

PETER FISK ASSOCIATES LTD

Chemical Risk Assessment

A Manual for REACH

WILEY

Table of Contents

[Title Page](#)

[Copyright](#)

[List of Figures](#)

[List of Tables](#)

[List of Contributors](#)

[Preface](#)

[How to Use This Book](#)

[What is REACH Trying to Achieve?](#)

[How Can This Book Help You Understand REACH and Comply With It?](#)

[How This Book is Set Out](#)

[How Different Types of Reader Might Use This Book](#)

[Chapter 1: Introduction: Policy and Scientific Context of Chemicals Risk and Risk Management](#)

[1.1 Overview of the Risk Assessment of Chemical Substances](#)

[1.2 Chemical Hazard and Risk Programmes](#)

[References](#)

Chapter 2: Roles and Responsibilities in REACH

2.1 The Structure and Responsibilities of the Authorities

2.2 Forum Enforcement Project – REACH-ENFORCE-1

2.3 Future Aims of the HSE (an Example of a ECHA-Related Authority Acting in the UK)

2.4 What Does REACH Require as Regards Enforcement?

2.5 What Powers Do Enforcing Authorities Have?

2.6 The Responsibilities of Industry

2.7 Communication in the Supply Chain and with Regulators

References

Chapter 3: Control of Chemicals – Legislative and Policy Context

3.1 How EU Chemical Legislation Evolved

3.2 Air Quality Regulations

3.3 Water Framework Directive

3.4 Carcinogens at Work

3.5 Cosmetics

3.6 Biocidal and Plant Protection Products

3.7 Nationally (UK)-Implemented Legislative and Policy Frameworks

3.8 UK Environmental Regulation

References

Chapter 4: Identification of Substances for REACH – Practicalities

4.1 Substance Identification

4.2 Sameness

4.3 Essentially-Pure Substances

4.4 Approaching the Substance Data Set –

Understanding the Substance

References

Chapter 5: Physico-Chemical Properties for REACH – Purpose and Practicalities

5.1 Physico-Chemical Properties

5.2 Strategy in Physico-Chemical Testing Plans

5.3 Difficult-to-Measure Substances

5.4 Hazardous Physico-Chemical Data

5.5 Relationship between Physico-Chemical Tests

5.6 Application of Physico-Chemical Test Data

5.7 Can Physico-Chemical Tests Be Omitted?

5.8 (Q)SAR and Physico-Chemical Tests

5.9 (Quantitative) Structure-Activity Relationships

((Q)SAR).

References

Chapter 6: Assessing and Documenting the Intrinsic Properties of Substances in REACH

6.1 Introduction to REACH Data Requirements

6.2 Hazards

[6.3 PBT](#)

[6.4 Equivalent Concern](#)

[6.5 Test Proposal Rule](#)

[6.6 Availability of Existing Data and Rights of Access](#)

[6.7 Data Reliability](#)

[6.8 Data Gaps – Options for Surrogate Data for Description of Hazard and Risk – Including Read-Across](#)

[6.9 Read-Across](#)

[References](#)

[Chapter 7: Assessing Environmental Properties Data](#)

[7.1 Environmental Properties Data](#)

[7.2 Environmental Fate](#)

[7.3 Ecotoxicology](#)

[7.4 Turning Intrinsic Properties into ‘No-Effect’ Concentrations](#)

[References](#)

[Chapter 8: Environmental Exposure](#)

[8.1 Substance Identity and Approach to Exposure Assessment](#)

[8.2 Characterising Releases](#)

[8.3 Evaluating Releases](#)

[8.4 Documentation for the Registration](#)

[8.5 Local Scale Releases](#)

[8.6 Exposure Assessment – Models or Measurements?](#)

[8.7 Water](#)

[8.8 Soil](#)

[8.9 Air](#)

[8.10 The Food Chain](#)

[References](#)

[Chapter 9: Assessing the Hazards to Human Health from Chemicals](#)

[9.1 Mammalian Toxicology](#)

[9.2 Exposure Routes and Local/Systemic Effect Types](#)

[9.3 Acute and Chronic Effects](#)

[9.4 Influences on Toxicity](#)

[9.5 How Chemicals Cause Harm](#)

[9.6 Toxicokinetics](#)

[9.7 Toxicological Testing](#)

