Environmental Impact Report: Doel Nuclear Power Station for the LTO of Doel 1 and 2

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Abbreviations

ALARA	As Low As Reasonably Achievable
AOX	Adsorbable organic halogen compounds
ARBIS	General Regulations on the Protection of the Population, the Workers and the Environment against the Danger of Ionizing Radiations
ASME	American Society of Mechanical Engineers
BBI	Belgian Biotic Index
DSA	Descriptive Soil Analysis
BAT	Best Available Technologies
BDBA	Beyond design-based accident
BEST	Belgian Stress Tests
BWK	Biologische Waarderingskaart (Biological Valuation Map)
BOC	Biological Oxygen Consumption
CH_4	Methane
CO	Carbon Oxide
CO_2	Carbon Dioxide
COC	Chemical Oxygen Consumption
dB	Decibel
DBA	Design-Based Accident
DEM	Digital Elevation Model Flanders
DNA	Deoxyribonucleic acid
DSF	Flanders Subsoil Database
DPC	Dual Purpose Cask
POP	Post Operational Phase
EBSD	Certified soil decontamination expert

EIN	Ecological Infrastructure Nature
FANC	Federal Agency for Nuclear Control
FHA	Fuel handling accident
GEN	Large Nature Areas
GENO	Large Nature Areas under Development
GGG	Controlled reduced tidal range
GIS	Geographic Information System
GNH	Nuclear Auxiliary Services Building
BES	Building Emergency Systems
RSIP	Regional Spatial Implementation Plan
HM	Hazardous materials
GSG	Steam Generator Building
BSD	Building for Secondary Discharges
GW	Gaseous Waste
ha	Hectares
HCSF	Hydrogeological Coding of the Subsoil in Flanders
HEPA	High Efficiency Particulate Arrestance
Hz	Hertz
I/C	Intensity/capacity ratios on a road section
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
RE	Population Equivalent
IED	Industrial Emissions Directive
CT	Conservation Target
INBO	Institute for Nature and Forest Research
IP	Immission Points

IRCE	Interregional Cell for the Environment
IRSN	Integrated Regeneration and Support Network
KCD	Doel Nuclear Power Station
KCD-1/2/3/4	Doel Nuclear Power Station (unit 1/2/3/4)
CDV	Critical Deposit Values
LOCA	Loss Of Coolant Accident
Lsp	Specific noise level
LTO	Long Term Operation
LwA	Sound power
EIR	Environmental Impact Report
EIR	Environmental Impact Report
EQS	Environmental Quality Standard
MPT	Measurement Point
m BGL	Metres below ground level
MSI	Main Safety Issue
MWe	MegaWatt electric
MWth	MegaWatt thermal
NIRAS	National Institution for Radioactive Waste and Enriched Fissile Materials
NO_x	Nitrogen oxides
ISA	Initial Soil Analysis
OBBO	Combined Initial Soil Analysis and Descriptive Soil Analysis
OANL	Original ambient noise level
OVAM	Public Flemish Waste Company
ESR	Environmental Safety Report
PAH	Polycyclic Aromatic Hydrocarbons
PPE	Personal Protective Equipment

PIO	Prati index for dissolved oxygen
PM	Fine Dust
PSA	Probabilistic safety assessment
PSR	Periodic Safety Review
PCU/h	Passenger car units per hour
PWR	Pressurized Water Reactor
QRA	Quantitative Risk Assessment
RGB	Reactor Building
SIP	Spatial Implementation Plan
SPP	Species Protection Program
SPA	Special Protection Area
FCB	Nuclear Fuel Container Building
SCK•CEN	Nuclear Energy Study Centre - Centre d'Etude de l'Energie Nucléaire
SF^2	Spent Fuel Storage Facility
RBMP	River Basin Management Plan
SO_2	Sulphur dioxide
SOx	Sulfur Oxides
SSC	Structures, Systems and Components
SWA-VR	Safety report under the Cooperation Agreement
TAW	Second General Water Level
TLD	ThermoLuminescence Dosimeter
TV	Test value
ΔT	Temperature increase
US-NRC	United States Nuclear Regulatory Commission
FEN	Flemish Ecological Network
Vlarebo	Flemish regulations on soil remediation

Vlarem	Flemish regulations on environmental permits
FEA	Flemish Environmental Agency.
WAB	Water and Waste Treatment
WENRA	Western European Nuclear Regulators Association
WHO	World Health Organization
WHO	World Health Organization

Systems list of the Doel nuclear power station

AFW	Auxiliary water circuit
BAR	Reactor auxiliary services building
CGA	Central Building A
EC	Emergency Intermediate Cooling Circuit GNS
ED	Fuel tanks and fuel pumps
EDG	Emergency Diesel Generator
EF	Emergency water circuit GNS
EI	Emergency compressed air GNS
FCV	Filtered Containment Vent
FE	Fire Circuit
FW	Feed water circuit
GEH	Electric Auxiliary Services building
GMH	Mechanical Auxiliary Services building
GNH	Building of Nuclear Auxiliary Services
BES	Emergency Systems Building
MAG	Warehouse

MAZ	Turbine hall
MS	Main steam circuit
NKZ	Emergency Control Rooms
PL	Storage pool circuit
RGB	Reactor Building
RJ	Emergency sealing water primary pumps GNS
RW	Raw Water Circuit
RWST	Refueling Water Storage Tanks

1 General section

1.1 Introduction

1.1.1 Background

All Doel nuclear units have an indefinite operating license. However, the Act of January 31, 2003 [FPS, 2003] limited the operating time of the production units and set the dates for the termination of electricity production using nuclear energy in Belgium. These dates corresponded to 40 calendar years of operation for Doel 1, Doel 2, Doel 3, and Doel 4 nuclear power plants (abbreviated as KCD-1 through KCD-4, respectively). This meant that KCD-1 and KCD-2 would stop operating in 2015 (KCD-3 in 2022 and KCD-4 in 2025).

The Act of June 28, 2015 [FPS, 2015] amending the Act of January 31, 2003 (on phasing out from nuclear energy for industrial electricity production with a view to ensuring security of supply in the field of energy), allowed KCD-1 to produce electricity again until February 15, 2025 and pushed back the date of decommissioning of KCD-2 to December 1, 2025.

Electricity generation using nuclear power through KCD-1 and KCD-2 beyond the initially established time frame of 2015 (called the long-term operation - LTO G1) was authorized based on the strategic note issued by FANC in 2009 [FANC, 2009] and the corresponding investments by Electrabel to ensure a high level of safety in the design and operation of the units. Assuming the longer electricity generation by and operation of KCD-1 and KCD-2, electricity generation through the four units was allowed until:

- Doel Nuclear Power Plant Unit 1 (KCD-1): 15 February 2025;
- Doel Nuclear Power Plant Unit 2 (KCD-2): 1 December 2025;
- Doel Nuclear Power Plant Unit 3 (KCD-3): 1 October 2022;
- Doel Nuclear Power Plant Unit 4 (KCD-4): 1 July 2025.

1.1.2 Description of the problem

Against the Act of 28 June 2015, an annulment appeal was filed with the Constitutional Court, which referred several preliminary questions to the European Court of Justice.

Based on the answers formulated by the Court of Justice in its judgment C-441/17 of 29 July 2019, the Constitutional Court issued its judgment No. 34/2020 on 5 March 2020.

With the aforementioned judgment of 5 March 2020, the Constitutional Court annulled the law of 28 June 2015 " amending the law of January 31, 2003 on the gradual phasing out of nuclear energy for industrial electricity production with a view to ensuring security of supply in the field of energy ". At the same time, the Court upheld the effects of the annulled law until the adoption, by the legislature, of a new law preceded by the required environmental impact assessment and appropriate assessment, with public participation and cross-border consultation, and no later than December 31, 2022.

In order to better frame the underlying problem, as well as the objective and scope of this EIR, it is useful to repeat the main considerations of the aforementioned Constitutional Court judgment:

"(...) B.5.1. In accordance with Article 4, § 1, of the Act of 31 January 2003, as replaced by the Act of 18 December 2013, the Doel 1 power plant was not allowed to produce electricity after 15 February 2015. However, Article 4, § 2, of the Act of 31 January 2003, as replaced by the Act of December 18, 2013, provides that in the individual operating and industrial electricity production licenses, only the provisions relating to the authorization of industrial electricity production shall terminate on the date of cessation referred to in Article 4, § 1, of the same Law, with the other provisions - including those relating to the operating license - continuing to apply until such time as they are amended.

(...)

B.5.3. It is clear from the wording of Article 4, § 1, of the Act of 31 January 2003, as replaced by the contested Act, that the contested Act has modified the phasing out of nuclear energy, as provided for in the aforementioned Article 4, § 1, in two respects: on the one hand, it allows the Doel 1 unit to produce electricity "once again" from the entry into force of the contested Act, that is, 6 July 2015, and defers its cessation until 15 February 2025; on the other hand, it defers the date of the cessation and of the end of the industrial electricity production of the Doel 2 unit by ten years, until 1 December 2025.

(...)

B.18.1. As mentioned in B.5, the context of the Act of June 28, 2015, sufficiently demonstrates that the legislator, by adopting the contested act, decided to extend the duration of the industrial electricity production of the Doel 1 and Doel 2 units by ten years, subject to substantial work being carried out on those units, more specifically to modernize them and to ensure compliance with the safety standards under the "LTO" plan.

As mentioned in B.5.4 to B.5.6, these extensive works are stipulated in the "LTO" agreement signed on 30 November 2015 between the Belgian State and Electrabel, and require investments estimated at around 700 million euros (Article 3 of the agreement). The Court of Justice noted in this respect that these works should concern in particular "the modernization of the domes of the Doel 1 and Doel 2 units, renovation of the spent fuel storage, the installation of a new pumping station and the modification of the substructure in order to improve the protection of these units against flooding", and imply that "not only improvements to the existing structures are carried out, but also the construction of three buildings. Two of these would be used to house the ventilation systems and the third for a firefighting system", so that " such works may impact the material condition of the places concerned, as referred to in the case law of the Court " (ibid., para. 66).

Even though those works are not mentioned in the 28 June 2015 Act, they nevertheless constitute, in light of the parliamentary preparation of the contested Act, a sine qua non for extending the life of nuclear *power plants (Parl. Records, House of Representatives, 2014-2015, DOC 54-0967/001, pp. 7 and 9; Parl. Records, House of Representatives, 2014-2015, DOC 54-0967/003, p.* 10

Article 4, § 3, of the Act of January 31, 2003, as it was inserted by the Act of 28 June 2015, also confirms the inextricable link between the signing of that agreement, by 30 November 2015, and the extension of the activity of industrial electricity production of the Doel 1 and Doel 2 units, since that provision provided that, if that agreement is not concluded, the King would advance the date of deactivation of those units to 31 March 2016.

B.18.2. As the Court of Justice observes in paragraphs 63 to 71 of its aforementioned Inter-Environnement Wallonie ASBL judgment, such modernization works, which involve investments estimated at 700 million euros, are inseparably linked to the adoption of the decision to extend, for ten years, the duration of the industrial electricity production of the Doel 1 and Doel 2 units, so that the contested law and the works laid down in the agreement "for the LTO" signed on 30 November 2015 between the Belgian State and Electrabel together constitute one and the same "project" within the meaning of the first indent of Article 1(2)(a) of Directive 2011/92/EU. The Court of Appeal sees no factual element that could challenge that finding.

The Court of Justice also held that those measures and those works were " must be found to be of a scale that is comparable, in terms of the risk of environmental effects, to that when those power stations were first put into service", and " fall within the scope of point 24 of Annex", so that " such a project carries an inherent risk of significant effects on the environment, within the meaning of Article 2(1) of that directive, and must therefore be subject to an assessment of its environmental impact under Article 4(1) of that directive." (CJEU, Grand Chamber, 29 July 2019, C-411/17, Inter-Environnement Wallonie ASBL, paragraphs 79-80).

B.18.3. It follows that the Act of 28 June 2015 had to be the subject of an environmental impact assessment, with public consultation, and that, since it was likely to have significant environmental effects in another member state, it also had to be subject to a cross-border assessment procedure as provided for in Article 7 of the EIA Directive (ibid., paras. 81 and 93).

(…)

B.19.4. Consequently, with the Act of 28 June 2015, the federal legislator passed a framework decree establishing the principle of a ten-year extension of the duration of industrial electricity production by the Doel 1 and Doel 2 units, the implementation and consequences of which in terms of modernization and security work were known at the time of the adoption of the contested law. In that context, the Act of 28 June 2015 constituted the first phase of the authorization procedure of the project at issue concerning the extension of the duration of industrial electricity production by the Doel 1 and Doel 2 units, the effects of which had been identified and assessed at the time of the adoption of the Act at issue, which therefore had to be preceded by the environmental impact report required by Directive 2011/92/EU.

For the rest, as the Court of Justice underlines, "As regards the need for the issuing of a new specific consent for the production of electricity for industrial purposes in respect of one of the two power stations concerned in order to proceed with the project, that fact cannot justify postponing the environmental *impact assessment until after the adoption of that legislation." (CJEU, Grand Chamber, 29 July 2019, C-411/17, Inter-Environnement Wallonie ASBL, para. 89).*

B.19.5. Since the Act of 28 June 2015 was to be regarded as the decision in principle which counts as a "development consent" within the meaning of Article 1(2)(c) of the EIA Directive, of a "project" within the meaning of the first indent of Article 1(2)(a) of Directive 2011/92/EU, read in conjunction with Annexes I and II to the same Directive, the contested Law had to be preceded, before its adoption, by an environmental impact assessment and a public consultation on the principle of extending by ten years the duration of the industrial production of electricity by the Doel 1 and Doel 2 units, and on the consequences of that extension as regards modernization and security work.(...)"

In essence, therefore, the following can be inferred or concluded from the aforementioned judgment:

1 The individual operating permits will continue to apply in full. In the individual licenses in question, only the provisions relating to the permit for industrial electricity production may have ended on the date of deactivation referred to in Article 4, § 1, of the Law of January 31, 2003, as replaced by the Act of December 18, 2013.

2 The Act of 28 June 2015 amended the aforementioned Act of 31 January 2003 in two ways:
- on the one hand, it allowed the KCD-1 unit to produce electricity "once again" from the entry into force of the contested Act, being 6 July 2015, and delayed its cessation until 15 February 2025;
- on the other hand, it postponed the date of deactivation and the end of industrial electricity production of the KCD-2 unit by ten years, until 1 December 2025.

The Act of 28 June 2015 sufficiently demonstrated that the legislature, by adopting the contested Act, decided to extend the duration of the industrial electricity production of the KCD-1 and KCD-2 units by ten years, subject to substantial work being carried out on those plants, specifically to modernize them and to ensure compliance with the safety standards under the " LTO " plan. Even though those works themselves were not specifically mentioned in the June 28, 2015 law, they were a *sine qua non* for extending the life of the nuclear power plants in question.

3 Since such modernization works are inextricably linked to the adoption of the decision to extend, for ten years, the duration of the industrial electricity production of units KCD-1 and KCD-2, the contested Act and the works together constitute one and the same " project " within the meaning of Article 1(2)(a), first indent, of Directive 2011/92/EU.

4 The measures taken by the legislature and the related work are considered comparable in magnitude to the risks that occurred when those plants were originally commissioned.

5 The Act of 28 June 2015 thus constituted the first stage of the authorization procedure of the project in question on the extension of the duration of industrial electricity production by the KCD-1 and KCD-2 units, the effects of which had been identified and assessed at the time of the adoption of the contested Act. The aforementioned Act therefore had to be preceded by the environmental impact report required by Directive 2011/92/EU.

The fact that the specific implementation of this Project for KCD-1 and KCD-2 requires the issuance of a new individual industrial power generation permit does not change this fact. The Act of June 28, 2015 was to be considered the decision in principle that counts as a "development consent" in the sense of Article 1(2)(c) of the EIA Directive, of a " project " in the sense of Article 1(2)(a), first indent, of the Directive 2011/92/EU.

6 The Act of June 28, 2015, before its adoption, had to be preceded by an environmental impact assessment and public consultation on the principle of extending by ten years the duration of industrial electricity production by the KCD-1 and KCD-2 units, and on the consequences of that extension on modernization and security work.

1.1.3 Objective and Scope

In view of the aforementioned conclusions that can be drawn from the judgment of the Constitutional Court, and in view of the maintenance in time of the effects of the annulled law, it was decided to draft an EIR for

- the Act to be adopted by the legislature for extended electricity production and
- the associated work, which should be considered together as one and the same "project".

For practical reasons, it was decided to prepare two separate EIRs, but they will need to be evaluated in conjunction. The first is a strategic level environmental impact assessment, which is drafted by SCK-CEN.

Since the annulled Act and the associated work are to be considered together as one and the same "project", it was decided that both for the law, as well as for the work resulting from it, in addition to a strategic EIR, the EIR presented here should be drafted.

The EIR preceding the Act to be adopted is being prepared at the initiative of the Belgian State.

The purpose of this EIR is to assess the (cross-border) environmental impacts of the concrete work to be carried out as a result of the act on extended electricity generation to be adopted by the legislature. In this context, the present document is subject to the procedure of an environmental impact report with cross-border assessment.

In the context of the present Project, this EIR has been drafted as part of the work on the KCD-1 and KCD-2 units for the purpose of extended electricity generation for the period 2015-2025.

In view of what was mentioned under 1.1.2, this EIR serves to remedy the situation that arose as a result of the 5 March 2020 ruling of the Constitutional Court.

Therefore, the reference date was the time of the vote on the (now annulled) Act (28 June 2015) taken into account to conduct the study. This EIR analyzed the difference between the Baseline Situation (prior to 2015) and the Expected Situation (i.e., the work to be performed as part of the 10-year extension of the life of the KCD-1 and KCD-2). The data used include both existing data through 2018, as well as projections.

Purpose
The purpose of this EIR is to determine the impacts of the LTO of KCD-1 and KCD-2 (the Project). As a result of the cessation of operation, the environmental impacts due to operation will decrease. In order to unambiguously determine the impacts of the Project, without considering the effect of the cessation of operation of KCD-3 and KCD-4, this EIR has assumed that the environmental impacts due to KCD-3 and KCD-4 units will remain the same after the cessation of electricity generation as they were before the cessation. This is a conservative assumption: it takes into account a longer period of environmental impact due to operation than will actually be the case.

Scope
The scope of this EIR concerns the continued operation of KCD-1 and KCD-2 during the period 2015-2025. Within the study period, a distinction is made between the operational phase of the Project (period 2015 and 2018) and the operational phase in the future situation (period 2019 - 2025). In the first period, work will be carried out as part of the Project. For the description of the work, see § 1.5.2 and § 1.6.1. In the following period, KCD-1 and KCD-2 will be operated further. The entirety of the work and operation of the units is included in the scope.

The POP of KCD-3 and KCD-4, as well as the dismantling of KCD-1, KCD-2, KCD-3 and KCD-4 are not within the scope of this EIR. Dismantling is subject to its own specific licensing process, which includes an environmental impact assessment. Figure 1-1 shows the phases schematically.

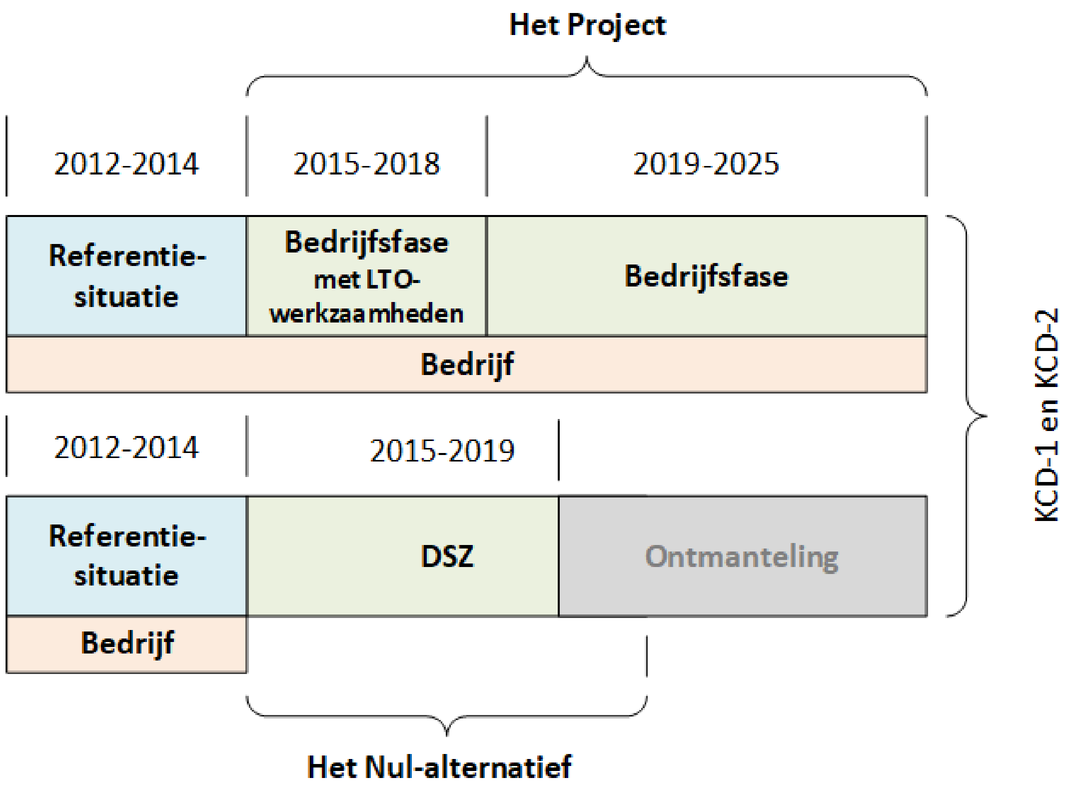

Figure 1-1 Phases of the Project

Parallel projects
Significant changes will occur during the period under study (2015-2025). The SF² project aims to increase the storage capacity for spent fuel at the Doel site will be carried out in this period. This project was not yet anticipated in 2015. Project SF² is not necessary for the operation of KCD-1 and KCD-2 until 2025: the fuel elements of KCD-1 and KCD-2 will remain in the existing dry storage building and the fuel elements of KCD-3 and KCD-4 will go to SF². Those changes are not part of the Project, but may have a cumulative effect with the Project. The impacts of the Project and Project SF² combined will be described in general terms where relevant.

In 2022 and 2025 respectively, the Post Operational Phase of KCD-3 and KCD-4 will take place unless the LTO G2 project goes ahead. The work within LTO G2 should ensure that the lifetime of KCD-4 can be extended.

Cessation of electricity production
For illustrative purpose. Figure 1-2 shows the life cycle of a nuclear power plant, including the Long Term Operation (LTO) (referred to in this EIR as the Project), the Post Operational Phase (POP) and dismantling of the nuclear power plant. Following the figure, the phases of a nuclear power plant when

power generation ceases are briefly discussed. In other words: ceasing the operation of the unit. The figure and description are largely taken from the 2019 Environmental Statement [Electrabel, 2019].

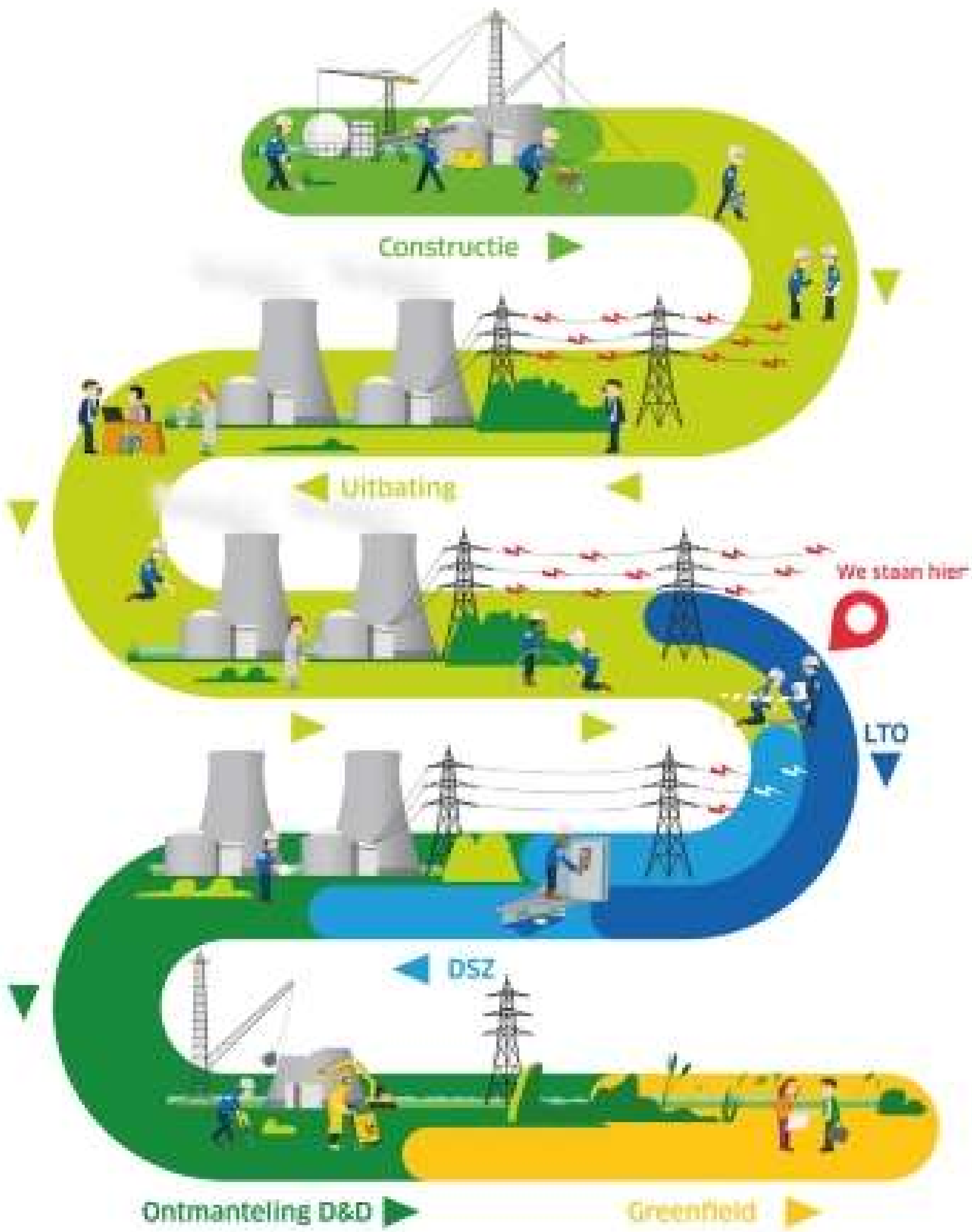

Figure1-2 Life cycle of a nuclear power plant

Post Operational Phase (POP)
The production of electricity in every nuclear power plant has to stop at some point. This starts with the permanent shutdown of the reactor, quenching and cleaning and/or decontamination of the plant and emptying the liquid circuits, etc. This phase ends with the removal of the last irradiated fuel elements and as much as possible of the radioactive materials present. During the Post Operational Phase (which is still part of the operational phase, under the reactor's operating license), the existing plant is prepared for dismantling. However, as part ofthe cessation, the environmental permit may need to be amended.

During the Post Operational Phase, in principle nothing is demolished in the nuclear installations. The objective is to remove the largest sources of radioactivity wherever possible so that dismantling can take place in complete safety and at the lowest possible dose (seeFigure 1-3).

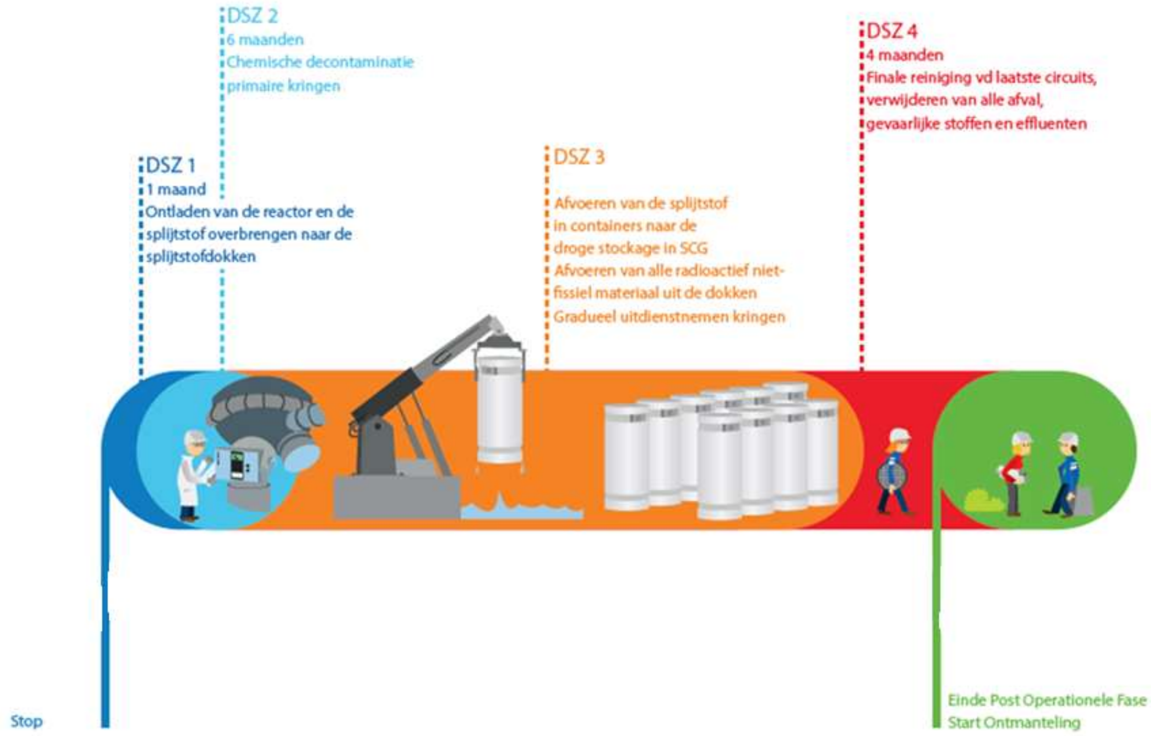

Figure 1-3 Schematic overview of the 4 stages of the Post Operational Phase

The stages of Post Operational Phase will last between 3 and 5 years, depending on the unit. Also during this phase, it will be necessary to monitor various systems and parameters: fuel cooling in the fuel basin, building ventilation, radioactivity measurements, fire protection systems, etc. Shift work therefore still remains required in this phase [Electrabel, 2019]. The POP is included in the nuclear operating license of the units. For KCD-1 and KCD-2, a period of just under 5 years is planned. The POP period can be divided into four stages. The stages are related to a group of pre-determined activities. The end of a stage is linked to a specific (operational / technical) condition of the unit.

Stage 1 starts with stopping the reactor and disconnecting it from the power grid. The reactor is unloaded and the fuel assemblies, control rods and other non-fissile highly radiating components are transferred to the fuel basin. The stage ends when the reactor is fully emptied.

Stage 2 involves the chemical decontamination of the primary circuits. The other circuits in the RCA (except around the fuel basin) are emptied and cleaned.

To ensure chemical decontamination, a methodology is followed, which is in line with international good practices and experiences. During chemical decontamination, the interior of the main components of the systems in question are cleaned using chemical products, removing all or part of the layer containing the majority of the radioactivity (precipitated activated and/or fission products). The chemical products used and the layer which was partially or completely removed are collected, processed and the remainder disposed of as radioactive waste.

Stage 3 ends when the fuel assemblies are removed from the fuel basin. After the residual heat is sufficiently reduced, the elements are loaded into containers and transported to the Fuel Container Building (FCB). Also, during this phase, the non-fissionable highly radioactive components present in the fuel basin are disposed of as radioactive waste in the appropriate manner. The remaining circuits are taken out of service.

Phase 4 involves emptying and cleaning the fuel basin and related circuits. After the completion of POP stage 4, the plant will be ready for dismantling [Electrabel, 2020].

The POP will have to be implemented with or without the Project. The only difference is the timing of the POP. If the Project is implemented, this will be approximately 10 years later than without the Project. The effects of the POP will be the same for both situations. The fact that there is an additional 10 years of production does not significantly affect the effects of the POP as such.

Dismantling
During dismantling, which can be done in several sub-phases, the plant is disassembled. Equipment, structures and components are removed and/or decontaminated for release, reuse, recycling or treatment as radioactive waste.

This stage is an integral part of the life cycle of the nuclear power plant. After all, it is the responsibility of the operator to demolish the plant in the Post Operational Phase and restore the original environment. In practice, this means that the plants will have to make way for a greenfield site or for other industrial uses.

After the plant's construction, dismantling will be one of the biggest projects the company will ever accomplish. As long as there is radioactivity, originating from the industrial activity of electricity generation, in the systems, you are obliged to comply with all nuclear practices, processes and regulations. This means that all demolition activities require various competencies in the various domains. This will continue to be the case until the radioactivity from industrial activities is gone. The dismantling phase will take about 10 to 15 years [Electrabel, 2019].

Dismantling requires a specific permit from FANC (Federal Agency for Nuclear Control). This permit will not be granted until NIRAS (National Agency for Radioactive Waste and Enriched Fissile Materials) approves the "Final Dismantling Plan". As a result, the environmental impacts of dismantling are examined at the time of the specific dismantling license application. Therefore, the environmental impacts of dismantling are not covered by this EIR.

Greenfield
As a responsible company, the final objective is to restore the sites to their original condition. This means that the site should basically be back to being a green field of grass. Then it is up to the authorities to decide whether or not these sites can be used again for an industrial activity. Restoring them to their original condition will be done after all nuclear systems at the Doel site have been dismantled.

1.1.4 Details of the applicant

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CEO:	Philippe van Troeye, Managing Director
Telephone number:	+32 2 518 61 11
Fax:	+32 2 518 64 00
VAT number:	BE 0403.170.701 (Electrabel)

Electrabel is the operator and owner of KCD-1 and KCD-2. Electrabel is part of ENGIE, a world leader in energy and the environment. Electrabel is the market leader in Belgium and the largest producer of green electricity. In this market, the company produces electricity and sells electricity, natural gas and energy services. The company offers its 3.1 million residential, professional and industrial customers energy solutions and a customized service. Electrabel has a diversified generation park of 9900 MW in Belgium (company share), consisting of plants operating with renewable energy sources, fossil fuels and nuclear energy. Greenhouse gas emissions from the production fleet are among the lowest in Europe. ENGIE confirms its strategic choice for a diversified, balanced and low-carbon energy mix. This consists mainly of natural gas, nuclear power and renewable energy, and ensures production with low CO^2 emissions. Nuclear power plays an important role in this strategy. Nuclear power represents approximately 8% of the Group's global electricity production. In addition to the seven reactors operated in Belgium (Doel and Tihange), the Group has a stake in two reactors in France (1,208 MW) and capacity (nuclear drawing rights) in Germany (700 MW). In 2015, the Doel nuclear power plant supplied about 29.9% of Electrabel's total electricity production in Belgium [Electrabel, 2016].

1.1.5 Data of Authorizing Authority

Name:	Federal Agency for Nuclear Control (FANC)
Address:	Ravensteinstraat 36 1000 Brussels
Telephone number:	+32 2 289 21 11
Fax:	+32 2 289 21 12

The government, in this case the King, has the authority to grant, supplement or modify a permit for anyone wishing to start a nuclear activity or nuclear facility. The Federal Agency for Nuclear Control (FANC) is the supervisory authority in the operation of the licensed facility and may propose new conditions for a license under Article 13 of ARBIS [ARBIS]. FANC also regularly inspects whether the permit's conditions are complied with.

FANC also manages a system that allows it to monitor radiation on Belgian territory. The TELERAD network constantly measures radioactivity in the air and in water. In addition, FANC also continuously takes samples from the main links of the food chain and the environment: the soil, air particles, milk, drinking water, meat, vegetables[1].

The above is in line with FANC's mission: to protect the health of the population, workers and the environment against the danger of ionizing radiation. Certain facilities (nuclear power plants, hospitals...) and activities (transport of nuclear materials, storage of radioactive waste...) require the use of ionizing radiation.

1.1.6 Project organization

The order for drafting this EIR was given by Electrabel (parent organization: ENGIE) to Arcadis and NRG. Electrabel instructed Tractebel to coordinate between the parties involved. Figure 1-4 is a schematic overview of the project organisation.

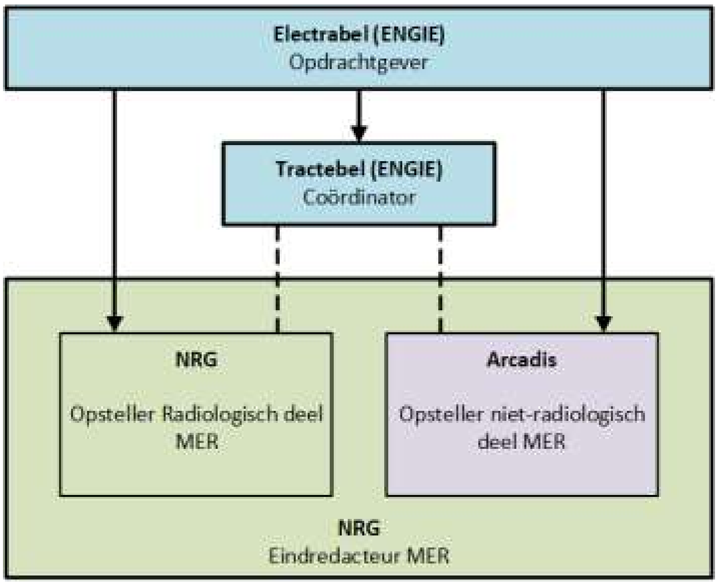


Figure 1-4 Project organization

Arcadis drafted the chapters of this EIR about the non-radiological aspects (Chapter 2, and the conclusions in § 4.1) and is thus responsible for the factual accuracy of the content they provide. Based on the information provided, calculations were performed by Arcadis to determine the effects of the Project and the Zero Alternative.

NRG drafted the chapters of this EIR dealing with radiological aspects (Chapter 3), as well as of the general section (Chapter 1) and conclusions in § 4.2. NRG is thereby responsible for the factual accuracy of the content they provide. NRG has not carried out any modeling and calculations of its own, such as for determining the effects during accident situations. These calculations were performed by Tractebel as part of the safety report of KCD-1 and KCD-2. This Safety Report was prepared by Electrabel and

[1] https://fanc.fgov.be/nl/

Tractebel and approved by BEL-V, the technical subsidiary of FANC. To guarantee the quality of this EIR, NRG has adopted a critical, questioning attitude towards Electrabel with regard to the calculation method used, data collection, etc., and the calculation results have been assessed on the basis of experience and engineering judgement. As the final editor of the entire EIR, NRG directly took the information provided by Arcadis and integrated it into the EIR, apart from layout-related changes to align Arcadis' and NRG's sections.

1.1.7 Team of experts

1.1.7.1 Non-radiological part

The team of external experts that will be in charge of drafting the EIR (non-radiological part) is shown in Table 1-1.

Table 1-1 Coordinators and experts for the non-radiological environmental aspects

Section	Name	Accreditation number
Coordinator Soil Landscape, architectural heritage and archaeology	Hanne Carlens (Arcadis)	Accredited EIR expert Soil - pedology; Landscape, architectural heritage and archaeology - landscape; Human - spatial aspects and accredited EIR coordinator EDA-817, Indefinite accreditation
Water	Dirk Libbrecht (Arcadis)	Accredited EIR expert Water - geohydrology, surface and wastewater, marine waters EDA-277, Indefinite accreditation
Noise and vibrations	Ann Himpen (Arcadis)	Accredited EIR expert Noise & Vibrations EDA-782, Indefinite accreditation
Biodiversity	Wouter Rommens (Arcadis)	Accredited EIR Expert Biodiversity EDA-593, Indefinite accreditation
Human - health Coordination	An Tombeur (Arcadis)	Accredited EIR expert Human - health 2016/00001, Indefinite accreditation
Air Climate	Frank Van Daele (Arcadis)	Accredited EIR expert Air - air pollution EDA-481, Indefinite accreditation
Human - Mobility	Adel Lannau (Arcadis)	Accredited EIR expert Human - mobility EDA-611, Indefinite accreditation

Company: Arcadis Belgium nv
Project Manager H. Carlens
Address: Borsbeeksebrug 22 (Post X)
Antwerp-Berchem, Belgium
Telephone number: +32 (2) 505 75 00

1.1.7.2 Radiological part

The study of the radiological impact on the environment was, in accordance with article 6.1.bis of the ARBIS, carried out at the initiative of the applicant by NRG, after approval by the Agency (FANC) on the basis of an approval file, the content of which is also laid down in article 6.2 of the ARBIS.

Based on an approval file with reference 24543/19.154718 rev.1 C&S/CR submitted by NRG (1 October 2019), FANC authorised NRG to author the radiological part of the environmental reporting and review [FANC, 2019].

Company:	Nuclear Research & consultancy Group (NRG)
Project Manager	C. Rooker
Address:	Westerduinweg 3 1755 LE Petten, Netherlands
Telephone number:	+31 (0)224 56 4356

1.1.8 Reader's Guide

This EIR is composed of four chapters. Chapter 1 is a general part. It gives the background and rationale for the EIR as well as an explanation of the project organization, the operation of a nuclear power plant in general, and describes the Doel nuclear power plant, and specifically units 1 and 2. In addition, this chapter describes the Project and the scenarios studied.

The effects of the Project are described in two separate chapters. Chapter 2 deals with non-radiological aspects and Chapter 3 with radiological aspects. Both chapters first provide an overview of the major environmental aspects relevant for the Project. Next, the methodology used is described after which the environmental assessment is given. The environmental assessment of Chapter 2 (non-radiological) includes effects on soil, water, biodiversity, climate and people & health. Chapter 3 focuses on radiological aspects dealing, among other things, with direct radiation, discharges and accident situations[2]. Both chapters have a conclusion and a reference list.

Chapter 4 draws the overall conclusions for both non-radiological environmental aspects and radiological environmental aspects.

1.2 Existing licenses

KCD's licensing status is a complex topic. The reactors KCD-1 and KCD-2 (as twin reactors), KCD-3 and KCD-4 are subject to the licensing system of Art.6 of the ARBIS [ARBIS] as a Class I nuclear facility. For non-radiological environmental impacts, KCD is subject to regional legislation, and for radiological environmental impacts it is subject to federal legislation.

[2] The impact of non-radiological accidents is considered in chapter 2

1.2.1 Federal Licenses

Units KCD-1 and KCD-2 were licensed by Federal State by Royal Decrees for the establishment and operation of the units of the nuclear power plant and for subsequent modifications, see Table 1-2 and Table 1-3.

Table 1-2 Basic licenses for the operation of KCD-1 and KCD-2

Date	Conclusion	Reference	Validity	Object
25.01.1974	RD 28/02/1963 ARBIS	Royal Decree S.3.497/C 10001860841 amended by: • the RD of May 7, 1987 (ref. S.3.497/L); • the RD of October 20, 2009 (ref. FANC 5000/AM-4-P/2B) authorizing the public limited company "Verenigde Energiebedrijven van het Scheldeland EBES" to establish a nuclear power plant in Doel, and authorizing the N.V. ELECTRABEL, as the legal successor of the above-mentioned N.V., to replace the steam generators and increase the thermal power of the nuclear reactor of the Doel 1 unit	- (unlimited duration)	Licensed to: • build a nuclear power plant, two units each with thermal capacity of 1192 MW, and turbo-alternator of 390 MWe • various systems indispensable to the operation of the nuclear power plant

Table 1-3 Overview of the operating licenses according to ARBIS for KCD-1 and KCD-2

Date	Conclusion	Reference	Validity	Object
10/03/1975	RD 28/02/1963 ARBIS	S.3.497/D 10001860843	-	Expansion with two additional steam vessels
06/05/1975	RD 28/02/1963 ARBIS	S.3.497/E (E1 + E2) 10001860845 10001866814	-	Expansion with one additional steam vessel
21/09/1981	RD 28/02/1963 ARBIS	S.3.497/G 10001860911	-	Replacement of two steam vessels
17/03/1981	RD 28/02/1963 ARBIS	S.3.497/H 10001860913	-	Additional operating conditions (security)
07/09/1981	RD 28/02/1963 ARBIS	S.3.497/I 10001860916	-	Addition of 2 stationary batteries
19/08/1983	RD 28/02/1963 ARBIS	S.3.497/J 10001860919	-	Relocation and expansion of a storage area for flammable liquids and moveable gas receptacles
03/10/1986	RD 28/02/1963 ARBIS	S.3.497/K 10001860931	-	Installation of 2 additional waste oil containers and 4 additional steam drums
07/05/1987	RD 28/02/1963 ARBIS	S.3.497/L 10001860932	-	Amendment of RD n° S.3497/C because of TJH
04/02/1988	RD 28/02/1963 ARBIS	S.3.497/M 10001860939	-	Replacement of 16 preheaters
12/04/1991	RD 28/02/1963 ARBIS	S.3.497/N 10001860949	-	Increase in fuel enrichment for nuclear reactors D1 and D2
1/03/2004	FPS Economy, SMEs, Self-employed and Energy	EP-2004-0010-A 10001861092	-	Individual license for the conversion of the systems for electricity production at unit 2, in Doel
06/05/2004	RD 20/07/2001 ARBIS	FANC-683/AM-4-N/1 10001861095	-	Increasing the enrichment rate of nuclear fuel for the Doel 1 and Goal 2 units
06/05/2004	RD 20/07/2001 ARBIS	FANC-683/AM-4-N/2 10001861104	-	Storage of the old steam generators of Doel 2 and the

Date	Conclusion	Reference	Validity	Object
				extension of the storage site for used steam generators
06/05/2004	RD 20/07/2001 ARBIS	FANC-683/AM-4-N/3 10001861136	-	Replacement of steam generators and increase in power of unit Doel 2
16/05/2004	RD 20/07/2001 ARBIS	FANC-683/AM-4-N/2A 10001861134	-	Confirmation of the decision to store the old steam generators of Doel 2 in the extension GSG
05/12/2004	RD 20/07/2001 ARBIS	FANC-683/AM-4-N/3A 10001861167	-	Confirmation decision replacement of steam generators and increase in power of the Doel 2 Unit (Steam Generator Replacement Aspect) VSG&P-D2 Overview of Documents
20/01/2005	RD 20/07/2001 ARBIS	FANC-683/AM-4-N/1A 10000546314	-	Confirmation decision to increase fuel enrichment level for Doel 1 and Doel 2 units
29/04/2005	RD 20/07/2001 ARBIS	FANC-683/AM-4-N/3B 10000546315	-	Confirmation Decision replacing the SGs and increasing the power for the Doel 2 unit (power increase aspect) VSS&P - D2 License FANC overview document
18/02/2008	FPS Economy, SMEs, Self-employed and Energy	EP-2007-0024-A 10001862415	-	Individual license for the conversion of the systems for electricity production at unit 1, in Doel
22/07/2008	RD 20/07/2001 ARBIS	3-1/FVW/06/08/7/ UN4/6252/53999 1001041985	-	Nuclear Power Plant Doel project "Replacement of D12 safety diesels"
23/06/2009	RD 20/07/2001 ARBIS	FANC-683/AM-4-N/3B 10010021026	-	BELV: R - Dec - Official Record - 09-001-0-no: Official Record of completion
20/10/2009	RD 20/07/2001 ARBIS	FANC 5000/AM-4-P/1; 2; 1A 10010136425 10010136425	-	Extension of GSG at Target 1 and VSG&P + for Doel 1
08/02/2010	FPS Home Affairs FANC	FANC 8658/AM-4-P	-	Authorization for change of conditions for Doel 1 and Doel 2
21/02/2010 26/10/2010	RD 20/07/2001 ARBIS	FANC 5000/AM-4-P/2A and 2B 10010170964 10010221377	-	RD authorising NV Electrabel, as the legal entity for said NV, to replace the steam generators and increase the thermal capacity of the Doel 1 nuclear power station

1.2.2 Regional licenses

KCD has several environmental permits. These permits are listed in Table 1-4.

Table 1-4 Overview of the environmental permits for KCD-1 and KCD-2

Date	Government	Reference	Validity	Object
04/02/1992	Ministry of the Flemish Community	V/2535 10001863750	-	Authorization for the intake of water from the Zeeschelde in Doel and for pumping water back into the Zeeschelde in Doel
31/03/2011	Provincial Government of East Flanders	M03/46003/46/2/A/5/HV/LW 10010248886	31.03.2031	License to continue operating a facility of generating electricity (non-nuclear facilities).
10/11/2011	Provincial Government of East Flanders	M03/46003/46/2/W/5/LBR/KVDB 10010294911	31.03.2031	Modification of special conditions for the facility K1
12/02/2015	Provincial Government of East Flanders	M03/46003/46/2/W/6/LDR/FV 10010529979	31.03.2031	Request for modification of the environmental permit conditions K1 regarding the discharge of the company's wastewater and cooling water.

1.3 General description of a nuclear power plant

1.3.1 Working Principle

A nuclear production unit consists of a nuclear part and a conventional part. Electricity is produced by using the heat released in the reactor core by the fission of uranium slightly enriched in ^{235}U(between 3 and 5%), which constitutes the nuclear fuel. This heat is used to warm up the pressurised water in the primary circuit. In steam generators, water from the primary circuit flows through thousands of sealed tubes and transfers its heat to the water in the secondary circuit. The water in the secondary circuit is converted to high-pressure steam that is used to drive a high-speed turbine, which drives an alternator that produces electricity. At the turbine exhaust, the steam in the condenser is converted back to water and then sent back to the steam generator for another cycle. The process of electricity generation is illustrated in Figure 1-5.

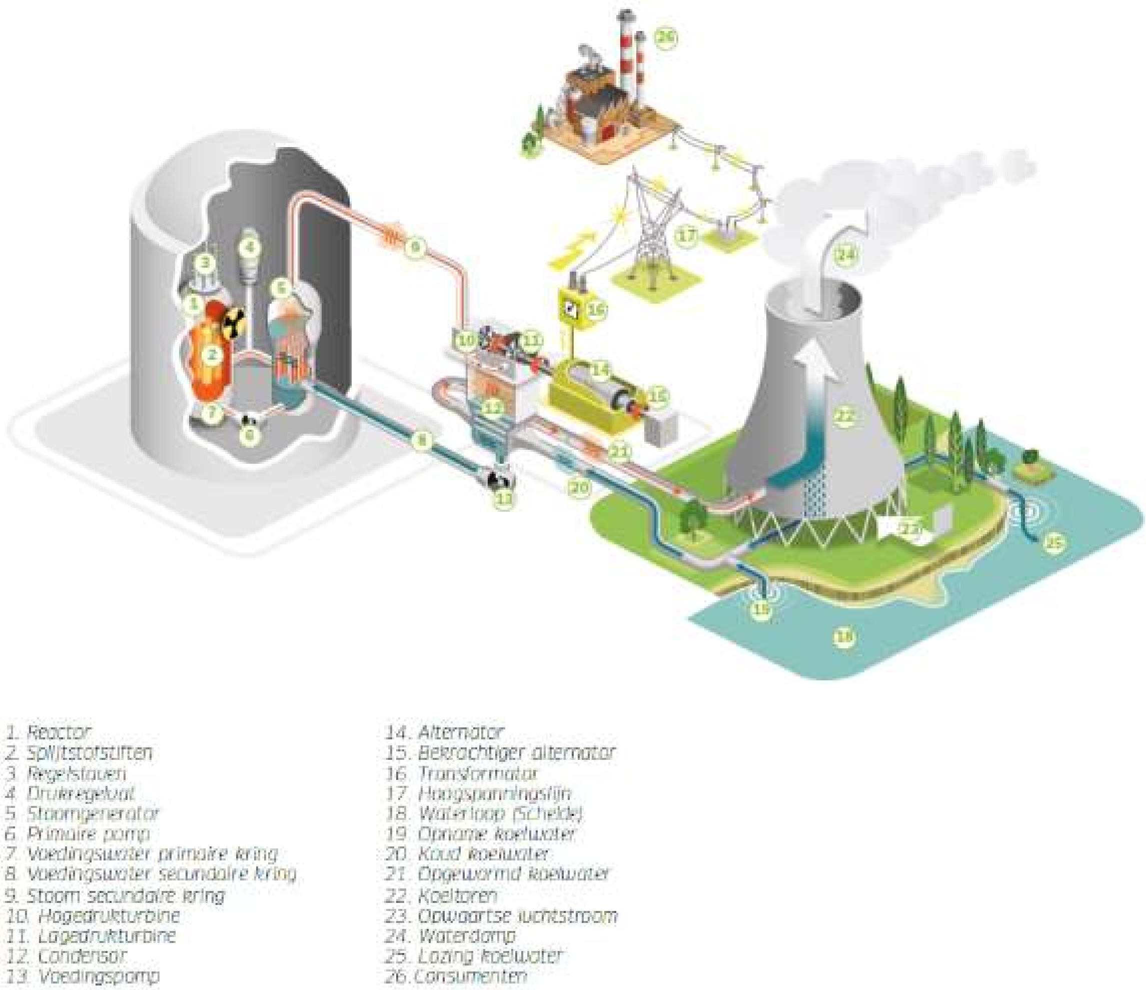
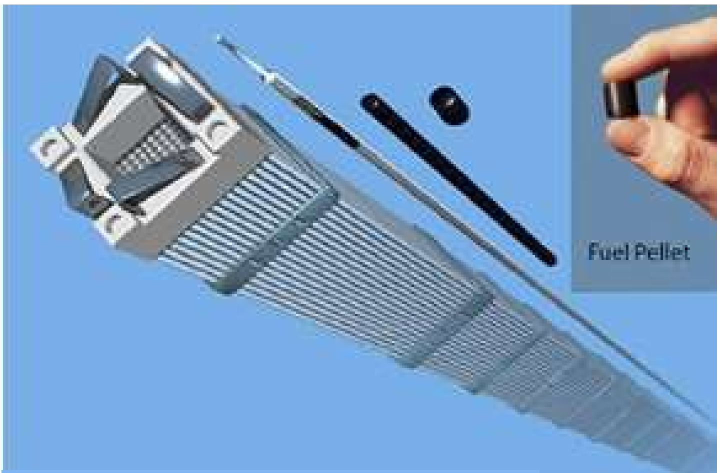


Figure 1-5 Schematic description of a nuclear power plant

1.3.2 Nuclear part

KCD has Pressurized Water Reactors (PWR). All reactor buildings have a dual containment system. The annular space between the two housings has negative air pressure to prevent leakage to the environment.

The fuel takes the form of uranium oxide pellets, cylindrical in shape about 8 to 9 mm in diameter and 15 mm high. The fuel pellets are stacked in closed tubes about 4 m high: the combination of the pellets and the tube is usually called the fuel rod. Fuel rods are assembled into several bundles to form a metal structure called a fuel element (see Figure 1-6). The nuclear fuel is delivered to the site and used in this form.



Fuel element (bottom) and fuel pellet (top right)

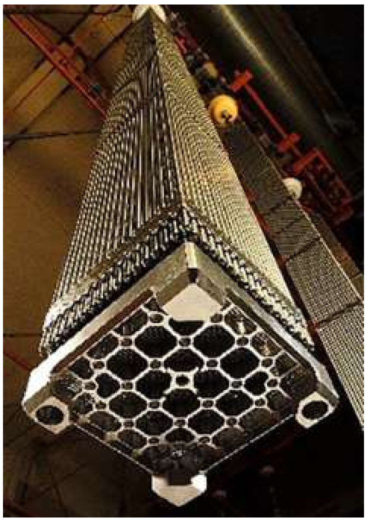


Figure 1-6 Fuel element

The part where the fission reaction takes place is called the core; it is the set of fuel elements that contains uranium. The fuel elements are inserted into the reactor vessel (steel vessel filled with water) in a well-defined order. The fuel elements will remain there for about 48 months. A quarter of the fuel is removed from the reactor approximately every 12 months and replaced with fuel assemblies containing new fuel. The spent fuel elements of KCD-1 and KCD-2 are stored in the fuel pool in the Nuclear Services Building (GNH). When the spent fuel elements are sufficiently cooled, they are transferred to the FCB.

This type of assembly allows the thermal energy released by fission to be transferred to the water in the primary circuit without the fission products leaving the sealed fuel rods.

The fission chain reaction brings the fuel elements up to high temperature (about 900°C). The heat from the reactor core is transferred to the water[3] which circulates in a closed and sealed circuit. This first circuit is called the primary circuit. The water in this circuit reaches an average temperature of 300°C. In a pressurized water reactor, the water is kept under pressure by means of a pressure regulator, which prevents the water from boiling. Primary pumps are used to compensate for pressure losses in the circuit.

The hot water in the primary circuit in turn transfers heat to a second closed circuit, the secondary circuit. Both are hermetically sealed from each other. The heat exchange takes place in a steam generator, a large cylindrical heat exchanger consisting of thousands of tubes. Units KCD-3 and KCD-4 have three loops, each equipped with a steam generator and a primary pump, but only one pressure regulator for the entire primary circuit. Units KCD-1 and KCD-2 have only 2 loops.

The operation of a nuclear reactor is carefully controlled. To start, stop or operate the reactor at different power levels, operators act on the intensity of the chain reaction using control rods made of materials that can absorb neutrons. Inserting these rods into the reactor core causes the neutrons to be absorbed and thus decreases the number of chain reactions. In the event of an unexpected situation, these same rods automatically fall into the core, stopping the chain reaction in less than 2 seconds. The rods are therefore

3 Water with added boric acid, which moderates (slows down) the process and absorbs excess neutrons to control the chain reaction.

used to ensure rapid variations in reactor power. In addition, a water-soluble neutron absorber, boron, is added to the nuclear water to control the intensity of the fission reaction; the boron concentration is adjusted daily.

1.3.3 Conventional part

The water in the primary circuit transfers its heat to the water circulating in the secondary circuit. So there is no exchange of fluids, only of heat, which takes place in the steam generator. When the water comes into contact with the tubes of the primary circuit of the steam generator, the water in the secondary circuit heats up and turns into steam. The steam that is generated drives a turbine: caloric energy is converted into kinetic energy. Each turbine consists of a high pressure body and two low pressure bodies. An alternator is attached to each turbine and converts the kinetic energy into electricity, which is sent to the high-voltage grid, see Figure 1-5.

The steam used by the turbine is cooled in the condenser, where it is converted back into liquid water after contact with thousands of tubes. In the tubes, water circulates from a third circuit, called the tertiary circuit or cooling circuit, which is fed by water from the Scheldt. The water in the secondary circuit can then be sent back to the steam generator to be reheated to steam and continue the cycle.

Like the large conventional thermal power plants, the KCD-3 and KCD-4 units use cooling towers, to reduce the temperature of the cooling water by natural air circulation. The heated water is dispersed at the base of the tower in the form of droplets and is cooled by the rising airflow. Most of this water returns to the condenser, while the rest is discharged into the river, with only a small portion, about 2%, evaporating into the atmosphere: this is the condensation plume leaving the tower. Condenser cooling of units KCD-1 and KCD-2 uses direct flow. Over the years, the possibility was added to also pump this cooling water to the cooling towers, as needed.

Many circuits and outbuildings also enable the operation of power plants, such as:

- conventional auxiliary diesel boilers for steam production at unit start-up or as a backup in the event of unavailability of steam transformers at nuclear facilities;
- emergency diesel engines related to nuclear safety and their associated tanks;
- stationary batteries;
- transformers that send the electricity produced to the high-voltage grid.

1.4 Description of the Doel nuclear power plant

Electrabel NV operates a nuclear power plant (KCD) in Doel with four production units with a total production capacity of 3,720 MWe.

KCD comprises:

- Four production units
  - The twin units KCD-1 and KCD-2 share certain circuits;

- The units of KCD-3 and KCD-4 are separate, yet nearly identical units;
- A nuclear waste treatment plant and process water supply;
- A dry storage facility for spent fuel elements;
- A building for the storage of the old steam generators.

KCD's net electricity generation (gross generation minus auxiliary consumption required to operate the plant) between 2012 and 2018 is shown in Table 1-5 [Electrabel, 2013] [Electrabel, 2014], [Electrabel, 2015a], [Electrabel, 2016], [Electrabel, 2017], [Electrabel, 2018], [Electrabel, 2019].

Table 1-5 Net electricity production at the Doel nuclear power plant, in GWh

Unit	Commissioning	Thermal power [MWth]	Installed production capacity [MWe][4]	Production [GWh]						
				2012	2013	2014	2015	2016	2017	2018
KCD-1	1975	1312	530	3 445	3 708	3 556	397	3 015	3 426	1 172
KCD-2	1975	1312	530	3 262	3 557	3 528	2 971	3 307	3 413	1 475
KCD-3	1982	3064	1330	3 695	4 998	2 072	64	7 287	6 380	3 756
KCD-4	1985	3000	1330	7 819	8 447	4 887	7 744	8 782	7 461	5 514
Total		8688	3720	18220	20720	14044	11177	22120	20681	11918

1.4.1 Location

KCD's site is located in the far north of what is described as the Waaslandhaven, in the Antwerp port area on Linkeroever in Doel, part of the municipality of Beveren in the province of East Flanders. The location is indicated in the following Figure 1-7.

[4] Alternator power

Figure 1-7 Situation (in red) of KCD's production site [5]

KCD's site was constructed in the 1960s, on raised polders using sprayed-on sand. Most Scheldt polders originated a long time ago.

KCD is quite isolated in a northern corner of the port area on the left bank of the river Scheldt. The site is geographically bounded by:

- Polders and the Paardenschor nature compensation area to the north;
- The polder village of Doel (or its remnants) to the south;
- The Scheldt to the east;
- Polders (designated as seaport area with temporary agricultural use - ZTA area) in the west.

1.4.2 Spatial Layout

KCD and its immediate surroundings were included in the Regional Spatial Implementation Plan (RSIP) "Afbakening Zeehavengebied Antwerpen – Havenontwikkeling Linkeroever" (Delimitation of the Antwerp Seaport Area - Port Development Left Bank), which was approved by the Flemish government in 2014. The judgment of the Council of State of December 20, 2016, annulled the 2014 RSIP. As a result, further nature development at Doelpolder Midden and the construction of the Saeftinghedok (at the level of the polder village Doel) will not take place for the time being. At present, a procedure "complex project" is ongoing, in which the Flemish government has taken a decision regarding the alternative regarding the implementation.

[5] http://geo-vlaanderen.gisvlaanderen.be/geo-vlaanderen/kleurenortho/#

This makes that the zoning of KCD and its immediate surroundings is redefined by the original regional plan dated 1978 (Royal Decree of November 7, 1978 establishing the Sint-Niklaas-Lokeren regional plan).

Figure 1-8 shows the current zoning of KCD and its immediate surroundings on the 1978 regional plan. Table 1-6 Includes the legend.

Figure 1-8 Environment of the KCD production site[6], with KCD outlined in black.

Table 1-6 Legend

Element	Description
	Industrial area
	Port expansion area
N	Natural area
R	Natural areas of scientific value or natural reserves
	Forest areas
	Natural area with easement (for transportation lines and pipelines)
	Agricultural areas
	Reserve area for expansion
	Residential area
	Residential areas with a rural character
	Residential areas of cultural, historical, and/or aesthetic value

[6] Source: http://geopunt.be

Element	Description
	Residential Expansion Areas
	Industrial area with possibility of tidal dock expansion

1.4.3 Natural environment

KCD is located along the Scheldt and is consequently also in its basin, more specifically in the Lower Scheldt basin.

The Scheldt is a tidal river. This tidal effect also means that there are numerous important natural reserves with a biologically very valuable character on the banks of the Scheldt, including at the level of KCD. These natural reserves include the polder areas and the mudflats and salt marshes located outside the dikes. The mudflats and salt marshes and the Scheldt itself are designated as Special Protection Area for Habitats. In addition, the entire area of the Waaslandhaven and the adjacent polder areas have been designated as faunistically important areas. It is also zoned as a special protection area for birds.

The Natura 2000 sites in the vicinity of KCD are:

- BE2300006 - Schelde- en Durme-estuarium van de Nederlandse grens tot Gent;
- BE2301336 - Beneden-Schelde.

There are also areas of the Flemish Ecological Network (VEN) areas and Integral Enhancement and Support Network (IRSN) and official nature reserves in the vicinity of the KCD site.

Figure 1-9 shows the main natural values in the vicinity of the nuclear power plant.

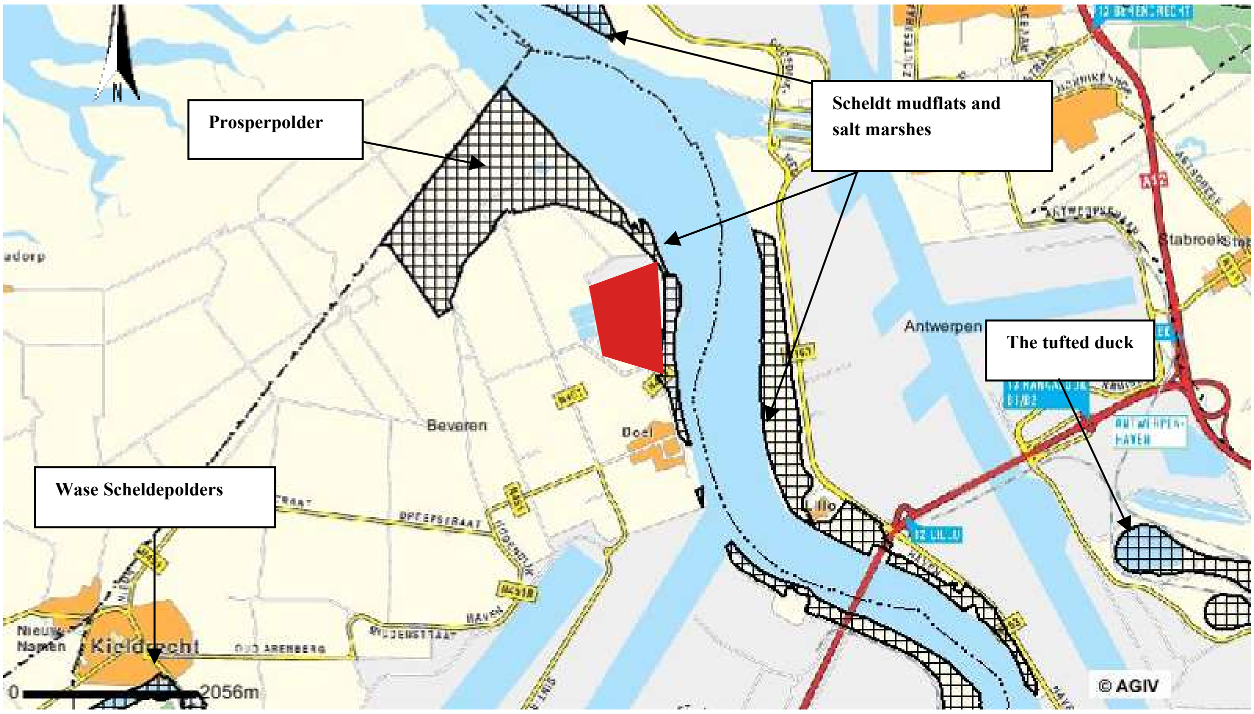


Figure 1-9 Natural areas in the vicinity of KCD and the wider environment[7]. KCD is shown in red.

1.4.4 Built-up Environment

No other businesses are located around the site of KCD. The closest activities are located on the right bank at about 2 km (chemical industry) and around the Deurganckdok (container traffic).

As far as inhabitation is concerned, in addition to the abandoned and partly expropriated village center of the polder village of Doel, there are some residential areas in the vicinity of the nuclear power plant (Prosperdorp and Oude Doel) and scattered farmsteads in the polders. These homes, except for Prosperdorp, are not located within demarcated residential areas on spatial plans (regional plan).

The nearest residential area is located 2,600 meters (from the site boundary) to the southeast, specifically Lillo-Fort. This is followed by Berendrecht (3,300 meters - northeast) and Zandvliet (4,000 meters - northeast). All of these residential zones are located on the right bank of the river Scheldt. The closest residential area on the left bank is Kieldrecht, about 5,700 meters southwest. Kallo is located at more than 6,700 meters (southeast), while the village center of Beveren is located 10 km south of the company site.

The nearest house is located at a distance of approximately 800 m west of the project area.

The polders in the immediate area are sparsely populated.

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[7] http://geo-vlaanderen.gisvlaanderen.be/geo-vlaanderen/ven/#

1.4.5 Land registry lots

The Project is entirely located on land registry lots owned by Electrabel S.A. (Figure110). All these plots are located in the municipality of Beveren.

Figure110 Land registry plan

1.4.6 Layout plan of the KCD site

The site layout plan is shown on Figure 1-11. The site has four reactors:

- the twin reactors of KCD-1 and KCD-2, which share some systems;
- KCD-3
- KCD-4

The water and waste treatment building (WAB building) and the fuel container building (FCB) also contain radioactive material. There is no radioactive material stored in the remaining buildings. A more detailed description of the various facilities and buildings is given in § 1.4.7.

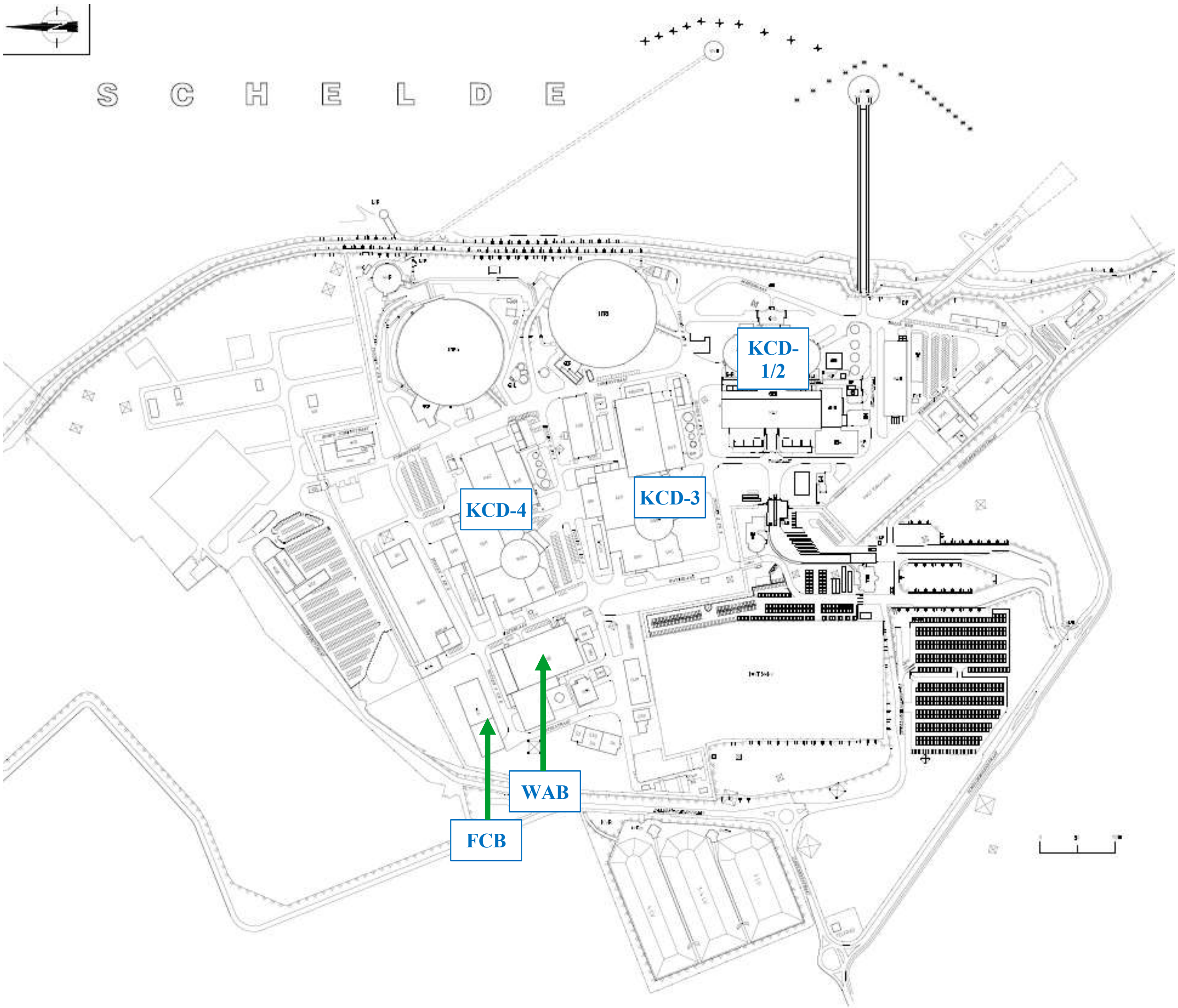

Figure 1-11 Layout plan of the Doel site

1.4.7 KCD-1 and KCD-2

KCD-1 and KCD-2 were built according to U.S. regulations. They were connected to the grid in 1974 and 1975 respectively. The main structures and buildings are described below.

1.4.7.1 Reactor Buildings (RGB)

The two reactor buildings (RGBs) of KCD-1 and KCD-2 are located symmetrically on either side of the Nuclear Auxiliary Services (GNH) building.

Each reactor building contains a double loop reactor and its primary circuit containing high-pressure water, as well as some of the nuclear auxiliary services, such as the accumulators of the safety injection system, and the spray collectors of the containment spray circuit. The safety injection system and the spray ring should ensure that the reactor core remains cooled during an accident with loss of primary coolant and that the pressure rise in the containment is limited so that the containment remains intact and the emission of radioactivity is limited.

Each of the two nuclear steam production units is installed in a leakproof containment building, consisting of a 46 m diameter metal sphere (the primary containment), surrounded by a concrete cylindrical shell with an outer diameter of 50 m (the secondary containment), topped by a rounded cap.

Internal structures mainly include:

- reinforced concrete ballistic shielding around the reactor's primary circuit;
- the reactor basin;
- the working floors divided into 4 levels (5 m - 9 m - 18.5 m and 24.5 m);
- the rolling track of the polar crane.

A 10% power increase was achieved with the replacement of the steam generators at KCD-1 (2010) and KCD-2 (2004). The old steam generators, which are considered a radioactive source after dismantling, are stored on the KCD site in a building equipped for the purpose.

1.4.7.2 Building of the reactor auxiliary services (BAR1, BAR2)

The reactor auxiliary services building (BAR) contains the steam lines (MS circuit) and feed water lines (FW circuit), the equipment of these circuits, and almost all of the equipment of the auxiliary feed water circuit (AFW circuit).

1.4.7.3 Nuclear Auxiliary Services Building (GNH)

The Nuclear Auxiliary Services Building (GNH), located between reactor buildings 1 and 2, was divided into two zones to isolate the potentially highly radioactive areas from the rest of the building. The division was made at the level of the floor 9 m. The GNH includes:

- the nuclear auxiliary and safety systems of the KCD-1 and KCD-2 reactors;
- the fuel basin for the spent fuel;
- the systems for the storage and treatment of the radioactive gaseous, liquid and solid waste, as well as the pumps for transferring the various liquid discharges to the WAB; the solid wastes are centralized in the WAB as for the other units;
- the room for the preparation and storage of concentrated boric acid solutions;
- the chemical laboratories and the changing rooms (with showers and toilet facilities) that provide access to the RCA;
- ventilation systems.

The Nuclear Auxiliary Services Building is 85 m long and 22 m wide.

1.4.7.4 Emergency Systems Building (GNS)

The building that houses the emergency systems is called the GNS building. The emergency systems building was constructed adjacent to the Nuclear Auxiliary Services (GNH) building along the side of the Scheldt. It contains the emergency control room and it is connected to the Electric Auxiliary Services building (GEH) by a corridor on the roof of the GNH.

This building primarily houses:

- dryers, filters and reservoirs of the EI circuit (emergency compressed air) and EI compressors;

- the glycol preparation and recovery of glycol-containing drains and vents;
- emergency diesels with their fuel tanks and fuel pumps (ED circuit) and their air coolers;
- the air coolers of the EC circuit (emergency intermediate cooling) and PL circuit (fuel basin cooling and purification);
- the EF pumps and EF reservoirs (emergency feed water);
- the RJ pumps and RJ reservoirs (emergency cooling for sealing the primary pumps);
- the 6.6 kV and 380 V cable halls;
- two sets of batteries;
- the rectifiers;
- the emergency control rooms (NKZ), which allow for the reactors of KCD-1 and KCD-2 to be kept in hot stop or brought to cold stop from the GNS;
- the extraction ventilation of the Nuclear Auxiliary Services Building (GNH) and the ventilation for the GNS.

The basement contains:

- a room with two tanks for the storage of gaseous discharges;
- a room for a GW compressor (gaseous waste);
- a room for the storage of radioactive waste.

1.4.7.5 Turbine hall (MAZ)

The turbine hall (MAZ) is 132 m long, 38 m wide and 40 m high. The exterior walls are covered with metal cladding and the roof is also metal.

The MAZ contains, arranged in line, the equipment of the secondary part of the units, except for the circulating pumps located in the water intake: the turbo-alternator groups with a speed of 1,500 rpm, their water stations, the condensers, the reheating station, etc.

The two turbo-alternator groups are placed opposite each other along a shared axis. The concrete foundation blocks of the turbo-alternator groups rest on piles.

The main transformers are located along the western façade of the turbine hall (MAZ), while the house transformers and the starting transformers are located along the eastern façade of the Electric Auxiliary Services building (GEH).

1.4.7.6 Electric Auxiliary Services (GEH) building

The Electric Auxiliary Services (GEH) building is adjacent to the turbine hall (MAZ), along the side of the Scheldt.

The Electric Auxiliary Services building includes:

- the control room with the control tables and the vertical main panels. There is only one control room (CR), located in the center of the GEH and adjacent to the Nuclear Auxiliary Services building (GNH); from there, the two units can be controlled from separate control tables and panels;
- the auxiliary control rooms with the vertical auxiliary panels;

- the electronics room;
- the relay and distributor room;
- the cable room;
- the battery room;
- the rooms with the electrical panels.

The building has an overall length of 132 m and a width of 10 m. In the center of the building, this width increases to 14 m over a length of 39.6 m. The total height of the building is 22.5 m.

1.4.7.7 Mechanical Auxiliary Services building (GMH)

The mechanical auxiliary services building contains the former safety diesels. This metal-framed building extends along the southern facade of the turbine hall. It is a 51 m by 28 m building.

It is independent of the turbine hall and has self-supporting structures. There are no basements. On the ground floor there are independent rooms for the diesels, the air compressors, as well as the *Onsite Technical Support Center* (OTSC) and the rooms with a social function. About half of the floor area is occupied by systems for demineralizing the water.

The part of the building with an extra floor is 18 m high. The part without the extra floor is 9 m high. The air coolers of the diesel groups and the ventilation of the OTSC have been placed on the roof.

1.4.7.8 Water intake and water discharge lines

The water intake for the supply of Scheldt water (tertiary circuit) is located about 200 m from the fairway, between the depth lines at - 4.00 m and - 6.00 m, about 225 m from the winter dike and 150 m from the summer dike. The structure includes a reinforced concrete cylinder, with an outer diameter of 40 m, divided into two equal halves, each dedicated to a separate system. It is protected by a series of obstacles, the three most important of which, arranged in herringbone along the side of the channel, are calculated to absorb the shock of a 50,000 ton ship.

The circulation water is pumped over to the turbine hall (MAZ) via a reinforced concrete pipe. The feed channels underneath the floor plate of the turbine hall are fed by this pipe and they distribute water to the condenser. After cooling the condenser, the circulation water moves to the atmospheric cooling towers of KCD-3 and KCD-4. Part of the common circulation water is discharged into the Scheldt via the discharge channels.

Connected to the feed ducts in the turbine hall, before the condenser, is a pipe that drains cooling water and leads it to a battery of heat exchangers for the nuclear equipment, in the Nuclear Auxiliary Services (GNH) building.

An independent cooling circuit (RW) provides a redundancy for the above circuit. It provides cooling the nuclear circuits when the main circuit fails due to malfunction. It consists of an assembly of four atmospheric cooling towers with suction fans.

1.4.7.9 Central Building A (CGA)

Central Building A (CGA), an administrative building, is located next to the MAZ and GMH buildings. It does not contain any safety-related equipment.

1.4.7.10 Emergency Diesels Building (DGG)
The diesel generator building contains the safety diesels and associated diesel tanks and systems (electrical rooms, battery rooms, etc.). This building is located between the workshop building (WPG) and the 150 kV station. The building is shared between KCD-1 and KCD-2.

1.4.7.11 Outbuildings
In addition to the production units and ancillary facilities that ensure the proper and safe operation of the plant there is:

- the entrance building;
- the office building;
- the "workshop - warehouse", which includes the following services:
  - the warehouse divided into two levels,
  - the warehouse for the gas cylinders (small, independent building, with a light roof and a natural ventilation, divided into two parts by a wall: one part for compressed air or compressed oxygen cylinders, and another part for the combustible gas cylinders (acetylene, hydrogen, methane, etc...); neutral gases can be stored in either part),
  - mechanics workshop,
  - the electrical workshop,
  - instrumentation and electrical laboratories,
  - the wood workshop,
  - a garage with firefighting equipment,
  - a garage with radiation protection department equipment.

1.4.7.12 Connection to the WAB
The KCD site also has a water and waste treatment building (WAB building) which houses the treatment systems for the solid and liquid effluents.

A number of changes were made to the KCD-1 and KCD-2 facilities to enable their connection to the WAB. The changes are mainly aimed at adapting the existing separation of waste materials to the principles applicable in KCD-3 and KCD-4:

- recyclable wastewater streams with non-degassed primary circuit water drains on the one hand and degassed primary circuit water drains on the other;
- non-recyclable wastewater streams containing: wastewater (floor drains, shower and laundry water), chemical drains and the regeneration wastewater from the continuous purification of the condensates.

Water is transferred to the WAB in "batches", by telephone agreement between the WAB and KCD-1 and KCD-2.

1.4.7.13 Spent fuel
Spent fuel from KCD-1 and KCD-2 is stored in the fuel pool in the Nuclear Services Building (GNH). When the spent fuel is sufficiently cooled, it is transferred to the FCB, where it is stored in Dual Purpose Casks (DPC).

The DPC are designed for the transportation of spent fuel between buildings on the site, temporary storage on-site, and transportation in the public domain. The containers are designed to provide shielding from ionizing radiation. Each DPC is designed to store a predefined number of fuel elements. The number of fuel elements per DPC depends on the type of DPC, the geometry and mass of the fuel elements, their enrichment rate and fission rate.

The safety functions are guaranteed by the DPC's design. The safety functions are guaranteed during storage, internal transport between the nuclear units' fuel buildings and the storage building, as well as during various handling and discharge/loading operations. These safety features are:

1. Containment of radioactive materials in the container;
2. Radiological protection from ionizing radiation from the spent fuel elements;
3. Assurance of the subcritical condition;
4. Discharge of residual heat from the fuel elements (building design must allow for this).

1.4.7.14 Protection levels

All units in Doel have two levels of protection: the safety systems of the first level of protection are designed to protect the unit from internal incidents and accidents and earthquakes, while the second level of protection of the ultimate safety systems are dedicated to external accidents.

1.5 Changes to KCD-1 and KCD-2 systems

1.5.1 Changes prior to the Project

The initial design of the plants is based on a solid regulatory foundation: the U.S. Nuclear Codes and the 10CFR50 nuclear island-wide regulation. Subsequently, the introduction of the ASME (American Society of Mechanical Engineers) code made it possible to distinguish between the importance of the various nuclear circuits and to strengthen the safety requirements for each circuit.

Over time, improvements have been made to the facilities, with the main objectives being:

- Improving nuclear safety;
- Increasing plant availability and reliability.

The main changes related to nuclear safety are based on Periodic Safety Reviews (PSRs). In addition to the improvements resulting from the PSRs, many other changes and improvements have been made as a result of internal and external inspections, maintenance, operating experience (including after major nuclear incidents and accidents, such as those at Three Miles Island, Chernobyl and Fukushima).

The first ten-year safety review (PSR 1, in 1984) led to sweeping changes. The new insights and requirements from recent national and international experience with PWR plants allowed for a significant increase in nuclear safety. The requirements for the construction of the new units were included and safety topics, experience and regulations from the foreign plants were taken into account. PSR 2 (1995) focused on safety review. From then on, the structural approach to aging and wear was started. The focus of PSR 3 (2012) was on the following aspects: confirmation of the initial safety level, evaluation of plant obsolescence, 'operating experience feedback' (internal and external). Other improvements were made as a result of experience management.

The main changes for KCD-1 and KCD-2 are shown below (from a long list of improvements using the principle of continuous improvement):

- Construction of the bunkered Emergency Systems Building (GNS), similar to the new units, KCD-3 and KCD-4. The GNS is important as a backup to the first level systems for a number of accident scenarios. The GNS design is based on extensive external accident studies, such as earthquakes, gas explosions and aircraft impacts. The GNS emergency systems are designed to ensure the following functions: preservation of the water level in the reactor circuit, preservation of the sub-criticality of the reactor, dissipation of the residual heat, emergency control room (PSR1, most striking accomplishment);
- Evaluating and increasing the seismic resistance of systems of nuclear relevance (PSR1);
- Increasing the fire resistance of the control room and adapting the ventilation of the control room against the risk of toxic gases and radioactive contamination (PSR1);
- Reinforcement of high-energy lines to reduce consequences in the event of rupture and to enable the unit to be brought into safe cold shutdown (PSR1);
- Replacement of the safety valves on the reactor circuit with hydraulically controlled safety valves to provide overpressure protection in both hot and cold state (PSR1);
- Installation of passive catalytic hydrogen recombiners in the reactor buildings to avoid the risk of hydrogen explosion (PSR1);
- Replacement of the four main steam valves to improve the reliability of the fast isolation of the main steam lines (PSR1);
- Installation of additional diesel generators to provide electrical power to the turbine auxiliary systems (PSR1);
- Full-scope simulator of the KCD-1 and KCD-2 control rooms (1988); since then the simulator has been upgraded and expanded;
- Upgrade of the low-pressure safety injection pumps/shutdown pumps to increase their reliability (PSR2);
- Expansion of the safety injection system recirculation filter in the reactor buildings (a second major expansion campaign followed later) (PSR2);
- Upgrade of earthquake resistance of some equipment (PSR2);
- Evaluation and validation of qualification for thermal stratification of piping on the pressure control vessel and steam generators (PSR2);
- Re-evaluation of accident studies, following PSR 1 updates (PSR2);
- Performance of Probabilistic Safety Assessment (PSA), to identify potential weaknesses in the systems; this demonstrated the beneficial effect of the modified accident procedures and the installation of catalytic hydrogen recombiners in the reactor buildings (PSR2);
- Modifications to the polar bridges in the reactor buildings to comply with evolved regulations (PSR3);

- Replacement of the cooling coils of the ventilation systems in the reactor building and electrical building (PSR3);
- Replacement and upgrading of the reactor circuit's Loose Part Monitoring System (PSR3).
- Application of a new coating to the outside concrete shell of the reactor building (PSR3);
- Replacement of the steam generators in KCD-2 and KCD-1; this improved the integrity of the reactor circuit (2004 and 2009);
- Extension of air cooling of the safety diesels, and the possibility of flooding the reactor cavity in case of core meltdown;
- Replacement of the safety diesels to comply with the highly evolved rating requirements for such safety equipment; the control logic is also being thoroughly changed, from complex crossed logic to mono-train logic: each diesel feeds its own electrical polarity, as in more modern units;
- In the turbine hall, the condensers were replaced with titanium condensers and several heat exchangers were also replaced.

1.5.2 Changes related to the Project

The operator continuously invests in the safety of its nuclear facilities through improved design and obsolescence management[8] of the structures, systems and components (SSC), with particular attention to knowledge management and the integration of internal and external feedback.

The Project was evaluated as part of the fourth Periodic Safety Review (PSR) of the power plants, with the following elements being analyzed more specifically:

- Obsolescence management;
- Rerating and design improvement;
- Relevant regulations and references;
- Plant reliability and human and organizational factors.

The fourth Periodic Safety Review (PSR) includes a Long Term Operation (LTO) program.

In addition, the European Commission took the initiative to organize stress tests after the Fukushima accident in March 2011. On 28 October 2011, Electrabel submitted the report to FANC on the stress tests ("Belgian Stress Tests", *BEST)* conducted in Belgium [Electrabel, 2011]. At the request of FANC, the actions mentioned in this report that relate to long-term activities have also been integrated into the Project.

The Project has demonstrated that aging processes and their potential consequences are under control.

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[8] Physical or material obsolescence is the aging of structures, systems and components (SSCs) due to physical, chemical or biological processes. Wear and tear, heat damage, radiation damage and corrosion are some examples of physical aging. Non-physical obsolescence, or technological obsolescence, relates to the process of expiration or obsolescence caused by changes in knowledge and technology, as well as the changes they cause in codes and standards.

FANC approved the safety improvement plan proposed by the operator [Electrabel, 2015b] to extend the operation of KCD-1 and KCD-2 by ten years until 2025. The proposed technical improvements are intended to reduce the difference with the design safety level of the most recent PWR nuclear power plants and to ensure a high level of plant reliability and availability [FANC, 2009], [FANC, 2011]. The investments approved by FANC and Bel V (corresponding to the Agreed Design Upgrade, taking into account the recommendations of the Scientific Council and the comments of FANC and Bel V) were the subject of detailed studies prior to their implementation.

The Integrated Action Plan and the works to be carried out as part of the Project are described in the Long Term Synthesis Report - Doel 1 and Doel 2 April 2015 - Version O [Electrabel, 2015b].

Every year, after each outage and without exception, the operator also reports on the progress of the performed modifications based on the synthesis report.

1.6 The Project

1.6.1 Description of the Project

Electrabel plans to continue operating the KCD-1 and KCD-2 nuclear power plants beyond 2015. To this end, Electrabel launched the Project (Long Term Operation, LTO). This involved examining whether Electrabel is technically and organizationally ready to safely operate KCD-1 and KCD-2 beyond 2015, and for a period of ten years. In the process, a number of technical improvements were formulated.

The determination of the changes to be made to the systems follows a long process of studies, based on national and international nuclear safety requirements, aimed at improving the level of safety to bring it as close as possible to the level of the most recent systems.

The process for identifying changes to systems is as follows [Electrabel, 2012]:

- Design analysis, specifically based on:
  - The unit's nuclear license;
  - Regulatory oversight (International Atomic Energy Agency (IAEA), United States Nuclear Regulatory Commission (USNRC) standards, etc.);
  - WENRA (Western European Nuclear Regulators Association)-reference levels;
  - Benchmarking at the national (with the most recent units) and international (foreign plants) level, as well as with recent conceptual developments;
  - Review of previous PSRs;
  - Experience data regarding operating experience;
  - Documentation of the basic design;
- Creating a long-list of concerns based on different information sources (see above);
- Moving toward a short-list of Main Safety Issues (MSI) based on risk assessments (which issues have the greatest impact on nuclear safety: avoiding nuclear damage);
- Finding the best technical solution to solve the MSIs comparing different alternatives.

Therefore, the definition of the proposed changes is the result of a long process of study and selection from among the possible alternatives, with a view to improving nuclear safety. By improving nuclear safety, there is less chance of nuclear damage and less chance of a discharge with environmental impact. The final choice is the subject of the LTO report [Electrabel, 2012].

The definition of the changes is based on an analysis by the Belgian Safety Authority of the proposed changes. This analysis aims to ensure the highest possible level of safety, taking into account technical and economic feasibility. This priority over nuclear safety has environmental benefits, in that, for example, radioactive discharges are kept as low as possible and the risks of accidents and their consequences are minimized (ALARA principle - As Low As Reasonably Achievable).

The LTO report [Electrabel, 2012] shows that the aging processes and their potential consequences are under control. It is assured that the systems, structures and components will continue to function as intended during the extended operating period. It also raises the safety level of the plants to the highest possible level.

The LTO Project is fully in line with international references. In addition, the design of the plants is improved by re-rating and comparing it with the design of more recent and newly designed plants. In addition, the human and organizational factors of operating a nuclear power plant (competence, knowledge and behavior) are addressed separately.

The main improvements are [Electrabel, 2012]:

- A new seismic FE pumping station will be built, with seismic supply lines to the premises containing safety systems needed after an earthquake. As a result, KCD-1 and KCD-2 will be better protected against fire caused by an earthquake. This design improvement will also make the automatic fire suppression system in the turbine hall more effective and will establish an additional, seismic feed capability for the steam generators;
- Basements with safety equipment will be additionally secured against flooding New, submersible pumps will also be placed on the water intake to refill the GV cooling towers (to ensure the ultimate cold source);
- The emergency systems (GNS) will be made more reliable and automatic, and their cables will be better physically separated from those with a primary safety function;
- A filtered pressure relief system or Filtered Containment Vent (FCV) will be installed to protect the containment from overpressure in the event of a nuclear meltdown accident, avoiding unacceptable radiological consequences for the environment.

1.6.2 Alternatives to the Project

The possible alternative is the Zero Alternative (§ 1.7.3), i.e., no LTO. Under this scenario, the units will stop generating electricity after 40 years of operation, on the legal date determined by the Act of January 31, 2003 [FPS, 2003]:

- 14 February 2015 for KCD-1;
- 30 November 2015 for KCD-2.

There are numerous options for the alternative supply of electricity to compensate for this loss of production and they depend on political and market decisions, particularly based on technical and economic considerations. These will not be reviewed in this environmental impact report and are considered in the Strategic EIR.

1.6.3 New permits or modifications to existing permits under the Project

KCD has several permits issued under the Project. These permits are listed in the table below.

Table 1-7 Overview of KCD-1 and KCD-2 permits issued under the project

Date	Government	Reference	Validity	Object
21/02/2014	Provincial Government of East Flanders	M03/46003/46/2/M/4/CW 10010674488	31.03.2031	Notification of minor change to establishment (K1) because of LTO
12/02/ 2015	Provincial Government of East Flanders	M03/46003/46/2/W/6/LDR/FV 10010529979	31.03.2031	Request for change of environmental permit conditions K1
12/03/2015	Provincial Government of East Flanders	M03/46003/46/2/M/2/FV 10010529973	31.03.2031	Notification of minor change to establishment (K1)
27/09/2015	FPS Home Affairs	FANC ANPP-0011847 10010655894	-	RD amendment permit conditions D1 and D2 in the context of LTO
1/03/2016	Provincial Government of East Flanders	M03/46003/46/2/M/3/FV 10010598533	31.03.2031	Notification of minor change to establishment (K1)
27/12/2016	Municipality of Beveren	B 2016/579 B 2016/580	/ (unlimited duration)	Filtered Containment Vent installed to protect the 'containment' from overpressure in the event of a nuclear meltdown accident
06/03/2017	Municipality of Beveren	B 2016/611	/	New seismic fire fighting circuit (FE) - Pump station with larger firewater tank and associated environmental works
15/05/2018	Flemish Government	OMV/2017009795 10010798142	31.03.2031	Ministerial Decree to adjust special conditions with respect to NO2
7/02/2019	Flemish Government	OMV/2018067813 10010826349	31.03.2031	Decision to rectify alternators and additional installations file 2018122825
24/05/2019	Department of Environment	BE-VL00000797	31.03.2031	Notification of evaluation for environmental permit in relation to BAT for large combustion plant
18/06/2019	Flemish Government	OMV2019028682 Re-routing road, raising site and constructing of storm drain	/	Basements with safety equipment additionally secured against flooding

1.7 Description of scenarios

The EIR addresses two scenarios. The first scenario (continuation, or implementation of the LTO Project) involves the implementation of the Project and thus the extension of the lifetime of KCD-1 and KCD-2 until 2025, while the other plants remain in operation until their scheduled closure dates, see Table 1-8.

Table 1-8 Scenarios for the EIR

Scenario name	Date of termination		Remark
	KCD-1&2	KCD-3&4	
Project	2025	2022 / 2025	KCD-3 is licensed until 2022. KCD-4 is licensed until the middle of the year 2025. The POP of KCD-3 and KCD-4 are not within the scope of this EIR.[9]
Zero alternative	2015	2022 / 2025	

The second scenario (Zero Alternative) assumes the absence of the Project (phase-out) i.e. KCD-1 and KCD-2 are shut down, while the other units at the site remain operational. This Zero Alternative is explained in more detail in the second section.

The only variable between the scenarios is the date of discontinuation of KCD-1 and KCD-2. All other nuclear facilities, not only KCD-3 and KCD-4, but also the WAB and FCB will continue to operate during this period.

As also shown in § 1.1.3, the termination of electricity generation is followed by the Post Operational Phase, after which dismantling starts. Dismantling is subject to its own specific licensing process, which includes an environmental impact assessment. Since this is a separate procedure, the dismantling of KCD-1 and KCD-2 is not part of this EIR.

1.7.1 Baseline situation

The baseline situation is defined as the period 2012-2014. In 2015, work on the Project started. As a result, 2014 is the last year without impact from the Project. However, within the normal operations (including the removal shipments of radioactive waste and spent fuel elements), fluctuations in electricity production occur. As a result, there are also fluctuations in the discharges and impact of the nuclear power plant on the environment. To get a better idea of the average situation, not only 2014 was considered, but also at least the two preceding years, namely 2012 and 2013.

The effects of KCD in the Baseline Situation were determined by examining what the measured and reported effects were in the period 2012-2014. Where possible, the data were broken down to look at the contribution of KCD-1 and KCD-2 and the combined contribution of all units. This provides insight into the contribution of KCD-1 and KCD-2 to the Baseline Situation. Where possible, an average effect was determined for the Baseline Situation, for both KCD-1 and KCD-2 together and for all units. These

[9] For more information about this assumption, see § 1.1.3

averages were then used to determine the impacts during the operational phase of the Project between 2015 and 2018, the operational phase in the future situation (period 2019 - 2025), as well as for the Zero Alternative.

1.7.2 Project (LTO scenario):

The Project will be divided into two phases: the operational phase of the Project between 2015 and 2018 and the operational phase in the future situation (period 2019 - 2025).

1.7.2.1 Operational phase of the Project between 2015 and 2018

The LTO synthesis report contains the integrated action plan to operate KCD-1 and KCD-2 for ten years longer than envisioned in the 2003 Nuclear Phase-Out Act. This action plan was submitted to FANC for review [Electrabel, 2015b]. FANC, together with Bel V, analyzed this plan and that analysis showed that the Project is feasible and the safety of KCD-1 and KCD-2 remains guaranteed during the period of Long Term Operation [FANC, 2015]. During the period 2015-2018, most work will focus on bringing the safety level of the units as close as possible to that of most recent systems, and that period is referred to within this Project as the "operational phase of the Project between 2015 and 2018." For the description of the work, see § 1.5.2 and § 1.6.1.

In this operational phase of the Project between 2015 and 2018, KCD-1 and KCD-2 are operated by Electrabel. However, it is not possible to separate and quantify the effects of the work and normal operations.

1.7.2.2 Operational phase in the future situation (period 2019 - 2025)

By 2018, the vast majority of the Project's work is completed. 2019 is the first year after the start of the Project in which there is normal operation i.e. without LTO work[10]. This phase of the Project is defined as the period 2019-2025 and is referred to as the "operational phase in future situation (period 2019 - 2025)" within this EIR. After the operational phase, KCD-1 and KCD-2 will be shut down and the Post Operational Phase followed by dismantling will begin.

1.7.3 Zero alternative

As indicated earlier, the Zero Alternative is the scenario that assumes that the operation of both KCD-1 and KCD-2 has ceased in 2015 and the Post Operational Phase of KCD-1 and KCD-2 starts. For this EIR, the following timeframe is used for the Post Operational Phase (POP):

- POP phase 1 will take place in 2015;
- POP phase 2 will take place after phase 1 in 2015;
- POP phase 3 will run in 2016 - 2018;

[10] During the 2019 maintenance shutdown (which lasted until early 2020), the final work regarding LTO will be completed. In particular, as not all the radioactive waste from the construction phase has been processed and this affects the totals of the years after 2018, this EIR assumes that no LTO work will be carried out after 2019.

- POP phase 4 will take place in 2019.

It should be noted that the Post Operational Phase of KCD-1 and KCD-2 will take place under both scenarios. Under the Project scenario, it will occur 10 years later than under the Zero alternative. It is likely that the Post Operational Phase of KCD-1 and KCD-2 will be similar under both scenarios, so the environmental impacts are not expected to differ between the two scenarios.

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FPS, 2015	Act of 28 June 2015 amending the Law of 31 January 2003 on the gradual phasing out of nuclear energy for industrial electricity production with a view to ensuring security of supply in the field of energy, Federal Public Service Economy, SMEs, the Self-Employed and Energy

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2 Non-radiological aspects

This chapter describes the non-radiological environmental impacts as a result of the project. The following topics are addressed in the EIR: soil; water; noise & vibration; air & climate; biodiversity; landscape, architectural heritage & archaeology; human - mobility; human - health and waste. The methodology and baseline situation are described for each section.

The baseline situation in this EIR is the period 2013-2014. In the effect discussion, the following phases are distinguished:

- Operational phase of the project between 2015-2018 (together with the works related to LTO): this situation is compared to the situation without operation of KCD;
- Operational phase in the future situation (period 2019-2025): the effects of LTO of KCD-1 and KCD-2 are compared with the baseline situation;
- Post Operational Phase (period 2025-2029): the effects of POP of KCD-1 and KCD-2 are compared with the baseline situation;
- Zero alternative (situation without LTO and with Doel 1 and 2 discontinued in 2015): The impact assessment of the zero alternative is not significantly different from that of the project. However, in the zero alternative, effects will decrease as early as 2015 rather than as late as 2025.

The effects of existing industrial and port activities around the KCD site are part of the baseline. Their impacts, as described in the project EIR for each of these, are part of the existing environmental quality (including noise climate, air quality, water quality, soil, mobility).

The table below summarizes a number of autonomous and controlled evolutions (in the study area or in its vicinity). It is indicated whether these developments may affect LTO's impact analysis and assessment. This can be done by increasing the magnitude of impacts, for example, by increasing the vulnerability of the environment or by these projects causing their own impacts that are cumulative to LTO's impacts.

Table 2-1: Overview of developments that may affect the impact analysis and assessment

Project	Description	Relevance
Complex project additional container capacity Antwerp (CP ECA)	This project includes the construction of a new tidal dock in the port of Antwerp, east of the village of Doel, connecting to the existing Deurganck dock. This dock will be home to large container ships (up to 400 m in length). At the container quays, containers are brought in and out, unloaded and loaded and/or temporarily stored. After the container quay, a new logistics area is also being	The potential for cumulative impacts as a result of this project is investigated under the Human - Mobility section (§1.8).

Project	Description	Relevance
	constructed where, for example, activities in the field of value added logistics can take place.	
Village of Doel	A separate project is underway for the village of Doel, which should not disappear before CP ECA, and the buffer zone along the new dock. On 17 May 2019, an order was given to draw up a sustainable future perspective for Doel, as well as for the mobility problems throughout the Waasland area, within the context of the preferential decision on ECA. This analysis is not part of the CP ECA, but both are closely coordinated. Because the preferred decision for ECA is currently being challenged at the Council of State, the study on the future of Doel has been temporarily halted.	In the human - health and safety section (§1.7), it is assumed that Doel is currently (according to the zoning plan) a residential area and that habitation is present and will remain so in the future.
INEOS 'Project ONE'	Across the Scheldt, between Scheldelaan and Kanaaldok B2, INEOS is planning 'Project ONE', an ethane cracker where ethane gas will be converted into ethylene. In 2021, the permit for the necessary deforestation and the plant will be applied for. Due to its size and complexity, completion of the project will be done in several phases over a period of 4-5 years. Consequently, there is no real overlap between the operation of this project and the present plan for keeping Doel 1 and 2 open 10 years longer.	No cumulative impacts are expected as a result of this project.
Nature Development:	As part of the development of the Port of Antwerp and the Sigmaplan, nature development projects are planned and implemented in the immediate vicinity of KCD. These projects give rise to an increase in natural values and thus in the potential vulnerability of the environment.	In the biodiversity section (§1.5), the cumulative effects of the Sigma Plan, Doelpolder Noord, Hedwige and Prosperpolder and GGG Doelpolder were considered.
Completion of the various phases in the nuclear phase-out act	On 1 October 2022, power production at nuclear reactor Doel 3	LTO of Doel 1 and 2 does not in itself affect the other steps envisaged in the nuclear phase-out

Project	Description	Relevance
	will cease. Doel 4 will stop on 1 July 2025.	act. The shutdown of Doel 3 and 4 is not taken into account in this EIR. When Doel 3 and 4 are shut down, the cumulative impact of the KCD will be lower. Consequently, no greater impacts are expected than already described in the EIR.

2.1 Soil

Annex A - Map 5: Soil

Annex A - Map 6: Digital Elevation Model

Annex A - Map 8: Soil testing and remediation

2.1.1 Methodology

2.1.1.1 Definition of the study area

Soil shall mean the solid part of the earth, including groundwater, and the other constituents and organisms contained therein. The study area for the Soil section, in horizontal direction, is wider than the boundaries of KCD, mainly because of the possible influence on the soils due to the salt precipitation from the steam plumes of the cooling towers. The study area is delineated at a 2 km radius around KCD. In a vertical direction, the study area is demarcated to the base of the Boom Formation, which is located at a depth of approx. 50m BGL[1].

2.1.1.2 Description of baseline situation

When discussing the baseline situation, we provide a description of:

- the topography of the study area: this is done using literature data, the topographical map and the digital elevation model.
- the pedological characteristics in the study area: this will be treated on the basis of the Belgian Soil Map.
- the (hydro)geological condition of the study area: for this purpose, the Flanders Subsoil Database (DSF) is used.
- the hydraulic parameters: basic hydraulic parameters include hydraulic conductivity, ground water level or head, ground water vulnerability, ground water flow direction. These data are discussed on the basis of the DSF database.

1 metres below ground level

- groundwater capture: the presence of water capture is discussed on the basis of information from the DSF database, the presence of protection zone for water capture areas is discussed on the basis of maps available at Geopunt.
- soil and groundwater quality: the discussion is based on the soil analyses carried out according to the database of the Public Waste Agency of Flanders (OVAM). Only the soil analyses carried out at the KCD site are taken into account.
- soil use within the study area: the discussion is based on a site visit and photographic material.

2.1.1.3 Description and assessment of the impact

The works that take place within the framework of the adjustments for LTO may lead to a deterioration of the soil structure and soil profile. No dewatering will take place during the works. No changes in the soil moisture system, increase in mobile pollution plumes and soil settlements due to a temporary lowering of the groundwater level are therefore expected. During the various phases of the project, there is a risk of soil or groundwater contamination. As a result of deposition of salt from the steam plume of the cooling towers, changes in soil suitability can occur beyond the limits of the KCD.

The effects to be expected for the soil section during the operational phase of the project between 2015-2018 will be described as follows:

- structural change: qualitative description and designation of areas where soil compaction may occur;
- profile change: qualitative description of the depth at which change occurs due to excavation work;
- impairment of soil hygiene: qualitative assessment of the risk of (spread of) contamination.

The expected effects during the future situation (period 2019-2025) will be described as follows:

- impairment of soil hygiene: qualitative assessment of the risk of (spread of) contamination.
- change in soil use and soil suitability: qualitative assessment of the effects of salt precipitation from the steam plume of the cooling towers.

In addition, the effects that may occur during the Post Operational Phase (period 2025-2029) and during the zero alternative will be described. A qualitative perspective is applied.

The impact assessment is carried out as follows for:

- profile change and structure change:
  - considerably negative: Disruption of valuable soils;
  - negative: Disruption of soils in natural/agricultural land/soil use or disruption of sensitive soils;
  - slightly negative: Disruption of (recently) disturbed soils or disruption of less sensitive soils;
  - negligible: Disruption of paved or non-sensitive soils;
  - limited positive: Restoration (restructuring) to agricultural use;
  - positive: Restoration (restructuring) to natural soil use;

  - significantly positive: The book of guidelines mentions the fact that significant positive effects, given that soil formation is a very lengthy process, are not allocated in the above framework;
- impairment of soil hygiene
  - considerably negative: The project results in a deterioration of the soil quality, causing (possible) health or ecotoxicological risks;
  - negative: The project results in a deterioration of the soil quality, causing remediation standards to be exceeded (possibly);
  - slightly negative: The project results in a deterioration of soil quality, without creating health or ecotoxicological risks and without exceeding remediation standards;
  - negligible: The project does not result in changes in soil quality;
  - limited positive: The soil quality improves after realisation. Existing contamination that poses no risk remains;
  - positive: The soil quality improves after realisation. Existing contamination that does not pose health or ecotoxicological risks is remediated;
  - significantly positive: The soil quality improves after realisation. Existing contamination with human or ecotoxicological risk is remediated;
- change in soil use and soil suitability:
  - considerably negative: The current soil use is severely jeopardised and/or disappears almost completely from the study area due to changes in soil suitability;
  - negative: Current soil use suffers moderate nuisance and disappears across parts of the study area due to changes in soil suitability;
  - slightly negative: Current soil use suffers minor nuisance due to changes in soil suitability;
  - negligible: No changes are to be expected in soil suitability for current soil use;
  - limited positive: The potential for soil use is improving due to changes in soil suitability, but this occurs only to a limited extent;
  - positive: The land use potential has a clear positive effect and can be improved, but spatial extension remains limited;
  - significantly positive: The possibilities for land use can greatly improve over large parts of the study area.

2.1.2 Baseline situation

2.1.2.1 Topography

The wide area around the KCD site show virtually no relief. Locally, the topography of the area has been disrupted, as a result of the construction of the industrial zones, but the industrial sites between the Scheldt and the canal docks themselves are fairly flat. On Figure 2-1 the raised plateau on which the KCD is located is clearly visible. The site was raised by spraying sand from the Scheldt to approximately + 9.00 m in relation to the reference level TAW (Second General Water Level), which is about 6 metres higher than the surrounding polders.

