



BIOTOPE AREAS BEFORE (HA) BIOTOPE AREAS AFTER (HA)

Critical biotope
General biotope
Rare biotope
Technotope

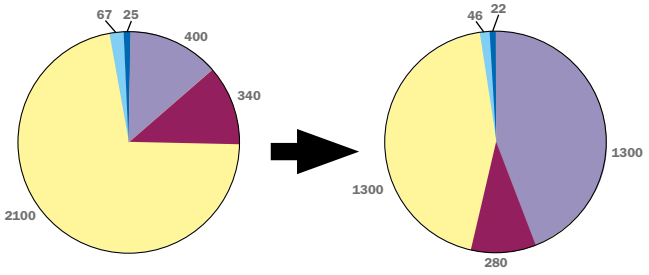
Biotope Category	Change per passenger kilometre (m^2/pkm)
Critical biotope	+0.000021
Rare biotope	-0.000011
General biotope	-0.00014
Technotope	+0.00013



BEFORE AFTER

The maps show changes in biotope categories in the area close to Umeå where compensatory measures have been taken. Said measures are largely responsible for the increase in critical biotope area after the building of the railway.

In the figures and table below, land use is also described in terms of utilisation of land categories as per CORINE land cover classes.



Land category	Change per passenger kilometre (m^2/pkm)
Artificial surfaces	+0.00014
Agricultural areas	$-9.2 \cdot 10^{-6}$
Forest and semi-natural areas	-0.00012
Wetlands	$-3.2 \cdot 10^{-6}$
Water bodies	$-4.6 \cdot 10^{-7}$

The Bothnia Line passes through a Natura 2000 site south of Umeå. Within that site, the following areas have been used as railway land:

- 7 hectares of classified biotopes according to the Council Directive 92/43 EEC of May 1992 on the conservation of natural habitats and of wild fauna and flora.
- 6 hectares of land protected according to the Council Directive 79/409/EEC of April 1979 on the conservation of wild birds.

Overview of compensatory measures that have been adopted in order to compensate for the encroachment into the Natura 2000 site.

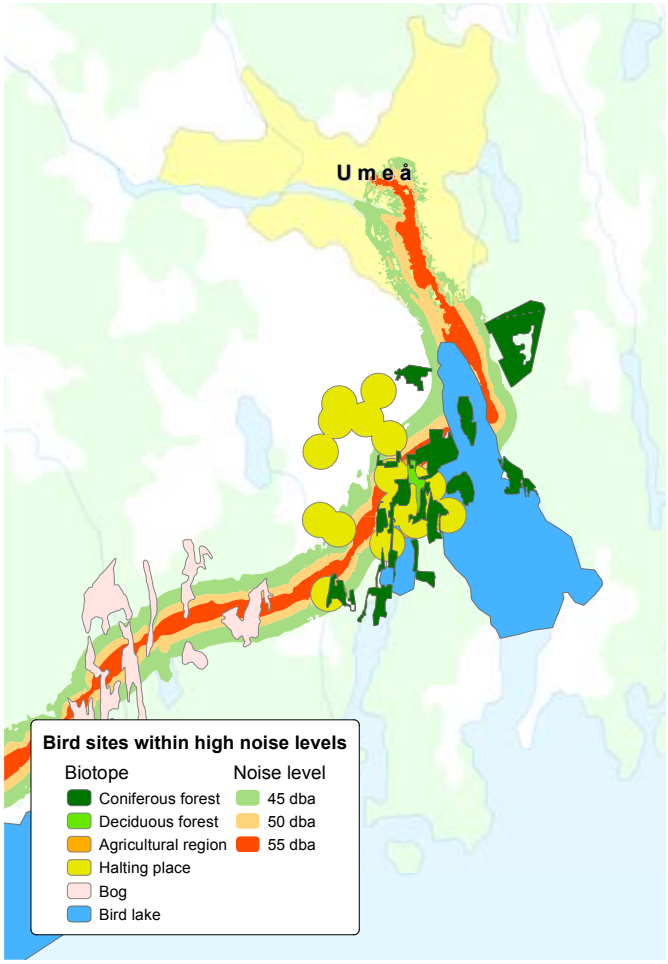
Affected areas		Compensatory measures	
Land type (pSCI category)	Area (ha)	Land type	Area (ha)
Primary forest of landupheaval coast (9030*)	6	Forestland as nature reserve, partly with nature conservation management	194
Transition mires and quaking bogs (7140)	1	Wetland as nature reserve	37
Valuable staging sites for birds	6	Valuable staging sites for birds as nature reserves	297

