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1. Management summary

This document is the second status report of the Linz Pilot Application. The document summarizes the general objectives of the Linz Pilot Application for the 2nd year of the SUDPLAN project. It reports on the implementation status including preparatory work performed regarding the local model used and the installation of the used sensor network. The software that has been finally used in the context of the Linz Pilot Application is described to provide an overview of the currently available functionality. In case of GUIs (Graphical User Interfaces) software is documented in the form of screenshots. In case of services and APIs a technical specification is given in chapter 5.2. The implementation status is mapped to tasks and use cases to give an impression on the progress made. In addition, a separate paragraph reports on the End User involvement in WP7. So far considerable progress has been achieved and the software (with enhancements and additional features) will go live in the course of 2012.

Besides, after the decision of LINZ AG to provide the project with some additional funding a sensor network was installed and taken into operation in late 2011. The goals, the design and the installation of the sensor network are also described in this document.

1.1. Objectives of the Linz Pilot

Urban drainage systems form a valuable backbone of urban infrastructure. On average, it is estimated that the value of the urban wastewater system is about 300 Mio € per 100.000 inhabitants. In many European cities waste water and storm water are drained in one sewerage system ("combined systems"). Thus the urban wastewater system is very vulnerable to potential climate change impacts, particularly to a potential increase of extreme flood events and more spilled out pollution loads to receiving waters. Due to the hydraulic limitation of waste water treatment plants (WWTPs) it is not possible to treat the whole amount of drained water at WWTPs; thus the runoff in combined sewer systems has to be either discharged at combined sewer overflows (CSO) into receiving waters or temporarily stored in reservoirs. CSO facilities can be designed with a retention volume ("CSO tank") in order to mitigate overflow events during heavy rains. CSO tanks also show considerable capacities to hold back the TSS (Total Suspended Solids) and COD (Chemical Oxygen Demand) loads in waste and storm water which are the key parameters to describe and quantify the transported pollution loads in sewer systems.

To limit the spilled out pollution loads from combined sewer systems into receiving waters a new guideline, the so called ÖWAV Regelblatt 19 (OEWAV 2007) was introduced in Austria in 2007 (Kleidorfer and Rauch 2010) The guideline defines the efficiency η of combined sewer overflows (CSO efficiency η) as an indicator for CSO pollution. It distinguishes between two different kinds of CSO efficiency: one for dissolved pollutants (η_d) and one for particulate pollutants (η_p).

The calculation of η should be done as an average over a long-time period of at least 10 years. Hence this requires long-term simulation by either hydrological or hydrodynamic models. Temporal resolution of rainfall data should be 10 minutes or higher. For the Linz pilot catchment area at the beginning two models were set up: a hydrological model with the software City Drain (Achleitner, Moderl et al. 2007) and a hydrodynamic model with the software SWMM 5 (Rossmann 2007).

In scope of the SUDPLAN project, three main tasks will be carried out within the Linz pilot:

(1) Develop and set up an information system based on WP3 and WP4 results that incorporates common services and local model components to:

(2) Estimate the overall CSO efficiency rates η for dissolved pollutants (η_d) and for particulate pollutants (η_p) in the total catchment area of the WWTP of Linz based on long-term simulations and future predicted rain data provided by the common services (Phase 1). By comparing the results of today's and of future scenarios possible effects and changes can be recognised and located and proper strategic adaptations can be developed within the catchment area in time.

(3) Estimate the sedimentation efficiency rate η_{sed} for the primary clarifiers of the WWTP in Linz by the installation and operation of a novel sensor network in the inflow and outflow of the primary clarifiers in order to quantify the TSS and COD retention efficiency under different rainwater flow regimes (Phase 2).

1.2. Status summary

This section gives a short summary of the Linz Pilot status after the second year of the project.

Work in the first year mainly focused on data acquisition and validation, evaluation of different available local models and simulation tools, as well as the preparation of the implementation in the SUDPLAN framework.

A historical rainfall time series for the catchment was acquired and prepared for the OGC-compliant Sensor Observation Service (SOS). Based on this 14-year time series the downscaling process was discussed and tested with one climate model projection.

In a selection process a software tool to be used for evaluation of the combined sewer overflows with regards to the required efficiency rates was decided upon. The software and model were tested and prepared for implementation.

During the second year an intensified evaluation of the sewer system model was carried out and the model services, input and visualisation were realized. In addition the sensor network at the Linz wastewater treatment plant was installed.

Concerning the catchment model, the available data was thoroughly checked and the model was analysed, calibrated and validated with state-of-the-art techniques. Additional scripts were implemented for evaluation of the efficiency rates as demanded in the Austrian guideline documents. Based on the historical and a downscaled predicted rainfall time series a first evaluation and comparison was carried out.

The sensor network at the Linz wastewater treatment plant was planned in detail, the necessary preparations were taken and the network was eventually put into operation in late 2011.

The model services were implemented and integrated into the SUDPLAN SMS. The SMS instance was configured and the model configuration was imported. A model wizard with full V2 functionality was set up and a visualization of the model input and first model results was realized.

2. Preparatory Work

Preparatory work concerning the selection of a local model and available measurement data was mostly done during the first year (see D 7.2.1). In the second year, additional preparatory work was necessary to set up the local SWMM model and to install the sensor network at Linz wastewater treatment plant.

The preparatory work for the SWMM model included several steps (see also section 2.1). First an intensified model check and evaluation of available measurement data was carried out. In a second step, a global sensitivity analysis was performed to assess the most important model parameters. Based on this, an automated model calibration and model validation with measurement data was carried out. For evaluation according to the Austrian guideline a script was developed calculating the efficiency rates for both hydraulics and particulate pollutants from rainfall time series and model output.

For the installation of the sensor network (see also section 2.3) first the requirements were defined and specified and the measurement layout was designed. Preparations for the installation were taken; the sensors were installed and put into operation in late 2011.

The processability and suitability were assured by collection and sighting of available data. In addition an Open Scientific Data Management System (OpenSDM) from TU Graz was adapted to provide a consistent (meta) data storage capacity and access to the sensor network data. OpenSDM acts as connector between the measurement stations and the Time Series Toolbox which is the basis of the OGC Sensor Services developed by AIT.

The Linz Pilot tasks have been defined in the Linz Pilot Definition Plans (Deliverable 7.1.1, updated and expanded with version 7.1.2).

