Improved hazardous waste & contaminated soil management in Greece

Final Report

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LIST OF ABBREVIATIONS

ACCREDIA	ITALIAN NATIONAL ACCREDITATION BODY
ADE	AVERAGE DAILY EXPOSURE
ADEME	FRENCH AGENCY FOR ECOLOGICAL TRANSITION
ALBON	LAND AND SOIL PROTECTION, NATURAL RESOURCES
ALUR	LAW FOR ACCESS TO HOUSING AND RENOVATED TOWN PLANNING
ASTM	AMERICAN SOCIETY FOR TESTING AND MATERIALS
BASIAS	HISTORICAL INVENTORY OF INDUSTRIAL SITES AND SERVICE ACTIVITIES
BASOL	FRENCH DATABASE FOR POLLUTED SITES AND SOILS
BAT	BEST AVAILABLR TECHNIQUES
BATNEEC	BEST AVAILABLE TECHNOLOGY NOT ENTAILING EXCESSIVE COSTS
BDES	SOIL-STATE DATABASE
BE-F	BELGIUM FLANDERS
BER	BACKGROUND POLLUTION
BE-W	BELGIUM WALLOON
BMU	GERMAN FEDERAL MINISTRY FOR ENVIRONMENT, NATURE CONSERVATION AND NUCLEAR SAFETY
BRGM	GEOLOGICAL AND MINING RESEARCH OFFICE
BS	BRITISH STANDARDS
BV	BACKGROUND CONCENTRATIONS
BTEX	Benzene, Toluene, Ethylbenzene and Xylenes
C4SL	CATEGORY 4 SCREENING LEVELS
CAP	COMMON AGRICULTURAL POLICY
CBA	COST BENEFIT ANALYSIS
CERCLA	COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION AND LIABILITY ACT
CLEA	CONTAMINATED LAND EXPOSURE ASSESSEMENT
CLR11	CONTAMINATED LAND REPORT 11
CLRM	CLASSICAL LINEAR REGRESSION MODEL
COFRAC	FRENCH ACCREDITATION COMMITTEE
CS	CONTAMINATED SITES
CSC	THRESHOLD CONCENTRATION LEVELS
CSM	CONCEPTUAL SITE MODEL
CSMF	CONTAMINATED SOIL MANAGEMENT FRAMEWORK
CSR	SITE-SPECIFIC CONCENTRATION LEVELS
CTC	COMMON TOXICITY CRITERIA
CWBP	WALLOON CODE OF GOOD PRACTICES
CWEA	WALLOON SAMPLING AND ANALYSIS MATHODS
D_{tb}	NO OBSERVED ADVERSE EFFECT LEVEL
DEFRA	DEPARTMENT OF ENVIRONMENTAL, FOOD AND RURAL AFFAIRS
DG	DIRECTORATE-GENERAL FOR STRUCTURAL REFORM SUPPORT OF THE EUROPEAN COMMISSION
DGATLP	DEPARTMENT OF LAND PLANNING, HOUSING AND CULTURAL HERITAGE
DIPA	ENVIRONMENTAL PERMITTING DIRECTORATE
DIR	DAILY INTAKE RATES
DNAPL	DENSE NONAQUEOUS PHASE LIQUIDS
DOMINO	DOCUMENTATION ENVIRONMENTAL STANDARDIZATION
DQRA	DETAILED QUANTITATIVE RISK ASSESSMENT
DREAL	REGIONAL DIRECTORATE FOR ENVIRONMENT, PLANNING AND HOUSING
DrWPAa	DRINKING WATER PROTECTED AREA
DWS	DEPARTMENT OF WATER AND SANITATION
EA	ENVIRONMENTAL AGENCY
EC	EUROPEAN COMMISSION
ECA	ENVIRONMENTAL CONSOLIDATED ACT
ED	ENVIRONMENTAL DAMAGE
EIA	ENVIRONMENTAL IMPACT ASSESSMENT

ELD	ENVIRONMNENTAL LIABILITY DIRECTIVE
EN	EUROPEAN STANDARDS
EQS	ENVIRONMENTAL QUALITY STANDARDS
ERA	ECOLOGICAL RISK ASSESSMENT
ESA	ENVIRONMENTAL SITE ASSESSMENT
ESYD	HELLENIC ACCREDITATION SYSTEM
EU	EUROPEAN UNION
EWC	EUROPEAN WASTE CODE
EWR	ELECTRONIC WASTE REGISTRY
FR	FRANCE
GAC	GENERIC ASSESSMENT CRITERIA
GHG	GREENHOUSE GASES
GIZ	DEUTSCHE GESELLSCHAFT FÜR INTERNATIONALE ZUSAMMENARBEIT
GIS	GEOGRAPHIC INFORMATION SYSTEMS
GQRA	GENERIC QUANTITATIVE RISK ASSESSMENT
GREC	REFERENCE GUIDE FOR THE CHARACTERIZATION STUDY
GREF	REFERENCE GUIDE FOR FINALASSESSEMENT
GREO	REFERENCE GUIDE FOR ORIENTATION STUDY
GRER	REFERENCE GUIDE FOR RISK ASSESSEMENT
GRPA	REFERENCE GUIDE FOR THE SANITATION PROJECT
GSV	GROUNDWATER SCREENING VALUES
GW	GROUNDWATER
GWSDAT	GROUNDWATER STATITICS FOR MONITORING AND COMPLIANCE
HC_5	HAZARD CONCENTRATION 5%
HC_{50}	HAZARD CONCENTRATION 50%
HCV	HEALTH CRITERIA VALUES
HI	HAZARD INDEX
HP	HIGH PRIORITY
HSGME	HELLENIC SURVEY OF GEOLOGY & MINERAL EXPLORATION
ICPE	FACILITIES CLASSIFIED FOR ENVIRONMENTAL PROTECTION
IED	INDUSTRIAL EMISSION DIRECTIVE
IEM	ASSESSMENT OF THE STATE MEDIA QUALITY
IMPEL	EU NETWORK FOR THE IMPLEMENTATION & ENFORCEMENT OF ENVIRONMENTAL LAW
INERIS	NATIONAL INSTITUTE FOR ENVIRONMENTAL TECHNOLOGY AND HAZARDS (FRANCE)
ID	INDEX DOSE
IGW	IMPACT TO GROUNDWATER
ISO	INTERNATIONAL ORGANIZATION FOR STANDARDIZATION
ISO/IEC	INTERNATIONAL ORGANIZATION FOR STANDARDIZATION/INTERNATIONAL ELECTROTECHNICAL COMMISSION
ISO/SD	INTERNATIONAL ORGANIZATION FOR STANDARDIZATION/ COMMITTEE DRAFT
ISO/TC	INTERNATIONAL ORGANIZATION FOR STANDARDIZATION/TECHNICAL COMMITTEE
ISS	SUPERIOR HEALTH INSTITUTE
ISPRA	INSTITUTE FOR ENVIRONMENTAL PROTECTION AND RESEARCH
ISRA	INDUSTRIAL SITE RECOVER ACT
ISSEP	SCIENTIFIC INSTITUTE OF PUBLIC SERVICES (BELGIUM)
IT	ITALY
IV	INTERVENTION VALUES
JMD	JOINT MINISTERIAL DECISIONS
JRC	JOINT RESEARCH CENTRE
LCRM	LAND CONTAMINATED RISK MANAGEMENT
LNAPL	LESS DENSE NONAQUEOUS PHASE LIQUIDS
LNE	MINISTRY OF ENVIRONMENT, NATURE AND ENERGY
LOW	LIST OF WASTE
LP	LOW PRIORITY
LRV	LOCAL REFERENCE VALUES
LSRP	LICENSED SITE REMEDIATION PROFESSIONALS

LULUCF	LAND USES, LAND USE CHANGE AND FORESTRY
MAB	MAN, AND THE BIOSPHERE PROGRAMME
MATTM	MINISTRY OF THE ENVIRONMENTAL AND PROTECTION OF LAND AND SEA
MD	MINISTERIAL DECREE
MIRA	REGIONAL ENVIRONMENTAL POLICY PLAN (BELGIUM)
MTBE	Methyl-tertiary-butyl-ether
MP	MEDIUM PRIORITY
MV	MEAN VALUE
NA	NEGLIGIBLE ADDITION
NAGREF	NATIONAL AGRICULTURAL RESEARCH FOUNDATION
NAPL	NONAQUEOUS PHASE LIQUIDS
NBSAP	NATIONAL BIODIVERSITY STRATEGY AND ACTION PLAN
NEN	NETHERLANDS INSTITUTE OF STANDARDIZATION
NJ	NEW JERSEY
NJDEP	NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION
NHI	NATIONAL HEALTH INSTITUTE
NICOLE	NETWORK FOR INDUSTRIAL Co-ORDINATED SUSTAINABLE LAND MANAGEMENT IN EUROPE
NL	NETHERLANDS
NQMS	NATIONAL QUALITY MARK SCHEME
NRV	NATIONAL REFERENCE VALUES
NTUA	NATIONAL TECHNICAL UNIVERSITY OF ATHENS
NWMP	NATIONAL WASTE MANAGEMENT PLAN
OECD	ORGANIZATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT
ONRW	OUTSTANDING NATIONAL RESOURCES WATERS
OVAM	PUBLIC WASTE AGENCY OF FLANDERS
PAH	Polycyclic Aromatic Hydrocarbon
PCB	POLYCHLORINATED BIPHENYL
PD	PRESIDENTIAL DECREE
PFAS	POLYFLUOROALKYL SUBSTANCES
PG	REMEDIATION PLAN
PNSE	NATIONAL HEALTH ENVIRONMENTAL PLAN
PPE	PERSONAL POTECTIVE EQUIPMENT
PQL	PRACTICAL QUANTITATION LEVEL
PRP	POTENTIALLY RESPONSIBLE PARTY
QA/QC	QUALITY ASSURANCE/QUALITY CONTROL
QSAR	QUANTITATIVE STRUCTURE-ACTIVITY RELATIONSHIP
RBCA	RISK-BASED CORRECTIVE ACTION
RCRA	RESOURCE CONSERVATION AND RECOVERY ACT
REX	REGISTERED EXPORTER SYSTEM
RfDo	ORAL REFERENCE DOSE
RI	RISK INDEX
RTM	REMEDIAL TARGETS METHODOLOGY
RIVM	NATIONAL INSTITUTE OF PUBLIC HEALTH AND ENVIRONMENT (NETHERLANDS)
SCI	SITES OF COMMUNITY IMPORTANCE
SEA	STRATEGIC ENVIRONMENTAL ASSESSEMENT
SESOIL	SEASONAL SOIL COMPARTMENT MODEL
SEV	HELLENIC FEDERATION OF ENTER PRISES
SGV	SOIL GUIDELINE VALUES
SIS	SOIL INFORMATION SYSTEM
SMP	SOIL MONITORING PROGRAM
SPA	SPECIAL PROTECTION AREA
SPAQuE	PUBLIC COMPANY FOR ENVIRONMENTAL QUALITY ASSISTANCE
SPLP	SYNTHETIC PRECIPITATION LEACHING PROCEDURE
SRRA	SITE REMEDIATION REFORM ACT
SPZ	SOURCE PROTECTION ZONE

SQS	SOIL QUALITY STANDARDS
SS	SPECIAL SITES
SSD	SPECIES SENSITIVITY DISTRIBUTIONS
SSL	SOIL SCREENING LEVELS
SSSV	SITE SPECIFIC SCREENING VALUE
SV	SCREENING VALUES
SRSP	STRUCTURAL REFORM SUPPORT PROGRAMME
SYGAPEZ	CO-ORDINATION OFFICE FOR THE REMEDIATION OF ENVIRONMENTAL DAMAGE
TDI	DAILY INTAKE INDEX
TNO	GEOLOGICAL INSTITUTE (NETHERLAND)
TORS	TERMS OF REFERENCES
TPH	TOTAL PETROLEUM HYDROCARBONS
TR	TARGET RISK
UK	UNITED KINGDOM
UKAS	UNITED KINGDOM ACCREDITATION SERVICES
UMS	ENVIRONMENT, PEOPLE, POLLUTANTS (Umwelt, Mensch, Schadstoff)
UNESCO	UNITED NATIONAL EDUCATION, SCIENTIFIC AND CULTURAL ORGANIZATION
USA	UNITED STATES OF AMERICA
USEPA	UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
USGS	UNITED STATES GEOLOGICAL SURVEY
VOC	VOLATILE ORGANIC COMPOUNDS
VS	TRIGGER VALUES
VS_E	ECOSUSTEM RISK CALCULATED VALUE
VS_H	HUMAN RISK CALCULATED VALUE
VS_L	LEACHING RISK CALCULATED VALUE
VR	REFERENCE VALUES
VROM	DUTCH MINISTRY OF ENVIRONMENT
YPEN	MINISTRY OF ENVIRONMENT AND ENERGY
WAC	WASTE ACCEPTANCE CRITERIA
WFD	WASTE FRAMEWORK DIRECTIVE
WHO	WORLD HEALTH ORGANIZATION

0. Background and disclaimer

The Greek government asked the European Commission (EC) for support in specific areas (including the improvement of municipal waste management, regulatory issues of the waste sector, the management of specific waste categories) in order to raise the quality and quantity of recycling, to improve data quality and to effectively use economic instruments. To achieve the aforementioned goals, the Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ) provides "Technical support for the implementation of the National Waste Management Plan (NWMP) of Greece" from 2018 to 2020. The project is funded by the European Union (EU) via the Structural Reform Support Programme (SRSP) and the German Federal Ministry for Environment, Nature Conservation and Nuclear Safety (BMU), and jointly implemented by GIZ and the Hellenic Ministry of Environment and Energy (YPEN), in collaboration with the EC.

GIZ commissioned Dr Iraklis Panagiotakis (ENYDRON – Environmental Protection Services) to provide specific technical expertise to GIZ and YPEN from November 2020 to February 2021 by supporting the project activity 3.2 "Improved hazardous waste management in Greece - Contaminated soil management framework". This is the Inception Report where the methodological approach and some preliminary results are presented.

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Project Name	Technical support for the implementation of the National Waste Management Plan (NWMP) of Greece (68.3045.9)
Client / Project Executing Agency	**Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ)** Project manager: Ulrich Laumanns (ulrich.laumanns@giz.de) Senior consultant: Βασιλική Παναρέτου (vasiliki.panaretou@giz.de) Senior consultant: Μαρία Πισιμίση (maria.pisimisi@giz.de)
Consultant	Dr Iraklis Panagiotakis Environmental Engineer ENYDRON – Environmental Protection Services panagiotakis@enydron.com, www.enydron.com
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Disclaimer

ENYDRON has taken due care in the preparation of this report to ensure that all facts and analysis presented are as accurate as possible within the scope of the study. However, no

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NATIONAL STAKEHOLDERS & EXPERTS

ALEXOPOULOU STELLA, MINISTRY OF DEVELOPMENT AND INVESTMENT

ARFANAKOU ANASTASIA, MINISTRY OF ENVIRONMENT AND ENERGY

ARGYRAKI ARIADNI, UNIVERSITY OF ATHENS

CAVOURA OLGA, UNIVERSITY OF WEST ATTICA

KARDARAS LEONIDAS, ELVAL

KARVOUNIS GIORGOS, DECENTRALIZED ADMINISTRATION OF ATTICA

KATSIAMBOULAS ALEXANDROS, TITAN

KAVVADIAS VICTOR, HAO-DEMETER

KONSTANTINOPOULOS GIORGOS, LAWYER

KONSTANTINOU KONSTANTINOS, SEV

LIAKOPOULOS ALEXANDROS, HSGME

MOUNTOURIS ANTONIS, HELPE

MPOUZAS DIMITRIS, MINISTRY OF ENVIRONMENT AND ENERGY

NIKOLAIDIS NIKOLAOS, TECHNICAL UNIVERSITY OF CRETE

NISIANAKIS PAVLOS, ATHENS ANALYSIS LABORATORIES

PANTAZIDOU MARINA, NATIONAL TECHNICAL UNIVERSITY OF ATHENS

PAPADOPOULOS STELIOS, INTERGEO

PAPASSIOPI NYMFODORA, NATIONAL TECHNICAL UNIVERSITY OF ATHENS

POULI STAVROULA, MINISTRY OF ENVIRONMENT AND ENERGY

SKIADAS PANAGIOTIS, VIOHALCO

TINIAKOS DIMITRIS, POLYECO

TSOLAKIDIS KONSTANTINOS, GRIFFIN ENVIRONMENTAL CONSULTING

VATSRERIS CHRISTOS, INTERGEO

NIKA KONSTANTINA, MINISTRY OF ENVIRONMENT AND ENERGY

International Experts

Albergaria Tomas, Instituto Superior de Engenharia do Porto, Portugal

Bagard Oliver, GOLDER, France

Boronat Jordi, MediTerra Environmental Consultants, Spain

Bosma Tom, Wageningen University, The Netherlands

Ceenaeme Johan, OVAM, Belgium

De Cleen Margot, Ministry of Infrastructure and Water Management, The Netherlands

De Fray Johan, Signify, Belgium

Falconi Marco, ISPRA, Italy

Grabherr Dietmar, Common Forum, EU

Guerin Valérie, BRGM, France

Henri Halen, RamSes, Belgium

Henseler Ole, CDM Smith, Germany

Leyrit Sebastien, AECOM, France

Leyrit Sebastien, AECOM, France

Lopez Aurora Santos, Universidad Complutense de Madrid, Spain

Maurer Olivier, GOLDER, France

Misyris Nikos, RSK, United Kingdom

Panagos Panos, Joint Research Centre (JRC), European Commission

Parkman Rick, AECOM, United Kingdom

Santilli Nazzareno, ISPRA, Italy

Slenders Hans, ARCADIS, NL

Swartjes Frank, National Institute for Public Health and the Environment, The Netherlands

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The responses of the experts participated reflect their own opinion and do not represent the view of their companies and the authorities.

1. Executive summary

Soil contamination is an old problem dating back to Industrial Revolution. However, this crucial environmental problem failed to receive prompt attention. Contaminated soil management is one of the most rapidly developing environmental protection subjects. However, the high cost that soil remediation requires along with the complexity of the problem render contaminated soil management a real challenge for environmental professionals and society altogether. Unlike most EU countries, Greece does not have a robust Soil Strategy and as a result a Contaminated Soil Management Framework (CSMF) yet. The legislation is incomplete and fragmentary, and no guidelines are provided for demanding technical subjects, such as site assessment and soil and groundwater sampling and chemical analysis. Currently in Greece, the contaminated soil is part of the hazardous waste management framework, a problematic practice for consultants, industries and pertinent authorities. On the other hand, hazardous waste management (HWM) in Greece requires significant improvements to catch up the advanced EU countries. Among the most significant HWM problems is the historic hazardous waste deposits, which obviously is closely related to contaminated soil management in the country.

The purpose for this assignment is to provide specific technical expertise to the GIZ team, by supporting the Greek Ministry of Environment and Energy (YPEN) to build institutional capacities, by contributing to the examination of relevant experiences and best available techniques (BAT) from other EU Member States and formulation of recommendations for a CSMF for Greece. In addition, in the context of this study, modification of the main hazardous waste legislation is recommended as well as a roadmap for improving HWM in Greece.

In practice the approach was divided into three phases. During phase 1 all the appropriate baseline work required for the entire project was accomplished. In particular, the national legislation was reviewed, key national stakeholders were identified, and online meetings were carried out. During this phase, the needs and the gaps were identified. A similar approach was also followed for the HWM. During phase 2 all data on the EU experience were reviewed and the best practices, useful toolkits and lessons learned were recorded and evaluated. In particular, during this phase a group of competent contaminated soil international experts was created and a tailored made questionnaire was delivered to them. For the improvement of hazardous waste management, the EU experience was studied by EU documents and legislations. The third was the last phase of the assignment during which the appropriate recommendations were gathered, and roadmaps for the CSMF and HWM were created.

The methodology followed to draw the main CSMF recommendations was mainly the data gathering from the experienced EU countries, as resulted by the literature review and a questionnaire survey with Greek and EU contaminated soil experts and stakeholders. These countries are Belgium (Flanders Region and Walloon Region), the Netherlands, France, United Kingdom (UK), Germany, Italy, Spain and Portugal. In addition, the framework applied in New

Jersey (NJ, USA), a State probably with the strictest environmental legislation framework in USA, is also presented herein. The results of the study are focused on the best practices applied in the participant countries with the main subjects be the legislative framework, the screening values application system and the risk assessment for human health and ecosystem.

The first significant best practice detected is the single framework governing both soil and groundwater policy, which is already the case for most EU countries. The framework should be neither complicated nor simplistic. Good example of such a framework is that of **Belgium Flanders**, **Germany** and **the Netherlands**. In addition, most of the advanced countries in EU and globally (e.g., USA) have instituted a soil screening value system. Only **France** operates a framework without such values (screening values were withdrawn in 2007), where decisions are solely based on site-specific risk assessment procedure. In some countries historical contaminated sites are treated differently in terms of screening values and there a pure risk-based approach is typically applied. Since the “multifunctional approach” has been replaced by the “fitness-for-use” approach in most of the countries, the linkage between the contaminated soil management framework and the land planning framework becomes a very crucial parameter and a growth lever for both financial development and environmental sustainability. Therefore, screening values and remediation based on land uses is a major parameter to be included in a CSMF. As mentioned above, the “multifunctional approach” has been replaced by the “fitness-for-use” approach in most of the countries. This also led most countries to move from single Screening values to values based on the land use, using risk assessment methodology. Another best practice, which has been identified during the study is the soil screening values correction based on site specific soil characteristics, which have typically an important role in fate and transport of contaminants. This is a practice followed by several countries such as **UK** and **Belgium Flanders** and **the Netherlands**. A typical best practice, which is also very straightforward to be adopted by other countries, is that of **Germany**, where soil screening values for different land uses and different pathways (soil-human, soil-groundwater, soil-plant) are provided. A complete and informative technical and non-technical framework (toolbox) is also a significant best practice. Since the technical issues faced in contaminated sites are very complicated, a complete and informative technical toolbox should be constructed and be publicly available. On the other hand, non-technical tools are also used for a more efficient public consultation. Currently, this is the case for several EU countries such as **France, UK** and **Netherlands**, where a technical documents, instruction videos etc. are available and understood not only by experts but by policymakers and the public as well.

Although decentralization is a very important parameter in all advanced contaminated soil management frameworks in EU, the pertinent authority should have the appropriate capacity building not only in terms of sufficient technological level or sufficient economic resources, but mainly in terms of knowledgeable human resources that understand the complicated nature of geo-environment. A typical example of such an authority is OVAM in **Belgium Flanders** covering issues of waste and sustainable material management and soil contamination. The national geological institutions can play also an important role in contaminated soil management frameworks since they typically have the national databases and the appropriate expertise. A good example of such institution is BRGM (The Bureau de recherches géologiques et minières) in **France**. In addition, brownfields is typically a very important environmental issue in most of the industrialized countries, including of course EU countries and the USA. The aspect of reusing brownfields for industrial or commercial purpose instead of consuming precious natural or agricultural land plays an essential role. The registration of contaminated sites is a standard practice in EU and worldwide. This is a strong policymaking tool that prioritize the contaminated sites in order to ensure the remediation of those posing high risk to environment and the society and be used in several EU countries.

The restriction of future land uses of a contaminated site is among the potential measures that can be used as part of the remediation actions. Thus, for example if remediation targets suitable for industrial use but not for residential use have been achieved, this site will be restricted to be used only as industrial site. This is a practice applied in several **EU** countries and the the **USA**. Since contaminated site assessment and remediation are typically very complicated projects an accreditation system of soil remediation expert exists in most of the advance EU countries. A typical example in **Belgium Flanders**, where two types of experts exist, type 1 and type 2. A very efficient tool of contaminated soil management in **Belgium Flanders** is the soil certificate which is necessary for any land transfer action. Soil certificates have been instituted also in other countries such as in **France** (Alur law 2014) in cases such as change of land use and where remediation is required. Last but not least in best practices, is the management of diffuse contamination, which tends to be part of the Soil strategy of advanced EU, countries such **the Netherlands**, but definitely should be a separate part of any CSMF.

Considering all the above best practices collected from the most advanced EU countries and the USA, it is shown that the need of a new integrated CSMF as part of an integrated Soil Strategy in Greece is imperative. The recommendations which will help to build the new CSMF are listed below.

<u>General</u>

- A new clear, independent, practical and informative legislation should be created on contaminated soil management, as part of a wider Soil Strategy. By then, the existing legislation (JMDs 13588/2006 and 24944/2006) should be modified accordingly (i.e., new terms, phased-approach, risk-based methodology).
- The CSMF should be robust & pragmatic not pretending to solve everything, but should provide coherence, transparency, ease of understanding and be appropriate for the needs of the different stakeholders.

- Be governed by a) the polluter pays principle, b) the risk-based approach, and c) the BATNEEC principle (Best available techniques not entailing excessive cost).
- Deal also with prevention of new contaminated sites and historic contaminated sites.
- Contaminated Soil Management Framework in Greece will be developed in phases.

Legislation, Administration & Professionals

- Create a Committee, under the Ministry of Environment and Energy, where all authorities involved will be represented and stakeholders and experienced academics should participate.
- Create a new pertinent administrative body (within an existing one or an independent one) to be responsible for the Soil Strategy and the contaminated soil management framework.
- Build a pyramid network between the Committee and the authorities, with competent staff.
- Complete and update the digital contaminated site register and decide what will be the ultimate use and the access to it from stakeholders.
- Enhance the capacity building of pertinent authorities, wherever it is necessary. Private sector professionals can be also used.
- Create a strong technical toolbox to support the legislative framework.
    - Guideline on environmental assessment of potentially contaminated sites (phased-approach) with suitable examples, including a list of potential parameters that should be evaluated per activity/incident
    - Guideline on land use categorization (especially for mixed land uses)
    - Use of an existing soil screening values list of another country with wide known experience (e.g., Germany) until such a list will be prepared based on the specific conditions of Greece
    - Guideline on soil, groundwater and soil gas sampling (including sampling equipment, sampling methodology, QA/QC)
    - Guideline on sample pre-treatment and preservation methodology
    - Guideline on analytical methods per parameter
- Create also a non-technical toolbox for public consultation
- Create a separate strategy to face brownfield management considering the new land stewardship approach.
- Create a strategy for diffuse contamination which is a very important issue in Greece due to nitrate and heavy metals (and maybe PAHs) contamination. Emerging contaminants, such as PFAS, should be also included.
- Participating to EU regulatory bodies such as the Common Forum on contaminated land and the Network for Industrial Co-ordinated Sustainable Land Management in Europe (NICOLE).

- Soil certificate before land transfer, especially in case when the land that will be transferred have previous environmental permit or where contamination is expected due to accident or unauthorized waste disposal.
- Add soil & groundwater investigation (like the Baseline Report) as part of the EIA of all A1 projects and works and to A2 & B projects that can cause significant soil and groundwater contamination.
- Create an accreditation procedure of contaminated site experts.

Land uses

- Adopt now a land use categorization similar to another EU country (e.g., Germany, Italy).
- Prepare a more sophisticated approach later (e.g., Belgium), if required, when adequate experience will have been gained but:
    - keep it as simple as possible, avoiding too many categories
    - follow the general land planning legislation, where possible
    - have provision for mixed land uses
    - take into account future land uses, particularly when a more sensitive use will be established (e.g., development of a former industrial facility to a mall)

Screening values

- Use now an existing soil screening values list of a country with wide known experience (e.g., Germany), until such a list will be prepared based on the specific conditions of Greece.
- Determine soil natural background (geogenic) values across the country (GeoAtlas)
- Create a new screening value list based on the Greek specific conditions.
- Create a risk assessment methodology based on the Greek specific conditions. This can be used as a tool for calculating site-specific screening values and remediation targets.

2. Introduction

2.1 General

Soil is usually defined as the three-phase system of the earth, including a solid, a gas and a liquid phase, which might range from very soft organic deposits through less compressible clays and sand to soft rock. Therefore, soil contamination is by definition a very complex problem to solve, since a three-phase medium is contaminated by chemicals, commonly in mixtures, which not only interact together but also with each phase of the soil concurrently. As a result, the way in which this system is changing both in place and in time depends on a series of different and interacting parameters relating both to the soil and the contaminants.

“Contaminated soil”, “contaminated site” and “contaminated land” are different terms for the same environmental problem, which we already encounter in millions of sites across the world. Soil becomes contaminated when a single or a mixture of contaminants reaches the soil surface, the vadose zone or the aquifer. Soil is a limited and valuable natural resource, since it controls the element and energy cycles within the ecosystems, it is the habitat to countless organisms and plants but, mainly, because it accommodates the groundwater, which makes up 97% of global freshwater, and the most important source of drinking water across the world. However, at the same time, soil is the field that accommodates numerous essential socioeconomic and inevitably contaminating human activities. As a result, the extended production of a high number of chemicals and their wide use for domestic, industrial and military reasons, combined with the common practice of its improper storage and neglectful disposal, has resulted in millions of contaminated sites across the world (Dermatas & Panagiotakis 2012).

Soil contamination is an old problem dating back to Industrial Revolution. However, this crucial environmental problem failed to receive prompt attention and it was only recognized when incidents such as the Love Canal site in New York and the Lekkerkerk site in the Netherlands were published in 1970s, increasing the public concern about this serious environmental issue. The extend of the above environmental disorder is vividly portrayed if one bears in mind that potentially polluting activities have taken or are still taking place on approximately 2.8 million sites in the EU. At EU level, 650,000 of these sites have been registered in national or regional inventories, while 65,500 contaminated sites already have been remediated (Perez and Eugenio 2018).

Contaminated soil remediation is one of the most rapidly developing environmental protection subjects. However, the high cost that soil remediation requires along with the complexity of the problem render contaminated soil remediation a real challenge for environmental professionals and society altogether.

The EU Commission submitted an official proposal for a Soil Framework Directive[1] on 22 September 2006. The aim of the Soil Framework Directive was firstly to prevent the further deterioration of soil quality and to preserve soil functions. Secondly, damaged soils must be treated with a view to restoring functionality and to cost containment. Although the EU Parliament has approved the draft proposal, a blocking minority of five Member States has prevented adoption of the Directive. In 2014 the EU Commission has withdrawn the proposal. In absence of a dedicated legislative framework, EU soil protection policy is shaped by the EU Soil Thematic Strategy[2] and provisions in a number of other policy instruments, for instance, the Industrial Emissions Directive[3], the Environmental Liability Directive[4], the EU Biodiversity Strategy[5], the EU forest strategy[6] and the Common Agricultural Policy[7] and the Green Deal[8]. Currently EU Soil Thematic Strategy is under consultation[9].

Regarding international law, there are three main treaties which contain relevant provisions on soil protection: the UN Convention to Combat Desertification of 1994[10], the Convention on Biological Diversity of 1992[11] and the Climate Framework Convention of 1992[12]. The main aims of the Desertification Convention are to combat desertification and to mitigate the effects of drought. The Convention on Biological Diversity focuses on the preservation and sustainable use of biological diversity, including that in terrestrial ecosystems. The Climate Framework Convention[13] contains agreements on mitigation and adaptation measures for greenhouse gases.

Unlike most EU countries, Greece does not have a robust Soil Strategy and as a result a Contaminated Soil Management Framework (CSMF) yet. The legislation is incomplete and fragmentary, and no guidelines are provided for demanding technical subjects, such as soil and groundwater sampling and chemical analysis. Currently contaminated soil is part of the hazardous waste management framework, a problematic practice for consultants, industries and pertinent authorities.

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[1] https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2006:0232:FIN:EN:PDF
[2] https://ec.europa.eu/environment/soil/three_en.htm
[3] https://ec.europa.eu/environment/industry/stationary/ied/legislation.htm
[4] https://ec.europa.eu/environment/legal/liability/index.htm
[5] https://ec.europa.eu/environment/strategy/biodiversity-strategy-2030_en
[6] https://ec.europa.eu/environment/forests/index_en.htm
[7] https://ec.europa.eu/info/food-farming-fisheries/key-policies/common-agricultural-policy/cap-glance_en
[8] https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en
[9] https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12634-New-EU-Soil-Strategy-healthy-soil-for-a-healthy-life/public-consultation
[10] https://www.unccd.int/convention/about-convention
[11] https://www.cbd.int/youth/0003.shtml
[12] https://unfccc.int/resource/docs/convkp/conveng.pdf
[13] https://unfccc.int/process-and-meetings/the-convention/what-is-the-united-nations-framework-convention-on-climate-change

2.2 Scope

The purpose for this assignment is to provide specific technical expertise to the GIZ team, by supporting the Greek Ministry of Environment and Energy (YPEN) to build institutional capacities, by contributing to the examination of relevant experiences and best available techniques (BAT) from other EU Member States and formulation of recommendations for α Contaminated Soil Management Framework (CSMF) for Greece. In addition, in the context of this study, modification of the main hazardous waste legislation are recommended as well as a roadmap for improving hazardous waste management in Greece.

In particular the scope of this assignment includes:

- Specific proposals for the amendment of the JMD 13588/725/2006 (Government Gazette 383 B) and JMD 24944/1159/2006 (Government Gazette 791 B)
- Recommendations for a CSMF after an overview on the best practices and legislation of other EU countries
- Provision of a roadmap of implementation of the CSMF and hazardous waste management in Greece
- Reporting/dissemination

2.3 Experts Team

This report was prepared by:

ENYDRON – Environmental Protection Services
1 Ipeirou str, 104 33 Athens, Greece
T +30 210 8836555
Email info@enydron.com
www.enydron.com

In particular the experts team comprises the following consultants:

- Dr Iraklis Panagiotakis, Environmental Engineer (Project Manager)
- Mrs Eleni Strompoula, Physicist MSc
- Mr Michalis Papamikroulis, Environmental Engineer MSc

In addition:

Professor Dimitris Dermatas is also participating on behalf of the National Technical University of Athens.

2.4 Report structure

The report consists of the following parts:

- Chapter 1: Executive summary
- Chapter 2: Introduction
- Chapter 3: Methodological approach
- Chapter 4: Main hazardous waste legislation in Greece and modifications required

- Chapter 5: Existing contaminated soil management framework in Greece
- Chapter 6: EU and international experience
- Chapter 7: Conclusions on EU and international experience
- Chapter 8: Recommendations for a Contaminated Soil Management Framework in Greece
- References
- Annexes

3. Methodological approach

3.1 General

In this Chapter, the methodological approach used is described. The approach used was designed based on the principles below:

- be integrated and holistic in line with the EU legislation and regulations;
- bring in good practices and lessons learned from other EU countries; and
- develop solutions adjusted to the Greek context and provide local know-how.

In practice the approach was divided into three (3) phases:

- Phase 1 - Background national data gathering: During this phase all the appropriate baseline work required for the entire project was accomplished. In particular, the national legislation was reviewed, key national stakeholders were identified, and online meetings were carried out. During this phase, the needs and the gaps of the existing contaminated soil framework were identified. A similar approach was also followed for the hazardous waste management.
- Phase 2 - EU experience/literature review: During this phase all data on the EU experience were reviewed and the best practices, useful toolkits and lessons learned were recorded and evaluated. In particular, during this phase a group of competent contaminated soil international experts was created and a tailored made questionnaire was delivered to them. For the improvement of hazardous waste management, the EU experience was studied by EU documents and legislations.
- Phase 3 - Roadmaps, reporting and dissemination: This was the last phase of the assignment during which the appropriate recommendations were gathered, and roadmaps for the CSMF and HWM were created.

Each of these phases are described in detail below.

3.2 Phase 1 – Background national data gathering

During this phase all the appropriate baseline work was accomplished, mainly including the national legislation review and the key national stakeholders' engagement. The detailed break-down structure of each task of Phase 1 is listed below:

- National legislation review
- Review of Greek data sources (see Reference Section)
- Interview key national stakeholders, including public authorities, institutions, universities, industry, consultants.

The list of stakeholders and the questionnaire based on which these virtual meeting is taking place are provided in the Annex.

Based on the conclusions of Phase 1, the gaps and the needs for a new applicable CSMF were identified. This was also the case for the hazardous waste management issue.

In particular for hazardous waste management the JMDs were thoroughly studied, and the articles were prioritized based on the review required. The best practices identified from the literature review and the consultation were incorporated in the corresponding articles. Some articles though did not need changes although other should be abolished.

3.3 Phase 2 - EU experience/literature review

During this phase all data on the EU experience was reviewed and the best practices, useful toolkits and lessons learned were recorded and prioritized. The detailed break-down structure of Phase 2 is listed below:

- EU legislations, regulations and reports review
- National regulations review
- Preparation of a tailored-made questionnaire (see annex)
- Questionnaire survey, where international experts from The Netherlands, United Kingdom, France, Belgium – Flanders region, Belgium – Walloon region, Germany, Italy, Spain, USA and the European Commission, NICOLE network, Common Forum network where participated.

An important part of the research was to identify the appropriate experts. For this purpose, the internationally recognized NICOLE and COMMON FORUM networks were mainly used, through which the appropriate communication was made, in order to ensure the appropriate number of experts for each country.

Based on the literature review the questionnaire was constructed to cover the following key aspects:

- General issues (e.g., date of issue of the framework, if it is standalone framework or part of another one)
- Administration (e.g., authority capacity, digital tool used)
- Professional issues (e.g., if a specific professional certification is required, if environmental site assessment is compulsory for selling or transferring real estate)
- Sampling methods (e.g., if there are specific sampling guidelines, if analyses are made in the bulk sample or to a fine fraction of it)
- Screening values (e.g., if there are different screening values for different land uses, the meaning of these values)
- Remediation targets (e.g., if remediation targets are equal to screening values, if screening values are site-specific)
- End of liability (e.g., if the liability ends, if restriction of future land uses is possible)
- Other questions (e.g., to criticize the current national framework, to propose the main best practices that should be included in the framework of Greece).

The questionnaire prepared and delivered to the international experts is included in the Annex.

Based on the above information and the extensive literature review, a section was written for each country. This text was reviewed again after its completion, in order to avoid any significant mistakes, by at least one international expert from that country. Based on the conclusions of Phase 2 the best practices applied in EU were determined and valuable points of experienced experts were gained, such a challenges and recommendations. In case of further communication was necessary this was typically conducted via online meeting or emails.

3.4 Phase 3 – Roadmaps, reporting and dissemination

This is the last phase of the assignment during which the appropriate recommendations were identified, and a roadmap was produced for the new CSMF. A roadmap was also provided for the recommended actions for improvement of the HWM as well.

The recommendations were generated based on the literature review, the international best practices and stakeholder consultation taking into account the Greek specific conditions (Figures 1,2).

These roadmaps include information on the further activities required, stakeholders involved, recommended timeline, cost estimates, and potential funding sources. For this reason, the available funding sources were reviewed and for each recommendation the suitable funding sources were suggested.

During this phase and in order to scaling-up the effects of the assignment, a workshop with the main stakeholders is planned to take place in order to present the main recommendations described herein and take any feedback for further improvement.

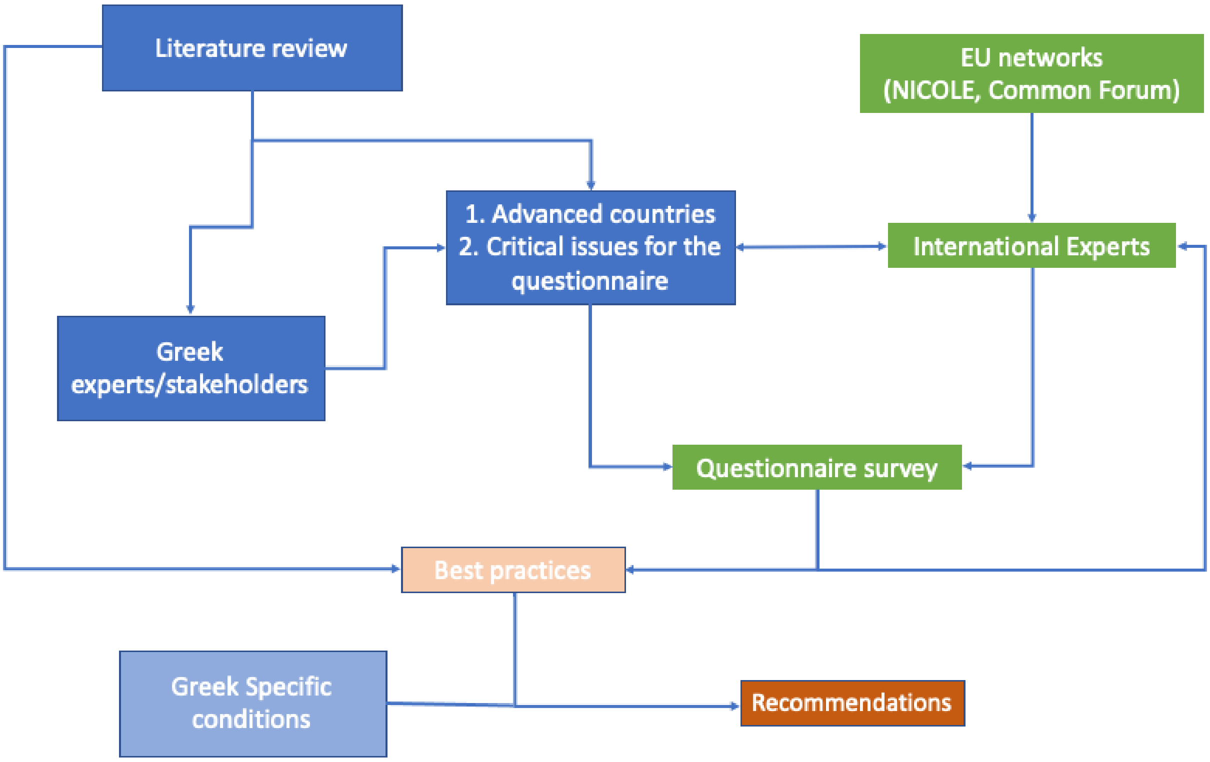


Figure 1 Diagram of methodology used for CSMF

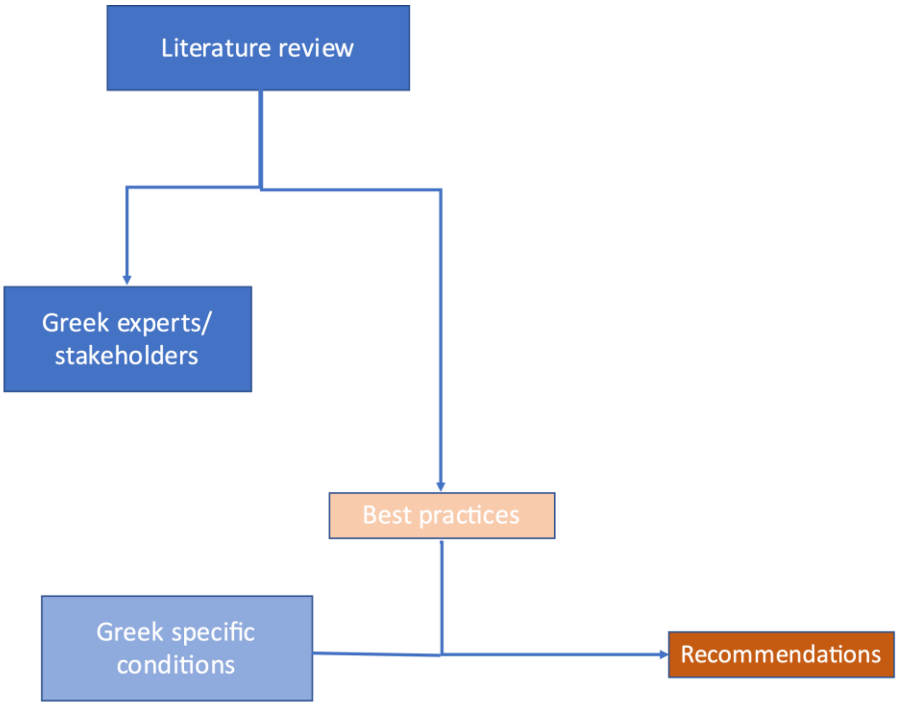


Figure 2 Diagram of methodology used for hazardous waste management

4. Hazardous waste management in Greece – Required modifications of the legislation

4.1 Current situation

Based on the recent National Waste Management Plan (NWMP 2020)[14], the most important hazardous waste stream generated in Greece is the industrial hazardous waste (IHW). It is estimated that 99,655 t of IHW are generated in the country in 2018, that is expected to be increased to 128,215 t and 159.056 t in 2025 and 2030, respectively. A significant part of this quantity, 35,726 t (i.e., 36% of HIW production), are solids wastes from gas treatment containing hazardous substances from metal production facilities. In 2018 the total amount of IHW that was management within Greece was 125,368 t (including imported wastes), 75% of which was recovered, 14% of was disposed of and 11% was managed with the intermediate recovery operations R12 - R13. The IHW part that was exported was equally to 86,832 tons, including stored quantities (historical waste deposits).