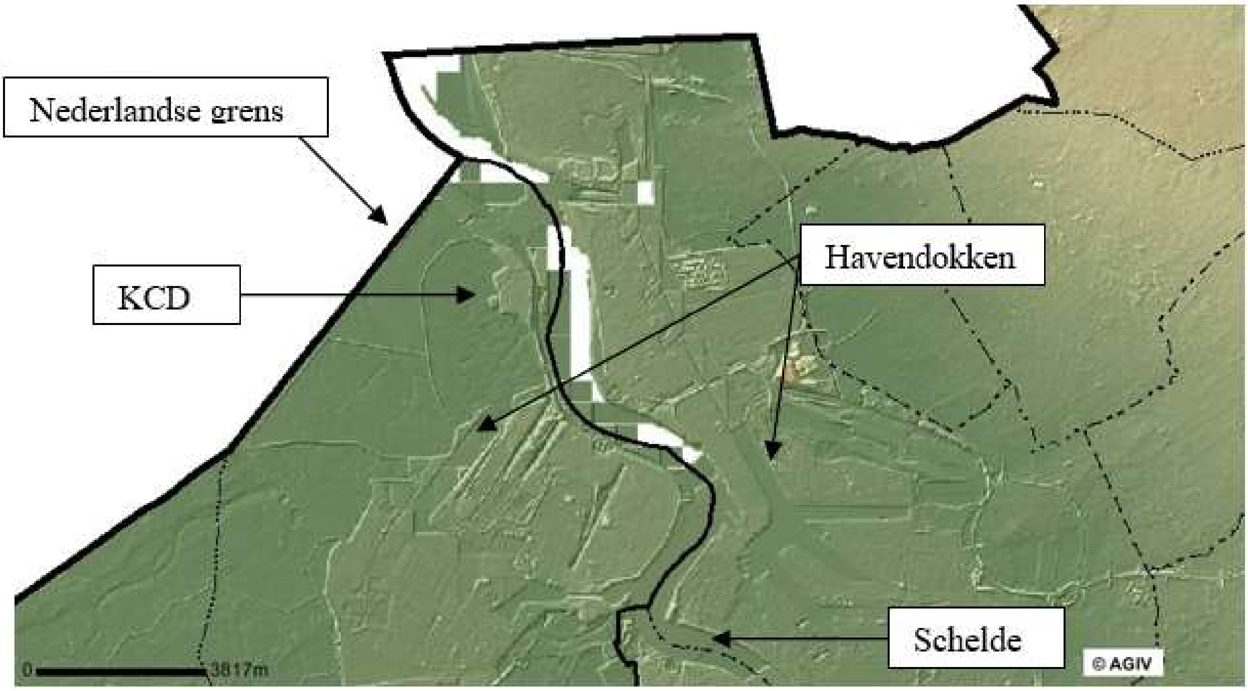

Figure 2-1 Topography of the study area

The area on which the nuclear power plant is located was raised between the 1960s and 1990s, in various stages, with dredged material from the Scheldt, on top of the polder grounds of that time.

On the basis of the available data, it is not possible to determine from which zone of the Scheldt the dredged sediment originated in the different phases. However, it is assumed that the composition of the dredge spoil varies due to the different periods of elevation.

In order to be able to raise the land, the dredged sediment was applied between dikes. On the one hand the existing dikes were used and on the other hand dikes were constructed. These dikes are not completely impenetrable in order to guarantee the drainage of the land. Near the ponds (in the west) these dikes were provided with a waterproof embankment.

The crest of the site's protective dike is approx. + 12.00 m TAW (dike between the site and the Scheldt). The crest of the remaining part of the dike of the settlement is at + 11.00 m TAW (dike between site and surrounding polders). As part of the Sigma Plan, the dikes on the Zeeschelde from the Dutch border to Oosterweel (just downstream of Antwerp) were raised to + 11.00 m TAW.

Figure 2-2 Height profile at KCD

2.1.2.2 Pedology

The soil map of Belgium provides information on the original soil profile up to a depth of 1.25 metres below ground level. According to the soil map of Belgium, moderately wet to wet, light sandy loam to (heavy) clay soils with no profile development initially occurred in the study area, (mainly soil types Pep, Eep, Uep, Udp):

- Texture class: Light sand loam (P), clay (E) to heavy clay (U);
- Drainage class: moderately wet, moderately moist (d) to wet, strongly moist with reduction horizon (e);
- Profile development: no profile development (p).

The area on which the nuclear power plant is located was raised between the 1960s and 1990s, in various stages, with dredged material from the Scheldt, on top of the polder grounds of that time. The newly created anthropogenic soil without profile structure consists mainly of tertiary sand, but also clay sediments up to a depth of 5 to 6 m below current ground level. The nature of the material is rather variable. Usually the elevations consist of heterogeneous, fine to moderately fine sands that are not very glauconite and in which silt layers may occur.

2.1.2.3 (Hydro)geology

The KCD site is elevated and is on average 5 to 6 m higher than the surrounding terrain. The replanted soils are of anthropogenic origin and predominantly consist of sand. The sand has a high permeability.

The undisturbed Holocene deposits, which were formed as alluvial deposits of the Scheldt, are located at 5 to 6 m BGL below the artificial elevations. They are largely composed of sand loam and clay, in which locally sandy, loamy and peaty intermediate layers occur. The thickness of these alluvial deposits is about 3 m. The alluvial deposits have poor to very poor permeability.

Underneath the Holocene deposits are the Pleistocene sandy deposits of niveo-aeolian or niveo-fluvial origin. This glauconite-containing sand complex consists mainly of sands in which loam and clay-bearing zones and loamy to vegetal interlayers also occur. The thickness of these Pleistocene sands is about 12 m.

Among the Pleistocene deposits are the formations of Lillo, Kattendijk and Berchem, which are also sandy in nature. The thickness of these deposits is about 30 m.

Lillo's formation consists of shell-containing sand, which can also be loamy at first. As the apex of the deposit is approached, the loam and/or shell content decreases to disappear completely at the apex. The thickness of these deposits is about 12 m. Adjacent is the Kattendijk formation, consisting of glauconite containing sand. At the base of the deposition layers, there may be traces of fossils and/or phosphates. The thickness of this layer is about 8 m. On the basis of samples, a clear loamy layer has been found to be present. The Kattendijk formation is followed by the sandy Berchem formation.

Underneath these sandy deposits, at a depth of about 50 m BGL, is the Boom formation, which consists of stiff clay and is considered to be very poorly permeable.

Table 2-2 shows the successive geological layers at the level of the study area. This table also shows the hydrogeological characteristics of the geological formations. The thicknesses of the soil layers given in Table 2-2 are indications and may vary locally.

Table 2-2 Overview of the (hydro)geological structure in the study area

Depth top-base (m BGL)	Period	Formation	Lithology	HCSF[2] code	Hydrogeology
0-5	-	Elevation (anthropogenic)	Sandy	0110 Quaternary Aquifer systems - elevations	Permeable, limited aquifer
5-8	Quaternary	Holocene	Sand loam or clay	0133 Quaternary Aquifer Systems - clayey polder deposits of Waasland-Antwerp	Poor permeability
8-20		Pleistocene	Glauconite sand	0233 Pleistocene and Pliocene Aquifer - sandy top of Lillo	Waterborne
20-32	Tertiary	Lillo Formation	Sand	0241 Pliocene clayey layer - clayey part of Lillo or Lillo-Kattendijk transition	Waterborne
32-40		Kattendijk Formation	Homogenous fine mica-containing to slightly glaucous	0251 Miocene Aquifer system - sand from Kattendijk or lower sand layer of Lillo	Waterborne

[2] HCSF = Hydrogeological coding of the Flemish Subsoil

Depth top-base (m BGL)	Period	Formation	Lithology	HCSF[2] code	Hydrogeology
40-50		Berchem Formation	Black-green glauconite-rich and clayey medium-fine sands of mica and shells	0254 Miocene Aquifer system - sands of Berchem or Voort	Waterborne
50-115		Boom Formation	Clay	0303/304 Boom Aquitard - clay of Terhagen/clay of Belsele-Waas	Very poor permeability

2.1.2.4 Hydraulic parameters

Originally, the complex of Quaternary covering sands and Tertiary sands formed an aquifer or aquifer, covered by a clay top layer, the polder deposits, and closed off at the bottom by the Boom clay. By raising the terrain with predominantly permeable sandy material, another aquifer was created above the original aquifer, separated by the clayey polder deposits. However, due to the fact that the elevation was created between dikes, this first soil package is only slightly aquiferous.

The groundwater flow underneath the polder clay is strongly influenced by the presence of the Scheldt (tidal effect). Overall, this groundwater flow is directed northeast, i.e. in the direction of the Scheldt.

The Quaternary soils in the port area are all characterized by a wet to very wet character. Groundwater measurements on-site have shown that in the elevated areas, groundwater is observed at a depth varying between 4 m BGL and 6 m BGL. In the zones that have not been elevated, groundwater is observed at a depth of approximately 2 m BGL. Locally, wet situations may occur, probably due to compacted soil or the heterogeneous quality of the elevation that makes infiltration and drainage of rainwater difficult.

The groundwater in the upper phreatic layer near the KCD site is classified as highly vulnerable according to the Vulnerability Map of the groundwater of the province of East Flanders. This is due to the limited thickness of the unsaturated zone, which is less than 10 m, and the sandy and therefore permeable/water-bearing nature of the topsoil. The absence of a layer of sufficient thickness to adequately protect it is also a factor here. Although the first aquifer is highly vulnerable to polluting activities, the geological structure is nevertheless favourable to prevent the spread of pollution in depth, due to the sealing clay layers (polder deposits) between the first and second aquifer (Tertiary aquifer). Finally, the groundwater in the vicinity of the Scheldt is highly saline, which makes it unsuitable as drinking water, cooling water or feed water for steam boilers.

The permeabilities of the successive layers are as follows (approximate values via DSF):

- sprayed sand: horizontal hydraulic permeability approx. 6 m/day (relatively well permeable deposit);
- polder deposits: vertical permeability of approx. 0.01 m/day;
- tertiary sand deposits: horizontal permeability approx. 6.9 to 17.2 m/day.

2.1.2.5 Groundwater capture

The study area is not situated in protected water catchment areas. Table 2-2 lists the permitted groundwater capture present in the baseline situation (2013-2014) within a radius of approx. 2 km around the area of the KCD on the left bank. Groundwater capture on the right bank is not considered relevant due to the presence of the Scheldt.

The KCD does not use groundwater for its operation.

Table 2-3 Overview of permitted groundwater capture in the baseline situation at the level of the study area

No installation	Operator	Authorised annual flow rate (m³/y)	Authorised daily flow rate (m³/d)	From date subperiod	End date subperiod	Aquifer (permit)	Authorised depth (m)	Authorised number of wells	Coordinates of the installation: X (m Lambert 72)	Y (m Lambert 72)
2019-058463	Hesse-Noord Natie, Deurganskdok zn 9120 Beveren	30000.0		08/01/2009	04/04/2024	0160 - Pleistocene deposits		1	141696.0	222315.0
2019-063711	De Bock Robby, Zoetenberm 26 9120 Beveren	2920.0	8.0	03/01/2002	03/01/2022	0400 - Oligocene Aquifer System	121.0	1	140200.0	223410.0
2019-063922	Gillis Petrus, Oostlangeweg 9 9120 Beveren	125.0		19/01/1998	19/01/2018	0100 - Quaternary aquifer systems	5.0	2	141698.0	222281.0
2019-064100	Gillis Eric, Zoetenberm 29 9120 Beveren	2939.0	10.0	11/10/2012	10/10/2032	0400 - Oligocene Aquifer System	132.0	1	140212.0	223753.0
2019-066843	Van Den Berghe André, Oostlangeweg 1 9120 Beveren	720.0	4.0	14/05/2001	06/12/2013	0100 - Quaternary aquifer systems	2.0	1	140734.0	224957.0

2.1.2.6 Soil and groundwater quality

Within the framework of the Soil Decree, periodic soil analysis is carried out on the site in view of the Vlarebo activities present. Soil analyses were also carried out in the past related to the transfer of plots of land.

In the event of an emergency involving soil contamination, the soil contamination is removed as soon as possible. A descriptive soil analysis is then carried out to confirm the removal. If the contamination has not been sufficiently removed, soil decontamination will be carried out.

An overview of the soil analyses performed under the Soil (Remediation) Decree at the time of the baseline situation (2010-2014) is given in Table 2-4. The table also includes the soil analyses performed at a later stage.

The results of the soil analyses are explained in the table below.

Table 2-4 Overview of the soil analyses performed at KCD

Date of the report	Type	EBSD	Plots analysed
April 1996	ISA	Becewa vzw	562/Z - 459/B - 457/B - 471/Z2 - 471/T2 - 471/R2 - 471/P2 - 471/N2 - 471/H3 – 471/H2 – 471/G3 – 471/G2 – 471/F3 – 471/F2 – 471/E3 - 459/B – 449/B
May 2000	ISA	Becewa vzw	562/Z - 471/P2 - 471/N2 - 471/H2 - 471/G2 - 471/F2
May 2001	BBO	Becewa vzw	562/Z – 471/Z2 – 471/R2 – 471/P2 – 471/N2 – 471/H3 – 471/H2 – 471/G3 - 471 G2 - 471 F3 - 471 F2 - 471 E3
September 2002	ISA	Soresma	562/Z - 471/N2 (only the part where the 150 kV and 380 kV substations are located)
May 2005	ISA	Becewa vzw	562/Z – 471/P2 – 471/N2
November 2007	BBO	ABO NV	471/P2
November 2009	OBBO	Becewa vzw	562/Z – 471/T2 – 471/R2 – 471/P2 – 471/N2 – 471/H3 – 471/H2 – 471/G3 – 471/G2 – 471/F2
May 2010	ISA	Becewa vzw	471/F2
December 2015	ISA	AIB Vinçotte International NV	562Z, 471N2, 471P2
October 2019	ISA	Sweco Belgium SA	471H2

Abbreviations used: OBO= Initial Soil Analysis; BBO=Descriptive Soil Analysis; OBBO=Combination of Initial Soil Analysis and Descriptive Soil Analysis; EBSD= Certified Soil Decontamination Expert

The last soil analysis submitted to OVAM dates from October 2019.

The following overview of the study results provides an overview of the quality of soil and groundwater in the study area and is based on the findings of the soil analyses performed at KCD:

- The entire site shows increased concentrations of arsenic in the groundwater, as a result of the elevation using dredged sediment of the Scheldt. The descriptive soil analysis (May 2001) has shown that there is no real threat and no soil decontamination project had to be started;
- The soil decontamination standard for the general pollution level in the sprayed sands has not been exceeded (solid part of the soil);
- Historical pollution with mineral oil, aromatics and chlorinated hydrocarbons was found at the level of underground waste oil tanks at the garage (ISA May 2000). On the basis of a BBO in May 2011, it was decided that there was no real threat and that no soil remediation project had to be started. A periodic ISA was recommended to monitor the state of contamination;
- In an ISA of May 2005, the soil decontamination standard was exceeded for lead, EOX, zinc, copper in the soil and for conductivity, arsenic, mineral oil and 1,1,1-trichloroethane in the groundwater at a number of locations on 3 plots. With the exception of lot 471 P2 (zinc and copper in soil), these contaminations have been considered as historical contaminations. For 471 P2, a descriptive soil analysis was required. A BBO for lot 471 P2 showed that no serious threat was present and no soil decontamination project was necessary;
- An indicative soil analysis (October 2007) revealed an excess of mineral oil (lot 471 H2) in the soil and groundwater near the fire department training grounds. At the landfill zone, a strong increase in pH, conductivity and heavy metals was measured in the soil and in the groundwater. In the other areas, an increased concentration of heavy metals and acenaphthylene in soils and arsenic and nickel in groundwater has been found. The contaminations were analysed further in a combined initial and descriptive soil analysis (November 2009). The contaminations were identified and assessed by the government as harmless to humans and the environment. There was no soil decontamination to be done;
- In a decree legally required periodic initial soil analysis of lot 471 F2 of KCD (May 2010), no concentrations were found to exceed the guide value for the solid portion of the soil. Based on the groundwater analyses, there was no reason to assume that the solid part of the earth was polluted.
- In the periodical ISA of December 2015, various (residual) contaminations (arsenic, mineral oil, VOCl, zinc, lead) were identified on the plots 562 Z, 471 N2 and 471 P2, which were also identified in previous analyses. The initial soil analysis shows that for the various contaminations, there are no indications that the increased concentrations constitute a severe soil contamination for humans or the environment. As a result, no descriptive soil analysis is required.
- In the periodical ISA of October 2019, lot 471 H2 was analysed. The study shows that the elevated concentrations found (zinc, mineral oil, arsenic) do not constitute serious soil pollution for humans or the environment. Consequently, no descriptive soil analysis or soil decontamination project had to be carried out.

2.1.2.7 Measures taken to protect soil and groundwater quality

KCD stores numerous substances that can be a possible source of soil and/or groundwater contamination.

For all current potential sources of contamination on the KCD sites, the necessary soil protection measures are always taken to prevent contamination of soil and groundwater. A clear overview of the current measures is given below.

- All above-ground storage tanks on-site have drip trays or double-walled. In many cases, these tanks are located inside a building, where additional measures have been taken to prevent the spread of possible contamination;
- The storage of hazardous products is located on separate sites and is also carried out with the necessary precautions (containment tanks);
- The underground tanks are double-walled and additionally have a leak detection system. With the exception of the contaminations found that were described in the soil analyses of the neighbouring (KCD) plots, there are no reports of any leaks;
- All storage tanks are equipped with electronic overfill protections linked to the truck's pump;
- For chemicals there are unloading bays with collection facilities. For gasoil deliveries, there are unloading bays or mobile bays (at the locations where there no bays are possible);
- The tank location is provided with a liquid-tight subsoil and collection;
- Unloading chemicals or gas oil is always done by means of a checklist and in the presence of the driver and a person appointed by the KCD;
- In the recycling grounds, only non-hazardous waste is stored. This only relates to solid inert waste. Storage takes place in containers and on a paved surface which drains to an oil separator;
- The 'extinguishing water' that is released during fire drills is collected via the internal sewerage system;
- Transformers are equipped with a drainage system. In the event of leaks, any cooling oil that may be released by the 'wet' transformers is collected in an underground drip tray;
- The KCD has intervention personnel and equipment on-site, which makes it easy to intervene if an incident occurs;
- If an incident occurs, a soil investigation is immediately initiated and, if necessary, the contamination is quantified, assessed for risk and removed.

For all future new potential sources of pollution, the necessary soil protection measures will also be taken at all times.

2.1.2.8 Soil use

The KCD site is located in the far north of what is described as the Waaslandhaven (Antwerp port area on the left bank).

The site of the power station is surrounded by open space. On the left bank of the Scheldt, this open space is mainly used for agricultural activities. According to the agricultural use map of 2014, cereals, seeds and legumes are the most common crops. Grasslands are also present and potatoes, maize and sugar beet are grown.

Within a 5 km radius around the KCD site, the population density is rather limited: the area consists largely of the port of Antwerp and the Scheldt and otherwise mainly of sparsely populated polders. There are various housing units and residential clusters scattered throughout the polders, including the polder hamlets of Ouden Doel, Saeftinghe and Prosperpolder. The nearest house (Scheldemolenstraat 65, 9130 Beveren) is 330 m south of the site.

The site is directly bordered:

- in the north and east by the Scheldt with its mud flats and salt marshes area;
- in the south and west by the Doelpolder with the small residential areas of Oude Doel (northwest), Rapenburg (west), Saftingen (southwest) and Doel (south) at a distance of 900 m and more;

Outside the study area, in the east at a distance of 2 km and more, Lillo-Fort and companies (petrochemistry) are located. This is followed by Berendrecht (3.3 km northeast) and Zandvliet (4 km northeast). All these residential areas are located on the right bank (across the Scheldt).

The wide area around the nuclear power plant is characterised by strong industrialisation (port area). The Antwerp port area is characterised by the presence of a (petro)chemical cluster on the one hand and container terminals on the other.

2.1.3 Impact assessment

2.1.3.1 Operational phase of the project between 2015-2018

For a description of the works carried out in the context of the adjustments for LTO, see the general section of the EIR (see Chapter 1.6).

2.1.3.1.1 Structural change

Structural changes in the soil can be caused by driving heavy equipment or by soil stacking. This results in a granular structure with an unfavourable water and air balance, which creates a lower (water) permeability, making the soil unsuitable for a certain type of soil use. The risk of structural changes - especially in clay and/or loamy soils - is greatest when the work is carried out in wet weather conditions.

The original soils within the project area have a sandy or clayey structure. However, the terrain was elevated with sand from the Scheldt, so that the upper 5 to 6 m mainly has a sandy texture. The risk of soil compaction is therefore limited. Moreover, the effect is less important in the zones where hard infrastructure (such as buildings, paving etc.) is installed. The supply and disposal of materials is also done via existing, paved roads, so that site traffic has no influence on the soil structure.

The effect on soil structure is therefore assessed as <u>negligible</u>.

2.1.3.1.2 Profile change

The original soil profile is disturbed during the excavation of soil and the introduction of foreign materials into the soil. On the one hand, disrupting the soil profile can have negative effects due to, among other things, changes in water management and local groundwater flow, possible decrease in microbial activity and loss of original soil functions. On the other hand, disruption the profile can also have positive effects by increasing the permeability and aeration of the soil and increasing the rooting depth. In the context of this project, negative profile changes are particularly important.

During the works related to LTO, there was disruption of the subsoil during the excavation works near the FE pump building and the Filtered Containment Vent. On the KCD site, however, only anthropogenic soils with no profile build-up are present as a result of the elevation using dredged sediment. The excavations were limited to this anthropogenic layer (with a thickness of 5 to 6 m) and did not extend into the original soils, which according to the soil map of Belgium also show no profile development.

The effect on profile development is considered negligible.

2.1.3.1.3 Impairment of soil hygiene

During the works associated with LTO, there was a risk of accidental soil pollution as a result of leaks in (fuel) pipelines or spillage of mainly oil and/or fuels. This is due to the use and maintenance of the machinery on site. Polluted substances that end up on or in the soil can leach out and migrate to groundwater under the influence of seeping rainwater. Taking into account the fact that, according to the provisions of the Soil Decree, such soil and/or soil contamination is to be regarded as new, the contractor must intervene immediately in the event of calamities and take the necessary measures to prevent any soil and groundwater contamination.

The earth moving works have been performed in accordance with the applicable legislation. In order to control the spread of soil pollution, the Flemish Government has drawn up regulations on the use of excavated soil. These regulations are described in Chapter XIII of the Vlarebo (Flemish Regulation on soil decontamination and soil protection). Where the total excavation exceeds 250 m³, a technical report must be drawn up by an accredited soil decontamination expert.

The technical report will determine the environmental quality and the possibilities for reuse of the land to be excavated. The measures to be taken as a result of the technical report shall ensure that the spread of soil contamination within the excavation zone is avoided.

For the excavations during the construction of the Filtered Containment Vent, a technical report was drawn up in 2016 (approved by Soil Bank NR: 2067-16-202396). The land to be excavated was given the following environmental qualities: 911[3] (zone near reactor building 1 to 1.5 m BGL) and 211[4] (zone near reactor building 1 1.5 - 3 m BGL + zone near reactor building 2 to 3 m BGL). The land was temporarily stored and reused for filling. Since the excavated soil was reused in accordance with the regulations, the impact due to possible quality changes due to earthmoving is not considered significant. No technical report had to be drawn up for the excavation work related to the new fire department building because the volume of soil to be excavated was less than 250 m³.

The impact on soil and groundwater quality during LTO activities is assessed as slightly negative to negligible.

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[3] These lands can be used freely within the land registry work zone. Outside the land registry work zone, this soil must be cleaned before it can be used as soil. The soils can be used for construction purposes or as a dimensionally stable product.

[4] These lands can be used freely within the land registry work zone. Outside the land registry work zone, they can be freely used as soil for destination types I through V. As the concentrations of heavy metals do not exceed the values for free use, these soils can be used as architectural soil or as a dimensionally stable product.

2.1.3.2 Operational phase in the future situation (period 2019-2025)

2.1.3.2.1 Impairment of soil hygiene

The storage and treatment of hazardous materials in large quantities (diesel, neutralisation agents, etc.) potentially involves certain risks of contamination of soil and groundwater. The measures taken to protect the soil and groundwater quality are listed in § 2.1.2.7.

To minimise the risks of this storage, the following risk management principles are applied:

- limit the amount of chemicals stored to what is strictly necessary;
- storage under the right conditions in tanks with drip tray or with double wall and leak detection.

KCD1 and KCD-2 have a management system to prevent soil and groundwater pollution. No changes to this system are scheduled for the operational phase in the future period. As the risk of soil and groundwater contamination is considered to be contained in the baseline situation, there is no reason to assume that this would change in the future. Continuous monitoring of compliance with the prescribed soil and groundwater protection measures is considered sufficient. In the most recent soil analyses (2015, 2019), no new soil contamination (arising after 2000) was found.

However, incidents that have an impact on soil and groundwater can never be ruled out. A significant impact on soil and groundwater quality is still likely to occur, in the sense that such an incident could lead to indications that the contamination in soil and groundwater exceeds or threatens to exceed soil decontamination standards, requiring a soil analysis and possible subsequent remediation.

For example, a fuel oil tank leak occurred in 2019. The calamity was reported to OVAM (05/09/2019). The contaminated soil was removed using a suction truck. The contaminated soil was transported for processing to Suez Remediation and GRC Kallo. The control samples showed the guide value had not been exceeded. It can be concluded that all contamination with mineral oil has been removed. The soil used for filling complied with the conditions for free use in accordance with the conformity declaration 2015-18202469 of the Soil Bank.

Immediate action will also be taken in the event of any new calamities and the necessary measures will be taken to prevent soil and groundwater pollution.

The impact on soil and groundwater quality during the operational phase in the future situation (period 2019-2025) is assessed as <u>slightly negative to negligible</u>.

2.1.3.2.2 Change in soil use and soil suitability

Within a 2 km radius around KCD, the soils are as described in the soil suitability map:

- moderately suitable for grassland;
- moderately to poorly suited to arable farming and maize;
- hardly suitable to unsuitable for extensive vegetable and fruit growing;
- unsuitable for intense vegetable cultivation, glasshouse cultivation, ornamental plant cultivation, orchard.

The soil suitability can be influenced by the emission of salt via droplets carried along in the steam plume of the KCD cooling towers, as a result of the brackish Scheldt water being used as cooling water.

Calculations in the Air section have shown that the deposition of salt in the environment (within a 2 km radius) amounts to a maximum of about 0.25 g/m² per month. The cooling towers only work to support Doel 3 and 4. As the adjustments under LTO only relate to Doel 1 and 2, no changes in salt deposition are expected therefore.

Moreover, KCD is located at a site that is already influenced by the presence of brackish Scheldt water. This is also evident from the groundwater vulnerability map, which indicates the presence of saline groundwater. The present vegetation and crops are probably already adapted to this salt influence. The influence of salt precipitation from the cooling towers is therefore considered to be limited. Also, the deposition decreases as the distance increases.

However, salinization can also have direct impact on the soil, such as soil clogging. Salt destroys the soil structure of clay soils due to a cation exchange process. However, this effect can be remedied by, among other things, adding lime or organic matter to the soil. It can be assumed that these additions are already taking place on the surrounding agricultural plots. No changes in the future situation are expected in this respect.

The change in soil use and soil suitability due to the deposition of salt is assessed as negligible.

2.1.3.3 Post Operational Phase (period 2025-2029)

During the Post Operational Phase, no changes to the infrastructure of the KCD site will be made involving excavation or construction works. There are no changes in the soil structure or soil profile.

The interventions that will take place in the framework of the Post Operational Phase will always be done according to the most recent available good practices, thus significantly reducing the risk of soil contamination. The reporting system for accidental emissions will always be strictly followed. In this way, the risk of soil and groundwater contamination is considered to be controlled. The impact on soil and groundwater quality is assessed to be slightly negative to negligible.

2.1.3.4 Zero alternative

In the zero alternative (= the non-LTO situation), no changes have taken place in the context of the lifetime extension of Doel 1 and 2. Consequently, no construction and excavation work would have taken place. The above effects on soil structure, soil profile and soil hygiene during the operational phase of the project between 2015-2018 would therefore not have occurred. It should be noted that in the LTO situation, these effects are assessed as negligible to slightly negative.

In the zero alternative, the storage activities and high-risk activities on the site would be discontinued from 2015 instead of 2025. Given that the risk of soil and groundwater pollution can be regarded as controlled, the difference with the LTO situation in terms of impact on soil and groundwater quality is considered to be limited.

The operation of the Doel 1 and 2 units has no impact on the salt deposition in the environment. Not performing the LTO of Doel 1 and 2 consequently does not have an impact on soil use and soil suitability.

As far as the soil section is concerned, it can be concluded that there is no difference between the POP in 2015 (= zero alternative) or in 2025.

2.1.3.5 Cumulative effects

As far as the soil section is concerned, no cumulative effects are expected with other projects in the area.

2.1.3.6 Cross-border effects

There are no cross-border effects for the Soil section. Salt precipitation from the plume of the cooling towers will not change either, as the cooling towers only work for Doel 3 and 4 (see Air section, chapter 2.4).

2.1.4 Monitoring

The Soil section does not require any measures related to monitoring and evaluation.

2.1.5 Mitigating measures and recommendations

As already stated, incidents with a possible impact on soil and/or groundwater can never be completely ruled out. The continued operation of the nuclear power plant will always be carried out in accordance with the latest available good practices, thus significantly reducing the risk of soil contamination.

As far as accidental emissions are concerned, the reporting system (for incidents, among others) will be strictly followed at all times in order to identify, analyse and remedy critical points.

No additional mitigating measures or recommendations are considered necessary.

2.1.6 Knowledge gaps

No knowledge gaps affecting the analysis carried out or the decisions taken have been identified.

2.1.7 Conclusions

The impact of the works that have taken place in the context of the adjustments for LTO can be assessed as slightly negative to negligible, for the soil section. There are no additional effects of the LTO situation expected, compared to the baseline situation.

The effects of the POP are also assessed as slightly negative to negligible. The difference between the POP in 2015 (= zero alternative) or in 2025 is somewhat limited for the soil.

However, it cannot be excluded that incidents with an impact on soil hygiene may occur in the future. However, KCD-1 and KCD-2 are currently equipped with both technical and organisational measures to prevent or counteract possible contamination as much as possible. The continued operation of the nuclear power plant will always be carried out in accordance with the latest available good practices, thus significantly reducing the risk of soil contamination.

The operation of the Doel 1 and 2 units has no impact on the salt deposition in the environment, and thus on soil use and soil suitability.

2.2 Water

Annex A - Map 8: Licensed groundwater extractions

Annex A - Map 9: Flemish Hydrographic Atlas

Annex A - Map 10: Water test - areas prone to flooding

Annex A - Map 11: Water test - areas prone to erosion

Annex A - Map 12: Water test - areas with sensitive groundwater flows

2.2.1 Methodology

2.2.1.1 Definition of the study area

The study area for the Water section comprises all surface waters belonging to the public hydrographic network, the quality, quantity and/or profile of which could be affected by KCD.

The groundwater aspect is dealt with together with the Soil section.

2.2.1.2 Description of baseline situation

When discussing the baseline situation, we provide a description of:

- hydrography: this is discussed on the basis of the topographic map and the Flemish Hydrographic Atlas;
- surface water quality: the overall status of the Zeeschelde and the adjacent Doorloop is described on the basis of the assessment under the 2nd River Basin Management Plan (RBMP) of the Lower Scheldt Basin, to be found on the River Basin Management Plans of the geological service desk. The surface water quality of the Zeeschelde is also described on the basis of the measurement database of the Flemish Environmental Agency (FEA) both upstream and downstream of KCD discharge points. The current water quality is tested against the applicable quality objectives;
- susceptibility to flooding, infiltration, groundwater flow and erosion and location within a winter bed: the water testing maps available from Geopunt are used for this purpose;
- water supply / water balance / internal sewerage system: the incoming and outgoing water flows of KCD are quantitatively determined and schematically represented on the sewerage plan;
- description of emissions: the concentrations of pollutants in the outgoing water streams of KCD are described, estimated and checked against the applicable discharge standards.

2.2.1.3 Description and assessment of the impact

During the construction phase, as part of the modifications for LTO, no effects are expected for the water section. There will also be no drainage works.

KCD uses the mains water and water extracted from the Scheldt for its operation. Rainwater is not reused. Adjustments within the framework of LTO can lead to additional paved areas or roof areas being constructed. During the operational phase (industrial and sanitary wastewater), discharges are made to surface water. Cooling water is discharged into the Scheldt at a higher temperature than the surface water. Discharge and monitoring of the cooling water are subject to special environmental conditions as imposed in the environmental permit. The location of KCD along the Scheldt may involve a flood risk (taking into account the expected effects of climate change).

The effects to be expected for the water section during the operational phase will be described as follows:

- water management (the water balance): both incoming and outgoing flows as a result of the project are determined quantitatively;
- change in infiltration and drainage characteristics: qualitative description of the rainwater discharge (based on the regional rainwater test). The risks of flooding (also due to climate change) are described qualitatively (vulnerability of the project);
- change in surface water quality: quantitative estimation of the pollution load of industrial and sanitary waste water discharged and determination of the effects of the discharge on the quality of the receiving watercourse by means of a static approach;
- thermal impact of the cooling water discharge: quantitative estimation of the temperature increase as a function of the distance to the discharge point and of the size of the heat plume based on the 5 monitoring campaigns carried out on the temperature influence of KCD's cooling water on the Scheldt (Arcadis, 2012). The influence of climate change on the cooling capacity of KCD and the thermal pollution of the Scheldt is described qualitatively.
- assessment of impacts on the status of bodies of water: With the ruling of 1 July 2015 of the European Court of Justice on the interpretation of the Water Framework Directive (Case C-461/13, the so-called Weser judgment), it appeared that more attention should be paid to the effects on water and the various elements that determine its status. A test against the Water Framework Directive will be carried out.

The impact assessment is carried out as follows for:

- water supply (quantitative - the water balance):
  - no rating is attached to this;
- modification of infiltration and discharge characteristics:
  - considerably negative: Significant changes in water management resulting in negative secondary effects (e.g. frequency and extent of flooding);
  - negative: Limited change in water management with limited negative secondary effects as a result;
  - slightly negative: Limited change in water management without negative secondary effects;
  - negligible: No change in water management to be expected;
  - limited positive: Limited change in water management without positive secondary effects as a result;
  - positive: Limited change in water management with limited positive secondary effects as a result;

- significantly positive: Significant change in water management with positive secondary effects as a result;

- change in surface water quality:
  For the evaluation of the permanent (average) impact of the discharge, the methodology of the most recent version of the book of guidelines for the water section is used (June 2011). This method initially consists of calculating a discharge downstream for the parameter x the concentration increase Cv at full mixing according to the following formula $Cv = \frac{Ce * Q_L}{Q_{surface\ area} + Q_L}$

  Where

  Ce = concentration parameter x in the discharged water (annual average);

  QL = waste water discharge flow rate (annual flow rate)

  $Qopp$ = discharge rate of surface water (average time flow)

  In order to indicate the significance of the permanent impact of the discharge, the following assessment framework from the aforementioned book of guidelines is used. The environmental quality standards set out in Annex 2.3.1 of VLAREM II are used as a reference value.

Total concentration increase discharges (X) vs. Test value	**1% < X ≤ 10%**	**10% < X ≤ 20%**	**X > 20%**
Current, immission quality (Y) vs. test value			
Y < 50%	-1	-1	-2
50% ≤ Y < 75%	-1	-2	-3
Y ≥ 75%	-2	-3	-3

-1: limited contribution = slightly negative impact; -2: relevant contribution = negative impact; -3: significant contribution = considerably negative impact
Y = average immission quality upstream of the discharge

- assessment of the temperature increase:
  - considerably negative - significant thermal impact: As a result of the discharge, a temperature increase of more than 3°C will occur;
  - negative - relevant (acceptable) thermal impact: As a result of the discharge, a temperature increase of between 1 and 3°C will occur;
  - slightly negative - limited thermal impact: As a result of the discharge, a temperature increase of less than 1°C will occur;
- assessment of heat plume size (cf. Assessment system for heat discharges of the Netherlands Committee on Integrated Water Management): the mixing zone near the discharge point (this is the zone bounded by a temperature higher than 25°C) should not take up more than 25% of the

cross-section of the surface water (this means that the heat barrier that is formed is still sufficiently passable for aquatic organisms).

- assessment of impacts on the status of water bodies: the assessment is carried out on the basis of the interim guidelines for the assessment of impacts on the status of water bodies (Coordinating Committee on Integrated Water Policy, 2019).

2.2.2 Baseline situation

2.2.2.1 Hydrography

The KCD site is located on the left bank of the river Scheldt.

The Scheldt is a lowland river, which is about 355 km long from its source at Saint Quentin (Northern France) to its mouth at Vlissingen (Netherlands). The catchment area of the Scheldt with its tributaries covers almost all of Lower Belgium, a part of Northern France and half of Zeeland. The catchment area is bordered to the west by the IJzer basin and to the north, east and south by the Meuse basin. The Scheldt and all its tributaries are so-called rain rivers. This means that the water flow at the Belgian-Dutch border can vary greatly throughout the year.

Roughly speaking, the Scheldt consists of two parts. The actual river part starts at Saint Quentin and ends at the weirs in Ghent. Downstream from Ghent to the mouth in Vlissingen, the Scheldt forms an estuary in which the tide from the North Sea has a significant impact on morphology and in which the interaction between river and sea water ensures a distinctly differentiated morphology development. The Scheldt at the level of KCD is a part of this estuary.

Up to a few kilometres from the Belgian-Dutch border, the Scheldt consists of a single stream channel. Further downstream, in the direction of the North Sea, a mostly low tide-dominated main channel with some, mostly flood-dominated, side gullies (so-called "scissors") can be discerned in the transverse profile. The main channel is deepest in the relatively narrow, sharp bends. In the straight gullies and on the relatively wide splits of main and secondary gullies, the river is naturally shallow. Such shallows are referred to as "thresholds". The Scheldt estuary is laterally connected to the intertidal area in the form of salt marshes and mud flats (e.g. the Galgenschoor).

The Scheldt at Doel is a tidal river, so there are two types of flows. First of all the tidal flows (low tide and high tide) and secondly the discharge of excess flow from the hydrographic hinterland to the sea. The tidal flows are very large and vary with the cycle of the tide. The tidal flow increases downstream.

To give you some idea of size: for an average tide passing at Liefkenshoek, high tide and low tide have an average flow of 5,300 and 5,400 m^3/s respectively. The durations are different: high tide lasts just over five and a half hours, while low tide lasts for almost seven hours. During high tide or low tide there is - on average - an instantaneous maximum flow of 9,400 or 8,300 m^3/s, respectively. In total, this is a high tide volume of 115 Mm^3 and a low tide volume equal to 123 Mm^3 (Source: Plancke et al., 2017).

The difference between the high tide and low tide flow rates immediately shows that there is an average excess flow rate of about 100 m^3/s.

High tide and low tide provide opposite flow directions, i.e. inland at high tide, seaward at low tide. Around the change in tide between high tide and low tide (the reversals; approx. 1 hour after high and low tide), the flow rate is quite small. At Lillo measurement pole, there are clear differences between the flow rates at high tide and those at low tide. For the upper device, speeds at high tide are measured of 0.4-0.8 m/s, for the lower unit they are around 0.4 - 0.7 m/s. Near the bottom, the speed becomes rather low. Nevertheless, it is often sufficient to move sand and silt over the soil. At low tide, speeds of around 0.2-0.35 m/s are measured at the upper device, and speeds around 0.25-0.4 m/s at the lower device. So the current is clearly tidal dominated here (Source: Plancke et al., 2017).

The bathymetry of the Scheldt near KCD can be described in a simplified way using the average rectangular bathymetry. The location of the transverse profile of the Scheldt for which the average rectangular bathymetry for the Scheldt is described is shown in Figure 2-3. The average depth of the Scheldt at low tide here is 7.8 m and its width is about 1,100 m. The calculation for the average depth ensures that the area of the actual cross section is equal to the area of the simplified rectangular cross section. At the upstream end of the tidal channel of the Doel plate, there is a breakwater, also indicated on Figure 2-3. A breakwater partially curbs the high tide flow and leads it to the overflow of the existing low tide gully. Here, the low tide flow is concentrated more in the main waterway and as a result, due to the increase in the sand transport capacity, greater erosion in the fairway is achieved and consequently greater natural depths are maintained. A breakwater in a sense defines a plate area and prevents the formation of continuous secondary low tide gullies in the plate system, which in their natural state show certain evolutions that can have a detrimental effect on the conservation of the waterways. It should be noted that in view of the specific location of the discharge point at the head of the Doel plate, it has been assumed for the situation at low tide that the largest volume of water flows back through this plate. At low tide, a depth of 3 m and a width of 300 m are taken into account for the Doel plate.

South of KCD there is the Doorloop, a watercourse of 3rd category managed by the Polder of the Land van Waas. It flows into the Scheldt, just upstream from KCD. KCD has no discharge points on this watercourse.

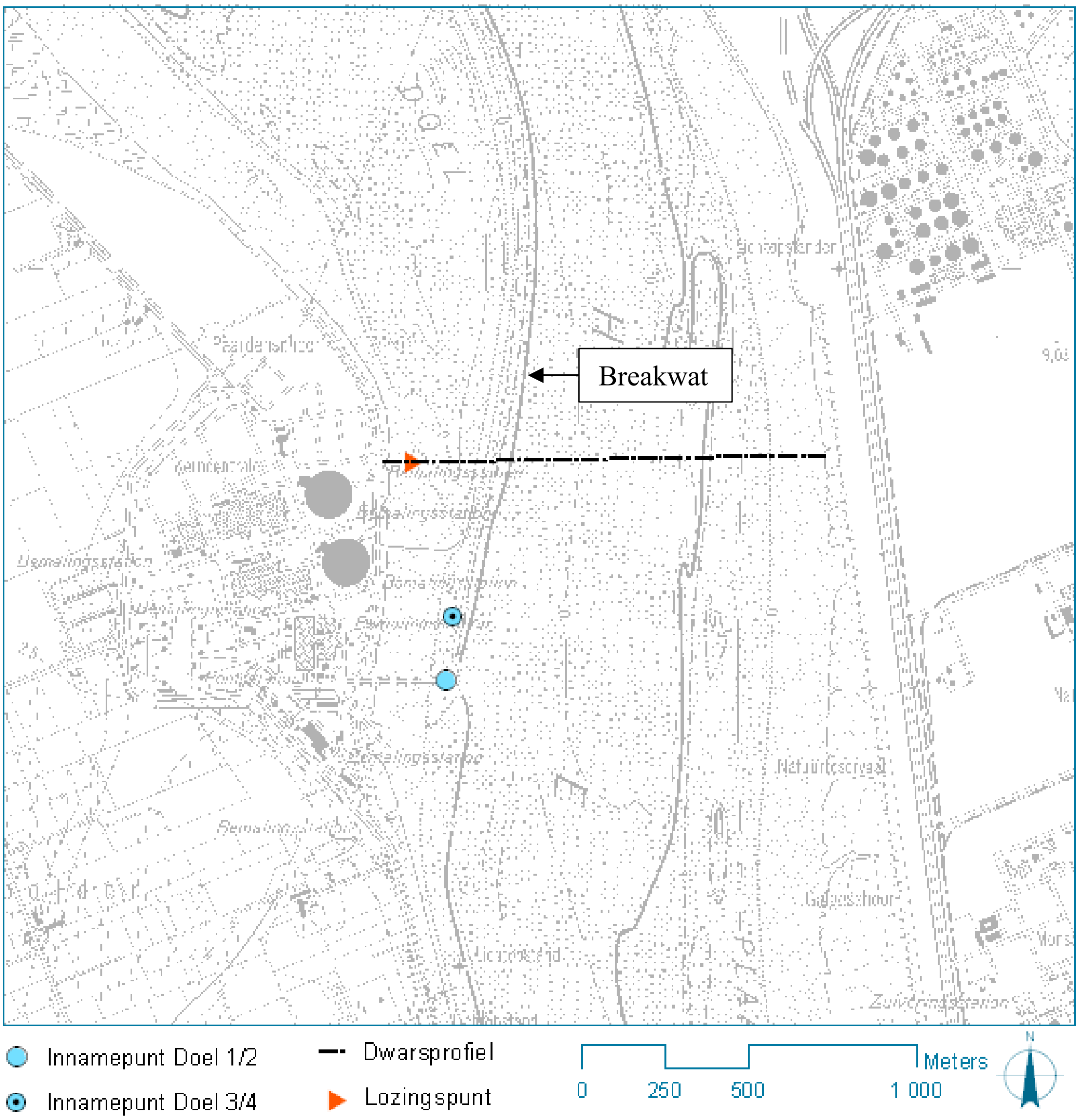


Figure 2-3 Scheldt Bathymetry near Doel

2.2.2.2 Surface water quality

2.2.2.2.1 Global Status Assessment under the River Basin Management Plan

Zeeschelde

For the description of the surface water quality of the Scheldt in the baseline situation, the assessment under the 2nd RBMP (river basin management plan) for the Scheldt is used for the basin-specific part of the Lower Scheldt basin. The Scheldt near KCD is part of the Flemish water body Zeeschelde IV with code VL08_43. This water body is categorized as brackish macrotidal lowland estuary type transitional water (O1b) and has the status of a heavily modified water body. The assessment is based on measurement results from the years 2005-2013 and can therefore be considered representative of the baseline situation:

- The overall assessment of the ecological potential of Zeeschelde IV is generally insufficient:

    - The evaluation of the biological elements is insufficient: insufficient for macrophytes and fish and moderate for macroinvertebrates.
    - The evaluation of the physico-chemical elements determining the biological elements is generally poor. The following applies for the evaluation of the individual physicochemical elements:
        - Poor assessment for nitrate + nitrite + ammonium;
        - Good assessment for temperature, dissolved oxygen and pH.
    - The evaluation for the specific pollutants is poor. There is an excess for dissolved arsenic, boron and uranium.
- The evaluation of the chemical status for Zeeschelde IV is poor. There is an excess for PAHs and total mercury.
- The seabed of the Zeeschelde IV is polluted.

For the description of the surface water quality of the Scheldt in the period 2015 - 2019, the assessment under the 3rd RBMP is used. The assessment is based on measurement results from the year 2018 and can therefore be considered representative for this period:

- The overall assessment of the ecological potential of Zeeschelde IV is generally insufficient:
    - The result of the evaluation of the biological elements is insufficient: insufficient for macrophytes, moderate for macroinvertebrates and good for fish.
    - The result of the evaluation of the physico-chemical elements is generally poor:
        - Poor assessment for nitrate + nitrite + ammonium;
        - Good assessment for dissolved oxygen and pH.
    - The result of the evaluation for the specific pollutants determining the biological elements is poor. There is an excess for dissolved arsenic, boron and uranium.
    - The evaluation of the hydromorphology is insufficient.
- The result of the evaluation of the chemical status for Zeeschelde IV is poor. There is an excess for PAHs, polybrominated diphenyl ether, tributyltin, perfluorooctane sulfonic acid, heptachlor epoxide and total mercury.
- The seabed of Zeeschelde IV is slightly polluted.

Doorloop

For the description of the surface water quality of the Doorloop in the baseline situation, the assessment under the 2nd RBMP (river basin management plan) for the Scheldt is used for the basin-specific part of the Lower Scheldt basin. The Doorloop is a local water body of 1st order with code L107_333. The water body is categorised as a brackish polder watercourse (Pb) type river and has the status of a heavily modified water body. The assessment is based on measurement results for the year 2012 and can therefore be considered representative of the baseline situation.

For the assessment of the ecological potential of the Doorloop, the following applies:

- The result of the evaluation of the biological elements is generally moderate: moderate for macrophytes and macroinvertebrates.

- The result of the evaluation of the physico-chemical elements determining the biological elements is generally insufficient. The following applies for the evaluation of the individual physicochemical elements:
    - Insufficient for total phosphorus;
    - Moderate assessment for total nitrogen, temperature and dissolved oxygen;
    - Good assessment for pH and conductivity.
- The result of the evaluation for the specific pollutants is poor. There is an excess for dissolved uranium.

The evaluation of the chemical status for the Doorloop is poor. There is an excess for dissolved uranium.

There was no overall situation assessment for the Doorloop under the 3rd RBMP.

2.2.2.2.2 Physico-chemical quality

The surface water quality of the Scheldt upstream and downstream of the KCD discharge points is further discussed on the basis of the FEA's surface water quality measurement network. The following measuring points are measured on a monthly basis and are important for this EIR:

- 159000: upstream, Beveren, Scheldebocht channel near the lock at Kallo;
- 157000: upstream, Lillo, channel near Fort Liefkenshoek and Fort van Lillo;
- 154100: downstream, Zandvliet, border with Doel, channel in the middle of the Scheldt at buoy height.

The location of the measuring points is shown in Figure 2-4.

Upstream and downstream of KCD, the Scheldt has to comply with the guide values determining good ecological and chemical status for the type "Transitional water - brackish macrotidal lowland estuary" (O1b), which can be found in Annex 2.3.1 of VLAREM II. Due to the brackish nature of the water in the Scheldt estuary, the objectives for chlorides, sulphate and conductivity are not applicable.

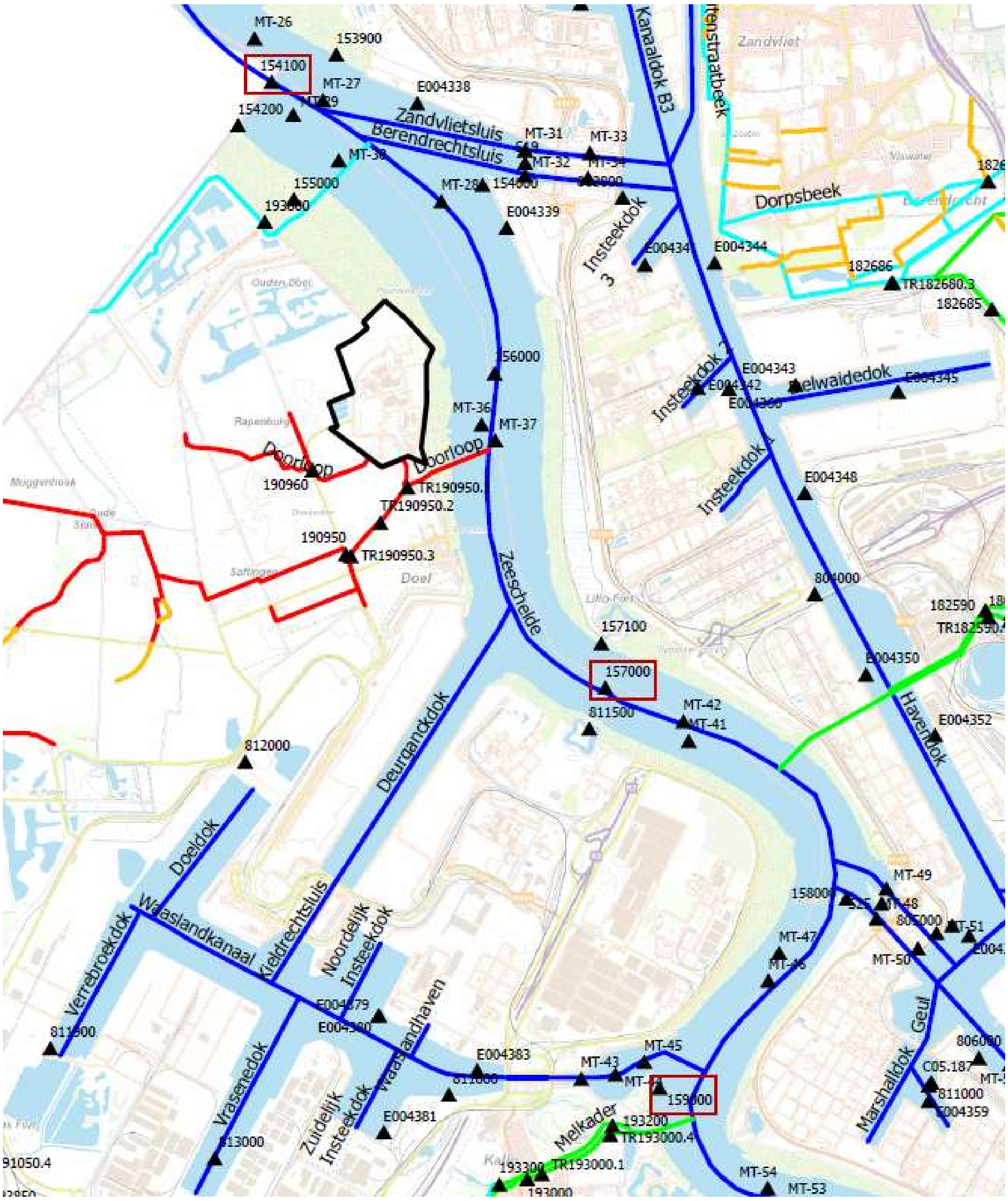


Figure 2-4 Location of FEA measuring points

Baseline situation 2013-2014

Table 2-4 shows the average measurement results of the physico-chemical water quality in the period 2013 - 2014 for the FEA measuring points mentioned above. The basic environmental quality standards for surface water are also included in the table. Values in red refer to an excess of the relevant environmental quality standard (EQS).

Table 2-5 shows that the maximum temperature measured is (just) below the 25°C environmental quality standard. The environmental quality objectives are not respected for the parameters pH, dissolved oxygen (the environmental quality objective is not met at the most upstream measurement point but is met further downstream), chemical oxygen consumption (COC), orthophosphate, nitrate + nitrite + ammonium, dissolved boron, arsenic, beryllium, thallium and uranium.

As mentioned above, the FEA measurement points under consideration are measured on a monthly basis. At the intake points of Doel 1 and Doel 2 and at the collection point of the units Doel 3 and 4, the Scheldt temperature is continuously measured by Engie herself. The intake point is shown in Figure 2-3. The continuous measurements for the baseline situation 2013-2014 show that the maximum temperature of 25 °C is generally not exceeded, except for one day at the end of July in both 2013 and 2014, where the maximum temperature rises to 26 °C (Figure 2-5 and Figure 2-6). Discontinuities in the measurements are due to measurement errors, an error in the recording system or a shutdown of the measuring equipment due to an outage.

The oxygen content at the intake points of Doel 1 and Doel 3 and 4 is also continuously measured by Engie herself. The measurements for the baseline situation 2013-2014 are shown in Figure 2-15 and Figure 2-16 of § 2.2.2.6.3.1. As the Scheldt contains a lot of suspended matter, the supply to the measuring device can get clogged up. Microbial activity then leads to oxygen consumption which causes the measurements to go to zero. This frequently leads to errors in measurements, as can be seen on the figures. Without taking into account the outliers and the values at the time of blockages of the measuring device, the measurements show that the environmental quality standard of 6 mg O2/L as P10 value is always respected for the Scheldt water taken in.

Period 2015 - 2019

Table 2-6 shows the average measurement results of the physico-chemical water quality in the period 2015 - 2019 for the FEA measuring points mentioned above. Table 2-6shows that the maximum measured temperature is (just) below the environmental quality standard of 25°C, except for the measuring point downstream of KCD (measuring point 1574100). Here, the environmental quality standard was exceeded in August 2018, when the temperature reached 25.2 °C. The environmental quality objectives are not respected for the parameters chemical oxygen demand (COC), nitrate+nitrite+ammonium, dissolved boron, arsenic, beryllium, cadmium and uranium.

The continuous temperature measurements for the period 2015-2019 (Figure 2-7 through Figure 2-11) show that the maximum temperature of 25 °C is not exceeded, except for a number of days in the summers of 2018 and 2019, where the maximum temperature rose to 26 °C (excluding sporadic overruns/outliers due to measurement errors).

The continuous oxygen content measurements for the period 2015 - 2019 are shown inFigure 2-1717 to Figure 2-21-21 of § 2.2.2.6.3.1. In the years 2016 and 2018, the P10 values of 6 mg O2/L are not met.

Table 2-5 Water quality and assessment against the environmental quality standard (EQS) at the measuring points upstream and downstream of the point of discharge of KCD in the Scheldt - Baseline situation 2013-2014

Parameter	Unit	EQS valid 2013-2014	Measuring points (results 2013 - 2014)																	
			159000 - upstream						157000 - upstream						1574100 - downstream					
		Annex 2.3.1 Vlarem II	Min	P10	avg.	P90	max.	Winter avg.	Min	P10	Avg.	P90	Max.	winter avg.	min	P10	avg.	P90	Max.	Winter avg.
Temperature	°C	25 (max)	6.90	8.06	14.04	20.88	24.10	8.25	6.70	7.74	14.11	20.66	23.50	8.23	7.00	7.92	13.90	20.22	24.20	8.12
pH	-	between 7.5 and 9	7.10	7.60	7.78	8.00	8.00	7.74	7.10	7.64	7.83	8.00	8.00	7.87	7.30	7.74	7.91	8.10	8.10	7.98
Oxygen, dissolved	mg/L	6 (P10)	4.90	5.56	7.61	9.66	10.30	9.24	5.30	6.44	8.20	10.08	10.50	9.60	6.80	7.20	9.01	10.94	11.80	10.47
Conductivity (20°C)	µS/cm		1667.00	2274.60	7574.72	12460.00	14480.00	5490.00	3590.00	5156.00	10529.20	14362.00	17210.00	7020.00	4990.00	7170.00	12540.00	17588.00	19490.00	8668.33
Chloride	mg/L		0.00	466.00	2289.60	4220.00	5300.00	1705.00	0.00	1274.00	3369.60	5120.00	6500.00	2433.33	0.00	2042.00	3988.80	6000.00	7300.00	3038.33
Biochemical oxygen consumption after 5d. (BOC)	mgO2/L	6 (P90)	0.00	0.50	0.86	1.54	2.30	1.03	0.50	0.50	0.86	1.66	2.00	0.85	0.25	0.50	1.51	2.32	12.00	0.68
Chemical oxygen consumption (COC)	mgO2/L	30 (P90)	19.00	20.80	32.64	48.40	81.00	34.63	19.00	20.60	31.48	43.20	56.00	29.33	13.00	20.40	34.60	58.40	80.00	24.50
Kjeldahl nitrogen	mgN/L		0.20	0.58	1.24	2.02	2.90	1.39	0.10	0.20	1.02	1.66	2.80	1.38	0.00	0.20	0.81	1.46	2.00	0.94
Ammonium	mgN/L		0.04	0.04	0.12	0.30	0.87	0.28	0.04	0.04	0.13	0.31	0.75	0.28	0.04	0.04	0.12	0.24	0.65	0.22
Nitrate	mgN/L		2.40	2.49	3.57	4.50	4.90	4.24	1.73	2.34	3.30	4.26	4.60	4.02	1.66	1.73	3.03	4.10	4.30	3.82
Nitrite	mgN/L	0.2 (average) 0.6 (max)	0.01	0.01	0.01	0.04	0.05	0.02	0.01	0.01	0.02	0.04	0.06	0.03	0.01	0.01	0.02	0.04	0.08	0.04
Nitrate + nitrite + ammonium	mgN/L	0.49 (winter avg.)	2.45	2.56	3.70	4.89	5.22	4.54	1.78	2.41	3.44	4.59	5.19	4.32	1.71	1.79	3.16	4.31	4.99	4.07
Nitrogen, total	mgN/L		3.20	3.46	4.84	6.34	6.80	5.15	2.80	2.90	4.36	5.86	6.20	5.42	0.00	2.50	3.71	5.14	5.70	4.80
Phosphorus, total	mgP/L		0.00	0.27	0.48	0.87	1.00	0.63	0.00	0.24	0.39	0.62	0.90	0.53	0.00	0.21	0.29	0.48	0.66	0.27
Orthophosphate	mgP/L	0.07 (average)	0.00	0.08	0.12	0.15	0.19	0.11	0.00	0.08	0.12	0.16	0.17	0.11	0.00	0.08	0.11	0.15	0.16	0.11
Sulphate	mg/L		0.00	130.00	375.36	656.00	750.00	297.88	0.00	238.00	512.40	720.00	870.00	371.67	0.00	332.00	614.40	886.00	1000.00	456.67
Cyanides, total	µg/L	50 (avg.) 75 (max)	0.00	0.00	0.22	0.70	1.40	0.09	0.00	0.00	0.03	0.00	0.70	0.00	0.00	0.00	0.03	0.00	0.70	0.00
Suspended substances	mg/L		0.00	39.40	109.68	264.00	290.00	154.63	0.00	27.00	94.16	196.20	350.00	145.83	0.00	19.80	54.52	113.40	193.00	42.00
Hardness, total	°F		0.00	0.00	30.24	118.00	150.00	10.88	0.00	0.00	46.28	166.00	220.00	24.50	0.00	0.00	50.80	188.00	250.00	30.00
Calcium, dissolved	µg/L		0.00	0.00	46000.00	156000.00	180000.00	26250.00	0.00	0.00	55600.00	180000.00	230000.00	43333.33	0.00	0.00	56000.00	192000.00	250000.00	43333.33
Magnesium, dissolved	µg/L		0.00	0.00	46520.00	198000.00	270000.00	10500.00	0.00	0.00	78600.00	282000.00	410000.00	32500.00	0.00	0.00	88000.00	324000.00	450000.00	46666.67
Silver, total	µg/L		0.00	0.08	0.14	0.34	0.54	0.25	0.00	0.08	0.11	0.15	0.38	0.15	0.00	0.08	0.08	0.08	0.15	0.08

Parameter	Unit	EQS valid 2013-2014	Measuring points (results 2013 - 2014)																	
			159000 - upstream						157000 - upstream						1574100 - downstream					
		Annex 2.3.1 Vlarem II	**Min**	**P10**	**avg.**	**P90**	**max.**	**Winter avg.**	**Min**	**P10**	**Avg.**	**P90**	**Max.**	**winter avg.**	**min**	**P10**	**avg.**	**P90**	**Max.**	**Winter avg.**
Silver, dissolved	µg/L	0.08 (average)	0.00	0.08	0.07	0.08	0.08	0.08	0.00	0.08	0.07	0.08	0.08	0.08	0.00	0.08	0.07	0.08	0.08	0.08
Arsenic, total	µg/L		0.00	4.62	7.44	13.18	15.60	9.28	0.00	4.52	6.60	10.18	13.40	8.15	0.00	4.20	5.36	7.68	9.70	5.03
Arsenic, dissolved	µg/L	3 (average)	0.00	2.39	3.00	4.02	4.20	2.64	0.00	2.54	3.24	4.42	4.80	2.80	0.00	2.47	3.14	4.12	4.50	2.83
Boron, total	µg/L		0.00	100.00	577.20	1020.00	1200.00	430.00	0.00	332.00	832.00	1360.00	1600.00	583.33	0.00	466.00	968.00	1460.00	1700.00	705.00
Boron, dissolved	µg/L	700 (average)	0.00	100.00	528.80	876.00	1200.00	380.00	0.00	308.00	748.80	1220.00	1400.00	523.33	0.00	422.00	884.80	1360.00	1600.00	633.33
Barium, total	µg/L		0.00	36.20	51.96	79.60	84.00	59.25	0.00	37.20	48.92	62.20	90.00	52.83	0.00	32.40	42.16	53.40	64.00	40.33
Barium, dissolved	µg/L	60 (average)	0.00	24.40	33.32	43.20	52.00	30.13	0.00	26.00	34.16	45.20	52.00	29.50	0.00	26.40	32.84	41.60	50.00	29.33
Berylium, total	µg/L		0.00	0.20	0.22	0.40	0.40	0.28	0.00	0.20	0.21	0.20	0.40	0.23	0.00	0.20	0.19	0.20	0.20	0.20
Berylium, dissolved	µg/L	0.08 (average)	0.00	0.20	0.19	0.20	0.20	0.20	0.00	0.20	0.19	0.20	0.20	0.20	0.00	0.20	0.19	0.20	0.20	0.20
Copper, total	µg/L		0.00	2.84	8.40	16.84	21.00	11.83	0.00	2.00	6.71	12.66	17.80	9.30	0.00	2.00	5.54	10.28	24.00	8.38
Copper, dissolved	µg/L	7 (average)	0.00	1.00	1.95	2.00	7.00	1.50	0.00	1.00	2.03	2.00	7.50	1.50	0.00	2.00	2.04	2.00	6.00	2.00
Cadmium, total	µg/L		0.00	0.15	0.51	1.10	1.40	0.68	0.00	0.15	0.40	0.74	1.20	0.52	0.00	0.15	0.27	0.48	0.76	0.18
Cadmium, dissolved	µg/L	0.2 (average) 0.45 (max)	0.00	0.08	0.08	0.08	0.15	0.08	0.00	0.08	0.09	0.15	0.15	0.08	0.00	0.08	0.10	0.15	0.15	0.08
Cobalt, total	µg/L		0.00	0.96	2.17	4.66	6.00	3.19	0.00	0.81	1.69	3.42	5.00	2.58	0.00	0.54	1.08	2.04	2.76	1.20
Cobalt, dissolved	µg/L	0.5 (average)	0.00	0.20	0.40	0.77	0.90	0.56	0.00	0.20	0.43	0.85	1.37	0.51	0.00	0.20	0.24	0.49	0.63	0.31
Chrome, total	µg/L		0.00	3.88	11.70	27.52	35.00	18.06	0.00	2.84	8.91	20.60	28.40	14.52	0.00	1.92	5.41	11.52	15.10	5.65
Chrome, dissolved	µg/L	5 (average)	0.00	0.50	0.48	0.50	0.50	0.50	0.00	0.50	0.85	0.50	8.10	0.58	0.00	0.50	0.48	0.50	0.50	0.50
Mercury, total	µg/L		0.00	0.02	0.08	0.21	0.23	0.12	0.00	0.02	0.06	0.13	0.25	0.09	0.00	0.01	0.04	0.08	0.13	0.03
Mercury, dissolved	µg/L	0.05 (average) 0.07 (max)	0.00	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01
Manganese, total	µg/L		0.00	66.40	175.04	392.00	510.00	259.88	0.00	30.00	138.84	316.00	460.00	226.00	0.00	30.00	78.04	179.20	246.00	84.00
Manganese, dissolved	µg/L		0.00	15.00	24.52	50.40	104.00	38.63	0.00	15.00	30.56	81.00	107.00	32.50	0.00	15.00	15.60	15.00	30.00	20.00
Molybdenum, total	µg/L		0.00	2.54	4.05	5.80	6.30	3.55	0.00	3.14	4.54	6.06	6.80	4.05	0.00	3.34	4.84	6.84	7.10	4.37
Molybdenum, dissolved	µg/L	340 (average)	0.00	2.38	3.94	5.86	6.20	3.20	0.00	2.94	4.46	6.26	6.70	3.67	0.00	2.98	4.78	6.56	6.90	4.02
Nickel, total	µg/L		0.00	2.00	5.10	9.46	12.30	6.93	0.00	2.00	3.93	8.14	10.00	6.22	0.00	2.00	2.72	5.52	6.10	2.80
Nickel, dissolved	µg/L	8.6 (average) 34 (max)	0.00	2.00	1.92	2.00	2.00	2.00	0.00	1.40	1.98	2.00	5.60	2.00	0.00	1.00	1.80	2.00	2.00	2.00
Lead, total	µg/L		0.00	3.88	12.54	30.60	37.00	18.65	0.00	3.40	9.39	20.20	35.40	14.58	0.00	2.18	5.50	11.74	19.00	5.23
Lead, dissolved	µg/L	1.3 (average) 14 (max)	0.00	0.25	0.29	0.25	1.40	0.25	0.00	0.25	0.67	0.25	6.00	0.25	0.00	0.25	0.25	0.25	0.50	0.25

Parameter	Unit	EQS valid 2013-2014	Measuring points (results 2013 - 2014)																	
			159000 - upstream						157000 - upstream						1574100 - downstream					
		Annex 2.3.1 Vlarem II	Min	P10	avg.	P90	max.	Winter avg.	Min	P10	Avg.	P90	Max.	winter avg.	min	P10	avg.	P90	Max.	Winter avg.
Antimony, total	µg/L		0.00	0.50	1.00	1.46	1.70	0.98	0.00	0.50	0.91	1.25	1.50	0.96	0.00	0.50	0.72	1.15	1.24	0.69
Antimony, dissolved	µg/L	100 (average)	0.00	0.50	0.79	1.24	1.44	0.60	0.00	0.50	0.71	1.10	1.19	0.68	0.00	0.50	0.55	0.81	1.08	0.59
Selenium, total	µg/L		0.00	1.00	2.22	3.56	4.30	2.21	0.00	1.00	2.03	3.56	4.30	1.83	0.00	1.00	1.80	3.24	3.60	1.35
Selenium, dissolved	µg/L	2 (average)	0.00	0.70	1.01	1.00	2.20	0.94	0.00	0.70	1.04	1.00	2.60	0.92	0.00	1.00	1.12	2.06	2.30	0.92
Tin, total	µg/L		0.00	0.50	1.65	2.76	5.80	1.94	0.00	0.50	1.44	2.00	3.20	1.17	0.00	0.50	1.38	2.00	6.00	1.00
Tin, dissolved	µg/L	3 (average)	0.00	0.50	0.50	0.50	1.00	0.50	0.00	0.50	0.48	0.50	0.50	0.50	0.00	0.50	0.48	0.50	0.50	0.50
Tellurium, total	µg/L		0.00	0.50	0.48	0.50	0.50	0.50	0.00	0.50	0.48	0.50	0.50	0.50	0.00	0.50	0.48	0.50	0.50	0.50
Tellurium, dissolved	µg/L	100 (average)	0.00	0.50	0.48	0.50	0.50	0.50	0.00	0.50	0.48	0.50	0.50	0.50	0.00	0.50	0.48	0.50	0.50	0.50
Titanium, total	µg/L		0.00	5.90	71.32	196.00	210.00	106.44	0.00	5.90	54.64	136.00	210.00	87.33	0.00	3.90	37.12	84.20	120.00	39.00
Titanium, dissolved	µg/L	20 (average)	0.00	0.50	0.52	0.50	1.00	0.50	0.00	0.20	0.44	0.50	0.50	0.50	0.00	0.50	0.50	0.50	1.00	0.50
Thallium, total	µg/L		0.00	0.50	0.48	0.50	0.50	0.50	0.00	0.50	0.48	0.50	0.50	0.50	0.00	0.50	0.48	0.50	0.50	0.50
Thallium, dissolved	µg/L	0.2 (average)	0.00	0.50	0.48	0.50	0.50	0.50	0.00	0.50	0.48	0.50	0.50	0.50	0.00	0.50	0.48	0.50	0.50	0.50
Uranium, total	µg/L		0.00	0.70	1.71	1.78	11.50	2.74	0.00	1.18	1.86	1.97	11.30	3.15	0.00	1.32	1.68	2.01	4.00	2.22
Uranium, dissolved	µg/L	1 (average)	0.00	0.50	1.09	1.54	1.64	1.05	0.00	0.50	1.22	1.62	1.70	1.14	0.00	1.05	1.39	1.78	1.85	1.31
Vanadium, total	µg/L		0.00	7.08	14.16	29.72	35.00	19.65	0.00	6.34	11.76	22.60	30.90	16.72	0.00	5.38	8.38	14.30	19.10	8.33
Vanadium, dissolved	µg/L	4 (average)	0.00	2.32	3.01	3.90	4.50	2.63	0.00	2.43	3.51	4.86	9.90	2.73	0.00	2.31	3.05	4.00	4.90	2.69
Zinc, total	µg/L		0.00	23.96	55.80	114.20	152.00	80.59	0.00	21.40	42.52	85.60	117.00	64.80	0.00	15.76	28.32	52.20	71.00	28.97
Zinc, dissolved	µg/L	20 (average)	0.00	3.50	7.06	11.30	33.00	5.88	0.00	3.50	7.38	16.60	35.00	4.58	0.00	5.00	5.78	10.00	15.00	5.00
Silicon, dissolved	µg/L		0.00	2040.00	4700.00	7060.00	9000.00	6887.50	0.00	1740.00	4536.00	7160.00	11000.00	6583.33	0.00	1540.00	3692.00	6560.00	8000.00	5783.33

Results < detection limit equaled detection limit / 2
Overrun of the EQS

Table 2-6 Water quality and assessment against the environmental quality standard (EQS) at the measuring points upstream and downstream of the point of discharge of KCD in the Scheldt - Baseline situation 2015-2020

Parameter	Parameter	Unit	EQS	Measuring points (results 2015 - 2020)																	
				159000 - upstream						157000 - upstream						1574100 - downstream					
			Annex 2.3.1 Vlarem II	Min	P10	Avg.	P90	Max.	Winter avg.	min	P10	avg.	P90	Max.	winter avg.	min	P10	avg.	P90	Max.	winter avg.
T	Temperature	°C	25 (max)	4.70	6.82	13.79	21.47	25.00	7.90	5.30	7.14	13.74	21.50	24.50	8.14	5.10	7.04	13.63	21.08	25.20	7.68
pH	pH	-	between 7.5 and 9	7.60	7.70	7.81	7.90	8.00	7.79	7.70	7.80	7.86	8.00	8.00	8.07	7.70	7.80	7.91	8.00	8.00	7.89
O2	Oxygen, dissolved	mg/L	6 (P10)	5.10	6.40	8.09	9.57	10.40	9.29	0.00	6.80	8.35	10.06	10.50	9.53	0.00	7.22	8.82	10.58	11.20	10.14
EC 20	Conductivity (20°C)	µS/cm		691.00	2644.00	10860.84	18869.00	23300.00	8549.39	1625.00	5122.00	13873.77	21126.00	24400.00	9284.04	0.00	7184.00	15642.70	23480.00	26500.00	13786.11

Parameter	Parameter	Unit	EQS	Measuring points (results 2015 - 2020)																	
				159000 - upstream						157000 - upstream						1574100 - downstream					
Cl-	Chloride	mg/L		93.00	723.00	3955.52	7810.00	8800.00	3119.61	0.00	1570.00	5019.69	8100.00	9400.00	3348.21	0.00	2263.00	5917.50	9400.00	11000.00	5066.11
BOC5	Biochemical oxygen consumption after 5d.	mgO2/L	6 (P90)	0.25	0.50	1.22	1.90	4.10	1.35	0.00	0.50	1.08	1.70	2.40	2.68	0.00	0.50	1.06	1.67	2.30	1.24
COC	Chemical oxygen consumption	mgO2/L	30 (P90)	0.00	3.00	29.39	53.70	78.00	22.39	0.00	6.00	32.89	58.60	86.00	23.32	0.00	0.00	36.09	75.70	130.00	34.50
KjN	Kjeldahl nitrogen	mgN/L		0.00	0.00	0.63	1.75	3.20	0.96	0.00	0.00	0.54	1.50	2.70	2.27	0.00	0.00	0.53	1.40	2.40	0.68
NH4+	Ammonium	mgN/L		0.03	0.03	0.14	0.33	0.55	0.21	0.00	0.03	0.13	0.27	0.47	1.71	0.00	0.03	0.13	0.26	0.45	0.17
NO3-	Nitrate	mgN/L		0.20	1.19	3.06	4.80	5.50	3.52	0.00	0.53	2.65	4.56	5.10	3.88	0.00	0.26	2.30	4.27	5.10	2.74
NO2-	Nitrite	mgN/L	0.2 (average) 0.6 (max)	0.00	0.01	0.02	0.06	0.10	0.04	0.00	0.01	0.02	0.06	0.09	1.58	0.00	0.01	0.03	0.07	0.09	0.04
NO3- + NO2- + NH4+	Nitrate + nitrite + ammonium	mgN/L	0.49 (winter avg.)	0.33	1.41	3.22	5.06	5.93	3.76	0.00	0.80	2.81	4.74	5.35	4.08	0.00	0.46	2.46	4.41	5.33	2.95
N t	Nitrogen, total	mgN/L		2.00	2.60	3.93	5.47	6.60	4.57	0.00	2.20	3.53	4.96	5.50	4.98	0.00	1.90	3.12	4.37	5.30	3.57
P t	Phosphorus, total	mgP/L		0.13	0.24	0.43	0.67	1.47	0.41	0.00	0.24	0.37	0.49	1.34	1.87	0.12	0.19	0.28	0.41	0.57	0.30
oPO4	Orthophosphate	mgP/L	0.07 (average)	0.00	0.00	0.06	0.15	0.24	0.06	0.00	0.00	0.06	0.15	0.19	1.59	0.00	0.00	0.05	0.14	0.18	0.06
SO4	Sulphate	mg/L		65.00	160.00	612.16	1128.00	1300.00	492.61	0.00	269.00	762.75	1256.00	1500.00	521.93	177.00	369.90	904.48	1400.00	1700.00	759.78
SS	Suspended substances	mg/L		19.00	33.00	116.84	260.00	1060.00	151.06	0.00	32.00	85.65	152.00	340.00	82.66	0.00	23.65	51.36	95.40	163.00	62.51
H t	Hardness, total	°F		0.00	0.00	48.59	167.00	260.00	49.67	0.00	0.00	81.00	260.00	330.00	37.38	0.00	0.00	133.06	320.00	380.00	116.89
Ca o	Calcium, dissolved	µg/L		0.00	0.00	54190.48	194000.00	255000.00	61555.56	0.00	0.00	88158.73	260600.00	299000.00	45612.66	0.00	0.00	124619.05	297000.00	331000.00	124111.11
Mg o	Magnesium, dissolved	µg/L		0.00	0.00	74366.67	298200.00	458000.00	83500.00	0.00	0.00	147190.48	480000.00	612000.00	59279.32	0.00	0.00	216761.90	590000.00	716000.00	207277.78
Ag t	Silver, total	µg/L		0.00	0.05	0.14	0.26	1.00	0.13	0.00	0.05	0.10	0.17	0.45	1.66	0.00	0.03	0.07	0.10	0.15	0.09
Ag o	Silver, dissolved	µg/L	0.08 (average)	0.00	0.03	0.05	0.10	0.10	0.06	0.00	0.03	0.06	0.10	0.12	1.60	0.00	0.03	0.05	0.10	0.10	0.06
As t	Arsenic, total	µg/L		0.00	3.86	6.47	10.37	15.60	6.15	0.00	3.80	5.84	7.90	14.10	6.41	0.00	3.60	4.79	6.22	8.40	4.75
As o	Arsenic, dissolved	µg/L	3 (average)	0.00	2.07	3.19	4.58	5.10	2.71	0.00	2.31	3.31	4.50	5.10	3.90	0.00	2.29	3.15	4.48	5.00	2.93
B t	Boron, total	µg/L		50.00	203.10	887.92	1584.00	2110.00	692.39	0.00	340.00	1124.11	1906.00	2170.00	764.32	210.00	520.00	1335.62	2150.00	2370.00	1131.76
B o	Boron, dissolved	µg/L	700 (average)	0.00	148.80	846.62	1528.00	2110.00	707.50	0.00	334.00	1130.78	1992.00	2250.00	779.32	0.00	414.00	1224.21	2148.00	2430.00	1150.00
Ba t	Barium, total	µg/L		0.00	29.00	41.22	59.70	74.00	37.72	0.00	28.00	38.47	54.60	65.00	33.82	0.00	28.20	34.44	46.60	62.00	34.41
Ba d	Barium, dissolved	µg/L	60 (average)	0.00	20.36	30.47	41.80	63.00	27.22	0.00	23.20	31.42	42.80	59.00	25.68	0.00	21.36	29.01	42.40	55.00	28.67
Be t	Berylium, total	µg/L		0.00	0.08	0.15	0.20	0.61	0.16	0.00	0.08	0.14	0.20	0.52	1.68	0.00	0.08	0.12	0.20	0.23	0.14
Be d	Berylium, dissolved	µg/L	0.08 (average)	0.00	0.05	0.11	0.20	0.20	0.11	0.00	0.05	0.11	0.20	0.20	1.64	0.00	0.05	0.11	0.20	0.20	0.11
Cu t	Copper, total	µg/L		0.00	4.70	8.64	15.94	32.10	8.44	0.00	2.50	7.52	13.34	31.00	7.73	0.00	2.00	5.51	8.78	11.60	6.08
Cu d	Copper, dissolved	µg/L	7 (average)	0.00	2.00	2.57	3.80	6.40	2.61	0.00	2.00	2.65	3.75	8.90	3.51	0.00	2.00	3.09	4.49	13.30	2.80
Cd t	Cadmium, total	µg/L		0.00	0.15	0.39	0.78	1.37	0.34	0.00	0.12	0.31	0.50	1.07	1.80	0.00	0.10	0.22	0.34	0.64	0.22

Parameter	Parameter	Unit	EQS	Measuring points (results 2015 - 2020)																	
				159000 - upstream						157000 - upstream						1574100 - downstream					
Cd d	Cadmium, dissolved	µg/L	0.2 (average) 0.45 (max)	0.00	0.05	0.09	0.15	0.26	0.07	0.00	0.05	0.10	0.21	0.30	1.62	0.00	0.05	0.11	0.22	0.60	0.13
Co t	Cobalt, total	µg/L		0.00	0.85	2.11	4.10	8.80	2.34	0.00	0.74	1.70	2.79	7.60	3.17	0.00	0.46	1.01	1.74	2.84	1.31
Co d	Cobalt, dissolved	µg/L	0.5 (average)	0.00	0.16	0.42	0.70	0.96	0.59	0.00	0.20	0.36	0.62	0.92	1.96	0.00	0.10	0.26	0.45	0.78	0.38
Cr t	Chrome, total	µg/L		0.00	2.08	9.17	19.04	32.00	10.26	0.00	2.00	7.19	12.86	27.60	8.43	0.00	1.50	4.06	8.00	18.60	5.51
Cr d	Chrome, dissolved	µg/L	5 (average)	0.00	0.50	0.64	0.75	1.50	0.67	0.00	0.50	0.69	0.75	2.04	2.09	0.00	0.50	0.67	0.75	1.50	0.71
Hg t	Mercury, total	µg/L		0.01	0.02	0.06	0.14	0.25	0.06	0.00	0.02	0.05	0.09	0.24	1.59	0.01	0.01	0.03	0.07	0.12	0.04
Hg d	Mercury, dissolved	µg/L	0.05 (average) 0.07 (max)	0.00	0.01	0.01	0.01	0.02	0.01	0.00	0.01	0.01	0.01	0.02	1.55	0.00	0.01	0.01	0.01	0.02	0.01
Mn t	Manganese, total	µg/L		30.00	52.00	155.89	318.30	590.00	181.44	0.00	33.00	119.46	222.00	500.00	129.66	15.00	30.00	67.55	132.60	209.00	90.95
Mn d	Manganese, dissolved	µg/L		0.00	5.96	24.55	49.70	98.00	37.87	0.00	5.58	19.32	31.00	115.00	29.94	0.00	3.09	12.54	16.17	67.00	19.89
Mo t	Molybdenum, total	µg/L		0.00	2.50	5.01	7.77	8.50	4.28	0.00	2.80	5.46	8.20	8.80	5.62	0.00	3.01	5.96	8.68	9.60	5.45
Mo d	Molybdenum, dissolved	µg/L	340 (average)	0.00	2.28	4.83	7.58	8.60	4.43	0.00	2.64	5.46	8.08	9.00	5.61	0.00	2.70	5.55	8.40	9.30	5.53
Ni t	Nickel, total	µg/L		0.00	2.00	5.72	10.57	18.40	5.81	0.00	1.85	4.90	8.64	17.00	5.40	0.00	1.75	3.66	6.24	10.80	4.09
Ni d	Nickel, dissolved	µg/L	8.6 (average) 34 (max)	0.00	1.50	2.41	3.80	7.50	2.51	0.00	1.15	2.45	3.80	7.40	3.46	0.00	1.00	2.00	3.60	6.90	2.11
Pb t	Lead, total	µg/L		0.00	2.72	9.15	19.31	40.70	9.69	0.00	2.20	7.00	11.94	32.80	8.80	0.00	1.50	3.81	7.92	13.60	5.05
Pb d	Lead, dissolved	µg/L	1.3 (average) 14 (max)	0.00	0.25	0.30	0.50	0.75	0.31	0.00	0.25	0.31	0.50	0.75	1.81	0.00	0.25	0.36	0.50	3.80	0.49
Sb t	Antimony, total	µg/L		0.00	0.50	0.79	1.38	1.80	0.81	0.00	0.50	0.76	1.80	1.80	2.23	0.00	0.50	0.78	1.80	1.80	0.81
Sb d	Antimony, dissolved	µg/L	100 (average)	0.00	0.50	0.66	1.06	1.80	0.66	0.00	0.50	0.67	1.09	1.80	2.10	0.00	0.50	0.64	1.17	1.80	0.65
Se t	Selenium, total	µg/L		0.00	0.65	1.28	2.40	3.70	1.22	0.00	0.46	1.27	2.96	4.20	2.67	0.00	0.33	1.12	2.70	4.30	1.08
Se d	Selenium, dissolved	µg/L	2 (average)	0.00	0.33	0.94	2.49	3.80	0.72	0.00	0.33	1.14	2.87	4.30	2.35	0.00	0.33	1.04	2.60	4.00	0.82
Sn t	Tin, total	µg/L		0.00	0.33	0.70	1.00	3.16	0.74	0.00	0.33	0.66	0.99	2.80	2.14	0.00	0.33	0.55	0.98	1.00	0.65
Sn d	Tin, dissolved	µg/L	3 (average)	0.00	0.33	0.45	0.75	0.98	0.47	0.00	0.33	0.46	0.75	0.98	1.96	0.00	0.33	0.45	0.75	0.98	0.47
Te t	Tellurium, total	µg/L		0.00	0.50	0.79	0.75	2.25	0.83	0.00	0.50	0.83	2.25	2.25	2.25	0.00	0.50	0.88	2.25	2.25	0.93
Te d	Tellurium, dissolved	µg/L	100 (average)	0.00	0.50	0.69	0.75	2.25	0.71	0.00	0.50	0.75	1.28	2.25	2.13	0.00	0.50	0.71	1.28	2.25	0.71
Ti t	Titanium, total	µg/L		0.00	15.37	57.74	115.90	222.00	60.32	0.00	11.82	46.07	89.60	192.00	46.02	0.00	9.40	26.76	56.76	91.00	34.19
Ti d	Titanium, dissolved	µg/L	20 (average)	0.00	0.50	0.81	1.00	2.00	0.92	0.00	0.50	0.80	1.00	1.00	2.21	0.00	0.50	0.90	1.00	9.80	1.32
Tl t	Thallium, total	µg/L		0.00	0.05	0.22	0.50	0.50	0.22	0.00	0.05	0.22	0.50	0.50	1.75	0.00	0.03	0.20	0.50	0.50	0.21
Tl d	Thallium, dissolved	µg/L	0.2 (average)	0.00	0.03	0.20	0.50	0.50	0.20	0.00	0.03	0.20	0.50	0.50	1.74	0.00	0.03	0.19	0.50	0.50	0.19
U t	Uranium, total	µg/L		0.00	0.98	1.38	1.87	1.95	1.27	0.00	1.14	1.55	1.99	2.26	2.72	0.00	1.14	1.57	2.05	2.29	1.56

Parameter	Parameter	Unit	EQS	Measuring points (results 2015 - 2020)																	
				159000 - upstream						157000 - upstream						1574100 - downstream					
U d	Uranium, dissolved	µg/L	1 (average)	0.00	0.50	1.18	1.67	1.90	1.09	0.00	0.98	1.40	1.87	2.06	2.57	0.00	1.04	1.45	1.94	2.09	1.42
V t	Vanadium, total	µg/L		0.00	4.70	10.83	19.31	31.00	10.94	0.00	4.70	9.18	15.24	27.00	9.62	0.00	4.00	6.47	10.16	15.60	7.11
V d	Vanadium, dissolved	µg/L	4 (average)	0.00	1.20	2.74	3.90	4.60	2.38	0.00	1.20	2.77	4.04	5.20	3.49	0.00	1.20	2.52	3.88	4.70	2.45
Zn t	Zinc, total	µg/L		0.00	20.00	47.26	92.00	194.00	49.13	0.00	20.00	38.06	60.20	155.00	37.01	0.00	11.25	23.79	33.90	56.00	30.49
Zn d	Zinc, dissolved	µg/L	20 (average)	0.00	3.75	7.44	11.97	20.00	8.48	0.00	3.75	7.03	11.92	21.00	8.02	0.00	3.75	7.71	13.70	20.00	7.91
Si d	Silicon, dissolved	µg/L		0.00	1800.00	3568.73	5380.00	7100.00	4866.67	0.00	1600.00	3247.46	5100.00	6600.00	3929.32	0.00	1400.00	2966.83	5060.00	6700.00	4111.11

Results < detection limit equaled detection limit / 2
Overrun of the EQS

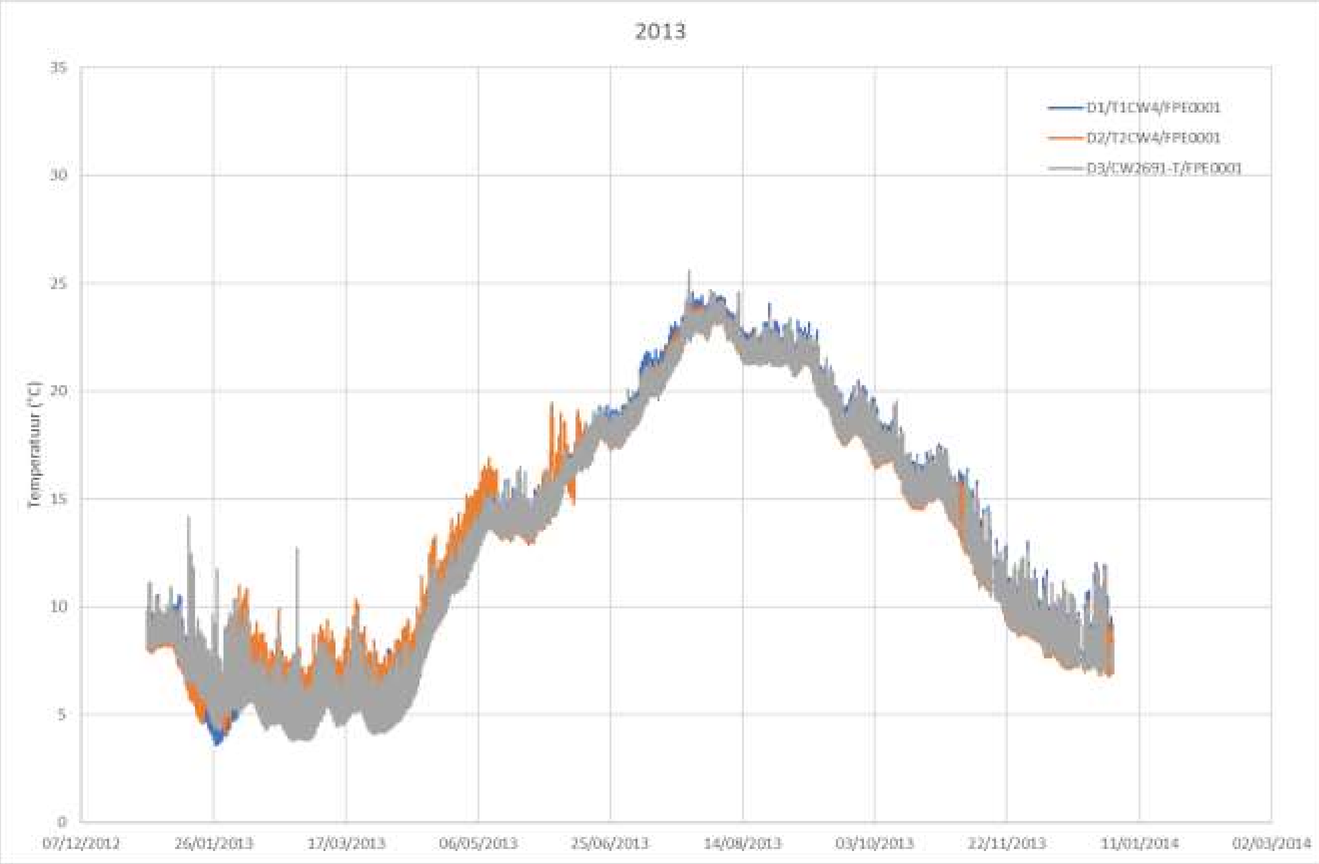


Figure 2-5 Temperature (°C) of the Scheldt water at intake points of Doel 1 (D1/xxx; blue line) and Doel 2 (D1/xxx; orange line) and at the intake point of units Doel 3 and 4 (D3/xxx; grey line) - 2013

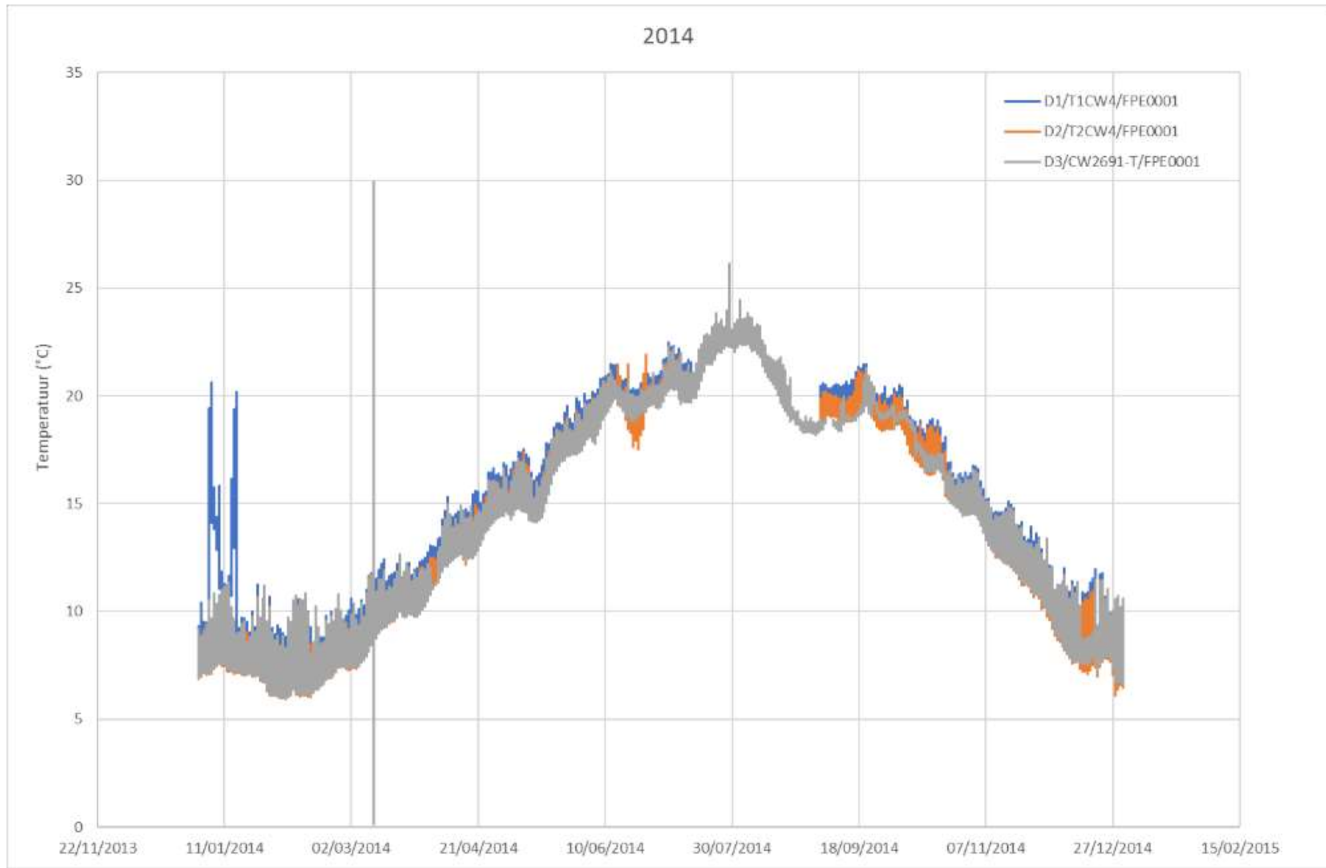


Figure 2-6 Temperature (°C) of the Scheldt water at intake points of Doel 1 (D1/xxx; blue line) and Doel 2 (D1/xxx; orange line) and at the intake point of units Doel 3 and 4 (D3/xxx; grey line) - 2014

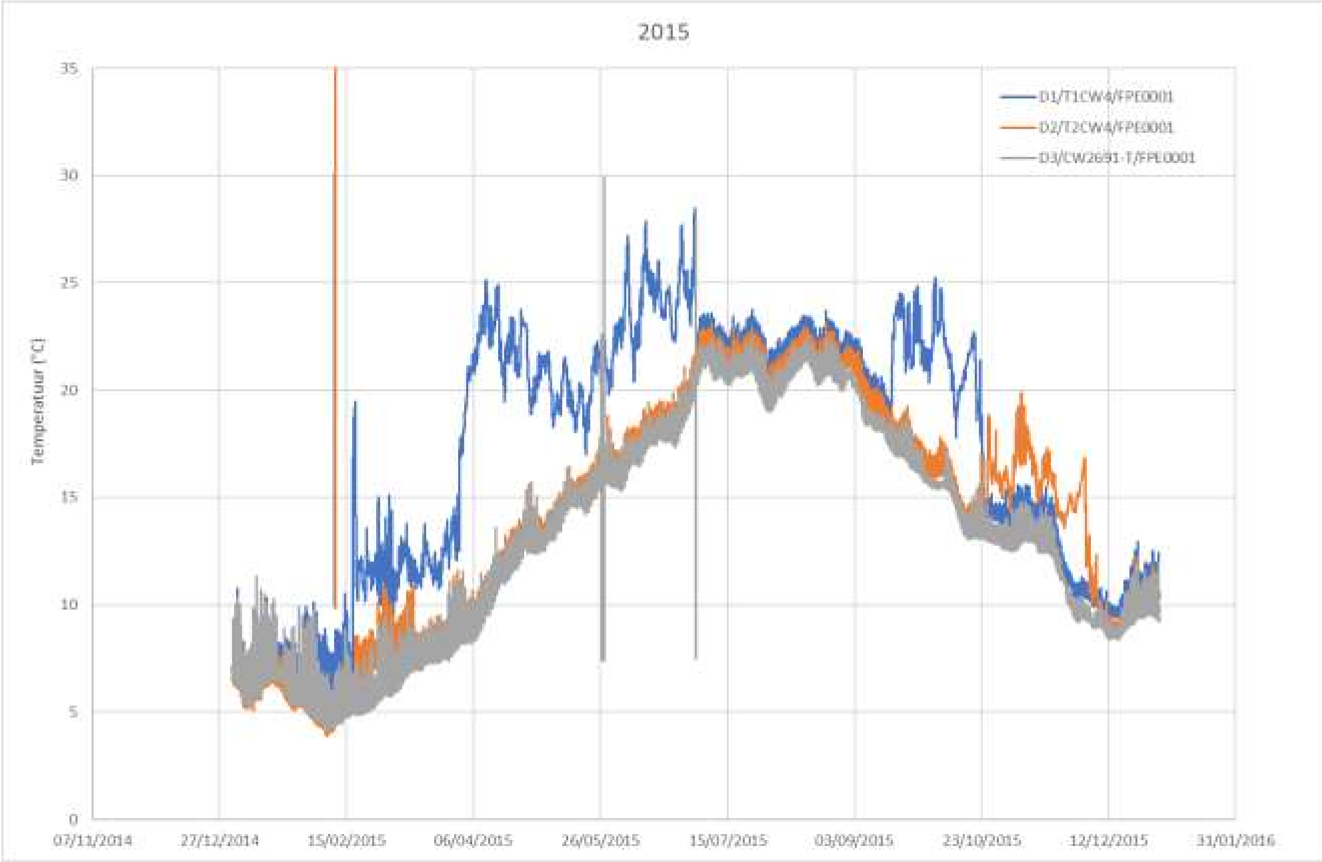


Figure 2-7 Temperature (°C) of the Scheldt water at intake points of Doel 1 (D1/xxx; blue line) and Doel 2 (D1/xxx; orange line) and at the intake point of units Doel 3 and 4 (D3/xxx; grey line) - 2015

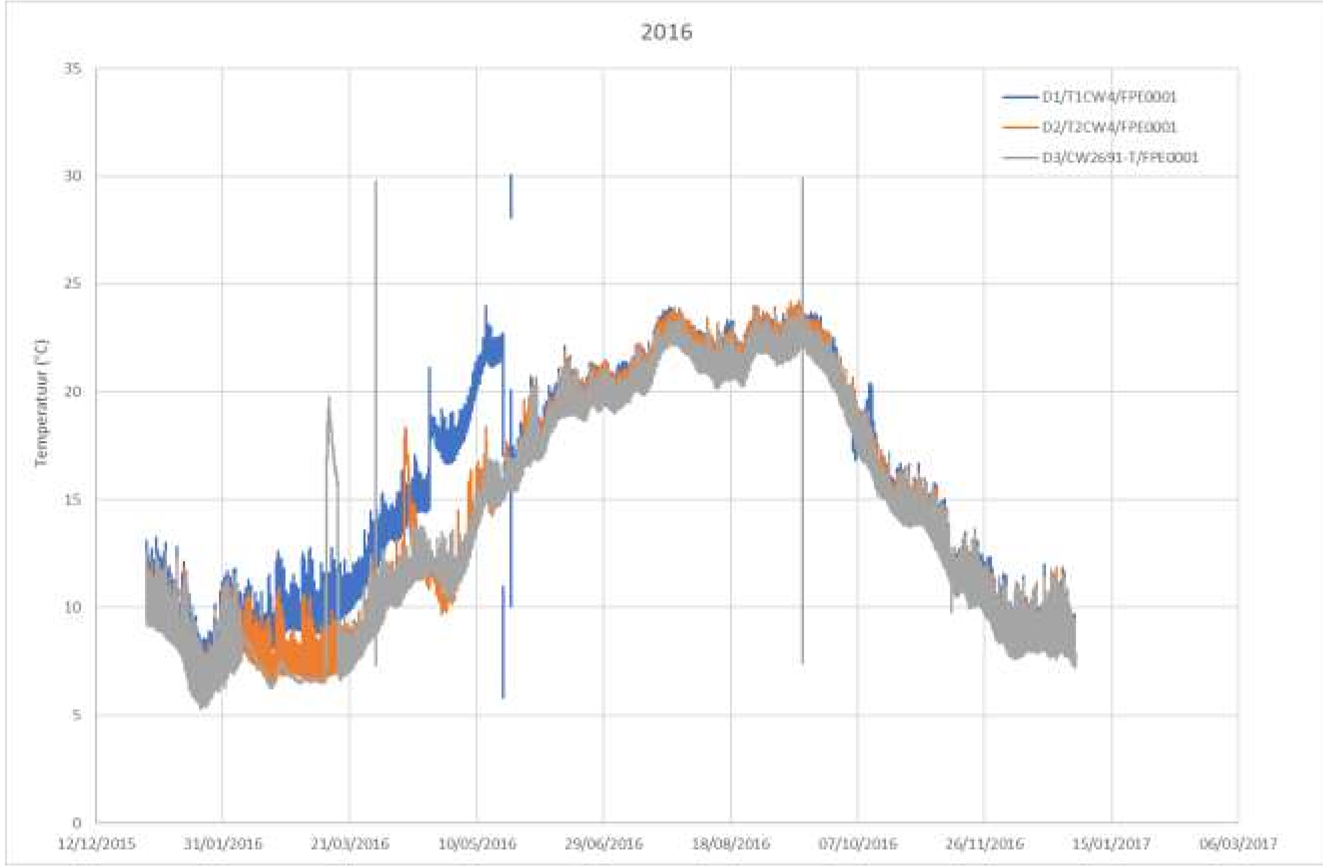


Figure 2-8 Temperature (°C) of the Scheldt water at intake points of Doel 1 (D1/xxx; blue line) and Doel 2 (D1/xxx; orange line) and at the intake point of units Doel 3 and 4 (D3/xxx; grey line) - 2016

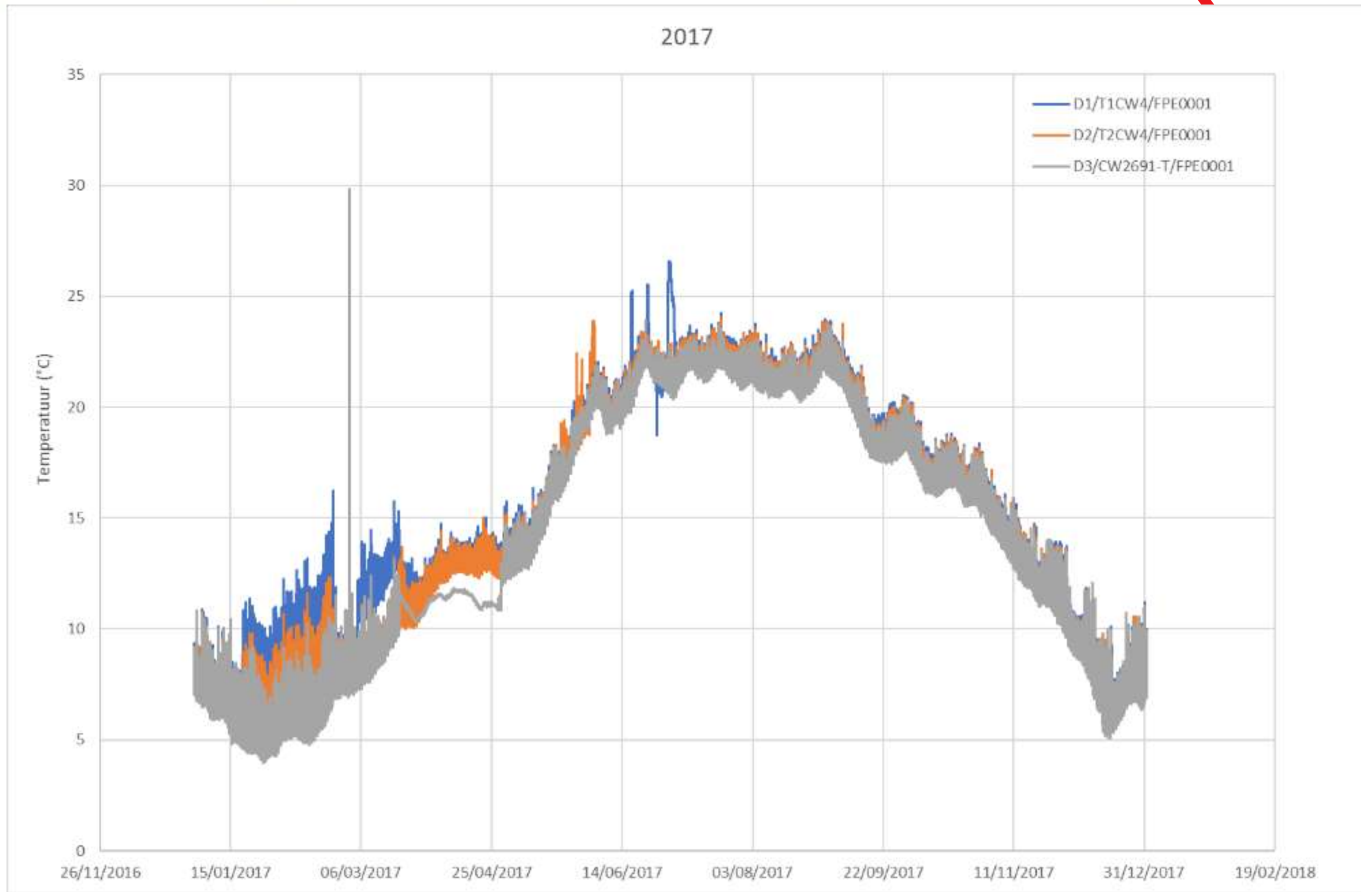


Figure 2-9 Temperature (°C) of the Scheldt water at intake points of Doel 1 (D1/xxx; blue line) and Doel 2 (D1/xxx; orange line) and at the intake point of units Doel 3 and 4 (D3/xxx; grey line) - 2017

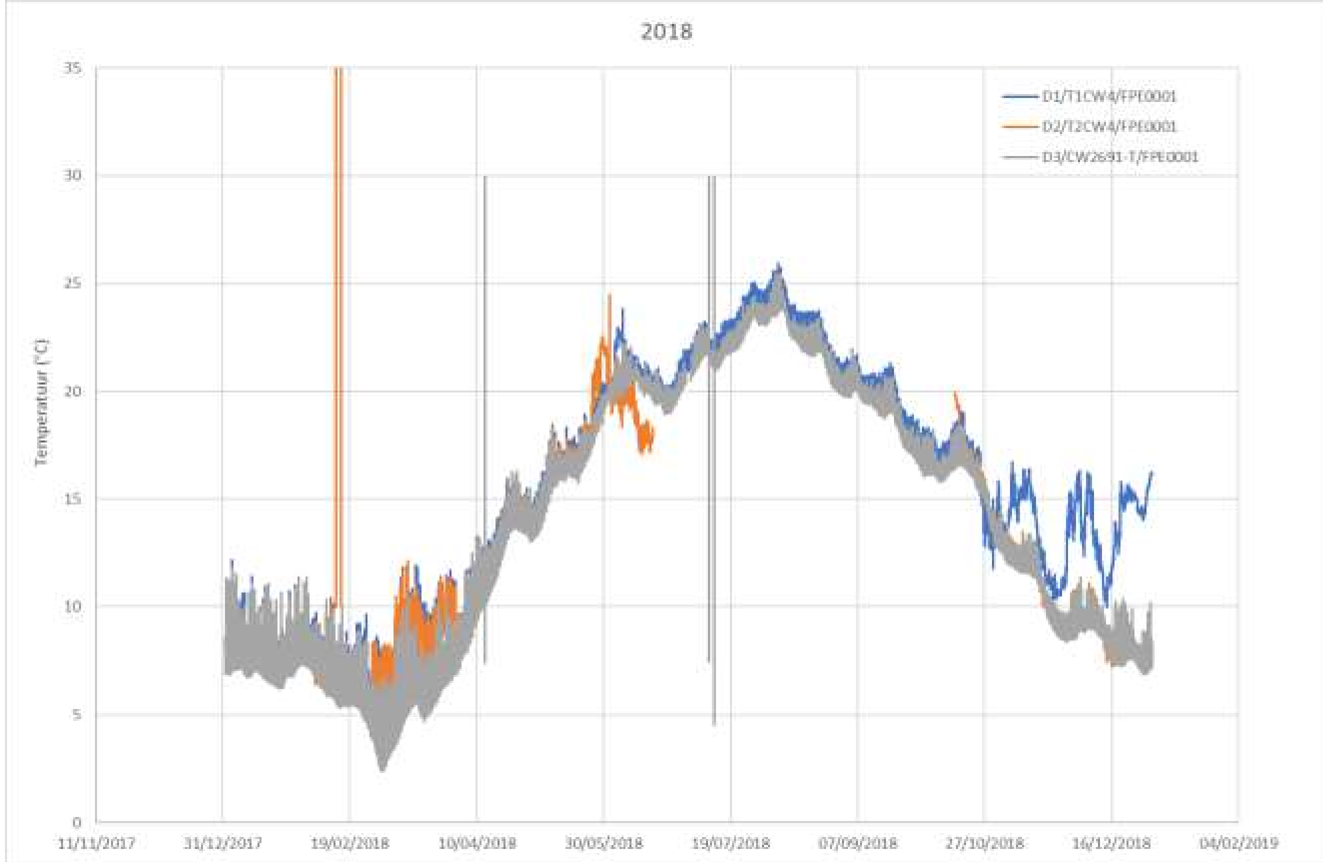


Figure 2-10 Temperature (°C) of the Scheldt water at intake points of Doel 1 (D1/xxx; blue line) and Doel 2 (D1/xxx; orange line) and at the intake point of units Doel 3 and 4 (D3/xxx; grey line) - 2018

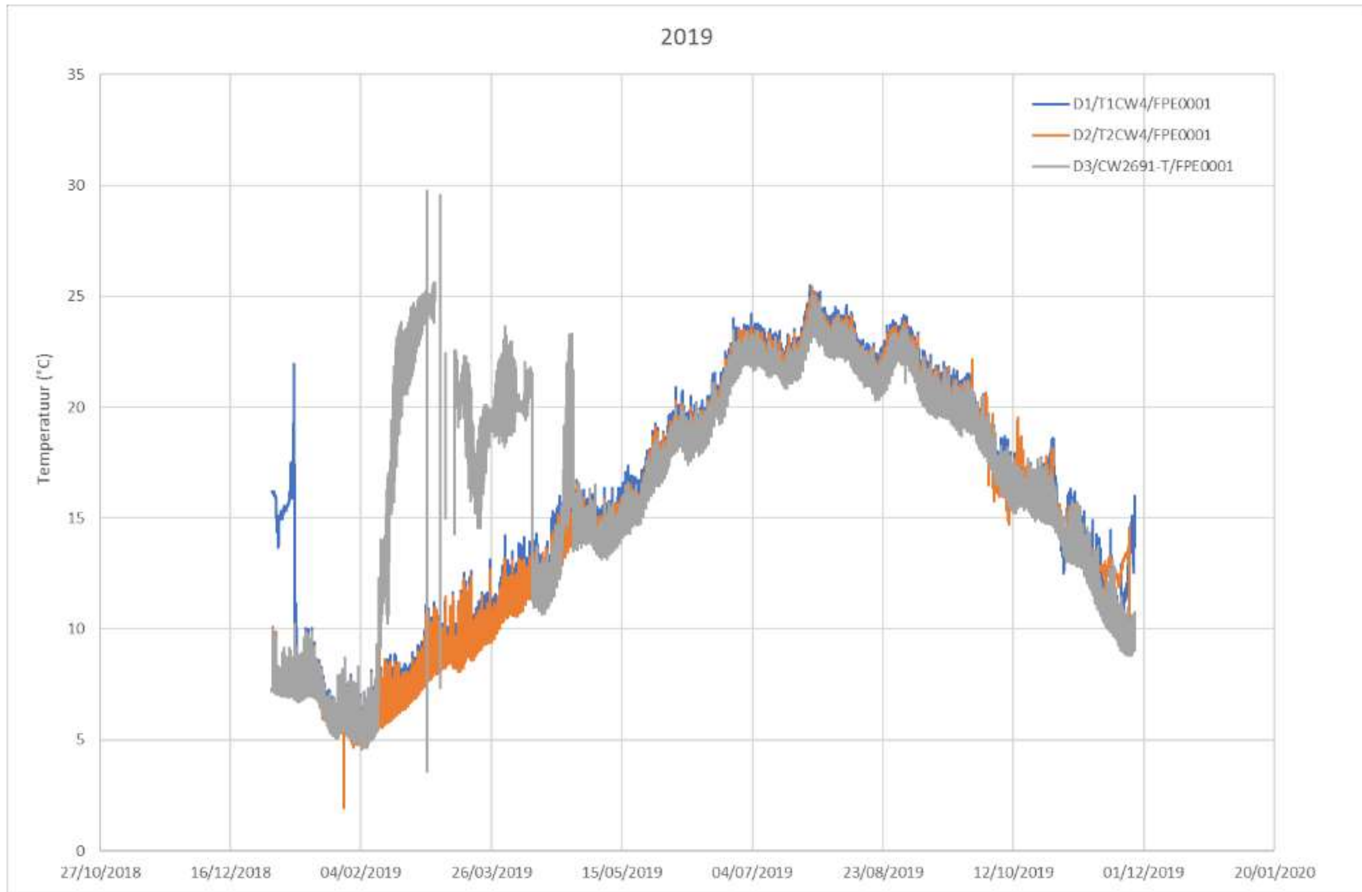


Figure 2-11 Temperature (°C) of the Scheldt water at intake points of Doel 1 (D1/xxx; blue line) and Doel 2 (D1/xxx; orange line) and at the intake point of units Doel 3 and 4 (D3/xxx; grey line) - 2019

2.2.2.2.3 Prati index for dissolved oxygen (PIO)

The FEA uses the Prati-index for dissolved oxygen (PIO) to assess water quality. This is an additional parameter that indicates the quality class of the oxygen balance in surface water.