2.1. Local Model (SWMM Model Component)

2.1.1 Software Selection and Procurement

As discussed in Linz Pilot Report for year one (D.7.2.1), the available SWMM 5 model of the Linz catchment was chosen as it was best suited for the SUDPLAN needs. The model was set up by University of Innsbruck and represents an aggregation of the real network structure.

SWMM (Storm Water Management Model) is a hydrodynamic rainfall-runoff simulation model that was first developed in 1971 in the US and has undergone several major upgrades since then. The latest re-write is version SWMM 5 (Rossmann 2007) from the US-EPA (United States Environmental Protection Agency). It is available as free software and open source. SWMM 5 and its source code can be obtained from the US-EPA webpages (http://www.epa.gov/ednnrmrl/models/swmm/; on 21-12-2011).

Figure 1 shows the model representation of the Linz catchment in the SWMM modelling software including subcatchments, manholes, main sewer conduits, overflow weirs and storage tanks. The subcatchments are represented according to their actual geometry and all data is geo-referenced.

Figure 1: Linz catchment representation in SWMM 5

2.1.2   Model Evaluation

In order to provide a sound model basis for the SUDPLAN project, the available SWMM model was intensively evaluated in the work of Wendner (Wendner 2011).

In a first step the base data as catchment information from downtown Linz as well as from the neighbouring communes, network data and data from special structures as CSOs, CSO tanks, pumping stations etc. were evaluated in detail.

Important and influential model parameters were determined and ranked by a state-of-the-art global sensitivity analysis (GSA) method. Based on the results from GSA the model was calibrated to the available measurement data by coupling with an optimiser based on evolutionary strategies.

A contribution on these topics was submitted to the 9th International Conference on Urban Drainage Modelling to be held in September 2012 in Belgrade, Serbia.

2.1.2.1   Global Sensitivity Analysis

Global sensitivity analysis (GSA) allows a thorough prior analysis of the model behaviour and permits deriving influential parameters e.g. for model calibration. In this study the Morris screening (Morris 1991) was chosen as it allows parameter ranking and identification of non-linear behaviour and/or interactions and works at low computational costs compared to other methods (Saltelli, Tarantola et al. 2004). Several screening runs were performed with different parameter ranges to identify parameter sensitivities with respect to CSO efficiency according to the Austrian Regelblatt 19 guideline.

It was shown that the GSA allowed identifying the important model parameters influencing the CSO efficiency. Especially the imperviousness of the neighbouring communes was highlighted as influential. Concerning the CSO efficiency for particulate pollutants the assumed sedimentation efficiency of the storage tanks showed to be highly influential. A better assessment could significantly increase model quality and reduce the uncertainties. On the other hand one subcatchment where considerable effort was made to assess its structure in the model set up was shown not to influence the results significantly (Gamerith, Wendner et al. submitted).

2.1.2.2   Automated Model Calibration and Validation

Concerning model calibration several objectives were minimised at the same time in the applied multi-objective optimisation process: the Nash-Sutcliffe efficiency and the percentage bias were optimised using data from three in-sewer water level measurements for five independent storm events. A synthetic parameter set was then determined from weighting the 5 obtained parameter sets. The algorithm was chosen as it has already been successfully applied in urban drainage studies (Muschalla (2008) and Gamerith *et al.* (2011)) and can be linked directly to SWMM 5.

Model calibration yielded different quality for the five selected events. For two of the events the use of one single rain gauge proved insufficient for the large catchment. Overall, however, satisfying results were obtained as basis for the SUPLAN project (Gamerith, Wendner et al. submitted). An exemplary calibration result for one optimisation run is shown in Figure 2:
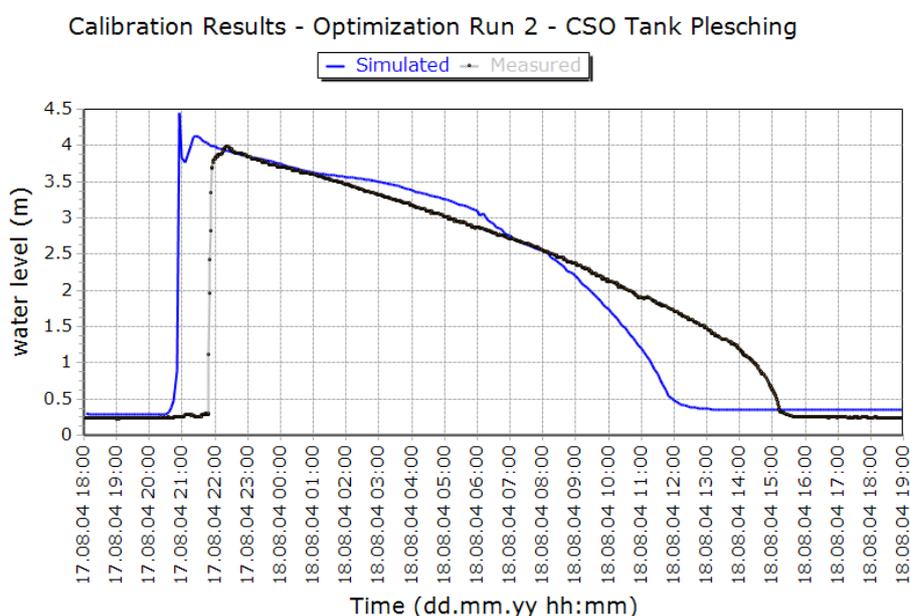

Figure 2: Exemplary results from model calibration for optimisation run 2

2.1.3   Evaluation of Results According to Austrian Regelblatt 19 Guideline

A script was developed in the software R (http://www.r-project.org/) that allows calculating the required and actual efficiency rates according to the Austrian Regelblatt 19 guideline based on the model run configuration.

The script first calculates the rainfall characteristic $r_{720,1}$ based on the German ATV A121 (ATV 1985) that is required for determining the required efficiency rates. The actual efficiency rates are then calculated based on the SWMM simulation results and given sedimentation efficiencies for the CSOs and CSO storage tanks in the sewer system.

2.1.4   First Model Results for Climate Change Impacts

Based on the available historical rainfall time series and a downscaled predicted rainfall time series a first comparison and evaluation of possible climate change impacts for the Linz Pilot was carried out.

A contribution on this topic was submitted to the IWA World Congress on Water, Climate and Energy to be held in May 2012 in Dublin, Ireland (Gamerith, Olsson et al. submitted).

