

# The Italian experience in implementing the INSPIRE rules for Soil Theme

Maria Fantappiè, Andrea Lachi, Lorenzo Gardin, Claudia di Bene,  
Rosario Napoli, Giovanni L'Abate



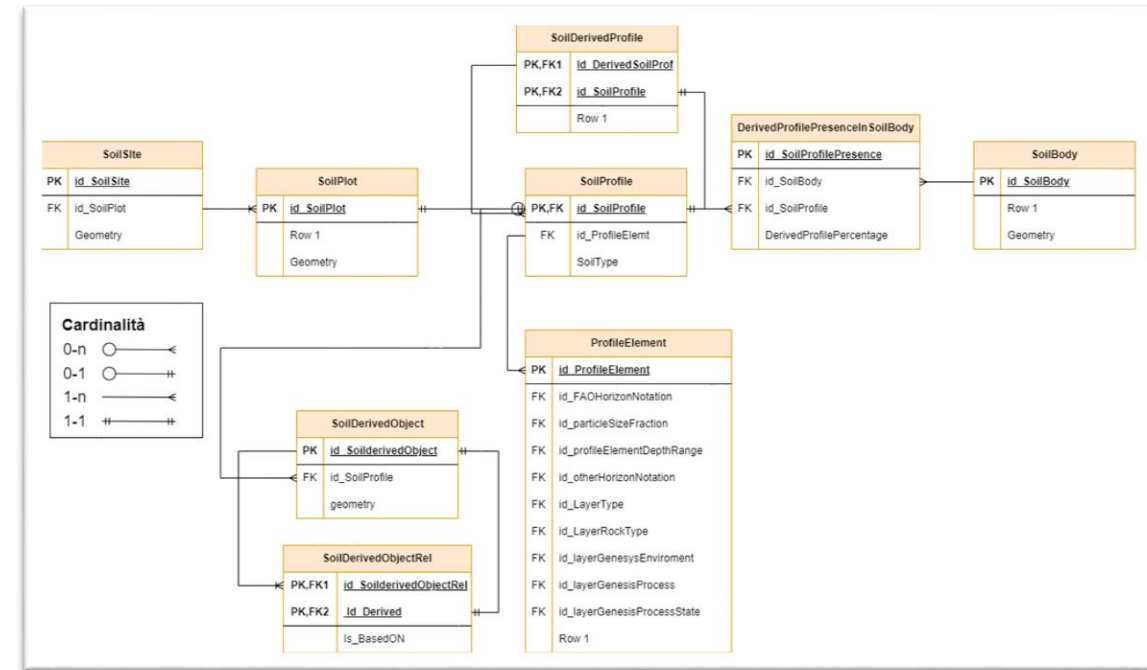
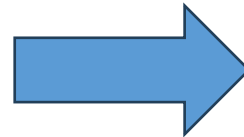
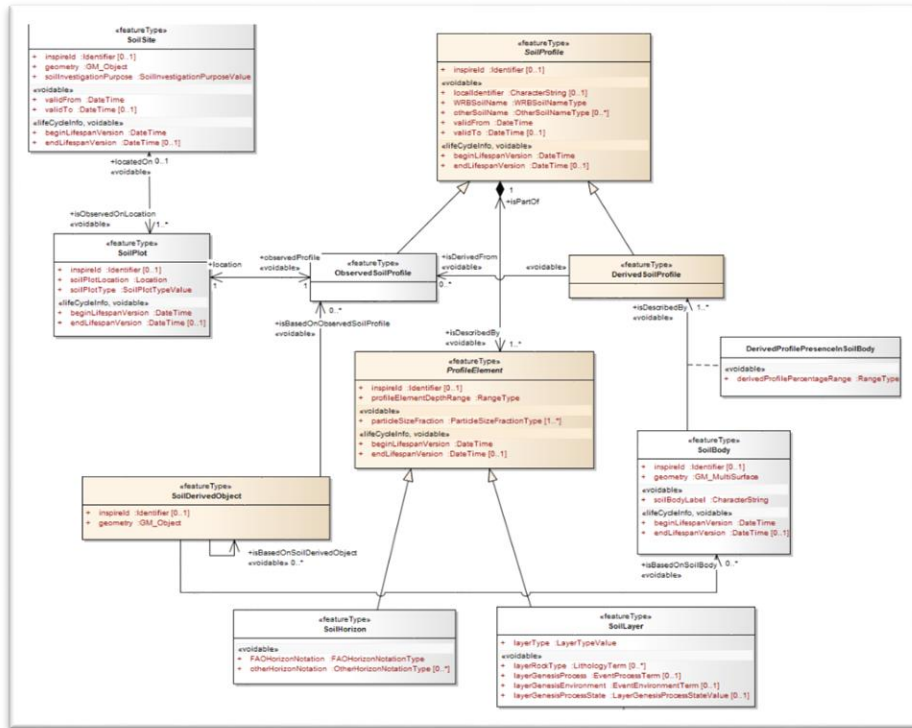
**EJP SOIL**  
European Joint Programme

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research and innovation  
programme: Grant  
agreement No 862695



