WEISS Water Emissions Inventory Support System

an innovative GeoFleX product made by VITO

What is WEISS?

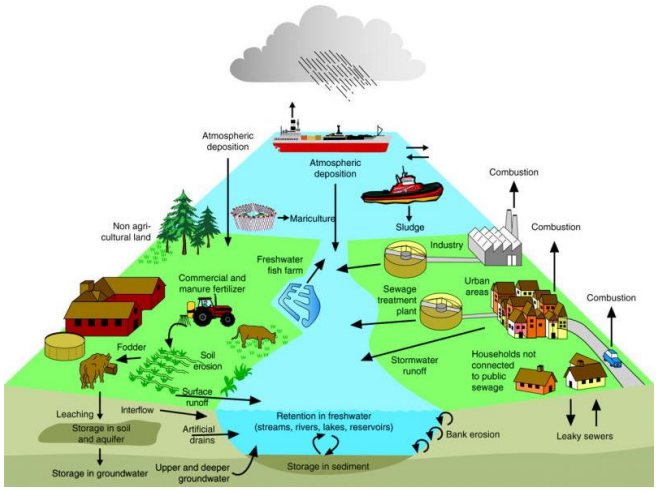
Good water quality in our rivers is a matter of concern to us all. It creates a healthy environment for fauna and flora, but also allows to keep the cost of drinking water as low as possible. To ensure that all Member States of the European Union endeavour to optimise the water quality of their rivers, the European Council and the European Parliament established the Water Framework Directive (2000/60/EEC) in 2000. This directive requires all Member States to achieve a good status of their water bodies by the end of 2015. Water bodies include surface water (rivers and lakes), but also groundwater. A good status relates to the chemical, ecological and quantitative properties of the water body. The deadline for compliance with the objectives can be extended until the end of 2027.

WEISS, the **Water Emission Inventory planning Support System** is developed to assist EU member states and regions small and large in meeting these objectives.

Achieving a good status of the water bodies is far from simple, especially in highly urbanised and densely populated regions. Moreover, the increasing urban sprawl in Europe complicates the development of effective wastewater treatment systems. Integral water management requires measures for cost-effective improvement of the water quality. This is possible by monitoring the current water quality, but more efficiently by identifying the sources of pollution, so that targeted measures can be taken beforehand. Is the pollution caused by systematic discharges from a single company, or by road traffic? Does it originate from another river basin, or does it end up in the rivers via atmospheric deposition? Dozens of sources of pollution may be active in a single river basin. These may be point sources such as discharges by a company, but also diffuse sources such as erosion. After detecting the sources, it must be examined how the pollutants move towards the surface water and how much of the pollution eventually ends up in the water. Only then an accurate picture of the major sources emerges and efficient measures can be defined.

WEISS is developed to support in this endeavour and provides among others answers to the following policy relevant questions:

- Which sources of pollution are responsible for the observed water quality and what is the contribution of each source?
- How much of the pollution actually ends up in the surface water?
- What is the contribution of the sewage infrastructure measures in the abatement?
- How does water quality in the river basins evolve over the years?
- Which and where are non-quantified sources of pollution in any given area?
- …



Diffuse (left) and point (right) sources that affect the water quality.
(Source: Ærtebjerg, G., Andersen, J.H. & Hansen, O.S. (eds.) (2003) Nutrients and Eutrophication in Danish Marine Waters. A Challenge for Science and Management. National Environmental Research Institute. 126 pp.)

What are intended uses of WEISS

WEISS stands for **Water Emissions Inventory planning Support System**. It investigates the location and size of sources of pollution as accurately as possible, as well as the routes along which the pollution reaches the surface water. Such data are to be gathered and reported in regional, national and European inventorying and registration systems, with a view to propose cost effective measures that contribute to the achievement of the specified environmental objectives.

WEISS manages data for among others the following (mandatory) reporting at EU-level:

- The inventory of emissions, losses and discharges (Directive 2008/105/EC EQS)
- Collection and treatment of urban wastewater (UWWT Directive)
- European Pollutant Release and Transfer Register regulation (E-PRTR) (Reporting by operators (art. 5) and Releases from diffuse sources (art. 9)
- State of Environment (SoE) assessment of Europe's water environment (SoE emissions)

WEISS assists in designing and implementing targeted reduction and phasing out measures with respect to priority and priority hazardous substances. It enables to:

- analyse emission trends and other indicators over time, also in the future.
- assess the efficiency of the River Basin Management Plans (RBMP) and Programme of Measures (PoM);
- identify gaps in knowledge and define the need to carry out studies/campaigns or develop strategies/policies.

