Interreg
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Danube Transnational Programme
Danube Hazard m³c

Deliverable D.T2.1.1

Datasets containing basic input data for pilot regions

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1. Introduction

1.1 Background

With the introduction of the Water Framework Directive (WFD, 2000/60/EEC), trace substances are included in the water status assessment, with priority substances and nationally relevant substances (other substances or river basin specific pollutants RBSP) being highlighted in particular.

According to the Directive, Member States are obliged to present national reports on the status of water bodies and the possibilities for improvement in management plans (Art. 13) and programs of measures (Art. 11). They are required to report an inventory of emissions, discharges and losses of priority substances. Such information can give information on significant pressures but also on the success of measures to reduce emissions and indicate whether further efforts may be needed to achieve good chemical status.

However, reporting of the inventory under the second river basin management plans was patchy and largely incomparable between Member States (Joost van den Roovaart et al., 2020).

Several projects related to emissions to water, carried out in recent years for the European Commission (EC) (Roovaart, J., et al., 2013a/b) and the EEA (ETC/ICM 2017, EEA 2018a, EEA 2018b) show serious problems regarding consistency, completeness and quality of the EU reported emission data. More specific, the EEA reports have shown:

- very little reporting on diffuse sources;
- limited (incomplete) reporting on urban wastewater treatment plant (UWWTP) effluents (not all UWWTPs, not all relevant pollutants);
- unclear quality of emission data of industrial sources (not all facilities, not all relevant pollutants);
- inconsistent reporting in time and space (no comparable and consistent time ranges and not all river basin districts reported) (Joost van den Roovaart et al., 2020);

In the current DRB District Management Plan (DRBMP) and national plans of the Danube region, this topic is heavily underrepresented, mostly owing to substantial knowledge gaps and to the lack of system understanding as well as institutional capacity regarding hazardous substances emissions pathways and effective management options.

At this moment, the considerations on possible measures are often related to punctual, continuous sources such as the discharge of municipal wastewater treatment plants. Emission from point sources are often well described due to a dense and standardized monitoring system, in addition often detailed process knowledge builds a sound fundament to assess the effect on potential measures. Another advantage is that once measures have been implemented at wastewater treatment plants, the effect is immediate and leads to verifiable reductions in pollution.

However, other, often diffuse, substance-specific input pathways are also of great relevance. This is particularly important for **u**biquitous **P**ersistent, **B**ioaccumulative and **T**oxic **s**ubstances (uPBTs). Especially uPBTs are subject to bans or restrictions, but due to their properties (persistence and accumulation potential) they can be displaced over long distances, are not degradable and accumulate in certain environmental compartments. Knowledge on both distribution and concentration in these compartments often is marginal, while process knowledge describing the behavior of these substances in some cases is insufficient.

While often concrete information on point source emission are available or at least comparatively easy to calculate, diffuse pollution can only be described by model approaches. Models are important tools for the comprehensive consideration of complex areas, for the understanding of processes, the assessment and evaluation of the emission behavior and estimation of the efficiency of measures. They can provide spatially differentiated fundamental insights of loads introduced into the water bodies from different sources and pathways, can contribute to a pressure and impact assessments also for catchments that have not been monitored and investigated in detail, and evaluate measures with regard to their effectiveness.

In the Interreg Danube Transnational Programme project "Tackling hazardous substances pollution in the Danube River Basin by Measuring, Modelling-based Management and Capacity building" (short title: Danube Hazard m3c) in seven pilot regions all over the Danube emission modelling will be performed with MoRE (Modelling of Regionalized Emissions).

All pilot regions with specific but representative physical characteristics and a typical expression of different pressures of hazardous substances will be setup and can be used as "Role Model" for further application in the Danube region. With a total area of around 7.900 km^2 the pilots cover nearly one percent of the total Danube catchment area and represent several specific landscape areas, like the alps (Ybbs), the Pannonian lowlands (Wulka, Zagyva, Koppány), Transylvania (Someșul Mic) including the Eastern Carpathians (Vișeu) and the Balkan mountains (Vit).

Furthermore, they represent distinctive characteristics with respect to climate, hydrology, land-use and pollution pressure (Del. 1.2.1, 2020), which cover the aspects of "natural background", "intensive agricultural use", "high share of treated wastewater", "high share of untreated wastewater", "rural wastewater management" and "abandoned and active mining".

The scope of modelled substances includes substances that are relevant for the Danube River Basin (DRB), are mobile, and provide information on specific sources and emission pathways: industrial chemicals with wide dispersive use, pharmaceuticals, herbicides, fungicides, and metals. Specifically, the following substances will be analysed:

- Perfluorooctanesulfonic acid (PFOS), Perfluorooctanoic acid (PFOA) (industrial chemicals)
- 16 EPA Polycyclic aromatic hydrocarbons (PAHs, industrial chemicals, and combustion by-products)
- Mercury (Hg), Cadmium (Cd), Copper (Cu), Nickel (Ni), Lead (Pb), Zinc (Zn), and Arsenic (As) (metals)
- Diclofenac and Carbamazepine (pharmaceuticals)
- 4-tert-Octylphenol (industrial chemical)
- Nonylphenol (industrial chemical)
- Bisphenol A (industrial chemical)
- Metolachlor (herbicide) including Metolachlor-ESA and Metolachlor-OA (metabolites)
- Tebuconazole (fungicide) (Del. 1.2.2, 2020)

Modelling period will be 2016 – 2021 and modelling time steps will be annual. Because most data for 2020 and 2021 are not already available or ordering specific data sets will cause costs, once they are requested, and thus should be ordered only once, it is clear that the data set presented in this deliverable cannot represent a completed version at this stage, but has to be improved step by step. This is also true for some content and algorithm related developments in the model during the project period, which will make adaption, changes and additions of data necessary throughout the whole model application and should be documented in Deliverable 2.1.2.

The project partners Umweltbundesamt (Ybbs), TU Wien (Wulka), BME (Zagyva and Koppány), BWA (Vit) and NARW (Someșul Mic and Vișeu) are responsible to provide data and crucial information on specific information on the pilot regions. Coordination, technical support on data evaluation, as well as model setup is prepared by Umweltbundesamt. The model setup is supported by TU Wien.

1.2 Objectives

In this report in a first step one first dataset of basic input data will be prepared and delivered for each pilot region (sub-divided in sub-catchments). The delineation process of sub-catchments will be documented. Each dataset is structured and formatted following predefined criteria and includes:

- Meta data
- Specific input data values.

These datasets contain all data and information required as input by the MoRE model, excluding the HS concentration data collected in WP T1.

The data is prepared in Input data files, predefined in the model environment and ready to be implemented into the model are prepared.

In order to exceed the usability of the deliverable as a purely tabular work, useful information on necessary input data, possible sources and examples of necessary data preparation steps will also be presented. In order to achieve a better overall understanding, the data will also be related to the context of the model, i.e. the input pathways for which the data are used will be described.

1.3 Overview on MoRE Model

"Modeling of Regionalized Emissions" (MoRE) is a model for the regionalised pathway analysis of substance inputs into surface waters (Fuchs et al., 2017) based on sub-catchments with a size of around 100 km^2. The emissions of different substances from various sources that reach surface waters via different input pathways are calculated with the help of empirical approaches (Kittlaus et al., 2021). The model calculates the emissions via different input paths (see Figure 1).

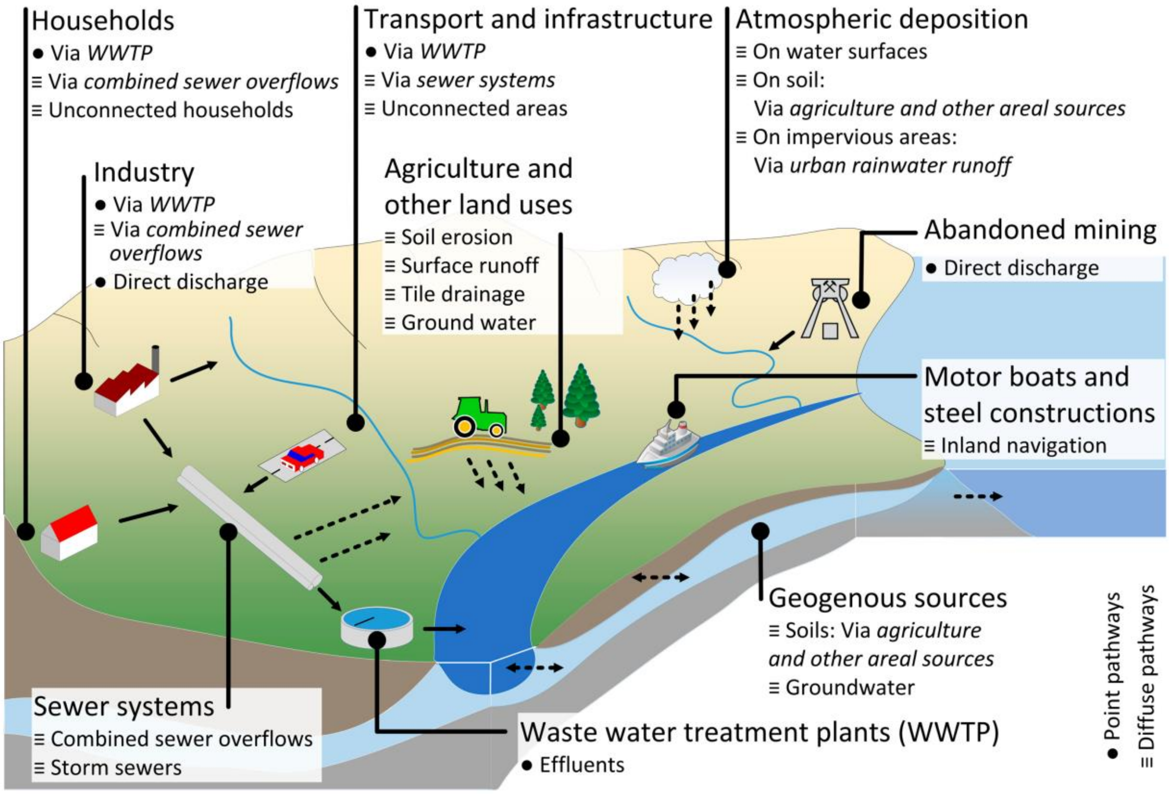


Figure 1: Substance emission pathways of current MoRE applications, arranged by source type (Fuchs et al., 2017)

The modelling approach considers annual time steps for hydrological sub-catchments. It takes into account the retention (sedimentation or degradation/gassing) of substances. Consequently, a substance load in the water body can be calculated for each sub-catchment at the area outlet. A plausibility check of the modelled water body loads is possible by means of a comparison with the loads obtained from observations (Amann et al., 2019).

2. General description of basic input data

To run the model a huge number of input data for each delineated sub-catchment are obligatory. In general the needed input data can be subdivided in:

- Basic input data
- Substance specific input data.

Basic input data subsume all kind of background information on the physical characterization of each sub-catchment and are not substance concentrations or substance-specific turnover or removal rates. In general these data represent GIS data (e.g. specific land use polygons or lines records), but also time series for precipitation or runoff available at specific locations can build these databases. In the latter case, punctual information often have to be interpolated by geo-statistical methods like kriging to produce a valid mean value for the analytical unit of the model: the sub-catchment. In some cases, even geo-statistical methods have to be applied to develop the needed data. This is especially the case if regionalization becomes difficult, because input data are not distributed over the whole area of interest and information are sparse or lacking in specific sub-catchments.

Basic input data includes easily determined morphological data, such as the mean elevation and the mean slope of a sub-catchment or on the other hand information on land use and hydrology, as well as, for example, the soil loss from agricultural areas derived from complex calculation methods.

The required basic data were compiled from a variety of different data sets for each of the seven pilot regions and are aggregated at the level of the sub-catchment. In general the model output is adopted to annual time steps, nevertheless for some pathways, the temporal information has to be prepared for monthly values and of course even data sets with a higher temporal resolution can be used as input data set and be aggregated to the needed time-step.

Because the model structure is flexible, which means that pathways can be added or retired and modelled pathways can be modified and adapted to available information, the data set and the model algorithms can change within different model applications.

With respect to data sampling this should clarify, that the description of a basic data set to start the model is meaningful on the one hand, but it should be acknowledged that the definition of these datasets is not final. On the contrary, the prescribed input data needs to be evaluated with respect to the prevailing data situation because the input data set as well as the model algorithms can be modified and balanced during an iterative determination.

2.1 Model basic input data requirements

In a first step, based on already applied model applications a list of basic input data was compiled. Necessary data were listed and shortly described with respect to the following attributes (see Table 1):

- Model input data code
- Name of input data set
- Short description
- Unit
- Prioritization

Overall Basic input data necessary for a first setup of the model in the pilot regions can be summarized under several main classes with number of datasets necessary in brackets:

- Analytical Unit (1)
- Topography (1)

- Landuse (16)
- Drainages (1)
- Meteorological data (2)
- Hydrological data (1)
- Erosion (2)
- Sewer system (13*)
- Point sources – municipal (5)
- Point sources – industrial (1)

While most of the basic input data are obligatory for the actual model setup, some are only optional. This is especially true for the input data describing emissions from sewer systems. For this pathway, different approaches are implemented in the model and can be used with respect to the data availability. On the other hand that means that not all of the 13 datasets have to be available in each pilot region.

From Table 1 it can be seen that besides area related basic input data some basic input data are related to other units, like time series, rates, shares and specific statistical data. For each country in which pilot regions are situated the data availability, transparency and data management is on a different level, but does show a typical gradient within the Danube region, which makes the results valuable and representative for the whole region.

Table 1: Overview of obligatory and mandatory basic input data for the model MoRE

Actual input data code	**Name**	**Description**	**Unit**	**Parameter**	**Prioritization**
Analitical Unit (AU)	**Topography**				
BI_A		Area of analytical units	km²	Area	1
Topography	**Digital Elevation model**				
BI_ELEVA		Mean hights of subcatchments	m	Elevation	1
Landuse	**Landuse data set**	Landuse categories in actual version	km²		
BI_A_AL_slope_0-1	Arable land	5 slope classes: 0-1; 1-2; 2-4; 4-8; >8 % if possible	km²	Area	1
BI_A_PST	Pastures		km²	Area	1
BI_A_WS_mr	Water surface	Main river (also lakes; reservoirs)	km²	Area	1
BI_A_WS_trib	Water surface	Tributaries (also lakes; reservoirs)	km²	Area	1
BI_A_FOR	Naturally covered areas	Woods; scrubland	km²	Area	1
BI_A_O	Open areas	Mountainous area without vegetation; beaches; dunes	km²	Area	1
BI_A_OPM	Surface mining	Mining areas	km²	Area	1
BI_A_URB	Settlements	Total urban areas	km²	Area	1
BI_A_IMP	Impervious urban area	Paved areas inside urban areas: settlements; industrial estates; car parks….	km²	Area	1
BI_A_WL	Wetlands	Area of Bog; swamp; floodplains	km²	Area	1
BI_A_OR	Country roads	Paved road area; not included in settlements	km²	Area	1
BI_A_REM	Other remaining areas	Other areas not listed above	km²	Area	1
Drainages	**Melioration cadastre**				
TD_SHR_a_td_agrl	Tile drained areas	From arable land and pastures	km²	Area	2
Meteorological Data	**Climatic data**				
AD_EVAPO_lt	Evapotranspiration	Longterm mean annual evapotranspiration	mm	Data series	1
BI_PREC_apr	Precipitation	Monthly values	mm	Data series	1
Hydrological data	**River Discharges**				
BI_Q_net	Net runoff	Modelling period; annual data	m^3/s	Data series	1

Actual input data code	Name	Description	Unit	Parameter	Prioritization
Erosion	**Soil loss**				
ER_agrl_SL_spec_lt_AL	Soil loss	Soil loss from arable land (optional from 5 slope classes)	t/(ha·a)	Soil loss (rate)	1
ER_agrl_SL_spect_lt_PST	Soil loss	Soil loss from pastures	t/(ha·a)	Soil loss, (rate)	1
Sewer sytem	**Statistical Data about inhabitants and waste water system (partly from UWWTD)**				1
BI_INH	Number of inhabitants		inh	Census	
US_ss_VOL_SST	Sedimentation tanks	Storage volume of stormwater sedimentation tanks in separate sewer systems	m^3	Volume	
US_cso_VOL_SOT	Stormwater overflow	Storage volume of stormwater overflow tanks in combined sewer systems	m^3	Volume	
US_cso_VOL_spec_SOT	Stormwater overflow	Storage volume of stormwater overflow tanks in combined sewer systems, area-specific	m^3/ha	Volume (area specific)	
US_L_CS	Combined sewers	Length of combined sewers	km	Length	
US_L_SS	Stormwater sewers	Length of stormwater sewers	km	Length	
US_L_WWS	Sewage sewers	length of sewage sewers	km	Length	
US_SHR_inh_con_tot	Connection rate	Percentage of inhabitants that are connected to sewer systems	%	percentage	
US_SHR_inh_conWWTP_tot	Connection rate	Percentage of inhabitants that are connected to sewer systems and waste water treatment plants	%	percentage	
US_SHR_inh_nss_tot	Connection rate	Percentage of inhabitants that are not connected to sewer systems	%	percentage	
US_INHC_H2O	Water consumption	Inhabitant specific water consumption	l/(inh·d)	Water consumption (rate)	
US_nss_SHR_inhl_towwtp_sept		Percentage of inhabitant load that is transported from septic tanks to waste water treatment plants	%	percentage	
US_Q_spec_COM		Runoff rate for commercial waste water	l/(ha·s)	Water use (rate)	

Actual input data code	**Name**	**Description**	**Unit**	**Parameter**	**Prioritization**
Point source data (one value for each treatment plant)	**Urban wastewater (partly from UWWTD)**				
WWTP_ps_INH_conWWTP	Connection rate	Number of inhabitants that are connected to sewer systems and waste water treatment plants (point sources)	Inh		1
WWTP_ps_CP	Capacity	Capacity of the waste water treatment plant (point sources)	PE		1
WWTP_ps_PE	Load	Nominal load of waste water treatment plant (point sources)	PE		1
WWTP_ps_TS	Treatment type	Current treatment type of waste water treatment plant (point sources)	-		1
WWTP_ps_Q	Discharge	Runoff via waste water treatment plant (point sources)	m³/a		1
Industrial wastewater					
ID_ps_Q	Discharge	Runoff via industrial direct dischargers	m³/a		1

2.2 Structure and Format of Basic input data

The structure and the format of the basic input data is predefined by the model input data templates, which are available in Excel format (Annex 2). In general, only few different formats of input data have to be considered and are explained below. The main difference among the input data structure can be found between point source data and all the other data, which are aggregated to the sub-catchment scale.