Another important stream of hazardous waste include asbestos containing materials (ACM) and packaging containing residues of or contaminated by hazardous substances. Regarding ACM it is estimated that an amount of 1,403 t was generated in 2018, although this is obviously underestimated since only the waste exported for further treatment abroad was considered. Similar figure, 1,565 t, was also estimated for waste packaging containing residues of or contaminated by hazardous substances. The amount of PCB/PCT waste was relatively smaller (approx. 26,3 t in 2018). Finally, healthcare waste is also a very important HW stream, since 17,770 t estimated to be generated in 2018 across the country. This is, however, a stream governed by an almost totally independent legislation and therefore it is not further discussed herein.

Hazardous waste management in Greece is still poor and far behind the EU general practices applied. The operation of the electronic waste register (HMA)[15] has significantly improved waste management in Greece in the traceability of the produced hazardous wastes but it needs improvements, such as in the matching of the produced quantities with those that end up in disposal / recovery works in Greece and abroad. Greece still lacks the necessary network of adequate hazardous waste treatment facilities and a hazardous waste landfill, other than small hazardous landfills within large industrial facilities used only for their purposes. This is also the case for landfills that can accept ACM, that again do not operate at regional or national level but are private covering only the owner's need. As with regards to waste packaging containing residues of or contaminated by hazardous substances all of them seems

[14] https://www.elinyae.gr/sites/default/files/2020-10/185a_2020.pdf
[15] https://wrm.ypeka.gr

to end up in recovery operations. As a results most hazardous waste streams including ACM are potentially stored and finally exported for landfilling abroad.

A very significant hazardous waste issue, closely related to contaminated soil management, which is discussed in detail in the following chapters, is the historical waste deposits stored within large industrial premises for years in Greece. The total estimate of this wastes is 545.085 t (NWMP 2020). Table 1 presents the IHW estimate per EWC code remaining stored in the country. This is coming from the NWMP (2020) but cannot be excluded that the actual figures are much higher.

Table 1 Historical deposits of hazardous waste in Greece

	EWC code	Remaining stored quantity (t)
1	10 02 07*	83.683,81
2	10 03 08*	58.115
3	11 01 09*	149.677
Total		**291.475,81**

4.2 Green deal and circular economy

Many countries around the globe have been working on sustainable waste management plans, including hazardous waste, mainly focusing on the reduction of the waste treatment footprint for a while now, with the EU and the USA playing leading roles. However, from now on, EU countries need to focus mostly on waste prevention and resources efficiency in order to fulfil the EU's Green Deal vision. This can only be achieved by the effective transition to a Circular Economy (CE).

Based on the discussion in the previous section, it is obvious that HWM in Greece requires significant improvements mainly regarding treatment and disposal facilities to catch up the EU countries. However, even if this is finally achieved, it will not be enough to achieve the new development model's goals and therefore giant modernization steps towards the goals of the new Green Deal and the Circular Economy model are really imperative.

This CE model is predominately based on the primary and secondary economic sectors, without displaying significant digital technology applications so far. Conversely, the COVID-19 crisis has clearly demonstrated that digital technologies will play a central role in the future of our society. However, potential digital tools and smart services that could support more efficient access to information relating to availability, monitoring, data utilisation etc., such as electronic platforms and databases are not widely available yet. This concerns both the private and public sectors, and it is easily ascertained that the degree of digital maturity of the target groups is still extremely low, which of course reinforces the need to implement targeted training actions in this field to achieve the envisioned goals.

All the above is taking place in the changing world of the so-called Industry 4.0, an ongoing revolution focusing on the creation of innovative ideas and the transformation of business models and processes for the benefit of technologically advanced industries. As a result, it is expected that net profits will be increased, business costs will be reduced, services will be optimised, customer relationships and relationships with the consumer and industry will be strengthened and innovative goods will be created to meet needs and improve daily life by significantly reducing the energy footprint created by the industrial revolution itself.

Overall, it is obvious that waste management, including hazardous waste, has already entered into a new era, where new unique opportunities (e.g., new jobs and services) but also challenges (e.g., universal digitalisation, social inclusion) are waiting. During this fascinating period, technological innovation and social policy tools should be concurrently used to make CE viable, improving human life on earth.

4.3 Legislation framework

The main legislations governing hazardous waste in Greece are the JMD 13588/725/2006[16] on general hazardous waste management and the JMD 24944/1159/2006[17] on technical specifications for hazardous waste management.

The JMD/13588/725/2006 is probably the most important legislative tool regarding hazardous waste management in Greece. It concerns terms, conditions and restrictions for hazardous waste management in compliance with the provisions of the Directive 91/689/EEC[18], which is not in force anymore, though. The JMD contains 19 articles, which ensure that hazardous waste is managed in such a way as to ensure that human health is not endangered, directly or indirectly, and that no procedures or methods are used that may harm the environment. A significant part of this legislation has already been modified by the Law 4042/2012[19], where hazardous waste management is part of the entire waste management framework.

Based on the present study's conclusions, 10 out 19 articles are proposed to be amended extensively in order to become clearer and to include references to updated legislation and references, while best available techniques (BAT) employed have been added. In addition, in six articles the recommended modifications are of minor importance and are mainly related to new legislations as well as to correct nomenclature, updated names etc. Finally, two articles retain their content as they are today, while one article is proposed to be completely removed.

One of the key articles that is recommended to be extensively amended is the Article 2, which deals with definitions, since some of them should be updated (e.g., "contaminated site") and new definitions should be included (e.g., "potentially contaminated site") in order to become

[16] https://elinyae.gr/sites/default/files/2019-07/383b_06.1152697467738.pdf
[17] https://www.elinyae.gr/sites/default/files/2019-07/791b_06.1152699067304.pdf
[18] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:31991L0689&from=EN
[19] https://www.elinyae.gr/sites/default/files/2019-07/24a_12.1329481379390.pdf

clear that apart from hazardous waste other materials, such as fuels or raw materials, can cause soil and groundwater contamination. In addition, the definitions used in the Law 4042/2012 should be replace the corresponding terms of the JMD 13588/2006, accordingly.

Another very important issue is to make the appropriate changes (in Article 4) in order to enter the “polluter pays principle” within this legislation.

Extensive modification is also required for the Article 7 on measures and conditions for the management of hazardous waste, which is considered very important. The most important of the recommended changes consider:

- the permitting procedure of mobile hazardous waste treatment units
- the specifications for hazardous waste management transport companies
- the legislation for transboundary transportation of hazardous waste

Finally, an extensive modification of Article 12 concerning remediation of contaminated sites is required, regarding the role of administration, the risk assessment approach, insurance contracts, and linkage with the new Law 4685/2020 where the liability of the owner of a contaminated site is also discussed.

With the ratification of JMD 24944/1159/2006, the general technical specifications for the management of hazardous waste were approved, in order to ensure their environmentally safe management and to achieve the prevention or reduction of the negative effects on the environment as well as any harm to human health.

It includes five articles, three of which are proposed to be amended extensively, while the remaining two are expected to be retained. More specifically, for Articles 1 and 2 the modification refers to references to legislation (National and European), which have been amended or repealed. In addition, these articles are supplemented by the latest legislation adopted after this JMD.

Major modification is made to Article 3 and concerns the content of the general technical specifications for the management of hazardous waste. This content includes 13 chapters, two of which are completely abolished, while only one is maintained as is. The remaining 10 chapters are amended extensively.

In summary, the most notable notification concerns Chapter 1 on the collection-packaging-labeling-transport of hazardous waste (including cross-border transport). More specifically, for the collection-packaging-labeling of hazardous waste, the article is proposed to be updated based on Law 4042/2012 and the European Regulation 1013/2006[20] regarding the transport of waste.

In addition, a significant modification is made in Chapter 2 regarding the storage of hazardous waste, with emphasis on the technical characteristics of the building storage facilities as well as the waste acceptance in the treatment facilities. More specifically, it is suggested to follow the techniques mentioned in the Best Available Techniques (BAT) of the Reference Document for Waste Treatment (2018)[21] regarding the specifications of the storage buildings and areas. In addition, information regarding hazardous waste storage tanks is proposed to be added based on the specifications described by the Reference Document on Emissions from Storage (2006)[22]. Furthermore, procedures that are more specific are proposed to be followed when receiving hazardous waste at the facility areas. For this purpose, the procedures mentioned in the Best Available Techniques (BAT) of the Reference Document for Waste Treatment (2018) are proposed.

Finally, the amendment of Chapter 5, regarding the technical specifications of the Hazardous Waste Landfills, is considered important (but not covered herein).

4.4 Roadmap and way forward for the improvement of hazardous waste management in Greece

In this Section a roadmap with the recommended actions for improving HWM in Greece is presented. The actions are divided to those that can be applied in short-term, mid-term and long-term. In addition, the stakeholder involved, the cost estimate and the potential funding sources are provided. The most important actions recommended are as follows:

- JMD 13588/2006 & 24944/2006 modifications according to the study
- Encourage timely manner management of historical deposits
- Investigation of alternative disposal methods for asbestos-contained materials within Greece (e.g., existing landfills)
- Investigation of opportunities emerging for each industrial sector in the new Circular Economy model and identification of potential symbiotic relationships
- Study on how digitalization can improve the presence of industries within the Circular Economy model
- Encourage the construction of a hazardous waste management facilities in Greece, in order to decrease high-cost exports to other countries
- Enhance building capacity of the pertinent public authorities to increase environmental audits

[20] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32006R1013&from=EN
[21] https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/best-available-techniques-bat-reference-document-waste-treatment-industrial-emissions
[22] https://eippcb.jrc.ec.europa.eu/reference/emissions-storage

- Technical guideline on classification and management of hazardous waste management to maintain clean recycling streams

Table 2 Roadmap for the improvement of hazardous waste management in Greece

Recommendations	Type of instrument	Involved stakeholders	Timeline (indicative timescale)	Cost estimates	Potential funding sources	Estimated achievable target
JMD modifications according to the study	Administrative	• YPEN • Decentralised administrations • HSWMA	Short-term	Low	OP Environment of PP 2021 – 2027 **or** OP Transport Infrastructure, Environment and Sustainable Development of PP 2014-2020	A modified hazardous waste framework
Encourage timely manner management of historical deposits	Administrative	• YPEN • Industries • Decentralised administrations • Prefectures • SEV	Mid-term	-	-	Increase the rate that historical deposits are moved from the facilities and are properly managed
Investigation of alternative disposal methods for asbestos-contained materials within Greece (e.g., existing landfills)	Technical	• YPEN • Decentralised administrations • Prefectures • Industries • Haz Was Man companies • HSWMA	Short-term	Medium	OP Environment of PP 2021 – 2027 **or** OP Transport Infrastructure, Environment and Sustainable Development of PP 2014-2020	A network of existing landfills suitable for accepting asbestos-contained materials in Greece

Recommendations	Type of instrument	Involved stakeholders	Timeline (indicative timescale)	Cost estimates	Potential funding sources	Estimated achievable target
Investigation of opportunities emerging for each industrial sector in the new Circular Economy model and identification of potential symbiotic relationships	Technical	• YPEN • MINEDEV • Industries • Universities • HSWMA	Mid-term	Medium	OP Environment of PP 2021 – 2027 **or** OP Transport Infrastructure, Environment and Sustainable Development of PP 2014-2020	Potential symbiotic relationships of industries that can be structured in Greece
Study on how digitalization can improve the presence of industries within the Circular Economy model	Technical	• YPEN • Industries • HSWMA	Short-term	Medium	OP Environment of PP 2021 – 2027 **or** OP Digital Transition of PP 2021 - 2027 **or** OP Transport Infrastructure, Environment and Sustainable Development of PP 2014-2020	A list of potential digitalization measures to improve the presence of industries in CE
Encourage the construction of a hazardous waste management facility in Greece, in order to decrease high-cost exports to other countries	Administrative	• YPEN • Industries • HSWMA • SEV	-	-	OP Environment of PP 2021 – 2027 **or** OP Transport	New hazardous waste management facilities in Greece

Recommendations	Type of instrument	Involved stakeholders	Timeline (indicative timescale)	Cost estimates	Potential funding sources	Estimated achievable target
					Infrastructure, Environment and Sustainable Development of PP 2014-2020	
Enhance building capacity of the pertinent public authorities to increase environmental audits	Administrative	• YPEN • Decentralised administrations • Prefectures	Long-term	High	OP Environment of PP 2021 – 2027 **or** OP Transport Infrastructure, Environment and Sustainable Development of PP 2014-2020	A more competent and well-staffed authorities
Technical guideline on classification and management of hazardous waste management to maintain clean recycling streams	Administrative/ Technical	• YPEN • Industries • HSWMA	Mid-term	Medium	OP Environment of PP 2021 – 2027 **or** OP Transport Infrastructure, Environment and Sustainable Development of PP 2014-2020	A technical guideline on classification and management of hazardous waste management

5. Existing contaminated soil management framework in Greece

5.1 Introduction

Greece is an EU country located in Southeast Europe. The national population reaches 11 million with a density of 84 inhabitants/km^2 (one of the lowest densities in Europe). About one third of Greek population concentrates along the coastline. Greece shares land borders with Albania to the northwest, North Macedonia and Bulgaria to the north, and Turkey to the northeast. Greece has a large number of islands.

Greece is a unitary State organised on a decentralised basis; it comprises two levels of governance, the central – State governance and the local self-government. The former is exercised centrally (Government - Ministries) as well as at a decentralised level (Decentralised Administration), while the latter is exercised at regional (Regions) and municipal level (Municipalities)[23].

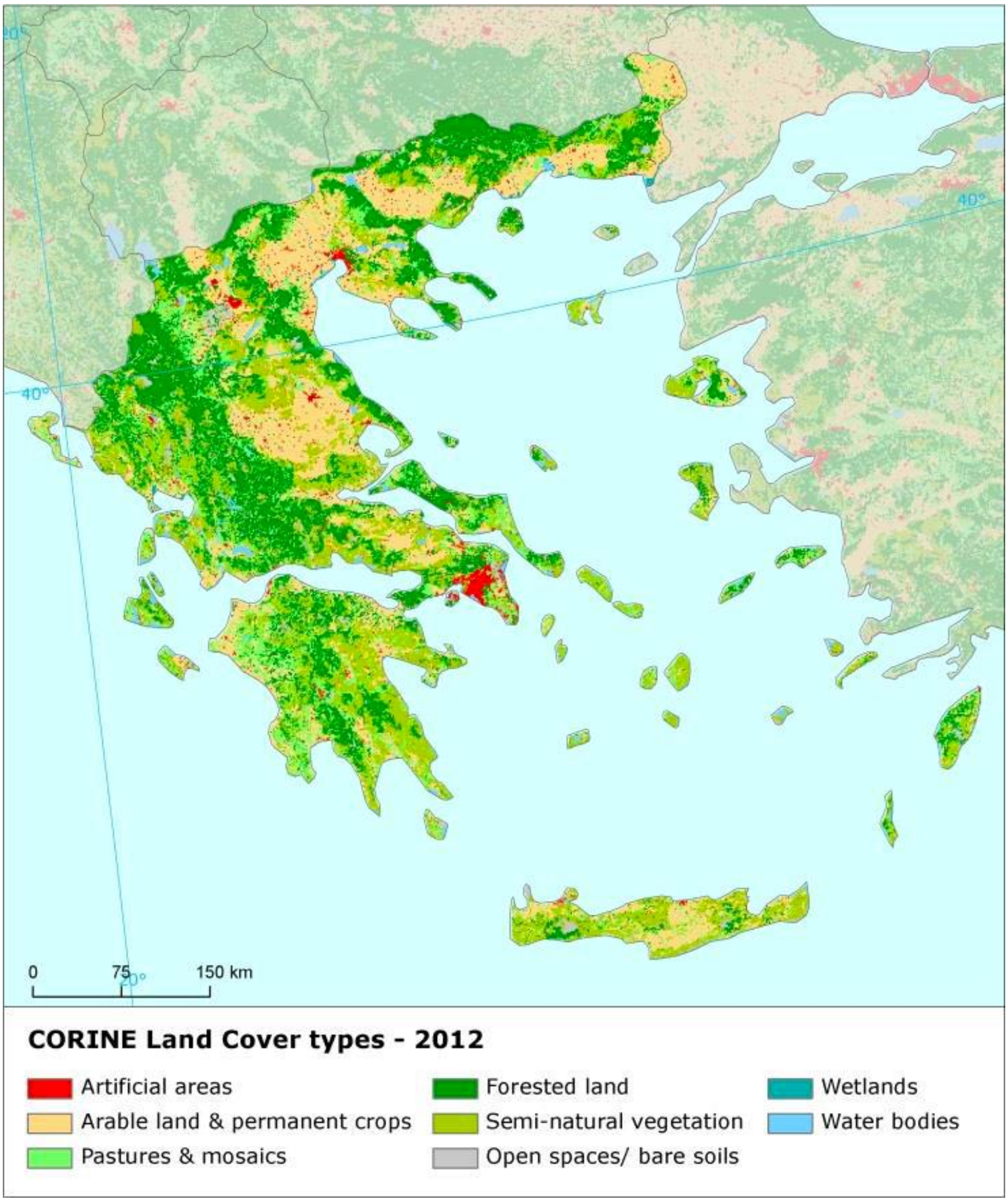
The surface area of Greece is approx. 130.000 km^2, 20% of which is distributed to its 3.000 islands, whereas, two thirds of the Greek territory is mountainous, making the country one of the most mountainous in Europe. Greece has the longest coastline in Europe with a total length exceeding 15.000 km, 5% of which belongs to areas of unique ecological value.

Greece is dependent on groundwater resources for its water supply. The main aquifers are within carbonate rocks (karstic aquifers) and coarse-grained Neogene and Quaternary deposits (porous aquifers). The use of groundwater resources has become particularly intensive in coastal areas during the last decades with the intense urbanization, touristic development and irrigated land expansion.

The long coastline favours hydraulic communication between coastal aquifers and seawater, also a non-homogeneous distribution of rainfalls and water resources. Water resources are characterized by high water requirements for agricultural (86% of the total consumption) and tourism during the dry period (April-October) when water availability is low. Greece is 31st in top 50 countries with severe water stress. The irrigated land increased greatly in last decades, as indicated by the large number of boreholes.

Water needs are mainly covered by groundwater abstracted from the aquifers via numerous wells and boreholes (approximately 300,000 across the country). As a result, a negative water balance is established in the coastal aquifer systems triggering sea water intrusion, which has negative consequences in the socioeconomic development of these areas.

[23] https://portal.cor.europa.eu/divisionpowers/Pages/Greece.aspx



Source: European Commission (2017a)

Figure 3 Land uses in Greece

Many aquifer systems are reported to be affected by quality deterioration due to irrational management[24]. The main forms of groundwater contamination Greece are:

- Nitrate pollution from over-fertilization of soil

[24] https://easac.eu/fileadmin/PDF_s/reports_statements/Greece_Groundwater_country_report.pdf

- Saltwater intrusion in coastal zones due to due to non-sustainable pumping practices
- Groundwater pollution due to industrial activity

Greece has designated 446 Natura 2000 sites, including 265 sites of Community importance (SCIs) under the Habitats Directive and 207 Special Protection Areas (SPAs) under the Birds Directive. These sites cover 27.4% of the national land area of Greece (EU average 18.2%), and a significant proportion of its marine area.

There is a lack of urban green space in Greece. The preservation of coastal and marine areas is also a challenge. This is due to factors such as: (i) a high concentration of human activity and land use; (ii) a lack of political will; (iii) no comprehensive planning for the preservation and management of these areas; (iv) inadequate control mechanisms; and (v) a lack of coordination between the relevant authorities[25].

5.2 Legislation, Administration & Professionals

The concept of contaminated site is initially introduced in the Greek legislation by the JMD 13588/725/2006 and the JMD 24944/1159/2006, which transposed the EU hazardous policy in the Greek law and are the main legislations of hazardous waste management in Greece. However, in this legislation, only the sites contaminated by hazardous wastes are defined and therefore other very important issues, such as contamination from fuels (e.g., underground fuel tanks) or raw materials (e.g., chemical storage tanks) are omitted.

These issues are rather covered by the JMD 36060/2013[26] that transposed the Industrial Emission Directive (2010/75/EC) into the national legislation, but again with a no clear and integrated way. This legislation introduces the concept of Baseline Report, a monitoring tool of soil and groundwater contamination from hazardous substances including also raw materials, fuels etc. in large installations. However, this report is prepared only when a new permit is required as part of the Environmental Impact Assessment (EIA) procedure (Panagiotakis & Dermatas 2018). Based on the Commission Guidance (2014/C 136/03)[27] the baseline report should include 8 stages, including identification of relevant hazardous substances, site-specific conditions, site history, environmental setting, site characterization and site investigation. In this approach the concepts of Conceptual Site Model and the phased approach are foreseen. Sometimes protocols such as ASTM E1527-13 and ISO 14015 are used

[25] https://ec.europa.eu/environment/eir/pdf/report_el_en.pdf
[26] https://www.elinyae.gr/ethniki-nomothesia/ya-360601155e1032013-fek-1450b-1462013
[27] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52014XC0506(01)&from=EN

for environmental site assessment, based on the site needs, which, however, are not mentioned in legislation or guidance documents. It has to be highlighted here, that the Commission Guidance has not been in any way transposed or adopted through an official legislative procedure (Ministerial Decision or at least a Circular).

Another very important legislation tool for contaminated site management in Greece is the Environmental Liability Directive (ELD) 2004/35/EC[28], as it was as transposed into Greek Legislation with the Presidential Decree (PD) 148/2009[29] (amended by Law 4014/2011[30]). The purpose of this decree is to establish environmental liability based on the "the polluter pays principle", by defining measures, conditions and procedures so that each operator, whose activity caused environmental damage or imminent threat of environmental damage can be held primarily financially responsible for preventing / restoring environmental damage. Based on the same legislation the environmental damage is defined as the measurable adverse impact to:

- protected species and natural habitats;
- to water resources chemical, ecological and quantitative status; and
- to land that may pose a serious risk for human health.

A very important parameter of this legislation is the aspect of “causal relationship” that should be verified between the alleged polluter and the environmental damage, both regarding point as also diffuse contamination sources.

Furthermore, certain provisions of waste legislation are also applicable (Law 4042/2012, transposing the Waste Framework Directive in the national legal order), especially regarding issues such as the prohibition of unauthorized dumping of waste. Finally, the recent Law 4685/2020[31] on modernization of environmental legislation mandates landowners to clean up their properties from any hazardous wastes or asbestos containing materials.

Currently contaminated site issues are managed by several different administrative levels, the main of which are as follows:

- Directorate of Waste Management of the Ministry of Environment and Energy (YPEN) –Responsible for coordinating waste and contaminated site policy.
- Environmental Damage Coordination Office (SYGAPEZ) of the Ministry of Environment and Energy (YPEN) – This is the authority that is responsible for the implementation of the PD 148/2009 on Environmental Liability.

28 https://eur-lex.europa.eu/legal-content/EL/TXT/PDF/?uri=CELEX:32004L0035&from=EN
29 https://www.elinyae.gr/sites/default/files/2019-07/190a_09.1254831742421.pdf
30 https://elinyae.gr/sites/default/files/2020-05/209a_2011.pdf
31 https://elinyae.gr/sites/default/files/2020-05/92a-2020.pdf

- Directorate of Environmental Permitting (DIPA) of the Ministry of Environment and Energy (YPEN) – This is the authority that is responsible for the environmental permitting of large works and projects (A1). This is also the authority that typically deals with most IED baseline reports.
- Directorate of Water Management - Decentralized Administrations – This is the authority responsible for water management monitoring within each Region.
- Directorate of Environmental Permitting (PEXO) - Decentralized Administrations – This is the authority responsible for environmental permitting works and projects (A2) and contaminated site remediation projects within each Region.
- The Special Service of Environmental Inspectors, who, in cooperation with the competent directorates of the Decentralised Administrations and the Prefectures are competent for the drafting and enforcement of the Compliance Plans, imposed against plans and activities which, upon inspection, are found non-compliant with the terms and conditions of their environmental permit.

The existing contaminated soil management in Greece is fragmentary and complicated and the authorities involved are understaffed without the appropriate expertise, in most of times.

The Greek inventory for contaminated sites started a couple of years ago but was never implemented. In 2009 a study was completed for the investigation, evaluation and remediation of uncontrolled (illegal) contaminated sites with industrial and hazardous wastes. In 2013 another study was initiated for recording and evaluation of the contaminated sites by industrial hazardous wastes in the region of Attica and the prefecture of Thessaloniki, Viotia, Evia, Kozani, Achaia, Heraklion, Magnisia, Kavala and Chalkidiki (the areas that account for most of the country's industrial activity) (Tsompanidis et al 2016). The goal of this study was the detection, recording and the initial characterisation of potentially contaminated sites focusing on areas with heavy industrial activity, storage areas of industrial and hazardous waste, waste-management areas, mining activities, shipyards etc. The study comprises the following 6 deliverables: 1) methodology followed, 2) recording and initial characterisation, 3) final characterisation, 4) effect of the contaminated site on the catchment water reservoirs, 5) guide for locating, recording and risk assessment of contaminated sites, 6) database - development conclusions.

All sites were classified into two categories: as controlled (legal) or uncontrolled (illegal) sites. In particular, 2.029 potentially contaminated sites were identified and prioritized. The 300 most important contaminated sites were selected for further investigation through questionnaires and on-site assessment. Of these, 135 were legal sites and 165 uncontrolled (illegal) sites, which were further investigated through field research, soil, sediment and water sampling, and chemical analyses. These sites were classified into three groups: 1. High priority group (urgent action) (HP); 2. Medium priority group (MP); 3. Low priority group (LP). After the investigation, the controlled sites were classified as 69 HP, 64 MP, 2 LP; and the illegal sites were classified as 82 HP, 82 MP and 1 LP. This project was the first approach and indicates that more research is needed, including ecotoxicological studies, a setting out of polluting parameters and thresholds, clarification of reference sampling and robust site sampling and monitoring (Tsompanidis et al 2016).

With regard to sites contaminated by illegal landfills, Greece has an analytical database. According to official data reported to the European Commission in the context of the relevant decision of the European Court of Justice imposing fines on Greece for the case of illegal landfills, there were 293 illegal landfills in December 2014. By December 2017 the number had dropped to 44. The rest (149) have been rehabilitated. It should be noted that the number of illegal landfills exceeded 3.000 landfills in 2010 but, in the meantime, most of them have been rehabilitated (Pérez and Eugenio 2018).

Therefore, based on the above it is obvious that the contaminated site in Greece is still pending.

Regarding professionals, there are specific certifications in Greece for studies and works that, however, are quite general regarding geotechnical studies and investigation, environmental studies, geological, hydrogeological and geophysical studies and investigation etc. However, the specialized scientific staff in Greece is very limited with no experience on contaminated sites most of times.

5.3 Screening values

A very important drawback of the current contaminated soil management framework in Greece is the absence of screening values, especially for soil, based on which a site can be characterized as contaminated or uncontaminated and further actions could be decided. This is the typical practice in most EU member states and other countries as well with long experience in contaminated site management, such as the USA (see Chapter 6). However, France is an exemption since this list was withdrawn in 2007 and currently the contaminated soil framework is based solely on site-specific conditions (See Chapter 6). In Greece the only legislation where soil screening values are provided is the JMD 80568/4225/1991[32], which is about wastewater sludge reuse in agriculture (see Annex).

Regarding groundwater screening values, the JMD 39626/2208/E130/2009[33], as modified by the JMD 182314/1241/2016[34], which lays down measures for the protection of groundwater

[32] https://elinyae.gr/sites/default/files/2019-07/641b_91.1149837816400.pdf
[33] https://elinyae.gr/sites/default/files/2019-07/2075b_09.1343380385484.pdf
[34] https://www.elinyae.gr/sites/default/files/2019-07/2888B_2016.1473750580533.pdf

against pollution and deterioration, in compliance with Directives 2006/118/EC[35] and 2014/80/EC[36], and the Ministerial Decree (MD) 1811/2011[37] (see Annex), which establishes threshold values of certain contaminants in groundwater, at national level, for good chemical status, regardless land uses, are typically used. However, the list of values is very limited. For those parameters that are not covered by the aforementioned legislation, the JMD Γ1(δ)/ΓΠ οικ.67322/2017[38] on quality of water intended for human consumption, that transposed the Directives 98/83/EC[39] and 2015/1787/EC[40], is typically used.

Based on the discussion above it is obvious that the aforementioned complicated legislation creates an unclear and non-sustainable regime, where both authorities and industries are facing numerous problems from legislation interpretation and sampling protocols implementation to data evaluation. In addition, due to the lack of soil screening values, most of times both authorities and consultants use legislative tools from other EU countries, such as the new Dutch list of the Netherlands and the Federal Soil Protection and Contaminated Sites Ordinance of Germany (Chapter 6), despite the fact that these do not possess any direct legal effect. Additionally, although these are definitely very important decision-making tools, they do not reflect the Greek complicated natural background (e.g., geogenic hexavalent chromium in soil and groundwater). The existing situation is further perplexed by the lack of land uses regulations in many parts of the country and the common mixed land use regime.

5.4 Remediation

The concept of remediation of contaminated sites is initially introduced in the Greek legislation by the JMD 13588/725/2006 (Articles 9 & 12), while a detailed table of contents of the Remediation Study required (for sites contaminated with hazardous waste) is provided by the JMD 24944/1159/2006 (Article 3, Chapter 7). However, the approach is inadequate and significant amendments are imperative, since key well established concepts of the international practice such as the Conceptual Site Model and the Phased Approach are not taken into account.

Another tool, is the Baseline Report that has been introduced into the Greek legislation with the JMD 36060/2013 that transposed the Industrial Emission Directive (IED) (2010/75/EC) into the national legislation, as described above (Section 5.2). The Baseline Report, however, is only required for a limited number of projects and activities (usually large industrial sites, as provided by the IED) and do not cover the entire spectrum of contaminated site needs.

[35] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32006L0118&from=EN
[36] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014L0080&from=EL
[37] https://elinyae.gr/sites/default/files/2019-07/3322b_11.1329140721046.pdf
[38] https://elinyae.gr/sites/default/files/2019-07/3282b_2017.1528374178932.pdf
[39] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:31998L0083&from=EN
[40] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32015L1787&from=EL

Therefore, in cases of private development's, especially when large multinational companies are involved, site assessment tools such as that of ASTM, are typically used to cover this need.

Regarding soil and groundwater sampling, there are no specific guidelines for significant parameters such as sampling depth, equipment required, appropriate containers, QA/QC practices etc. As a result, the reliability of assessment is rather limited generating many problems for consultants, chemical laboratories and authorities that should decide remedial targets, select proper remediation technologies, charge fines etc.

Regarding chemical analyses, chemical laboratories in Greece generally follow well-known international standards for water and soil analysis (e.g., EN, ISO, BS, ASTM). The laboratories in Greece are accredited by the Hellenic Accreditation System (ESYD)[41]. However, typical problems that mainly are faced during a site assessment include:

- No standard pre-treatment procedures used across the laboratories
- No standard containers used based on the parameter's characteristics
- QA/QC methods during sampling are generally of limited use

The general practice used in Greece is the measurement of total concentrations of contaminants in soil and groundwater samples. Most of times sampling protocols focus on heavy metals (e.g., Cu, Pb, Hg, Cr, Cd, Ni), while organic parameters (e.g., TPH, PCB, VOC) are less common. Emerging contaminants such as Per- and polyfluoroalkyl substances (PFAS) are very rarely, if ever, included in the sampling protocols in Greece. The last decade Cr(VI) has been detected in groundwater of several sites in Greece, either as result of anthropogenic contamination or as natural constituent of groundwater in areas with ultrabasic geological background (Dermatas et al. 2015, Panagiotakis et al. 2015). Therefore, Cr(VI) has been typically included in groundwater sampling protocols in Greece, although no such screening value exist, and the threshold of the total Chromium concentration is used instead (50 μg/L).

Apart from the conventional chemical analyses of soil samples, leaching tests according to the Decision 2003/33/EC[42] establishing criteria and procedures for the acceptance of waste at landfills, is also a typical practice in Greece. However, the implementation of these measurements is controversial, since non-excavated soil is not considered waste.

In Greece, remediation targets are typically identical to the natural background values, which are determined by background samples taken during the sampling campaign, since there are not available background geochemical data that could be used. This, however, requires personnel with great experience and deep knowledge of the local geology and hydrogeology

[41] http://www.esyd.gr/portal/p/esyd/en/index.jsp
[42] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32003D0033&from=EN

to ensure a reliable sampling and data evaluation, which is not always the case, a practice creating significant problems during data evaluation and remedial targets determination.

5.5 Liability

As regards the liability on contaminated sites, it is governed by the general provisions of the Greek Civil Code, in combination with the harmonized provisions of the Environmental Liability Directive (ELD) 2004/35/EC, as it was as transposed into Greek Legislation through PD 148/2009 (amended by Law 4014/2011). Furthermore, certain provisions of waste legislation are also applicable (Law 4042/2012), especially regarding issues such as the prohibition of unauthorized dumping of waste. Finally, the recent Law 4685/2020 on modernization of environmental legislation mandates landowners to clean up their properties from any hazardous wastes including asbestos containing materials.

Potential contamination of a land property usually follows the actual owner, whether a natural or a legal person. In case that a property has been bought by a new owner, the competent authorities shall turn against him for the restoration of the land, in case of historical contamination. Of course, according to the general provisions of the Civil Code, the new owner can subsequently turn against the previous owner, in case that the new owner was not aware of the relevant fact or fault.

In general, until today a rather limited number of cases of environmental damage have been addressed in the framework of the environmental liability legislation and even fewer have reached a full restoration on the cost of the polluter. This is mainly due to inadequate administrative infrastructure, lack of access to specialised services and excessive length of both administrative as also judicial procedures.

6. EU and international experience

6.1 Introduction

As mentioned above (Section 2.1), in absence of a dedicated legislative framework, EU soil protection policy is shaped by the **EU Soil Strategy, which currently is under consultation,** and provisions in a number of other policy instrument. The most important of the EU tools are as follows:

- **Environmental Liability Directive (2004/35/EC)** establishes a framework based on the polluter pays principle to prevent and remedy environmental damage. Besides a common framework on remediation of damage to water or natural habitats, it also sets the most appropriate measures to remediate land damage (e.g., to ensure that relevant contaminants are managed in a way that the contaminated land no longer poses any significant risk of adversely affecting human health).
- **Industrial Emission Directive (IED) (2010/75/EU)** is the main EU instrument regulating pollutant emissions from industrial installations. It aims to achieve a high level of protection of human health and the environment taken as a whole by reducing harmful industrial emissions across the EU. It provides an integrated approach to prevention and control of emissions into air, water and soil, to waste management, to energy efficiency and to accident prevention, and as well ensuring that the operation of an installation does not lead to a deterioration of the quality of soil and groundwater. An important tool specified in this directive is the Baseline Report on the assessment of the condition of soil and groundwater in industrial facilities covered by this directive.
- **Environmental Impact Assessment Directive (85/337/EEC)** (EIA Directive) is in force since 1985 and has been amended three times, in 1997, in 2003 and in 2009. This Directive shall apply to the assessment of the environmental effects of those public and private projects which are likely to have significant effects on the environment. The EIA will identify, describe and assess in an appropriate manner the direct and indirect effects of a project on the following factors: human beings, fauna and flora, soil, water, air, climate and the landscape, material assets, etc.
- **Sewage Sludge Directive (86/278/EEC)** encourages the use of sewage sludge in agriculture and to regulate its use in such a way as to prevent harmful effects on soil, vegetation, animals and people. The use of sewage sludge must not impair the quality of the soil and of agricultural products. To this end, it prohibits the use of untreated sludge on agricultural land unless it is injected or incorporated into the soil. Treated sludge is defined as having undergone biological, chemical or heat treatment, long-term storage or any other appropriate process so as significantly to reduce its fermentability and the health hazards resulting from its use.
- **Regulation on fertilisers (2019/1009)** sets out the definition of ‘EU fertilising products’ and lays down rules on making them available on the market. Among others, it also defines thresholds for contaminants presence in fertilising products, notably cadmium (Cd), to minimize soil pollution.

- **Mercury Regulation (2017/852)** covers the full life cycle of Hg. It establishes measures and conditions concerning the use, storage and trade in Hg, its compounds and mixtures, the manufacture and use of, and trade in, Hg-added products, and the management of Hg waste.
- **Land use, land use change and forestry Regulation (2018/841**) sets a binding commitment for each Member State to ensure that accounted emissions from land use are entirely compensated by an equivalent removal of CO_2 from the atmosphere through action in the sector.
- **Common Agriculture Policy:** The Common Agricultural Policy (CAP) is an important economic driver for farming decisions across the EU and has the potential to advance soil protection in both agriculture and forestry through Member States' and land managers' implementation of its measures and associated obligations. Soil is one of the basic resources for agriculture and forestry production. The CAP objective of sustainable management of natural resources and climate action are clearly relevant to the soil protection and improvement.
- **The European Green Deal:** In December 2019 the European Commission presented the European Green Deal, which resets the Commission's commitment to tackling climate and environmental-related challenges. The European Green Deal is a response to these challenges through a new growth strategy that aims to transform the EU into a fair and prosperous society, with a modern, resource-efficient and competitive economy, where there are no net emissions of greenhouse gases in 2050 and where economic growth is decoupled from resource use. It also aims to protect, conserve and enhance the EU's natural capital, and protect the health and well-being of citizens from environment-related risks and impacts. The EU Green Deal has been confirmed also at the core of the recovery plan from the Covid-19 crisis.
- **New EU Biodiversity Strategy for 2030:** In line with the EU Green Deal, the Commission adopted in May 2020 the new EU Biodiversity Strategy for 2030, a comprehensive and ambitious long-term plan for protecting nature and reversing the degradation of ecosystems. The strategy contains specific commitments and actions to be delivered by 2030:
    - Establishing a larger EU-wide network of protected areas on land and at sea
    - Launching an EU nature restoration plan
    - Introducing measures to enable the necessary transformative change
    - Introducing measures to tackle the global biodiversity challenge

Part of the EU biodiversity strategy for 2030, the new Soil Strategy (healthy soils) will update the current strategy to address soil degradation and preserve land resources ('land degradation neutrality'). Healthy soils are essential to meet climate and biodiversity goals under the European Green Deal. The goals are to:

- protect soil fertility
- reduce erosion and sealing
- increase organic matter

- identify contaminated sites
- restore degraded soils
- define what constitutes ‘good ecological status’ for soils.

Many Member States have developed overarching instruments such as national plans, frameworks and codes, which implement at the same time multiple EU directives in order to facilitate the applications of these measures. These national regulations generally include procedures and national plans to prevent new soil and groundwater contamination. The responsibility for identification and remediation varies within countries, as well as between states, as does the funding regime. The main EU and national legislation regarding contaminated soil management is listed in Table 3 (non-exhaustive list).

Table 3 Main national policies and EU legislations regarding contaminated soil management

EU legislation	Year	National legislation
Sewage-sludge directive	1986	
	1987	**Netherlands** – Soil Protection Act
	1990	**United Kingdom** – Environmental Protection Act
Nitrates directive Hazardous waste directive	1991	
	1995	**Belgium (Flanders)** – Decree on soil remediation and soil protection
		Belgium (Wallonia) – Soil remediation decree
	1997	**Italy** – Legislative decree no.22
	1998	**Germany** – Federal soil protection Act
The landfill directive	1999	**Italy** – Regulation laying down criteria, procedures and methods for the safety, reclamation and restoration of contaminated sites
Water framework directive	2000	**France** – Environmental code
		United Kingdom – Contaminated-land regime (Part 2A of environmental -protection act, 1990)
SEA directive	2001	
	2004	**Belgium (Wallonia)** – Decree on the management of soils
	2005	**Spain** – Decree on defining soil polluting activities and criteria
Thematic strategy for soil protection	2006	**Italy** – Environmental code
Waste-management extractive industries directive		**Belgium (Flanders)** – Decree for soil remediation and soil protection
Groundwater directive		
	2007	**France** – Classified installations for the protection of the environment (ICPE)
Waste framework directive (WFD)	2008	**Belgium (Wallonia)** – Soil decree
		Netherlands – Soil quality decree
Pesticides directive	2009	
Industrial emissions directive (IED)	2010	
EIA Directive	2011	**Spain** – Law on waste and contaminated soils

EU legislation	Year	National legislation
Biodiversity strategy		
Mercury regulation	2017	
Green Deal	2019	
Biodiversity strategy	2020	

The scope of this chapter is to present the CSMF applied in most advanced and experienced EU countries, as resulted by the literature review and the questionnaire survey where a series of international experts participated. These are:

- Belgium (Flanders Region and Walloon Region)
- the Netherlands, France,
- United Kingdom,
- Germany
- Italy

In addition, the framework applied in New Jersey (USA), a State probably with the strictest environmental legislation framework in USA, is also presented herein. Moreover, in the questionnaire survey Spain and Portugal were also added, for comparison reasons, since they are not generally included in those countries with advance contaminated soil management framework.