WEISS is highly innovative in the way it literally maps out the sources. This not only involves the totals for a specific study area, rather the individual sources are located as accurately as possible by assigning them to cells in a regular grid that is superimposed on the study area. Results can be viewed as maps, but in WEISS they are also aggregated into various types of tables and graphs. The spatial resolution of the calculations and maps is flexibly adjustable and can be aligned with the availability and quality of the underlying data.

Who are the intended users of WEISS

The prototypical users of WEISS are public administrations having reporting obligations. Examples are: the Flemish Environment Agency (VMM), the Brussels Environment Institute (BIM/IGBE), and the Walloon Public Service (SPW-DGARNE). All three have a WEISS system installed tailored to their needs and data availability.

The system is also particularly useful for users other than public authorities that gain from a thorough knowledge and control of the water quality, such as drinking water companies, operators of ports, logistics complexes or infrastructure. For example the Port of Antwerp implemented its emission inventory in line with the WEISS methodology. For companies that treat, pump and distribute water that must be compliant with stringent quality requirements, knowledge of the sources of pollution in and around their water extraction areas is essential.

For sectors contributing to the pollution, WEISS is useful to gain insight into ways in which abatement programmes can be optimised. One example is the use of crop protection products in the agricultural sector or in the public domain.

When output of WEISS is made available via a web portal individual citizens can be informed about sources of pollution in their immediate vicinity and to estimate their own contribution to the pollution.

What is the output of WEISS

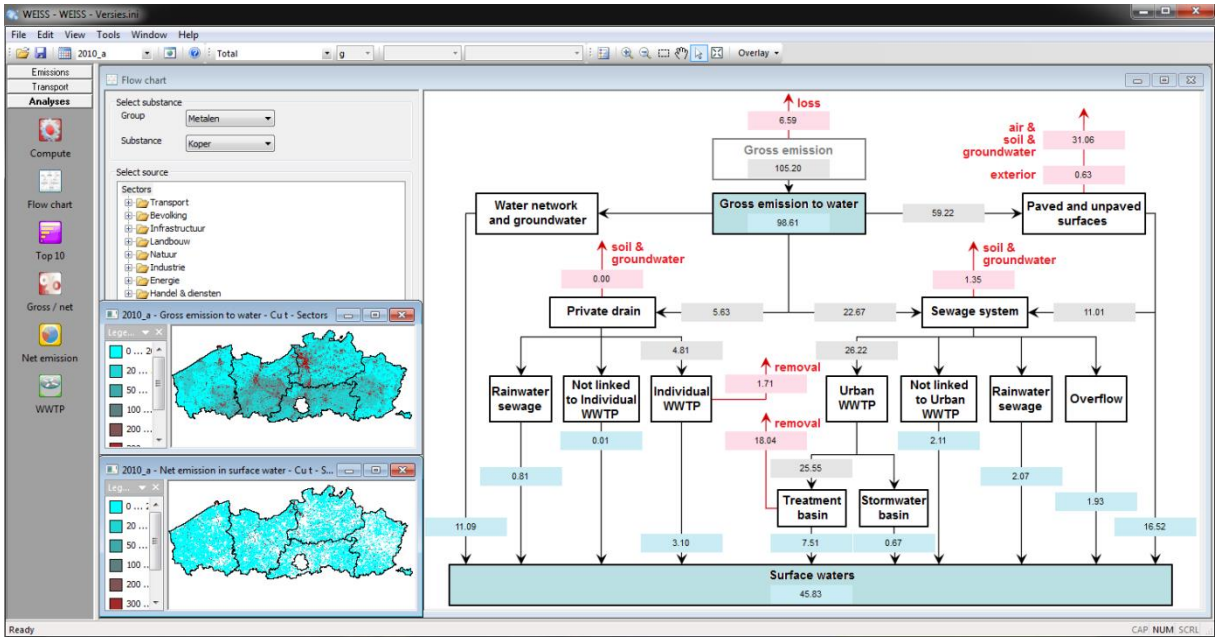
WEISS is a generically applicable system. It can be deployed for regions large and small and operates at the level of detail and resolution determined by the user. For example, the WEISS application developed for Flemish Environment Agency covers the entire territory of Flanders (1.350.000 hectares). All maps are calculated and visualised at a level of detail of one hectare (1ha). It currently comprises all reported point sources (close to 1500) and a hundred or so diffuse sources for heavy metals, PAH's and crop protection products in agriculture for the years 2010, 2011, 2012 and 2015. A total of forty substances are covered.