Point source information used in this model approach represent discrete emission to the surface water at a predefined point (discharge point) from a well described source (Waste Water Treatment Plant). Consequently, in a first step in a specific data sheet a database on Waste Water Treatment Plants is prepared, where most important master data are provided, which can be summarized:

- Plant ID (national data base)
- Discharge point ID (national data base)
- ID of analytical unit (linking source and reference space considering the discharge point)
- Type of point source (municipal – treatment type, industrial)
- Short Description
- Sectors (mainly for industrial plants or if high share of industrial influent from industry is in place)
- Coordinates of plants
- Coordinates of discharge point.

This master data on WWTPs are important background information, when in a later step the effect of mitigation measures should be calculated. Furthermore, the differentiation on discrete information of the location of a WWTP and its discharge point avoids possible inconsistencies, in case the Plant is situated at the border of catchment A but the effluent emitted to the surface water is situated in catchment B.

A further differentiation of the basic input data is addressed on the frequency of use in the calculation process. Most of the basic input data represent more or less stable data, without or only with a minor annual dynamic. Average slope or elevation but also landuse data remain stable over the period of investigation. Here one value for each analytical unit (sub – catchment) is sufficient for the whole period. These data are called “Analytical Units Variables”. Other basic input data, like soil loss, precipitation, runoff can differ a lot from year to year. This natural dynamic is considered by annual input data called “Periodical Analytical Unit Variables”. In some cases even monthly information have to be provided (precipitation).

2.3 Role of basic input data in the model approach

The basic input data feed into different calculation approaches and pathways of the model. For a perfect approach, detailed information on the water balance components (here with respect to each evaluated pathway and for each spatial unit) would be combined with detailed information of substance concentration values in all pathways and spatial units that contribute to the total emission to surface waters. In such a case, the spatial and temporal resolution of the information (e.g. from measurements) would determine the calculation of loads and another model than a pure balance model would not be needed. However, in almost no case such detailed sets of data exist on the mesoscale and can only be found (if at all) on the plot scale or the river reach scale. Consequently, the basic input data are used to calculate missing values, which are particularly often needed when describing diffuse substance emissions. The simple example of drainages should illustrate this procedure. There is no information on discharges from drainages. Simple algorithms can calculate this discharge on the basis of precipitation during the summer and the winter half-year and the agricultural used area under melioration, based on each spatial unit (sub catchment) of the model.

With respect to point source emission from municipal wastewater we can very often fall back on detailed information, especially from agglomerations > 2.000 PE, reported under the Urban Waste Water Treatment Directive 91/271/EC (UWWTD), at least in the European member states of the Danube region. In agglomeration < 2.000 PE these point source information already became much more uncertain and random.

Moreover, no, or at least very little information are available, neither for runoff nor for concentration values in diffuse emission pathways. Here the application of models is essential, calculating runoff and concentration values of different substances on base of different, most empirical or statistical approaches.

To increase transparency of the role of basic input data in the MoRE model, each input data set or at least the main group (like landuse data) is briefly described with respect to its functionality within the model framework.

2.3.1 Analytical Unit (BI_A)

In a very first step, the Analytical unit (sub-catchment) in each pilot region needs to be defined. The analytical unit is the reference area to which all input data are related. Important aspects of the delineation of the analytical unit or sub-catchment can be summarized:

- Opportunity of model validation (total runoff and/or total substance load).
- Catchment area sizes as uniform as possible, with a size of some tenth to some hundreds of km^2 considering the model scale (mesoscale).
- Consideration of Hydrological aspects, like delineation of large tributaries.

Please find a detailed description of the delineation for all pilot regions and sub-catchments in chapter 2.5.

2.3.2 Mean elevation (BI_ELEVA) and mean slope (BI_SLP)

For each of the catchments, the mean elevation in m above sea level and the average slope were calculated. The results are the mean altitude in metres above Adriatic Sea level (m.a.s.l.) for the mean sea level and a mean percentage value for the mean slope (100% corresponds to 45°).

The mean elevation is a criteria, which is used to separate different model approaches. Originally, the model was applied for the Nort Eastern German lowlands. In an application some model adaptations were implemented for its application in alpine regions in Austria (Zessner et al., 2011). These changes are used, when the mean elevation exceeds a specific threshold.

The mean slope is used to calculate shares of surface runoff in each sub-catchments and is also used for a calculation of the Soil Delivery Ratio (SDR), which gives an estimate on the share of particulate material, mobilized during erosion events, which reaches the surface water and is not stored on plain areas of the field.

2.3.3 Landuse data set (BI_A_...)

Table 1 gives an overview of the manifold landuse classes, which are used as basic input data in the model. The specific landuse is an essential parameter set to describe the specific physical appearance of a catchment or a sub-catchment. Furthermore, many pathways are interlinked and related to specific landuses. E.g. the atmospheric deposition is calculated for the total surface water area in each sub-catchment. Erosion processes are calculated for different conditions and processes in the model. Erosion of arable land and grassland can be calculated with the Revised Universal Soil Loss Equation

(RUSLE). For erosion from forests, on the other hand, there is little data and these processes are often estimated using specific rates. Even the input from open areas or from glaciers into surface waters is not extensively studied and only few data are available on these topics.

2.3.4 Meteorological data

Meteorological data like monthly values of precipitation (BI_PREC_apr i.e.) and longterm evapotranspiration (AD_EVAPO_lt) are important basic input parameters. As already mentioned above the share of different water balance components is calculated with the help of this information. Furthermore, if runoff data are lacking these input data can help to estimate the runoff in sub-catchments without any specific information.

2.3.5 Hydrological data (BI_Q_net)

Hydrological data describe the net runoff of each sub-catchment. On the one hand, the net runoff determines the values of the whole water balance in the model, calculating surface runoff, runoff from drainages, runoff from groundwater (a summed value of the subsurface runoff and the baseflow), runoff from sewer systems (stormwater overflows) and runoff from urban and industrial Waste Water Treatment Plants and thus contributes significantly to the model result. On the other hand based on the net runoff at the sub-catchment outlet the validation of the model results is realized. As a product of the net-runoff and measured concentrations annual surface water loads are calculated and are compared to the model results.

2.3.6 Drainages (TD_SHR_a_td_agrl)

The share of drained areas on the agricultural land (arable land and pastures) is a parameter, which often underlies huge uncertainties. Melioration cadasters, if available, are often not in an actual state. Drainages from many decades can be collected and it is unclear, if the old drainages are still in place, or if they still work. Furthermore, often the inclusion of drains in a cadaster is subject to various criteria, such as a minimum size. Many small drained areas are therefore not included in the melioration cadasters. Often the cadasters exist in analogue form and digitization is progressing slowly. In many cases the quality of the documentation depends on the responsible administrative authority and can also vary greatly within a country if not managed centrally.

2.3.7 Soil loss from agricultural area

As mentioned before the soil from agricultural refers to losses from arable land (ER_agrl_SL_spec_lt_AL) and losses from pastures (ER_agrl_SL_spect_lt_PST). In the case of soil loss from pastures, the loss is usually well below 1 t ha^{-1} yr^{-1}, at least for relevant areas. Soil loss from arable land can be many times higher and is usually highly relevant, not only for the transport of suspended matter, but also for the input of various substances transported in adsorbed form into surface waters. The calculation of soil loss is not simple and needs a lot of input parameters. To provide soil losses you can apply the universal soil loss Equation (USLE) or the revised Universal Soil Loss Equation (RUSLE). On the European scale data are provided by the JRC at a resolution of 100 m (https://esdac.jrc.ec.europa.eu/content/soil-erosion-water-rusle2015) using the RUSLE. In Austria or in Germany the Invekos data build a solid database for the calculation of soil loss on the field scale. For the complete Austrian territory, an actualized soil loss map was produced based on a long-term precipitation data series. Using the RUSLE, potential soil losses in this map are primarily calculated based on different crop rotations or previous crop - main crop combinations (BAW, 2020).

2.3.8 Sewer System

The calculation procedure of sewer systems highly depends on the data availability and can show huge variations.

The following paragraph describes how the sewer systems were modelled in the Stobimo Spurenstoffe Project (Amann et al., 2019). In that project the loads from surface areas entering the sewer systems were calculated using the surface potentials for settlement areas and roads which were established in the SCHTURM Project (Clara et al., 2014), for 16 PAK the surface potentials where taken from Hillenbrand et al. (2016). The surface potentials were calculated from measured concentrations in the sewer systems (separate sewer system and combined sewer system without wastewater), the catchment area of the sewer system and the amount of precipitation leading to the measured event.

From the surface potentials and the mean annual precipitation per AU a mean concentration in surface runoff is calculated, which is used as concentration for the separate sewer system. The same concentration is used for the surface runoff portion of combined sewer systems. The concentration of combined sewer systems is calculated in the following way:

The load from the surface run off and the load from the wastewater portion are summed and divided by the total discharge of the combined sewer system to obtain a theoretical concentration for the combined sewer system.

Furthermore, in SCHTURM the mean annual run-off from combined sewer systems (US_cso_Q) and separate sewer systems (US_ss_Q) were balanced for Austria, based on all existing Treatment Plant catchments, long-term precipitation rates and a detailed analyses and balance of the impervious (urban) areas and the country roads. In another step the data on base of Treatment Plant catchments (defined by the sewage system network) were aggregated to the sub-catchments used in Austria. In another step, the mean annual discharges were disaggregated to annual data to describe the annual variations of the runoff in the model period. This adaptation was simply achieved, by the calculation of the ratio of the annual runoff data with the mean long-term data set in each Treatment Plant catchment.

Most of the variables from Table 1 dealing with sewer systems and not addressed yet, however they can be used or should help to calculate runoff from the sewer systems. Especially information on the number of inhabitants (BI_INH) and the inhabitant specific water consumption (US_INHC_H2O) as well as:

- the percentage of inhabitants that are connected to sewer systems (US_SHR_inh_con_tot),
- the percentage of inhabitants that are connected to sewer systems and waste water treatment plants (US_SHR_inh_conWWTP_tot),
- the percentage of inhabitant, where the sewer is transported from septic tanks to waste water treatment plants (US_nss_SHR_inhl_towwtp_sept),
- the percentage of inhabitants that are not connected to sewer systems (US_SHR_inh_nss_tot)

are related to information, which can be derived from the UWWTD reporting for agglomerations bigger than 2.000 PE (https://uwwtd.eu/). These data sets gain in importance the more we move to the downstream countries in the Danube catchment. In Germany or Austria, more than 96% of all inhabitants are connected to sewer systems and waste water treatment plants. Only a small share of population is using Individual Appropriate Systems (IAS) or decentralized solutions. In countries like e.g. Bulgaria and Romania the share of population using decentralized solutions or IAS, or are not connected to a sewer system at all can increase significantly and thus may play an important pathway for organic pollution but also for selected hazardous substances.

2.3.9 Municipal Waste Water Treatment Plants

Waste Water Treatment Plants >2000 PE are reported under the UWWTD (https://uwwtd.eu/) in EU member states. From this data source many helpful information like current load (WWTP_ps_PE), the type of waste water treatment (WWTP_ps_TS) or the number of inhabitants connected to sewer systems and treatment plants (WWTP_ps_INH_conWWTP) can be derived. Reporting of runoff (WWTP_ps_Q) or emission loads of specific substances is not included in this reporting, which has its clear focus in the assessment of the legal regulations. However, discharge can be calculated from current load and the country specific water consumption per Population Equivalent (PE).

More detailed information on discharge and loads from treatment plants are often available in national databases. One example from Austria is the Emission Register for Surface Water Bodies (EMREG-OW) established in 2008, following the “Kläranlagendatenbank”. In this database all significant pressures on surface water bodies from substances from point sources, authorized under water legislation are to be recorded.

Information on municipal Waste Water Treatment Plants smaller than 2000 PE are often random and the Water and Waste Management Associations can support the evaluation of those data. Often these data are not available or cannot be related to a discrete coordinate but are aggregated at higher regional planning units, like NUTS-3.

2.3.10 Industrial Waste Water Treatment Plants

In European member states industrial operations report the release of pollutants, the emission of quantities of waste and the emission of pollutants in waste water, if certain threshold values or quantities of waste are exceeded, under the European Pollutant Release and Transfer Register (PRTR). Furthermore, national databases (e.g. the EMREG-OW in Austria) can give information on direct discharges of industrial Waste Water Treatment Plants, which undershoot the often-high thresholds of substance loads, permitted in the PRTR.

2.4 Examples of basic input data and their preprocessing

Basic input data availability can differ significantly with respect to the thematic requirements, but also among countries or even River Basin Districts. If specific data sets are insufficient, because of incompleteness, being outdated, uncertain or at least not available at all e.g. on the national base, there are two opportunities:

- To evaluate similar data sets from which the necessary information can be transferred by methodological adaptations.
- To evaluate information on a more common scale (e.g. European level).

On a mid-term perspective, in case of important input data are not available, a well-coordinated process should be started to close these data gaps on base of a clear prioritization.

In this chapter we will give examples on selected input data and how different preprocessing approaches can generate the needed input data sets. To consider different approaches, examples will be presented from a German MoRE model application and an Austrian MoRE model application. Furthermore, to address the situation in the Danube catchment even examples from an actual model approach on nutrient emission modelling with MONERIS should be demonstrated here, dealing with very similar input data, but often use more general data sources, partly on European scale.

2.4.1 Basic input data availability and Preprocessing - Examples from Germany

Information on selected basic input data, the used data sources, the spatial and temporal resolution, the preprocessing and aggregation on sub-catchment scale in a German-wide MoRE model application are kindly provided by the German Environment Agency (Umweltbundesamt – UBA), which is an Associated Partner of this project.

All information on different basic input data provided are presented in “Annex 3 Data availability & preprocessing – Examples from Germany”. The focus in this chapter is laid on the data sources and preprocessing of input data used to quantify emission from sewer systems. These emissions are realized via storm sewer outlet, combined sewer over flows and inhabitants not connected to waste water treatment plants. On the one hand, sewer systems represent important pathways for a number of substances modelled in Danube Hazard m3c. On the other hand, within Danube countries pronounced differences in data availability, procedure of technical application and relevance exist especially in this sector.

The quantification of emissions from storm sewers follows the following approach:

$$E_{SSS} = SFL_{imp} \cdot A_{SSS,imp} \cdot 100$$

with

E_{SSS} = $emissions\ from\ stormwater$ outlet $in\ separated\ sewer\ system\ (SSS)[kg/a]$

SFL_{imp} =$surface\ load\ of\ impervious\ areas\ [kg/(ha{\cdot}a)]$

$A_{SSS,}$ = $impervious\ areas\ in\ separated\ sewer\ system\ [km^2]$

The efficiency of storm water tanks depends on the basin type. In the German MoRE-modelling a reduction of load was assumed only for storm water treatment tanks. If the storm channel is connected to a stormwater treatment tank the emitted load could be reduced by 20% because of the sedimentation (Fuchs et al 2013). The existence (share) of this basin type was calculated based on information available from two of the 16 German federal states (Baden-Württemberg (BW) and North Rhine-Westphalia (NW)) on NUTS2-level (German federal states). According to this for approximately 43% of German storm water tanks a load reduction of 20% has been considered.