[9.8 Genetic Toxicology](#)

[9.9 Turning Intrinsic Properties into ‘No-Effect’ Levels](#)

[References](#)

[Chapter 10: Human Exposure to Chemicals](#)

[10.1 Exposure](#)

[10.2 Exposure to Chemicals in the Workplace](#)

[10.3 Risk Management Measures](#)

[10.4 Consumer Exposure](#)

[10.5 Indirect Exposure \(Humans via the Environment\)](#)

[10.6 Risk due to Physico-Chemical Hazard](#)
[References](#)

[Chapter 11: Managing Hazard and Risk](#)

[11.1 Characterisation, Assessment and Management of Risk](#)

[11.2 What Is 'Risk' under REACH?](#)

[11.3 What Are Risk Reduction and Risk Management?](#)

[11.4 Where Safe Levels Cannot Be Established – CMRs and PBTs \(and vPvBs\)](#)

[11.5 Responsibilities in the Supply Chain – Introduction](#)

[11.6 Regulatory Requirements](#)

[11.7 Guidance](#)

[11.8 The Extended Safety Data Sheet](#)

[11.9 When Communication Is Difficult](#)

[11.10 Exposure Measurements in the Workplace – Occupational Hygiene](#)

[11.11 Control of Environmental Releases – Abatement Techniques](#)

[11.12 Effectiveness of Risk Reduction – Risk Management Options](#)

[11.13 Types of Risk Management – in the Workplace](#)

[11.14 Types of Risk Management – for the Environment](#)

[11.15 Consumer Protection](#)

References

Chapter 12: Avoiding the Use of Hazardous Substances: Substitution and Alternatives

12.1 Properties That Contribute to Hazard and Risk for Human Health and the Environment

12.2 Assessment of Alternatives – Replacement of Use

12.3 What Is an Alternative?

12.4 Analysis of Alternatives

12.5 Substitution – Replacement with Substances of Reduced Hazard

12.6 Sustainability and Green Chemistry

12.7 What Is Green Chemistry in Practice? Principles and Concepts

References

Chapter 13: Hazards, Risks and Impacts—The Development and Application of Frameworks for the Assessment of Risk

13.1 Policy Context – Risk, Hazard and the Precautionary Principle

13.2 From Hazards to Risks to Impacts – Understanding the Implications of Exposure to Dangerous Chemicals

13.3 Risk Management Options – REACH Processes for Control of Hazardous and Risky Substances

References

Chapter 14: Socio-Economic Analysis in REACH

14.1 Background - the Need for and Development of Socio-Economic Analysis in the Regulation of Chemicals

14.2 What Is SEA and Why Is It Needed and Applied in REACH?

14.3 Role, Purpose and Performing an SEA in REACH

14.4 The Difficulties of Moving from Risks to Impacts

14.5 Regulatory Processes - Who Are the Decision Makers and What Are Their Roles?

14.6 The Wider Benefits of Performing an SEA

14.7 Developments and the Future

References

Chapter 15: REACH: How It Is Working and May Develop

15.1 Introduction

15.2 Experiences and Observations

15.3 Basics of Successful Submission

15.4 Testing, Prediction and Read-Across

15.5 The Community Rolling Action Plan

15.6 EU and National Responsibilities

15.7 Risk-Based Regulation and the Precautionary Approach

[15.8 Higher Tiers of Assessment](#)
[15.9 REACH Developments](#)
[15.10 Rationalising Overlap with Other Legislation](#)
[15.11 Scientific Developments and Challenges](#)
[15.12 Impact on Industry](#)
[15.13 ECHA Evaluation Report 2012](#)
[References](#)
[Web Reference](#)

[Chapter 16: Resources, Official Guidance, Further Reading and Centres of Expertise](#)

[16.1 Introduction to Resources and Organisations](#)
[16.2 Facts and Statistics](#)
[References](#)
[Web References](#)

[Appendix A: Substance Classification and Labelling under REACH](#)

[A.1 Important Differences](#)
[A.2 CLP Symbols](#)
[A.3 Specific Target Organ Systemic Toxicity – Single Exposure](#)
[A.4 Harmonised Classification and Labelling](#)
[References](#)

[Appendix B: Further Discussion of Substance Identification and Sameness](#)

[B.1 Substance Identifiers](#)