Italian researcher Prati developed a conversion formula for several parameters in order to convert a measured value into a comparable quality index. On the basis of this index the quality class can be determined. The quality index for dissolved oxygen is a figure between 0.1 and >16 (see Table 2-7). The scores obtained are classified in classes from 1 to 6, assessing the quality of the water from not polluted (Class 1) to very heavily polluted (Class 6). Table 2-8 shows the PIO at the measurement points considered in the period 1994-2019.

At all measuring points, a gradual improvement in water quality is observed over time. For the upstream measurement points 159000 and 157000, the quality evolves from contaminated to acceptable and at measurement point 154100 from contaminated to pure. There is also an improvement in the oxygen levels, downstream of KCD.

Table 2-7 Prati-index according to oxygen: classes

Class	Index	Description
1	0.1 – 1	Not polluted
2	1 – 2	Acceptable
3	2 – 4	Moderately polluted
4	4 – 8	polluted
5	8 – 16	Heavily polluted
6	> 16	Very heavily polluted

Table 2-8 Prati-index according to oxygen

Measurement site	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
159000 (upstream)		7.1	5.45	6.26	4.88	5.5	4.74	5.51	4.63	3.75	3.97	4.45	4.78	3.29	3.13	2.42	2.4	1.99	1.96	2.16	2.02	1.72	2.06	1.66	1.7	1.32
157000 (upstream)		5.48	4.36	5.08	3.96	4.64	4.49	4.72	3.5	2.75	3.02	3.04	3.15	2.5	2.51	1.95	1.8	1.5	1.5	1.53	1.56	1.34	1.61	1.25	1.26	1.04
154100 (downstream)	4.65			4.13	3.13	3.91	3.59	4.39	3	2.29	2.68	1.98	1.5	1.43	1.51	1.35	1.28	0.9	0.88	0.85	1.01	0.84	1.1	0.85	0.66	0.76

2.2.2.2.4 Belgian Biotic Index (BBI)

The FEA also determines the biological quality of the surface water. The biological analysis assesses the watercourse as a biotope, rather than just looking at the quality of the water column. The Belgian Biotic Index (BBI) method is used to determine the biological quality of surface fresh water. To determine the BBI, macro-invertebrates are collected from the soil and from the water using a scoop net. The presence or absence of certain macro-invertebrates determines the BBI. The biotic index is a function of the relative sensitivity of certain indicator species to pollution on the one hand and diversity on the other hand. In contrast to chemical analyses, which reflect the moment at which the water sample is taken, the biological determination evaluates pollution effects that have occurred over a longer period of time. For the assessment, a score of 10 (very good quality) to 0 (extremely poor quality) is given.

No values for the BBI are available for measuring points 159000, 157000 and 154100. After all, the BBI is a measuring instrument developed for the evaluation of fresh surface water and does not give usable results for brackish and salt water.

2.2.2.2.5 Water Quality Decree

In general, on the basis of all the above-mentioned data from FEA's monitoring network, it can be concluded that the Scheldt, both upstream and downstream of the KCD discharge point, does not meet all quality objectives. The most critical parameters are temperature (a few days above 25°C in summer), dissolved oxygen (the P10 value of 6 mg O2/L is not always respected), chemical oxygen consumption (COC), nitrate+nitrite+ammonium, dissolved boron, arsenic, beryllium, cadmium and uranium. However, based on the Prati index for dissolved oxygen, a gradual improvement of the oxygen balance at all measuring points is observed over time. There is also an improvement in the oxygen levels, downstream of KCD. This can be explained by the greater tidal flow in the downstream direction.

Also the Doorloop next to KCD does not meet all quality objectives. The most critical parameters are total phosphorus and dissolved uranium.

2.2.2.3 Water testing maps: susceptibility to flooding, infiltration, groundwater flow and erosion and location within a winter bed

KCD's site is located in a zone designated as follows, according to the water testing maps:

- not susceptible to flooding. The lower-lying polders to the west of KCD have been identified as potentially sensitive to flooding.
- non infiltration-sensitive
- very sensitive to groundwater flow (type 1)
- slopes of 0.5% or 0.5-5%
- not in a winter bed.

2.2.2.4 Water supply / water balance

KCD's water balances for baseline 2013 and 2014 are included in Figure 2-12 and Figure 2-13, respectively. These water balances are also representative for the period 2015 - 2019 as the operation of KCD has not changed from the baseline situation. This is why the water balances for this period are not included separately in the EIR.

KCD uses the following water sources:

- Mains water (city water): is used mainly for the production of demineralised water used for steam production in the secondary circuit, for the replenishment of cooling ponds and for sanitary purposes. In 2013 and 2014 respectively 299,011 m^3 and 338,727 m^3 of mains water was consumed. The difference between the consumption in 2014 and 2013 is due to the fact that only mains water and no Scheldt water was used for the production of process water in 2014 and to the increase in consumption for sanitary purposes in 2014.
- Scheldt water: is almost exclusively used as cooling water in the tertiary circuit. The cooling water is extracted from the Scheldt and discharged back into the Scheldt after use. Part of the cooling water evaporates in 2 cooling towers (Doel 3 and Doel 4). In 2013, 1,191,981,940 m^3 of cooling water was pumped out of the Scheldt. Of this, 1,172,731,154 m^3 was discharged back. In 2014, 1,240,058,030 m^3 of cooling water was pumped out of the Scheldt. Of this, 1,230,973,030 m^3 was discharged back. A very small fraction of the surface water is used for the production of process water by distillation.

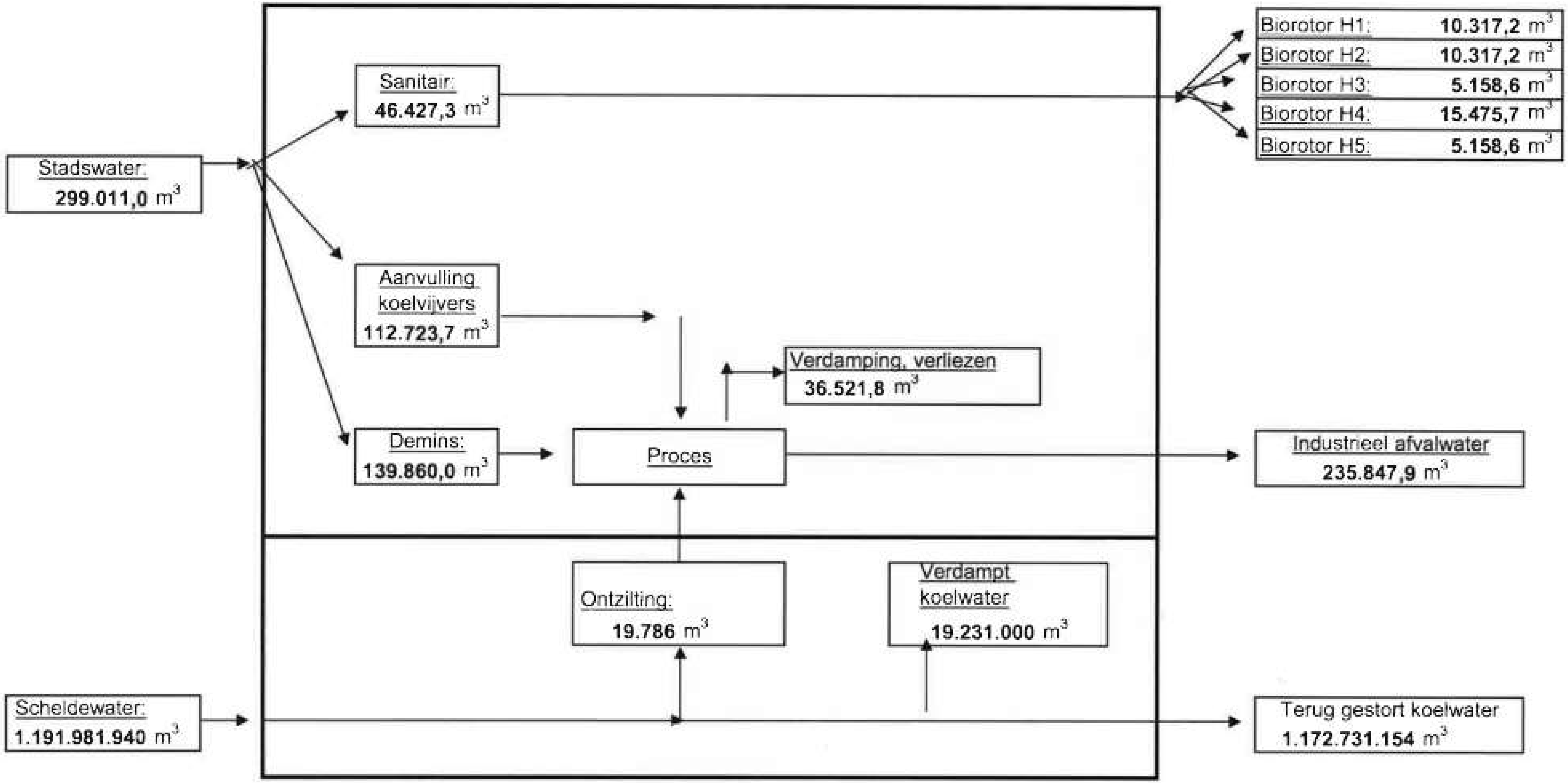


Figure 2-12 Water balance 2013 (m³)

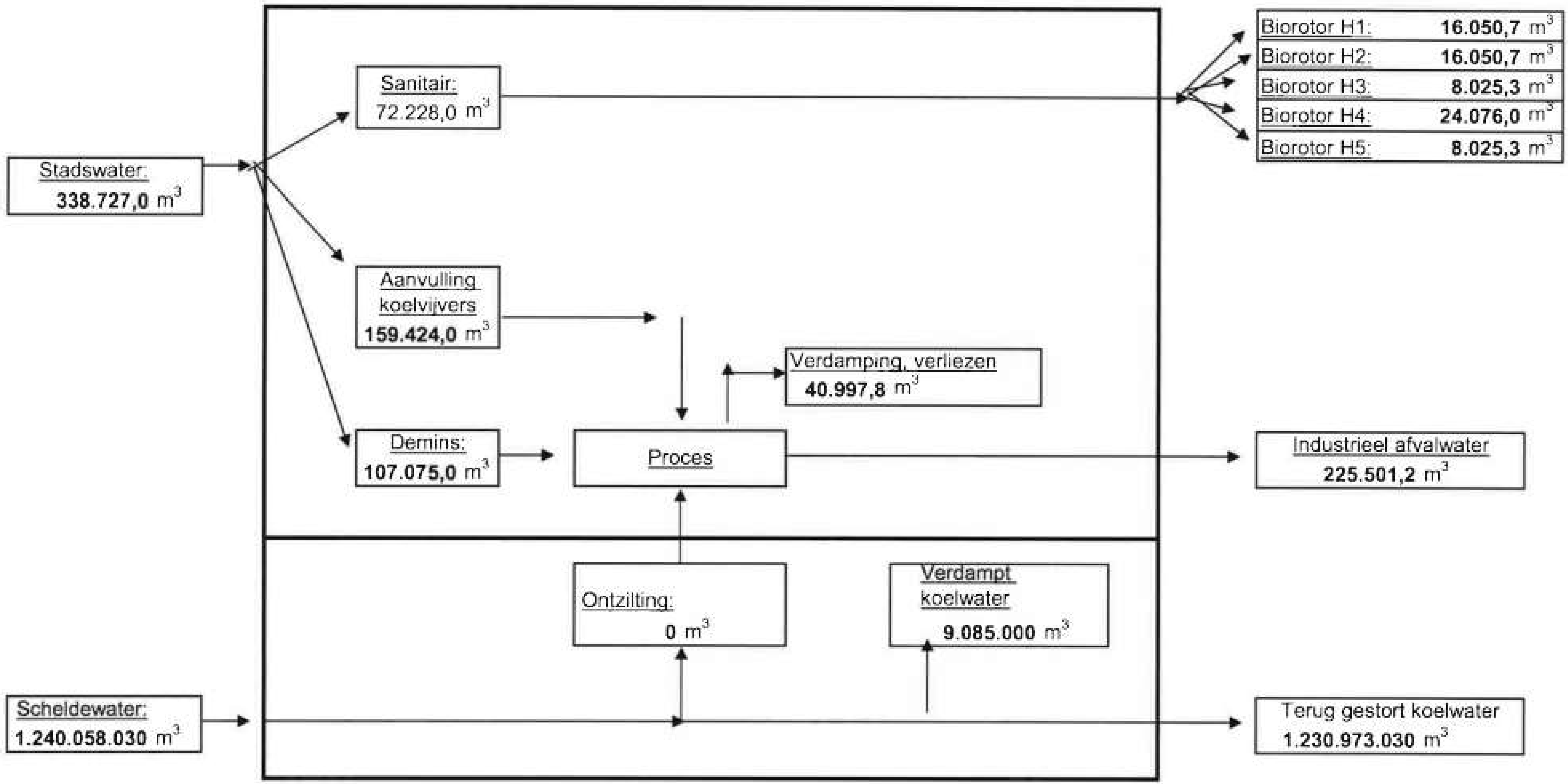


Figure 2-13 Water balance 2014 (m³)

2.2.2.5 Internal sewerage system

KCD has an internal sewage system for the removal of the various (waste) water flows. A schematic representation of the internal sewerage system and the discharge points can be found in Figure 2-14.

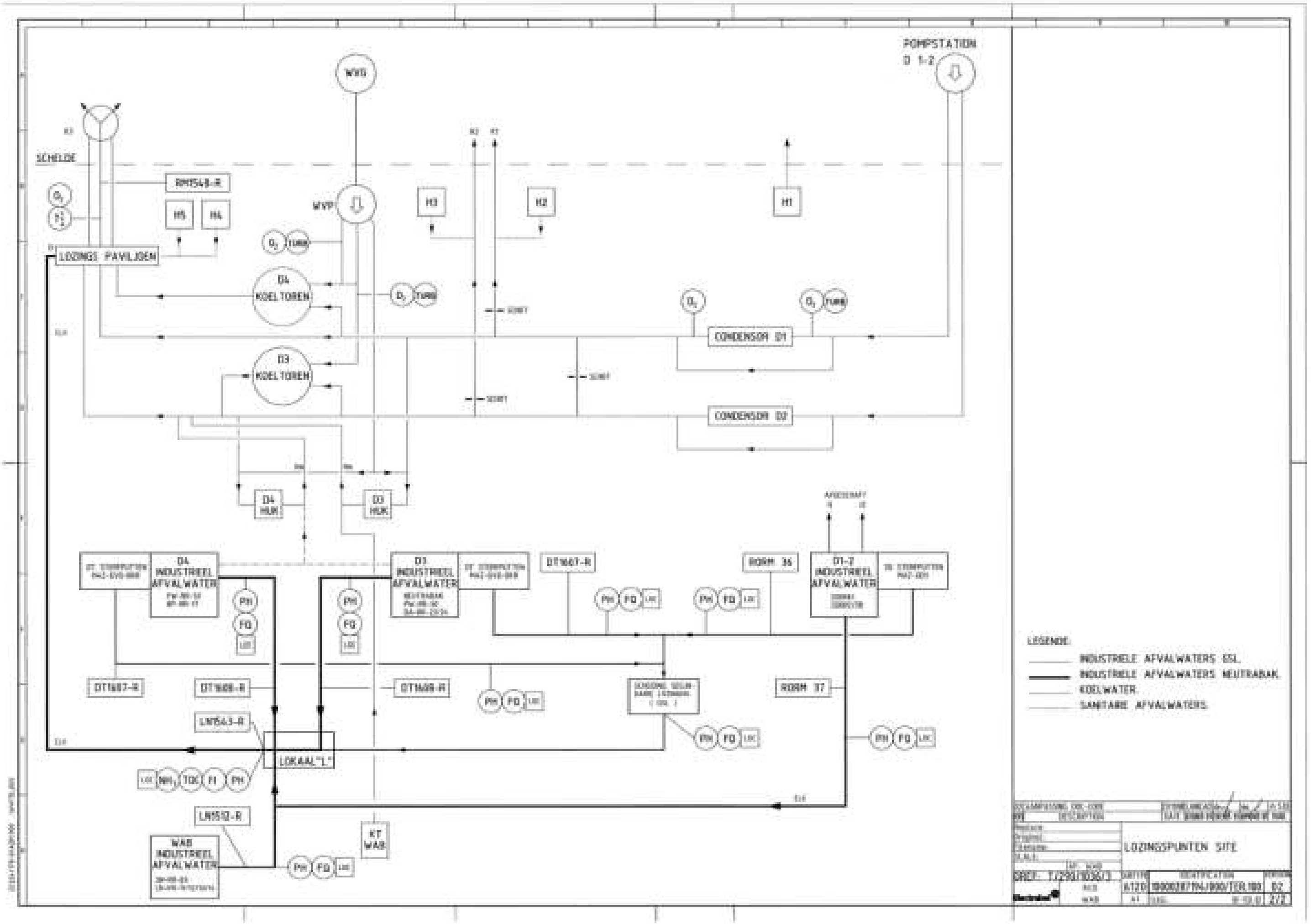
KCD does not have a separate sewage system for rainwater. The sanitary waste water is collected together with the rainwater from the roofs and most of the paved surfaces and discharged to five collection wells. These wells are equipped with submersible pumps that pump the water to the Scheldt during heavy rainfall. Under normal conditions, this water is purified in 5 biorotors before being discharged into the Scheldt (H1 - H5 at Figure 2-12 and Figure 2-13). In 2013, this well pump system was operational for 18 days and in 2014 this was 14 days. For the period 2015 to 2019, the system was operational between 12 and 46 days. There are leaks in the underground galleries between the units and the cooling towers (mainly due to settlements). These galleries consist of large-bore concrete tubes. During each outage, the galleries are cleaned and checked for leaks, which are then repaired. Leak detection and repair is a time- and cost-intensive job. During repair, the respective reactor unit must be shut down. The leaked cooling water enters the mixed sewer system via the soil. The mixed sewer system itself is not watertight and drains cooling water and groundwater. These leaks of cooling water and, to a lesser extent, groundwater in the mixed sewerage system explain the frequent operation of the collection wells.

In total there are 5 discharge points. Each biorotor has its own discharge point. The industrial waste water is discharged together with the cooling water via one collective discharge point (discharge pavilion at Figure 2-14). The discharge points K1 and K2 in the figure are the old ducts of Doel 1 and Doel 2 which are only used in emergencies, when the other discharge channel for cooling water (K3) is not available, e.g. due to an outage.

Rainwater is not reused. The rainwater from roofs and most of the paved surfaces is collected in a joint system together with the sanitary wastewater and purified by means of five biorotors. The water from the car parks at the entrance drains into the nearby Doorloop. Reuse of rainwater for the production of demineralised water, use as cooling water or for sanitary purposes is possible, in principle. However, the necessary infrastructure for the reuse of rainwater is lacking. The urban planning regulation on rainwater wells, infiltration facilities, buffer facilities and separate discharges of waste water and rainwater does not apply to existing buildings and structures.

The total surface area of the KCD site is 1,154,583 m^2. Of this, 555,894 m^2 is paved or built on and 598,689 m^2 is unpaved. The KCD site is therefore 52% water permeable. The amount of rainwater that is removed is not known and is not included in the water balance (see Figure 2-12 and Figure 2-13). Taking into account the paved or built-up area above and an average precipitation of 690 mm/year in the baseline situation 2013-2014 at the FEA VMM measuring station (Melsele, P04_001)[5], the amount of rainwater discharged in the baseline situation 2013-2014 is estimated to be roughly 383,600 m^3.

[5] Source: waterinfo.be (FEA)



WVG = water intake building; WVP = pump water intake; D3 HUK = auxiliary cooling tower Doel 3; D4 HUK = auxiliary cooling tower Doel 4; KT WAB = cooling tower WAB; DT = waste water system; MAZ = turbine hall; GEH = building electrical emergency services; O = oxygen measurements; T = temperature measurement; Turb = Turbidity measurement

Figure 2-14 Schematic representation of the internal industrial Waste and cooling water

2.2.2.6 Description of emissions

2.2.2.6.1 Wastewater streams

KCD discharges various wastewater streams:

- Sanitary waste water: the sanitary waste water is collected together with the rainwater from the roofs and discharged into the Scheldt after treatment in five biorotors;
- Industrial waste water: the industrial waste water is collected and discharged into the Scheldt, either separately or after treatment (see further);
- Cooling water: The cooling water from the tertiary circuit is extracted from the Scheldt and is largely discharged back into the Scheldt after use.

2.2.2.6.1.1 Sanitary wastewater/rain water

Every building on the KCD that creates sanitary wastewater is equipped with a septic tank. There are about 38 septic tanks on the KCD site. These septic tanks are checked periodically. Sanitary wastewater is collected in the septic tanks. KCD does not have a separate sewage system for rainwater. After these septic tanks, the rainwater from the roofs and most of the paved surfaces is connected to the mixed sewage system. The mixed sewer is then drained to five collection wells. These wells are equipped with submersible pumps that pump the water to the Scheldt during heavy rainfall. Under normal circumstances, this water is purified in 5 biorotors before it is discharged into the Scheldt.

The purpose of the biorotors is to remove the load of biochemical oxygen consumption (BOC)/chemical oxygen consumption (COC) through aerobic biodegradation of organic components to CO_2 and water by microorganisms. These microorganisms are immobilized as a solid film on the biorotor.

Biorotors are also suitable for denitrification. Denitrifying microorganisms grow slowly; the immobilization in a biorotor allows these microorganisms to thrive. The biorotor is a unit that consists of a drum as a frame with a honeycomb structure or a filling material inside on which the micro-organisms are immobilized. The drum is partially submerged in a tank with a continuous flow of wastewater, where the organic substances are adsorbed and converted. Aeration takes place by means of rotation and contact with the open air. The waste water then flows into a clarifier where the sludge settles. An additional denitrification step is required for complete nitrogen removal.

The most important parameters in sanitary wastewater are BOC, COC, suspended solids, N and P.

2.2.2.6.1.2 Industrial waste water

Industrial waste water consists of the following substreams:

- Effluent from the regeneration of the Doel 1 to 4 demineralisation plants and the Water and Waste Treatment Unit (WAB). This effluent has a high salt content and a deviating pH. After neutralisation (with sulphuric acid, hydrochloric acid and sodium hydroxide), this wastewater stream is discharged via the unique discharge point (room L) and sampled;
- Floor waters (e.g. water from purification, groundwater, ...) from Doel 1 to 4 and from the WAB that contain little pollution are diverted to a common neutralisation installation (CNI). After neutralization with CO_2 and sodium hydroxide, the wastewater is also discharged and sampled via the unique discharge point (Room L);

- Waste water from the WAB in which waste water from the primary circuit is treated. This waste water, which potentially contains radioactive elements, is treated in demineralisations and distillers. The concentrate is processed in concrete barrels for active waste. The purified water and the distillate, which no longer contains radioactive elements, are also discharged and sampled via the unique discharge point.

The system also has a reverse osmosis unit to isolate ammonia-rich effluents from the vacuum pumps for external discharge and treatment.

Some relevant parameters in industrial wastewater are:

- Boron: the water of the primary circuit contains boric acid which is used to control the reactivity of the core. If boric acid cannot be recovered, it should be discharged after purification;
- Nitrogen: Corrosion in the secondary circuit is prevented by using high pH water and oxygen-binding products. Ammonia and hydrazine, respectively, are used for this purpose. Ion exchangers purify part of the secondary circuit. However, these chemical filters cannot distinguish between the impurities that need to be removed from the circuit and the ammonia that does not. In addition, ammonia is a gas which, together with other non-condensable gases and a limited steam fraction, is extracted from the condenser. After the vacuum pumps, that operate under atmospheric pressure, this steam condenses and dissolves the gases in it. This water stream can no longer be reused and ends up in industrial wastewater. Nitrogenous components therefore enter the wastewater along these two ways. 80% of the total nitrogen load comes from wastewater from Doel 3 and 4. To reduce the amount of nitrogen in this wastewater, 2 systems were built in 2011. For Doel 4, this is a collection installation for the effluents that are discharged for external processing. For Doel 3, this is a reverse osmosis installation for the effluents of the vacuum pumps. This system thickens the dirty water extracted from the wastewater to a nitrogen-concentrated liquid (ammonium), reducing the amount of wastewater transported. The thickened waste water from this installation is also disposed of for external processing. The purified water is discharged via the industrial wastewater;
- Chlorides: coming from HCl used for the regeneration of the ion exchangers of the demineralisation systems. The demineralisation systems now serve as back-up installations. Since 2018, an osmosis method for the production of demineralised water is used. H_2SO_4 was replaced by HCl;
- Chromium: chromium is used for the passivation of specific internal closed water circuits.
- (Molybdenum): Before 2012, molybdenum was also used for the treatment of specific water systems. As of 2012, a switch was made to molybdenum-free products, as a result of which molybdenum discharge was stopped;
- Arsenic: The soil in the port of Antwerp was sprayed with soil contaminated with arsenic. Therefore, the arsenic discharged by KCD probably originates from groundwater, which enters the industrial wastewater via the floor waters.

2.2.2.6.1.3 Cooling water

Scheldt water is used as cooling water for the process, which is pumped up via two nearby intakes. The intake point of the Doel 1 and 2 units (oldest units) is built "in the Scheldt". In other words, the purification plants, grids, scrapers and drum filters are located in a construction that is on the Scheldt. The water is pumped to the Doel 1 and 2 units via pumps. The cooling circuit of these units is of the open type, which means that the water sent through the condenser is used only once. To build Doel 3 and 4, the cooling water from Doel 1 and Doel 2 was brought back into the Scheldt via discharge points K1 and K2. These discharge points are currently only used when e.g. the general discharge point K3 or the "distribution system" is unavailable. Through this distribution system, it is possible to bring the water either directly to the discharge point K3 or to pump it into the cooling towers of Doel 3 and or 4 via existing pumps.

The intake point on the Scheldt of the Doel 3 and 4 units only concerns an open structure from which a gallery leads to the pumping station on the "mainland". The tube is only equipped with a stationary grid to keep large objects out.

The pumping station consists of a buffer tank equipped with scrapers and rotating basket filters. There are two suppletion pumps in the pumping station that inject water into the closed cooling systems of Doel 3 and 4. Both pumps can supply both units. The cooling circuits of the Doel 3 and 4 units are closed cooling systems, which means that cooling water circulates between the cooling tower and the condenser. The suppletion helps replenish the evaporation losses and the deconcentration sluices. A small part of the cooling water is used to feed the auxiliary cooling tower that cools the safety circuits. These deconcentration sluices are also fed back into the Scheldt via discharge point K3.

In 2013, 1,191,981,940 m³ of cooling water was extracted from the Scheldt. The licensed quantity is 1,500,000,000 m³. In 2013, 19,786 m³ of the total pumped volume of Scheldt water was desalinated and used as process water, 19,231,000 m³ was evaporated in the cooling towers and the remaining part (1,172,731,154 m³) was discharged back into the Scheldt. In 2014, 1,240,058,030 m³ of cooling water was pumped out of the Scheldt. Of this, 0 m³ was desalinated to be used as process water (in 2014 only mains water was used for this and no Scheldt water), 9,085,000 m³ was evaporated in the cooling towers and 1,230,973,030 m³ was discharged back.

The most important parameters of the cooling water are temperature, oxygen content, COC, chlorides and AOX. The temperature and the content of dissolved oxygen are measured continuously. Monthly analyses are performed on COC, quarterly analyses on active chlorine. The cooling water flow rate is determined on the basis of hour counters and pump characteristics. The cooling water heats up by cooling the water from the secondary circuit and condensing the steam in the condensers of the units. The chlorides come from NaOCl, which is added to the cooling water to prevent biological growth in the cooling towers. This prevents additional COC from being discharged into the Scheldt via the cooling water. Measurements show that there is no noticeable difference between the COC content of the incoming and outgoing cooling water. Weekly a calculated shock dose of NaOCl is injected (approx. 4.000 litres per cooling tower). The shock dose was determined on the basis of analysis of the excess active chlorine and experience with the cooling speed gasket. Any additional doses are based on checking the biological growth on sample plates and on ATP measurements of the cooling towers. The NaOCl reacts to form chlorides.No active chlorine above the detection limit (<0.1 mg/L) is found in the discharged cooling water. Together with the shock dose of NaOCl, approx. 200 litres per cooling tower are administered to the biodetergent SPECTRUS BD1501E on a weekly basis. It is a mixture of non-ionic surfactants in aqueous solution. During periods of heat waves, twice as much NaOCl with SPECTRUS BD1501E is injected into the cooling towers every week.

When NaOCl is used as a conditioning agent, AOX (= adsorbable organic halogen compounds) is formed. The AOX levels will consist of haloforms, also called trihalomethanes (mainly bromoform in brackish and salt water) and various halogenated polar compounds (e.g. chloric and bromacetic acids) (Berbee, 1997).

An anti-foaming agent is continuously added to the cooling water to prevent foaming due to algae growth. This is the FOAMTROL AF4039 (a combination of modified fatty alcohols and special alcohols). This antifoaming agent is continuously dosed with a pump in the incoming Scheldt water. During the weekly injections of NaOCl with SPECTRUS BD1501E, an additional quantity of antifoaming agent is also dosed with a second pump each time. The quantity of antifoaming agent purchased averages approx. 5,500 kg per year. There is a large variation, due to stock levels. The conclusion is that the discharged concentrations of antifoaming agent are very limited.

2.2.2.6.2 Waste water flow and waste loads

In the baseline situation (2013), the following (waste) water flows were discharged:

- Sanitary wastewater (+ rainwater): 46,427.3 m³
- Industrial waste water: 235,847.9 m³
- Cooling water: 1,172,731,154 m³.

In the baseline situation (2014), the following (waste) water flows were discharged:

- Sanitary wastewater (+ rainwater): 72,228.0 m³
- Industrial waste water: 225,501.2 m³
- Cooling water: 1,230,973,030 m³.

The wastewater flows and pollutant loads for the baseline situation 2013-2014 are also representative for the period 2015 - 2019 as the operation of KCD has not changed compared to the baseline situation.

2.2.2.6.2.1 Sanitary wastewater

The sanitary wastewater discharged in 2013 and 2014 must meet the standards for the discharged flow in the environmental permit dated 31/03/2011 (M03/46003/46/2/A/5/HV/CW). The concentrations in the effluent must comply with Article 4.2.8.1.1 of VLAREM II. For parameters referred to in Annex 2C to Title I of VLAREM, the effluent must not contain concentrations exceeding 10 times the classification criteria listed in the column "classification criterion DS (dangerous substances)" of Article 3 of Annex 2.3.1 to VLAREM II.

Table 2-9 allows for the following conclusions to be drawn for the sanitary wastewater in the baseline situation 2013 - 2014:

- For the year 2013, all discharge standards for the treated sanitary wastewater were met;
- For the year 2014, the discharge standard for the annual flow rate and suspended solids is not met:
    - The annual flow rate is calculated on the basis of counters. However, this is an excess of the actual sanitary wastewater discharged. For example, the sealing water of the cooling water pumps (using mains water) and the power supply of the IC circuits is included. The flow rate calculation is based on a counting period of 3 days, with extrapolation to the

full year. The mains water circuit is a rather complicated circuit with connections to various installations. In practice, the permitted annual flow rate is not exceeded. After all, the permitted annual flow rate is determined on the basis of the flow rate of the biorotors' supply pumps present.

  - For suspended matter, the increased value was caused during the first day of the measurement campaign in 2014. A 24h water sample is taken by means of a sampling device. The hose is placed in the settling pit exit "reaction chamber". In this case, the hose was placed too deep and sludge was pumped up with it;

- An atypical parameter in the effluent of treated sanitary wastewater for 2013 and 2014 is AOX (adsorbable organic halogen compounds). The presence of AOX is probably due to the leakage of cooling water through the soil into the mixed sewage system (see description in § 2.2.2.5) and/or the sporadic use of disinfecting sanitary products. The average concentration lies between 62.4 and 68.4 µg/L for the years 2013 and 2014, respectively, and lies between the classification criterion DS (dangerous substances) of 40 µg/L (Art.3, Annex 2.3.1 VLAREM II) and 10 times this classification criterion, thus complying with the discharge standard.
- For the parameters of ammonium, B, Sb, Co, Mo, Se, Sn, Ag, Ba, Tl, Ti, V, Be, Te, anionic, non-ionic and cationic surfactants, the measurements are performed inconsistently for the years 2013 and/or 2014 or the detection limit of the measurements is higher than the discharge standard. As a result, it is not possible to make well-founded statements about the concentrations and reaching discharge standards for these parameters.

The quality of the sanitary wastewater for the years 2015 - 2019 was checked as part of this EIR. Concentrations and pollutant loads for the period 2015 - 2019 do not differ significantly from the baseline situation 2013 - 2014 as the operation of KCD has not changed from the baseline situation.

Table 2-9 Discharge standards, effluent concentrations and pollutant loads sanitary wastewater

	Valid 2013-2014		2013				2014			
Parameter	**Discharge standard**		**Number of measurements**	**Average (mg/L)**	**Max (mg/L)**	**Total average load (kg/year)**	**Number of measurements**	**Average (mg/L)**	**Max(mg/L)**	**Total average load (kg/year)**
Flow rate	Max. 90 m^3/hour, 135 m^3/day and 50,000 m^3/year, divided over 5 discharge points as follows: H1: 20 m^3/hour and 30 m^3/day; H2: 20 m^3/hour and 30 m^3/day; H3: 10 m^3/hour and 15 m^3/day; H4: 30 m^3/hour and 45 m^3/day; H5: 10 m^3/hour and 15 m^3/day.		46,427.3 m^3/year: H1: 10,317.2 m^3/year; H2: 10,317.2 m^3/year; H3: 5,158.6 m^3/year; H4: 15,475.7 m^3/year; H5: 5,158.6 m^3/year.				72,228 m^3/year: H1: 16,050.7 m^3/year; H2: 16,050.7 year; H3: 8,025.3 m^3/year; H4: 24,076 m^3/year; H5: 8,025.3 m^3/year.			
BOC (mg/L)	Max. 25	mg/L	40	3.7	23	170	36	4.4	25	317
COC (mg/L)			36	35.9	100	1668	25	34.3	74	2479
Suspended substances (mg/L)	Max. 60	mg/L	39	21.6	55	1002	34	24.1	200	1742
Tot P (mg/L)	Max. 10	mg/L	42	2.5	6.6	115	31	2.6	10	185
NO2 (N-mg/L)	Max. 6.6	mg N/L	13	0.043	0.230	2	20	0.332	1.8	24
NO3 (N-mg/L)			8	10.8	42	503	20	12.4	66	898

	Valid 2013-2014		2013				2014			
Parameter	**Discharge standard**		**Number of measurements**	**Average (mg/L)**	**Max (mg/L)**	**Total average load (kg/year)**	**Number of measure ments**	**Averag e (mg/L)**	**Max(m g/L)**	**Total average load (kg/year)**
Kjld N (N-mg/L)			8	3.1	16	142	20	4.3	34	314
NH4 (N-mg/L)			0	-	-	-	5	3	13	217
Tot N (N-mg/L)			23	19.2	71	890	35	19.2	85	1386
B (mg/L)	Max. 7	mg/L	5	0.066	0.160	3	0	-	-	-
Sb (mg/L)	Max. 1	mg/L	5	<0.020	<0.020	-	0	-	-	-
Cd (mg/L)	Max. 0.008	mg/L	20	0.0001	0.001	0.003	15	<0.001	<0.001	-
Cr (mg/L)	Max. 0.5	mg/L	20	<0.010	<0.010	-	15	0.002	0.016	0.128
Co (mg/L)	Max. 0.006	mg/L	5	<0.010	<0.010	-	0	-	-	-
Cu (mg/L)	Max. 0.5	mg/L	20	0.008	0.053	0.361	15	0.004	0.036	0.289
Mn (mg/L)			5	0.117	0.380	5	0	-	-	-
Mo (mg/L)	Max. 3.5	mg/L	5	<0.020	<0.020	-	0	-	-	-
Se (mg/L)	Max. 0.03	mg/L	5	<0.005	<0.005	-	0	-	-	-
Sn (mg/L)	Max. 0.4	mg/L	5	<0.04	<0.04	-	0	-	-	-
Zn (mg/L)	Max. 2	mg/L	20	0.054	0.170	3	15	0.073	0.210	5
As (mg/L)	Max. 0.05	mg/L	20	0.013	0.030	1	15	0.015	0.031	1
Hg (mg/L)	Max. 0.003	mg/L	20	<0.0001	<0.0001	-	15	<0.000 1	<0.000 1	-
Pb (mg/L)	Max. 0.5	mg/L	20	<0.025	<0.025	-	15	0.003	0.025	0.201

	Valid 2013-2014		2013				2014			
Parameter	**Discharge standard**		**Number of measurements**	**Average (mg/L)**	**Max (mg/L)**	**Total average load (kg/year)**	**Number of measurements**	**Average (mg/L)**	**Max(mg/L)**	**Total average load (kg/year)**
Ni (mg/L)	Max. 0.3	mg/L	20	0.002	0.017	0.111	15	<0.010	<0.010	-
Ag (mg/L)	Max. 0.004	mg/L	20	<0.010	<0.010	-	15	<0.010	<0.010	-
Al (mg/L)			5	0.206	0.320	10	0	-	-	-
Ba (mg/L)	Max. 0.700	mg/L	5	0.010	0.021	0.469	0	-	-	-
Fe (mg/L)			5	0.808	2.200	38	0	-	-	-
Tl (mg/L)	Max. 0.002	mg/L	5	<0.020	<0.020	-	0	-	-	-
Ti (mg/L)	Max. 1	mg/L	5	0.021	0.033	1	0	-	-	-
V (mg/L)	Max. 0.05	mg/L	5	<0.010	<0.010	-	0	-	-	-
U (mg/L)	Max. 0.01	mg/L	5	<0.001	<0.001	-	0	-	-	-
Be (mg/L)	Max. 0.001	mg/L	5	<0.005	<0.005	-	0	-	-	-
Te (mg/L)	Max. 1	mg/L	5	<0.010	<0.010	-	0	-	-	-
F (mg/L)	Max. 9	mg/L	5	0.102	0.290	5	5	0.184	0.470	13
Anion det (mg/L)	Max. 1	mg/L	0	-	-	-	0	-	-	-
Cation det (mg/L)	Max. 10	mg/L	0	-	-	-	0	-	-	-
Non-ion det (mg/L)			0	-	-	-	1	0.278	2.5	20
AOX µg/L	Max. 400	µg/L	10	62.4	210	3	9	68.4	93	5
DOC mg/L			10	6.1	10	281	9	8.6	12	621
free cyanide	Max. 0.5	mg/L	5	<0.005	<0.005	-	5	<0.005	<0.005	-

Red: exceeding the discharge standard in 2013 and/or 2014 Yellow: no measurements in 2013 and/or 2014 or detection limit of measurement exceeds discharge standard.

2.2.2.6.2.2 Industrial waste water

2.2.2.6.2.2.1 Flow rate and waste load

The industrial waste water discharged in 2013 and 2014 must comply with the discharge standards as included in the (special) environmental conditions of the environmental permits dd. 31/03/2011 (M03/46003/46/2/A/5/HV/CW) and 10/11/2011 (M03/46003/46/2/W/5/LDR/KVDS). Concentrations in the effluent of the non-nominative parameters listed in the permit and referred to in Annex 2C to Title I of the VLAREM are limited to concentrations listed in the classification criteria listed in the column 'classification criterion DS (dangerous substances)' of Article 3 of Annex 2.3.1 to Title II of the VLAREM or, failing that, to a maximum of 10 times the reporting limit.

Table 2-10 allows for the following conclusions to be drawn for the industrial wastewater in the baseline situation 2013 - 2014:

- For the years 2013 and/or 2014, the discharge standard for nitrite, titanium and AOX is not met:
    - In 2013 and 2014, a study was carried out on the prevention and treatment of nitrite in industrial wastewater. The average nitrite concentration was above the discharge standard in 2013. In 2014, the average concentration was below the discharge standard but still peak concentrations were measured above the discharge standard. Analysis by KCD showed that the nitrite in the industrial wastewater comes from biological growth at the CNI treatment plant. It was investigated what measures could be taken to inhibit biological growth. In order to correct bacterial growth, KCD performed a one-off test with the injection of H_2O_2 into the sumps. Because of the reactivity (clogging filters by loosening dirt) and foam formation, this method was not deemed suitable. At the end of 2014, a request was submitted to change the environmental permit conditions, among other things to adapt the special condition relating to the nitrite content in industrial waste water. The request asked for a daily average standard of 20 mg/L NO_2-N and a sliding annual load of 1,200 kg/year of NO_2-N to be allowed. The request was still pending at the end of 2014.
    - The discharge standard for titanium is 0.1 mg/L. In 2014, there was a one-off measurement of Ti. The concentration was 0.11 mg/L. The cause of exceeding the discharge standard is unknown. No Ti is processed at KCD. This is a one-off incident that was not further investigated. In later years there were no more overruns for Ti.
    - The increased concentrations for AOX are inexplicable as the use of chlorinated products is reduced to a minimum. In addition, no organic products are used or added in the process. Presumably the increased values are measured due to interference by chlorides from the regeneration effluents or due to leakage of cooling water to the industrial wastewater circuit. At the end of 2014, a request was submitted to change the environmental permit conditions, among other things to obtain a special discharge standard for AOX of 400 µg/L. The request was still pending at the end of 2014.
- For the parameters of ammonium, Co, Ag, Tl, V, Be, anionic, non-ionic and cationic surfactants and sodium fluorinate, the measurements are carried out inconsistently for the years 2013 and/or 2014 or the detection limit of the measurements is higher than the discharge standard. As a result, it is not possible to make well-founded statements about the concentrations and reaching discharge standards for these parameters.

The quality of the industrial wastewater for the years 2015 - 2019 was checked as part of this EIR. Concentrations and pollutant loads for the period 2015 - 2019 do not differ significantly from the baseline situation 2013 - 2014 as the operation of KCD has not changed.

Table 2-10 Discharge standards, effluent concentrations and pollutant loads industrial wastewater

	Valid 2013-2014		**2013**				**2014**			
Parameter	**Discharge standard**		**Number of measurements**	**Average (mg/L)**	**Max (mg/L)**	**Total average load (kg/year)***	**Number of measure ments**	**Avera ge (mg/L)**	**Max(m g/L)**	**Total avera ge load (kg/ye ar)***
Flow rate	Max. 700 m³/hour; 3,000 m³/day; 600,000 m³/year		Max. 1,686 m³/day; 235,848 m³/year.				Max. 2,055 m³/day; 225,501 m³/year.			
BOC (mg/L)			8	13.3	41	3137	9	6.3	18	1423
COC (mg/L)	Max. 125	mg/L	11	22.4	57	5283	9	17.9	28	4034
Suspended substances (mg/L)			17	11.5	55	2712	15	9.3	23	2094
Tot P (mg/L)	Max. 2	mg/L	8	0.609	0.930	144	9	0.686	1.2	155
NO2 (N-mg/L)	Max. 6.089	mg N/L	106	6.4	24	1518	68	1.1	6.5	244
NO3 (N-mg/L)			72	5, 2	21	1217	67	5.4	33	1212
Kjld N (N-mg/L)			70	17, 3	63	4069	68	9.3	52	2105
NH4 (N-mg/L)			0	-	-	-	5	13.2	51	2980
Tot N (N-mg/L)	Daily avg: 100 mg/L; sliding annual avg: 27 mg/L; sliding annual load: 7200 kg/year		338	17.9	63.2	4,226	310	11.8	67.8	2,663
B (mg/L)	Max. 7,300	kg/year	54	29.0	370	6842	55	22.5	470	5070
Sb (mg/L)	Max. 0.07	mg/L	3	<0.020	<0.020	-	1	<0.020	<0.020	-
Cd (mg/L)	Max. 0.003	mg/L	9	<0.0001	<0.0001	-	9	<0.0001	<0.0001	-
Cr (mg/L)	Max. 0.15	mg/L	10	<0.010	<0.010	-	9	0.006	0.051	1
Co (mg/L)	Max. 0.006	mg/L	2	<0.010	<0.010	-	1	<0.010	<0.010	-

	Valid 2013-2014		2013				2014			
Parameter	**Discharge standard**		**Number of measurements**	**Average (mg/L)**	**Max (mg/L)**	**Total average load (kg/year)***	**Number of measurements**	**Average (mg/L)**	**Max(mg/L)**	**Total average load (kg/year)***
Cu (mg/L)	Max. 0.2	mg/L	7	0.007	0.047	2	7	<0.025	<0.025	-
Mn (mg/L)	Max. 1	mg/L	4	0.088	0.110	21	2	0.078	0.078	17
Mo (mg/L)	Max. 0.35	mg/L	4	<0.020	<0.020	-	2	<0.020	<0.020	-
Se (mg/L)	Max. 0.03	mg/L	2	<0.005	<0.005	-	1	<0.005	<0.005	-
Sn (mg/L)	Max. 0.04	mg/L	1	<0.04	<0.04	-	1	<0.04	<0.04	-
Zn (mg/L)	Max. 0.8	mg/L	9	0.033	0.064	8	9	0.058	0.120	13
As (mg/L)	Max. 0.05	mg/L	9	0.017	0.028	4	9	0.011	0.030	2
Hg (mg/L)	Max. 0.0005	mg/L	9	<0.0001	<0.0001	-	9	0.000	0.0001	0
Pb (mg/L)	Max. 0.050	mg/L	7	<0.025	<0.025	-	6	<0.025	<0.025	-
Ni (mg/L)	Max. 0.1	mg/L	9	<0.010	<0.010	-	6	0.002	0.011	0
Ag (mg/L)	Max. 0.002	mg/L	7	<0.010	<0.010	-	6	<0.010	<0.010	-
Al (mg/L)			1	<0.100	<0.100	-	1	0.100	0.100	23
Ba (mg/L)	Max. 0.25	mg/L	4	0.026	0.047	6	4	0.032	0.064	7
Fe (mg/L)			2	0.710	1.000	167	1	0.700	0.700	158
Tl (mg/L)	Max. 0.002	mg/L	1	<0.020	<0.020	-	1	<0.020	<0.020	-

	Valid 2013-2014		2013				2014			
Parameter	**Discharge standard**		**Number of measurements**	**Average (mg/L)**	**Max (mg/L)**	**Total average load (kg/year)***	**Number of measurements**	**Average (mg/L)**	**Max(mg/L)**	**Total average load (kg/year)***
Ti (mg/L)	Max. 0.1	mg/L	1	<0.020	<0.020	-	1	0.110	0.110	25
V (mg/L)	Max. 0.005	mg/L	1	<0.010	<0.010	-	1	<0.010	<0.010	-
U (mg/L)	Max. 0.001	mg/L	1	<0.001	<0.001	-	1	<0.001	<0.001	-
W (mg/L)			0	-	-	-	0	-	-	-
Sr (mg/L)			0	-	-	-	0	-	-	-
Be (mg/L)	Max. 0.0001	mg/L	1	<0.005	<0.005	-	1	<0.005	<0.005	-
Te (mg/L)	Max. 0.1	mg/L	1	<0.010	<0.010	-	1	<0.010	<0.010	-
F (mg/L)	Max. 9	mg/L	4	0.465	0.650	110	3	0.393	0.680	89
Cl (mg/L)			4	635	970	149,763	4	392.5	800	88,509
SO4 (mg/L)			4	452.5	810	106,721	4	559.5	1900	126,168
Anion det (mg/L)	Max. 0.1	mg/L	0	-	-	-	1	<0.2	<0.2	-
Cation det (mg/L)	Max. 1	mg/L	0	-	-	-	1	<0.5	<0.5	-
Non-ion det (mg/L)			0	-	-	-	1	<0.5	<0.5	-
S (mg/L)			4	<0.050	<0.050	-	4	<0.050	<0.050	-
Si (mg/L)			0	-	-	-	0	-	-	-

	Valid 2013-2014		2013				2014			
Parameter	**Discharge standard**		**Number of measurements**	**Average (mg/L)**	**Max (mg/L)**	**Total average load (kg/year)***	**Number of measure ments**	**Avera ge (mg/L)**	**Max(m g/L)**	**Total avera ge load (kg/ye ar)***
Sodium fluorinate	Max. 50	mg/L	0	-	-	-	0	-	-	-
AOX µg/L	Max. 4	µg/L	4	52	86	12	6	82.7	170	19
DOC mg/L			4	4.7	7.5	1,097	6	5.2	9.9	1,169
SO3 mg S/l			0	-	-	-	4	<0.05	<0.05	-
CN mg/L	Max. 0.05	mg/L	3	<0.005	<0.005	-	5	0.001	0.005	0
TOC mg/L			1	3.3	3.3	778	0	-	-	-
Chromium (VI) as Cr			4	<0.005	<0.005	-	4	0.004	0.010	1
Conductivity µS/cm							3	3033.333	4600	684,020

Red: exceeding the discharge standard in 2013 and/or 2014 Yellow: no measurements in 2013 and/or 2014 or detection limit of measurement exceeds discharge standard.

*In 2013, approx. 235,847.9 m³ of industrial wastewater was discharged. Approx. 19,786 m³ or 8% of this volume was consumed Scheldt water. The remaining 92% was consumed mains water. As it concerns a negligible volume of Scheldt water, this is not taken into account when calculating the total net pollution load to the Scheldt. In 2014, only mains water was used as process water.

2.2.2.6.2.2.2 Temperature

Discharge conditions

The discharged industrial wastewater in 2013 and 2014 must comply with the environmental conditions of the environmental permits dated 31/03/2011 (M03/46003/46/2/A/5/HV/CW) and 10/11/2011 (M03/46003/46/2/W/5/LDR/KVDS):

The maximum discharge temperature of the industrial wastewater may be 35°C under one of the following conditions:

- at an outside temperature of 25°C or more;
- a cooling water intake temperature of 20°C or more

in so far as the temperature of the receiving surface water as stated in the environmental quality standards is not exceeded (Art. 4.2.2.2.1.4° VLAREM II).

Industrial wastewater temperature

For the baseline situation 2013 - 2014 and the period 2015 - 2019, the continuous temperature measurements of the discharged industrial wastewater at the common K3 discharge point of KCD were evaluated within the framework of this EIR. This evaluation was done together with the evaluation of the continuous temperature measurements of the Scheldt water at the intake point for Doel 3/4. This assessment shows that there are no exceedances of the above mentioned discharge conditions for the temperature of the discharged industrial effluent from KCD. This with the exception of one day at the end of December in 2018 for 2 hours, here the temperature of the industrial wastewater is 36°C, while the intake temperature of the Scheldt water is below 20°C and the outside temperature is below 25°C.

2.2.2.6.3 Cooling water

2.2.2.6.3.1 Flow rate and waste load

The discharged cooling water in 2013 and 2014 must comply with the standards for maximum discharge flow rate and active chlorine content as included in the (special) environmental conditions of the environmental permits dated 31/03/2011 (M03/46003/46/2/A/5/HV/CW) and 10/11/2011 (M03/46003/46/2/W/5/LDR/KVDS). The concentrations in the effluent of the parameters not mentioned by name in the permits shall be limited to the concentrations mentioned in Article 4.2.4.1. of VLAREM II. This means, inter alia, that the discharged cooling water must not contain substances belonging to the families and groups of substances listed in Annex 2C.

in application of Article 4.2.5.1.2 of VLAREM II, the calculation method based on the measured water intake data may be applied for the flow rate measurement of the cooling water.

The chloride load is not measured but calculated on the basis of NaOCl consumption. In 2013, 379,997 kg NaOCl (15%) was used. The calculated chloride load in the cooling water is approx. 27,161 kg. In 2014, 319,420 kg NaOCl (15%) was used. The calculated chloride load in the cooling water is approx. 22,831 kg.

The oxygen content of the discharged cooling water must be at least 4 mg/L and, if lower, at least as high as the oxygen content of the water taken in. The oxygen content of the Scheldt water taken in and the discharged cooling water is continuously monitored by Engie and the measurements for the baseline situation 2013-2014 are shown in Figure 2-15 and Figure 2-16 The oxygen content of the Scheldt water taken in and the discharged cooling water is continuously monitored by Engie and the measurements for the period 2015-2019 are shown in Figure 2-17 through Figure 2-21. As the Scheldt contains a lot of suspended matter, the supply to the measuring device can get clogged up. Microbial activity then leads to oxygen consumption which causes the measurements to go to zero. This frequently leads to errors in measurements, as can be seen on the figures. The imposed standard of 4 mg/L for the discharged cooling water is always respected, without counting the outliers. In the autumn, winter and spring period, the oxygen content of the Scheldt water taken in is equal to or higher than that of the discharged cooling water. During the summer period, the oxygen content of the discharged cooling water is higher than that of the Scheldt water taken in. This phenomenon is probably temperature related.

Table 2-11 allows for the following conclusions to be drawn for the cooling water in the baseline situation 2013 - 2014:

- For the parameters pH, active chlorine and COC, the discharge standards are met for the years 2013-2014. Measurements show that there is no noticeable difference between the COC content of the incoming and outgoing cooling water. This means that no additional COC is discharged via the cooling water. The COC load in the cooling water is not considered relevant.
- In 2014, the AOX group parameter was measured on the incoming and outgoing cooling water. An increase in concentration for the parameter AOX (adsorbable organohalogen compounds found), belonging to the families and groups of substances listed in Annex 2C, is found in the discharged cooling water. It should be noted that this is brackish water that may interfere with the analysis. The measured concentration of AOX was 190 µg/L, which in addition exceeds the classification criterion DS (dangerous substances) of 40 µg/L (Art.3, Annex 2.3.1 VLAREM II). In 2014, a study was performed into the effect of NaOCl on the AOX parameter during possible oxidation of nitrite to nitrate. The conversion of nitrite to nitrate is possible with a considerable excess of NaOCl. The dosage has a striking influence on the AOX formation. In brackish water, mainly bromoform appears to be an important component.
- For the faecal coliforms and total N parameters, the measurements are inconsistent for the years 2013 and/or 2014. As a result, it is not possible to make well-founded statements about effluent concentrations and pollutant loads and meeting discharge standards for these parameters.

The quality of the cooling water for the years 2015 - 2019 was checked as part of this EIR. Concentrations and pollutant loads for the period 2015 - 2019 do not differ significantly from the baseline situation 2013 - 2014 as the operation of KCD has not changed from the baseline situation.

Table 2-11 Discharge standards, effluent concentrations and pollutant loads of cooling water

Parameter	Discharge standard	2013				2014			
		Number of measurements	Average (mg/L)	Max (mg/L)	Total average load (tonnes/year)	Number of measurements	Average (mg/L)	Max (mg/L)	Total average load (tonnes/year)
Flow rate	- K1 (cooling water from Doel 1): max. 44,500 m³/hour in winter (October to April) and max. 56,800 m³/hour in summer (May to September); - K2 (cooling water from Doel 2): max. 44,500 m³/hour in winter and max. 56,800 m³/hour in summer; - K3: max. 171,160 m³/hour in winter and max. 195,760 m³/hour in summer, of which: max. 44,500 m³/hour (w)/56,800 m³/hour (s) from Doel 1; max. 44,500 m³/hour (w)/56,800 m³/hour (s) from Doel 2; max. 40,000 m³/hour + 1,080 m³/hour from Doel 3; max. 40,000 m³/hour + 1,080 m³/hour from Doel 4.	The flow rate is not measured but calculated on the basis of pump capacity and number of operating hours				The flow rate is not measured but calculated on the basis of pump capacity and number of operating hours			
Chlorides (Cl conc is not measured. Cl load is calculated on the basis of NaOCl consumption)		*0*	-	-	*27.161*	*0*	-	-	*22.831*
pH	Between 6.5 and 8.5	12	7.78	8	-	19	7.91	9.1	-

Parameter	Discharge standard	2013				2014			
		Number of measurements	Average (mg/L)	Max (mg/L)	Total average load (tonnes/year)	Number of measurements	Average (mg/L)	Max (mg/L)	Total average load (tonnes/year)
Residual active chlorine (mg/L) discharge point	1 mg/L as instantaneous value 0.2 mg/L as daily average value	4	<0.1	<0.1	-	4	<0.1	-	-
Faecal coliforms/100 mL	No pathogenic germs in the discharged cooling water that would dangerously contaminate the receiving water	0	-	-	-	3	6.33	10	-
Total N (mg/L) cooling water taken in	N/A	Monthly measurements upstream FEA measurement points 159000 and 157000	5	7	-	Monthly measurements upstream FEA measurement points 159000 and 157000	4.2	5.9	-
Total N (mg/L) discharged cooling water	-	3	0.55	1.3		0	-	-	
AOX (mg/L) intake Doel 1	No Annex 2C substances	0	-	-	-	1	0.065	0.065	153.87
AOX (mg/L) intake Doel 3		0	-	-		1	<0.04	<0.04	
AOX (mg/L) discharge point		0	-	-		1	0.19	0.19	
COC (mg/L) cooling water taken in	Difference out - in max. 30 mg/L	Monthly measurements upstream FEA measurement points 159000 and 157000	30	56	-	Monthly measurements upstream FEA measurement points 159000 and 157000	35	81	-

Parameter	Discharge standard	2013				2014			
		Number of measurement s	Average (mg/L)	Max (mg/L)	Total average load (tonnes/year)	Number of measurement s	Average (mg/L)	Max (mg/L)	Total average load (tonnes/year)
COC (mg/L) discharged cooling water		12	33	55		19	33	66	

Red: exceeded the discharge standard in 2013 and/or 2014 Yellow: no measurements in 2013 and/or 2014.

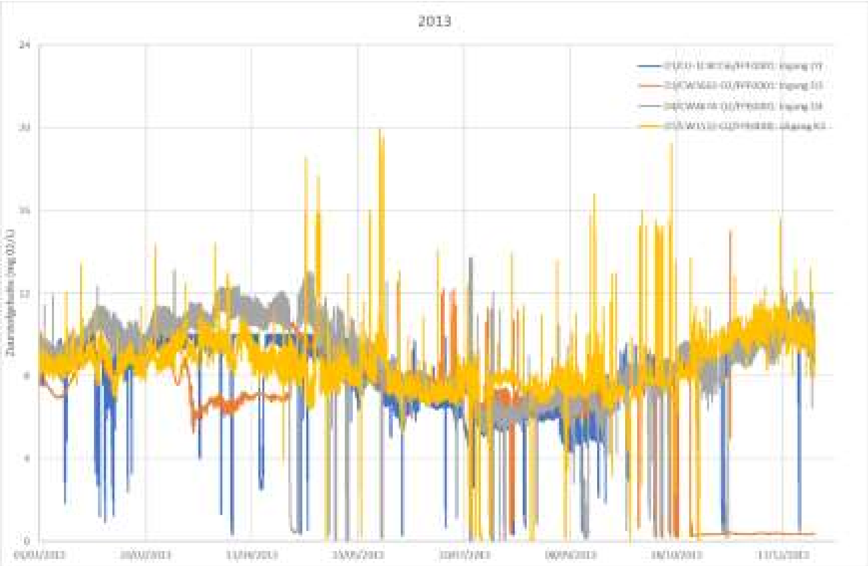


Figure 2-15 Oxygen content (mg O2/L) of the Scheldt water at the intake points of Doel 1, Doel 3 and 4 and of the cooling water at the common discharge point K3 - 2013

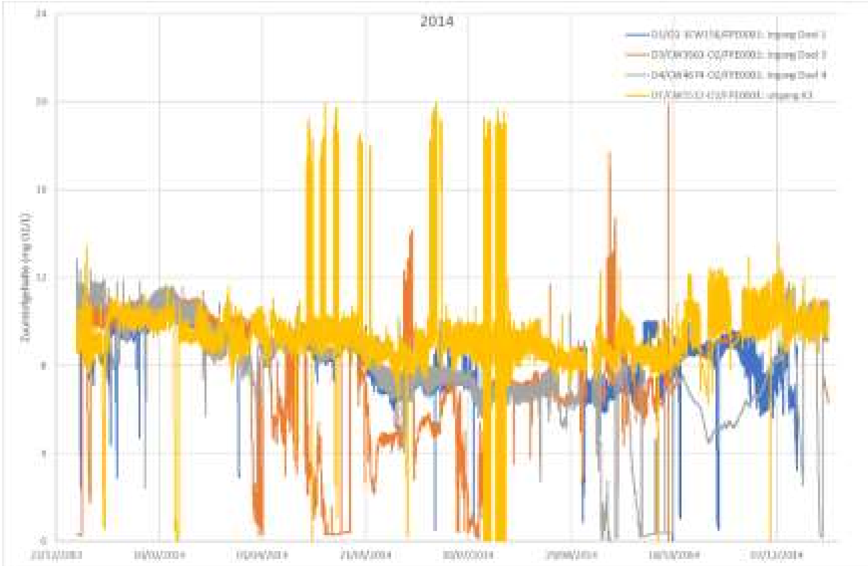


Figure 2-16 Oxygen content (mg O2/L) of the Scheldt water at the intake points of Doel 1, Doel 3 and 4 and of the cooling water at the common discharge point K3 - 2014

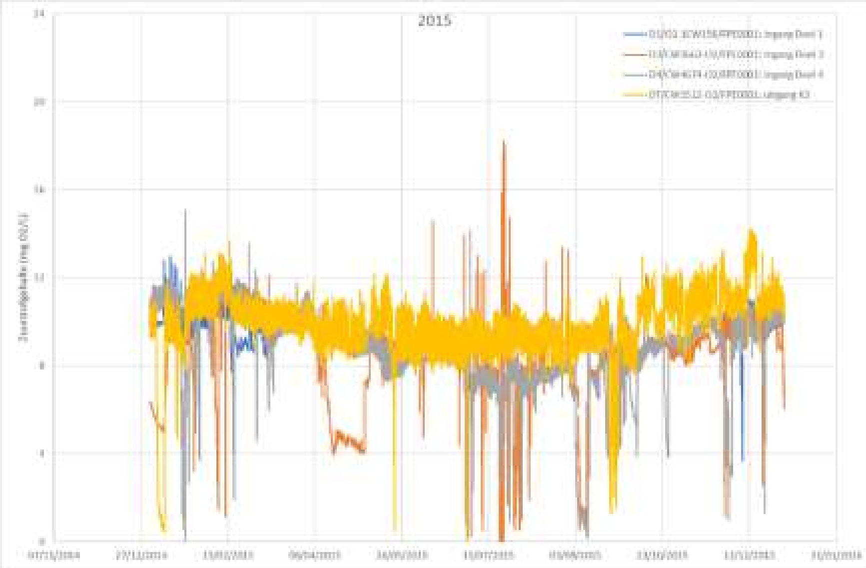


Figure 2-17 Oxygen content (mg O2/L) of the Scheldt water at the intake points of Doel 1, Doel 3 and 4 and of the cooling water at the common discharge point K3 - 2015

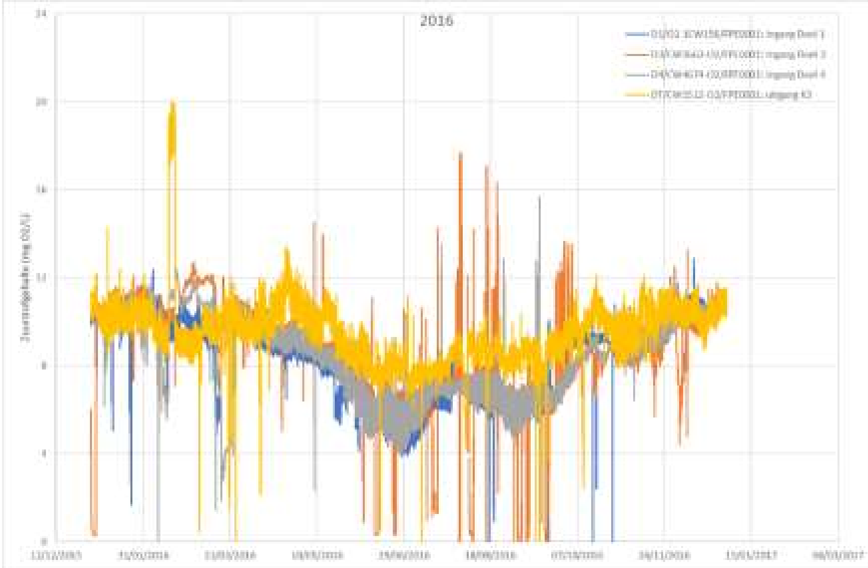


Figure 2-18 Oxygen content (mg O2/L) of the Scheldt water at the intake points of Doel 1, Doel 3 and 4 and of the cooling water at the common discharge point K3 - 2016

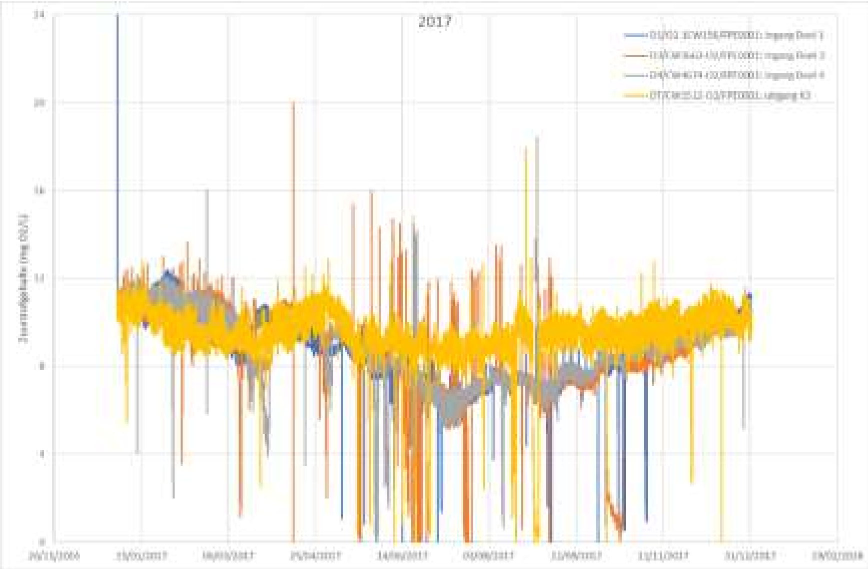


Figure 2-19 Oxygen content (mg O2/L) of the Scheldt water at the intake points of Doel 1, Doel 3 and 4 and of the cooling water at the common discharge point K3 - 2017

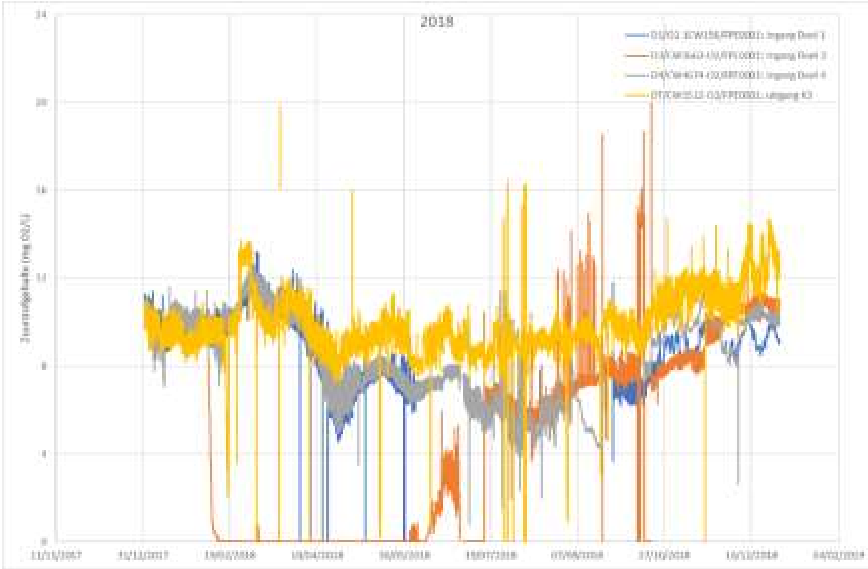


Figure 2-20 Oxygen content (mg O2/L) of the Scheldt water at the intake points of Doel 1, Doel 3 and 4 and of the cooling water at the common discharge point K3 - 2018

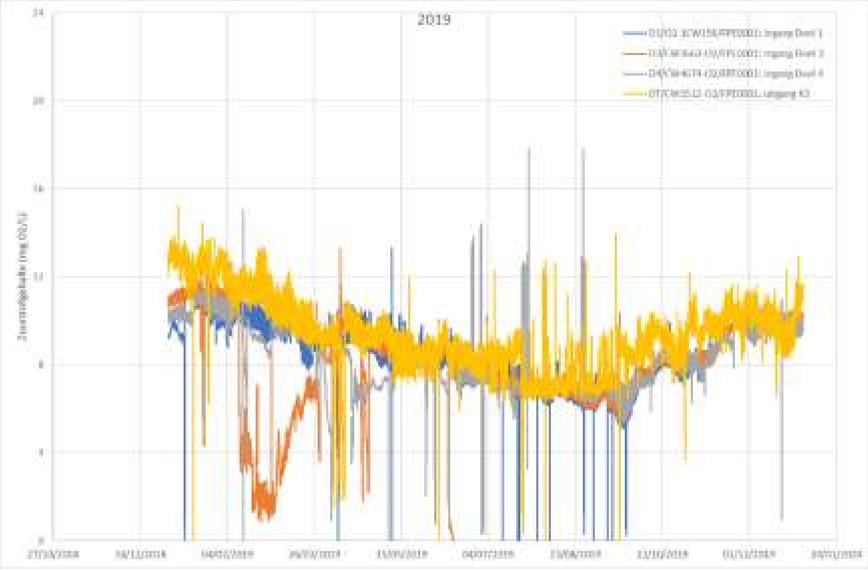


Figure 2-21 Oxygen content (mg O2/L) of the Scheldt water at the intake points of Doel 1, Doel 3 and 4 and of the cooling water at the common discharge point K3 - 2019

2.2.2.6.3.2 Temperature and thermal load cooling water

Discharge conditions

The cooling water discharged in 2013 and 2014 must comply with the temperature standards set out in the sectoral environmental conditions for the discharge of cooling water from power plants in Article 4.2.4.1. of VLAREM II and the special environmental conditions of the environmental permits dated 31/03/2011 (M03/46003/46/2/A/5/HV/CW) and 10/11/2011 (M03/46003/46/2/W/5/LDR/KVDS):

The temperature of the discharged cooling water is subject to the following emission limit values:

- maximum 33 °C as instantaneous value;
- a maximum of 32 °C as the daily average, taking into account the hourly values measured from noon (12 h) of one day to noon (12 h) of the following day;
- maximum 30 °C as a 30-day moving average.

When the maximum discharge temperature is reached on a daily basis, as well as when an average daily temperature of 26°C of the water taken in is reached, the thermal load should be limited, especially at the turn of low to high tide, so that the effects are mitigated. The percentage restriction of the thermal load must be in accordance with the relevant provisions of the VLAREM:

- at an average daily temperature of 26 °C of the water taken in: up to 70 % of the maximum daily thermal load;
- at an average daily temperature of 27 °C of the water taken in: up to 40 % of the maximum daily thermal load;
- at an average daily temperature of 28 °C of the water taken in: up to 10 % of the maximum daily thermal load;

To achieve this, as needed:

- the cooling towers should be used to the maximum and the water from the direct cooling circuits of Doel 1 and Doel 2 should be diverted to the cooling towers;
- the temperature at the common discharge point K3 should be limited as much as possible, by opening the bypass cooling towers.

Cooling water temperature

The continuous temperature measurements of the discharged cooling water at the common K3 discharge point of KCD for the baseline situation 2013 and 2014 are shown in Figure 2-22 and Figure 2-23 respectively. The continuous temperature measurements of the discharged cooling water at the common K3 discharge point of KCD for the period 2015 to 2019 are shown inFigure 2-24 to Figure 2-28 respectively. For the baseline situation 2013 - 2014 and the period 2015 - 2019, the guide values for the instantaneous value, the daily average value and the 30-day average value are met (with the exception of a limited number of temperature sensor outliers).

The temperature impact of the discharged cooling water on the Scheldt for both the baseline situation and the operational phase of the present project is described and assessed in detail in § 2.2.3.1.5.

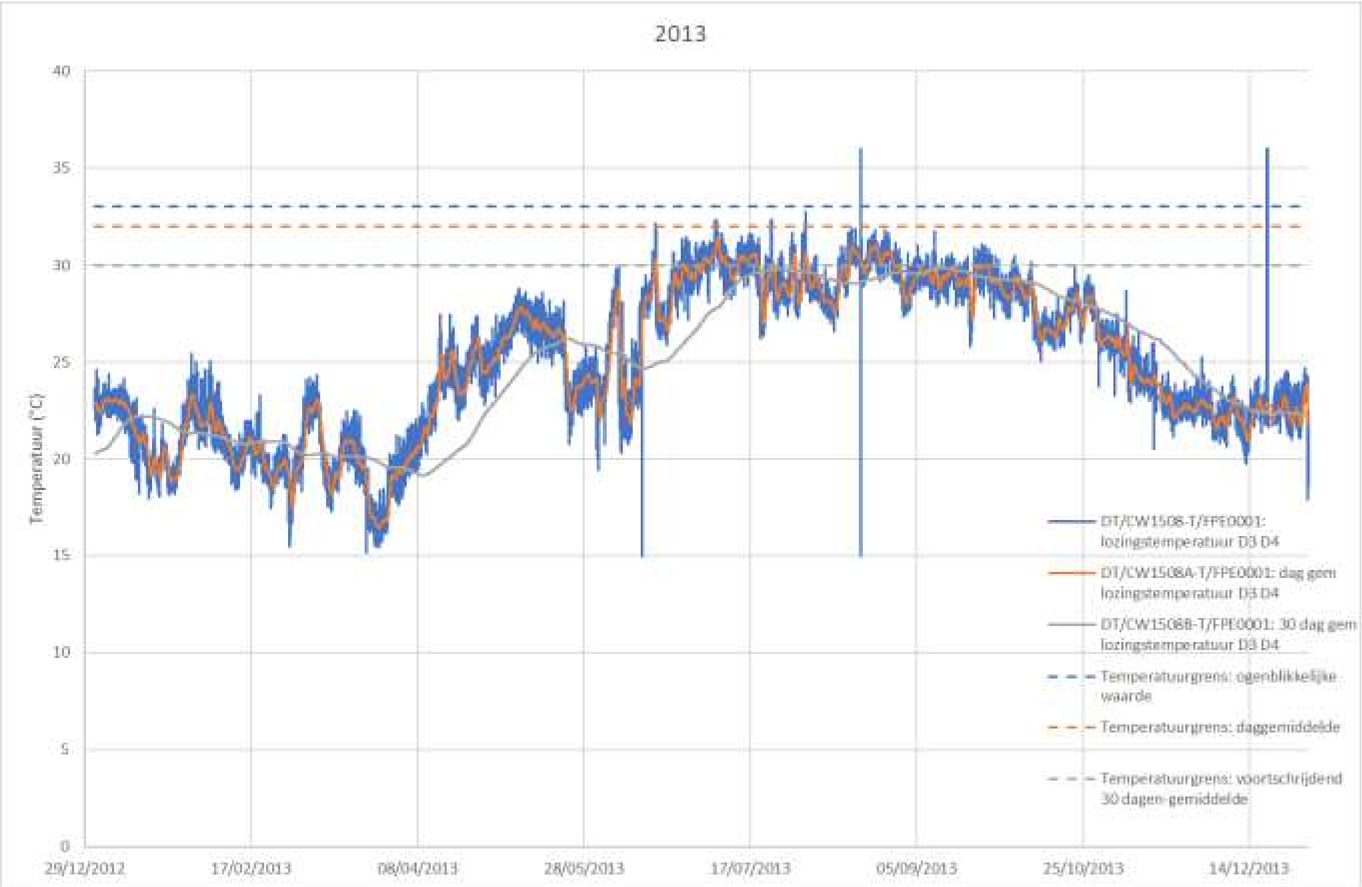


Figure 2-22 Temperature (°C) cooling water at common discharge point K3 - 2013

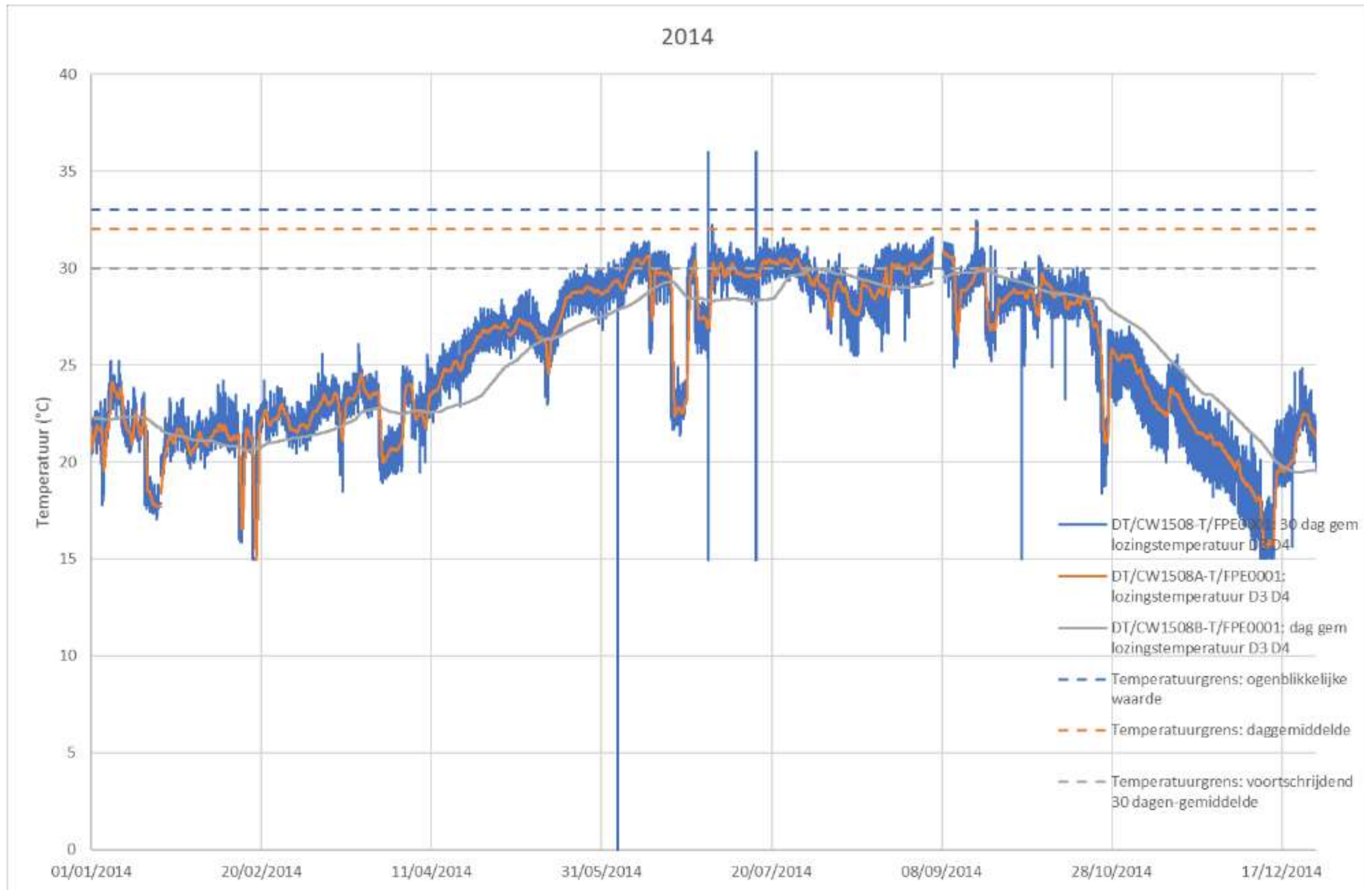


Figure 2-23 Temperature (°C) cooling water at common discharge point K3 - 2014

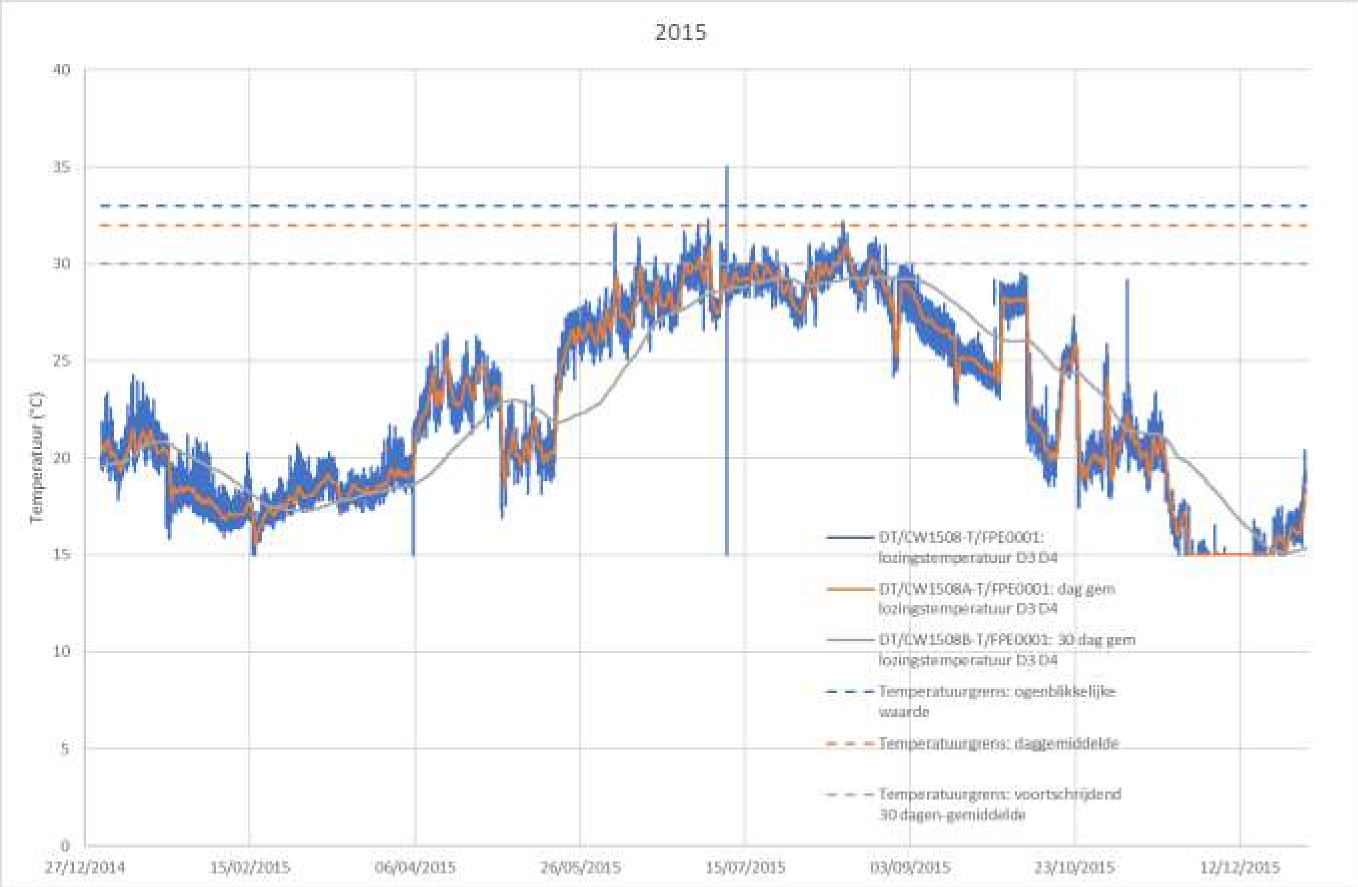


Figure 2-24 Temperature (°C) cooling water at common discharge point K3 - 2015

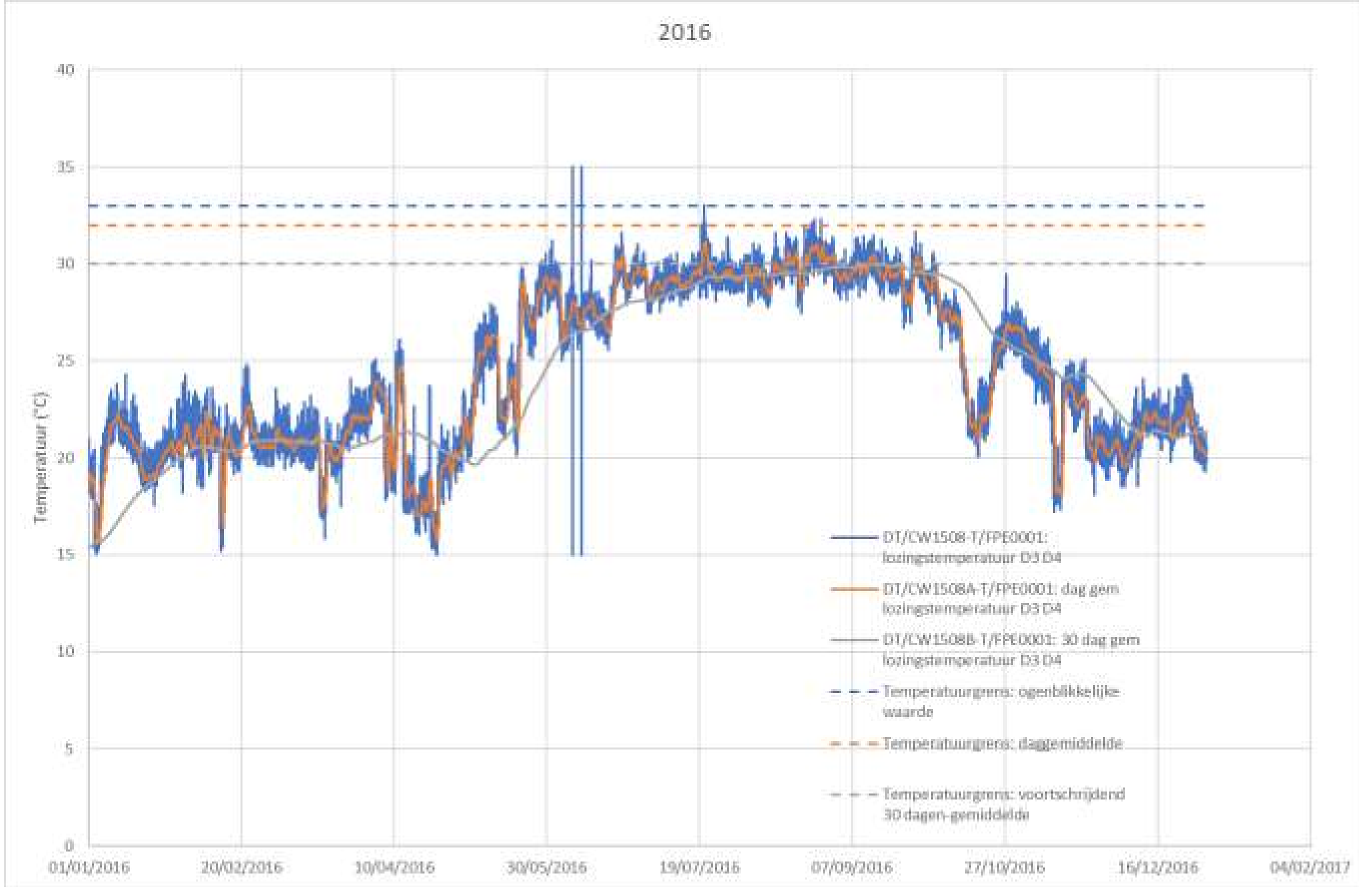


Figure 2-25 Temperature (°C) cooling water at common discharge point K3 - 2016

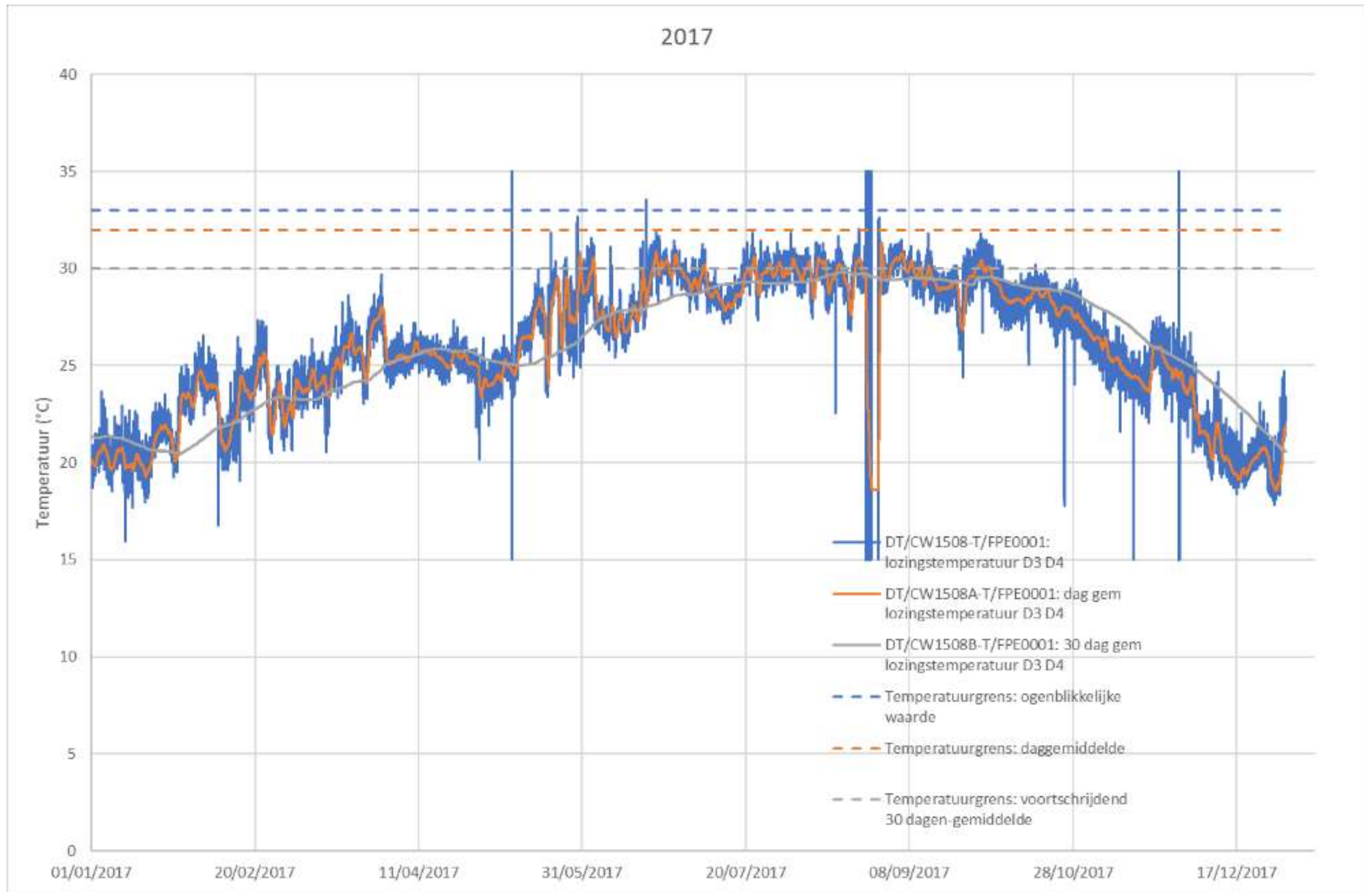


Figure 2-26 Temperature (°C) cooling water at common discharge point K3 - 2017

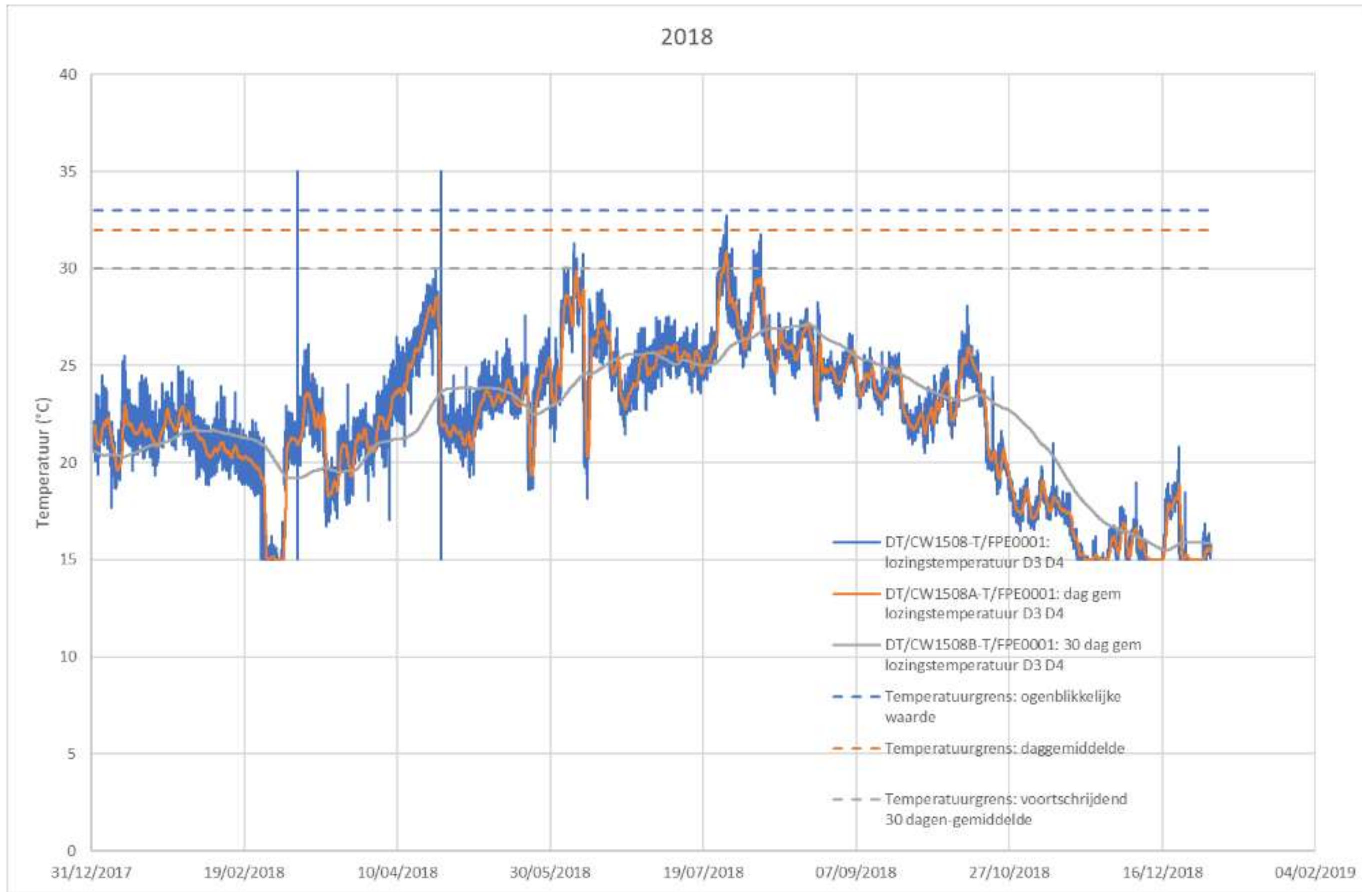


Figure 2-27 Temperature (°C) cooling water at common discharge point K3 - 2018

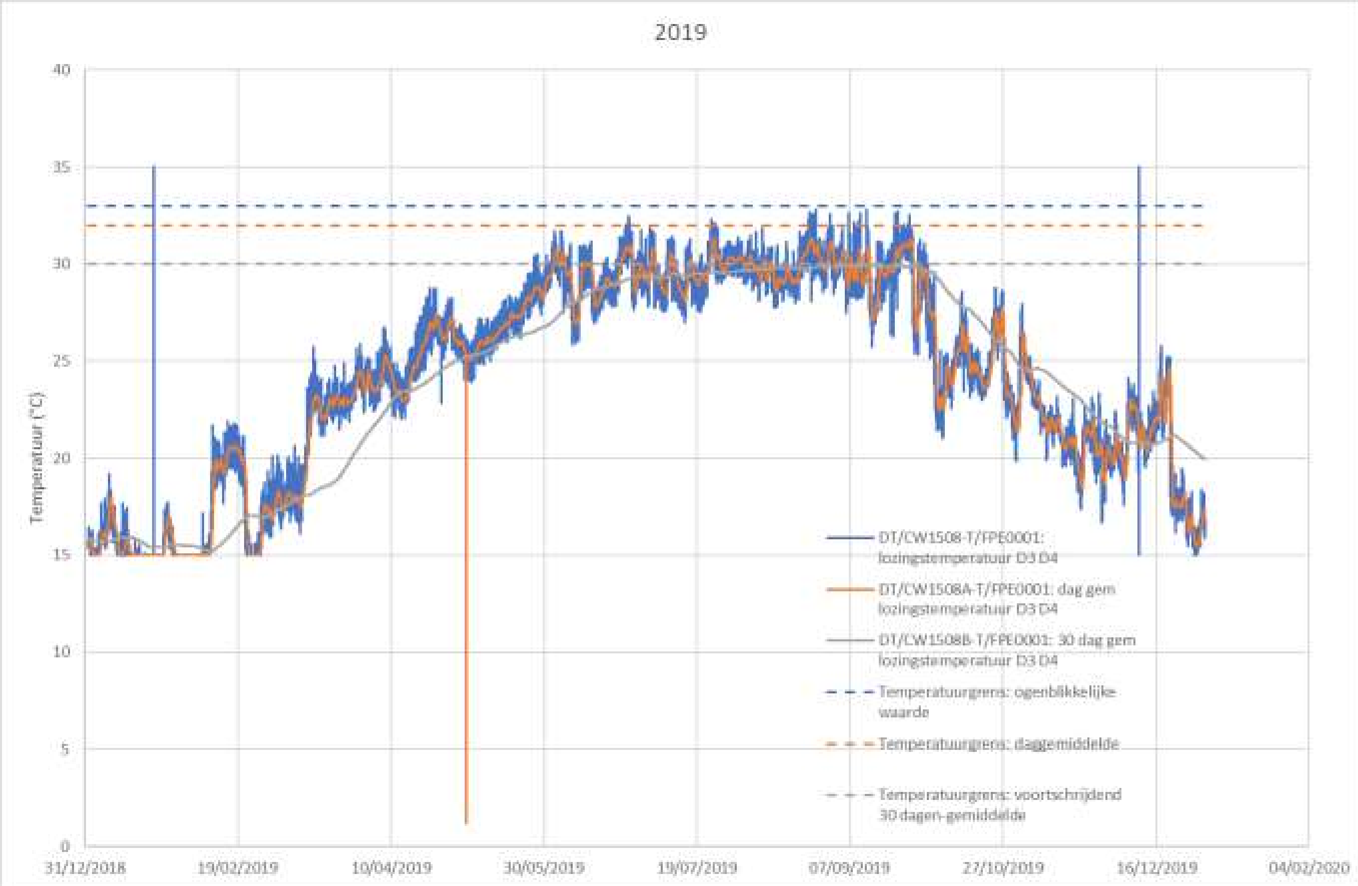


Figure 2-28 Temperature (°C) cooling water at common discharge point K3 - 2019

2.2.3 Impact assessment

2.2.3.1 Operational phase of the project between 2015-2018

2.2.3.1.1 LTO works

For a description of the works carried out in the context of the adjustments for LTO, see the general section of the EIR (see Chapter 1.6). As no drainage work was carried out during the works, no effects are expected for the Water section.

2.2.3.1.2 Water supply / water balance

KCD's environmental permit determines the maximum discharge rates for sanitary and industrial wastewater and cooling water and inherently also the maximum water consumption. The project includes a re-licensing of the existing KCD systems and the water balance for the base years 2013-2014 is considered representative for the production in the following years of the re-licensing period. Therefore, no relevant changes in water consumption and water balance are expected compared to the baseline situation.

2.2.3.1.3 Change in infiltration and discharge characteristics - Water test and climate change

Water test

The water test is one of the general instruments of the Decree on Integrated Water Policy of 18 July 2003, coordinated on 15 June 2018 (Water Code). The main purpose of the water test is to prevent or minimize the occurrence of adverse effects on water systems and, if that is not possible, to restore the adverse effects.

All operations with a potentially harmful effect on water systems that require a permit are subject to the water test. Examples are interventions for which an environmental permit is required and which have an effect on the quality or quantity of surface water or groundwater.

For activities, plans or programmes subject to permits and subject to environmental impact assessment, the analysis of the occurrence or non-occurrence of an adverse effect and the conditions to be imposed to prevent, reduce, restore or offset that effect shall be included in this report.

The water test must be carried out by the government. This chapter provides the necessary elements for the performance of the water test.

KCD's site is located in a zone designated as follows, according to the water testing maps:

- not susceptible to flooding;
- not susceptible to infiltration;
- very sensitive to groundwater flow;
- slopes of 0.5% or 0.5-5%;
- not in a winter bed.

The project includes the re-licensing of KCD's existing installations. Compared to the baseline situation, a limited number of paved surfaces have been added to the KCD site: 70 m² for a new fire department room with tank and 2x104 m² for the filter containment buildings. Also, a temporary paving of 50x50 m was put in for a workshop. Considering the limited amount of additional paved surfaces, there will be no harmful effects due to changes in surface water runoff, structural changes of watercourses, infiltration of rainwater, loss of quality of surface water or groundwater or changes in groundwater flow.

The main impact of KCD on the water system is the discharge of wastewater and cooling water into the Scheldt. The Water Test Decree states that the water test for an application for a permit relating to a discharge into a sewerage system, surface water or groundwater must be carried out in accordance with the assessment scheme set out in Annex V of the Decree. According to this assessment scheme, quality aspects are dealt with in VLAREM I and in the general and sectoral environmental conditions of VLAREM II that apply. For a discussion of the quality aspects, please refer to § 2.2.3.1.2.

In § 2.2.2.5 the frequent operation of the sanitation wastewater collection wells was discussed. In 2013, this well pump system was operational for 18 days and in 2014 this was 14 days. For the period 2015 to 2019, the system was operational between 12 and 46 days. The frequent operation of the sanitary wastewater collection wells is due to leaks of cooling water from the underground galleries and, to a lesser extent, groundwater in the mixed sewer system. These operations can cause peaks of nutrient concentrations in the Scheldt at the level of KCD. This is considered a negative effect (-2) compared to the situation without the operation of KCD. Engie is already taking the following measures:

- Regular inspection of the septic tanks;
- Leak detection and repair of the underground cooling water galleries.

Rainwater is not reused. The rainwater from roofs and most of the paved surfaces is collected in a joint system together with the sanitary wastewater and purified by means of five biorotors. The water from the car parks at the company entrance drains into the nearby Doorloop. Reuse of rainwater for the production of demineralised water, use as cooling water or for sanitary purposes is possible, in principle. In this way, mains water consumption can be reduced. It can also reduce the frequency of pumping the contents of the five rainwater and sanitary waste water collection pits in the event of heavy rainfall. However, the necessary infrastructure for the reuse of rainwater is lacking. The urban planning regulation on rainwater wells, infiltration facilities, buffer facilities and separate discharges of waste water and rainwater does not apply to existing buildings and structures.

Impact of climate change

In order to estimate the effects of this project on the climate or its specific vulnerability to climate change, it is important to first give an overview of the expected climate changes for water, based on different climate scenarios for Belgium[6] and relevant for KCD:

- more periods of intense rain in winter and heavy thunderstorms in summer, increasing the risk of flooding;

[6] Source: klimaat.be

- lower river flow rates in summer (drop by more than 50% by the end of the 21st century) due to declining summer precipitation combined with increased evaporation, leading to risks of water shortages.

Figure 2-29 and Figure 2-30 show that excess rainwater accumulates on the KCD site around certain buildings, both in the current climate and in the future climate in 2050, under FEA's high impact climate scenario (high summer). This is due to precipitation showers with a frequency of 10, 100 and 1000 years. The flooding depth and the area to be flooded are limited both in the current climate and in the future climate in 2050. The increase in the floodable area in the future climate in 2050 compared to the current climate is also limited.

Recommendations
Considering the considerable amount of paved surface of KCD, the frequency and volume of flooding of the collection wells for sanitary waste water from the site to the Scheldt in the baseline situation and in the operational phase 2015-2018, the fact that the environmental quality standards for N, P and COC for the Scheldt are not met in the baseline situation and in the operational phase 2015-2018 and the expected periods of intense rain in winter and heavy thunderstorms and water shortages in summer due to climate change, the Water section recommends examining the feasibility of the following measures at concept level and according to the Best Available Technology:

- Source-specific measure: for new projects, analyse the impact of disconnecting rainwater from sanitary wastewater and the possibilities for reuse of rainwater, infiltration or buffering according to BAT. The climate-scaled showers must be taken into account. The high-impact scenario provides a good frame of reference for making KCD more climate-proof;
- End-of-pipe measure: analysis of the installation of additional collection volume for sanitary waste water according to BAT with the aim of reducing overflow.

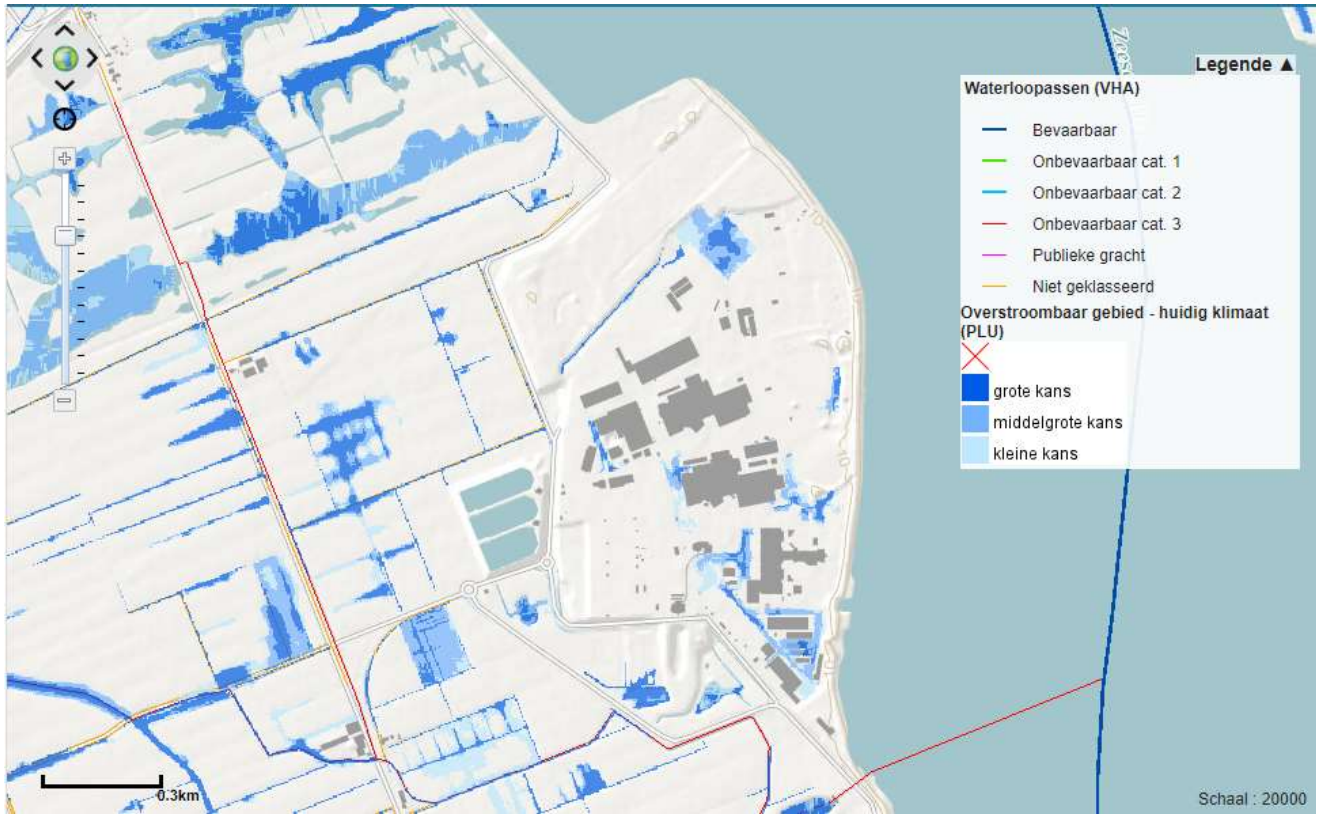


Figure 2-29 Pluvial flood map - floodable area under the current climate. High probability: precipitation with a frequency of 10 years (T10); medium probability: a frequency of 100 years (T100); small probability: a frequency of 1000 years (T1000) (Source: www.waterinfo.be/overstromingsrichtlijn).