The storage volume of sedimentation tanks in separate sewer systems (US_ss_VOL_SST) was carried out on NUTS3-level on base of national statistics. Transfer to catchment level (analytical units) was carried out area weighted (based on sealed area connected to separate sewer systems).

Information about the regional distribution of different sewage systems is not available on the national level. Therefore, the available statistical information on the length of sewage systems (*US_L_WWS as sum of US_L_CS and US_L_SS)* has to be used (available on NUTS4-level) to estimate the share of combined and separate sewer systems based on the total length of sewers (US_L_WWS). To calculate the length of sewage system in a sub-catchment, information on the impervious urban area is needed. This information is derived from Corine Landcover maps combined with an European map of Imperiousness (Fast Track Service Precursor on Land Monitoring, EEA, 2010). The information on inhabitants connected to the sewer systems and UWWTP (WWTP_ps_INH_conWWTP) are based on the national statistics (NUTS4-level) and was linked with NUTS4 geometry. The aggregation on catchment level is realized by weighting the urban area in analytical units. Furthermore, the information was used to calculate the connected inhabitants to IAS and to the sewer system without treatment in an UWWTP (were at least mechanical treatment is applied). A detailed description of the aggregation of population and connection rates to surface water sub-catchments can be find at (Stephan Fuchs et al., 2017, page 82 and 88).

The specific surface load ready to be wash of annually with the stormwater runoff results from different monitoring programs recently conducted in Europe. The assumption is that the annual area specific surface load is completely mobilized on a long-term average independent from the annual precipitation.

For the calculation of emissions via combined sewer overflows further input data is required:

- Number of inhabitants (BI_INH)
- Water usage (average) per capita (US_INHC_H2O)

- Storage volume of combined sewer overflow tanks (US_cso_VOL_SOT)

(BI_INH)

The number of inhabitants is reported in EUROSTAT (https://ec.europa.eu/eurostat/de/home) on an annual base.

(US_INHC_H2O)

The average water use per capita is derived from the national statistics at NUTS2-level and provided (US_ss_VOL_SST) by the German federal states. The national statistics is updated approximately every 3 years. Data are available in L per capita per day (with a range in 2016 between 93 – 140 L and a German average of 123 L; https://www-genesis.destatis.de/genesis/online?sequenz=tabelleErgebnis&selectionname=32211-0001#abreadcrumb).

(US_ss_VOL_SST) Storage volume of combined sewer overflow tanks

The storage volume of combined sewer overflow tank is available on federal state level. Together with the share of impervious catchment areas drained with combined sewers it can be used to calculate the degree of implementation and need for further action. According to Brombach, H. and Michelbach, S. (1998) a specific volume of 22.3 m³/ha can be used as a benchmark for 100% implementation. The degree of implementation is finally used to calculate a discharge rate and the corresponding amount of sanitary sewage.

Calculations were carried out on NUTS3-level. The transfer to the catchment level (analytical units) is area weighted (based on the impervious area connected to combined sewer systems).

2.4.2 Basic input data availability and Preprocessing - Examples from Austria

One example of complex basic input data preprocessing is the calculation of soil loss from agricultural land (arable land and pastures) by using the RUSLE. This input data was chosen for a more detailed presentation, because the evaluation of data availability in the pilot regions clearly pointed out that soil loss calculations (on the national scale) are not available for the downstream pilots in the Danube Basin.

In these cases, it was agreed, to use the soil loss map provided from the European Soil Data Centre (ESDAC), esdac.jrc.ec.europa.eu, European Commission, Joint Research Centre at European scale in a first step (Panagos et al., 2012; Panagos et al. 2015).

For Austria the soil loss calculation for emission modelling was provided during two projects founded by the BMLRT (Fuchs et al., 2019) and (Amann et al., 2019). Annual data are available representing values from 2007-2014. On the national level, data are available for a period of 2009-2014 (six years) representing different crop cultivation and crop rotation and even an annual variety of climatic conditions on field scale. Data, with a high spatial but even thematic variety were prepared in an Access database and transferred to Excel sheets. The thematic variety makes this input database a flexible tool to calculate mitigation measures.

In general the RUSLE calculations in this approach are disaggregated for:

-arable land (in five different slope classes: 0-1%, 1-2%, 2-4%; 4-8% and >8%) and pastures

-specific crop types

-with mitigation measures already in place and without mitigation measures.

This disaggregated database has the advantage, that different types of mitigation measures (crop specific or catch crop specific in different slope classes) can be integrated in the evaluation and thus make first estimates of mitigation measures on soil loss by defined measures possible. For example, the effect of greening or a substitution of erosive cultures in unfavorable slopes by other cultures can be easily estimated.

The data source providing all main input data on the field scale is the INVEKOS database. All relevant information to calculate the soil loss are summarized here. Within the database each factor of the RUSLE is prepared.

Aggregation of soil losses on the level of cadastral municipalities and later to the sub-catchments is prepared in a final phase of the processing procedure.

In general, the USLE is calculated by:

A=R×K×S×L×C×P

A	Soil loss (t*ha^{-1}*a^{-1})
R	Rainfall intensity (measure of the area-specific erosion force of precipitation)
K	Soil erodibility (depends on the grain size composition (texture) of the soil)
S	Slope factor (Ratio of the soil loss of a slope of any inclination to that of the standard slope (9% gradient))
L	Length factor (Ratio of the soil loss of a slope of any length to that of the standard slope (22 m length))
C	Cultivation factor (Ratio of the soil loss on a slope of any type of cultivation (e.g. crop) to that under fallow land – standard values often country specific)
P	Factor of soil loss mitigation measures (Ratio of soil erosion with any erosion control measures to that without measures – often standard values)

To demonstrate more in detail, how these factors can be calculated and in in what order of magnitude they are, some examples are given from Austria.

R-factor

The R-factor is calculated based on long-term measurements of 20 years' time series.

In Austria the R-factor ranges between 48 and 306 N/h, with a clear maximum in regions rich in high precipitation and even heavy rain precipitation (mountainous area).

Quantification can be arranged by simple regression calculation (e.g. Schwertmann et al, 1990):

R= 0,141 * summer precipitation -1,48

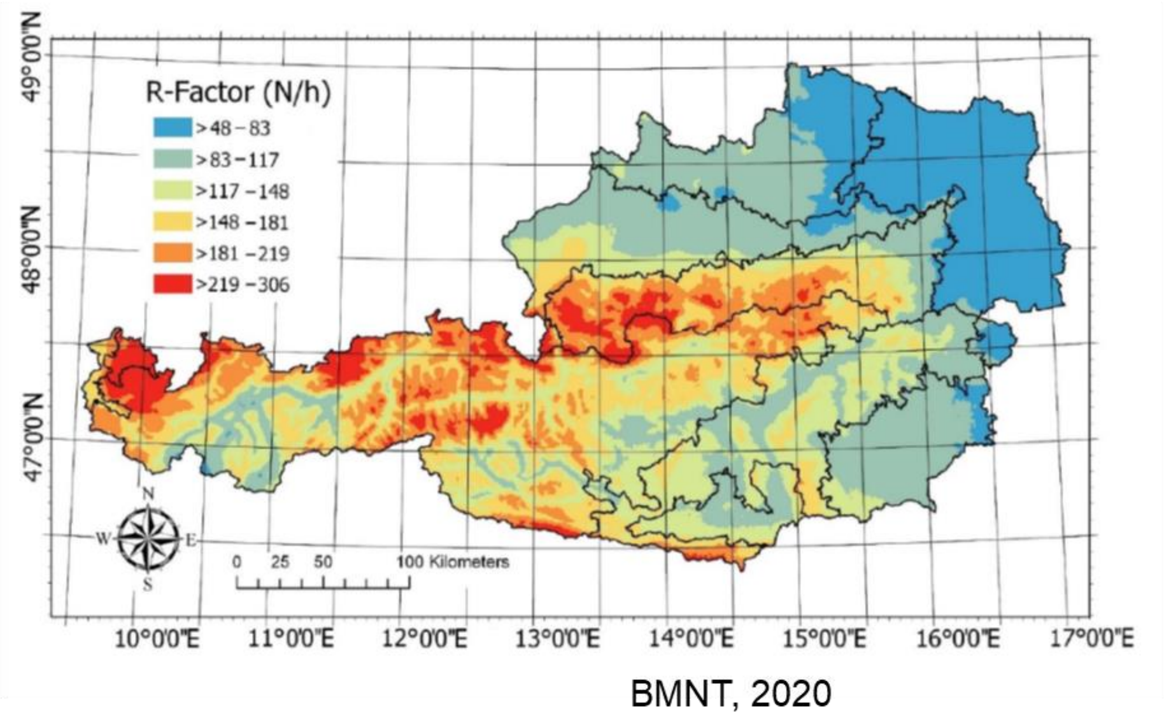


Figure 2: R-factor map for Austria (BMNT, 2020)

K-factor

The k-factor is a function of stone cover and silt cover of a soil. In Austria it is calculated by:

0,0086*silt content [%]

The variation of the K-factor in Austria ranges from 0,01 to 0,086.

LS-factor

The LS factor describes the topographical condition of a field and is calculated in Austria based on the DEM 10m (10mx10m grid). The value in Austria ranges from 1 to more than 10 in the mountainous area.

C-factor and P-factor

All crops listed in INVEKOS were allocated to specific reference crops. The higher the erosion risk caused by the crop, the higher is the value of the C-factor.

The P-factor expresses if soil loss is reduced by specific mitigation measures, like kind of tillage, catch crop cultivation or the cover of the uncultivated surface with mulch seeding to prevent black fallow land.

2.4.3 Basic input data availability and Preprocessing - Examples from the Danube Basin

In the Danube River Basin Management Plan the nutrient emission modelling with MONERIS plays an important role to give a sound system analyses and to identify significant pressures and pathways on base of sub-catchments. Activities are proceeded by the IGB-Berlin, were the model MONERIS was developed and is applied and further developed since two decades.

For the 3rd DRBMP activities to setup an actualized model are already finished an a second progress report summarizes the status of the modelling. In the Danube catchment, EU countries and non-EU members come together, which poses a great challenge for modelling in the way that data availability is often very heterogeneous, which is also exacerbated by a west-east divide. To provide a harmonized model approach therefore in some cases basic input data from large scale databases (e.g. European or worldwide) are applied.

In the following paragraphs tested and used databases on the Danube River Basin scale are summarized, which are prepared by IGB-Berlin and documented in an interim report (Gericke & Venohr, 2021). Some of this databases should be listed and briefly introduced here.

Soil loss

As mentioned in chapter 2.3.2 the JRC has published a map for EU countries and a global map based on more recent and more complex input data. The EU map considers the soil management (conservation, P factor) and provides data on a 100 x 100 m raster.

Landuse data – main rivers and tributaries

The area of rivers – main rivers or tributaries is a basic input data set, which is often not easy to collect. In many cases databases provide no information on the width of the rivers or show serious lack of data especially among the smaller tributaries. After testing different landuse data sets Gericke & Venohr, 2021 used the EC-RINS river network (European Environment Agency 2012) for Danube-wide modelling. It was found, that streams which have been derived from a digital elevation modelcan deviate from their true location. The most serious uncertainties in the dataset were found in Hungary and in Serbia. Additionally, ECRINS lacks information on canals. Even this data set provides no information on the river width (polylines not polygons). Consequently, you have to estimate the area of the surface water, e.g. by using the STRAHLER classification and estimate the total surface water area in a sub-catchment.

The dataset was intended to correspond to a map scale of 1:250000, which was confirmed by comparing the stream lengths to exemplary national datasets of Austria and Germany and OpenStreetMap data10 for Hungary.

Industrial dischargers

Data on industrial dischargers can vary significantly in the Danube basin. In absence of a basin-wide inventory of industrial dischargers, the E-PRTR database could be used, which covered the EU countries, Serbia, and even Switzerland. Reporting under the PRTR is obligatory at significant thresholds, which, as a consequence means, that industrial direct dischargers emitting specific substances below this thresholds do not have to report it.

Population numbers

The annual population could be derived from national statistics and the global GHS-POP grid (up to 2015) (Schiavina et al., 2019).

Precipitation and Evapotranspiration

If no precise national information on precipitation or evapotranspiration are in place, the E-OBS dataset provides detailed information on daily precipitation on a 0.1 and 0.25 degree regular grid (https://www.ecad.eu/download/ensembles/download.php#maps), from which the monthly precipitation data can be derived. Before using them, the meteorological stations used for interpolation needs to be checked, because of an unregularly density of stations used for interpolation at different landscapes. In most regions, E-OBS data are based on a very dense network of information. In few regions, e.g. in the Austrian Alpine Region, the number of stations used to interpolate precipitation is not sufficient and national information could provide data that are more reliable.

Two alternative global Evapotranspiration datasets were processed by Gericke & Venohr (2021). Both prepared reliable information. This is the GLEAM dataset (https://www.gleam.eu/22) and the MODIS dataset, which provide comparable information.

An alternative data source which could provide both precipitation as well as evapotranspiration is Copernicus. Copernicus provides numerous data sets based on satellite data in different areas of expertise (i.e. Atmosphere, Land, Climate change). There are different data sets for precipitation and Evapotranspiration (i.e. sen4ET), however the preprocessing that is needed to obtain a usable data set is quite extensive.

2.5 Delineation of catchments and sub catchments

The spatial units used in the MoRE model are sub catchments, who are preferable around 100 km^2 or comparable in size. To ensure a possibility to validate the model it is important that as many as possible outlets points of sub catchments coincide with discharge and water quality measurement. In order to reach these objectives the delineation of the sub catchments was updated in respect to the delineation in the project proposal. In the following two chapters, first the delineation process and second the changes made will be described.

By updating the delineation of the catchments, it was also ensured that in all seven pilot areas the same method was used.

2.5.1 Delineation method

This method delineates catchments from a Digital Elevation Model (DEM) with existing ArcGIS functions from the Watershed toolbox. The following input data is needed:

- DEM (raster data)
- Water network (raster data)
- Outlet points (vector data)

The first step is to push the water network into the DEM. This is done by lowering the raster cells representing the water network by a small amount, only the cells of the water network are lowered. The next steps will be listed as bullet points:

- The prepared DEM is filled with the ArcGIS spatial analyst function fill, this results in a filled DEM.
- From this filled DEM, the flow direction is calculated, the results is a raster file with the flow direction. The flow direction represent the way in which water would flow from one raster cell to an adjacent cell.
- The flow direction water is used to calculate the flow accumulation, which represent how many cell flow into a particular raster cell, the result is a raster file with the flow accumulation.
- The outlet points and the snap distance together with the flow accumulation are used as input for the function snap pour points to distinguish the cells with the highest accumulated flow within the specified distance from the outlet points. This results in a raster with the outlet points.
- The flow direction and outlet points rasters are used as input data for the Watershed function, which calculated the watersheds belonging to the predefined outlet points. The watershed raster is converted into watershed polygons.
- The raster based watershed borders are smoothed.

2.5.2 Changes in the pilot areas in respect to the project proposal

The revised catchment delineation results in the following allocation. Table 2 expresses the final catchment delineation in the pilot regions, the sub-catchments, their ID, the catchment hierarchy (ToID), the seize, the summed area considering the discharge tree and the mean average elevation.

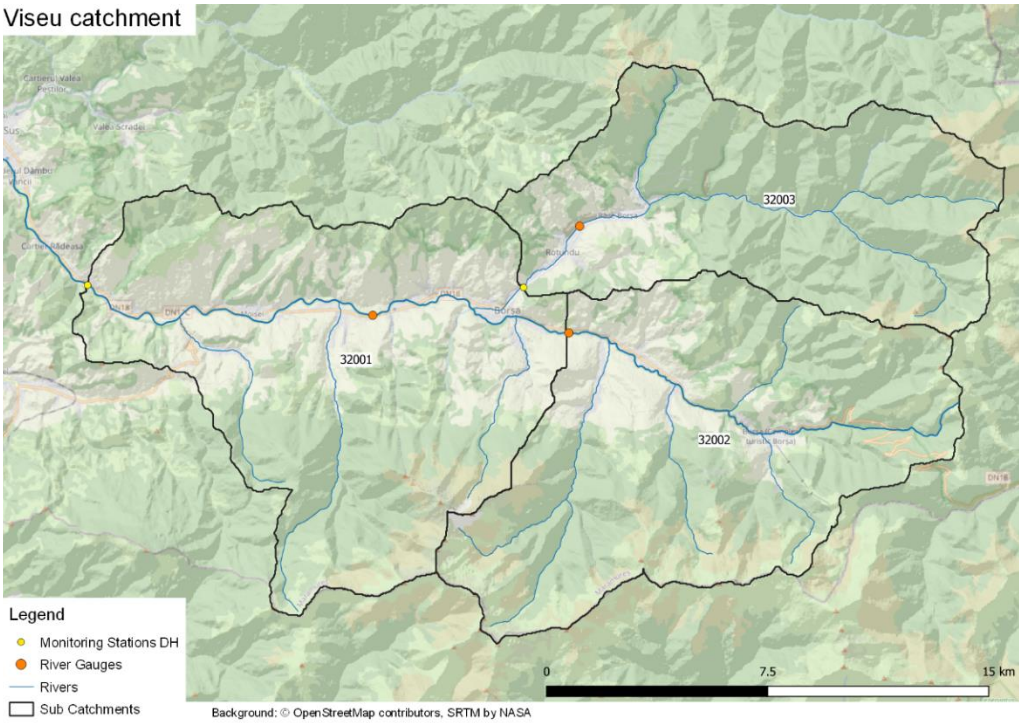
In total in seven pilot regions distributed among four countries 34 sub-catchments were delineated and will be modelled. The seize of the sub-catchments varies from 41,4 to 66,8 km^2 and have a mean seize of 232,3 km^2. The mean elevation varies from 169,7 m a A. in a Wulka sub-catchment to 1276,9 m a A. in a Viseau sub-catchment.