The system's performance is assessed by long term simulations with a historical and a predicted rainfall time series in the SWMM 5 model. The predicted rainfall (climate model projection ECHAM5_A1B_3) shows a decrease of rainfall intensities in the summer period and an increase in winter. Strong precipitations intensities generally increase.

In a first assessment, 12 of 44 modelled CSO structures were identified as influential. The primary clarifiers at the WWTP proved to be the most important structure contributing with about 57% to the total overflow volume. The total overflow volume is increased by approximately 17%. The requirements as defined in the Austrian Regelblatt 19 guideline, however, are met for both dissolved and particulate pollutants for the historical and the predicted time series (see Table 1). While the system efficiency decreases with the predicted time series so do the requirements with increased rainfall (based on the calculated $r_{720,1}$).

Table 1: Required and calculated efficiency rates for historical and predicted rainfall time series (Gamerith, Olsson et al. submitted)

	historical		predicted	
	η_d	η_P	η_d	η_P
-	%	%	%	%
required efficiency rates	57.4	72.4	55.4	70.4
calculated efficiency rates	67.4	73.9	64.5	71.3

For particulate pollutants, an important impact of the assumption of the sedimentation efficiency for storage tanks was identified. This efficiency, however, is only estimated and its true value is not known.

For a more comprehensive assessment of the Linz pilot study in Phase 3, additional climate model projections will be applied to estimate an uncertainty range of predicted rainfall and different development scenarios. In addition, data from the installed measurement network will allow assessing the actual sedimentation efficiency in the primary clarifiers during storm water conditions.

2.2. SWMM Model Configuration Import

SWMM model configurations for the Linz sewage system are not only important for the model execution itself. They contain also information useful for visualisation and results analysis. Therefore, an important requirement of the Linz Pilot is that it should not only be possible to manage and run different configurations of the SWMM model, it shall also be possible to visualise the SWMM model configurations directly in the Linz Pilot Application. Such a configuration consists of general SWMM project information, rainfall input data and the layout of the sewage system. The sewage system modelled in the SWMM model configurations is composed of different entities like weirs, pumps, conduits, etc. along with their specific properties and their relations. Among those properties which are important for the overflow calculation is also a geographic reference (shown in Figure 3) which can be used to visualise the entities on a map.

Figure 3: Properties of a SWMM Entity (Outfall)

A SWMM model configuration is represented by a proprietary but nevertheless well defined textual file format. The configuration can be visually edited using the SWMM 5 application shown in Figure 4. However, this file format is not suitable for the SUDPLAN SMS which relies on OGC standards like WMS and WFS to visualise geospatial data.
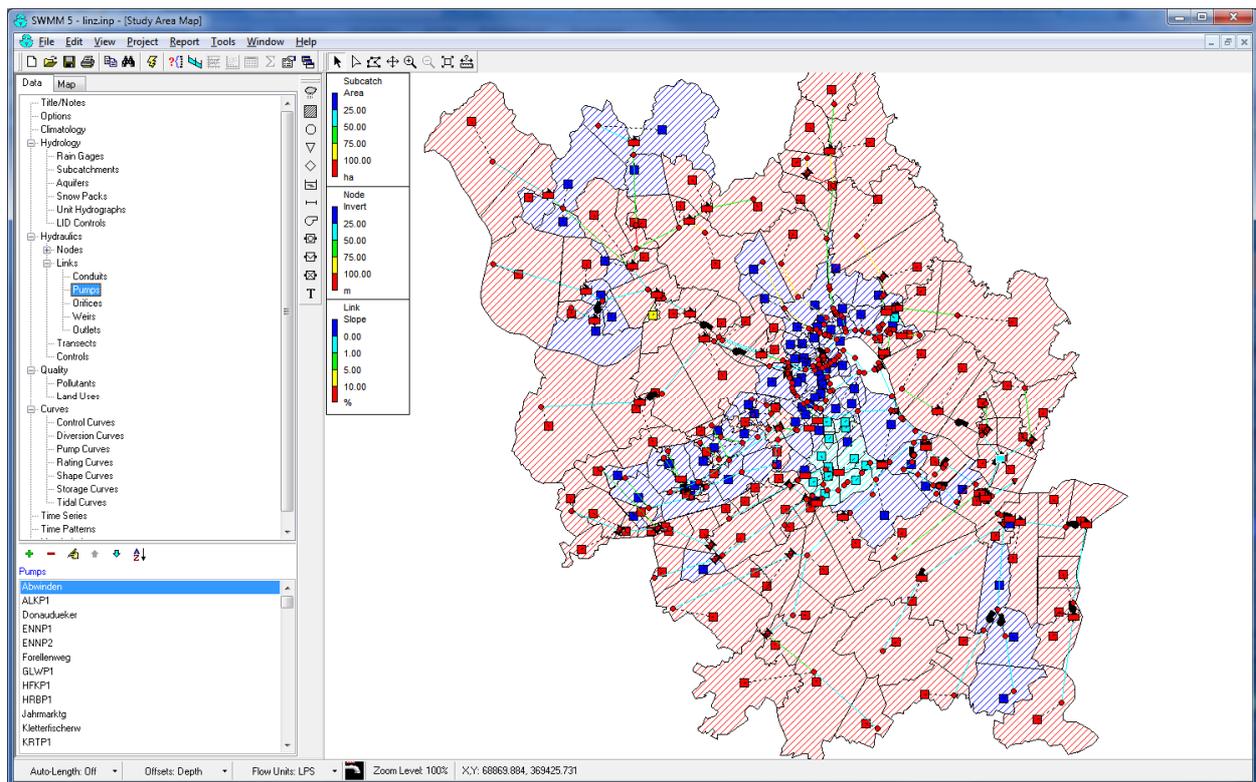
Figure 4: SWMM Model Configuration in SWMM Application

Therefore, the SWMM configuration file had to be transformed in a format that is both suitable to be shown in the SMS catalogue and to be served as geospatial data by a WMS and WFS. Ideally the same data repository for spatial and non-spatial visualisation shall be used. Furthermore, such a transformation shall be configurable and (semi-)automated, since additional SWMM model configuration will be added in the future.