# OBJECTIVES - INTRODUCTION

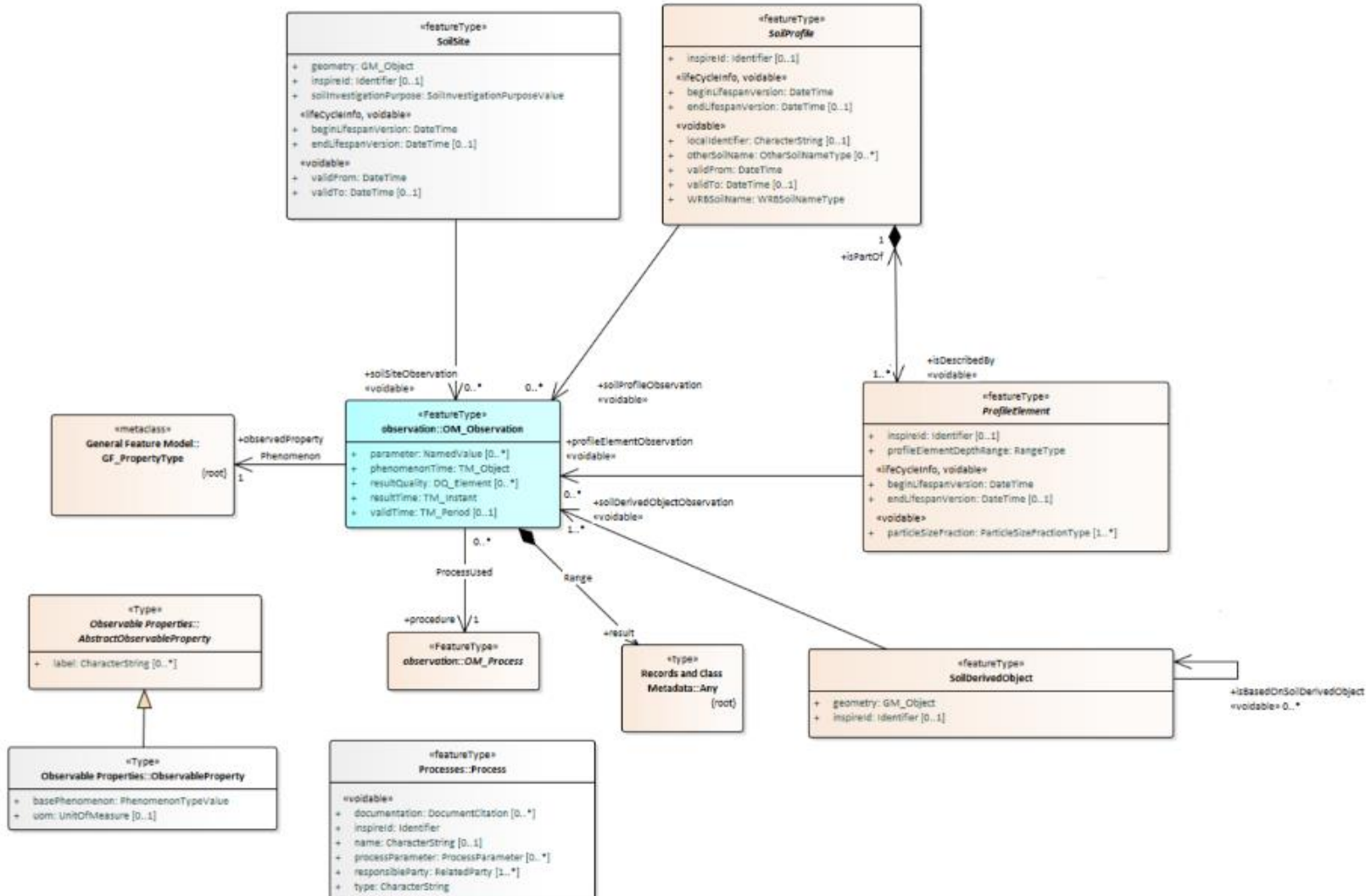
The INSPIRE Good Practices requires publishing datasets into GML format. This format is not of practical usage for the soil scientific community. **CREA** has developed a **relational database** for soil data storage, which in the years has been structured towards the implementation of INSPIRE rules.



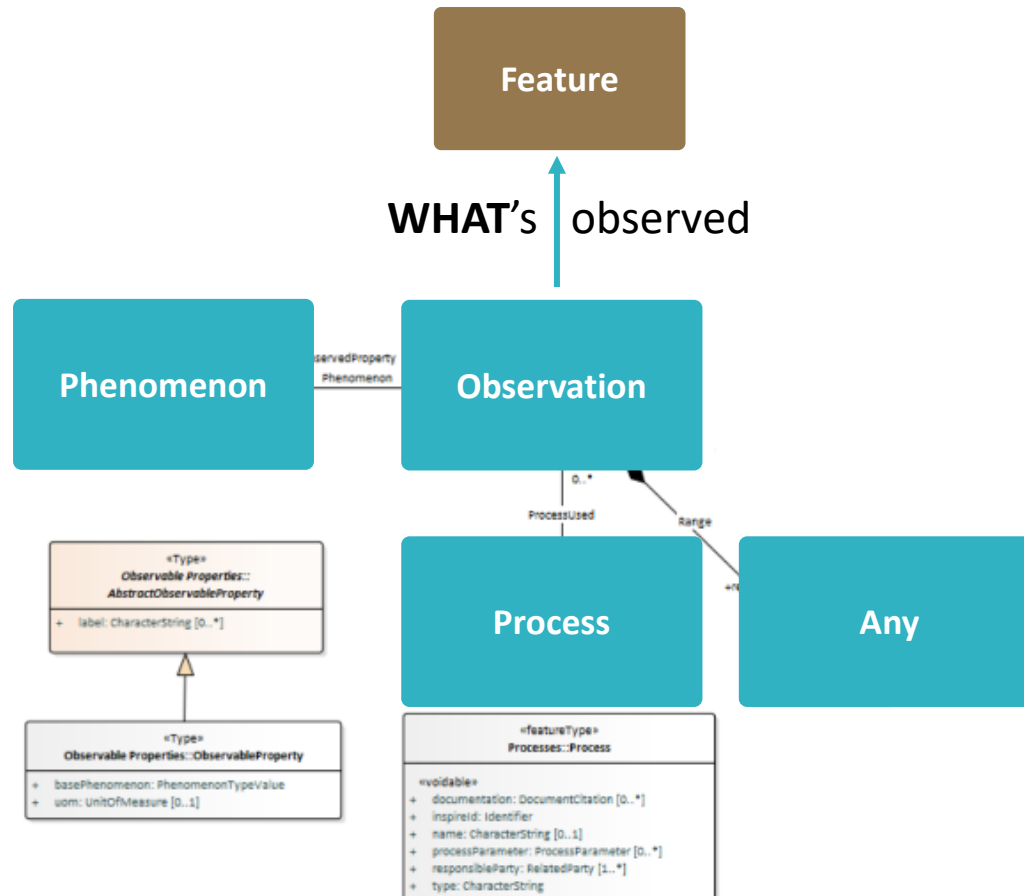
A PIECE OF THE INSPIRE SOIL UML SCHEME  
«applicationSchema» for Soil: Overview - Vector