Table 2: Overview of Sub Catchments for all Pilot regions

Sortier_N	State	Riversystem	Catchment	ID MORE	TOID MORE	Rivername	Area [km^2]	Summed Area [km^2]	Mean Elevation [m a A]
1	AT	Danube	Ybbs	11001	11000	Ybbs	224,4	1111,9	396,0
2	AT	Danube	Ybbs	11002	11001	Url	158,7	158,7	439,0
3	AT	Danube	Ybbs	11003	11001	Ybbs	112,5	728,8	599,0
4	AT	Danube	Ybbs	11004	11003	Kleine Ybbs	111,8	111,8	684,0
5	AT	Danube	Ybbs	11005	11003	Ybbs	71,0	504,5	728,6
6	AT	Danube	Ybbs	11006	11005	Ybbs	118,3	433,5	842,4
7	AT	Danube	Ybbs	11007	11006	Ybbs	199,4	315,2	945,1
8	AT	Danube	Ybbs	11008	11007	Ybbs	115,7	115,7	1039,1
9	AT	Danube	Wulka	12001	12000	Wulka	41,4	383,0	169,7
10	AT	Danube	Wulka	12002	12001	Eisbach	66,8	66,8	226,9
11	AT	Danube	Wulka	12003	12001	Nodbach	62,4	62,4	200,1
12	AT	Danube	Wulka	12004	12001	Wulka	136,8	212,3	260,1
13	AT	Danube	Wulka	12005	12004	Wulka	75,5	75,5	386,3
14	HU	Danube	Koppany	21001	21000	Koppany	389,3	658,4	170,4
15	HU	Danube	Koppany	21002	21001	Koppany	269,1	269,1	196,4
16	HU	Danube	Zagyva	22001	22000	Zagyva-patak	411,3	1200,2	215,1
17	HU	Danube	Zagyva	22002	22001	HerXdi-Bér-patak	180,2	180,2	221,2
18	HU	Danube	Zagyva	22003	22001	Zagyva-patak	376,7	608,8	306,8
19	HU	Danube	Zagyva	22004	22003	Zagyva-patak	157,7	157,7	336,6
20	HU	Danube	Zagyva	22005	22003	Tarján-patak	74,4	74,4	304,8
21	RO	Danube	Somesul	31001	31000	Somesul Mic	528,0	1959,7	441,4
22	RO	Danube	Somesul	31002	31001	Nadas	290,3	290,3	508,2
23	RO	Danube	Somesul	31003	31001	Somesul Mic	285,4	1141,4	619,8
24	RO	Danube	Somesul	31005	31003	Somesul Mic	210,4	521,0	896,9
25	RO	Danube	Somesul	31006	31003	Somesul Mic	335,1	335,1	1228,0
26	RO	Danube	Somesul	31004	31005	Somesul Rece	310,5	310,5	1238,5
27	RO	Danube	Viseu	32001	32000	Viseu	145,3	378,0	991,4
28	RO	Danube	Viseu	32002	32001	Viseu	133,3	133,3	1276,9
29	RO	Danube	Viseu	32003	32001	Tisla	99,4	99,4	1205,2
30	BG	Danube	Vit	41001	41000	Vit	548,0	2206,3	234,4
31	BG	Danube	Vit	41002	41001	Vit	666,8	1658,3	335,8
32	BG	Danube	Vit	41003	41002	Vit	524,7	991,5	583,6
33	BG	Danube	Vit	41004	41003	Cherni Vit	161,1	161,1	1032,6
34	BG	Danube	Vit	41005	41003	Beli Vit	305,7	305,7	1053,1

Viseu

In the Viseu catchment the number of sub-catchments was not changed and remains three Analytical Units. The delineation of the sub catchments were changed in such a way that each outlet coincides with either discharge measurements or a water quality monitoring station. To guarantee this, the outlet point of AU 32003 was brought into line with the monitoring station. Because monitoring station and runoff measurements are subject to a tolerable deviation and no relevant tributaries or sources of additional discharges are known between gauging station and quality monitoring station, it was agreed to use the existing runoff measurements and adapt them (area specific runoff correction). In the central and northern parts of AU 32003, several mining sites are localized. For AU 32002 only runoff measurements are available. The outlet sub-catchment (AU 32001) is characterized by the second quality monitoring station in the Viseau catchment. Here no discharge measurement is available. To solve this problem the quality sampling at the outlet will be combined with additional flow measurements. In a second step the water level will be read at the Moisei hydrometric station (about ten kilometers upstream), so that a flow adjustment coefficient from Moisei hydrometric station can be calculated and used for discharge estimates at the outlet point.



Background: © OpenStreetMap contributors, SRTM by NASA

Figure 3: Viseau catchment subdivided into three sub-catchments

Somesul Mic

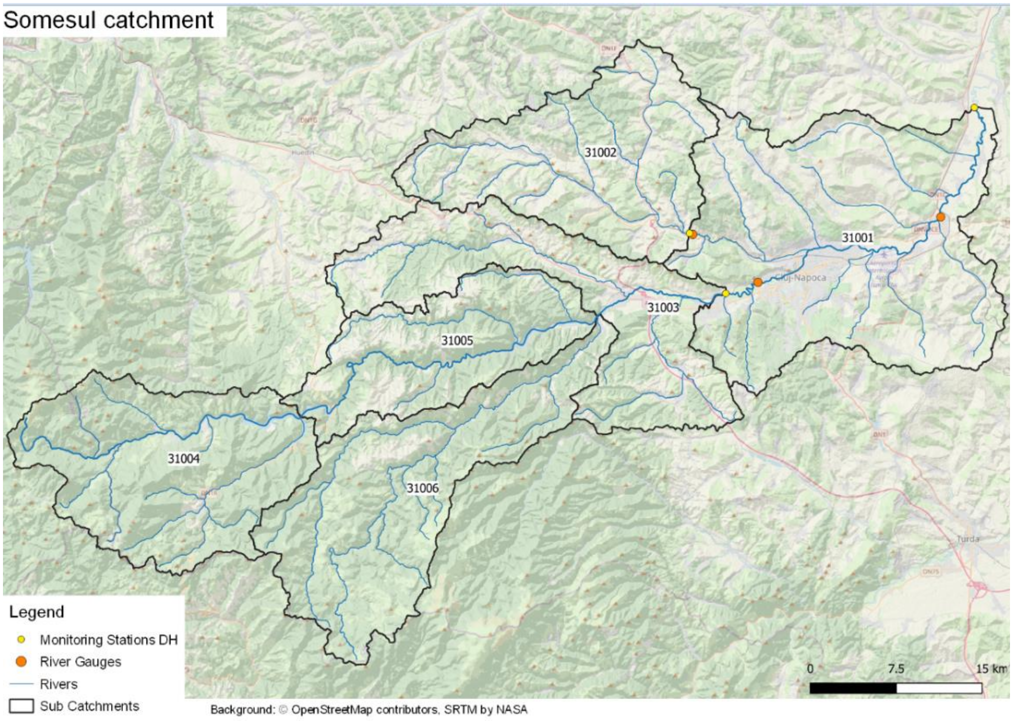


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Figure 4: Somesul catchment, subdivided into six sub-catchments

For Somecul Mic major changes were done. The largest sub catchment was divided into three sub catchments, to make the size of the sub catchments more comparable. Consequently, the number of AU increased from four to six. The outlet of the catchment (AU 31001) was moved approximately 8 km north to ensure that industrial discharges are included in the catchment. The three main industrial dischargers identified beforehand were found to be inoperative or connected to municipal WWTPs. The extension of the catchment of around 100 km^2 ensures to have industrial discharges from TETAROM INDUSTRIAL PARK - JUCU, Cluj included, which was the intention in the beginning of the project. However, the extension also causes a distinct discrepancy of the existing gauging station and the catchment outlet. In accordance with the Viseau catchment, this lack of validation opportunity should be counteracted by combining quality and quantity measurements (with water level measurements) at the outlet and transfer them to the time series of the upstream gauge to generate a valid water level – discharge relationship at the outlet.

Vit

The first catchment delineation resulted in three sub-catchments, with two upstream catchments (now AU 41004 and AU 41005) and one large midstream and downstream catchment. In the new delineation this large sub-catchment is subdivided into three sub-catchments (AU 41003, AU 41002 and AU 41001) to harmonized the size of the sub catchments. At both upstream catchments a monitoring station is installed, which is combined with a gauging station. The same situation can be found at the outlet of the Vit catchment.

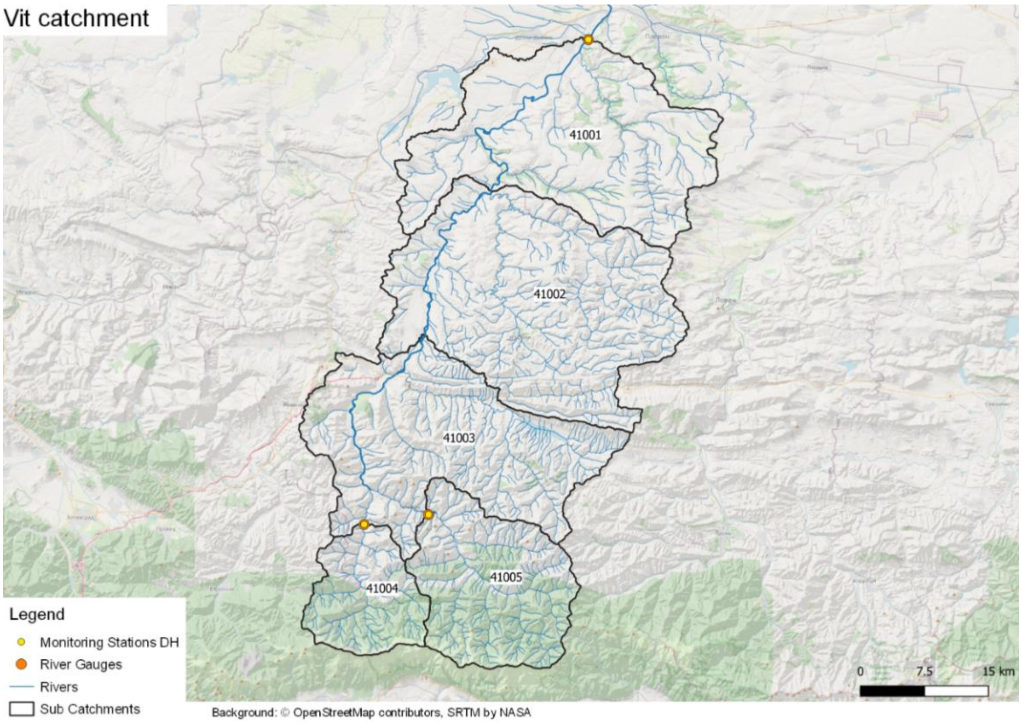


Figure 5: Vit catchment, subdivided into five sub-catchments

Koppany

For the Koppany catchment, the existing delineation was repeated with the standardized method. This led to only minor changes. The number of the sub-catchments remains two. At each sub-catchment outlet one monitoring station is situated at a gauging station, to guarantee the model validation of each sub-catchment.

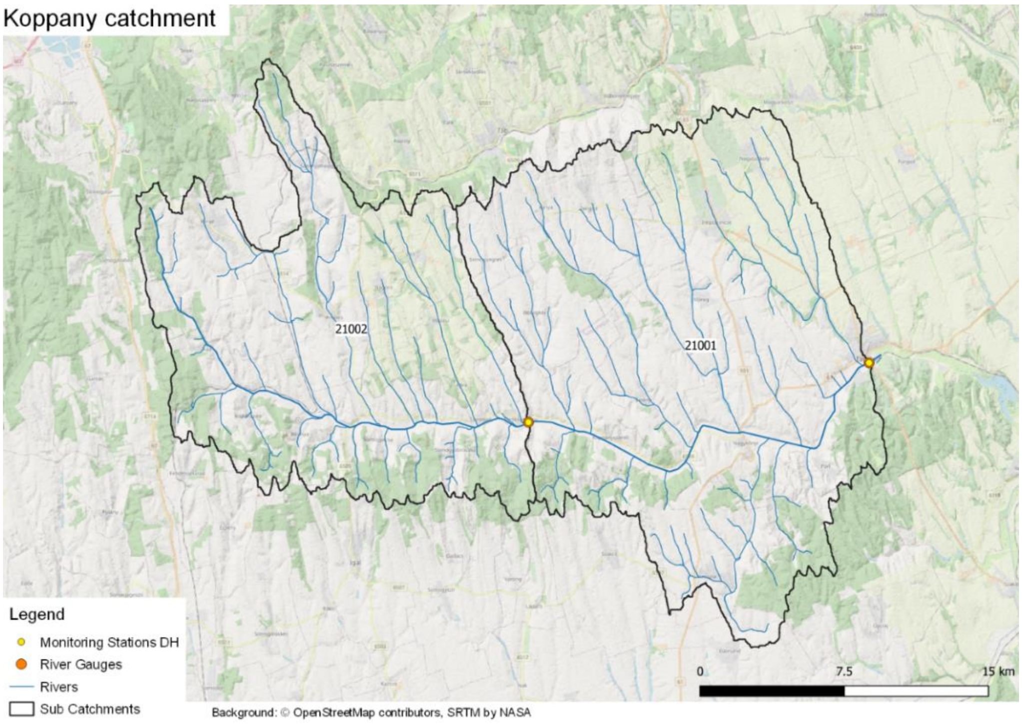


Figure 6: Koppany catchment, subdivided into two sub-catchments

Zagyva

For the Zagyva catchment, the existing delineation was repeated with the standardized method.