As mentioned in Chapter 3, the information presented herein comes from an extensive literature review and a questionnaire survey where a large number of experts from those countries participated. The CSMF applied typically involves complicated legislation and decision-making procedures and commonly they are not straightforward processes that can be simply replicated to other countries, since policy-making parameters, including public consultation and authorities competent, are strongly affect the final outcome.

Nevertheless, the research carried out in the present study is of particular importance as, despite any differences identified between countries, important information best practices and lessons learned from the multiannual implementation of respective CSMFs in these countries, that can be applied in countries with limited experience, such as Greece, after of course the appropriate adjustments.

Each of the sections is divided into sub-sections that deal with:

- general data of each country (population, area, land uses, geomorphology, geology, water resources, protected areas)
- legislation, administration & professionals
- land uses categorisation in the context of contaminated soil management
- screening values
- sampling & monitoring
- risk assessment methodology
- environmental liability

6.2 Belgium

6.2.1 Introduction

The Kingdom of Belgium is a country in Western Europe. It is bordered by the Netherlands to the north, Germany to the east, Luxembourg to the southeast, France to the southwest, and the North Sea to the northwest. Belgium covers an area of 30.689 km^2 and has a population of approx. 11.5 million[43]. The territory of the country is divided into three Regions, the Flemish Region, the Walloon Region and Brussels Capital Region. The first two Regions are divided further into five provinces each. The three Regions in Belgium has generally different environmental policy and legislation.

The country lies in the basins of two rivers, the Scheldt and the Meuse. Belgium has great variation in topography, notwithstanding it is considered predominantly a flat land (JRC, 2009).

The rivers account for about 40% of Belgium's annual freshwater availability, with the precipitation covers the rest. The major aquifers are in Wallonia, which supplies 55% of the country's water, despite only housing 37% of the population. As such, the other regions are highly dependent on water flows from Wallonia (40% of water in Flanders and 98% in Brussels-Capital). Belgium's land area is about 50% dedicated to agricultural production, with forests (22%) and residential (16%) areas the next largest land-use types. This allocation of land use is highly stable, with Belgium's annual land cover change rate of 0.1% amongst the lowest in Europe.

Groundwater meets approximately two-thirds of Belgium's drinking water use needs. Industry is the largest user of freshwater resources, accounting for around 85% of total use. Belgium has a comparatively high level of development, an industrialized and urbanized country, shown by its level of GDP per capita (€36,300 in Flanders, €25,700 in Walloon)[44].

The protected areas in Belgium are divided in special areas conservation (i.e., Natura 2000)[45], nature reserves, designated areas of international importance, other areas with ecological importance and National and Natural parks. There are both marine and terrestrial protected areas. The Belgium is a heavily industrialized country, and the biodiversity is under great threat. For that reason, Belgium has developed a National Biodiversity Strategy and Action Plan (NBSAP) in line with European commitments. The NBSAP will be updated under the Global Biodiversity Framework and European Biodiversity Strategy to 2030.

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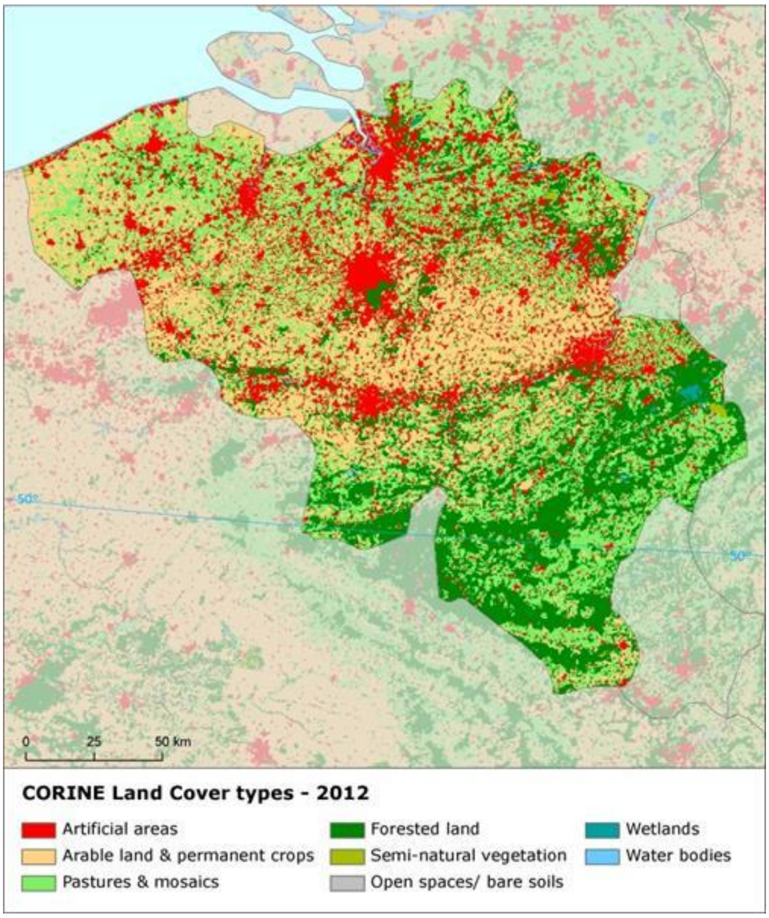
[43] https://statbel.fgov.be/nl/themas/bevolking/structuur-van-de-bevolking
[44] https://ec.europa.eu/growth/tools-databases/regional-innovation-monitor/base-profile/flanders#:~:text=Within%20Belgian%20regions%2C%20in%202018,as%20a%20whole%20117%25
[45] http://bch-cbd.naturalsciences.be/belgium/biodiversity/natura2000/natura2000.htm



Source: European Commission (2017b)

Figure 4 Land uses in Belgium

In Belgian legislation the term «soil» includes both the solid phase and the groundwater (Lavrysen et al. 2017). Each Region has developed a customized River Basin Management Plan.

6.2.2 Legislation, Administration & Professionals

6.2.2.1 Flanders Region

Legislation

In Flemish Region the first Decree on Soil Remediation set out on 1995, to establish legally the framework of contaminated land and soil remediation [Order of the Flemish Government of 5 March 1996 establishing the Flemish Regulations concerning Soil Remediation (Vlarebo)], which was further amended by the Decree for Soil remediation and Soil protection, valid since 2008[46]. Both Decrees focus on two major aspects:

[46] https://navigator.emis.vito.be/mijn-navigator?woId=23006

- the identification of high-risk activities that could cause soil contamination in combination with the compulsory environmental site assessment before land transfer (there is an extensive list of potentially contaminating activities) and
- the soil investigation by the Public Waste Agency of Flanders (OVAM), which is the authorized body.

CSMF is a stand-alone framework; different than that of the waste management framework. The Vlarebo 1996 and the updated version, are the basic Flemish Regulation framework for soil remediation dealing with the land use involvement, sampling protocols and screening values guidelines[47].

Soil remediation management is OVAM's responsibility, while soil protection is responsibility of the land and soil protection service (ALBON), under the Environment Department[48]. The main duties of ALBON include soil erosion, organic matter loss, loss of basic soil function and landslides. Both authorities are responsible for applying the contaminated soil framework in regional level.

Digital tools

The OVAM's recorded data is registered in the Land Information Register (Art. 5, 2006 Soil Decree). This inventory includes every known contaminated site (maps, soil certifications etc.) and it is publicly accessible as an information tool which is based on a soil investigation methodology. The official digital tools are linked with the waste management framework via the reuse of excavated soil.

Historical vs. new contaminated sites

The distinction between the new and the historical contaminated sites established in 1995 under the Soil Remediation Decree. The historical contamination principle refers only on continuous and serious hazards (Art. 30, 1995 Soil Remediation Decree; Art. 2(5), 2006 Soil Decree) and it is far more lenient. The remediation in this case is taking place only if the operator of this type of land has been ordered by OVAM to carry out the action of remediation. If the operator or user of this land has not caused the pollution and/or at the time he/she became the operator, he/she has not been aware of the pollution, he/she is not obliged to remediate the historical polluted site. On the other hand, in new contaminated sites, when soil screening values are exceeded, the remediation is obligatory and according to the legislation the clean-up actions last as far as the contamination is present and can be detected on the site (JRC, 2009). In this case the land uses are the most important aspect for the site management.

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[47] https://navigator.emis.vito.be/mijn-navigator?woId=23755
[48] https://omgeving.vlaanderen.be/departement-omgeving

Land transfer

For the land transfer, in Flanders, there are some significant obligations which have to be met, such as the soil certification of the site, the soil investigation actions by risk activities and the soil remediation actions, which are requested before the land transfer. All these obligations are the optimal protection of the new owner of the site (OVAM, 2007). In case of risk activities, the obligations for soil survey are conducted in two situations: a) in case of land transfer and b) in case of closure of the site and have to be in periodically scale.

6.2.2.2 Walloon Region

Legislation

In Walloon Region the soil framework was firstly introduced in 1967 with the frameworks for rehabilitation of brownfields and coal-production sites. In 1995[49], the stand-alone framework for contaminated sites was established (Soil Remediation Decree, 1995). In 1st of April 2004 the contaminated land Law was published and in 2008 the Law revised with the Soil Decree also covered soil and groundwater protection (Soil Decree 2008). The Waste Decree of 1985 includes only the rehabilitation of the contaminated sites and not the soil remediation framework. The current regional legislation is updated for third time in 2018 and introduced the new Soil Decree (Décret relatif à la gestion et à l'assainissement des sols, 2018), which is currently used and focuses on the land stewardship. The basic objectives of this Decree are: a) the prevention of soil contamination, b) the identification of the potential contaminated sites and c) the determination of the organization which is responsible for soil investigations and clean-up actions. Today, the corresponding authorities are under the Administration of the Environment.

Analysing further the Soil Decree in Walloon Region, the legislation is based on the following principles (Annex III, Soil Decree):

- Identification of the activities that, potentially, may cause land pollution;
- Mapping the background values of contaminants;
- Establishment of the threshold values based on the land uses;
- Mapping the potential polluted sites by the authorized bodies;
- Adopting the ''polluter pays'' principle;
- Determining the soil investigation procedure;

[49] http://environnement.wallonie.be/legis/solsoussol/sol002.htm

- Determining the criteria for the soil control certification;

In Wallonia, there are two major bodies involved in the contaminated site rehabilitation. These bodies are:

- The Department of Land Planning, Housing and Cultural Heritage (DGATLP)[50], which is responsible for the slightly contaminated sites; and
- The Public Company for Environmental Quality Assistance (SPAQuE)[51], which is responsible for the ‘’orphan’’ sites and for the sites needed emerge remediation because they considered as highly risk sources for the public health.

Digital tools

The Walloon soil condition database (BDES) is a tool which provides publicly all the information for contaminated soil and sites based on the available data[52].

Historical vs. new contaminated sites

In Wallonia the historical contamination is specified as that occurring before 30 April 2007 and a risk-based approach is used to remove serious threats from the historical contaminated sites. New contamination refers to a contamination due to an incident that has occurred since 30th of April 2007, the date corresponds to the Environmental Liability Directive. For historical contamination sites the methodology is based on the risk-based approach, while in case of new contamination itis based on the screening values system (see Section 6.2.4.1).

6.2.3 Land use categorization

6.2.3.1 Flanders Region

For the CSMF purposes in Flanders Region, land uses are divided into five classes:

- Nature
- Agriculture
- Residences
- Recreation
- Industry

In Flanders it is paid special attention to the brownfields. Based on the development plan of brownfields, Flemish government introduced a new framework in 2007, the Brownfields Decree[53]. On this referred that in case of brownfields’ remediation, if the owner has obtained

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50 http://lampspw.wallonie.be/dgo4/site_amenagement/
51 https://spaque.be/
52 https://sol.environnement.wallonie.be/bdes.html
53 http://www.zerobrownfields.eu/HombreTrainingGallery/06_Miseur.pdf

the ‘‘innocent owner’’ status, then the OVAM is responsible to supervise and remediate the site.

6.2.3.2 Walloon Region

For the CSMF purposes in Walloon Region the types of land uses are five:

- Natural
- Agricultural
- Residential
- Recreational/commercial
- Industrial

6.2.4 Screening values

6.2.4.1 Flanders Region

Soil screening values

In Flanders the screening values used for soil management and remedial actions are divided in two types (Carlon 2007):

- Background values: The background values correspond to the chemical concentrations in uncontaminated soils. These values represent the 90% of the measured topsoil’s concentration, for metals and metalloids, while for organic contaminants, the background values are equal to the limit of detection. In the case of diffuse contamination background values used are the 90% of the measured values;
- Soil clean-up standards: The soil clean-up standards have been calculated using the risk assessment approach. If the measured concentration of contaminants is above the clean-up standards, the risk estimation, including soil characteristics and soil function, is considered notable and that it could cause irreversible effects in both ecosystems and human health.

During soil investigation, in order to be decided further actions and site remediation, the clean-up standards are used as the lowest requirement level. The background values serve as naturally occurred limits and remediation guide. The standards are derived from the human health risk assessment. Moreover, the phytotoxicity is included on an ad-hoc basis (Carlon 2007). For example, S-Risk assessment model is used to derive soil remediation standards.

In Vlarebo 2008 there is a structural derivation of different Annexes for the different types of values. There are the background values (Annex III) for metals, metalloids, organic compounds (in mg/kg of dry soil) and the groundwater background values (in μg/L)[54]. Moreover, the Annex IV for soil clean-up standards divided in five different types of land uses and more specific sub-groups, in order to cover all the potential land use affected by the

[54] https://navigator.emis.vito.be/mijn-navigator?woId=23676

contamination. Except the screening values for contaminated soil there are values for excavated soil as part of structural soil use and leachability values (Annex V, VI and VII).

When clean-up standards are exceeded, further investigation is required considering the land uses. The derivation of the values for the historical sites is based on the site-specific approach and for the new contaminated sites the soil remediation standards define the clean-up actions.

Site-specific screening values are created according to Vlier-Humaan model, similar to Netherland's model for screening values in soil, HESP and C-Soil[55]. Moreover, the S-Risk[56] is used mainly for human health risk assessment.

Groundwater screening values

The groundwater screening values in Flanders are divided in two types:

- Background values: Which are derived from uncontaminated groundwater; and
- Clean-up standards: Which follow a risk-based approach.

In Flanders, there is no direct connection between the clean-up values in groundwater and soil (Carlon 2007). The application of background values for groundwater referred to natural levels in groundwater, specifically for metals and metalloids and the limits of detection for organic compounds. The methodology in case of groundwater mostly refers to only one receptor. The model used for assessing the groundwater risks is the F-leach[57]. There is no specific approach for surface water receptors.

6.2.4.2 Walloon Region

Soil screening values

The derivation of the screening values is a whole region system, although in some cases the background values slightly differ site-by-site. The derivation of the screening values is based either on the generic human health risk assessment or on the methodologies according to the ''Walloon Guide for Good Practices''[58] for soil and groundwater.

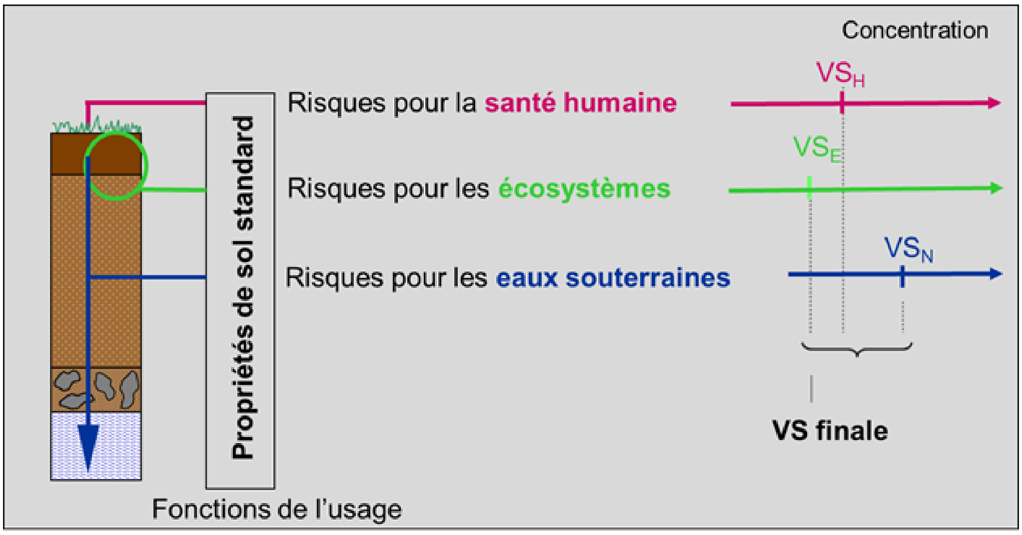
The Walloon Region established a system of one type of screening value for soil and groundwater, which is the Trigger Values (*Valeur Seuil - VS*); the Reference Values (*Valeurs de référence - VR*) and Intervention Values (*Valeurs d'intervention - IV*) used to be used but not anymore. The Trigger Values are risk-based standards and calculated according to the risk

[55] http://www.risc-site.nl/index.html?riscmainFrame=sw_vlier_nl.htm
[56] https://www.s-risk.be/
[57] https://www.ovam.be/bepaling-risicos-door-uitloging-en-beschrijving-evolutie-bodemkwaliteit
[58] https://sol.environnement.wallonie.be/home/sols/sols-pollues/code-wallon-de-bonnes-pratiques--cwbp-.html

level. If these values are exceeded further investigation is required. Also, these values are in principle the minimum value between the:

- human risk calculated value (VS_H);
- leaching risk calculated value (VS_L or VS_N in Figure 5); and
- ecosystem risk calculated value (VS_E).

Analysing the application rules of the screening levels, it seems that below trigger values the soil (including groundwater) is considered as uncontaminated, while, above the trigger value, a detailed investigation is necessary, including in principle a risk assessment procedure. The actions could be remediation actions, soil treatment application or risk management plans (Carlon 2007). As in Flanders, so in Walloon Region, the way screening values are used differs depending on whether the contamination is qualified as new or historical. In case of new contaminated site, if the trigger values are exceeded, then remediation is compulsory. For historical contamination the remediation is compulsory only if the risk is characterized as heavy threat (Annex I, Soil Decree). Also, in Walloon Region the Trigger Values are distinguished according to the land use types and land use mapping data and used as quality criteria for deciding on the possibility of reusing excavated soil (see Figure 5).



Source: Henry Halen (2021)

Figure 5 Soil screening values and risk assessment standards for Walloon Region

The Soil Decree provides trigger values for many chemical substances (metals, BTEX, PAH, TPH and chlorinated solvents). The Soil Decree requests two public institutes (ISSeP1 and SPAQuE2) to be the responsible parties of deriving soil and groundwater screening values for these compounds, when a chemical substance is quantified but not listed (ISSEP 2019).

Groundwater screening values

Groundwater is included in the national contaminated soil management policy and trigger values have been established, aligned with the idea of potential drinking water standards.

These values are mainly for heavy metals, metalloids, organic and inorganic contaminants and calculated based on:

- National limits for drinking water;
- The WHO limits for water quality;
- The European Directive on drinking water; and
- The WHO procedure for genotoxics.

The quality criteria in groundwater are the values adopted in order to protect human health from contaminants transport mainly via water pathways.

6.2.5 Sampling and analytical protocol

6.2.5.1 Flanders Region

In Flanders the use of sampling and analysis protocol is compulsory for all soil and groundwater investigations including land transfer[59]. The framework of sampling protocols is included on the soil contaminated framework and determined as a site-specific approach. All the approvals, the laboratories protocols, experts' categories, provisions, samplers' activities and inspections bodies referred on the Decree of the Flemish Government establishing the Flemish regulations on environmental approvals (VLAREL 2010)[60].

The chemical analysis is based on the bulk soil sample and the pre-treatment procedure and analysis is instituted. For that reason, all the authorized laboratories are included in a regulated list[61]. According to the Flemish Act on soil remediation and protection, the maximum detectable concentrations are converted to the clay, organic matter, pH-KCl content, during the analytical procedure. On 15 January 2021 the CMA (Compendium for sampling and analysis of waste and soil) applied in the context of Flemish environmental legislation. This guidance includes the sampling protocols for soil, groundwater, sediments, soil gas and methods of inorganic, organic analysis and sample pre-treatment guidelines[62].

6.2.5.2 Walloon Region

The Walloon Sampling and Analysis Methods (CWEA) is a recently updated tool, which combines the methods for taking and pre-treating samples with the analytical procedures for determining the levels of contaminants' concentration in soil and groundwater based on the framework of the soil decree. This tool includes the reference sampling method for the soil or groundwater[63]. Currently, there are no instituted natural background concentration values and an additional "uncontaminated" sample typically used for determining the natural

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[59] https://www.ovam.be/standaardprocedures
[60] https://navigator.emis.vito.be/mijn-navigator?woId=38542
[61] https://omgeving.vlaanderen.be/erkende-personen-bedrijven-en-opleidingscentra-zoeken
[62] https://emis.vito.be/nl/erkende-laboratoria/bodem-en-afvalstoffen-ovam/compendium-cma
[63] https://sol.environnement.wallonie.be/files/Document/CWEA/CWEA%20-%20version%20du%204%20dec%202018.pdf

background of each site. Although, the background concentration maps are foreseen according to the law. Their recognition as a strict guide tool is a further step to be achieved.

6.2.6 Risk Assessment

6.2.6.1 Flanders Region

In the conceptual site model of risk assessment many factors play a major role in order to be identified the fate & transport and all the exposure pathways leading to end up point, which is the human being and ecosystems. The most important factors are: leaching to groundwater, volatilization to indoor and outdoor air, transfer of soil-dust, uptake by plants, dermal adsorption from soil-dust, inhalation of particles and vapours, consumption of vegetables and dairy products etc. Each factor is under examination according to the land-use relevance (Carlon 2007). The site-specific risk assessment follows the soil remediation standards adopting the screening values methodology. The external dose refers to the human exposure calculation for each contaminant and the absorbed dose refers to the dermal contact calculation. In case of non-carcinogenic effects, all these conduct to the risk index (RI) which is the ratio between the total exposure for each compound and the tolerable daily intake (TDI). For non-carcinogenic pollutants in soil contamination, the background values are not enough if the source is still active. In this case the risk assessment considering all the possible exposure pathways, is forced and delimits the measures needed. Alternatively, for carcinogenic effects, calculated the ratio of the total lifetime exposure and risk cancer index of 10^{-5} exposed persons (Carlon 2007). The ecological soil clean-up standards are not available and only the phytotoxicity is included and based on ad-hoc processes. In Flanders region ecological screening values is not implemented by the current legislation.

6.2.6.2 Walloon Region

The risk assessment approach is used mainly during the characterization study to examine the need or not of the remediation actions. The first step is the mandatory study of the site included the site characterization (as historical or new), conceptual models etc. After that, if the risk of contamination is high for human health and ecosystem, the application of the threshold values is necessary. In case of low or no risk, a soil control certificate is assessed. The main factors and technical approaches using for the risk assessment are: the land uses, the matrix analysis (for soil and water) and the receptors sensitivity factor for both human beings (child or adults according to land uses) and ecosystems (Carlon, 2007).

The application of screening values is based on a risk assessment approach and used according to the combination of the toxicological, ecotoxicological risk assessment and the groundwater contamination factor. The final values used are the minimum value among the above considering the land uses (Carlon, 2007). Moreover, the drinking water standards, determined by WHO, are also considered, especially in case of drinking water exposure route.

The exposure scenario is based on the land use types, which specifies the receptor and the exposure routes. For nature and residential land uses the sensitive receptors considered children and for industrial uses the adults. The exposure routes are the outdoor/indoor air inhalation, the inhalation of soil and vapours, the ingestion of soil, agricultural products and drinking water and dermal contact with soil and water (via shower). Except the route of exposure, the time (in days) that person spend on the site, is considering as well with differentiations according to land uses.

6.2.7 Remediation targets and monitoring

6.2.7.1 Flanders Region

The three main pillars in the remediation management procedure are: a) the division between new and historical contaminated sites, b) the soil remediation standards used and c) the site-specific risk assessment approach. The soil remediation procedure in Flanders Region is a site-specific approach divided in different phases. The phases are:

- Phase I - the descriptive investigation;
- Phase II - the soil remediation project; and
- Phase III - the remediation actions.

The execution and monitoring officially accredited by the corresponding ministry after OVAM's procedure. The supervision of investigation and remediation activities is responsibility of the qualified experts. The experts involved in the execution and supervision of the site remediation are two types: a) the experts responsible for the investigation activities and b) the experts responsible for the remediation activities (OVAM, 2007). The sampling method is analysed in Soil Remediation and Protection Decree. In 2020, OVAM published new guidelines for the preliminary soil investigation and the descriptive soil investigation[64].

Nowadays, it seems that the *in-situ* treatment is used (e.g., soil vapor extraction), while the *ex-situ* techniques (e.g., pump & treat) are not used anymore. The soil remediation standards are designed based on the specific remedial targets and is a site-specific approach. Although, the determination of this approach is based on a multicriteria analysis according to land uses, for metal and metalloids (taking into account the clay, organic matter and pH-KCl content) and the natural background values (Art. 1 and 2 of the Decree of the Flemish Government). The soil remediation standards for heavy metals in the solid part of the earth is published in an updated report by OVAM (Table 3)[65]. In case of nature, the soil remediation standards are set equal to those for agriculture (Carlon 2007). The remediation goal is to reach the target value for the soil quality using the best practices for remediation or, if this is not possible, to reach as better soil quality as possible based on remediation standards. The BATNEEC principle (Best Available Technology Not Entailing Excessive Cost) is the guide to the final decision of the remediation techniques used. Soil remediation is activated only if the clean-up values are exceeded and only in case of new contamination. In case of historical

[64] https://www.ovam.be/standaardprocedures

[65] https://www.ovam.be/sites/default/files/atoms/files/Methodologie%20DAEB%20en%20risico-evaluatie%20-%20Code%20van%20goede%20praktijk_2.pdf

contamination, the clean-up standards create a base for further investigation of the risk apply on the site (Carlon 2007).

6.2.7.2 Walloon Region

The basic goal of the soil remediation is to reduce, in a considerable level, the soil contamination. This level considered as the reference values (or soil quality level), taking into account all the factors (land uses, matrix analysis, background concentration etc.). The soil targets are based on the regional Environmental Plan for Sustainable Development of 1995. The three main aspects are: a) the prevention of the soil contamination, b) the criteria of rehabilitation especially in agriculture, waste, industrial, infrastructure and transport sectors and c) the improvement of soil quality monitoring (JRC, 2009). The remediation actions are different between the new and historical contamination according to the Soil Decree.

In Walloon, the technical soil management guidelines are provided from the Walloon Code of Good Practices (CWBP)[66]. Some of the basic tools are the: Reference Guide for Orientation Study (GREO), Reference Guide for the Characterization Study (GREC), Reference Guide for Risk Assessment (GRER), Reference Guide for the Sanitation Project (GRPA) and the Reference Guide for Final Assessment (GREF).

The basic tool for the site characterization is the Reference Guide for the Characterization study (GREC), which explains the methodology of the characterization. The proposed methodology is conducted in three phases, in accordance with the Soil Decree:

- Phase I: Preparatory study
- Phase II: Characterization
- Phase IIIa: Results of interpretation (and if applicable, follows the Phase IIIb)
- Phase IIIb: Risk study
- Phase IIIc: Operational conclusions

In Phase II, the characterization of the site as historical or new contaminated is significant. In case of new pollution or historical pollution constituting a serious threat to humans or the environment, a project of sanitation is needed. While in case of historical pollution not constituting a serious threat, a soil control certificate is compulsory.

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66 https://sol.environnement.wallonie.be/home/sols/sols-pollues/code-wallon-de-bonnes-pratiques--cwbp-.html#:~:text=Le%20CWBP%20%3A%20qu'est%2D,en%20gestion%20des%20sols%20pollu%C3%A9s

6.2.8 Liability

6.2.8.1 Flanders Region

In Flanders the 2006 Degree on soil protection and remediation distinguishes clearly the chain of liability. Firstly, the operator of the installations present on the site is liable, where the pollution is originated, secondly the liability is upon the land user and thirdly on the landowner of the site. These three individuals or companies are considered as different obligators. The site closure procedure has a risk-based approach which includes the obligation of a soil investigation before it is completed. Finally, the liability on remediation is completed, only if the duty of remediation is vanished and the remediation criteria are fulfilled. Although, the liability, mainly for the cost of remediation, can be made up even 30 years after the integration and until the liable sides have met the financial requirements according to the Belgian Civil Code (Belgian Civil Code, Art 1382 – 1384).

It is possible that the owner of contaminated land has not caused the pollution. If no other financially solvent party can be identified for the liability of the contamination, the owner will bear the losses. For this reason, the Flemish Decree includes the term ‘‘innocent landowner’’. The owner or operator of the site is not obliged to carry out the clean-up actions if he can prove that he did not cause the pollution himself and that when acquiring the property, he was not been aware of the event. For historical contaminated sites the owner’s exception of the clean-up actions is broader as the owner is not obliged to carry out the remediation actions if he can prove that he did not cause the contamination himself and he was not been aware of the event. Finally, the owner is not obliged to carry out the remediation actions if he can prove that the contaminated site was acquired prior to 1993 and since then was exclusively used for a non-professional use (Dries et al. 2014).

6.2.8.2 Walloon Region

In liability chain for contaminated land, the polluter is the first responsible person or body for the remediation management actions. If the polluter is absent, then the occupier (in case that polluter and occupier are different persons or bodies) takes the responsibility and lastly the landowner is the person in the chain of liability, who is responsible for the actions required. The liability is considered completed only if all the procedures and actions have been done by the law. If the cleaning actions are pending, then the liability ends once the actions are completed. Moreover, it has to be mentioned that the soil control certification, which indicates that all the needed actions have been taken by the liable individual, is issued by the corresponding authority. For groundwater the monitoring plan is a duty in case that risk uncertainties remain after the end of remediation actions.

6.3 The Netherlands

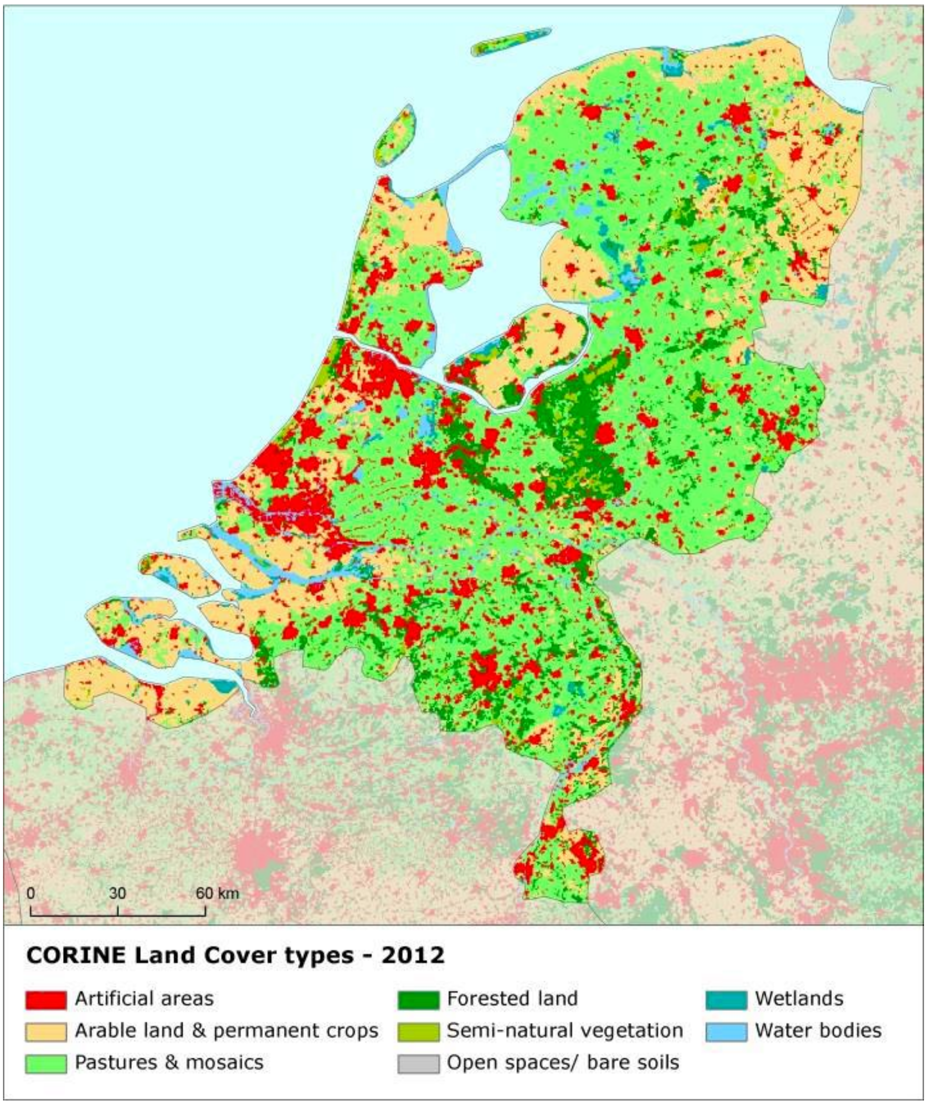
6.3.1 Introduction

The Kingdom of the Netherlands is a European country located in Western Europe and partly in the Caribbean, forming the largest constituent country of the Kingdom of the Netherlands. In European area, neighbours with Germany, Belgium and through the North Sea, with the United Kingdom and consisting of twelve provinces. European Netherlands occupies an area of 38.000 km² and is one of the world’s most densely populated countries with population approx. 17.5 million[67]. The biggest part of the west and north Netherlands is low-lying with approximately 20% of its area below the sea level and the east and south part of it, composed of higher lands. The Netherlands has three main rivers, the Rhine, the Maas (Meuse), and the Scheldt[68]. The Netherlands is one of the strongest economies of the Western Europe, partly because it is a highly industrialized country[69]. The Netherlands is one of the EU member states with the highest level of per-capita GDP (47,049€ for 2019), although future economic growth is expected to be slightly below the EU median. The high urbanisation rate of 91% is expected to climb even higher to 96% by 2050, representing an increased urban and total population. The coverage and compliance performance of water supply and sanitation is the best in the EU, reflecting a high level of expenditure per capita. Exposure to riverine and coastal flood risks is distinctively high. Situated in the delta of four international rivers, with a quarter of its territory below sea level, flood risk management has been central to Dutch water management for centuries.

The Netherlands is a heavily industrialised country whereas the agricultural use of soils is one of the most intense in the world. Because of the wide use of fertiliser there are great problems of groundwater pollution in wide areas, especially sandy regions, about 42% of the whole country. In urbanised regions hundreds of thousands local pollution sources can be found and therefore groundwater quality is often endangered. In more than 90% the country groundwater level is less than 4 m below the surface level. Figure 6 shows land uses in the Netherlands.

The Netherlands has a number of protected areas categorized them in National Parks, National Landscapes, Protection woodland, Protection Wadden sea and Protection North Sea. According to their category they are part of the National Ecological Network (NEN), the Nature Conservation Act, Ramsar Convention, Natura 2000 etc.[70]

[67] https://www.eea.europa.eu/publications/92-9167-032-4/page013.html
[68] https://www.nationsonline.org/oneworld/map/netherlands_map.htm
[69] https://www.britannica.com/place/Netherlands/Economy
[70] https://www.government.nl/topics/nature-and-biodiversity/protected-nature-areas



Source: European Commission (2017c)

Figure 6 Land uses in the Netherlands

6.3.2 Legislation, Administration & Professionals

Legislation

The Netherlands has developed a strong soil protection framework including a system of screening values and site-specific risk assessment procedures. The soil protection framework was established in 1987 with the Soil Protection Act (Wet Bodembescherming). In 1994, the first series of screening values and procedures for site-specific risk assessment were launched. In 2008 the soil protection framework was extended with Maximal Values for specific land uses, in the Soil Quality Decree. This Decree tries to balance between the human health and ecosystem protection and the reuse of the ''slightly'' contaminated soil (Swartjes et al. 2012). The basic principles of this Decree are the ''stand still'' principle and ''fitness-to-use'' principle (Ministry of VROM, 2009). To prevent soil pollution a National Guideline on Soil protection has been introduced in 1997, risk based and with provisions and measures to prevent leaching and spilling. This guideline has been revised in 2012. The provincial authorities are responsible for the enforcement of the Act. At the same time, a local standards' system has been developed giving to local authorities the flexibility of the decision-making. This is a strong point in Dutch framework meaning that local authorities could create their own soil policy. The assignments and tasks for local administrations (provinces and municipalities) are (Otte, 2017):

- Prevention and minimization of the health risk;
- Safety of soil use (e.g., for agriculture) and soil reuse (i.e., in building activities);
- Remediation decisions; and
- Spatial planning optimization.

The main principles of the Dutch framework are:

- The prevention approach;
- The land uses-based management; and
- Priority setting for remediation, based on risk assessment.

The Soil Quality Decree also regulates how to control and use excavated soil. To stimulate circularity by reuse of excavated soil, landfilling of soil is only allowed when clean-up of polluted soil is not technically feasible or within reasonable costs. There is a special procedure to determine whether this is the case. Slightly contaminated soil can be reused based on their composition and quality on sites with the same or a worse soil quality. To facilitate this, all municipalities have their own soil quality maps[71].

The Circular for Soil Remediation (Circulaire bodemsanering 2009, Staatscourant 67, 2009), as updated in 2013 and the Regulation on Soil and Groundwater Quality (Regeling en Besluit bodemkwaliteit) valid from 9th of June 2020[72], analyse the adopted criteria for soil and groundwater screening values and both currently used by the experts and authorities. The policy for contaminated soil and groundwater is based on the following points:

- Soil Protection Act and Circular for Soil Remediation;
- Human health risk assessment, ecological risk assessment, risk on spreading;
- Intervention Values as the first trigger for the authorities;
- Site-specific risk assessment in Tier 2 and Tier 3 for the determination of the priority of remediation;

[71] https://www.bodemrichtlijn.nl/Bibliotheek/grondstromen/grondstromen-wettelijke-kaders
[72] https://wetten.overheid.nl/BWBR0023085/2020-06-09#Hoofdstuk2

- Background Values and Maximal Values for the reuse of soil material;
- Background Values and Maximal Values as remediation targets (clean-up goals)

The whole legislation includes, on the top of the pyramid, the Soil Protection Act, on the second layer, the Soil Quality Decree, after that the next layer contains the Circular of Soil Remediation, which is a technical and practical guide and finally all the documentation and accreditation schemes, which are not directly published by the government but are maintained by the national institutes such as the Netherlands Standardisation Institute (NEN), the Foundation Infrastructure for Quality Assurance of Soil Management (SIKB) and the Rijkwaterstaat, an executive Agency of the Ministry of Infrastructure and Water Management[73].

The main authority bodies and actors of risk assessment framework for soil protection are the National Institute for Public Health and Environment (RIVM) and the Dutch Ministry of Infrastructure and Water Management (Min IenW) (formerly VROM). For data management and mapping the Geological Survey of the Netherlands (TNO) is also involved (INERIS 2013). For contaminated soil management the instruments used are screening values, risk assessment tools and the technical guidelines (Otte, 2017). Also, there are more parties involved in the identification and remediation of contaminated sites. These are the owner of the contaminated site, the consultants, the authorized laboratory, the competent authority and the contractors. Practically, the consultants are in charge of all practical work and consequently they bear a large part of the responsibility. This is recognised in the Soil Quality Decree in which quality assurance is an integral part[74].

The last 10 years a special effort has been made to identify all sites with historical contamination, which cause a risk for human health, ecology or spreading. Nowadays, these sites are either remediated, controlled or under site investigation. This has become able by profound agreements between the Ministry, the provinces, the municipalities and the water authorities. Other contaminated sites, not causing risk, will only be considered in case of land use change activities.

Digital tools

The exposure model which assists the process of risk assessment is CSOIL[75] created by RIVM, latest version is from 2020. Using this digital tool, the actual exposure to the contaminated soil using the site-specific dataset is calculated. In addition, there are many cases recorded with volatile contaminants and for that reason the VOLASOIL model (Bakker et al. 2008) is also used to assess the actual risk of volatile contaminants evaporating mainly in indoor environments. The type of contaminants, the soil and building's characteristics and

[73] https://rwsenvironment.eu/subjects/soil/publications/
[74] https://rwsenvironment.eu/subjects/soil/publications/
[75] https://www.rivm.nl/bibliotheek/rapporten/2020-0165.pdf

groundwater depth are some of the basic input data required. VOLASOIL calculates the crawl space air and indoor air concentrations from the concentration in soil or groundwater, via convection, diffusion and dilution. Important input parameters are the depth of contamination, the depth of the groundwater tables and the building characteristics.

The VOLASOIL consists of:

- four successive compartments (from the bottom to the top): saturated zone (groundwater), capillary fringe, vadose zone (soil and/or floor), indoor air (here in the crawl space, basement, or first floor);
- three flux mechanisms: diffusion in the soil water of the capillary fringe and of the vadose zone; diffusion in the soil air of the capillary fringe and of the vadose zone; convection in the soil air of the vadose zone.

Besides, the multiphase equilibrium between soil air, soil water, and soil, is considered to take place. The different fluxes are not independent: it is the same soil air (or soil water in equilibrium with the soil air), which is simultaneously submitted to the different mechanisms, and the total pollutant flux is constant (steady state model and mass conservation)[76].