A PIECE OF THE TABULAR IMPLEMENTATION IN  
THE CREA SOIL DB: THE VECTOR PART

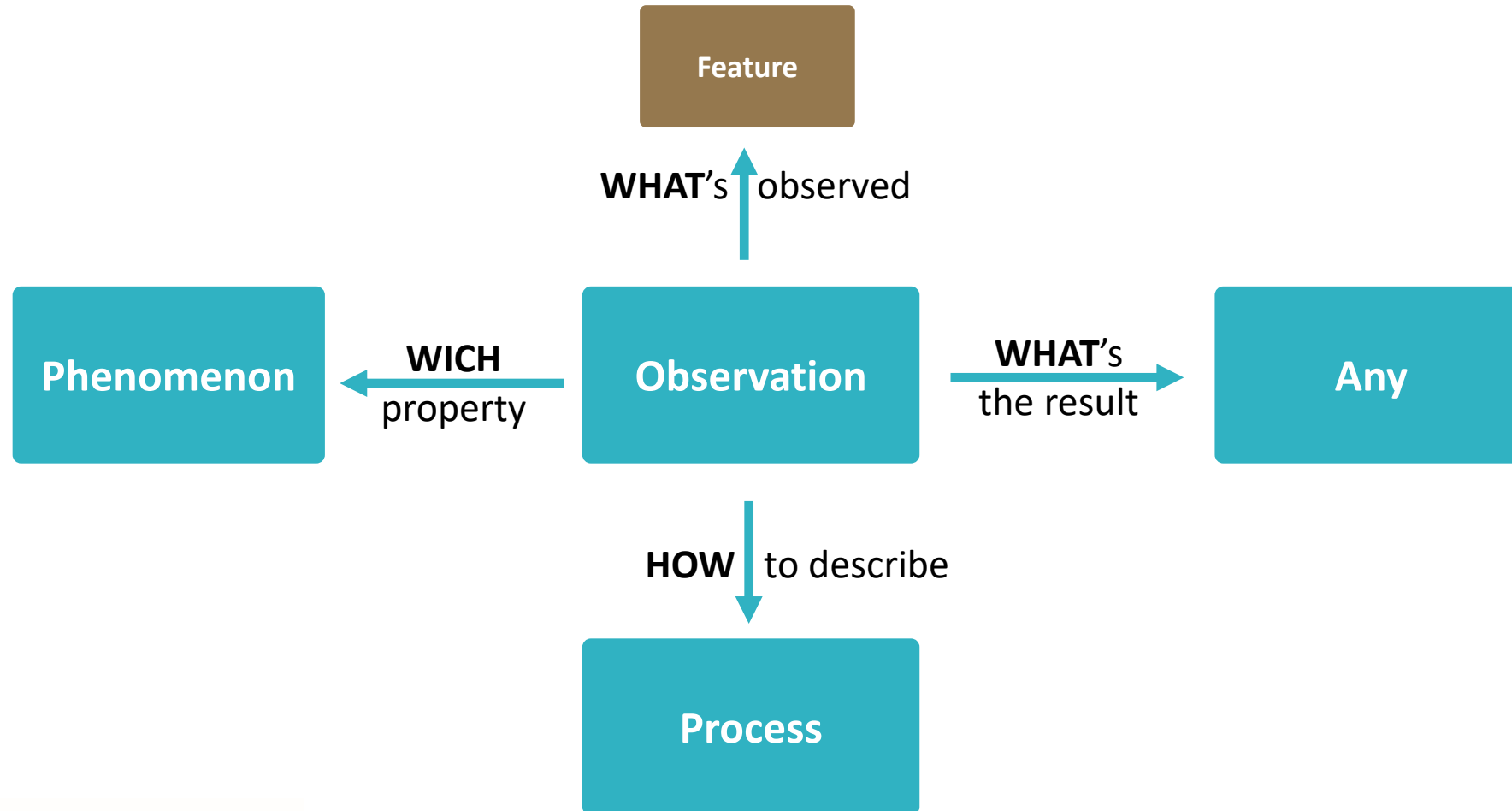
# Implementing the O&M for Soil



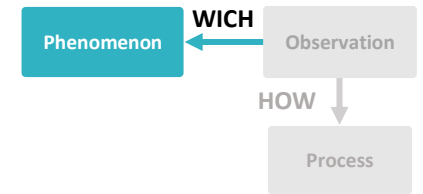
# Implementing the O&M for Soil



# Implementing the O&M for Soil

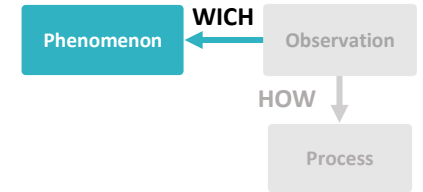


# About Phenomenon and basePhenomenon



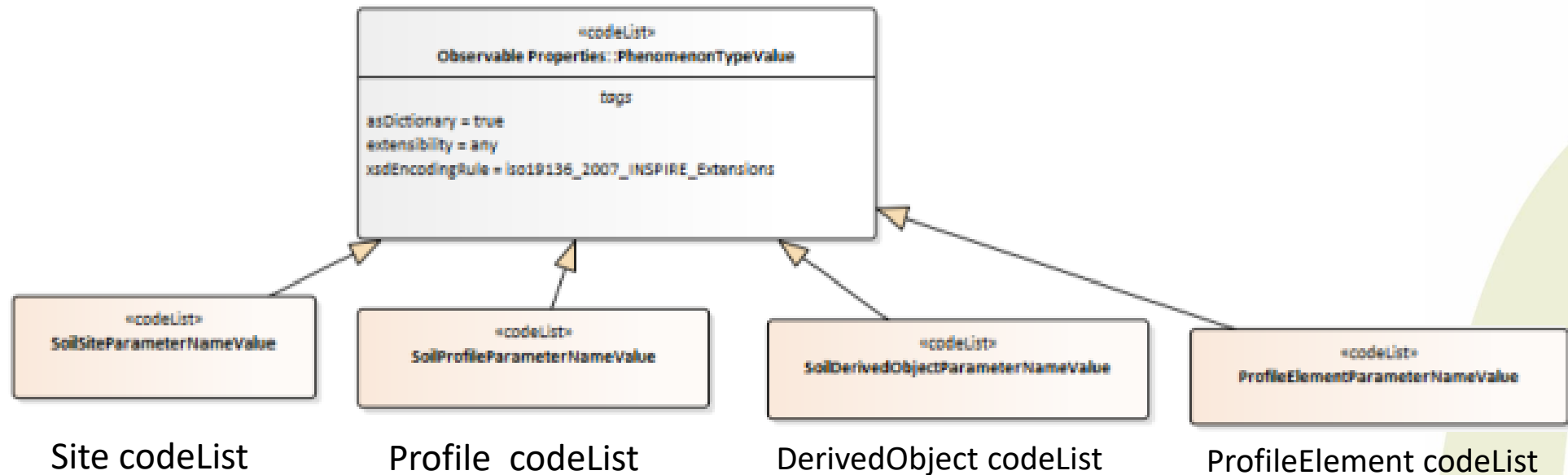
- Definitions from Oxford Languages: a fact or situation that is observed to exist or happen, especially one whose cause or explanation is in question.
- From Wikipedia, the free encyclopedia: In scientific usage, a **phenomenon** is any **event that is observable**, including the use of instrumentation to observe, record, or compile data. Especially in physics, the study of a phenomenon may be described as measurements related to matter, energy, or time. A mechanical phenomenon is a physical phenomenon associated with the equilibrium or motion of objects.