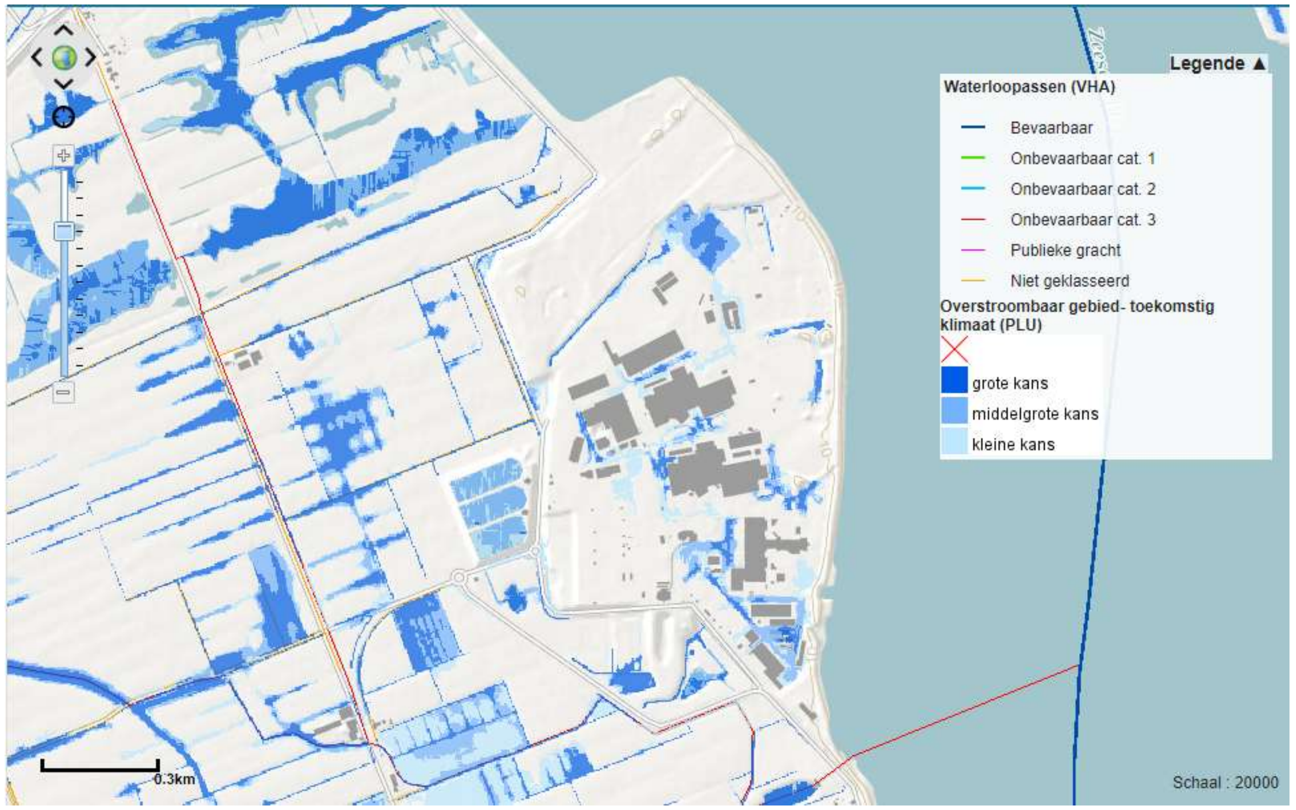


Figure 2-30 Pluvial flood map - floodable area under the high-impact climate scenario (high summer) 2050. High probability: shower with a frequency of 10 years (T10); medium probability: a frequency of 100 years (T100); small probability: a frequency of 1000 years (T1000) (Source: www.waterinfo.be/overstromingsrichtlijn)

2.2.3.1.4 Surface water quality

The waste water from KCD is discharged into the Scheldt.

The flow rate of the Scheldt can vary greatly. High drain levels occur mainly in winter and spring, low drain levels mainly in summer. The actual flow rate of the Scheldt at KCD is strongly determined by the tides (the average tide difference at Antwerp is 5 m) and is therefore difficult to quantify. For the purposes of this EIR, an annual average net flow rate of 70 m^3/s is assumed.

KCD discharge points are located between upstream FEA measurement points 159000 and 157000 and downstream FEA measurement point 154100. As a result of the tidal effect, the loads discharged are mixed upstream and downstream.

The calculated average concentration increase due to the activities of KCD of the pollution load in the Scheldt in the base years 2013-2014 is included in

Table 2-12. The calculation of the concentration increase took into account the total average pollutant load of sanitary wastewater, industrial wastewater and cooling water from KCD, the total net average discharge of KCD and the average net discharge of 70 m^3/s from the Scheldt. The wastewater flows and pollutant loads for the baseline situation 2013-2014 are also representative for the period 2015 - 2019 as the operation of KCD has not changed compared to the baseline situation.

For each parameter, the concentration increase obtained is tested against the environmental quality standard and the effect is assessed according to the significance framework proposed in § 2.2.1.3.

Table 2-12 Calculation of the contribution

				Scheldt avg. conc. FEA measuring points 2013-2014			EQS	Concentration increase	% contribution compared to EQS	Assessment
				Average Scheldt flow rate	70	m³/s				
Parameter	**Unit**	**Average load KCD 2013-2014**	**Unit**	**159000 - upstream**	**157000 - upstream**	**1574100 - downstream**	**Annex 2.3.1 Vlarem II**			
Net discharge rate	m³/year	290002								
	m³/s	0.0092								
Biochemical oxygen consumption after 5d.	kg/year	2524	mgO2/L	0.86	1.66	12.00	6	0.00114	0.02%	negligible:
Chemical oxygen consumption	kg/year	6732	mgO2/L	32.64	43.20	80.00	30	0.00305	0.01%	negligible:
Suspended substances	kg/year	3775	mg/L	109.68	196.20	193.00		0.00171	-	
Orthophosphate	kg/year	57	mgP/L	0.12	0.16	0.16	0.07	0.00003	0.04%	negligible:
Phosphorus, total	kg/year	299	mgP/L	0.48	0.62	0.66		0.00014	-	
Nitrite	kg/year	894	mgN/L	0.01	0.04	0.08	0.2	0.00040	0.20%	negligible:
Nitrate	kg/year	1916	mgN/L	3.57	4.26	4.30		0.00087	-	
Kjeldahl nitrogen	kg/year	3315	mgN/L	1.24	1.66	2.00		0.00150	-	
Ammonium	kg/year	3197	mgN/L	0.12	0.31	0.65		0.00145	-	
Nitrogen, total	kg/year	4837	mgN/L	4.84	5.86	5.70		0.00219	-	
Nitrate + nitrite + ammonium	kg/year	4408	mgN/L	3.70	4.59	4.99	0.49	0.00200	0.41%	negligible:
Boron, dissolved	kg/year	5957	µg/L	528.80	1220.00	1600.00	700	0.00270	0.00%	negligible:
Antimony, dissolved	kg/year	-	µg/L	0.79	1.10	1.08	100	-	-	
Cadmium, dissolved	kg/year	0.003	µg/L	0.08	0.15	0.15	0.2	0.00000	0.00%	negligible:
Chrome, dissolved	kg/year	1	µg/L	0.48	0.50	0.50	5	0.00000	0.00%	negligible:
Cobalt, dissolved	kg/year	-	µg/L	0.40	0.85	0.63	0.5	-	-	
Copper, dissolved	kg/year	1	µg/L	1.95	2.00	6.00	7	0.00000	0.00%	negligible:

				Scheldt avg. conc. FEA measuring points 2013-2014			EQS	Concentration increase	% contribution compared to EQS	Assessment
				Average Scheldt flow rate	70	m³/s				
Parameter	**Unit**	**Average load KCD 2013-2014**	**Unit**	**159000 - upstream**	**157000 - upstream**	**1574100 - downstream**	**Annex 2.3.1 Vlarem II**			
Manganese, dissolved	kg/year	22	µg/L	24.52	81.00	30.00		0.00001	-	
Molybdenum, dissolved	kg/year	-	µg/L	3.94	6.26	6.90	340	-	-	
Selenium, dissolved	kg/year	-	µg/L	1.01	1.00	2.30	2	-	-	
Tin, dissolved	kg/year	-	µg/L	0.50	0.50	0.50	3	-	-	
Zinc, dissolved	kg/year	14	µg/L	7.06	16.60	15.00	20	0.00001	0.00%	negligible :
Arsenic, dissolved	kg/year	4	µg/L	3.00	4.42	4.50	3	0.00000	0.00%	negligible :
Mercury, dissolved	kg/year	0.006	µg/L	0.01	0.01	0.01	0.05	0.00000	0.00%	negligible :
Lead, dissolved	kg/year	0.201	µg/L	0.29	0.25	0.50	1.3	0.00000	0.00%	negligible :
Nickel, dissolved	kg/year	0.262	µg/L	1.92	2.00	2.00	8.6	0.00000	0.00%	negligible :
Silver, dissolved	kg/year	-	µg/L	0.07	0.08	0.08	0.08	-	-	
Aluminium, dissolved	kg/year	16		-	-	-		0.00001	-	
Barium, dissolved	kg/year	7	µg/L	33.32	45.20	50.00	60	0.00000	0.00%	negligible :
Iron, dissolved	kg/year	181		-	-	-		0.00008	-	
Thallium, dissolved	kg/year	-	µg/L	0.48	0.50	0.50	0.2	-	-	
Titanium, dissolved	kg/year	13	µg/L	0.52	0.50	1.00	20	0.00001	0.00%	negligible :
Vanadium, dissolved	kg/year	-	µg/L	3.01	4.86	4.90	4	-	-	
Uranium, dissolved	kg/year	-	µg/L	1.09	1.62	1.85	1	-	-	
Tungsten, dissolved	kg/year	-		-	-	-		-	-	
Strontium, dissolved	kg/year	-		-	-	-		-	-	
Berylium, dissolved	kg/year	-	µg/L	0.19	0.20	0.20	0.08	-	-	

				Scheldt avg. conc. FEA measuring points 2013-2014			EQS	Concentration increase	% contribution compared to EQS	Assessment
				Average Scheldt flow rate	70	m³/s				
Parameter	**Unit**	**Average load KCD 2013-2014**	**Unit**	**159000 - upstream**	**157000 - upstream**	**1574100 - downstream**	**Annex 2.3.1 Vlarem II**			
Tellurium, dissolved	kg/year	-	µg/L	0.48	0.50	0.50	100	-	-	
Fluoride, dissolved	kg/year	108	µg/L	-	-	-	900	0.00005	0.00%	negligible :
Chloride	kg/year	144132	mg/L	2289.60	5120.00	7300.00		0.06528	-	
Sulphate	kg/year	116445	mg/L	375.36	720.00	1000.00		0.05274	-	
Magnesium, dissolved	kg/year	-		46520.00	282000.00	450000.00		-	-	
Silicon, dissolved	kg/year	-		4700.00	7160.00	8000.00		-	-	
AOX	kg/year	76954	µg/L	-	-	-	40	0.03486	0.09%	negligible :
Cyanides, total	kg/year	0.226	µg/L	0.22	0.00	0.70	50	0.00000	0.00%	negligible :

Yellow: no measurements in 2013 and 2014 or detection limit of the measurement is higher than discharge standard, so no contribution calculation can be done.

Table 2-11 shows that for all parameters, the contribution to the EQS is less than 0.1% and a negligible impact is expected (0), compared to the situation without operation of KCD.

On average, a negligible contribution (less than 0.1%) is calculated for the nutrient parameters nitrate+nitrite+ammonium and orthophosphate. In § 2.2.2.5 the frequent operation of the sanitation wastewater collection wells was discussed. In 2013, this well pump system was operational for 18 days and in 2014 this was 14 days. For the period 2015 to 2019, the system was operational between 12 and 46 days. The frequent operation of the sanitary wastewater collection wells is due to leaks of cooling water from the underground galleries and, to a lesser extent, groundwater in the mixed sewer system. These operations can create peaks of nutrient concentrations in the Scheldt at the level of KCD, in the area within the breakwater. This is considered a negative effect (-2) compared to the situation without the operation of KCD.

In order to reduce the overflow of sanitary wastewater from KCD, recommendations for analyses, according to the BAT into the construction of a separate sewerage system for rainwater and sanitary wastewater and research according to the BAT into the installation of an additional collection volume for sanitary wastewater were made in § 2.2.3.1.3.

Change in nitrite standard

The contribution for nitrite compared to the EQS is less than 0.1%, so a negligible impact is expected (<1%), compared to the situation without operation of KCD. The company was authorised in 2013 and 2014 for a discharge standard for nitrite of 20 mg/L until 31 December 2014, thereafter reduced to 2 mg/L. The average nitrite concentration was above the discharge standard in 2013. In 2014, the average concentration was below the discharge standard but still peak concentrations were measured above the discharge standard. In 2013 and 2014 a study was carried out on the prevention and treatment of nitrite in industrial wastewater. Research by KCD showed that the nitrite in the industrial wastewater comes from biological growth at the CNI treatment plant, where ammonium and/or nitrate is converted into nitrite. It was investigated what measures could be taken to inhibit biological growth. In order to correct bacterial growth, KCD performed a one-off test with the injection of H_2O_2 into the sumps. Because of the reactivity (clogging filters by loosening dirt) and foam formation, this method was not deemed suitable. At the end of 2014, a request was submitted to change the environmental permit conditions, among other things to adapt the special condition relating to the nitrite content in industrial waste water. The request asked for a daily average standard of 20 mg/L NO_2-N and a sliding annual load of 1,200 kg/year of NO_2-N to be allowed.

In the subsequent decision dated 09/04/2015 (M03/46003/46/2/W/6/LDR/FV), the standard for nitrites was replaced by 20 mg N-NO2/L until 31 December 2017 and 2 mg N-NO2/L from 1 January 2018. To this the following condition was added:

For nitrite, the company should continue to carry out research into:

- the route along which the microbial conversion takes place;
- the causes of increased nitrogen concentrations that are (discontinuously) released from certain units or during certain operations;
- (optionally) the feasibility of the ELONITA process.

An interim report on the state of affairs of this study, as well as on the effectiveness of the planned shock dosing with H_2O_2 towards the attainment of the temporary standard of 20 mg NO2-N/L should be submitted to the LNE Environmental Licences Division, the experts, the environmental officer of the municipality and the FEA by 31 December 2016.

An interim report was drawn up by Engie (Study into the origin of nitrite in industrial wastewater, ref. 10010675123/000/, dated 08/03/2017) on nitrite analysis. Batch discharges of industrial waste water were additionally analysed for nitrites, starting in 2013. The conclusion of this interim report was:

- The nitrite present in the waste water is formed at the Secondary Discharge Building (CNI) by the conversion of ammonium because of the biology present;
- The presence of ammonium is a prerequisite for the formation of nitrites. However, there is no correlation between the concentration of ammonium and nitrite;
- The ammonium present comes from discharges of process water from the secondary circuits. The majority comes from the Doel 3 unit. The main source of the ammonium present is malfunctioning of the processing system (by reverse osmosis) for the effluents from the vacuum pumps of Doel 3. This causes a buffer tank for collecting the condensates from these vacuum pumps to overflow. Another contribution is the gasket leak from these vacuum pumps.

Limiting the ammonium load to the CNI would reduce the risk of nitrites being formed, but it is possible that the remaining ammonium will be completely converted to nitrite. The conclusion of this report was confirmed in a study by Sweco (Justification for change of standard for nitrite, ref. 0546-0182, dated 01/12/2017). In addition to analysing the cause of nitrite formation, this study also investigated end-of-pipe solutions. The report showed that the disadvantages of an end-of-pipe solution outweigh the advantages and that the feasibility is questionable. This study was attached to a request for changing the standard for nitrite. In the subsequent decision dated 07/02/2019 (2018122825) the standard for nitrites was replaced by 8 mg N-NO2/L until 31 December 2021 and 2 mg N-NO2/L from 1 January 2022. To this the following condition was added:

- *A control program is implemented with actions to avoid overflow of the vacuum condensate collection tank;*
- *Further research is carried out to reduce the hydraulic retention time in the CNI system;*
- *The operator must draw up an interim evaluation report in order to indicate the progress of the study and the elaboration of the source-based measures (control programme and further investigation of the hydraulic retention time) and to demonstrate the impact on the final discharge quality; this report will be submitted to the Ecological Surveillance Division of the Flemish Environmental Agency and the GOP (Environment) Division of the Environment Department by 31 December 2019.*

Engie drew up an interim evaluation report for nitrites (Interim evaluation report nitrites KCD, ref. 10010933709, dated 03/12/2019). The following source-based measures were introduced in the period 2016-2018:

- Discharge to neutralisation tank of the overflow of the vacuum condensate collection tank;
- Collection of sealing water from vacuum pumps D3;

- Replacing the buffer tank of the CNI system (less dead volume; shorter time in the system);
- Repairs of leaks in the cooling circuits of the vacuum pumps;
- The removal of the concentrate from the reverse osmosis plant used to take place on demand when the tank was full. This was changed to a weekly emptying of the storage. This avoids the risk of downtime due to full tanks.

By implementing these measures aimed at the source, the standard of 8 mg N-NO2/L can be respected. The future norm of 2 mg N-NO2/L is sporadically exceeded but the concentration is on average below the norm.

Change of the AOX standard
The contribution for AOX compared to the EQS is less than 0.1%, so a negligible impact is expected (<1%), compared to the situation without operation of KCD. Increased concentrations of AOX were measured in the sanitary and industrial waste water and in the cooling water, which is why this parameter is described separately.

NaOCl is added to the cooling water as a conditioning agent to prevent growths in the cooling system. This can cause AOX. In brackish water, mainly bromoform appears to be an important component.

Presumably the increased values for AOX in the industrial waste water are measured due to interference by chlorides from the regeneration effluents or due to leakage of cooling water to the industrial wastewater circuit. In 2014, a study was performed into the effect of NaOCl during possible oxidation of nitrite to nitrate. The formation of AOX was also investigated. The conversion of nitrite to nitrate is possible with a considerable excess of NaOCl. The dosage appears a striking influence on the AOX formation.

At the end of 2014, a request was submitted to change the environmental permit conditions, among other things to obtain a special discharge standard for AOX of 400 µg/L. This discharge standard was accepted in the decision dated 09/04/2015 (M03/46003/46/2/W/6/LDR/FV).

An optimum conditioning regime can reduce the amount of NaOCl used and the period during which conditioning must be applied, ultimately leading to a reduction in emissions of organohalogens via cooling systems to surface water on an annual basis. Excessive dosing can be caused by sub-optimal process control, but also by process leaks. Policies should be aimed primarily at reducing the use of NaOCl (Berbee, 1997).

In addition to all kinds of chemical reactions, process aspects also appear to be very important. Practice shows that with comparable cooling water, if the water stays in the cooling system longer, this may require more chlorine to be dosed at the inlet (Berbee, 1997).

By far the most important parameter appears to be the use of active chlorine. By regulating this consumption properly, it is possible to minimise the environmental impact (Berbee, 1997). Currently, the dosing of NaOCl at KCD is based on the analysis of the excess active chlorine and experience with the cooling speed gasket. Any additional doses are based on the control of biological growth on sample plates in the cooling towers and weight measurements of the gasket. No active chlorine above the detection limit is found in the discharged cooling water (<100 µg/L). To monitor active chlorine in cooling water based on the shock dosage of NaOCl, it is recommended to perform the monitoring of active chlorine with an online measuring sensor, with a detection limit up to approx. 10 µg/L (instead of 100 µg/L in the existing condition). This in order to be able to refine the control of the dosage of NaOCl with the aim of a lower NaOCl consumption, lower active chlorine levels in the discharged cooling water and less AOX formation.

2.2.3.1.5 Thermal impact of the discharge of cooling water

The environmental quality standards cf. Annex 2.3.1 of VLAREM II on temperatures determining good ecological and chemical status for the Scheldt at the level of KCD (type "Transitional water - brackish macrotidal lowland estuary" (O1b)):

- Max temperature: 25°C;
- Impact thermal discharge: max. + 3 °C.

In the 2010 EIR for the re-granting of KCD's environmental permit, the impact of the cooling water discharge on the temperature of the Scheldt was described and assessed by applying the CORMIX model. The EIR then proposed to carry out a monitoring of the temperature of the Scheldt at the Doel plate, in order to verify the evolution of the temperature during the tidal cycle, in particular during low tide turnaround, and to validate the CORMIX model. In the permit decision for the further licensing of KCD (dated 31/03/2011, M03/46003/46/2/A/5/HV/CW), this Recommendation has been followed and it has been included that a monitoring programme should be carried out to assess the influence of the cooling water of the nuclear power plant on the Scheldt and to further validate and specify the model results.

In 2012 Arcadis, commissioned by Engie, carried out 5 monitoring campaigns to meet this requirement. The monitoring campaigns were carried out in accordance with the monitoring programme drawn up on 24 May 2011, in accordance with the 'proposal for further monitoring' included in the report of monitoring campaigns 1 and 2 (dated 05/09/2011) and in accordance with the comments and proposals made by the competent authorities indicated before the start of the 1st monitoring campaign and at the consultation of 12 September 2011. The full report on the results of the monitoring campaign is attached in Annex B.

The 5 monitoring campaigns were carried out in the period June 2011 - March 2012 where temperature and oxygen content were measured at two depths in relation to the water surface in and around the discharge plume under various tidal conditions, particularly during low tide turnaround. Knowing about this evolution is especially desirable at the highest Scheldt temperatures in warm periods. To this end, the monitoring campaigns were carried out in the different seasons. The 5 monitoring campaigns took place each time all units were in service, at an average discharge rate of 195,760 m^3/h. This flow rate and the resulting thermal load is representative for both the initial situation and the operational phase 2015-2018 of the present project.

The measurements show no oxygen depletion of the Scheldt water due to the discharge of warm cooling water, rather a slight enrichment (when the cooling water flows through the cooling process, the water is strongly aerated). The results of the oxygen measurements are not discussed in detail in the report.

Determination of temperature measurements

Below, the observations for the temperature measurements are discussed per period in the tidal cycle:

- Outgoing water:
  - With outgoing water, a plume forms in the zone within the breakwater, whereby the temperature decreases over the distance from the discharge point.
  - In the zone up to 200 to 300 m from the point of discharge, the temperature remains virtually the same as the discharge temperature.
  - At the end of the breakwater, at a distance of approximately 1300 m downstream of the discharge point, the temperature increase (ΔT) is approximately 1 °C.
  - In the period after high tide, the breakwater remains under water for a long time, which theoretically allows the cooling water to spread over the entire width and depth of the Scheldt, and the cooling water is constantly mixed with fresh and cool Scheldt water from upstream. The zone with perceptible temperature increase is thus limited to a cone within the breakwater (shaded zone in Figure 2-31).

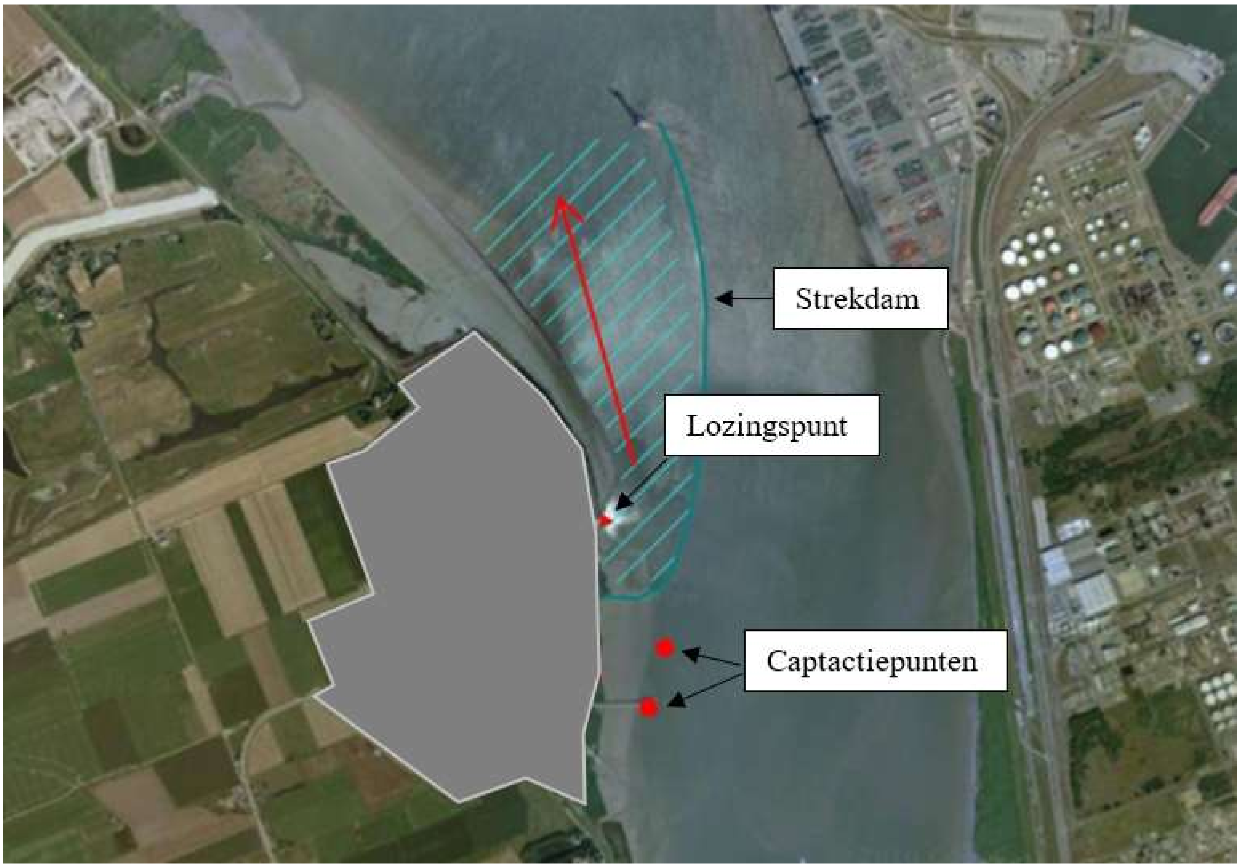


Figure 2-31 Zone with perceptible temperature increase (>1°C) at outgoing water, underwater breakwater

  - From the moment the breakwater rises above the surface of the water (approx. 1.5 hours before turnaround) there will be no more flow of fresh, cool Scheldt water from upstream to the zone within the breakwater, and no further spread downstream over the entire width and depth of the Scheldt. The zone with perceptible temperature increase is then defined as the entire area within the breakwater (shaded zone in Figure 2-32).

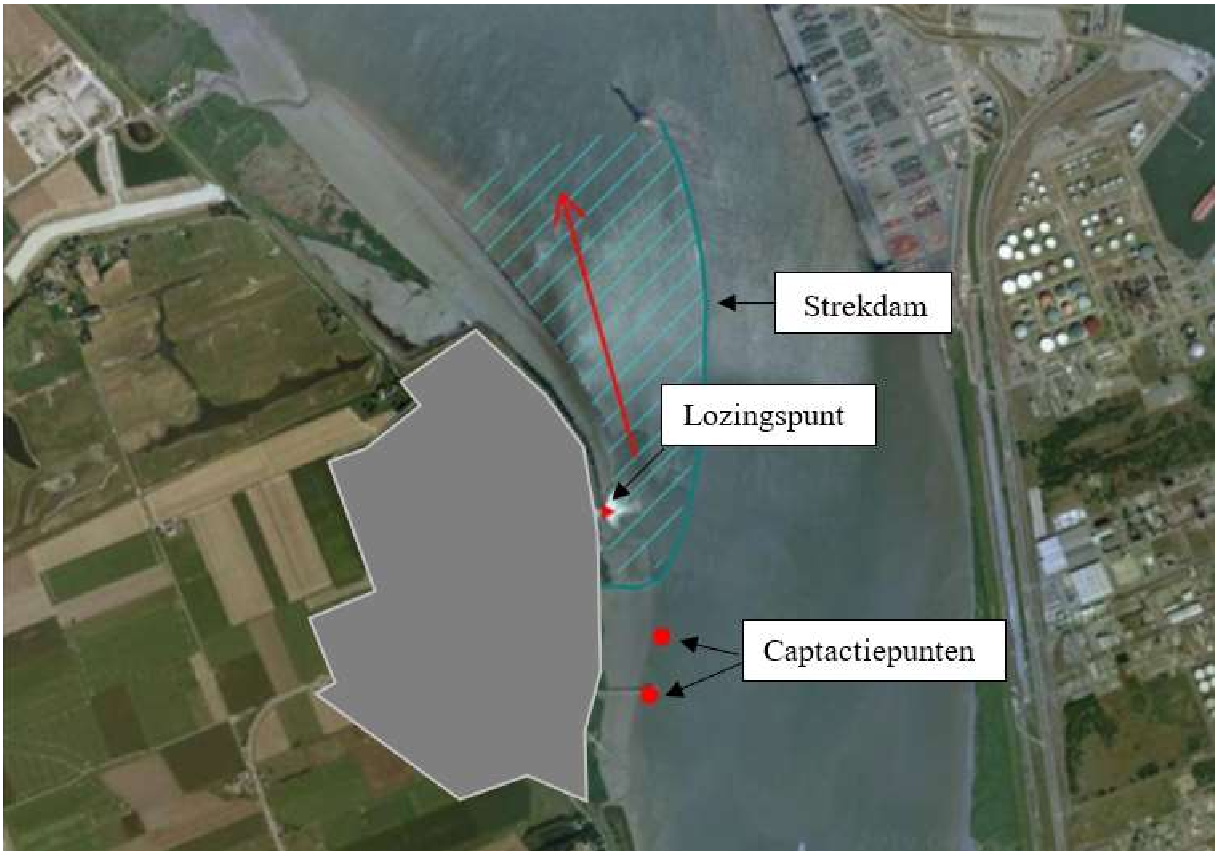


Figure 2-32 Zone with perceptible temperature increase (>1°C) at outgoing water, above water breakwater

- A clear thermal stratification is noticeable, with the warmer, less dense cooling water floating on the surface. The temperature difference between the water at the surface and the water at greater depths decreases with increasing distance to the discharge point.
- At a depth of 2 to 2.5 m, a strong temperature increase can only be observed close to the discharge point (< 300 m). In this area there is a good vertical mixing due to the turbulence caused by the influx of cooling water, the low water depth and the erratic morphology. There is probably a deeper zone at the discharge point, followed a little further downstream by a dune.

- Turn around at low tide:
  - At low tide, the cooling water accumulates within the breakwater, causing the temperature in this area to rise. The temperature decreases as one moves further away from the point of discharge.
  - At a distance of 400 to 500 m downstream from the point of discharge, the temperature increase (ΔT) of the Scheldt water during the surface turnaround is on average 10 to 12°C (for a ΔT at a discharge of 11 to 16°C); at a depth of 2 to 2.5 m, it is on average 6 to 7°C. The temperature increase on the surface remains higher than 5°C up to a distance of approx. 850 m. At a depth of 2 to 2.5 m, ΔT is limited to approx. 3°C at a distance of 800 m. At a distance of 1250 m downstream from the point of discharge, ΔT is 0.5 to 1°C.
  - The highest water temperatures at both the intake of cooling water and downstream of the discharge point appear to occur during the 2nd monitoring campaign in the summer

(02/08/2011). During this monitoring campaign, the average temperature of the Scheldt at intake of KCD was approx. 19.8°C. For the downstream temperatures of the discharge point, the following appears:

- Up to approx. 800 m downstream from the point of discharge, the surface water temperature (up to a depth of 0.5 m) can exceed 25°C at the turn of the low water tide.
- For water temperatures between 2 and 2.5 m deep, the temperature at the turn of the low water tide can exceed 25°C up to approx. 450 m downstream of the discharge point.

- Rising water:
  - When the water rises, the discharge plume located within the breakwater is gradually pushed back towards the discharge point.
  - As the water level rises again, the breakwater is submerged again. The freshly discharged cooling water and accumulated water within the breakwater is pushed out and flows upstream across the width of the dam.
  - Within the breakwater, an increase in temperature is barely measurable over time.
  - Upstream, outside the breakwater, the impact zone is limited in size; a cloud appears to form south of the discharge point → the cooling water is more or less short-circuited between the discharge point and the intakes (shaded zone in Figure 2-33).
  - The impact zone for rising water is measurable up to a maximum of 500 m from the discharge point in an easterly direction and extends up to a maximum of 800 m upstream of the discharge point (southern direction). Within this zone, the temperature increase is 1 to 3°C; exceptionally a higher ΔT was measured (maximum 6°C).

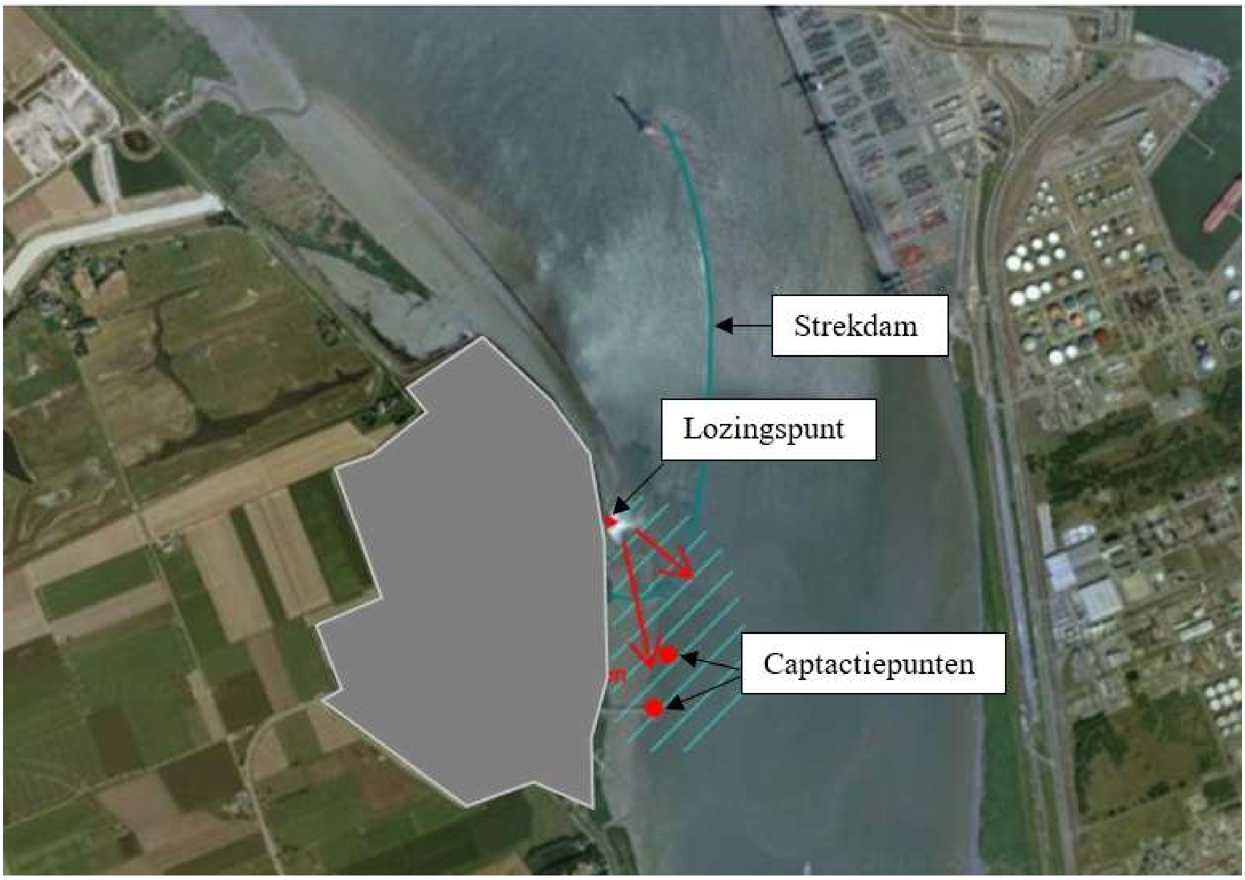
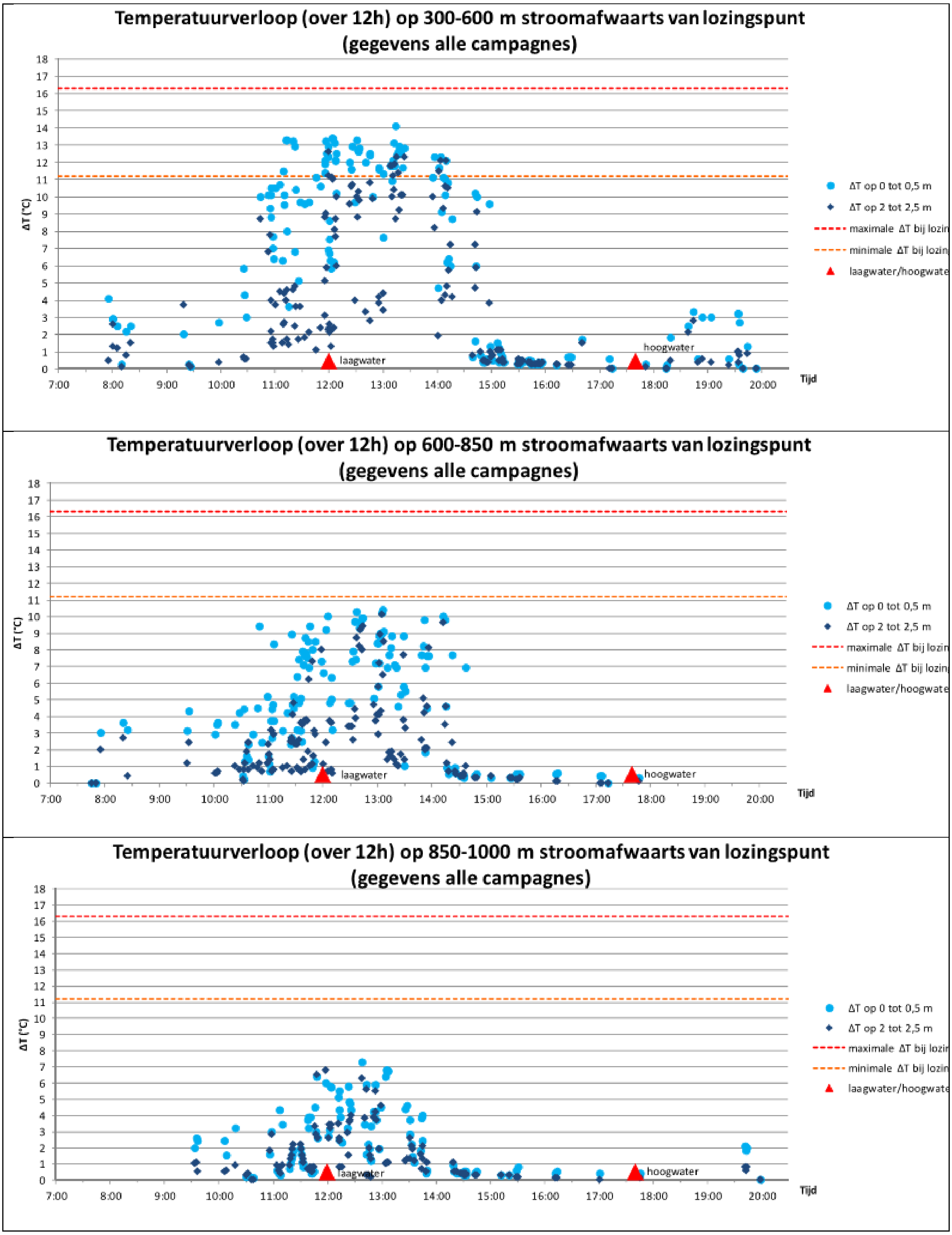
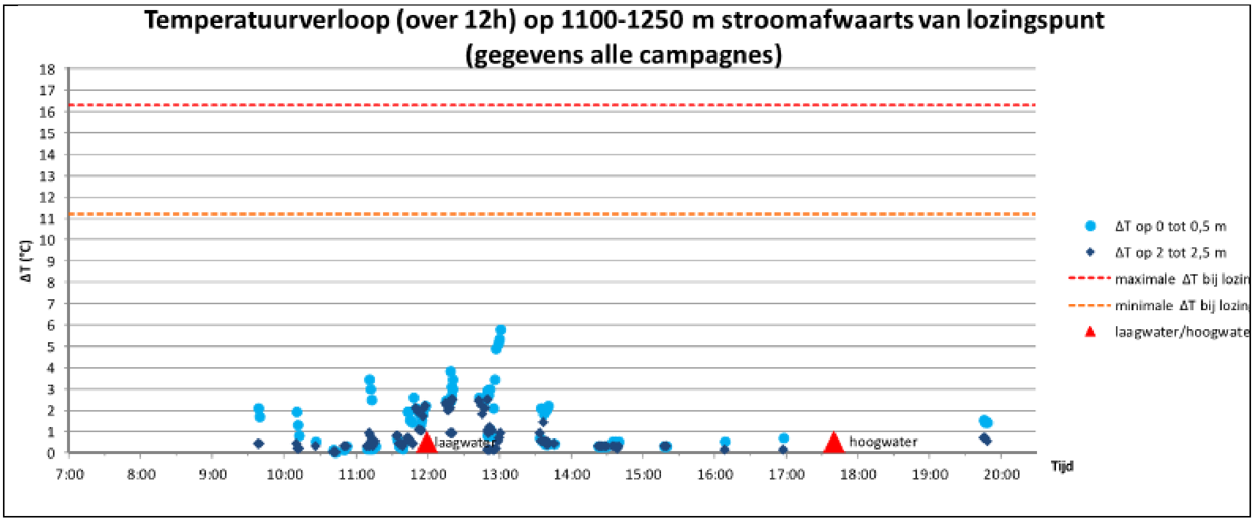


Figure 2-33 Maximum zone with perceptible temperature increase (>1°C) at rising water

- Water going out, just after high tide turnaround:
  - After the tide turns, after high tide, the cooling water flows downstream again. The thermal plume upstream outside the breakwater disappears completely. Shortly after high tide, the water temperature in the zone within the breakwater rises again. The cycle repeats itself.
- Overall temperature evolution per zone of influence over 12 hours:
  - From the figures in Table 2-13 it can be deduced that in the zone 300-600 m downstream of the discharge point there is a strong temperature increase from 1.5 hours before low tide to 3 hours after low tide. In the zones further downstream from the point of discharge, ΔT decreases further and further and the period in which a clear increase in temperature can be observed also decreases further and further:
    - At 600-850 m downstream there is a clear temperature increase from 1 hour before low tide to 2.5 hours after low tide.
    - At 850-1000 m downstream there is a clear temperature increase from 1 hour before low tide to 2 hours after low tide.
    - At 1000-1250 m downstream, there is a clear temperature increase from less than 1 hour before low tide to less than 2 hours after low tide.

Table 2-13 Graphical representation of temperature evolution, as a function of time for various distances from the point of discharge (data from all monitoring campaigns) (Arcadis, 2012)




Temperatuurverloop (over 12h) op 1100-1250 m stroomafwaarts van lozingspunt (gegevens alle campagnes)
ΔT (°C)
Tijd
laagwater
hoogwater
ΔT op 0 tot 0,5 m
ΔT op 2 tot 2,5 m
maximale ΔT bij lozin
minimale ΔT bij lozin
laagwater/hoogwate

Conclusions about temperature measurements

- Water temperature increase at turn of tide, low tide: The CORMIX model does not appear to be suitable for the prediction of the instantaneous increase in water temperature at low tide. Therefore, based on the measured values of the 5 monitoring campaigns carried out, formulae were derived for both monitoring depths (0-0.5 m and 2-2.5 m) describing the relationship between ΔT and the distance to the discharge point for 1 hour at low tide turnaround. Using these formulas, the temperature increase can be predicted for each distance to the point of discharge, and vice versa:
    - ΔT is 10°C at the surface 500 m downstream and 5.7°C at a depth of 2-2.5 m during the tide turnaround;
    - At a distance of 750 m, ΔT is 6.1°C on the surface and 3.3°C at 2-2.5 m depth;
    - At a distance of 1 km, ΔT at the surface is 3.4°C and 1.6°C at a depth of 2-2.5 m;
    - ΔT drops to 1°C at a distance of 1300 m on the surface, and at a depth of 2-2.5 m at a distance of 1100 m.
- Daily average water temperature increase: The CORMIX model appears to give a representative prediction for the daily average water temperature increase of the Scheldt water in the outgoing water scenario. Based on the model, tested against the measurements, the following daily average water temperature increases can be calculated:
    - Downstream:
        - At 500 m, ΔT is 1 to 2°C;
        - From 750 m distance, ΔT is approx. 1°C or less.
    - Upstream:
        - At 500 m, ΔT is 0.5 to 1°C;
        - From 750 m, ΔT is approximately 0.5°C or less.

Assessment of temperature increase and size of heat plume due to cooling water discharge from KCD compared to the situation without operation of KCD
Major temperature increases above 3°C due to KCD's cooling water discharge appear to occur only within the area of the breakwater, up to a maximum distance of approx. 1050 m from the discharge point (considerably negative effect, -3).

Relevant (acceptable) temperature increases between 1 and 3°C appear to occur during outgoing water and at the turn of the low water tide up to a maximum distance of approx. 1,300 m from the discharge point, the area that is still within the breakwater (negative effect, -2). In the case of rising water, a relevant temperature rise occurs between 1 and 3 °C outside the breakwater up to a maximum of 500 m from the discharge point in an easterly direction and up to a maximum of 800 m upstream of the discharge point in a southerly direction (negative effect, -2).

The size of the heat plume is greatest at the turn of the low water tide. The area bounded by a temperature higher than 25°C (strictly speaking the mixing zone, according to the definition cf. the assessment framework) is smaller than the zone in which significant temperature increases occur greater than 3°C. This follows from the results of the 2nd monitoring campaign described above in the summer and at the turn of the low water tide. On this basis, it can be assumed that the zone bounded by a temperature higher than 25°C (strictly speaking the mixing zone, cf. the definition of the assessment framework) will not extend beyond the breakwater, since the significant temperature increases, greater than 3°C are always bounded by the breakwater.

For the specific situation of KCD, it can be stated that the area within the breakwater will form a heat barrier for certain aquatic organisms. For the area within the breakwater, the environmental quality standards with regard to temperature for the Scheldt due to the cooling water discharge of KCD are not met. However, the gully of the Scheldt east of the breakwater remains passable for aquatic organisms. The average cross-sectional surface area of the area within the breakwater does not exceed 25% of the cross-sectional area of the Scheldt. The gully of the Scheldt east of the breakwater is considered to be passable for aquatic organisms at all times.

The above impact assessments apply both to the baseline situation and to the operational phase 2015-2018 of the present project.

Cumulative effects

Other industrial cooling water discharges in the vicinity of KCD

In the report of the 5 temperature monitoring campaigns on the Scheldt (Arcadis, 2012), the temperature increase of the cooling water discharge of KCD is shown in relation to a measured background value upstream of the discharge at outgoing water and downstream of the discharge at rising water. The background values measured are located within the Hansweert Antwerp zone, which is already under thermal pressure. Due to the discharge of thermal loads at various locations in the Lower-Zeeschelde, during winter, the area between Hansweert and Antwerp is 1 to 2 degrees warmer than the upstream and downstream areas (Stevens & Van den Bergh, 2010). The production situation for 2010 is representative for the baseline years 2013-2014 and for the operational phase 2015-2018. As a result, it is assumed that the applicable environmental quality standard cf. Annex 2.3.1 of VLAREM II on temperature for the part of the Scheldt under consideration is met, i.e. the impact of thermal discharges cannot exceed 3 °C.

This EIR incorporates the monitoring measure cf. the recommendation of INBO (Van den Bergh et al., 2013), namely that Engie provides routine monitoring of the spatial-temporal evolution of the temperature gradient between Hansweert and Antwerp. Given the fairly general availability of (thermal) satellite imagery and the experience with it abroad, this method may also be applied in the Zeeschelde to monitor the temperature gradient in the wider environment of KCD. In this way, changes in the cumulative thermal load on the Zeeschelde can be better visualized and detected.

Impact of climate change

In case of an autonomous development during the next twenty years, an increase of the Scheldt temperature can be expected. In addition, lower river flows are expected in summer (drop of more than 50% by the end of the 21st century) due to declining summer precipitation combined with greater evaporation. This creates risks of water shortages.

Climate change will have a negative impact on the cooling capacity of the Scheldt water. The capacity of cooling water depends, among other things, on the temperature of the water taken in. With the current cooling capacity of KCD's cooling towers, the temperature difference between the entrance and exit of the cooling towers will likely remain the same. Due to the expected increase in the Scheldt temperature as a result of climate change, the temperature of the discharged cooling water will increase proportionally. As a result, the maximum discharge temperature of the cooling water can be reached more frequently, which could see a more frequent restriction of the maximum thermal loads to be discharged on a daily basis, cf. the conditions included in the existing permit of KCD, with summer as the most sensitive period. These effects may have a significant impact on the overall performance of KCD. Due to the expected decrease in the flow rate of the Scheldt due to climate change, the impact of the thermal load of KCD in the Scheldt is expected to increase. The area in which the temperature rise exceeds 3°C may extend beyond the breakwater, especially around the turn of the low water tide. It is then possible that the heat barrier formed in the Scheldt during certain periods in the tidal cycle is more difficult or even impossible for certain aquatic organisms to pass. The increase in the size of the heat plume will be most pronounced in summer.

The significance of the negative effects of climate change on the one hand on the functioning of KCD and on the other hand on the thermal pollution in the Scheldt with derived secondary effects on biodiversity depends on the evolution of climate change.

In view of climate adaptation, a possible future scenario is that KCD will have to expand its cooling capacity in order to maintain the same production capacity as in the baseline situation and the operational phase 2015-2018. This means more losses due to evaporation and an increase in the thermal load discharged into the Scheldt.

2.2.3.1.6 Assessment of impacts on the status of bodies of water - Test under KRW Annex V

2.2.3.1.7 Estimation of the probability of effect - test for further analysis

In accordance with the interim guidelines for the assessment of impacts on the status of water bodies (Coordinating Committee on Integrated Water Policy, 2019), a number of criteria are used to determine whether further analysis is needed:

- Hydromorphological changes: The project does not relate to hydromorphological changes to the water body → no further analysis is needed
- Discharges: the project relates to a class 1 discharge of industrial waste water → further analysis is indicated
- Changes to groundwater: the project does not relate to changes to groundwater → no further analysis needed

Further analysis is needed into the effects of the discharge.

2.2.3.1.8 Analysis of the effects of the discharge

The physico-chemical elements to be analysed are the following, in the case of transitional water:

- dissolved oxygen
- temperature
- pH
- nitrate+nitrite+ammonium

The following elements have to be analysed (they must be analysed to predict the effects on the biological elements, but are not taken into account for the assessment of the condition):

- BOC
- COC

In addition, an assessment should be carried out for 'specific pollutants which contribute to determining the ecological status' and 'polluting substances which contribute to determining the chemical status' for those parameters for which, in their current state, the environmental quality standard is exceeded or whose concentration would increase. Finally, the biological quality elements should be assessed, if possible.

Table 2-14 shows the limit values against which the quality of the body of water is assessed.

Table 2-14: Classification for the transitional water category (Source: Lower Scheldt River Basin Management Plan) - at KCD level O1b applies

				Ondergrens of bereik van de klassen			
Parameter	Eenheid	Toetswijze	Typen	Zeer goed	Goed	Matig	Ontoe-reikend
Thermische omstandigheden							
Temperatuur	°C	Maximum	Alle	21	25	27,5	30
Impact thermische lozing	°C	Maximum	Alle	+1	+ 3	+4	+5
Zuurstofhuishouding							
Opgeloste zuurstof (concentratie)	mg/l	10-percentiel	Alle	8	6	4	3
Opgeloste zuurstof (verzadiging)	%	Maximum	Alle	80-110	60-80 / 110-120	50-60 / 120-130	40-50 / 130-140
Biochemisch zuurstofverbruik (BZV)	mg/ l	90-percentiel	Alle	3	6	10	25
Chemisch zuurstofverbruik (CZV)	mg/ l	90-percentiel	Alle	20	30	40	80
Verzuringstoestand							
Parameter	Eenheid	Toetswijze	Typen	Zeer goed	Goed	Matig	Ontoe-reikend
pH		Minimum-maximum	O1b O2zout	7,5-9,0	7,5-9,0	<7,5-7,0 of >9,0-9,5	<7,0 of >9,5
		Minimum-maximum	O1o	7,0-9,0	7,0-9,0	<7,0-6,5 of >9,0-9,5	<6,5 of >9,5
Nutriënten							
Kjeldahl-stikstof	mg N/l	90-percentiel	O1o	1.5	6	12	18
Nitraat	mg N/l	90-percentiel	O1o	1,3	5,65	11,3	17
Nitraat + nitriet + ammonium	mg N/ l	Wintergemiddelde	O1b O2zout	0,25	0,49	1,0	2,0
Totaal stikstof	mg N/ l	Zomerhalfjaargemiddelde	O1o	2	2,5	5	7,5
Totaal fosfor	mg P/ l	Zomerhalfjaargemiddelde	O1o	0,06	0,14	0,19	0,42
Orthofosfaat	mg P/ l	Gemiddelde	O1o	0,02	0,14	0,28	0,56
			O1b O2zout	0,01	0,07	0,14	0,28
Diversen							
Doorzicht*	m	90-percentiel	Alle	1,5	0,7	0,3	0,1

*uitgezonderd de mortaliteitszone voor fytoplankton voor O1b

Physico-chemical elements that determine the biological elements:
Methodology For the physico-chemical quality elements in surface water, with the exception of dissolved oxygen, pH and water temperature, it can be calculated whether a deterioration will occur.

For dissolved oxygen, it is assumed that no deterioration will occur if the standards for biological and chemical oxygen demand are met. If the physico-chemical elements show a deterioration, it is assumed that there will also be an effect in the biological quality elements and that the status of the body of water will deteriorate.

The average discharge is pH neutral, no changes to the pH are expected due to the present project.

The impact of the discharge on the temperature of the Scheldt is discussed in detail in § 2.2.3.1.5. In conclusion, there is no deterioration in temperature for the entire body of water as a result of the thermal discharge of the KCD.

For the parameters nitrite+nitrate+ammonium, BOC and COC, the impact of the discharge was calculated in Table 2-11. The impact is negligible for these parameters and therefore no change in the status of the body of water is expected.

Specific pollutants that help to determine the ecological status:
Methodology For the specific pollutants and chemical status, an exceedance of the environmental quality standards set out in Annex 2.3.1. of VLAREM and the class boundaries described in the river basin management plans are regarded as deterioration. As with the physico-chemical elements, the specific pollutants are assumed to have an effect on the biological quality elements if they deteriorate and the status of the water body deteriorates.

In the current state, the following parameters exceed the basic environmental quality standard: arsenic, boron, uranium. The assessment for the 'specific pollutants that help determine the ecological status' is 'poor'.

For the parameters arsenic and boron, the impact of the discharge was calculated in Table 2-11. Uranium is not a relevant parameter because it is not discharged by the KCD. The calculated impact for the parameters arsenic and boron is negligible; therefore, no deterioration is expected for the 'evaluation of the specific pollutants that help determine the ecological status'.

Pollutants that determine the chemical status:
In the current state, the following parameters exceed the basic environmental quality standard: PAHs, polybrominated diphenyl ether, tributyltin, perfluoroctane sulfonic acid, heptachlor epoxide and total mercury.

For the parameters, the impact of the discharge was calculated for the mercury parameter in Table 2-11. The impact is negligible. The other parameters are not discharged by the KCD. Consequently, no deterioration is expected for the 'pollutants that determine the chemical status'.

Biological quality elements:
The impact on the biological quality elements cannot be determined quantitatively. Based on the assessments in the Biodiversity section of the impact of water intake, cooling water discharge and chemical discharge on aquatic organisms in the Scheldt, no deterioration of the biological quality elements in the entire water body is expected.

Conclusion:
It is not expected that the implementation of the project will lead to deterioration or jeopardise the objectives set for the entire body of water.

2.2.3.2 Operational phase in the future situation (period 2019-2025)

The water supply, the infiltration and discharge characteristics and the emissions to the water system will not differ significantly in the LTO situation, as explained above, from the emissions in the baseline situation. There are no additional effects of the LTO situation compared to the baseline situation.

2.2.3.3 Post Operational Phase (period 2025-2029)

The Post Operational Phase or POP of KCD starts in 2025 and ends in 2028. After the POP period, the dismantling of the reactors can start when the necessary permits have been obtained. The POP period consists of 3 phases in which KCD gradually evolves from a nuclear power plant over, the wet storage of irradiated fuel to a building with radioactive waste to be processed. During the POP period, the following is scheduled:

- unloading of the reactors and transfer of all irradiated fuel to the Pool Loops docks in the Nuclear Auxiliary Services Building
- to allow the radioactivity of the irradiated fuel to decay in the Pool Loops docks in the Nuclear Auxiliary Services Building.
- to load the irradiated fuel into containers and transport it to Fissile Fuel Container Building.
- to carry out operation and maintenance activities as before the Post Operational Phase, but with a smaller amplitude (no more electricity production).

These are all activities covered by the current permit. Specifically for the production of waste water, process circuits are drained for treatment in the Water and Waste Treatment Unit (WAB) or disposed of for external processing, as would be done for an outage.

Conclusion: The main characteristics of the POP period are that this period is an extension of the current KCD operation (= with current KCD processes ongoing) and that the processes will run in accordance with the current permit. Emissions to the water system will be similar or lower than in the baseline situation.

No difference is expected in effects between a POP in 2015-2019 versus 2025-2029.

2.2.3.4 Zero alternative

Potable water supply

Under the alternative situation no-LTO, a decrease in consumption of both mains water and Scheldt water is expected.

However, the consumption of mains water is not expected to decrease drastically. After all, the initiator did not notice any drastic drop when a unit was out of service. Only the consumption of mains water for the steam cycle is expected to decrease slightly.

The Doel 1 and 2 units will no longer be in operation, so the cooling circuits of these units will no longer be used. The consumption of Scheldt water as cooling water will therefore also decrease and is expected to amount to approximately 704 million m³ annually. This calculation was made by the initiator on the basis of the expected number of operating hours and the average hourly flow rate of the pumps at the intake point for Doel 3/4. The Scheldt water consumption in the alternative situation non-LTO amounts to approx. 60% of the Scheldt water consumption in the baseline situation.

Change of infiltration and discharge characteristics

Under the alternative situation no-LTO, no physical interventions are scheduled compared to the baseline situation. In the situation under the basic project, there is a limited increase in paving. The effect groups due to changes in the discharge of surface water, changes in the structure of watercourses, changes in infiltration of rainwater, loss of quality of surface water or groundwater or changes in groundwater flow are not relevant in the Zero alternative or for the base project.

Considering the considerable amount of paved surface of KCD, the frequency and volume of flooding of the collection wells for sanitary waste water from the site to the Scheldt in the baseline situation, the fact that the environmental quality standards for N, P and COC for the Scheldt are not met in the baseline situation and the expected periods of intense rain in winter and heavy thunderstorms and water shortages in summer due to climate change, the Water section recommends examining the feasibility of the following measures at concept level and according to the Best Available Technology:

- Source-specific measure: for new projects, analyse the impact of disconnecting rainwater from sanitary wastewater and the possibilities for reuse of rainwater, infiltration or buffering according to BAT. The climate-scaled showers must be taken into account. The high-impact scenario provides a good frame of reference for making KCD more climate-proof;
- End-of-pipe measure: analysis of the installation of additional collection volume for sanitary waste water according to BAT with the aim of reducing overflow.

Surface water quality

The concentrations of pollutants in the discharged sanitary and industrial waste water are expected to be the same as in the baseline situation. However, no drastic decrease is expected for the production of sanitary and industrial waste water. After all, the initiator did not notice any drastic drop when a unit was out of service. Only the consumption of mains water for the steam cycle is expected to decrease slightly. It is not possible to quantify this decrease.

The concentrations of pollutants in the cooling water, including temperature and chlorides, are expected to be equal to those of the baseline situation. The Doel 1 and 2 units will no longer be in operation, so the cooling circuits of these units will no longer be used. The consumption of Scheldt water as cooling water will therefore also decrease and is expected to amount to approximately 704 million m³ annually. This calculation was made by the initiator on the basis of the expected number of operating hours and the average hourly flow rate of the pumps at the intake point for Doel 3/4. The Scheldt water consumption in the alternative situation non-LTO amounts to approx. 60% of the Scheldt water consumption in the baseline situation. The discharged pollutant loads and thermal loads of the cooling water are therefore also expected to decrease to approx. 60% of those in the baseline situation.

To monitor active chlorine in cooling water based on the shock dosage of NaOCl, it is recommended to perform the monitoring of active chlorine with an online measuring sensor, with a detection limit up to approx. 10 µg/L (instead of 100 µg/L in the existing condition). This in order to be able to refine the control of the dosage of NaOCl with the aim of a lower NaOCl consumption, lower active chlorine levels in the discharged cooling water and less AOX formation.

Thermal impact of the discharge of cooling water

The thermal load of the cooling water on the Scheldt is expected to decrease to approx. 60% of the baseline situation. The size of the heat plume in the Scheldt is therefore also expected to be lower. This may have a positive impact, especially in the light of climate change as described in the assessment of the thermal impact of the cooling water discharge during the operational phase 2015-2018 of the basic project.

The significance of this positive effect depends on the degree of shrinkage of the heat plume relative to the baseline situation, which is difficult to estimate with current data, and also depends on the evolution of the expected climate effects.

2.2.3.5 Cumulative effects

Under §2.2.3.1.5 the possible cumulation of the thermal impact of industrial cooling water discharges on the Scheldt is discussed qualitatively. The monitoring measure cf. the recommendation of INBO (Van den Bergh et al., 2013) is applied, namely that Engie provides routine monitoring of the spatial-temporal evolution of the temperature gradient between Hansweert and Antwerp. Given the fairly general availability of (thermal) satellite imagery and the experience with it abroad, this method may also be applied in the Zeeschelde to monitor the temperature gradient in the wider environment of KCD. In this way, changes in the cumulative thermal load on the Zeeschelde can be better visualized and detected.

§2.2.3.1.5 provides a qualitative discussion of the cumulative impact of climate change on the thermal impact of cooling water discharges from KCD.

2.2.3.6 Cross-border effects

At the Dutch border, at a distance of about 3.4 km from the point of discharge of KCD, the influence of the discharge of the cooling water can at most be considered slightly negative (-1). This is based on the 5 monitoring campaigns of the temperature impact of Doel's cooling water on the Scheldt (Arcadis, 2012). This temperature increase will slowly decrease further downstream on Dutch territory.

2.2.4 Monitoring

This EIR incorporates the monitoring measure cf. the recommendation of INBO (Van den Bergh et al., 2013), namely that Engie provides routine monitoring of the spatial-temporal evolution of the temperature gradient between Hansweert and Antwerp. Given the fairly general availability of (thermal) satellite imagery and the experience with it abroad, this method may also be applied in the Zeeschelde to monitor the temperature gradient in the wider environment of KCD. In this way, changes in the cumulative thermal load on the Zeeschelde can be better visualized and detected.

For the parameters of ammonium, B, Sb, Co, Mo, Se, Sn, Ag, Ba, Tl, Ti, V, Be, Te, anionic, non-ionic and cationic surfactants, the measurements on the sanitary waste water are performed inconsistently or the detection limit of the measurements is higher than the discharge standard. As a result, it is not possible to make well-founded statements about the concentrations and reaching discharge standards for these parameters. KCD should measure these parameters in the sanitary effluents consistently where the detection limits of the analytical methods are lower than the relevant discharge standards.

For the parameters Co, Ag, Tl, V, Be, anionic, non-ionic and cationic surfactants and sodium fluorinate, the measurements on the industrial effluent are carried out inconsistently on industrial waste water, for the years 2013 and/or 2014 or the detection limit of the measurements is higher than the discharge standard. As a result, it is not possible to make well-founded statements about the concentrations and reaching discharge standards for these parameters. KCD should measure these parameters in the industrial waste water consistently where the detection limits of the analytical methods are lower than the relevant discharge standards.

For the faecal coliforms parameter, the measurements are performed inconsistently for the years 2013 and/or 2014. As a result, it is not possible to make well-founded statements about effluent concentrations and pollutant loads and meeting discharge standards for these parameters. KCD should measure these parameters in the cooling water consistently where the detection limits of the analytical methods are lower than the relevant discharge standards.

To monitor active chlorine in cooling water based on the shock dosage of NaOCl, it is recommended to perform the monitoring of active chlorine with an online measuring sensor, with a detection limit up to approx. 10 µg/L (instead of 100 µg/L in the existing condition). This in order to be able to refine the control of the dosage of NaOCl with the aim of a lower NaOCl consumption, lower active chlorine levels in the discharged cooling water and less AOX formation.

2.2.5 Mitigating measures and recommendations

No mitigating measures are set from the Water section.

The Water section makes the following recommendations:

- To monitor active chlorine in cooling water based on the shock dosage of NaOCl, it is recommended to perform the monitoring of active chlorine with an online measuring sensor, with a detection limit up to approx. 10 µg/L (instead of 100 µg/L in the existing condition). This in order to be able to refine the control of the dosage of NaOCl with the aim of a lower NaOCl consumption, lower active chlorine levels in the discharged cooling water and less AOX formation.

- Considering the considerable amount of paved surface of KCD, the frequency and volume of flooding of the collection wells for sanitary waste water from the site to the Scheldt in the baseline situation and in the operational phase 2015-2018, the fact that the environmental quality standards for N, P and COC for the Scheldt are not met in the baseline situation and in the operational phase 2015-2018 and the expected periods of intense rain in winter and heavy thunderstorms and water shortages in summer due to climate change, the Water section recommends examining the feasibility of the following measures at concept level and according to the Best Available Technology:
  - Source-specific measure: for new projects, analyse the impact of disconnecting rainwater from sanitary wastewater and the possibilities for reuse of rainwater, infiltration or buffering according to BAT. The climate-scaled showers must be taken into account. The high-impact scenario provides a good frame of reference for making KCD-1 and KCD-2 more climate-proof;
  - End-of-pipe measure: analysis of the installation of additional collection volume for sanitary waste water according to BAT with the aim of reducing overflow.

2.2.6 Knowledge gaps

Taking into account the opinion of climate experts, and the still considerable uncertainty in climate modelling, three climate scenarios for Flanders have been developed from many dozens of scenario variants and model results via 'statistical downscaling': low, medium and high. Man-driven climate change in Flanders is likely to evolve between the extremes of these 3 scenarios.

The climate scenarios span a range that encompasses the future reality with a high probability. However, the uncertainty remains high. After all, the exact probability of the occurrence of a particular climate scenario is not known. In addition, there are known processes and mechanisms that cannot yet be explicitly taken into account (e.g. exceeding tipping points). There are also uncertainties whose existence is not even known yet.

However, the consequences of climate scenarios can be calculated. If the consequences of a particular scenario are large, it is important to take them into account in policy and management decisions. It should be possible to make adjustments - at the lowest possible cost - as knowledge about climate change increases. Decisions must also be effective and cost-efficient, regardless of the precise evolution of the climate.

2.2.7 Conclusions

The water supply, the infiltration and discharge characteristics and the emissions to the water system will not differ significantly in the LTO situation from the emissions in the baseline situation. There are no additional effects of the LTO situation compared to the baseline situation.

The project includes a re-licensing of the existing systems of KCD-1 and KCD-2 and the water balance for the base years 2013-2014 is considered representative for the production in the following years of the re-licensing period. Therefore, no relevant changes in water consumption and water balance are expected compared to the baseline situation.

The main impact of KCD on the water system compared to the situation without operation of KCD is the discharge of wastewater and cooling water into the Scheldt.

- Discharge of waste water:
  - The average concentration increase in the Scheldt due to the activities of KCD compared to the environmental quality standard (EQS) is less than 0.1% (negligible, 0). The parameters of nitrite and AOX were highlighted separately:
    - Average nitrite concentration in 2013 was above the then applicable discharge standard of 2 mg/L in industrial wastewater. In 2014, the average concentration was below the discharge standard but still peak concentrations were measured above the discharge standard. KCD carried out a study on the prevention and treatment of nitrite in industrial wastewater. In the decision dated 07/02/2019 (2018122825) the standard for nitrites was replaced by 8 mg N-NO2/L until 31 December 2021 and 2 mg N-NO2/L from 1 January 2022. By implementing some measures aimed at the source, the standard of 8 mg N-NO2/L can be respected in the period 2016-2018. The future norm of 2 mg N-NO2/L is sporadically exceeded but the concentration is on average below the norm.
    - Increased concentrations of AOX were measured in the sanitary and industrial waste water and in the cooling water, which is why this parameter is described separately. NaOCl is added to the cooling water as a conditioning agent to prevent growths in the cooling system. This can cause AOX. In 2014, a study was performed by KCD into the effect of NaOCl during possible oxidation of nitrite to nitrate. The formation of AOX was also investigated. The conversion of nitrite to nitrate is possible with a considerable excess of NaOCl. The dosage appears a striking influence on the AOX formation. An optimum conditioning regime can reduce the amount of NaOCl used and the period during which conditioning must be applied, ultimately leading to a reduction in emissions of organohalogens via cooling systems to surface water on an annual basis. By far the most important parameter appears to be the use of active chlorine. By regulating this consumption properly, it is possible to minimise the environmental impact (Berbee, 1997). Currently, the dosing of NaOCl at KCD is based on the analysis of the excess active chlorine and experience with the cooling speed gasket. Any additional doses are based on the control of biological growth on sample plates in the cooling towers and weight measurements of the gasket. No active chlorine above the detection limit is found in the discharged cooling water (<100 µg/L). To monitor active chlorine in cooling water based on the shock dosage of NaOCl, it is recommended to perform the monitoring of active chlorine with an online measuring sensor, with a detection limit up to approx. 10 µg/L (instead of 100 µg/L in the existing condition). This in order to be able to refine the control of the dosage of NaOCl with the aim of a lower NaOCl consumption, lower active chlorine levels in the discharged cooling water and less AOX formation.

- A frequent operation of KCD's sanitary wastewater collection wells into the Scheldt was found. The frequent operation of the sanitary wastewater collection wells is due to leaks of cooling water from the underground galleries and, to a lesser extent, groundwater in the mixed sewer system. These operations can cause peaks of nutrient concentrations in the Scheldt at the level of KCD. This is considered a negative effect (-2). Rainwater is not reused. The urban planning regulation on rainwater wells, infiltration facilities, buffer facilities and separate discharges of waste water and rainwater does not apply to existing buildings and structures. The Water section recommends examining the feasibility of disconnecting rainwater from sanitary wastewater systems (source-based measure) for new projects and the possibility of installing additional collection capacity for sanitary wastewater (end-of-pipe measure) at concept level and according to the Best Available Technology.

- Discharge of cooling water:
  - Major temperature increases above 3°C due to KCD's cooling water discharge appear to occur only within the area of the breakwater, up to a maximum distance of approx. 1050 m from the discharge point (considerably negative effect, -3).
  - Relevant (acceptable) temperature increases between 1 and 3°C appear to occur during outgoing water and at the turn of the low water tide up to a maximum distance of approx. 1,300 m from the discharge point, the area that is still within the breakwater (negative effect, -2).
  - In the case of rising water, a relevant temperature rise occurs between 1 and 3 °C outside the breakwater up to a maximum of 500 m from the discharge point in an easterly direction and up to a maximum of 800 m upstream of the discharge point in a southerly direction (negative effect, -2).
  - For the specific situation of KCD, it can be stated that the area within the breakwater will form a heat barrier for certain aquatic organisms. For the area within the breakwater, the environmental quality standards with regard to temperature for the Scheldt due to the cooling water discharge of KCD are not met. However, the gully of the Scheldt east of the breakwater remains passable for aquatic organisms. The average cross-sectional surface area of the area within the breakwater does not exceed 25% of the cross-sectional area of the Scheldt. The gully of the Scheldt east of the breakwater is considered to be passable for aquatic organisms at all times.

The water supply, the infiltration and discharge characteristics and the emissions to the water system will not differ significantly in the LTO situation from the emissions in the baseline situation. There are no additional effects of the LTO situation compared to the baseline situation.

2.3 Noise & vibrations

Annex A - Map 3: Regional Plan

Annex A - Map 4: Regional Spatial Implementation Plan

2.3.1 Methodology

2.3.1.1 Definition of the study area

Electricity production is a classified site according to the Flemish environmental legislation (Vlarem II).

The study area for classified sites according to Vlarem II is determined according to the provisions of Vlarem II and consequently delimited by:

- the 200 m boundary in relation to the plot boundaries of the site,
- the 200 m limit to the border of the industrial area.

KCD is located in an industrial area according to the regional plan. In the absence of houses in a 200 m buffer around the company site, also 200 m to the area boundaries of the industrial area, the assessment can be performed on the 200 m contour.

The specific noise level in the surrounding area is thus determined up to a minimum distance of 200 m from the plot boundaries of the KCD site, supplemented by the determination of the noise impact at the level of the nearest houses. The reference points are thus in line with those used in previous EIR studies for the KCD site.

2.3.1.2 Description of the reference situation

The intended development in the project area will always be part of an existing noise environment. Depending on the functions given to the intended development, they may be such that they have a temporary or permanent impact on the existing noise environment and thus on the current liveability. To make it possible to weigh up the reference situation in the vicinity of the project area, the reference situation is first described.

As part of the discussion about the reference situation, a description is given of:

- the noise climate in the study area, based on <u>immission measurements</u>: inventory of ambient noise by means of in-situ noise measurements already carried out at discrete measurement points around the KCD site (immission measurement campaigns 2009, 2014, 2017)
- the noise transmission by KCD in the study area based on an <u>acoustic calculation model</u>: the noise transmission calculation for the EIR for the re-licensing of the site in 2010, and updated at the time of the WMF EIR in 2013-2014 - is used as the basis for this EIR.

2.3.1.3 Description and assessment of the impact

The KCD has sources emitting noise to the open air that can have an impact on the environment. A distinction is made between continuous sources and sources that are only in operation for a limited period of time, such as emergency diesels and emergency pumps. Changes related to LTO may involve changes in the noise emissions of KCD, both in terms of total noise emissions and in terms of source-specific noise emissions.

During the works taking place as part of the LTO adjustments, noise- and/or vibration-emitting works are carried out in different work zones and at different times during the implementation period. Switching on noise sources will cause ambient noise levels to change. The basic principle is that the environmental disruption caused by the planned works is limited, to the maximum extent possible, taking into account the BAT principle.

During the various phases of the project, the following effects can be expected for the noise and vibration section:

- Modification of the KCD noise immission: quantitative description of the specific noise contribution to the environment in the current and planned situation and comparison with the status during the baseline situation (2009, 2014).
- Change in ambient noise: quantitative description of the impact of the changed noise immission of KCD on the ambient noise.
- Conformity test with the applicable Vlarem II noise conditions: quantitative control in relation to the respect of the guide values for the specific noise level in open air.

The EIR deals with the change in noise immission resulting from the operation of KCD for 2 possible scenarios and 4 periods:

1. Baseline situation (period 2009-2014);
2. LTO scenario: continuation of Doel 1/2 units in the period 2015-2025:
    a. Operational phase in the period 2015-2019;
    b. Operational phase in the future situation, 2020-2025;
    c. Post Operational Phase (period 2025-2029)
3. No-LTO scenario: Zero Alternative: POP of the Doel 1/2 units (2015-2019), other units still in operation (period 2015-2025).

For the operational phases with a distinctive acoustic emission state for KCD, the noise impact with respect to the environment is calculated.

The quantitative description of the noise effects is determined using an acoustic calculation model for the KCD site. For this purpose, the calculation model is built using the calculation program (GEOMILIEU), which is based on the international standard ISO 9613 and takes into account the following environmental conditions:

- geometric simulation of influential objects (e.g. noiseproofing or reflecting buildings, screens, earthen verges, etc.) in x, y, z coordinates;
- geometric simulation of the noise source in x, y, z coordinates;

- noise power level and directivity of the noise source;
- location and height of calculation points;
- ground level lines, reflective or absorbent soil areas.

The computational model is used to calculate the noise contribution of each modelled noise source at any point in the environment.

The calculated noise extension to the surroundings of the of entire source KCD under specific operating conditions is presented by means of coloured noise contours (= noise map). The critical zone, i.e. the zone within which the noise pressure level exceeds a certain level of nuisance (i.e. applicable Vlarem II guide value), can be clearly identified.

The impact assessment is carried out in accordance with the Significance Framework included in the EIR book of guidelines for the Noise and Vibrations section (February 2011). Also applied in previous IERs.

Table 2-15: Significance framework noise section

Impact on the environment		Final score after correction Are the Vlarem conditions met?				
Lafter - Lbefore $\Delta L_{AX,T}$	Intermediate score (effect score)	'New' or 'Change'		'Existing' or 'Re-licensing'		
		Lsp ≤ GW	Lsp > GW	Lsp ≤ GV	GV < Lsp ≤ RW+10	Lsp > RW+10
$L_{AX,T} > +6$	-3	-1	-3	-1	-2	-3
$+3 < \Delta L_{AX,T} \leq +6$	-2	-1	-3	-1	-2	-3
$+1 < \Delta L_{AX,T} \leq +3$	-1	-1	-3	-1	-1	-3
$-1 \leq \Delta L_{AX,T} \leq +1$	0	0	-1 / -2 **	0	-1	-3
$-3 \leq \Delta L_{AX,T} < -1$	+1	+1	-	+1	+1	-
$-6 \leq \Delta L_{AX,T} < -3$	+2	+2	-	+2	+2	-
$L_{AX,T} < -6$	+3	+3	-	+3	+3	-

Where the symbols and abbreviations used have the following meaning:

- ΔLAX,T = difference in ambient noise before and after a project is carried out with X and T to be determined and justified by the expert
  - With T being equal to the duration.
  - With X being equal to 'N' as a parameter of statistical analysis LAN, T, in Vlarem II N = 95 is used as a test against environmental quality standard or equal to 'eq' for the equivalent noise pressure level LAeq,T of the ambient noise
- LAN, T A-weighted percentage noise pressure level, which is exceeded during N% (1, 5,... , 95, 99) of the time interval
- GW = limit value
- GV = guide value
- Lsp = specific noise level

note ** : the choice -1 or -2 depends on the size of the GW excess, whether or not within the reliability interval of the calculated specific immission

The final negative scores are linked to mitigating measures as follows:

Table 2-16: Link assessment to mitigating measures

Significance	Description	Mitigating measures
+3	Significantly positive	No measures required
+2	Positive	
+1	Limited positive	
0	Negligible	No measures required
-1	Slightly negative	Research into mitigating measures is less mandatory, but if the investigative framework conditions indicate that a problem may arise, the expert should proceed to propose mitigating measures. If none are proposed, reasons must be given.
-2	Negative	Mitigating measures must be found as a matter of necessity, possibly linked to the longer term. If none are proposed, reasons must be given.
-3	Considerably negative	Mitigating measures must be found as a matter of necessity, linked to the short term. If none are proposed, reasons must be given.

2.3.2 Baseline situation (= 2013-2014)

2.3.2.1 Immission measurements (2009-2014)

In order to determine the ambient noise, continuous and simultaneous measurements were taken for the 2010 EIR at 3 measurement points, located at the plot boundary (mpt 1) or approximately 200 m from the plot boundary (mpt 2 and 3), for 3 weeks in 2009, until sufficiently representative measurement data were available for the wind situation (i.e. with wind direction from KCD to the measurement point in question). In 2014, Vinçotte carried out a new measurement campaign for the WMF EIR[7]. When selecting the measuring points, the location of inhabited buildings and nature reserves were taken into account. The exact location of the measuring points is shown in the table and figure below.

[7] The measurement campaign was conducted again in 2014 in MPTs 1 to 3 (see Table II.2-19 and the discussion below accompanying the table).

TABLE II.2-17: LOCATION OF IMMISSION MEASURING POINTS

Point	Location	Lambert coordinates		Area according to regional plan (Cf. § 2.6.3 in Part I) in accordance with Vlarem II	
		X	Y	Cat.	Description
MPT-1	Site boundary North at the British Monument, 0 m from the site boundary	142384	224665	2	Natural area < 500 m from industrial area
MPT-2	Scheldt dyke at ± 200m from the site boundary	142716	222989	2	
MPT-3	Lindenhofstraat at ± 200m from the site boundary	141509	223509	2	agricultural area < 500 m from industrial area

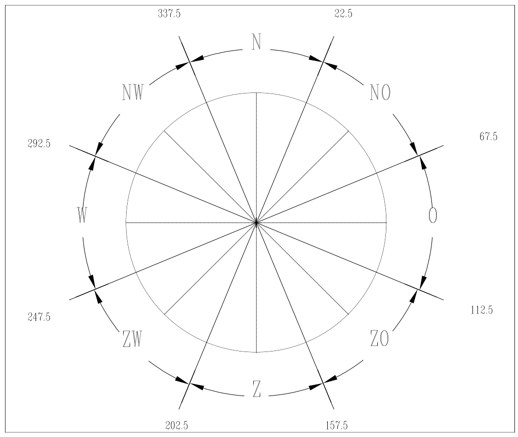
Since there is no difference between daytime (7 a.m. to 7 p.m.) and nighttime (10 p.m. to 7 a.m.) in production conditions and hence in noise emissions, only the most critical period, i.e. the night period, is considered. In addition, the $L_{A95,1h}$ parameter was considered because it is the most representative to assess continuous and stable noise sources (on an hourly basis).

For the entire night period, an average value was determined by considering the entire $L_{A95,1h}$ level during the night period. This average was calculated in accordance with the technical provisions of VLAREM II. This is the arithmetic mean of the lowest 4 hour values during the night period measured under comparable and representative conditions.

The ambient noise during the night period - averaged over the entire measurement campaign - was calculated for the various wind sectors. For this purpose, a distinction was made between eight different sectors, namely:

TABLE II.2-18: THE DIFFERENT WIND SECTORS

Wind sector	from	to
North	337.5°	22.5°
Northeast	22.5°	67.5°
East	67.5°	112.5°
Southeast	112.5°	157.5°
South	157.5°	202.5°
Southwest	202.5°	247.5°
West	247.5°	292.5°
Northwest	292.5°	337.5°



For the calculation of the averages per wind direction, only the values measured at an average wind speed of less than 5 m/s were considered.

The results of the total ambient noise measurements carried out in 2014 are compared with the results of the Vinçotte measurement campaigns carried out in September 2009, as well as with the applicable environmental quality standard (EQS).

TABLE II.2-19: RESULTS OF IMMISSION MEASUREMENT AND COMPARISON WITH EQS

Point	**Measuring period**	**Average $_{LA95.1h}$ night period** in dB(A)								**EQS** in dB(A)
		N	**NE**	**E**	**SE**	**S**	**SW**	**W**	**NW**	
MPT-1	Sept 2009	48.9	50.0	49.8	50.2	**50.5**	49.8	49.0	49.0	45
	Sept 2014	46.5	49.1	49.5	48.4	(-)	47.9	48.0	(-)	
MPT-2	Sept 2009	**48.1**	48.9	44.2	42.7	40.5	40.2	41.5	**45.7**	45
	Sept 2014	**47.5**	48.4	47.1	43.8	(-)	43.1	46.2	(-)	
MPT-3	Sept 2009	45.5	**47.1**	(35.4)	37.4	37.3	34.0	(33.8)	(37.3)	45
	Sept 2014	43.6	**44.5**	43.3	39.8	(-)	35.9	39.6	(-)	

- Values between brackets (xx): Not enough relevant values to calculate a representative average.
- Indication (-): No values measured with the corresponding wind direction
- Value xx in bold: Results for tailwind from KCD to the measurement point considered

When comparing the measurement results, the different operating conditions between September 2009 and 2014 should be taken into account.

MPT-1: Site boundary North:

The measuring point is located north of KCD, so there is headwind from KCD to the measuring point with a southerly wind. This wind direction did not occur during the 2014 measurement campaign. The values measured for the closest wind directions, SE and SW, were approximately 2.0 dB(A) lower in 2014. This may be due to operating conditions (fewer units in service).

The environmental quality standard (EQS) is therefore still exceeded here in the order of magnitude of 5 dB, both in case of tailwind and in other wind directions.

MPT-2: Scheldt dyke south:

This measuring point is about the same distance south of KCD. With tailwind, from KCD to the reference point, i.e. northerly or northwesterly wind, the ambient noise measured in September 2014 is 47.5 to 48.5 dB(A). These values are only 0.5 dB(A) lower than in September 2009.

The environmental quality standard (EQS) is therefore exceeded here in the order of magnitude of 1 to 3 dB in case of tailwind.

MPT-3: Lindenhofstraat West:

The measuring point is further away from other (non-KCD) industrial installations. The total ambient noise measured, during the September 2014 measurement campaign, with tailwind from the industrial area to the reference point was 44.5 dB(A), which is a decrease of 2.6 dB(A) compared to the situation in September 2009.

Based on these results, it can be assumed that the environmental quality standard EQS of 45 dB(A) is complied with in tailwind conditions.

2.3.2.2 Description of the noise emission

In November-December 2009, Vinçotte carried out an extensive source inventory of the most relevant outside sources that could have a potential impact on the ambient noise. A distinction has to be made between sources that are in continuous operation and sources that are actually in operation for only a limited part of the time. For example, the company has emergency diesels and emergency cooling condensers, spread across the site, which in principle only operate in emergency situations, but for safety and maintenance reasons are also tested on a monthly basis.

The noise power of these sources, both continuous and non-continuous, was determined by means of intensity measurements and/or noise pressure measurements. Multiple systems are identical for the individual plants - Doel 1-2, Doel 3, Doel 4 - and were therefore not measured again and again. For larger systems, such as the auxiliary cooling towers, measurements were also carried out on a representative sample, from which the noise power level, per 1/3 octave, of the entire installation was subsequently determined.

For the noise sources that were part of the 2013-2014 condition but are not included in the source inventory of 2009 or which were replaced, the noise power level was measured on site by Tractebel Engineering during a representative operating condition on 3 June 2020.

Specific noise from new noise sources with more than 10% operation in the assessment period are to be tested against the limit value for continuous noise for 'new sites'. Emergency diesels[8] (new discontinuous sources) have an operating time of less than 10% of the daytime period at all times. The new sources are to be considered incidental noises. Since the limit values for incidental noises are more tolerant than those for continuous noises, it can be said that the emergency diesels also comfortably meet the applicable limit value for incidental noises.

Note: The tables below give an overview of the LwA noise power levels of the considered continuous and discontinuous sources.

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[8] The 'Best' pumps and diesel generators (new discontinuous sources) are tested periodically in the GUM building with the rolling gate open. In the noise transfer calculation, an open-air setup was assumed as the worst-case.

2.3.2.2.1 *Continuous sources*

Source group	Description	Sound power levels considered in dB(A) re 1 pW 2013-2014
1	Doel 1 - Transformers	102.6
2	Doel 1 - Reactor building ventilation	102.3
3	Doel 2 - Transformers	102.6
4	Doel 2 - Reactor building ventilation	102.3
5	Doel 1&2 - Auxiliary cooling towers	107.0
6	Doel 1&2 - Turbine hall	104.0
7	Doel 1&2 - Water intake	102.9
8	Doel 1&2 - GNH Ventilation	100.3
9	Doel 3 - Main transformers	98.9
10	Doel 3 - Auxiliary transformers at Turbine Hall MAZ	92.0
11	Doel 3 - Auxiliary transformers between MAZ and CGB	87.4
12	Doel 3 - Auxiliary cooling tower - high speed fan	111.7
13	Doel 3 - Cooling compressor Yoric-type	100.8
14	Doel 3 - Turbine hall - windows and ventilation grids	103.2
15	Doel 3 - Ventilation BKR north side	103.7
16	Doel 3 - Ventilation BKR south side	103.7
16a	Doel 3 - Ventilation GEH	96.0
17	Doel 4 - Main transformers	98.9
18	Doel 4 - Auxiliary transformers at Turbine Hall MAZ	92.0
19	Doel 4 - Auxiliary transformers between MAZ and CGB	87.4
20	Doel 4 - Auxiliary cooling tower - high speed fan	111.7
21	Doel 4 - Cooling compressor Carrier-type	99.2
22	Doel 4 - Turbine hall - windows and ventilation grids	102.8
23	Doel 4 - Ventilation grids on the GEH roof	94.8
24	Doel 4 - Ventilation BKR north side	109.7
25	Doel 4 - Ventilation BKR south side	108.4
26	Doel 3&4 - Water intake	95.5
27	Doel 1&4 - Cooling tower	117.8
28	Doel 1&4 - Circulation pumps	109.3
29	Doel 1&4 - Auxiliary feed pumps	103.3
30	Doel 2&3 - Cooling tower	117.8
31	Doel 2&3 - Circulation pumps	103.2
32	Doel 2&3 - Feed pumps	98.4
33	WAB - Auxiliary cooling towers	107.0
TOTAL LwA installed on KCD site		**123.4**

The total noise power of the continuous sources of KCD is therefore 123.4 dB(A). Of this, 55% can be attributed to the two cooling towers, which together have a noise power level of 120.8 dB(A). The auxiliary coolers represent another 20%. The emission from the walls of the turbine halls, and the ventilation of bunkers and reactor buildings provide 15% of the total power.

Some noise sources or source groups have a tonal character, but this is no longer the case for the overall noise power level of KCD.

2.3.2.2.2 Discontinuous sources

n°	Description	Number	Total noise power in dB(A) re 1pW 2013-2014
	Doel 1&2 - Diesel generators (4.3 MWth)	2	111.2
2	Doel 1&2 - Safety diesel generators (6.2 MWth)	4	Out of service
3	Doel 1&2 - Emergency diesel generators (6.1 MWth)	2	115.1
4	Doel 1&2 - EC and PL circuit emergency coolers	3	115.9
5	Doel 3 - Emergency diesel generators (12.6 MWth)	4	125.6
6	Doel 3 - Smoke gas chimneys of the safety diesel generators (5.7 MWth)	3	106.8
7	Doel 4 - Emergency diesel generators (12.6 MWth)	3	124.4
9	Doel 4 - Smoke gas chimneys of the safety diesel generators (5.7 MWth)	3	106.8
	Total noise power level DISCONTINUOUS sources		**128.6 dB(A)**

The discontinuous sources as a whole represent a noise power level of 128.6 dB(A), of which, however, only a limited proportion is in operation under normal conditions for a limited period of time and non-simultaneously.

2.3.2.3 Noise transfer calculation

The noise transfer calculations were carried out on the basis of the available data as described in the previous paragraph, using the "GEOMILIEU" model according to the ISO 9613-2 standard. The calculation took into account the correct location of the different noise sources, the distance between source and reference point, air absorption, possible shielding effects and the influence of the soil. The calculations were performed for the most critical wind direction, i.e. the wind direction from each noise source to each reference point. For humidity and temperature, 70% and 10°C were taken respectively. The calculations were carried out for the standardised 1/3 octave bands between 25 Hz and 10 kHz.

The specific noise level (Lsp) of KCD was calculated at different reference points.

MPTs 1, 2 and 3 are identical to the measuring points where immission measurements were previously carried out. The points with a code IP-1x are located at the level of the nearest houses but more than 200 m from the site boundary. However, since the specific noise level of a facility is evaluated at 200 m from the site boundary, reference points with code IP-2x were selected in the different wind directions, just at the 200 m boundary around the licensed KCD plots.

To assess the noise emission, the specific noise level of the continuous sources of KCD should be compared with the conditions of VLAREM II. In doing so, the conditions for an **existing Class 1** site must be met. These can be summarised as follows:

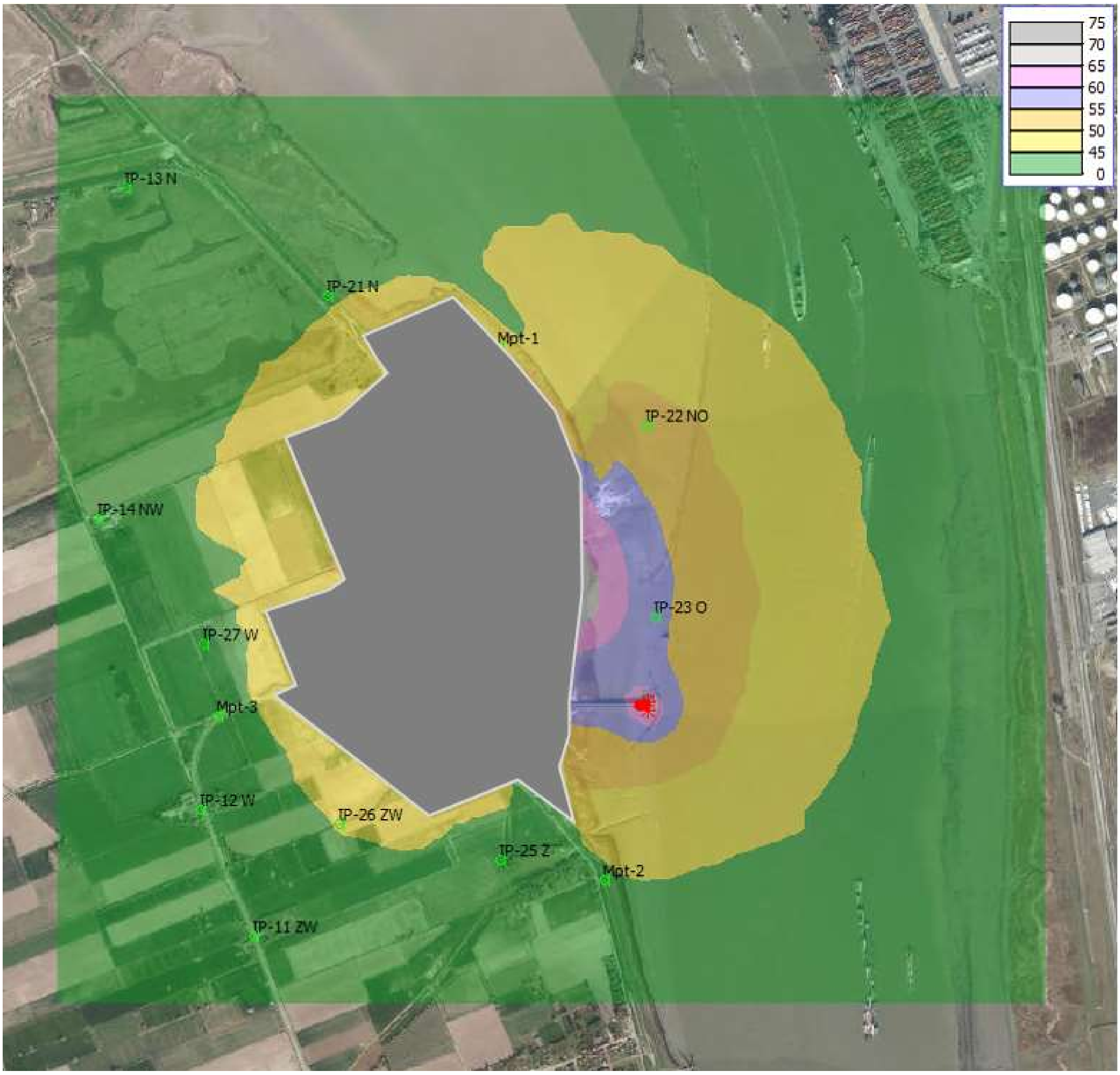
- If the specific noise level **Lsp** of the site remains **below or equal** to the **applicable guide value, the site complies** with the noise requirements of VLAREM II and therefore no additional mitigating measures are necessary.
- However, if the specific noise level **Lsp exceeds** the guide value, **but** this exceedance is **limited to a maximum of 10 dB(A)**, the licensing authority **may**, on the advice of the section competent for site permits, **impose** a **remediation plan** in accordance with the provisions in VLAREM II, Annex 4.5.3.
- If the specific noise level **Lsp** is found to **exceed 10 dB(A)**, the operator of the site concerned must, at their own initiative, **draw up** and implement a **remediation plan** in accordance with the provisions of VLAREM II, Annex 4.5.3.

As all immission points are less than 500 m from an industrial area, **the limit value**should be **the guide value during the night period for areas less than 500 m from an industrial area, i.e. 45 dB(A)**.

2.3.2.3.1 Continuous sources

Two calculations were carried out depending on the operating condition of the noise sources. In the first calculation, the total noise contribution of all continuously operating sources is calculated. Since there is no difference in the operating conditions of the continuous sources during the day, evening and night period, no period-dependent condition state should be calculated. The review of the calculated value is carried out for the most critical assessment period, i.e. the night period: 45 dB(A) at 200 m from the site boundary (in the absence of dwellings within 200 m of the site boundary). The contribution of non-continuous sources such as emergency diesels is discussed further down.

The calculated noise extension to the surroundings is presented by means of coloured noise contours (= noise map). A noise contour is formed by connecting grid points of equal noise pressure level. On the noise contours map, areas with the same noise level (sound class) are shown in the same colour so that there is a clear visual overview of the noise propagation. The critical zone, i.e. the zone within which the noise pressure level exceeds a certain level of nuisance (i.e. applicable Vlarem II guide value), can be clearly identified. The noise contour map provides insight into the way in which noise pollution is spread and the extent of the pollution.



The figure above shows the noise map, calculated based on the noise power levels of the continuous sources of KCD. The noise contours are shown from 45 dB(A) with a step size of 5 dB(A) to the noise contour value of 75 dB(A).

This shows that the specific noise from the continuous sources at 200 m from the site boundary on the east side, i.e. in the nature reserve along the Scheldt, is the highest and varies from 45 to 60 dB(A). From south to west to north, the Lsp for the continuous sources varies mostly below 45 dB(A) and therefore complies with the guide value here. Further to the northeast, the specific noise level goes up to 50 dB(A) and more.

In addition, the specific noise level for KCD was calculated as an absolute value for the above reference points (incl. assessment points and measurement points).

Condition in 2013-2014		Exceeding Vlarem II guide value (dB(A))		
Name	Lsp	D:50	A:45	N:45
IP-11 ZW_A	40,7	-	-	-
IP-12 W_A	41,4	-	-	-
IP-13 N_A	38,2	-	-	-
IP-14 NW_A	41,3	-	-	-
IP-21 N_A	44,6			
IP-22 NO_A	51,7	1,7	6,7	6,7
IP-23 O_A	56,6	6,6	11,6	11,6
IP-25 Z_A	43,1			
IP-26 ZW_A	45,3			
IP-27 W_A	43,4			
Mpt-1_A	48,7			
Mpt-2_A	43,4			
Mpt-3_A	43,6			

L_{sp} < GV
GV < Lsp < GV + 10
L_{sp} > GV + 10

Only the framed reference points are tested against the Vlarem II target value as they are located at a distance of 200 m from the site boundary. The reference points at the nearby houses (IP-1x) should not be tested against the guide value, strictly speaking, because they are located at a distance of more than 200 m from the site boundary. As MPT 1 is located on the site boundary, this is not an assessment point.

Calculations show that during the **evening and night period**, the specific noise level from KCD exceeds the guide value at reference points IP-22 NE and IP-23 E. This exceedance at IP-23 E, i.e. 200 m east of the site boundary, is greater than 10 dB(A), which means, as such, that the operator must draw up a remediation plan[9] for this on his own initiative.

[9] In 2010, a remediation study was already carried out with regard to the noise impact from the cooling towers. In a study carried out by Technum (Studie geluidsanering koeltorens (Cooling towers noise remediation study); 090-390-0225 14/06/2012) the falling water was identified as the cause of the noise emission. In addition, a number of possible measures were proposed to reduce the noise contribution to the surrounding area:

The feasibility of the remediation measures was investigated by the constructor Hamon Thermal Europe and the engineering firm Tractebel. The modification of the cooling tower is not justified from an economic and safety point of view.

Impact on ambient noise: In addition to the above-mentioned testing of the calculated specific noise level with the applicable guide value of Vlarem II, the expected impact of the specific noise level on the ambient noise is also taken into account when determining the effect score in the significance framework. The noise level of the ambient noise at a certain location is determined by the cumulative of all noise sources present in the area, including industrial noise on the other side of the Scheldt. The specific noise level of KCD is thus part of the ambient noise level.

In order to determine the impact of KCD's specific noise level on the ambient noise level, knowledge of the original ambient noise level, i.e. the ambient noise level that would be measured when KCD is completely inactive, is first required. This measured ambient noise level is considered to be the original ambient noise level (abbreviated to OANL). Since no measurements can be made with KCD not in operation, the OANL should be calculated using the logarithmic difference between the ambient noise measured at the measurement points around KCD under tail wind conditions and the calculated specific noise level of KCD from the continuous sources at the measurement points using the transfer model. The **determination of the** OANL was already carried out in the 2010 EIR, where a calculated OANL of **45.6 dB(A) on average** was determined at the measurement points.

On the basis of the estimated original ambient noise level, the levels of significance can then be determined according to the frame of significance at the various reference points, as shown in the table below.

Table 2-20: Significance levels for noise in 2013-2014 condition

Condition in 2013-2014 Name	Lsp	OANL	TOT = Lsp + OANL	Δ TOT OANL	Intermediate score	Exceedance of Lsp vs GV	Final score
IP-11 ZW_A	40,7	45,6	46,8	1.2	-1	-4.3	-1
IP-12 W_A	41,4	45,6	47	1.4	-1	-3.6	-1
IP-13 N_A	38,2	45,6	46,3	0,7	0	-6.8	0
IP-14 NW_A	41,3	45,6	47	1.4	-1	-3.7	-1
IP-21 N_A	44,6	45,6	48,1	2,5	-1	-0.4	-1
IP-22 NO_A	51,7	45,6	52,7	7,1	-3	6,7	-2
IP-23 O_A	56,6	45,6	56,9	11,3	-3	11,6	-3
IP-25 Z_A	43,1	45,6	47,5	1,9	-1	-1.9	-1
IP-26 ZW_A	45,3	45,6	48,5	2,9	-1	0,3	-1
IP-27 W_A	43,4	45,6	47,6	2,0	-1	-1.6	-1
Mpt-1_A	48,7	45,6	50,4	4,8	-2	3,7	-2
Mpt-2_A	43,4	45,6	47,6	2,0	-1	-1.6	-1
Mpt-3_A	43,6	45,6	47,7	2,1	-1	-1.4	-1

At the level of the closest houses (IP-1x) around KCD we find a significance level (final score) of 0 or -1, which means that KCD has a negligible to 'slightly negative' impact. It should be noted that, strictly speaking, these points do not qualify as Vlarem II assessment points, given that the distance of the dwellings from the plot boundary is more than 200 metres.

In the Vlarem II assessment points (IP-2x) a significance level of -1 is obtained with respect to the northern, southern and western zone. In the eastern zone a significance level of -2 (= 'negative' impact) is obtained in the northeast and a significance level of -3 (= 'significant negative' impact) in the east, situated in the nature reserve along the Scheldt.

2.3.2.3.2 Discontinuous sources

In addition to continuously operating machines with permanent noise emission during the day, evening and night period, KCD has a number of power generators and pumps to switch on in case of emergency. These emergency systems, some of which are trailer-mounted, are spread throughout the site, in a technical building (with the exception of one emergency diesel generator from the warehouse and one pump at Doel ½). The noise emission levels of the discontinuous sources were already determined during the 2009 source inventory. However, the four safety diesel generators (PKD-D0/DG 12.14.22.24) were taken out of service since the 2009 source inventory and replaced by five new machines, all set up in a compartmented concrete building with an intake/outlet grid and a battery of outdoor cooling units.

The emergency systems are permanently out of operation and are only briefly put into operation for monthly tests and maintenance.

None of these emergency installations operate simultaneously, unless of course in an emergency. An average time-weighted impact will therefore be determined on the basis of the provided data of the counter readings (runtime hours) of the emergency systems included in 2013 and 2014.

In an emergency situation in the event of a disaster, the noise contribution from the simultaneous operation of all emergency system can amount to a maximum specific noise level then is approx. 20 dB(A) more than the 'time-weighted total specific noise level' of the non-continuous sources calculated below. In such a situation, the impact on the environment is comparable to the current impact of the continuous sources.

During LTO, additional testing is not desirable.

Assuming that there are 220 working days in a year, and 12 hours in a day period, the daily average operating time was determined per emergency system. In combination with the specific noise levels of each individual emergency system, calculated on the basis of the transmission model, the time-weighted contribution of each emergency system was determined. The logarithmic sum of all these individual contributions then gives the average specific noise level of the whole set-up of these non-continuous emergency systems of KCD at the considered reference points.

Name	2013-2014
IP-11 ZW_A	20,3
IP-12 W_A	21,4
IP-13 N_A	26,8
IP-14 NW_A	32,2
IP-21 N_A	32,1
IP-22 NO_A	38,7
IP-23 O_A	33,1
IP-25 Z_A	25,8
IP-26 ZW_A	28,9
IP-27 W_A	33,9
Mpt-1_A	40,3
Mpt-2_A	26,4
Mpt-3_A	28,2

This 'time-weighted total specific noise level' of the non-continuous sources remains well below the specific noise of the continuous sources at all reference points.

The logarithmic sum of the 'time-weighted total specific noise levels' of the non-continuous sources with the continuous sources and their testing against the guide value of 50 dB(A) during the daytime period (since the non-continuous sources are only tested during the daytime period) is shown in the table below for the reference points.

Table 2-21: Time-weighted total specific noise in 2013-2014 condition

Condition in 2013-2014 Name	Continuous sources Lsp	Non-continuous sources 'Time-weighted' Lsp	Continuous + Non-continuous sources TOT Lsp	Exceedance TOT vs GV 50 (daytime period)
IP-11 ZW_A	40,7	20,3	40,7	-
IP-12 W_A	41,4	21,4	41,4	-
IP-13 N_A	38,2	26,8	38,5	-
IP-14 NW_A	41,3	32,2	41,8	-
IP-21 N_A	44,6	32,1	44,8	-
IP-22 NO_A	51,7	38,7	51,9	+1.9
IP-23 O_A	56,6	33,1	56,6	+6.6
IP-25 Z_A	43,1	25,8	43,2	-
IP-26 ZW_A	45,3	28,9	45,4	-
IP-27 W_A	43,4	33,9	43,9	-
Mpt-1_A	48,7	40,3	49,3	-

Mpt-2_A	43,4	26,4	43,5	-
Mpt-3_A	43,6	28,2	43,7	-

The logarithmic sum of the two remains below the guide value for the day period at most points, except for the reference points IP-22-NO and IP-23 O, located in the nature reserve 200 m from the site boundary in the east and north-east. At these points this 'time-weighted total specific noise level' exceeds the guide value for the day period by approx. 2 to 6 dB(A). With only the contribution of the continuous sources, the guide value 50 dB(A) is already exceeded. The 'time-weighted specific noise level' of the non-continuous noise sources only causes a negligible additional excess of 0.2 dB(A) in reference point IP-22 NO. In reference point IP-23 O, no additional exceedance is obtained by the non-continuous sources in the cumulative noise level.

Finally, the noise produced by the discontinuous sources could be considered separately as incidental noise, to be tested against the relevant guide values, i.e. 65 dB(A) during the day and 55 dB(A) in the evening and at night. These guide values for incidental noise are well below the threshold for all reference points. This has already been confirmed in the 2010 EIR.

The calculated noise extension to the surroundings of the 'time-weighted specific noise level' of the non-continuous sources is presented by means of coloured noise contours (= noise map). A noise contour is formed by connecting grid points of equal noise pressure level. On the noise contour map, areas with the same noise level (noise class) are shown in the same colour so that there is a clear visual overview of the noise propagation. The critical zone, i.e. the zone within which the noise pressure level exceeds a certain level of nuisance (i.e. applicable Vlarem II guide value), can be clearly identified. The noise contour map provides insight into the way in which noise pollution is spread and the extent of the pollution.

The figure above shows the noise map for the 'time-weighted specific noise level' of the non-continuous sources of KCD. The noise contours are shown from 45 dB(A) with a step size of 5 dB(A) to the noise contour value of 75 dB(A).

This shows that the 'time-weighted specific noise level' of the non-continuous sources does not exceed the Vlarem II target value of 50 during the daytime period anywhere in the vicinity of KCD. The noise map even shows that the nuisance contour of 50 dB(A) is entirely situated within the KCD site.

As applied for continuous sources, for the combination of continuous and non-continuous sources, the effect on ambient noise and the significance level at the different reference points for the 'time-weighted total specific noise level' can be determined.

Table 2-22: Significance level based on time-weighted total specific noise level in 2013-2014 condition

Condition in 2013-2014 Name	Continuous + Non-continuous sources Lsp	OANL	TOT = Lsp + OANL	Δ TOT OANL	Intermediate score	Exceedance of Lsp vs GV	Final score
IP-11 ZW_A	40,7	45,6	46,8	1.2	-1	-9.3	-1
IP-12 W_A	41,4	45,6	47	1.4	-1	-8.6	-1
IP-13 N_A	38,5	45,6	46,4	0,8	0	-11.5	0
IP-14 NW_A	41,8	45,6	47,1	1.5	-1	-8.2	-1
IP-21 N_A	44,8	45,6	48,2	2,6	-1	-5.2	-1
IP-22 NO_A	51,9	45,6	52,8	7,2	-3	1,9	-2
IP-23 O_A	56,6	45,6	56,9	11,3	-3	6,6	-2
IP-25 Z_A	43,2	45,6	47,6	2,0	-1	-6.8	-1
IP-26 ZW_A	45,4	45,6	48,5	2,9	-1	-4.6	-1
IP-27 W_A	43,9	45,6	47,8	2,2	-1	-6.1	-1
Mpt-1_A	49,3	45,6	50,8	5,2	-2	-0.7	-1
Mpt-2_A	43,5	45,6	47,7	2,1	-1	-6.5	-1
Mpt-3_A	43,7	45,6	47,8	2,2	-1	-6.3	-1

For the 'weighted total specific noise level' of the continuous and non-continuous sources together, we find a significance level (final score) of 0 or -1 for 'daytime' at the closest dwellings (IP-1x) around KCD, which means that KCD has a negligible to 'slightly negative' impact. It should be noted that, strictly speaking, these points do not qualify as Vlarem II assessment points, given that the distance of the dwellings from the plot boundary is more than 200 metres.