Historical vs. New contaminated sites

The benchmark between the new and the historical contaminated sites is 1987. As for new soil contamination, the principal duty of care is applied (bring back to the original situation). However, this is not the case for soil that was contaminated prior to 1987, where the concept of a multifunctional soil has been abandoned. In view of experiences over previous years, it was evident that the demands of the multifunctional soil concept for 'historical' soil pollution often cannot be met. Therefore, if the measured soil concentration exceeds the intervention value (see section 6.3.4.1) and the contamination dated before 1987, site specific risk assessment is required to determine the priority of remediation. For immobile contaminants the aim was to establish a soil quality that fits to its future land use. The new function of the soil, therefore, determines the extent to which remediation is necessary. For mobile contaminants the remediation measures should be determined by cost effectiveness, which might imply the treatment of contamination over a longer period rather than trying to solve the problem within a few weeks or months.

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[76] https://www.ineris.fr/sites/ineris.fr/files/contribution/Documents/INERIS_consoil-2005_volasoil_multilayer.pdf

However, exceeding the Intervention value (see Section 6.3.4.1) does not imply an immediate remediation. It meant that the urgency of remediation has to be determined. In practice, remediation takes place for urgent cases of soil contamination, in particular in cases that are urgent on the basis of human health risks. Other sites with serious soil contamination generally can be remediated at a convenient moment in time, for example, when building activities or other soil-related activities take place at the site (Dutch Soils 2014)[77].

On the other hand, if the soil concentration exceeds the intermediate value[78] and the contamination is dated after 1987, further investigation (e.g., delineation, investigation to identify the severity of soil and groundwater contamination) and probably remediation is needed.

For soil contamination occurring after 1987, the polluter has exclusively the liability. Furthermore, due to the early entry into force of the Dutch soil legislation, the ‘‘orphan sites’’ affected by historical contamination are not very common, but when it occurs, the competent authorities are responsible for the remediation (JRC, 2018).

6.3.3 Land use categorization

For the CSMF purposes in the Netherlands, land uses are divided into seven classes:

- Residential with garden
- Places where children play
- Residential with vegetable/kitchen garden
- Agriculture
- Nature
- Green with nature value, sports, recreation and city parks
- Other greens, buildings, infrastructure and industry

Also, the concept of buffer zones is another approach used to protect the soil and water quality by minimising the negative impacts of anthropogenic activities on nature.

6.3.4 Screening values

The Dutch screening value system is regulated in national level. Currently it is under revision in order to include also diffuse contamination and emerging contaminants (i.e., PFAS) that are

[77] https://rwsenvironment.eu/subjects/soil/publications/

[78] It is the average between background value and intervention value (soil) or between target value and intervention valuer (groundwater). The meaning was that when the intermediate, but not the intervention value, is exceeded further research is required. At the latest update of the investigation standard NEN5740 in 2009, the concept of intermediate value was not included, however, still it used in some cased for practical reasons.

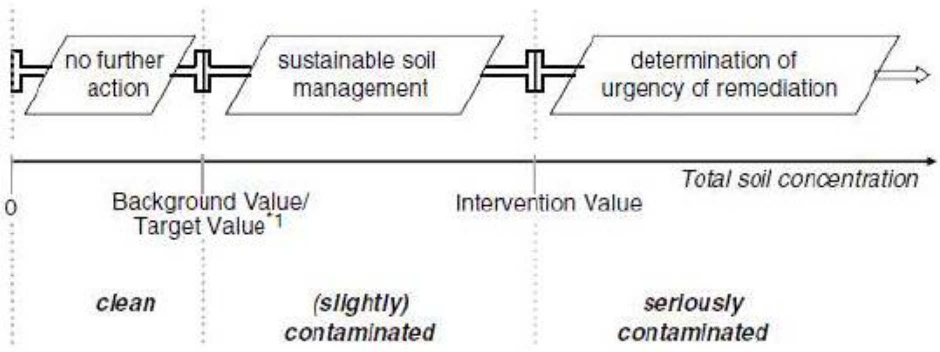
not listed in the existing framework. According to the Circular on Soil Remediation of 2013, which is a supplement of Soil Protection Act, the soil and groundwater measured concentrations are compared with the soil quality standards (SQSs) (Swartjes et al. 2012). The system of SQSs is based on risk assessment, related to human health and the ecosystem.

6.3.4.1 Soil Screening values

The former Ministry of Housing, Spatial Planning and the Environment (VROM) developed a system of screening values according to protection of human health and the ecosystems. According to that, the soil quality is assessed by two types of screening values (Ministry of VROM 2009; Gong 2010):

- Target values (for groundwater only): values (based on ecological risks) represent the level above which the soil is considered as contaminated.
- Intervention values: values (based on human health and ecological risks) represent the level above which the functional properties of the soil are seriously impaired, and threaten human health, as well as plant and animal life. Also, they serve as criterion for cases of serious contamination, workers safety measures and for soil reuse.
- Background values (for soil only): values indicate the level below which there is sustainable soil quality.

The result of this comparison allowed classifying the site into "clean soil", "slightly contaminated soil" or "seriously contaminated soil" (see Figure 7). A serious soil contamination is defined as a volume of soil (unsaturated upper soil layer) of at least 25 m^3 showing concentrations above the Intervention Value (Swartjes et al. 2012). A serious case of groundwater contamination is defined as a volume of groundwater (saturated zone) of at least 100 m^3 that is contaminated at levels exceeding the Intervention Value (Swartjes et al. 2012; INERIS 2013).



Source: Carlon (2007)

Note: Background values are used for the unsaturated soil compartment ('soil'); Target values are used for groundwater.

Figure 7 Soil screening values in the Netherlands

If the concentration of the contaminant is below the background value, the risk considered as negligible and there are no restrictions for soil use. The derivation of soil intervention values is based on the human health risks and the SSD (Species Sensitivity Distributions) approach, with a reference of a 10% organic matter content and 25% clay content. The screening values are independent of land uses (instead of the SQSs) and follow a tiered approach based on the exceedance. When the intervention value is exceeded then a more detailed site-specific assessment is conducted (Swartjes and Otte 2017).

The background values are based on a soil survey of approximately 100 sites in Netherlands using a random sampling based on soil characteristics and land uses. These values are the 95 percentile of the normalized topsoil (0 – 10 cm) concentrations and created in order to separate the clean natural soil and contaminated soil (Brus et al. 2009). The background values serve as a generic and standard value in the cases of anthropogenic influence in natural land use. Every municipality has a unique soil quality map as a digital tool[79] for identification and categorization of the contaminated land.

On the other hand, local Maximal values can be established by the local authorities, which have the jurisdiction to establish the site- or region-specific factors in order to determine the soil quality criteria for the reuse of soil material or as remediation targets. The procedure is a risk assessment process based on chemical, biological and physical soil quality.

6.3.4.2 Groundwater screening values

The groundwater policy in Netherlands is under the Soil Protection Act and partly under the Water Act. The groundwater SQSs derivation is based on risk assessment considering the negligible risk for aquatic ecosystem as well. This level is the so called Maximal Permissible Risk level for aquatic ecosystems (Swartjes et al. 2012). The values divided into two categories (Carlon 2007):

- Target values: values for groundwater (based on ecological risks and background concentrations), which correspond to the negligible risk level; and
- Intervention values: values for groundwater (based on human health and ecological risks), which is in balance with the intervention values for soil and take into account the possibility of direct consumption of groundwater as source of drinking water.

Target values for groundwater has a distinction between the shallow and deep groundwater, mainly for metals. The reason is the different background values between these two types of groundwater. An arbitrary and indicative boundary of 10 m has been adopted to distinguish between shallow and deep groundwater (Soil Remediation Circular 2013).

[79] https://www.bodemloket.nl/;https://www.bodemloket.nl/;https://basisregistratieondergrond.nl/

6.3.5 Sampling and analytical protocols

The Dutch policy for sampling soil and groundwater proposed by RIVM recommends that in case of serious contamination the average concentration of a minimum of 25 m^3 in soil volume (or 100 m^3 for pore saturated soil volume in case of groundwater contamination) must be greater than the soil intervention value at least for one contaminant.

When assessing the soil quality, the measured contents are converted to standard soil by means of a soil type correction. The measured percentages of organic matter and clay are used for standardization and the standardized values are tested against the standard values using the following formula[80]:

$$G_{standaard} = G_{gemeten} * \frac{(A + B * 25 + C * 10)}{(A + B * \%\,lutum + C * \%\,org.stof)}$$

- $G_{standaard}$: standardized content;
- $G_{gemeten}$: measured content;
- A, B, C: the given substance-dependent constants for metals,
- % lutum percentage: the percentage by weight of mineral components with a diameter smaller than 2 µm, based on the total dry weight of the soil, bank earth or dredging sludge; and
- % organic matter the measured percentage of organic matter based on the dry weight.

The Dutch soil and groundwater standards are environmental pollutants reference values used for sampling, analysis, investigation and clean-up actions[81]. The data for analysis and measurement standards apply to the list of all substances for which the intervention values have been established, given from NEN – Netherlands Institute of Standardization[82]. The standards apply for soil (terrestrial and aquatic soil) and groundwater and the substances are grouped in metals, inorganic compounds, aromatic compounds, polycyclic aromatic hydrocarbons (PAHs), chlorinated hydrocarbons, pesticides and other compounds (i.e., cyclohexanone, mineral oils, pyridine etc.). *The* NEN 5740 is a Dutch protocol which includes a list of contaminants for a standard site investigation procedure (Otte, 2017). This list includes the intervention values for 120 contaminants and the background values for approx. 150 compounds.

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[80] https://wetten.overheid.nl/BWBR0023085/2020-06-09#BijlageG
[81] https://www.esdat.net/environmental%20standards/dutch/annexs_i2000dutch%20environmental%20standards.pdf
[82] https://www.nen.nl/en

6.3.6 Risk Assessment

The risk assessment includes the human health risk, ecosystem and groundwater risk assessment. The human exposure calculations are combined with toxicological reference values. The derivation of the reference values is made with a separation between carcinogenic and non-carcinogenic (Carlon 2007). For non-carcinogenic contaminants the Tolerable Daily Intake (TDI) is calculated according to human toxicological data, using extrapolation factors based on animal tests and accordance to WHO procedure. The TDI is the threshold exposure of a contaminant to which human beings can be exposed daily without adverse effect and is considered as the maximum permissible risk for human intake (MPR_{human}) (Carlon 2007). For carcinogenic contaminants is taken under consideration the lowest exposure rate as even then, there is an increased chance of adverse effects in human beings[83]. On the other hand, the ecotoxicological effects are quantified based on the soil concentrations above which the 50% of the species may experience negative effects. In this case, to calculate the HC_{50} as mentioned previously, the SSD are used in the same way as screening values.

The most significant human exposure pathways are soil ingestion, vegetable consumption, inhalation of air particles and dust and dermal uptake (via shower or rain exposure). The inhalation and direct contact with contaminated groundwater are considered as well (INERIS, 2013).

A very useful decision support system for risk assessment and soil management is the Sanscrit[84]. This is a generic system with application to any field in the Netherlands. Finally, for the ecological risk assessment and according to the application of the screening values, the intervention values are created to protect the 50% of species and represented by the HC_{50} index (the concentration of the hazardous compound that allows the 50% of the species to be affected) and the target values define the HC_5 index (the concentration of the hazardous compound that allows the 5% of the species to be affected) (Carlon 2007).

6.3.7 Remediation targets and monitoring

The Dutch remediation strategy is described in Soil Remediation Circular 2013 and condenses in Figure 8.

In the Netherlands the local authority has determined the soil quality setting maximum values (SQSs) in accordance with the Soil quality Decree and the Building Decree in case of soil reuse. For severe contamination the remediation is not necessarily the first action. As mentioned above, a case of contamination is characterized as severe if the average concentration of at least one contaminant measured in a soil volume of at least 25 m^3 in the case of soil

[83] http://eca-suelo.com.pe/wp-content/uploads/2018/08/15.-Soil-Remediation-Circular-2013-version-of-1-July-2013.pdf
[84] www.sanscrit.nl

contamination, or in a pore saturated soil volume of at least 100 m^3 in the case of groundwater contamination, is greater than the Intervention Values. However, there are also cases of severe contamination where the Intervention Value has not been exceeded, while a case of contamination may also be characterized as severe even when substances are non-listed or no Intervention Value has been derived for them. The next steps are based on the characterization of each site. Moreover, there is a different approach for mobile and immobile contaminants. In case of immobile contaminants, the goal of remediation is focused on the reduction of human health risk alighted with a cost-efficient approach (INERIS, 2013).

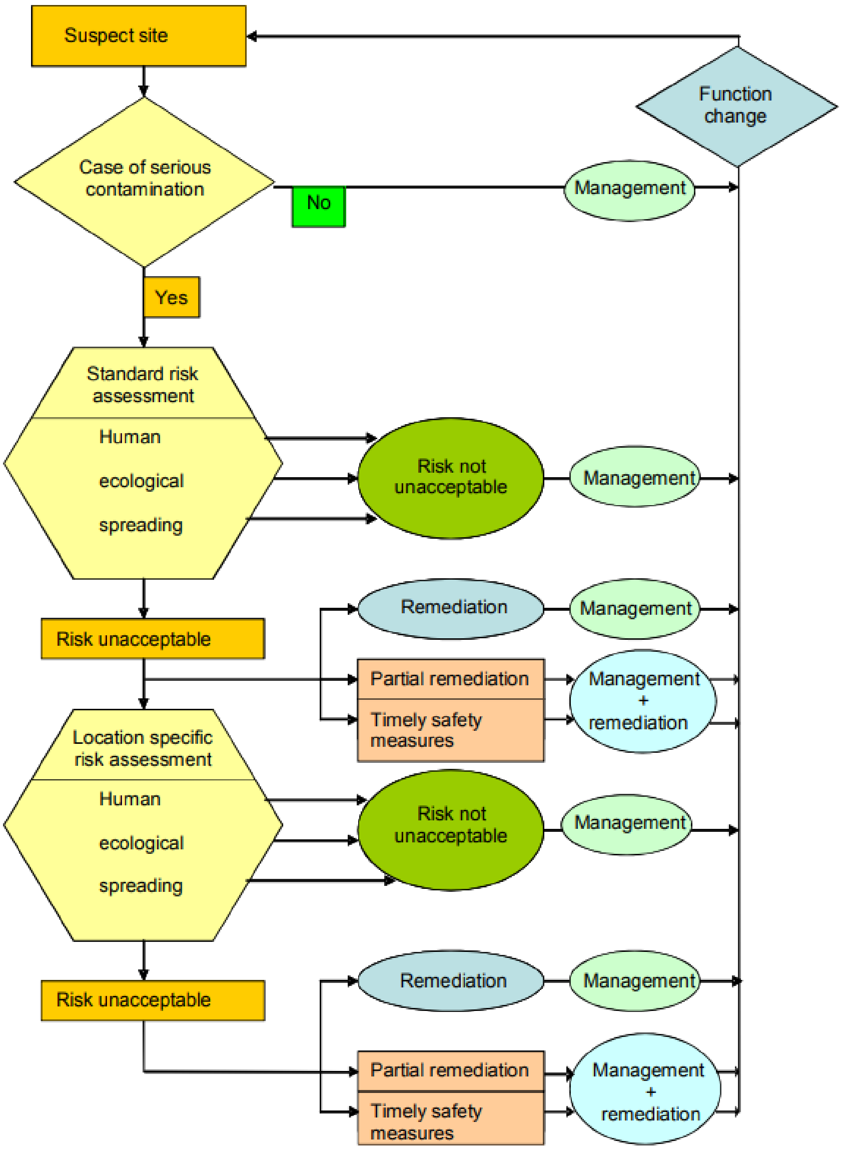
Once a site is suspected that is contaminated, the assessment determines the level of severity. The risk assessment is completed on three steps (Soil Remediation Circular 2013, section 3.4):

Step 1: Investigation to determine if the contamination is severe or not. In case the contamination is severe the step 2 is compulsory.

Step 2: Investigation to determine whether unacceptable risks exist for the case of severe contamination. A standard risk assessment method is used to determine whether any risks are involved in the present and/or future use of the contaminated site that would have an unacceptable impact on humans, the ecosystem, or from the point of view of the contamination spreading. According to the results of step 2 there are three options:

- The risk is not unacceptable, the urgent remediation is not needed, and the competent authority is responsible to register the concentrations and manage the site in order to prevent any future contamination.
- The risk is unacceptable and urgent remediation is needed.
- The risk is unacceptable and site-specific assessment is needed. The owner of the site has the option to conduct a site-specific assessment in case of overestimated results. The competent authority could also call for site-specific risk assessment to be carried out if it deems such an assessment necessary for decision-making.

Step 3: Finally, the objective in this step is the decision in case of different conclusions between the standard risk assessment and site-specific assessment. The result obtained in Step 3 may also lead to better dimensioning of the remediation measures. Step 3 may yield the following results: The risk is not unacceptable or the risk is unacceptable and urgent remediation is required.



Source: Soil Remediation Circular (2013)

Figure 8 Diagram of soil remediation process

In case of an urgent remediation, the remediation plan refers that the remediation has to be started during the first four years of the recorded date. The selection of the remediation techniques depends on the site's contamination level, the urgency of the situation and the cost of technology. Both *ex-situ* and *in-situ* techniques are used according to the spatial planning of the site and the estimated sensitivity of the land. The *in-situ* technologies are used mainly for groundwater remediation and in case of application of natural attenuation. The organization which is responsible for the remediation techniques research is the SKB

(Foundation for Knowledge Development and Knowledge Transfer) that provides with the remediation guidelines, research strategies and techniques[85].

As far as the groundwater remediation is concerned, this has three aims (Carlon 2007):

- Eliminate the source of contamination;
- Remove the plumes (in a cost-efficient approach); and
- Avoid the spread of contamination.

Based on the same concept, the determination of contamination's level (urgent and non-urgent) in groundwater is a site-specific approach aiming the identification of the actual risk of contaminants considering the contamination migration (Carlon 2007).

6.3.8 Liability

In the Netherlands the liability chain starts from the polluter, then the landowner and finally to the render. The pass of the liability is provided by the Soil Protection Act, section 55b, Art. 3 «If ownership or the lease is transferred, the obligation to decontaminate shall continue to rest upon the owner of leaseholder who transferred the ownership or lease until such time as the succeeding owner or leaseholder has furnished, and the Provincial Executive has duly accepted, financial security for the decontamination costs (…)». Moreover, the liability is no longer activated if the clean-up actions are completed, but except that, no further specifications or monitoring actions for the closure of the site are available. After the remediation of the site, the owner remains responsible for any new contamination case. Moreover, the Activities Decree (Activiteitenbesluit milieubeheer) also includes the soil pollution obligations in case of industrial pollution and defines the duty of the land operator[86]. In the Netherlands, a Real Estate Register system and a database of contaminated sites have been organized[87], where it referred the restrictions for soil quality, the duty of rehabilitation and the authority which is responsible to investigate and take the decisions of rehabilitation. The only procedure in this case, is that the owner of the potential or existing source of contamination is responsible to remediate the site and manage the created plumes, which is under the jurisdiction of the regional body. Overall, the decision for the site investigation in

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[85] https://www.bodemrichtlijn.nl/Home/de-inhoud-van-de-richtlijn
[86] https://uk.practicallaw.thomsonreuters.com/1-619-6750?transitionType=Default&contextData=(sc.Default)&firstPage=true#co_anchor_a761868
[87] https://www.kadaster.nl/

order to be closed is upon the local authorities and the monitoring plan depends on remediation plan, the site's characteristics and future land uses.

6.4 France

6.4.1 Introduction

France is one of the largest north western European countries with 550.000 km^2 land cover between the Atlantic Ocean and the Mediterranean Sea and is bordered by 8 countries[88]. It has a low population density (approx. 67 million, 107 inhabitants/km^2)[89] comparing to other EU countries. The geomorphic profile of France is complicated with high mountains (Alps, Pyrenees etc.) and large plain areas. The biggest part of country's landscape consists by plateaus, plains and mountain blocks. Moreover, France is one of the world's leading countries in the agricultural sector and is characterized by a great diversity of land-based and marine ecosystems. In agricultural sector, between 2008 and 2014, the amount of pesticides' use increased by 29%, in contrast with the declination of the nitrogen and phosphorous surpluses. The main land uses in France are illustrated in Figure 9.

The water resources stress in France could be characterized as moderate and water resources are getting scarce[90]. The French geology varies among different types of formations resulting in many different types of aquifers from sedimentary to alluvial plains and limestone rocks. Nowadays, the groundwater resources represent about 66% of France domestic water supply, 31% of industrial water supply and 37% of total water use in agriculture. About 33% of groundwater bodies were considered in good chemical quality status. One of the environmental issues in France is degradation of groundwater quality mainly related to diffuse contamination from the pesticides and fertilizers use. For that reason, groundwater and aquifers recharge management have an important role in the country (Marechal and Rouillard 2020).

In France there are 5.640 protected areas, 1.776 out of them are under the Natura 2000 protection scheme and 3.864 sites are under the supervision of national laws[91].

European law is determinant for the Environmental legislation and policy in France, which is implemented mainly by the local authorities. The contaminated land management framework, and overall, the environmental legislation, is well defined and implemented at different levels, State and Prefectures, which work in the direction of controlling and enforcing the legislation.

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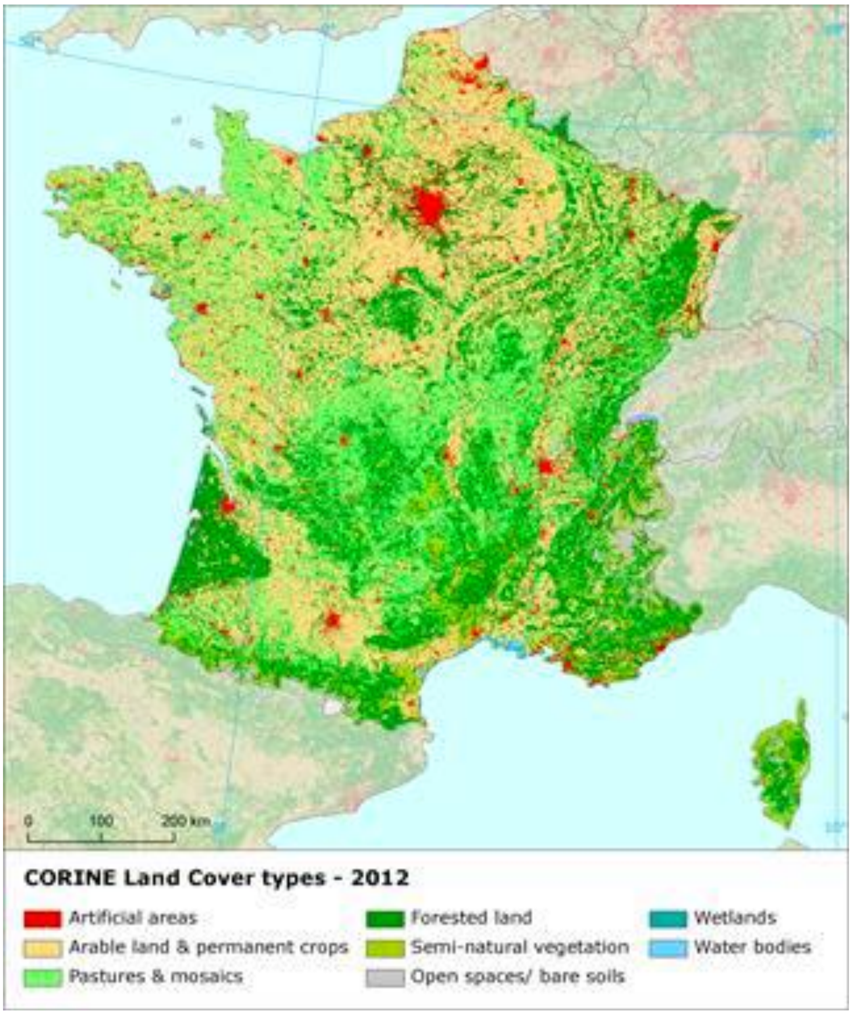
[88] https://www.britannica.com/place/France
[89] https://data.worldbank.org/indicator/SP.POP.TOTL?locations=FR
[90] https://www.oecd.org/environment/countryreviews/Highlights%20France%20ENGLISH%20WEB.pdf
[91] https://biodiversity.europa.eu/countries/france



Source: European Commission (2017d)

Figure 9 Land uses in France

6.4.2 Legislation, Administration & Professionals

The first methodologies for contaminated sites management were implemented in 1999 and have evolved since then (2002, 2005, 2007). However, it should be noted that the main law texts which drive the obligation of a site operator to perform remediation at the end of activity came in force in the 1976 (and updated since). In 2007, new circulars for Classified Installations came into force to update the management methodologies for contaminated sites including the liability chain, the recognition of «orphan» sites and the remediation of contaminated sites, where sensitive population is exposed via the emissions or actions of specific facilities. In 2017, the 2007 methodological guidelines about the management of contaminated sites were updated[92] and are in use since then.

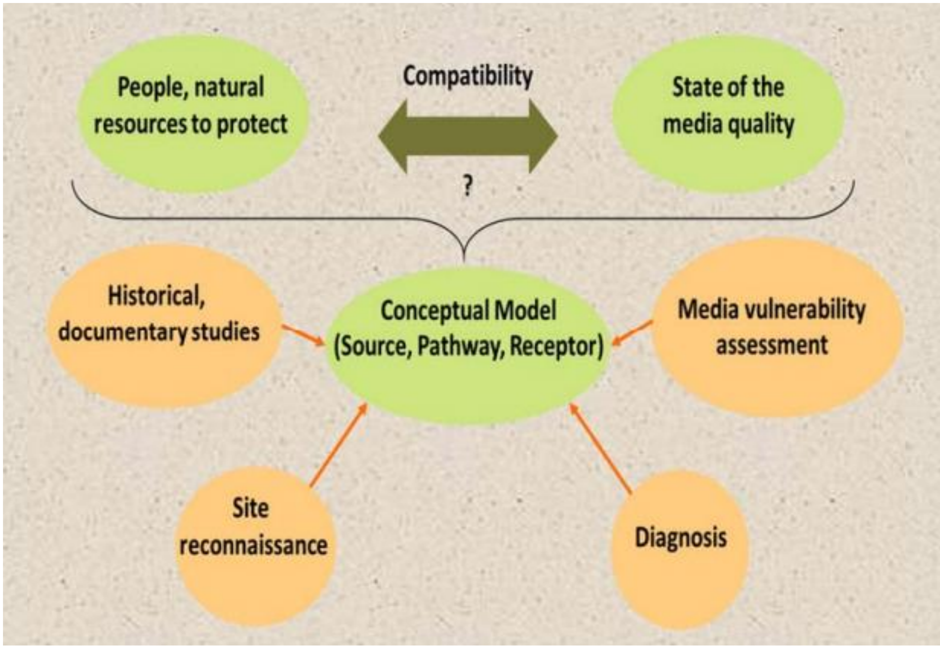
[92] https://www.legifrance.gouv.fr/download/pdf/circ?id=42093

The national policy for managing contaminated land relies on the management of human health and environmental risks taking into account land uses. On this principle, the national methodology applies to all sites that potentially present issues of pollution in soil or other media. The main principles of the contaminated soil management framework in France are:

- A distinction between i) current and future pollution to be managed according to the principle of precaution and reparation, and ii) the historical pollution to be managed according to the principle of land use.
- An assessment of the risks, based on the actual uses, on the exposure media characterization and remediation thresholds reflecting national objectives for public health.
- The “specificity” principle implying an assessment on a case-by-case basis, as close as possible to the site’s reality,
- Technical feasibility assessments and well-argued financial demonstrations.

The methodological guidance presents a range of specific tools such as the Conceptual Model, the Assessment of the State of Media Quality (Interprétation de l’Etat des Milieux—IEM), Remediation Plan (Plan de Gestion—PG). It is recommended to carry out IEM or PG in a progressive manner, i.e., when acquiring data and producing results. The first and indispensable stage is to establish a factual assessment of the state of the site’s media, in order to understand the relations between sources of the pollution, migration pathways and receptors that must be protected (e.g., people, water resources). This approach, i.e., “Conceptual Model” development, relies first on gathering of information from historical records and other possible sources, media vulnerabilities assessment (Etude de vulnérabilité des milieux), site reconnaissance, and then on-site investigations concerning relevant media. The model ought to be revised continuously as new information is acquired.

The Assessment of the State of Media Quality (“Interprétation de l’Etat des Milieux” approach—IEM), helps to evaluate for a given site if there is compatibility between the current state of its environmental media quality and its current land use (e.g., residential, single dwellings with or without crawlspace, playgrounds, vegetable gardens, agriculture, groundwater uses). The results of the investigations (Diagnostic) are compared to different values provided by the methodology (values chosen depending on situations). Using these results, the IEM can identify exposure media that do not need any particular attention, and media in need of actions that may be simple or lead to a Remediation Plan (Plan de Gestion - PG).



Source: Ministry of the Environment (2017)

Figure 10 Assessment of the state of media quality approach

The administrative organizations, which are responsible for the contaminated soil and water management in France are as follows:

- Ministry of Environment, at a central (national) level, which is responsible for the collaboration with the different stakeholders and to provide general policies and methodologies for pollution elimination and industrial Installations classifications;
- Prefecture, at local level, which make the decisions and ensure law enforcement.
- DREAL (Direction Régionale de l'Environnement, de l'Aménagement et du Logement), at regional level;
- Municipalities, which are involved via the management of land uses status.
- ADEME, which is responsible for the orphan sites.

Also, the French BRGM (French Geological Survey)[93] is a public organization specialized in geology and hydrogeology providing technical guidance on the contaminated land methodology and guidance. The BRGM provides advice and technical guidance for

[93] https://www.georisques.gouv.fr/

contaminated site management to all stakeholders (i.e., site inventory, remediation technology, groundwater management, management of excavated sites, soil information system etc). Moreover, the BRGM provides a public GIS data base compiling documents linked with contaminated sites management[94].

In France, two public databases identify potentially contaminated and known contaminated sites:

- BASOL, is a list of sites on which an action has already been taken (either confirmed clean, under treatment, or already treated) and
- BASIAS, which lists former or current, industrial or services sites with a potentially polluting activity.

In 2014, the ALUR legislation introduced a new tool of historic pollutions' register, enforcing the creation of a soil database in different geographical sectors, the Soil Information System (SIS)[95] by the Ministry of Ecology and Sustainable Development.

Regarding the professionals, after 2011 the procedure of certification issuance is divided in four domains:

- Domain A: Including studies, assistance and control (parts 1 and 2 of standard NFX 31-620)
- Domain B: Including engineering of remediation actions (parts 1 and 3 of standard NFX 31-620)
- Domain C: Including execution of remediation works (parts 1 and 4 of standard NFX 31-620)
- Domain D: Including the establishment of the certificates, for soil and groundwater pollution management measures, in the design of development projects (parts 1 and 5 of standard NFX 31-620 - cf. article 2 of the ministerial decree of 19/12/18)

Although, there is no obligation for companies or operators and owners of the sites to hold the certification for the first 3 domains. In addition, since 19 December of 2018 the above procedure become legally mandatory according to the Domain D to establish the certificates, created by the ALUR law (for Access to Housing and Renovated Urban Planning).

6.4.3 Land use categorization

The French national policy for contaminated land is based on the approach of human health and environmental risk management, considering land uses. The sites which are included on this principle are all historic, active and potentially future contaminated sites. Moreover, in

[94] http://ssp-infoterre.brgm.fr/
[95] https://www.georisques.gouv.fr/articles-risques/secteurs-information-sols

France, the brownfields are not included in the contaminated sites framework (they are managed by a specific agency, ADEME).

6.4.4 Screening values

6.4.4.1 Soil screening values

In France, there is no soil screening values system and screening values used are typically derived on site-specific conditions and be validated by the corresponding authorities. Because of that there is no involvement of the land-use types in the derivation of the screening values. and the procedure is a case-by-case approach. The criteria used are always defined based on site-specific toxicological data of current and future land uses. This is typically approved by the DREAL.

6.4.4.2 Groundwater screening values

Unlike soil, and as in most EU countries, derived from the EU directives, there are groundwater screening values in France by the following ministerial orders:

- AM 11/01/2007: drinking water and raw water standards
- AM 17/12/2008: objectives for groundwater quality

Leachate tests is a method used in France, only in case the soil can be disposed of in inert landfills or, in some exceptions for reuse on site and it is related mainly to the waste legislation.

6.4.5 Sampling and analytical protocols

The sampling procedure for the soil and groundwater is based on the national framework. There are sampling guidelines for soil[96], water[97], soil gas and indoor air[98]. The sampling is a procedure based on site-specific approach.

6.4.6 Risk Assessment

The human health risk assessment is based on the toxicological and environmental data by the National Institute for the Environmental and Industrial Risk (INERIS)[99]. The three main stages of a human health risk assessment according to the French methodology are:

- Identification of the source of soil contamination

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[96] http://ssp-infoterre.brgm.fr/analyse-sols-en-contexte-ssp
[97] http://ssp-infoterre.brgm.fr/analyse-eaux-en-contexte-ssp
[98] http://ssp-infoterre.brgm.fr/guide-pratique-caracterisation-gaz-du-sol-et-air-interieur
[99] https://www.ineris.fr/fr

- Estimation of soil concentration, in which local human population is exposed
- Verification that the remediation aims have been reached

The residual risk assessment is a tool, which is conducted when the Management Plan results does not allow any possible contact between the contaminated site and the receptor (in this case humans)[100]. The residual risk assessment is a quantitative tool of health risks assessment procedure carried out taking into account the plan's management measures and the proposed scenarios for future land use of the site. In case variations arise in the management measures, which can dispute the acceptability of the risks, a new Risk Assessment must be conducted. There are different values in an acceptable risk level, for carcinogenic and non-carcinogenic end-points. For substances with no threshold effect the risk level is the excess of 10^{-5}, while for substances with threshold effect the risk level is the excess of danger of 1[101]. The risk levels are calculated by adding all calculated risk levels taking into account all the possible exposure routes and the contaminants involved, according to the recommendations of the health authorities.

6.4.7 Remediation and monitoring protocols

The Remediation Plan (Plan de Gestion—PG) can be implemented for different situations for which it is still possible to take an action on the environmental media and/or to make changes to land uses (e.g., cessation of activity for a site under Regulation for facilities classified for environmental protection (ICPE), rehabilitation of former industrial sites).

As a guiding document, it aims to establish different scenarios for remediation. An analysis of residual risk (Analyse des Risques Résiduels — ARR) is carried out for the scenarios that do not lead to a total elimination of the sources of pollution. In this context, the methodology provides new tools that allow to:

- Have a better delimitation of the sources of pollution and hot spots using cartographical interpretation and mass balance calculations;
- Define remedial targets, considering the pollutant and the media characteristics, the media quality objectives, and the incapacity for the soils to release pollutants, that could result in a significant degradation of the groundwater quality;
- Have well-founded cost benefit analysis (Bilan «coûts-avantages») using criteria that are objective, clear, and well-argued;
- Develop well-argued financial demonstrations for each of the possible solutions (iterative process: remediating whole or part of the pollution);

[100] http://ssp-infoterre.brgm.fr/sites/default/files/upload/documents/arr.pdf
[101] http://ssp-infoterre.brgm.fr/lanalyse-risques-residuels

The Remediation Plan should present all of these results, as well as the monitoring and control program to be put in place in order to ensure the efficiency of the remediation measures during the remediation works.

This is the last step of the methodology. It comprises of two stages:

- developing the remediation design plan and
- the follow-up of their implementation

The remediation design plan is built to secure the remediation projects. It makes a link between the previous study stage and the specifications of the clean-up effort. Feasibility and treatability tests in the laboratory or onsite can also be used to strengthen the selected remediation scenarios.

After the design stage, comes the implementation stage, where the remediation engineering works includes the follow-up of the clean-up effort until the reception stage (réception des travaux). These controls ensure that the implemented remedial measures are carried out as expected. They are recorded in the construction record (dossier de récolement) as well as the work completion report and the clean-up effort validation.

Cost – benefit analysis

The cost-benefit analysis (CBA) is an approach which is considered for the choice of remedial solution in France. The point at which this concept is introduced is when the risk management policy recommends the use of Best Available Practices in a cost-efficient way (BATNEEC). After the new regulation of 2007, the CBA focuses on the way to reach the high level of public health and environmental protection together with an efficient cost approach.

Finally, in case that the remediation targets are not achieved there are three different scenarios: a) another remediation technique may be implemented, b) the land use must be changed, and additional construction requirement shall be proposed in order to mitigate residual risks (i.e., use of liners to prevent vapor intrusion or enhanced ventilation) and c) the restrictions of the land use must be defined. The remediation management shall be controlled by an independent service provider (independent from the remediation work company). Moreover, the technical guidelines help choosing the good remediation technique[102].

6.4.8 Liability

In France, the ICPE legislation (the French site classification system for environmental protection) classifies installations in industrial or agricultural areas in order to protect the health and safety of people living nearby (site workers are protected via other regulation). For contaminated sites where no ICPE had been operated, the waste producer or the waste holder who caused or contributed to the contamination is responsible for clean-up measures.

[102] http://ssp-infoterre.brgm.fr/quelles-techniques-quels-traitements

The owner of the contaminated land is responsible for the remediation. ICPE operators are liable for investigations and clean-up actions at the closure of the operation. Besides, everyone is liable to article L511-1, which lists the different types of target which must not be damaged by anyone.

The liable parties are the owner and/or occupier and the previous owner and/or occupier. On the ICPE regime, the basic rule is 'the last site operator is liable'. The occupier is liable in case that he was the last operator of an ICPE on the site or he was the waste producer or holder who contributed to the pollution. The corresponding authorities recall the owner only if he participates in the contamination or if the site operator does not exist.

A voluntary clean-up procedure, under the ICPE regime, allows previous owners and/or operators to be replaced by third parties in relation with the performing remediation measures.

In 2018 the procedure of soil certification, which is an important driver on the French remediation market, became legally mandatory (ALUR law). The State develops the Sectors of Information on Soils (SIS), these sectors include areas where data of soil pollution exists especially in case of a land-use change, carrying out soil pollution management measures to preserve health or public health and the environmental protection. If the examined area or site is located on a sector of SIS, the ALUR law introduces the obligation of a certificate for all construction or development actions on a former contaminated site.

In order to liability ends a report is required at the end of the clean-up actions with site characterization to assess that remediation targets have been achieved. This report is done by an independent service company (Quiot et al. 2020). Moreover, it is regulated that after the end of clean-up actions there are specific technical requirements to fulfill, especially for groundwater monitoring[103].

Land transfer

If the site is an industrial site (ICPE classification), the transfer is managed under the ICPE legal framework. As regulated in the 1977 Decree, the sale is covered by a specific site prefectural order ("Arrêté préfectoral") specifying all remedial requirements, including:

- Elimination of all hazardous substances, including existing wastes, if the site is not a classified waste storage installation
- Access limitation to the site
- Suppression of risks linked to explosions actions
- Emissions to the air, water, environment in general

[103] http://ssp-infoterre.brgm.fr/sites/default/files/upload/documents/guide_arret-evol-eso-2020-12_vf.pdf

- Monitoring of the effects of the industrial activities
- Management Plan

If there is a proven risk to the environment, the pertinent Prefecture may order an investigation. If there is a suspected risk (existing or future land use), the Prefecture may request the application of clean-up actions. If the site is not classified as an ICPE the investigation is not compulsory but strongly recommended in case that a suspicion of pollution is known.

The ALUR Law introduces the “third party procedure” by which the responsibility for the remediation of a site, on which a Classified Installation activity has been operated, transfer to a third party. Once the third party asks the local authorities to replace the operator, with a specific agreement, after then he becomes fully responsible to carry out the remediation work. The Land Planning Code for civil liability of the owner and/or the purchaser and territorial authority can be called upon in this type of transaction. The seller of land on which a Classified Installation subject to authorization has been operated must inform the purchaser of that characteristic and of any known risk to the environment but the buyer must verify if it is sufficient.

6.5 United Kingdom

6.5.1 Introduction

United Kingdom (UK) is an island sovereign country at the Northwest of Europe. Its population is approx. 67 million, 83.4% of which leaves in urban areas and the rest 16.6% in rural areas. UK includes England, Wales, Scotland and Northern Ireland and covers an area of 242.500 km^2 [104]. Each of the above countries has its own devolved government through the aim of decentralization of power[105]. UK is characterized by a diversity in its landscapes and geology, mainly because of the nature and the types of the underlying rocks[106]. UK choose, through a referendum on 2016, the withdrawal from the EU, the Single Market and the Customs Union. This choice entails many barriers to trade and financial activity largely after 1 January 2021[107].

[104] https://www.britannica.com/place/United-Kingdom
[105] https://www.gov.uk/guidance/devolution-of-powers-to-scotland-wales-and-northern-ireland#devolved-administrations
[106] https://www.britannica.com/place/United-Kingdom
[107] https://ec.europa.eu/info/relations-united-kingdom/overview/consequences-public-administrations-businesses-and-citizens-eu_en.

The groundwater is a source of drinking water in the country and supports the rivers, wetlands and the plants and wildlife that exist in and around them. The principal aquifers of the UK are found mainly in the lowlands of England[108]. In areas with good quality of aquifers, such as much of South East England, most drinking water comes from groundwater, but, in areas like Scotland and Northern Ireland the aquifers have limited usage for drinking water. The main factors for groundwater pollution in UK are farming, landfills leachate, oil and petrol underground storage tanks and the mining activity[109].

There are many different types of protected areas in UK, which are categorized in National Parks and Areas of Outstanding Natural Beauty, Marine Conservation Zones, Sites of Special Scientific Interest, Special Areas of Conservation, Special Protection Areas and Ramsar wetland sites[110].

The UK is a world leader in the regeneration and management of industrial land. As the first industrialised country in the world, it has over 400.000 hectares (or 4.000 km2) of contaminated land, as a result of the Industrial revolution. Stimulated by economic drivers, world-class regulation and a determination to regenerate the physical business environment, the UK has made the clean-up of this land a key priority. Moreover, based on the National Planning Policy Framework (Communities and Local Government 2018) planning policies and decisions should encourage the effective use of land by reusing land that has been previously developed (brownfield land), provided that it is not of high environmental value. Figure 11 shows the different land uses in the United Kingdom.

In the text below, information regarding contaminated soil management in England and Wales are mainly discussed.