# Phenomenon Type according INSPIRE

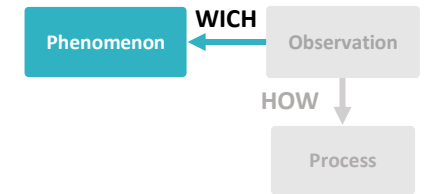


Definition: A code list of phenomena (e.g. temperature, wind speed).

Description: A code list of phenomena. This code list itself is an **empty placeholder** and **should be extended** and specified **for any thematic domain**.



# The basePhenomenon – a hierarchically structured list

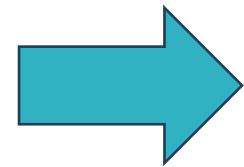
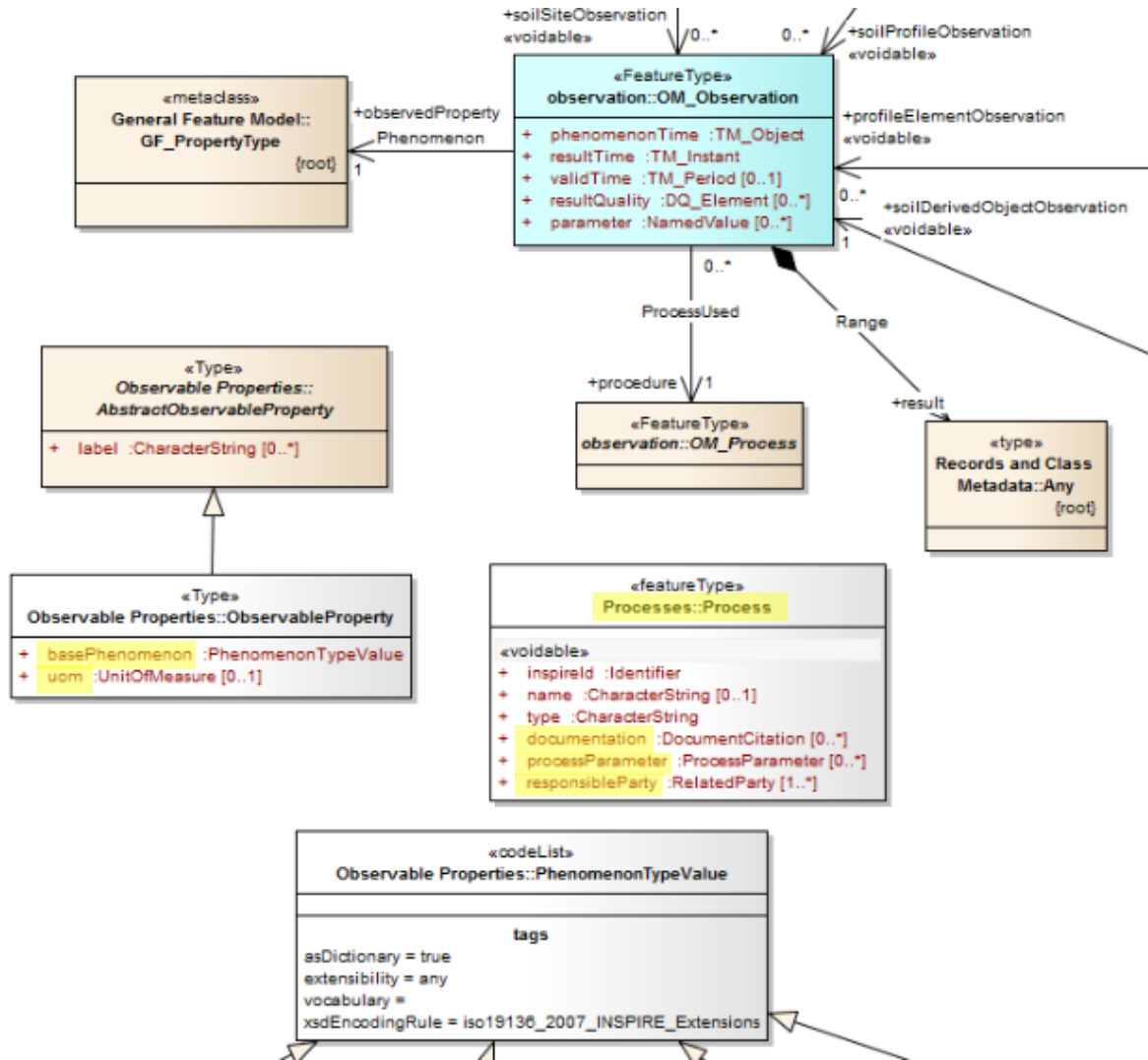
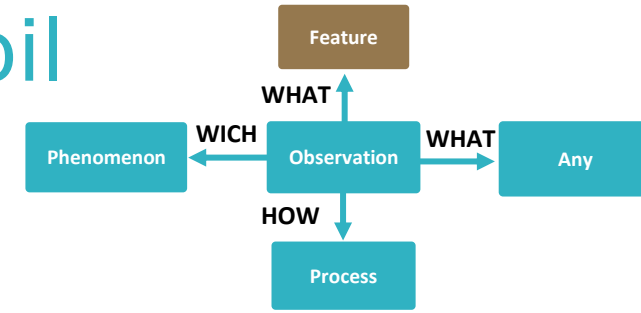