One of the environmental goals within Botniabanan AB has been to build the railway without thereby giving rise to any fish migration barriers in watercourses. For this reason, a methodology for inspecting watercourses was developed within the project. One hundred and eleven sections of watercourses (mainly culverts) have been examined by a nature conservation expert and 96% (107) of the sections were approved from a fish migration perspective.

Noise

A number of different methods have been used to quantify the noise disturbance that traffic on the Bothnia Line causes for animals and people. All assessments were based on noise levels calculated for the traffic forecast in Basprognos 2020. The calculation model (topography, placement of noise barriers, etc.) was specific to the Bothnia Line.

The assessment of noise impact on animals used a method developed jointly by Ekologigruppen AB and SLU (Swedish University of Agricultural Sciences) with birds as indicator species. Sensitive bird biotopes were identified as per the method and the areas affected by different disturbance levels in these biotopes were calculated. The relationship between disturbance levels and noise levels is based on scientific research and is described in the method.



Example of sensitive bird biotopes disturbed by noise from traffic on the Bothnia Line. The map shows a selected area close to Umeå.

Noise impact on people was assessed by calculating:

1. Outdoor recreational areas within 2 km of the railway and affected by different disturbance levels.
2. Number of people affected by different (outdoor) disturbance levels in residential areas.

For the outdoor recreational areas, the relationship between disturbance and noise levels was mapped out using the same method as that used for bird biotopes. For the residential areas, the calculated relationship between disturbance and noise levels was based on other studies.

Noise disturbance from traffic on the Bothnia Line on selected sensitive bird biotopes. Total affected area is presented as well as affected area for 1 passenger transported 1 km (1 pkm) – calculated as per the allocation rules in PCR 2009:03.

Disturbance levels in sensitive bird biotopes	Affected area (ha)	% of total area sensitive bird biotopes	Affected area per pkm (m^2/pkm)
>50% disturbance (≥ 55 $dBA_{eq.}$)	909	8 %	0.00014
50% disturbance (50–55 $dBA_{eq.}$)	1241	11 %	0.00019
20% disturbance (45–50 $dBA_{eq.}$)	1832	17 %	0.00028
Total disturbance (sum of affected areas)	**3982**	**36 %**	**0.00061**

Noise disturbance from traffic on the Bothnia Line on outdoor recreational areas. Total affected area is presented as well as affected area for 1 passenger transported 1 km (1 pkm) – calculated as per the allocation rules in PCR 2009:03.

Disturbance levels in outdoor recreational areas	Affected area (ha)	% of total outdoor recreational areas within 2 km of railway	Affected area per pkm (m^2/pkm)
>50% disturbance (≥ 55 $dBA_{eq.}$)	665	6 %	0.00014
50% disturbance (50–55 $dBA_{eq.}$)	905	8 %	0.00014
20% disturbance (45–50 $dBA_{eq.}$)	1514	13 %	0.00023
Total disturbance (sum of affected areas)	**3084**	**27 %**	**0.00047**

Noise disturbance from traffic on the Bothnia Line on residential areas. Total number of affected persons is presented as well as number of affected persons for 1 passenger transported 1 km (1 pkm) – calculated as per the allocation rules in PCR 2009:03.