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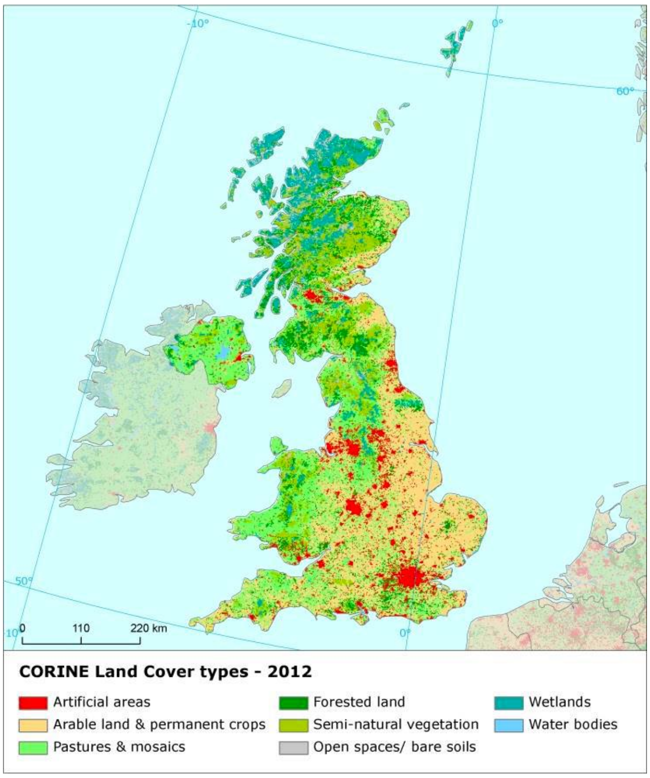
108 http://www.groundwateruk.org/downloads/the_aquifers_of_the_uk.pdf

109 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/692989/Envirnment-Agency-approach-to-groundwater-protection.pdf

110 https://www.gov.uk/check-your-business-protected-area



Sources: European Commission (2017e)

Figure 11 Land uses in UK

6.5.2 Legislation, Administration & Professionals

In the UK legislation the term "land" is used instead of "soil" and the term "contaminated land" is used for land on which significant harm is being caused or there is a possibility of harm being caused to the human beings or the environment (Part IIA[111]).

The legislation for contaminated "land" in UK has established in 1990 with the Environmental Protection Act 1990 (Crown Copyright, 2000). The Environmental Damage (Prevention and Remediation) Regulations in 2005 for England and 2009 for Wales[112] are overlapped with the Act of 1990. The amendments through Section 57 of the Environment Act 1995, provide a legal framework for dealing with non-radioactive contaminated land in England[113]. The latest revision was published in 2012. The intention of Part IIA (Part IIA, Environmental Protection

[111] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/223705/pb13735cont-land-guidance.pdf
[112] https://uk.practicallaw.thomsonreuters.com/Document/Id4af1a371cb511e38578f7ccc38dcbee/View/FullText.html?transitionType=SearchItem&contextData=(sc.Search)&firstPage=true#co_anchor_a991116
[113] https://www.legislation.gov.uk/ukpga/1995/25/section/57

Act 1990) is to deal with contaminated land issues that are considered to cause significant harm on land that is not undergoing development in England and Wales.

Contaminated land is often dealt with through planning because of land redevelopment. The National Planning Policy Framework (NPPF), February 2019, forms the new framework which includes limited guidance on contaminated land, mainly in the aspects of a) making effective use of land, b) conserving and enhancing the natural environment, c) ground conditions and pollution.

The Water Resources Act 1991 (Amendment) (England and Wales) Regulations 2009 updated the Water Resources Act 1991, which introduced the offence of causing or knowingly permitting pollution of controlled waters.

The Water Framework Directive (2000/60/EC) (WFD) and the Priority Substances Directive (2013/39/EC) (PSD) work together to ensure progressive reduction of groundwater and surface water pollution and set out a priority list of substances posing a threat to or via the aquatic environment.

The Environmental Permitting (England and Wales) Regulations 2016 provide a single regulatory framework that integrates waste management licensing, pollution prevention and control, groundwater authorisations, and radioactive substances regulation etc.

The Environmental Agency and the Department of Environment, Food and Rural Affairs (DEFRA) have developed the risk assessment procedure for human health and ecosystems (Carlon 2007). Finally, the British Geological Survey assists the procedure providing data and maps[114].

In regulation level, the ED Regulations (Environmental Damage Regulations) connect to prevention and remediation of environmental damage (damage of species, population, surface and groundwater water and land). These regulations apply to the most serious cases of the environmental damage. Moreover, the Local Authority (Regional body) and the Environment Agency (EA) are responsible to act as a technical input. On special sites of high potential impact, or sites where remediation implementation is necessary to protect controlled waters, the Environment Agency take the lead as the main regulator.

As far as contaminated site characterization is concerned, risk is assessed by reference to the current land use. If only the present contamination on a site is occurred that does not mean

[114] http://mapapps2.bgs.ac.uk/ukso/home.html

that it is contaminated land. Moreover, land characterized as contaminated if the contaminants which are present on the site are causing or are likely to cause any water pollution or there is a possibility of other media pollution.

In the UK there are numerous optional professional accreditations (such as Specialist in Land Condition, Suitably Qualified Persons, Chartered Scientist, Chartered Environmentalist etc.).

Digital tools

A basic digital tool for quantitative human health risk assessment is the CLEA model[115]. CLEA is used to derive soil guideline values taking generic assumptions about fate and transport of the chemicals in the environment and this output is used to the conceptual site model in order to estimate the exposure of the children and adults to contaminated soil. Other tools are the RISC-HUMAN, the RBCA toolkit for chemical releases and the ConSim[116] for groundwater assessment. For groundwater monitoring data the GWSDAT is used[117].

New vs. Historical

England has a legacy of historical land contamination including a wide range of chemical substances. The historical contamination is managed by the Part IIA regulatory regime. The new or existing contamination is managed and regulated separately by the Environmental Permitting Regulations and the Environmental Damage Regulations. In the sites that the remediation of historical contamination is dealt, it is not always possible for the operator to get sign off from and he have to get a letter of acknowledgement. Specifically, for industrial sites the new or existing contamination needs to be dealt with through the regulatory permitting approval process. The owner or operator must demonstrate that all pollution risk has been removed and also that the site is being returned in the same condition as it was before the operations. Moreover, the principle of causing «no deterioration» often applies to new contamination sites via accidental events. The pollution prevention measures are expected to be adopted by the operators to occur mainly the new land contamination. The Environment Agency expects the operators and landlords to act responsibly for cleaning up historic land contamination as well in accordance with the corresponding guidance[118].

6.5.3 Land use categorization

The land uses regulated for the purposes of the CSMP are as follows:

- Residential (with homegrown produce)

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[115] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/455747/LIT_10167.pdf
[116] http://www.consim.co.uk/
[117] https://www.claire.co.uk/projects-and-initiatives/gwsdat?showall=
[118] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/692989/Envirnment-Agency-approach-to-groundwater-protection.pdf

- Residential (without homegrown produce)
- Public Open Space - Park
- Public Open Space - Residential
- Allotments (Public gardens)
- Commercial
- Playgrounds
- Industrial
- Protected areas

6.5.4 Screening values

There are background levels of substances including these that naturally occur as a result of the complex geology and substances resulting from diffuse anthropogenic pollution. In some cases, there background levels are linked with industrial use and waste disposal.

6.5.4.1 Soil screening values

The SAC (Soil Assessment Criteria) used in a risk assessment should be screening criteria that represent a low or minimal level of risk to human health, for the intended land use, and that is indicative of suitability for use. An exceedance of a SAC means that there may be an unacceptable risk to human health and should trigger further assessment or remedial action. There are a variety of soil assessment criteria published by different organisations and private consultancies, using primarily the CLEA Model.

Different SAC's have been published as outlined below depending on number of substances listed, associated land end uses, set of exposure parameters and the indication of the chemical contamination in soil below which the long-term human health risks are considered tolerable, minimal or low:

- Soil Guideline Values (Environment Agency, 2002-2010) – SGV
- Generic Assessment Criteria (LQM/CIEH, 2009) – GAC
- Generic Assessment Criteria (CL:AIRE, 2010) – GAC
- Category 4 Screening Level (Defra 2014) – C4SL
- Suitable for Use Level (LQM/CIEH, 2015) – S4UL

The soil guideline values (SGVs) in UK are derived using the framework guidance (Environment Agency, 2009a and Environment Agency, 2009b).

SGVs are guidelines on the level of long-term human exposure to average levels of chemical substances in soil and mainly used for the examination of the low-risk areas. SGVs are available only for a specific number of chemical substances. Analysing the process of derivation, the CLEA software estimates the exposure to chemicals from soil sources affecting human receptors (adults and children living or working on the contaminated site). These estimated concentrations are compared in order to establish the Health Criteria Values (HCVs). The derivation of Health-Based Guidance Values (HBGV) is an important tool in order to define the estimated dose in humans (for negligible risk) over the lifetime. The HBGVs include a tolerable daily intake (TDI) used for environmental contaminants. In the same direction, the HCVs has been used to represent a health protection baseline in order to minimise the risk of significant harm for the population exposed. They do not represent thresholds above which an intake would be unacceptable. The HCVs differ according to whether they relate to adverse effects that are expected to demonstrate a threshold TDI or effects for which no threshold is assumed Index Dose (ID) (Jeffries and Martin, 2009).

The basic principle used to establish SGVs is that they are set at the soil concentration where the Average Daily Exposure (ADE) from soil sources by a particular exposure route equals the HCV for that route (Jeffries and Martin, 2009). However, for many substances, exposure by all routes may contribute to the same systemic toxic effect. Finally, the soil guidelines cannot be used to assess risks for waters or ecological receptors' control, and they are not considering as remediation standards. In addition, the SGVs cannot be used for every type of site and does not cover the case of potential acute risk of contamination affecting public health.

Furthermore, there is no statutory requirement to use them. Alternative technical guidance or assessment criteria produced by other organisations can be used provided they meet the requirements of the legislation. For instance, under Part IIA of the Environmental Protection Act 1990, the requirements of the statutory guidance should be met. In the context of Part IIA, and if applied appropriately, SGVs can be used to identify sites where there is unlikely to be a possibility of significant harm (Defra, 2008b):

- Representative site soil concentrations at or below the SGV indicate that it is unlikely that a significant possibility of significant harm exists.
- Representative site soil concentrations above the SGV might represent a significant possibility of significant harm. Further investigation and/or more detailed evaluation of human health risks will usually need to be conducted[119].

In case of significant harm, a new classification system assists the assessment of risk to human health from exposure to contaminated land in UK. DEFRA introduced the new system of four categories classifying the land under Part IIA of the Environmental Protection Act for cases of significant harm to public health. Land is determined as contaminated under Part IIA if it is included to categories 1 or 2. While category 4 includes land where the level of risk posed is acceptably low. DEFRA is authorized to create a methodology to assess and classify the land

[119] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/297676/scho0309bpqm-e-e.pdf

within these four categories, including the derivation of category 4 screening levels (C4SLs) and recommend values for six chemical substances (arsenic, benzene, benzo(a)pyrene, cadmium, chromium (VI) and lead). These values were derived for four land uses: residential, commercial, allotments and public (open) space. The SGVs and GAC are derived at a risk that is considered to be minimal. Therefore, C4SLs describe a higher level of risk than do SGVs and GAC. C4SLs are intended not only for use in the Part IIA system but also as generic screening criteria for land development planning within a generic quantitative risk assessment (GQRA)[120]. For CLEA model parameters selection a more specific approach was adopted to derive the C4SLs compared to the derivation of SGVs. The approach included modification of the toxicology data and the exposure parameters used in this model.

Separate protocols are defined for dealing with waste. The use of waste soil characterisation assessment tools and waste acceptance criteria (WAC) both form a legal requirement to correctly assess and classify waste. Under the Waste Framework Directive, materials are only considered waste if 'they are discarded, intended to be discarded or required to be discarded, by the holder'. Naturally occurring soils or soils such as made ground are not considered waste if reused on the site of origin for the purposes of development.

6.5.4.2 Groundwater screening values

The Environmental Agency uses the source protection zones (SPZs), Drinking Water Protected Areas (DrWPAa) and aquifers designation (Principal aquifer, Secondary A aquifer, Secondary B aquifer, Secondary undifferentiated aquifer, Unproductive strata), as a designation of risk, for a risk-based approach to regulate the prevention and limitation of the groundwater pollution. A three – fold classification of source protection zones (SPZ) surround abstractions for public water supply is generally adopted. The Site is situated in an area defined as follows:

- Zone 1 or the 'inner protection zone' is located immediately adjacent to the groundwater source and is based on a 50-day travel time from any point below the water table to the source. It is designed to protect against the effects of human activity and biological/chemical contaminants that may have an immediate effect on the source

- Zone 2 or the 'outer protection zone' is defined by a 400-day travel time from a point below the water table to the source. The travel time is designed to provide delay and attenuation of slowly degrading pollutants

- Zone 3 or the 'total catchment' is the area around the source within which all groundwater recharge is presumed to be discharged at the source.

[120] https://www.envchemgroup.com/human-health-exposure-from-contaminated-land-a-defra-report.html#:~:text=Category%204%20Screening%20levels%20describe,than%20do%20SGVs%20and%20GAC

Generic groundwater values are taken from the Water Framework Directive (2000/60/EC), drinking water standards, groundwater directive (2006/118/EC) etc.

These can then be further progressed to a controlled waters risk assessment. The leachate screening values can be assessed directly against generic groundwater screening criteria but, this often leads to exceedances. The next stage from this is the usage of simple models and calculations. In addition, the leachate data is assessed in accordance with standards considered applicable for protection of controlled waters and also in comparison with waste criteria if considering potential routes for disposal or treatment. As for the measurable free phase it is required to be removed.

Main contaminant linkages for controlled waters are:

- leaching of soil contaminants to groundwater (comparison of leachate data to the relevant GAC identified, depending on if the substance is a hazardous substance / non-hazardous pollutant (GWDD) (2006/118/EC) and the receptors identified in the CSM)
- lateral migration of dissolved phase contaminants to wider principal/secondary aquifer (comparison of groundwater data to relevant GAC based on UK Drinking Water Standards). If a principal aquifer is present, the DWS should be used as there is the potential for abstraction. If a secondary aquifer is present consideration should be given to the CSM and the known uses of that aquifer and the associated receptor(s)
- lateral migration of dissolved phase contaminants to surface waters (comparison of groundwater data to relevant GAC based on freshwater or transitional Environmental Quality Standard (EQS)
- vertical and lateral migration of NAPL and dissolution into groundwater

For the assessment process the following steps are taken:

- Soil - direct comparison of soil leachate data with appropriate GAC (Level 1 soil assessment)
- Groundwater or surface water samples - direct comparison of groundwater concentrations with appropriate GAC (Level 2 groundwater assessment)

In many cases, the exceedance in GAC’s is due to wrong GAC’s being used. If that is not the case, either DQRA may be required or there is a need to re-assess the conceptual site model (CSM).

6.5.4.3 Soil gas risk assessment

The risks from soil gases have been assessed in accordance with *BS8485:2015+A1:2019 (BS8485)*, which is a code of practice providing guidance on soil gas (methane and carbon dioxide) characterisation and hazard assessment, as well as providing a framework for the prescription of protection measures within new buildings. The process involves characterising the gas hazard from combining the qualitative assessment of risk with ground investigation data so that a ‘‘characteristic situation’’ (CS) can be derived for the site or zones within the site. Gas protection measures within new buildings can be prescribed using a point scoring system, taking into consideration the CS and the proposed building type.

6.5.5 Remediation and monitoring protocols

Contamination on a site can be identified with the following ways:

- The site owners or polluters who's responsible for the contamination can voluntarily deal with the existing land contamination. This is a way to ensure that the polluter pays for remediation.
- Using the planning system for the existing contamination by contaminated sites under development (Town and Country Planning Act, 1990). This is a very cost-effective way to manage contamination as those who will benefit from the development pay for the remediation as well.
- Using regulation Part IIA of the Environmental Protection Act (1990).

In England almost 90% of the contaminated sites have been managed by the planning system and only 10% use the regulation Part IIA way of management121. The sites to be remediated are divided in two types: a) the contaminated sites (CS) and b) the special sites (SS) (e.g., land that is contaminated by radioactivity, land that is owned or occupied by the Ministry of Defence, oil refineries, industrial developments manufacturing explosives etc.) (Environmental Agency, 2019). Remediation of a contaminated site can be achieved by:

- Removing or reducing the source of contamination
- Blocking the pathway link between the contamination and the receptor
- Reducing exposure to the contamination
- Removing the receptor altogether

In England and Wales, the remediation actions, under Part IIA, does not necessarily include the source of contamination has to be removed (i.e., in case of an old landfill covering)[122].

6.5.5.1 Inspections

In England and Wales, the local authorities are responsible for the inspection strategies. Part IIA refers that local authorities are responsible to inspect the land, which is in their possession, in order to identify contaminated land according to the Guidance. In Section 78B (1) it is

[121]https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/313964/geho0109bpha-e-e.pdf
[122]https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/313964/geho0109bpha-e-e.pdf

referred that “Every local authority shall cause its area to be inspected from time to time for the purpose: a) of identifying contaminated land and b) of enabling the authority to decide whether any such land is land which is required to be designated as a special site.” (Environmental Agency, 2009). This Guidance categorizes the inspections in two types[123]:

- The strategic inspections: Gathering data and the local authority identifies the priority land for detailed study. The strategic approaches may vary between local authorities. According to best practices it should aim to review the strategy at least every five years.
- The detailed inspections: Specific ground data collection (soil characteristics and functions) and the local authority carries out a risk assessment for giving priority to particular areas that pose the greatest risk to public health and/or the environment.

6.5.5.2 Testing and monitoring

The chemical testing of soil can be undertaken for a wide range of parameters using a variety of methods. The methods that a laboratory uses to generate data that are submitted to the Environment Agency for regulatory purposes are based on EN ISO/IEC 17025. These standards are applicable to all laboratories where results for the chemical testing of soil are submitted to the Environment Agency for regulatory purposes. When a laboratory satisfies all of the appropriate criteria of this standard procedure it will be regarded by the Environment Agency. In the UK the laboratories are certified by the United Kingdom Accreditation Service (UKAS) which is the UK's National Accreditation Body which is responsible for determining the technical jurisdiction of organisations such as those offering testing and certification services[124].

The analysis of the samples will be use either for all of the sample or on a representative or homogenised sub-sample. The shallow soil sampling is performed for assessing human health risk. Typically, samples taken within the top 1.2 m below ground level (e.g., 0.3, 0.7, 1.2 m bgl), though this does depend on encountering made ground and natural horizons. This approach ensures an appropriate characterization of the shallow soil zone.

In order to verify if the remediation objectives have been met, the lines of evidence approach are used. For soil and water testing these lines are:

- The soil sample tests (defined locations, time intervals, volume of soil excavated, moved or treated)
- The parameters such as pH, dissolved oxygen, flow rates
- The testing of water quality in nearby groundwater bodies

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[123] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/223705/pb13735cont-land-guidance.pdf
[124] https://www.ukas.com/

For contaminants:

- The measurements of rates of reaction, product breakdown, degradation measurements
- The measurement of the contaminants' quantities or the contaminated media removed
- The monitoring plan for the contaminant concentrations and geochemical properties in groundwater to show the effectiveness of treatments or natural attenuation

For soil gases and vapours:

- The verification of gas and vapour protection measures
- The visual inspection of gas resistant membranes for evidence of tears (Usually immediately after installation, gas membranes need to be checked and validated from an engineer prior to them being covered up by the ensuing construction processes to make sure that they don't have any faults)

The lines of evidence can be used along with a conceptual site model to address any uncertainties associated with the remediation activities[125].

6.5.6 Risk Assessment

The updated procedure used is the Land Contamination Risk Management (LCRM), which is divided into three stages[126]:

1. The preliminary risk assessment: In which the evaluation of the initial conceptual site model is to identify any potentially unacceptable risk.
2. The generic quantitative risk assessment: In which the core is the estimation of the risk through the generic assessment criteria.
    a. BS 10175: Investigation of potentially contaminated sites – code of practice
    b. BS 5930: Code of practice for ground investigations
    c. BS 8576: Guidance on investigations for ground gas – permanent gases and volatile organic compounds

[125] https://www.claire.co.uk/useful-government-legislation-and-guidance-by-country/189-implementation-verification-and-monitoring-info-imp2
[126] https://www.claire.co.uk/useful-government-legislation-and-guidance-by-country/183-risk-assessment-preliminary-info-ra1

3. The detailed risk assessment: In which the core is the estimation of the risk using site-specific data.

The technical approach of the risk assessment is structured based on the evaluation criteria for all the Tiers. These criteria include the human health toxicological assessment of contaminated soil for TDI, the site-specific assessment derived using the remedial targets methodology (RTM), the environmental quality standards (EQSs), the ecosystem end-points, which take into account the ecological quality of a site and the Drinking Water Standards.

The Tier 1 has a specific guidance[127] and some extra practices (for investigation of potentially contaminated sites, investigations of soil gas etc.), which based on the baselines of the Tier 1. For Tier 2 the generic assessment criteria includes the SGVs values' system, the C4SLs and the Society of Brownfields Risk Assessment (SoBRA). This report focuses only on the human health[128] and ecosystem[129] risk assessment for brevity reasons. In Tier 3 the important factors are the type of receptors, the complexity of the site (i.e., the contaminants mixtures) and the condition for contaminants to being assessed. The guidance is the same with the Tier 2.

On second stage the decision has been made to remediate and are three steps to follow: a) the identification of feasibility of the remediation options b) the assessment of detailed evaluation of remediation options and c) the selection of the final remediation option. The responsible party needs to produce an appraisal report by National Quality Mark Scheme (NQMS), which is a voluntary scheme set up by the National Brownfield Forum and administered by CL: AIRE.

Through that scheme, land contamination reports are quality checked and verified by a Suitably Qualified Person (SQP) who is an experienced professional in the field of land contamination[130].

Finally, in stage 3, which is the stage of remediation and verification, the competent person has to follow a four steps procedure:

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[127] https://www.claire.co.uk/useful-government-legislation-and-guidance-by-country/183-risk-assessment-preliminary-info-ra1

[128] https://www.claire.co.uk/useful-government-legislation-and-guidance-by-country/209-assessing-risks-to-human-health-info-ra2-2

[129] https://www.claire.co.uk/useful-government-legislation-and-guidance-by-country/210-assessing-risks-to-ecosystems-info-ra2-5

[130] https://www.claire.co.uk/projects-and-initiatives/nqms/83-supporting-sqp-process/271-what-is-a-suitable-qualified-person

1) Develop a remediation strategy
2) Remediation actions
3) Create a verification report
4) Schedule a long-term monitoring plan

Each step has a number of criteria as described in LCRM, although, an important point of the remediation strategy is the monitoring timetable (frequency and duration). For sites that are regulated the monitoring certification scheme is required (MCERTS)[131].

6.5.6.1 Human Toxicological Assessment

The Risk assessment is the process of identifying and evaluating the risks to public health, ecosystems and water environments that may occur by the condition of a site. In UK the risk assessments are three main categories as divided in section 6.5.5.1. However, the generic and detailed risk assessment are further divided in[132]:

1) general including the data and tools;
2) human health risk assessment including the toxicological reports, SGVs, GACs, C4SLs, SR2&3 and CLEA data;
3) water environment using the ConSim data;
4) risk assessment associated with gases and vapours;
5) ecosystems risk assessment including SSVs and ERA framework; and
6) building and services risk assessment.

6.5.7 Liability

The Environmental Agency (EA) is responsible for specific areas and have to inspect them to identify any contaminated land. If the EA identifies any contamination event, the remediation notice issued requiring the responsible person to remediate the contamination. Under the ED Regulations, an operator must take all the steps to prevent environmental damage. If environmental damage has already occurred, then the operator must take all the needed steps to prevent further damage. If the regulator decides that environmental damage has occurred, it can serve the measures that must be taken. For the contaminated land, the remediation process requires the removal and control of contamination in order to reduce the level of the risk to a level below the unacceptable and to take reasonable measures to control and maintain pollution that has been caused. If a remediation plan is launched, the corresponding authorities can impose specific measures requiring immediate remediation before the development starts. This is the procedure of the most contaminated sites management cases in UK. The liability for the remediation of contaminated land is divided in

[131] https://www.claire.co.uk/information-centre/water-and-land-library-wall/41-water-and-land-library-wall/188-long-term-monitoring-and-maintenance-info-imp3
[132] https://www.claire.co.uk/information-centre/water-and-land-library-wall

two classes under the Part IIA. If it is taken by those who caused the contamination, then it is in Class A liability group. In order, for an individual, to qualify as a permitter has to:

- Be aware of the contamination event
- Have the ability to control and/or remove the contamination

The liability level is varied according to the person's position on the site.

- The owner or occupier liability: If neither of the above persons can be found, liability passes to the Class B liability group
- Previous owner or occupier liability: Previous owners or occupiers who caused contamination remain liable after the sale of the land. However, an owner/occupier who is not a polluter will no longer be liable when they finish the ownership or occupation of the site.

There are complex rules on the exclusion and allocation of liability. Exclusion of liability cannot be applied if the rules have no result to the members of the liability group. However, if the relevant parties agreed on distribution of liability between themselves (i.e., if the seller agrees to recompense the buyer for the contamination event) the regulator should accept that agreement. The regulation also predicts the voluntary clean-up programme. The Land Remediation Relief against Corporation Tax is available for a company that cleans up contaminated land occurred from third parties but only if the company was not responsible for the contamination.

In the ED Regulations only the responsible operator is liable. The operator is defined as the person whose activities caused the environmental damage. These regulations provide extra guidelines for the lender person. The lender of the site usually does not have any liability because he has not the ability to prevent the contamination. Although, the lender may have the liability under the contaminated land only if: a) he exercises commercial or contractual actions on the site caused extra pressure or b) is involved in activities causing the contamination. Nevertheless, if the lender takes possession of the property then it may also have liability to remediate as an owner of the site. Under the Part IIA regime, the Environmental Agency can carry out the remediation actions and retrieve the costs from the responsible party. In this case the EA can place a charge on the site, and it is possible that this charge will rank higher in priority than a lender's charge.

Practically, no official certificate is issued to certify the end of liability for a remediated site. The liable party is asked by the regulators to provide a sign-off letter that the remediation actions and obligations have been completed. In case that they refuse to provide it then they tend to be warned for further actions and penalties. For that, there is not an actual end of liability for the polluter but there are only safeguards that can be implemented.

Finally, in UK the principle of "caveat emptor" (buyer beware) is into force, which provides professional advice to the buyer or seller of a site, advising him for the tools should be used.

6.6 Germany

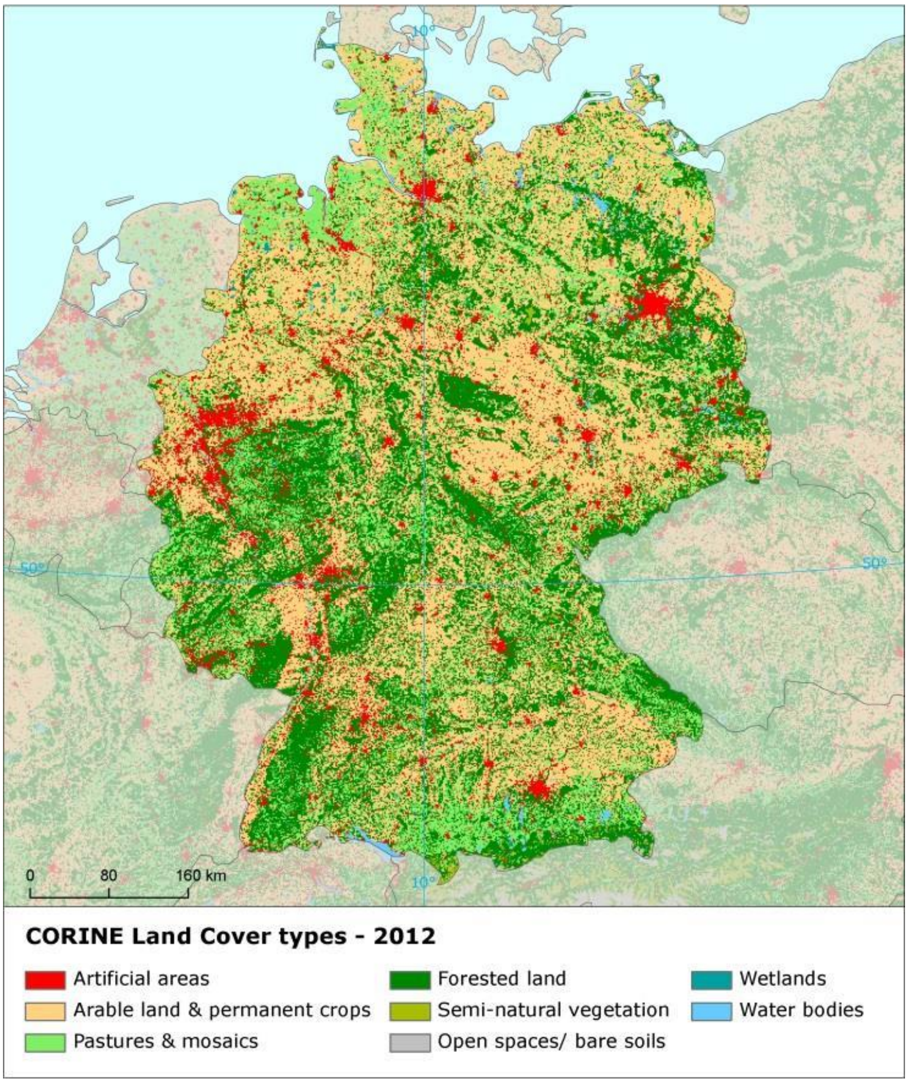
6.6.1 Introduction

Germany is a country of Central and Western Europe with a population of approx. 83 million [133]. The country lies between the Baltic Sea and the North Sea and the Alps to the south covering an area of 357.022 km^2. Germany consists of sixteen partly sovereign federal states, which are responsible for the internal security, universities, culture, municipal administration and they enforce not only their own laws, but also those of the federation (foreign affairs, defence etc.)[134]. Germany encompasses a wide variety of landscapes, such as the mountains in the south, the sandy areas in the north, the forested areas of the urbanized west and the agricultural east[135].

The types of the protected areas in Germany are defined according to the Germany's Federal Nature Conservation Act (BNatSchG). These are the nature conservation areas, the national parks, the biosphere reserves, the landscape protection areas, the nature parks and the Natura 2000 sites. Especially, there are 17 biosphere reserves, 16 national parks, 8.676 nature conservation areas and 4.557 Sites of Community Importance[136].

Concerning the groundwater resources and its quality the reduction since 1990 of the annual abstraction (including spring water) by public water suppliers is significant. Also significant is the variation of the groundwater abstractions of public and other water across the federal states. In some of them, as Hamburg, Bremen and Saarland, the whole public water supply depends on the groundwater and spring water and in some others is the highest percentage of the total public water supply. In contrast, in Saxony the corresponding percentage is 27% mainly because of the use of surface water volumes from reservoirs. The good quality of drinking water is a very important goal in Germany and for this reason the monitoring is strict. In conclusion, the enactment of the environmental law, the exclusion of contaminated sites and the determination of protected areas are the foundation of every further acts[137].

[133] https://data.worldbank.org/indicator/SP.POP.TOTL?locations=DE
[134] https://www.deutschland.de/en/topic/politics/federal-republic-of-germany
[135] https://www.britannica.com/place/Germany/Relief
[136] https://www.bfn.de/fileadmin/BfN/daten_fakten/Dokumente/accessible_Flyer_Data_BfN.pdf
[137] https://www.bgr.bund.de/EN/Themen/Wasser/Beschaffenheit/beschaffenheit_node_en.html



Sources: European Commission (2017f)

Figure 12 Land uses in Germany

6.6.2 Legislation, Administration & Professionals

The Federal Soil Protection Act in Germany came into force in 1998 (Federal Law Gazette I p. 502) and one year later, in 1999, the sublegal regulations by the Federal Soil Protection and Contaminated Sites Ordinance (BBodSchV). The contaminated groundwater is covered by the Federal and state water protection law. In Germany several public authorities are responsible for the enforcement of the framework, called soil protection agencies. The application of contaminated soil regime belongs to a local level.

In case of land's contamination evidence, the competent authority can order all potentially responsible parties to investigate the contaminated event. If the investigations identify levels of contamination above certain threshold values, then remediation measures and actions such as clean-up actions and monitoring plans can be ordered. The remediation standards that the soil protection agency can order depends on the sensitivity of the land.

The Act focuses on both protection and remediation pillars of the contaminated sites. More specific, it aims to:

- Maintain the functions of the soil
- Prevent soil against harmful changes
- Prevent any existing damage that affect public health
- Eliminate the soil damage

In order to reach the above goals, the Act defines some basic duties for everyone who act in a harmful way and the site owners (for both soil and groundwater pollution) (Carlon 2007). In the Act two terms are introduced, the "harmful changes of the soil" and the "contaminated soil". The contaminated sites referred to the abandoned waste disposal sites and the abandoned industrial sites (Art. 2 of BBodSchV, 1999). Abandoned waste disposal sites refer to those sites that had been under operation before enactment of the circular economy law Closed Substance Cycle Waste Management Act in 1994. The information of the public for the remediation actions is an essential point is German legislation.

6.6.3 Land use categorization

According to the Annex 2 of the BBodSchV 1999, the land uses are divided in four general categories. However, for each pathway (soil – human, soil – plant and soil – groundwater) the land types may vary. For the soil-human pathway the land uses are:

- The playgrounds
- The residential areas
- The parks and recreational facilities
- The plots of land used for industrial and commercial purposes

For the soil-plant pathway the considered land uses are the:

- Agriculture
- Vegetable gardens
- Grasslands

For soil-groundwater pathway the Act does not provide any specification on land uses.

6.6.4 Screening values

In Annex 2 of the BBodSchV of 1999 referred all the types of the screening values from the precautionary values for soil to the values for soil – human, soil – plant and soil – groundwater pathway.

6.6.4.1 Soil screening values

For soil assessment the derivation of screening values is based on a national level strategy. In general soil screening values are divided in three main categories:

- Trigger levels: values which, if exceeded, investigation with respect to the individual case in question is required, taking the relevant soil use into account, to determine whether a harmful soil change or site contamination exists.
- Action levels: values for impacts or pollution which, if exceeded, normally signal the presence of a harmful soil change or site contamination, taking the relevant soil use into account, and measures are required.

- Precaution levels: This is a level which indicates the assessment to identify and prevent future pollution problems.

The above categorization is further illustrated in Figure 13.

Source: INERIS (2013)

Figure 13 The contaminated soil management approach

These categories are customized according to the pathway and based on risk assessment approach (Carlon, 2007). As the soil - human pathways concerns, the action values (ng/kg dry matter, fine soil) are calculated for the direct intake of dioxins/furans at the corresponding land uses. The values vary according to the areas with values in playgrounds be stricter. The variation in trigger values for metals and organics (mg/kg dry matter, fine soil) is based on the land uses as well.

For the soil - groundwater pathway the trigger values (μg/L) are given for metals and organic compounds (Annex 2, BBodSchV 1999). These values refer to the transition area between the unsaturated zone and the water-saturated zone and this is considered as the place of assessment. If trigger values for leachate are likely to be exceeded at the point of assessment, the changes in contaminants concentrations in the leachate passing through the unsaturated soil zone must be taken into account (Annex 2, sect. 3.2b, BBodSchV 1999).

The precautionary values for metals (mg/kg dry matter, fine soil) and organics (mg/kg dry matter, fine soil), are referred as well. The derivation of precautionary values is varying according to the soil texture and pH as referred in the Pedological Mapping Guide (1996).

In the soil – plant pathway, the action and trigger values (mg/L dry soil, fine soil) are derived considering the plants quality and calculated only for metals in agricultural and vegetable garden lands. The trigger values vary between the metals, but the action value is considered only for Cd (0.04 mg/kg dry matter) (BBodSchV 1999). The action values for grassland are calculated separately. An exception is made for agricultural land where cultivated plans growth and the trigger values of arsenic, copper, nickel and zinc are stricter.

6.6.4.2 Groundwater screening values

Groundwater contamination is identified when the chemical status of the groundwater is changed according to the Groundwater Ordinance. According to this framework the measured concentration of the contaminants is compared with the regional background levels. If no ecotoxicological effects occur and if the demands of the Drinking Water Ordinance are met the result characterized as Insignificance Threshold[138]. The Groundwater Insignificance Threshold (mg/L) is based on toxicological and ecotoxicological standards and used to assess the groundwater quality (Carlon 2007).

The Act of 1999 for sampling procedure in groundwater refers that when trigger values are applied, the geogenic background of the groundwater is considered. If the contaminants' concentrations in the leachate can be measured directly, the soil samples have to be taken at the place of assessment for the groundwater (Annex 2, sect. 3.2d, BBodSchV 1999). If contaminated sites are located in the water-saturated zone they must be examined in accordance with the legal guidelines of Water Law to assess their risk for the groundwater.

6.6.5 Remediation and monitoring protocols

According to the legislation, the site investigation should be investigated step by step. Sites with low or no risks can be excluded from further investigation in favour of sites where acute hazards are identified and the remediation measures have to be taken (INERIS, 2013). There are four types of investigation:

- the historical
- the orienting
- the detailed
- the remediation

The historical investigation consists of gathering data concerning the technologies implemented, waste released through manufacturing processes etc. by the environmental authorities, local registers and interviewing population. At this stage there is no chemical or technical investigation. After that, the orientating investigation is started with measurements and soil samplings. At this stage the soil remediation standards are used in order to identify the situation and make the recommendations for the risk assessment. The detailed investigation identifies the contamination source, pathways of spreading, the protected receptors and sets the criteria for the choice of the treatment have to be used. The result is the proposed remedial plan and the remediation technologies for the specific site. Finally, the investigations for the suitability of the remediation techniques aim to examine and choose the most suitable remediation technique and the proper actions. At this stage there are three options of contamination's elimination: a) the decontamination actions, b) the securing measures and monitoring and c) the protection and restriction measures (INERIS, 2013).

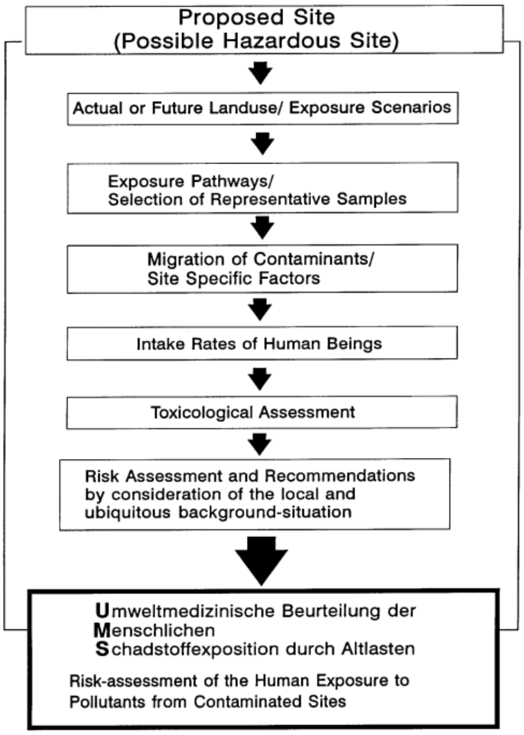
The Act of 1999 includes the remediation plan requirements (Annex 3, sect. 2, BBodSchV 1999). Firstly, a statement of the initial situation of the site is required providing information as local conditions, hazard situation, decisions taken by authorities and the results of the investigations. Furthermore, a long-listed factor for the description of the measurements,

[138] https://www.lawa.de/documents/gfs-report_1552302508.pdf

which have to be carried out, is included. The list includes the remediation plan (schedule, demolition work, earthwork, waste disposal, storage, safety measurements), the technical calculations (*in-situ* measurements), the amounts to be treated and the requirements of the official licences.

6.6.6 Risk Assessment

In Germany the main principle for the risk assessment of contaminated sites is the graduated examination strategy. It is a case-by-case approach based on land uses and exposure pathways (INERIS, 2013). The model which used for risk assessment is the UMS (Umwelt, Mensch, Schadstoff) (Figure 14).



Source: Stubenrauch et al. (1997)

Figure 14 The UMS risk assessment model in Germany

The UMS quantifies the existing or potential exposure relevant to human health based on physicochemical and toxicological data, site specific characteristics and population habits. All the parameters used are the land uses, the exposure routes and the exposed age groups. There are nine scenarios based on land uses which are: playground areas, public areas, parks and green areas, gardens, living buildings, industry, sport areas, business areas and wells. The exposure groups used for the calculations are five: the babies, the young children, the young adults and the older people (65+). The exposure routes are the oral (i.e., direct soil ingestion), inhalation, crop consumption and dermal. The model calculates the risk index which, in turn, is used to calculate the risk level. Three categories of risk level (RL) are determined in order to be decided about the remediation and monitoring action of the site. According to the results the three coloured categories vary between the green, the yellow and the red. Between the same risk level one more distinction is made between the balance with the background pollution (BER) >1.1 and <1.1. This model is not suitable for groundwater receptors (INERIS, 2013).

For the carcinogenic substances an additional cancer risk of 10^{-5} connected to a 70-year lifetime and is considered as tolerable dose. Moreover, it is assumed that the time for the uptake of soil is 8 years. The D_{tb} levels are referred to the no observed adverse effect level in sensitive population and calculated based on the LOAEL (lowest observed adverse effect level) from animal tests. According to that, the risk level is lying between the D_{tb} level (no risk) and the LOAEL (damage). The exposure routes are, for children, the soil ingestion and dust inhalation in the playgrounds and parks and for adults the soil and dust inhalation only in industrial areas. The Daily Intake Rates (DIR) are calculated based on these exposure routes. For each chemical compound a D_{tb} (ng/kg dry matter) value is calculated for oral and inhalative uptake (Carlon 2007).

6.6.7 Liability

The liable parties which are responsible to investigate and remediate the contamination are:

- The person or company that caused the residual contamination (polluter) even if he no longer occupies the land
- The polluter's legal successor
- The owner or any occupant or render even if they did not cause the contamination event
- Any former owner of the property (eternal liability), if he sold the property on or after 1 March 1999 or were aware of the residual contamination's presence when they sold the property.

If the above persons cannot be found then the shareholders and parent companies may be liable, in line with established corporate with the law. The liability is not ended but a liability relief for a party given by the authorities including a statutory claim for compensation. There are no governmental programmes providing motivations for a third-party to undertake the clean-up actions for redevelopment. However, there are many programmes (voluntary clean-up programmes) that support environmental protection redevelopment such as *chance.natur* which is supported by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) and is concerned aspects of the nature which are worthy of protection. Municipalities can apply as well for funds under the above scheme[139]. On the level of the federal states there are funding programmes for situations where the liability for land reclamation cannot be executed (i.e., Gesellschaft für Altlastensanierung in Bayern mbH).