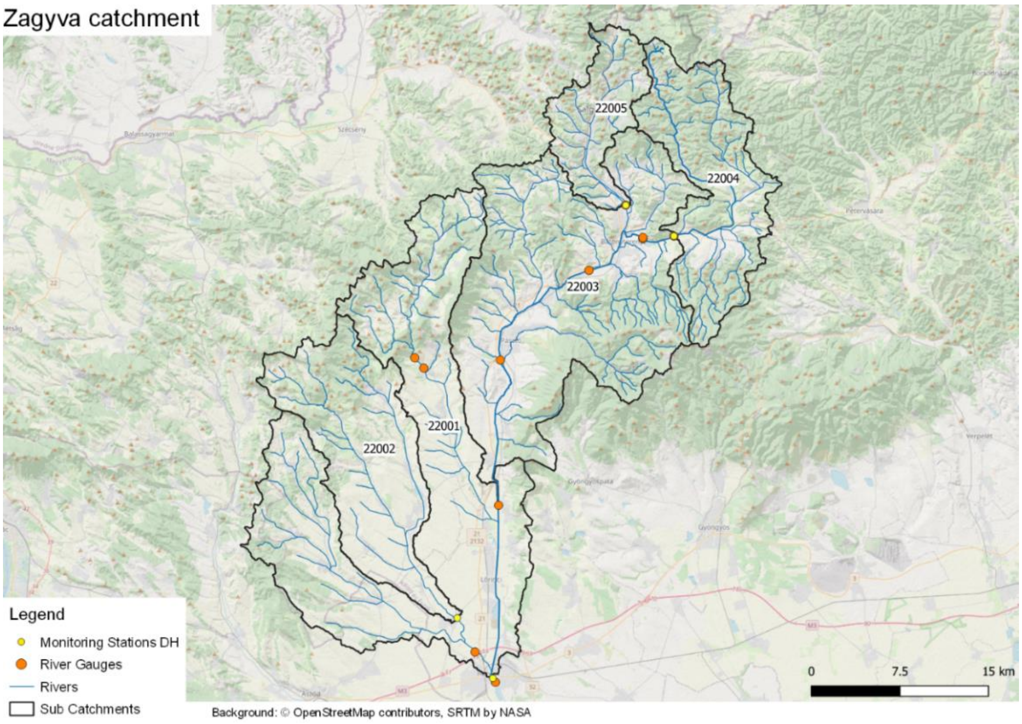
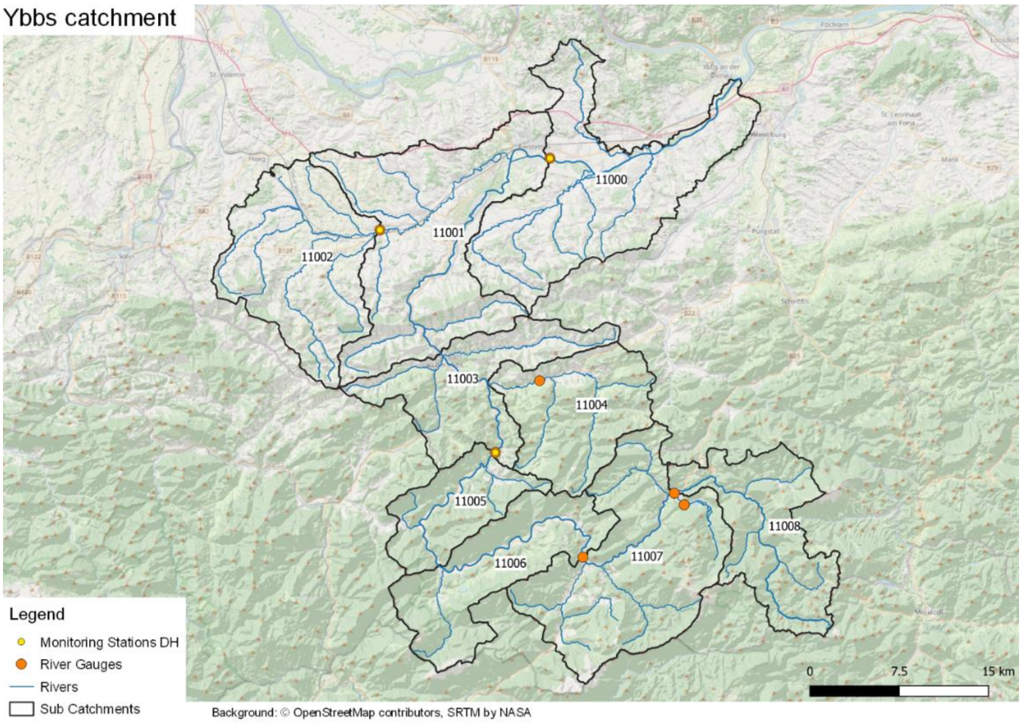


Figure 7: Zagyva catchment, subdivided into five sub-catchments

Furthermore, in the upstream catchment AU 22005 the outlet point was shifted 3 kilometer upstream, directly to the monitoring station. This makes an optimized model validation possible. The total number of five sub-catchments remains in the new delineation. In four of five sub-catchments a model validation is possible.

Ybbs


Ybbs catchment

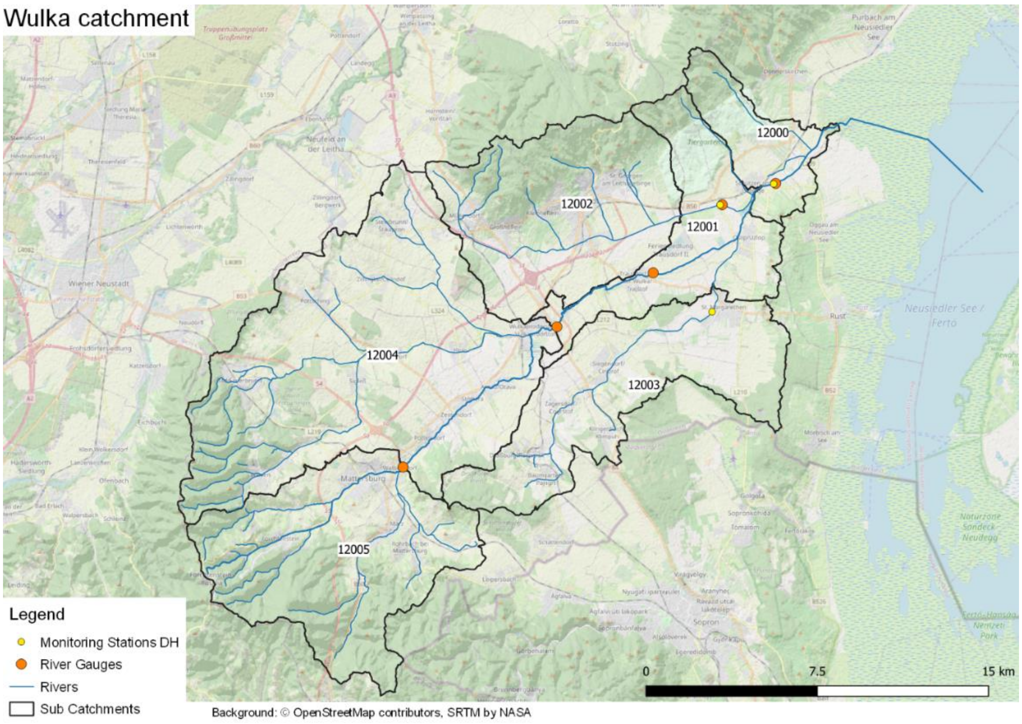
Background: © OpenStreetMap contributors, SRTM by NASA

Figure 8: Ybbs catchment, subdivided into eight sub-catchments

The Ybbs catchment was divided in 7 subcachtments to make optimal use of the discharge measurements in the catchments.

Wulka

Instead of 3 sub-catchments the Wulka catchment was divided into 5 sub-catchments to make optimal use of the discharge measurements in the catchment.


Wulka catchment

Background: © OpenStreetMap contributors, SRTM by NASA

Figure 9: Wulka catchment, subdivided into five sub-catchments

3. Basic input data for pilot regions

Together with the responsible project partner of the pilot regions in a first round of intensive data research a list of basic input data was prepared, discussed and its availability clarified. Most data needed as basic input data were found to be available in most of the pilot regions. Only few data sets were addressed not available or underlie an uncertain quality. The result of the data availability check can be find in Table 3. In several meetings of the Work package members and also in bilateral meetings the needs of data submission were specified. For some data sets Umweltbundesamt could offer support to the partners, namely to the intersection of the soil loss map from JRC and on the intersection of the Corine Land Cover map.

In another step technical support was provided in form of templates, were the needed data structure was clarified. On the one hand partners provided master data describing data sources, spatial and temporal resolution, preprocessing procedure, scale and many more. This information are prepared in the Annex 1.

Finally, the values of the input data were submitted. The data sets give a sound overview of the specific conditions in the pilot regions and prepare the opportunity to compare and interpret the most important pressures in the pilot regions.

To prepare the final input files of basic data, the input files were prepared in English and the different types of input data classes, like “catchment specific”, “catchment specific temporal data”, “point source data”, etc. were described and explained by Umweltbundesamt.

As was said before, not in all cases the temporal data can be provided at this stage of the project (data of 2020 and 2021 are often not available yet) and also not all data must be provided by all partners. Datasets like these listed under “sewer system” can vary with regard to the system and its expression, which determines data availability.

Consequently, the basic input data files summarized for each pilot region or at least for each country (Annex 2), can only represent an interim status and has to be further improved and actualized throughout the project.

Of course, the data set available at this stage represents a strong and sound fundament to continue the model setup and the development of an initial runnable model approach in all pilot regions.

3.1 Basic input data availability

The availability of input data was evaluated by the partners responsible for the pilot regions. In several meetings the basic input data needed for the model application were described, possibilities discussed and alternative data sets - if necessary - found. After a detailed study of available data sets, consultation of different contact persons from national and local administration, science and different associations only for very few datasets the project partners could not provide data. This is most often the case in basic input data dealing to describe the sewer systems and the reason (a slightly different practical handling of the canal systems among the countries) was already mentioned before.

For only few basic inputdata sets alternatives have to be analysed, like the dataset on soil loss from the JRC. In a first step the project team agreed, that these data are a suitable information for soil loss calculation on a smaller scale based on national or regional data sets. However, it is planed for Vit, Viseau and Somesul Mic to carefully test, if soil loss calculations based on the RUSLE can be prepared. This would be reasonable, because the processing of JRC soil loss raster data (100m x 100m) provokes uncertainties, when disaggregating them to different landuse types, like arable land and pastures.

Table 3: Overview of the availability of the basic input data

Input data type	Actual input data code	Name	description	unit	Wulka	Ybbs	Koppany	Zagyva	Vit	Viseu	Somesul Mic
Analytical Unit	BI_A	Area of analytical unit	Area of analytical units	km^2	Available	Available	Available	Available	Available	Available	Available
Topography	BI_ELEVA	Digital Elevation model	mean hights of subcatchments	m	Available	Available	Available	Available	Available	Available	Available
Landuse	BI_A_AL_slope_0-1	arable land	(in 5 slope classes: 0-1; 1-2; 2-4; 4-8; >8 % if possible]	km^2	Available	Available	Available	Available	Available	Available	Available
Landuse	BI_A_PST	pastures		km^2	Available	Available	Available	Available	Available	Available	Available
Landuse	BI_A_WS_mr; BI_A_WS_trib	water surface	main river; tributaries; but also lakes; reservoirs	km^2	Available	Available	Available	Available	Available	Available	Available
Landuse	BI_A_FOR	naturally covered areas	woods; scrubland	km^2	Available	Available	Available	Available	Available	Available	Available
Landuse	BI_A_O	open areas	alpine-mountainous area without vegetation; beaches; dunes	km^2	Available	Available	Available	Available	Available	Available	Available
Landuse	BI_A_OPM	surface mining areas		km^2	Corine (1.3.1)	Corine (1.3.1)	Available	Available	Available	Available	Available
Landuse	BI_A_URB	settlements	total urban areas	km^2	Available	Available	Available	Available	Available	Available	Available
Landuse	BI_A_IMP	impervious urban area	paved areas inside urban areas: settlements; industrial estates; car parks….	km^2	Available	Available	Available	Available	Available	Available	Available
Landuse	BI_A_WL	wetlands		km^2	Available	Available	Available	Available	Available	Available	Available
Landuse	BI_A_OR	country roads	paved road area; not included in settlements	km^2	Available	Available	Available	Available	Available	Available	Available
Landuse	BI_A_REM	other remaining areas	if not very small, please indicate landuse as comment	km^2	Available	Available	Available	Available	Available	Available	Available
Drainages	TD_SHR_a_td_agrl	Tile drained areas	from arable land and pastures	km^2	Available	Available	Available	Available	Not available	Available	Available
Meteorological Data	AD_EVAPO_lt	Evapotranspiration,	mean annual evapotranspiration	mm	Available	Available	Available	Available	Not available	Available	Available
Meteorological Data	(e.g.) BI_PREC_apr	Precipitation	monthly values	mm	Available	Available	Available	Available	Available	Available	Available
Hydrological data	BI_Q_net	Net runoff from	modelling period; annual data on subcatchment level	m^3/s	Available	Available	Available	Available	Available	Available	Available
Erosion	ER_agrl_SL_spec_lt_AL	Soil loss	potential soil loss from arable land (optional from 5 slope classes)	t/(ha·a)	Available	Available	Available	Available	Not available	Available	Available
Erosion	ER_agrl_SL_spect_lt_PST	Soil loss	potential soil loss from pastures	t/(ha·a)	Available	Available	Available	Available	Not available	Available	Available
Sewer sytem	BI_INH	number of inhabitants		inh	Available	Available	Available	Available	Available	Available	Available
Sewer sytem	US_ss_VOL_SST	sedimentation tanks	storage volume of stormwater sedimentation tanks in separate sewer	m^3	Not available	Not available	Available	Available	Available	Available	Available
Sewer sytem	US_cso_VOL_SOT	stormwater overflow	storage volume of stormwater overflow tanks in combined sewer systems	m^3	Not available	Not available	Available	Available	Available	Available	Available
Sewer sytem	US_cso_VOL_spec_SOT	stormwater overflow	storage volume of stormwater overflow tanks in combined sewer systems	m^3/ha	Not available	Not available	Available	Available	Available	Not available	Not available
Sewer sytem	US_L_CS	combined sewers	length of combined sewers	km	Available	Available	Not available	Not available	Available	Available	Available
Sewer sytem	US_L_SS	stormwater sewers	length of stormwater sewers	km	Available	Available	Not available	Not available	Available	Available	Available
Sewer sytem	US_L_WWS	sewage sewers	length of sewage sewers	km	Available	Available	Not available	Not available	Available	Available	Available
Sewer sytem	US_SHR_inh_con_tot	connection rate	percentage of inhabitants that are connected to sewer systems	%	Available	Available	Available	Available	Available	Available	Available
Sewer sytem	US_SHR_inh_conWWTP_tot	connection rate	percentage of inhabitants that are connected to sewer systems and waste	%	Available	Available	Available	Available	Available	Available	Available
Sewer sytem	US_SHR_inh_nss_tot	connection rate	percentage of inhabitants that are not connected to sewer systems	%	Available	Available	Available	Available	Available	Available	Available
Sewer sytem	US_INHC_H2O		inhabitant specific water consumption	l/(inh·d)	Available	Available	Available	Available	Available	Available	Available
Sewer sytem	US_nss_SHR_inhl_towwtp_sept		percentage of inhabitant load that is transported from septic tanks to waste	%	Available	Available	Available	Available	Not available	Not available	Available
Sewer sytem	US_Q_spec_COM		runoff rate for comercial waste water	l/(ha·s)	Not available	Not available	Not available	Not available	Not available	Not available	Not available
Urban wastewater	WWTP_ps_INH_conWWTP	connection rate	number of inhabitants that are connected to sewer systems and waste	inh	Available	Available	Available	Available	Available	Available	Available
Urban wastewater	WWTP_ps_CP	capacity	capacity of the waste water treatment plant (point sources)	PT	Available	Available	Available	Available	Available	Available	Available
Urban wastewater	WWTP_ps_PE	load	nominal load of waste water treatment plant (point sources)	PT	Available	Available	Available	Available	Available	Available	Available
Urban wastewater	WWTP_ps_TS	treatment type	current treatment type of waste water treatment plant (point sources)	-	Available	Available	Available	Available	Available	Available	Available
Urban wastewater	WWTP_ps_Q	discharge	runoff via waste water treatment plant (point sources)	m^3/a	Available	Available	Available	Available	Available	Available	Available
Industrial wastewater	ID_ps_Q	discharge	runoff via industrial direct dischargers	m^3/a	Available	Available	Available	Available	Available	Available	Available

3.2 Master data

3.2.1 Pilot regions in Romania (Viseau and Somesul Mic catchments)

The data sets for the Viseu and Somesul Mic pilot regions that we use in this project are either those in the National Administration Romanian Waters (NARW) database or are available free of charge (Corine Land Cover, EOBS, National Institute of Statistics).

Elevation and slope values are extracted from the digital terrain model DEM - 30mand land use values are extracted from Corine Land Cover. Climatic parameters: temperature and precipitation are extracted from the EOBS daily gridded dataset. Analyzes performed on this gridded dataset compared to the observed values showed that for this region the modeled results are close to the observed values (Sidau et al., 2021). Data on discharge and runoff volumes are provided by the Department of Hydrology, Hydrogeology and Basin Forecasts (department within NARW), based on the values measured at the gauging stations located in the two pilot basins.

Regarding the evapotranspiration parameter, data sources for the two pilot regions are not available, which is why the ones made by JRC will be used. Soil loss values (pasture and arable land) will be calculated using the Universal Soil Loss Equation (USLE) method.

Data on the number of inhabitants are extracted from the Database of the National Institute of Statistics, then processed at the analytical unit level. Information on sewerage networks (lengths, connection rates) and urban sewage treatment plants (UWWTP) is extracted from the National UWWTD Implementation Report 2018 and 2020. These report were elaborated based on information provided by water operators, as well as data available at the level of NARW (national water management authority): regulatory acts, monitoring, inspection reports, etc.

3.2.1.1 Data documentation

Table 4 shows all variables that compose the Basic input data, for each variable, the underlying data set is given. To obtain one value for each sub Catchment processing steps might be necessary, these steps are also given in Table 4.

A detailed description of the Data sets can be found in Table 8Table 8 in Annex 1 Datasets.