so	Soil	<a href="http://inspire.ec.europa.eu/theme/so">http://inspire.ec.europa.eu/theme/so</a>
so.bi	Biologic	<a href="http://inspire.ec.europa.eu/codelist/ProfileElementParameterNameValue/biologicalParameter">http://inspire.ec.europa.eu/codelist/ProfileElementParameterNameValue/biologicalParameter</a>
so.ch	Chemical	<a href="http://inspire.ec.europa.eu/codelist/ProfileElementParameterNameValue/chemicalParameter">http://inspire.ec.europa.eu/codelist/ProfileElementParameterNameValue/chemicalParameter</a>
so.cl	Soil classification	<a href="http://lod.nal.usda.gov/nalt/956">http://lod.nal.usda.gov/nalt/956</a>
so.mn	Soil management	<a href="http://lod.nal.usda.gov/nalt/314998">http://lod.nal.usda.gov/nalt/314998</a>
so.pd	Pedodiversity	<a href="http://lod.nal.usda.gov/nalt/314998">http://lod.nal.usda.gov/nalt/314998</a>
so.ph	Physical	<a href="http://inspire.ec.europa.eu/codelist/ProfileElementParameterNameValue/physicalParameter">http://inspire.ec.europa.eu/codelist/ProfileElementParameterNameValue/physicalParameter</a>
so.ph.a	Physical - acoustics	<a href="http://lod.nal.usda.gov/nalt/2990">http://lod.nal.usda.gov/nalt/2990</a>
so.ph.c	Physical - Mechanic	<a href="http://lod.nal.usda.gov/nalt/29789">http://lod.nal.usda.gov/nalt/29789</a>
so.ph.cg	Physical - Mechanic - Geotechnical investigation	<a href="http://aims.fao.org/aos/agrovoc/c_1dbbb28b">http://aims.fao.org/aos/agrovoc/c_1dbbb28b</a>
so.ph.e	Physical - Electric and magnetic	<a href="http://lod.nal.usda.gov/nalt/36181">http://lod.nal.usda.gov/nalt/36181</a>
so.ph.g	Physical - granulometric	<a href="http://www.foodvoc.org/resource/Valerie-9/soil_granulometry">http://www.foodvoc.org/resource/Valerie-9/soil_granulometry</a>
so.ph.h	Physical - Hydrologic	<a href="http://lod.nal.usda.gov/nalt/46369">http://lod.nal.usda.gov/nalt/46369</a>
so.ph.hs	Physical - Hydrologic -solute mobility	<a href="http://lod.nal.usda.gov/nalt/610">http://lod.nal.usda.gov/nalt/610</a>
so.ph.m	Physical - soil morphological features	<a href="http://lod.nal.usda.gov/nalt/26939">http://lod.nal.usda.gov/nalt/26939</a>
so.ph.mm	Physical - Micromorphologic	<a href="http://lod.nal.usda.gov/nalt/35129">http://lod.nal.usda.gov/nalt/35129</a>
so.ph.mv	Physical - Voids	<a href="http://lod.nal.usda.gov/nalt/63409">http://lod.nal.usda.gov/nalt/63409</a>
so.ph.o	Physical - Optical	<a href="http://lod.nal.usda.gov/nalt/40036">http://lod.nal.usda.gov/nalt/40036</a>
so.ph.t	Physical - Thermic	<a href="http://lod.nal.usda.gov/nalt/61641">http://lod.nal.usda.gov/nalt/61641</a>
so.ph.tg	Physical - thermogravimetry	<a href="http://lod.nal.usda.gov/nalt/8495">http://lod.nal.usda.gov/nalt/8495</a>
so.qi	soil quality	<a href="http://lod.nal.usda.gov/nalt/35826">http://lod.nal.usda.gov/nalt/35826</a>

URI to the definitions



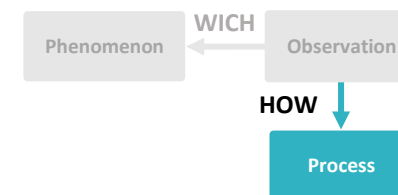
# Implementing the O&M for Soil



Definition of the  
 1 Processes  
 1.1 documentation  
 1.2 ProcessParameter  
 1.3 responsibleParty  
 2. UnitOfMeasure  
 3. basePhenomenon

Inside specific tables in the relational dataset

# About the Processes

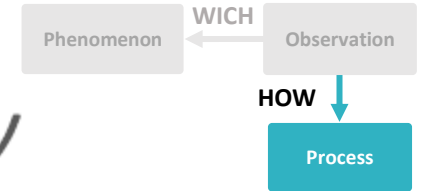


**Process** has a **responsibleParty** (Manual, Author, Guideline, etc.) and might have **documentation(s)** and (different) **processParameter**

- **responsibleParty**: individual or organization related to the process
- **documentation**: further information (online/offline) associated with the process
- **processParameter**: parameter controlling the application of the process and as a consequence its output