The first step towards the SWMM model import was to define a relational database base model which defines the most important entities as well as their essential properties and the relationships between those entities. The Initial Linz Pilot Data Model shown in Figure 5 encompasses not only SWMM entities but models also entities like efficiency calculation configuration, CSOs, sensors, etc.
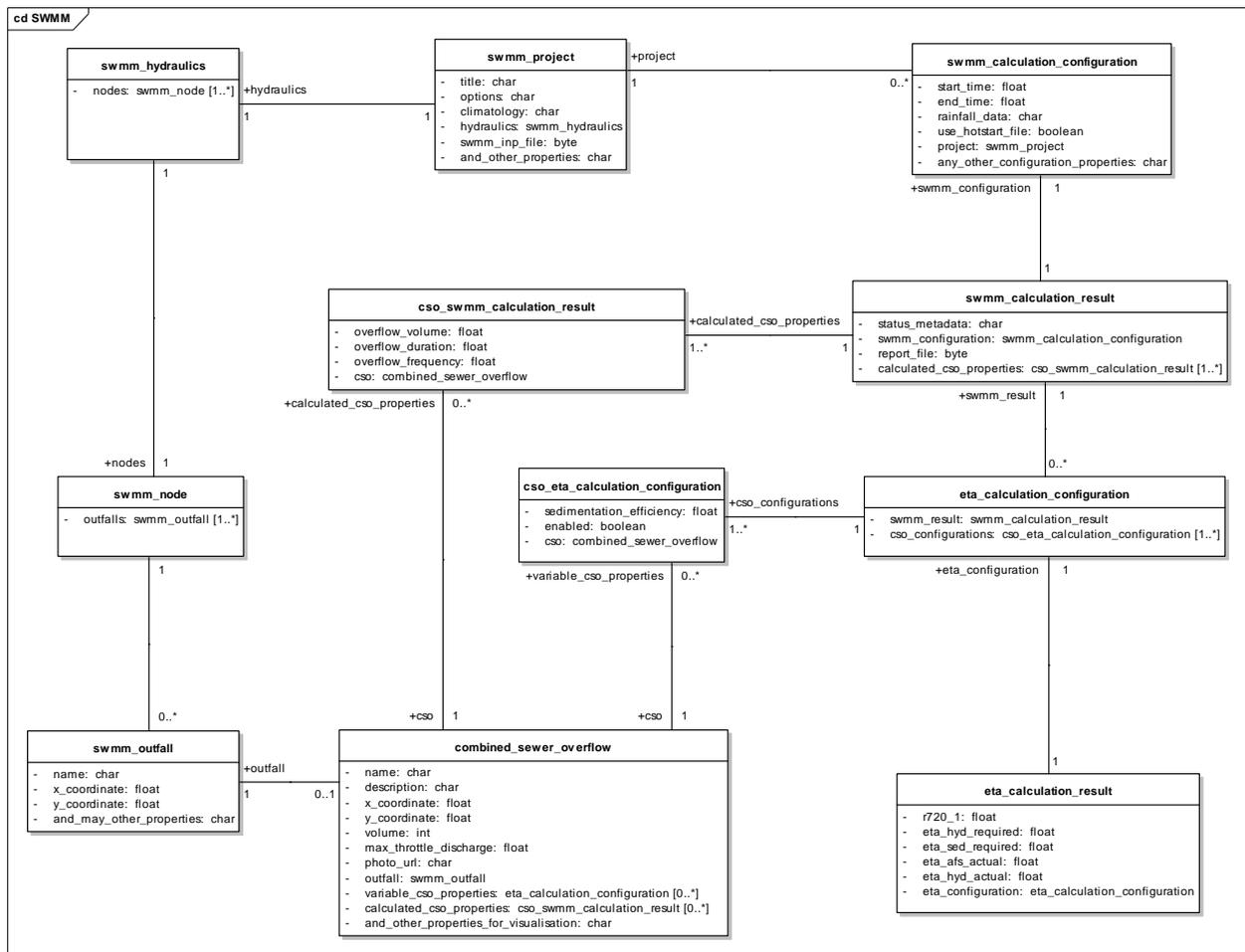
Figure 5: Initial Linz Pilot Data Model (excerpt)

Figure 6 shows a more detailed example of the CSO entity. The CSO itself is not part of SWMM model configuration but it has relationships with SWMM outfall and SWMM storage unit entities which contribute several properties to the CSO entity. Furthermore, a CSO has to provide references to several calculated and configured properties used for scenario-dependent visualisation & comparison which are specific to a certain SWMM model and efficiency calculation run.
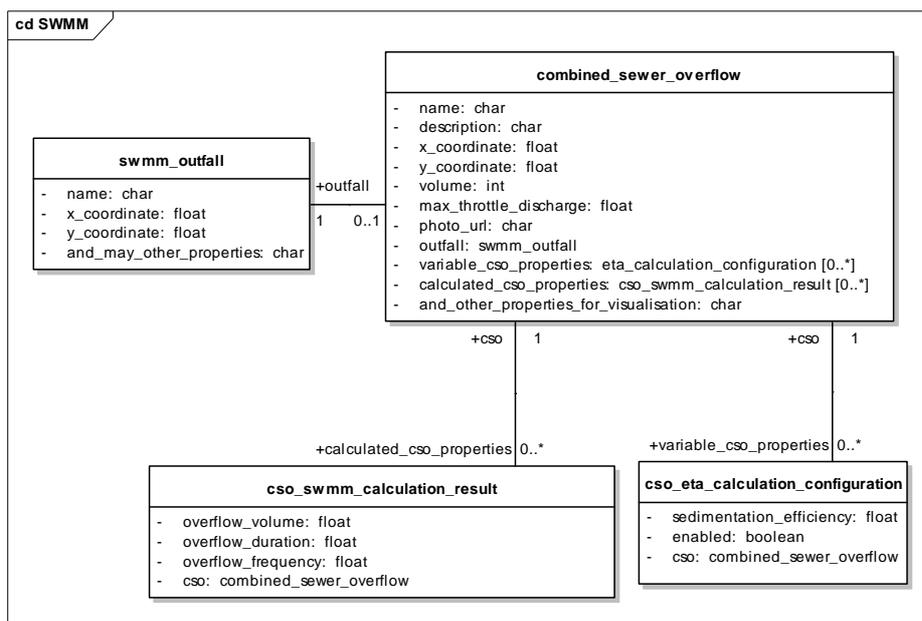
Figure 6: Initial Data Model of the CSO entity