Table 4: Description of Basic Input data for the Viseau and Somesul Mic catchments

Actual input data code	Source Dataset	Description of processing
BI_A	ANCPI	Intersection
BI_ELEVA	ANCPI	Intersection
BI_A_AL_slope_0-1	Corine Land Cover	Intersection
BI_A_PST	Corine Land Cover	Intersection
BI_A_WS_mr; BI_A_WS_trib	ANCPI	Spatial aggregation for each analytical units, calculation
BI_A_FOR	Corine Land Cover	Intersection
BI_A_O	Corine Land Cover	Intersection
BI_A_OPM	Corine Land Cover	Intersection
BI_A_URB	ANCPI	Intersection
BI_A_IMP	Corine Land Cover, ANCPI	Intersection
BI_A_WL	Corine Land Cover	Intersection
BI_A_OR	ANCPI	Intersection
BI_A_REM	Corine Land Cover	Intersection
TD_SHR_a_td_agrl		-
AD_EVAPO_lt	JRC, if not available we apply	Raster spatial interpolation, calculation

Actual input data code	Source Dataset	Description of processing
BI_PREC_month	EOBS	Spatial and temporal aggregation,
BI_Q_net	Hydrological service of ABA Somes Tisa	aggregation in time: annual mean
ER_agrl_SL_spec_lt_AL	0	USLE, Spatial aggregation for each analitical units
ER_agrl_SL_spect_lt_PST	0	USLE, Spatial aggregation for each analytical units
BI_INH	National institute of Statistic	Spatial aggregation for each analytical units
US_ss_VOL_SST	UWWTD Report	Spatial aggregation for each analytical units
US_cso_VOL_SOT	UWWTD Report	Spatial aggregation for each analytical units
US_cso_VOL_spec_SOT	UWWTD Report	Spatial aggregation for each analytical units
US_L_CS	NARW,Water authority	Spatial aggregation for each analytical units
US_L_SS	NARW,Water authority	Spatial aggregation for each analytical units
US_L_WWS	NARW,Water authority	Spatial aggregation for each analytical units
US_SHR_inh_con_tot	UWWTD Report, National annual report	Spatial aggregation for each analytical units
US_SHR_inh_conWWTP_tot	UWWTD Report, National annual report	Spatial aggregation for each analytical units
US_SHR_inh_nss_tot	UWWTD Report, National annual report	Spatial aggregation for each analytical units
US_INHC_H2O	NARW	Spatial aggregation for each analytical units
US_nss_SHR_inhl_towwtp_sept	UWWTD Report, National annual report	Spatial aggregation for each analytical units
US_Q_spec_COM	Water operator	Spatial aggregation for each analytical units
WWTP_ps_INH_conWWTP	UWWTD Report, National annual report	Spatial aggregation for each analytical units
WWTP_ps_CP	UWWTD Report, National annual report	Spatial aggregation for each analytical units
WWTP_ps_PE	UWWTD Report, National annual report	Spatial aggregation for each analytical units
WWTP_ps_TS	UWWTD Report, National annual report	Spatial aggregation for each analytical units
WWTP_ps_Q	UWWTD Report, National annual report	Spatial aggregation for each analytical units
ID_ps_Q	UWWTD Report, National annual report	Spatial aggregation for each analytical units

3.2.2 Pilot region in Bulgaria (Vit catchment)

For preliminary calculation, data for Landuse, water surface, and other specific areas (like country roads, etc.) will be based on CORINE. Information are available for the years 2020 – 2021 from the Ministry of Agriculture Food and Forestry in Bulgaria, so the model can be updated in the future. An additional source about Wetlands can be found from WetMainAreas.

Regading soil loss, the only available data for the catchments is from JRC-ESDAC. There is no national data available for evapotranspiration. As a first estimate data from the JRC (Pistocchi, A., 2015) are used.

From National Institute for Meteorology and Hydrology Bulgaria data for temperatures and precipitation in four stations has been collected for the period 2016 – 2020. For the same source and period, data for net runoff from catchments has been collected.

Connection with Water Utilities in Lovech and Pleven has been established and some data has been collected, mostly for water consumption, connection rates to water supply, and length of the water supply systems. However, the water utilities don’t operate with the sewerage systems in the settlements. The given information from them about the sewerage systems in the catchment shows, that there are three small WWTPS (Toros, Glozhene, and Glogovo) and two sewerage systems (Teteven, Ugarchin), which discharge directly into the Vit river. Information about the type and the length of the sewerage systems, and even about the WWTP treatment processes were also provided.

Based on information from Basin Directorate – Pleven, there is one more village with a sewerage network - Dermantsi, which obviously directly discharges into the water body.

Information about the quantities and qualities of the discharged water has been collected from the Municipalities of Teteven and Lukovit, from the Regional Inspectorate of Environment and Water, and Water Utilities. They were checked, but the information seem to be misleading. The only available data for quantities are based on the Discharges Permits from Basin Directorate – Pleven. Data for the qualities of discharged water is available only for the Teteven sewerage system (direct discharge).

Inspections on site have been carried out. Currently, WWTP are not operating.

3.2.2.1 Data documentation

Table 5 shows all variables that compose the Basic input data, for each variable, the underlying data set is given. To obtain one value for each sub Catchment processing steps might be necessary, these steps are also given in Table 5.

A detailed description of the Data sets can be found in Table 10Table 9 in Annex 1 Datasets.

Table 5: Overview of Basic Input data for the Vit catchment

Actual input data code	Source Dataset (see sheet "Datasets")	Description of processing
BI_A	CORINE Land Cover	intersection
BI_ELEVA	CORINE Land Cover	intersection
BI_slp	CORINE Land Cover	intersection
BI_A_AL	CORINE Land Cover	intersection
BI_A_PST	CORINE Land Cover	intersection
BI_A_WS_mr	CORINE Land Cover	calculation
BI_A_WS_trib	CORINE Land Cover	calculation
BI_A_FOR	CORINE Land Cover	intersection
BI_A_O	CORINE Land Cover	intersection
BI_A_OPM	RBMP - Danube region	-
BI_A_URB	CORINE Land Cover	intersection
BI_A_IMP	CORINE Land Cover	intersection
BI_A_WL	CORINE Land Cover	intersection
BI_A_OR	CORINE Land Cover	calculation
BI_A_REM	CORINE Land Cover	intersection
TD_SHR_a_td_agrl		
AD_EVAPO_lt	JRC	calculation of annual time steps
BI_PREC_month	NIMH	interpolation
BI_Q_net	NIMH	-
ER_agrl_SL_spec_lt_AL	JRC-ESDAC	intersection
ER_agrl_SL_spect_lt_PST	JRC-ESDAC	intersection
BI_INH	National Statistic Institute	intersection
US_ss_VOL_SST	Teteven Municipality, Lukovit Municipality	-
US_cso_VOL_SOT	Teteven Municipality, Lukovit Municipality	-

Actual input data code	Source Dataset (see sheet "Datasets")	Description of processing
US_cso_VOL_spec_SOT	Teteven Municipality, Lukovit Municipality	-
US_L_CS	Teteven Municipality, Lukovit Municipality	-
US_L_SS	Teteven Municipality, Lukovit Municipality	-
US_L_WWS	Teteven Municipality, Lukovit Municipality	-
US_SHR_inh_con_tot	MOEW	-
US_SHR_inh_conWWTP_tot	MOEW	-
US_SHR_inh_nss_tot	MOEW	-
US_INHC_H2O	WSS Lovech, WSS Pleven	calculation
US_nss_SHR_inhl_towwtp_sept	WSS Lovech, WSS Pleven	calculation
US_Q_spec_COM	WSS Lovech, WSS Pleven	calculation
Point sources		
WWTP_ps_INH_conWWTP	MOEW	-
WWTP_ps_CP	MOEW	-
WWTP_ps_PE	MOEW	-
WWTP_ps_TS	MOEW	-
WWTP_ps_Q	Teteven Municipality, Lukovit Municipality	-
ID_ps_Q	Teteven Municipality, Lukovit Municipality	-
WWTP_small_Q	Teteven Municipality, Lukovit Municipality	-

3.2.3 Pilot regions in Hungary (Koppany and Zagyva catchments)

In Hungary, emission modelling has a tradition of 10-15 years. The last years excepted this was restricted to traditional components: TSS, nutrients (Jolánkai et al. 2021). A hydrologically corrected DEM of 20m resolution is available from the General Directorate of Water Management. The AUs were delineated based on this DEM. The landuse shares/areas were calculated based on Corine Land Cover and the National Ecosystem Map of Hungary (Tanács et al. 2019). This latter was prepared last year, has a resolution of 20m and is freely available.

Two hydrological stations are located in the Koppány pilot region; there is at least one hydrological station for each subcatchment of the Zagyva pilot region.

The erosion maps were prepared according to the USLE method. Unfortunately, there is no central database on tile drainages for the pilot regions.

Concerning the sewer system, the central database on the population (number of inhabitants per settlement) was available from the Hungarian Central Statistical Office. Other data on municipal wastewater treatment plants were available from the Water Utility-Online Data Processing System. However, this system is lacking data on stormwater overflow as well as the length and type of sewer network. Data for urban WWTP’s is more easily accessible than industrial ones.

Meteorological data is available from the Hungarian Meteorological Service and traditionally it has be payed for. Starting in January 2021, the Service inaugurated its Open Data Program, which means that data recorded after this date is freely available from their website.

3.2.3.1 Data documentation

Table 6 shows all variables that compose the Basic input data, for each variable, the underlying data set is given. To obtain one value for each sub Catchment processing steps might be necessary, these steps are also given in Table 6.

A detailed description of the Data sets can be found in Table 9 in Annex 1 Datasets.

Table 6: Overview of Basic Input data for the Koppany and Zagyva catchments

Actual input data code	Source Dataset (see sheet "Datasets")	Description of processing
BI_A		
BI_ELEVA	National Water Directorate	Spatial and temporal aggregation.
BI_A_AL_slope_0-1	Government Office of the Capital City Budapest	Spatial and temporal aggregation.
BI_A_PST	Government Office of the Capital City Budapest	Spatial and temporal aggregation.
BI_A_WS_mr; BI_A_WS_trib	Government Office of the Capital City Budapest	Spatial and temporal aggregation.
BI_A_FOR	Government Office of the Capital City Budapest	Spatial and temporal aggregation.
BI_A_O	Government Office of the Capital City Budapest	Spatial and temporal aggregation.
BI_A_OPM	Government Office of the Capital City Budapest	Spatial and temporal aggregation.
BI_A_URB	Government Office of the Capital City Budapest	Spatial and temporal aggregation.
BI_A_IMP	Government Office of the Capital City Budapest	Spatial and temporal aggregation.
BI_A_WL	Government Office of the Capital City Budapest	Spatial and temporal aggregation.
BI_A_OR	Government Office of the Capital City Budapest	Spatial and temporal aggregation.
BI_A_REM	Government Office of the Capital City Budapest	Spatial and temporal aggregation.
TD_SHR_a_td_agrl	National Water Directorate	Spatial and temporal aggregation.
AD_EVAPO_lt	Doctoral research	Spatial aggregation
BI_PREC_month	National Water Directorate	Needs spatial interpolation and aggregation
BI_Q_net	Water District Directorates	Aggregation in time
ER_agrl_SL_spec_lt_AL	BME	Spatial aggregation
ER_agrl_SL_spect_lt_PST	BME	Spatial aggregation
BI_INH	Central Statistical Office	Spatial aggregation
US_ss_VOL_SST	National Water Directorate	Spatial aggregation
US_cso_VOL_SOT	National Water Directorate	Spatial aggregation
US_cso_VOL_spec_SOT	National Water Directorate	Spatial aggregation
US_L_CS	National Water Directorate	Spatial aggregation
US_L_SS	National Water Directorate	Spatial aggregation
US_L_WWS	National Water Directorate	Spatial aggregation
US_SHR_inh_con_tot	National Water Directorate	Spatial aggregation
US_SHR_inh_conWWTP_tot	National Water Directorate	Spatial aggregation
US_SHR_inh_nss_tot	National Water Directorate	Spatial aggregation
US_INHC_H2O	-	Spatial aggregation
US_nss_SHR_inhl_towwtp_sept	National Water Directorate	Spatial aggregation
US_Q_spec_COM	BME	Spatial aggregation
Point sources		
WWTP_ps_INH_conWWTP	National Water Directorate	Spatial aggregation
WWTP_ps_CP	National Water Directorate	Spatial aggregation
WWTP_ps_PE	National Water Directorate	Spatial aggregation
WWTP_ps_TS	National Water Directorate	Spatial aggregation
WWTP_ps_Q	National Water Directorate	Spatial aggregation
ID_ps_Q	National Water Directorate	Spatial aggregation

3.2.4 Pilot regions in Austria (Ybbs and Wulka catchments)

In Austria emission modelling has a tradition of about two decades. As a consequence different model applications (especially on nutrient emission modelling (Gabriel et al., 2011) but also actual models on selected hazardous substances (Amann et al., 2019) build a good fundament for further data evaluation. Many basic input data are owned by the Federal Ministry of Agriculture, Regions and Tourism (BMLRT), where the water agendas are also housed. Most data are available in specific databases. Besides the BMLRT the most data are available from Statistics Austria (e.g. inhabitants) and are available for free. Other data sets must be purchased, like precipitation data from the SPARTACUS database (Zentralanstalt für Meteorologie und Geodynamik (ZAMG)). Consequently, to keep the model results up to date (2016-2021), these data sets can only be requested when all data are available, which means early 2022. Other data sets that require adaptations by the annual variability of precipitation will accordingly only be finalized later. For Austria these dataset could be prepared as statistically derived approximate values in this early phase, which guarantees to build a first model by autumn.

As was already mentioned in the text before, not all input data listed in Table 1 have to be necessarily prepared for all pilot regions to run the model and have all pathways quantified. Especially, this is true for the sewer systems, where slightly different systems and data availability strongly determines, which basic input data sets are needed. In Austria in further projects (Clara et al., 2016) and model applications (Amann et al., 2019) sewer systems could be calculated by balancing annual runoff data. Therefore, some of the basic input data listed in Table 1 are not reported for the Austrian pilot regions Ybbs and Wulka.

3.2.4.1 Data documentation

Table 7 shows all variables that compose the Basic input data, for each variable, the underlying data set is given. To obtain one value for each sub Catchment processing steps might be necessary, these steps are also given in Table 7.

A detailed description of the Data sets can be found in Table 11 and Table 12 in Annex 1 Datasets.

Table 7: Overview of Basic Input data for the Ybbs and Wulka catchments

Actual input data code	Source Dataset (see sheet "Datasets")	Description of processing
BI_A	River basin Ybbs catchment: sub catchments	calculation of area from the geometry of spatial data
BI_ELEVA	Digital elevation Model Austria	calculation of average value of elevation values within each sub catchment
BI_SLP	Digital elevation Model Austria	intersection of DEM with sub catchments
BI_A_AL	Land Use Map Austria	intersection of Land use map with sub catchments and calculation of area for class 'arable land'
BI_A_PST	Land Use Map Austria	intersection of Land use map with sub catchments and calculation of area for class 'pastures'
BI_A_WS_mr	Land Use Map Austria	intersection of Land use map with sub catchments and calculation of area for class 'water surface area (main river)'
BI_A_WS_trib	Land Use Map Austria	intersection of Land use map with sub catchments and calculation of area for class 'water surface area (tributary)'
BI_A_FOR	Land Use Map Austria	intersection of Land use map with sub catchments and calculation of area for class 'naturally covered areas '

Actual input data code	Source Dataset (see sheet "Datasets")	Description of processing
BI_A_O	Land Use Map Austria	intersection of Land use map with sub catchments and calculation of area for class 'open areas '
BI_A_OPM	Land Use Map Austria	intersection of Land use map with sub catchments and calculation of area for class 'surface mining areas'
BI_A_URB	Land Use Map Austria	intersection of Land use map with sub catchments and calculation of area for class 'settlements'
BI_A_IMP	Land Use Map Austria	intersection of Land use map with sub catchments and calculation of area for class 'impervious urban area'
BI_A_WL	Land Use Map Austria	intersection of Land use map with sub catchments and calculation of area for class 'wetlands'
BI_A_OR	Land Use Map Austria	intersection of Land use map with sub catchments and calculation of area for class 'country roads'
BI_A_REM	Land Use Map Austria	intersection of Land use map with sub catchments and calculation of area for class 'other remaining areas'
TD_SHR_a_td_agrl	digital maps (polygons)	digitalisation/geoprocessing
AD_EVAPO_lt	time rows	Top kriging/HBV Modelling
BI_PREC_month	time rows	kriging
BI_Q_net	time rows	calculation
ER_agrl_SL_spec_lt_AL	digital map (polygons)	RUSLE/ intersection
ER_agrl_SL_spect_lt_PST	digital map (polygons)	RUSLE/ intersection
BI_INH	national database	intersection
US_ss_VOL_SST	-	-
US_cso_VOL_SOT	-	-
US_cso_VOL_spec_SOT	-	-
US_L_CS	Cadastre	intersection
US_L_SS	Cadastre	intersection
US_L_WWS	Cadastre	intersection
US_SHR_inh_con_tot	national database	intersection
US_SHR_inh_conWWTP_tot	national database	intersection
US_SHR_inh_nss_tot	national database	intersection
US_INHC_H2O	-	-
US_nss_SHR_inhl_towwtp_sept	-	-
US_Q_spec_COM	-	-
Point sources		
WWTP_ps_INH_conWWTP	national database	discrete data
WWTP_ps_CP	national database	discrete data
WWTP_ps_PE	national database	discrete data
WWTP_ps_TS	national database	discrete data
WWTP_ps_Q	national database	discrete data
ID_ps_Q	national database	discrete data
WWTP_small_Q	Cadastre	intersection

4. Conclusions

In this report, we first prepared a description on different general aspects of basic input data and pointed out:

- Basic input data requirements
- The role of basic input data within the model MoRE
- Examples of preprocessing of basic input data of variable complexity
- Examples of different data sources
- The needed structure and format of the basic input data.