- [B.2 Substance Analysis](#)
- [B.3 Straightforward Organic Substances](#)
- [B.4 Complex Organic Substances](#)
- [B.5 Inorganic Substances](#)
- [B.6 Analysis of UVCBs](#)

[Appendix C: Tools for REACH Compliance: IUCLID, Chesar and In-House Databases](#)

- [C.1 International Uniform Chemical Information
Database \(IUCLID\)](#)
- [C.2 IUCLID and PPORDs](#)
- [C.3 Submission of PPORD to ECHA](#)
- [C.4 Chesar](#)
- [C.5 Advice on Storing of Data Outside of the
IUCLID](#)
- [Reference](#)

[Appendix D: Glossary](#)

- [Regulations and Background
Technical](#)

[Index](#)

Chemical Risk Assessment: A Manual for REACH

Peter Fisk Associates Ltd

WILEY

V V A L L A

This edition first published 2014

© 2014 John Wiley and Sons Ltd

Registered office

John Wiley & Sons Ltd, The Atrium, Southern Gate,
Chichester, West Sussex, PO19 8SQ, United Kingdom

For details of our global editorial offices, for customer services and for information about how to apply for permission to reuse the copyright material in this book please see our website at www.wiley.com.

The right of the author to be identified as the author of this work has been asserted in accordance with the Copyright, Designs and Patents Act 1988.

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, except as permitted by the UK Copyright, Designs and Patents Act 1988, without the prior permission of the publisher.

Wiley also publishes its books in a variety of electronic formats. Some content that appears in print may not be available in electronic books.

Designations used by companies to distinguish their products are often claimed as trademarks. All brand names and product names used in this book are trade names, service marks, trademarks or registered trademarks of their respective owners. The publisher is not associated with any product or vendor mentioned in this book. This publication is designed to provide accurate and authoritative information in regard to the subject matter covered. It is sold on the understanding that the publisher is not engaged in rendering professional services. If professional advice or other expert assistance is required, the services of a competent professional should be sought.

Limit of Liability/Disclaimer of Warranty: While the publisher and author have used their best efforts in preparing this book, they make no representations or warranties with respect to the accuracy or completeness of the contents of this book and specifically disclaim any implied warranties of merchantability or fitness for a particular purpose. It is sold on the understanding that the publisher is not engaged in rendering professional services and neither the publisher nor the author shall be liable for damages arising herefrom. If professional advice or other expert assistance is required, the services of a competent professional should be sought.

The advice and strategies contained herein may not be suitable for every situation. In view of ongoing research, equipment modifications, changes in governmental regulations, and the constant flow of information relating to the use of experimental reagents, equipment, and devices, the reader is urged to review and evaluate the information provided in the package insert or instructions for each chemical, piece of equipment, reagent, or device for, among other things, any changes in the instructions or indication of usage and for added warnings and precautions. The fact that an organization or Website is referred to in this work as a citation and/or a potential source of further information does not mean that the author or the publisher endorses the information the organization or Website may provide or recommendations it may make. Further, readers should be aware that Internet Websites listed in this work may have changed or disappeared between when this work was written and when it is read. No warranty may be created or extended by any promotional statements for this work. Neither the publisher nor the author shall be liable for any damages arising herefrom.

Library of Congress Cataloging-in-Publication Data

Chemical risk assessment : a manual for REACH / Peter Fisk Associates Ltd.

pages cm

Includes index.

ISBN 978-1-119-95368-5 (cloth)

1. Chemicals-- Law and legislation-- European Union countries. 2. Chemicals-- Safety regulations-- European Union countries. 3. Hazardous substances-- Law and legislation-- European Union countries. I. Peter Fisk Associates.