In the Vlarem II assessment points (IP-2x) a significance level of -1 is obtained with respect to the northern, southern and western zone. In the eastern and northeastern zone a significance level of -2 (= 'negative' impact) is obtained, situated in the nature reserve along the Scheldt.

During the night period this assessment condition does not occur, since the non-continuous sources are only tested during the day period.

2.3.3 Impact assessment

2.3.3.1 Operational phase between 2015-2019

2.3.3.1.1 Immission measurements (2016-2017)

The most recent noise immission measurements were carried out in 2017 by Vinçotte in the context of SF2 EIR at 3 measurement points over a period of 18 days. The measurement points considered are identical to those in the 2010 EIR for the entire KCD site, and to those used for the 2014 WMF EIR.

The results of the total ambient noise measurements recently carried out in February 2017 are compared with the results of the Vinçotte measurement campaigns of September 2009 and 2014 and Technum of September 2016 (for +/- 4 weeks in June-July 2016), as well as with the applicable environmental quality standard (EQS).

TABLE II.2-23: RESULTS OF IMMISSION MEASUREMENT AND COMPARISON WITH EQS

Point	**Measuring period**	**Average $_{LA95.1h}$ night period** in dB(A)								**EQS** in dB(A)
		N	**NE**	**E**	**SE**	**S**	**SW**	**W**	**NW**	
MPT-1	Sept 2009	48.9	50.0	49.8	50.2	**50.5**	49.8	49.0	49.0	45
	Sept 2014	46.5	49.1	49.5	48.4	(-)	47.9	48.0	(-)	
	Sept 2016	47.4	(50.5)	50.7	50.2	**50.2**	50.0	48.1	47.4	
	Feb 2017	(-)	(-)	48.0	50.5	**51.4**	50.8	49.0	(-)	
MPT-2	Sept 2009	**48.1**	48.9	44.2	42.7	40.5	40.2	41.5	**45.7**	45
	Sept 2014	**47.5**	48.4	47.1	43.8	(-)	43.1	46.2	(-)	
	Sept 2016	**46.9**	(47.6)	43.7	40.9	40.9	41.1	42.0	**46.2**	
	Feb 2017	(-)	(-)	46.0	46.3	44.9	43.2	46.3	(-)	
MPT-3	Sept 2009	45.5	**47.1**	(35.4)	37.4	37.3	34.0	(33.8)	(37.3)	45
	Sept 2014	43.6	**44.5**	43.3	39.8	(-)	35.9	39.6	(-)	
	Sept 2016	37.8	**(42.4)**	41.1	32.7	32.7	32.2	32.2	35.6	
	Feb 2017	(-)	(-)	40.2	41.6	40.5	37.0	36.3	(-)	

- Values between brackets (xx): Not enough relevant values to calculate a representative average.
- Indication (-): No values measured with the corresponding wind direction
- Value in bold XX: Results with tailwind from KCD to the measurement point considered

When comparing the measurement results, the different operating conditions between September 2009, 2014 and 2016 and February 2017 should be taken into account.

MPT-1: Site boundary North:

The measuring point is located north of KCD, so there is headwind from KCD to the measuring point with a southerly wind. This wind direction did not occur during the 2014 measurement campaign. The values measured for the closest wind directions, SE and SW, were approximately 2.0 dB(A) lower in 2014. This may be due to operating conditions (fewer units in service).

The measurement campaigns of September 2016 (Technum) and February 2017 (Vinçotte) yield comparable values, which are also in line with the 2009 results.

Ultimately, the ambient noise levels at SW, S and SE appear to remain stable over the years, and to average ±50.5 dB(A) during the night.

The environmental quality standard (EQS) is therefore still exceeded here in the order of magnitude of 5 dB, both in case of tailwind and in other wind directions.

The variation in ambient noise level depending on the wind direction is limited to 3.0 dB. This can be explained by the fact that MPT-1 is located at a relatively short distance from other, non-KCD industrial installations on the other side of the Scheldt.

MPT-2: Scheldt dyke south:

This measuring point is about the same distance south of KCD. With tailwind, from KCD to the reference point, i.e. northerly or northwesterly wind, the ambient noise measured in September 2014 is 47.5 to 48.5 dB(A). These values are only 0.5 dB(A) lower than in September 2009.

The measurement campaigns of September 2016 (Technum) and February 2017 (Vinçotte) yield widely varying results. The results of September 2016 are lower than those of 2014, while those of February 2017 are higher than those of 2009. In 2017 there were no values for tailwind conditions.

Ultimately, the ambient noise level at N and NW over the years appears to be in the order of magnitude of 46 to 48 dB(A) during the night.

The environmental quality standard (EQS) is therefore exceeded here in the order of magnitude of 1 to 3 dB in case of tailwind.

MPT-3: Lindenhofstraat West:

The measuring point is further away from other (non-KCD) industrial installations. The total ambient noise measured, during the September 2014 measurement campaign, with tailwind from the industrial area to the reference point was 44.5 dB(A), which is a decrease of 2.6 dB(A) compared to the situation in September 2009.

This trend is confirmed by the measurement campaign of September 2016. The results of February 2017 are more in line with those of 2009, but there are no results for tailwind conditions.

Based on these results, it can be assumed that the environmental quality standard EQS of 45 dB(A) is complied with in tailwind conditions.

2.3.3.1.2 Description of the noise emission

The tables below give an overview of the LwA sound power levels of the considered continuous and discontinuous sources.

2.3.3.1.3 Continuous sources

The noise emission status for the operational phase 2015-2019 is in line with the status of 2013 - 2014.

2.3.3.1.4 Discontinuous sources

Table 2-24: Total noise power level from discontinuous sources

n°	Description	Number	Total noise power in dB(A) re 1pW	
				2015-2019
1	Doel 1&2 - Diesel generators (4.3 MWth)	2		111.2
2	Doel 1&2 - Safety diesel generators (6.2 MWth)	4		Out of service
3	Doel 1&2 - Safety diesel generators	5	New	105
4	Doel 1&2 - Emergency diesel generators (6.1 MWth)	2		115.1
5	Doel 1&2 - EC and PL circuit emergency coolers	3		115.9
6	Doel 3 - Emergency diesel generators (12.6 MWth)	4		125.6
7	Doel 3 - Smoke gas chimneys of the safety diesel generators (5.7 MWth)	3		106.8
8	Doel 4 - Emergency diesel generators (12.6 MWth)	3		124.4
9	Doel 4 - Smoke gas chimneys of the safety diesel generators (5.7 MWth)	3		106.8
10	Fire department GUM - Best pumps	9	New	114.5
11	Fire department GUM - Best diesel generators	11	New	98.5 102.5
12	Warehouse - Emergency diesel generator	1	New	91
Total noise power level DISCONTINUOUS sources				**128.8 dB(A)**

Note: Best = BElgian Stress Tests

The discontinuous sources as a whole represent a noise power level of 128.8 dB(A), of which, however, only a limited proportion is in operation under normal conditions for a limited period of time and non-simultaneously. This represents a negligible increase in the total noise power level of 0.2 dB(A) compared to the situation in 2013-2014.

2.3.3.1.5 Noise transfer calculation

2.3.3.1.6 Continuous sources

As the noise emission situation for the operational phase 2015-2019 is in line with the situation in 2013-2014, the situation in 2013-2014 is referred to for the noise effects.

2.3.3.1.7 Discontinuous sources

In addition to the changes that took place for the description of the situation in 2013-2014, 11 new 'Best diesel generators' and 9 'Best diesel pumps' were set up in the GUM building of the fire department. The sound power levels of these new sources were measured in June 2020.

The emergency systems are permanently out of operation and were only briefly put into operation for monthly tests and maintenance.

Four times a year, the pumps are serviced (5 large 150 type ones and 5 small 80 type ones), incl. 3 times minor maintenance with a focus on battery voltage and once a year large maintenance where oil, filters, etc. are also replaced. At the same time, the technicians start up the pump where it runs for 1 minute to a maximum of 5 minutes. This is done on-site in the GUM building with the doors open and for 1 pump at Doel ½ as it is permanently outside at Doel ½. In addition to starting the pump during maintenance, monthly tests are also carried out on the pumps, where they are also run for a maximum of 5 minutes. Once every 3 years there is also a full load test of all pumps. The running time for this test is a maximum of half an hour per pump. All tests are carried out during the daytime period.

Assuming that there are 220 working days in a year, and 12 hours in a day period, the daily average operating time was determined per emergency system. In combination with the specific noise levels of each individual emergency system, calculated on the basis of the transmission model, the time-weighted contribution of each emergency system was determined. The logarithmic sum of all these individual contributions then gives the average specific noise level of the whole set-up of these non-continuous emergency systems of KCD at the considered reference points.

Table 2-25: Average specific noise level compared to reference points

Name	2015-2019
IP-11 ZW_A	21,2
IP-12 W_A	23,1
IP-13 N_A	26,9
IP-14 NW_A	32,2
IP-21 N_A	32,1
IP-22 NO_A	38,7
IP-23 O_A	33,1
IP-25 Z_A	26,1
IP-26 ZW_A	29,3
IP-27 W_A	33,9
Mpt-1_A	40,3
Mpt-2_A	26,6
Mpt-3_A	28,8

* calculated in Genoise

This 'time-weighted total specific noise level' of the non-continuous sources remains well below the specific noise of the continuous sources at all reference points.

The logarithmic sum of the 'time-weighted total specific noise levels' of the non-continuous sources with the continuous sources and their testing against the guide value of 50 dB(A) during the daytime period (since the non-continuous sources are only tested during the daytime period) is shown in the table below for the reference points.

Table 2-26: Time-weighted total specific noise level in 2015-2019 condition

Condition in 2015-2019 Name	Continuous sources Lsp	Non-continuous sources 'Time-weighted' Lsp	Continuous + Non-continuous sources TOT Lsp	Exceedance TOT vs GV 50 (daytime period)
IP-11 ZW_A	40,7	21,2	40,7	-
IP-12 W_A	41,4	23,1	41,5	-
IP-13 N_A	38,2	26,9	38,5	-
IP-14 NW_A	41,3	32,2	41,8	-
IP-21 N_A	44,6	32,1	44,8	-
IP-22 NO_A	51,7	38,7	51,9	+1.9
IP-23 O_A	56,6	33,1	56,6	+6.6
IP-25 Z_A	43,1	26,1	43,2	-
IP-26 ZW_A	45,3	29,3	45,4	-
IP-27 W_A	43,4	33,9	43,9	-
Mpt-1_A	48,7	40,3	49,3	-
Mpt-2_A	43,4	26,6	43,5	-
Mpt-3_A	43,6	28,8	43,7	-

The logarithmic sum of the two remains below the guide value for the day period at most points, except for the reference points IP-22-NO and IP-23 O, located in the nature reserve 200 m from the site boundary in the east and north-east. At these points this 'time-weighted total specific noise level' exceeds the guide value for the day period by approx. 2 to 6 dB(A). With only the contribution of the continuous sources, the guide value 50 dB(A) is already exceeded. The 'time-weighted specific noise level' of the non-continuous noise sources only causes a negligible additional excess of 0.2 dB(A) in reference point IP-22 NO. In reference point IP-23 O, no additional exceedance is obtained by the non-continuous sources in the cumulative noise level. As a result, the impact assessment remains identical to the situation in 2013-2014.

The calculated noise extension to the surroundings of the 'time-weighted specific noise level' of the non-continuous sources is presented by means of coloured noise contours (= noise map). A noise contour is formed by connecting grid points of equal noise pressure level. On the noise contour map, areas with the same noise level (noise class) are shown in the same colour so that there is a clear visual overview of the noise propagation. The critical zone, i.e. the zone within which the noise pressure level exceeds a certain level of nuisance (i.e. applicable Vlarem II guide value), can be clearly identified. The noise contour map provides insight into the way in which noise pollution is spread and the extent of the pollution.

The figure above shows the noise map for the 'time-weighted specific noise level' of the non-continuous sources of KCD. The noise contours are shown from 45 dB(A) with a step size of 5 dB(A) to the noise contour value of 75 dB(A).

This shows that the 'time-weighted specific noise level' of the non-continuous sources does not exceed the Vlarem II target value of 50 during the daytime period anywhere in the vicinity of KCD. The noise map even shows that the nuisance contour of 50 dB(A) is entirely situated within the KCD site.

As applied for continuous sources, for the combination of continuous and non-continuous sources, the effect on ambient noise and the significance level at the different reference points for the 'time-weighted total specific noise level' can be determined.

Table 2-27: Significance level based on time-weighted total specific noise level in 2015-2019 condition

Condition in 2015-2019 Name	Continuous + Non-continuous sources Lsp	OANL	TOT = Lsp + OANL	Δ TOT OANL	Intermediate score	Exceedance of Lsp vs GV	Final score
IP-11 ZW_A	40,7	45,6	46,8	1.2	-1	-9.3	-1
IP-12 W_A	41,5	45,6	47	1.4	-1	-8.5	-1
IP-13 N_A	38,5	45,6	46,4	0,8	0	-11.5	0
IP-14 NW_A	41,8	45,6	47,1	1.5	-1	-8.2	-1
IP-21 N_A	44,8	45,6	48,2	2,6	-1	-5.2	-1
IP-22 NO_A	51,9	45,6	52,8	7,2	-3	1,9	-2
IP-23 O_A	56,6	45,6	56,9	11,3	-3	6,6	-2
IP-25 Z_A	43,2	45,6	47,6	2,0	-1	-6.8	-1
IP-26 ZW_A	45,4	45,6	48,5	2,9	-1	-4.6	-1
IP-27 W_A	43,9	45,6	47,8	2,2	-1	-6.1	-1
Mpt-1_A	49,3	45,6	50,8	5,2	-2	-0.7	-1
Mpt-2_A	43,5	45,6	47,7	2,1	-1	-6.5	-1
Mpt-3_A	43,7	45,6	47,8	2,2	-1	-6.3	-1

For the 'weighted total specific noise level' of the continuous and non-continuous sources together, we find a significance level (final score) of 0 or -1 for 'daytime' at the closest dwellings (IP-1x) around KCD, which means that KCD has a negligible to 'slightly negative' impact. It should be noted that, strictly speaking, these points do not qualify as Vlarem II assessment points, given that the distance of the dwellings from the plot boundary is more than 200 metres.

In the Vlarem II assessment points (IP-2x) a significance level of -1 is obtained with respect to the northern, southern and western zone. In the eastern and northeastern zone a significance level of -2 (= 'negative' impact) is obtained, situated in the nature reserve along the Scheldt.

During the night period this assessment condition does not occur, since the non-continuous sources are only tested during the day period.

As a result, the impact assessment remains identical to the situation in 2013-2014.

2.3.3.2 Description of the noise impact of LTO works

Two construction projects are planned in the LTO construction phase:

- CFVS buildings (with FCV)
- FE pump house (on bored piles)

The construction site for the FE building will partly be carried out at the same time as the site for the CFVS buildings. In order to make a conservative estimate, it is assumed for the noise impact that both construction sites will be in operation at the same time.

A construction site creates many types of noise nuisance:

- Noisy machines, equipment and works.
- Poor arrangement of the noise sources (close to homes, no a noise-mitigating measures, etc.).
- Shouting and certain behaviors.

Each site generates specific noise emissions depending on the type of work being carried out. In addition, these noise emissions change as the work progresses.

The main works for the project with a risk of noise/vibration nuisance are listed below:

- Pile foundations are provided for the FE pump house.
- The excavated soil must be removed and the construction/ foundation materials brought in.

Table 2-28 shows the tools used in the above work:

- Excavators
- Tower cranes
- Pile turning machine
- Elevating work platforms (scissor lifts)
- Power generator
- Small construction tools
- Concrete mixers

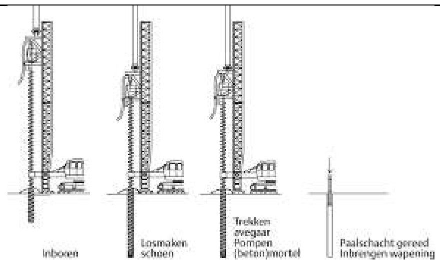
N.B.: No drainage is planned, so no drainage pumps.

The noise exposure of the works depends on the surroundings of the site, the progress of the works and the noticeable difference between the theoretical noise emission (limited by the Royal Decree of 6 March 2002 on the noise power level of equipment for use outdoors) and its actual noise emission.

The noise power level of the tools specified is shown in the table below according to the technical specifications. In the absence of data, the noise data of the typical work instruments were given.

Nevertheless, each work instrument must comply with the maximum permissible noise power level according to the Royal Decree of 6 March 2002.

Table 2-28: Typical work tools used during the construction phase and their noise power level

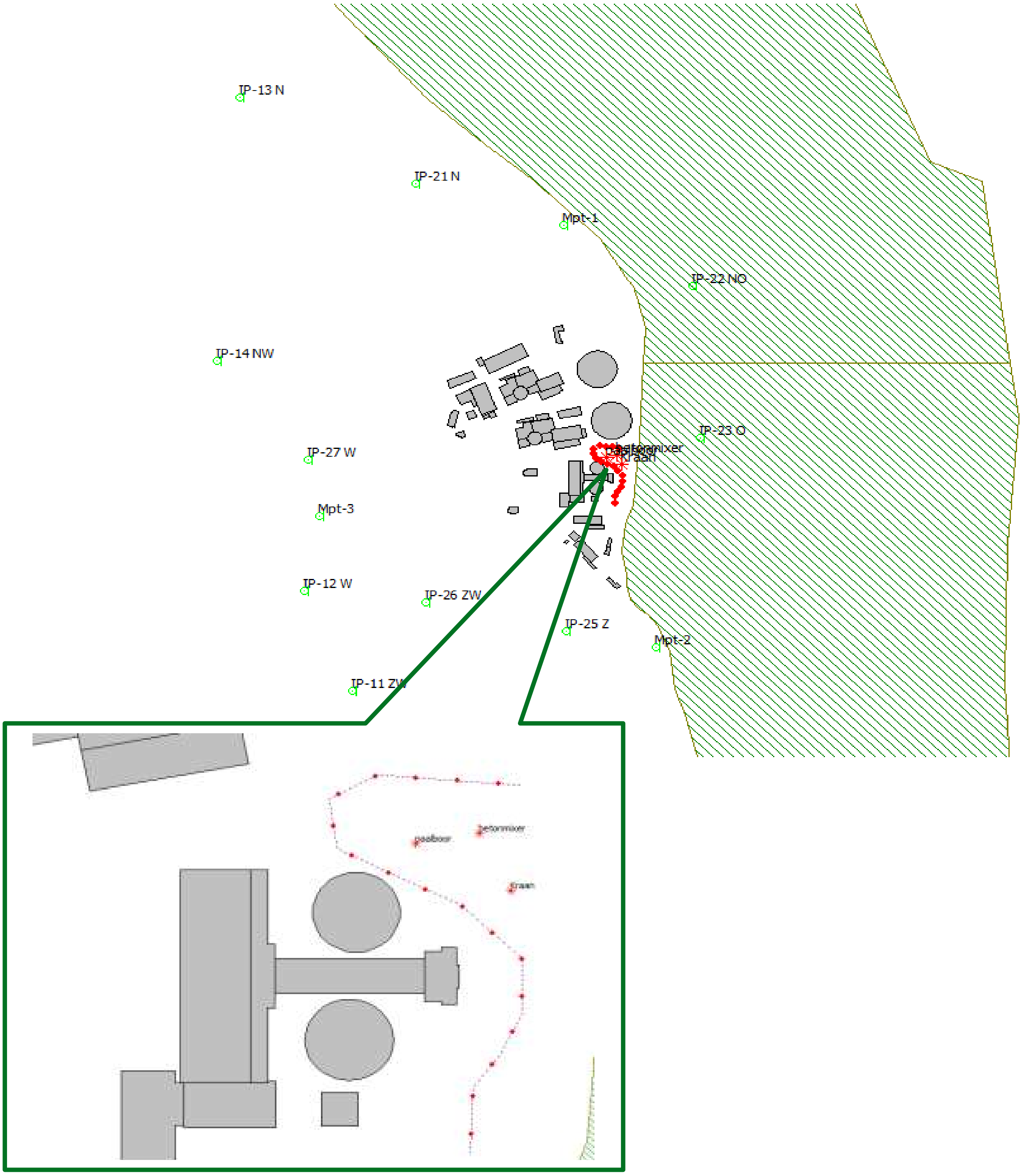
Type of work tool	Typical work tool Net installed power P in kW	Sound power level according to technical data sheet
Excavator	 Type: Caterpillar 328 DL 140kW	106 dB(A)
Tower crane	 Type: Liebherr 280 ECH 65kW & Liebherr 200 ECH 45kW	105 dB(A)
Pile turning machine		< 110 dB(A)

Type of work tool	Typical work tool Net installed power P in kW	Sound power level according to technical data sheet
Concrete mixer	 DAF CF85/410 – 302 kW	107 dB(A)[10]
Dumper/truck [Transport of materials by road]		104 dB(A)

The estimated earth movement volume is 1000 m^3 (500 m^3 per project). As a result, the number of truck movements is limited and mainly in the case of excavation work and the supply of materials. Freight transport is only scheduled to take place during the daytime period. There are no construction site roads outside KCD's plot boundaries, as the excavated soil is temporarily stored on-site for reuse. For the internal construction site route, the adjacent road to the project zones is partly used.

On the basis of the data for the construction work, an acoustic calculation model was built based on the maximum load condition, i.e. the instantaneous specific noise level at which all work tools (one tool of each type) are operating simultaneously. This in combination with the hourly average noise contribution of the internal construction site transport on the adjacent road between the project zone and the nearby storage area for earthmoving within the construction site zone. In the following extract from the calculation model, the location of the works tools in the construction area is represented by an asterisk and the site route by a red line. The location of the reference points is also indicated, together with the water surface (green shading) of the Scheldt.

[10] Noise power level as per the study: Peutz B.V. - Construction Noise: how to deal with it in practice.



The logarithmic sum of the 'time-weighted total specific noise level' of the non-continuous sources, the continuous sources with the contribution of the construction site noise levels and their testing against the guide value of 50 dB(A) during the daytime period (since the non-continuous sources are only tested during the daytime period) is shown in the table below for the reference points.

Table 2-29: Testing of the logarithmic sum of the time-weighted total specific noise level against the guide value compared to reference points in 2015-2019 condition

Condition in 2015-2019 **Name**	**Continuous + Non-continuous sources Lsp**	**Work tools for the LTO construction Lsp of the construction site**	**Continuous + Non-continuous sources + construction site tools TOT Lsp**	**Exceedance TOT vs GV 50 (daytime period)**
IP-11 ZW_A	40,7	31,4	41,3	-
IP-12 W_A	41,5	20,7	41,6	-
IP-13 N_A	38,5	24,7	39	-
IP-14 NW_A	41,8	23,3	42,3	-
IP-21 N_A	44,8	19,3	45,1	-
IP-22 NO_A	51,9	39,8	52,4	+2.4
IP-23 O_A	56,6	50,4	57,6	+7.6
IP-25 Z_A	43,2	36,2	44	-
IP-26 ZW_A	45,4	33,9	45,8	-
IP-27 W_A	43,9	33,2	44,6	-
Mpt-1_A	49,3	17,0	49,8	-
Mpt-2_A	43,5	42,9	46,3	-
Mpt-3_A	43,7	20,2	43,9	-

The logarithmic sum of the two remains below the guide value for the day period at most points, except for the reference points IP-22-NO and IP-23 O, located in the nature reserve 200 m from the site boundary in the east and north-east. This is already the case without the construction site activities. At these points this 'time-weighted total specific noise level' exceeds the guide value for the day period by approx. 2 to 7 dB(A). With only the contribution of the continuous sources, the guide value 50 dB(A) is already exceeded. The additional noise contribution from the works will result in a limited additional exceedance of 0.5 dB(A) in reference point IP-22 NO and 1 dB(A) in reference point IP-23 O, respectively, in a limited time window. This keeps the impact assessment during the works phase (for the worst-case load situation) in line with the situation in 2013-2014.

Noise standards for testing the specific noise levels during temporary works are not regulated by legislation in Flanders. One can, however, refer to noise standards drawn up for construction work in our neighbouring countries. The Dutch Building Decree 2012 sets a noise level of 60 dB(A) as a limit value at the level of the facades of surrounding buildings or other noise-sensitive destinations.

- After all, up to 60 dB(A) there is no limitation in exposure time.
- From 60 dB(A) to a maximum of 80 dB(A), the number of days residents can be exposed to the noise of construction work is regulated (limited).

If the noise level due to the works is ± 60 dB(A), this will certainly be noticeable and clearly identifiable, but certainly not unacceptable in relation to the existing ambient noise levels due to residential activities, road traffic, rail traffic, industrial noise, etc. For noise levels of certain work activities that are expected to exceed 60 dB(A), it is advisable to take additional measures.

Based on the regulations of the Dutch Building Decree 2012, we can state that the guide value of 60 dB(A) is already respected at a distance of less than 200 m from the KCD plot boundary. This means that there is certainly compliance at the level of the dwellings for which the guide value was determined, given that all dwellings are located more than 200 m from the plot boundary.

2.3.3.3 Operational phase in the future situation (2020-2025)

2.3.3.3.1 Description of the noise emission

2.3.3.3.2 Continuous sources

The noise emission status for the operational phase 2020-2025 is in line with the status of 2013 - 2014. There are no changes in noise emissions.

2.3.3.3.3 Discontinuous sources

The noise emission status for the operational phase 2020-2025 is in line with the status of 2015 - 2019. There are no changes in noise emissions.

2.3.3.3.4 Noise transfer calculation

2.3.3.3.5 Continuous sources

As the noise emission situation for the operational phase 2020-2025 is in line with the situation in 2013-2014, the situation in 2013-2014 is referred to for the noise effects.

2.3.3.3.6 Discontinuous sources

As the noise emission situation for the operational phase 2020-2025 is in line with the situation in 2015-2019, the situation in 2015-2019 is referred to for the noise effects.

2.3.3.4 Operational phase Post Operational Phase (2025-2029)

2.3.3.4.1 Description of the noise emission

2.3.3.4.2 Continuous sources

The noise emission status for the operational phase 2025-2029 is in line with the status of 2013 - 2014. There are no changes in noise emissions.

2.3.3.4.3 Discontinuous sources

The noise emission status for the operational phase 2025-2029 is in line with the status of 2015 - 2019. There are no changes in the noise emissions

2.3.3.4.4 Noise transfer calculation

2.3.3.4.5 Continuous sources

As the noise emission situation for the operational phase 2025-2029 is in line with the situation in 2013-2014, the situation in 2013-2014 is referred to for the noise effects.

2.3.3.4.6 Discontinuous sources

As the noise emission situation for the operational phase 2025-2029 is in line with the situation in 2015-2019, the situation in 2015-2019 is referred to for the noise effects.

2.3.3.5 Operational phase zero alternative

2.3.3.5.1 Description of the noise emission

The tables below give an overview of the LwA sound power levels of the considered continuous and discontinuous sources. For the description of the zero alternative, please refer to the general section of the EIR (see § 1.7).

2.3.3.5.2 Continuous sources

Table 2-30: Considered sound power levels of the continuous sources

Source group	**Description**	**Sound power levels considered** in dB(A) re 1 pW
		Zero alternative
1	Doel 1 - Transformers	102.6
2	Doel 1 - Reactor building ventilation	102.3
3	Doel 2 - Transformers	102.6
4	Doel 2 - Reactor building ventilation	102.3
5	Doel 1&2 - Auxiliary cooling towers	107.0
6	Doel 1&2 - Turbine hall	Out of service
7	Doel 1&2 - Water intake	Out of service
8	Doel 1&2 - GNH Ventilation	Out of service
9	Doel 3 - Main transformers	98.9
10	Doel 3 - Auxiliary transformers at Turbine Hall MAZ	92.0
11	Doel 3 - Auxiliary transformers between MAZ and CGB	87.4
12	Doel 3 - Auxiliary cooling tower - high speed fan	111.7
13	Doel 3 - Cooling compressor Yoric-type	100.8
14	Doel 3 - Turbine hall - windows and ventilation grids	103.2
15	Doel 3 - Ventilation BKR north side	103.7
16	Doel 3 - Ventilation BKR south side	103.7
16a	Doel 3 - Ventilation GEH	96.0
17	Doel 4 - Main transformers	98.9
18	Doel 4 - Auxiliary transformers at Turbine Hall MAZ	92.0
19	Doel 4 - Auxiliary transformers between MAZ and CGB	87.4
20	Doel 4 - Auxiliary cooling tower - high speed fan	111.7
21	Doel 4 - Cooling compressor Carrier-type	99.2
22	Doel 4 - Turbine hall - windows and ventilation grids	102.8
23	Doel 4 - Ventilation grids on the GEH roof	94.8
24	Doel 4 - Ventilation BKR north side	109.7
25	Doel 4 - Ventilation BKR south side	108.4
26	Doel 3&4 - Water intake	95.5
27	Doel 1&4 - Cooling tower	117.8
28	Doel 1&4 - Circulation pumps	109.3
29	Doel 1&4 - Auxiliary feed pumps	103.3
30	Doel 2&3 - Cooling tower	117.8
31	Doel 2&3 - Circulation pumps	103.2
32	Doel 2&3 - Feed pumps	98.4
33	WAB - Auxiliary cooling towers	107.0
TOTAL LwA installed on KCD site		**123.2**

The total noise power of the continuous sources of KCD is therefore 123.2 dB(A). Of this, 55% can be attributed to the two cooling towers, which together have a noise power level of 120.8 dB(A). The auxiliary coolers represent another 20%. The emission from the walls of the turbine halls, and the ventilation of bunkers and reactor buildings provide 15% of the total power. This represents a negligible decrease in the total noise power level of 0.2 dB(A) compared to the situation in 2013-2014.

2.3.3.5.3 Discontinuous sources

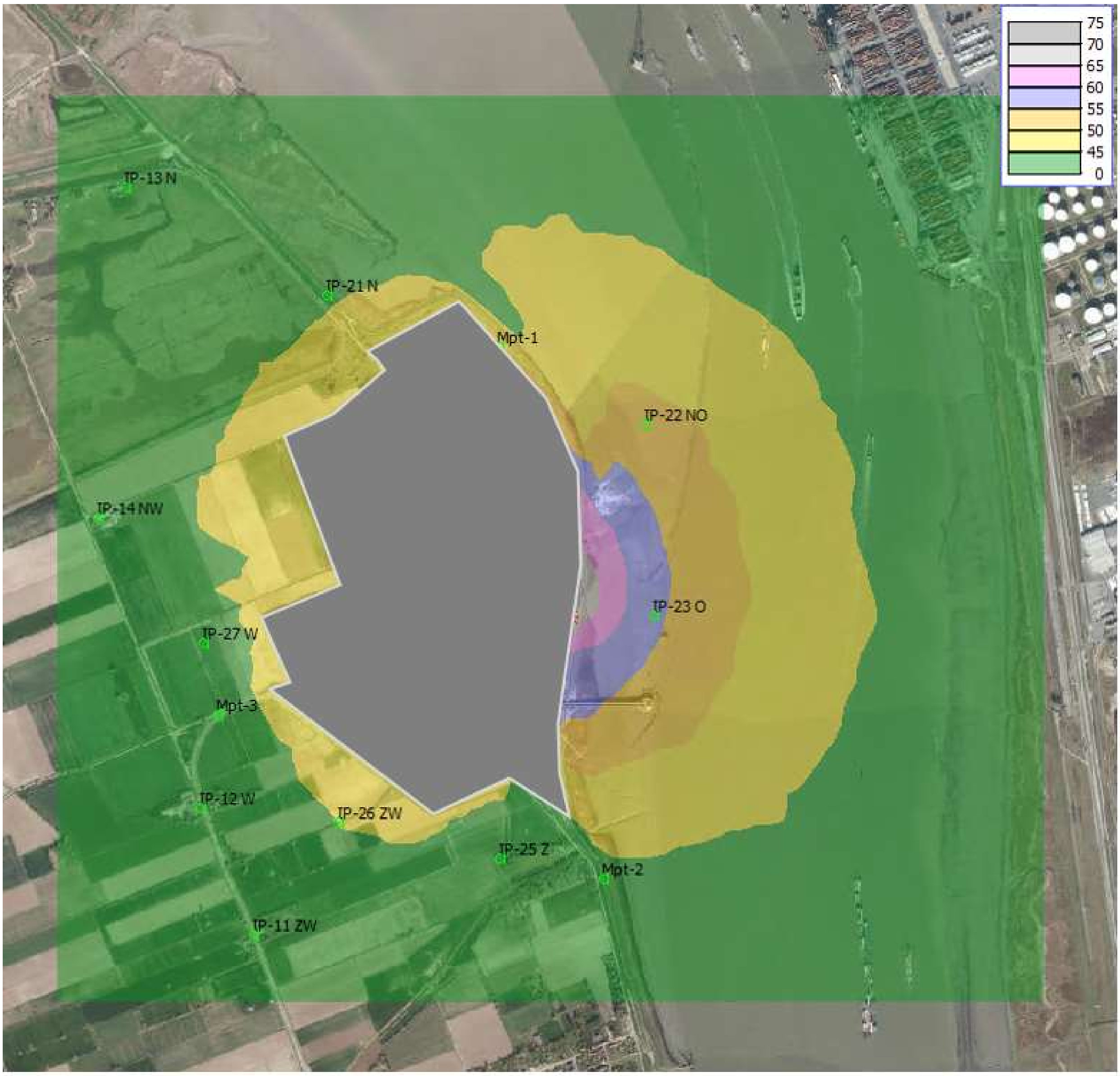
The noise emission status for the operational phase "zero alternative" is in line with the status of 2015 - 2019.

However, for the period 2019-2025 only the emergency systems for Doel 3 and 4 would still be tested. The total noise power level of the continuous sources at KCD is thus 128.3 dB(A) or a noise reduction of only 0.5 dB(A) compared to the situation before 2019.

2.3.3.5.4 Noise transfer calculation

2.3.3.5.5 Continuous sources

The calculated noise extension to the surroundings is presented by means of coloured noise contours (= noise map). A noise contour is formed by connecting grid points of equal noise pressure level. On the noise contour map, areas with the same noise level (noise class) are shown in the same colour so that there is a clear visual overview of the noise propagation. The critical zone, i.e. the zone within which the noise pressure level exceeds a certain level of nuisance (i.e. applicable Vlarem II guide value), can be clearly identified. The noise contour map provides insight into the way in which noise pollution is spread and the extent of the pollution.



The figure above shows the noise map, calculated based on the noise power levels of the continuous sources of KCD. The noise contours are shown from 45 dB(A) with a step size of 5 dB(A) to the noise contour value of 75 dB(A).

This shows that the specific noise from the continuous sources at 200 m from the site boundary on the east side, i.e. in the nature reserve along the Scheldt, is the highest and varies from 45 to 60 dB(A). From south to west to north, the Lsp for the continuous sources varies mostly below 45 dB(A) and therefore complies with the guide value here. Further to the northeast, the specific noise level goes up to 50 dB(A) and more.

Comparison with the 2013-2014 noise map shows a visible reduction in the noise contour in the southeast zone.

In addition, the specific noise level for KCD was calculated as an absolute value for the above reference points (incl. assessment points and measurement points).

Table 2-31: Specific noise in reference points versus Vlarem II guide value

Zero Alternative condition		Exceeding Vlarem II guide value (dB(A))		
Name	**Lsp**	**D:50**	**A:45**	**N:45**
IP-11 ZW_A	40,5	-	-	-
IP-12 W_A	41,2	-	-	-
IP-13 N_A	38,2	-	-	-
IP-14 NW_A	41,2	-	-	-
IP-21 N_A	44,6			
IP-22 NO_A	51,7	1,7	6,7	6,7
IP-23 O_A	56,3	6,3	11,3	11,3
IP-25 Z_A	42,7			
IP-26 ZW_A	45,1			
IP-27 W_A	43,2			
Mpt-1_A	48,7			
Mpt-2_A	42,4			
Mpt-3_A	43,4			

L_{sp} < GV

GV < Lsp < GV + 10

L_{sp} > GV + 10

Calculations show that during the **evening and night period**, the specific noise level from KCD exceeds the guide value at reference points IP-22 NE and IP-23 E. This exceedance at IP-23 E, i.e. 200 m east of the site boundary, is greater than 10 dB(A), which means, as such, that the operator must draw up a remediation plan for this on his own initiative. The same assessment has already been made for the situation in 2013-2014. Taking out of service the noise sources of the MAZ-12 warehouse, the sources at the water intake and the ventilation of GNH-12, yields a negligible noise reduction of 0.3 dB(A) for reference point IP-23 O only. The assessment result thus remains in line with the situation in 2013-2014.

Impact on ambient noise:

In addition to the above-mentioned testing of the calculated specific noise level with the applicable guide value of Vlarem II, the expected impact of the specific noise level on the ambient noise is also taken into account when determining the effect score in the significance framework.

On the basis of the estimated original ambient noise level, the levels of significance can then be determined according to the frame of significance at the various reference points, as shown in the table below.

Table 2-32: Significance levels for noise in the zero alternative

Zero Alternative condition Name	Lsp	OANL	TOT = Lsp + OANL	Δ TOT OANL	Intermediate score	Exceedance of Lsp vs GV	Final score
IP-11 ZW_A	40,5	45,6	46,8	1.2	-1	-4.5	-1
IP-12 W_A	41,2	45,6	46,9	1.3	-1	-3.8	-1
IP-13 N_A	38,2	45,6	46,3	0,7	0	-6.8	0
IP-14 NW_A	41,2	45,6	46,9	1.3	-1	-3.8	-1
IP-21 N_A	44,6	45,6	48,1	2,5	-1	-0.4	-1
IP-22 NO_A	51,7	45,6	52,7	7,1	-3	6,7	-2
IP-23 O_A	56,3	45,6	56,7	11,1	-3	11,3	-3
IP-25 Z_A	42,7	45,6	47,4	1,8	-1	-2.3	-1
IP-26 ZW_A	45,1	45,6	48,4	2,8	-1	0,1	-1
IP-27 W_A	43,2	45,6	47,6	2,0	-1	-1.8	-1
Mpt-1_A	48,7	45,6	50,4	4,8	-2	3,7	-2
Mpt-2_A	42,4	45,6	47,3	1,7	-1	-2.6	-1
Mpt-3_A	43,4	45,6	47,6	2,0	-1	-1.6	-1

2.3.3.5.6 Discontinuous sources

As the noise emission situation for the 'Zero Alternative' operational phase is in line with the situation in 2015 - 2019, the situation in 2015 - 2019 is referred to for the 'time-weighted specific noise level'.
As applied for continuous sources, for the combination of continuous and non-continuous sources, the effect on ambient noise and the significance level at the different reference points for the 'time-weighted total specific noise level' can be determined.

Table 2-33: Significance level based on time-weighted total specific noise level in the zero alternative

Zero Alternative condition Name	Continuous + Non-continuous sources Lsp	OANL	TOT = Lsp + OANL	Δ TOT OANL	Intermediate score	Exceedance of Lsp vs GV	Final score
IP-11 ZW_A	40,6	45,6	46,8	1.2	-1	-9.4	-1
IP-12 W_A	41,3	45,6	47	1.4	-1	-8.7	-1
IP-13 N_A	38,5	45,6	46,4	0,8	0	-11.5	0
IP-14 NW_A	41,7	45,6	47,1	1.5	-1	-8.3	-1
IP-21 N_A	44,8	45,6	48,2	2,6	-1	-5.2	-1
IP-22 NO_A	51,9	45,6	52,8	7,2	-3	1,9	-2
IP-23 O_A	56,3	45,6	56,7	11,1	-3	6,3	-2
IP-25 Z_A	42,8	45,6	47,4	1,8	-1	-7.2	-1
IP-26 ZW_A	45,2	45,6	48,4	2,8	-1	-4.8	-1
IP-27 W_A	43,7	45,6	47,8	2,2	-1	-6.3	-1
Mpt-1_A	49,3	45,6	50,8	5,2	-2	-0.7	-1
Mpt-2_A	42,5	45,6	47,3	1,7	-1	-7.5	-1

Mpt-3_A	43,5	45,6	47,7	2,1	-1	-6.5	-1

For the 'weighted total specific noise level' of the continuous and non-continuous sources together, we find a significance level (final score) of 0 or -1 for 'daytime' at the closest dwellings (IP-1x) around KCD, which means that KCD has a negligible to 'slightly negative' impact. It should be noted that, strictly speaking, these points do not qualify as Vlarem II assessment points, given that the distance of the dwellings from the plot boundary is more than 200 metres.

In the Vlarem II assessment points (IP-2x) a significance level of -1 is obtained with respect to the northern, southern and western zone. In the eastern and northeastern zone a significance level of -2 (= 'negative' impact) is obtained, situated in the nature reserve along the Scheldt.

During the night period this assessment condition does not occur, since the non-continuous sources are only tested during the day period.

As a result, the impact assessment remains identical to the situation in 2013-2014.

2.3.3.6 Cross-border effects

The nearest house on Dutch territory is 3.5 to 4 km away from KCD. By extrapolating the calculated specific noise level at MPT 3 -- housing North at 1,350 m from KCD -- to the Dutch houses, we obtain a specific noise level of a maximum of 30 dB(A) during the night as the noise contribution from the continuous sources of KCD. The 'time-weighted total specific noise level' of the continuous and non-continuous sources also amounts to a maximum of 30 dB(A) since the contribution of the non-continuous sources is well below the contribution of the continuous sources.

It can then be assumed that KCD will cause a negligible to at most a minor impact on ambient noise at the level of the considered homes in the Netherlands.

2.3.4 Monitoring

The various operational phases do not deviate significantly from the baseline situation in 2013-2014, either in a negative or positive sense.

Additional monitoring to identify significant negative effects for the coming operational phases is not necessary, but may be useful to take stock of the evolution of the noise impact on the environment by means of noise measurements. On the basis of the results obtained, it can then be decided what further actions and/or studies are necessary to control the noise impact during the coming operational phases and dismantling phases.

2.3.5 Mitigating measures and recommendations

The various operational phases do not deviate significantly from the baseline situation in 2013-2014, either in a negative or positive sense.

Additional mitigating measures will therefore not be formulated for the future operational phases.

2.3.6 Knowledge gaps

Based on knowledge from current and previous studies (measurements and calculations), there are no knowledge gaps that could have a significant impact on the assessment.

2.3.7 Conclusions

In general, it can be said that no distinctive noise effects are expected for the different operational phases compared to the baseline situation 2013-2014. The deviations in the assessment points are limited to less than 0.5 dB(A) for all operational phases compared to the situation in 2013-2014. This means that the noise effects and assessment already to be determined for the situation 2013-2014 will be maintained for the coming years.

The specific noise from the continuous sources of the KCD at the western, southern and northern assessment points (= direction where there is still some habitation) is considered to be 'minor negative'. In addition, at these assessment points (200 m from the plot boundary) for the specific noise level, the applicable guide value during the day, evening and night period is met.

Although the nearby houses are not among the assessment points (as they are more than 200 m away from the plot boundary), a limited noise increase to a maximum of 1.5 dB(A) on the original ambient noise level is obtained there, as a result of which the maximum noise effect can be considered 'minor significant'.

In the east, a 'negative' effect is obtained for the assessment point, located in the nature reserve along the Scheldt and determined mainly by the noise contribution of the cooling towers

In 2010, a remediation study was already carried out with regard to the noise impact from the cooling towers. In a study carried out by Technum (Studie geluidsanering koeltorens (Cooling towers noise remediation study); 090-390-0225 14/06/2012) the falling water was identified as the cause of the noise emission. In addition, a number of possible measures were proposed to reduce the noise contribution to the surrounding area:

Source-specific measures:

- Reduction of falling height
- Floating, noise-dampening mats

Transfer-restriction measures

- Silencers around the cooling towers
- Noise barriers along the cooling towers

The feasibility of the remediation measures was investigated by the constructor Hamon Thermal Europe and the engineering firm Tractebel. The modification of the cooling tower is not justified from an economic and safety point of view. All this was presented to the monitoring committee which accepted the studies and the decisions.

The cross-border effect on Dutch homes is expected to be limited to a maximum of 30 dB(A) for the specific noise from KCD's continuous noise sources. It can then be assumed that KCD will not cause an increase in the ambient noise levels at the houses under consideration in the Netherlands.

2.4 Air & climate

Annex A - Map 26: Map with differences NO2 LTO

Annex A - Map 27: Map with differences NO2 no LTO

2.4.1 Methodology

2.4.1.1 Definition of the study area

The study area for the Air & Climate section comprises the zone where atmospheric emissions have a demonstrable effect on air quality. Although atmospheric pollutants can spread over very long distances, the size of the study area is initially limited to the immediate vicinity of KCD (1 km radius). However, due to the specific location of the measuring stations, the air quality in the study area will be described on the basis of data that is or may be collected from outside the study area.

2.4.1.2 Description of baseline situation

The air quality in the year 2014 (and where this may be relevant in 2013) is described using the interpolation Maps of the Interregional Cell for the Environment (IRCEL). Doel 1 and 2 were operational in that year (and also Doel 4).

Immission values in the baseline situation are tested against the environmental quality standards for air according to VLAREM II. With respect to KCD emissions (see par. 2.3.4.1.3), the pollutants CO, NO_2, SO_2, PM_{10} en $PM_{2,5}$ are relevant. For $PM2_{.5}$, the indicative limit value of 20 µg/m³ that would take effect from 2020 will be assessed (also for the situation in 2014).

A model will also be drawn up (see also §2.3.4.1.3), in which only emissions related to the operation of Doel 3, 4 and WAB are taken into account.

2.4.1.3 Description and assessment of the impact

In the construction phase, the following emissions can be expected for the air section:

- Emissions from construction site machinery
- Emissions from construction site traffic (trucks, vans)

In principle, these machines run on diesel fuel and therefore mostly emit CO, CO_2, SOx, NOx and fine dust. The extent to which these emissions may have relevant effects will be examined as part of the EIR.

In the operational phase, KCD has only one regular type of emissions with a relevant mass flow, i.e. guided emissions from the various combustion systems present on the site. The associated emissions will be mapped out, paying attention to their specific characteristics. As this relates to the combustion of gas oil (diesel), the main substances emitted are CO2, NOx, SOx, CO and fine dust. Monitoring data can be used to draw up an inventory of the emissions. The emission data are mapped for the LTO situation and for the baseline situation.

In addition, there are possible (diffuse) emissions from the storage of various products on KCD's premises. This mainly involves ammonia and hydrazine. Both products are present as an aqueous solution and are added to the different water flows to keep the pH optimal and to keep the oxygen concentration low. Potential emissions are mainly expected for ammonia, given the high vapour pressure of this product, also in aqueous solution. The volatility of hydrazine in water is very limited, so no relevant emissions are expected. In addition, it is stored in such a diluted concentration that breathing losses are minimised. Furthermore, measures have been taken to prevent possible airborne dispersion, such as water locks and active carbon filters. Both substances are also completely soluble in water. KCD has several procedures in place concerning the handling and storage of these products. Because of this, no relevant emissions of ammonia or hydrazine to the environment are expected. The impact of emissions of ammonia or hydrazine are therefore not considered further in the EIR.

The (guided) KCD emissions will be listed and quantified. Emission sources shall, where possible, be identified and described according to their position, mass flows and the nature of the pollutants.

Exceptional or one-off emissions are not taken into account. Emissions related to transport, which are mainly related to internal combustion engines, are not considered relevant in relation to the total emissions and will not be treated further. Based on an average daily presence of 1,300 vehicles and data from the mobility section[11], the share of Doel 1 and Doel 2 in the total amount of traffic generated by the nuclear power plant is estimated at 364 vehicle movements per day. As the N451/Oostlangeweg is located in open terrain, the impact of traffic on local pollutant concentrations is considered negligible.

The emission from a steam plume from the cooling towers and the associated salt precipitation in the surrounding area will be discussed separately, since it concerns a very specific issue that is separate from the classic emissions. Existing studies will be used to quantify salt emission and precipitation:

- Gassman, F., Tinguely, M. & Haschke, D. EIR Notice No. 475, 1982. Calculs de panaches de tours de refroidissement pour des situations de haute pression hivernales.
- Méry, P. Aménagement et Nature no 94, Association pour les espaces naturels, Paris, France, 1989. Impact de la réfrigération atmosphérique.
- International Atomic Energy Agency, 1974. Technical Reports Series no 155. Thermal discharges at nuclear power stations. Their management and environmental impacts.
- Argonne National Laboratory, Environmental Science Division, 2014. Saline Water for Power Plant Cooling: Challenges and Opportunities.

[11] 14% of the staff (Engie and external) are related to the operation of Doel 1 and 2. Considering a daily presence of 1,300 vehicles (or 2,600 vehicle movements), this corresponds to a share of 2,600 * 14% = 364 vehicle movements per day.

- Lauver, T.L., Curtis C.R., Patterson, G.W. & Douglass, L.W., 1978. Effects of saline cooling tower drift on seasonal variations of sodium and chlorine concentrations in native perennial vegetation.

The possible impact on the microclimate of this steam plume is also discussed from a quality point of view.

The air emission flows identified are assessed and checked against the applicable regulations (if any). In the absence of applicable regional regulations, an assessment is made compared to international references.

In summary, the following effects can be expected in the operational phase:

- Air pollution: as a result of the emission of NOx, SOx, CO, PAHs and fine dust, from combustion systems;
- acidifying and eutrophying deposition: as a result of NOx and SOx emissions from combustion systems;
- salt precipitation: as a result of the emission of the steam plume from the cooling tower;
- climate impact due to CO_2 emissions (from combustion systems) and fluorinated hydrocarbons (due to the emission of refrigerants from cooling groups).

The EIR assesses whether or not dispersion modelling is required for an air pollutant. The consideration made is based inter alia on article 4.1.8.1. of VLAREM II, which, pursuant to Title III of the Decree of 5 April 1995 laying down general provisions on environmental policy, requires an annual environmental report on certain establishments on the basis of their classification according to VLAREM and on the basis of threshold values for relevant pollutants. The list of relevant substances and threshold values is given in the 'air emissions' subform of the Full Environmental Annual Report (FEAR).

In addition, the following circumstances are taken into account:

- the pollutant's mass flow and distribution (cf. chimney height);
- the potentially harmful effect (the properties of the pollutants, related to their dispersal);
- other sources in the area;
- the 'natural' background concentrations;
- presence/absence of local residents;
- the expert's experience in other similar projects.

For the emitted parameters it will be investigated to what extent a relevant impact can be expected, and consequently whether dispersion modelling is necessary. This will be done on the basis of the above consideration.

Depending on the outcome of the above consideration, the distribution of the relevant parameters is then mapped using the IMPACT model. The immission concentrations calculated in this way are then clarified and visualised using maps. For acidifying and eutrophic deposition a dispersion modelling is planned in any case, due to the proximity of natural areas.

For the pollutants for which dispersion modelling is developed, this modelling is created for both the reference situation (only emissions related to Doel 3, Doel 4 and WAB) and for the planned situation (emissions reference situation + emissions related to Doel 1 and 2). The impact of the project (LTO) can then be described and assessed on the basis of the calculated difference in immission contribution in both situations.

The environmental impact of the relevant pollutants for which dispersal calculations were carried out will be typified according to significance, depending on the calculated immission contribution.

The impact assessment is carried out as follows for:

- air pollution resulting from the emission of NOx, SOx, CO, PAHs and fine dust (based on modelled immission contributions, as far as relevant parameters are concerned):
  - average immission contribution:
    - considerably negative: the immission contribution is more than 10% of the environmental quality standard or guide value
    - negative: the immission contribution is more than 3% of the environmental quality standard or guide value
    - slightly negative: the immission contribution is more than 1% of the environmental quality standard or guide value
    - negligible: the immission contribution is less than 1% of the environmental quality standard or guide value
  - percentiles and/or circumstances that cannot be fully assessed with averages:
    - considerably negative: the immission contribution is more than 20% of the environmental quality standard or guide value
    - negative: the immission contribution is more than 5% of the environmental quality standard or guide value
    - slightly negative: the immission contribution is more than 1% of the environmental quality standard or guide value
    - negligible: the immission contribution is less than 1% of the environmental quality standard or guide value
- acidifying and eutrophic deposits: this is only calculated in the Air section; the assessment is carried out in the Biodiversity section and as part of the appropriate assessment;
- salt precipitation: assessment of the potential impact on agriculture and nature based on the available literature (impact on agriculture within the soil section, on nature within the biodiversity section)
- impact on climate: there is currently no generally accepted framework of significance for the assessment of greenhouse gas emissions. The calculated CO_2-equivalent emissions are therefore not assessed.

2.4.2 Baseline situation

The description of the baseline situation covers existing installations for the reference year 2014. To estimate the impact of meteorological conditions, the data for several years (2009 to 2014) are given where possible to describe air quality.

2.4.2.1 Air quality

As indicated in §5.1, the effects in the scheduled situation had to be assessed in comparison with the reference situation, in particular the situation where Doel 1 and 2 are assumed not to be in operation. For the description of the air quality in the baseline situation, measurement data from FEA measurement stations are used. These measurements therefore already include the contribution of Doel 1 and 2.

To estimate the impact of meteorological conditions, data from three years (2012, 2013 and 2014) are given where relevant. The following FEA measurement stations are located in the vicinity of KCD:

Table 2-34 Overview of FEA measurement sites in the vicinity of KCD

Measurement station	Name	Distance from and direction to KCD (km)	SO_2	NOx	PM	BC	CO	PAHs	BTEX
AB01	Antwerp - Boudewijnsluis	approx. 6.3 km SE			x	x			
AB02	Berendrecht - Antwerpse baan	approx. 4 km NE			x				
AL01	Antwerp LO - Scheldeweg	approx. 12.3 km SE		x	x	x			x
AL02	Doel - Engelsesteenweg	approx. 2.1 km SW							
AL05	Kallo-sluis	approx. 6.3 km at S			x			x	
R830	Doel – Scheldemolenstraat	approx. 6.1 W	x	x					
R891	Antwerpen - Scheurweg	approx. 7 SE	x	x					
R892	Kallo-sluis	approx. 7 SW	x	x					
R893	Antwerp – Ekerse dijk	approx. 4.5 SE	x	x					
R894	Antwerp - Muisbroeklaan	approx. 3.5 S	x	x					
R897	Antwerp – Scheldelaan	approx. 7,3 S	x	x					

Regulatory and advisory values for air quality are shown in Annex 4.1.

2.4.2.1.1 Sulphur dioxide

In the period 2012 to 2014, the annual averages for SO_2 at the measurement site in Doel were between 2 µg/m³ and 4 µg/m³ (see Table 2-35).

Table 2-35 SO_2 concentrations (µg/m³) in the vicinity of KCD

Measuring station	Name	Annual average (µg/m³)			Daily values P99 (µg/m³)			Hourly values P99 (µg/m³)		
		2012	2013	2014	2012	2013	2014	2012	2013	2014
R830	Doel – Scheldemolenstraat	3	4	4	13	17	12	19	21	21
R891	Antwerpen – Scheurweg	6	5	5	39	13	22	63	38	35
R892	Kallo-sluis	4	5	4	18	13	17	35	39	33
R893	Antwerp – Ekerse dijk	5	4	4	17	11	16	31	25	30
R894	Antwerp - Muisbroeklaan	10	8	9	34	23	36	65	59	62
R897	Antwerp – Scheldelaan	4	5	5	17	13	18	32	35	39

Give table ??? number ???

Measuring station	Name	Max. daily value (µg/m³)			Max. hourly values (µg/m³)		
		2012	**2013**	**2014**	**2012**	**2013**	**2014**
R830	Doel – Scheldemolenstraat	16	88	21	54	447	75
R891	Antwerpen – Scheurweg	56	35	55	166	116	262
R892	Kallo-sluis	21	37	29	159	175	193
R893	Antwerp – Ekerse dijk	25	21	24	96	87	66
R894	Antwerp - Muisbroeklaan	49	38	41	162	157	394
R897	Antwerp – Scheldelaan	35	59	48	164	426	318
	Limit value EU Directive 2008/50/EC	**125, max. 3 overruns per year**			**350, max. 24 overruns per year**		

On an annual basis, 24 overruns of the hourly average of 350 µg/m³ are allowed. In 2013, one overrun was recorded at the measuring stations R830 and R897, in 2014 there was one overrun in R894. This means that the hourly limit value was not exceeded. Incidentally, all measurement sites in Flanders in 2012, 2013 and 2014 met the hourly limit value, the daily limit value and the alarm threshold for SO_2 (see Annex 6) so it is assumed that this is the case for the whole study area.

Because of the dense built-up area, the extensive road network and the scattered industrial activities, strictly speaking there are no areas in Flanders where the critical level for vegetation protection applies. After all, there are no zones that meet the criteria for the location of measuring stations imposed by Directive 2008/50/EC.

2.4.2.1.2 Nitrogen oxides

In the years 2012, 2013 and 2014, the annual average concentration at the measurement site in Doel was 26 to 27 µg/m³. The European limit value for the annual mean below 40 µg/m³ was well respected. For the measurement station Muisbroeklaan, the annual average was 40 to 42 µg/m³. This measurement site is located in an area for which a delay for reaching the annual limit value of 40 µg/m³ has been granted. The results of these measurement sites will be reviewed against an annual limit value of 60 µg/m³ until 2014.

Table 2-36 NO_2 concentrations (µg/m³) in the vicinity of KCD

Measuring station	Name	Annual average (µg/m³)			Hourly values P99 (µg/m³)			Max. hourly value (µg/m³)		
		2012	**2013**	**2014**	**2012**	**2013**	**2014**	**2012**	**2013**	**2014**
AL01*	Antwerpen - Linkeroever	-	-	26	-	-	84	-	-	142
R830	Doel – Scheldemolenstraat	26	27	27	76	83	85	110	135	136
R891	Antwerpen – Scheurweg	38	37	36	88	95	88	167	196	199
R892	Kallo-sluis	33	38	34	80	91	94	124	132	135
R893	Antwerp – Ekerse dijk	40	36	36	84	85	83	177	137	139
R894	Antwerp - Muisbroeklaan	41	40	42	82	96	95	165	203	159
R897	Antwerp - Scheldelaan	35	37	35	84	94	96	128	127	143
	Limit value EU Directive 2008/50/EC	**40 µg/m³ ****			**-**			**200 µg/m³, max. 18 overruns per year**		

*For AL01, there were no NOx measurements in 2012, in 2013 there were insufficient data.

** The European Commission granted a postponement for the zones Antwerp Port and Antwerp Agglomeration, as a result of which the results were assessed on the basis of an annual limit value of 60 µg/m³ until 2014.

On an annual basis, there are 18 overruns of the hourly average of 200 µg/m³ are allowed. In 2013, one overrun was counted in the measuring station R894. This means that the hourly limit value was not exceeded.

Because of the dense built-up area, the extensive road network and the scattered industrial activities, strictly speaking there are no areas in Flanders where the critical level for vegetation protection applies. Indeed, there are no areas that meet the criteria for the location of measuring stations, as required by Directive 2008/50/EC.

Figure 2.34 shows a spatial representation of the NO_2 annual average in 2012. This model Map is calculated with the model RIO-IFDM v5.1.0. In the vicinity of the port of Antwerp and the motorways there are significantly higher average NO_2 annual averages. The annual average concentration of KCD is 26 to 30 µg/m³. A slight improvement in air quality is noticeable in 2013 and 2014.

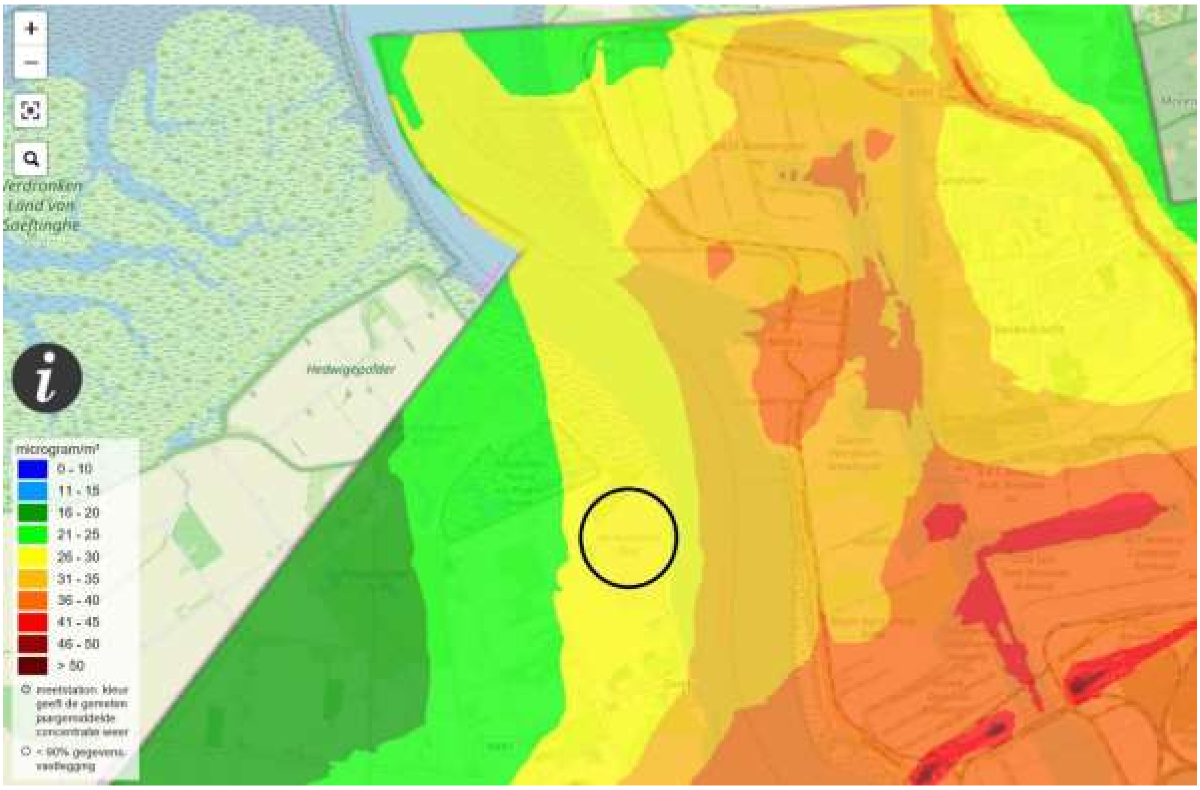


Figure 2.34 Interpolated NO2 annual average in 2012 in the vicinity of KCD (black circle)

Figure 2.35 Interpolated NO2 annual average in 2013 in the vicinity of KCD (black circle)

Figure 2.36 Interpolated NO2 annual average in 2014 in the vicinity of KCD (black circle)

2.4.2.1.3 *Fine dust*

Table 2-37 shows the concentrations of PM10 at measurement sites in the vicinity of KCD.

Table 2-37 PM_{10} concentrations (µg/m³) in the vicinity of KCD

Measuring station	Name	Annual average (µg/m³)			Number of daily values > 50 µg/m³		
		2012	2013	2014	2012	2013	2014
40 AB01	Antwerp - Boudewijnsluis	27	27	23	25	24	11
40 AB02	Berendrecht - Antwerpse baan	26	26	22	26	18	10
40 AL01	Antwerpen LO – Scheldeweg	24	25	22	22	18	11
40 AL02	Doel - Engelsesteenweg	25	26	25	26	19	16
40 AL05	Kallo-sluis	29	28	25	35	25	12
	Limit value EU Directive 2008/50/EC	**40 µg/m³**			**35**		

Both the European daily limit value and the annual limit value were reached at the measurement sites in the vicinity of KCD (and in all of Flanders, for that matter).

Figure 2.37 shows an estimate of the PM_{10} annual average in 2014 in the study area. The annual average PM_{10} concentration of KCD is between 21 and 25 µg/m³. The absolute uncertainty for the RIO background map is between 7.4 and 10.0 µg/m³. The maps for 2012 and 2013 show a similar outlook (figures not included).

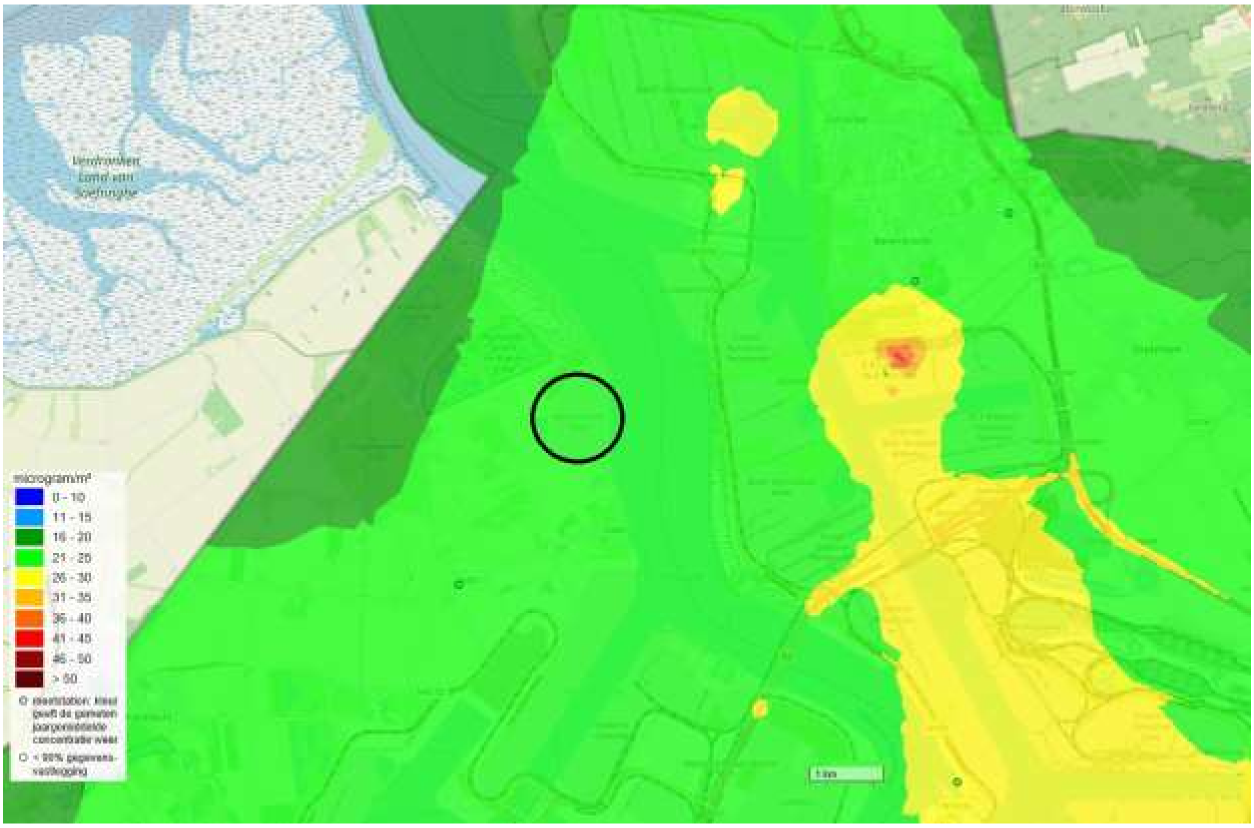


Figure 2.37 Modelled PM10 concentrations in the vicinity of KCD (black circle)

Table2-38 $PM_{2,5}$ concentrations in the vicinity of KCD

Measuring station	Name	Annual average (µg/m³)			Number of daily values > 25 µg/m³		
		2012	**2013**	**2014**	**2012**	**2013**	**2014**
40 AB01	Antwerp - Boudewijnsluis	-	-	-	-	-	-
40 AB02	Berendrecht - Antwerpse baan	-	-	-	-	-	-
40 AL01	Antwerpen LO – Scheldeweg	-	-	13	-	-	13
	Limit value EU Directive 2008/50/EC	**25 µg/m³ from 2015**			**-**		

Measurements of $PM2_{.5}$ for the period under consideration (2012-2014) were only carried out at measurement sites AL01 in 2014. Table2-38 shows that the European annual limit value for $PM2_{.5}$ of 25 µg/m³ was respected (as in the whole of Flanders). The lower indicative annual limit value of 20 µg/m³ applicable from 2020 was also achieved.

Figure 2.38shows an estimate of the $PM_{2,5}$ annual averages in 2014. The annual average PM_{10} concentration of KCD is between 16 and 20 µg/m³. The absolute uncertainty for the RIO background map varies between 2.8 and 3.4 µg/m³. According to the model, the whole of Flanders reaches the European annual limit value and so no Flemish citizen was exposed to $PM2_{.5}$ concentrations higher than the limit value. The maps for 2012 and 2013 show a similar outlook (figures not included).

All $PM2_{.5}$ annual averages were above 10 µg/m³ in 2014 and at each measurement site there were more than three days with an average concentration of more than 25 µg/m³. Consequently, the WHO advisory values were exceeded at all measurement sites (as in the whole of Flanders).

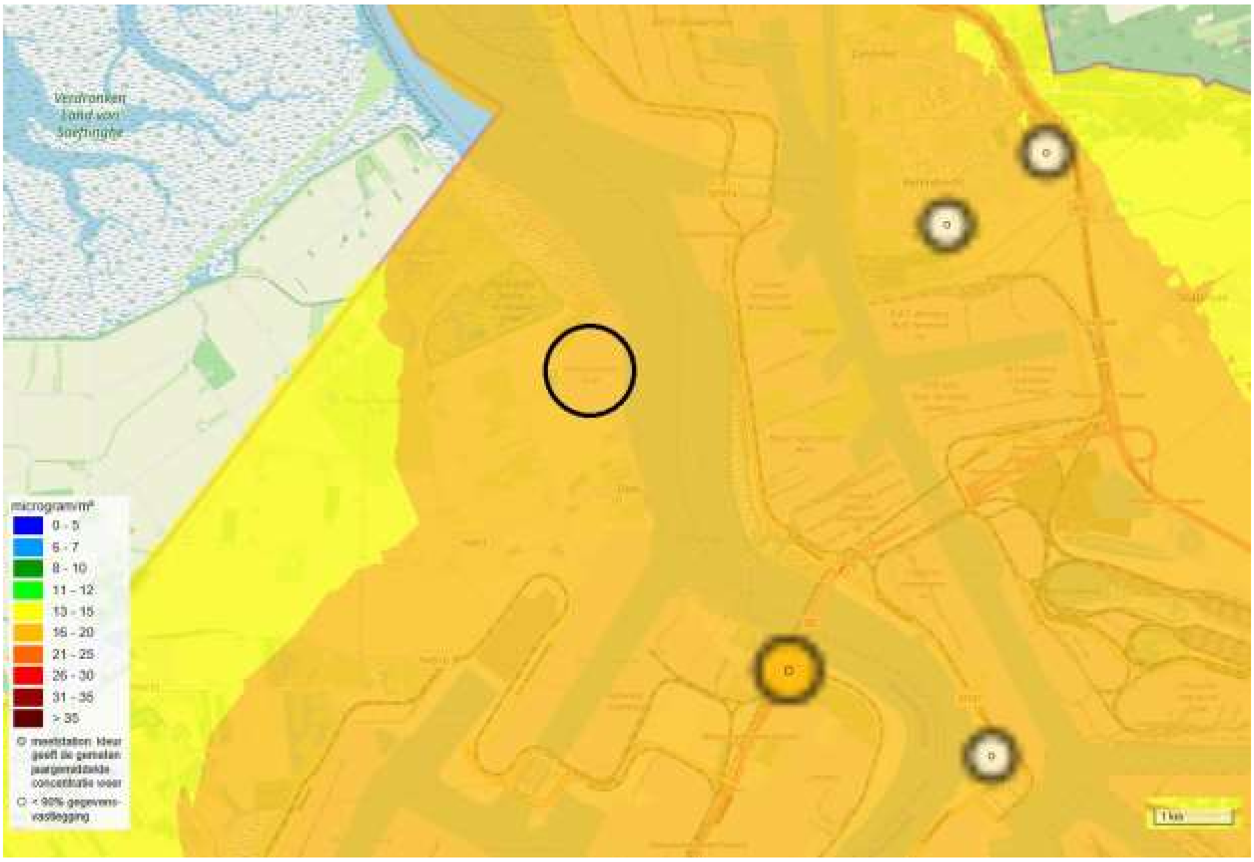


Figure 2.38 Modelled PM2.5 concentrations in the vicinity of KCD (black circle)

Table 2-39 Black carbon concentrations in the vicinity of KCD

Measuring station	**Name**	**Annual average (µg/m³)**			**Hourly values P99 (µg/m³)**		
		2012	**2013**	**2014**	**2012**	**2013**	**2014**
40 AB01	Antwerp - Boudewijnsluis	1.7	1.7	1.6	7.6	7.7	6.7
40 AL01	Antwerpen LO – Scheldeweg	1.5	1.5	1.4	6.2	7.1	5.9

Figure 2.39 shows an estimate of the annual black carbon averages in Flanders in 2014. The absolute

uncertainty for the RIO background map varies between 0.68 and 0.90 µg/m³. A concentration of 1.26 to 1.50 µg/m³ is estimated for KCD.

There is currently no legislation about black carbon at European or Flemish level.

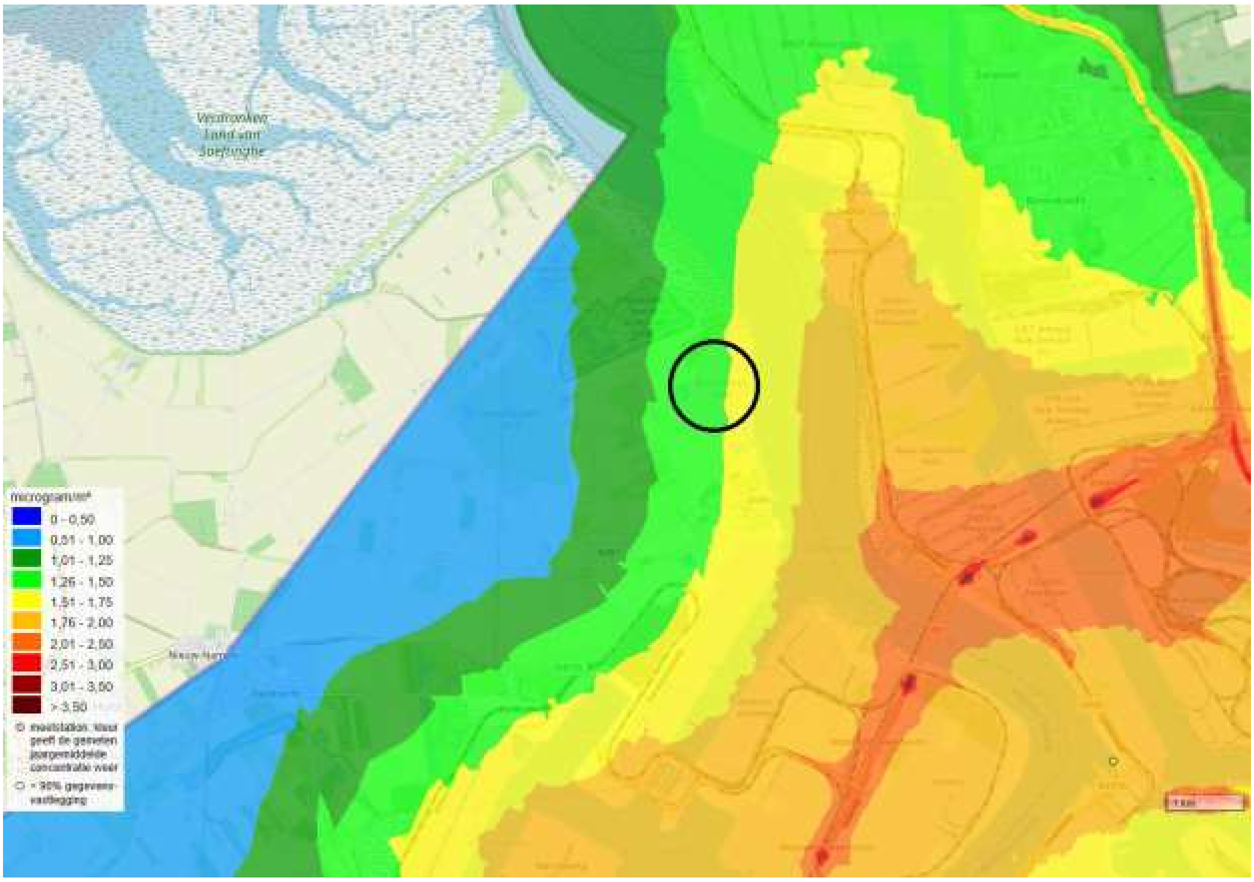


Figure 2.39 Modelled black carbon concentrations in 2014 in the KCD area (black circle)

2.4.2.1.4 CO

In 2012, 2013 and 2014, all Flemish measuring stations respect the European limit value for CO of 10 mg/m³ as the highest 8-hour average of a day.

2.4.2.1.5 PAHs

The European 4th directive 2004/107/EC defines a target value of 1 ng/m³ as an annual average for benzo(a)pyrene (B(a)P). Member States had to respect that value by 31 December 2012.

In 2012, 2013 and 2014, the annual average of benzo(a)pyrene was below the target value at all measurement sites.

In 2014, the average concentration of benzo(a)pyrene was 0.14 ng/m³ in Berendrecht.

2.4.2.2 Identification and quantification of guided emissions

2.4.2.2.1 General

In the case of KCD, the guided emissions are emissions from various combustion systems: auxiliary steam boilers, emergency diesels and heating system. The location of these emission points is shown in Appendix 4.1 of this chapter.

Auxiliary steam is necessary for the proper operation of the units. The auxiliary steam is normally supplied by the units. If this is not possible, 2 auxiliary steam boilers take over the function. To ensure their availability, they are tested on a regular basis. In the 2014 period, they were only started up for such tests.

Emergency diesels provide the safety, emergency and auxiliary systems with a back-up electrical power supply in case the outside electrical power supply is not available. To ensure their proper functioning, they are tested regularly. The emergency diesels (with the exception of emergency diesel PKD-D3/ES-DG0004) are not equipped to supply electrical power to the external power grid. In 2014, the emergency diesels were only started up for testing.

Finally, there is a heating system in the warehouse.

2.4.2.2.2 Emission limits

KCD is licensed for boiler systems with a total rated thermal input exceeding 50 MW (section 43.3.2°) and therefore falls under the application of the IED (Industrial Emissions Directive).

Chapter 3.12 of VLAREM III sets out the sectoral environmental conditions for large boiler systems. The provisions of this chapter do not apply to units with a rated thermal input below 15 MW. All diesel engines have a capacity of less than 15 MW, so Chapter 3.12 does not apply to them.

The auxiliary steam boilers each have a capacity of about 43 MW and are therefore subject to the provisions of the chapter. However, the emission limit values to air do not apply to emergency turbines and engines that operate <500 hours per year when such emergency use is not compatible with compliance with the emission limit values (in which case the installation's relevant technical installations mentioned in BAT apply).

The auxiliary steam boilers are in use for less than 500 hours a year. For systems operating less than 500 hours per year no emission limit values are set out in Subsection 3.12.4.1 (boilers fired with heavy fuel oil or gas oil).

In addition, VLAREM II, Chapter 5.43 should also be taken into account. Indeed, if the sectoral conditions of VLAREM II regulate the same issues, the strictest conditions apply.

For the diesel generators, Chapter 3.12 does not apply, as stated above. The sectoral provisions of VLAREM II, Chapter 5.43 apply here.

VLAREM II stipulates provides that boiler systems with less than 100 operating hours per calendar year, which is the case for emergency generators and the steam boilers of KCD, are not subject to emission limit values (Art. 5.43.2.2). Consequently, there are no measurement obligations (Art. 5.43.2.23).

Therefore, no emission measurements are available for the auxiliary steam boilers or the diesel generators.

2.4.2.2.3 Emission factors

KCD has no measurement obligations for the above guided emissions. It can therefore be expected that the guided emissions from the activities described above at KCD will be limited.

However, the absence of an obligation to measure also means that little data is available on emissions. However, in order to provide a framework, emissions are calculated on the basis of the reported fuel consumption of each combustion system, using emission factors.

The emission factors used were tuned to the year of construction[12] of the installations.

These emission factors are listed in Table 240 .

Table 240 Emission factors for liquid fuel combustion systems year of construction 1982-1984

Pollutant	**Diesel engines**		**Auxiliary steam boilers**	
Year of construction	**1982, 1984[13]**	**Unit**	**1982[14]**	**Unit**
CO	12.2	kg/m³ diesel	0.63	kg/m³ diesel
NO_x	56.2	kg/m³ diesel	2.8	kg/m³ diesel
SO_x	3.74	kg/m³ diesel	17*sulphur content[15] (%)	kg SO2/m³ diesel
PM_{10}	4.01	kg/m³ diesel	0.25	kg/m³ diesel
$PM_{2,5}$	4.01	kg/m³ diesel	0.25	kg/m³ diesel

[12] The year of construction is assumed to be the year of permit.

[13] AP-42 1977, table 3.3.3-1 'Emission factors for gasoline- and diesel-powered industrial equipment – emission factor rating: C' (diesel)

[14] AP-42 1977, table 1.3-1 'Emission factors for fuel oil combustion – Emission factor rating: A' (distillate oil)

[15] maximum 0.1%

Table 2-41: Emission factors for liquid fuel combustion system, year of construction 2000-2017

Pollutant	Diesel engines		
Year of construction	2000, 2010[16]	2015, 2017[17]	Unit
CO	385	130	g/GJ
NO_x	1450	942	g/GJ
SO_x	46.1	48	g/GJ
PM_{10}	22.4	30	g/GJ
$PM_{2,5}$	21.7	30	g/GJ

2.4.2.2.4 Fuel consumption

The fuel consumption of all these emission points for the period 2014 is shown in Table 2-42.

Table 2-42 Fuel consumption (2014)

Functional element	Number on plan	Output [MWth]	Type	Running hours [h]	Gas oil consumption [m³]
DOEL 1 and 2					
PKD-D1/DG0011	1	4.3	Gas oil engine	6.49	1.57
PKD-D1/ED0022	8	6.1	Gas oil engine	47.39	15.76
PKD-D0/DG0014[18]	4	6.2	Gas oil engine	0.00	0.00
PKD-D0/DG0012	3	6.2	Gas oil engine	0.00	0.00
PKD-D0/DG0024	6	6.2	Gas oil engine	0.00	0.00
PKD-D0/DG0022	5	6.2	Gas oil engine	0.00	0.00
PKD-D2/DG0021	2	4.3	Gas oil engine	5.14	1.25
PKD-D2/ED0012	7	6.1	Gas oil engine	51.53	17.14
PKD-D0/DGS12	30	6.79	Gas oil engine	28.33	10.50
PKD-D0/DGS14	31	6.79	Gas oil engine	47.09	17.46
PKD-D0/DGS22	33	6.79	Gas oil engine	35.85	13.29

[16] EMEP EEA Guidebook 2009, Table 3-38, Tier 2 emission factors for non-residential sources - gas oil piston engines

[17] EMEP EEA Guidebook 2013, Table 3-37, Tier 2 emission factors for non-residential sources - gas oil piston engines; only applicable to diesel generators licensed in 2015 and 2017 (see operational phase from 2015).

[18] Diesels PKD-D0/DG0014, PKD-D0/DG0012, PKD-D0/DG0024 and PKD-D0/DG0022 are old diesels which are still licensed but disconnected and therefore no longer tested.

Functional element	Number on plan	Output [MWth]	Type	Running hours [h]	Gas oil consumption [m³]
PKD-D0/DGS24	34	6.79	Gas oil engine	29.19	10.82
PKD-D0/DGS99	32	6.79	Gas oil engine	31.73	11.76
Subtotal					**35.72 m³**
DOEL 3					
PKD-D3/ES-DG0012	17	2.4	Gas oil engine	1.60	0.19
PKD-D3/ES-DG0022	18	2.4	Gas oil engine	18.60	2.26
PKD-D3/ES-DG0001	13	12.6	Gas oil engine	55.20	38.97
PKD-D3/ES-DG0002	14	12.6	Gas oil engine	34.10	24.07
PKD-D3/ES-DG0003	15	12.6	Gas oil engine	55.00	38.83
PKD-D3/ES-DG0004	16	12.6	Gas oil engine	53.70	37.91
PKD-D3/KE-DG0001	10	5.7	Gas oil engine	33.00	10.97
PKD-D3/KE-DG0002	11	5.7	Gas oil engine	31.00	10.31
PKD-D3/KE-DG0003	12	5.7	Gas oil engine	32.30	10.74
Subtotal					**174.26 m³**
DOEL 4					
PKD-D4/ES-DG0022	26	2.4	Gas oil engine	131.30	15.97
PKD-D4/ES-DG0012	25	2.4	Gas oil engine	8.30	1.01
PKD-D4/ES-DG0001	22	12.6	Gas oil engine	84.20	59.44
PKD-D4/ES-DG0002	23	12.6	Gas oil engine	31.40	22.17
PKD-D4/ES-DG0003	24	12.5	Gas oil engine	39.70	28.03
PKD-D4/KE-DG0001	19	5.7	Gas oil engine	29.90	9.94
PKD-D4/KE-DG0002	20	5.7	Gas oil engine	26.90	8.95
PKD-D4/KE-DG0003	21	5.7	Gas oil engine	25.00	8.31
Subtotal					**153.82 m³**
WAB					
Auxiliary steam boiler ABN	27	43.126	steam boiler	0.00	0.00
ABZ auxiliary steam boiler	28	43.126	steam boiler	54.00	87.15
Subtotal					**87.15 m³**
MISCELLANEOUS					
Fire department diesel	9	0.125	Gas oil engine	14.00	0.15
heating MAI	29	0.204	boiler		15.04
Subtotal					**15.20 m³**

Functional element	Number on plan	Output [MWth]	Type	Running hours [h]	Gas oil consumption [m³]
TOTAL					**529.99 m³**

2.4.2.2.5 Emissions of the combustion systems

The following emission factors are used for the various combustion systems:

Table 2-43: Emission factors per combustion system

Functional element	Year of construction	Source:
Doel 1 and 2		
PKD-D1/DG0011	2000	EMEP/EEA 2009, table 3-38 tier 2, non-residential sources, reciprocating engines burning gasoil. Ref: US EPA (1996), chapter 3.4
PKD-D1/ED0022	2000	EMEP/EEA 2009, table 3-38 tier 2, non-residential sources, reciprocating engines burning gasoil. Ref: US EPA (1996), chapter 3.4
PKD-D2/DG0021	2000	EMEP/EEA 2009, table 3-38 tier 2, non-residential sources, reciprocating engines burning gasoil. Ref: US EPA (1996), chapter 3.4
PKD-D2/ED0012	2000	EMEP/EEA 2009, table 3-38 tier 2, non-residential sources, reciprocating engines burning gasoil. Ref: US EPA (1996), chapter 3.4
PKD-D0/DGS12	2010	EMEP/EEA 2009, table 3-38 tier 2, non-residential sources, reciprocating engines burning gasoil. Ref: US EPA (1996), chapter 3.4
PKD-D0/DGS14	2010	EMEP/EEA 2009, table 3-38 tier 2, non-residential sources, reciprocating engines burning gasoil. Ref: US EPA (1996), chapter 3.4
PKD-D0/DGS22	2010	EMEP/EEA 2009, table 3-38 tier 2, non-residential sources, reciprocating engines burning gasoil. Ref: US EPA (1996), chapter 3.4

Functional element	Year of construction	Source:
PKD-D0/DGS24	2010	EMEP/EEA 2009, table 3-38 tier 2, non-residential sources, reciprocating engines burning gasoil. Ref: US EPA (1996), chapter 3.4
PKD-D0/DGS99	2010	EMEP/EEA 2009, table 3-38 tier 2, non-residential sources, reciprocating engines burning gasoil. Ref: US EPA (1996), chapter 3.4
Doel 3		
PKD-D3/ES-DG0012	1982	AP-42 1977, Table 3.3.3-1
PKD-D3/ES-DG0022	1982	AP-42 1977, Table 3.3.3-1
PKD-D3/ES-DG0001	1982	AP-42 1977, Table 3.3.3-1
PKD-D3/ES-DG0002	1982	AP-42 1977, Table 3.3.3-1
PKD-D3/ES-DG0003	1982	AP-42 1977, Table 3.3.3-1
PKD-D3/ES-DG0004	1982	AP-42 1977, Table 3.3.3-1
PKD-D3/KE-DG0001	1982	AP-42 1977, Table 3.3.3-1
PKD-D3/KE-DG0002	1982	AP-42 1977, Table 3.3.3-1
PKD-D3/KE-DG0003	1982	AP-42 1977, Table 3.3.3-1
Doel 4		
PKD-D4/ES-DG0022	1984	AP-42 1977, Table 3.3.3-1
PKD-D4/ES-DG0012	1984	AP-42 1977, Table 3.3.3-1
PKD-D4/ES-DG0001	1984	AP-42 1977, Table 3.3.3-1

Functional element	Year of construction	Source:
PKD-D4/ES-DG0002	1984	AP-42 1977, Table 3.3.3-1
PKD-D4/ES-DG0003	1984	AP-42 1977, Table 3.3.3-1
PKD-D4/KE-DG0001	1984	AP-42 1977, Table 3.3.3-1
PKD-D4/KE-DG0002	1984	AP-42 1977, Table 3.3.3-1
PKD-D4/KE-DG0003	1984	AP-42 1977, Table 3.3.3-1
WAB		
PKD-DT/ABN	1982	AP-42 1977, Table 1.3-1
PKD-DT/ABZ	1982	AP-42 1977, Table 1.3-1
MISCELLANEOUS		
heating MAI	unknown	AP-42 1977, Table 1.3-1
fire department diesel PKD-D0/FEOP2	unknown	EMEP EEA 2013, Table 3-37 Non residential sources, reciprocating engines burning gas oil (ref: Nielsen et al. 2010)

If the consumption from Table 2-42 is combined with the given emission factors[19], an (indicative) picture is obtained of the total guided emissions from KCD, shown in Table 2-44.

Table 2-44 Boiler system emissions (2014)

Functional element	CO emission in kg/year	NOx emission in kg/year	SOx emission in kg/year	PM10 emission in kg/year	PM2.5 emission in kg/year
DOEL 1 and 2					

[19] Taking into account a density of gas oil of 0.85 and a lower calorific value of 42,279 GJ/tonne

Functional element	CO emission in kg/year	NOx emission in kg/year	SOx emission in kg/year	PM10 emission in kg/year	PM2.5 emission in kg/year
PKD-D1/DG0011	39	149	5	2	2
PKD-D1/ED0022	395	1487	47	23	22
PKD-D0/DG0014	0	0	0	0	0
PKD-D0/DG0012	0	0	0	0	0
PKD-D0/DG0024	0	0	0	0	0
PKD-D0/DG0022	0	0	0	0	0
PKD-D2/DG0021	31	118	4	2	2
PKD-D2/ED0012	429	1617	51	25	24
PKD-D0/DGS12	263	991	32	15	15
PKD-D0/DGS14	438	1648	52	25	25
PKD-D0/DGS22	333	1255	40	19	19
PKD-D0/DGS24	271	1022	32	16	15
PKD-D0/DGS99	295	1110	35	17	17
Subtotal	**2,495**	**9,397**	**299**	**145**	**141**
DOEL 3					
PKD-D3/ES-DG0012	4	20	1	1	1
PKD-D3/ES-DG0022	50	230	15	16	16
PKD-D3/ES-DG0001	861	3967	264	283	283
PKD-D3/ES-DG0002	532	2451	163	175	175
PKD-D3/ES-DG0003	858	3953	263	282	282
PKD-D3/ES-DG0004	838	3859	257	275	275
PKD-D3/KE-DG0001	243	1117	74	80	80
PKD-D3/KE-DG0002	228	1049	70	75	75

Functional element	CO emission in kg/year	NOx emission in kg/year	SOx emission in kg/year	PM10 emission in kg/year	PM2.5 emission in kg/year
PKD-D3/KE-DG0003	237	1093	73	78	78
Subtotal	**3,851**	**17740**	**1,181**	**1,266**	**1,266**
DOEL 4					
PKD-D4/ES-DG0022	353	1626	108	116	116
PKD-D4/ES-DG0012	22	103	7	7	7
PKD-D4/ES-DG0001	1314	6051	403	432	432
PKD-D4/ES-DG0002	490	2257	150	161	161
PKD-D4/ES-DG0003	619	2853	190	204	204
PKD-D4/KE-DG0001	220	1012	67	72	72
PKD-D4/KE-DG0002	198	911	61	65	65
PKD-D4/KE-DG0003	184	846	56	60	60
Subtotal	**3,399**	**15659**	**1,042**	**1117**	**1117**
WAB					
Auxiliary steam boiler ABN	0	0	0	0	0
ABZ auxiliary steam boiler	125	476	3	50	50
Subtotal	**125**	**476**	**3**	**50**	**50**
MISCELLANEOUS					
Fire department diesel PKD-D0/FEOP2	9	36	0.3	3.8	3.8
heating MAI	1	5	0.2	0.1	0.1
Subtotal	**10**	41	**0.5**	**3.9**	**3.9**
TOTAL (kg)	**9881**	**43314**	**2525**	**2582**	**2582**

Based on the emission data of the different combustion systems, as shown in the table above, it can be established that the emissions of CO, SOx and fine dust (PM_{10}, $PM_{2.5}$) are small compared to the emissions of NO_x.

2.4.2.3 Identification and quantification of non-guided emissions

KCD stores aqueous solutions of both ammonia and hydrazine in various tanks on the site. These products are used to maintain an optimal pH in the water circuits and to limit the oxygen content in them in order to prevent corrosion. For more information on this subject and for data on the discharge of these products into the water, please refer to the Water section.

Both ammonia and hydrazine are toxic. Hydrazine is also a carcinogenic product. Ammonia has a high vapour pressure, which means that vapours are formed under normal conditions and therefore possible emissions can occur. However, the volatility of hydrazine in water is very limited, so no relevant emissions are expected. In addition, it is stored in such a diluted concentration that breathing losses are minimised. Furthermore, measures have been taken to prevent possible airborne dispersion, such as water locks and active carbon filters. Both substances are also completely soluble in water. KCD has several procedures in place concerning the handling and storage of these products.

Because of this, emissions of ammonia or hydrazine to the environment are not relevant.

2.4.2.4 Emission of steam plumes from the cooling towers

2.4.2.4.1 Identification and quantification of salt precipitation from the steam plumes of the cooling towers

The Doel 3 and 4 power plants use cooling water that is cooled down in the open cooling towers after use. Salt precipitation from the steam plume of cooling towers in which salt water is used is a known problem. The Scheldt water near Doel is naturally brackish due to the tidal effect on the Scheldt.

In the past, based on measurements, a methodology was drawn up to map the emission and associated salt precipitation from a large cooling tower with natural draught and a supply of salt water.

In addition, it was determined on the basis of trial measurements to what extent the salt precipitation has an influence on the cultivated land from the point of view of yield and quality, on the soil and on natural plant growth.

The salt precipitation data in this section is taken from the note "Main cooling tower - Estimate of salt precipitation, translation of note no. 51158 NTNUSO 3753", Tractebel Engineering, 01/08/1983.

The salt content of the circulation water in the cooling towers, which is pumped up from the Scheldt, is set at 20 g/l, which is a pessimistic annual average[20].

The salt deposition is estimated on the basis of the following parameters:

- The circulation water flow rate in the towers 259,200 m^3/h
- The droplet transport rate: 2^{10-5}

[20] Measurements over the period 2010-2019 show a maximum salt content of the pumped Scheldt water of approx. 10.8 g/l.

- Salt content in circulation water: 20 kg/m³
- The height of the towers 167 m

Combining these data leads to a salt emission from the 2 cooling towers of Doel (plants 3 and 4) of 103.7 kg/h. The salt deposit in the vicinity of the cooling towers (within a 2 km radius) can be estimated at 0.25 g/m² per month.

2.4.2.4.2 Influence of the steam plumes on the microclimate in the area

Steam plumes from cooling towers can have an influence on the local microclimate due to their size.

The effects that traditionally occur are the precipitation of the steam plume in the environment as a result of (local) meteorological conditions, causing fog to form. However, this is mainly observed in cooling towers with a lower height than KCD's cooling towers, which are 160 m high and so enough to protrude above the surrounding area to avoid such fogging.

There are no further indications that the steam plumes have an effective influence on the surrounding climate. Therefore, KCD's steam plumes do not require further research into the impact on the microclimate.

2.4.2.5 History of emissions

Comparing the guided emissions across different years is difficult, as consumption is mainly related to non-production factors, in this case testing the engines.

With regard to salt precipitation, a comparison of the data is also impossible, partly because the salt content of the Scheldt varies greatly from year to year, within a given year itself and even depends on the tide.

2.4.2.6 Energy and climate

2.4.2.6.1 Energy plan

The European IPPC Directive 96/61/EC (Integrated Pollution Prevention & Control) obliges Member States, within the framework of environmental legislation, to ensure that the energy efficiency of installations is taken into account both when operating the establishment and when applying for a permit for a new establishment.

Specifically for Flanders, this means that the permit conditions are linked to an energy study and/or energy plan. The Flemish Government Decree of 14 May 2004 (Official Gazette 16.07.2004) on energy planning for classified energy-intensive facilities adds a chapter 4.9 'Energy planning' to Part 4 of Title II of Vlarem. It states that every classified site with a primary energy consumption of at least 0.5 petajoules (500,000 GJp) per year must have a certified energy plan.

The Decree of the Flemish Government containing general provisions on energy policy ("Energiebesluit") of 19 November 2010 imposes requirements on the content of the Energy Plan.

A first energy plan was drawn up for KCD in 2010. A screening of potential energy saving measures was carried out. For each of these measures, it was assessed whether they are safety, technically feasible and sufficiently economically viable. This plan was evaluated and updated in 2014.

In addition to the measures in the energy plan, additional measures are being taken at the initiative of ENGIE. Table 5-3 below (from the Energy Plan 2014) shows that the measures taken (between 2010 and 2014) enabled more than 3,700 tonnes of CO_2/year to be saved[21].

Table 2-45: Savings due to energy measures in KCD (according to 2014 Energy Plan)

	maatregel EP2010	Besparingsoverzicht van uitgevoerde maatregelen van het EP2010		
			MWh_e/jaar	t CO_2/jaar
1	DOGB01a	ADG: verminderen verlichting	43,4	6,1
2	DOGB0a3a	WPG: aanwezigheidsdetectie	13,6	1,9
3	DOGB06a, 07a, 08a	CGA: optimalisatie van de verlichting	22,5	3,2
4	DOGB10a	CGB: optimalisatie van de verlichting	12,6	1,8
		totaal	**92,1**	**12,9**

	Besparingsoverzicht van uitgevoerde maatregelen niet vermeld in het EP2010		
		MWh_e/jaar	t CO_2/jaar
1	Andere gebouwen: optimalisatie verlichting en verwarming	1.240	174
2	WPG: warmtepomp i.p.v. directe verwarming	16	2
3	TGB: optimalisatie van de verlichting	8	1
4	Technische gebouwen: vervanging verlichting	843	118
5	WPG: verbeterde isolatie	3.223	451
6	vervangen van UPS uitrustingen	1626	228
7	vervanging van koelgroepen	73	10
8	vervanging van noodaggregaten	93	13
9	vervanging van opvoertransformatoren D3	2.759	386
10	vervanging van opvoertransformatoren D4	4.663	653
11	vervanging van de pakking van koeltoren D3	12.005	1.681
	Totaal	**26.547**	**3.717**

KCD has integrated energy care into its daily operations. The energy consumption of the different systems is reported and analysed per unit on a monthly basis. Both electricity consumption and the consumption of gas oil for the various emergency systems are monitored. All support services (buildings, workshops, machine tools, etc.) are constantly working to reduce their energy consumption.

[21] Laborelec, Energy Plan 2014 Electrabel Power Station of Doel, 2014.

Electricity consumption in the non-technical buildings amounted to 2,200 MWh in 2014, compared to 2,600 MWh in 2013. The decrease is due to a number of energy-saving measures, including the replacement of lighting and pumps, and settings. In addition to the reduction in electricity consumption, the heat loss of the administrative building was reduced by installing double glazing and insulating roofs and walls.

2.4.2.6.2 Energy study

An energy study is only necessary for new systems with a total annual energy consumption of at least 0.1PJ or in the case of a change to an existing system, which involves a (primary) additional consumption of at least 10 TJ per year.

As no new systems are planned or any increase in capacity is planned, KCD does not fall into these categories and therefore does not have to carry out an energy study.

2.4.2.6.3 Greenhouse gas emissions

At the climate conference in Kyoto Belgium and the European Union committed themselves to reducing the emissions of CO_2 and other greenhouse gases. The Protocol was approved by Council Decision 2002/358/EC of 25 April 2002. To this end, European Directive 2003/87/EC established a system of greenhouse gas emission allowances, within the countries of the European Community.

Since the trading period 2013-2020, KCD is also covered by this Directive due to the operation of combustion system with a total rated thermal input exceeding 20 MW (in 2014, this concerned 31 permanently installed engines, 2 boiler systems associated with auxiliary steam boilers and 1 boiler associated with a heating system, with a total capacity of 298.031 MWth).

Since then, KCD has been required to produce an annual monitoring report. For the year 2014, the CO_2 emissions calculated in this way amounted to 1,411.33 tonnes.

The entire Electrabel GDF Suez production system generated 47.008 GWh (net production at 100%) of electricity and 7,617,325 tonnes of CO_2 emissions in Belgium in 2014. The four nuclear units of Doel combined generated about 14.044 GWh net, thus emitting 1,411.33 tonnes of CO_2 from the testing of diesels and steam boilers. KCD therefore accounted for 29.87% of all electricity produced by Electrabel in Belgium and is only responsible for around 0.019% of CO_2 emissions[22].

As these CO_2-emissions under normal circumstances are the result of testing the combustion systems responsible for ensuring the safe operation of the nuclear systems, the level of these emissions will remain fairly constant.

The CO_2 emissions from these emission sources are so small, certainly compared to those from a conventional power plant, that the negative impact of these emissions on the climate cannot be quantified.

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[22] Electrabel, Environmental Statement 2015 - performance 2014, 2015.

2.4.3 Impact assessment

2.4.3.1 Operational phase of the project between 2015-20199

2.4.3.1.1 Emissions

LTO works

For a description of the works carried out in the context of the adjustments for LTO, see the general section of the EIR (see § 1.6.2 and 1.7.1).

The following emissions were possible during the works:

- dust emissions from excavation work and supply by lorries (earthmoving, construction work, etc.);
- emissions from exhaust gases from construction site machinery and trucks (combustion of fossil fuels and includes CO, CO_2, unburnt hydrocarbons , NOx, SO_2 and fine dust (PM 2.2 and PM 10)).

Diffuse dust emissions could arise from a number of activities (supply of materials by road transport, storage and loading of materials, excavation work). However, there are no methods available to carry out a reliable quantitative estimate of these emissions.

The dust emissions depend on a whole range of factors such as the number and type of construction site machinery used, the work instructions during construction, etc.

Given the distance from the site to the nearest houses, no impact was expected due to dust emissions (dust from the construction site machinery) during the work.

The share of emissions from construction site machinery and site traffic varied from day to day, and was considered rather small compared to current emission sources at the site and in the surrounding area such as traffic. The impact on air quality due to the construction site machinery and site traffic is assessed as slightly negative to negligible taking into account its temporary nature.

The number of transports that took place during the work is not known. There are only a limited number of houses along the access roads of KCD. It can therefore be said that the impact of the exhaust gases from these transports can be assumed to be negligible.

combustion systems

As part of the LTO project, 3 additional diesel engines were provided for the fire department pumps. These will be commissioned in 2020. Under normal operating conditions, the number of operating hours is limited to the periodic tests only.

Furthermore, in 2015 and 2017 some additional diesel generators were installed in the new GUM building.

The number of running hours varies from year to year. The frequency and duration of testing depend on the function of the diesel generator (auxiliary diesel, safety diesel, emergency diesel, diesel generators GUM).

The new diesel engines will also emit sulphur dioxide ($SO2_2$), nitrogen oxides (NOx), carbon monoxide (CO) and fine dust, but will comply with much stricter emission limits. Lower emission factors are therefore calculated for the 2015 and 2017 generators (see Table 240).

Based on the data per system during the period 2015-2019, a realistic worst case total test duration per year was determined:

Table 2-46: Theoretical number of operating hours and gas oil consumption, realistic worst case period 2015-2019

Functional element	Running hours (h)	Gas oil consumption (m³)
PKD-D1/DG0011	10	4,4
PKD-D1/ED0022	100	60,2
PKD-D0/DG0014	0	0,0
PKD-D0/DG0012	0	0,0
PKD-D0/DG0024	0	0,0
PKD-D0/DG0022	0	0,0
PKD-D2/DG0021	10	4,4
PKD-D2/ED0012	100	60,2
PKD-D0/DGS12	50	33,6
PKD-D0/DGS14	50	33,6
PKD-D0/DGS22	50	33,6
PKD-D0/DGS24	50	33,6
PKD-D0/DGS99	50	33,6
PKD-D3/ES-DG0012	10	2,2
PKD-D3/ES-DG0022	10	2,2
PKD-D3/ES-DG0001	50	63,9
PKD-D3/ES-DG0002	50	63,9
PKD-D3/ES-DG0003	50	63,9
PKD-D3/ES-DG0004	50	63,9
PKD-D3/KE-DG0001	50	30,1
PKD-D3/KE-DG0002	50	30,1
PKD-D3/KE-DG0003	50	30,1
PKD-D4/ES-DG0022	10	2,2

Functional element	Running hours (h)	Gas oil consumption (m³)
PKD-D4/ES-DG0012	10	2,2
PKD-D4/ES-DG0001	50	63,9
PKD-D4/ES-DG0002	50	63,9
PKD-D4/ES-DG0003	50	63,9
PKD-D4/KE-DG0001	50	30,1
PKD-D4/KE-DG0002	50	30,1
PKD-D4/KE-DG0003	50	30,1
PKD-DT/ABN	40	146,9
PKD-DT/ABZ	40	146,9

Using the emission factors from Table 240, the following emissions were calculated for the LTO situation:

Table 2-47: Emissions from combustion systems realistic worst case 2015-2019 situation LTO (tonnes/year)

	CO	NOx	SOx	PM10	$PM_{2,5}$
Doel 1&2	4.1	15.5	0.5	0.2	0.2
Doel 3	4.3	19.7	1.3	1.4	1.4
Doel 4	3.5	16.1	1.1	1.1	1.1
Auxiliary steam boilers	0.18	0.7	0.005	0.073	0.073
Miscellaneous	0.02	0.1	0.006	0.004	0.004
Total	**12.1**	**52.1**	**2.9**	**2.9**	**2.9**

Salt emission and salt precipitation (via the steam plume)
Salt emissions are not calculated or monitored annually, as the salt content of the Scheldt water varies greatly. Only a rough estimate can be made (see §2.4.2.4.1). No changes are expected as a result of LTO.

2.4.3.1.2 Selection of relevant pollutants

The table below shows, based on various criteria, for which pollutants an impact assessment is carried out. The following is taken into account:

- the emission load (comparison with FEAR reporting threshold),
- current air quality (more or less than 80% of the quality goals),

- toxicity (in particular mutagenic, carcinogenic and reprotoxic substances[23]),
- location near residential and natural areas,
- method of emission (diffuse, chimney, etc.).

On the basis of the table we arrive at the next selection of pollutants to be evaluated further:

- CO, SO_2, dust: no (separate) evaluation due to the low emission load and the fairly good air quality in the study area;
- NOx: further evaluation because the emission is (just) above the FEAR threshold;
- Acidifying and eutrophic emissions: further evaluation due to the location close to nature reserve.

Table 2-48 Selection of the relevant pollutants

Pollutant	Emission load realistic worst case [tonnes/year]	Current air quality (measurements above or below 80% of the quality standard)	Carcinogenicity and toxicity (H-phrases)	Location in relation to residential and natural areas	Decision for further impact assessment
NO_x	52.1 tonnes/y > 50 tonnes/y (FEAR)	Measurements < 80% of the quality standard	H330	Max. 150 persons < 2km, Doel village approx. 900 m to the S	Yes
CO	12.1 tonnes/y < 200 t/y (FEAR)	Measurements < 80% of the quality standard	H331	Max. 150 persons < 2km, Doel village approx. 900 m to the S	No
SO_x	2.9 tonnes/y < 100 tonnes/y (FEAR)	Measurements < 80% of the quality standard	H331	Max. 150 persons < 2km, Doel village approx. 900 m to the S	No
PM10	2.9 tonnes/y < 20 tonnes/y (FEAR)	Measurements < 80 % of the quality standard	No rating with H phrases	Max. 150 persons < 2km, Doel village approx. 900 m to the S	No
PM2,5	2.9 tonnes/y < 10 tonnes/y (FEAR)	Measurements < 80 % of the quality standard	No rating with H phrases	Max. 150 persons < 2km, Doel village approx. 900 m to the S	No
Acidifying emissions	N/A	N/A	No rating with H phrases	Location near nature reserve	Yes
Eutrophic emissions	N/A	N/A	No rating with H phrases	Location near nature reserve	Yes

[23] Pollutants with H-phrases H340, H341, H350, H351, H360 and/or H361

2.4.3.1.3 Determination of the immission contribution

It appears from the above that NO_2 and acidifying and eutrophic depositions are identified as relevant parameters. The distribution is then mapped using the IMPACT model. For NO_2, the 2015 background value is used.

The emissions calculated in Table 2-47 are entered into the dispersion model (together with the emission characteristics[24]) and are carried out for the emission points that together account for at least 95% of the emission load.

The diesel generators installed in the GUM building, and the diesel generators installed as part of the LTO project are negligible compared to the other emission sources, given their low power (and therefore lower fuel consumption) and lower emission factors.

For the pollutants for which dispersion modelling is performed , this is done both for the LTO situation (including Doel 1 and 2) and for the no-LTO situation[25] (excluding Doel 1 and 2) (zero alternative).

➔ NO_2

The annual average impact contribution of KCD is less than 1% of the environmental quality standard (see Figure 2.40) and can therefore be assessed as negligible.

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[24] The emission characteristics are not fully known, as no emission measurements are available. The following assumptions were made: smoke gas factor 10, emission temperature 420 °C for the diesel generators and 200 °C for the steam boilers, chimney height 1.5x the building height and chimney diameter 0.5 to 1.5m. Meteorological year 2012 and the standard deposition rates in IMPACT were used.

[25] This applies for the period 2019-2025. After all, in the no-LTO situation, testing of the Doel 1 and 2 diesel generators would still take place in the period 2015-2019 (during the POP), as long as fuel is still present in the reactors.

Figure 2.40: Annual average NO2 immission contribution in the operational phase, LTO scenario

➔ Eutrophic and acidifying deposition

The emissions of NOx and SO_2 as a result of the project lead to a contribution in eutrophying and acidifying deposition in the environment, e.g. near the Special Protection Area - Habitats 'Schelde- en Durmeëstuarium van de Nederlandse grens tot Gent' and the (partly overlapping) VEN area 'Slikken en schorren langs de Schelde'. This deposition is calculated and the results are displayed and evaluated in the 'Biodiversity' section.