[139] https://www.bmu.de/themen/natur-biologische-vielfalt-arten/naturschutz-biologische-vielfalt/foerderprogramme/chancenatur/

In case of land transfer, the buyer is potentially liable under the contaminated land regime as the property's owner. If there is any event of migration of contamination to nearby sites, then the buyer is also accountant to the owner of the land. The buyer is responsible to examine whether:

- The selling business has all the necessary environmental permits
- The permits are transferable
- The seller has complied with all the environmental laws

For the closure site activity, the site is dismissed from the register list by the corresponding authority and the use of specific target values is activated for any future use on the land.

6.7 Italy

6.7.1 Introduction

Italy is a country in South Central Europe with a population of approx. 60 million, making the country the third most populous country in the EU[140]. Italy is divided in 19 regions and every region is further divides in provinces[141]. The regions are local areas with specific responsibilities, five of them are special statute regions that enjoys particular forms and conditions of autonomy over particular topics. Because of the length of the Italian peninsula, there is many variations between the north and the south part of the country regarding climate, geology, geography, land uses etc. The water bodies in Italy include about 1.500 lakes, but the rivers are significant fewer. Moreover, Italy consists of high mountain such as the Alps at the north and the Apennines at the centre and south, which formed from the uplift of igneous and primarily marine sedimentary rocks. Part of the centre and part of the south are volcanic. In Italy a wide range of soil types can be found mainly because of the variation of climate conditions and altitude together with the different types of rocks' formations [142].

Today there are 3.925 protected areas, covering approx. 21.5% of the country's land and the corresponding percentage of marine protected areas is 9.7%. The 75.9% of them is designated as regional based on Birds Directive, Habitats Directive and Barcelona Convention, the 22.3% is designated as national (National Parks, State Nature Reserve, State Marine Reserve etc.)

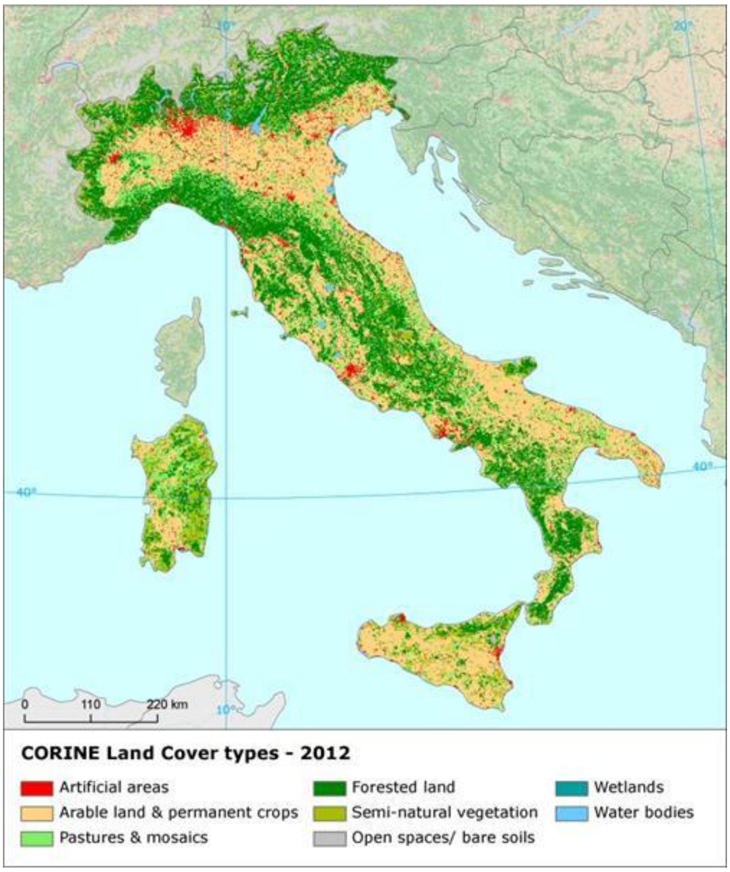
140 https://data.worldbank.org/indicator/SP.POP.TOTL?locations=IT

141 https://web.archive.org/web/20140713161607/http://epp.eurostat.ec.europa.eu/portal/page/portal/nuts_nomenclature/correspondence_tables/national_structures_eu

142 https://www.britannica.com/place/Italy

and the rest 1.8% is designated as international (Ramsar Site, UNESCO-MAB and World Heritage Site)[143].

The “Water Act” Law n° 36/94 – Legge “Galli” was the first regulation of groundwater use. According to this Act, the state started to control the groundwater resources and made the license of every water use mandatory. Based on the above, both the solid overview of physical, chemical, biological and hydrogeological status and the availability of these information became mandatory for the regions through specific monitoring programs. Moreover, it is significant for the water recourses of the country the spatial distribution, since in the north part of the country it is allocated the 65% of the total renewable and exploitable water resources, in contrast with the 15% in the central regions, the comparable small 12% in the south part of the country and the 4% in the major islands[144].



Sources: European Commission (2017g)

Figure 15 Land uses in Italy

[143] https://www.protectedplanet.net/country/ITA
[144] https://easac.eu/fileadmin/PDF_s/reports_statements/Italy_Groundwater_country_report.pdf

6.7.2 Legislation, Administration & Professionals

In Italy the Legislative Decree no.22 is in force since 1997 concerning waste management and contaminated soil management and this is the first reference of the "threshold values" and the introduction of the term of contaminated sites (Art. 17). As a result, the Ministerial Decree of 1999 concerning the soil contamination aims to: a) define the terms of contaminated sites, potentially contaminated sites, safety measures, remediation environmental recovery, b) establish the criteria for the remediation and monitoring operations, c) set the limits for contaminated soils, groundwater and surface water via chemical analysis protocols and d) set up risk analysis guidelines (Carlon, 2007). Furthermore, the Legislative Decree no. 152/2006, Environmental Consolidated Act (ECA) (Part IV, Title V), predicts the cases of limits' exceedance and defines the level of liability of the polluter and/or the landowner to carry out the remediation actions.

The actors of the environmental regulation are firstly the Ministry of the Environment and Protection of Land and Sea (MATTM), the Ministry of Health, the Ministry of Cultural and Landscape Heritage, the Ministry of Economic Development and secondarily the scientific agencies (with regulatory role) such as the Geological Survey as the corresponding department of the Institute for Environmental Protection and Research (ISPRA) and the Superior Health Institute (ISS). The regions can issue environmental regulations and the local authorities have the power to issue permits. In cases of remediation projects on a site, it is required a signed professional's certification and technical documents.

Historical vs. new contaminated sites

In Italy there is no differentiation between the new and the historical contaminated sites but there is a different approach on the operational sites (industrial/commercial activities) management according to the Legislative Decree 152/2006. Moreover, there is a distinguish between the mega-sites (i.e., refineries) and the small sites (i.e., petrol stations) that have simplified procedure (Annex 4 to the part V of the Legislative Decree 152/2006 for small sites, DM 31/2015 for petrol stations).

Digital Tools

A digital database of contaminated sites and the associated maps is currently under preparation and will be published soon with yearly updates.

Currently, the RomePlus software is currently used for risk assessment methods for soil gas[145].

6.7.3 Land Use categorization

For the CSMF purposes, the land uses are divided into two main categories:

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145 https://www.isprambiente.gov.it/it/attivita/suolo-e-territorio/siti-contaminati/monitoraggio-delle-matrici-aeriformi/RomePlusManualed_uso1.0d.pdf

- Green areas and areas of residential use
- Industrial and commercial area

6.7.4 Screening values

6.7.4.1 Soil screening values

In Italy the screening values are regulated in national level and are reported in Annex V of the of Legislative Decree 152/2006[146]. The derivation of the screening values is based on risk assessment but also on other criteria (i.e., the drinking water guidelines). There is a list of screening values based on land uses in the Decree 152/2006. The exceeding of threshold concentration levels (CSC) means that the area is potentially contaminated site. Site-specific risk concentration levels (CSR) (or remediation target) are calculated based on the site-specific conditions and the exceeding of CSR means that the area is a contaminated site. Both CSC and CSR are defined for soil and groundwater and may constitute remediation target. The screening values are used for the *in-situ* assessment and in some cases, these could equal the background values of the area. Soil gas threshold values have been set in a specific national guideline.

In case that the screening values of a contaminant is not listed in the Decree and this is found on the site, then a concentration limit is determined ad-hoc via the toxicological affinity criterion. A site-specific risk assessment by the Italian National Institute of Health (Istituto Superiore di Sanità - ISS) then is compulsory in order to identify the properties and behaviour of the new contaminant and be on the list (Carlon 2007). Also, the toxicological data is used for the derivation of the soil screening values.

The national background values are used in region and local level and each Municipality has its own calculated background values because of the great complicated geology of the country. In case that the screening level is lower that background values then the latter is used. A significant limitation in the current legislation for the management of contaminated sites is the lack of ecological criteria since only the risk assessment of human health is required.

6.7.4.2 Groundwater screening values

The groundwater screening values are derived from the European Water Framework (Directive 2000/60/EC) and the European Council Directive 98/83/EC on water quality for human consumption and according to the United States Decree for Drinking Water for the missing parameters (Carlon 2007). This system of screening values characterised as conservative and do not change between the different water bodies and the land uses.

[146] http://extwprlegs1.fao.org/docs/pdf/ita64213.pdf

6.7.5 Remediation and monitoring protocols

According to current legislation the definition of remediation implies that an action on the source should be carried out to minimize the contaminant concentration below the site-specific risk concentration levels (CSR). The remediation of the contaminated sites in Italy is based on the risk assessment and the remedial targets are determined by the site-specific procedure. The site-specific risk assessment is structured on the basis of a three pillars conceptual site model: a) source, b) pathways and c) receptors. Each of the pillars is evaluated within a number of parameters (with site-specific determination process). In case that the remediation targets cannot be achieved then the competent authority can decide the modification of the remediation project by using different plan or technologies, using the "Service Conference" procedure. The monitoring practices after the remediation actions are not regulated by the law but defined on the site-specific approach.

In Italy there are specific soil, groundwater and soil gas sampling guidelines including on the Annexes of the Legislative Decree 152/2006[147] [148] [149] [150].

The regions where the obligated bodies are responsible to develop Regional Remediation Plans, including a list of "potentially contaminated sites". After the Legislative Decree n.152/06 came into force the definition of potentially contaminated sites has changed to «sites where CSCs are exceeded». Even then some Regional Remediation Plans still contain the original list. According to current legislation the registers of the sites which need to be remediated have been developed at the regional level. The contents of the registers are different between the regions. Although, in registers included information about the: a) site location, b) type of polluting activity, c) nature of contamination and contaminants behaviour, d) the current management reduction measures. This information dataset is periodically collected from regions elaborated and published in the Environmental Data Yearbook.

A far as investigation requirements concern, a technical Annex (Annex II to Part IV, Title V of the Legislative Decree 152/06) deliver general criteria for detailed site investigations, including:

- Collection of data about polluting activities carried out at the site
- Construction of conceptual site model for the site investigation plan

The minimum requirements for the investigation plan are the:

- sampling points location

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[147] https://www.snpambiente.it/wp-content/uploads/2018/11/LG_SNPA_15_18.pdf
[148] https://www.snpambiente.it/wp-content/uploads/2018/11/Appendice_A_linee_guida_snpa_15_2018.pdf
[149] https://www.snpambiente.it/wp-content/uploads/2018/11/Appendice_C_linee_guida_snpa_15_2018.pdf
[150] https://www.snpambiente.it/wp-content/uploads/2018/11/Linee_guida_SNPA_17_2018.pdf

- definition of the analytical dataset
- sampling strategy for soil, subsoil and groundwater
- analytical methods for soil, subsoil and groundwater

The presentation of results of the site investigation of the conceptual site model is needed in order to evaluate the requirements of the further investigation.

Generally, the sampling procedure is based on the general rule of three samples. One sample of surface (0 – 1 m bgs), one sample on the capillary fringe and one of an independent depth between the previous two. After the collection of the samples, the testing procedure includes the adding of the 10% of topsoil samples for specific analytes (i.e., asbestos, PCBs, dioxins etc.) and the adding of the additional only in case that there is any smell or visual evidence of contamination event. According to the sample analysis procedure, the coarse part greater than 2 cm is discharged in the field. The medium part of granulometry comprehended between 2 cm and 2 mm is sampled on the laboratory, where it is separated and weighted. The chemical analysis is conducted on the fraction <2 mm and the final result is normalized taking into consideration the volume of the medium part of the sample. The laboratories authorized by the Italian authority ACCREDIA[151], which regulates them under the UNI CEI EN ISO/IEC 17025:2018.

After sampling there are international standards for the pre-treatment procedure. In the majority of the cases, the project manager and the control authority of the site both agreed to the pre-treatment and analytical techniques to be used.

The most frequently used remediation techniques are dig & dump for soil and pump & treat for groundwater but in situ technologies (e.g., SVE, ISCO, Thermal desorption, Phytoremediation, Landfarming, Soil washing) are taking place as well for a good number of sites.

6.7.6 Risk Assessment

The human health risk assessment techniques are based on site-specific approach and used in order to evaluate the level of the risk on-site. The technical approach of risk assessment is referred in Annex I to Part IV, Title V of the Legislative Decree 152/06 including the general procedure for creating a human health site specific risk assessment and sets:

- Acceptable risk level:
    - Hazard Index: HI = 1 for not carcinogenic substances (for a single substance or cumulated over more substances)
    - Target Risk: TR = 1E-06 for a single carcinogenic substance
    - Target Risk: TR = 1E-05 cumulated over more carcinogenic substances

[151] https://www.snpambiente.it/wp-content/uploads/2018/11/Linee_guida_SNPA_17_2018.pdf

- Procedure for the selection of chemicals substances of concern for risk assessment on the basis of:
  - the frequency of exceeding CSCs or background values
  - toxicity
  - mobility and persistence in the media
  - connection with polluting activities
- Procedure for the identification of the source (calculated chemical concentrations in soil, sub-soil and groundwater)
- Exposure pathways to be considered:
  - soil ingestion
  - dermal contact with soil
  - indoor/outdoor inhalation of vapours
  - dust inhalation
  - soil to groundwater leaching
- Relevant protection factors for human health and groundwater

The compliance of the above with the CSC for groundwater is required.

Except the existing pollution sources, other relevant sources considering for the risk evaluation are the surface soil, subsurface soil and groundwater. Other contribution to human health risk such as air emissions are not included in the assessment. Risk assessment calculated concentrations of some chemical compounds such as heavy metals should be compared against natural background levels.

6.7.7 Liability

In Italy the regulations are based on the "polluter pays" principle with liability determined by the link between an action and an event of pollution. Therefore, the current or previous owner can be liable only in case that he caused the contamination. If the polluter is not identified, then the local public authority carries out the clean-up actions (Art. 250 of ECA). In cases that the local authority carries out the clean-up actions, a registered claim of the land is taken. The authority's remediation costs can also be claimed from the innocent owner up to a limit of the fair market value increase of the real estate after clean-up activities. The innocent owner and the occupier can take precautionary measures if the contamination is already existing or caused by third parties. If the source of pollution is still active and might spread outside the site, then the owner must take any precautionary measures needed in order to stop the leakage. Operators are only liable where they have caused the pollution of the land. The owner itself remains liable and there is no mechanism of inheritance or transfer the liability of the site. In general, the seller always maintains the environmental liability because of the "polluter pays" principle.

There are no obligations on the owner to carry out preventive inspections on a site. However, when a potentially contaminating event occurs (including historical events) the person responsible for the pollution immediately adopts the necessary emergency measures to prevent the further spreading of the contamination and informs the corresponding authorities (Art. 242 of ECA). Remediation is approved by the competent authority which varies case-by-case and the cost of the remediation actions is posted by the person or company who is responsible for the clean-up (Art. 242 of ECA).

In case of land transfer, the seller may provide all the relevant information about pollution and/or remediation past actions or active pollutions but this is up to buyer responsible to ask for a specific Environmental due diligence. Environmental due diligence is carried out in three phases via technical analysis and legal assessments. Public authorities are responsible for finding the polluter and in case of the polluter/owner are not liable anymore (orphan site), public funds are available at local or national level to carry out the remediation actions. However, the landowner after discovering the potential contamination source has the duty to apply the prevention measures in order to limit the contamination and avoid a further environmental damage.

Finally, the Environmental Due Diligence could be useful in cases of landowner change but is not mandatory. In Italy, the end of remediation activities according to the approved remediation project is certifies by the province with the “Remediation Certification”. The competent authority is the Ministry for the Environment for all the procedures regarding the Sites of the National Priority List established by Art. 252 of ECA.

6.8 New Jersey, USA

6.8.1 Introductions

New Jersey is a constituent State of the United States of America with Trenton as the capital. The New Jersey are among those States with the strictest environmental legislation framework in USA, which is captured in the contaminated soil framework as well. The population is approximately 9 million[152]. New Jersey borders with Atlantic Ocean to the east and south, New York to the north and to the East, Pennsylvania and Delaware to the west[153]. It occupies an area of 22.591 km^2, of which 780 km^2 consist of lakes and ponds. It is one of the most urbanized states of the USA. Moreover, it is a significant industrial centre for the whole country and one of the first to deliberately develop infrastructure to support industrialization.

New Jersey is a very geologically diverse State. There are four physiographic provinces, the Atlantic Coastal Plain Province, the Piedmont Province, the Highlands Province and the Ridge

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152 https://www.census.gov/quickfacts/fact/table/NJ/PST045219
153 https://www.britannica.com/place/New-Jersey

and Valley Province, which reflect the underlying geology, and control population growth, transportation and industrialization.

Forests cover 45%, or approximately 2.1 million acres, of New Jersey's land area. According to the National Wetlands Inventory, in the mid-1970's New Jersey possessed roughly 916.000 acres of wetland and 413.000 acres of deep-water habitat, excluding marine waters and smaller rivers and streams that either appear as linear features on wetland maps or wetlands that were not identified due to their small size. About 19% of the State's land surface was represented by wetland. In New Jersey the largest industries include biopharmaceuticals, manufacturing, financial services, transportation and logistics and life sciences. On the other hand, the technology industry is shrinking while the healthcare and life sciences industry grow[154]. Figure 16 shows the different land cover types in New Jersey, USA.

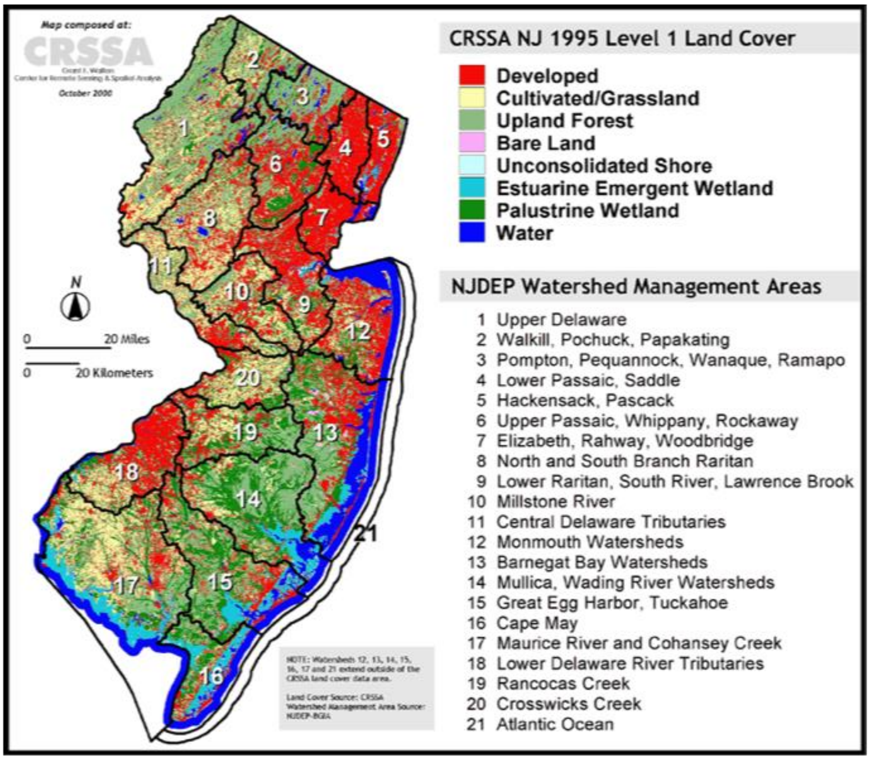


Figure 16 Land uses in NJ, USA

6.8.2 Legislation, Administration & Professionals

In the USA, environmental remediation framework consists of three levels:

a) the Law (general obligations etc., but is some States details, such as screening values, are included in laws),

[154] https://nj.gov/labor/lpa/pub/lmv/cluster_handout.pdf

b) the Regulations (more details of i.e., investigation process, application of the standards, reporting requirements etc.) and

c) the Guidance documents (sampling methodology details, QA/QC etc.)

Laws and Regulations are promulgated and are enforceable. Guidance is not promulgated and is, generally, not enforceable, but provides the standard of care and an explanation of the regulatory expectations.

The basic United States (Federal) framework for contaminated site management consists of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) also called the Superfund Act of 1980. The Superfund Act was intended to identify the responsible parties, to assist and fund the clean-up actions of contaminated sites under the “polluter pays principle” and prevent the risk to public health and ecosystem. The CERCLA authorizes two type of actions: the removal and remedial actions (Gong 2010). The removal actions are short-term response actions classified in three categories: a) emergency, b) time-critical and c) non-time critical. The aim is to address localized risks (i.e., abandoned site contaminated by hazardous substances, which pose risk to public health). The remedial actions are long-term response actions aiming the remove of the hazardous substances and prevent the migration of contaminants. In these cases, the level of the risk is associated with the release of the contaminants (Gong 2010).

Individual States may promulgate their own environmental Laws and Regulations, that are more specific and often stricter than the Federal ones. Most states have their own contaminated soil Laws, Regulations and Guidance, such as New Jersey, California, Florida (Florida Department of Environmental Protection 2005), Massachusetts, and Alaska (ITRC, 2008). New Jersey regulations are codified in the New Jersey Administrative Code. The regulations that are utilized by the Department of Environmental Protection constitute New Jersey’s Environmental Rules (Regulations) and are found in Title 7 of the Code. Regulations related to soil and groundwater contamination are 7:9D - groundwater quality standards, 7:26D - remediation standards, 7:26E - technical requirements for site remediation, 7:26I - regulations of the New Jersey Site Remediation Professional Licensing Board 7:26B Industrial Site Recovery Act Rules[155]

The New Jersey Department of Environmental Protection (NJDEP) generally follows steps similar to USEPA’s superfund process and based on the remediation of a site for the protection of human health and safety and environment. To standardize the remediation process and established minimum technical requirements, the NJDEP adopted the “Technical Requirements for Site Remediation” in 1993 (ITRC, 2008).

155 https://www.nj.gov/dep/rules/nj_env_law.html

In 2009, the New Jersey Site Remediation Reform Act (SRRA) set forth sweeping changes to the way in which sites are remediated in New Jersey. SRRA established the affirmative obligation for responsible parties to remediate contaminated sites in a timely manner. To achieve this goal, SRRA created a category of remediation professionals known as Licensed Site Remediation professionals (LSRP). SRRA requires that the LSRP comply with all remediation statutes and rules and consider Department-developed guidance when making remediation decisions. Under this new remediation paradigm, the remediating party need not wait for the Department's direction and pre-approvals to commence and continue clean-ups. Instead, they must initiate and complete the clean-up under the direction of an LSRP, who has responsibility for oversight of the environmental investigation and remediation. The Department monitors the remediation progress and the actions of LSRPs by requiring the submittal of forms and reports as remediation milestones are reached[156].

Historic vs. New contaminated sites

The liability to remediate a contaminated site is perpetual. In some instances, the actual laws or regulations governing the administration of the clean-up may differ. For example, in New Jersey, an active industrial facility that is being sold, would be remediated through the provisions of the Industrial Site Recovery Act. However, the technical aspects of the remediation (such as methods of investigation, clean-up levels, remedial technologies) would be the same as for a site in the Brownfield program. On the other hand, certain aspects of active facilities may be regulated through other Laws and Regulations. For example, closure of a disposal lagoon, may be regulated under the Resource Conservation and Recovery Act (RCRA) that may allow for different methodologies and compliance points. However, if the facility is sold at some time in the future, compliance with State real estate transaction requirements, could necessitate additional clean-up.

6.8.3 Land uses

Every municipality in New Jersey has a Master Plan, which is a document describing, among other things, the existing and future land use. Development is controlled by zoning, which can range from several types of commercial zones to office parks, to varying densities of housing, to open space, or to a mixture of any of the above. Because land use is regulated by both the municipality and the State, there are many permits that control development. An example is the wetland permit program, which governs disturbance of ecological areas by development. Wetlands are strictly defined by the NJDEP by their special hydrology, their soils characteristics and their vegetation. New Jersey is divided into Soil Conservation Districts[157], which set requirements for soil erosion control and protection of surface water. Moreover, New Jersey has specific regulations about how close to a body of water a development can

[156] https://www.nj.gov/dep/srp/srra/lsrp/lsrp_program_overview.pdf
[157] https://www.nj.gov/agriculture/divisions/anr/pdf/soilconservationdistricts2017.pdf

be located. The higher the ecological value and sensitivity of a stream, the wider the buffer zone must be between the water and the nearest development area. The highest quality waters in NJ are designated "Outstanding National Resource Waters" (ONRW). These include some waters in National and State Parks, Wildlife Refuges and "waters of exceptional recreational or ecological significance". Further "Category one waters" are waters of exceptional ecological significance, exceptional recreational significance, exceptional water supply significance or exceptional fisheries resources to protect their aesthetic value (colour, clarity, scenic setting) and ecological integrity (habitat, water quality and biological functions). These classifications set the strictest standards for protection of surface waters. If the proposed activities of a land developer (or even the remediation of a contaminated site) interfere with a stream, then a stream encroachment permit will be necessary[158].

6.8.4 Clean-up Standards and Criteria

The USA legal framework for contaminated site clean-up can vary among the States and the Federal model. While the basic legal theory may be the same, the actual legal and technical requirements and standards can vary. Most states set their own “clean-up standards”. They are derived based on the risk assessment methodology developed by USEPA for the protection of human health. The assumptions for the derivation are based in current USEPA policy and may be modified based on state regulations (e.g., duration of exposure assumptions can vary). Practical considerations including analytical limitations and natural background values are also taken into consideration (ITRC, 2008).

Clean-up standards are based on land uses and exposure pathway assumptions (such as residential versus industrial land uses, migration to groundwater or vapor intrusion). The most cases clean-up standards are promulgated in regulation and are enforceable. Clean-up levels that have not been promulgated are considered “criteria” or “guidance” and, while they may be used as standards, they do not have the same legal standing as promulgated standards.

Human Health based standards or criterial are derived using the equations developed by USEPA[159]. Toxicological parameters used are typically those provided by USEPA but the NJDEP reserves the right to use alternatives when USEPA inputs are not deemed adequately protective. The remaining variables can be similar to what is used by USEPA or be tailored to New Jersey’s specifics. Groundwater protection criteria are back-calculated from the health-based groundwater quality standards, using fate and transport equations.

In many cases, the regulations will provide methods for adjusting clean-up standards to reflect site conditions (e.g., NJDEP Alternative Remediation Standards). Parameters such as depth

[158] NJDEP-Division of Water Monitoring and Standards
[159] Risk Assessment Guidance for Superfund (RAGS): Part A, Risk Assessment, US EPA

range of contamination, organic carbon content of the soil and site size can be varied, as defined in the regulation.

Generally, clean-up standards will not be set lower than naturally occurring background, as, for example, mandated in the New Jersey "Brownfield and Contaminated Site Remediation Act, N.J.S.A. 58:10B-1 et seq." At the same time, the same law sets the acceptable health risk standards for cancer and non-cancer risk (1E-06 and 1, respectively). That risk standard cannot be changed in regulation. Natural background is defined based on studies conducted by the US and the New Jersey geological surveys[160].

The NJDEP also recognizes the impacts of Diffuse Anthropogenic Pollution (DAP), i.e. contamination originated from other ubiquitous sources, such as roadways adjacent to the site. The State of New Jersey has published Soil Remediation Standards that address human health pathways (ingestion, dermal, inhalation). There are also criteria for protection of groundwater (which are being proposed to be elevated to standards).

The clean-up standards and criteria (soil remediation standards in New Jersey) are used to evaluate data collected in the various stages of site remediation. Samples collected during the "Site Investigation" (New Jersey's terminology) are used as a screening tool to assess whether an Area of Concern has been contaminated and whether further investigation is necessary. If further investigation is necessary, a remedial investigation must be conducted to characterize the nature and extent of contamination and to collect information needed for remedy selection. Analytical data collected in the course of the remedial investigation are compared against the standards. Data is typically evaluated either point-by-point or statistically. If the outcome of these evaluation is that the standards have been exceeded, then an appropriate remedial action is selected. The performance of the remedial action is measured by collecting performance samples, such as post-excavation samples, post-treatment samples, containment pre-design samples, etc.

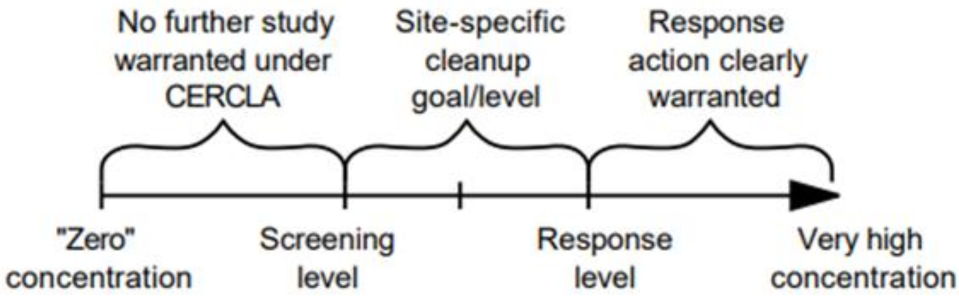
It is not necessary to implement a remedy that will reduce contaminant concentrations below the applicable standards, provided the remedy is protective of human health and safety and the environment (e.g., containment).

6.8.4.1 Soil screening values

Federal

[160] https://www.state.nj.us/dep/dsr/soilrep.pdf) (https://pubs.usgs.gov/pp/1270/pdf/PP1270_508.pdf

The USEPA uses soil screening levels (SSLs) to evaluate potentially contaminated sites and to assess whether further investigation and remediation is warranted. The SSLs are not national clean-up standards. They are risk-based concentrations derived from equations combining exposure assumptions with EPA toxicity data. Generally, at sites where contaminant concentrations fall below SSLs, no further action or study is required under the CERCLA[161] (see Figure 17).



Source: USEPA (1996)

Figure 17 The derivation of screening values related to the investigation actions.

The derivation of screening values based on the soil screening process, which is a site-specific procedure, conducted of the seven following stages (USEPA, 1996):

- Developing a conceptual site model (CSM)
- Comparing the CSM to the SSL scenario
- Defining data collection needs
- Sampling and analysing soils at site
- Calculating site-specific SSLs
- Comparing site soil contaminant concentrations to calculated SSLs
- Determining which areas of the site require further study

Analysing further the soil screening process, there is a structured procedure which should be followed to calculate the SSLs of a site[162].

In stage two, the comparison between the existing data and background is an important point. The USEPA categorizes background as naturally and anthropogenic. Natural background is referring to metals while anthropogenic includes both organic and inorganic compounds. A comparison of the local background concentrations with the generic SSLs may indicate if the background concentrations are elevated at the site. When background concentrations exceed the SSLs, no further investigation is warranted (USEPA, 1996).

[161] https://semspub.epa.gov/work/HQ/175238.pdf
[162] https://semspub.epa.gov/work/HQ/175238.pdf

Considering the soil properties data collected and analysed in stage four then the site-specific soil screening levels are calculated based on the Reasonable Maximum Exposure (RME) for chronic exposures on a site-specific base to chemical compounds. The parameters used on the equations are the average time (in years), the oral reference dose (RfD_o) (in mg/kg-d), the exposure duration (in years) (for carcinogenic compounds the average time is equal to exposure duration), exposure frequency (in d/yr) and the exposure pathway. The screening levels are calculated for all the exposure pathways which are for the surface soil: a) the direct ingestion, b) the dermal contact and c) the inhalation of dust (dusts considerate as the semi-volatile organics and metals. For surface soil: a) the inhalation of volatiles and b) the ingestion of groundwater (USEPA, 1996).

According to the detailed soil screening process the migration of contaminants to groundwater is considered and determined as well, using either a linear equilibrium soil/water partition equation or a leach test in order to estimate the concentration of the contaminant released in soil leachate. The methodology for deriving SSLs for the migration to groundwater pathway is based on assumptions of the fate & transport of the contaminants in the subsurface. The calculation is conducted by multiplying the acceptable groundwater concentration by the dilution factor to reach a target soil leachate concentration. On the other hand, if a leach test is used then the process is to compare the target soil leachate concentration to extract concentrations from the leach tests (USEPA, 1996).

For the purpose of providing a default set of screening criteria and preliminary remediation goals, the USEPA has developed risk-based Regional Screening Levels calculated using the latest toxicity values, default exposure assumptions and physical and chemical properties, and a calculator where default parameters can be changed to reflect site-specific risks[163].

6.8.4.2 Soil Standards for the Protection of Groundwater

In New Jersey groundwater is classified according to its hydrogeologic and ecological properties. Groundwater classifications are defined in the Ground Water Quality Standards[164] in the classes are:

- Class I-A: Exceptional Ecological Areas and I-PL (Pinelands)
- Class II-A: groundwater for potable water supply
- Class II-B: groundwater for any reasonable use except potable supply
- Class III-A: areas with the characteristics of average at least 50 feet in thickness, have a typical hydraulic conductivity of approximately 0.1 ft/day or less and have an aerial extent of at least 100 acres
- Class III-B: groundwater consists of all geologic formations or units which contain groundwater having natural concentrations or regional concentrations exceeding

[163] https://www.epa.gov/risk/regional-screening-levels-rsls
[164] https://www.nj.gov/dep/rules/rules/njac7_9c.pdf

3,000 mg/l Chloride or 5,000 mg/l Total Dissolved Solids, or where the natural quality of groundwater is otherwise not suitable for conversion to potable uses.

To evaluate whether contaminated soils may impact groundwater and, if so, to set remediation standards, the NJDEP has developed Impact to Ground Water remediation standards (IGW). Currently, IGW are criteria published in guidance, but have recently been proposed for adoption as regulation. In addition to the generic standards, the regulation provides methodologies for development of site-specific standards. The methodologies are further developed in the relevant guidance.

The methods to develop site-specific IGW soil remediation standards are:

- Soil – water partition equation: This is a calculation from the health-based Ground Water Quality Criteria, N.J.A.C. 7:9C using the USEPA soil-water partition equation[165]. Further guidance for the estimation of additional parameters (e.g., Dilution and Attenuation Factor) is also provided. The NJDEP is using this method, with default inputs, to establish IGW.
- Synthetic precipitation leaching procedure (SPLP): This is used mainly for inorganic and low volatility organic contaminants and will often be used to develop site-specific IGW soil remediation standards[166].
- SESOIL Model: At sites where a discharge has occurred and groundwater has not yet been contaminated, the person responsible for conducting the remediation is required to ensure that groundwater quality is not impacted. When clean soil exists between the soil contamination and the seasonal high-water table, the Seasonal Soil Compartment Model (SESOIL) may be used to determine whether current levels of soil contamination may impact the groundwater in the future. This model is most useful for low mobility contaminants[167].
- **SESOIL and AT123D Model**: In case that the groundwater is already impacted by contaminated soil, the SESOIL/AT123D model is used to estimate the time required for contamination to attenuate to levels where groundwater quality standards are met. The SESOIL model is used for the transport of the contaminant and the AT123D model for the evaluation of this groundwater transport[168].

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165 https://www.nj.gov/dep/srp/guidance/rs/partition_equation.pdf).
166 https://www.nj.gov/dep/srp/guidance/rs/splp_guidance.pdf
167 https://www.nj.gov/dep/srp/guidance/rs/sesoil.pdf
168 https://www.nj.gov/dep/srp/guidance/rs/at123d_guidance.pdf

Requirements for sampling and delineation are specified in the Technical Requirements for Site Remediation and in related guidance documents. Additional sampling and analyses may be required to collect the data needed to develop site-specific IGW. If soils are contaminated above IGW, then an appropriate remedial action must be implemented.

The NJDEP recognizes that certain compounds tent to adsorb strongly to the soil matrix and would not be expected to leach and migrate to groundwater. These compounds are termed “immobile chemicals”. If there is a clean zone of at least 2 feet (approx. 60 cm) between the contaminants and the saturated zone, no remedial action is required. However, if certain conditions which can affect contaminant mobility are present, then this concept cannot be applied. Such conditions include the presence of other compounds or co-solvents that can increase mobility, coarse grained soil texture, soil pH and presence of free product[169].

6.8.5 Remediation and monitoring protocols

The remediation process is guided by a set of technical regulations which are readopted through a public process every five years. The level of remediation required to reuse contaminated property is set by the soil standards and criteria. These criteria are established using the most current scientific information and a risk assessment process to evaluate potential exposure scenarios for sensitive populations such as children, elderly and nursing mothers.

The technical regulations apply to all remediation undertaken in New Jersey and direct each step of the process. That process generally follows three phases: a) Initial Assessment (called Preliminary Assessment and Site Investigation), b) Remedial Investigation (where the site is studied to determine the full extent of the contamination) and c) Remedy Construction (the actual physical remediation phase)[170].

When a site enters the remediation program, there is a two-step initial assessment. The Preliminary Assessment is a search of historic records and deeds to determine what type of activities may have occurred on the site. This review identifies possible contamination based on the land use and where on the property the contamination may exist. Locations selected for further evaluation are called Areas of Concern. The Technical Requirements for Site Remediation include the definitive list of possible types of Areas of Concern. In the process, we also try to determine whether contamination was remediated in the past or may still be present above levels of regulatory concern. This Preliminary Assessment is followed by a Site Investigation during which samples are taken to verify the existence of contamination at Areas of Concern that were deemed to require further investigation.

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[169] https://www.nj.gov/dep/srp/guidance/rs/immobile_chemicals.pdf

[170] https://www.nj.gov/dep/srp/community/basics/srbasics_rp.htm

If the Site Investigation concludes that contamination is present above clean-up standards, then a detailed Remedial Investigation is required. This stage is signified by a thorough series of samples of both soil and groundwater, if needed. It can also involve sampling of properties adjacent to the site, especially when there is an indication that the contamination has travelled off-site. This commonly happens when groundwater has been contaminated and less frequently soil of adjacent sites is contaminated. The successful implementation and completion of a remedial investigation requires the preparation of a plan that incorporates an accurate Conceptual Site Model (which should be periodically updated) the identification of Data Quality Objectives and the development of a detailed investigation approach to ensure proper contaminant characterization and complete horizontal and vertical delineation soil and groundwater (and other media if impacted).

The final phase of remediation comes after the site has been thoroughly investigated: samples are analysed, and the results have been verified. A work plan for conducting the remediation must be prepared. The Remedial Action Work Plan will specify a remedy that is consistent with current or planned future land use, is protective of receptors and is acceptable to third-party stakeholders (e.g., property owner is not the polluter). It is possible for a remedial action to incorporate more than one technological and regulatory approach, such as contaminated soil removal in some Areas of Concern and containment at others, followed by recording of institutional controls. If necessary, the remedial action will also address groundwater, surface water, sediment and vapor intrusion.

If a remedial action incorporates the long-term operation of an active remediation system (e.g., soil vapor extraction, groundwater treatment), or long-term passive controls (e.g., cap) or long term Monitored Natural Attenuation (MNA) of groundwater contaminants, the work plan will also include provisions for long-term monitoring and the party conducting the remediation will be required to post financial assurance, to ensure there is funding for the long-term follow-on remediation obligations.

Collecting sound data (i.e., data of known quality) is key to ensure proper delineation and implementation of a remedy that is protective of human health and safety and the environment. For that purpose, the NJDEP (as well as most other States and the USEPA) require that the analyses be conducted by a properly licensed laboratory. The NJDEP has also developed detailed guidance for the development of proper sampling and analysis plans and the proper assessment of analytical laboratory data as follows:

- Analytical Laboratory Data Generation, Assessment and Usability Technical Guidance
- Quality Assurance Project Plan Technical Guidance
- Data of Known Quality Protocols Technical Guidance
- Data Quality Assessment and Data Usability Evaluation Technical Guidance

Generally, the NJDEP has developed an extensive library of Technical and Administrative Guidance that defines the methods and actions that must be completed in the course of the various phases of investigation and remediation.[171]

Because contamination identified at site may be due to natural background the NJDEP has developed guidance for this contingency[172]. Key aspects of this guidance are summarized below (NJDEP, 2015):

- Select a background reference area that has as similar as possible physical, chemical, geological, and biological soil characteristics as the Area of Concern being investigated but that is not affected by activities on the site.
- Collect a minimum of 10 background soil samples from the selected background reference area. This number of samples is necessary for the subsequent statistical analysis. Collect the samples from a depth that coincides with the interval of interest or comparable soil horizon to the Area of Concern soil sample.
- Collect background samples at locations unaffected by current and historic site operations as documented by the Preliminary Assessment, from locations which are topographically upgradient and upwind of contaminant sources.
- Collect and analyse background samples using the same methods as were used for Area of Concern samples.
- Samples should not be collected from areas that may be impacted by contamination, such as parking lots, roads, disposal areas, storage areas, etc.
- Examine the data for statistical outliers. The investigator should verify the statistical assumptions of the data distribution. The analysis can be done using programs, such as ProUCL.
- Apply the highest contaminant concentration found in the background samples as an upper limit for the contaminant concentrations found on the site.

6.8.6 Risk assessment

The NJDEP relies on the use of promulgated default standards to assess whether a receptor may be adversely impacted by the presence of contaminants. Other States, such as Massachusetts, will use either promulgated default standards or a risk-assessment based development of site-specific clean-up standards. The USEPA provides the definitive methodologies for conducting human health and ecological risk assessment[173].

171 https://nj.gov/dep/srp/guidance/
172 https://nj.gov/dep/srp/guidance/srra/soil_inv_si_ri_ra.pdf
173 https://www.epa.gov/risk

As defined by the USEPA, human health risk assessment is the process to estimate the nature and probability of adverse health effects in humans who may be exposed to chemicals in contaminated environmental media, now or in the future.