Overall, WEISS uses the best available GIS and other data for the accurate localisation of the sources. For the transport routes, algorithms are available to work with the detailed spatial layout and characteristics of the sewage system. Similarly, for handling transport via run-off, a dedicated water budget model is available. However, WEISS' transport algorithms are configured so that applications can also be developed for regions that lack the type of sophisticated data and models. In fact, the user can select the type of algorithm and model that fits best the data and models available.

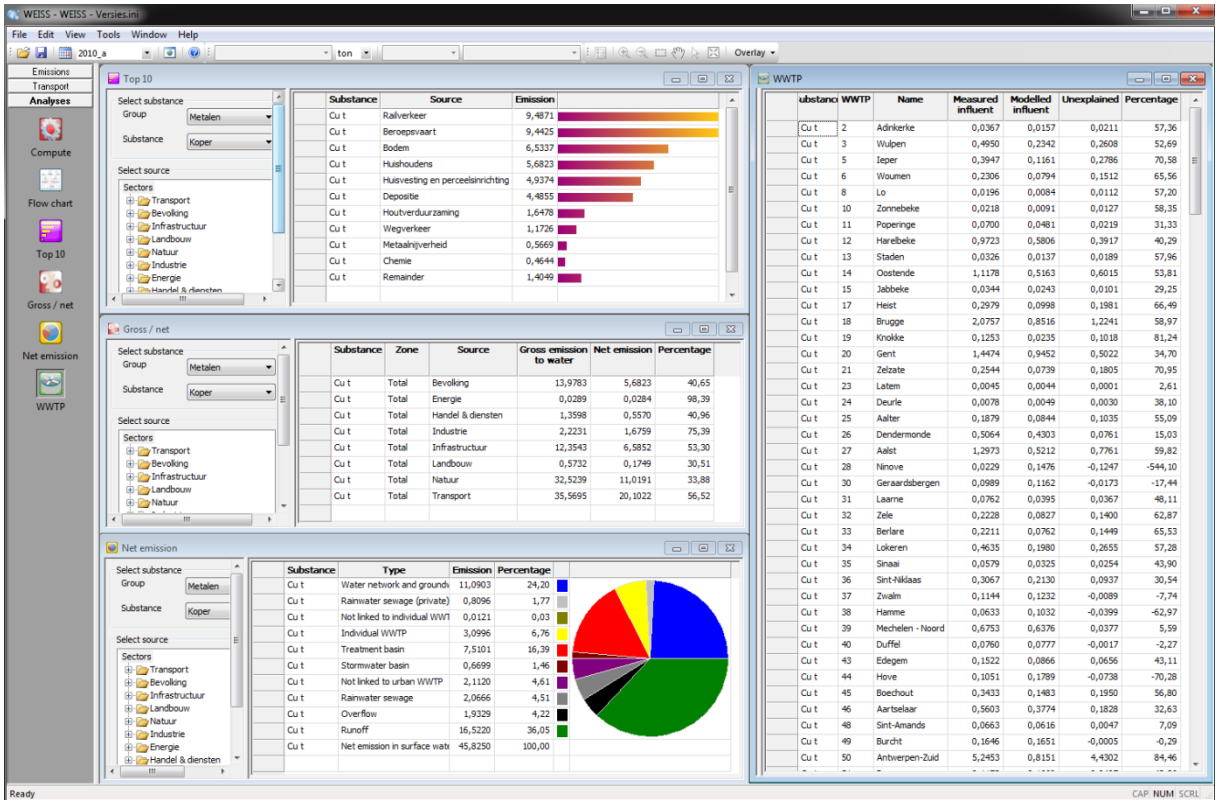
WEISS can save data for different moments in time, hence it can also calculate and visualise trends. Consequently, it can also quantify the effectiveness of measures, changes in technology, application of new materials and products. To this effect, it supports scenario analysis and "what if" exercises. This allows to determine the effects of applying a treatment technology in one or more wastewater treatment plants, the extension of the sewage systems, the connection of individual sewers, changes in stormwater overflow, etc. "What if" questions can also be carried out with respect to the future. This provides answers to questions related to the evolution of water pollution towards 2030, for example, given known or computed demographic and economic trends and the associated changes in the use of land. It is also possible to simulate the consequences of spatial planning policies integrating environmental concerns, hence pay more or less attention to existing sewage infrastructure and its planned extension. The latter may result in great differences in associated investment costs in sewage infrastructure once such policies are implemented.