KJE6011.C44 2014

363.17'91-- dc23

2013028620

List of Figures

Figure 1.1 REACH Overview

Figure 1.2 Flow Diagram of SVHC, Placing on ANNEX XIV, Authorisation and Review Process

Figure 1.3 Flow Diagram of CoRAP, ANNEX XV Dossier and Placing on ANNEX XVII, Restriction Process

Figure 1.4 Overview of Substance Use Patterns

Figure 7.1 Flow Chart Illustrating the Processes in a Chemical Safety Assessment

Figure 12.1 Overview of Substance Substitution

Figure 13.1 A Simplified Risk Assessment Framework, with Areas of Uncertainty

Figure 13.2 A Simple Illustration of Source, Pathway, Receptor and Impact

Figure 14.1 Illustration of the Main Processes and Steps in an Authorisation SEA (adapted from Nickel Institute, 2012)

Figure 14.2 Total Economic Value

Figure 14.3 Illustration of a Possible Authorisation Timeline with Actions for Applicant, Regulator and Interested/Third Party

Figure B.1 Decision Tree for a Straightforward Organic Substance

Figure C.1 Overview of Assessment Workflow of Chesar. (Source:

<http://chesar.echa.europa.eu/web/chesar/support/manuals-tutorials>, last accessed 5 August 2013.)

List of Tables

Table 1.1 Relation to REACH of chemical risk management

Table 1.2 Examples of regulatory systems for hazardous chemicals outside EU

Table 1.3 Definitions of the Klimisch reliability codes

Table 2.1 Regulatory authorities in the United Kingdom

Table 2.2 Descriptor list for sectors of use (SU)

Table 2.3 Descriptor list for chemical product categories (PC)

Table 2.4 Descriptor list for process categories (PROC)

Table 2.5 Descriptor list for environmental release categories (ERC)

Table 2.6 Descriptor list for substances in articles (AC)

Table 3.1 Relation to REACH of chemical risk management

Table 5.1 Discussion of the use of (Q)SAR for different endpoints

Table 5.2 Examples of common predictive methods in different endpoints

Table 6.1 Reach data requirements

Table 6.2 Key terms

Table 6.3 Example of read-across

Table 7.1 Studies required for each REACH Annex level

Table 8.1 Useful sources of published information for environmental exposure

Table 8.2 Definitions of some terms relevant to modelling or measuring exposure

Table 9.1 Definitions of types of toxicity relevant in REACH and CLP

[Table 9.2](#) Studies required for each REACH Annex level

[Table 9.3](#) $\{it\ In\ vivo\}$ testing in REACH

[Table 11.1](#) Example problems with DU communication with possible solutions

[Table 11.2](#) Summary of typical efficacies of possible abatement measures

[Table 13.1](#) Environmental impact of chemical contaminants

[Table 13.2](#) How REACH was implemented

[Table 14.1](#) Actors and roles for the SEA

[Table 16.1](#) Guidance on general needs and registration of specific chemical types

[Table 16.2](#) Guidance and resources on property data

[Table 16.3](#) Guidance and resources on hazard assessment, PBT and classification and labelling

[Table 16.4](#) Guidance and resources on exposure and risk

[Table 16.5](#) Guidance and resources on roles and responsibilities of parties in a supply chain, and communication between them

[Table 16.6](#) Guidance and resources on interaction between registrants

[Table 16.7](#) Guidance and resources on submitting the registration within REACH-IT

[Table 16.8](#) Guidance and resources post-registration

[Table A.1](#) Generic cut-off values. There are some endpoints with different concentration cut-off values

[Table A.2](#) CLP symbols

[Table A.3](#) Organic peroxides

[Table A.4](#) Oxidising gas

[Table A.5](#) Oxidising liquid

[Table A.6](#) Oxidising solid

[Table A.7](#) Corrosive to metals

<u>Table A.8</u>	Flammable gas
<u>Table A.9</u>	Flammable liquid
<u>Table A.10</u>	Flammable solid
<u>Table A.11</u>	Acute oral toxicity
<u>Table A.12</u>	Acute toxicity dermal
<u>Table A.13</u>	Acute toxicity by the inhalation of a dust or mist
<u>Table A.14</u>	Acute toxicity inhalation of a vapour
<u>Table A.15</u>	Acute toxicity inhalation of a gas
<u>Table A.16</u>	Aspiration hazards
<u>Table A.17</u>	Skin corrosion/irritation
<u>Table A.18</u>	Eye irritation
<u>Table A.19</u>	Respiratory sensitisation
<u>Table A.20</u>	Skin sensitisation
<u>Table A.21</u>	Specific target systemic toxicity\emdash repeated exposure (STOT RE)
<u>Table A.22</u>	Specific target organ systemic toxicity\emdash single exposure (STOT SE)
<u>Table A.23</u>	Carcinogenic substances
<u>Table A.24</u>	Substances toxic for reproduction
<u>Table A.25</u>	Mutagenic substances
<u>Table A.26</u>	Effect during lactation
<u>Table A.27</u>	Aquatic environment
<u>Table A.28</u>	Criteria for the aquatic environment chronic category
<u>Table A.29</u>	Ozone
<u>Table B.1</u>	The subdivision of EC numbers
<u>Table B.2</u>	Generic cut-off values