Looking at this simple CSO example it is obvious that a SWMM configuration import is not a matter of a simple file import. Pre-processing of the input file is required to transform the data into a tabular format that can be used for a relational data base import. Transformation rules are required to establish the (geospatial) relationships between objects and to populate the cids integration Base with appropriate meta-information, a configuration of the SMS catalogue structure as well as of the WMS and WFS instances is needed, etc.
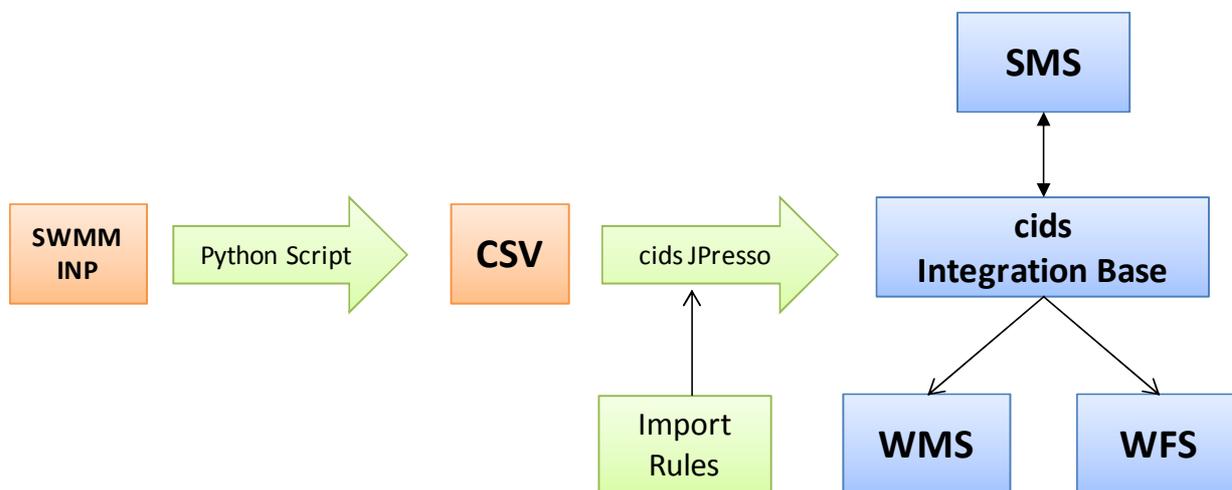
Figure 7: SWMM Model Configuration Import

In Figure 7 only the major steps of the import are shown. The SWMM input file is transformed into CSV format and then imported in a relational database. The JPresso ETL-Tool (Extraction, Transformation and Loading) is then used to define the transformation rules which consist of SQL statements and mapping rules. Transformation rules can be visually edited in JPresso, the rules can be saved and executed for additional SWMM model configurations.

Relevant parts of the SWMM data structure have been modelled as cids Meta Classes (including object references and geographic references). Additional properties needed for visualisation

which are not part of the INP file have been added, e.g. links to photos, documents, etc. Since those relevant SWMM entities are represented by cids objects, cids built-in visualisation and editing functionality can be used. This includes for example geospatial search (e.g. "show all storage units in subcatchment x"), interaction with the map (e.g. "zoom to selected outfall"), editing of objects, etc. Thus SWWM entities can be represented in the catalogue as object nodes with their attributes and in the map as WFS Features or WMS Layers.

Figure 8 shows an excerpt of the Linz Pilot Data Model in the cids Integration Base and its relations to the generic model management information model (see D3.2.2 - Product Implementation V2 - Companion Report, section 4.1.2). The management of the SWMM and efficiency calculations is already covered by the general SMS functionality additional entities are needed to meet pilot specific visualisation requirements.
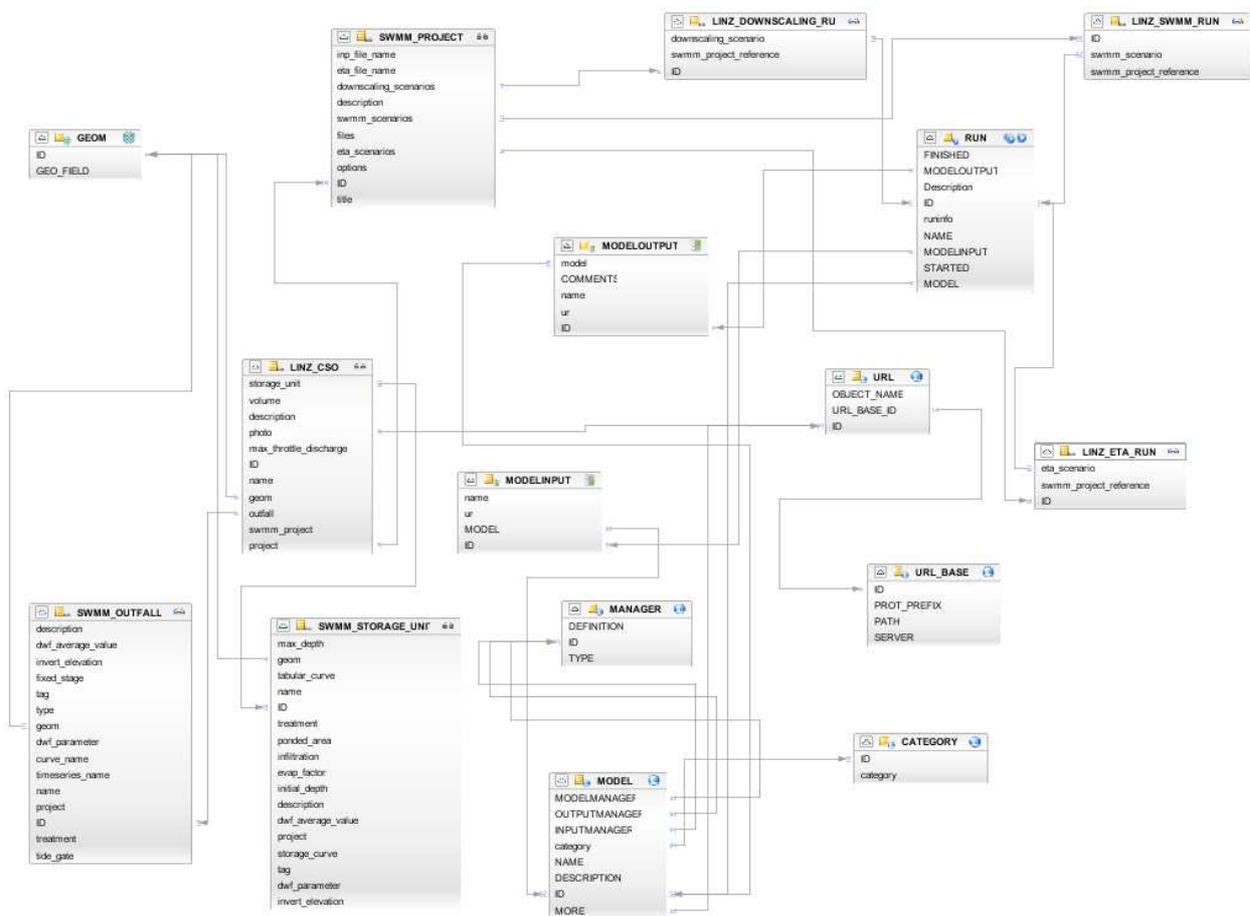
Figure 8: cids Linz Pilot Data Model (excerpt)