Furthermore, detailed information were provided on the delineation procedure of the pilot regions with respect to technical and even content-specific aspects.

It was found that data availability in all seven pilot regions is reported to be sufficient or sound to setup a first version of the MoRE model. Only few basic input data sets are not in place in the pilots (see Table 3). Sources of all basic input data sets were reported and data sets are described by detailed master data information (Tables 4-7 and in “Annex 1 Datasets”). Although not all data values for every pilot region is prepared yet, all the important basic data are available and can be downloaded at links documented under “Annex 2 MoRe Inputfiles Basic_data”.

Missing basic input data are:

- Not relevant to setup the MoRE model because as alternative input data provide the necessary information (e.g. Wulka, Ybbs, Koppany or Zagyva)
- Could be replaced by other (e.g. European) data sets (e.g. Vit catchment and partly Somesul Mic and Viseau)
- Needs some further preprocessing (Koppany and Zagyva)
- Belong to the measured data (like precipitation or evapotranspiration), that are partly not yet available for 2020 and could not have been completely collected for 2021.

The prepared information are already prepared as MoRE model input files, which are ready to be implemented in the model. They build a sound input to setup a first model version in the following months and are suitable for identifying focal points of the modelling activities in the different pilot regions.

5. Outlook

The basic information input files build a sound fundament to setup a first MoRE model version in the pilot catchments. They are even suitable to identify potential most important pressures and hot spots within the different catchments (e.g. agriculture, sewer systems or mining sites) and therefore build the fundament for a more detailed modelling approach. In the following, it is planned to further adapt the modelling of the identified focal points in the pilot areas and, if necessary, to further improve or expand the data situation and adapt model approaches and algorithms to the prescribed situation.

Furthermore, as mentioned above, it is necessary to actualize specific data sets with measured values for 2020 and especially for 2021 (e.g. for precipitation or evapotranspiration) and to adapt other data sets which depend on the variation.

Another clear focus of WP T2 ongoing activities will be the technical setup of the MoRE model. Approaches and algorithms have to be implemented, calculation piles defined and basic input data imported and accomplished by concentration specific values under evaluation in WP T1.

As was already initialized during the last months, even the dialogue and the exchange of important data and information between WP T2 and WP T3 will be continued and intensified.

Abbreviations and acronyms

BME	Budapest University of Technology and Economics
BTEX	benzene, toluene, and three xylene (ortho-, meta- and paraxylene) hydrocarbons
BWA	Bulgarian Water Association
DDT	Dichlorodiphenyltrichloroethane
HS	Hazardous substance(s)
inh.	Inhabitants
LMQ	Long term mean flow
N	Nitrogen
NARW	National Administration of Romanian Waters
NE	Northeast, northeastern
NIHWM	National Institute for Hydrology and Water Management (Romania)
NW	Northwest, northwestern
P	Phosphorus
PA	Pilot area
PAH	policyclic aromatic hydrocarbons
PE	Population equivalent
SE	Southeast, southeastern
SW	Southwest, southwestern
TU Wien	Technical University Vienna
UBA	Umweltbundesamt – Environment Agency Austria
WIMS	Water Information Management System Romania
WW	Wastewater
WWTP	Wastewater treatment plant

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Annex 1 Datasets

Table 8: Overview of the datasets used for the Basic Input data for the Viseau and Somesul Mic catchments

Dataset name	**ANCPI**	**Corine Land Cover**	**JRC, if not available we apply**	**EOBS**	**Hydrological service of ABA Somes Tisa**	**National institute of Statistic**	**UWWTD Report**	**NARW,Water authority**	**UWWTD Report, National annual report**
Data type		digital map (polygon)	digital map (raster data)	digital map (nc data)	extrapolation of monitoring data	Value	Value	Value	Value
Spatial distribution	1:10 000	1:100 000	30m	0.1 *0.1 deg aprox 10km	point	-	-	-	-
Temporal distribution	-	-	annual data	day	daily data	one in ten years data census (from 2011)	annual data	annual data	annual data
Period of evaluation	-	-	-	1950-2020	2011-2020	2011	2016-2018	2016-2018	2016-2018
Projection/Coordinate system	EPSG:3857	EPSG:3035 (ETRS89, LAEA)	EPSG:3857	EPSG:3857	none	-	-	-	-
Time of publication	-	-	-	2016 ongoing	2021	2012	2018, 2020	2018, 2020	2018, 2020
Spatial availability of data	National data	EU	EU	National data		Local level(commune)	National data	National data	National data
Data source	ANCPI	Corine Land Cover	JRC, if not available we apply	EOBS	Hydrological service of ABA Somes Tisa	National institute of Statistic	UWWTD Report	NARW,Water authority	UWWTD Report, National annual report
Lineage									
Completeness of data	complete	complete	Ongoing	Ongoing	complete for Wulka, 2-3 catchments missing for Ybbs	complete	Reported by water operators	complete	Reported by water operators
Reliability of data	high	moderate	low	moderate	high	high	moderate	high	high
Information									
link									

Further preprocessing needed/planed to be implemented in MoRE	Intersection	Intersection	Raster spatial interpolation, calculation	Spatial and temporal aggregation,	aggregation in time: annual mean	Spatial aggregation for each analitical units	Spatial aggregation for each analitical units	Spatial aggregation for each analitical units	Spatial aggregation for each analitical units

Table 9: Overview of the datasets used for the Basic Input data for the Vit catchment

Dataset name	**CORINE Land Cover**	**RBMP - Danube region**	**NIMH**	**JRC-ESDAC**	**National Statistic Institute**	**Teteven Municipality, Lukovit Municipality**	**MOEW**	**WSS Lovech, WSS Pleven**	**Teteven Municipality, Lukovit Municipality**
Data type	digital map	pdf map / table data	time rows	digital map	national database	municipality database	national database	water utility database	municipality database
Spatial distribution		1:1 250 000 in A3 format	-		settlement based	settlement based	agglomeration based	settlement based	settlement based
Temporal distribution	-	-	monthly	-	one in ten years data census (last from 2011)	-	yearly	yearly	-
Period of evaluation		-	2016-2020		2020	-	2016,2018	2018,2019,2020	-
Projection/Coordinate system		-	-		-	-	-	-	-
Time of publication		2015	-		-	-	-	-	-
Spatial availability of data		Bulgaria	Bulgaria		Bulgaria	Bulgaria	Bulgaria	Bulgaria	Bulgaria
Data source	CORINE Land Cover	RBMP - Danube region	NIMH	JRC-ESDAC	National Statistic Institute	Teteven Municipality, Lukovit Municipality	MOEW	WSS Lovech, WSS Pleven	Teteven Municipality, Lukovit Municipality
Lineage	digital map	pdf map / table data	time rows	digital map	national database	municipality database	national database	water utility database	municipality database
Completeness of data		complete	preprocessing		complete	-	complete	-	-
Reliability of data		high	???		high	moderate	moderate	high	moderate
Information						waiting for answer		waiting for answer	waiting for answer
link									
Further preprocessing needed/planed to be implemented in MoRE		pdf map / table data	time rows		national database	municipality database	national database	water utility database	municipality database

Table 10: Overview of the datasets used for the Basic Input data for the Koppany and Zagyva catchments

Data source	**National Water Directorate**	**Government Office of the Capital City Budapest**	**National Water Directorate**	**Doctoral research**	**National Water Directorate**	**Water District Directorates**	**BME**	**Central Statistical Office**	**National Water Directorate**	**National Water Directorate**	**BME**
Data Set											
Data type	raster	raster	raster	raster	raster	Estimation on AU	raster	Point data	raster	raster	raster
Spatial distribution	50m	20m	50m	50m	50m	AU level	50m	-	50m	50m	50m
Temporal distribution	fix data	remote sensing data 2015	fix data	Decadal average	fix data	annual data aggregated from daily Q	Long term average	Cencus data	fix data	fix data	Long term average
Period of evaluation	N/A	2015	N/A	2000-2009	N/A	2016-2020	1990-2010	2019	N/A	N/A	1990-2010
Projection/Coordinate system	EPSG:23700	EPSG:23700	EPSG:23700	EPSG:23700	EPSG:23700	none	EPSG:23700	EPSG:23700	EPSG:23700	EPSG:23700	EPSG:23700
Time of publication	2012	2015	2012	2010	2012	2021	2019	2019	2012	2012	2019
Spatial availability of data	Hungary	Hungary	Hungary	Hungary	Hungary	Hungary	Hungary	Hungary	Hungary	Hungary	Hungary
Data source	National Water Directorate	Government Office of the Capital City Budapest	National Water Directorate	Doctoral research	National Water Directorate	Water District Directorates	BME	Central Statistical Office	National Water Directorate	National Water Directorate	BME
Lineage											
Completeness of data	Complete	Complete	Complete	Complete	Complete	Raw Runoff	May be recalculated with R factor for current period	Complete	Complete	Complete	May be recalculated with R factor for current period
Reliability of data	High	High	High	Mid	High	Rating curve acuracy	Mid (USLE based, not calibrated)	High	High	High	Mid (USLE based, not calibrated)
Information											

link											
Further preprocessing needed/planed to be implemented in MoRE	Spatial and temporal aggregation.	Spatial and temporal aggregation.	Spatial and temporal aggregation.	Spatial aggregation	Spatial and temporal aggregation.	Aggregation in time	Spatial aggregation	Spatial aggregation	Spatial and temporal aggregation.	Spatial and temporal aggregation.	Spatial aggregation

Table 11: Overview of the datasets used for the Basic Input data for the Ybbs and Wulka catchment

Dataset name	**Digital elevation Model Austria**	**Land Use Map Austria**	**GGN 10.1 (Gesamtgewässernetz)**	**INVEKOS database**	**NAVTEQ database**	**Tile drained areas**	**Evapotranspiration, longterm mean**	**Spartacus**
Data type	raster dataset	File Geodatabase Feature Class	digital map (line data)	digital map (polygons)	digital map (line data)	digital maps (polygons)	time rows	time rows
Spatial distribution	10m	-	1:500 - 1:5000/ GGN 10.1	field scale	no information	related to soiltypegroups and landuse	-	-
Temporal distribution	-	-	-	field scale	-	-	daily	daily/aggregated to monthly
Period of evaluation	-	-	2014	field scale	no information	1900-2014	1976-2014	2009-2017
Projection/Coordinate system	MGI Austria Lambert (EPSG:31287)	MGI Austria Lambert (EPSG:31287)	WGS84	field scale	no information	-	0	0
Time of publication	2014	2016		field scale	no information	2011	2015	2020
Spatial availability of data	Austria	Austria	Austria	field scale	Austria	Provinces; upscaled to Austria	Austria	Austria
Data source	Bundesamt für Eich- und Vermessungswesen (BEV)	created in a preceding project	GGN 10.1 (Gesamtgewässernetz)	field scale	BMLRT study	BMLRT, Study, Melioration cadastres of the provinces	TU-Wien	Zamg

Lineage	-	the land use dataset was created from the digital cataster and INVEKOS datasets, land use classes correspond to the MoRE model classes						
Completeness of data	complete	complete	complete	complete	no information	complete	complete	complete
Reliability of data	high	medium	high	high	no information	medium	high	high
Information	suited for internal used at Umweltbundesamt only - data may not be distributed		GGN 10.1 was compared to DKM and main rivers defined	Optimized Landuse map for emission modelling in Austria; Inn-Project (in German), STOBIMO-Spurenstoffe (in German)	line data set used in the project SCHTURM, 2014	Database from cadastres and geoprocessing		
link			https://www.data.gv.at/katalog/dataset/gesamtgewssernetzbasiseinzugsgebiete	https://www.bmlrt.gv.at/wasser/wasserqualitaet/fluesse_seen/stobimo-spurenstoffe.html	https://www.bmlrt.gv.at/service/publikationen/wasser/Spurenstoffemissionen-aus-Siedlungsgebieten-und-von-Verkehrsflaechen.html	https://www.bmlrt.gv.at/wasser/wasserqualitaet/fluesse_seen/stobimo.html		https://www.zamg.ac.at/cms/de/forschung/klima/klimatografien/spartacus
Further preprocessing needed/planed to be implemented in MoRE	no	no	-	actualization 2020	-	-	actualization	actualization

Table 12: Overview of the datasets used for the Basic Input data for the Ybbs and Wulka catchment

Dataset name	**Discharge fron e-Hyd**	**Sewer system Cadastre**	**UWWTD**	**EMREG**	**Small WWTP plants**
Data type	time rows	Cadastre	national database	national database	Cadastre
Spatial distribution	-	Kanal- und Kläranlagennachbarschaften	Agglomeration > 2000 PE	Treatment Plants > 2000 PE	Treatment Plants 50 -< 2000 PE
Temporal distribution	daily/aggregated to annual	-	biannual	annual	singular
Period of evaluation	2009-2020	-	2016, 2018	2016, 2017, 2018, 2019, 2020, 2021	
Projection/Coordinate system	Bessel 1841	-	-		
Time of publication	annual actualisation	2014	2019, 2021	2016, 2017, 2018, 2019, 2020, 2021	
Spatial availability of data	Austria	Austria	Austria	Austria	Austria
Data source	BMLRT	BMLRT, SCHTURM Project	BMLRT, UWWTD	BMLRT, Emreg	Kommunalkredit
Lineage					
Completeness of data	complete	complete	complete	complete	complete
Reliability of data	high	high	high	high	high
Information	quality checked data have a delay of about 2-3 years	-		national database	national database

link	https://ehyd.gv.at/#	https://www.bmlrt.gv.at/service/publikationen/wasser/Spurenstoffemissionen-aus-Siedlungsgebieten-und-von-Verkehrsflaechen.html		https://secure.umweltbundesamt.at/edm_portal/cms.do?get=/portal/informationen/anwendungenthemen/emreg.main	https://www.bmlrt.gv.at/wasser/wasserqualitaet/fluesse_seen/stobimo-spurenstoffe.html
Further preprocessing needed/planed to be implemented in MoRE	actualization	-	-	-	-

Annex 2 MoRe Inputfiles Basic_data

The MoRe inputfiles for each country can be found at the following location:

Austria:

https://owncloud.tuwien.ac.at/index.php/apps/files/?dir=/Shared/DanubeHazard_m3c/PP_space/WP_T2_Modelling_pilot_regions/DT2.1.1_Basic_input_data/AT&fileid=566841166

Hungaria:

https://owncloud.tuwien.ac.at/index.php/apps/files/?dir=/Shared/DanubeHazard_m3c/PP_space/WP_T2_Modelling_pilot_regions/DT2.1.1_Basic_input_data/HUN&fileid=571043996

Bulgaria:

https://owncloud.tuwien.ac.at/index.php/apps/files/?dir=/Shared/DanubeHazard_m3c/PP_space/WP_T2_Modelling_pilot_regions/DT2.1.1_Basic_input_data/Bulgaria_Vit&fileid=591689591

Romania:

https://owncloud.tuwien.ac.at/index.php/apps/files/?dir=/Shared/DanubeHazard_m3c/PP_space/WP_T2_Modelling_pilot_regions/DT2.1.1_Basic_input_data/Romania&fileid=591143225