Human health risk assessment includes four basic steps:

- **Step 1 – Hazard Identification:** Examines whether a stressor has the potential to cause harm to humans and/or ecological systems, and if so, under what circumstances.
- **Step 2 – Dose-Response Assessment:** Examines the numerical relationship between exposure and effects.
- **Step 3 – Exposure Assessment:** Examines what is known about the frequency, timing, and levels of contact with a stressor.
- **Step 4 – Risk Characterization:** Examines how well the data support conclusions about the nature and extent of the risk from exposure to environmental stressors.

Subsequent iteration of the processed are used to estimate the levels to which contaminant concentrations must be reduced to, to mitigate the identified risks.

6.8.7 Liability

The Superfund law [officially the Comprehensive Environmental Response, Compensation and Liability Act, (CERCLA)] imposes liability on parties responsible for, in whole or in part, the presence of hazardous substances (i.e., contamination) at a site[174].

Under CERCLA there are four classes of Superfund liable parties:

- Current owners and operators of a facility,
- Past owners and operators of a facility at the time hazardous wastes were disposed,
- Generators and parties that arranged for the disposal or transport of the hazardous substances, and
- Transporters of hazardous waste that selected the site where the hazardous substances were brought.

Superfund Liability is:

- **Retroactive** – Parties may be held liable for acts that happened before Superfund's enactment in 1980.
- **Joint and Several** – Any one potentially responsible party (PRP) may be held liable for the entire clean-up of the site (when the harm caused by multiple parties cannot be separated).

[174] https://www.epa.gov/enforcement/superfund-liability

- **Strict** – A PRP cannot simply say that it was not negligent or that it was operating according to industry standards. If a PRP sent some amount of the hazardous waste found at the site, that party is liable.

Superfund liability is triggered if:

- Hazardous wastes are present at a facility,
- There is a release (or a possibility of a release) of these hazardous substances,
- Response costs have been or will be incurred, and
- The defendant is a liable party.

A PRP is potentially liable for:

- Government clean-up costs,
- Damages to natural resources (e.g., to a fishery),
- The costs of certain health assessments, and
- Injunctive relief (i.e., performing a clean-up) where a site may present an imminent and substantial endangerment.

The Superfund law provides several exemptions from and protections to Superfund liability. Those include protections for innocent purchasers (e.g., parties not connected to a contaminated land, who may be interested in acquiring and cleaning up this land, as in the case or brownfields redevelopment), properties impacted by off-site sources of contamination, residential property owners who purchase contaminated property, etc.[175] Responsible parties are liable for the costs to investigate and remediate the contaminated property, under the oversight of USEPA. If the responsible party refuses to cooperate, the USEPA may carry out the investigation and clean-up and sue for cost recovery. Court can award USEPA three times the actual cost of clean-up.

It is also important to recognize that, especially under State laws, clean-up liability may persist even after a site has been remediated. For example, in NJ an industrial site that his being sold, will be cleaned up under the requirements of the Industrial Site Recover Act (ISRA). If the industrial operation is sold again at a later time, it will once again be subject to the requirements of ISRA. If the clean-up standards have changed (i.e., have become stricter), additional clean-up of the previously cleaned up areas will be required. This is often referred to as “Reopening of a Case". Of course, any new contamination caused by the second operation will need to be remediated, as an entirely new case.

[175] https://www.epa.gov/enforcement/addressing-liability-concerns-support-cleanup-and-reuse-contaminated-lands

7. Conclusions on EU and international experience

In this chapter the main conclusion drawn by the literature review as well as by the international experts are presented. In particular, in Sections 7.1-7.7 the results drawn by the international experts are presented regarding general information on contaminated soil framework, the administration supporting the framework, the professionals involved, the sampling methods used, and the screening values regulated and finally the liability regime established in each of the countries participated. The results of the questionnaire survey are presented in detail in Tables of the Annex. Finally, in Section 7.8 the best practices stood out are listed and discussed, while in Section 7.9 the challenges faced by these countries that should be taken into account also in Greece are presented.

7.1 General

The most important conclusions drawn regarding the general aspects of the CSMF in the countries participated in the survey are as follows:

- The experience of the countries participated in this study (BE-F, BE-W, NL, FR, DE, UK, IT) is wide, which is reflected by the duration that the framework is already in place.
- The contaminated soil management framework is rather a stand-alone framework and not part of the waste management framework in most of countries.
- Radionuclides are not covered by this framework in most of countries.
- Agrochemicals are generally part of the contaminated site framework, but not from the diffusive contamination perspective.
- The frameworks that have been developed in these countries (BE-F, BE-W, NL, FR, DE, UK, IT) are widely accepted and can be used as good example for Greece.

7.2 Administration

The most important conclusions drawn regarding administration aspects of the CSMF in the countries participated in the survey are as follows:

- Regional authorities (and sometimes local authorities) are involved in all countries.
- In most countries the framework is implemented by rather special authorities/departments, which however, most of times, have other duties as well, such as environmental permitting and waste management.
- These authorities/departments have generally sufficient capacity building.
- National geological institutions have sometimes important role in the framework implementation for creation of technical documents (e.g., BRGM in France, ISPRA in Italy, TNO in the Netherlands, USGS in USA).
- Digital tools are always used to facilitate authorities and professionals and to strengthen the public consultation. They are generally updated.
- These tools are often linked to waste management tools for ex situ contaminated soil management.

7.3 Professionals

The most important conclusions drawn regarding professional issues of the CSMF in the countries participated in the survey are as follows:

- A specific professional certification is required for undertaking contaminated soil remediation in most of countries.
- Site assessment tools are generally used in most of countries.
- These tools are compulsory for certain circumstances (e.g., land transfer) in some countries.

7.4 Sampling methods

The most important conclusions drawn from the information regarding sampling issues are listed below:

- All countries participated (BE-F, BE-W, NL, FR, DE, UK, IT) have guidelines for soil and groundwater sampling, including also soil gas sampling.
- Soil sampling does not refer only to topsoil but also to soil of greater depth, based on site specific conditions.
- Most of countries have instituted natural background concentration values in GIS format or as a list, mostly in regional level.
- Background samples are compulsory in some countries although natural background values exist to acquire more site-specific data.
- Chemical analyses are carried out either in bulk samples or in a fine fraction (<2 mm).
- Sample pre-treatment methods are either instituted or determined based on site-specific conditions.
- Laboratories used are licensed or regulated in all countries.

7.5 Screening values

The most important conclusions drawn from the information regarding screening values are listed below:

- All countries participated (BE-F, BE-W, NL, IT, UK, DE) have instituted Screening values, except France where only for groundwater exist. The State of the NJ (USA) has also instituted Screening Values. In France Screening values are always determined based on site-specific conditions.
- In most of countries there are also Screening values for other parameters, such as soil gas and vapours.
- In most countries Screening values are instituted at National level. However, there are also countries where the Screening values are instituted in regional level (e.g., BE).
- For the evaluation of the impact of potential contaminated soil on aquifers, leaching tests are sometimes applied in all countries.
- In most countries Screening values are widely accepted and are characterized as reasonable.
- Screening values for in-situ and ex-situ soil are for some countries the same. In case of ex-situ soil this is categorized as waste in most of countries.

- Most of time the exceedance of Screening values means further investigation and not direct remediation actions, which sometimes depends on the difference between historical and new contaminated sites. For example, in Belgium-Flanders, if the site is new and exceedance is observed this means further investigation and remediation, while if this is a historical site this exceedance means that risk assessment should be elaborated.
- Some countries use correction methods for the screening values in order to reflect site-specific soil characteristics (e.g., NL, BE, UK).
- In most countries participated Screening values have been calculated based not only on human health criteria. In Germany there are different Screening values for different pathways (soil-human, soil-groundwater, soil-plants).
- Ecological risk assessment is sometimes undertaken in most of countries.
- All countries participated (apart from France) have different Screening values for different land uses. In France, land use is taken into account though, during the site-specific risk assessment.
- Land use classification ranges from the simple Italian model [a) Green areas and Residential use, Industrial and commercial use] to the more complicated Dutch (residential with garden, places where children play, residential with vegetable/kitchen garden, agriculture, nature, green with nature value, sports, recreation and city parks, other greens, buildings, infrastructure and industry)
- Emerging contaminants have been already included in the Screening values list of some countries, but this is not the case for all of them.

7.6 Remediation targets

The most important conclusions drawn from the information regarding remediation targets and monitoring are as follows:

- In most countries, remediation targets are determined based on site-specific criteria. This is, however, also determined if the site is historical or new.
- The most important parameter used for the determination of site-specific remediation targets is the land use type.
- In cases when no remediation targets can be achieved tools such as land use restrictions are typically used. Thus, when for example the targets of housing cannot be achieved other uses such as commercial or industrial can be licensed instead.
- In most countries historical contaminated sites are not treated as conventional (new) contaminated sites and this is regulated in their framework. This is also the case in some countries for operational vs. abandoned contaminated sites.

7.7 Liability

The most important conclusions drawn from the information regarding liability are as follows:

- Most of countries have a standard practice for soil and groundwater monitoring after remediation of contaminated sites has been achieved.

- Most of countries issue a certification to confirm the end of liability. However, this is not always a straightforward process and sometimes liability exist and after remediation has been completed. In NJ USA, "Reopening of a Case" is always an alternative for the authorities if further investigation is considered necessary, even after remediation actions have been completed (e.g., if the clean-up standards have become stricter).
- Land use restriction is a measure that can be used in several countries including USA.

7.8 Best practices

In this Section the best practices encountered during this study from the most advanced EU countries in contaminated soil management are further discussed below.

1. **A single framework governing both soil and groundwater policy**: This is an important issue since soil and groundwater is two parts of the same environmental system (geoenvironment) and therefore they should be regulated by a single framework. This is already the case for most EU countries demonstrated a long experience in contaminated soil management. The framework should be neither complicated nor simplistic. Good example of such a framework is that of Belgium Flanders, Germany and the Netherlands.
2. **Soil screening values:** Most of the advanced countries in EU and globally (e.g., USA) have instituted a soil screening value system. These values are typically the most conservative value among those calculated with risk assessment procedures taking into account the potential pathways of soil-human, soil-groundwater and soil-ecosystems. Only France operates a framework without such values (screening values were withdrawn in 2007 in France), where decisions are solely based on site-specific risk assessment procedure. Most of times, soil screening values are used as thresholds for further investigation and not for immediate remediation. In some countries historical sites are treated differently in terms of screening values and in these cases pure risk-based approach is typically applied.
3. **Soil screening values correction based on site specific soil characteristics:** Geochemical conditions have typically a very important role in fate & transport of contaminants. Therefore, contaminants concentration should be corrected based on soil characteristics. This is a practice followed by several countries, such as UK and Belgium Flanders and the Netherlands.
4. **A framework closely linked to the land planning framework:** Since the "multifunctional approach" has been replaced by the "fitness-for-use" approach in most of the countries, the linkage between the contaminated soil management framework and the land planning framework becomes a very crucial parameter and a growth lever for both financial development and environmental sustainability.
5. **Screening values and remediation based on land uses:** As mentioned above, the "multifunctional approach" has been replaced by the "fitness-for-use" approach in most of the countries. This also led most countries to move from single Screening values to values based on the land use, using risk assessment methodology. Even

when it seems that it is not the case, as in the Netherlands, where a single Intervention value list exist for all land uses, this parameter is taken into account in the remediation target calculation. A typical best practice which is also very straightforward to be adopted by other countries is the German list, where soil screening values for different land uses and different pathways (soil-human, soil-groundwater, soil-plant) are provided.

6. **A complete and informative technical and non-technical framework (toolbox):** Since the technical issues faced in contaminated sites are very complicated and the approaches that can be followed might give totally different results, a complete and informative as much as possible technical toolbox should be constructed and be public available. Currently, this is the case for several EU countries, such as France, UK and Netherlands, where technical documents, instruction videos etc. are available. A typical example of such a toolbox is the Land contamination risk management (LCRM) of UK. However, a non-technical approach is also very significant to make this very complicated issue understood not only by experts but by policymakers and the public as well. This practice creates a clear and transparent technical environment as well as a stable base for policymaking and public consultation. A typical example of this the fact sheets for USEPA in USA and several documents by BRGM in France.
7. **A pertinent authority of the contaminated soil management framework:** Although decentralization is a very important parameter in all advanced contaminated soil management frameworks in EU, a national umbrella of central policymaking actions and overall coordination is imperative. This makes the framework more efficient and transparent. This authority should have the appropriate capacity building not only in terms of sufficient technological level or sufficient economic resources, but mainly in terms of competent human resources that understand the complicated nature of geoenvironment. A typical example of such an authority is OVAM in Belgium Flanders covering issues of waste and sustainable material management and soil contamination.
8. **National geological institutions with an important role:** The national geological institutions can play an important role in contaminated soil management frameworks since they typically have the national databases and the appropriate expertise. A good example of such institution is BRGM (The Bureau de recherches géologiques et minières) in France. BRGM is the reference public institution for Earth Science applications in the management of surface and subsurface resources and risks. BRGM has 5 key roles: scientific research, support to public policy development, international cooperation, mine safety, training. Activities are organized around 10 main topics: geology, water, geothermal energy, CO_2 geological storage, mineral resources, risks, post mining, polluted sites and soils, waste, metrology and laboratories, information systems. BRGM has an important role in contaminated soil management framework in France publishing standard protocols, risk assessment methodologies etc.
9. **Brownfield policy/legislation as a different tool:** Brownfields is typically a very important environmental issue in most of the industrialized countries, including of course EU countries and USA. Towards the new era of the Green Deal and Circular

Economy, land restoration, land use and land management (land stewardship) are the key in this transform. All these transitions make a strong appeal on land and its services. Therefore, the already high pressure on land is expected to further increase. At this point the aspect of reusing brownfields for industrial or commercial purpose instead of consuming precious natural or agricultural land plays an essential role. As land is mostly privately owned and services are often also used to achieve the Sustainable Development Goals, public-private cooperation is essential. It is obvious that brownfield policy should be an important but definitely a separate part of the contaminated soil management framework.

Source: Caring together for nature. Manual on land stewardship as a tool to promote social involvement with the natural environment in Europe[176]

Figure 18 Land Stewardship stakeholder model

10. Contaminated site register: Registration of contaminated sites is a standard practice in EU and worldwide. This is a strong policymaking tool that prioritize the contaminated sites in order to ensure the remediation of those posing high risk to environment and the society. A good example is the Dutch contaminated soil register, a government run site that and contains specific historical information for the whole country, about previous land use, remediation etc.

11. Land use restriction: Restriction of future land uses of a contaminated site is among the potential measures that can be used as part of the remediation actions. Thus, for example if remediation targets suitable for industrial use but not for residential use have been achieved, this site will be restricted to be used only as industrial site. If the

[176] https://elcn.eu/sites/default/files/2018-02/XCT%202013%20European%20Land%20Stewardship%20Manual.pdf

use should be changed, further remediation actions are required to achieve the corresponding remedial targets. This is a practice applied in several EU countries and the USA.

12. **Digital tools:** Digital tools (e.g., dynamic georeferenced contaminated sites, Risk Assessment tools) are very important parts for any administrative framework. They typically facilitate public consultation, provide a clear and stable base for scientific studies and technical documentation and increase the total level of contaminated sites assessment and remediation. Most of the leading EU countries have enabled this kind of digital tools for the contaminated soil management framework. Typical examples are the dynamic GIS tool of contaminated soil register in the Netherlands discussed above and the Risk Assessment S-Risk tool in Belgium.
13. **Accreditation as a Soil Remediation Expert:** Since contaminated site assessment and remediation are typically very complicated projects an accreditation system of soil remediation expert exists in most of the advance EU countries. A typical example is of Belgium Flanders, where two types of experts exist, type 1 and type 2. A type 1 soil remediation expert can be either a natural person or a legal person. A type 2 soil remediation expert can be a legal person only. Type 1 expert has limited responsibilities mainly conducting site assessments, while Type 2 can undertake the entire project.
14. **Soil certificate:** The leader in this subject is Belgium Flanders, where before any land transfer a soil certification should be issued by OVAM for each plot of land that will be transferred. The notion of "land transfer" is quite broad and covers most real estate transactions. If the "land transfer" is related to a "risk soil", an exploratory soil investigation must be conducted, and the soil certificate is obtained based on the result of the investigation. Soil certificates have been instituted also in other countries, such as in France (Alur Law 2014) in cases such as change of land use and where remediation is required.
15. **Diffusive contamination management policy:** Diffuse contamination can be caused by a variety of activities that have no specific point of discharge. Agriculture is a key source of diffuse pollution, but urban land, forestry, atmospheric deposition and rural dwellings can also be important sources. By its very nature, the management of diffuse contamination is complex and requires the careful analysis and understanding of various natural and anthropogenic processes. Diffusive contamination is a concept that will be included in the updated frameworks in EU countries, such as in the Netherlands, but definitely should be a separate part of any contaminated soil management framework.
16. **Plans for tanks, gas filling stations, chemical cleaners etc.:** A series of activities have a very important impact to human health and the environment due to their application including activities such as tanks, gas filling stations and chemical cleaning facilities. Therefore, the preparation of specific technical (and non-technical) plans should be prepared and be public available.

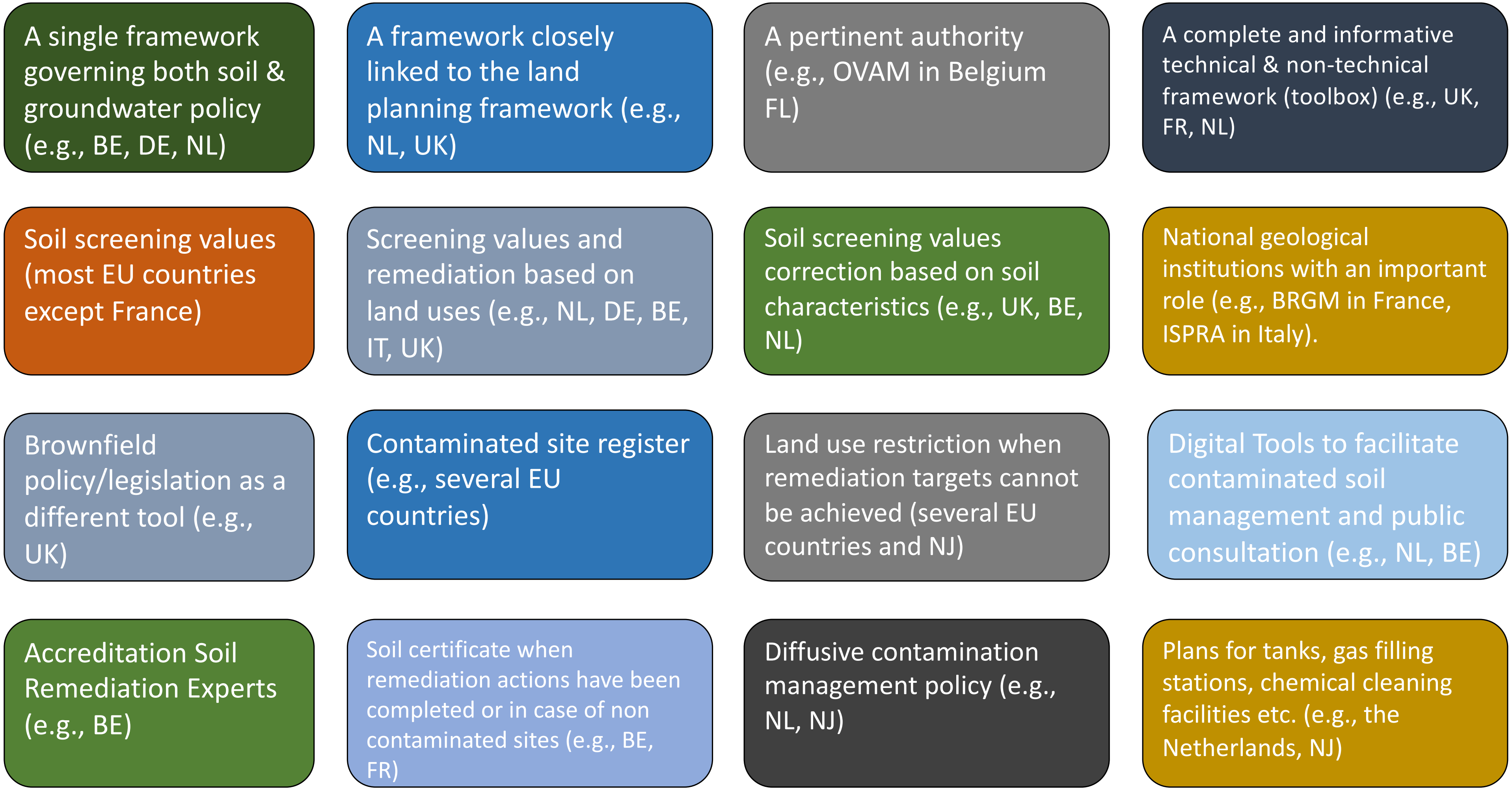

Figure 19 Main best practices applied in contaminated soil management frameworks in EU and NJ (USA)

Table 4 Best practices examples

Best practice	Country	Source
A single and clear framework	Belgium (Flanders)	https://navigator.emis.vito.be/mijn-navigator?woId=23024
A brownfield decree		http://www.zerobrownfields.eu/HombreTrainingGallery/06_Miseur.pdf
Land Transfer		https://www.eui.eu/Documents/DepartmentsCentres/Law/ResearchTeaching/ResearchThemes/EuropeanPrivateLaw/RealPropertyProject/Belgium.PDF
Mapping		https://services.ovam.be/ovam-geoloketten/#/bodemdossier?x=140258&y=198535&z=10
Administrative data of a report for soil control		https://www.ovam.be/sites/default/files/atoms/files/Standaardprocedure%20Bodemsaneringsproject%2C%20versiel%202020.pdf
Structured monitoring plan (MIRA)		https://en.milieurapport.be/about-mira
Initiative on emerging contaminants		https://www.ovamenglish.be/emconsoil
Risk assessment model		https://www.s-risk.be/
Soil control certification	Belgium (Walloon)	https://sol.environnement.wallonie.be/home/sols/sols-pollues/code-wallon-de-bonnes-pratiques--cwbp-/etude-dorientation.html
Recent sampling and analysis protocol		https://sol.environnement.wallonie.be/files/Document/CWEA/CWEA%20-%20version%20du%204%20dec%202018.pdf
Mapping		https://sol.environnement.wallonie.be/bdes.html
Real Estate Register	The Netherlands	https://www.kadaster.nl/
Correction equation		https://wetten.overheid.nl/BWBR0023085/2020-06-09#BijlageG
Sanscrit tool		www.sanscrit.nl
Site historical data and mapping		https://www.bodemloket.nl/kaart
Certification/accreditation system		https://wetten.overheid.nl/BWBR0023085/2020-06-09#BijlageC
A single and clear framework	UK (England)	https://www.gov.uk/government/publications/land-contamination-risk-management-lcrm

Best practice	Country	Source
		https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/223705/pb13735cont-land-guidance.pdf
National Planning Framework (for soil re-use and development)		https://www.london.gov.uk/sites/default/files/ad_114_state_of_brownfield_2019.pdf
Geological mapping		http://mapapps2.bgs.ac.uk/ukso/home.html
Risk assessment		https://www.gov.uk/government/publications/land-contamination-risk-management-lcrm/lcrm-stage-1-risk-assessment https://www.claire.co.uk/information-centre/water-and-land-library-wall
Standards		https://shop.bsigroup.com/ProductDetail?pid=000000000030310186 https://www.ags.org.uk/item/standards-relating-to-investigation-assessment-remediation-and-development-of-potentially-contaminated-and-contaminated-sites/
Funding and support programs	**Germany**	https://www.bmu.de/themen/natur-biologische-vielfalt-arten/naturschutz-biologische-vielfalt/foerderprogramme/chancenatur/
Screening values according to receptor pathways		https://www.elaw.org/content/germany-federal-soil-protection-and-contaminated-sites-ordinance-bbodschv-12-july-1999
Set remediation targets and alternative remediation technologies	**France**	http://ssp-infoterre.brgm.fr/guide-methodologique-plan-conception-travaux-pct https://www.selecdepol.fr http://ssp-infoterre.brgm.fr/definir-une-strategie-de-depollution
Public consultation – simple technical and non-technical documents		http://ssp-infoterre.brgm.fr/sites/default/files/upload/documents/leaflet_french_methodology_2018_12_19.pdf
Soil gas sampling guideline	**Italy**	
Risk assessment model		https://www.isprambiente.gov.it/it/attivita/suolo-e-territorio/siti-contaminati/monitoraggio-delle-matrici-aeriformi/RomePlusManualed_uso1.0d.pdf
Soil gas sampling		https://www.snpambiente.it/wp-content/uploads/2018/11/Appendice_A_linee_guida_snpa_15_2018.pdf
Remediation standards	**New Jersey USA**	https://www.nj.gov/dep/rules/rules/njac7_26d.pdf
Public consultation		https://semspub.epa.gov/work/HQ/175229.pdf
Technical requirements for site remediation		https://www.nj.gov/dep/rules/rules/njac7_26e.pdf

Best practice	Country	Source
Emerging contaminants		https://www.nj.gov/dep/srp/emerging-contaminants/
Licensed Site Remediation professionals (LSRP)		https://www.nj.gov/dep/srp/srra/lsrp/lsrp_program_overview.pdf
Technical guidelines		https://www.nj.gov/dep/srp/guidance/

7.9 Potential challenges for contaminated soil management framework

Although the experience that have been gained already in EU countries and worldwide regarding the contaminated soil frameworks is wide, a series of challenges should be met successfully in order to increase the current efficiency and make possible new more complicated and demanding policies regarding the Green Deal and the Circular Economy. Some of the most important challenges that contaminated soil management frameworks should be faced in EU and worldwide are as follows:

- Site investigation and remediation with significant natural background concentrations of heavy metals
- Consistent behaviour of pertinent authorities
- Excessive role attributed sometimes to standards considering the uncertainties (in the measured concentration, risk calculates etc.)
- Diffuse contamination management
- Interfaces with other policies and particularly of land planning policy and waste and wastewater policies
- Emerging contaminants (e.g., PFAS)
- Inclusion of biodiversity and ecosystem protection since contaminated site management is still mainly driven by human health
- Timely and efficient management of orphan contaminated sites
- More reliable risk assessment methodologies
- Moving to land stewardship
- Balance between the cost-benefit analysis for remediation and use of land use restrictions

8. Recommendations for a Contaminated Soil Management Framework in Greece

8.1 Introduction

Most EU countries have developed contaminated soil management frameworks. Among them the Netherlands, UK, France and Belgium have probably the oldest ones, while other countries such as Germany and Italy have gained valuable experience throughout the years. On the other hand, USA is definitely the global leader of this very complicated subject, both of scientific and policy point of view. As a result, there is plenty of available experience to be used by Greece as lessons learned from other countries. However, it is very important to make clear that all these countries have developed different contaminated soil management frameworks mainly due to different environmental baselines and different development priorities. Therefore, although Greece has a great opportunity to set up a modern and efficient contaminated soil management framework based on other counties' experience this should be not just a replicate, but a carefully designed procedure taking into account the country's specific environmental and socio-political conditions and needs (e.g., mixed land uses, complicated geological background, limited technical experience).

Legislation is always the driver for environmental issues, such as the contaminated soil management. Since this is a very complex topic an efficient administration scheme equipped with expertise is required to run the framework and particularly to:

- create the legislative framework
- create the technical and not non-technical framework (toolbox)
- critically review site assessment and remediation studies
- make all the appropriate inspections
- consult with stakeholders
- improve all the above continuously

Based on the international practices and the lessons learned, the soil contaminated management framework in Greece should be based on the following principles:

- Be part of the national intergraded Soil Management Policy that should be developed.
- Be robust and pragmatic and not pretending to solve everything, but at the same time provide: coherence, transparency, ease of understanding and be appropriate for the needs of the different stakeholders.
- Be governed by a) the polluter pays principle, b) the risk-based approach, and c) the BATNEEC principle.
- Be supported not only by legislation but by technical guidance document as well, including best practices, lessons learned and case examples.
- Be transparent and take into account stakeholder input as much as possible.
- Address historic contaminated sites
- Prevent future releases to the environment

Since authorities and professionals in Greece still have limited experience and they require time to be acclimatized to this new regime, and creation of the legal tools required for supporting the framework is typically a time-consuming process, **the Contaminated Soil Management Framework in Greece will be developed in phases.**

In the following Sections the recommendations for this new framework are presented, while at the last Section a roadmap is provided including the main actions, the milestones, the cost estimate etc.

8.2 Legislation, Administration & Professionals

8.2.1 Legislation

Contaminated soil is a complex system that cannot be expected to be managed by a simple legislation. However, complicated legislation is typically not effective if it is confusing and no longer understandable to stakeholders. Therefore, a robust framework should be created not pretending to solve everything, but at the same time provide: coherence, transparency, ease of understanding and be appropriate for the needs of the different stakeholders.

As mentioned above (Section 5.2), contaminated soil issues are currently governed in Greece, mostly indirectly, by legislation on hazardous waste management (JMD 13588/725/2006, JMD 24944/1159/2006, Law 4042/2012), industrial emissions (JMD 36060/2013), environmental liability (PD 148/2009) and environmental permitting (Law 4685/2020). Since the current legislation is not adequate and most of times confusing **a new clear, stand-alone and more practical and informative legislation should be created on contaminated soil management, as part of a wider Soil Management Policy.** However, since this is typically a time-consuming procedure, a first step of modification of the existing legislations is recommended.

8.2.2 Administration

Administration is a very important part of a contaminated soil management framework. Generally speaking, the more experienced and advanced the country is, the wider the responsibilities that the local authorities have. However, it is obvious that for countries like Greece, with limited experience in contaminated soil management, a centralised administration system taking into account local conditions is necessary, at least, at the beginning. Currently contaminated site issues are managed by several different authorities at administrative levels. The communication among them is generally not satisfactory and their experience in complex technical subjects is still limited. The personnel, although very experienced in other environmental topics (such as permitting and waste management), are not always knowledgeable and staffing is generally inadequate.

In order to make the new contaminated soil framework operational a series of improvements in administration are required and the following actions should be implemented:

1. Create a new integrated CSMF as part of an integrated Soil Strategy. This Strategy should include all required topics regarding soil management in Greece based on the new legislation of EU (EU Soil Strategy).

2. Create a Committee, under the Ministry of Environment and Energy, where all authorities involved (Directorate of Waste, SYGAPEZ, DIPA, Inspectorates, Decentralised Administrations) will be represented and stakeholders, such as HSGME, NAGREF, experienced academics and consultants should participate. The purpose of this Committee will be a) the transition to a basic contaminated soil management framework based on other EU countries' experience that is immediate applicable towards a new more sophisticated one taking into account the specific conditions of Greece and b) a new pertinent administrative body (within an existing one or an independent one) to be responsible for the Soil Strategy and the contaminated soil management framework. Organize technical meetings (formal or not) of the Committee with stakeholders, such as industrial, commercial, real estate, technical professional and public interest groups in order to understand their perspectives and make the framework more applicable.
3. Build a pyramid network between the Committee and the authorities (Ministry, Decentralised Administration, Prefectures, Municipalities) that will be responsible for the Soil Strategy and they can support one another. At least a person with technical university education in each Decentralised Administration, Prefecture and Municipality should be appointed and properly trained. The capacity building of pertinent authorities should be evaluated and should be enhanced, wherever it is necessary.
4. Create a new pertinent administrative body (within an existing one or an independent one) to be responsible for the Soil Strategy and the contaminated soil management framework.
5. Complete and update the digital contaminated site register and decide what will be the ultimate use and the access to it from stakeholders. Initially at least the public contaminated sites, such as the remediated uncontrolled waste disposal sites (ΧΑΔΑ) and the remediation measures employed to each of them could be public available (in GIS format).
6. Enhance the capacity building of pertinent authorities, wherever it is necessary. Experts from the private sector can be also used.
7. Create a strong technical toolbox to support the legislative framework. This should include at least:
    - Guideline on environmental assessment of potentially contaminated sites (phased-approach) with suitable examples, including a list of potential parameters that should be evaluated per activity/incident.
    - Guideline on land use categorization (especially for mixed land uses).
    - Screening value list (adopted from another EU country, such as Germany, Belgium, the Netherlands).
    - Guideline on soil, groundwater and soil gas sampling (including sampling equipment, sampling methodology, QA/QC)
    - Guideline on sample pre-treatment and preservation methodology
    - Guideline on chemical analytical methods per parameter
8. Create technical guidelines for common technical topics such as:

- Gas stations
- Underground storage tanks
- Chemical cleaning installations

9. Create and non-technical guideline to make public consultation more efficient.
10. Create a separate strategy to face brownfield management taking into account the new land stewardship approach.
11. Create a strategy for diffuse contamination which is a very important issue in Greece due to nitrate and heavy metals (and maybe PAHs) contamination. Emerging contaminants such as PFAS should be also included.
12. Participating to EU regulatory bodies such as the Common Forum on contaminated land and the Network for Industrial Co-ordinated Sustainable Land Management in Europe (NICOLE), in order to be connected with more experienced countries on contaminated site management.

8.2.3 Professionals

Currently the experienced and competent professionals performing environmental site assessments and particularly remediation studies are very limited and experienced firms from other countries are typically required in such cases. In order to make the new contaminated soil framework operational an accreditation procedure of Experts should be instituted (like in Belgium Flanders). As a result, a pool of expertise will be created that will be competent to elaborate:

- Environmental site assessments
- Design remedial action and remedial systems
- Design and evaluate monitoring programs

8.3 Land uses

Land use is typically a very important parameter in CSMF in EU countries and elsewhere. This parameter is closely related to the risk that contaminated site may pose to human health and the environment, since every land use has different exposure pathways and conditions, and different receptors. Thus, the risk is higher for a school, where the main receptors are children coming in intense contact with the environment (e.g., play), than for an industrial site, where the receptors are adults, having limited contact with the environment (e.g., driving a track to a loading dock).

As mentioned above currently the "fitness-for-use" approach is followed. Therefore, a categorization of land uses should be decided, based on the country specific conditions. However, as mentioned many times above, one of the most important difficulties for such a provision is the mixed land uses that are typically encountered across the country. For example, an automobile repair garage may be located in a residential neighbourhood. The site investigation and remediation must be such that it protects both the site users and the neighbours.

Different approaches are generally adopted across the countries for land uses categorization in contaminated soil frameworks that ranging from a quite detailed list (e.g., Nature/Agriculture/Residential/Recreational/Industrial in Belgium) to a simpler one (e.g., Green areas & residential use/Industrial & commercial use in Italy). Taking onto account the country specific conditions, it is recommended that land categorization should be based on the following principles:

- be as simple as possible, avoiding too many categories
- follow the general land planning legislation, where possible
- have provision for mixed land uses
- take into account future land uses, particularly when a more sensitive use will be established (e.g., development of a former industrial facility to a mall

Therefore, the following actions should be implemented:

1. adopt initially a land categorization similar to another EU country (e.g., Germany)
2. prepare a more sophisticated approach later (e.g., Belgium), when adequate experience will have been gained.

8.4 Screening values

As discussed in detail in Chapter 6, most of the countries studied (Belgium, Netherlands, UK, Germany, Italy) have a specific screening value list, while only France operates a framework without such values (screening values were withdrawn in 2007 in France). Most of times, however, screening values are used as thresholds for further investigation and not for immediate remediation, although this sometimes also depends on whether the contaminated site is a historical or a new one.

Although the approach of France is probably the ideal model, where all actions are planned and implemented based on site-specific conditions, it is too difficult for countries like Greece with limited experience. Therefore, a screening value list is recommended at least until the necessary experience will be gained. The recommended actions regarding screening values are as follows:

1. Use of an existing soil screening values list of another country with wide known experience until such a list will be prepared based on the specific conditions of Greece. A good example of such a screening value list is that of Germany. This is because:
    - The methodology used is simple and clear
    - Screening values are based on land uses
    - All different pathways are included (soil-human, soil-groundwater, soil-plants)
    - Sample pre-treatment methodology (the fine fraction of <2 mm is analysed) and examples of chemical analyses methods are provided for several different inorganic and organic parameters.

    An indicative decision tree for using is provided in Figure 20.

2. Determine soil natural background (geogenic) values across the country (GeoAtlas). This is a large multi-year project where HSGME can have a critical role. The ultimate

purpose is to prepare the geochemical Atlas of Greece, where an adequate number of soil samples should give the appropriate information across the country.

3. Create a new screening value list based on the Greek specific conditions. This is a very important step for a new CSMF. This new screening values can be used as trigger values and when exceedance will be detected, if urgent control measures are not necessary, further investigations will be required to delineate the actual problem. In case remediation will be required, remediation targets will be determined based on a proper risk assessment methodology or will be equal to the screening values.
4. Create a new risk assessment methodology based on the Greek specific conditions. This can be used as a tool for calculating site-specific risk values (SSRV) and remediation targets. An indicative diagrammatic decision-tree that include the aspect of risk assessment and can be used in the future is provided in Figure 21. In this framework the following screening value system is suggested:
    - SV1 calculated based on the worst-case scenario and
    - SV2 calculated based on contaminants properties and land uses.
    - In cases when inconsistencies exist between the SV calculation procedure and the site-specific conditions, a site-specific risk value (SSRV) may be calculated and used.

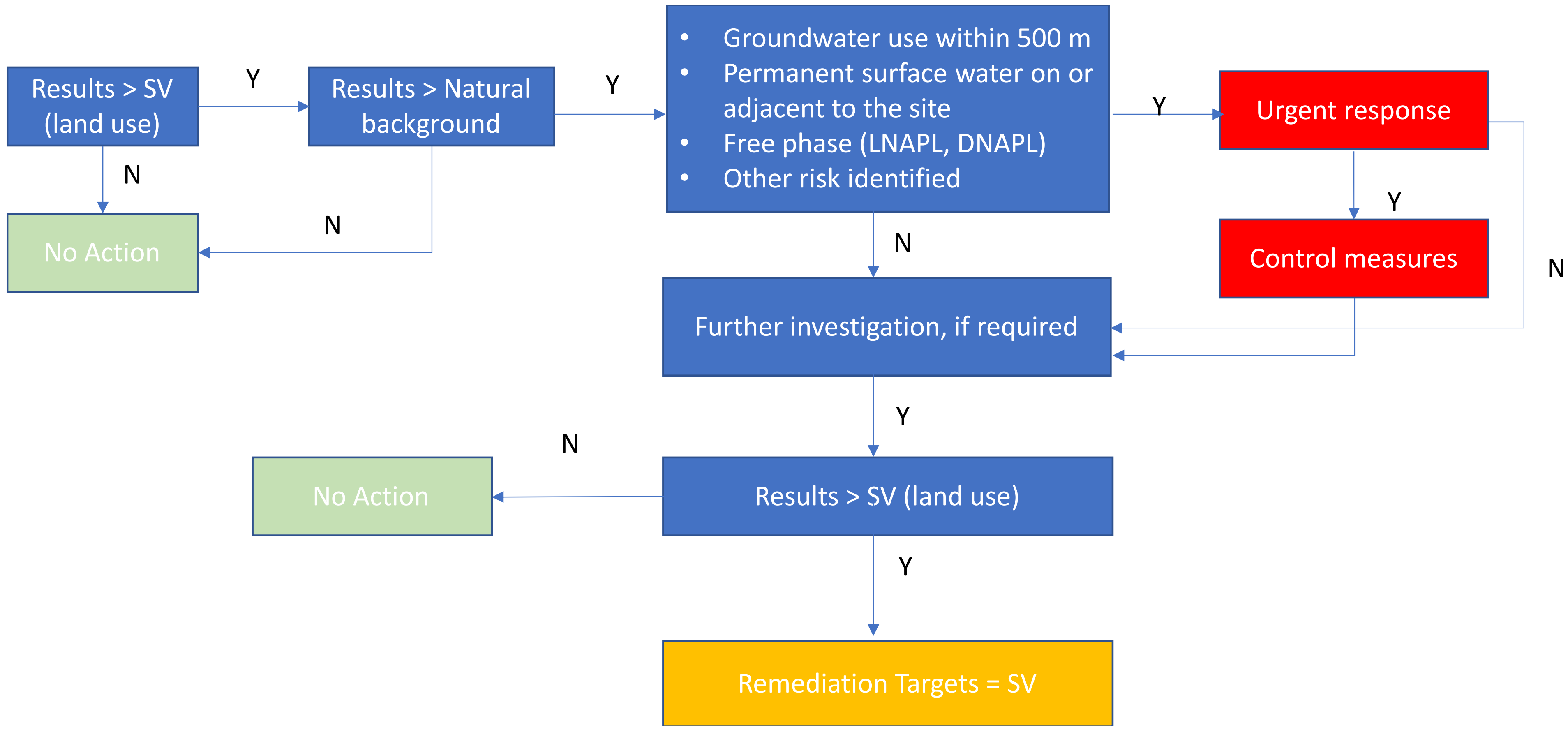

Figure 20 Indicative diagrammatic decision-tree for potentially contaminated sites assessment for immediate use

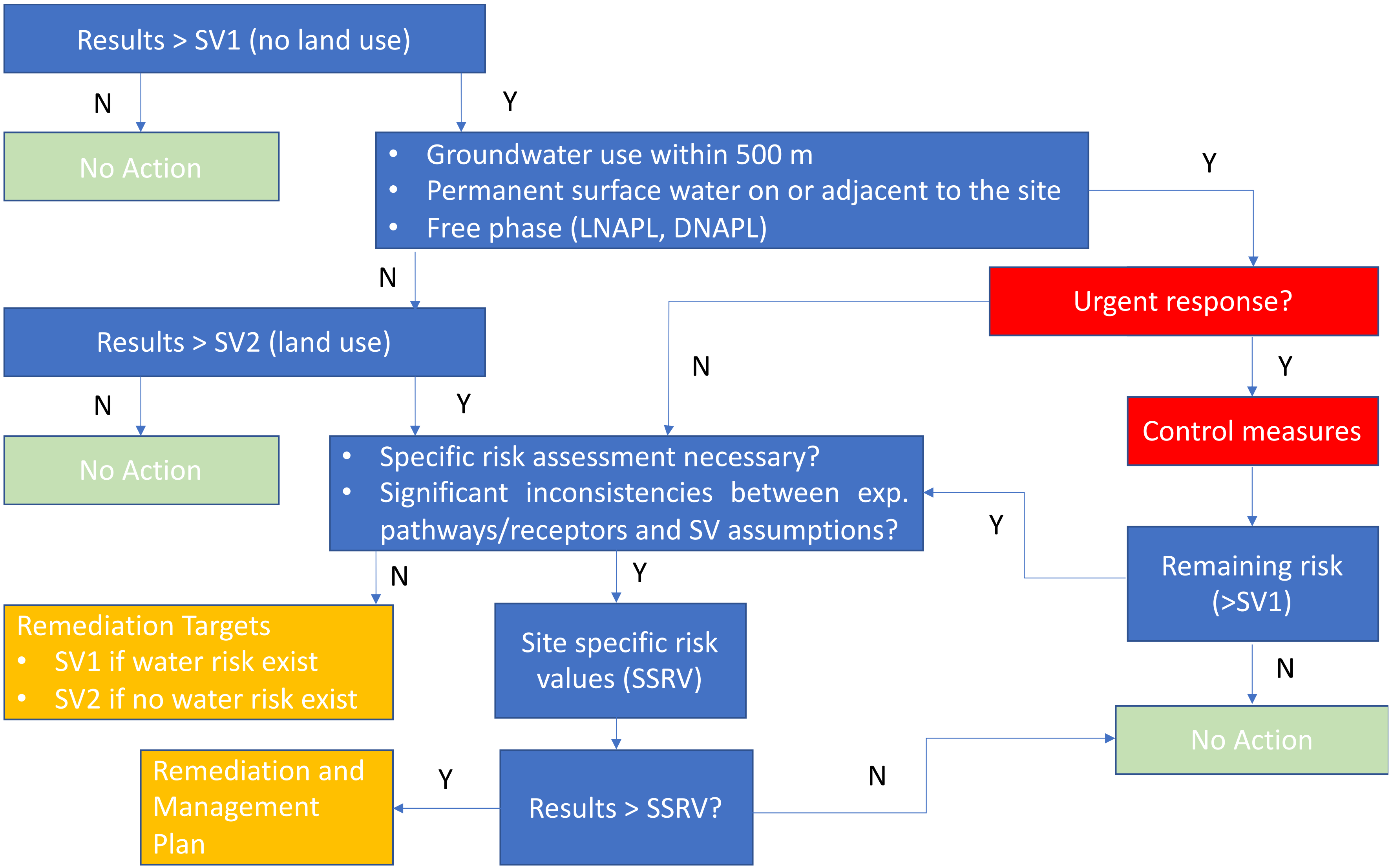

Figure 21 Indicative diagrammatic decision-tree for advanced assessment of contaminated sites for future use

8.5 Environmental site assessment

The commonly encountered international practice of Environmental Site Assessment consists of three distinct reporting phases. It progresses from Phase 1 desktop and site walkover assessments with limited investigation and testing to a Phase 2 detailed invasive investigation and testing for site characterization to a comprehensive Phase 3 report, with an evaluation of remediation objectives and a proposed remediation plan, supported by control and monitoring measures for the activities.έ

The reporting system requires norms and standards of practice to be strictly applied, but also must retain flexibility to allow for decisions on the contaminated status of sites to be made in the most beneficial manner (considering ecological, social and economic aspects) also taking into account timeframes. In some cases, urgent priority works may require that the phased approach to reporting has to move forward in a concurrent single report.