List of Contributors

Peter Fisk Associates includes the following staff members who have contributed to this book:

Peter Fisk—Managing Director
Oliver Warwick—Project Manager
Louise McLaughlin—Director
Rosalind Wildey—Director

Principal Consultants:

Helen Disley
Stephen Summerfield
Andrew Girling
Laura Robinson
Helen Barnes

Senior Consultants:

David Akinosho
Lucy Wilmot
Ola Dosunmu
Elina Kansikas
Sam Fisk

Consultants:

Gillian Federici

Additional Contributors:

Michel De Poortere by kind permission of Siletz sprl
Rohit Mistry by kind permission of eftec

Preface

How to Use This Book

This book about REACH is a handbook, providing practical advice aimed at the level of consideration of strategy, technical insights, and commercial realities. It does not intend to reproduce or summarise the official detailed guidance – of which there are many thousands of pages! Although that level of detail and amount of guidance is necessary, the abundance of guidance can in itself create problems. It is not possible for a single individual to absorb and understand such a huge amount of information, especially considering the diversity of issues concerning chemical properties, hazards, and risks. This book can help you understand REACH, whatever your responsibilities or interest in it.

What this handbook does do is provide a broad overview, but one that includes the details that the authors have found necessary in their experience in practice of all aspects of the REACH Regulation. The purpose of the book is to explain how REACH works, with an emphasis on an overall understanding and explanation of responsibilities, in order to help you to set strategy and priorities.

What is REACH Trying to Achieve?

REACH has many objectives, contained within what is one of the most comprehensive pieces of legislation ever enacted in the European Union. Its major objectives include:

- bringing all REACH-relevant substances, regardless of whether they have been previously assessed or not, into a common registration and evaluation process;
- moving the burden of responsibility more clearly into the hands of industry;
- placing priority of effort onto substances of very high concern;
- improving communication in the supply chain;
- encouraging the sharing of data between data owners;
- widening the availability of data on substances;
- removing unacceptably hazardous substances from the market.

How Can This Book Help You Understand REACH and Comply With It?

This book will help you to understand your part in REACH:

- **Policy maker** – business strategy in the chemicals industry in the European Union requires an awareness of the costs and impacts of REACH. This involves understanding the current and potential status of substances under REACH, and also how other related legislation may be affected.
- **Business manager** – if you are developing a substance or group of substances you will have to understand REACH, to ensure that appropriate and timely actions on substance are taken.
- **Scientist in R&D** – it is not possible to maintain the view that R&D can be seen as separate from acceptability in commercial and regulatory terms – you need to be informed about REACH and its impacts on substances with potentially hazardous properties.
- **Regulator** – if you are not working on REACH, then this book can help you understand how your work interfaces with REACH.
- **Specialist or Consultant** – you need to know where your speciality fits into the bigger picture of REACH.

How This Book is Set Out

Chapter Summary

Chapter	Title	Summary of contents
1	Introduction – policy and scientific context of chemicals risk and risk management.	An overview of REACH and other regulations, describing the purposes of hazard and risk assessment.
2	Roles and responsibilities in REACH.	What the supply chain and the various regulatory bodies must do.
3	Control of chemicals – legislative and policy context.	What REACH requires and where it fits in a global context.
4	Identification of substances for REACH – practicalities.	An introduction to a key step in establishing what needs to be done in REACH compliance.
5	Physico-chemical properties for REACH – purpose and practicalities.	These properties need to be understood before moving on to toxicology and environmental effects.
6	Assessing and documenting the intrinsic properties of substances in REACH.	Overview of REACH requirements in respect of the basics of how hazards and risks are assessed.
7	Overview of the assessment of the risks to the environment from chemicals.	Detail of REACH requirements in respect of the basics of how environmental hazards are assessed.
8	Environmental exposure.	Detail of REACH requirements in respect of the basics of how environmental exposures and risks are assessed.
9	Assessing the hazards to human health from chemicals.	Detail of REACH requirements in respect of the basics of how hazards are assessed.
10	Human exposure to chemicals.	Detail of REACH requirements in respect of the basics of how environmental exposures and risks are assessed.
11	Managing hazard and risk.	How to deal with management of hazard in respect of classification and labelling, and