Annex 3 Data availability & preprocessing – Examples from Germany

Table 13: Overview of data availability and preprocessing: Examples from Germany, Part 1

sort of information	**Land use**	**Urban sealed areas (build-up areas)**	**Relief, slope, ...**	**Precipitation**	**Soil information**	**Evapotranspiration**
data set	CORINE CLC 2012	Copernicus High Resolution Layer „Imperviousness e.g. 2012“	Digital Elevation Model	E-OBS data set	BÜK 1000	MOD 16 data set
spatial resolution	25 ha x 25 ha	20 m x 20 m // 100 m x 100 m	100 m x 100 m	0.1°	1:1,000,000	
temporal resolution	updated approximately every 6 years	updated approximately every 3 years	-	daily	not updated	daily
data source	free (European Environment Agency (EEA): CORINE Land Cover vector data. 2012. Copernicus Land Monitoring Services. Online available: http://land.copernicus.eu/pan-european/corine-land-cover/view (2016))	free (European Environment Agency (EEA): Online available: http://land.copernicus.eu/pan-european/high-resolution-layers/imperviousness/view (2016))	free (National Aeronautics and Space Administration (NASA): Shuttle Radar Topography Mission (SRTM) Digital Elevation Model. Online available: http://www2.jpl.nasa.gov/srtm/index.html (2005))	ECA&D (v 17.0, see Haylock, M. R.; Hofstra, N.; Klein Tank, A. M. G.; Klok, E. J.; Jones, P. D.; New, M. (2008): A European daily high-resolution gridded data set of surface temperature and precipitation for 1950–2006. In: J. Geophys. Res. 113 (D20).)	free (BGR)	based onRunning, S.; Mu, Q.; Zhao, M. (2017): MOD16A3 MODIS/Terra Net Evapotranspiration Yearly L4 Global 500m SIN Grid V006 [Data set]. NASA EOSDIS Land Processes DAAC. doi: 10.5067/MODIS/MOD16A3.006.
data preparation	different CORINE land use classes were aggrigated to main land use classes; arable land was further differentiated by slope (different slope classes) using Digital Elevation Model;		used to calculate soil loss and to differentiate arable land by slope (see landuse)	daily precipitation was aggregated on analytical unit level and summed up to monthly -, summer- and winterprecipitation		
transfer to catchment level	GIS - intersect with analytical units (smallest hydrologically based	to select urban sealed areas (build-up areas) data set was prepared				aggregated on analytical unit level

	derived modelling units)	(GIS-intersect with CORINE urban areas (considering CORINE subclasses, level 3 of landuse class continuous urban fabric)); sealing rate was transfered to absolute numbers to calculate sealed area (e.g. in km²); sealed industrial areas (build-up areas) are considered seperately to calculate pollutant concentrations in combined sewer systems				
advantage	european wide information available	need to take into account only sealed areas for urban runoff from sealed areas (to calculate inputs e.g. from storm water overflows)	availability in former modeling periods		harmonized data set	
disadvantage	spatial resolution should be higher; still problems in classification of pasture		spatial resolution should be higher		spatial resolution should be higher	
future data set	LBM (Germany) because of higher spatial resolution; CORINE (international parts of RBDs); Digital Elevation Model 10 m x 10 m	Data set sealing rates - Source: Stephan F., Tatyana Weber, Ramona Wander, Snezhina Toshovski, Steffen Kittlaus, Lucas Reid, Martin Bach, Laura Klement, Thomas Hillenbrand, Felix Tettenborn (2017): Effizienz von Maßnahmen zur Reduktion von Stoffeinträgen. UBA-Texte 05/2017. Dessau-Rosslau. https://www.umweltbundesamt.de/publikationen/effizienz-von-massnahmen-zur-reduktion-von; page 84	Digital Elevation model 10 m x 10 m (Germany)	RADKLIM (DWD, Deutscher Wetterdienst); raster based shall be used for hydrology, soil loss (R-factor) and urban runoff calculation	BÜK 200 (1:200,000) harmonized data set for Germany available since 2020; we would like to use soil maps 1:50,000 (still not harmonized for whole Germany - only harmonized on federal state level	

Table 14: Overview of data availability and preprocessing: Examples from Germany, Part 2

sort of information	Industrial Discharger	waste water treatment plants	waste water treatment plants		kalibration and validation of hydrology	number of inhabitants	water usage (average) per
data set	PRTR data (national register)	UWWTD data (plants >= 2,000 p.e. nominal load)	plants > 50 p.e. - < 2,000 p.e.)		discharge gauges	EUROSTAT	national statistics
spatial resolution			aggregated on NUTS4 level				NUTS2 (German federal state
temporal resolution		every two years			daily flow	yearly	updated approximately every
data source	national PRTR data base: https://www.thru.de/thrude/	national UWWTD data base (data of federal states): selected information online available: https://kommunales-abwasser.de/	stastistical data (national); FDZ		data of German federal states		
data preparation							data are available in L per cap (range in 2010: 84 - 135; Ger average: 121)
transfer to catchment level	mapping by coordinates	mapping by coordinates			mapping by coordinates		
advantage							
disadvantage					it is always better to have more gauges		
future data set			hope to integrate data of single plants (> 50 p.e. - < 2,000 p.e.) in future (by coordinates)		calibration and validation gauges - Source: KIT not published	Method to distribute inhabitants – Source: Stephan F., Tatyana Weber, Ramona Wander, Snezhina Toshovski, Steffen Kittlaus, Lucas Reid, Martin Bach, Laura Klement, Thomas Hillenbrand, Felix Tettenborn (2017):	

						Effizienz von Maßnahmen zur Reduktion von Stoffeinträgen. UBA-Texte 05/2017. Dessau-Rosslau. https://www.umweltbundesamt.de/publikationen/effizienz-von-massnahmen-zur-reduktion-von; page 82	

Table 15: Overview of data availability and preprocessing: Examples from Germany, Part 3

sort of information	**connection of inhabitants to sewage systems and uwwtp**	**length of sewage systems (combined and seperated (differentiated: domestic and stormwater sewer))**	**storage volume of rain water tanks**	**Efficiency of rain water treatment basins**	**storage volume of mixed water overflow basins**
data set	national statistics	national statistics	national statistics		national statistics
spatial resolution	NUTS4	NUTS4	NUTS4		NUTS4
temporal resolution	updated approximately every 3 years	updated approximately every 3 years	updated approximately every 3 years		updated approximately every 3 years
data source				based on basin type: redution was assumed only for storm water tanks with overflow (Durchlaufbecken); share of this basin type was calculated based on information from two of 16 German federal states	
data preparation	number of inhabitants and connection rates on NUTS4-level were used to calculate the connected inhabitants to IAS, sewer system without treatment	urban area (build-up) area is needed; connection information was linked with NUTS4 geometry; for modelling the share of combined and seperate systems is needed - it was calculated as ratio of length of combined sewers and the total length of sewers (combinded and seperated (only rain-water))		share of basin type in Germany: federal state BW = 36,.7%, federal state NW: 50%, for all other federal states (14): average value was used (43.4%); reduction efficiency of storm water tank with overflow (Durchlaufbecken) was assumed to be: 20% (see Fuchs, S.; Eyckmanns-Wolters, R.; Uhl, M.; Mohn, R.; Maus, C.; Sommer, M. (2013c): Reduktion des Feststoffeintrages durch Niederschlagswassereinleitungen, 2013. Online availabe: http://isww.iwg.kit.edu/medien/ Abschlussbericht_ReduktionFeststoffeintrag Phase1.pdf.)	Based on the current storage volume the rate of expantion is calculated (ratio of current volume and a volume which is supposed to represent 100% specific basin volume (22.3 m^3/ha; see Brombach, H.; Michelbach, S. (1998): Abschätzung des einwohnerbezogenen Nährstoffaustrags aus Regenentlastungen im Einzugsgebiet des Bodensees. (Studie). 1. Aufl. 1 Band (IGKB-Berichte, 49).). Specific basin volume is the ratio of basin volume and to combined sewer system conenected sealed area (NUTS 3 level).
transfer to catchment level		transfer to catchment level is carried out weighted by urban area in analytical units	Calculation was carried out on NUTS3 level. Transfer to catchment level (analytical units) was carried out aera weighted (based on sealed	based on NUTS2 level information (attribution of analytical units)	Calculation was carried out on NUTS3 level. Transfer to catchment level (analytical units) was carried out aera weighted (based on sealed

			area connected to seperate sewer system (rain water sewer)).		area connected to combined sewer system).
advantage					
disadvantage					
future data set	method to distribute connection rates - Source: Stephan F., Tatyana Weber, Ramona Wander, Snezhina Toshovski, Steffen Kittlaus, Lucas Reid, Martin Bach, Laura Klement, Thomas Hillenbrand, Felix Tettenborn (2017): Effizienz von Maßnahmen zur Reduktion von Stoffeinträgen. UBA-Texte 05/2017. Dessau-Rosslau. https://www.umweltbundesamt.de/publikationen/effizienz-von-massnahmen-zur-reduktion-von; page 88				

sort of information	data set	spatial resolution	temporal resolution	data source	data preparation	transfer to catchment level	advantage	disadvantage	future data set	
Land use	CORINE CLC 2012	25 ha x 25 ha	updated approximately every 6 years	free (European Environment Agency (EEA): CORINE Land Cover vector data. 2012. Copernicus Land Monitoring Services. Online available: http://land.copernicus.eu/pan-european/corine-land-cover/view (2016))	different CORINE land use classes were aggrigated to main land use classes; arable land was further differentiated by slope (different slope classes) using Digital Elevation Model;	GIS - intersect with analytical units (smallest hydrologically based derived modelling units)	european wide information available	spatial resolution should be higher; still problems in classification of pasture	LBM (Germany) because of higher spatial resolution; CORINE (international parts of RBDs); Digital Elevation Model 10 m x 10 m	
Urban sealed areas (build-up areas)	Copernicus High Resolution Layer „Imperviousness e.g. 2012“	20 m x 20 m // 100 m x 100 m	updated approximately every 3 years	free (European Environment Agency (EEA): Online available: http://land.copernicus.eu/pan-european/high-resolution-layers/imperviousness/view (2016))		to select urban sealed areas (build-up areas) data set was prepared (GIS-intersect with CORINE urban areas (considering CORINE subclasses, level 3 of landuse class continuous urban fabric)); sealing rate was transfered to absolute numbers to calculate sealed area (e.g. in km²); sealed industrial areas (build-up areas) are considered seperately to calculate pollutant concentrations in combined sewer systems	need to take into account only sealed areas for urban runoff from sealed areas (to calculate inputs e.g. from storm water overflows)			Data set sealing rates - Source: Stephan F., Tatyana Weber, Ramona Wander, Snezhina Toshovski, Steffen Kittlaus, Lucas Reid, Martin Bach, Laura Klement, Thomas Hillenbrand, Felix Tettenborn (2017): Effizienz von Maßnahmen zur Reduktion von Stoffeinträgen. UBA-Texte 05/2017. Dessau-Rosslau. https://www.umweltbundesamt.de/publikationen/effizienz-von-massnahmen-zur-reduktion-von; page 84
Relief, slope, ...	Digital Elevation Model	100 m x 100 m	-	free (National Aeronautics and Space Administration (NASA): Shuttle Radar Topography Mission (SRTM) Digital Elevation Model. Online available: http://www2.jpl.nasa.gov/srtm/index.html (2005))	used to calculate soil loss and to differentiate arable land by slope (see landuse)		availability in former modeling periods	spatial resolution should be higher	Digital Elevation model 10 m x 10 m (Germany)	
Precipitation	E-OBS data set	0.1°	daily	ECA&D (v 17.0, see Haylock, M. R.; Hofstra, N.; Klein Tank, A. M. G.; Klok, E. J.; Jones, P. D.; New, M. (2008): A European daily high-resolution gridded data set of surface temperature and precipitation for 1950–2006. In: J. Geophys. Res. 113 (D20).)	daily precipitation was aggregated on analytical unit level and summed up to monthly -, summer- and winterprecipitation				RADKLIM (DWD, Deutscher Wetterdienst); raster based shall be used for hydrology, soil loss (R-factor) and urban runoff calculation	
Soil information	BÜK 1000	1:1,000,000	not updated	free (BGR)			harmonized data set	spatial resolution should be higher	BÜK 200 (1:200,000) harmonized data set for Germany available since 2020; we would like to use soil maps 1:50,000 (still not harmonized for whole Germany - only harmonized on federal state level	
Evapotranspiration	MOD 16 data set		daily	based onRunning, S.; Mu, Q.; Zhao, M. (2017): MOD16A3 MODIS/Terra Net Evapotranspiration Yearly L4 Global 500m SIN Grid V006 [Data set]. NASA EOSDIS Land Processes DAAC. doi: 10.5067/MODIS/MOD16A3.006.		aggregated on analytical unit level				
Industrial Discharger	PRTR data (national register)			national PRTR data base: https://www.thru.de/thrude/		mapping by coordinates				
waste water treatment plants	UWWTD data (plants >= 2,000 p.e. nominal load)		every two years	national UWWTD data base (data of federal states): selected information online available: https://kommunales-abwasser.de/		mapping by coordinates				
waste water treatment plants	plants > 50 p.e. - < 2,000 p.e.)	aggregated on NUTS4 level		stastistical data (national); FDZ					hope to integrate data of single plants (> 50 p.e. - < 2,000 p.e.) in future (by coordinates)	
atmospheric deposition nitrogen, Cd, Hg, Pb and Benzo(a)pyren	EMEP	50 km x 50 km	yearly	EMEP-Meteorological Synthesizing Centre - East (EMEP/MSC-East) (2016): atmospheric deposition Cadmium, Mercury Lead and Benzo[a]pyren. Online available: http://www.msceast.org/index.php?option=com_content&view=article&id=162&Itemid=29; EMEP-Meteorological Synthesizing Centre - West (EMEP/MSC-West) (2016): Wet and dry atmospheric Deposition (Nitrogen). Online available: http://webdab.emep.int/Unified_Model_Results/		GIS - intersect with water surfaces in analytical units (based on CORINE land use class)	european wide available	spatial resolution	use a national data set (PINETI) in future?	
atmospheric deposition nitrogen, Cu, Ni, Zn	Monitoring stations			EMEP/Norwegian Institute for Air Research (EMEP/NILU) (2016): Concentrations of heavy metals and persistent organic pollutants in air and precipitation. Measurement data online. Kjeller. Online available: http://www.nilu.no/projects/ccc/emepdata.html;		interpolation using Ordinary-Kriging-method				
kalibration and validation of hydrology	discharge gauges		daily flow	data of German federal states		mapping by coordinates		it is always better to have more gauges		calibration and validation gauges - Source: KIT not published
number of inhabitants	EUROSTAT		yearly							Method to distribute inhabitants - Source: Stephan F., Tatyana Weber, Ramona Wander, Snezhina Toshovski, Steffen Kittlaus, Lucas Reid, Martin Bach, Laura Klement, Thomas Hillenbrand, Felix Tettenborn (2017): Effizienz von Maßnahmen zur Reduktion von Stoffeinträgen. UBA-Texte 05/2017. Dessau-Rosslau. https://www.umweltbundesamt.de/publikationen/effizienz-von-massnahmen-zur-reduktion-von; page 82
connection of inhabitants to sewage systems and uwwtp	national statistics	NUTS4	updated approximately every 3 years		number of inhabitants and connection rates on NUTS4-level were used to calculate the connected inhabitants to IAS, sewer system without treatment					method to distribute connection rates - Source: Stephan F., Tatyana Weber, Ramona Wander, Snezhina Toshovski, Steffen Kittlaus, Lucas Reid, Martin Bach, Laura Klement, Thomas Hillenbrand, Felix Tettenborn (2017): Effizienz von Maßnahmen zur Reduktion von Stoffeinträgen. UBA-Texte 05/2017. Dessau-Rosslau. https://www.umweltbundesamt.de/publikationen/effizienz-von-massnahmen-zur-reduktion-von; page 88
water usage (average) per capita	national statistics	NUTS2 (German federal states)	updated approximately every 3 years		data are available in L per capita per day (range in 2010: 84 - 135; German average: 121)					
length of sewage systems (combined and seperated (differentiated: domestic and stormwater sewer))	national statistics	NUTS4	updated approximately every 3 years		urban area (build-up) area is needed; connection information was linked with NUTS4 geometry; for modelling the share of combined and seperate systems is needed - it was calculated as ratio of length of combined sewers and the total length of	transfer to catchment level is carried out weighted by urban area in analytical units				
storage volume of rain water tanks	national statistics	NUTS4	updated approximately every 3 years			Calculation was carried out on NUTS3 level. Transfer to catchment level (analytical units) was carried out aera weighted (based on sealed area connected to seperate sewer system (rain water sewer)).				
Efficiency of rain water treatment basins				based on basin type: redution was assumed only for storm water tanks with overflow (Durchlaufbecken); share of this basin type was calculated based on information from two of 16 German federal states	share of basin type in Germany: federal state BW = 36,.7%, federal state NW: 50%, for all other federal states (14): average value was used (43.4%); reduction efficiency of storm water tank with overflow (Durchlaufbecken) was assumed to be: 20% (see Fuchs, S.; Eyckmanns-Wolters, R.; Uhl, M.; Mohn, R.; Maus, C.; Sommer, M. (2013c): Reduktion des Feststoffeintrages durch Niederschlagswassereinleitungen, 2013. Online availabe: http://isww.iwg.kit.edu/medien/Abschlussbericht_R	based on NUTS2 level information (attribution of analytical units)				
storage volume of mixed water overflow basins	national statistics	NUTS4	updated approximately every 3 years		Based on the current storage volume the rate of expantion is calculated (ratio of current volume and a volume which is supposed to represent 100% specific basin volume (22.3 m³/ha; see Brombach, H.; Michelbach, S. (1998): Abschätzung des einwohnerbezogenen Nährstoffaustrags aus Regenentlastungen im Einzugsgebiet des Bodensees. (Studie). 1. Aufl. 1 Band (IGKB-Berichte, 49).). Specific basin volume is the ratio of basin volume and to combined sewer system conenected sealed area (NUTS 3 level).	Calculation was carried out on NUTS3 level. Transfer to catchment level (analytical units) was carried out aera weighted (based on sealed area connected to combined sewer system).				