Such as phased-approach methodology should be also used for Environmental Site Assessment in Greece (such modification is recommended for the JMD 24944/2006).

This procedure is recommended to be applied also during the environmental permitting procedure of works and activities, at least of all A1 category and some A2 & B category projects that can cause significant soil and groundwater contamination.

8.6 Liability

As mentioned above the leader in this subject is Belgium Flanders, where before any land transfer a Soil Certificate should be issued by OVAM for each plot of land that will be transferred. Generally, this is tool that trigger soil assessment and remediation in a timely manner that should be also adopted in Greece, taking into account the legal differences and special conditions prevailing in each country. In particular such a Soil Certificate can be instituted in Greece and be required before land transferring, especially in case when the land that will be transferred have previous environmental permit (A1, A2 and B category of JMD 1958/2012 as modified) or where contamination is expected due to accident or unauthorized waste disposal. However, this can be only adopted after the capacity building of the pertinent authorities have been sufficiently enhanced.

8.7 Roadmap and way forward

In this Section a roadmap with the recommended actions is presented. The purpose of this roadmap is to present a list of recommended actions that should take place the following years in order to a) improve the existing framework and b) create a new sustainable contaminated soil management framework in Greece. The actions are divided to those that can be applied in short-term, mid-term and long-term. In addition, the stakeholder involved, the cost estimate and the potential funding sources are provided. The list of recommended actions as well as the stakeholders involved will be finalised after the workshop with YPEN and selected stakeholders has taken place.

Recommendations	Type of instrument	Involved stakeholders	Timeline (indicative timescale)	Cost estimates	Potential funding sources	Estimated achievable target
Create a new integrated CSMF as part of an integrated Soil Strategy. This Strategy should include all required topics regarding soil management in Greece based on the new strategy of EU.	Administrative/ Legislative	• YPEN-Directorate of Waste • YPEN-SYGAPEZ • YPEN-DIPA • YPEN-INSPECTORATES • YPEN-Special Water Secretariat • Decentralised administrations-PEXO • Decentralised administrations-Water Directorate • HSGME • HAO-DEMETER • Universities	Long-tern	High	OP Environment of PP 2021 – 2027 **or** OP Transport Infrastructure, Environment and Sustainable Development of PP 2014-2020	An integrated Soil Strategy, where the CSMF will belong.
Create a Committee, under the Ministry of Environment and Energy (YPEN), where all authorities involved will be represented and experts, such as HSGME, HAO-DEMETER and experienced academics should participate. **This committee will also organize technical meetings (official or not) with stakeholders, such as the industry and NGOs in order to understand their perspectives and make the framework more applicable.**	Administrative	• YPEN-Directorate of Waste • YPEN-SYGAPEZ • YPEN-DIPA • YPEN-INSPECTORATES • YPEN-Special Water Secretariat • Decentralised administrations-PEXO	Short-term	Medium	OP Environment of PP 2021 – 2027 **or** OP Transport Infrastructure, Environment and Sustainable Development of PP 2014-2020	The transition of a basic contaminated soil framework based on other EU countries' experience that is immediate applicable towards a new more sophisticated one taking into account the specific conditions of Greece. A new pertinent administrative body (within an existing one or an independent one) to be responsible for the Soil

Recommendations	Type of instrument	Involved stakeholders	Timeline (indicative timescale)	Cost estimates	Potential funding sources	Estimated achievable target
		• Decentralised administrations-Water Directorate • HSGME • HAO-DEMETER • Universities				Strategy and the contaminated soil management framework.
Build a network between the Committee and the authorities (Ministry, Decentralised Administration, Prefectures, Municipalities) so they can sustain one another. At least a person with technical university education in each Decentralised Administration, Prefecture and Municipality should be appointed and properly trained. The capacity building of pertinent authorities should be evaluated and should be enhanced, wherever it is necessary. Freelance certified Soil experts can be also used, when experience in the administrative bodies is limited.	Administrative	• YPEN • Decentralised administrations • Prefectures • Municipalities • HSGME • HAO-DEMETER • Universities	Mid-term	High	The staff of the authorities will be paid through their monthly salaries. Any technical assistance required could be financed by Technical Assistance resources of OP Environment of PP 2021 – 2027 **or** OP Transport Infrastructure, Environment and Sustainable Development of PP 2014-2020	A pyramid network of competent public employees connecting the Committee, YPEN, Decentralised Administration, Prefectures and Municipalities that will be responsible for Soil Strategy and contaminated soil management framework across the country.
Complete and update the digital contaminated site register and decide what will be the ultimate use and how stakeholders will have access. Initially, at least the public contaminated sites, such as the remediated uncontrolled waste disposal sites (ΧΑΔΑ)	Technical	• YPEN • Decentralised administrations • Prefectures • Municipalities • HSGME	Medium-term	Medium	OP Environment of PP 2021 – 2027 **or** OP Digital Transition of PP 2021-2027 **or** OP Transport	A digital tool as much accessible as possible to be used by authorities, consultants and public.

Recommendations	Type of instrument	Involved stakeholders	Timeline (indicative timescale)	Cost estimates	Potential funding sources	Estimated achievable target
and the remediation measures employed to each of them could be public available (in GIS format).		• Universities • HAO-DEMETER • Consultants • Industries			Infrastructure, Environment and Sustainable Development of PP 2014-2020	
Determination of soil natural background (geogenic) values across the country (GeoAtlas)	Technical	• YPEN • Decentralised administrations • Prefectures • Municipalities • HSGME • Universities • HAO-DEMETER	Long-term	High	OP Environment of PP 2021 – 2027 **or** OP Transport Infrastructure, Environment and Sustainable Development of PP 2014-2020	A Geochemical Atlas across the country, where the natural concentrations of soil will be presented in a public domain GIS-format tool.
Technical and non-technical framework required to support the legislative framework (RemTool). This technical framework should include at least the following: • **Guideline on environmental assessment of potentially contaminated sites (phased-approach) with suitable examples, including a list of potential parameters that should be evaluated per activity/incident.** • **Guideline on land use categorization (especially for mixed land uses).** • **Screening value list (adopted from another EU country, such as Germany, Belgium, the Netherlands).** • **Guideline on soil, groundwater and soil gas sampling (including sampling equipment, sampling methodology, QA/QC)** • **Guideline on sample pre-treatment and preservation methodology**	Technical	• YPEN • Decentralised administrations • HSGME • Universities • HAO-DEMETER • Consultants • Industries • Laboratories	Mid-term	Medium	OP Environment of PP 2021 – 2027 **or** OP Transport Infrastructure, Environment and Sustainable Development of PP 2014-2020	A list of documents where all the appropriate guidance and standards required for environmental site assessment and remediation will be included. The documents should be in Greek and should be simple with the available pictures, videos etc. Practices adopted in more advanced countries and organizations (e.g., BRGM France) may be selected and adopted.

Recommendations	**Type of instrument**	**Involved stakeholders**	**Timeline** (indicative timescale)	**Cost estimates**	**Potential funding sources**	**Estimated achievable target**
• **Guideline on chemical analytical methods per parameter**						
Technical guidance for specific and common topics such as: • **Gas stations** • **Underground storage tanks** • **Chemical cleaning installations**	Technical	• YPEN • Decentralised administrations • Universities • Consultants	Short-term	Low	Green Fund **or** OP Transport Infrastructure, Environment and Sustainable Development of PP 2014-2020 **or** National Development Programme	Technical guidance for common topics.
Create new screening values based on the Greek specific conditions	Technical	• YPEN • Decentralised administrations • HSGME • Universities • HAO-DEMETER • Consultants • Industries	Mid-term	High	Green Fund **or** OP Transport Infrastructure, Environment and Sustainable Development of PP 2014-2020 **or** National Development Programme **or** OP Environment of PP 2021 - 2027	A new soil and groundwater screening value list based on the Greek specific conditions
Create a Risk Assessment methodology based on the Greek specific conditions, including Ecological Risk Assessment.	Technical	• YPEN • Ministry of Public Health • Decentralised administrations • HSGME • Universities • HAO-DEMETER	Mid-term	Medium	Green Fund **or** OP Transport Infrastructure, Environment and Sustainable Development of PP 2014-2020 or	A Risk Assessment methodology based on the Greek specific conditions

Recommendations	Type of instrument	Involved stakeholders	Timeline (indicative timescale)	Cost estimates	Potential funding sources	Estimated achievable target
		• Consultants • Industries			OP Environment of PP 2021 - 2027	
Create accreditation procedure of Soil Remediation Experts should be instituted (like in Belgium Flanders)	Administrative & Technical	• YPEN • School of Public Administration • Universities	Mid-term	Medium	OP Competitiveness, Entrepreneurship and Innovation of PP 2014 - 2020	A pool of experts competent to elaborate: • Environmental site assessments • Design remediation works • Design and evaluate monitoring programs
Create a strategy for diffuse contamination	Administrative & Technical	• YPEN • MRDF • Decentralised administrations • HSGME • HAO-DEMETER • Universities • Farmers' co-op • NGO's	Mid-term	Medium	OP Environment of PP 2021 – 2027 **or** OP Transport Infrastructure, Environment and Sustainable Development of PP 2014-2020	A separate strategy to face diffuse contamination (e.g., nitrate contamination), which is a very important issue in Greece. Emerging contaminants such as PFAS should be also included.
Create a strategy for brownfields management	Administrative & Technical	• YPEN • Ministry Development • Decentralised administrations • Prefectures • Municipalities • HSGME • Universities • NGO's	Mid-term	Medium	OP Environment of PP 2021 – 2027 **or** OP Transport Infrastructure, Environment and Sustainable Development of PP 2014-2020	A separate strategy to face brownfield management taking into account the new land stewardship approach.

Recommendations	Type of instrument	Involved stakeholders	Timeline (indicative timescale)	Cost estimates	Potential funding sources	Estimated achievable target
Introduce the Soil Certificate in land transfer actions for sites where activities/works required environmental permitting are/were installed or if accidents or unauthorized waste disposal have potentially cause soil or groundwater contamination.	Administrative	• YPEN • Ministry Development • Ministry of Finance • Decentralised administrations	Long-term	Medium	OP Environment of PP 2021 – 2027 **or** OP Transport Infrastructure, Environment and Sustainable Development of PP 2014-2020	A process to include Soil Certificate in land transfer actions
Participation to EU regulatory bodies such as the Common Forum on contaminated land and the Network for Industrial Co-ordinated Sustainable Land Management in Europe (NICOLE)	Administrative	YPEN	Short-term	Low	OP Transport Infrastructure, Environment and Sustainable Development of PP 2014-2020 **or** OP Environment of PP 2021 – 2027	Connection with more experienced counties on contaminated site management.

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10. Annex

10.1 National Stakeholders

Table 5 National stakeholders list

No.	Name	Surname	Affiliation	Email address
1	Stavroula	Pouli	YPEN	poulis@prv.ypeka.gr
2	Dimitris	Mpouzas	YPEN	mpouzasd@prv.ypeka.gr
3	Konstantina	Nika	YPEN	k.nika@prv.ypeka.gr
4	Anastasia	Arfanakou	YPEN	a.arfanakou@prv.ypeka.gr
5	George	Karvounis	Decentralized Administration of Attica	georgkarvounis@yahoo.gr
6	Alexandros	Liakopoulos	HSGME	aliakopoulos@igme.gr
7	Victor	Kavvadias	HAO-DEMETER	vkavvadias.kal@nagref.gr
8	Nymfodora	Papassiopi	NTUA	papasiop@metal.ntua.gr
9	Ariadni	Argyraki	UOA	argyraki@geol.uoa.gr
10	Olga	Kavoura	UNIWA	okavoura@uniwa.gr
11	Panagiotis	Skiadas	VIOHALCO	pskiadas@viohalco.com
	Leonidas	Kardaras	VIOHALCO	lkardaras@elval.com
12	Konstantinos	Konstantinou	SEV Business Council for Sustainable Development	Via LinkedIn
13	Antonis	Mountouris	HELPE	AMountouris@helpe.gr
14	Konstantinos	Tsolakidis	Griffon	tsolakidis@gmail.com
15	Giorgos	Konstantinopoulos	Lawyer	konstantinopoulosg@gmail.com
16	Christos	Vatseris	INTERGEO	christos.vatseris@intergeo.com
17	Stelios	Papadopoulos	INTERGEO	stelios@intergeo.com
18	Dimitris	Tiniakos	POLYECO	d.tiniakos@polyeco.gr
19	Pavlos	Nisianakis	ALA	p.nisianakis@ergastiria.gr
20	Alexandros	Katisamboulas	TITAN	alex@titan.gr
21	Stella	Alexopoulou	MINDEV	s.alexopoulou@gmail.com
	Nikos	Nikolaidis	TUC	ninikolaidis@isc.tuc.gr
	Marina	Pantazidou	NTUA	mpanta@central.ntua.gr

10.2 International experts

Table 6 International experts list

No.	Name	Surname	Affiliation	Email address
1	Rick	Parkman	AECOM, UK	rick.parkman@aecom.com
2	Johan	De Fraye	Signify, BE (Flanders)	johan.de.fraye@signify.com
3	Marco	Falconi	ISPRA, IT	marco.falconii@gmail.com
4	Ruben	Weeda	AECOM, NL	ruben.weeda@aecom.com
5	Tom	Bosma	Wageningen University, NL	tom1.bosma@wur.nl
6	Margot	De Cleen	Ministry of Infrastructure and Water Management, NL	margot.de.cleen@rws.nl
7	Sebastien	Leyrit	AECOM, FR	sebastien.leyrit@aecom.com
8	Henri	Halen	Ram-Ses, BE	h.halen@ram-ses.eu
9	Wouter	Gevaerts	Arcadis, BE	wouter.gevaerts@arcadis.com
10	Nicholas	Tymko	Honeywell, UK	nicholas.tymko@honeywell.com
11	Ole	Henseler	CDM Smith, DE	Ole.Henseler@cdmsmith.com
12	Harald	Weigand	Technishe Hochschule Mittelhessen, DE	harald.weigand@lse.thm.de
13	Johan	Ceenaeme	OVAM, BE	johan.ceenaeme@ovam.be
14	Olivier	Maurer	Golder, FR	Olivier_Maurer@golder.com
15	Valérie	Guérin	BRGM, FR	V.Guerin@brgm.fr
16	Panos	Panagos	EU/ESDAC	Panos.PANAGOS@ec.europa.eu
17	Theodoros	Toskos	Woodard & Curran, USA	theodoros.toskos@gmail.com
18	Olivier	Begard	Golder, FR	Olivier_Bagard@golder.com
19	Dietmar	Grabherr	Common Forum	dietmar.mueller-grabherr@umweltbundesamt.at
20	Hans	Slenders	ARCADIS, NL	hans.slenders@arcadis.com
21	Thomas	Albergaria	Instituto Superior de Engenharia do Porto, PO	jtva@isep.ipp.pt
22	Jordi	Boronat	MediTerra Environmental Consultants, SP	boronat@mediterra.es
23	Aurora	Santos Lopez	Universidad Complutense de Madrid, SP	aursan@quim.ucm.es

No.	Name	Surname	Affiliation	Email address
24	Nikos	Misyris	RSK, UK	nikolaos_misyris@yahoo.com
25	Panos	Panagos	Joint Research Centre (JRC), European Commission, EU	Panos.PANAGOS@ec.europa.eu
26	Nazzareno	Santilli	ISPRA, IT	nazzareno.santilli@isprambiente.it
27	Sebastien	Leyrit	AECOM, FR	sebastien.leyrit@aecom.com
28	Hans	Slenders	ARCADIS, NL	hans.slenders@arcadis.com
29	Frank	Swartjes	Institute for Public Health and the Environment, NL	frank.swartjes@rivm.nl

10.3 Questionnaire for international experts

1. Personal data		
Name:		
Title:		
Affiliation:		
Nature of duties/expertise:		
Experience (years):		
Country:		
Date:		
Notes:		
2. General		
2.1.	When was the contaminated soil framework approximately established in your country? (the year is enough)	
2.2.	Is this part of the waste management framework or it is a stand-alone framework?	Y / N / Not sure
2.3.	Does this framework also cover radionuclides?	Y / N / Not sure
2.4.	Does this framework also cover agrochemicals?	Y / N / Not sure
2.5.	Do you think that this framework satisfies your country needs?	Y / N / Not sure
2.6.	If not, is it too simple (S) or too complicated (C)?	S / C / Not sure
2.7.	If the framework is satisfying, do you think that this can be a good example for other EU countries as well (e.g., Greece)?	Y / N / Not sure
2.8.	What would you change of the above to make the framework more efficient?	

Notes		
3. Administration		
3.1.	Do the responsible authorities for applying the contaminated soil framework belong to national (N), regional (R) or local (L) administrative level in your country?	N / R / L / Not sure
3.2.	Is there any special department within this authority (or authorities) that manage these issues?	Y / N / Not sure
3.3.	If yes, does this authority (or authorities) also manage other environmental issues (e.g., permitting)?	Y / N / Not sure
3.4.	Is the capacity of this authority (or authorities) sufficient?	Y / N / Not sure
3.5.	Do national geological institutions have a significant role in the contaminated soil framework in your country? (If yes, please, provide any reference at the Notes below).	Y / N / Not sure
3.6.	Are there any digital tools currently used for contaminated sites management in your country? (Please, provide any reference at the Notes below).	Y / N / Not sure
3.7.	If yes, are they updated?	Y / N / Not sure

3.8.	Are these tools linked to the waste management framework, land uses etc.? (Please, provide any reference at the Notes below).	Y / N / Not sure
3.9.	What would you change of the above to make the framework more efficient?	
	Notes	
	4. Professionals	
4.1.	Is there a specific professional certification required for undertaking contaminated soil remediation (site characterization, remediation design, remediation and monitoring)? (Please, provide any reference at the Notes below).	Y / N / Not sure
4.2.	Has the tool of Environmental Site Assessment (ESA) (e.g., ASTM), or any other similar tool, been included in the contaminated soil framework of your country? (Please, provide any reference at the Notes below).	Y / N / Not sure
4.3.	Is this tool compulsory for certain circumstances (e.g., selling or transferring real estate)? (Please, provide any reference at the Notes below).	Y / N / Not sure

4.4.	What would you change of the above to make the framework more efficient?	
	Notes	
	5. Sampling methods	
5.1.	Are there specific soil and groundwater sampling guidelines within the contaminated soil framework in your country? (Please, provide any reference at the Notes below).	Y / N / Not sure
5.2.	What about soil gas?	Y / N / Not sure
5.3.	Is only a topsoil sampling procedure foreseen during site characterization?	Y / N / Not sure
5.4.	If not, is soil sampling from greater depth also foreseen?	Y / N / Not sure
5.5.	In any case, is this something determined based on site-specific conditions? (Please, provide any reference at the Notes below).	Y / N / Not sure
5.6.	Are there any instituted natural background concentration values across your country?	Y / N / Not sure

5.7.	If yes, is there a GIS database or a list?	Y / N / Not sure
5.8.	If there is a list, is this applicable throughout the country?	Y / N / Not sure
5.9.	If not, different administrative districts have different lists?	Y / N / Not sure
5.10.	If no instituted natural background concentration values exist are additional “uncontaminated” samples typically used for determining the natural background of each site?	Y / N / Not sure
5.11.	Are chemical analyses conducted on the bulk soil (B) sample or on a fine fraction (F) of it in your country?	B / F / Not sure
5.12.	If the fine fraction is analyzed, is the generic 2 mm used? (If other size is used, please, provide any reference at the Notes below).	Y / N / Not sure
5.13.	Are there specific soil pretreatment and analyses methods instituted? (If yes, please, provide any reference at the Notes below).	Y / N / Not sure
5.14.	If this is not the case, is this regulated case-by-case? (If yes, please, provide any reference at the Notes below).	Y / N / Not sure
5.15.	Are laboratories licensed of regulated? (By which authority? Please, provide any reference at the Notes below).	Y / N / Not sure
5.16.	What would you change of the above to make the framework more efficient?	

Notes

6. Screening values		
6.1.	A set of screening values (also called trigger values, action values, intervention values etc.) have been set in most of the countries to facilitate potential contaminated site characterization. Does the contaminated soil framework in your country include such values for soil and groundwater? (If yes, please, provide any reference at the Notes below).	Y / N / Not sure
6.2.	If yes, have these values determined based solely on scientific criteria (i.e., risk assessment methodology)?	Y / N / Not sure
6.3.	Are there additional screening values (e.g., soil gas, vapors) or further requirements (e.g., free phase contaminants removal) instituted in your country? (If yes, please, provide any reference at the Notes below).	Y / N / Not sure
6.4.	Are screening values instituted in a national (N) or a regional (R) level in your country?	N / R / Not sure
6.5.	If no screening values have been instituted, are they regulated on site-specific criteria? (If yes, please, provide which are the responsible authorities at the Notes below).	Y / N / Not sure
6.6.	For the evaluation of the impact of potential contaminated soil on aquifers, leaching tests are sometimes applied. Is this the practice in your country?	Y / N / Not sure
6.7.	Are there screening values for leachate as well? (If yes, please, provide any reference at the Notes below).	Y / N / Not sure
6.8.	The screening values that have been adopted are very different amongst different countries. Would you characterize the values	Y / N / Not sure

	adopted in your country as reasonable? (Could you give a specific example at Notes below?)	
6.9.	Does your country have different screening levels for the in-situ and the ex-situ contaminated soil management?	Y / N / Not sure
6.10.	Is contaminated soil in the latter case classified as waste? (If yes, please, provide any reference at the Notes below).	Y / N / Not sure
6.11.	If the concentration of a contaminant in soil and/or groundwater exceeds the screening value, does this mean further investigation (i.e., further sampling and risk assessment) (I) or definitely commencement of immediate remedial actions (R)?	I / R / Not sure
6.12.	Soil contamination typically demonstrates different characteristics amongst different locations. Are there correction methods of the screening values based on site-specific soil characteristics (e.g., organic matter content)? (If yes, please, provide any reference at the Notes below).	Y / N / Not sure
6.13.	Screening values have been calculated in most countries based on Human Health Risk Assessment methodology. Are there screening values calculated also based on other pathways in your country (e.g., soil-plant transfer pathway, groundwater-leachate pathway)?	Y / N / Not sure
6.14.	Is Ecological Risk Assessment also used? (If yes, please, provide any reference at the Notes below).	Y / N / Not sure
6.15.	Screening values calculation may also take into account different land uses (e.g., residential vs industrial). Is this the case in your country?	Y / N / Not sure
6.16.	If yes, which is the land uses categorization used in your country? (e.g., playgrounds (P), residential (R), parks/recreational facilities (P&R), industrial (I), commercial (C), protected areas (PA), other (O); if other land uses categories are also used, please, provide reference at the Notes below).	P / R / P&R / I / C / PA / O

6.17.	Is there a fixed acceptable risk level used developing the screening values, for cancer and non-cancers end-points? (If yes, please, provide any reference at the Notes below).	Y / N / Not sure
6.18.	Is there an option to develop an alternative screening value using a different risk level?	Y / N / Not sure
6.19.	If your country has already a screening values list, is the Risk Assessment methodology or any other methodology used for those contaminants that have not been listed yet? (Please, provide any reference at the Notes below).	Y / N / Not sure
6.20.	Ideally the screening value list should be an updated dynamic tool to include also emerging contaminants in a timely manner. Is there any specific procedure for updating this list in your country?	Y / N / Not sure
6.21.	Do you consider this method adequate and protective?	Y / N / Not sure
6.22.	Have emerging contaminants (e.g., PFAS) been already included in this list?	Y / N / Not sure
6.23.	What would you change of the above to make the framework more efficient?	
Notes		

7. Remediation targets		
7.1.	Remediation of contaminated sites should be designed based on specific remedial targets. Are these targets identical to the screening values in your country or are they site-specific?	Y / N / Not sure
7.2.	When the remedial targets are site-specific, are they determined based on the land use (L), the natural background levels (N) or on any other way (O)? (Please, provide any reference at the Notes below).	L / N / O
7.3.	When numerical remedial targets cannot be achieved are there any other way to proceed? (Please, provide any reference at the Notes below).	Y / N / Not sure
7.4.	In some countries different policy for historical (legacy) vs. new contaminated sites and operational vs. abandoned contaminated sites is applied. Is this also the case in your country?	Y / N / Not sure
7.5.	If yes, has this difference foreseen in the framework or it is just a standard practice? (Please, provide any reference at the Notes below).	Y / N / Not sure
7.6.	What would you change of the above to make the framework more efficient?	
Notes		

8. End of liability		
8.1.	Is there any standard practice for soil and groundwater monitoring after remediation of contaminated sites has been achieved? (Please, provide any reference at the Notes below).	Y / N / Not sure
8.2.	Is there a specific point that a contaminated site investigation considered completed? (Please, provide any reference at the Notes below).	Y / N / Not sure
8.3.	Is there a final certification issued to confirm the end of liability for remediated sites?	Y / N / Not sure
8.4.	Can this also include restriction for specific future land uses?	Y / N / Not sure
8.5.	What would you change of the above to make the framework more efficient?	
Notes		

9. Is there something that you consider important that was not covered above?
10. Based on your experience, which are the main best practices that should be adopted for an integrated contaminated soil framework and which the main lessons learned from the application of the framework in your country?

10.4 Screening values in Greece

Table 7 Soil screening values for wastewater sludge reuse (JMD 80568/4225/1991)

(mg/kg ξηράς ουσίας αντιπροσωπευτικού δείγματος του εδάφους με pH 6 έως 7, όπως ορίζεται στο παράρτημα ΙΙ Γ)

Παράμετροι	Οριακές τιμές (1)
Κάδμιο	1 έως 3
Χαλκός (2)	50 έως 140
Νικέλιο (2)	30 έως 75
Μόλυβδος	50 έως 300
Ψευδάργυρος (2)	150 έως 300
Υδράργυρος	1 έως 1,5
Χρώμιο	-

Table 8 Groundwater screening values for water of good chemical status (MD 1811/2011)

Ορίζονται τα ακόλουθα ποιοτικά πρότυπα υπόγειων υδάτων σύμφωνα με το Παράρτημα Ι της ΚΥΑ με αριθμ.: 39626/2208/Ε130/2009 (Β' 2075):

ΡΥΠΟΣ	ΠΟΙΟΤΙΚΑ ΠΡΟΤΥΠΑ
Νιτρικά Άλατα	50 mg/l
Δραστικές ουσίες φυτοφαρμάκων (συμπεριλαμβάνονται αντίστοιχοι μεταβολίτες, προϊόντα αποικοδόμησης και αντιδράσεων)[1]	0,1 μg/l 0,5 μg/l (συνολικό[2])

1.Ως «φυτοφάρμακα», νοούνται τα φυτοπροστατευτικά προϊόντα και τα βιοκτόνα, όπως ορίζονται αντίστοιχα στις σχετικές διατάξεις της κείμενης εθνικής και κοινοτικής νομοθεσίας.
2.Ως «συνολικό», νοείται το άθροισμα όλων των επιμέρους φυτοφαρμάκων που ανιχνεύονται και προσδιορίζονται ποσοτικά κατά τη διαδικασία παρακολούθησης, συμπεριλαμβανομένων σχετικών προϊόντων μεταβολισμού, προϊόντων αποδόμησης και προϊόντων αντίδρασης.

ΠΑΡΑΜΕΤΡΟΣ	ΑΝΩΤΕΡΗ ΑΠΟΔΕΚΤΗ ΤΙΜΗ
pH	6,50-9,50
Αγωγιμότητα	2500μS/cm
Αρσενικό	10 μg/l
Κάδμιο	5 μg/l
Μόλυβδος	25 μg/l
Υδράργυρος	1,0μg/l
Νικέλιο	20μg/l
Ολικό χρώμιο	50μg/l
Αργίλιο	200μg/l
Αμμώνιο	0,50 mg/l
Νιτρώδη	0,50mg/l

ΠΑΡΑΜΕΤΡΟΣ	**ΑΝΩΤΕΡΗ ΑΠΟΔΕΚΤΗ ΤΙΜΗ**
Χλωριούχα ιόντα	250 mg/l
Θειικά ιόντα	250 mg/l
Άθροισμα Τριχλωροαιθυλένιου και Τετραχλωροαιθυλένιου	10 μg/l

10.5 Results of the questionnaire survey with international experts

Table 9 General information for the contaminated soil framework

	BE-F	BE-W	NL	FR	IT	UK	DE	SP	PO	NJ
When was the contaminated soil framework approximately established in your country?	1995	2004	1987	1993	1997	1990	1998	2005	-	1983
Is this part of the waste management framework or it is a stand-alone framework?	Stand-alone	Stand-alone	Stand-alone	Related to IED	Stand-alone (in the same law, though)	Stand-alone	Stand-alone	Stand-alone/ Partly	There is no an official one – No Law	Waste
Does this framework also cover radionuclides? (Y/N)	N	N	Y	N	N	N	N	N	-	N
Does this framework also cover agrochemicals? (Y/N)	Y	Y	Y	Y	Y	Y	N	N	-	Y
Do you think that this framework satisfies your country needs? (Y/N)	Y	Y	Y	Y	Y	Y	Y	Y	N	Y
If the framework is satisfying, do you think that this can be a good example for other EU countries as well (e.g., Greece)? (Y/N)	Y	Y	Y	Y	Y	Y	Y	Y	-	Y

BE-F: Belgium Flanders, BE-W: Belgium Walloon, NL: the Netherlands, FR: France, IT: Italy, UK: United Kingdom, DE: Germany, PO: Portugal, SP: Spain, NJ: New Jersey (USA).

Table 10 Information regarding administration

	BE-F	BE-W	NL	FR	IT	UK	DE	SP	PO	NJ
Do the responsible authorities for applying the contaminated soil framework belong to national (N), regional (R) or local (L) administrative level in your country?	R	R	N/R/L	N/R	N/R/L	N/R/L	L	R	N	N/R
Is there any special department within this authority (or authorities) that manage these issues?	Y	Y	N	Y	Y	Y	Y	Y	Y	Y
If yes, does this authority (or authorities) also manage other environmental issues (e.g., permitting)?	Y	Y	Y	Y	Y	Y	N	Y	Y	Y
Is the capacity of this authority (or authorities) sufficient?	Y	Y	Y	Y	Y	N	-	N	N	Y
Do national geological institutions have a significant role in the contaminated soil framework in your country?	N	N	Y/TNO	Y/ BRGM	Y/ ISPRA	N	N	Y	-	Y/ USGS
Are there any digital tools currently used for contaminated sites management in your country?	Y	Y	Y	Y	Under constru ction	Y	Y	N	Y	Y
If yes, are they updated?	Y	Y	Y	Y	-	Y	Y	N	-	Y
Are these tools linked to the waste management framework, land uses etc.?	Y/Reuse of excavated soil	Y/Old waste deposits	N	N/Indir ectly	N	Y	N	Y	-	Y

Table 11 Information regarding professionals involved

	BE-F	BE-W	NL	FR	IT	UK	DE	SP	PO	NJ
Is there a specific professional certification required for undertaking contaminated soil remediation (site characterization, remediation design, remediation and monitoring)?	Y	Y	Y	Y	Y	N	Y	N	-	Y
Has the tool of Environmental Site Assessment (ESA) (e.g., ASTM), or any other similar tool, been included in the contaminated soil framework of your country?	Y	Y	Y	Y	Y	N	N	N	-	Y
Is this tool compulsory for certain circumstances (e.g., selling or transferring real estate)?	Y	Y	Y	Y	N	N	N	N	-	Y

BE-F: Belgium Flanders, BE-W: Belgium Walloon, NL: the Netherlands, FR: France, IT: Italy, UK: United Kingdom, DE: Germany, PO: Portugal, SP: Spain, NJ: New Jersey (USA).

Table 12 Information regarding sampling

	BE-F	BE-W	NL	FR	IT	UK	DE	SP	PO	NJ
Are there specific soil and groundwater sampling guidelines within the contaminated soil framework in your country?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
What about soil gas?	Y	Y	Y	Y	Y	Y	Y	Y	-	Y
Is only a topsoil sampling procedure foreseen during site characterization?	N	N	N	N	N	N	N	N	N	N
If not, is soil sampling from greater depth also foreseen?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
In any case, is this something determined based on site-specific conditions?	Y	Y	Y	Y	Y	Y	-	Y	-	Y
Are there any instituted natural background concentration values across your country?	Y	Y	Y	Y	Y	Y	Y	Y	N	N
If yes, is there a GIS database or a list?	Y	Y	Y	Y	Y	Y	Y	N	-	N
If there is a list, is this applicable throughout the country?	N/ Regional	N/ Regional	Y	-	N	Y	N	N	-	N
If not, different administrative districts have different lists?	Y/ Regional	Y/ Regional	N	-	Y	Y	Y	Y	-	Y
If no instituted natural background concentration values exist are additional "uncontaminated" samples typically used for determining the natural background of each site?	N	Y/ sometimes	-	Y	-	Y	-	N	-	Y
Are chemical analyses conducted on the bulk soil (B) sample or on a fine fraction (F) of it in your country?	B	B	F	F/B	F	F	F	B/F	-	B
If the fine fraction is analyzed, is the generic 2 mm used?	-	-	Y	Y	Y	Y	Y	N	-	-
Are there specific soil pretreatment and analyses methods instituted?	Y	Y	Y	N/Only some parameters	N/site specific	Y	Y	Y	N	N

If this is not the case, is this regulated case-by-case?	-	-	-	Y	Y	-	-	N	-	N
Are laboratories licensed or regulated?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

BE-F: Belgium Flanders, BE-W: Belgium Walloon, NL: the Netherlands, FR: France, IT: Italy, UK: United Kingdom, DE: Germany, PO: Portugal, SP: Spain, NJ: New Jersey (USA).

Table 13 Information regarding screening values

	BE-F	BE-W	NL	FR	IT	UK	DE	SP	PO	NJ
Does the contaminated soil framework in your country include such values for soil and groundwater?	Y	Y	Y	N (yes for GW)	Y	Y	Y	Y	Y	Y
Are there additional screening values (e.g., soil gas, vapors) or further requirements (e.g., free phase contaminants removal) instituted in your country?	Y	Y	Y	-	Y	Y	Y	Y	N	Y
Are screening values instituted in a national (N) or a regional (R) level in your country?	R	R	N	-	N	N	N	N/R	N	N/R
If no screening values have been instituted, are they regulated on site-specific criteria?	-	-	-	Y	-	-	-	Y	-	-
For the evaluation of the impact of potential contaminated soil on aquifers, leaching tests are sometimes applied. Is this the practice in your country?	Y	Y	Y	Y/ sometimes	Y	Y	Y	N	-	Y
Are there screening values for leachate as well?	Y	Y	-	N	N	Y	Y	N	-	Y
Would you characterize the values adopted in your country as reasonable?	Y	Y	Y	-	Y	Y	-	N	Y	Y
Does your country have different screening levels for the in-situ and the ex-situ contaminated soil management?	Y	N	Y	-	N	N	N	Y	N	N
Is contaminated soil in the latter case classified as waste?	N	Y	N	Y	Y	Y	Y	Y	-	N
If the concentration of a contaminant in soil and/or groundwater exceeds the screening value, does this mean further investigation (i.e., further sampling and	I&R (depends on historical	I&R (depends on historical	I&R (depends on historical	-	I	I	I	I&R	I	I&R

	BE-F	BE-W	NL	FR	IT	UK	DE	SP	PO	NJ
risk assessment) (I) or definitely commencement of immediate remedial actions (R)?	or new contamination)	or new contamination)	or new contamination)							
Are there correction methods of the screening values based on site-specific soil characteristics (e.g., organic matter content)?	Y	N	Y	-	N	Y	N	N	-	Y
Screening values have been calculated in most countries based on Human Health Risk Assessment methodology. Are there screening values calculated also based on other pathways in your country (e.g., soil-plant transfer pathway, groundwater-leachate pathway)?	Y	Y	Y	-	N	Y	Y	N	-	Y
Is Ecological Risk Assessment also used?	Y	Y	Y	Y but limited	N	Y	-	Y	-	Y
Screening values calculation may also take into account different land uses (e.g., residential vs industrial). Is this the case in your country?	Y	Y	Y	-	Y	Y	Y	Y	Y	Y
If yes, which is the land uses categorization used in your country?	-Nature -Agric/re -Resid/tial -Recr/tional -Industrial	-Nature -Agric/re -Resid/tial -Recr/tional -Industrial	-Allotment gardens -Nature areas -Agriculture, -Living with a garden - Places where children play -Green with nature -Other including industry and infrast/re	-	-Green areas and Res/tial -Ind/rial and com/cial	-Playg/nd -Resid/tial -Recr/nal -Industrial -Com/cial -Prot/ted area	-Playg/nd -Resid/tial -Agric/re -Industrial	-Resid/tial -Industrial/ Com/cial - Agric/re / Forest	-Resid/tial -Industrial/Com/cial - Agric/re	-Resid/tial -Com/cial -Industrial
Is there a fixed acceptable risk level used developing the screening values, for cancer and non-cancers end-points?	Y	Y	-	Y	-	Y	-	N	-	Y

	BE-F	BE-W	NL	FR	IT	UK	DE	SP	PO	NJ
Is there an option to develop an alternative screening value using a different risk level?	-	-	-	N	-	Y	-	Y	-	N
If your country has already a screening values list, is the Risk Assessment methodology or any other methodology used for those contaminants that have not been listed yet?	Y	Y	Y	-	N	Y	-	Y	-	Y
Ideally the screening value list should be an updated dynamic tool to include also emerging contaminants in a timely manner. Is there any specific procedure for updating this list in your country?	Y	Y	Y	-	Y	Y	In terms of updates of the ordinance	N	N	Y
Do you consider this method adequate and protective?	Y	Y	Y	-	Y	Y	Y	N	-	Y
Have emerging contaminants (e.g., PFAS) been already included in this list?	Y	Y	Y	N	N	Y	N	N	N	N for soil

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Table 14 Information regarding remediation targets and monitoring

	BE-F	BE-W	NL	FR	IT	UK	DE	SP	PO	NJ
Remediation of contaminated sites should be designed based on specific remedial targets. Are these targets identical to the screening values in your country or are they site-specific?	Screening values for new contamination Site specific for historical sites	Screening values for new contamination Site specific for historical sites	Site specific	Site specific	Site specific	Site specific	Site specific	-	-	Identical or site specific
When the remedial targets are site-specific, are they determined based on the land use (L), the natural background levels (N) or on any other way (O)?	L/N/O use of a multicriteria-analysis for historical sites	L/N/O use of a multicriteria-analysis for historical sites	L	L/N/O	L	L	L	L	L	O
When numerical remedial targets cannot be achieved are there any other way to proceed?	Y	Y	Y	Y	Y	Y	-	Y	-	Y
In some countries different policy for historical (legacy) vs. new contaminated sites and operational vs. abandoned contaminated sites is applied. Is this also the case in your country?	Y	Y	Y	N	Y	Y	N	Y	Y	Y
If yes, has this difference foreseen in the framework (F) or it is just a standard practice (SP)?	F	F	F	-	F	F	-	-	-	SP

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Table 15 Information regarding liability

	BE-F	BE-W	NL	FR	IT	UK	DE	SP	PO	NJ
Is there any standard practice for soil and groundwater monitoring after remediation of contaminated sites has been achieved?	Y	Y	Y	Y	N (site-specific)	Y	Y	Y	-	Y
Is there a specific point that a contaminated site investigation considered completed?	Y	Y	Y	Y	N	Y	Y	Y	-	Y
Is there a final certification issued to confirm the end of liability for remediated sites?	Y	Y	Y	Y	Y	N	Y	Y	-	Y
Can this also include restriction for specific future land uses?	Y	Y	Y	Y	Y	Y	Y	Y	-	Y

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