Figure 9 shows as an example the CSO entity with its relations to the SWMM outfall and storage unit entities. If compared to the initial data model presented in Figure 6, one will note that the model run specific properties like efficiency calculation results and efficiency calculation configuration are not included in the new data model. In fact, they are now represented by the generic model management information model as can be seen Figure 8.
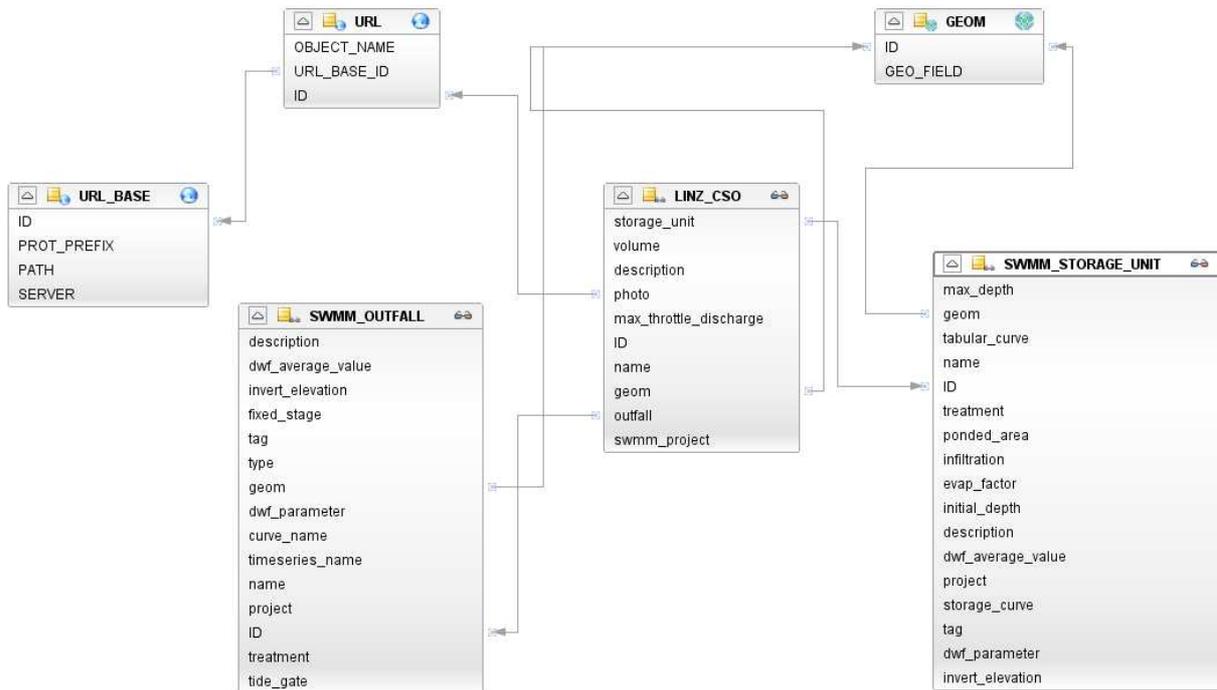
Figure 9: CSO entity modelled in cids Integration Base

As already stated, the SWMM model input file contains all relevant information on the model structure, geometry and simulation settings. In the following the format of the input file is shortly explained in order to be able to understand the implications on the import into the previously described data model.

The SWMM model input file contains various sections whereby the start of each section is marked by [SECTIONNAME]. The [TITLE] section contains information about the model consisting of one string. Sections like [OPTIONS] or [FILES] contain one-valued parameters as can be seen in Figure 10 below.

```
[OPTIONS]
FLOW_UNITS          LPS
INFILTRATION        HORTON
FLOW_ROUTING        DYNWAVE
START_DATE          01/01/2004
…
```

Figure 10: SWMM [OPTIONS]

Table sections are started by headers, which contain information about the columns. The last line of the header, which is started by ;;--- delivers information about column-header-splitting. Column names can be multi-line. An example of an outfall entity is given in Figure 11. Please note that the same entity shown in Figure 3 in the SWMM applications has additional properties which are not available in the [OUFALLS] section but have to be resolved from other sections.

```
[OUTFALLS]
;;                 Invert     Outfall    Stage/Table       Tide
;;Name             Elev.      Type       Time Series        Gate
;;-------------- ---------- ---------- ---------------- ----
RDSRUE51           288        FREE                         NO
ULKS1              240.6      FREE                         NO
FUEAusl            245.75     FREE                         NO
RKL_Ablauf         240.6      FREE                         NO
```