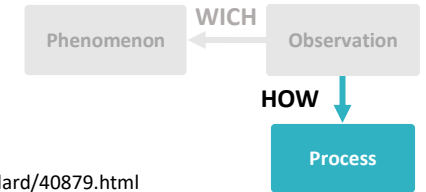
# ProcessResponsibleParty

## How CREA implements *ProcessResponsibleParty*



ProcessResponsibleParty		
Reference	Citation	URL
Hollis, 2012	J. M. Hollis J. Hannam P. H. Bellamy (2012). Empirically-derived pedotransfer functions for predicting bulk density in European soils. European Journal of Soil Science (EJSS) 63, 1: 96-109	<a href="https://onlinelibrary.wiley.com/doi/full/10.1111/j.1365-2389.2011.01412.x">https://onlinelibrary.wiley.com/doi/full/10.1111/j.1365-2389.2011.01412.x</a>
ISO/TC 119/SC 4	ISO/TC 119/SC 4 Sampling and testing methods for hardmetals	<a href="https://www.iso.org/committee/51960.html">https://www.iso.org/committee/51960.html</a>
ISO/TC 147/SC 2	ISO/TC 147/SC 2 PHYSICAL, CHEMICAL AND BIOCHEMICAL METHODS	<a href="https://www.iso.org/ics/13.060.50/x/">https://www.iso.org/ics/13.060.50/x/</a>
ISO/TC 190	ISO/TC 190 Soil quality	<a href="https://www.iso.org/ics/13.080.20/x/">https://www.iso.org/ics/13.080.20/x/</a>
ISO/TC 190/SC 3	ISO/TC 190/SC 3 CHEMICAL AND PHYSICAL CHARACTERIZATION	<a href="https://www.iso.org/ics/13.080.10/x/">https://www.iso.org/ics/13.080.10/x/</a>
ISO/TC 190/SC 4	ISO/TC 190/SC 4 Biological characterization	<a href="https://www.iso.org/committee/54366.html">https://www.iso.org/committee/54366.html</a>
ISO/TC 190/SC 7	ISO/TC 190/SC 7 IMPACT ASSESSMENT	<a href="https://www.iso.org/committee/54408.html">https://www.iso.org/committee/54408.html</a>
ISO/TC 20/SC 13	Space data and information transfer	<a href="https://www.iso.org/committee/46612.html">https://www.iso.org/committee/46612.html</a>
ISO/TC 211	ISO/TC 211 GEOGRAPHIC INFORMATION/GEOMATICS	<a href="https://www.iso.org/ics/35.240.70/x/">https://www.iso.org/ics/35.240.70/x/</a>
ISO/TC 24/SC 4	ISO/TC 24/SC 4 PARTICLE CHARACTERIZATION	<a href="https://www.iso.org/committee/47176.html">https://www.iso.org/committee/47176.html</a>
Jabro, 1992	Jabro, J.D. 1992. Estimation of saturated hydraulic conductivity of soils from particle size distribution and bulk density data. Tran. Am. Soc. of Agr. and Biolo. Eng., 35, 557-560.	<a href="https://elibrary.asabe.org/abstract.asp?aid=28633">https://elibrary.asabe.org/abstract.asp?aid=28633</a>

# About process. Documentation - DocumentationCitation



reference	title	description_method	URI
ISO/TC 190/SC 3	ICS : 13.080.10 ISO 10390:2005	Soil quality -- Determination of Ph using a glass electrode in a 1:5 (volume fraction) suspension of soil water (pH in H2O)	<a href="https://www.iso.org/standard/40879.html">https://www.iso.org/standard/40879.html</a>
ISO/TC 190/SC 3	ICS : 13.080.10 ISO 10693:1995	Soil quality -- Determination of carbonate content -- Volumetric method	<a href="https://www.iso.org/standard/18781.html">https://www.iso.org/standard/18781.html</a>
ISO/TC 190/SC 3	ICS : 13.080.10 ISO 10694:1995	Soil quality -- Determination of organic and total carbon after dry combustion (elementary analysis)	<a href="https://www.iso.org/standard/18782.html">https://www.iso.org/standard/18782.html</a>
ISO/TC 190/SC 3	ICS : 13.080.10 ISO 11047:1998	Soil quality -- Determination of cadmium, chromium, cobalt, copper, lead, manganese, nickel and zinc -- Flame and electrothermal atomic absorption spectrometric methods	<a href="https://www.iso.org/standard/24010.html">https://www.iso.org/standard/24010.html</a>
ISO/TC 190/SC 3	ICS : 13.080.10 ISO 11048:1995	Soil quality -- Determination of water-soluble and acid-soluble sulfate	<a href="https://www.iso.org/standard/19029.html">https://www.iso.org/standard/19029.html</a>
ISO/TC 190/SC 3	ICS : 13.080.10 ISO 11260:1994	Soil quality -- Determination of effective cation exchange capacity and base saturation level using barium chloride solution	<a href="https://www.iso.org/standard/19238.html">https://www.iso.org/standard/19238.html</a>
ISO/TC 190/SC 3	ICS : 13.080.10 ISO 11261:1995	Soil quality -- Determination of total nitrogen -- Modified Kjeldahl method	<a href="https://www.iso.org/standard/19239.html">https://www.iso.org/standard/19239.html</a>
ISO/TC 190/SC 3	ICS : 13.080.10 ISO 11262:2003	SOIL QUALITY -- DETERMINATION OF TOTAL CYANIDE	<a href="https://www.iso.org/standard/36131.html">https://www.iso.org/standard/36131.html</a>
ISO/TC 190/SC 3	ICS : 13.080.10 ISO 11262:2011	SOIL QUALITY -- DETERMINATION OF TOTAL CYANIDE	<a href="https://www.iso.org/standard/53737.html">https://www.iso.org/standard/53737.html</a>
ISO/TC 190/SC 3	ICS : 13.080.10 ISO 11263:1994	SOIL QUALITY -- DETERMINATION OF PHOSPHORUS -- SPECTROMETRIC DETERMINATION OF PHOSPHORUS SOLUBLE IN SODIUM HYDROGEN CARBONATE SOLUTION	<a href="https://www.iso.org/standard/19241.html">https://www.iso.org/standard/19241.html</a>
ISO/TC 190/SC 3	ICS : 13.080.10 ISO 11466:1995	Soil quality -- Extraction of trace elements soluble in aqua regia	<a href="https://www.iso.org/standard/19418.html">https://www.iso.org/standard/19418.html</a>
ISO/TC 190/SC 3	ICS : 13.080.10 ISO 13536:1995	Soil quality -- Determination of the potential cation exchange capacity and exchangeable cations using barium chloride solution buffered at pH = 8,1 - (Bascomb modified),1995	<a href="https://www.iso.org/standard/22180.html">https://www.iso.org/standard/22180.html</a>
ISO/TC 190/SC 3	ICS : 13.080.10 ISO 13878:1998	Soil quality -- Determination of total nitrogen content by dry combustion ("elemental analysis")	<a href="https://www.iso.org/standard/23117.html">https://www.iso.org/standard/23117.html</a>
ISO/TC 190/SC 3	ICS : 13.080.10 ISO 14235:1998	SOIL QUALITY -- DETERMINATION OF ORGANIC CARBON BY SULFOCHROMIC OXIDATION	<a href="https://www.iso.org/standard/23140.html">https://www.iso.org/standard/23140.html</a>
ISO/TC 190/SC 3	ICS : 13.080.10 ISO 14254:2001	Soil quality -- Determination of exchangeable acidity in barium chloride extracts	<a href="https://www.iso.org/standard/22919.html">https://www.iso.org/standard/22919.html</a>
ISO/TC 190/SC 3	ICS : 13.080.10 ISO 14254:2018	Soil quality -- Determination of exchangeable acidity using barium chloride solution as extractant	<a href="https://www.iso.org/standard/60567.html">https://www.iso.org/standard/60567.html</a>
ISO/TC 190/SC 3	ICS : 13.080.10 ISO 14255:1998	Soil quality -- Determination of nitrate nitrogen, ammonium nitrogen and total soluble nitrogen in air-dry soils using calcium chloride solution as extractant	<a href="https://www.iso.org/standard/23081.html">https://www.iso.org/standard/23081.html</a>
ISO/TC 190/SC 3	ICS : 13.080.10 ISO 14256-2:2005	Soil quality -- Determination of nitrate, nitrite and ammonium in field-moist soils by extraction with potassium chloride solution -- Part 2: Automated method with segmented flow analysis	<a href="https://www.iso.org/standard/32399.html">https://www.iso.org/standard/32399.html</a>
ISO/TC 190/SC 3	ICS : 13.080.10 ISO 14870:2001	Soil quality -- Extraction of trace elements by buffered DTPA solution	<a href="https://www.iso.org/standard/25232.html">https://www.iso.org/standard/25232.html</a>
ISO/TC 190/SC 3	ICS : 13.080.10 ISO 17184:2014	Soil quality -- Determination of carbon and nitrogen by near-infrared spectrometry (NIRS)	<a href="https://www.iso.org/standard/59262.html">https://www.iso.org/standard/59262.html</a>