2.4.3.2 Operational phase in the future situation (period 2020-2025)

In the LTO situation, as explained above, the emissions from the combustion systems will not differ significantly from the emissions in the baseline situation.

2.4.3.3 Post Operational Phase (period 2025-2029)

During the period 2025-2029 (Post Operational Phase period) the diesel generators for Doel 1 and 2 will remain in operation as long as fissile material is present. This situation is therefore similar to the LTO situation in the period 2019-2025 and the period 2015-2019. Only during the last phase of the POP (3 months), when all fissile material has been removed from the docks to the fuel container building (FCB), they may be taken out of service. The worst case scenario for this period can be based on a testing schedule as in the period 2019-2025. For its discussion please refer to §2.4.3.1.

2.4.3.4 Zero alternative

Emissions of the combustion systems

The emissions in the zero alternative are:

- In the period 2015-2019 (Post Operational Phase in the no-LTO situation): the diesel generators for Doel 1 and 2 will remain in operation as long as fuel is available. This situation is therefore similar to the LTO situation;
- In the period 2019-2029: emissions reduced for the emission points of Doel 1 and 2 (see Table 2-49).

Table 2-49: Emissions from combustion systems, realistic worst case 2019-2029 situation non-LTO (tonnes/year)

	CO	NOx	SOx	PM10	$PM_{2,5}$
Doel 1&2	0	0	0	0	0
Doel 3	4.3	19.7	1.3	1.4	1.4
Doel 4	3.5	16.1	1.1	1.1	1.1
Auxiliary steam boilers	0.18	0.7	0.005	0.073	0.073
Miscellaneous	0.02	0.1	0.006	0.004	0.004
Total	**8.0**	**36.6**	**2.4**	**2.6**	**2.6**

In this situation, KCD's annual average NO2 contribution is also less than 1% of the environmental quality standard everywhere and therefore negligible everywhere.

Figure 2.41: Annual average NO_2 immission contribution in the operational phase (non-LTO scenario)

As a result, the contribution of Doel 1 and 2 diesel generators is also negligible.

The zero alternative therefore differs from the basic alternative at the time of the Post Operational Phase (2015-2019 in the zero alternative vs. 2025-2029 in the basic alternative).

In the first case, there will be lower emissions for 10 years (in particular emissions linked to the testing of Doel 1 and 2 diesel generators).

However, as can be seen from Figure 2.41, the contribution of these emissions to air quality is negligible. Consequently, the impact of LTO on air quality is also negligible.

➔ Eutrophic and acidifying deposition

The deposition is calculated and the results are displayed and evaluated in the 'Biodiversity' section.

Salt emission and salt precipitation (via the steam plume)
Salt emissions are not calculated or monitored annually, as the salt content of the Scheldt water varies greatly. Only a rough estimate can be made (see §2.4.2.4.1). No changes are expected in the zero alternative compared to the basic alternative. After all, the cooling towers are only linked to Doel 3 and 4. The Doel 1 and 2 reactors are cooled using water-water cooling (not using the cooling towers). The water circulation in the cooling tower therefore remains the same regardless of the operation of Doel 1 and 2.

2.4.3.5 Energy and climate

2.4.3.5.1 Operational phase period 2015-2019

During the works for the LTO modifications, direct emissions were caused by freight traffic and construction site machinery. These constituted the most significant part of the total emissions. It is not really possible to estimate these emissions because some parameters such as fuel consumption are not known. It is also difficult to estimate the waste generated during the works, giving rise to emissions during processing.
Furthermore, the use of electrical energy is of little relevance, which means that there are no indirect emissions caused by electricity production in this area.
A significant indirect source of emissions came from the production of the building materials and technical systems needed for the project. The production of steel and concrete, for example, is very energy-intensive. Since the works under the LTO project are mainly technical changes that required only small quantities of such materials, these indirect emissions are considered to be negligible.

The CO_2 emissions reported under the ETS obligations in the years 2015-2019 are shown below (for comparison, emissions from the years 2009 to 2014 are also given).

Table 2-50 Annual CO2 emissions in the period 2009-2019

	CO_2 (tonnes/year)
2009	1608.99
2010	1660.60
2011	1809.43
2012	2253.13
2013	1683.98
2014	1411.33
2015	1887.49
2016	1419.54
2017	1414.46
2018	1674.72
2019	1272.34

The table above shows that there is no trend in CO_2 emissions.

2.4.3.5.2 Operational phase in the future situation (period 2019-2025)

Direct greenhouse gas emissions during the future situation are negligible because of the very limited emissions.

Indirectly, the operational phase causes emissions because of the consumption of electrical energy required. Energy consumption will be limited. Emissions can also be expected from the processing of industrial waste such as plastics, paper & cardboard, residual waste. Again, it is not possible to make a prediction because the necessary parameters are not known.

No significant impact is expected from the direct CO_2 emissions of KCD as a result of LTO or the zero alternative.

There may be an indirect impact, however, because if energy demand remains the same or rises, the energy requirement for the shutdown of Doel 1 and 2 power stations will have to be met in a different way.

The International Energy Agency (IEA) published the report 'Nuclear Power in a Clean Energy System' in 2019. Nuclear energy is currently the 2nd largest low carbon energy source in the world, accounting for 10% of global electricity production. Only hydropower has a higher share (16%). For advanced economies such as those of the United States, Canada, the European Union and Japan, it has been the largest source of low-carbon electricity for 30 years. However, the future of nuclear energy is uncertain as older power plants are being phased out, partly because of political decisions, but also for economic or regulatory reasons. According to the study, without policy changes, advanced economies could lose 25% of their nuclear capacity by 2025 and two thirds by 2040. Without further LTOs of existing nuclear power plants or new projects, an additional 4 billion tonnes of CO_2 could be emitted.

Some countries have opted for nuclear phase-out for security or other reasons. However, many countries still see a role for nuclear energy in their energy transition, but, according to the report, they are not doing enough to meet their targets.

By using nuclear energy, 55 Gt of CO_2 emissions have been avoided over the last 50 years, which is almost equal to 2 years of global CO_2 emissions. Despite the contribution of nuclear energy and the rapid growth of renewable energy, 2018 was a record year of energy-related CO_2 emissions, as energy demand grew faster than low-carbon energy production.

According to the report, a range of technologies, including nuclear energy, will be needed for the energy transition.

Belgium was a net importer of electricity in the period 2010-2018. In the zero alternative, more electricity will therefore have to be imported than in the LTO situation. The CO_2 emissions in both scenarios depend on the energy mix of the exporting countries. In these years, Belgium mainly imported electricity from its neighbouring countries, France and the Netherlands. Since these countries also have fossil energy sources in their energy mix, it can be assumed that CO_2 emissions in the zero alternative are higher than in the LTO situation (basic alternative). In that respect, the LTO situation is more positive for climate than the zero alternative. This assumes that in the zero alternative the same amount of low carbon electricity is produced by other sources (e.g. wind, solar, biomass...), and the same amount of electricity is consumed, as compared to the LTO situation. We therefore do not take into account any compensation of the production by the Doel 1 and Doel 2 power stations by gas-fired power stations or by other fossil or non-fossil power stations.

Of course, these assumptions contain a great deal of uncertainty. An undesirable side-effect of extending the operation of Doel 1 and 2 could, for example, be that it discourages investment in renewable energy. However, this potential effect cannot be estimated within the scope of this EIR.

2.4.3.6 Cumulative effects

Of the plans and projects in the vicinity of KCD, the Complex project 'Extra container handling capacity for the port' may have an impact on air quality.

In the S-EIR drawn up for this complex project, various alternatives for achieving the set objective were weighed against each other. This S-EIR shows that all alternatives are accompanied by a significant increase in emissions of greenhouse gases (especially CO_2) and air pollutants (especially NO_2) in both the port area and the hinterland. The S-EIR shows that there is a need to implement emission reduction measures in order to comply with international and European obligations regarding the containment of air pollution and climate change and not to jeopardise the growth of other activities/projects with relevant emissions.

The assessment framework for the impact on air quality is independent of the air quality in the reference situation - only the impact contribution of the project influences the qualification. There is a link with the mitigating measures. Starting from a limited (negative) immission contribution, mitigation measures should be sought if the environmental quality standard is met for more than 80%. However, as the impact of KCD is assessed as negligible, mitigation measures are not necessary.

2.4.3.7 Cross-border effects

The above analysis shows that potential effects of KCD as a result of emissions to air outside (regional) boundaries are completely negligible.

2.4.4 Monitoring

As the effects are assessed as negligible, no proposals for monitoring are made. The legal obligations must of course be respected.

2.4.5 Mitigating measures and recommendations

Given the absence of significant impacts, no mitigating measures or recommendations are proposed.

2.4.6 Knowledge gaps

There are no knowledge gaps affecting the assessment.

2.4.7 Conclusions

The above analysis shows that the effects of KCD-1 and KCD-2 on air quality:

- are to be assessed as negligible in the basic alternative, both during the operational phase and during the Post Operational Phase;
- in the zero alternative, are to be assessed as negligible both during the operational phase and during the Post Operational Phase;
- the continued operation of the Doel 1 and Doel 2 power plants for a period of 10 years can also be assessed as negligible.

With regard to direct CO_2 emissions, no significant difference is expected between the zero and the basic alternative.

However, it is assumed that in the zero alternative more electricity is imported than in the LTO situation. Consequently, indirect CO_2 emissions will be higher in the Zero alternative than in the LTO situation (basic alternative). In that respect, the LTO situation is more positive for the climate than the Zero alternative (assuming that everything else remains the same). However, the assumptions contain a great deal of uncertainty.

2.5 Biodiversity

Annex A - Map 3: Regional Plan

Annex A - Map 4: Regional Spatial Implementation Plan

Annex A - Map 13: Biologische Waarderingskaart (Biological Valuation Map)

Annex A - Map 14: Special Areas of Conservation

Annex A - Map 15: European habitats

Annex A - Map 16: Ramsar areas

Annex A - Map 17: Flemish Ecological Network

Annex A - Map 18: Nature reserves

Annex A - Map 19: Risk atlas - summarising map birds

2.5.1 Methodology

2.5.1.1 Definition of the study area

The study area for the biodiversity section concerns the KCD site and the wider environment on the basis of the impact zone determined by noise and air emissions on the one hand and the impact by discharge of cooling water on the other hand. Of particular importance here is the impact on the areas of interest in which the Scheldt estuary is the most important.

2.5.1.2 Description of baseline situation

When discussing the baseline situation, we provide a description of:

- vegetation types: vegetation in the immediate vicinity is described on the basis of the Biological Valuation Map (BWK) - status 2018, the Natura 2000 Habitat Map - status 2018 and the ecotopic map of the Scheldt (INBO, 2015);
- the protected areas: for this purpose, freely consultable databases and data concerning VEN, Special Protection Areas for Habitats and Birds are used. Their location is shown using maps. Vegetation, birds, mammals, amphibians, invertebrates and fish are described;
- ecological vulnerability at micro level: this is described on the basis of ecosystem vulnerability maps;
- important bird areas and routes: the discussion is based on the Flemish bird-wind turbine risk atlas (INBO 2015).

2.5.1.3 Description and assessment of the impact

Adjustments within the framework of LTO only took place within the boundaries of the KCD site. Ecotopic and habitat loss due to land use is therefore not considered relevant. For the same reason, no effects of fragmentation are expected. The KCD activities lead to air emissions of NO_X, SO_X, CO,CO_2 and particulate matter (see Air & Climate section). Related to these emissions, effects of acidification and eutrophication can be expected for the Biodiversity section. In addition, the various systems present cause noise emissions (see Noise & Vibrations section). Therefore, the effect of rest disturbance will be investigated. Finally, the extraction and discharge of cooling water as well as the discharge of waste water can also have an effect on the organisms in and along the Scheldt.

The expected effects for the biodiversity section during the adaptations within the framework of LTO will be described as follows:

- eutrophication and acidification due to atmospheric deposition: qualitative evaluation of NO_X and SO_2 emissions from construction site machinery and site traffic (based on assessment in the Air & Climate section);
- rest disturbance: qualitative description of noise nuisance caused by construction site machinery and site traffic (from the Noise & Vibrations section).

The expected effects during the operational phase in the future situation will be described as follows:

- eutrophication and acidification due to atmospheric deposition: quantitative evaluation based on the emission calculations of NO_X and SO_2 due to guided emissions from the Air & Climate section.

- rest disturbance: qualitative description of noise nuisance caused by continuous and non-continuous sources (from the Noise & Vibrations section);
- water intake: qualitative description based on research results concerning the fish and other fauna that may or may not be sucked in during capture;
- cooling water discharge: qualitative description of the thermal effect by means of temperature monitoring data (Arcadis, 2012) and of the population of fish and crustaceans in the vicinity of the cooling water discharge points from KCD (Breine & Van Thuyne, 2013A);
- discharge of chemical substances: qualitative description (from the Water section). Attention will focus mainly on those substances for which a limited to significant contribution was determined according to the framework of significance of the Water section. A distinction is made between the effects of eutrophication due to the discharge of nutrients and ecotoxicological effects due to the discharge of hazardous substances into the Scheldt.

The following nature tests will be performed:

- appropriate assessment within the framework of Article 36ter of the Nature Decree, examining the impact on the Special Areas of Conservation;
- stricter nature assessment within the framework of Article 26ter of the Nature Decree, which examines the impact on the Flemish Ecological Network;

The impact assessment is done as follows for:

- eutrophication and acidification due to atmospheric deposition: The significance frameworks to be used for eutrophication and acidification due to atmospheric deposition are described in, respectively, the Practical Guidelines for Eutrophication[26] and Acidification[27] via Air, published by ANB. These practical Guidelines should be understood as the most up-to-date guidance for assessing the significance of an impact on the conservation objectives in Special Areas of Conservation, in particular the Special Protection Area - Habitats. These practical guidelines are not guidelines for assessment in Special Protection Area - Birds, either for VEN or for protected species or for biologically valuable and highly valuable areas according to the Biological Valuation Map outside Special Protection Areas - Habitats. As KCD is located next to the Scheldt, which is designated as a Special Protection Area - Habitats, the use of these practical guidelines is most suitable in this EIR.
  On the basis of the immission calculations related to the activities of the KCD in the Air section and on the basis of the critical deposition values (CDV) of the European habitat types present - shown in the practical guidelines for eutrophication and acidification via air - a judgement will be made on the possible effect of eutrophication and acidification by deposition of NOx and SO_2

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[26] https://pww.natuurenbos.be/eutrofiering-de-lucht

[27] https://pww.natuurenbos.be/verzuring-lucht

from KCD. The assessment framework from the practical guidelines for acidification and eutrophication will be used for this purpose, shown in Table 2-51251.

Table 2-51251 Assessment framework for eutrophication and airborne acidification taken from ANB's practical guides to eutrophication and airborne acidification

Share of predicted deposition X relative to the critical deposition value (CDV) of the affected sensitive habitat	Ratio of allowable emissions to current activity	Technique to be used, to be included as a condition in the permit
X < 5%	Not significant	Typical Emission Reduction Measures (BAT)
5 ≤ X < 5%	Not significant, if a substantial decrease is achieved	If necessary to reduce emissions, additional emission reduction measures are imposed
X ≥ 50%	Significant	/

- Rest disturbance:
  - considerably negative:
    - Permanent effect or temporary effect during vulnerable periods (breeding season, hibernation, ... depending on the area);
    - Area is vulnerable to highly vulnerable to rest disturbance;
    - Presence of sensitive to very sensitive species for rest disturbance;
    - A noise contribution as a result of the plan/project of more than 55 dB(A);
  - negative:
    - Temporary effect outside vulnerable periods (breeding season, hibernation, ... depending on the area);
    - Area is vulnerable to highly vulnerable to rest disturbance;
    - Presence of sensitive to very sensitive species for rest disturbance;
    - A noise contribution as a result of the plan/project of 50-55 dB(A);
  - slightly negative:
    - Permanent or temporary effect;
    - Area is little or not vulnerable or vulnerable to rest disturbance;
    - Presence of species of low sensitivity, sensitive to very sensitive to rest disturbance;
    - A noise contribution as a result of the plan/project of less than 50 dB(A);
  - negligible:
    - Permanent or temporary effect;
    - Area has little to no vulnerability to rest disturbance;
    - There are no species sensitive to rest disturbance;
- water intake: the impact of water intake on biodiversity consists of describing and assessing which species are affected during the water intake. However, the nuclear power plant has already taken several measures to minimise the intake of fish and other animal species. The description and assessment of this impact group will be done in a qualitative way, based on data from the nuclear power plant;

- discharge of cooling water: the discussion of the discharge of cooling water at KCD is dealt with in three parts:
    - A summary is given of the measured temperature increase and the size of the heat plume due to the cooling water discharge of KCD. For a detailed description please refer to the Water section;
    - Next, the potential direct and indirect effects that may occur as a result of a temperature increase due to cooling water discharge are discussed. In terms of direct effects, there are general effects on aquatic organisms and communities, specific effects on fish, and specific effects on plankton and macroinvertebrates. The potential effects of thermal plumes on exotic species are also discussed.
    - Finally, an assessment of the potential effects of cooling water discharge on organisms for KCD is carried out. The results of the sampling of the fish stock in the cooling water plume of the KCD (Breine & Van Thuyne, 2013A) are used for this purpose.
- discharge of chemicals:
    - considerably negative: The project entails a risk of water quality deterioration in European or Flemish protected areas;
    - negative: The project poses a risk of water quality degradation outside European or Flemish protected areas and/or poses a limited risk of water quality degradation within European or Flemish protected areas;
    - slightly negative: The project poses a limited risk of water quality degradation outside European or Flemish protected areas;
    - negligible: The project does not change the water quality or the risk is negligible;
    - limited positive: The project provides a limited improvement of water quality outside European or Flemish protected areas;
    - positive: The project provides an improvement of water quality outside European or Flemish protected areas;
    - significantly positive: The project provides a, improvement of water quality in European or Flemish protected areas;

2.5.2 Baseline situation

2.5.2.1 Information about the natural reserves

In the vicinity of KCD there are several valuable natural reserves and protected areas. These areas are largely located near the banks of the river Scheldt and are protected at both European and Flemish level.

2.5.2.1.1 Natura 2000 areas

At the European level, the natural structure of the delimited study area is dominated by the following Special Areas of Conservation (see Annex A - Map 14):

- **BE2301336 Special Protection Area - Birds (SPA-B) '‘Schorren en polders van de Beneden-Schelde’ (Salt marshes and polders of the Lower Scheldt)**. This includes the polder area on the left bank, which is currently largely occupied by the port, and a smaller area of polder area on the right bank, but also the Galgenschoor and the Groot Buitenschoor. The KCD site is surrounded by the Special Protection Area for Birds on the left bank and overlaps with it locally. As a the Special Protection Area for Birds on the left bank was taken over by port-related infrastructure (including the Deurganck dock), a great deal of nature was lost. In order to compensate for this loss of natural area, a number of areas were demarcated and set up to compensate, these are the so-called compensation areas. Nearby KCD are the Paardenschor (see § 2.5.2.2.3) Doelpolder Noord and the Brakke Kreek as compensation areas (see § 2.5.2.2.5). Doelpolder Midden will have to be created still.

- **BE2300006 Special Protection Area - Habitats 'Schelde- en Durmeëstuarium van de Nederlandse grens tot Gent' ('Scheldt and Durme estuary from the Dutch border to Ghent')**. This includes both the Scheldt stream area and the mudflats and salt marshes along the Scheldt and the Paardenschor area outside the dikes. KCD is located on the edge of the Scheldt and this Special Protection Area - Habitats.

Both Special Areas of Conservation overlap at the level of the Scheldt banks.

The Special Protection Area - Birds BE2300222 'De Kuifeend en de Blokkersdijk' and the Special Protection Area - Habitats BE2100045 'Historische fortengordels van Antwerpen als vleermuizenhabitat' (Historic ring of forts of Antwerp as a bat habitat) are located more than 3 km from the KCD site. They are outside the sphere of influence of KCD's activities because they are further away from the site, in combination with the expected effects of KCD's activities on biodiversity.

On Dutch territory, the 'Verdronken land van Saeftinghe' (Drowned Land of Saeftinghe) is part of the Natura 2000 area 'Westerschelde & Saeftinghe' and designated as a Special Protection Area for birds and habitats (NL9803061). This area is located more than 3 km north of KCD and therefore outside the study area. Other Natura 2000 areas in the Netherlands such as the Oosterschelde, Markiezaat and Brabantse Wal are at a greater distance (> 10 km) from KCD. These areas are outside the sphere of influence of KCD's activities because they are further away from the site, in combination with the expected effects of KCD's activities on biodiversity.

2.5.2.1.2 Ramsar areas

Ramsar areas are wetlands of international importance and designated because of their importance for waterfowl, biodiversity and fish populations.

The **Galgeschoor**, **Groot Buitenschoor** and the **Schorren van Ouden Doel** are designated as Ramsar area (Ramsar no. 327; see Annex A - Map 16). The distance of Galgenschoor and Groot Buitenschoor to KCD is 1.2 km and 2.7 km respectively; these areas are located on the right bank of the Scheldt. Schor van Ouden Doel is located next to the KCD site at less than 1 km distance and within the study area. The Ramsar areas are located near the banks of the Scheldt and overlap with the Special Protection Areas for Birds and Habitats.

2.5.2.1.3 VEN areas

The '**Slikken en schorren langs de Schelde' (mudflats and salt marshes along the Scheldt**) are designated as Large Nature Areas (GEN) (area no. 304) and are part of the Flemish Ecological Network (VEN) (See Annex A - Map 17). The KCD site borders this VEN area.

The Scheldt waterway and the adjacent mud flats and salt marshes are very dynamic due to the tidal effect and have a very high ecological value. The high natural productivity of the ecosystem has repercussions throughout the food chain both in terms of species and numbers. The salt-bracket-fresh gradient present in the tidal zones is important. The landscape-determining structure means that migratory fauna also use this route as a migration route. The riparian zones along the Scheldt form important connections between the larger nature areas (Verdronken land van Saeftinghe), the remaining large brackish water areas (Galgenschoor, Groot buitenschoor, Schor van Ouden Doel) and the more recent compensation areas with mudflats and salt marshes (Ketenisseschor, Paardenschor, Prosperpolder, Lillo-Potpolder,...) along the Scheldt. As a result, the riparian zones have an important network function. These listed zones are all part of this VEN area. The banks of the Scheldt near KCD are also part of this demarcated VEN area.

The VEN areas near the banks of the Scheldt overlap with the Special Protection Area - Birds, the Special Protection Area - Habitats and the Ramsar area.

2.5.2.1.4 Nature reserves

The **Schorren van Ouden Doel** are a recognized nature reserve (reserve no. E-110) located on the left bank of the Scheldt (see §2.5.2.2.4). It overlaps with the Special Protection Area - Birds, Special Protection Area - Habitats, Ramsar area and VEN area. The Schor van Ouden Doel is located north of the KCD site, less than 1 km away. In the further surroundings along the Scheldt there are the **Galgenschoor and Groot Buitenschoor** (reserve No. E-021), these two nature reserves are located on the right bank of the Scheldt at respectively 1.2 km and 2.7 km distance from KCD.

2.5.2.1.5 Other areas important for nature

Other important areas in the vicinity of KCD are the **Hedwigepolder** and **Prosperpolder** (see § 2.5.2.2.6; Figure 2-42). The Prosperpolder is located northwest of KCD at a minimum distance of 0.9 km. The Hedwigepolder is connected to this polder and is located across the border in the Netherlands, at least 2.1 km away. Both areas belong to the cross-border intertidal area under development. These polders connect to the Verdronken Land van Saeftinghe and form a nature reserve of international significance of about 4,000 hectares.

Near KCD are the **Paardenschor, Doelpolder Noord** and the **Brakke Kreek** were created as **compensation areas** (see § 2.5.2.2.3 and § 2.5.2.2.5). These areas link up with the Schor van Ouden Doel and the Hedwigepolder and have been important areas for biodiversity for several years now. A layout of these areas is shown in Figure 2-42.

The other zones around KCD have been preserved as polder areas **(Doelpolder, Arenbergpolder**). These polder areas (§ 2.5.2.2.7) are part of the Special Protection Area for Birds on the left bank. In time, Doelpolder Midden can still be set up as a tidal area **(controlled reduced tidal area (GGG) Doelpolder)**, together with the meadow bird area Doelpolder Noord. As the RSIP Delimitation of the Antwerp Seaport

Area - Port Development Left Bank[28] was overturned, this nature development cannot continue as planned for the time being.

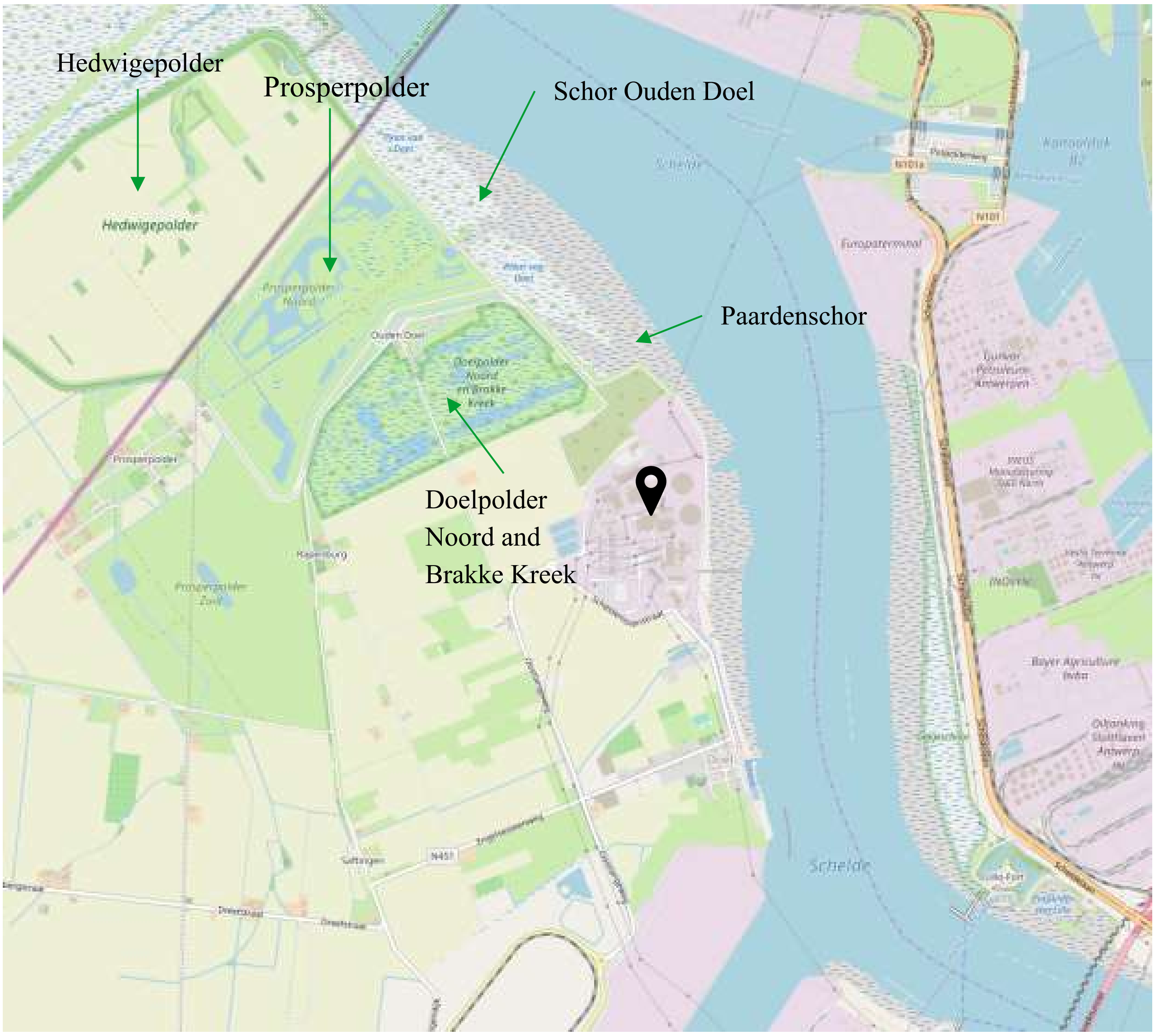

Figure 2-42 Other areas of importance for nature in the vicinity of KCD

[28] On Friday 12 May 2017, the Council of State voided the April 2013 Regional Spatial Implementation Plan (RSIP) delimitation of the Antwerp seaport area for the left bank of the Scheldt. As a result, the expropriation plans for the hamlets of Ouden Doel and Rapenburg and for the nature areas of Prosperpolder Zuid phase 1, Doelpolder Midden, Nieuw Arenberg phase 1 and Grote Geule have been dropped. On Right Bank, the RSIP remains in full force.
The Council of State has said that port development and nature development on the left bank of the Scheldt are inextricably linked. Since the Council already voided the RSIP for port development on 20 December 2016, it believes that the RSIP for nature should now also be voided. This means that all the areas designated as nature in the RSIP (Prosperpolder Zuid phase 1, Nieuw Arenberg phase 1, Doelpolder Midden en Grote Geule) now revert back to the spatial zoning in the Regional Plan of 1978. Large parts of the left bank of the Scheldt now again have the mixed-use agriculture / port expansion. However, the Council had already made an exception for the western part of the Waasland Logistics Park, and now confirms this, so that the port's destination will remain at that location.

The Scheldt and its immediate surroundings are a **faunistically important area**. According to the 'Vlaamse risicoatlas vogels-windturbines' (Flemish risk atlas bird-wind turbines) (INBO, 2011) various breeding areas, meadow bird areas, roosting areas and bird sanctuaries are located in the mudflats and salt marshes, polders and docks. The Scheldt is an important migratory route for birds, many species visit the area to come together or wintering. Around the Doel site there are many birds flying over, to and from their roosts, resting grounds or feeding grounds. KCD is almost completely enclosed by the Beveren Linkeroever Polders resting ground. Other important areas are the Zeeschelde Nederlandse Grens - Lillo (resting ground), Linkeroever (breeding ground), Galgeschoor and the Groot Buitenschoor (breeding and resting ground), Kanaaldok B2, Kanaaldok B3, Zandvliet lock, Doeldok and Deurganckdok (see Figure 2-43). Bird migration routes avoid the site of the KCD in itself, but around the site there is a heavy traffic of sleep, food and seasonal migration. The cooling towers of KCD have been a breeding site for peregrine falcons since 1996 due to the presence of a nesting box. Below is an overview of how many peregrine falcons were born at this breeding site in the period 2013-2019:

- 2013: 1
- 2014: 3
- 2015: 4
- 2016: none
- 2017: 4
- 2018: 3
- 2019: none

Figure 2-43 Important nesting and resting grounds in the vicinity of KCD

2.5.2.2 Description of the nature reserves

The following is a brief description of the various natural areas in the vicinity of the KCD that are located within the study area. These nature reserves are protected at both Flemish and European level.

2.5.2.2.1 The Scheldt and its banks

The Scheldt and its banks are part of the **Special Protection Area - Habitats** ('Schelde- en Durmeëstuarium van de Nederlandse grens tot Gent'). Parts of the banks of the Scheldt also belong to the **Special Protection Area - Birds** 'Schorren en polders van de Beneden-Schelde' and/or the **VEN area** 'Slikken en schorren langs de Schelde'.

The Scheldt refers to both the water zone and its immediate surroundings, namely the banks to the dikes. The banks of the Scheldt form narrow strips along the Scheldt and are bounded by the dikes. The banks of the Scheldt are protected on a Flemish and European level by the designation on the regional plan as a nature area, nature reserve, nature reserve with easement (with regard to transport and pipelines) or special nature areas and by the designation of parts of the banks as VEN area and/or Special Protection Area - Habitats.

2.5.2.2.1.1 Biotopes

An estuary is the downstream part of a river that is under the influence of the tidal action of the sea. Unlike estuaries and lagoons, estuaries have a constant flow of fresh river water. This creates a typical fresh-salt gradient from inland (fresh) to the estuary (saline). In the brackish water zone, strong fluctuations in salinity occur. The mixing of fresh and salt water and the reduction of flow rate gives rise to the sedimentation of fine silt particles. This creates a highly dynamic system of side channels, shallow water, flats, mudflats and salt marshes. The mudflat area is flooded twice a day, the higher shelf area only floods during storm and spring tides. The construction of dikes reduced this riparian zone to narrow strips and separated it from the inner dike area, the Scheldt polders.

Estuaries are biologically very rich ecosystems. The occurrence in these tidal areas of various gradients (fresh to salt, silty to sandy, etc.) provides for a great diversity of organisms, notwithstanding in the brackish parts the number of species is rather low. In addition to this diversity, estuaries are especially productive. For example, the annual production of organic matter in estuaries is much higher than that of rivers and seas. This high primary production has always been exploited by humans. Estuaries are normally good fishing grounds and suitable areas for aquaculture.

The Scheldt estuary was severely damaged by human intervention during the 20th century. The estuary was increasingly reclaimed and diked. The port of Antwerp grew to be a world-class port so the channel was dredged to make it deeper and wider. The main bottlenecks for the ecological functioning of the Scheldt estuary are the changes in the hydromorphology, the increased tidal energy, the poor water quality and the pollution of the water bottom. As a result of the dikes and deepening of the Scheldt, the area of mudflats and salt marshes has greatly decreased over the past 150 years. In 2003, the area was still only a third of the area in 1850. The remaining intertidal areas are unsustainable in many places because they are under high hydro-morphological pressure. The transition between the gully and the salt marsh is becoming steeper. Mudflats, low and middle salt marsh become vulnerable and erode under the increased tidal energy. The gradual transitions are disappearing and high cliffs are forming which may finally disappear due to erosion ('coastal squeezing').

However, in recent decades, the change in international and local environmental and nature policy (more specifically, the pursuit of a more integrated management of the estuary) brought about a number of initiatives, including the renewed Sigma Plan, which may slowly turn the tide.

The mudflats and salt marshes in the outer dike area are brackish water at the level of the KCD; south of Antwerp, the sea influence decreases and freshwater salt marshes occur. The mudflats and salt marshes present on the left bank of the Scheldt are the Schor van Ouden Doel and the Paardenschor north of KCD. The Ketenisse salt marshes south of the KCD are more distant and outside the study area. At the level of the KCD there is a short and steep transition zone from the dike to the Scheldt, which means that mudflats and salt marshes have very little space and consequently are also little developed. On the right bank, the Galgenschoor and the more northerly Groot Buitenschoor are the most valuable mudflats and salt marshes.

Along the banks of the Scheldt, plant areas can be clearly distinguished, namely grassy vegetation on the highest parts of the salt marsh and on the dikes; reed beds and zones of Elytrigia atherica and Bolboschoenus maritimus on the lower parts of the salt marsh. The mudflat is a muddy plain between the waterline and the higher located salt marsh; this zone has a rich benthic life, contains many unicellular organisms (diatoms, blue-green algae,...) and has little to no vegetation (salicornia, cordgrass).

Salt marsh plants bound to salt influence include Bolboschoenus maritimus, seaside arrowgrass, cochlearia officinalis, lysimachia maritima, puccinellia maritima, juncus gerardii, and aster tripolium. Moisture-loving plants include reed, persicaria amphibia, rumex palustris, rumex obtusifolius, calystegia sepium, and lycopus europaeus. Plants with less specific preference are urtica dioica, arctium minus, cirsium arvense and anthriscus sylvestris.

On the Biological Valuation Map (See Annex A - Map 13) , vegetations at the level of the dikes and banks along the Scheldt on the left bank at the level of KCD are designated as biologically valuable or biologically very valuable. Biologically very valuable vegetations are mud flat (ds), salt marsh (da), bolboschoenus maritimus vegetations (mz), reed vegetations (mr) and hay meadow vegetations (hu). Biologically valuable are dikes (kd), reed beds (mru), storage of all kinds with willow (sz+sal), ruderal vegetation (ku), and beds (ku/kz) on raised areas.

On the Natura 2000 Habitat Map (Annex A - Map 15) , the Scheldt is designated as habitat type 1130 'Estuaries'. The Scheldt bank is also part of habitat type 1130 'Estuaries' with the salt marsh vegetations along the KCD designated as habitat type 1330_da 'Atlantic salt meadows' and the reed beds along the KCD designated as regionally important biotope and other Phragmition vegetations (rbbmr). A limited area on the banks of the Scheldt near the Doel 1/2 intake point of the KCD is designated as habitat type 6430_mr 'Reed lands with althaea officinalis, lathyrus palustris and/or sonchus palustris'. A limited area on the banks of the Scheldt south of the Doel 1/2 intake point of the KCD is designated as regionally important biotope rhamno-Prunetea on loamy soils (rbbsp). The Scheldt embankment north of KCD is designated as uncertain habitat for habitat type 6510, gh 'Lowland hay meadows: arrhenaterion: arrhenaterion or no Habitat type from the directive'. The Scheldt embankment south of KCD is designated as partial habitat for habitat type 6510_hu 'Lowland hay meadows: arrhenaterion'.

On the ecotopic map of the Scheldt (INBO, 2015) in Figure 244, for the Scheldt and left bank at the level of KCD, the following can be seen from east to west:

- the channel of the Scheldt east of the breakwater is characterized as deep subtidal;
- the area within the breakwater is characterized by the moderately deep subtidal zone with the transition to a narrow zone of shallow subtidal;
- the mud flat zone along the left bank of the Scheldt at the level of KCD is entirely on soft substrate - with the exception of the muddy zone at the discharge point of KCD which is on anthropogenic substrate - and is characterized by a narrow zone of low mud with the transition to a wide strip of medium mud and a narrow zone of high mud;
- adjacent to the KCD site, a narrow salt marsh zone is present.

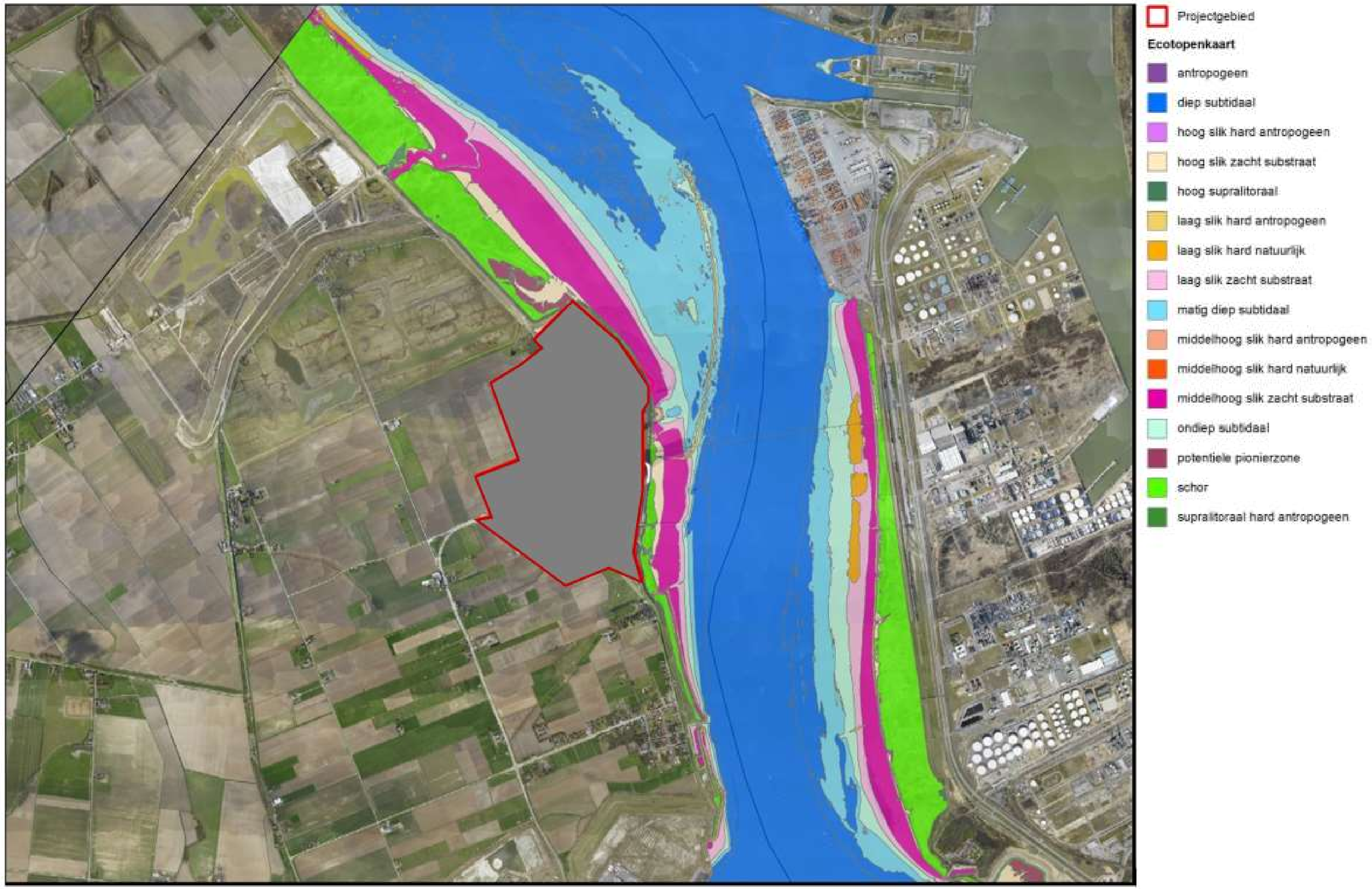

Figure 244 Ecotopic map Scheldt (INBO, 2015)

2.5.2.2.1.2 Benthos

The large food supply in estuaries also gives rise to a high concentration of bottom invertebrate organisms, the benthos. Here we find important populations of gray shrimp, large numbers of crustaceans such as the limecola balthica and mya arenaria, and various species of worms such as sabellaria alveolata and roundworms. This rich soil fauna is a food source for both birds and fish. Birds forage on the mudflats at low tide, and rest on the salt marshes during high tide; fish do exactly the opposite: at high tide they enter the flats and at low tide they rest in the gulleys.

2.5.2.2.1.3 Fish

Estuaries also play an important role in the life cycle of many fish. However, the species composition of the community in the Lower Zeeschelde changes throughout the year. In summer-autumn, this area functions as a nursery where the larvae and juveniles of a number of species such as shrimp and gobiidae feed. In winter, the Lower-Zeeschelde serves as a hibernation area for species such as herring, sprat and sea bass. In the spring, the estuary has an important transit and passage function for a number of migratory species such as thinlip mullet, lamprey, eel, and flounder. Likewise, a number of freshwater species (crucian carp, blicca bjoerkna, ruffe, rhodeus amarus and rutilus rutilus) occur because of the lower salinity levels (Maes *et al.*, 1996).

INBO does an annual follow up of the fish stock of the Zeeschelde estuary using anchorage trawling, three times a year (May, July and September) and along the estuarine gradient, namely Doel, Antwerp, Steendorp and Branst. For the 2013 and 2014 baseline situation, the following observations apply (Breine & Van Thuyne, 2013B and 2014):

Smelt appear to be the most abundant species in the Zeeschelde. All life stages (larvae, juveniles and adults) are caught which indicates that this diadromous species spawns successfully in the Zeeschelde;
Adult twait shad were captured again. Despite the fact that spawning activity was observed and eggs were caught, the recruitment is apparently unsuccessful as no larvae or juvenile twait shad were caught;
The presence of juvenile anchovy, herring and sea bass illustrates that marine species, like the diadrious flounder, use the Zeeschelde as a nursery;
Gray shrimp and palaemonidae swim far upstream in the Zeeschelde;
Specifically at Doel, the following findings apply:

- In Doel, the annual data show more species at low tide than at high tide;
- Near Doel, mainly marine and estuarine fish are found;
- Among the 4 monitoring sites, the largest number of species is caught in Doel (mesohaline zone),
- Of the 4 monitoring sites, the lowest number of individuals of exotic species and the lowest relative percentage of exotic species are observed in Doel (mesohaline zone).

For the period 2015-2019, the following observations apply (Breine & Van Thuyne, 2015, 2016, 2017, 2018 and 2019):

Smelt appear to be the most abundant species in the Zeeschelde. All life stages (larvae, juveniles and adults) are caught which indicates that this diadromous species spawns successfully in the Zeeschelde;
Adult twait shad were caught. In contrast to 2014, juvenile twait shad were captured for all years 2015-2019. This indicates that recruitment has taken place;

The presence of juvenile sprat, herring and sea bass illustrates that marine species, like the diadrious flounder, use the Zeeschelde as a nursery;
Gray shrimp and palaemonidae swim far upstream in the Zeeschelde;
From 2012 to 2017, the number of individuals of exotic species caught increased at almost all sites. The high numbers of exotic species in 2016 and 2017 were mainly due to the high number of pikeperch.
An increase in the relative percentage of exotic species was also observed in the 4 monitoring sites from 2012 to 2019.
Specifically at Doel, the following findings apply:

- In Doel, the annual data show more species at low tide than at high tide;
- Near Doel, mainly marine and estuarine fish are found;
- Among the 4 monitoring sites, the largest number of species is caught in Doel (mesohaline zone),
- Of the 4 monitoring sites, the lowest number of individuals of exotic species and the lowest relative percentage of exotic species are observed in Doel (mesohaline zone).

In 2013, INBO conducted a sampling of the fish stock with beam trawling in the cooling water plume (within the breakwater) of KCD (Breine & Van Thuyne, 2013A). During the month of November, 17 beam trawl hauls were conducted inside and outside the KCD's breakwater for two days. The report answered the following questions:

- Is there increased abundance of heat-loving native species within the breakwater versus outside the breakwater? If so, what species and their numbers?
- Is there increased abundance of exotic species within the breakwater versus outside the breakwater? If so, what species and their numbers?

Inside the breakwater, 13 fish were caught and 7 were caught outside. Flounder was caught the most. Within the breakwater, the common goby is the second most abundant species while at high tide the proportion of sole increases. Outside the breakwater, the contribution of gobiidae, tadpole and common goby, is greater. Again, more sole are caught at high tide. Sole normally migrates to warmer and deeper water in the fall and winter. Within the breakwater, only one exotic fish was found: a specimen of round goby. This species has reportedly also established itself in some canals and rivers. Verreycken (2013) states that round goby can occupy all types of habitat. Their environmental effect is mainly related to food and habitat competition as well as predation. Within the breakwater, warmth-loving sea bass were also caught. This is quite remarkable given that this species was not caught often in the Zeeschelde in 2013.

In addition to fish, shrimp and crabs were also caught. Four specimens of Caridina Multidentata were caught within the breakwater. The Chinese mitten crab has been caught in large numbers: 274 inside and 452 outside the breakwater. Gray shrimp are mainly found within the breakwater (18,096 specimens caught) and to a lesser extent palaemonidae (544).

These catch data show that the fish fauna as well as shrimp and crabs are more likely to reside in the area within the breakwater where there is a higher water temperature. In addition, the area is less dynamic than outside the breakwater. The presence of sea bass, a warmth-loving marine species, demonstrates that this species uses the area within the breakwater as a winter refuge. Sole holds up within and near the breakwater area. Some species use the warmed up area within the breakwaters to reach adulthood. There is an indication that there is an increased abundance of heat-loving native species (sea bass and sole) within the breakwater.

The presence of exotic fish is not remarkable, only one round goby was caught within the breakwater. Palaemonidae and Chinese mitten crab are commonly distributed in the Zeeschelde. Thus, one cannot speak of an increased abundance of exotic species within the breakwater (Breine & Van Thuyne, 2013A).

2.5.2.2.1.4 Birds

The Scheldt and Scheldt Banks are indicated as faunistically important areas. The rich soil life in the mudflats provides an important food source for birds. The banks of the Scheldt are therefore an important migratory, wintering, breeding and rearing area for numerous bird species. The mudflats and salt marshes serve as roosts for seagulls, ducks and geese.

Monitoring of waterfowl on the Zeeschelde is done annually by the INBO. Some common **waterbirds** for the Zeeschelde near the KCD are (Van Ryckegem *et al.*, 2014, 2015, 2016, 2017, 2018):

- Cormorant
- Shelduck
- Dunlin
- Canada goose
- Great crested grebe
- Greylag Goose
- Northern lapwing
- Avocet
- Gadwall
- Tufted Duck
- Northern pintail
- Oystercatcher
- Wigeon
- Common pochard
- Redshank
- Wild duck
- Teal
- Curlew
- Mediterranean gull

For the 2013 and 2014 baseline situation, the following observations apply to waterbirds (Van Ryckegem *et al.*, 2014 and 2015):

- The overall patterns in monthly bird numbers along the Zeeschelde in 2013 and 2014 remain similar to previous years. Winter numbers have shown a downward trend since 1999, the number stabilizing since 2008 to around 25 000 to 30 000 winter birds counted. The main decline is due to a sharp decline in the numbers of wigeon and teal. Winter maximums are counted in the months of December-January. The lowest numbers are counted in March. The Zeeschelde is one

of the most important wintering areas for waterbirds in Flanders. However, the international importance of the Zeeschelde as a wintering area has become more limited and currently only the gadwall reaches the 1% standard (numbers of international significance). For the Zeeschelde as a Special Protection Area for Birds, less than 2% and less than 1% of the Northwest European population resided in the Zeeschelde during winter 2013 and winter 2014, respectively. Contrary to expectations, there is no major increase in fish-eating bird species. On the contrary, the Great crested grebe has declined significantly in the mesohaline zone (to which the present study area belongs) since the late 1990s;
- The shelduck is the dominant "water breeding bird" in the Zeeschelde. The wild duck is the most numerous breeding bird along the Zeeschelde, in addition to the shelduck. Gadwall is not a common breeder along the Zeeschelde.

For the period 2015-2017, the following observations apply to waterbirds (Van Ryckegem *et al.*, 2016, 2017 and 2018):

- Monthly number of birds along the Zeeschelde River were slightly lower overall in the winters of 2015, 2016 and 2017 than in previous years. As a result, the international importance of the Zeeschelde for wintering waterbirds is historically low. Only the gadwall in the Zeeschelde still reaches 1% of the estimated Northwest European population.
- After a period of increase (2012-2015), a decrease in benthivorous bird species was observed in the Lower-Zeeschelde.
- As a general conclusion, bird numbers on the Zeeschelde show a continuing downward trend.

In the period 2013-2017, all large brackish water salt marsh areas along the Zeeschelde in the CT area - including Doelpolder Noord, Doelpolder Midden, Prosperpolder, the Schor Ouden Doel and the Paardenschor - were inventoried annually for **breeding birds** (Van Ryckegem et *al.).* The bird species listed below breed annually within the Northern Area of the Antwerp Port Area on the left bank - this includes Doelpolder Noord, Doelpolder Midden, Prosperpolder, the Schor Ouden Doel and the Paardenschor:

- Bearded reedling
- Bluebird
- Marsh Harrier
- Little grebe
- Avocet
- Spotted Crake
- Sedge warbler
- Oystercatcher
- Shoveler
- Redshank

Over the past five years, the rarer species bearded reedling, avocet, spotted crake and redshank have shown a stable trend. When considered over the longer term, the marsh harrier shows a declining trend. For the more common species of bluebird, little grebe, sedge warbler, shoveler and garganey, the importance increases as more Sigma areas are established.

Of the annually nesting species in the CT area of Scheldt estuary, a significant proportion of the population of black-tailed godwit, savi's warbler, little bittern and garganey occur outside the harbor. Several species rarely breed within the Scheldt estuary CT area until 2017 (great reed warbler, black-crowned night heron, corn crake, spoonbill, bittern, and capercaillie) or have never been established as breeding birds (purple heron).

2.5.2.2.1.5 Mammals

Every year seals swim up the Zeeschelde in small numbers and stay there for longer or shorter periods. The species does not reproduce in the Belgian part of the Scheldt estuary. Harbor porpoise are also regularly observed on the Zeeschelde. There seems to be no real return to the Zeeschelde of this species for the time being (Van Ryckegem *et al.*, 2014, 2015, 2016 and 2017).

Bats are more likely to occur in closed to semi-open forests and small-scale, wetland landscapes or landscapes with wooded edges and rows of trees. Pond bats are found near large bodies of water, rivers and canals. However, the Scheldt itself is not a known area. There are no known flyways for bats in the vicinity of the KCD (Baetens *et al.* 2016).

2.5.2.2.2 Galgenschoor

The Galgenschoor belongs to the **Special Protection Area - Habitats** 'Schelde- en Durmeëstuarium van de Nederlandse grens tot Gent' (Scheldt and Durme estuary from the Dutch border to Ghent) and to the VEN area **'** Slikken en schorren langsheen de Schelde'. The Galgenschoor is also a **recognized nature reserve** 'Groot Buitenschoor and Galgeschoor' and is designated as a **Ramsar area**.

The Galgenschoor is about 46 ha in size and 2 km long and is located east of the KCD on the right bank of the Scheldt between Lillo-Fort and the Europa Terminal. It is a very valuable, brackish salt marsh on the territory of the municipalities of Zandvliet and Lillo. The southern part of the Galgeschoor passes through a narrow strip of reed vegetation into the reserve of Fort Lillo.

The entire Galgeschoor is colored on the Biological Valuation Map (Appendix A - Map 13) as a biologically highly valuable area with mud (ds), salt marsh (da) and reed bed (mr). The European habitat type 1130 'Estuaries' occurs there and the habitat type 1330 'Atlantic salt meadows (Glauco-Puccinellietalia maritimae)' on the slightly higher parts, which do not flood at every high tide, but only at spring tide. In addition, the regionally important biotope 'Rietland en andere Phragmition-vegetaties' (Reed land and other Phragmition vegetation) also occurs there.

On the ecotopic map of the Scheldt (INBO, 2015) in Figure 244, the following can be seen from east to west for the mud and salt marsh zone near the Galgenschoor:

- The westernmost area is characterized by a salt marsh zone, which is wide in the south and narrows toward the north;
- The salt marsh transitions into a mud zone characterized by: medium mud soft substrate, low mud soft
- substrate, 3 small zones low mud hard natural;
- The mudflat transitions into a shallow subtidal zone and a deep subtidal zone.

The faunistic value of the Galgenschoor is mainly determined by the avifauna. Tidal areas such as the Galgenschoor possess great value for many bird species. This is especially the case because of the gradient from salt to fresh. They also have a very clear seasonal element: you have breeding birds, migrants and winter visitors.

Due to the abundant invertebrate fauna on the mud and sand areas, large numbers of waders such as plovers and sandpipers often forage here. At high tide, salt marshes also provide a refuge for a variety of wading birds that forage on the surrounding mudflats or beaches.

2.5.2.2.3 Paardenschor

The Paardenschor is part of the **Special Protection Area - Habitats** 'Schelde- en Durmeëstuarium van de Nederlandse grens tot Gent' and the **Special Protection Area - Birds '**Schorren en polders van de Beneden-Schelde', but not of the VEN area 'slikken en schorren langs de Schelde'.

The Paardenschor is located north of the KCD, contiguous to the nuclear power plant site. This area outside of the dikes, which is influenced by tides, was redesigned in 2004 to compensate for the loss of natural values during the construction of the Deurganck dock. The objective is the development of mudflats and salt marshes. Most of the area is occupied by mudflats. Spatial expansion of the salt marsh is limited to the peripheral zones of the area. Sea aster, Bolboschoenus maritimus and reeds form the main vegetation; this connects to the northern Schor Ouden Doel, where mainly high salt marsh is present. In the initial phase, a vegetation of vaucheria was mainly present; this has largely disappeared due to colonization with higher plants.

The Paardenschor is designated on the Biological Valuation Map (Annex A - Map 13) as a biologically highly valuable mudflat and salt marsh area (ds + da) with reed vegetation (mr) and Bolboschoenus maritimus vegetation (mz).

On the Natura 2000 Habitat Map (Annex A - Map 15), the Paardenschor is designated as habitat type 1130 'Estuaries' with the salt marsh vegetation designated as habitat type 1330_da 'Atlantic salt meadows' and the reed vegetation designated as regionally important biotope reed bed and other Phragmition vegetation (rbbmr). A limited area on the Paardenschor is designated as habitat type 1310_zk 'Pioneer communities with salicornia'. The Scheldt embankment along the Paardenschor is designated as uncertain habitat for habitat type 6510,gh 'Lowland hay meadows: arrhenaterionor no Habitat type from the directive'.

On the ecotopic map of the Scheldt (INBO, 2015) in Figure 244, the following can be seen from east to west for the mud and salt marsh zone near the Paardenschor:

- a rather narrow zone of low mud with the transition to a wide zone of medium mud and a narrow zone of high mud. The mud zone is entirely located on soft substrate;
- the mudflat zone is followed by a wide strip of salt marsh with an adjacent potential pioneer zone north of the KCD.

The Paardenschor is home to many wintering and resting waterfowl, it also serves as a nesting area.

2.5.2.2.4 Schor van Ouden Doel

The Schor Ouden Doel belongs to the **Special Protection Area - Habitats** 'Schelde- en Durmeëstuarium van de Nederlandse grens tot Gent', the Special Protection Area - Birds **'** Schorren en polders van de Beneden-Schelde', the **VEN area** 'Slikken en schorren langsheen de Schelde', is protected as a **Ramsar area** and is an **official nature reserve.**

The Schor Ouden Doel joins the Verdronken land van Saeftinghe, both areas together forming the largest brackish water salt marsh in Western Europe.

The Schor Ouden Doel is 51 ha in size and is located on the left bank of the Scheldt in the Prosperpolder about 1.2 km north of the KCD. This area outside of the dikes, up to the Scheldt and the Dutch border is a brackish water salt marsh of about 51 ha and is managed by Natuurpunt. The area is under tidal influence and is inundated by both salt water from the North Sea and fresh water from the Scheldt. The mud flat area is submerged twice daily. The higher elevation salt marshes flood only during storm and spring tides (Gyselings, 2011). Part of the area consists of reed and Bolboschoenus maritimus. To prevent encroachment, parts of the area are grazed.

On the Biological Valuation Map (Annex A - Map 13) , the Schor Ouden Doel is designated as a biologically highly valuable area. In addition to the designation of mud (ds) and salt marsh (da), reed land (mr), reed thicket (mru), and Bolboschoenus maritimus vegetation (mz) also occur.

On the Natura 2000 Habitat Map (Annex A - Map 15), the Schor Ouden Doel is designated as habitat type 1130 'Estuaries' with the salt marsh vegetation designated as habitat type 1330_da 'Atlantic salt meadows' and the reed vegetation designated as regionally important biotope reed bed and other Phragmition vegetation (rbbmr). A limited area on the Schor Ouden Doel is designated as habitat type 1320 'Spartina swards (Spartinion maritimae)'. The Scheldt embankment along the Paardenschor is designated as partial habitat for habitat type 6510_hu 'Lowland hay meadows: arrhenaterion'.

On the ecotopic map of the Scheldt (INBO, 2015) in Figure 244, the following can be seen from east to west for the mud and salt marsh zone near the Schor Ouden Doel:

- a rather narrow zone of low mud with the transition to a wide zone of medium mud and a narrow zone of high mud. The mud zone is largely located on soft substrate. The mud flat zone narrows northward and at the level of the narrowing, the mud zone is on natural hard substrate;
- the mudflat zone is followed by a wide strip of salt marsh with an adjacent potential pioneer zone north of the KCD.

Due to the specific flora (salt-loving species) and the presence of invertebrates, this area is important for wintering waterfowl, migratory birds and breeding birds.

2.5.2.2.5 Doelpolder Noord (met Brakke Kreek) and Doelpolder Midden

The Doelpolder-Noord and Brakke kreek are part of the **Special Protection Area - Birds** 'Schorren en polders van de Beneden-Schelde'.

Doelpolder-Noord is located just behind the Scheldt dike at the level of Paardenschor less than 1 km northwest of the KCD. The Doelpolder-Noord area was redeveloped as a meadow bird area (compensation area). Brakke Kreek was created along with the pasture bird area Doelpolder-Noord and is located south of it. However, the inlet structure is still being designed, so there is no tide on the creek yet. A lock in the Scheldt dike will allow a limited amount of brackish water into Doelpolder-Noord, creating a slightly saline tidal creek (36 ha). The Doelpolder Midden has yet to be developed (still in agricultural use). The objective for the Doelpolder Noord (with Brakke Kreek) and Doelpolder Midden is the development of a tidal area (GGG Doelpolder with a controlled reduced tidal effect), in which mud and salt marsh, creeks, gulleys and islets and a meadow bird area are present. Around the GGG Doelpolder there will be dikes that stop the water. The dike between Doelpolder Noord and Doelpolder Midden will be excavated. Brakke Kreek will be retained as the main creek. An outflow channel will be constructed at the level of the Paardenschor. The layout will be done in phases.

However, due to the overturning of the RSIP Delimitation of the Antwerp Seaport Area - Port Development Left Bank, this development of the tidal area and the nature development in Doelpolder Midden cannot go ahead as planned for the time being.

Currently, the Brakke Kreek area still forms one entity with Doelpolder-Noord. The same habitats now occur in both volumes. These two nature reserves are intended to compensate for the disappearance of natural values during the construction of the Deurganck dock and are therefore protected as bird sanctuaries.

On the Biological Valuation Map (Annex A - Map 13) , the Doelpolder-Noord area is designated as biologically highly valuable, consisting of ditch-rich grasslands (hpr+), eutrophic water bodies (ae), and strips of reed beds (k(mr)). Near the Doelpolder Midden, fields (bu) and grasslands (hx, hp) still occur according to the Biological Valuation Map; these vegetations are less biologically valuable. Lines of trees, ditches, and sedges present between plots are biologically valuable to highly valuable.

The fields and grazing pastures of Doelpolder Midden are a foraging area for geese, such as greater white-fronted goose, greylag goose and tundra bean goose. The Doelpolder-Noord and the Brakke Kreek are important areas for breeding birds, meadow birds and wintering waterfowl.

2.5.2.2.6 Hedwigepolder and Prosperpolder

The Prosperpolder is part of the **Special Protection Area - Birds** 'Schorren en polders van de Beneden-Schelde' and the **VEN area** 'Slikken en schorren langsheen de Schelde'.

The Prosperpolder (Belgian territory) and the Hedwigepolder (Dutch territory) are part of the cross-border intertidal area under development. These polders lie to the south of the Verdronken Land van Saeftinghe and will eventually form a nature reserve of international significance. The Prosperpolder is located northwest of KCD at a minimum distance of 0.9 km. The Hedwigepolder is connected to this polder and is located across the border in the Netherlands, at least 2.1 km away. The total area of these areas to be developed is approximately 655 ha, of which 465 ha will be established as mudflats and salt marshes. 170 ha of this is on Belgian territory in the Prosperpolder.

The Scheldt estuary is unique in Europe. The transition from river (fresh) to sea water (salt) and the tide is still reasonably intact here. The ecosystem is under pressure from man (deepening of the Scheldt), so more space for nature is needed as part of the nature restoration obligation. This will allow European conservation obligations to be met. The Hedwige and Prosperpolder is the most suitable area to achieve this restoration. An important aspect here is that the Hedwigepolder connects with the Prosperpolder and thus also forms the connecting link between this area and the Verdronken Land van Saeftinghe. The areas also connect to the mudflats and salt marshes on the left bank of the Scheldt (Schor Ouden Doel and Paardenschor) and to the GGG Doelpolder. In this way, a large nature reserve of international importance can eventually be created, which even offers special potential for species requiring a lot of space.

In the Hedwige and Prosperpolder estuarine nature will be created by moving the dikes. In a first step, a new dike is constructed inland from the Scheldt to the Verdronken Land van Saeftinghe. In a second step, the tide of the Scheldt is let into the area. The creation of the breaches in the current Scheldt dikes can only be carried out if the entire ring dike (both on Flemish and Dutch territory) is constructed. Once the work on the Dutch side of the dike is completed, estuarine nature should naturally develop here.

The future habitats are mudflats and salt marshes, whose vegetation will be similar to that in the connecting areas of the Verdronken land van Saeftinghe, the Schor Ouden Doel and Paardenschor.

Currently, the area is still under development and has been disturbed by the sand raising and landscaping works taking place there. The area is shown on the Biological Valuation Map (Annex A - Map 13) as a less valuable to valuable elevated area with ruderal vegetation (kz and ku). The constructed dike between the Prosperpolder and Doelpolder-Noord is overgrown with a ruderal vegetation. At the edge, rows of poplar and willow trees still occur. The dike and surrounding area is designated as biologically valuable.

The Prosperpolder was and still is an important area for wintering geese and it also serves as a breeding ground. A large number of other bird species occur on site, hunting or foraging, in the Prosperpolder.

2.5.2.2.7 Other polder areas

The Doelpolder and Nieuwe Arenbergpolder belong to the **Special Protection Area - Birds 'Schorren en polders van de Beneden-Schelde'.**

In addition to the redeveloped Prosperpolder and Doelpolder-Noord, there are the **Nieuwe Arenbergpolder** and the **Doelpolder** in the immediate vicinity of KCD as remaining polder areas on the Left Bank. The Doelpolder lies to the west contiguous to the KCD and the village of Doel and is bordered to the north by Doelpolder-Noord (GGG Doelpolder). The part south of Doelpolder Noord is also called Doelpolder Midden. The Nieuwe Arenbergpolder is located west of the Doelpolder and borders the Prosperpolder and the Dutch border.

The Doelpolder consists mostly of arable land and to a lesser extent of grasslands and ditch-rich grassland. The latter are biologically valuable, the fields and meadows are less so.

Both polder areas serve as both a resting ground and a nesting area. Given the predominant agricultural use, reed-breeding species occur only in small numbers.

2.5.2.2.8 Network ecological infrastructure port of Antwerp and species protection program

2.5.2.2.9 Network ecological infrastructure

The Flanders SIP envisaged that a maximum of 5% of all seaport area would be safeguarded from industrial development to serve as ecological infrastructure. To achieve this and thus guarantee the survival of certain plants and animals in the Antwerp seaport area, a network of ecological infrastructure nature (EIN) was delineated within the RSIP Delimitation of the Antwerp Seaport Area. Permanent habitats are established on public lands (permanent EIN). Additionally, temporary areas and initiatives on sites can also be incorporated into the network (temporary EIN)[29] (Figure **2-45**).

The EIN consists of a network of corridors and stepping stones that connects the key areas. Key areas are larger areas of contiguous nature and often have a higher nature value. Corridors form elongated connecting zones between areas, while stepping stones are small remnant areas where species have more room to stay. In stepping stones, there is normally more suitable habitat present for reproduction (such as for natterjack toad) than in a corridor. In reality, the two blend together.

To achieve a functional network, numerous roadsides were also included in the network of ecological infrastructure. Most of the roadsides consist of dry grasslands. In places where pipelines are present, the soil is regularly turned over, so those roadsides offer many potentials for pioneer vegetation and its associated species.

In the immediate vicinity and north of KCD, the permanent natural core area of polders and salt marshes is found. The Galgenschoor on the other side of the Scheldt is also a permanent nature reserve and was already discussed above. The dikes (BWK code kd) and grassland borders (BWK code hp) west of the KCD are part of a permanent ecological infrastructure that connects the northern part with the southern part of the port area on the left bank.

[29] The permanent EIN and natural key areas will always be preserved. The temporary EIN and the temporary compensation areas were included during the current Species Protection Program Antwerp Port to support the natural key areas and the permanent EIN to achieve the Conservation Objectives (IHDs). Those IHDs were prepared for the European protected habitats and species in all Flemish Special Areas of Conservation (SPAs) of the European Special Protection Areas for birds and Habitats, as part of the European Natura 2000 network. These are mainly species of the Birds Directive, such as Marsh harrier, Common tern and Mediterranean gull. If in 2019, after the end of the first Species Protection Program Antwerp Port, the IHDs in the natural key areas are achieved, the temporary EIN areas and the temporary compensation areas will be released for port development (website Natuurpunt WAL, Baetens et al., 2015).

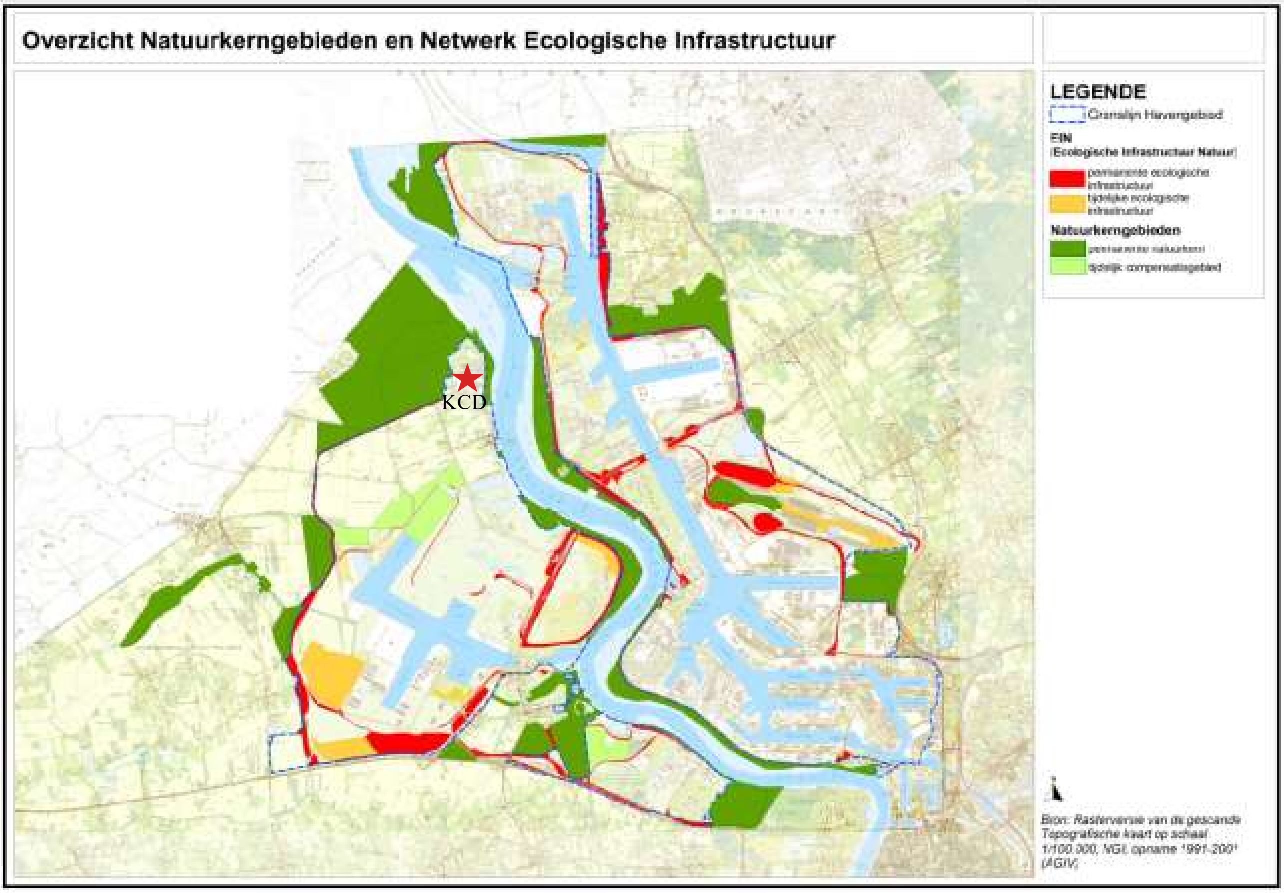

Figure 2-45 Network of ecological infrastructure in the Antwerp Port Area (Baetens *et al.*, 2015)

2.5.2.2.10 Types

The species protection program (SPP) of the Port of Antwerp (MB May 23, 2014 and MB September 5, 2019 for renewal) is an area-based program that includes a series of actions for the development and conservation of umbrella species and their associated species. The Antwerp Port Authority has committed itself in an agreement with the Flemish government to ensuring the actions are taken.

The Port of Antwerp is home to 51 port-specific protected species and 39 non-port-specific protected species. Fourteen species were selected from the broader group of 90 protected species because conservation measures for these species immediately cover the conservation of the remaining 76 protected species. These species are called umbrella species. These umbrella species represent a specific (developmental stage of a) habitat, each time assuming that the measures taken for the umbrella species also benefit the associated species (= the other 76 species). For each umbrella species, the so-called Functional Ecological Unit was also delineated. This is the minimum area required to maintain a viable population of this species.

The measures in the SPP aim to ensure the sustainable conservation of umbrella and associated species within the port area.

The area needed to achieve the quantitative and qualitative nature goals of the 14 umbrella species can be met within the network of ecological infrastructure and key areas. These objectives are - as far as

European protected species are concerned - aligned with the conservation objectives drawn up for the relevant Special Areas of Conservation.

The validity of the Ministerial Decree establishing the species protection program for the Antwerp port area of 23 May 2014 was extended until 20 February 2020, but the legality of this extension is currently being questioned in the context of a revocation procedure pending before the Council of State.

A second SPP is currently being drafted, further anchoring the visions and actions of the first SPP. Here, the umbrella species and associated species are largely the same as in the first SPP, with some modifications (e.g. Brown argus is replaced by Argus butterfly) (communication Port of Antwerp).

2.5.3 Impact assessment

2.5.3.1 Operational phase of the project between 2015-2018

2.5.3.1.1 LTO works

For a description of the works carried out in the context of the adjustments for LTO, see the general section of the EIR (see Chapter 1.6).

2.5.3.1.1.1 Eutrophication and acidification due to atmospheric deposition

Emissions from exhaust gases from construction site machinery and trucks (combustion of fossil fuels and including CO, CO_2, unburnt hydrocarbons, NOx, SO_2 and particulate matter ($PM_{2.5}$ and PM_{10}) occurred during the work on LTO modifications.

The share of emissions from construction site machinery and site traffic varied from day to day, and was considered rather small compared to current emission sources at the site and in the surrounding area such as (shipping) traffic. The acidifying and eutrophic due to the construction site machinery and site traffic is not assessed as significantly negative for the habitats around KCD, taking into account its temporary nature.

2.5.3.1.1.2 Rest disturbance

It follows from the Noise Section that the work carried out as part of the adjustments for LTO in itself caused a negligible increase in ambient noise. The rest disturbance to fauna is therefore considered to be negligible.

2.5.3.1.2 Eutrophication and acidification due to atmospheric deposition

Acidification occurs as a result of air pollution by the substances sulfur dioxide, ammonia and nitrogen oxides. These gases react with oxygen and water vapor to form sulfuric and nitric acids, among others. When these compounds have an acidifying effect after being deposited on the soil or plants, it is called acidifying deposition.

Fertilization occurs due to pollution of the air with ammonia and nitrogen oxides, which makes more nutrients available to the plants. They have a fertilizing effect on growth sites, causing qualifying habitat types or habitats of qualifying species to deteriorate in quality and possibly even disappear. For example, grassification and felting of species-rich grasslands or heathland vegetation is a typical consequence of atmospheric nitrogen deposition, which can result in the displacement of special species and in a decline in biodiversity.

Acidification and eutrophication both play important roles in the disruption of ecosystems. For example, forests are losing vitality, heathland is being degraded, plant and animal species diversity is decreasing, lakes are acidifying, fish stocks are being degraded, and groundwater is being polluted (FEA , 2014).

The emissions of NOx and SO_2 as a result of the project lead to a contribution in eutrophying and acidifying deposition in the environment, e.g. near the Special Protection Area - Habitats 'Schelde- en Durmeëstuarium van de Nederlandse grens tot Gent' and the (partly overlapping) VEN area 'Slikken en schorren langs de Schelde'. This deposition is calculated in the Air section and the results are shown and evaluated below.

2.5.3.1.2.1 Test of nitrogen deposition compared to critical deposition values

Figure 2.5.1.3 shows the nitrogen deposition assessment framework used.

In

Table 2-52 shows all European habitat types that occur within a radius of about 2.5 km around the site of KCD. The Biological Valuation Map and Natura 2000 Habitat Map (Condition 2018) were used to verify the location of European habitat types in the vicinity of KCD's site.

For each habitat type, the critical deposition value (CDV) for nitrogen (expressed in kg N per ha and per year) is given. Since the assessment framework used assumes 5% of this CDV to assess whether or not the contribution of a project in terms of total N deposition can be considered negligible, the last column of

Table 2-52 shows how much 5% of the CDV is.

Table 2-52 Overview of critical nitrogen deposition rates for European habitat types within a 2.5 km radius of the KCD site

Habitat type		**CDV for N * (kg N/(ha.year))**	**5% of the CDV for N * (kg N/(ha.year))**
1130	Estuaries	>34	>1.7
1310_zk	Salicornia and other annuals colonizing mud and sand	23	1.15
1320	Spartina swards (Spartinion maritimae)	23	1.15
1330_da	Atlantic salt meadows	22	1.1
3270	Rivers with muddy banks with Chenopodion rubri pp and Bidention pp vegetation	>34	>1.7
6430_mr	Reed lands with althaea officinalis, lathyrus palustris and/or sonchus palustris	>34	>1.7
6510,gh and 6510_hu	Lowland hay meadows: arrhenaterion	20	1

*For each habitat type, the critical deposition value (CDV) for nitrogen is shown (expressed in kg N/(ha.year)) and how much 5% of this CDV is. Habitats with a CDV > 34 kg N/ha.y are not sensitive to nitrogen deposition.

From

Table 2-52 shows that habitat type 6510 'Lowland hay meadows: arrhenaterion' has the lowest critical deposition value. Of the salt marsh vegetation, habitat type 1330_da 'Atlantic salt meadows' has the lowest critical deposition value.

Figure 2-46 shows the contours of nitrogen deposition caused by the KCD in the operational phase in the future situation within the study area. The maximum nitrogen deposition is 0.071 kg N/(ha.year) for the operation of KCD. These values occur at the mudflats and salt marshes along the KCD (habitat type 1330) and primarily on the estuary channel (habitat type 1130).

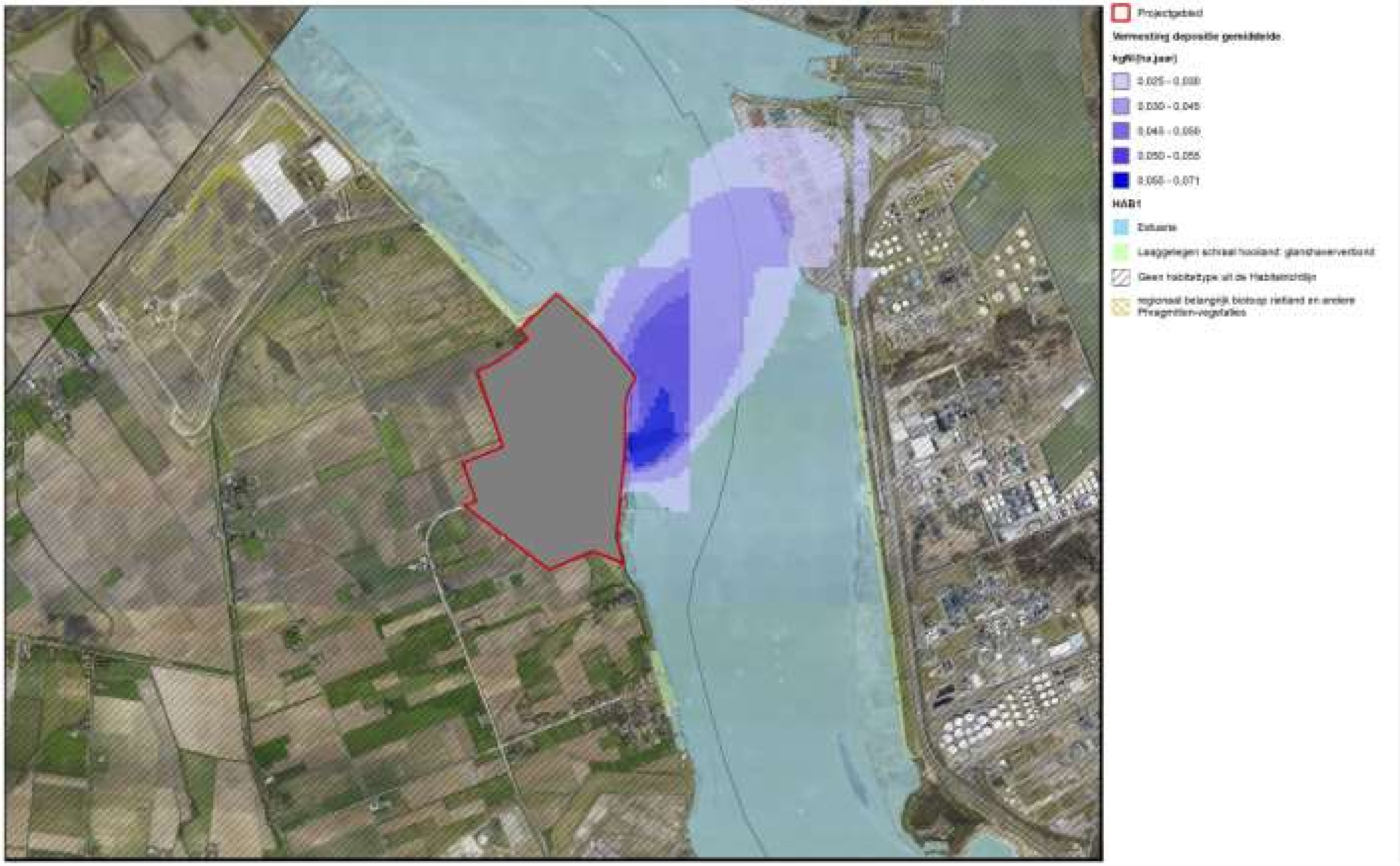

Figure 2-46 Contour nitrogen deposition (in kg N/(ha.year)) caused by KCD's operations in the operational phase in the future situation

The figure above shows the following:

- The figure shows that there is no deposition of more than 1 kg N/(ha.year) (5% of the lowest CDV of the occurring European habitat types) at the level of the European habitat types in the Special Protection Areas - Habitats 'Schelde- en Durmeëstuarium van de Nederlandse grens tot Gent' due to nitrogen emissions to the air by KCD. Consequently, the impact on the Special Protection Area - Habitats 'Schelde- en Durmeëstuarium van de Nederlandse grens tot Gent' due to atmospheric nitrogen deposition from the KCD is not assessed as significant, compared to the situation without operation of KCD.
- No deposition of more than 1.1 kg N/(ha.year), 5% of the lowest CDV for salt marsh vegetation, occurs in the VEN area 'Slikken en schorren langsheen de Schelde' due to nitrogen emissions to the air by KCD. Consequently, the impact on the VEN area 'Slikken en schorren langsheen de Schelde' as a result of atmospheric nitrogen deposition from the KCD is assessed as not significant, compared to the situation without operation of KCD.

2.5.3.1.2.2 Conclusion nitrogen deposition

It can be concluded that the nitrogen deposits of KCD in the present project do not have a significant negative effect compared to the situation without operation of KCD on eutrophication of the surrounding European habitat types in the Special Protection Area - Habitats 'Schelde- en Durmeëstuarium van de Nederlandse grens tot Gent' and of the mudflats and salt marshes in the (partly overlapping) VEN area 'Slikken en schorren langsheen de Schelde'. Nitrogen deposits in the operational phase of KCD in the future situation is max. 0.071 kg N/(ha.year), which is lower than 5% of the critical N deposition values for the European habitat types located in the vicinity of the site.

2.5.3.1.2.3 Testing of acidifying deposition in relation to critical deposition values

Figure 2.5.1.3 shows the nitrogen deposition assessment framework used.

In

Table 2-52 shows all European habitat types that occur within a radius of about 2.5 km around the site of KCD. The Biological Valuation Map and Natura 2000 Habitat Map (Condition 2018) were used to verify the location of European habitat types in the vicinity of KCD's site.

For each habitat type, the critical deposition value (CDV) for acidification (expressed in acid equivalents (Zeq) per ha and per year) is given. Since the assessment framework used assumes 5% of this CDV to assess whether or not the contribution of a project in terms of total acidifying effect can be considered negligible, the last column of Table 2-53 shows how much 5% of the CDV is.

Table 2-53 Overview of critical acidification load for European habitat types within a 2.5 km radius of the KCD site

Habitat type		**CDV (Zeq/(ha.year)) according to van Dobben *et al*, 2012**	**5% of the CDV for acidification (Zeq/(ha.year))**
1130	Estuaries	>2400	>120
1310_zk	Salicornia and other annuals colonizing mud and sand	1643	82
1320	Spartina swards (Spartinion maritimae)	1643	82
1330_da	Atlantic salt meadows	1571	79
3270	Rivers with muddy banks with Chenopodion rubri pp and Bidention pp vegetation	>2400	>120
6430_mr	Reed lands with althaea officinalis, lathyrus palustris and/or sonchus palustris	>2400	>120
6510,gh and 6510_hu	Lowland hay meadows: arrhenaterion	1429	71

Figure 2-47 shows the outlines of the contours of acidifying deposition caused by KCD's activities in the project area in the operational phase in the future situation.

Table 2-53 shows that of the habitats found in the vicinity of the KCD, habitat type 6510 "Lowland hay meadows: arrhenaterion" is the most sensitive to acidifying deposition. Consequently, this value is used as a test (71 Zeq/(ha.year)) to describe the acidification from KCD's activities.

The maximum total acidifying deposition from the emission points of KCD (from NOx; plume maximum) is located in the navigation channel of the Scheldt and amounts to 5.06 Zeq/(ha.year) in the operational phase in the future situation.

Figure 2-47 Contour of the acidifying deposition (in Zeq/(ha.year)) caused by KCD activities in the operational phase, in the future situation

Figure 2-47 andTable 2-53 show that the maximum acidifying deposition of KCD is significantly below 5% of the critical deposition rates of all relevant ecosystems in the vicinity of KCD.

2.5.3.1.2.4 Conclusion acidifying deposition

It can be concluded that the acidifying deposits of KCD assessed in the present project do not have a significant negative impact on the ecosystems in the study area, compared to the situation without operation of KCD, since the acidifying deposition of KCD is maximum 5.06 Zeq/ha.year, which is lower than 5% of the critical deposit rates for acidifying deposits of the ecosystems in the vicinity of the site. Therefore, no significant negative effects are expected from acidification as a result of the operational activities of KCD compared to the situation without operation of KCD, on the surrounding European habitat types in the Special Protection Area - Habitats 'Schelde- en Durmeëstuarium van de Nederlandse grens tot Gent' and of the mud and salt marsh vegetation in the (partly overlapping) VEN area 'Slikken en schorren langsheen de Schelde'.

2.5.3.1.3 Rest disturbance

2.5.3.1.3.1 Disturbance of avifauna

The potential impact of chronic noise from business activities and peak noise from events on birds was examined in the study by Sierdsema *et al.* (2014) and is a relevant study for this EIR.

Studies of chronic noise pollution caused by industrial noise and urban noise indicate that the effects are similar to those of traffic on birds. There is considerable evidence that especially low-pitched bird sounds are masked by chronic noise pollution (both urban noise, and industrial noise contain many low-pitched sounds (<2 kHz) with which communication is disrupted), which may have implications for breeding success and fitness. Based on this, it is likely that species that communicate with low tones are especially sensitive to this type of noise exposure. Effects were observed from 50-60 dB(A). Impact distances are not determined.

In addition to chronically present noise, some sources produce short-lived noise or spiked noise, such as the sound of pile driving. Again, gradations can be distinguished from a one-time bang, a passing airplane to a pop concert lasting a (part of a) day.

Some species show disruption responses, such as (temporary) flight in the face of sudden strong noise, but others do not. There is also evidence that when sound recurs regularly, adaptation occurs. One example is the mudflats and salt marshes in the Scheldt estuary, which are of great value to all kinds of water birds, despite the large traffic of ships and noise from all kinds of port activities.

For chronic noise, effects on densities of birds can be assumed to start from 50dB(A). This is a 24-hour average. Noise sources that have peaks higher than 50dB, but no 24-hour average higher than 50dB fall under peak noise. The sensitive species are expected to be primarily those that communicate in low tones.

There is no evidence that low frequency peak noise affects bird densities. An assumption regarding peak noise is that incidental noise does not substantially affect densities of breeding birds. If it occurs more frequently, the impact of the noise should be assessed as chronic noise.

The figure below shows the disturbance sensitivity of the different species groups of birds, both as breeding and non-breeding birds (Krijgsveld *et al.*, 2008). The following sensitivity classes are used for this purpose:

- 1-6: not very sensitive
- 7-12: sensitive
- 12-17: highly sensitive to disturbance.

The species groups relevant to the vicinity of KCD are mainly gulls, cormorants, oystercatcher & avocets, waders, ducks, geese, grebes and small songbirds (bluebirds, sedge warbler, ...).

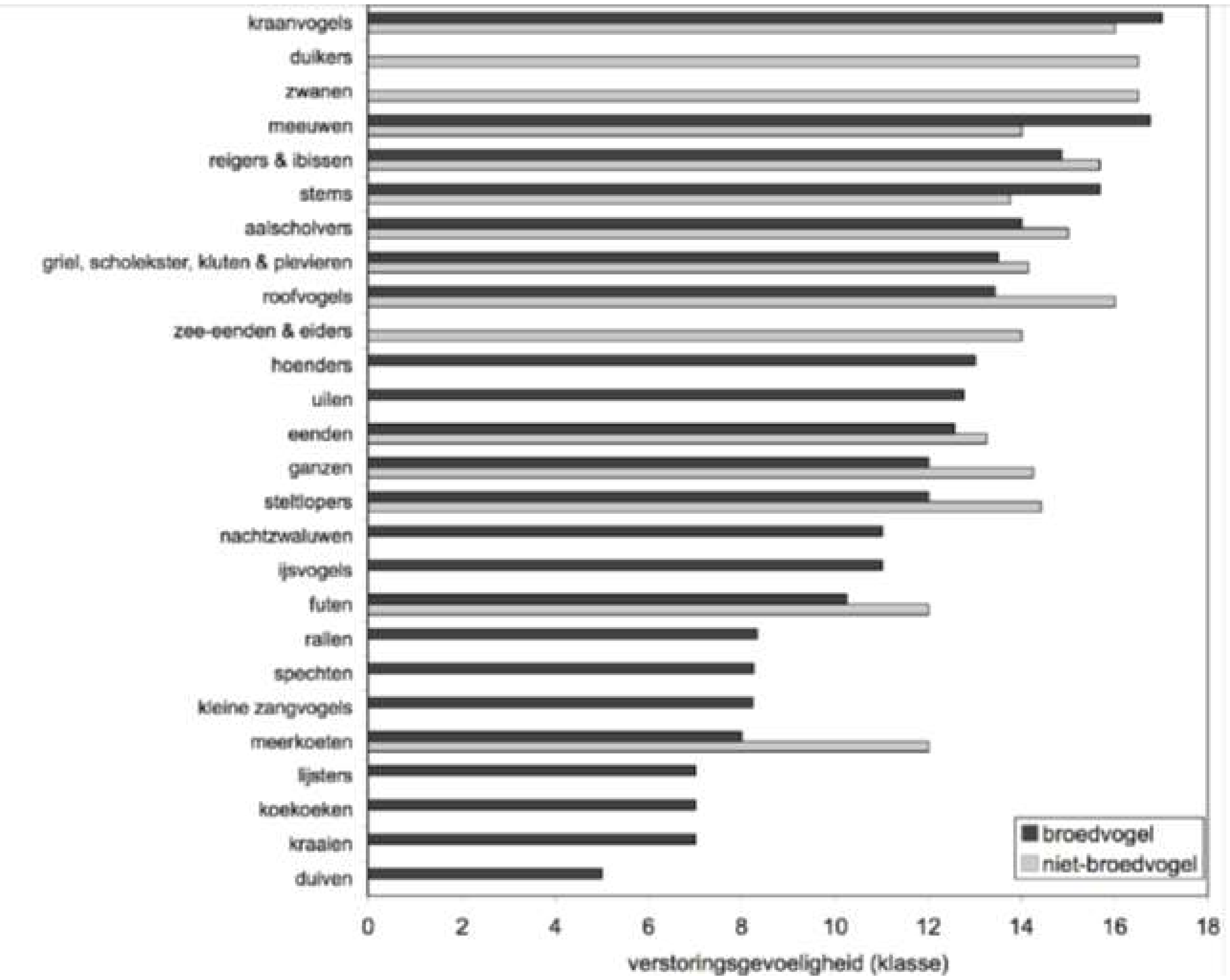

Figure 2-48: Disturbance susceptibility of the different groups of species, (averages of relevant Dutch species, Krijgsveld et al. 2008)

Besides disturbance sensitivity of groups species, there is also a relative sensitivity to noise disturbance of birds relevant for Flanders, according to a methodology proposed by Cuperus (in Tamis, W.L.M. & Runhaar, J. 1994). He proposes a sensitivity assessment for each bird species using five criteria, each of which is assigned a sensitivity score between 1 (highly sensitive) and 3 (moderately sensitive). These criteria are:

- reproductive capacity/lay size: species with high reproductive capacity (> 10) are less sensitive than species with low reproductive capacity (< 6);

- territory size: species with large area requirements (> 40 ha) are more sensitive than those with small area requirements (< 4 ha);
- migration strategy: migratory birds are more sensitive than resident birds;
- singing/calling: loud singers are less sensitive than quiet singers;
- ecological amplitude or attachment to landscape open areas, such as grasslands: species living in open areas are more sensitive.

These are 5 of the 7 so-called Life History characteristics. Cuperus (in Tamis, W.L.M. & Runhaar, J. 1994) further distinguishes the criteria "colony formation" and "risk of road casualties" which are not relevant in this case.

The product of the score across the five criteria then provides an overall sensitivity score for each bird species which is finally converted to a 5-part ordinal sensitivity scale:

- 1 insensitive
- 2
- 3 sensitive
- 4
- 5 very sensitive.

The following shows the disturbance sensitivity for the relevant bird species in the vicinity of KCD (published in Aeolus & Lisec, 2001).

Table 2-54: Disturbance susceptibility of birds (Aeolus & Lisec, 2001)

Bird species	Disturbance susceptibility	Breeding Birds	Notified species in the Special Protection Area - Birds 'Beneden-Schelde: schorren en polders op rechter- en linkerscheldeoever'
Cormorant	1		
Bearded reedling	2	X	
Shelduck	1		X
Bluebird	3	X	X
Dunlin	-		
Marsh Harrier	5	X	X
Canada goose	4		
Little grebe	3	X	
Great crested grebe	4		
Greylag Goose	4		X

Bird species	Disturbance susceptibility	Breeding Birds	Notified species in the Special Protection Area - Birds 'Beneden-Schelde: schorren en polders op rechter- en linkerscheldeoever'
Northern lapwing	3		
Avocet	5	X	X
Gadwall	3		X
Tufted Duck	2		
Northern pintail	-		X
Spotted Crake	4	X	X
Sedge warbler	5	X	
Oystercatcher	4	X	
Shoveler	2	X	X
Wigeon	2		X
Common pochard	1		
Redshank	4	X	
Wild duck	1		
Teal	1		X
Curlew	5		
Mediterranean gull	-		X

Based on the study by Krijgsveld *et al.* (2008) and Cuperus (in Aeolus & Lisec, 2001), the disturbance sensitivity of the relevant species groups and species for the vicinity of KCD is as follows:

- **Gulls**: highly sensitive to disturbance.
- **Cormorants**: highly sensitive to disturbance, but it should be added that based on Cuperus' research (in Aeolus & Lisec, 2001) cormorants are insensitive to disturbance.
- **Oystercatcher & avocets:** highly sensitive to disturbance.
- **Ducks and geese**: highly sensitive to disturbance, but it should be noted that, based on Cuperus' research (in Aeolus & Lisec, 2001) the most common duck species, such as teal, wild duck, common pochard, shelduck and tufted duck are insensitive to low sensitive. Gadwall, Canada Goose and Greylag Goose are sensitive to disturbance though.
- **Charadrii**: highly sensitive to disturbance.
- **Grebes**: highly sensitive to disturbance.

- **Small songbirds**: sensitive to highly sensitive to disturbance, such as Eurasian reed warbler which has a sensitivity score of 5. The common linnet and Reed Bunting are less sensitive to disturbance. Bluebird has a score of 3.

2.5.3.1.3.2 Thresholds

Two threshold values emerge from the research of Reijnen and Foppen (2006): 42 dB(A) for forest birds and 47 dB(A) for grassland species and meadow birds. However, these are averages across a large group of species. Substantial variation exists for individual species.

A comprehensive study of the relationship between birds and traffic noise has been conducted in Germany (Garniel *et al.,* 2007). The threshold values found for about 20 species range from 47-58 dB(A), but 85% are between 52 and 55 dB(A).

There is little experience with reasoned extension of traffic studies to effects of noise disturbance from industrial activities. No dose-effect studies have been done for industrial noise but in practice a value of 45 dB(A) at 24-hour level is often used. However, given the threshold values observed in the traffic study, it can be argued, based on the available literature, that it is better to stretch this to 50 dB(A) which is also a value clearly above background levels (Sierdsema *et al.*, 2014). For example, in a rural environment this is 40 dB(A), in urban environments 50 dB(A).

2.5.3.1.3.3 Noise Modeling

Figure 2-49, Figure 2-50 and Figure 2-51 show the 45-, 50-, and 55 dB(A) noise contours for the continuously operating sources during the day, evening, and night periods in the 2013-2014 baseline situation. These are the same as in the operational phase 2015-2018 because the source field does not change for this purpose.

For the discontinuous sources (not relevant in the evening and night period as these sources are only tested during the daytime period) it appears that the nuisance contour of 50 dB(A) is located entirely on the site of KCD. Thus, the rest disturbance due to the discontinuous sources of KCD is not discussed further.

Figure 2-49 Sound contours 2013-2014 (ibid for the operational phase 2015-2018) relative to the Natura 2000 areas

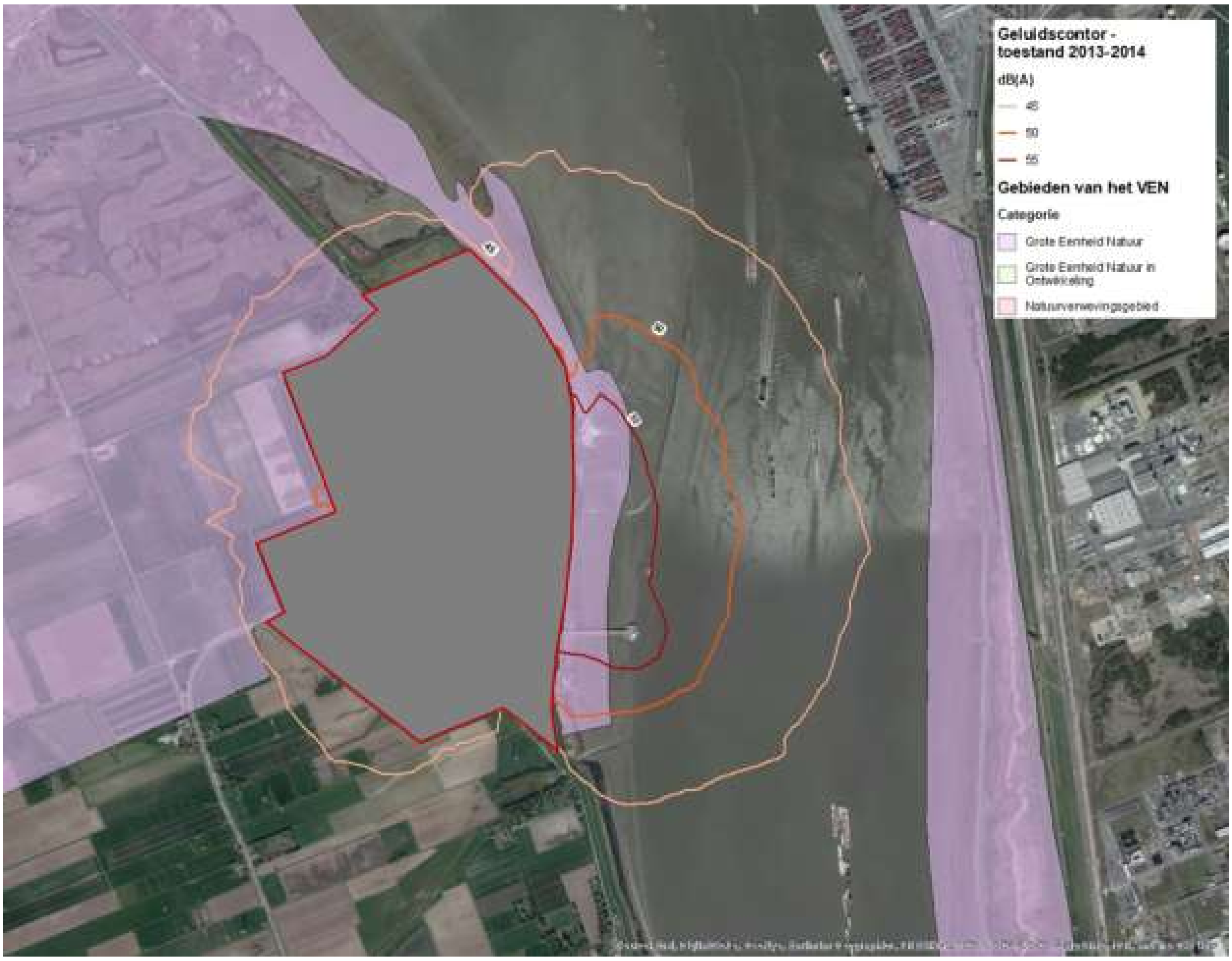

Figure 2-50 Sound contours 2013-2014 (ibid for the operational phase 2015-2018) relative to the VEN areas

Figure 2-51 Sound contours 2013-2014 (ibid for the operational phase 2015-2018) relative to the recognized and Flemish nature reserves

2.5.3.1.3.4 Impact on rest disturbance

The rest disturbance due to the operation of KCD in the 2013-2014 baseline situation, also equal to the rest disturbance in the 2015-2018 operational phase, compared to the situation without the operation of KCD can be assessed as follows:

- To the east of the KCD, the 55 dB nuisance contour extends into the Special Protection Area - Birds
  'Schorren en polders van de Beneden-Schelde', also designated as the VEN area 'Slikken en schorren langs de Schelde' and as a Ramsar area. It can be concluded that these reed beds and mudflats along the banks of the Scheldt, are highly disturbed by the noise coming from KCD. The groups of species found there (small songbirds, waders, grebes, oystercatcher & avocets, etc.) are sensitive to highly sensitive to rest disturbance. On the other hand, this is a continuous noise disturbance and it is reasonable to assume that the avifauna present will show some habituation. Rest disturbance due to the operation of KCD along the reed beds and mudflats on the banks of the Scheldt, near the KCD, is assessed as negative. The 50 dB and 45 dB nuisance contours do not extend to the Galgenschoor across the Scheldt.

- North of the KCD the 50 dB and 45 dB nuisance contours do not reach the protected nature reserve 'Schor Ouden Doel' (negligible effect).
- To the west and south of KCD, the nuisance contour of 50 dB is largely limited to the KCD site itself and there is only a slight overlap with the Special Protection Area - Birds 'Schorren en polders van de Beneden-Schelde'. The 50 dB nuisance contour does not overlap with the VEN area 'Slikken en schorren langs de Schelde' here. The 45 dB nuisance contour has limited overlap with the Special Protection Area - Birds "Schorren en polders van de Beneden-Schelde" and with the VEN area "Slikken en schorren langs de Schelde". The rest disturbance caused by the operation of KCD in the polder areas to the west and south of KCD is assessed as a slightly negative effect.

2.5.3.1.4 Water intake

KCD extracts cooling water from the Scheldt via a water intake that is divided into two separate components: one for cooling the Doel 1 and Doel 2 units and another, commissioned in 1991, for Doel 3 and Doel 4. The water is always first passed over a sieve to filter out any objects to prevent obstruction of the pipes. However, for the two intakes, this is done in a different way.

For the Doel 1 and 2 cooling water intake, mechanical treatment takes place outside the dike, at the level of the water intake, by means of grids on the inlet. Fish and crustaceans cannot enter the cooling water circuit in this way. Therefore, no mortality of fish or crustaceans will be observed at this intake.

For Doel 3 and 4, the set-up is different. A cooling water intake system was fitted, in which the water was first gravitated from the Scheldt to a collection pit on the site itself. From that intake, the water is then transported over a system of rotating belt filters. The separated fraction (plastic, plant material, fish...) was collected in a container. This led to the landing and dumping of large quantities of fish and crustaceans (crabs and shrimp) in the dumpster. As a result, the operation of the plant had some impact on the biota in the Scheldt in the vicinity of the water intake, which was budgeted for in a study by Maes *et al.* (1996).

In 1997, a fish protection system was installed at the water intake with a fish-friendly filter system and a drain channel. Sound waves keep fish away from the intake. Because of this noise, the fish are deterred and fewer of them end up in the water intake. Especially fish species with swim bladders are chased away. This organ is similar to a lung and regulates its position in the water and also captures sound underwater. Those organisms that do get caught are diverted back to their biotope via a return system.

Fish mortality is therefore reduced by 88% for fish and 100% for crustaceans. This corresponds to 95.5% of the numbers and 90% of the biomass of fish and crustaceans (Maes *et al.*, 1999). The numbers of fish in the system are highly dependent on the seasons and tides. Therefore, no absolute figures are given. Based on the monitoring carried out by KU Leuven (Maes *et al.*, 1996), where it was found that the daily catch for fish and crustaceans without measures was about 22,437 and 50,248 individuals respectively, it can be stated that an average of 1,010 fish die daily and almost no crustaceans as a result of the presence of the water intake of Doel 3 and 4 with the fish protection system. Compared to the fact that the KU Leuven study (Maes *et al.*, 1996) shows that there are approximately 18 million fish and 7 million crustaceans that pass by the plant per hour the impact has been reduced to a negligible level thanks to the various measures taken.

On this basis, it can be said that no significant negative effects are to be expected with regard to mortality of fish and crustaceans at the level of water intake, compared to the situation without operation of KCD. The capacity of the water intake points in the Scheldt will not be changed by the project.

2.5.3.1.5 Discharge of cooling water

Discharge of cooling water: the discussion of the discharge of cooling water at KCD is dealt with in three parts:

- A summary of the measured temperature increase and the size of the heat plume due to the cooling water discharge from the KCD is provided, based on the results of the 5 monitoring campaigns at KCD (Arcadis, 2012). For a detailed description please refer to the Water section;
- Next, the potential direct and indirect effects that may occur as a result of a temperature increase due to cooling water discharge are discussed. In terms of direct effects, there are general effects on aquatic organisms and communities, specific effects on fish, and specific effects on plankton and macroinvertebrates. The potential effects of thermal plumes on exotic species are also discussed.
- Finally, an assessment of the potential effects of cooling water discharge for KCD is carried out. Here, the results of the sampling of the fish stock in the cooling water plume of the KCD (Breine & Van Thuyne, 2013A) and the results of the 5 monitoring campaigns of temperature at the level of the KCD (Arcadis, 2012) are used.

2.5.3.1.5.1 Temperature increase and size of heat plume

Major temperature increases above 3°C due to KCD's cooling water discharge appear to occur only within the area of the breakwater, up to a maximum distance of approx. 1050 m from the discharge point.

Temperature increases between 1 and 3°C appear to occur during outgoing water and during the turn of the low water tide up to a maximum distance of approx. 1,300 m from the discharge point, the area that is still within the breakwater. In the case of rising water, a relevant temperature rise occurs between 1 and 3 °C outside the breakwater up to a maximum of 500 m from the discharge point in an easterly direction and up to a maximum of 800 m upstream of the discharge point in a southerly direction.

The size of the heat plume is greatest at the turn of the low water tide. It can be assumed that the zone bounded by a temperature higher than 25°C will not extend beyond the breakwater.

For the specific situation of KCD, it can be stated that the area within the breakwater will form a heat barrier for certain aquatic organisms. For the area within the breakwater, the environmental quality standards with regard to temperature for the Scheldt due to the cooling water discharge of KCD are not met. However, the gully of the Scheldt east of the breakwater remains passable for aquatic organisms. The average cross-sectional surface area of the area within the breakwater does not exceed 25% of the cross-sectional area of the Scheldt. The gully of the Scheldt east of the breakwater is considered to be passable for aquatic organisms at all times.

2.5.3.1.5.2 Potential effects of temperature increase

Direct and indirect effects of temperature increase

An increase in water temperature leads directly to changes in the life communities found. These changes are primarily determined by a direct response of the individual species to the increased ambient temperature. The capacity of an organism to survive in its biotope is largely determined by its degrees of tolerance to abiotic factors. Figure2-52 provides a schematic representation of the response of an organism to a temperature increase (Hartholt & Jager, 2004). The curve describes the relationship between the degree of change in the physiological activity of a species with a 10°C increase in temperature.

Regarding ambient temperature, each species has a natural range for each stage in which optimal functioning (homeostasis intact) is possible. This optimal temperature range is linked to the geographical location of the habitat. If the current ambient temperature exceeds the bandwidth, then stress occurs, eventually followed by mortality if the temperature rises too high or the stress lasts too long. Many species avoid critical temperatures by vertical or horizontal migration to more favorable conditions. The temperature tolerance of aquatic organisms is affected by several factors that cause stress. Of influence are the salinity, the amount of dissolved oxygen, the hardness of the water and physical factors such as pressure. For example, a combination of changing salinity and decreasing oxygen concentration in the water has a negative reinforcing effect on temperature tolerance (Hartholt & Jager, 2004).

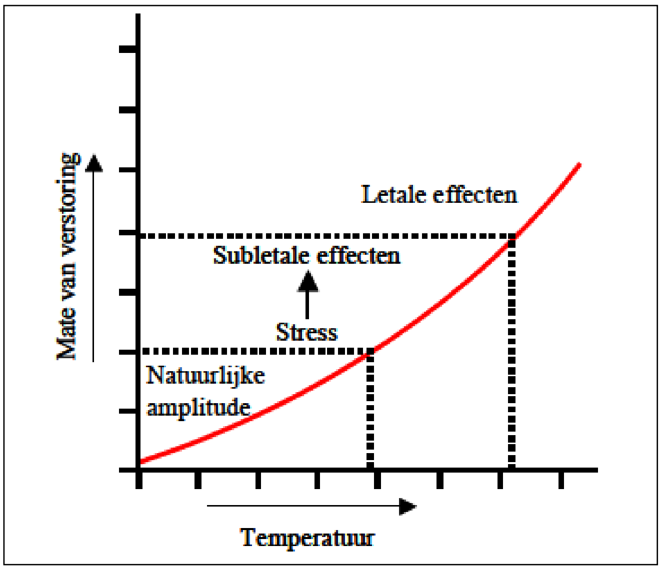

Figure2-52 Level of disruption as a function of the increase in water temperature (Hartholt & Jager, 2004)

Temperature increases can also lead to indirect effects on the ecosystem, such as the reduction of the solubility of certain substances, such as oxygen. The increased temperature may also have an effect on the microbial degradation of the organic material present, which may cause an additional oxygen deficiency. During the cooling process in KCD, enrichment with oxygen takes place. As a result, it is assumed that the indirect effects on oxygen concentration due to limited solubility and microbial degradation in the Scheldt River at the level of the KCD are largely compensated.