<p align="center">Figure 11: SWMM [OUTFALLS]</p>

Relations between elements from various sections are handled by the name of the item. For example, every subcatchment has an outlet node. By looking for example at the *RDSS26* outlet node of the *01_Asv_1* subcatchment in the [JUNCTIONS] section, one can find the corresponding node. The Polygons of the subcatchments can be found in the [Polygons] section (Figure 12).
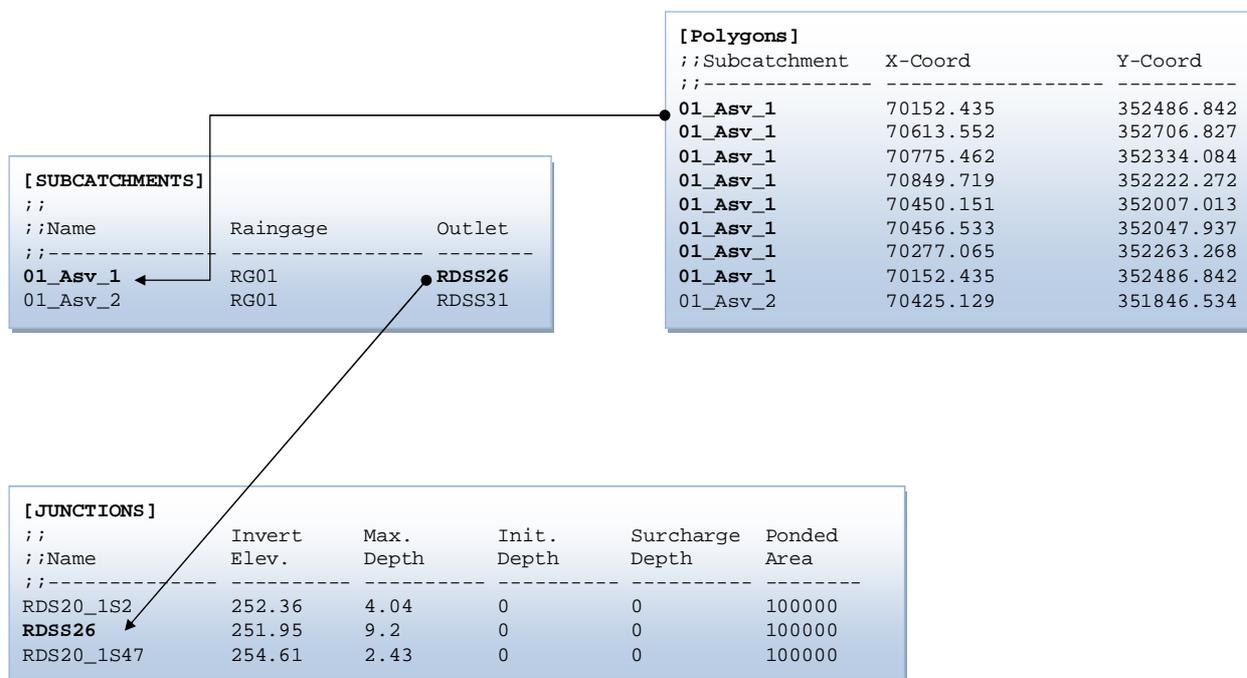
<p align="center">Figure 12: Relationships between entities in the SWMM input file</p>

The Coordinates of all other objects in the input file like [JUNCTIONS], [OUTFALLS], [STORAGE], etc. can be found by searching for the name of the node in the [COORDINATES] section (Figure 13).

```
[COORDINATES]
;;Node            X-Coord           Y-Coord
;;-------------- ----------------- -----------------
DLLS22            80888.343         347090.121
ULA1S5V           79676.480         345201.657
HSMS26            71291.329         351196.969
```

<p align="center">Figure 13: SWMM [COORDINATES]</p>

These relationships have also to be resolved by the import logic. As mentioned before, the SWMM input file has first to be transformed into tabular format (CSV) and then imported into a relational database. The advantage of this approach is that SQL statements can be used to select appropriate views that contain already basic relationships. Furthermore, the PostGis extension of PostgreSQL can used for coordinate transformations, e.g. to transform between different spatial reference system and to join points (see Figure 13) to polygons (e.g. subcatchment) and lines (e.g. conduits).

The transformation of respective sections in the SWMM input file to CSV is performed by a Python script (Figure 7). Creation and execution of the SQL coordinate conversion, views and import statements as well as the mappings between the input tables and the source tables of the cids Integration Base are performed with help of cids JPresso (Figure 14). JPresso is a powerful ETL-Tool for the integration of heterogeneous data-sources. It supports visual mappings that describe the connection between data-sources and the cids Integration Base.
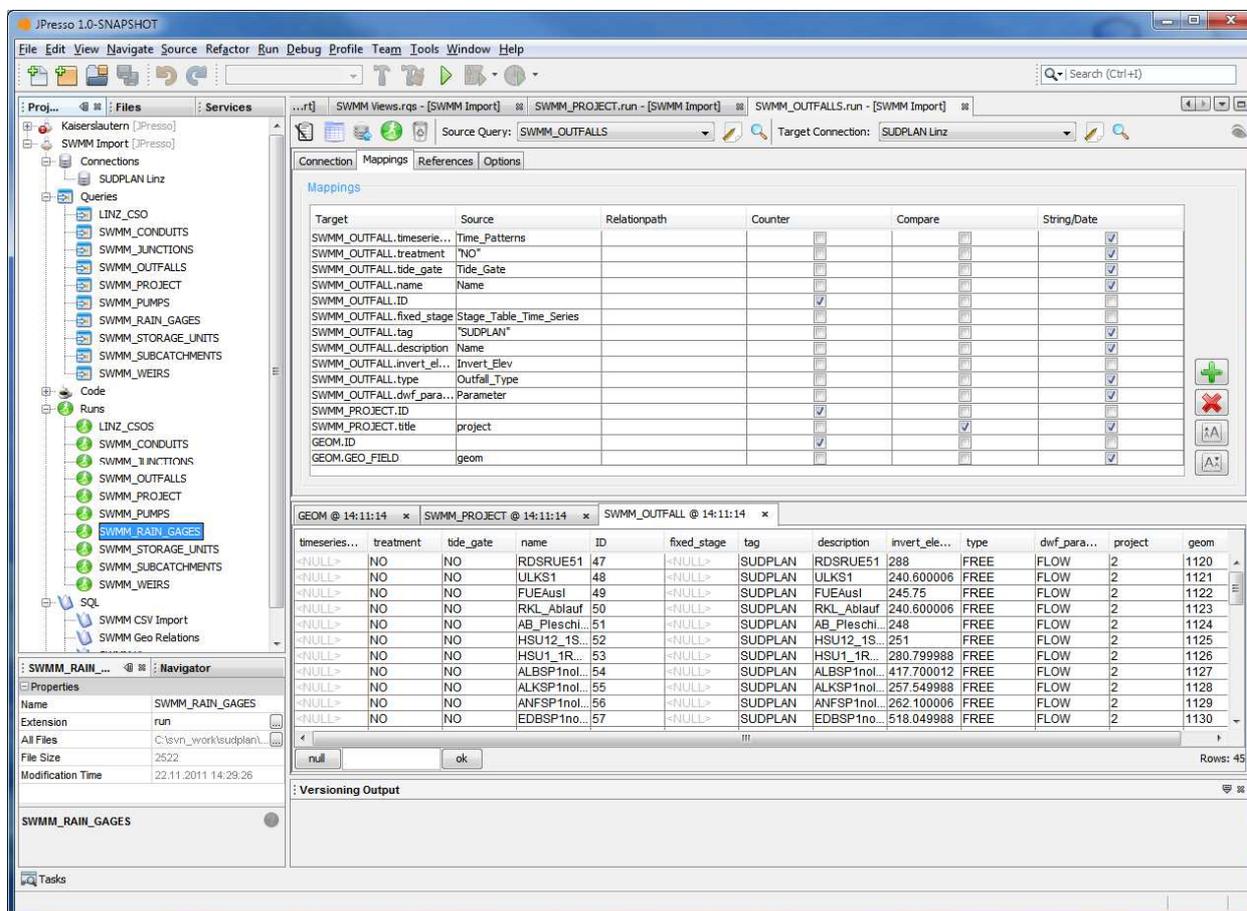
Figure 14: JPresso ETL Tool with SWMM Import Configuration