		controlling exposure to substances to the level necessary to establish safety.
12	Avoiding the use of hazardous substances: substitution and alternatives.	Overview of how to find viable alternatives to hazardous substances, in terms of new substances or technologies.
13	Hazards, risks and impacts – the development and application of frameworks for the assessment of risk.	Risk management options: how can risk be managed, appraisal of methods to control risk and the time and costs needed for implementation of control measures.
14	Socio-economic analysis in REACH.	The need for assessing the costs and benefits of control measures using socio-economic analysis as a tool in the context of the authorisation, restriction and risk management option appraisal processes of REACH.
15	REACH: how it is working and may develop.	What has worked well, what is failing. Future developments – neither science nor regulations are static.
16	Resources, official guidance, further reading and centres of expertise.	Reference sources for further information focussing on the technical resources.
Appendix A	Substance Classification and labelling under REACH.	The new CPL Regulations.
Appendix B	Further discussion of substance identification and sameness.	The importance of substance identification as a first technical step.
Appendix C	Tools for REACH compliance: IUCLID, Chesar and in-house databases.	Some practical advice for registrants.
Appendix D	Glossary	—

How Different Types of Reader Might Use This Book

The contents cover a wide range of needs. The following are suggestions for how to make the most of the content.

	Chapters
Strategy for REACH	1, 2, 3, 4, 11, 13-15
Substance assessment and registration	1, 4-10
Authorisation concerns	1, 13, 14
Substance substitution	12, 13

Chapter 1

Introduction: Policy and Scientific Context of Chemicals Risk and Risk Management

This chapter acts as a foundation of understanding for the rest of the book. It introduces the regulatory systems that demand the evaluation of risk for chemical substances that are intended to be used and placed on the market. It sets out the development of risk assessment in the European, global and national contexts. This chapter also explains the key concepts of hazard and exposure. Hazard is defined as the inherent properties of a substance that may make it harmful – flammability, toxicity and so on. Exposure refers to the ways in which humans and the environment come into contact with substances. The reasons for bringing together hazard and exposure in order to understand risk are explained.

The focus of this book is the REACH Regulation (most often referred to just as ‘REACH’), as this is the main regulatory driver for the risk assessment of chemical substances in the European Union. REACH (**R**egistration, **E**valuation, **A**uthorisation & restriction of **C**hemicals), however, should be viewed in the context of other legislation that is either directly or indirectly connected to the REACH Regulation. With this in mind, the later sections of this chapter include consideration of United Kingdom legislation on chemicals,

including worker and environmental protection. These sections are intended to serve as examples of how REACH is connected to prior legislation and how compliance with REACH works with such legislative regimes at national level.

The purpose of this book is to set out in a simple and concise way how to assess and manage the risks of chemicals to humans and the environment. This is done within the context of the main legislation that applies to the safety of the manufacture and use of chemicals in the European Union (EU) – the REACH Regulation. It is not the intention to give detailed guidance on each aspect of risk assessment or in depth assessment of specific aspects of REACH, but rather to explain the main aspects of chemical risk assessment and the processes that are applied, so that each aspect can be understood within the context of REACH. This book should act as a handbook, so the reader/user can find out about specific aspects of the process and technical elements in sufficient detail to understand where and how they fit in the risk assessment of chemicals, and where to look for more detailed information.

Legislation on chemicals has specific purposes and is aimed at control of particular processes or aspects of the manufacture, use, reuse and disposal of chemicals. In addition, some legislation is aimed at chemicals that are used in a particular way (for example pharmaceuticals or pesticides), or because they have specific dangerous qualities (carcinogens, explosives and highly flammable substances), and some legislation is aimed at protection of specific sections of the population (e.g. workers, consumers, pregnant workers). Other legislation is aimed at environmental protection by specific control of releases to the environment (e.g. integrated pollution potential and control – IPPC) or monitoring specific parts of the environment (e.g. the Water Framework Directive – WFD for water). Inevitably there is overlap between all this