# Process Parameter

## processParameter

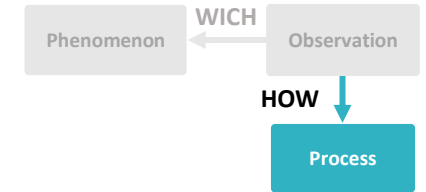
ac\_s  
ac\_tot  
al\_dition  
al\_libero  
al\_oss  
al\_pirof  
al\_s  
b  
b\_solub  
c\_org  
ca  
ca\_%  
ca\_ass  
  
ca\_mg\_s  
ca\_s  
ca\_s\_ppm  
ca\_solub  
cn  
co  
co3\_solub  
csc  
csc\_sc  
si\_dition  
si\_os  
si\_tot  
so4\_scamb  
so4\_solub  
ec\_1  
ec\_2  
ec\_5

## observedproperty

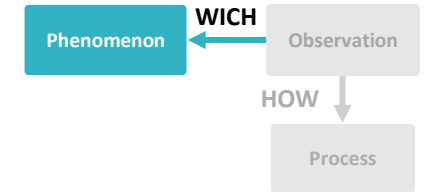
acidity\_exchange  
acidity\_total  
aluminium\_al\_dithionite\_extractable  
aluminium\_al+++\_exchangeable  
aluminium\_al\_oxalate\_extractable  
aluminium\_al\_pyrophosphate\_extractable  
aluminium\_al+++\_exchangeable  
boron\_b\_total  
boron\_b\_extractable  
carbon\_c\_organic  
calcium\_ca++\_total  
calcium\_ca++\_exchangeable  
calcium\_cao\_extractable  
calcium\_ca++\_magnesium\_mg++\_exchangeable  
calcium\_ca++\_exchangeable  
calcium\_ca\_exchangeable  
calcium\_ca++\_soluble  
carbonnitrogen\_cn\_ratio  
cobalt  
carbonate\_co3--\_soluble  
cationexchangecapacity\_cec  
cationexchangecapacity\_cations\_sum  
silicon\_si\_dithionite\_extractable  
silicon\_si\_oxalate\_extractable  
silicon\_si\_oxalate\_extractable  
sulfate\_so4--\_exchangeable  
sulfate\_so4--\_soluble  
electricalconductivity  
electricalconductivity  
electricalconductivity

## abstractobservableproperty

Acidity  
Acidity  
Aluminium (Al)  
Aluminium (Al+++)  
Aluminium (Al)  
Aluminium (Al)  
Aluminium (Al+++)  
Boron (B)  
Boron (B)  
Carbon (C )  
Calcium (Ca++)  
Calcium (Ca++)  
Calcium (CaO)  
Calcium (Ca++)  
Calcium (Ca++)  
Calcium (Ca)  
Calcium (Ca++)  
Carbon/Nitrogen (C/N) ratio  
extractable cobalt (mg/kg)  
Carbonate (CO3--)  
Cation Exchange Capacity (CEC)  
Cation Exchange Capacity (CEC)  
Silicon (Si)  
Silicon (Si)  
Silicon (Si)  
Sulfate (SO4--)  
Sulfate (SO4--)  
Electrical conductivity  
Electrical conductivity  
Electrical conductivity