This assertion is supported by the results of the 5 monitoring campaigns at the KCD, which were carried out in the period June 2011 - March 2012 where temperature and oxygen content were measured at two depths in relation to the water surface in and around the discharge plume under various tidal conditions, particularly during low tide turnaround. The measurements show no oxygen depletion of the Scheldt water due to the discharge of warm cooling water, rather a slight enrichment (when the cooling water flows through the cooling process, the water is strongly aerated).

Thus, the remainder of the effects discussion primarily addresses the direct effects of temperature increase.

Effects of temperature increase on phytoplankton and zooplankton
Phytoplankton or algae are primary producers that form the basis of the food chain. Changes in phytoplankton community composition due to increased surface water temperatures may therefore have an impact on higher trophic levels. It is possible to divide algae into two groups: planktonic algae, which float freely in the water and sessile algae that require substrate to grow on (Kerkum *et al.*, 2004).

With increasing water temperature, effects were observed for phytoplankton mainly with respect to primary production and growth rate of algae. As a result, water blooms of algae (both blue-green algae and green-green algae) can occur, changing the species composition. Eventually this leads to a community consisting of fewer species than the original one.

Very localized changes in biomass, species composition, diversity and productivity can be observed at discharge points. No further impacts are expected at some distance from the discharge point. A decrease in primary production and acute mortality in phytoplankton is considered unlikely in the estuary at temperatures below 30°C. In addition, it has been found that some species can form toxins that are harmful to humans and animals (Kerkum *et al.*, 2004).

Zooplankton are the organisms suspended in the water, such as small singe-cell organisms, jellyfish, and free-living larvae of fish. For zooplankton, an increase in water temperature has a marked effect on growth and reproduction rates. Acute effects on zooplankton can only be clearly demonstrated at exposure temperatures above 30°C (Kerkum et al. , *2004)*.

Effects of temperature increase on macroinvertebrates
Temperature influences on marine invertebrate species have been studied primarily on benthic species such as the larger crustaceans. Macroinvertebrates that live on tidal flats are exposed to strong temperature fluctuations and are less sensitive to high temperatures. As a rule, therefore, bottom-dwelling animals on tidal flats will be little affected by the discharge of cooling water (Hartholt & Jager, 2004).

A permitted maximum temperature appears to depend on salinity and oxygen concentration. For marine species, temperature resistance decreases with stress due to decreasing salinity and oxygen concentration. Temperature tolerance of crustaceans is significantly greater in coastal waters than species living in deeper waters. Especially crustaceans, shellfish and snails from intertidal zones can tolerate relatively high temperatures without harm (Hartholt & Jager, 2004).

A marked extension of the growth and reproduction period was observed in a number of species, due to temperature increase. A temperature higher than 30 ºC appears to be detrimental to the occurrence of species (Kerkum et *al. ,* 2004).

Effects of temperature increase on fish
Of the organisms that live in water, fish are generally the least tolerant of high water temperatures. In particular, benthic species such as flatfish are directly threatened with mortality in the 25-28°C range. Herring-like species already early as 22 °C. In the zone where the discharged water has these temperatures, the sensitive species cannot survive if they cannot swim away (Hartholt & Jager, 2004).

During the summer months, the surface waters of coastal waters and estuaries have high temperatures. For the Scheldt estuary, temperatures around 24°C were measured. This is due to the shallow average water depth and the twice-daily drying of the tidal flats, which collect heat from the sun due to their dark color. Fish that cannot survive at these temperatures are then no longer present in the estuary (Hartholt & Jager, 2004).

In addition to lethal effects due to increased surface water temperatures, there is the fact that some fish species require low temperatures (< 10°C) during the spawning period (winter/early spring). If this temperature is no longer reached during winter months, reproduction will stagnate, cause species to disappear and lead to a lower diversity of fish species. Increasing temperature during periods when it is below 10°C results in lower reproduction in fish that spawn in early spring. As a result, the water becomes unsuitable for these fish (Kerkum *et al.*, 2004). An overview is given in Figure2-53.

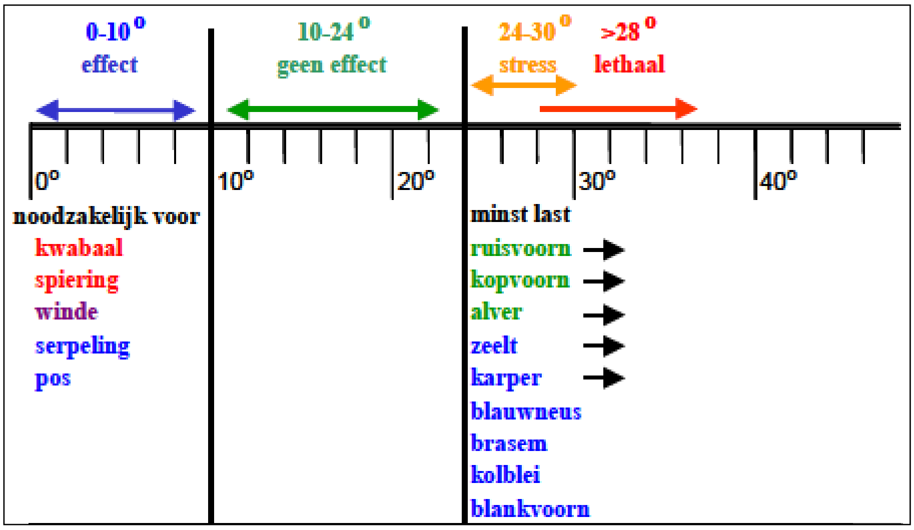

Figure2-53 Temperature requirements of some fish species (red: fish eater; blue: macrofauna eater; purple: fish/macrofauna eater; green: vegetation/macrofauna eater. An arrow behind the species indicates that it can tolerate temperatures >28°C) (Kerkum et *al.* , 2004)

A general principle is that with increasing temperature, respiration of fish increases (Kitchell *et al.*, 1977). The growth rate also increases with increases in temperature, provided there is sufficient food in the system to maintain the increased metabolism (Ficke *et al.*, 2007). In warmer water, fish are also more susceptible to infection, disease and parasites (De Kruik, 1983).

Migrating fish may experience a temperature threshold when the river water temperature varies too much from the seawater temperature. Studies on sea trout showed that this is not the case for this species, but this does not mean that it cannot be a problem for other species. Research on salmonids has shown that the temperature difference between river and sea water should not exceed 1°C. Juvenile salmonids can detect and avoid a cooling water plume and thus be less affected than if they could not. The actual behavior at a cooling water plume in a river will depend on various factors such as size, shape and gradient of the plume and the shape of the receiving water (Kerkum et *al.* , 2004).

Thermal pollution also positively affects the growth and reproduction of heat-loving species, and a cooling water plume can act as a refuge for these species during the winter months. These can also be exotic species. As a result, within the area where there is a constant temperature increase as a result of the cooling water discharge, the species composition may differ from the area without warming. This applies not only to fish but also to other organisms (Hartholt & Jager, 2004).

Effects of temperature increase on vegetation
Within the study area, both inside and outside the dikes are some important natural areas. The discharge of cooling water can only have an effect on the mudflats and salt marshes located outside the dikes with regard to the aspect of 'vegetation'.

Mud flats are flooded twice a day, at high tide. Salt marshes flood only at spring tides, which is on average about twice a month. From the report of the 5 monitoring campaigns of the temperature at the height of the KCD (Arcadis, 2012), it is clear that the heat plume extends upstream of the KCD during rising water and therefore does not reach the mudflats and salt marshes located downstream of KCD, such as the Schor van Ouden Doel and the Paardenschor. Based on this information, it can be clearly concluded that the discharge of cooling water will not affect the vegetation on the mudflats and salt marshes along the Scheldt.

Effects of temperature increase on birds
No literature was found on the direct effect of temperature increase on birds. It can be expected that a local increase in the Scheldt water temperature will not have direct effects on waterfowl.

As already described in the baseline situation, the Scheldt estuary is an important resting, breeding, foraging and migration area for a large number of internationally protected species. The brackish water area of the Scheldt is mainly home to large numbers of waders, ducks and geese. Waders forage at the level of the mudflats and feed on a variety of macroinvertebrates. Ducks and geese occur in large numbers within the study area in the Verdronken Land van Saeftinghe.

The effects on avifauna due to the discharge of cooling water are considered negligible. In fact, the area affected is so limited in area compared to the entire brackish water zone that no indirect effects are expected. The expected temperature increases at the mudflats near the Paardenschor (about 800 m north of the KCD discharge point) and the Schor van Ouden Doel (about 1.2 km north of the KCD discharge point), which are important foraging areas for waders, are limited to negligible.

Assessment of the effects of discharge of cooling water for KCD
The study by Kerkum *et al.* (2004) concluded that at temperatures below 30°C, primary production and acute mortality are unlikely to decrease or increase. For the zone closest to the discharge point, effects in primary production and acute mortality are expected, given that temperatures there can reach above 30°C. For phytoplankton, as a result of temperature increase, there may be a shift from diatoms over green algae to a dominance of blue-green algae (cyanobacteria). This shift may lead to lower biodiversity. For the entire zone within the breakwater, within which the heat plume due to the KCD's cooling water discharge extends, a local shift in fauna in favor of cyanobacteria may possibly occur. Earlier algal blooms and a slightly different species ratio can translate into a change in zooplankton, which in turn can have further effects on the food chain. In the area outside the breakwater, the effects are considered negligible because the results of the 5 monitoring campaigns of temperature at KCD show that the heat plume is limited to the area inside the breakwater (Arcadis, 2012).

To what extent a local increase in cyanobacteria and the production of toxic substances by these cyanobacteria effectively manifest themselves, and to what extent these effects have a significant impact on the carrying capacity of the Scheldt estuary in the area within the breakwater, currently remains a gap in knowledge. Van Damme *et al.* (2003) and Brys *et al.* (2006) state that the phytoplankton communities in the brackish zone do not allow the ecological status to be assessed. A full analysis of the phytoplankton communities is thus not considered meaningful for the assessment of the effects in the EIR.

For zooplankton, an increase in water temperature has a marked effect on growth and reproduction rates. Acute effects on zooplankton can only be clearly demonstrated at exposure temperatures above 30°C and are expected in the zone closest to the point of discharge, given that temperatures there may exceed 30°C. For the entire zone within the breakwater, within which the heat plume due to the KCD's cooling water discharge extends, a local in shift the growth and reproduction rate of zooplankton may occur. In the area outside the breakwater, the effects are considered negligible because the results of the 5 monitoring campaigns of temperature at KCD show that the heat plume is limited to the area inside the breakwater (Arcadis, 2012).

As with zooplankton, temperature increases in macroinvertebrates affect growth and reproduction rates. Mortality occurs from 30°C and is expected in the area closest to the point of discharge, given that temperatures there can rise above this level. For the entire zone within the breakwater, within which the heat plume due to the KCD's cooling water discharge extends, a local shift of macroinvertebrates may possibly occur. It should be noted that some of the macroinvertebrates found along the Scheldt are species that can also live in tidal flats, and are therefore naturally exposed to large temperature fluctuations. Sampling of aquatic organisms within the KCD cooling water plume by INBO in 2013 (Breine & Van Thuyne) indicated that shrimp and crabs are more likely to reside in the area within the breakwater where higher water temperatures prevail. In addition, the area is less dynamic than outside the breakwater. The presence of exotic macroinvertebrate species in the area within the breakwater was not remarkable and this is no increased abundance of exotic species within the breakwater. Based on these sampling results, no significant adverse effects on macroinvertebrates are expected. On the contrary, the increased temperature can be expected to lead to a somewhat faster development and biomass formation of macroinvertebrates.

The most sensitive animal group are fish. The lethal temperature for fish is highly species-dependent. Fish generally show no effect in the temperature range from 10 to 22°C (see Figure2-53). Between 22 and 28 to 30°C is a stress zone and lethal consequences occur only above 28°C, due to significant stress. On this basis, it can be stated that under average conditions and virtually throughout the entire year, no significant negative effects on fish fauna are to be expected. Only the most sensitive species will avoid the zone closest to the point of discharge by swimming away from it. However, species-specific data on the avoidance behaviour and startle reactions of fish with respect to cooling water discharges have not been found in the literature, hence the assessment is mainly based on lethal temperatures. In the area within the breakwater, from 850 m downstream of the point of discharge, the temperature falls below 10°C in winter and spring (Arcadis 2012 monitoring campaigns), which means that the low temperature that fish species such as ruffe and smelt need to induce their reproduction is reached.

Sampling of the aquatic organisms within the cooling water plume of KCD by INBO in 2013 (Breine & Van Thuyne) showed that fish are more likely to be found in the area within the breakwater with a higher water temperature. In addition, the area is less dynamic than outside the breakwater. The presence of sea bass, a warmth-loving marine species, demonstrates that this species uses the area within the breakwater as a winter refuge. Sole holds up within and near the breakwater area. Some species use the warmed up area within the breakwaters to reach adulthood. There is therefore an indication that there is an increased abundance of heat-loving native species (sea bass and sole) within the breakwater. Finally, discharge of cooling water can be important for the survival of thermophilic exotic species. Sampling of the aquatic organisms within the cooling water plume of the KCD by INBO in 2013 (Breine & Van Thuyne), showed no marked presence of exotic species in the area within the breakwater and there is no increased abundance of exotic species within the breakwater.

Based on the previous impact discussion, the impact of the KCD's cooling water discharge on the aquatic communities in the Lower Scheldt is not considered to be considerably negative.

2.5.3.1.6 Discharge of chemical substances

During the operation of KCD, the following effluents are produced: sanitary wastewater, industrial wastewater and cooling water. The discharge of nutrients into the Scheldt can cause eutrophication. The discharge of hazardous materials into the Scheldt can cause ecotoxicological effects:

2.5.3.1.7 Eutrophication

For the Scheldt in the vicinity of KCD, the environmental quality standards for nitrate+nitrite+ammonium and orthophosphate are not met in the baseline situation and in the operational phase 2015-2018. These nutrients are directly related to eutrophication.

Nitrite by itself has an almost negligible contribution to eutrophication, but it has a toxic effect. Given that the environmental quality standard for nitrite is met for the Scheldt in the vicinity of the KCD and a negligible contribution is calculated in the Water section, no toxic effect is expected from the discharge of nitrite by KCD to the Scheldt.

For the nutrient parameters nitrate+nitrite+ammonium and orthophosphate, an annual average negligible contribution is calculated in the Water section. Therefore, no significant eutrophying impact is expected on an annual average basis from the discharge of the KCD to the Scheldt. In the Water section, frequent operation of the sanitary waste water collection wells was found. Although the load is rather limited, these operations can create peaks of nutrient concentrations in the Scheldt at the level of KCD, in the area within the breakwater where the discharge of the sanitary and industrial wastewater and cooling water of the KCD takes place.

The consequences of eutrophication can be:

- The initial, direct consequence of eutrophication is an increase in plant growth. In most aquatic systems, this involves an increase in phytoplankton; in some shallow systems, it may also involve an increase in short-lived macroalgae (e.g., sea lettuce) and microphytobenthos. Large algal blooms occur in the Scheldt estuary due to eutrophication. Plants such as eelgrass and remaining macroalgae can grow less deeply and eventually disappear, due to deterioration of the light climate. As visibility decreases, predatory fish can no longer see their prey (Prins *et al.*, 2002).
- Another consequence of an increase in nitrogen and phosphorus availability is a change in the species composition of phytoplankton. This is mainly caused by the fact, that anthropogenic

eutrophication leads to an increase of nitrogen and phosphorus, but not of silicate (silica). Since silicate is an essential building material for diatoms (the most abundant group of algae) but not for other phytoplankton groups, the consequence of anthropogenic eutrophication is that growth conditions do not improve for diatoms but do for the other groups. This may result in a shift in the species composition of the phytoplankton from diatoms to other algae. During the spring bloom of diatoms, silicon becomes depleted, and diatom growth is inhibited due to Si limitation. This leads to a shift in algal composition and increasing dominance of other species of algae, which do not use Si, but can take advantage of the not yet depleted nitrogen and phosphorus supply. This mechanism is believed to be one of the causes of the increased bloom of *Phaeocystis*. The global increase in other pest algal blooms is also blamed on increases in phosphorus and nitrogen. Secondary effects of increased plant production caused by eutrophication, are an increase in the biomass of higher trophic levels (e.g., benthic animals) (Prins *et al.*, 2002).

- Increasing plant production can have negative effects on oxygen levels in the water and in the soil (Prins *et al.*, 2002). For dissolved oxygen levels in the vicinity of the KCD, the environmental quality objective is not met at the most upstream monitoring point but is met further downstream of KCD. A possible explanation for this is the aeration effect of the KCD's cooling water system (the oxygen content of the discharged cooling water is usually higher than that of the cooling water taken in).
- However, hard scientific evidence for causal relationships between eutrophication and shifts in biotopes is often difficult to find. In part, this is because eutrophication of coastal waters is a relatively recent phenomenon. More importantly, physical and biological characteristics of water systems, and interactions with other factors (e.g., climate) impact the response to increased nutrient loads. Because of the great diversity in coastal ecosystems, the response to eutrophication is therefore not straightforward and difficult to predict. Unlike freshwater, phosphate plays a much less controlling role in coastal waters. Only for a short time in spring can P-limitation of algal growth occur (Prins *et al.*, 2002).

It can be assumed that the frequent operation of the sanitary waste water collection wells of KCD contributes to a limited extent to the problem of eutrophication in the Scheldt, albeit locally at the discharge point of the KCD in the area within the breakwater. However, to what extent this leads to an increase in algal blooms and a reduction in visibility for predatory fish, a shift in the species composition of phytoplankton, and an increase in the biomass production of the higher trophic levels in the area within the breakwater, is not known. The cumulative impact of the physical characteristics (tidal dynamics, residence time, turbidity, depth) and of the temperature increase of the area within the breakwater, within which the discharge of the sanitary and industrial wastewater and cooling water from the KCD takes place, on the degree of eutrophication is also unknown. Van Damme *et al.* (2003) and Brys *et al.* (2006) state that the phytoplankton communities in the brackish zone do not allow the ecological status to be assessed. A full analysis of the phytoplankton communities is thus not considered meaningful for the assessment of the effects in the EIR. In order to reduce the operation of the sanitary waste water collection wells of KCD, the Water section recommended looking into the feasibility of disconnecting the rainwater system from the sanitary wastewater system (source-based measure) and the possibility of installing an additional collection volume for sanitary wastewater (end-of-pipe measure) at concept level and according to the Best Available Techniques.

2.5.3.1.8 Ecotoxicological effects

Sodium hypochlorite (NaOCl) is added to the cooling water to prevent biofouling. Biofouling is the process by which mainly sessile organisms, such as oysters, mussels, etc. attach themselves to the inlet and outlet pipes of, among other things, cooling water systems. The addition of sodium hypochlorite NaOCl should counteract this biofouling.

The NaOCl reacts to form chlorides. No active chlorine above the detection limit is found in the discharged cooling water (<100 µg/L). Active chlorine is considered to be an acutely toxic substance. For active chlorine, the concentration at which fish are not affected appears to be below 1 µg/l. Active chlorine is not very persistent and will disappear in surface water fairly quickly (the degradability has an order of magnitude of minutes). However, the conversion rate is impacted by many factors (temperature, degree of mixing in surface water, reducer content) (Berbee, 1997). The levels of active chlorine in KCD's discharged cooling water are below 100 µg/l. It can be concluded that at times of discharge of active chlorine, acute toxicological effects for aquatic organisms can occur locally around the discharge point for a short period of time (slightly negative effect).

When NaOCl is used as a conditioning agent, AOX (= adsorbable organic halogen compounds) is formed. The AOX levels will consist of haloforms, also called trihalomethanes (mainly bromoform in brackish and salt water) and various halogenated polar compounds (e.g. chloric and bromacetic acids) (Berbee, 1997). For the additional AOX contamination, chronic toxicity is more important. The contribution for AOX was considered a negligible effect in the Water section. However, elevated concentrations for AOX were measured in the sanitary and industrial wastewater and in the cooling water, so AOX will still be briefly discussed. Substances such as bromoform and bromate are considered potentially carcinogenic to humans. Therefore, this also deserves attention for aquatic organisms. Bromate problems also play a role in the chlorination of cooling water. There is evidence that when cooling water is chlorinated, very harmful bromate can be formed (especially at higher pH > 8 to 9, and active chlorine levels above 2 mg/L). Incidentally, Bromate has been found to occur in the NaOCl solution itself (ca. 34-37 mg bromate/kg bleach lye). Although it is possible in theory, in practice it will be technically very difficult to produce low-bromate bleach. In practical terms, when dealing with cooling water discharges, control of chlorine doses from the discharge of acutely toxic substances (load and concentrations) will usually come first. By limiting these discharges, the discharge of the more chronically toxic substances can also be reduced.

Currently, the dosing of NaOCl at KCD is based on the analysis of the excess active chlorine and experience with the cooling speed gasket. Any additional doses are based on the control of biological growth on sample plates in the cooling towers and weight measurements of the gasket. No active chlorine above the detection limit is found in the discharged cooling water (<100 µg/L). To monitor active chlorine in cooling water based on the shock dosage of NaOCl, it is recommended to perform the monitoring of active chlorine with an online measuring sensor, with a detection limit up to approx. 10 µg/L (instead of 100 µg/L in the existing condition). This in order to be able to refine the control of the dosage of NaOCl with the aim of a lower NaOCl consumption, lower active chlorine levels in the discharged cooling water and less AOX formation.

2.5.3.2 Operational phase in the future situation (period 2019-2025)

The impacts of eutrophication and acidification, rest disturbance, water intake, cooling water discharge, and chemicals will not be significantly different in the LTO situation, as explained above, compared to the baseline situation. There are no additional effects of the LTO situation compared to the baseline situation.

2.5.3.3 Post Operational Phase (period 2025-2029)

The Post Operational Phase or POP of KCD starts in 2025 and ends in 2028. After the POP period, the dismantling of the reactors can start when the necessary permits have been obtained. The POP period consists of 3 phases in which KCD gradually evolves from a nuclear power plant over, the wet storage of irradiated fuel to a building with radioactive waste to be processed. During the POP period, the following is scheduled:

- unloading of the reactors and transfer of all irradiated fuel to the Pool Loops docks in the Nuclear Auxiliary Services Building
- to allow the radioactivity of the irradiated fuel to decay in the Pool Loops docks in the Nuclear Auxiliary Services Building.
- to load the irradiated fuel into containers and transport it to Fissile Fuel Container Building.
- to carry out operation and maintenance activities as before the Post Operational Phase, but with a smaller amplitude (no more electricity production).

These are all activities covered by the current permit.

Conclusion: The main characteristics of the POP period are that this period is an extension of the current KCD operation (= with current KCD processes ongoing) and that the processes will run in accordance with the current permit. Air, noise and water emissions and the derived effects on biodiversity will be similar or less than in the baseline situation.

No difference is expected in effects between a POP in 2015-2019 versus 2025-2029.

2.5.3.4 Zero alternative

Eutrophication and acidification due to atmospheric deposition

Figure 2-54 shows the contours of nitrogen deposition caused by from KCD in the study area in the zero alternative. The maximum nitrogen deposition is 0.035 kg N/(ha.year) for the KCD emissions, which is less than 5% of the critical deposition values for N deposition of the European habitat types located in the vicinity of the site. The modelled contour of nitrogen deposition does not reach the mudflats and salt marshes along the right bank of the Scheldt.

It can be concluded that the nitrogen deposits of KCD assessed in the zero-alternative of the present project do not have a considerably negative effect on the eutrophication of the surrounding European habitat types in the Special Protection Area - Habitats 'Schelde- en Durmeëstuarium van de Nederlandse grens tot Gent' and of the mudflats and salt marshes in the (partly overlapping) VEN area 'Slikken en schorren langs de Schelde'.

Figure 2-54 Contour nitrogen deposition (in kg N/(ha.year)) caused by KCD's activities under the zero alternative

Figure 2-55 shows the contours of acidifying deposition caused by KCD's activities in the project area under the zero alternative. The maximum nitrogen deposition is 2.507 Zeq/(ha.year), which is less than 5% of the critical deposition rates for acidifying deposition of the European habitat types located in the vicinity of the site.

It can be concluded that the acidifying deposits of KCD assessed in the Zero alternative of the present project do not have a considerably negative impact on the ecosystems in the study area. Consequently, no substantial negative effects are expected from acidification as a result of KCD's activities on the surrounding European habitat types in the Special Protection Area - Habitats 'Schelde- en Durmeëstuarium van de Nederlandse grens tot Gent' and from the mud and salt marshes in the (partly overlapping) VEN area 'Slikken en schorren langs de Schelde'.

Figure 2-55 Contour of the acidifying deposition (in Zeq/(ha.year)) caused by KCD activities in the zero alternative

Rest disturbance

Figure 2-56, Figure 2-57 and Figure 2-58 show the 45-, 50-, and 55 dB(A) noise contours for the continuously operating sources during the day, evening, and night periods in the zero alternative. In this scenario, a number of sources from Doel 1 and 2 will no longer be active, i.e. the auxiliary cooling towers, the turbine hall and the water intake. As a result, the noise level of the facility (LwA) decreases by 0.2 dB(A) to 123.2 dB(A).

For the discontinuous sources (not relevant in the evening and night period as these sources are only tested during the daytime period) it appears that the nuisance contour of 50 dB(A) is located entirely on the site of KCD. Thus, the rest disturbance due to the discontinuous sources of KCD is not discussed further.

Rest disturbance due to the operation of KCD in the Zero alternative can be assessed as follows:

- To the east of the KCD, the 55 dB nuisance contour extends into the Special Protection Area - Birds
  'Schorren en polders van de Beneden-Schelde', also designated as the VEN area 'Slikken en schorren langs de Schelde' and as a Ramsar area. It can be concluded that these reed beds and mudflats along the banks of the Scheldt, are highly disturbed by the noise coming from KCD. The groups of species found there (small songbirds, waders, grebes, oystercatcher & avocets, etc.) are sensitive to highly sensitive to rest disturbance. On the other hand, this is a continuous noise disturbance and it is reasonable to assume that the avifauna present will show some habituation. Rest disturbance due to the operation of KCD along the reed beds and mudflats on the banks of the Scheldt, near the KCD, is assessed as negative. The 50 dB and 45 dB nuisance contours do not extend to the Galgenschoor across the Scheldt.
- North of the KCD the 50 dB and 45 dB nuisance contours do not reach the protected nature reserve 'Schor Ouden Doel' (negligible effect).
- To the west and south of KCD, the nuisance contour of 50 dB is largely limited to the KCD site itself and there is only a slight overlap with the Special Protection Area - Birds 'Schorren en polders van de Beneden-Schelde'. The 50 dB nuisance contour does not overlap with the VEN area 'Slikken en schorren langs de Schelde' here. The 45 dB nuisance contour has limited overlap with the Special Protection Area - Birds "Schorren en polders van de Beneden-Schelde" and with the VEN area "Slikken en schorren langs de Schelde". The rest disturbance caused by the operation of KCD in the polder areas to the west and south of KCD is assessed as a slightly negative effect.

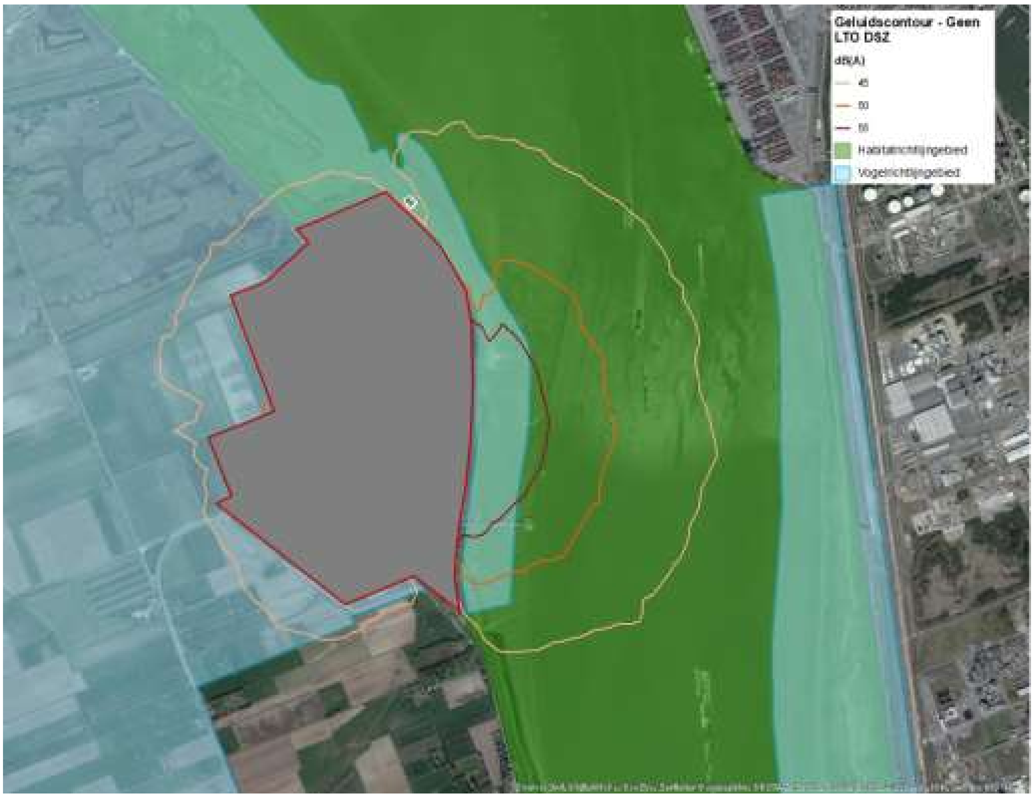

Figure 2-56 noise contours in the zero alternative relative to Natura 2000 areas

Figure 2-57 noise contours in the zero alternative relative to VEN areas

Figure 2-58 noise contours in the zero alternative relative to recognized and Flemish nature reserves

Water intake

The Doel 1 and 2 units will no longer be in operation, so the water intake and cooling systems of these units will no longer be used. As no mortality of fish or crustaceans has been observed at the cooling water intake of Doel 1 and 2 due to the presence of grids on the inlet, no changes are expected for the impact of the water capture on the organisms in the Zeeschelde near KCD in the zero alternative (= the no-LTO situation).

Discharge of cooling water|

The thermal load of cooling water on the Scheldt is expected to decrease by about 60%. The size of the heat plume in the Scheldt is therefore also expected to be lower. This can have a positive impact on the communities of phytoplankton, zooplankton, macro-invertebrates and fish within the area of the breakwater, especially in the light of climate change as described in the assessment of the thermal impact of the cooling water discharge during the operational phase 2015-2018 of the basic project.

The significance of this positive effect depends on the degree of shrinkage of the heat plume relative to the baseline situation, which is difficult to estimate with current data, and on the evolution of the expected climate effects.

Discharge of chemicals|

The concentrations of pollutants in the discharged sanitary and industrial waste water are expected to be the same as in the baseline situation. However, no drastic decrease is expected for the production of sanitary and industrial waste water. After all, the initiator did not notice any drastic drop when a unit was out of service. Only the consumption of mains water for the steam cycle is expected to decrease slightly. It is not possible to quantify this decrease. The Zero alternative will have the same effects on eutrophication as the baseline project.

The concentrations of pollutants in the cooling water, including temperature and chlorides, are expected to be equal to those of the baseline situation. In the Zero alternative, the same possible ecotoxicological effects will occur as in the basic project. To monitor active chlorine in cooling water based on the shock dosage of NaOCl, it is recommended to perform the monitoring of active chlorine with an online measuring sensor, with a detection limit up to approx. 10 µg/L (instead of 100 µg/L in the existing condition). This in order to be able to refine the control of the dosage of NaOCl with the aim of a lower NaOCl consumption, lower active chlorine levels in the discharged cooling water and less AOX formation.

2.5.3.5 Cumulative effects

The following plans/projects may be relevant regarding cumulative effects with the operation of KCD:

- Sigma plan
- Doelpolder Noord
- Hedwigepolder and Prosperpolder
- Creation of the GGG Doelpolder

The construction phase of the above plans/projects will cause noise disturbance at the level of KCD, which may lead to cumulative noise disturbance due to the operation of KCD. The information currently available on the above plans/projects, does not allow for this cumulative noise disturbance to be quantified or assessed.

The operational phase of the above plans/projects is not expected to have any cumulative effects on biodiversity due to the operation of KCD.

2.5.3.6 Cross-border effects

At the Dutch border, at a distance of about 3.4 km from the point of discharge of KCD, the influence of the discharge of the cooling water can at most be considered slightly negative. This is based on the 5 monitoring campaigns of the temperature impact of Doel's cooling water on the Scheldt (Arcadis, 2012). This temperature increase will slowly decrease further downstream on Dutch territory.

2.5.4 Preliminary assessment/appropriate assessment Natura 2000

2.5.4.1 INTRODUCTION

Article 36ter §3 of the Flemish Nature Decree (transposition of Article 6 §3 of the Habitats Directive) states that "Any plan or project not directly connected with or necessary to the management of the site but likely to have a significant effect thereon, either individually or in combination with other plans or projects, shall be subject to appropriate assessment of its implications for the site in view of the site's conservation objectives." (SPA).

Since the Doel nuclear power plant wishes to apply for a renewed license and it cannot be ruled out that its operation could have an effect on the adjacent Special Areas of Conservation, an appropriate assessment will be carried out as a separate chapter in the EIR.

The appropriate assessment addresses the following aspects:

- the presence or absence of an SPA within the sphere of influence of the proposed activity;
- description of Special Areas of Conservation with their conservation objectives;
- description and assessment of the impact groups which play a role and which may have an impact on the conservation objectives of the protected habitats and species.

This document will be drafted as a separate readable chapter within the Biodiversity section of the EIR. Certain background information from the Water, Air & Climate and Noise sections, on which this Appropriate Assessment is based, were described in the EIR and are not repeated as such in the present Appropriate Assessment.

2.5.4.2 Situation of the Natura 2000 sites

The nuclear power plant is located in Doel, a borough of the municipality of Beveren, on an industrial estate that is situated to the north of the Waaslandhaven on the Left Bank, but is otherwise separate from it. It is shielded from the rest of the port area by the polder village of Doel. The following Special Areas of Conservation are located in the vicinity of the Doel nuclear power plant (see Annex A - Map 14):

SPA-V BE2301336 ‘Beneden-Schelde: schorren en polders op rechter- en linkerscheldeoever’, which is located entirely around the Doel nuclear power plant. In addition to the polder areas west of the power station, the mud and salt marsh areas are also designated as a Special Protection Areas for Birds;
SPAZ-H BE2300006 'Schelde- en Durmeëstuarium van de Nederlandse grens tot Gent', which is located adjacent to the nuclear power plant in Doel and includes, in addition to the mud and salt marsh areas, the entire Scheldt as a river. At KCD, subarea 38 of this SPA-H (BE2300006-38) is located.

The Special Areas of Conservation SPA-V 'De Kuifeend and Blokkersdijk', SBZ-H 'Historische fortengordels van Antwerpen als vleermuizenhabitat', and the VEN areas 'De Kuifeend' and 'Wase Scheldepolders' are not considered further in this appropriate assessment. Because of their great distance from the project area (more than 3 km), no effects are expected on the protected habitats and species for which these areas are delineated. Also the area Groot Buitenschoor, Galgenschoor and Ketenisseschor, which are part of the SPA-V 'Beneden-Schelde: schorren en polders op rechter- en linkerscheldeoever' and the SPA-H 'Schelde- en Durmeëstuarium van de Nederlandse grens tot Gent' will not be considered further here, as no effects are expected because of the large distance (more than 1 km) to the nuclear power plant in Doel.

No significant negative effects are expected with respect to the Special Areas of Conservation located on Dutch territory either. It concerns the Verdronken Land van Saeftinghe, which is part of the SPA Westerschelde en Saeftinghe, Brabantse Wal (Special Protection Areas for Birds & Habitats), Markiezaat (Special Protection Area - Birds), Zoommeer (Special Protection Area - Birds) and Vogelkreek (Special Protection Areas - Habitats) (not indicated on the map).

2.5.4.3 SPA-H BE2300006 'Schelde- en Durme-estuarium van de Nederlandse grens tot Gent'

2.5.4.3.1 Protected habitats

Below is a listing of the protected habitat types (Annex I of the Nature Decree) of the BE2300006 Special Protection Area - Habitats, insofar as they are relevant to the location of KCD, the nature of its activities and the project characteristics:

- habitat type 1130: Estuaries.
- habitat type 1310: Salicornia and other annuals colonizing mud and sand
- habitat type 1320: Spartina swards (Spartinion maritimae)
- habitat type 1330: Atlantic salt meadows (Glauco-Puccinellietalia maritimae)
- habitat type 3270: Rivers with muddy banks with Chenopodion rubri pp and Bidention pp vegetation
- habitat type 6430: Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels

In addition to the estuarine habitats, the Special Protection Area - Habitats is also notified for a number of non-estuarine (wetland) habitat types (Annex I of the Nature Decree), of which mainly the ones below are relevant to the location of KCD, the nature of its activities and the project characteristics:

- habitat type 6430: Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels
- habitat type 6510: Lowland hay meadows (Alopecurus pratensis, Sanguisorba officinalis)

2.5.4.3.2 Protected species

Below is a list of the protected species (Annex II of the Nature Decree) in the Special Protection Area - Habitats BE2300006 'Schelde- en Durme-estuarium van de Nederlandse grens tot Gent' which, as a result of their occurrence at the KCD site are relevant:

- Twait shad
- Spined loach
- River lamprey

No other notified species for the Special Protection Area - Habitats occur in the vicinity of KCD:

- Rhodeus amarus is found in ponds, pools, ditches and enclosed meanders (cf. habitat 3260 and 3150.
- Spined loach inhabits smaller streams and rivers (cf. habitat 3160).
- Bats (Natterer's bat, Geoffroy's bat, Serotine bat, Pond bat, Common noctule) are more likely to occur in closed to semi-open forests and small-scale, wetland landscapes or landscapes with wooded edges and rows of trees. Pond bats are found near large bodies of water, rivers and canals. However, the Scheldt itself is not a known area. No flight paths are known in the vicinity of KCD (Baetens et al. 2016). Several species utilize the forts in the forts belt around Antwerp as wintering grounds.

2.5.4.3.3 Conservation Objectives

The conservation objectives for the Scheldt estuary (CT-Zeeschelde) in particular the SPA areas 'BE2300006 Schelde- en Durme-estuarium van de Nederlandse grens tot Gent' and establishing for that zone and for the SPAs designated under the Birds Directive 'BE2301336 Schorren en polders van de Beneden-Schelde', 'BE2301235 Durme en Middenloop van de Schelde' and the Blokkersdijk part of 'BE2300222 De Kuifeend en Blokkersdijk' were definitively approved by the Flemish Government on 23/04/2014.

Spatially, there are 4 ecotope clusters: 'estuary', 'wetlands', 'forest landscape' and 'grassland and marsh landscape in stream and river valleys with local transitions to alluvial forest'.

The ecotopic clusters 'estuary' and 'wetlands' cover most of the Zeeschelde ecosystem and were included in the CT for the Zeeschelde (IHD-Z) and the updated Sigmaplan. The total area within the habitat types of estuaries currently covers about 4680 ha, of which about 3460 ha is water (gulley). The IDH-Z for the ecotope cluster 'estuary' and relevant to the location of KCD and its nature of activities are shown in Table 2-55.

Wetlands, on the other hand, are tied to alluvial valley soils and are largely located within the dikes (on the land side). Typical terrestrial habitats here include lowland hay meadows, wet marshes, locally eutrophic ponds, very local drift islands and transitional peat and alluvial forests. European protected species that find their habitat here are the Spined loach, Rhodeus amarus, crested newt, pool frog, large white-faced darter, beaver and many European protected bird species: kingfisher, bittern, marsh harrier, corn crake, little bittern, bluebird, black-crowned night heron, spoonbill, spotted crake, avocet, purple heron, aquatic warbler and the migrating and wintering water birds pintail, teal, gadwall, shelduck, shoveler and black-headed gull. The IDH-Z for the ecotope cluster 'wetlands' and relevant to the location of KCD and its nature of activities are shown in

Table 2-56.

The third and fourth ecotope clusters, "forest landscape" and "'forest landscape' and 'grassland and marsh landscape in stream and river valleys with local transitions to alluvial forest' are not within the study area of the present appropriate assessment and will not be affected by the project in any case.

Table 2-57 shows the CT-Z for the relevant European protected species for the location of KCD, the nature of its activities and the project characteristics.

Table 2-55 Conservation goals SPA areas BE2300006 Schelde- en Durme-estuarium van de Nederlandse grens tot Gent, BE2301336 Schorren en polders van de Beneden-Schelde, BE220135 Durme en Middenloop van de Schelde, BE2300222 Kuifeend en Blokkersdijk- relevant European habitat types for the location of KCD, the nature of its activities and the project characteristics within the ecotope cluster 'estuary'

Habitat		**Surface objective**	**Quality objective**
1130 - Estuaries	*Objective*	(+):	(+):
	Description	Current: 4684 ha outside of the Sigmaplan natural development areas.[Because current habitat in the Sigmaplan natural development areas will mostly be converted to other habitat types, only the area outside of the Sigmaplan natural development areas was considered in determining the area of current habitat for those habitat types for which increases are proposed] • 4156 ha in SPA-H BE2300006, • 2 ha in SPA-H BE2300044, 488 ha in SPA-V BE2301235, • 33 ha in SPA-V BE 2301336 and • 5 ha outside SPA [This concerns very narrow areas of mudflats/salt marshes along the Grote and Kleine Nete and mismatches between the habitat map and the SPA map] Objective: + 2000 ha net of which 905 in SPA-H2300006, 460 ha in SPA-V2301336, 346 ha outside SBZ and 300 ha still to be determined; by effective expansion (guide value 1420 ha, of which target value 628 ha in SPA-H2300006) and conversion; by creation of new estuarine tidal areas in the form of controlled floodplains with controlled reduced tides (GOG-GGG) and in the form of de-poldering (2000 ha compared to the situation in 2005. Since then, 30 ha have already been realized in the GOG-GG Lippenbroek and the de-poldering of Heusden)	Good conservation status with respect to ecological functioning of the entire estuary including the pelagic/navigation channel. Good chemical water quality with high oxygen concentrations not lower than 5 mg/l in summer and 6 mg/l in winter in the estuary. Sufficient space for estuarine processes with specific attention to shallow water, mudflats and salt marsh. No further promotion of the increase in tidal amplitude and energy. Avoid disposal of dredged material or strategically dispose of it in a way that takes into account the morphodynamics of the river as much as possible. Take maximum account of seasonal patterns in the life cycle of estuarine species in management and infrastructure works. Decrease in high freshwater discharge during peak flows. Reduce sediment input from upper reaches.

1310 - Salicornia and other annuals colonizing mud and sand	*Objective*	(+):	(+):
	Description	Current: 0.6 ha (1310) and 0.2 ha (1320). These areas are contained in the area of habitat type 1130. Objective: Expansion, area difficult to quantify. This expansion is contained in the expansion of habitat type 1130.	Objective: Sufficient space for natural dynamics and hydromorphological processes with succession from mud to salt marsh. Pursue permanently good water and sediment quality.
1320 - Spartina swards (Spartinion maritimae)	*Objective*	(+):	(+):
	Description	Current: 0.6 ha (1310) and 0.2 ha (1320). These areas are contained in the area of habitat type 1130. Objective: Expansion, area difficult to quantify. This expansion is contained in the expansion of habitat type 1130.	Objective: Sufficient space for natural dynamics and hydromorphological processes with succession from mud to salt marsh. Pursue permanently good water and sediment quality.
1330 - Atlantic salt meadows (Glauco-Puccinellietalia maritimae)	*Objective*	(+):	(+):
	Description	Current: 48.9 ha. This area is contained within the area of habitat type 1130. Objective: +110 ha. This expansion is contained in the expansion of habitat type 1130.	Objective: Maintain or create sufficient space for dynamics of erosion and sedimentation with natural succession from mudflats to salt marsh. Pursue permanently good water and sediment quality.
Rivers with muddy banks with Chenopodion rubri pp and Bidention pp vegetation	*Objective*	(+):	(+):
	Description	Current: 1.8 ha. This area is contained within the area of habitat type 1130. Objective: Expansion, difficult to quantify. This expansion is contained in the expansion of habitat type 1130.	Objective: Maintain or create sufficient space for dynamics of erosion and sedimentation with natural succession from mudflats to salt marsh. Pursue permanently good water and sediment quality.
6430 - Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels	*Objective*	(+):	(+):
	Description	Current: ca. 65 ha [The habitat map shows 39 ha 6430_hw, the vegetation map 2003 (Vandevoorde *et al.* in press) shows 67 ha 6430_hw, of which ca. 65 ha are within SPA]. This area is contained in the area of habitat type 1130. Objective: Expansion, difficult to quantify. This expansion is contained in the expansion of habitat type 1130.	Objective: Maintain or create sufficient space for dynamics of erosion and sedimentation with natural succession from mudflats to salt marsh. Pursue permanently good water and sediment quality.

Table 2-56 Conservation goals SPA areas BE2300006 Schelde- en Durme-estuarium van de Nederlandse grens tot Gent, BE2301336 Schorren en polders van de Beneden-Schelde, BE220135 Durme en Middenloop van de Schelde, BE2300222 Kuifeend en Blokkersdijk- relevant European habitat types for the location of KCD, the nature of its activities and the project characteristics within the ecotope cluster 'wetlands'

Habitat		**Surface objective**	**Quality objective**
6430 - Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels	*Objective*	(+):	(+):
	Description	Current: 52 ha outside of the Sigmaplan nature development areas. - 46 ha in SPA-H BE2300006 - 6 ha in SPA-V BE2301235 Target: total area of 69 ha The additional habitat for corn crake and spotted crake, foreseen in the G-CT, will be realized in the nature development areas of the Sigma Plan (as decided by the Flemish Government on July 22, 2005 and April 28,2006). Habitat 6430 will be provided within the habitat for these species. The habitat type will develop as a border between other habitat and RBB types on sites with intermediate management or intermediate abiotic conditions. E.g., less intensively managed borders around moist hay meadows or less wet stands along sedges or other marsh types. This is sufficient for corn crake and spotted crake because they require only a small proportion of this habitat type in their habitat.	
6510 - Lowland hay meadows (Alopecurus pratensis, Sanguisorba officinalis)	*Objective*	(+):	(+):
	Description	Current: 37 ha outside of the Sigmaplan nature development areas: - 22 ha in SPA-H BE2300006 - 15 ha in SPA-V BE2301235 Well-developed forms are very rare and the habitat type occurs almost exclusively on dikes (less than 5 ha is not on dikes). Target: + 132 ha , with 98 ha as the target for expansion. In addition, additional habitat for corn crake is provided in the G-CT, which will be realized in the nature development areas of the Sigma Plan (as decided by the Flemish government on 22 July 2005 and 28 April 2006). Within this habitat 232 - 476 ha should be provided, which will occur in mosaic with other grassland types on moderately nutrient-rich soils (rbb_hf, rbb_hc...): - 132 ha in SPA-H BE2300006 - 106-227 ha outside SPA	

Table 2-57 Conservation goals SPA areas BE2300006 Schelde- en Durme-estuarium van de Nederlandse grens tot Gent, BE2301336 Schorren en polders van de Beneden-Schelde, BE220135 Durme en Middenloop van de Schelde, BE2300222 Kuifeend en Blokkersdijk- relevant European protected species for the location of KCD, the nature of its activities and the project characteristics.

Rhodeus amarus	
Population target	Conservation of current population and acreage
Quality objective	Striving for good habitat quality
Twait shad	
Population target	Restore population to good conservation status in the Zeeschelde and tidal tributaries; Expand current area upstream and tidal tributaries Mass migration of adults in spring and massive presence of juveniles in summer
Quality objective	Strive for good habitat quality. Good water quality in Scheldt and tributaries, sufficiently oxygenated. Restore good structural quality of the estuary with sufficient low dynamic mudflats and (shallow) subtidal zones. Maintain and restore suitable spawning and juvenile habitats in the freshwater tidal area (Scheldt and tributaries), specifically undisturbed (shallow) zones with not too high flow velocities.
Geoffroy's bat	
Population target	Presence of summer colonies of the species with annually pregnant females and/or juveniles. The presence of a sustainable population is pursued
Quality objective	**Summer objective:** Increase in habitat quality in the forests and insect-rich grasslands and ruins in a surrounding landscape with KLEs. Creation of gradual forest edges, particularly near open water features. Maintain and improve quality of water features. The objectives are met as part of the objectives for habitats 3150, 6430, 9120, 9160 and 91E0. Additional focus on maintaining existing connections, and where necessary expanding and connecting forests and foraging areas. **Winter objective**: Preserving, furnishing and improving winter quarters
Spined loach	
Population target	Expand current population to good status and expand area in SPA-H BE2300006.

Quality objective	Good water quality in estuary and waterways in the valley. Good connectivity (for fish) between the estuary and waterways in the valley. Low dynamic shallow subtidal zones in the estuary and sufficient structural diversity in estuary and other waterways.
River lamprey	
Population target	Establish a population in good condition in Flanders with the Scheldt estuary as a suitable migration corridor.
Quality objective	The Scheldt and its tributaries function as an optimal migration corridor for this species between the sea and its spawning grounds. Good water quality in the estuary. No migration bottlenecks between the estuary and the upper reaches.
Nathusius's pipistrelle, Common noctule, Natterer's bat, Daubenton's bat, Pond bat	
Population target	Presence of summer colonies of the species, with pregnant females and/or juveniles annually. The presence of sustainable populations of each of these species is sought.
Quality objective	**Summer objective:** Increase in habitat quality in the forests and insect-rich grasslands and ruins in a surrounding landscape with KLEs. Creation of gradual forest edges, particularly near open water features. Maintain and improve quality of water features. The objectives are met as part of the objectives for habitats 3150, 6430, 9120, 9160 and 91E0. Additional focus on maintaining existing connections, and where necessary expanding and connecting forests and foraging areas. **Winter objective:** Conservation, establishment and improvement of winter quarters.
Soprano pipistrelle, Common pipistrelle, Serotine bat	
Population target	Conservation and expansion of the existing population
Quality objective	Maintain existing quality, preserve and expand connectivity between areas.

2.5.4.4 SPA-V BE2301336 'Beneden-Schelde: schorren en polders op rechter- en linkerscheldeoever'

2.5.4.4.1 Protected species

The following have been reported under the Special Protection Area - Birds:

Breeding Birds:

- Marsh Harrier
- Bluebird
- Kingfisher
- Bittern
- Spoonbill
- Spotted Crake
- Avocet
- Common tern
- Kentish plover
- Mediterranean gull
- Black-winged stilt

Migratory and wintering waterbirds:

- Teal
- Shelduck
- Bewick's Swan
- Spoonbill
- Shoveler
- Northern pintail
- Gadwall
- Ruff
- Avocet
- Golden plover
- Greylag Goose
- Wigeon
- Greater white-fronted goose
- Hen Harrier
- Black-headed gull
- Aquatic warbler

Monitoring of waterfowl on the Zeeschelde is done annually by the INBO. Some common **waterbirds** for the Zeeschelde near the KCD are (Van Ryckegem *et al.*, 2014, 2015, 2016, 2017, 2018):

- Cormorant
- Shelduck
- Dunlin
- Canada goose
- Great crested grebe

- Greylag Goose
- Northern lapwing
- Avocet
- Gadwall
- Tufted Duck
- Northern pintail
- Oystercatcher
- Wigeon
- Common pochard
- Redshank
- Wild duck
- Teal
- Curlew
- Mediterranean gull

For the 2013 and 2014 baseline situation, the following observations apply to waterbirds (Van Ryckegem *et al.*, 2014 and 2015):

The overall patterns in monthly bird numbers along the Zeeschelde in 2013 and 2014 remain similar to previous years. Winter numbers have shown a downward trend since 1999, the number stabilizing since 2008 to around 25 000 to 30 000 winter birds counted. The main decline is due to a sharp decline in the numbers of wigeon and teal. Winter maximums are counted in the months of December-January. The lowest numbers are counted in March. The Zeeschelde is one of the most important wintering areas for waterbirds in Flanders. However, the international importance of the Zeeschelde as a wintering area has become more limited and currently only the gadwall reaches the 1% standard (numbers of international significance). For the Zeeschelde as a Special Protection Area for Birds, less than 2% and less than 1% of the Northwest European population resided in the Zeeschelde during winter 2013 and winter 2014, respectively. Contrary to expectations, there is no major increase in fish-eating bird species. On the contrary, the Great crested grebe has declined significantly in the mesohaline zone (to which the present study area belongs) since the late 1990s;

The shelduck is the dominant "water breeding bird" in the Zeeschelde. The wild duck is the most numerous breeding bird along the Zeeschelde, in addition to the shelduck. Gadwall is not a common breeder along the Zeeschelde.

For the period 2015-2017, the following observations apply to waterbirds (Van Ryckegem *et al.*, 2016, 2017 and 2018):

Monthly number of birds along the Zeeschelde River were slightly lower overall in the winters of 2015, 2016 and 2017 than in previous years. As a result, the international importance of the Zeeschelde for wintering waterbirds is historically low. Only the gadwall in the Zeeschelde still reaches 1% of the estimated Northwest European population.
After a period of increase (2012-2015), a decrease in benthivorous bird species was observed in the Lower-Zeeschelde.
As a general conclusion, bird numbers on the Zeeschelde show a continuing downward trend.

In the period 2013-2017, all large brackish water salt marsh areas along the Zeeschelde in the IHD area - including Doelpolder Noord, Doelpolder Midden, Prosperpolder, the Schor Ouden Doel and the Paardenschor - were inventoried annually for **breeding birds.** The bird species listed below breed annually within the Northern Area of the Antwerp Port Area on the left bank - this includes Doelpolder Noord, Doelpolder Midden, Prosperpolder, the Schor Ouden Doel and the Paardenschor:

- Bearded reedling
- Bluebird
- Marsh Harrier
- Little grebe
- Avocet
- Spotted Crake
- Sedge warbler
- Oystercatcher
- Shoveler
- Redshank

Over the past five years, the rarer species bearded reedling, avocet, spotted crake and redshank have shown a stable trend. When considered over the longer term, the marsh harrier shows a declining trend. For the more common species of bluebird, little grebe, sedge warbler, shoveler and garganey, the importance increases as more Sigma areas are established.

Of the annually nesting species in the CT area of Scheldt estuary, a significant proportion of the population of black-tailed godwit, savi's warbler, little bittern and garganey occur outside the harbor. Several species rarely breed within the Scheldt estuary CT area until 2017 (great reed warbler, black-crowned night heron, corn crake, spoonbill, bittern, and capercaillie) or have never been established as breeding birds (purple heron).

2.5.4.4.2 Conservation Objectives

For breeding birds, population targets refer to the targeted breeding birds and the targeted numbers of breeding pairs. For non-breeding birds, the target migratory and wintering species and the target number of individuals.

In each case, the quality objectives involve improving habitat quality, including tranquility and good water quality.

2.5.4.5 Description and assessment of the impact

2.5.4.5.1 Effects on the SPA-H Schelde- en Durmeëstuarium van de Nederlandse grens tot Gent

2.5.4.5.1.1 Impact on habitats

Effects due to temperature increase due to cooling water discharge

Within the study area, both inside and outside the dikes are some important natural areas. The discharge of cooling water can only have an effect on the mudflats and salt marshes located outside the dikes with regard to the aspect of 'vegetation'.

Mud flats are flooded twice a day, at high tide. Salt marshes flood only at spring tides, which is on average about twice a month. From the report of the 5 monitoring campaigns of the temperature at the height of the KCD (Arcadis, 2012), it is clear that the heat plume extends upstream of the KCD during rising water and therefore does not reach the mudflats and salt marshes located downstream of KCD, such as the Schor van Ouden Doel and the Paardenschor. Based on this information, it can be clearly concluded that the discharge of cooling water will not affect the vegetation on the mudflats and salt marshes along the Scheldt.

Acidification and eutrophication due to atmospheric deposition
The effect description and assessment of acidification and eutrophication due to atmospheric deposition of NOx and SO2 from KCD was done in § 2.5.3.1.2of the Biodiversity section. The methodology described in the practical signposts for airborne acidification and eutrophication was followed for assessing the significance of an effect on conservation objectives in Special Protection Area - Habitats. No significant negative impacts are expected from acidification and eutrophication as a result of the KCD's operations on the surrounding European habitat types in the Special Protection Area - Habitats 'Schelde- en Durmeëstuarium van de Nederlandse grens tot Gent.

2.5.4.5.1.2 Impact on species

Effects due to temperature increase due to cooling water discharge
For the overall impact assessment for aquatic organisms, see paragraph 2.5.3.1.5 of the Biodiversity section. The following specifically addresses the fish species for which the SPA-H has been notified being river lamprey, twait shad and which occur in the estuary at the level of KCD,

River lamprey
River lamprey, although not a fish, is an indicator species that is highly sensitive to pollution and low oxygen concentrations. River lamprey are so far only occasionally caught upstream from Doel in the Zeeschelde. This round-billed species is caught in low numbers annually, especially in the spring. The length of the individuals caught, and the period in which they were caught (especially in spring) suggests that it is mainly adults that migrate towards the sea (Breine & Van Thuyne et *al.* , 2015 to 2019).

River lamprey essentially use the Zeeschelde only as a passage route between the adult habitats (Western Scheldt, North Sea) and the nursery areas (freshwater). Juveniles grow up in streams and rivers with good water quality, where they burrow into silt banks and feed on detritus, algae and small organisms. After metamorphosis, the adults migrate seaward. They stay in coastal waters and estuaries for 2.5 to 3.5 years, where they lead a parasitic life on other fish (mainly herring and cod). At the onset of spawning, they migrate again to the middle and upper reaches of rivers to deposit eggs in coarse sandy to gravelly river sediments at a depth of 0.5 to 1 m, after which the animals die.

Spawning migration of the adult river lamprey takes place in the period December - April. The migration of juvenile river lamprey to the sea peaks in February and March. The migration occurs at night. Based on the available field observations, we can infer that river lamprey exclusively use the channel as a migration route. Fishing gears placed in the portion of the water column between the low water and high water line rarely catch river lamprey (Maes & Ollevier, 2005).

The Water section shows that the navigation channel of the Scheldt east of the breakwater is considered passable for aquatic organisms at all times. It may also be decided that river lamprey do not occur at the level of the KCD during the period when the impact of the temperature increase due to the cooling water period is greatest, i.e. during extremely warm periods. In addition, it can also be stated that the area where the temperature increase will be significant, namely in the area within the breakwater, cannot be considered as an essential habitat for river lamprey. Larval habitats, where larvae burrow, are located in freshwater and therefore will also not be affected as a result of the operation of the KCD.

Maes & Ollevier (2005) conducted a study on the occurrence of river lamprey based on the monthly river lamprey catches in cooling water sampled at Doel. This concluded that river lamprey have an increased chance of entering cooling water especially during migrations. Relatively high numbers of recently metamorphosed lampreys are captured mainly in February while adults peak in the fall. A regression analysis on these data could not show a statistically significant relationship between the occurrence of river lamprey in the Lower-Zeeschelde near Doel and a number of important environmental factors, such as water temperature, freshwater discharge, salinity, oxygen concentration, amount of suspended matter (Maes & Ollevier, 2005). The density gradient is mainly related to the life cycle itself and therefore very stable and predictable.

Based on the above arguments, it can be concluded that the impact of the temperature discharge will not have a significant impact on the conservation of this species within the Scheldt estuary.

Twait shad
Twait shad are now often caught off the Flemish coast in beach nets set for recreational fishing. Since 1996, Twait shad have again been caught in increasing numbers in the Zeeschelde. This increase is probably directly caused by higher oxygen levels. However, there are no indications that the species is actually reproducingthere.

Twait shad spend part of their lives in saltwater but migrate to freshwater areas to reproduce. Twait shad spawn upstream a river just where tidal action is no longer workable. However, Breine & Van Thuyne (2014) observed spawning twait shad in the freshwater tidal zone on the Zeeschelde. However, it is true that spawning activities were not observed during strong currents. With successful recruitment, the young twait shad migrate back to sea during the months of August-September. In late April - early May, at a water temperature of 10 to 12°C, adult twait shad migrate back upstream the Zeeschelde. The moment of migration is positively correlated with increasing temperature and oxygen content. After spawning, they disappear back to sea (Breine & Van Thuyne, 2014).

The occurrence of twait shad off the KCD is also confirmed by recent sampling by Breine & Van Thuyne (2014 through 2019). The number of twait shad varies greatly from year to year. They are usually caught in the spring. These are adult individuals. In contrast to 2014, juvenile twait shad were captured for all years 2015-2019. This indicates that recruitment has taken place. Improvement of water quality and remediation of contaminated silt soils in the freshwater tidal area of the Zeeschelde is desired to enable successful reproduction. Twait shad do not occur at oxygen levels below 3 mg/l and avoid zones where oxygen levels are below 4 mg/l.

Based on the available field observations, we can infer that twait shad use the Zeeschelde at KCD primarily as a migration route. Twait shad is a herring-like species that spawns upstream of Antwerp in the Scheldt River. The Water section shows that the navigation channel of the Scheldt east of the breakwater is considered passable for aquatic organisms at all times. The area near the KCD is not essential spawning and larval habitat, these areas are more upstream.

Based on the above arguments, it can be concluded that the impact of the temperature discharge will not have a significant impact on the conservation of this species within the Scheldt estuary.

Spined loach
Spined loach is a species observed in the Scheldt estuary mainly in the streams and ditches located inside the dikes. Spined loach does not occur in the Lower-Zeeschelde (Vandelannoote *et al.*, 1990). Recent fish data from Breine & Van Thuyne (2013 through 2019), also show that the Spined loach was not observed at the level of KCD.

Based on the occurrence and habitat requirements of this species, it can be assumed with certainty that the operation of KCD will not affect this species and therefore its conservation objectives.

Rhodeus amarus
Rhodeus amarus is a species with little to no occurrence at the level of KCD. This species is mainly observed along the Scheldt upstream of Antwerp (Breine & Van Thuyne, 2013 to 2019).

Based on the occurrence and habitat requirements of this species, it can be assumed with certainty that the operation of KCD will not affect this species and thus its conservation objectives.

Effects on oxygen concentration due to discharge of cooling water
For the Scheldt estuary, the quality objective for an oxygen concentration in the estuary is no lower than 5 mg/l in summer and 6 mg/l in winter.

Measurements show that no decrease in oxygen concentration can be observed as a result of the cooling water discharges, perhaps due to oxygen enrichment during the cooling process itself. As a result, it can be concluded that the cooling water discharge will not affect the conservation objective for the Scheldt estuary with regard to oxygen concentration.

Direct mortality at the cooling water intake point
The Doel Nuclear Power Plant is equipped with a sound-based fish guidance system. Because of this noise, the fish are deterred and fewer of them end up in the water intake. Especially fish species with swim bladders are chased away. This organ is similar to a lung and regulates its position in the water and also captures sound underwater. River lamprey do not have a swim bladder; Twait shad and Rhodeus amarus do have a swim bladder.

Fish and shrimp that do slip through the mesh of the deterrent system return safely to the Scheldt via a fish-friendly system. Fish mortality is therefore reduced by 88% for fish and 100% for crustaceans. This corresponds to 95.5% of the numbers and 90% of the biomass of fish and crustaceans (Maes *et al.*, 1999).

Based on this, it cannot be ruled out that mainly river lamprey are sporadically killed at the water intake. However, given the well-functioning fish deterrent system and fish guidance system, the number of deaths of river lamprey and all other fish species occurring at the level of the water intake due to direct mortality is assessed to be low. With respect to this aspect, no significant negative effects on the conservation objectives for fish species are identified.

Pollution due to discharge of chemicals
The quality objective for the Scheldt estuary is good chemical water quality. This is also important for the species river lamprey, Twait shad and spined loach.

During the operation of KCD, the following effluents are produced: sanitary wastewater, industrial wastewater and cooling water.

For the parameters nitrate+nitrite+ammonium and orthophosphate, an annual average negligible contribution is calculated in the Water section (less than 0.1%). Therefore, no significant eutrophying impact is expected on an annual average basis from the discharge of the KCD to the Scheldt. In the Water section, frequent operation of the sanitary waste water collection wells was found. Although the load is rather limited, the operation of the sanitary waste water collection wells can cause peaks of nutrient concentrations in the Scheldt at the level of KCD.

The water quality of the Zeeschelde has improved greatly in recent years, but even now there is no good chemical or ecological status anywhere in the estuary according to the criteria of the Water Framework Directive. In the 1970s and 1980s, the water quality in the Zeeschelde was very poor, especially in the freshwater part. Very high organic loads led to very low oxygen concentrations, which virtually killed the river. Moreover, the water at that time also contained significant amounts of toxic substances (including heavy metals, organic pollutants...). In the Western Scheldt, the situation was slightly better due to mixing with cleaner and more oxygenated seawater. Because of efforts made in water treatment, water quality in the estuary improved in the 1990s. Both toxic and nutrient levels decreased significantly and oxygen concentrations increased (Soetaert *et al.*, 2006). However, very high levels of nutrients still flow into the estuary leading to algal blooms. The improved oxygen environment also leads to a return, an increase and shifts in the species composition of bottom dwelling animals. When a healthy zooplankton population once again develops in the fresh-water area of the Zeeschelde, these animals can help keep the algal bloom under control. If there is oxygen and plankton in the Scheldt, fish stocks will also increase. A development that is already noticeable. The limited primary production in the period of heavy pollution could be explained by limitation of algal growth by the very low oxygen levels or high ammonium concentrations, but also by a limited availability of light in the turbid Scheldt water (Management Plan Natura 2000 1.0, Zeeschelde (SIGMA), 19/12/2014).

It can be assumed that the frequent operation of the KCD's sanitary wastewater collection wells, contribute to the problem of eutrophication in the Scheldt to a limited extent. On average, a negligible contribution (less than 0.1%) is calculated for the nutrient parameters nitrate+nitrite+ammonium and orthophosphate, in the Water section. The contribution of KCD for nutrient concentrations on the Scheldt is not considered to have a significant adverse effect on the quality objectives of the Scheldt estuary and the conservation objectives for the notified fish species.

For the other parameters discharged by the KCD, the contribution relative to the environmental quality standard is negligible (less than 0.1%) and no significant negative impact is expected on the quality objectives of the Scheldt estuary and the conservation objectives for the notified fish species either.

Exotic species
Due to the discharge of cooling water, the local higher temperatures can provide refuge for exotic species

mainly during the winter period. In the summer, these species may then be able to reproduce better in the warm plume.

As long as these species do not reproduce, the danger is less. In case the temperature conditions become optimal for reproduction due to the cooling water discharge and they can also survive during the winter period with us, competition with the indigenous species can occur, which can have major consequences for the entire estuarine ecosystem of the Scheldt. Since this could therefore potentially affect native fish fauna, some of which are European protected species, it is appropriate, when reproducing exotics are identified, to monitor this effect and, if necessary, take appropriate measures. The extent to which exotic species pose a threat to European protected species is difficult to assess at this time. Sampling of the aquatic organisms within the cooling water plume of the KCD by INBO in 2013 (Breine & Van Thuyne), showed no marked presence of exotic species in the area within the breakwater and there is no increased abundance of exotic species within the breakwater.

2.5.4.5.2 Effects on SPA-V Lower Scheldt: salt marshes and polders on right and left banks of the Scheldt

The effects on the Special Protection Area for Birds SPA-V Lower Scheldt: salt marshes and polders on the right and left banks of the Scheldt are mainly situated in the area of rest disturbance. In fact, as a result of the re-licensing, there will be no direct loss of breeding, resting or foraging habitat for nesting, migrating, foraging and resting birds. Also as a result of the discharge of cooling water, no significant effects are expected on the bird populations present.

For rest disturbance, an estimate is made of the effect of the operation of the nuclear power plant in Doel on the Annex I breeding birds and non-breeding birds present for which conservation objectives have been drawn up. Here, the focus is on:

- Doelpolder Noord, Doelpolder midden and Prosperpolder
- The Schor Ouden Doel and the Paardenschor
- The left bank of the Scheldt at the Doel nuclear power plant.

In the other locations that are part of the SPA-V Lower Scheldt: salt marshes and polders on the right and left bank of the Scheldt, such as Galgenschoor, Groot Buitenschoor, Ketenisseschor, ... no rest disturbance is expected. Indeed, these areas are located at a considerable distance and outside the sphere of influence for noise.

For discussion of the disturbance sensitivity and thresholds of relevant bird species in the vicinity of KCD, please refer to §2.5.3.1.3.1 and § 2.5.3.1.3.2 of the EIR. Figure 2-59 shows the 45-, 50-, and 55 dB(A) noise contours for the continuously operating sources during the day, evening, and night periods in the 2013-2014 baseline situation. These are the same as in the operational phase 2015-2018 because the source field does not change for this purpose.

For the discontinuous sources (not relevant in the evening and night period as these sources are only tested during the daytime period) it appears that the nuisance contour of 50 dB(A) is located entirely on the site of KCD. Thus, the rest disturbance due to the discontinuous sources of KCD is not discussed further.

Figure 2-59 Sound contours 2013-2014 (ibid for the operational phase 2015-2018) relative to the Natura 2000 areas

The rest disturbance resulting from the operation of KCD in the period 2015-2018 and in the future situation 2019-2025 can be assessed as follows:

- To the east of the KCD, the 55 dB nuisance contour extends into the Special Protection Area - Birds
  'Schorren en polders van de Beneden-Schelde'. It can be concluded that these reed beds and mudflats along the banks of the Scheldt within the Special Protection Area - Birds and adjacent to the KCD are highly disturbed by the noise coming from KCD. The groups of species found there (small songbirds, waders, grebes, oystercatcher & avocets, etc.) are sensitive to highly sensitive to rest disturbance. On the other hand, this is a continuous noise disturbance and it is reasonable to assume that the avifauna present will show some habituation. The 50 dB nuisance contour does not reach into the Galgenschoor across the Scheldt.
- North, west and south of KCD, the 50 dB nuisance contour is largely confined to the site of KCD itself and there is only a slight overlap with the Special Protection Area - Birds. Rest disturbance due to the operation of KCD in the Special Protection Area - Birds north, west and south of KCD is assessed as limited.

It can be concluded that the 50 dB nuisance contour extends beyond the site boundaries of KCD and mainly to the east of KCD. It can be concluded here that the reed beds and mudflats present along the banks of the Scheldt and adjacent to the KCD are strongly disturbed by the noise from KCD. On the other hand, this is a continuous noise disturbance and it is reasonable to assume that the avifauna present will show some habituation. This riparian zone is relatively narrow compared to the mudflat and salt marsh zones in the Special Protection Area - Birds north of the KCD (Paardenschor, Schor Ouden Doel), to which the 50 dB nuisance contour from the operation of the KCD does not extend. North, west and south of KCD, the nuisance contour of 50 dB is largely limited to the KCD site itself and there is only a slight overlap with the Special Protection Area - Birds 'Schorren en polders van de Beneden-Schelde'. Based on the fact that the disturbed area along the riparian zone of the Scheldt adjacent to the KCD is rather limited in area and no changes to the noise disturbance by KCD are planned, no significant negative impact is expected on the conservation objectives of the bird species within the Special Protection Area - Birds.

2.5.4.6 Conclusion

In conclusion, the operation of the Doel nuclear power plant will not have a significant negative impact on the conservation objectives laid down for the Special Areas of Conservation SPA-V Beneden-Schelde: schorren en polders op rechter- en linkerscheldeoever and SPA-H Schelde- en Durmeëstuarium van de Nederlandse grens tot Gent. There are no additional effects of the LTO situation compared to the baseline situation.

Based on the appropriate assessment, no mitigation measures are required as no significant negative impacts are expected on the conservation objectives for the SPAs in the study area.

2.5.5 Stricter nature assessment

2.5.5.1 Introduction, background and description of the VEN area

In implementation of the Nature Decree, a Flemish Ecological Network (VEN) was delineated, consisting of Large Nature Areas (GEN) and Large Units of Nature in Development (GENO).

Article 26bis states that it must be demonstrated that an activity that goes ahead in or near a VEN area cannot cause unavoidable and irreparable damage to nature in the VEN (stricter nature assessment).

If a permit is applied for an activity inside or outside the VEN, the government may not grant it if this activity could cause unavoidable and irreparable damage to the nature of the VEN. A municipality, province, ... always asks for advice from the Agency for Nature and Forests in such cases (for example, in the context of a building permit or an environmental permit). Conditions may be imposed to permit or license the works.

Inevitable damage is the damage that one will cause anyway, in whatever way one performs the activity. Avoidable damage is that damage which can be avoided by carrying out the activity in a different way (e.g. with different materials, in a different place...) and is prohibited everywhere in Flanders.

Irreparable damage means that the damage cannot be repaired. Repair of damage, means repair at the site of damage with a quantity and quality of habitat similar to that which was present before the damage.

Therefore, a permit for unavoidable damage that is repairable may be allowed.

The '**Slikken en schorren langs de Schelde' (mudflats and salt marshes along the Scheldt**) are designated as Large Nature Areas (GEN) (area no. 304) and are part of the Flemish Ecological Network (VEN) (See Annex A - Map 17). Since KCD's site is adjacent to this VEN area, an stricter nature assessment will be made.

The Scheldt waterway and the adjacent mud flats and salt marshes are very dynamic due to the tidal effect and have a very high ecological value. The high natural productivity of the ecosystem has repercussions throughout the food chain both in terms of species and numbers. The salt-bracket-fresh gradient present in the tidal zones is important. The landscape-determining structure means that migratory fauna also use this route as a migration route. The riparian zones along the Scheldt form important connections between the larger nature areas (Verdronken land van Saeftinghe), the remaining large brackish water areas (Galgeschoor, Groot buitenschoor, Schor van Ouden Doel) and the more recent compensation areas with mudflats and salt marshes (Ketenisseschor, Paardenschor, Prosperpolder, Lillo-Potpolder,...) along the Scheldt. As a result, the riparian zones have an important network function. These listed zones are all part of this VEN area. The Scheldt banks at the level of KCD also belong to this delimited VEN area.

2.5.5.2 Impact assessment

2.5.5.2.1 Land use

The project will not result in any direct land use on the VEN area.

2.5.5.2.2 Acidification and eutrophication due to atmospheric deposition

The effect description and assessment of acidification and eutrophication due to atmospheric deposition of NOx and SO2 from KCD was done in § 2.5.3.1.2of the Biodiversity section. The methodology described in the practical signposts for airborne acidification and eutrophication was followed for assessing the significance of the effects. No significant negative impacts are expected from acidification and eutrophication as a result of the KCD's operational activities on the adjacent mud flat and salt marsh vegetation in the VEN area 'Slikken en schorren langsheen de Schelde'. There are no additional effects of the LTO situation compared to the baseline situation.

2.5.5.2.3 Rest disturbance

For discussion of the disturbance sensitivity and thresholds of relevant bird species in the vicinity of KCD, please refer to § 2.5.3.1.3.1 and § 2.5.3.1.3.2 of the EIR. Figure 2-60 shows the 45-, 50-, and 55 dB(A) noise contours for the continuously operating sources during the day, evening, and night periods in the 2013-2014 baseline situation. These are the same as in the operational phase 2015-2018 because the source field does not change for this purpose.

For the discontinuous sources (not relevant in the evening and night period as these sources are only tested during the daytime period) it appears that the nuisance contour of 50 dB(A) is located entirely on the site of KCD. Thus, the rest disturbance due to the discontinuous sources of KCD is not discussed further.

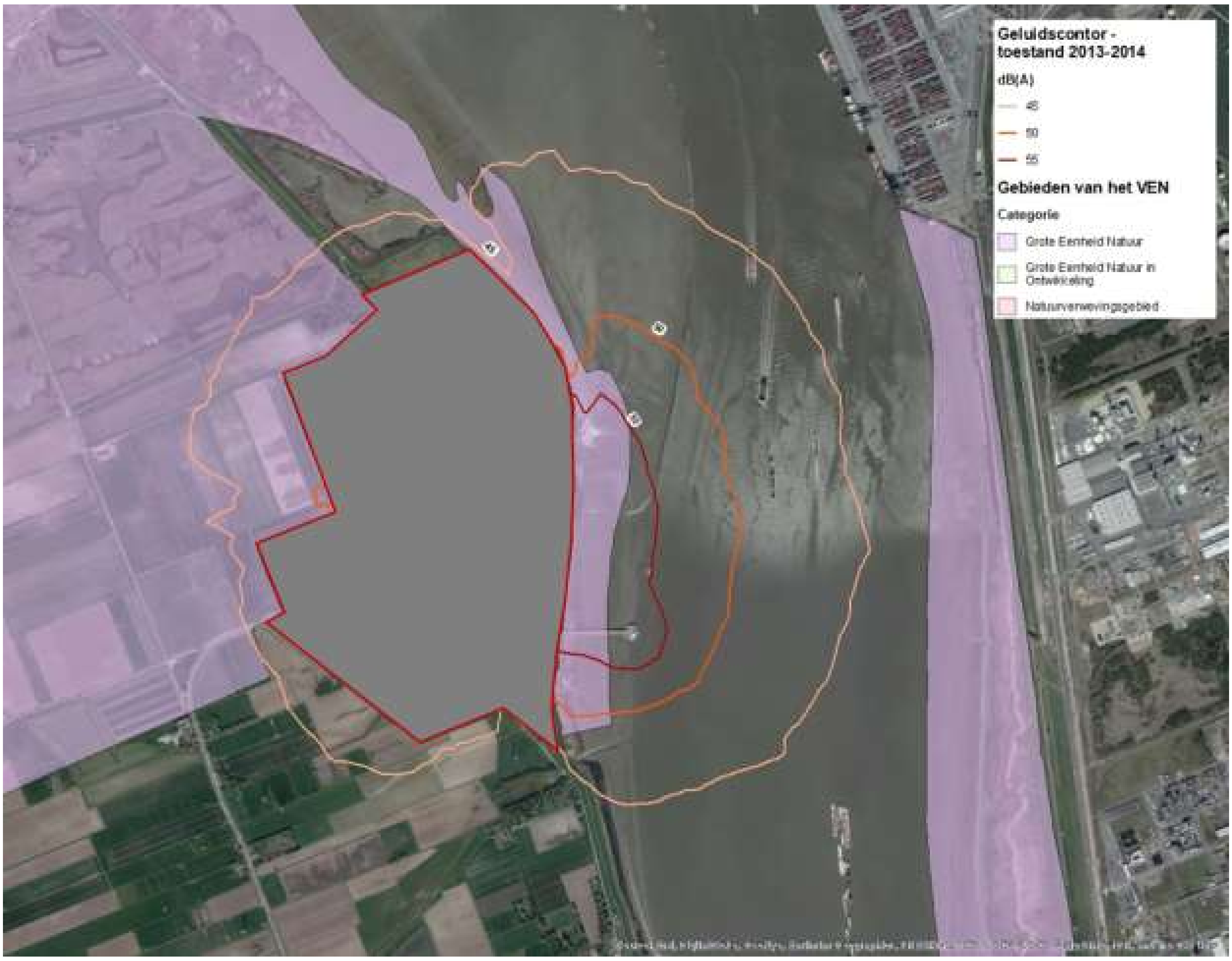

Figure 2-60 noise contours 2013-2014 (= in the operational phase in the future situation) relative to VEN areas

The rest disturbance resulting from the operation of KCD in the period 2015-2018 and in the future situation 2019-2025 can be assessed as follows:

- To the east of KCD, the 55 dB nuisance contour extends into the VEN area. It can be concluded that these reed beds and mudflats along the banks of the Scheldt within the Special Protection Area - Birds and adjacent to the KCD are highly disturbed by the noise coming from KCD. The groups of species found there (small songbirds, waders, grebes, oystercatcher & avocets, etc.) are sensitive to highly sensitive to rest disturbance. On the other hand, this is a continuous noise disturbance and it is reasonable to assume that the avifauna present will show some habituation. The 50 dB nuisance contour does not reach into the Galgenschoor across the Scheldt.
- North, west and south of KCD, the 50 dB nuisance contour is largely confined to the site of KCD itself. Rest disturbance due to the operation of KCD in the VEN area north, west and south of KCD is assessed as limited.

It can be concluded that the 50 dB nuisance contour extends beyond the site boundaries of KCD and mainly to the east of KCD. It can be concluded here that the reed beds and mudflats present along the banks of the Scheldt and adjacent to the KCD are strongly disturbed by the noise from KCD. On the other hand, this is a continuous noise disturbance and it is reasonable to assume that the avifauna present will show some habituation. This riparian zone is relatively narrow compared to the mudflat and salt marsh zones in the VEN area north of the KCD (Paardenschor, Schor Ouden Doel), to which the 50 dB nuisance contour from the operation of the KCD does not extend. North, west and south of KCD, the 50 dB nuisance contour is largely confined to the site of KCD itself. Based on the fact that the disturbed area along the riparian zone of the Scheldt adjacent to the KCD is rather limited in area and no modifications of the noise disturbance by the KCD are planned, no unavoidable and irreparable damage to the VEN area is expected as a result of the operation of KCD. There are no additional effects of the LTO situation compared to the baseline situation.

2.5.6 Monitoring

No monitoring measures are considered necessary.

2.5.7 Mitigating measures and recommendations

No mitigation measures are considered necessary.

2.5.8 Knowledge gaps

No literature data have been found on the temperature at which a flight reaction occurs in fish as a result of a temperature change, therefore the EIR considered the impact assessment with respect to the lethal temperature.

No full analysis of phytoplankton communities is available. Van Damme *et al.* (2003) and Brys *et al.* (2006) state that the phytoplankton communities in the brackish zone do not allow the ecological status to be assessed. A full analysis of the phytoplankton communities is thus not considered meaningful for the assessment of the effects of the temperature increase, as a result of the discharge of cooling water and the operation of the sanitary waste water collection wells of KCD in the EIR.

2.5.9 Conclusions

The impacts of eutrophication and acidification, rest disturbance, water intake, cooling water discharge, and chemicals will not be significantly different in the LTO situation compared to the emissions in the baseline situation. There are no additional effects of the LTO situation compared to the baseline situation.

The impact of KCD on biodiversity is assessed as follows compared to the situation without the operation of KCD:

- Eutrophication and acidification due to atmospheric deposition as a result of the operation of KCD:
  - **Nitrogen deposits** in the operational phase of KCD is max. 0.071 kg N/(ha.year), which is lower than 5% of the critical N deposition values of the European habitat types located in the vicinity of the site. It can be concluded that the nitrogen deposits of KCD in the present project do not have a significant negative effect on eutrophication of the surrounding European habitat types in the Special Protection Area - Habitats 'Schelde- en Durmeëstuarium van de Nederlandse grens tot Gent' and of the mudflats and salt marshes in the (partly overlapping) VEN area 'Slikken en schorren langs de Schelde'.
  - It can be concluded that the **acidifying deposits** of KCD assessed in the present project do not have a significant negative impact on the ecosystems in the study area, since the acidifying deposition of KCD is maximum 5.06 Zeq/ha.year, which is lower than 5% of the critical deposit rates for acidifying deposits of the ecosystems in the vicinity of the site. Therefore, no significant negative effects are expected from acidification as a result of the operational activities of the KCD on the surrounding European habitat types in the Special Protection Area - Habitats 'Schelde- en Durmeëstuarium van de Nederlandse grens tot Gent' and of the mud and salt marsh vegetation in the (partly overlapping) VEN area 'Slikken en schorren langsheen de Schelde'.
  - Rest disturbance: to the east of the KCD, the 55 dB nuisance contour extends into the Special Protection Area - Birds
    'Schorren en polders van de Beneden-Schelde', also designated as the VEN area 'Slikken en schorren langs de Schelde' and as a Ramsar area. It can be concluded that these reed beds and mudflats along the banks of the Scheldt, are highly disturbed by the noise coming from KCD. The groups of species found there (small songbirds, waders, grebes, oystercatcher & avocets, etc.) are sensitive to highly sensitive to rest disturbance. On the other hand, this is a continuous noise disturbance and it is reasonable to assume that the avifauna present will show some habituation. Rest disturbance due to the operation of KCD along the reed beds and mudflats on the banks of the Scheldt, near the KCD, is

assessed as negative. The 50 dB and 45 dB nuisance contours do not extend to the Galgenschoor across the Scheldt.
  - North of the KCD the 50 dB and 45 dB nuisance contours do not reach the protected nature reserve 'Schor Ouden Doel' (negligible effect).
  - To the west and south of KCD, the nuisance contour of 50 dB is largely limited to the KCD site itself and there is only a slight overlap with the Special Protection Area - Birds 'Schorren en polders van de Beneden-Schelde'. The 50 dB nuisance contour does not overlap with the VEN area 'Slikken en schorren langs de Schelde' here. The 45 dB nuisance contour has limited overlap with the Special Protection Area - Birds "Schorren en polders van de Beneden-Schelde" and with the VEN area "Slikken en schorren langs de Schelde". The rest disturbance caused by the operation of KCD in the polder areas to the west and south of KCD is assessed as a slightly negative effect.
- Water intake:
  - KCD extracts cooling water from the Scheldt via a water intake that is divided into two separate components: one for cooling the Doel 1 and Doel 2 units and another, commissioned in 1991, for Doel 3 and Doel 4. The water is always first passed over a sieve to filter out any objects to prevent obstruction of the pipes. However, for the two intakes, this is done in a different way.
  - For the Doel 1 and 2 cooling water intake, mechanical treatment takes place outside the dike, at the level of the water intake, by means of grids on the inlet. Fish and crustaceans cannot enter the cooling water circuit in this way. Therefore, no mortality of fish or crustaceans will be observed at this intake.
  - For Doel 3 and 4, the set-up is different. A cooling water intake system was fitted, in which the water was first gravitated from the Scheldt to a collection pit on the site itself. From that intake, the water is then transported over a system of rotating belt filters. In 1997, a fish protection system was installed at the water intake with a fish-friendly filter system and a drain channel. Sound waves keep fish away from the intake. Because of this noise, the fish are deterred and fewer of them end up in the water intake. Based on the monitoring carried out by KU Leuven (Maes *et al.*, 1996), where it was found that the daily catch for fish and crustaceans without measures was about 22,437 and 50,248 individuals respectively, it can be stated that an average of 1,010 fish die daily and almost no crustaceans as a result of the presence of the water intake of Doel 3 and 4 with the fish protection system. Compared to the fact that the KU Leuven study (Maes *et al.*, 1996) shows that there are approximately 18 million fish and 7 million crustaceans that pass by the plant per hour the impact has been reduced to a negligible level thanks to the various measures taken. On this basis, it can be said that no significant negative effects are to be expected with regard to mortality of fish and crustaceans at the level of water intake. The capacity of the water intake points in the Scheldt will not be changed by the project.
- Discharge of cooling water
  - The most sensitive animal group for thermal discharges are fish. The lethal temperature for fish is highly species-dependent. Fish generally show no effect in the temperature range from 10 to 22°C. Between 22 and 28 to 30°C is a stress zone and lethal consequences occur only above 28°C, due to significant stress. On this basis, it can be stated that under average conditions and virtually throughout the entire year, no

significant negative effects on fish fauna are to be expected. Only the most sensitive species will avoid the zone closest to the point of discharge by swimming away from it. However, species-specific data on the avoidance behaviour and startle reactions of fish with respect to cooling water discharges have not been found in the literature, hence the assessment is mainly based on lethal temperatures. In the area within the breakwater, from 850 m downstream of the point of discharge, the temperature falls below 10°C in winter and spring (Arcadis 2012 monitoring campaigns), which means that the low temperature that fish species such as ruffe and smelt need to induce their reproduction is reached.

  - Sampling of the aquatic organisms within the cooling water plume of KCD by INBO in 2013 (Breine & Van Thuyne) showed that fish are more likely to be found in the area within the breakwater with a higher water temperature. In addition, the area is less dynamic than outside the breakwater. The presence of sea bass, a warmth-loving marine species, demonstrates that this species uses the area within the breakwater as a winter refuge. Sole holds up within and near the breakwater area. Some species use the warmed up area within the breakwaters to reach adulthood. There is therefore an indication that there is an increased abundance of heat-loving native species (sea bass and sole) within the breakwater. Finally, discharge of cooling water can be important for the survival of thermophilic exotic species. Sampling of the aquatic organisms within the cooling water plume of the KCD by INBO in 2013 (Breine & Van Thuyne), showed no marked presence of exotic species in the area within the breakwater and there is no increased abundance of exotic species within the breakwater.
  - Based on the previous impact discussion, the impact of the KCD's cooling water discharge on the aquatic communities in the Lower Scheldt is not considered to be considerably negative.

- Discharge of chemicals: During the operation of KCD, the following effluents are produced: sanitary wastewater, industrial wastewater and cooling water. The discharge of nutrients into the Scheldt can cause eutrophication. The discharge of hazardous materials into the Scheldt can cause ecotoxicological effects:
  - Eutrophication:
    - For the nutrient parameters nitrate+nitrite+ammonium and orthophosphate an annual average negligible contribution is calculated in the Water Section. Therefore, no significant eutrophying impact is expected on an annual average basis from the discharge of the KCD to the Scheldt. In the Water section, frequent operation of the sanitary waste water collection wells was found. Although the load is rather limited, these operations can create peaks of nutrient concentrations in the Scheldt at the level of KCD, in the area within the breakwater where the discharge of the sanitary and industrial wastewater and cooling water of the KCD takes place.
    - It can be assumed that the frequent operation of the sanitary waste water collection wells of KCD contributes to a limited extent to the problem of eutrophication in the Scheldt, albeit locally at the discharge point of the KCD in the area within the breakwater. However, to what extent this leads to an increase in algal blooms and a reduction in visibility for predatory fish, a shift in the species composition of phytoplankton, and an increase in the biomass production of the higher trophic levels

in the area within the breakwater, is not known. The cumulative impact of the physical characteristics (tidal dynamics, residence time, turbidity, depth) and of the temperature increase of the area within the breakwater, within which the discharge of the sanitary and industrial wastewater and cooling water from the KCD takes place, on the degree of eutrophication is also unknown. Van Damme *et al.* (2003) and Brys *et al.* (2006) state that the phytoplankton communities in the brackish zone do not allow the ecological status to be assessed. A full analysis of the phytoplankton communities is thus not considered meaningful for the assessment of the effects in the EIR. In order to reduce the operation of the sanitary waste water collection wells of KCD, the Water section recommended looking into the feasibility of disconnecting the rainwater system from the sanitary wastewater system (source-based measure) and the possibility of installing an additional collection volume for sanitary wastewater (end-of-pipe measure) at concept level and according to the Best Available Techniques.

- Ecotoxicological effects:
  - Sodium hypochlorite (NaOCl) is added to the cooling water to prevent biofouling. Biofouling is the process by which mainly sessile organisms, such as oysters, mussels, etc. attach themselves to the inlet and outlet pipes of, among other things, cooling water systems. The addition of sodium hypochlorite NaOCl should counteract this biofouling.
  - The NaOCl reacts to form chlorides. No active chlorine above the detection limit is found in the discharged cooling water (<100 µg/L). Active chlorine is considered to be an acutely toxic substance. For active chlorine, the concentration at which fish are not affected appears to be below 1 µg/l. Active chlorine is not very persistent and will disappear in surface water fairly quickly (the degradability has an order of magnitude of minutes). However, the conversion rate is impacted by many factors (temperature, degree of mixing in surface water, reducer content) (Berbee, 1997). The levels of active chlorine in KCD's discharged cooling water are below 100 µg/l. It can be concluded that at times of discharge of active chlorine, acute toxicological effects for aquatic organisms can occur locally around the discharge point for a short period of time (slightly negative effect).
  - Currently, the dosing of NaOCl at KCD is based on the analysis of the excess active chlorine and experience with the cooling speed gasket. Any additional doses are based on the control of biological growth on sample plates in the cooling towers and weight measurements of the gasket. No active chlorine above the detection limit is found in the discharged cooling water (<100 µg/L). To monitor active chlorine in cooling water based on the shock dosage of NaOCl, it is recommended to perform the monitoring of active chlorine with an online measuring sensor, with a detection limit up to approx. 10 µg/L (instead of 100 µg/L in the existing condition). This in order to be able to refine the control of the dosage of NaOCl with the aim of a lower NaOCl consumption, lower active chlorine levels in the discharged cooling water and less AOX formation.

2.6 Landscape, architectural heritage & archaeology

Annex A - Map 20: Listed immovable heritage

Annex A - Map 21: Established inventories

Annex A - Map 22: Scientific inventories

2.6.1 Methodology

2.6.1.1 Definition of the study area

The study area for the Landscape, architectural heritage & archaeology section is the site of the KCD and its immediate surroundings. Especially valuable heritage that has a visual relationship with the site, such as Lillo, is taken into account.

2.6.1.2 Description of baseline situation

When discussing the baseline situation, we provide a description of:

- The historical evolution of the landscape: this description is based on available literature and historical maps;
- valuable heritage: freely consultable databases and data on the geo-portal of immovable heritage are used for this purpose;
- the visual landscape at micro level: this is described on the basis of a site visit, photomontage, etc.

2.6.1.3 Description and assessment of the impact

The changes made to KCD with a view to LTO may impact the environment. The location of these changes is limited to the boundaries of the KCD site. Disruption may take the form of visual changes of the site, due to changes in the infrastructure and of disruption of the soil during excavation work. Relevant effects for the Landscape, architectural heritage & archaeology section are therefore visual changes that have a visual impact on the landscape and disruption of landscape relics and heritage. The landscape may also be affected by the processes associated with the KCD. The most typical example is (historic) buildings being affected by acid rain. This can lead to a disruption of landscape relics and heritage. Other effects due to changes in groundwater level or soil or effects of noise and vibrations are not considered.

The expected effects for the Landscape, architectural heritage & archaeology section will be described as follows:

- changes with a visual impact on the landscape: qualitative assessment of visual features;
- disruption of landscape relics and heritage: qualitative assessment of the impact on the existing heritage.

Both effects may occur during both the operational phase of the project between 2015-2018 and the operational phase in the future situation (period 2019-2025). The effects that may occur during the Post

Operational Phase (period 2025-2029) and the zero alternative are also described. A qualitative perspective is applied.

The impact assessment is carried out as follows:

- changes with a visual impact on the landscape:
    - considerably negative: Strong visual disruption of large-scale heritage elements;
    - negative: Temporary strong visual disruption of heritage elements OR permanent disruption of a reasonable magnitude;
    - slightly negative: Temporary visual disruption of heritage elements and disruption of a rather limited scale;
    - negligible: No or negligible visual disruption of heritage elements;
    - limited positive: Temporary improvement of the visual features of heritage elements or improvement of limited size;
    - positive: Improvement of the visual features of heritage elements of a reasonable size (local level);
    - significantly positive: Permanent improvement of the visual features of large-scale heritage elements;
- disruption of landscape relics and heritage:
    - considerably negative: Destruction/permanent disappearance of listed valuable landscape, architectural or archaeological heritage;
    - negative: Destruction/permanent disappearance of non-listed landscape or architectural heritage values included in the landscape atlas or in the list of architectural heritage. Destruction of undocumented archaeological heritage;
    - slightly negative: Temporary modification/limited impairment of heritage elements. Impairment of documented archaeological heritage;
    - negligible: Negligible effects. No heritage present. No indications of and low probability of the presence of archaeological heritage;
    - positive: Preservation of valuable heritage, with possible improvement of the context.

2.6.2 Baseline situation

2.6.2.1 Historical evolution of the landscape

Natural-physical evolution of the landscape

During the Tertiary, the north of Belgium was still covered by the North Sea. The section with the province of Antwerp and Limburg formed the Kempen Basin. As layers of sediments were deposited by the sea over time, the Kempen Basin was filled layer after layer. A number of major sand layers have created an important aquifer of more than 300 m wide in the middle of the province of Antwerp, the largest in Flanders. At the beginning of the Quaternary, only the northern part of the province of Antwerp was covered by the sea. Only very fine materials were deposited such as fine sands, but locally also a clay layer. This layer never exceeded 8 meters in thickness. During the penultimate ice age, some 200,000 years ago, the sea level dropped so drastically (the ice reached the area of Amsterdam) that it was up to 130 m lower than the North Sea today, at the coldest time. As a result, most of the North Sea dried up, which led to erosion. Flanders' current river system, which had already formed to a large extent at that time, created its own deep valleys. All rivers flowed in a westerly direction. The Lower Scheldt, from Rupelmonde, did not yet exist. The result was a large elongated valley with an east-west main axis, 10 to 20 km wide, and a strong widening to 40 km northwest of Ghent. This area is called the "Flemish Valley". At the end of this ice age, 100,000 years ago, ice caps started to melt and the sea level started to rise. The sea reached quite deep into this Flemish valley, as far as the mouths of the rivers Dender and Zenne and almost reaching Mechelen. As a result, the valley was partly filled with sand and a few thin layers of clay, with a maximum thickness of 30m. After the sea had withdrawn from the Flemish Valley, erosion started levelling the relief again. River valleys were filled again, with material from the intermediate areas. The heavily loaded rivers clogged their own beds until some 10,000 years ago, the water found a new way out to the sea via the Lower Scheldt[30].

The extensive polder area on the river Scheldt is almost completely flat. The minor differences in elevation of the polder surface are usually due to, on the one hand, higher silted up strips in the young polders and, on the other hand, the depressions in the lower lying older polders. However, large parts of the polders were raised with sand. Along the entire edge of the polders, a number of watercourses started springing up. Water runs from the edge of the polder towards the polder via an almost artificially rectilinear network of canals, where several brooks drain water to the river Scheldt.

Historical evolution of the cultural landscape

During the Middle Ages, there was widespread deforestation. This caused a large-scale run-off of soil from the slopes and deposits of large quantities of alluvium in the valleys (Nieuwborg, 1996).

In the 8th and 9th centuries, the first river embankments were created in the basin of the Lower Scheldt to reclaim land and prevent spring tides (Kruibeekse and Rupelmond polders). From the 12th and 13th centuries, the first winter dikes were erected. As a result, large areas of mudflats and salt marshes were lost and polders were created which were used as hay meadows. In the 19th century willows, alders and poplars were planted in the polders (Nieuwborg, 1996).

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[30] http://dov.vlaanderen.be/html/geologieSchetsWeb.pdf

The great significance of the Scheldt and its tributaries as a shipping route led to a strong industrialisation of the valleys, resulting in the construction of industrial and port areas, shipyards and an extensive road network. From the 19th century onwards, the Scheldt polders on the right bank and later also on the left bank were raised and strongly industrialised.

KCD's premises are located in the traditional landscape 'Scheldt Polders West of the Scheldt'. In terms of landscape, the open polders contrast sharply with the harbour and industrial buildings (Antrop & Van der Reest, 2001). The perceived influence of the vertical structures of the port area (e.g. cooling towers of KCD) are an essential part of the current landscape. However, valuable landscapes have been preserved or created on the polder relics and the raised lands. The open agricultural land is bordered by planted dikes and the Scheldt polders are home to small villages and hamlets. The dykes are a very typical feature of this landscape with a high relict value and they are also home to valuable nature elements. The most important landscape elements of the polders are the dikes, ditches and brooks.

2.6.2.2 Valuable heritage

Below, the valuable heritage that was part of the baseline situation (2013-2014) is described, according to the classification structure enshrined in the current Immovable Heritage Decree.

Listed immovable heritage

The 'Slikken en schorren van Oude Doel' (mud flats and salt marshes of Oude Doel), which are located near and downstream of the KCD, are listed as a cultural-historical landscape. These mudflats and salt marshes are part of the brackish water marshes along the Scheldt, north of Antwerp. These are the relics of an extensive system of lands outside the dikes, which were repeatedly diked and converted into fertile agricultural land.

The mudflats and salt marshes of Oude Doel are listed for their scientific value. They have great geomorphological value because they are a relic of an originally very extensive and complex system of lands outside the dikes. In addition, the vegetation present is rare and forms an important habitat for birds (resting and foraging area for water birds).

There is a 'British War Memorial' located on the Scheldt dike (Zoetenberm) at the northern edge of the KCD site. This monument is a listed monument.

In the vicinity of the KCD site, the following listed real estate heritage is still present:

- Listed cultural-historical landscape:
  - Groot Buitenschoor - Galgeschoor (Scheldelaan, Lillo);
- Listed townscape:
  - Sint-Engelbertusstraat (Sint-Engelbertusstraat, Kieldrecht);
  - Groothof, Prosperhoeve and manor farm and surroundings (Belgische Dreef, Kieldrecht);
  - Lillo Fortress with ferry and tidal harbour (Lillo);
- Listed monument:
  - Stone windmill (Scheldemolenstraat, Doel);
  - Hooghuis (Hooghuisstraat, Doel);
  - Presbytery of the St. Engelbertus parish with garden (Engelbertusstraat, Kieldrecht);
  - The St. Engelbertus parish church (Engelbertusstraat, Kieldrecht);

- The cemetery site of St. Engelbertus parish (Engelbertusstraat, Kieldrecht);
- Manor farm with mill and forge equipment (Belgische Dreef, Kieldrecht);
- Lillo Fortress: rampart (Lillo);
- Lillo Fortress: powder magazine (Kazerneplein, Lillo);
- Lillo Fortress: facades and roofs of officers' houses (barracks square, Lillo);
- Lillo Fortress: casemates (Kazerneplein, Lillo);
- Grain windmill De Eenhoorn (Scheldelaan, Lillo);

Established inventories

There is scattered architectural heritage in the vicinity of the KCD. This is mainly farms and houses. Also the school, presbytery, parish church, train station and windmill of Doel have been identified in this architectural heritage inventory.

Near Prosperdorp, architectural heritage (included in the established inventory) is found within the demarcated listed villagescape Sint-Engelbertusstraat. It includes the Sint-Michiels school, the sexton's houses and some corner houses, villas and manor houses as well as the listed monuments mentioned above. The transverse barn of the 't Weideland farmhouse has also been included in the established architectural heritage inventory.

Near Lillo, the Lillo fortress has been identified in the architectural heritage inventory. In addition, the town hall, the toll booth and the parish church of Sint-Benedictus-Haven are also identified in this inventory.

Scientific inventories

KCD's site is surrounded in the north and east by the landscape units 'Brackish water marshes along the Scheldt, north of Antwerp' (Brakwaterschorren langsheen de Schelde ten noorden van Antwerpen). This valuable heritage, included in the scientific inventory, consists of the salt marshes area (Galgeschoor, Groot Buitenschoor and Schorren van Doel) along both banks of the river Scheldt north of Antwerp between the border with the Netherlands and the former polder village of Lillo. In addition, part of the historical polder village Doel, as well as the Prosperpolder and Prosperdorp were included. The area is enclosed on the east side by industry and port infrastructure; the southern boundary is the Liefkenshoek tunnel.

These are the relics of an extensive and complex system of 'land outside the dikes' which has been continually diked and converted into fertile farmland throughout history, with varying opportunities. The open and natural character of the entire area results in an aesthetically valuable 'green' enclave, within the industry and infrastructure of the Port of Antwerp. The polder village Doel is a rare and historically valuable remnant of the old, small residential centres along the Scheldt. The salt marshes and mudflats are extremely rare on a national scale and are home to a rare flora. The area is also an important resting and foraging area for water birds.

To the west of the KCD's site, in the open polder landscape, there is a willow tree, which acts as a chapel tree in the Prosperpolder. This tree is a landscape element included in the scientific inventory. The solitary narrow-leaved willow stands along a dirt road starting from the Polderdijk on the edge of a meadow plot in the Prosperpolder. The tree may have been planted to mark the administrative boundary between Doel and Kieldrecht. A small tree chapel is attached to the trunk.

A 'British War Memorial Second for the World War' on the Scheldedijk (Zoetenberm) on the northern edge of the KCD site is included in the 'architectural heritage' scientific inventory.

Archaeology
No known archaeological traces have ever been found near KCD (according to the Central Archaeological Inventory Database). Nor is the site designated as an area without archaeological heritage (Heritage Geoportal).

The original lands (polder, mud flats and salt marshes) on the KCD site - as in the rest of the port area on the left and right banks of the Scheldt - were raised using dredged sediment in the 1960s. The replanted soils are of anthropogenic origin and predominantly consist of sand. There may be archaeological traces underneath these elevations.

2.6.2.3 Visual landscape at a micro level

Layout of the current infrastructure.
For the general layout of the KCD site and the individual buildings on this site, see the General section of this EIR (Chapter 1). The elements that determine the structure of the power station's layout are of course the various nuclear units themselves. The units form blocks, which are oriented roughly along an east-west axis. Doel 1 and 2 form a single block, while Doel 3 and Doel 4 form a separate block. Each of these blocks forms a power plant in itself including all of the functions associated with it. Along the river Scheldt there are also 2 cooling towers, which largely determine the view of the power station, due to their height of about 168m. The electricity produced is distributed via overhead lines. The high-voltage pylons are also regarded as beacons in the open and flat polder landscape.

Visual situation of KCD
Photographs of the KCD were taken from different points, to visualize its presence in the landscape. Figure 2-61 shows the location where the photos were taken. They are numbered 1 to 6. We used Google Street view, for the pictures. The photos date back to the baseline situation, i.e. October 2013.

The photos show that the KCD site is an important landmark in the open and flat polder landscape, from all directions, mainly because of the 168 meter high cooling towers, which dominate the view of the power station. The closer you get to the power station, the more the typical dome-shaped reactor buildings appear as landmarks. The cooling towers and the entire nuclear power plant are a beacon in the landscape.

From the polder, the harbour landscape behind is visible. However, the KCD site does not completely merge with the industrial background. The distances to the right bank or to the Deurganck dock - the nearest industrial zones - are too large.

The electricity produced is transported via overhead lines, both in a southern and a northern direction. Along the northern side, the overhead line runs across the rive Scheldt in the direction of the BASF site. Along the south the above-ground powerlines lead to the Waasland port, in the direction of the Deurganck dock. The western and northern polders are spared as much as possible.

In summary, it can be concluded that the nuclear power plant is an important visual anchor point in the landscape. However, by connecting the industrial site to the existing industrial landscape formed by the port, there is spatial support for the large-scale industrial elements present.

Figure 2-61 Location of the photos

Photo at point 1, Oostlangeweg (source Google street view - October 2013)

Photo at point 2, Scheldemolenstraat (source Google street view - October 2013)

Photo at point 3, Belgischedreef (source Google street view - October 2013)

Photo at point 4, Petrusstraat (source Google street view - October 2013)

Photo at point 5, Engelsesteenweg (source Google street view - October 2013)

Photo at point 6, Scheldemolenstraat (source Google street view - October 2013)

2.6.3 Impact assessment

2.6.3.1 Operational phase of the project between 2015-2018

For a description of the works carried out in the context of the adjustments for LTO, see the general section of the EIR (see Chapter 1.6). This situation is compared to the situation without the operation of KCD but with still the presence of the current buildings and systems of KCD.

2.6.3.1.1 Disruption of landscape relics and heritage

The interventions to KCD for the purpose of the LTO were located within the boundaries of the KCD site.

The grounds where the works took place were raised in the past and then excavated. Any archaeological potential is therefore only expected underneath the embankments. The excavation work was limited to the embankment, so that there was no disruption of any archaeological heritage present.

There is no other heritage within the site that could be impacted by the works.

The disruption of landscape relics and heritage is considered to be negligible.

2.6.3.1.2 Changing the visual impact on the landscape

The visual disruption caused by the LTO works was only temporary in nature. This disruption was caused by the construction works and the storage of excavated soil and materials.

The works were located on the east side of the site. This disruption was largely shielded by the existing buildings and dikes. This is the side, however, where the listed cultural-historical landscape 'Slikken en schorren van Oude Doel' (mudflats and salt marshes of Oude Doel) and the landscape units 'Brakwaterschorren langsheen de Schelde ten noorden van Antwerpen' (Brackish water marshes along the Scheldt, north of Antwerp') are located.

Given the temporary nature of the visual disruption, the shielding provided by the intermediate dike and the current industrial context at the level of the works, the visual impact on the existing heritage in the landscape is considered to be negligible.

2.6.3.2 Operational phase in the future situation (period 2019-2025)

2.6.3.2.1 Disruption of landscape relics and heritage

As far as the operational phase in the future situation is concerned, only the airborne effects on valuable heritage and elements of the landscape are considered to be potentially relevant. Airborne effects are mostly the result of air pollution, with the impact of acid rain being one of the best known effects. Acidification is a term that refers to the effects of acids being deposited in the environment as a result of SO_2 being converted into sulphuric acid (H_2SO_4) and NO_x into nitric acid (HNO_3) via NO_2. Deposition of these acids leads to changes in vegetation and degradation of buildings.

The new diesel generators provided for under LTO are subject to much stricter emission limits than those for legacy systems. In addition, low-sulphur diesel is used as fuel. The emissions of the new systems will be negligible compared to the total emissions of the Doel 1 and Doel 2 engines.

The discussion of the effects in the Air section showed that emissions into the air by the KCD are too limited to impact the environment.

Consequently, no disruption of landscape relics and heritage is to be expected (negligible).

2.6.3.2.2 Changing the visual impact on the landscape

From a landscape point of view, the project does not bring about any relevant changes compared to the baseline situation. The baseline situation of the nuclear power plant continues almost unchanged, with the exception of a few new installations, namely the Filtered Containment Vent and the pump building. However, these systems are small compared to the current scale of the cooling towers and reactor buildings. As a result, the visual impact of KCD on the environment will hardly change at all. The new installations are designed (size, colour and materials) to integrate as well as possible into the overall architecture of KCD's existing buildings. Consequently, no additional disruption will occur with regard to the listed cultural-historical landscape 'Slikken en schorren van Oude Doel' (mudflats and salt marshes of Oude Doel) and the landscape units 'Brakwaterschorren langsheen de Schelde ten noorden van Antwerpen' (Brackish water marshes along the Scheldt, north of Antwerp').

From the point of view of other valuable heritage in the area, the changes resulting from the new installations are not visible as they are visually shielded by the existing buildings and dikes. By way of illustration, some photos of the current situation are shown that were taken at the same locations as in 2013 (Figure 2-61).

The visual impact on the landscape is therefore assessed as negligible.

Photo at point 1, Oostlangeweg (ARCADIS - August 2020)

Photo at point 2, Scheldemolenstraat (ARCADIS - August 2020)

Photo at point 3, Belgischedreef (ARCADIS - August 2020)

Photo at point 4, Petrusstraat (ARCADIS - August 2020)

Photo at point 5, Engelsesteenweg (ARCADIS - August 2020)

Photo at point 6, Scheldemolenstraat (ARCADIS - August 2020)

Lastly, a photo has been added from the right bank, across the Scheldt (Scheldelaan). The adjustments made in the context of LTO are not visible at this location.

Photo at Scheldelaan (source: Google street view - August 2019)

2.6.3.3 Post Operational Phase (period 2025-2029)

During the Post Operational Phase, no changes to the infrastructure of the KCD site will be made involving excavation or construction works. Consequently, the visual impact on the landscape of KCD will not change (negligible).

The Air section shows that during the POP the diesel generators will continue to run as in the baseline situation. However, the emissions are too limited to give rise to a disruption of landscape relics and heritage as a result of acidification. The effect on landscape relics and heritage is therefore negligible.