Disturbance levels in residential areas	Number of persons affected	Number of persons affected per pkm
Affected (> 55 $dBA_{eq.}$)	1728	$2.6 \cdot 10^{-8}$
Heavily affected (> 65 $dBA_{eq.}$)	598	$9.1 \cdot 10^{-9}$

Risk-related issues

Risk assessments were carried out within the framework of the railway plans for the Bothnia Line and high safety requirements were imposed throughout building. The railway is crossing-free and has ERTMS, a new radio-based signalling system that makes the risk of collisions between trains and other trains or road traffic very low. Other risk-reducing measures include: emergency exits and firefighting water in tunnels; fencing; dimensioning of water culverts to minimise risk of/from erosion; and, where the railway passes larger water sources, ground water protection.

To reduce the risk of animal accidents, the measures below have also been implemented.

Risk reducing measure	Qty./installation	Comment
Cable manhole evacuation pipes for amphibians, reptiles and rodents	574	Makes it possible for animals to escape from cable manholes if they fall down and get trapped.
Small game passages near watercourse culverts	24	Separate, dry, concrete culverts that makes it easier for small game to cross the railway
Insulated lines for auxiliary power	Along the entire railway	Reduces risk of bird collisions and electrocution
Auxiliary power in cable on the ground	2 km	Reduces risk of collisions in bird rich areas
Luminous tags on carrier cables	500	Reduces risk of collision in bird rich areas
Insulated transformers	80	Reduces risk of bird electrocution
Vertical plastic bars on cantilever	100	Reduces risk of bird electrocution
Pointed cones on top of catenary posts	600	Prevents birds of prey using the posts as observation points (reduces the risk of bird collisions with trains)

Recycling declaration

Infrastructure

The main infrastructure elements that are relevant as regards waste management and recycling in the calculation period (60 years) are track, power, signalling and telecom equipment. Other elements such as track foundations, bridges and tunnels are not to be replaced during the calculation period.

For older signalling systems, Banverket has listed strategic components that should be returned to Banverket Material Service for revision when they are replaced. For other materials, there is currently no national strategy for recycling materials that are replaced during maintenance. Such materials often become the property of the contractor. Banverket's environmental strategy contains the following prioritised goals for the future:

- Development, from an environmental perspective, of long–term reutilisation plans for strategic materials.
- Development of environmentally sound and effective management procedures for prioritised categories of waste.

Vehicles

Rolling stock manufacturers state that the recyclability of modern passenger locomotives can be up to 98%. Besides building disassembly into their designs, manufacturers also put great effort into developing plans and procedures for dismantling and recycling. See www.transport.bombardier.com and www.transport.alstom.com for more information.

Route and travel centres/stations on the Bothnia Line (tunnels and bridges also shown).

EPDs from different programmes may not be comparable
See **www.botniabanan.se** for more information on the EPD and for background material.

PCR review was conducted by the Technical Committee (TC) of the International EPD Consortium (IEC).
See **www.environdec.com** for more information and contact for IEC.

Independent verification of the declaration and data, according to ISO 14025:

☐ Internal ☒ external

Third party verifier:

Bureau Veritas Certification AB
Fabriksgatan 13 · SE-412 50 Göteborg SWEDEN

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Management of materials and substances

Infrastructure

Throughout the construction of the Bothnia Line, all contractors have, as regards any chemical products and potentially environmental harmful materials they use, been required to obtain the approval of Banverket's Chemicals Board. Another requirement has been that PVCs and certain other materials (a number of specified harmful substances included therein) must not be used before the contractor has made an environmental risk assessment and Botniabanan AB has agreed with the use. If the use of any of these substances could not be avoided, the location of the components containing the substances has been documented by the contractor.

The satisfaction of these requirements has been checked in audits of all major contractors.

Hazardous waste generated in all contracts for the building of the Bothnia Line has been collected in environmental stations supplied by Botniabanan AB and managed by companies accredited for management of hazardous waste.

Vehicles

In adhering to international legislation on prohibited materials and their own strategies for environmentally friendly product development, rolling stock manufacturers observe strict rules as regards the choice of materials. See www.transport.bombardier.com and www.transport.alstom.com for more information.