# How CREA implements UnitOfMeasure



Unit_type	Quantity	Symbol	Label	URI	Dimension
Base Unit	Dimensionless (count)	-	Unitless	<a href="https://units.unf.edu/umis/units/view/000008">https://units.unf.edu/umis/units/view/000008</a>	[U1]
Derived Unit	Temperature	°C	Celsius Degree	<a href="http://ecoinformatics.org/oboe/oboe.1.0/oboe-standards.owl#Celsius">http://ecoinformatics.org/oboe/oboe.1.0/oboe-standards.owl#Celsius</a>	[H1]+[273.16]
Composite Unit	Speed	µm/s	Micrometer (micrometre) per second	<a href="http://ecoinformatics.org/oboe/oboe.1.0/oboe-standards.owl#MeterPerSecond">http://ecoinformatics.org/oboe/oboe.1.0/oboe-standards.owl#MeterPerSecond</a>	[L1 T-1][10-6]
Derived Unit	Length	cm	Centimeters	<a href="http://ecoinformatics.org/oboe/oboe.1.0/oboe-standards.owl#Centimeter">http://ecoinformatics.org/oboe/oboe.1.0/oboe-standards.owl#Centimeter</a>	[L1][10-2]
Derived Unit.Adimensional	Length Fraction	cm/m	Centimeters per Meter	<a href="http://ecoinformatics.org/oboe/oboe.1.0/oboe-standards.owl#Percent">http://ecoinformatics.org/oboe/oboe.1.0/oboe-standards.owl#Percent</a>	[L1 L-1][10-2]
Derived Unit	Area	cm <sup>2</sup>	Square Centimeter	<a href="http://ecoinformatics.org/oboe/oboe.1.0/oboe-standards.owl#CentimeterSquared">http://ecoinformatics.org/oboe/oboe.1.0/oboe-standards.owl#CentimeterSquared</a>	[L2]
Quantity.molality	molality	cmol(+)/kg	Centimoles of Cations per 1000 Grams	<a href="http://goldbook.iupac.org/terms/view/M03970">http://goldbook.iupac.org/terms/view/M03970</a>	[M-1 N1][10-2]
Derived Unit.Adimensional	Mass Fraction	dag/kg	Decagrams per 1000 Grams	<a href="http://ecoinformatics.org/oboe/oboe.1.0/oboe-standards.owl#Percent">http://ecoinformatics.org/oboe/oboe.1.0/oboe-standards.owl#Percent</a>	[M1 M-1][10-2]
Derived Unit.Adimensional	plane angle	DD	Decimal Degrees (DD)	<a href="http://www.w3.org/2003/01/geo/wgs84_pos#SpatialThing">http://www.w3.org/2003/01/geo/wgs84_pos#SpatialThing</a>	[L1 L-1]
Derived Unit.Adimensional	Area Fraction	dm <sup>2</sup> /m <sup>2</sup>	Square Decimeters per Square Meter	<a href="http://ecoinformatics.org/oboe/oboe.1.0/oboe-standards.owl#Percent">http://ecoinformatics.org/oboe/oboe.1.0/oboe-standards.owl#Percent</a>	[L2 L-2][10-2]
Composite Unit	electrical conductivity	dS/m	Decisiemens per meter	<a href="http://ecoinformatics.org/oboe/oboe.1.0/oboe-standards.owl#SiemensPerMeter">http://ecoinformatics.org/oboe/oboe.1.0/oboe-standards.owl#SiemensPerMeter</a>	[M-1 L-3 T3 I2][10-1]
Derived Unit	Mass	g	Grams	<a href="https://units.unf.edu/umis/units/view/000017">https://units.unf.edu/umis/units/view/000017</a>	[M1][10-3]
Composite Unit	Density	g/cm <sup>3</sup>	gram per cubic centimetre	<a href="http://www.ontology-of-units-of-measure.org/resource/om-2/gramPerCubicCentimetre">http://www.ontology-of-units-of-measure.org/resource/om-2/gramPerCubicCentimetre</a>	[M1 L-3][10-3]
Composite Unit	Amount of substance concentration	g/dl	Gram per deciliter	<a href="http://www.ontology-of-units-of-measure.org/resource/om-2/gramPerDecilitre">http://www.ontology-of-units-of-measure.org/resource/om-2/gramPerDecilitre</a>	[M1 L-3]
Derived Unit.Adimensional	Mass Fraction	g/g	Grams per Gram	<a href="http://ecoinformatics.org/oboe/oboe.1.0/oboe-standards.owl#GramPerGram">http://ecoinformatics.org/oboe/oboe.1.0/oboe-standards.owl#GramPerGram</a>	[M1 M-1]
Derived Unit.Adimensional	Mass Fraction	g/kg	Grams per 1000 Gram	<a href="http://data.nasa.gov/qudt/owl/unit#Milli">http://data.nasa.gov/qudt/owl/unit#Milli</a>	[M1 M-1][10-3]
Derived Unit	Area	ha	Hectares	<a href="http://ecoinformatics.org/oboe/oboe.1.0/oboe-standards.owl#Hectare">http://ecoinformatics.org/oboe/oboe.1.0/oboe-standards.owl#Hectare</a>	[L2][10 <sup>4</sup> ]
Base Unit	Mass	kg	Kilogram	<a href="https://units.unf.edu/umis/units/view/000005">https://units.unf.edu/umis/units/view/000005</a>	[M1]
Composite Unit	Pressure	kPa	kilopascal	<a href="http://www.ontology-of-units-of-measure.org/resource/om-2/kilopascal">http://www.ontology-of-units-of-measure.org/resource/om-2/kilopascal</a>	[M1 L-1 T-2]
Base Unit	Length	m	Meters	<a href="https://units.unf.edu/umis/units/view/000003">https://units.unf.edu/umis/units/view/000003</a>	[L1]
Derived Unit.Adimensional	Length Fraction	m/m	Meters per Meter	<a href="http://data.nasa.gov/qudt/owl/unit#Unitless">http://data.nasa.gov/qudt/owl/unit#Unitless</a>	[L1 L-1]
Derived Unit	Area	m <sup>2</sup>	Square Meter	<a href="http://ecoinformatics.org/oboe/oboe.1.0/oboe-standards.owl#MeterSquared">http://ecoinformatics.org/oboe/oboe.1.0/oboe-standards.owl#MeterSquared</a>	[L2]
Composite Unit	specific volume	m <sup>3</sup> /kg	cubic metre per kilogram	<a href="http://www.ontology-of-units-of-measure.org/resource/om-2/cubicMetrePerKilogram">http://www.ontology-of-units-of-measure.org/resource/om-2/cubicMetrePerKilogram</a>	[M-1 L3]
Quantity.concentrationNumber	amount of substance concentration	mEq/100g	Milliequivalents per 100 Grams	<a href="http://goldbook.iupac.org/terms/view/N04260">http://goldbook.iupac.org/terms/view/N04260</a>	[M-1 N1][10-2]

Proposal to use the: UCUM - The Unified Code for Units of Measure, <https://unitsofmeasure.org/ucum>