The following two figures illustrate the user interface of the WEISS system with its analytical capabilities. Results are shown in the form of tables, graphs and maps. Results can be viewed for all

substances present in the WEISS system. Maps showing the distribution of the various substances are most likely the unique feature of WEISS. Apart from a total map across all sectors, the spatial distribution for each individual sector can be viewed. The user can zoom in on a specific river basin, municipality or province. Administrative boundaries, rivers and roads can be overlaid on the maps to facilitate orientation.



Mass balance in the material flow diagram and maps related to the node 'Gross emission to water' and 'Surface waters'



The 'Top 10', 'Gross/Net', 'Net emission' and 'WWTP' tables in the Analysis part of WEISS

In the material flow scheme, for example, the mass balance is shown for each node in the transport network. The user can retrieve the map associated with the most important nodes or links, coloured in blue in the scheme. In addition, the results can be viewed in the form of a top 10 of major emission sources per sub-region, the gross/net ratio, the contributions of the various transport routes to the net emissions, and a table quantifying the unexplained load per WWTP. Flexibility is provided in terms of measuring units, administrative and other sub-regions, position of the sources in the tree structure, position in the material flow scheme, etc.

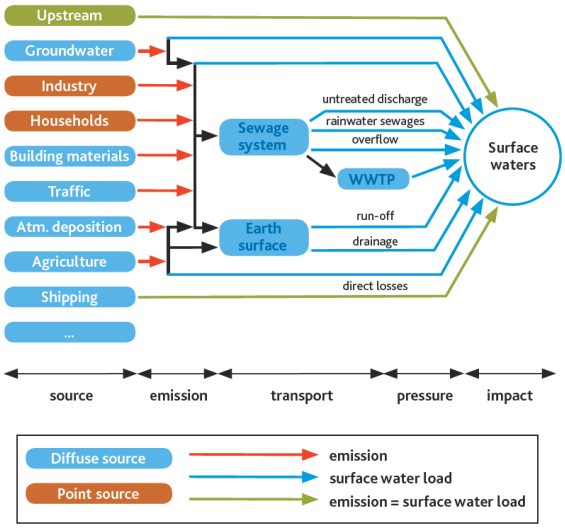
What methodology underlies WEISS?

WEISS enables to map all relevant pollutants in a geographically detailed manner. This covers all substances caused by all major sources and their pathways to the water bodies.

The WEISS system has a generic design and software implementation, making it into a unique tool for the purpose. It can be applied to areas of different sizes: from industrial or rural complexes to entire EU Member States or from small sub-catchments to large transnational river basins. The study area is represented as a regular grid made up of cells, in resolutions ranging from a few square metres to several square kilometres. The resolution can be chosen according to the quality of the available data, the specific requirements and, of course, the processing speed expected during use of the system. WEISS also allows the user to decide on the sources and substances to be included in the system. These lists can be expanded as new information becomes available with time. Sources are represented in a hierarchical structure of maximum five levels, enabling a clear overview and fast access to the required information.

WEISS handles both point and diffuse sources and the aggregation of both. The system is available as a software application that can be fully configured by the user and is perfectly able to grow with the user's needs and the availability of data.

WEISS can be used to create and maintain an emissions inventory of annual loads per substance and per source. Loads can be aggregated by sector, by sub-area, by substance, etc., both at the source and in each point of the material flow scheme. The material flow scheme represents all possible transport routes, from the source to the surface water. This enables to track the substance on its path and to determine the contribution of different pollutants at a geographically detailed level at all times. WEISS thus provides insight into the origin of pollutants which concentrations are measured in rivers.



WEISS is technical in nature, yet very user-friendly. Input screens are available to define the entire application, involving characteristics of each substance and source as well as the geographical information required to represent the sources. The user interface hides the technicalities of the underlying software framework for the user. This software framework consists of coupled algorithms to be selected from a built-in library, specified, chained, and sequentially executed according to the characteristics of each source. The algorithms implement alternative methods for the spatial allocation of point, line and surface sources and the integration of different transport routes, via direct discharge, run-off, or sewage. In addition, algorithms are available to perform quantitative analyses and visualise results as graphs. These analyses range in complexity. Simple analyses involve summing substances over sources, across hierarchical levels and over various geographical administrative or hydrological sub-divisions. Sophisticated analyses involve scenario and trend