2.6.3.4 Zero alternative

In the zero alternative (= no LTO), no interventions took place in the context of the lifetime extension of Doel 1 and 2. Therefore, no disruption of the visual landscape caused by construction works and additional infrastructure would therefore have occurred. It should be noted that this disruption in the LTO situation is assessed as negligible

The Air section shows that in the zero alternative (i.e. with Doel 1 and 2 no longer in operation), emissions in 2015 would decrease to a limited extent compared to the baseline situation. However, KCD's airborne emissions are too limited to give rise to a disruption of landscape relics and heritage as a result of acidification. Consequently, no change in the impact on landscape relics and heritage is expected. The effect remains negligible.

As far as the Landscape, architectural heritage & archaeology section is concerned, it can be concluded that there is no difference between the POP in 2015 (= zero alternative) or in 2025.

2.6.3.5 Cumulative effects

As far as the Landscape, architectural heritage & archaeology section is concerned, no cumulative effects are expected with other projects in the area.

2.6.3.6 Cross-border effects

No cross-border effects are expected for the Landscape, architectural heritage & archaeology section.

2.6.4 Monitoring

For the Landscape, architectural heritage & archaeology section, no monitoring and evaluation measures are needed.

2.6.5 Mitigating measures and recommendations

No mitigating measures or recommendations are necessary for the Landscape, architectural heritage & archaeology section.

2.6.6 Knowledge gaps

There are no gaps in knowledge.

2.6.7 Conclusions

The impact of the works that have taken place in the context of the adjustments for LTO can be assessed as negligible for the Landscape, architectural heritage & archaeology section. There are no additional effects of the LTO situation expected, compared to the baseline situation.

The effects of the POP and the Zero Alternative are also negligible.

2.7 People - Health and Safety

Annex A - Map 3: Regional Plan

Annex A - Map 4: Regional Spatial Implementation Plan

Annex A - Map 23: Soil use

Annex A - Map 24: Vulnerable functions

Annex A - Map 25: Sites of Seveso companies

Annex A - Map 26: Map with differences NO2 LTO

Annex A - Map 27: Map with differences NO2 no LTO

2.7.1 Methodology

2.7.1.1 Definition of the study area

The study area for this discipline is defined by a 5 km area around the company site. If the analysis shows that the potential effects reach further, a larger zone will be studied.

2.7.1.2 Description of baseline situation

According to the new book of guidelines for People - Health, the description of the reference situation is done in the first step of Phase A:

- PHASE A: Inventory (pre-phase)
  - Step 1. Description of land use and population concerned: This phase includes the description of land use and the population concerned in the study area.

In addition, a description is given of the acoustic climate and air quality at the level of the study area. For this, we refer to the sections on Noise & Vibrations and Air & Climate.

2.7.1.3 Description and assessment of the impact

According to the new book of guidelines for People - Health, the impact description and assessment is carried out in the following steps:

- Step 2. Identification of potentially relevant environmental stressors:
  - The expert lists all potential (relevant) environmental stressors originating from the activities. Potential chemical stressors that are relevant and discussed within the EIR are included in a sector-specific list. For KCD, this is the "power plants" sector. For this sector, emissions to air include SO_X, NO_X, ozone, N_2O, CH_4, PAHs, metals, $PM2_{.5}$, PM_{10} and dioxins. However, since there is only combustion of diesel fuel, only SO_X, NO_X, PAHs, $PM_{2,5}$, PM_{10} are emitted. Ozone is a secondary pollutant and therefore no dispersion modelling can be performed.

    In addition, additional chemical stressors can be defined by the abiotic EIR sections (i.e. CO).

Table 2-58 List of the stressors and related health impacts for the project

Stressors	**Specific description of the stressor and/or source, health impact**	**Argument why stressor, if present, is not included**
Chemical stressors		
Air pollution	Emissions from construction site machinery and site traffic Emissions from the operation of KCD	The air section shows that the impact on air quality, both in the construction phase and in the operational phase, is negligible. Therefore, no relevant health effects are expected.
Soil and groundwater pollution	Accidental emission	In the event of any accidental emission, in line with the Soil Decree, immediate action must be taken. Within the KCD, the necessary measures are taken to avoid deterioration of soil and groundwater quality. In addition, soil legislation imposes immediate intervention in the event of accidental contamination. Exposure to accidental soil or groundwater pollution is therefore not further investigated in the People - Health section.
Surface water pollution	Discharge of waste water	Sanitary waste water is discharged into the Scheldt after treatment in 5 biorotors. The industrial waste water is collected and discharged into the Scheldt, either separately or after treatment. Since the Scheldt water is not used for drinking water abstraction, nor as recreational water, exposure to pollution via surface water is not relevant and is not further investigated in this section.

Stressors	Specific description of the stressor and/or source, health impact	Argument why stressor, if present, is not included
Odour	The main combustion gases emitted are odourless (CO, NO and CO_2) or only detectable at high concentrations (NO_2)[31]. Other substances with a typical odour in KCD are ammonia and hydrazine, but their storage characteristics avoid odour emissions. Odour nuisance is therefore not further investigated in the discipline People - Health.	/
Physical stressors		
Noise	Noise emissions from construction site machinery and site traffic Noise emissions resulting from the operation of Doel 1 and 2.	/ (Possible health effects due to noise emissions will be investigated)
Vibrations	The new filter building for Doel 1 and 2 was founded on bored piles (filter building Doel 1 and 2). This does not cause any perceptible vibrations off-site.	/
Wind	Despite the presence of tall buildings (cooling towers), no relevant wind nuisance is to be expected given the distance to the houses.	/
Light, shadow	Shadow of the steam plume (operational phase)	/ (It will be investigated whether the shadow cast by the steam plume causes nuisance)
Heat	Discharge of cooling water into the Scheldt	No effects on human health are to be expected from the thermal effects of the

[31] Nitrogen dioxide has a pungent, irritating odour. The odour threshold lies between 100 µg/m³ and 410 µg/m³. However, due to adjustment, no odour was observed in case of a gradual increase (15 minutes) in the concentration from 0 to 51000 µg/m³ (source: WHO, Air Quality Guidelines, 2000).

Stressors	Specific description of the stressor and/or source, health impact	Argument why stressor, if present, is not included
		discharge of cooling water into the Scheldt.
Electromagnetic radiation	No effects of electromagnetic radiation outside the site boundaries of KCD are expected.	/
Biological stressors		
Infection risk	Cooling towers may pose a risk of Legionella development (operational phase)	/ (The risk of exposure to Legionella will be assessed on the basis of the history of possible infections and existing preventive measures)
Acute poisoning by toxins	There are no relevant sources of biological toxins associated with the construction or operational phase of KCD.	/
Chronic toxicity	There are no relevant sources of chronic toxicity of biological origin associated with the construction or operational phase of KCD.	/
Allergens	There are no relevant sources of allergens associated with the construction or operational phase of KCD.	/
Nuisance from pests	There are no elements that attract pests during the construction or operational phase of KCD.	/
Other		
Dust problems	Dust precipitation during the construction phase	The houses are located at a sufficient distance from the KCD. In addition, the works must be carried out cf. the Vlarem requirements, to reduce dust deposition as much as possible.
Proximity of green space	Occupying green space	Adjustments within the framework of LTO only take place within the boundaries of the KCD site. The site is closed off with a fence. This means that the site does not

Stressors	Specific description of the stressor and/or source, health impact	Argument why stressor, if present, is not included
		currently have a public function. Proximity to green space is therefore not relevant in the discipline People - Health.
Psychosomatic aspects	Concern from local residents about the activities at KCD (operational phase)	/ (Possible psychosomatic effects related to the operation of KCD will be investigated)

- PHASE B: Environmental Impact Report (EIR phase)
  - Step 3. Inventory of stressors: Potentially relevant environmental stressors are listed. The relevance is tested against the selection criteria for further health assessment of exposure (different per stressor). Exposure data are provided as a result of modelling, measured external concentrations (emissions, immissions), calculated estimates or qualitative assessments.
  - Step 4. Health impact assessment: A health risk analysis involves the study of physical, chemical and biological agents in the living environment that can have a (relevant) impact on health. In order to assess the impact of an activity/institution on the health of the population concerned in the study area in the EIR, the following is taken into account:
    - the severity of the change in the environment - if relevant - tested against the extent to which advisory values are exceeded;
    - the extent and nature of existing environmental pressures and the size of the population concerned
- PHASE C: Post-evaluation
  - Step 5: Post-evaluation:
    - The initiator of the project formulates proposals to follow up certain stressors caused by the project over time. These may include the type of environmental measurements, health records, complaints recorded and treated, public inquiries, organisation of communication (about risks), follow-up of scientific literature, cooperation with government agencies or local health professionals (e.g. medical environment specialists), or possible local sounding board groups.

2.7.2 Description of land use and population concerned

Table2-59 provides an overview of various aspects of the land use in the study area.

Table2-59 Land use in the study area of the site

Land use & population	Unit	Area of influence		Argument
		Number or % of the area	Distance & wind direction to source	
Land use				**Source: Geopoint, regional plan, orthophoto**
Kindergartens	number	6	2 at 4.5 km - NE 4.7 km - NE 4.8 km - NE 4.9 km - NE 4.9 km - SW	
Kindergartens	number	3	4 km – NE 4.4 km - NE 4.9 km - NE	
Primary school	number	3	4 km – NE 4.4 km - NE 4.9 km - NE	
Secondary education	number	0		
Playgrounds, holiday accommodations	number	0		
Sports grounds, scouting grounds, forest play areas, etc.	number	10	4.2 km – NE 4.3 km – NE 4.5 km – NE 4.6 km - NE 4.7 km - NE 2 at 5 km - NE 3.7 km - E 500 m - S 3 km - S	
Hospitals	number	0		
Old people's homes / residential care centres	number	2	4.6 km - NE 4.7 km - NE	
Residential area	% of study area	2%	900 m - S	Doel
Agricultural activity	% of study area	25%	100 m - W	Polder area
Water catchment area: surface water + groundwater	% of study area	17%	800 m - E	Scheldt
Green area / nature	% of study area	19%	600 m - E	Paardenschor, Schor Ouden Doel, Galgenschoor
Industrial area	% of study area	36%	1.5 km - S	

Land use & population	Unit	Area of influence		Argument
		Number or % of the area	Distance & wind direction to source	
Other: recreational area, motorways, community facilities area and public utility area	% of study area	0.4%		

The KCD is bordered by polder areas.

Within a 5 km radius around the project area, the population density is rather limited. This perimeter includes a large part of the port of Antwerp, the Scheldt and the sparsely populated polders. The number of people in the vicinity of the plant (in a radius of 2,000 m around the site) is very limited. A maximum of 150 people live a short distance from the power station.

Table 2-60 Population in a 2 to 5 km radius around the Doel nuclear power plant (source: Statbel)

	Population of statistical sectors in a 2 km radius around KCD	Population of statistical sectors in a 5 km radius around KCD
2014	146	10445
2015	141	10486
2016	136	10521
2017	121	10557
2018	110	10680
2019	110	10685

In the centre of the polder village of Doel, about 900 m south of KCD, there are about 20 inhabitants. The population in the village of Doel has been declining for many years under the influence of port developments and housing insecurity.

In the regional SIP 'Delimitation of the Antwerp Seaport Area' established in April 2013, the plan was for the hamlets of Ouden Doel and Rapenburg to be expropriated to build the Saefthinge dock and create nature compensations. This SIP was partially suspended by the Belgian Council of State in December 2013 because the nature compensations had to precede the port development. This meant that Doel (residential area), was again subject to regional zoning laws. For the port development on the left bank, a modified SIP was adopted in October 2014. This SIP was annulled in December 2016. In May 2017, the Council of State also annulled the April 2013 SIP relating to the right bank of the Scheldt area.

As a result, a starting decision was taken in July 2016 to perform a strategic analysis of the construction of additional container handling capacity in accordance with the 'Complex Projects' procedure. On 20 December 2019, the Flemish Government adopted the preferential decision on the complex project

"Realisation of additional container handling capacity in the Antwerp port area" ("CP ECA") in principle, which will create additional space for container handling capacity in several places, but without the need for Doel to disappear. In cooperation with the parties involved in a 'Doel Working Group', the Flemish government is working on a future perspective for Doel.

There are no other residential areas in the immediate vicinity of KCD. However, there are various housing units and residential clusters scattered throughout the polders, including in the polder hamlets of Ouden Doel, Rapenburg, Saftingen and Prosperpolder. Approximately 100 people still live in the scattered houses of the Grote Doelpolder. Lillo is located on the other side of the Scheldt at about 2.5 km, with a residential population of about 40 people. In a 5 km radius, most inhabitants are in Zandvliet (approx. 3,500 persons) and Berendrecht (approx. 6,000 people).

Lastly, the Port Centre Lillo (Scheldelaan 444 - Port 621, Lillo) is mentioned. The Port Centre is located in the port area, near Lillo-Fort (2.5 km southeast of KCD). Training is given here and large groups of people (schools, ...) may be present during working hours. Annex A - Map 23 shows the land use within the wider area around the KCD.

The wide area around the nuclear power plant is characterised by strong industrialisation (port area). KCD is located in the Antwerp port area. This port area contains extensive industrial areas on both sides of the Scheldt. The industrial companies in the Antwerp port area directly employ more than 60,000 people. In addition, there are the many subcontractors who work in the Antwerp port area on a daily basis. The presence of this industry significantly increases the population within the study area, both during the day and at night, as a significant proportion of the companies run continuously.

The Antwerp port area is characterised by the presence of a (petro)chemical cluster on the one hand and container terminals on the other. Examples of (petro)chemical installations around the site are BASF, Ineos Manufacturing Belgium, Invoyn Manufacturing Belgium, Gunvor Petroleum Antwerp and Bayer Agriculture. On the left bank, there are companies such as Borealis Kallo, Ineos Phenol Belgium and Ashland Specialities Belgium. Broadly speaking, these are sites subject to the so-called SEVESO Directive on the prevention of major-accident hazards which could be caused by certain industrial activities.

The nearest Seveso companies are located at approx. 1.5 km from the KCD. These are the companies along the Scheldelaan on the right bank of the Antwerp port area (including Gunvor Petroleum Antwerp, Ineos Manufacturing Belgium, Inovyn Manufacturing Belgium, Vesta Terminal Antwerp, Bayer Agriculture). The Seveso companies in the wider area around KCD are located on Annex A - Map 25.

2.7.3 Baseline situation

2.7.3.1 Noise

The original level of ambient noise at the closest houses, located in agricultural area (immission points IP-11, IP-12, IP-13 and IP14 in the noise section) is estimated at 45.6 dB(A). This is already a (slight) excess of the environmental quality standard for the evening and night (45 dB(A)).

The specific noise level from the continuous sources at KCD is 38.2 to 41.4 dB(A) at the level of these houses. The impact of KCD on the ambient noise level is therefore 0.7 to 1.4 dB(A). In addition, many emergency diesels have installed at KCD, which can be considered non-continuous sources. However, except in effective emergencies, these systems only run during the day. In the noise section, a time-weighted impact was therefore determined on the basis of the running hours of the emergency systems. The operation of the discontinuous sources leads to a time-weighted specific noise level of 20.3 to 32.2 dB(A) at the level of the nearest houses. So this is well below the specific noise level of the continuous sources.

The time-weighted total specific noise level therefore amounts to 38.5 to 41.8 dB(A) at the level of the houses. The environmental quality standard for the day (50 dB(A)) is not exceeded.

The impact of the continuous and discontinuous sources results in an increase of 0.8 to 1.5 dB(A) compared to the original ambient noise. This difference is not audible. This also applies a fortiori to houses that are located further away (hamlet Ouden Doel (IP-13), residential area of Lillo). The impact of KCD is assessed as slightly negative for the nearest houses (with a specific contribution of more than 1 dB(A)) due to the environmental quality standard already being exceeded.

For the other houses and further away residential areas, the impact is negligible.

2.7.3.2 Shadow of the water vapor plume

The white water vapor plume from the cooling towers can be seen from a great distance. However, the greater the distance, the smaller the impact, because the steam plume mixes with clouds and is no longer distinguishable.

A study[32] carried out near the French Bugey nuclear power plant in 1979 - 1980 observed plumes and collected statistics on their type, length and height, and interaction with low clouds, mist or fog. Of the 1,000 observed plumes, 72% were fully visible, 13% little visible due to the presence of mist, fog or low clouds, and 15% mixed with higher clouds.

Of the fully visible plumes, 63% were less than 1 km long and only 9% longer than 5 km. The average length was about 1.6 km. Other findings were:

- visible tufts are longer when the relative humidity is higher and the ambient temperature is lower,
- the longest plumes are formed when the sky is covered with natural clouds and when the wind speed is low to medium,
- the longest and tallest plumes form in the early morning. Their length and height then decrease until they are at their smallest around the end of the afternoon. Furthermore, the largest plumes are observed in winter and spring.

At n the Bugey site, changes in the microclimate due to the water vapour plumes were also investigated, in particular variations in temperature, humidity, number of hours of sunshine and precipitation. In the vicinity of the power plant, both a reference measurement point (outside the sphere of influence of the

[32] Impact de la réfrigération atmosphérique, P. Méry, Aménagement en Nature nº 94

plumes) and 2 measurement sites within the sphere of influence were placed. Data were collected from January 1978 to December 1983. The following conclusions were drawn:

- the reduction in the number of hours of sunshine is 2 to 5%, which corresponds to a reduction of 40 to 100 hours of sunshine per year[33], at distances of 1.5 to 3 km from the power station. This appears to be much less than the natural variation in number of hours of sunshine from year to year;
- the overall decrease in luminous intensity is between 4 and 6%;
- no significant differences in humidity, temperature or precipitation between the reference station and the 2 target stations are found, either during the day or during the night.

We note that most houses are located more than 3 km from the nuclear power plant, so the decrease in hours of sunshine here is negligible.

The town centre of Doel is located about 1.3 km south of the cooling towers. This means that in a northerly wind direction (up to NNW and NNE) there is the greatest chance of shade from the vapor plumes. This wind direction occurs only about 12% of the time in Belgium. The prevailing wind direction in Belgium is SW (32% SSW, SW and WSW). This is in the direction of the Scheldt and the harbour where there is no habitation.

In view of the above, the reduction in sunshine duration due to the vapour plumes of the cooling towers is considered to be slightly negative to negligible.

2.7.3.3 Risk of infection by Legionella

At the KCD site, the following cooling towers are present:

- 2 open recirculating cooling towers (CW) for Doel 3 and Doel 4;
- various auxiliary cooling towers for D3 / D4 and WAB;
- cooling towers for D1/2.

Due to the presence of open cooling towers, the legionella decree (Flemish Government Decree of 09/02/2007) applies to KCD. This Decision lays down measures against Legionella pneumophila in order to prevent legionnaires' disease.

Legionella is widely found in water. It grows in biofilms at the surface of lakes, rivers and streams. Low quantities can develop into high concentrations if growth-enhancing factors (iron pipes, rubber seals) are present. Circumstances that promote the growth of Legionella bacteria:

- Stagnant water;
- Water temperature of between 20°C and 50°C, the ideal temperature is 35°C - 46°C;
- Acidity level between 5 and 8.5;
- Sediment that gives rise to the formation of a biofilm;
- Presence of micro-organisms such as algae, flavobacteria, Pseudomonas, amoebas.

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[33] For comparison: in 2014 there were about 1600 hours of sunshine in Uccle, which is a normal value.

Infection with the Legionella bacterium takes place through the lungs and it is assumed that the infection is transmitted by inhaling bacteria in very small droplets of water scattered in the air (mist).

According to the above mentioned decision, KCD has to prepare a management plan that includes a description of the systems, a risk analysis and preventive measures. This management plan will be evaluated and, if necessary, adjusted every five years whenever the plant is modified in such a way as to affect the chances of Legionella developing.

The open recirculating cooling towers of Doel 3 and Doel 4 and the auxiliary cooling towers of D3 / D4 and WAB make use of Scheldt water. Considering that this is brackish water, these cooling towers do not pose a risk of Legionella contamination due to the high salt content.

Only the Doel 1 and 2 auxiliary cooling towers are fed with mains water. In accordance with the management plan, these auxiliary cooling towers are sampled at least twice a year and analysed for the presence of Legionella. If, exceptionally, the limit value of the decision is exceeded, the necessary measures are taken (cleaning, more biocidal product) and analyses are carried out again.

As far as we know, Legionella infections have never occurred as a result of the operation of the cooling towers at KCD.

It can therefore be concluded that, provided the management plan is applied, the risk of Legionella contamination from the cooling towers is negligible.

2.7.3.4 Psychosomatic aspects and risk perception

Psychosomatic complaints are related to risk perception.

As far as we know, there are no data on the occurrence of psychosomatic complaints (in the vicinity, or in Belgium or Flanders as a whole) as a result of the operation of the Doel nuclear power plant.

However, data are available from surveys and surveys on the attitudes (including risk perception) of the general Belgian population towards nuclear energy, nuclear technology and nuclear power plants.

Risk perception

Data on the population's risk perception of KCD are limited. The PISA research group of SCK-CEN periodically carries out a national survey (SCK-CEN Barometer). This is not only about the KCD, but is a general survey on the risk perception of the nuclear industry (http://science.sckcen.be/en/Institutes/EHS/SPS/STS/Risk_perception/Barometer).

The risk perception of Doel's site itself has not been specifically examined.

SCK•CEN Barometer

SCK•CEN has been examining the public perception of radiation risks and the attitude towards nuclear energy since 2002. This research is part of the Programme for Integration of Social Aspects into nuclear research (PISA). The research is mainly done through the "SCK•CEN Barometer". This is a broad survey of the population (more than 1,000 people), representative for adult Belgians (18+), divided over the provinces, regions, level of urbanisation, gender, age and employment status. Due to the large number of participants, general trends can be identified, but also more in-depth research into underlying processes related to the social aspects of nuclear technology is possible. The data is collected via "Computer Assisted Personal Interviewing", which means that a personal interview is carried out at people's homes where the answers are recorded on a portable hard disk. The interviews are conducted by professional interviewers from a market research agency. The SCK•CEN Barometers include recurrent topics such as perception of various radiation risks, confidence in the stakeholders in the nuclear industry and opinions on the use of nuclear energy, but also more detailed questions on specific topics. In the period before 2015, the latest data are from 1002 interviews conducted between 15 August and 13 September 2013.

Attitude towards nuclear energy

To the question "What is your opinion on nuclear energy?" 38% answered that they were neither for nor against nuclear energy; 32% were against or totally against nuclear energy and 27% were in favour of nuclear energy. The reliability of energy availability, high electricity production and low CO2 emissions are identified as the main advantages. The main arguments against nuclear energy are the radioactive waste, followed by the risk of major accidents and the possibility of replacing nuclear with renewable energy.

Twelve risk areas were surveyed to evaluate the perception of potential risks to one's own health. 53% of respondents are concerned about the risks of a nuclear accident and 52% about the risks of radioactive waste. There is slightly less concern about chemical waste or chemical accidents (48% and 47% respectively). Medical X-rays and natural radiation, which contribute significantly to the annual dose for the general public but are more familiar, give less cause for concern (20%). 38% of respondents estimate the risks of climate change to be high to very high.

Furthermore, 42% feel well protected against risks from nuclear installations, while 30% feel unsafe. 52% agree or completely agree with the statement that nuclear reactors in Belgium are operated in a safe way. 14% disagree or disagree completely.

Given the relatively high confidence in the safe operation of nuclear reactors in Belgium, the high risk perception of nuclear reactor accidents is therefore somewhat surprising. According to the study, this may be explained by the fact that people are also concerned about accidents or treatment of waste outside national borders, but with implications for Belgium. This would mean that after the Fukushima accident, there is a greater awareness that nuclear accidents can have widespread consequences.

Furthermore, 57% of respondents felt that Belgium should continue to operate its existing nuclear power plants until the end of their lifetime, without building new ones after that.

The level of perceived safety of nuclear plants in 2013 was higher than the level recorded in 2011, shortly after the Fukushima accident. In the background, there was an increased focus on the safety of nuclear plants in the following years, which resulted in concrete actions such as the stress tests or the integrity checks of the Doel 3 reactor containment.

Perception of the competence and reliability of the stakeholders in the nuclear industry

This subject is investigated in the SCK•CEN Barometer survey from 2011 onwards. In the 2013 edition, it was asked to indicate which actors are known in the nuclear sector. For the known actors, additional questions were asked. This research shows that (then) Electrabel / GdF-SUEZ is known by almost everyone (96%). The people who know Electrabel / GdF-SUEZ gave the following answers:

- Is Electrabel / GdF-SUEZ telling the truth about the risks and benefits of nuclear technology?
  - Agreed or totally agreed: 29% in 2013
- Is Electrabel / GdF-SUEZ technically competent in the nuclear industry?
  - Agreed or totally agreed: 62% in 2013 (57% in 2011)

2.7.3.5 Safety and non-nuclear accidents

The Doel nuclear power plant is a low threshold Seveso plant. This means that hazardous materials are present in quantities exceeding the low threshold, but below the high threshold. This refers to both the actual or planned presence in storage facilities, in process installations, in pipes and elsewhere (as raw material, intermediate product, catalyst, solvent, end product, etc.), and the presence that can occur when an industrial chemical process is out of control. The Seveso test shows that the Doel nuclear power plant is a low threshold facility due to the amount of gas oil stored.

Lower-threshold establishments must, within the framework of the Cooperation Agreement

- submit a notification;
- draw up a prevention policy;
- put in place a safety management system to implement this policy.

An SWA-VR or drawing up of an ESR when applying for a single permit is therefore not mandatory.

As part of the EIR for the renewed permit, an assessment of the external human and environmental risks for the Seveso products present was drawn up in 2010 (Tractebel Engineering, 9/07/2010). The main findings are summarised below.

The following systems contain hazardous substances (i.c. Seveso substances):

- gas oil systems: storage tanks for the safety and emergency installations of the Doel 1, 2, 3 and 4 production units, for the heating system of the warehouse, for the auxiliary steam boilers and for the garage;
- hydrogen systems: hydrogen-cooling system for alternators of production units Doel 1, 2, 3 and 4;
- hydrazine (4.9%) systems: storage tanks for the Doel 1, 2, 3 and 4 production units;
- systems with an aqueous solution of potassium chromate[34], as a conditioning agent in the closed cooling circuit: buffer tanks for the production units Doel 1/2, 3 and 4 and for the water conditioning unit WAB;
- warehouses: storage of unit packs of all kinds of products.

External risks to humans

[34] In 2010 the buffer tanks still contain concentrations of up to 16.8% potassium chromate. Under REACH, however, the use of potassium chromate has been prohibited since 21/9/2017 (unless an authorisation or exception is granted). For this reason, the systems are no longer topped up with these concentrations and the concentrations remain below 1% (solutions below 1% are not covered by the rules).

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NRG

The external risks to humans of a major accident were quantified by means of a quantitative risk assessment (QRA). Only products with properties (toxic, flammable, explosive) that affect the external risk to humans were included in this analysis. For example, potassium chromate solutions are not covered in this section as they are only environmentally hazardous.

The maximum impact distances (greatest distance to 1% lethality) were calculated for:

- thermal radiation;
- overpressure effects;
- toxic fumes;

The following maximum impact distances were calculated:

Table 2-61 Maximum impact distances per containment system

Containment system	Scenario	Event	Effect	Maximum effect distance
Gas oil installations	ignition	Fire in auxiliary steam boilers (1,200 m³)	Heat radiation	30 m from the centre of the tank
Hydrogen systems	breakage of the charging hose + delayed ignition	Explosion	Overpressure	84 m
	breakage of the charging hose + immediate ignition	Torch fire	Heat radiation	27 m
Hydrazine systems	rupture of the discharge hose of the tanker	Release of toxic fumes	Toxic effects	Evaporation of the puddle is minimal; concentration with 1% lethality is not achieved anywhere.
Unit packaging in warehouse	ignition	Fire	Heat radiation	A couple of dozen meters

These impact distances do not extend beyond the borders of the site. The external risk to human (risk to persons present outside the site) is therefore negligible.

Environmental risks

Contrary to the external risk to humans, the environmental risk is not calculated and not tested against risk criteria. The environmental risk analysis is essentially a qualitative cause and effect analysis, listing the preventive, protective and mitigating measures.

For the identification of system components, it was ascertained where environmentally hazardous substances[35] occur in the company, as well as in what quantities and - if applicable - in which unit packaging they are stored.

The analysis showed that only the products of hydrazine and gas oil can be released with a quantity higher than the limit value.

[35] These are substances with one or more of the following properties: toxic, dangerous to the aquatic environment, corrosive, substances with a significant biological oxygen consumption (BOC > 0.1 kg O2/kg), substances which may form a floating layer (substances which are lighter than water and have a water solubility of less than 100 mg/l). Extinguishing water should also be considered.

For the systems with these products, a qualitative environmental risk analysis was carried out according to the bowtie model.

Bow ties are set up for:

- Hydrazine systems Doel 3
- Hydrazine systems Doel 4
- Hydrazine systems Doel 1/2
- Gas oil systems Doel 3
- Gas oil systems Doel 4
- Gas oil systems Doel 1/2

These reports are periodically checked during Seveso inspections.

Below is a brief summary of the analyses carried out. As the systems are quite identical for the different units, this is a general summary of the analyses.

Table 2-62 Bow tie gasoil - storage section

Installatie : Gasolie **Sectie : opslag**			
vrijzetting : vrijzetting van gasolie door breuk of lek aan de opslagtank			
oorzaken	preventieve maatregelen	gevolgen	beschermingsmaatregelen
1. Overvulling opslagtank door lossen vrachtwagen	1.1 Controle op voldoende vrije ruimte in de opslagtank door niveaumeting 1.2 Overvulbeveiliging 1.3 Noodstop op de vrachtwagen + permanent toezicht (chauffeur + afgevaardigde KCD)	1. Vrijzetting van grote hoeveelheden	1.1 Regelmatige controlerondes 1.2 Alarmering laag peil
		2. Bodemverontreiniging	2.1 Inkuiping 2.2 Gecontroleerde verwijdering van water (en/ of andere vloeistoffen) in de inkuiping 2.3 Periodieke controle van grondwater 2.4 Grondwater– en bodemsanering
2. Blootstelling aan corrosieve condities	2.1 Coating 2.2 Opslagtanks opgesteld in gesloten lokaal (uitz. tank van hulpstoomketels) 2.3 Periodieke inspectie van de opslagtanks		

Table 2-63 Bow tie gasoil - loading section

Installatie : Gasolie **Sectie : verlading**			
vrijzetting : vrijstelling van gasolie door breuk of lek aan verladingsflexibel			
oorzaken	preventieve maatregelen	gevolgen	beschermingsmaatregelen
1. Beweging van aangekoppelde vrachtwagen	1.1 Procedure: chauffeur niet toegelaten in vrachtwagen tijdens transfer 'ielblokken plaatsen	1. Vrijzetting van grote hoeveelheden	ermanente aanwezigheid losoperator / chauffeur 1.2 Noodstop op vrachtwagenverpomping
2. Loskoppelen van een producthoudende flexibel	2.1 Procedure: lospistool sluiten aan het einde van de lossing	2. Verspreiding van lekvloeistof naar riolering	2.1 Absorptiemateriaal 2.2 Opvangrecipiënt onder vrachtwagen – of vloeistofdichte losplaats
3. Gebruik en manipulatie van flexibels (slijtage, ...)	3.1 Keuringsverslag slangen van leverancier		
		3. Verspreiding via riolering naar Schelde	3.1 Opvangputten (H-putten) met biorotor

Table 2-64 Bow tie hydrazine - storage section

Installatie : Hydrazine **Sectie : opslag**			
vrijzetting : vrijzetting van hydrazine oplossing door lek of breuk aan hydrazine tanks			
oorzaken	preventieve maatregelen	gevolgen	beschermingsmaatregelen
1.Overvulling van hydrazine tank	1.1 Niveauregelkring stopt vulling automatisch	1. Vorming vloeistofplas in lokaal	1.1 Interventiemateriaal absorptieworsten
	1.2 Overloop naar een gesloten put	2. Bodemverontreiniging	2.1 Inkuiping lokaal
2. Corrosie	2.1 Tank staat intern gebouw opgesteld		
	2.2 Materiaal van de omhulling is corrosiebestendig; nl. Inox		

Table 2-65 Bow tie hydrazine - loading section

Installatie : Hydrazine **Sectie : verlading**			
vrijzetting : vrijzetting van hydrazine oplossing door breuk of lek aan verladingsflexibel			
oorzaken	preventieve maatregelen	gevolgen	beschermingsmaatregelen
1. Beweging van aangekoppelde vrachtwagen	1.1 Procedure: chauffeur niet toegelaten in vrachtwagen tijdens transfer	1. Vrijzetting van grote hoeveelheden	1.1 Permanente aanwezigheid losoperator / chauffeur
			1.2 Noodstop op vrachtwagenverpomping
		2 . Bodemverontreiniging	2.1 Vloeistofdichte vloer met afgesloten opvangbak afgeleid naar riolering
	1.2 Wielblokken plaatsen		2.2 Interventiemateriaal absorptieworsten
2. Loskoppelen van een producthoudende flexibel	2.1 Procedure leegmaken flexibel op het einde van de lossing	3. Verspreiding via riolering naar Schelde	3.1 Opvangputten (H-putten) met biorotor
3. Gebruik en manipulatie van flexibels (slijtage,...)	3.1 Keuringsverslag slangen van leverancier		

The measures taken to prevent releases of hydrazine and gas oil and to limit knock-on harm to the environment show that the remaining environmental risk is negligible.

2.7.4 Impact assessment

2.7.4.1 Operational phase of the project between 2015-2019

For a description of the works carried out in the context of the adjustments for LTO, see the general section of the EIR (see § 1.6.2 and 1.7.1).

There have been no changes in this period that have a significant impact on the health relevant environmental stressors, with the exception of the installation of additional diesel generators in the GUM building (period 2015-2017).

In the noise section, just as for the baseline situation, a time-weighted impact was determined on the basis of the running hours of the emergency systems. The operation of the discontinuous sources leads to a time-weighted specific noise level of 21.2 to 32.2 dB(A) at the level of the nearest dwellings (still well below the specific noise of the continuous sources).

The time-weighted total specific noise level therefore amounts to 38.5 to 41.8 dB(A) at the level of the houses. The difference with the situation 2013-2014 is a maximum of 0.1 dB(A) which is entirely negligible. The environmental quality standard for the day (50 dB(A)) is not exceeded.

There are no changes in the operation of the continuous sources compared to the baseline situation.

The impact of the continuous and discontinuous sources results in an increase of 0.8 to 1.5 dB(A) compared to the original ambient noise. This difference is not audible. This also applies a fortiori to houses that are located further away (hamlet Ouden Doel (IP-13), residential area of Lillo). The impact of KCD is assessed as slightly negative for the nearest houses (with a specific contribution of more than 1 dB(A)) due to the environmental quality standard already being exceeded.

For the other houses and further away residential areas, the impact is negligible.

The impact of whether or not the Doel 1 and 2 plants are operated on the overall perceived risk of KCD is considered negligible.

The construction of the CFVS buildings and the FE pump house (earthmoving, foundations, supply of materials, etc.) also generate noise emissions. Combined with the continuous and time-weighted non-continuous sources, the specific contribution of KCD at the level of the nearest dwellings is 39 to 42.3 dB(A). The environmental quality standard for the daytime is therefore not exceeded. The noise level increases by 0.9 to 1.7 dB(A) compared to the original ambient noise. The work in itself does not cause a relevant increase at the level of the dwellings compared to the original ambient noise (maximum 0.2 dB(A)).

No other health effects requiring further evaluation are identified.

2.7.4.2 Operational phase in the future situation (period 2020-2025)

2.7.4.2.1 Noise

There are no changes in the operation of the continuous sources compared to the baseline situation. The status of discontinuous sources for the period 2020-2025 is in line with the status of 2015-2019 (see § 2.7.4.1).

2.7.4.2.2 Shadow of the water vapor plume

There are no changes in the operation of the open cooling towers of Doel 3 and 4 in the LTO situation compared to the baseline situation (see § 2.7.3.3).

2.7.4.2.3 Risk of infection by Legionella

As a result of the LTO project, there are no changes in the operation of the open cooling towers of Doel 3 and 4 compared to the baseline situation.

Reference is therefore made to § 2.7.3.3.

2.7.4.2.4 Psychosomatic aspects and risk perception

SCK•CEN Barometer

In the period 2015 to date, the following data are available:

- 2015 barometer: 1,028 interviews between 11/09/2015 and 13/10/2015
- 2018 barometer: 1,083 interviews between 27/11/2017 and 26/02/2018

Attitude towards nuclear energy

The attitude towards nuclear energy has become more pronounced and polarised in recent years compared to 2013: in 2018, 26% were neither in favour or against (compared to 35% in 2015 and 38% in 2013), in 2018, 35% were either against or completely against (compared to 26% in 2015 and 32% in 2013), 37% in 2018 were in favour or completely in favour (also 37% in 2015 and 27% in 2013),

In 2015 and 2018, several risk areas were again surveyed in order to evaluate the perception of potential risks to one's own health. The percentage of respondents with a high or very high risk perception of nuclear or chemical accidents and waste in 2018 is comparable to the year 2013, and slightly lower than 2015. Medical X-rays and natural radiation are still considered the least risky.

Compared to 2013, people feel slightly less protected against risks from nuclear plants: 40% felt well protected in 2015 and 35% in 2018 compared to 42% in 2013; 35% in 2015 and 45% in 2018 felt unsafe (compared to 30% in 2013).

The percentage of respondents who agree with the safe operation of nuclear reactors in Belgium in 2018 is similar to 2015, but slightly lower than in 2013 (see Figure2-62).

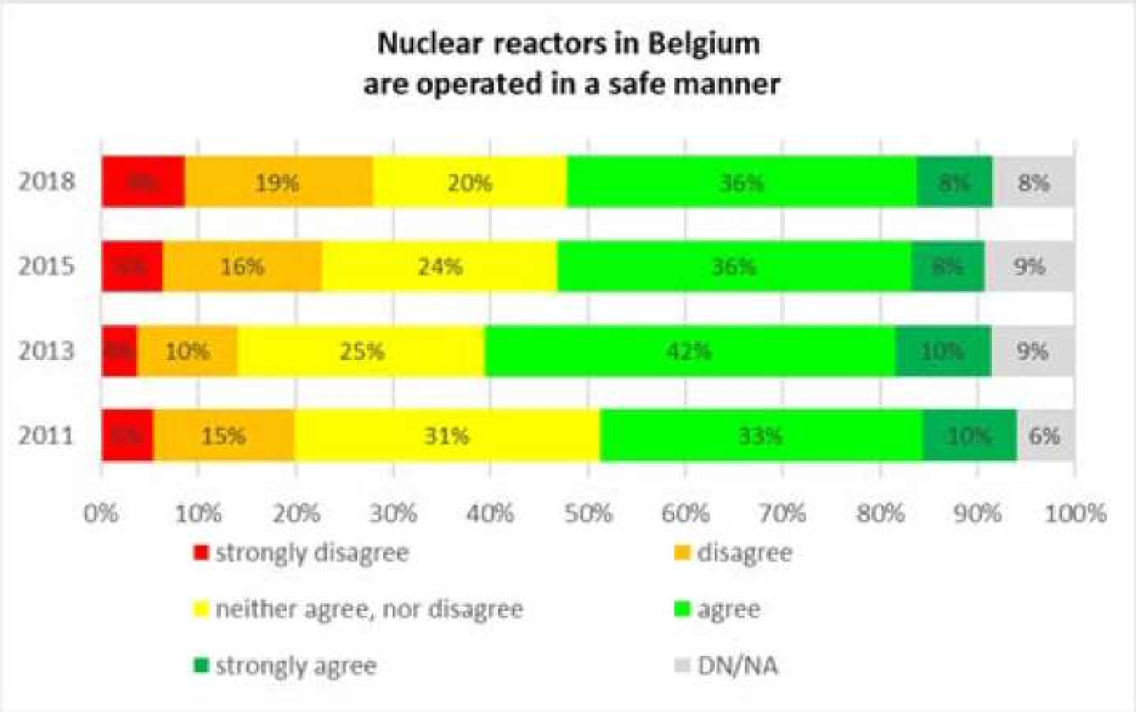

Figure2-62 Perception of the safety of nuclear reactors in Belgium in the period 2011-2018 (N>1000, weighted sample in 2015 and 2018)

The following answers were given to the people who knew ENGIE Electrabel[36]:

- Is ENGIE Electrabel telling the truth about the risks and benefits of nuclear technology?
  - Agreed or totally agreed: 18% in 2018, 21% in 2015 (compared to 20% in 2013 and 14% in 2011)
- Is ENGIE Electrabel technically competent in the nuclear industry?
  - Agreed or totally agreed: 49% in 2018, 58% in 2015 (compared to 62% in 2013 and 59% in 2011)

There are no clear trends in the level of confidence in ENGIE Electrabel.

Although very valuable, the results of the Barometer do not tell us whether the interviewees are so worried about a nuclear accident that they (residents or persons living further away from a nuclear power plant) would develop psychosomatic complaints (e.g. insomnia, headaches, back complaints) as a result.

However, one can expect that if a nuclear accident occurs, both physical and mental health effects will be felt. The severity of these health effects will of course depend on the severity of the nuclear accident.

On the other hand, risk perception (irrespective of whether or not it leads to health effects) is influenced by knowledge of these risks.

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[36] Electrabel GdF SUEZ in the 2015 survey

The questionnaires from the SCK-CEN Barometer show that the knowledge of the interviewees about ionising radiation is relatively limited. More than one in four respondents had no knowledge of the natural radioactivity of the human body, radioactive decay or the difference between irradiation and contamination. General knowledge about the nuclear sector is slightly higher than specific knowledge about radioactive radiation. Two out of three respondents know that radioactive waste is not only produced by nuclear power plants and 80% know that radioactive waste is treated separately from chemical waste.

Communication

ENGIE Electrabel and the KCD site inform the public through various channels. ENGIE Electrabel is represented in the Belgian Nuclear Forum. This Forum brings together most companies and institutions active in the various uses of nuclear technology. The Belgian Nuclear Forum provides information through a website (www.nucleairforum.be) and various actions ranging from the organisation of conferences and technical visits to the publication of general information brochures and documents on nuclear energy and technology.

KCD itself has a policy regarding both internal and external communication. This includes any request for information, investigating and following up of complaints, but also actively informing interested target groups, including, of course, local residents. From this point of view, the Doel Infocenter was established (1997), a visitor and information centre. Due to increasingly strict access rules and laws, visitors to the plant are no longer allowed. Photos and images can still be consulted in the library (https://nuclear.engie-electrabel.be/nl/pers-media). KCD also distributes a quarterly information magazine, 'Doelbewust', to local residents within a 15 km radius of the site. It provides information on nuclear energy and its generation, on energy-related issues (rational use of energy), but also on KCD's efforts in the field of safety and the environment. As part of its EMAS registration (since 2002), KCD also publishes an annual validated environmental statement on its environmental performance.

KCD has put in place a procedure to ensure every question received, via any channel, is answered. This is done by means of so-called environmental communication sheets.

KCD also participates in various environmental projects (Peregrine falcons project) and nature experience projects (Doel Ecofietsroute).

Finally, KCD also organises various forms of consultation with stakeholder groups. On the one hand there is the "sounding board group", which holds representatives of the different municipalities around the power station, together with KCD management, in order to promote the relationship between the power station and its surroundings. The reports of this sounding board group are public. On the other hand, there is the environmental consultation platform, where KCD meets with representatives from various environmental and nature organisations, but also with local and regional authorities.

Conclusion

Although a significant part of the population is concerned about a nuclear accident, there are no data that this, as a highly perceived risk, also causes psychosomatic effects. However, it is very likely that if a nuclear accident occurs, mental health effects can be expected.

The impact of whether or not the Doel 1 and 2 plants are operated on the overall perceived risk of KCD (see § 2.7.4.4.3) is considered negligible.

2.7.4.2.5 Safety and non-nuclear accidents

The LTO situation does not differ significantly from the baseline situation. Some diesel generators have been added since 2013/2014, but since the quantities of gas oil stored in these generators are much lower than those in the auxiliary steam boilers (1,200 m³), the fire of this last storage tank is still an enveloping scenario.

Consequently, the external risk to humans will still be negligible.

There are no other changes affecting the external risk to humans.

Since the nature and method of storage and delivery of products that are hazardous to the environment remain the same, the same provisions as regards the management of environmental risks continue to apply. These show that the remaining environmental risk is negligible.

In addition to the safety report, which analyses the external human risks of accidents involving hazardous substances, the environmental and health effects (other than immediate death) of these accidents can be described in qualitative terms. As indicated in the safety report, fire, explosion and release of hydrazine are possible accident scenarios. In 2009, RIVM carried out a analysis[37] of the spread of substances in fires.

In the event of a fire, the RIVM report states, based on a large number of measurements, that there is generally no risk to people and the environment from 1 kilometre away. Exceptions are very large fires or fires in which people and the environment are exposed to extremely hazardous substances, such as a fire in a large storage with PVC materials or a large amount of pesticides. If at all there is an increase in the concentration of certain pollutants, it is so small that there is no health risk from any exposure to them. However, within 1 km of the fire, airborne concentrations may be elevated and, on a case-by-case basis, it will be necessary to investigate which substances pose a potential risk, the level of exposure to these substances, and any effects on the environment and health.

The deposition of dust particles from a fire and the resulting contamination of the environment and crops is usually not very high, especially if the plume rise is large. In those cases, where significant or strong elevation does occur, the area of elevation extends to a few hundred meters from the fire, as a maximum. From about half a kilometer and further away, deposition is almost always zero and in any case does not lead to harmful effects on the environment or significant contamination of the food chain (crops or

[37] RIVM report 609022031/2009, 'Spread of substances in the event of fires: an exploratory study'. 2009.

products of animals in the impacted area). Critical components are dioxins, PAHs, a number of heavy metals and, sometimes, components such as brominated dioxins, nitro PAHs and sulphur PAHs, which are formed from specific materials.

Based on literature, it is believed that most animals are more sensitive to inhalation exposure to hydrazine. However, as the 1% (human) lethality concentration is not reached in a potential accident, and hydrazine in the atmosphere is unstable (lifetime of about 1h in a pure atmosphere), it will not spread over long distances and no relevant effects on fauna are expected beyond the boundaries of the site.

Furthermore, animals are generally more sensitive to overpressure effects than humans (where birds are more sensitive than mammals, and small mammals are more sensitive than large ones). The maximum effect distance for 1% (human) lethality was only 84 m. This distance does not extend beyond the KCD site boundary. As the overpressure in an open environment decreases exponentially with distance, the effect outside the boundaries of the terrain will therefore decrease rapidly. Consequently, no relevant effects on fauna are expected.

Overall, the risk of significant environmental and health impacts from non-nuclear accidents is considered to be very low.

2.7.4.3 Post Operational Phase (period 2025-2029)

2.7.4.3.1 Noise

During the Post Operational Phase, the safety-related equipment, and therefore the diesel generators, will continue to be maintained and tested as before (unless possibly in the last three months). For the discussion of possible noise problems, please refer to §2.7.4.2.1.

2.7.4.3.2 Shadow of the water vapor plume

There are no changes in the operation of the open cooling towers of Doel 3 and 4 compared to the baseline situation during this period (see § 2.7.3.3).

2.7.4.3.3 Risk of infection by Legionella

During this Period, there are no changes in the operation of the open cooling towers of Doel 3 and 4 compared to the baseline situation.

Reference is therefore made to § 2.7.3.3.

2.7.4.3.4 Psychosomatic aspects and risk perception

During the Post Operational Phase, the nuclear risk from Doel 1/2 decreases as less radioactivity is present in the Doel 1/2 facilities. During this period, no electricity will be produced anymore. It is possible that this will have an impact on the risk perception of KCD as a whole, but presumably this effect will be small.

In any case, no difference in effects is expected between a POP in 2015-2019 versus 2025-2029.

2.7.4.3.5 Safety and non-nuclear accidents

At the start of the POP, the water-steam circuits and the mixing and injection tanks at Doel 12 will be emptied so that no hydrazine will be present. No toxic fumes can therefore be released here. The (negligible) risk associated with this is therefore no longer present.

Also the hydrogen cylinders for the cooling circuit of Doel 12 will be emptied at the start of the POP. The associated explosion risk will therefore no longer be present.

The diesel tanks for emergency generators are only emptied at the end of the POP or at the earliest when the fuel is removed from the fuel pools. The associated risk of fire therefore remains during this period.

It can be concluded that the external risk to humans as a result of accidents with hazardous materials during the POP will be slightly smaller (and still negligible).

The same applies to environmental risks. The environmental risks posed by the Doel 12 gas oil installations will still be present; those of the hydrazine installations of Doel 12 will no longer be present.

2.7.4.4 Zero alternative

2.7.4.4.1 Noise

The noise section shows that there will be no significant difference in the noise contribution of the continuous sources of KCD at the level of the nearest dwellings in the situation LTO versus no-LTO. During the Post Operational Phase period cessation (2015-2019) the safety equipment will be tested as before. The new diesel generators that were added, were not installed for the LTO. For its discussion please refer to §2.7.4.2.1.

Afterwards (2020-2025), the emergency diesels of Doel 1/2 would not be tested. As a result, the total noise output of KCD will only decrease by 0.5 dB(A) compared to the situation before 2020.

2.7.4.4.2 Shadow of the water vapor plume

The cooling towers that emit the water vapour plumes are the open cooling towers of Doel 3 and 4. In the zero alternative there are no changes in the operation of these cooling towers compared to the baseline situation. Risk of infection by Legionella

In the zero alternative, Doel 1 and 2 will no longer have a need for cooling water. As the auxiliary cooling towers of Doel 1 and 2 are the only cooling towers with a Legionella contamination risk for the surrounding area, it can be stated that the risk of infection by Legionella in the surrounding area[38] is non-existent in this scenario.

2.7.4.4.3 Psychosomatic aspects and risk perception

In the zero alternative, power stations Doel 1 and 2 are shut down. However, Doel 3 and 4 power stations will still be operated. The risk perception of KCD as a whole (and possible psychosomatic effects) is not expected to change compared to the LTO situation (negligible effect).

2.7.4.4.4 Safety and non-nuclear accidents

During the Post Operational Phase period (2015-2019) some hazardous substances will be removed as described in §2.7.4.3.5 (there is no difference with a cessation in 2025).

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[38] Sources of contamination for employees, such as humidifiers and hot water drains, are not considered here.

In the period thereafter (2020-2025), the diesel tanks will also be emptied. The (negligible) risk associated with this is therefore no longer present.

The environmental risks posed by the gas oil installations and hydrazine of Doel 12 will then also no longer be present.

It can be concluded that the environmental and external risk to humans due to accidents involving hazardous materials will be slightly lower in the zero alternative than in the LTO scenario and negligible in both cases.

2.7.4.5 Cross-border effects

The effects in terms of noise, shade of the water vapour plume and risk of infection for Legionella are negligible given the distance to KCD.

However, people in the Netherlands may also be concerned about the risk of nuclear accidents at KCD. As for Flanders or Belgium, no specific data on psychosomatic effects resulting from this risk perception are known. The risk perception of KCD as a whole (and possible psychosomatic effects) is not expected to change compared to the LTO situation (negligible effect).

2.7.5 Monitoring

As the effects are assessed as negligible, no proposals for monitoring are made.

2.7.6 Mitigating measures and recommendations

Given the absence of significant impacts, no mitigating measures or recommendations are proposed.

2.7.7 Knowledge gaps

As far as we know, there are no data on the occurrence of psychosomatic complaints (in the vicinity, or in Belgium or Flanders as a whole) as a result of the operation of the Doel nuclear power plant.

However, data are available from surveys and surveys on the attitudes (including risk perception) of the general Belgian population towards nuclear energy, nuclear technology and nuclear power plants. Although psychosomatic effects are associated with risk perception, it cannot be deduced from this whether persons who perceive the risk of a nuclear accident as high also develop psychosomatic complaints.

2.7.8 Conclusions

The above analysis shows that the LTO of Doel 1 and 2, including the construction and operation of the plants, as well as the activities during the Post Operational Phase have no relevant health effects compared to the zero alternative.

2.8 Human - Mobility

Annex A - Map 1: Location of project area on topographic map

Annex A - Map 2: Street map

2.8.1 Methodology

2.8.1.1 Definition of the study area

The study area for the Human - Mobility section includes the access infrastructure in the immediate vicinity of the project and the R2.

KCD is mainly accessed by the Lindenhofstraat/Oostlangeweg. The key intersection to access to the higher-up road network is the junction between the Oostlangeweg and the N451 (see Figure 2-63).

The Oostlangeweg will provide access in the direction of the Waaslandhaven (Kieldrechtsluis) and the R2 (direction Antwerp, Bruges, the Netherlands). The N451 provides access to the power plant in the direction of the Netherlands (Hulst).

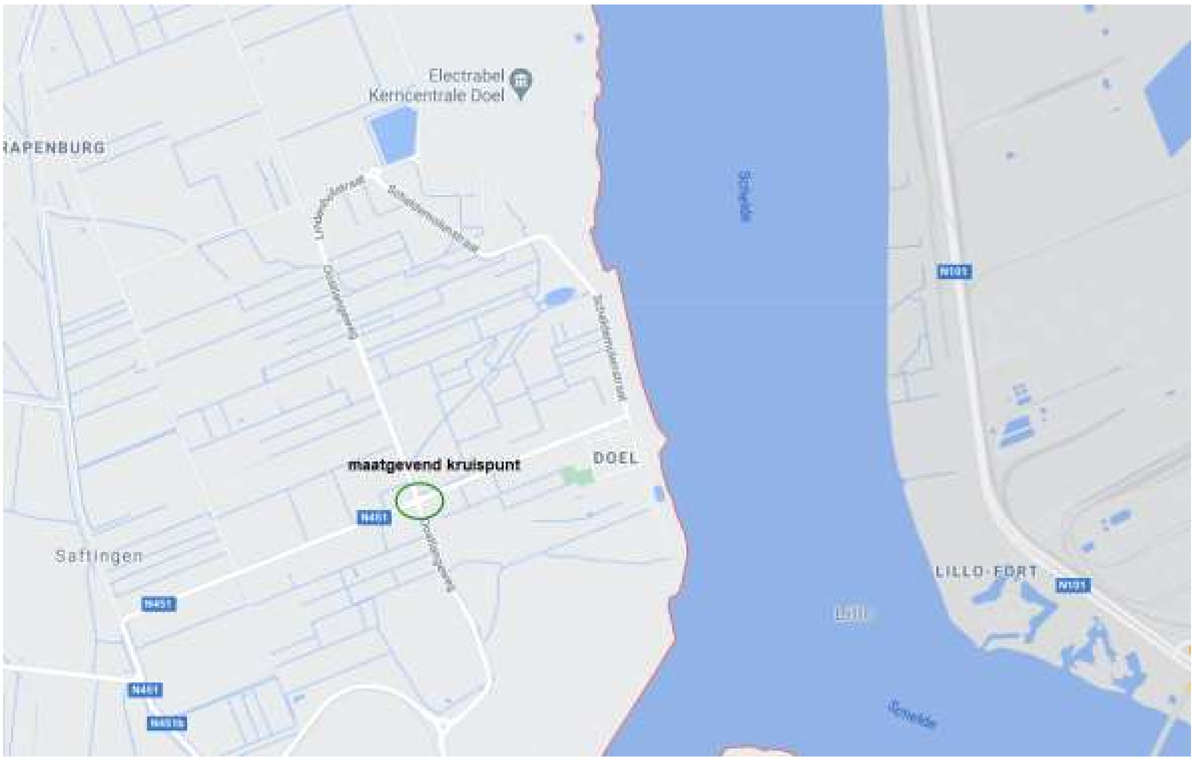

Figure 2-63 Situation of the access roads at meso level

The entrances to the site are located near the Paardenschorstraat and the Scheldemolenstraat (see Figure 2-64).

Figure 2-64 Location of the entrances

2.8.1.2 Description of baseline situation

The accessibility profile in the baseline situation includes a description of the networks for the different traffic and transport modes (slow traffic, public transport, freight traffic, car traffic) for the accessibility of the project area.

2.8.1.3 Description and assessment of the impact

As a result of the works at KCD for the LTO adjustments, works-related traffic will take place to transport employees and materials. The traffic flow to and from the KCD will therefore temporarily increase. The traffic flow during the operational phase in the future situation will also be mapped out to show its effects on traffic flows. In addition, it is also examined whether changes in traffic flows occur during the Post Operational Phase and in the zero alternative.

For the human - mobility discipline, the effect will be described as follows:

- changes in the traffic flows: quantitative description based on estimation of the traffic generated and resulting intensity/capacity (I/C) ratios of the road sections and/or intersections.

The impact assessment is carried out as follows for:

- changes in traffic flows: assessment based on (the change in) the I/C ratio in the future situation according to the following assessment framework (Table 2-66).

Table 2-66 Significance framework for the human - mobility discipline

Verzadigings-graad toekomstige situatie (incl. plan/project)	Evolutie t.o.v. verzadigingsgraad referentiesituatie (in procentpunt*)								
	Toename verzadigingsgraad				Verschil < 5 %-punt	Afname verzadigingsgraad			
	> 50 %-punt	20 à 50 %-punt	10 à 20 %-punt	5 à 10 %-punt		5 à 10 %-punt	10 à 20 %-punt	20 à 50 %-punt	> 50 %-punt
>100%	---	---	---	--	0	0	0	+	+
90-100%	---	---	--	-	0	0	+	++	++
80-90%	--	--	-	-	0	+	++	+++	+++
<80%	-	-	0	0	0	+	+++	+++	+++

As no traffic data is available, the assessment is based on assumptions and expert judgement.

2.8.2 Baseline situation

2.8.2.1 General

KCD can be reached via the public road and, due to its location on the Scheldt, also via water. For this latter connection, KCD has a roll-on roll-off quay, along which heavy material can be supplied. This quay is used rather sporadically.

The transport associated with the day-to-day operation of the nuclear power plant is mainly by road. Traffic mainly consists of the vehicles of staff and subcontractors to and from the site. In addition, there are the transports for the supply and maintenance of the installations (chemicals, fuel, spare parts, waste disposal).

The (heavy) traffic to and from the nuclear power plant passes through the Waasland harbour, more specifically around the Deurganckdok, with a connection to the R2. These roads do not cross residential areas. On this main route there are of course a number of other routes, where traffic finds its way through the polders, possibly via Kieldrecht and via the N451 directly to the connection with the N49 expressway Antwerpen - Knokke. From the R2, there is a connection to the A12, the E34, N70, the E17 or the E19.

KCD has a car park with approx. 1,500 parking spaces where staff and contractor vehicles can be parked. On average, there are some 1,700 people present on the site (during the day) and this results in some 1,300 vehicles (cars, trucks, vans, etc.). The following division is assumed: 900 passenger cars, 300 vans, 100 trucks. This is an average, during large works/outages the number increases.

The transport of people to and from the site takes place during peak periods, while deliveries by truck can be expected to take place throughout the day. In peak periods, passenger transport is up to 600 PCU/h (Passenger Car Units per hour) together with a truck density of 25 PCU/h (100 trucks equal 200 PCUs, spread over 8 hours). At the most busy times (between 7 a.m. and 9 a.m. and between 4 p.m. and 6 p.m.

in the evening), this gives 625 PCU/h (EIR Project, KCD Renewal of the Vlarem license, Vincotte, 2010).

The presence of KCD on the territory of Beveren naturally has an influence on traffic flows and their handling. The port area is well connected locally and connects from the R2 directly to important arterial roads such as the A12, the E34, N70, the E17 or the E19. However, it is only logical that KCD, like any other company, has a share in the saturation of the road network around Antwerp during peak periods. There is no saturation of the local road network to and from KCD. However, heavy traffic in the morning and evening rush hour is possible.

In the baseline situation, there are some sections on the R2 (left bank) and the connecting sections of the E34 and the A12, where the I/C ratio of road traffic at peak hours reaches a ratio of 80-100% (generally, this ratio is lower than 80%). No structural traffic jams occur during rush hours. In the various scenarios studied for the future opening up of Antwerp (EIR Plan Oosterweelverbinding, Antea, January 2014) no saturation is reached on R2 either.

2.8.2.2 Pedestrians

Network

There is no network for pedestrians or foot traffic within the study area. However, there is a footpath on the Scheldedijk that provides the connection between KCD on the one hand and the polder village Doel on the other hand.

Infrastructure

There are no footpaths on the surrounding roads.

2.8.2.3 Bicycle traffic

Network

The N451 Engelsesteenweg and the Oostlangeweg have been included as functional bicycle routes in the Supra-local functional bicycle route network, which makes a loop in the village of Doel (Figure 2-65).

Figure 2-65 Supra-local Functional Bicycle Route Network (source: gisoost.be)

Within the recreational cycle route network, the Scheldemolenstraat has been selected as a recreational cycle route. This provides the connection between cycle node 17 and cycle node 13 through Doel. The Oostlangeweg has also been selected as a recreational cycling route. This connects cycle node 14 with cycle node 17. Cycling node 16 can also be found in the area (Figure 2-66).

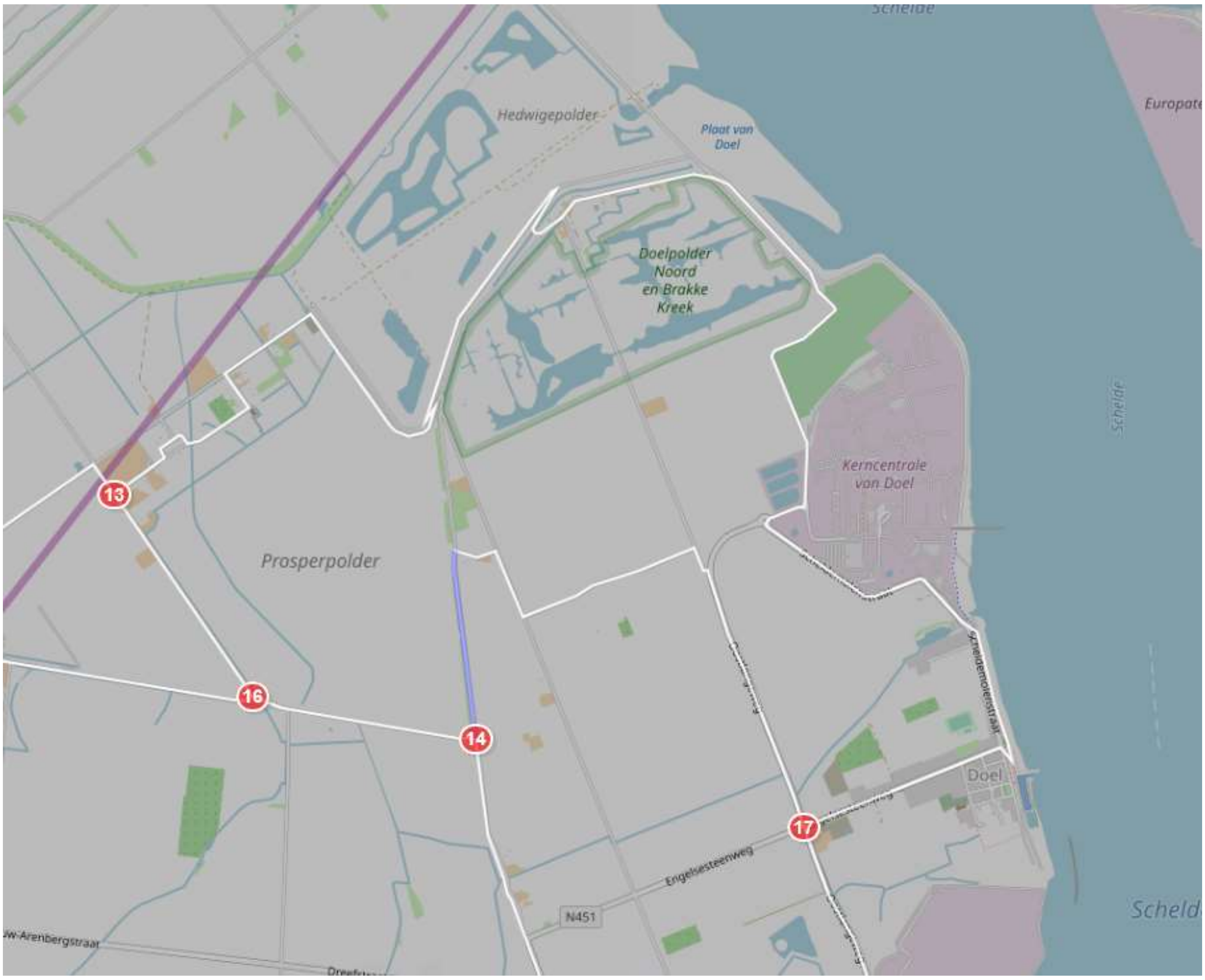

Figure 2-66 Bicycle node network (source: fietsnet.be)

Infrastructure

There are no bicycle facilities along the Paardenschorsstraat

Along the Scheldemolenstraat, there is a two-way cycle path near KCD.

A bicycle crossing by means of a central island is planned to provide access to the nuclear power plant.

The part of the Scheldemolenstraat parallel to the Scheldt has no bicycle facilities.

Along the Lindenhofstraat, there are two-sided one-way cycle paths. A country road must be used over a limited area

At the Paardenschorstraat roundabout, a bicycle crossing is planned in the direction of the two-way bike path in the Scheldemolenstraat.

Also along the Oostlangeweg, there are separate cycle paths on both sides.

Along the N451Engelsesteenweg, east of the Oostlangeweg, there are separate cycle paths on both sides. In the direction of Doel, they change into adjacent one-way cycle paths.

There are no bicycle facilities along the N451 Engelsesteenweg west of Oostlangeweg.

At the priority intersection between the N451 and Oostlangeweg, cyclists along Oostlangeweg will have right of way on the N451 Engelsesteenweg. Cyclists wishing to cross from the N451 to the Engelssteenweg (or vice versa) must give priority to traffic on the Oostlangeweg.

2.8.2.4 Public transport

No bus line stops at the Doel power plant. The nearest public transport line is line 31: Sint-Niklaas – Kieldrecht – (Doel). This line stops in the centre of Doel twice a day.

At the entrance on the Scheldemolenstraat, 2 bus stops are situated. These are accessed by means of a separate footpath (including pedestrian crossing) to the access road. However, there is no De Lijn stop any longer.

2.8.2.5 Car traffic

Network

The N451 Engelsesteenweg has been selected as a type II local road (a local collecting road). There is a connection to the higher up road network N49 via the off and on ramps complex 10 (Figure 2-67).

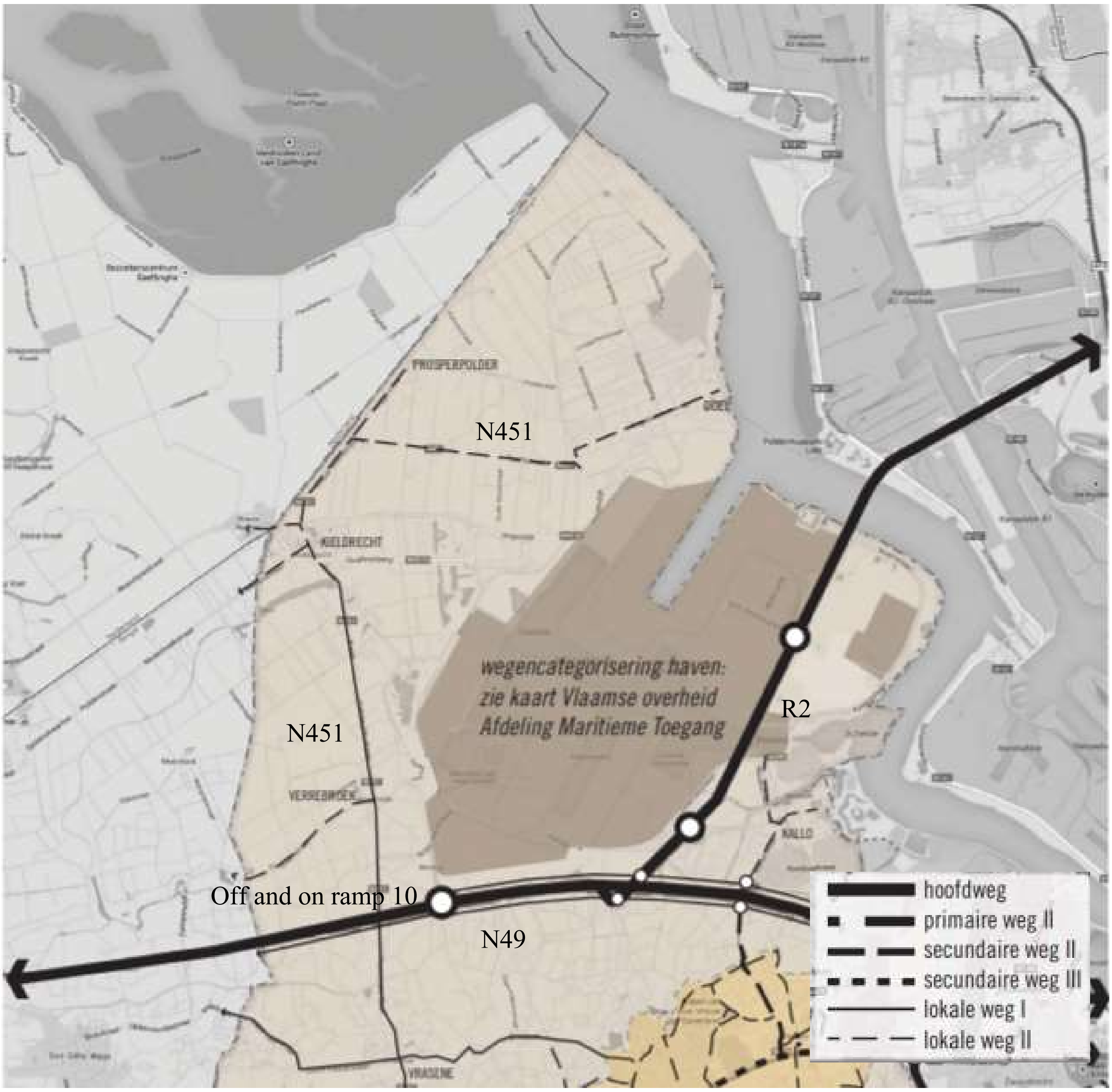

Figure 2-67 Road categories

Infrastructure

All roads in the vicinity of the power station are equipped as 2x1 roads. The only priority intersection in the study area is the intersection between the N451 and the Oostlangeweg. The traffic flow on the Oostlangeweg has priority over the other branches.

Near the Paardenschorstraat, two intersections can be found in the form of a roundabout. One provides for the internal access to the nuclear power plant. The other divides the traffic between the Paardenschorstraat, the Lindehofstraat and the Scheldemolenstraat. The Scheldemolenstraat has an exit lane towards the access road to the nuclear power plant.

The roads leading to the R2 are assumed to have a capacity of 1200 PCU per hour per road section (2x1, few intersections). This road mainly provides access to KCD and it was already indicated that about 625 cars are expected during rush hour, mainly in one direction (in the morning towards KCD, in the evening towards R2). It can therefore be assumed that the saturation level on these roads is below 80%. A saturation level of <80% corresponds to a smooth flow.

For R2, higher saturation levels were shown (80% to 100%, generally lower than 80%). A saturation level of 80-90% corresponds to light congestion, 90-100% with severe congestion and >100% with oversaturation.

2.8.3 Impact assessment

2.8.3.1 Operational phase of the project between 2015-2018

For a description of the works carried out in the context of the adjustments for LTO, see the general section of the EIR (see Chapter 1.6).

2.8.3.1.1 Changes in traffic flows

The EIR for the 2010 re-licensing of the KCD site indicates that the traffic volumes caused by KCD transport on the access road to KCD is significant at peak times and negligible beyond. Also due to the isolated location of KCD, the road to KCD from the Deurganckdok is almost exclusively used for transport to and from KCD. Saturation of this road network due to the presence of the nuclear power plant is therefore not expected.

Construction traffic has taken place as a result of the works required for the adjustments within the framework of LTO. This related to:

- the supply of construction materials;
- transport of waste and materials to be reused;
- transport of staff by private or commercial vehicles.

As a result, traffic to and from the nuclear power plant has temporarily increased.

In view of the origin, the frequency of delivery and the quantities of the loads and/or the disposal chain of the waste and recyclable materials, the transport was carried out exclusively by lorry. However, the potential share of construction traffic remained limited and did not lead to a structural increase in traffic flow. In addition, it can be assumed that shipments for the supply of construction materials, waste materials and materials to be reused mainly took place outside peak hours.

No figures are available for the number of additional traffic movements during the 2013-2015 period. As the saturation level (off-peak) was less than 80% (see paragraphs 2.8.2.1 and §2.8.2.5), that part of the additional transports took place off-peak and that the increase was limited, it can be assumed that the effect on traffic flows during the operational phase was at most slightly negative. Also due to the isolated location of KCD, the road to KCD from the Deurganckdok is almost exclusively used for transport to and from KCD. Saturation of this road network due to the presence of the nuclear power plant was therefore not expected.

The impact as a result of construction traffic within the framework of LTO on the supra-local level, i.e. the traffic junctions around Antwerp, can be considered negligible.

2.8.3.2 Operational phase in the future situation (period 2019-2025)

2.8.3.2.1 Changes in traffic flows

During the future operational phase, additional transports will take place for the additional fuel supply for the additional installed capacity of diesel generators to provide emergency power supply and a quantity of iodine-absorbing pellets for the filtered pressure relief. The extra transport is considered to be a one-off as the consumption of these products will only occur in case of emergencies).

The number of employees will increase slightly with the LTO of Doel 1 and 2. The number of employees is estimated at

- In the baseline situation (2013-2014):
  - Internal employees: 1,018 (987.69 fulltime equivalents)
  - Outside staff: 758
- In the operational phase in the future situation (period 2019-2025):
  - Internal employees: 1,045 (1,014.44 full-time equivalents)
  - Outside staff: 932

In total, an increase in the workforce is therefore expected of approximately 11%.

If it is assumed that traffic intensities are proportionate to the number of employees (assuming the same modal split and comparable work shifts), it can be stated that in the future situation (with LTO) traffic intensities will also increase by 11% compared to the baseline situation (2013-2014). Taking into account a saturation level (off-peak) of less than 80% (see § 2.8.2.1 and 2.8.2.5), the effect on traffic flows can be assessed as slightly negative on the basis of the Significance Framework (Table 2-66).

2.8.3.3 Post Operational Phase (period 2025-2029)

Due to the cessation of electricity production at Doel 1 and 2, many systems and equipment will lose their function. As a result, there are fewer systems and equipment to operate and maintain. This has an effect on the required staffing levels. A gradual reduction of the workforce is therefore expected.

On the other hand, there may also be an increase in transport because of the supply or removal of materials as part of the Post Operational Phase. This increase is considered to be limited.

Taking into account a gradual decrease in staff and a limited increase in material transports, the overall impact on traffic flows during the Post Operational Phase is assessed as negligible.

2.8.3.4 Zero alternative

In the zero alternative (= the non-LTO situation), no changes have taken place in the context of the lifetime extension of Doel 1 and 2. As a result, no construction work transports were carried for changes to Doel 1 and 2. It should be noted that the effect on traffic flows in the LTO situation was at best only slightly negative.

If the LTO of Doel 1 and 2 had not been implemented, the number of employees would have decreased slightly from 2015 onwards. This trend will continue gradually into the coming years. The number of employees is estimated at

- In the baseline situation (2013-2014):
  - Internal employees: 1,018 (987.69 fulltime equivalents)
  - Outside staff: 758
- For the zero alternative (from 2015):
  - Internal employees: 934 (904 full-time equivalents)
  - Outside staff: 764

In total, a reduction in the workforce is therefore expected of approximately 4%.

Assuming that the traffic intensities are proportionate to the number of employees (with the same modal shift and comparable work shifts), a decrease of about 4% in traffic intensities can therefore also be expected. The effect of such a decrease on traffic flows is negligible.

As far as the Mobility section is concerned, it can be concluded that the difference between the POP in 2015 (= zero alternative) or in 2025 will be limited.

2.8.3.5 Cumulative effects

To be able to cope with the expected growth in container traffic until 2030, the Flemish Government wants to provide additional opportunities for container handling in the Antwerp port area. To this end, the complex project "Realisation of additional container handling capacity in the Antwerp port area" is underway. It is planned to provide additional terminals within the area that has been developed as a port and to build a new tidal dock at right angles to the Deurganck dock. These developments will be accompanied by additional traffic but will also influence the accessibility of the KDC.

At the moment the project is still in the development phase. The implementation phase is still to be determined[39]. Given the nature and size of the project, it can be assumed that the project will not yet be (fully) completed by 2025. Consequently, there are no cumulative effects with the operational phase in the future situation. When the Second Tidal Dock and the "Three Docks" logistics area were to be completed during the Post Operational Phase (period 2025-2029), a new access to the study area towards the R2 should be envisaged. Measures will have to be taken in the complex project to guarantee traffic flows.

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[39] https://www.cpeca.be/verloop

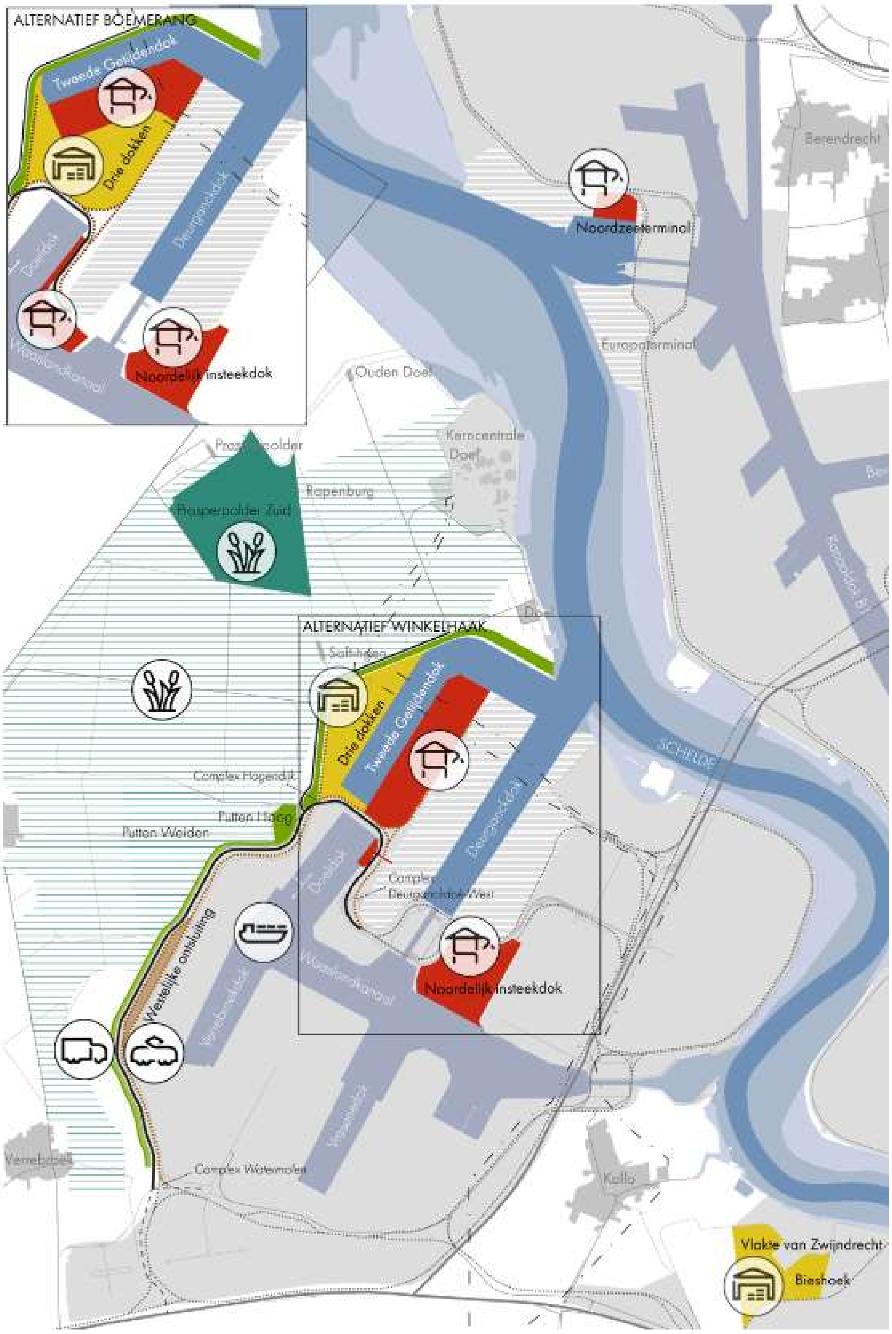


Figure 2-68 Presentation "Construction of additional container handling capacity in the Antwerp port area"

There are no other projects in the area with cumulative effects.

2.8.3.6 Cross-border effects

There are no cross-border effects for the mobility section.

2.8.4 Monitoring

The mobility section does not require any measures related to monitoring and evaluation.

2.8.5 Mitigating measures and recommendations

On the basis of the impact assessment, no mitigating measures are considered necessary. However, some recommendations are proposed:

- Further focus on sustainable modes such as cycling. This can be further expanded by constructing sufficiently comfortable bicycle sheds (covered). Initiatives regarding company bicycles, bicycle allowances, shower facilities and bicycle sharing can also contribute to making travel to and from work more sustainable.
- Focus on carpooling. This has a positive impact on traffic generation and parking needs. By encouraging carpooling within the company (e.g. reserved car-pool parking spaces, car-pool fee, car-pooling system) both among permanent employees and contractors, the nuclear power plant can reduce the traffic intensities produced and make them more sustainable.

2.8.6 Knowledge gaps

No traffic counts were carried out during the baseline situation. The exact traffic intensities at the intersections are therefore not known.

2.8.7 Conclusions

The impact of the works that have taken place in the context of the adjustments for LTO can be assessed as slightly negative at most, for the mobility section. Relative to the baseline situation there is a slight increase in the number of transports, respectively due to construction traffic. In the LTO situation, a slight increase in the number of transports is also expected due to the additional number of employees. The effect is assessed as slightly negative. During the POP, there will be a gradual decrease in staff, together with a limited increase in material transports. The knock-on effect on traffic flows is assessed as negligible. In the Zero alternative, a reduction in the workforce would be expected from 2015 onwards, which would have a negligible impact on traffic flows. In the LTO situation, this decline will only occur after 2025.

2.9 Waste

2.9.1 Methodology

2.9.1.1 Definition of the study area

The study area for the Waste section matches the boundaries of the KCD site.

2.9.1.2 Description of baseline situation

The KCD waste stream will be mapped. A list is made of the type and quantity of waste and the collection points.

2.9.1.3 Description and assessment of the impact

The quantities of waste in the various phases of the project will be estimated (quantitatively as far as possible). No assessment will be made of this impact. The zero alternative is also considered.

2.9.2 Baseline situation

2.9.2.1 General description

In Flanders, waste management is governed by the Decree of the Flemish Government of 17 February 2012 establishing the Flemish Regulation on the sustainable management of material cycles and waste materials (VLAREMA).

This decision lays down detailed rules on:

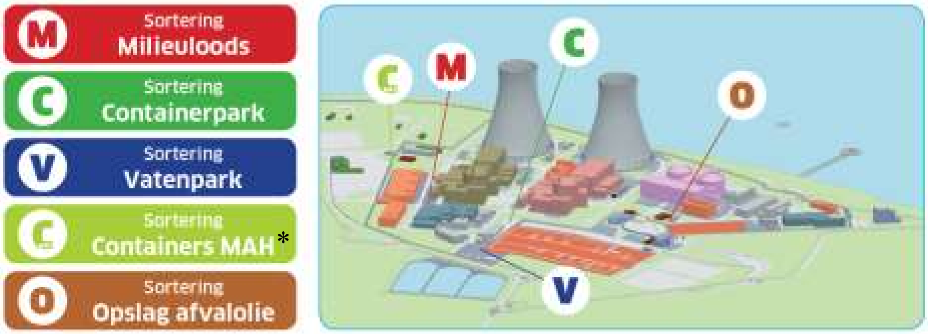
- transport and trading of waste materials;
- reporting on waste and materials;
- use of raw materials;
- selective collection (sorting and pick-up) from companies;
- extended manufacturer liability.

In addition to the obligations pursuant to VLAREMA, KCD's waste policy is also determined on the basis of the environmental management system in accordance with the international standard ISO14001 and the European EMAS (Eco Management and Audit Scheme) regulation. Both standards have the same goal: to implement a well-functioning environmental care system that strives for continuous improvement with regard to the environment.

Non-radioactive waste exists in solid, gaseous and liquid forms. Solid waste includes filters, construction waste, computer waste, lamps, paper and household waste. Liquid wastes include waste oils, degreasers, chemicals and sludges from septic tanks. Some wastes may be residual refrigerant waste gases.

Solid and gaseous waste is recycled externally as much as possible, liquid waste is purified. Only if this is not possible, incineration, dumping and discharge are possible. This is done by external approved waste processing companies. The companies authorised to pick up the waste and, subsequently, to process the waste are responsible for the consequences of their activities. The environmental permit for these waste pick-up and processing companies contains preconditions to limit environmental nuisance caused by the removal and recovery of waste.

KCD collects all waste separately. Various collection points are available for this purpose. A recycling park is reserved for non-hazardous waste and an environmental warehouse for hazardous waste (fluorescent tubes, absorbent cloths, batteries and solvents). This park is only accessible at set times and in the presence of an expert. KCD keeps track of how much waste is disposed of by whom and where it is processed. These accounts meet the legal requirements.



* MAH = Central Recycling Warehouse

Figure 2-69 Location of collection points

Figure 2-70 Schedule of containers Recycling park and Central Recycling Warehouse (MAH)

2.9.2.2 Operating conditions

The non-radiological waste is collected and stored separately awaiting transport to an authorised treatment facility.

Regulations from the Flemish Regulation on the Environmental Permit (VLAREM) and the Flemish Regulation on Soil Decontamination (VLAREBO) must be strictly respected. In addition to the general and sectoral permit conditions that apply to KCD, the following special conditions relating to waste imposed in the Provincial Environmental Permit Decree 2011 (basic permit for non-nuclear installations, reference M03/46003/46/2/A/5/HV/CW) are met:

- The construction of the rooms where waste is temporarily stored has been designed in such a way to ensure that liquids, spillages and leachates escaping from certain receptacles end up on a flooring equipped with gutters and are then led to one or more collection areas.
- Setting fire to waste or disposing of waste by discharging is not allowed.
- Waste materials can only be disposed of by transporting them to authorised or licensed collectors and processors of waste materials.

2.9.2.3 Current waste streams

Figure 2-3 shows the amount of non-radioactive waste generated for the period 2005-2014. There is no clear main fraction in total waste over the various years, therefore only the distinction between regular waste and residual waste is made.

Despite the large total volume of waste, the amount of residual waste (fraction remaining after sorting) is only about 5% of the total weight, due to all kinds of efforts. In 2006, a peak of more than 1,000 m³ of residual waste was recorded. After that time, the amount of residual waste decreased. Every year, the optimisation of KCD's waste policy is included in the environmental objectives in the form of a number of concrete measures (prevention, sorting and recycling). In the following year, the extent to which the measures have been effectively implemented will be assessed. A tool is available for monitoring the amount of waste produced. This explains the decreasing trend in the amount of residual waste. In 2014, the total volume of regular waste was 4,830 tonnes, of which 193 tonnes was residual waste.

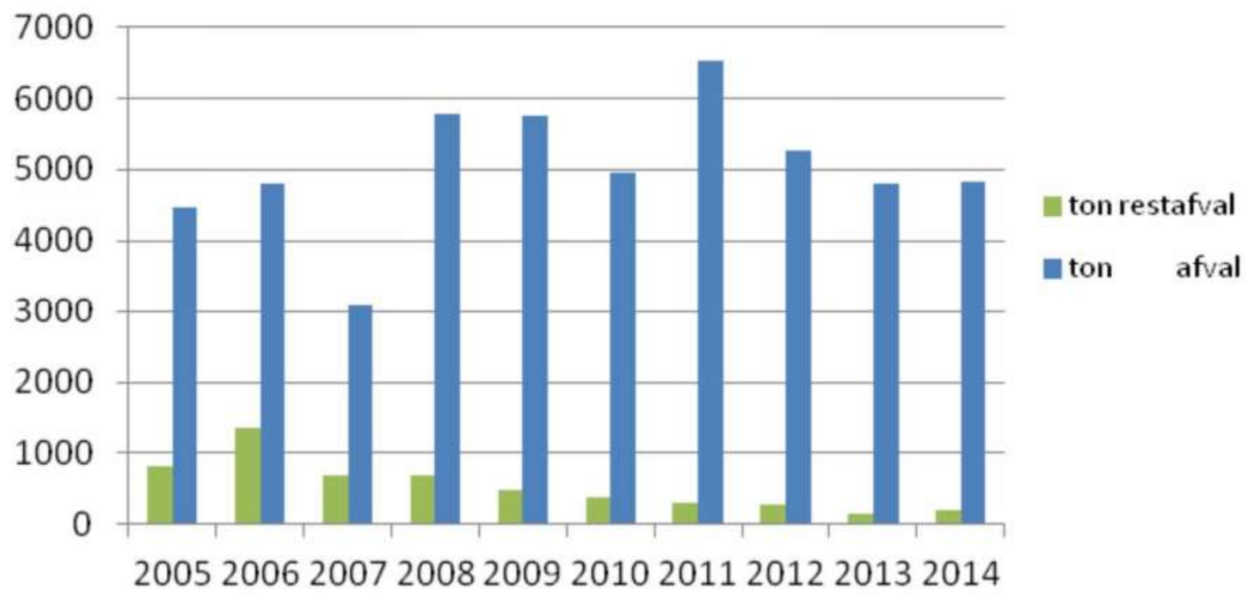


Figure 2-71 Total amount of non-radioactive waste and residual waste generated

2.9.3 Impact assessment

2.9.3.1 Operational phase of the project between 2015-2018

2.9.3.1.1 Waste production

For a description of the works carried out in the context of the adjustments for LTO, see the general section of the EIR (see Chapter 1.6).

As a result of the various projects that are part of the LTO programme, the following waste materials have been produced:

- waste from the preparation of planned construction works (removal of unusable structures, creation of a construction site area, etc.);
- construction waste (concrete, steel, cement, formwork, insulation materials, packaging machines, electrical waste, etc.);
- waste from construction site finishing (levelling, restoration of the original condition, ...);
- waste produced in new buildings (office activities, maintenance of equipment, etc.).

The total quantities of regular waste produced are:

- in 2015: 6,041 tonnes of which 183 tonnes of residual waste;
- in 2016: 3,391 tonnes of which 201 tonnes of residual waste;
- in 2017: 7,650 tonnes of which 210 tonnes of residual waste;
- in 2018: 7,311 tonnes of which 350 tonnes of residual waste.

The waste quantities recorded are general numbers for the entire KCD site. No distinction was made between the waste generated because of LTO and other projects ongoing at the same time. Variations in the amount of waste can usually be explained by major works on the site.

The total sum of non-radioactive waste generated in 2018 was 7,311 tonnes. This can be compared to the amount of waste that had left the site in 2017. The large amount of waste is mainly due to the many major projects related to the LTO of Doel 1 and Doel 2 and the repair works on the concrete. Due to the presence of a large number of employees on the site and the incorrect sorting of a number of fractions, residual waste rose to 350 tonnes in 2018.

The waste is selectively collected, sorted and disposed of according to specific properties and according to the strict procedures used by KCD.

Of the 7,311 tonnes of regular waste generated in 2018, 2,242 tonnes were hazardous and 5,069 tonnes were non-hazardous waste. 48.09% (3,517 tonnes) of the waste was recycled. 38.26% (2,798 tonnes) were treated, 13.38% (978 tonnes) were incinerated and 0.26% (18 tonnes) were removed to landfill.

Waste generated as a result of renovation and replacement projects of components of technical systems (motors, drives, electrical cabinets, cables, sensors, etc.) is managed in accordance with VLAREMA regulations.

The earth moving work was done according to the provisions of the VLAREBO. These regulations provide how excavated soil must be handled, starting at the place of excavation, including transport up to and including the final destination of the soil.

2.9.3.2 Operational phase in the future situation (period 2019-2025)

2.9.3.2.1 Waste production

The conditions as stated above (§ 2.9.2) continue to apply. The non-radiological waste is collected and stored separately awaiting transport to an authorised treatment facility.

Non-radioactive waste arising from the implementation of LTO measures is disposed of in accordance with the internal procedures of KCD, in accordance with the provisions of VLAREMA, VLAREBO and the provisions of the environmental management system.

After the implementation of the LTO measures, waste production did not differ significantly from the baseline situation (4,830 tonnes of regular waste). In 2019, the total volume of waste was 5,392 tonnes (including 301 tonnes of residual waste). This is 1,919 tonnes less than in 2018 because work on the LTO adjustments and the concrete repairs to units 3 and 4 had been completed. Also, there have been no replacements of cooling tower packing.

Of the 5,392 tonnes of regular waste produced in 2019, 37.35% (2,014 tonnes) was recycled. 54.24% (2,925 tonnes) were treated, 7.75% (417 tonnes) were incinerated and 0.67% (36 tonnes) were removed to landfill.

2.9.3.3 Post Operational Phase (period 2025-2029)

During the Post Operational Phase, in principle nothing is demolished in the nuclear installations. The objective is to remove the largest sources of radioactivity wherever possible so that dismantling can take place in complete safety and at the lowest possible dose. Waste will be produced by emptying circuits and decontamination.

Non-radioactive waste arising from the Post Operational Phase will be disposed of in accordance with the internal procedures of KCD, in compliance with the provisions of VLAREMA, VLAREBO and with the provisions of the environmental management system.

2.9.3.4 Zero alternative

In the zero alternative (= the non-LTO situation), no changes have taken place in the context of the lifetime extension of Doel 1 and 2. Consequently, no construction and excavation work would have taken place. The waste described under § 2.9.3.1 would therefore not have been produced. In the zero alternative, the amount of waste will therefore be less.

In addition, there will be no LTO of Doel 1 and 2 in the zero alternative. The POP would have taken place in 2015 instead of 2025. This means that the waste resulting from the normal operation of Doel 1 and 2 would no longer have been generated.

As far as the discipline section is concerned, it can be concluded that a POP in 2015 (= zero-alternative) would generate less waste in total than an LTO of Doel 1 and 2 until 2025.

2.9.3.5 Cumulative effects

No cumulative effects are expected with other projects in the area.

2.9.3.6 Cross-border effects

There are no cross-border effects on waste.

2.9.4 Monitoring

The waste section does not require any monitoring and evaluation measures, in addition to the registrations required by law.

2.9.5 Mitigating measures and recommendations

KCD has an environmental management system for its waste streams in accordance with the international standard ISO14001 and the European EMAS Regulation. In addition, the regulations laid down in VLAREMA and VLAREBO are followed. No additional mitigating measures or recommendations are considered necessary.

2.9.6 Knowledge gaps

The quantities of waste produced only within the framework of the LTO are not known. There are only figures available about the total amount of waste generated at the KCD site.

2.9.7 Conclusions

The work carried out as part of the LTO adjustments generated a certain amount of waste. Additional waste streams will also be created in the POP. In addition, waste is also generated during normal operation of the nuclear power plant. However, KCD makes every effort to reduce the impact of non-radioactive waste on the environment. However, a POP in 2015 (= zero alternative) would have produced less total waste than an LTO of Doel 1 and 2 to 2025.

2.10 Accident situations (non-radiological)

The following facilities contain hazardous materials (i.c. Seveso substances):

- gas oil (diesel) systems: storage tanks for the safety and emergency installations of the Doel 1, 2, 3 and 4 production units, for the heating system of the warehouse, for the auxiliary steam boilers and for the garage;
- hydrogen systems: hydrogen-cooling system for alternators of production units Doel 1, 2, 3 and 4;
- hydrazine (4.9%) systems: storage tanks for the Doel 1, 2, 3 and 4 production units;
- systems with an aqueous solution of potassium chromate[40], as a conditioning agent in the closed cooling circuit: buffer tanks for the production units Doel 1/2, 3 and 4 and for the water conditioning unit WAB;
- warehouses: storage of unit packs of all kinds of products.

2.10.1 Methodology

An environmental risk analysis has been carried out, qualitatively analyzing the causes and consequences, together with the enumeration of preventive, protective and mitigating measures. The analysis showed that only the products of hydrazine and gas oil can be released with a quantity higher than the limit value. Hydrogen by itself is not considered harmful when released into the environment. Only its explosion risk is dangerous.

Bow ties have been prepared for the systems with the following products:

- Hydrazine systems Doel 3
- Hydrazine systems Doel 4
- Hydrazine systems Doel 1/2
- Gas oil systems Doel 3
- Gas oil systems Doel 4
- Gas oil systems Doel 1/2

These reports are periodically checked during Seveso inspections.

Below is a brief summary of the analyses carried out. As the systems are quite identical for the different units, this is a general summary of the analyses.

[40] In 2010 the buffer tanks still contain concentrations of up to 16.8% potassium chromate. Under REACH, however, the use of potassium chromate has been prohibited since 21/9/2017 (unless an authorisation or exception is granted). For this reason, the systems are no longer topped up with these concentrations and the concentrations remain below 1% (solutions below 1% are not covered by the rules).

Table 2-1 Bow tie gasoil - storage section

Installatie : Gasolie **Sectie : opslag**			
vrijzetting : vrijzetting van gasolie door breuk of lek aan de opslagtank			
oorzaken	preventieve maatregelen	gevolgen	beschermingsmaatregelen
1. Overvulling opslagtank door lossen vrachtwagen	1.1 Controle op voldoende vrije ruimte in de opslagtank door niveaumeting	1. Vrijzetting van grote hoeveelheden	1.1 Regelmatige controlerondes
			1.2 Alarmering laag peil
	1.2 Overvulbeveiliging	2. Bodemverontreiniging	2.1 Inkuiping
	1.3 Noodstop op de vrachtwagen + permanent toezicht (chauffeur + afgevaardigde KCD)		2.2 Gecontroleerde verwijdering van water (en/ of andere vloeistoffen) in de inkuiping
			2.3 Periodieke controle van grondwater
			2.4 Grondwater– en bodemsanering
2. Blootstelling aan corrosieve condities	2.1 Coating		
	2.2 Opslagtanks opgesteld in gesloten lokaal (uitz. tank van hulpstoomketels)		
	2.3 Periodieke inspectie van de opslagtanks		

Table 2-2 Bow tie gas oil - loading section

Installatie : Gasolie **Sectie : verlading**			
vrijzetting : vrijstelling van gasolie door breuk of lek aan verladingsflexibel			
oorzaken	preventieve maatregelen	gevolgen	beschermingsmaatregelen
1. Beweging van aangekoppelde vrachtwagen	1.1 Procedure: chauffeur niet toegelaten in vrachtwagen tijdens transfer	1. Vrijzetting van grote hoeveelheden	ermanente aanwezigheid losoperator / chauffeur
	ielblokken plaatsen		1.2 Noodstop op vrachtwagenverpomping
2. Loskoppelen van een producthoudende flexibel	2.1 Procedure: lospistool sluiten aan het einde van de lossing	2. Verspreiding van lekvloeistof naar riolering	2.1 Absorptiemateriaal
3. Gebruik en manipulatie van flexibels (slijtage, ...)	3.1 Keuringsverslag slangen van leverancier		2.2 Opvangrecipiënt onder vrachtwagen – of vloeistofdichte losplaats
		3. Verspreiding via riolering naar Schelde	3.1 Opvangputten (H-putten) met biorotor

Table 2-3 Bow tie hydrazine - storage section

Installatie : Hydrazine **Sectie : opslag**			
vrijzetting : vrijzetting van hydrazine oplossing door lek of breuk aan hydrazine tanks			
oorzaken	preventieve maatregelen	gevolgen	beschermingsmaatregelen
1.Overvulling van hydrazine tank	1.1 Niveauregelkring stopt vulling automatisch	1. Vorming vloeistofplas in lokaal	1.1 Interventiemateriaal absorptieworsten
	1.2 Overloop naar een gesloten put	2. Bodemverontreiniging	2.1 Inkuiping lokaal
2. Corrosie	2.1 Tank staat intern gebouw opgesteld		
	2.2 Materiaal van de omhulling is corrosiebestendig; nl. Inox		

Table 2-4 Bow tie hydrazine - loading section

Installatie : Hydrazine **Sectie : verlading**			
vrijzetting : vrijzetting van hydrazine oplossing door breuk of lek aan verladingsflexibel			
oorzaken	preventieve maatregelen	gevolgen	beschermingsmaatregelen
1. Beweging van aangekoppelde vrachtwagen	1.1 Procedure: chauffeur niet toegelaten in vrachtwagen tijdens transfer	1. Vrijzetting van grote hoeveelheden	1.1 Permanente aanwezigheid losoperator / chauffeur
			1.2 Noodstop op vrachtwagenverpomping
		2. Bodemverontreiniging	2.1 Vloeistofdichte vloer met afgesloten opvangbak afgeleid naar riolering
	1.2 Wielblokken plaatsen		2.2 Interventiemateriaal absorptieworsten
2. Loskoppelen van een producthoudende flexibel	2.1 Procedure leegmaken flexibel op het einde van de lossing	3. Verspreiding via riolering naar Schelde	3.1 Opvangputten (H-putten) met biorotor
3. Gebruik en manipulatie van flexibels (slijtage,...)	3.1 Keuringsverslag slangen van leverancier		

2.10.2 Baseline situation

It is examined below whether, and if so, what proposed changes within the LTO project may affect the ambient effects of KCD-1 and KCD-2 in the event of an accidental hydrazine and gasoline (diesel) situation. Hydrogen is also taken into account because its explosion can also be considered accidental.

PLANOP (Protection Layer Analysis and OPtimization) surveys were conducted following a Seveso inspection for conventional safety of KCD-1 and KCD-2 facilities. PLANOP is a risk analysis methodology for analyzing systems that handle hazardous materials. A summary of the recommendations made is provided below.

The preparation of the PLANOP analysis involved the following:

- creating the PLANOP files;

- entering substances and reactions and completing the substance sheets and reaction sheets;
- defining and dividing the systems into sections and parts;
- identifying the substances and reactions in the components;
- identifying opportunity sources and release steps;
- introducing measures (existing or proposed new measures).

Table 2-5 PLANOP analysis of diesel system at KCD-1 and KCD-2

Nr	Origin	Action
1	Opportunity source Heat or gas production as a result of reaction with undesirable substances in component Storage tank 80000 l	A connection must be provided at the unloading point where an unloading pistol can be inserted (in accordance with the rest of the plant)
2	Measure Liquid-tight loading area	Monitoring program should regularly check that there is no oil lying on oil separator of the unloading site.
3	Measure Procedure: ask driver if hand brake is on	The use of wheel blocks will become mandatory in the unloading procedure.
4	Measure Hydraulic pressure tests flexible wires	Check whether inspection certificates of hoses on the truck have been requested & viewed.

Table 2-6 PLANOP analysis hydrogen plants KCD-1 and KCD-2

Nr	Origin	Action	Status
1	Opportunity Source Internal Explosion in component Pressure containers	The Royal Decree of March 26, 2003 (Published on 5 May 2003) on the welfare of workers who may be at risk from explosive atmospheres (transposition of European Directive 1999/92/EC) stipulates that the employer must prepare an explosion safety document.	implemented
2	Measure Procedure: hydrogen supply	General unloading procedure is in place, but the checklist specific to hydrogen unloading point still needs to be made.	implemented
3	Opportunity source Movement of hitched vehicles in component Loading of tube trailer	The use of wheel blocks will become mandatory in the unloading procedure.	implemented
4	Opportunity source Use of flexible wires	Add request for periodic check to checklist.	implemented

Nr	Origin	Action	Status
	in component Loading of tube trailer		
5	Component Loading of tube trailer	Investigate the need for interlocked equipotential connection to the load	implemented

Table 2.7 PLANOP analysis of hydrazine plant KCD-1 and KCD-2

Nr	Origin	Action	Status
1	Opportunity source Breakthrough of high pressure from nitrogen supply in component Unloading bay tanker	Include in unloading checklist: check inspection certificate of flexible wires.	Implemented
2	Opportunity source Movement of hitched truck in component Unloading bay tanker	Recommendation: place wheel blocks during unloading.	Implemented
3	Component Unloading bay tanker	What happens to the gases from the pushed up truck: truck exhausts directly into the atmosphere (see comment objective 3 - measurements Werner)	Implemented
4	Component Hydrazine dilution	Verify that a periodic leak detection check of double-walled tank RI-0R22 is done.	Implemented
5	Opportunity source Overfill due to addition of MW in day tanks in component Hydrazine injection	Consider whether locked-closed valves for supply of MW to day tanks are necessary.	Implemented
6	Opportunity source Overfill due to misaligning circulation pump to day tank in component Hydrazine injection	Writing a procedure: follow up on level measurement of day tank 1/2 so that if misalignment occurs, there will be no outflow via the pumping action.	Implemented
7	Opportunity source Overfill day tank 1 /2 by pumping from RI0R22 in component Hydrazine injection	Review the PLANOP analysis as it progresses through the design of the Doel 1/2 RI system. Pay attention to sufficient reliability of the overfilling prevention system of the day tanks to prevent overfilling.	Project is being restarted as part of the LTO
8	Opportunity source Poor performance of activated carbon filter in component Hydrazine dilution	Set up a maintenance program for activated carbon filter PKD-D0/NI0F2.	Implemented
9	Opportunity Source Overfill RI0R22 due to unloading truck or water overfilling in component Hydrazine dilution	Investigate in more detail the reliability of the measures to prevent overfilling of the tank RI0R22: Two options: (compare two gauge measurements against each other) - Either add second measurement on tank - Or replace low level measurement with a new level measurement	Implemented
10	Opportunity Source Overfill RI0R22 due to unloading truck or water overfilling in component Hydrazine dilution	Valve ORI 1063 must be made locked-closed	Project is being restarted as part of the LTO

2.10.3 Impact assessment

The potential impacts of accidental situations on the environment are assessed for both scenarios to be addressed:

- Implementation of the Project
  It is divided into two phases, each of which is covered in a separate Section.
  - Operational phase of the Project between 2015 and 2018: the construction of the LTO measures. These are made particularly during outages. Electrabel also operates both KCD-1 and KCD-2 during this period.
  - Operational phase in future situation (period 2019 - 2025): regular operations after implementation of the LTO measures.
- Zero alternative, no LTO.

2.10.3.1 Operational phase of the Project between 2015 and 2018

The external risks to humans of a major accident were quantified by means of a quantitative risk assessment (QRA). Only products with properties (toxic, flammable, explosive) that affect the external risk to humans were included in this analysis.

The maximum impact distances (greatest distance to 1% lethality) were calculated for:

- heat radiation (as a result of a fire in the containment tank of auxiliary steam boilers, a warehouse fire and a flare fire during the loading of hydrogen)
- over-pressure effects (due to explosion when loading hydrogen);
- toxic fumes (due to release of hydrazine).

The largest maximum effect distance occurs for a hydrogen explosion due to the rupture of the loading hose with delayed ignition, specifically 84 meters. The maximum impact distances do not extend beyond the borders of the site. The external risk to human (risk to persons present outside the site) is therefore negligible. No significant negative impact is expected on the IHDs of surrounding SPA areas.

2.10.3.2 Operational phase in the future situation (period 2019 - 2025)

The LTO situation does not differ significantly from the baseline situation. Some diesel generators have been added since 2013/2014, but since the quantities of gas oil stored in these generators are much lower than those in the auxiliary steam boilers (1,200 m³), the fire of this last storage tank is still an enveloping scenario. Hydrazine and hydrogen systems have not changed. Therefore, the external risk to humans remains unchanged.

The potential for potential environmental impact from the diesel generators is considered negligible.

At the same time, KCD-3, KCD-4, WAB and FCB are operated and they are not part of the Project. Therefore, the probability of a possible non-radiological incident does not change. So neither is the likelihood of a potential environmental impact. No significant negative impact is expected on the IHDs of surrounding SPA areas.

2.10.3.3 Zero alternative

Under the Zero Alternative, LTO adjustments will not be made. Therefore, no additional diesel generators will be installed. Consequently, the probability of a potential environmental impact will still be negligible.

If no LTO takes place, both KCD-1 and KCD-2 will be permanently discontinued. The Post Operational Phase until the start of the dismantling will occur under both the Zero Alternative (no Project) and the Project. In both situations, the Post Operational Phase is similar in terms of duration and preparations for dismantling. The only difference is the time at which the Post Operational Phase occurs.

Consequently, there will be no difference in terms of accident situations between the Zero Alternative (no Project) and the Project. This also applies to non-radiological incidents and their associated environmental impact.

At the same time, KCD-3, KCD-4, WAB, and FCB are operated and the probability of a potential non-radiological incident for these facilities does not change. So neither is the likelihood of a potential environmental impact. When aggregated for the entire site, the probability of an environmental impact occurring due to an incident will be lower under the Zero Alternative (no Project) than under the baseline situation because KCD-1 and KCD-2 will not be operated further.

2.10.4 Cross-border effects

Regarding the external risk to humans, it was stated above that the maximum effect distance (1%-lethality) does not extend beyond the site boundaries of KCD. Therefore, the external risk to humans is also negligible outside the country and region boundaries.

In the event of a fire, the RIVM report states, based on a large number of measurements, that there is generally no risk to people and the environment from 1 kilometre away.

Based on literature, it is believed that most animals are more sensitive to inhalation exposure to hydrazine. However, as the 1% (human) lethality concentration is not reached in a potential accident, and hydrazine in the atmosphere is unstable (lifetime of about 1h in a pure atmosphere), it will not spread over long distances and no relevant effects on fauna are expected beyond the boundaries of the site.

Furthermore, animals are generally more sensitive to overpressure effects than humans (where birds are more sensitive than mammals, and small mammals are more sensitive than large ones). The maximum effect distance for 1% (human) lethality is only 84 m. This distance does not extend beyond the KCD site boundary. As the overpressure in an open environment decreases exponentially with distance, the effect outside the boundaries of the terrain will therefore decrease rapidly. Consequently, no relevant effects on fauna are expected.

The above leads us to conclude that no significant negative impact is expected on the IHDs of SPA areas.

Consequently, it can be assumed that the consequences of major accidents are not cross-border in nature.

2.10.5 Monitoring

No monitoring is considered necessary.

2.10.6 Mitigating measures

ENGIE/Electrabel can and must meet the accident criteria in force in Belgium. To this end, KCD-1 and KCD-2, as well as KCD-3, KCD-4, WAB and the FCB, are equipped with various safety features and an emergency plan is in place. No additional mitigation measures under the Project are therefore necessary.

2.10.7 Knowledge gaps

There are no gaps in knowledge that affect the alternatives considered and thus do not impede decision making.

2.10.8 Conclusions

The maximum impact distances of a non-radiological incident at KCD-1 and KCD-2 do not extend beyond the site boundaries. The probability of a potential environmental impact does not change significantly as a result of LTO works or as a result of the longer operation of KCD-1 and KCD-2. No significant negative impact is expected on the IHDs of surrounding SPA areas.

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