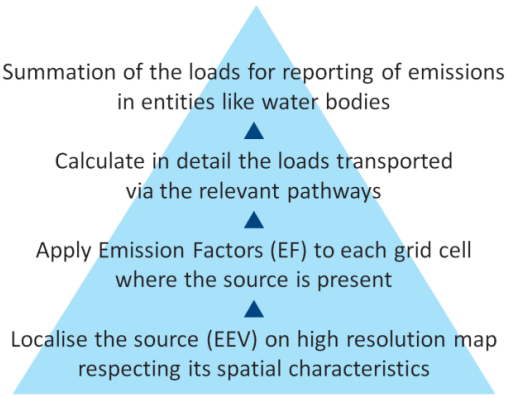
analyses. The algorithms deployed to the effect vary too from general to highly specific. Specific algorithms usually require more input data of higher quality and can therefore only be used if the necessary input data is available.

WEISS is continually expanded with new algorithms, allowing the system to grow in terms of functionality, capability and accuracy. If necessary, or if efficiency gains can be achieved, specific algorithms can be developed and added to optimise the processing of available data, to improve the representation of specific sources, or to facilitate applications in specific areas.

Bottom-up approach in WEISS

The representation of diffuse sources in WEISS is based on a basic formula stating that the gross emission (GE) of a substance is the product of an emission explanatory variable (EEV) and an emission factor (EF).

The emission explanatory variable (EVV) is the physical activity or the physical element that causes the emission. Examples are the number of square metres of zinc gutter in terraced houses, or, the fields where maize is grown, for which farmers use Terbuthylazine, an active crop protection product. The emission explanatory variables in WEISS are generally represented in a spatially explicit manner. They are spatial patterns showing the occurrences of the sources. To the effect, WEISS is supporting the user to generate a map featuring the pattern. In the above examples, these are maps with the location of terraced houses specifying the associated square metres of zinc gutter, or, the map with the parcels where maize is grown.



The emission factors (EF) represent the quantity of substance that is annually released per unit of the emission explanatory variable. Thus, there is an emission factor that represents the amount of zinc released per square metre of gutter and another one specifying the quantity of active substance of Terbuthylazine per hectare of maize. In WEISS, emission factors may also have a spatial dimension. The corrosion of building materials, for example, is known to be a function of volumes of precipitation, of acid rain in industrial areas, and, of concentrations of salt in the air in coastal areas. Scientific research is required to define both the EEV and the EF per source-substance combination. WEISS supports the factual use of this scientific knowledge in policy-making by automating the necessary calculations.

What are technical characteristics of WEISS

WEISS is programmed in C++ as a stand-alone application for the PC platform. It features a graphical user-friendly interface that enables an application to be built from scratch for a new area, using all available functions. The system has built-in GIS functionality and stores its data in an MS Access database. WEISS comes as a software product ready to receive all the base data and start the analyses. A one-day course suffices to know how to set up a new application, use it and manage it.

A demo version of WEISS, complemented with a syllabus featuring training exercises and a comprehensive manual, is available free of charge from this website. It enables new users to quickly set up a small WEISS application for their region and thus discover the functionalities of the system.

VITO can be contracted to assist in the collection and ingestion of all the necessary data as well as the development of scenarios, analysis and interpretation as well as the selection of promising cases for more in depth analysis and action. Similarly, VITO can provide for customization of the WEISS application by incorporating tools, algorithms and models already used by the client.

Who is using WEISS

WEISS was initially developed in 2010-2013 by the Flemish Environment Agency (VMM) and VITO in Project LIFE08 ENV/B/042 of the EU-Life+-programme. Already during its development it was installed to support the agency in its mandatory inventorying and reporting tasks. Since then its capabilities and functionality have evolved with every new application developed and user supported.

In 2013-2014, a WEISS-based water emission inventory for the Brussels Capital Region has been put in place. Since 2015 also the Walloon Region (SPW-DGARNE) uses WEISS for its emission inventory. In this way WEISS has become the unique system to inventory and report emissions to the surface in Belgium. This greatly increases the compliance and interoperability of data exchange between the VMM, BIM and SPW and facilitates greatly the reporting to the EU, the European Environment Agency, the EPRTR, etc.

In 2016 the Port of Antwerp began a WEISS application to analyse the emissions to the surface waters in the port area.

Finally, LIBOVITO, VITO's daughter company in Beijing, China distributes and applies WEISS for Chinese cities and regions.

Acknowledgement and contact details

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