JPresso distinguishes between SQL Runs, Queries and ETL Runs. A SQL Run is a set of SQL statements that can be executed to prepare an import. For the import of the SWMM Model configuration these SQL Runs consist of statements to create the import data base structure, to import the previously generated CSV files into the data base, to perform a coordinate conversion to WGS84 and to generate polygons and lines for the respective SWMM entities. An excerpt of such a SQL run is shown in Figure 15.
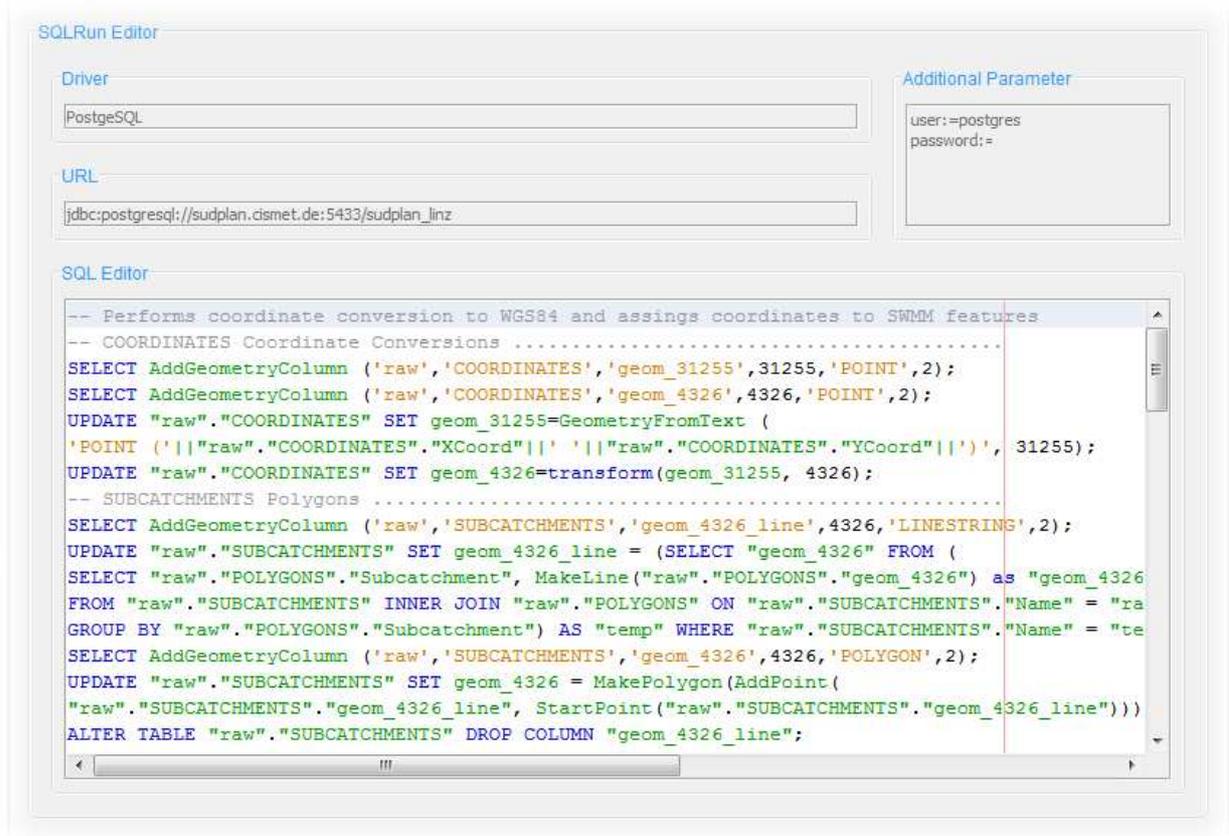
Figure 15: SQL Run Example

Queries are used to create views of the source data base. Those views will later be used in an ETL Run to create a mapping from the source to the target schema. Figure 16 shows the Queries and ETL Runs for the various SWMM entities.
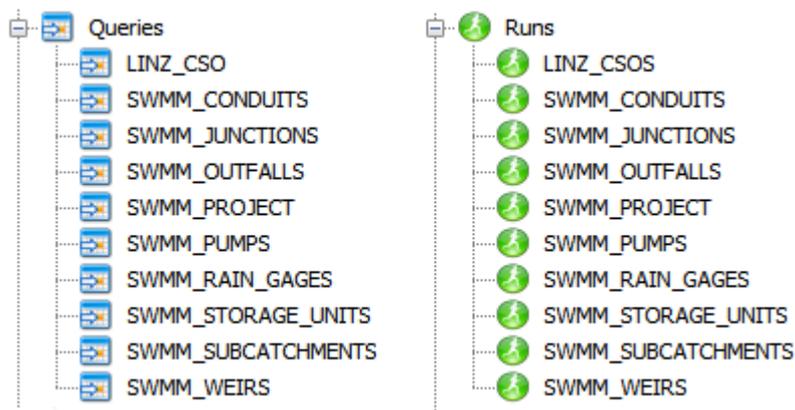
Figure 16: SWMM Import Queries and ETL Runs

Figure 17 shows a query for the CSO entity which is not directly part of a SWMM model configuration but can be derived from a SWMM outfall and a storage unit.

Figure 17: CSO Query

Figure 18 shows the corresponding mapping that maps the columns of the result of the above Query to the data model of the CSO entity of the cids Integration Base presented in Figure 9.

Figure 18: CSO mapping

Figure 19 shows and example of the visualisation of the imported SWMM model configuration in the SMS. The complete input of the SWMM model is now available in the SMS for result visualisation and comparison, e.g. to show a CSO along with its computed efficiency rates.
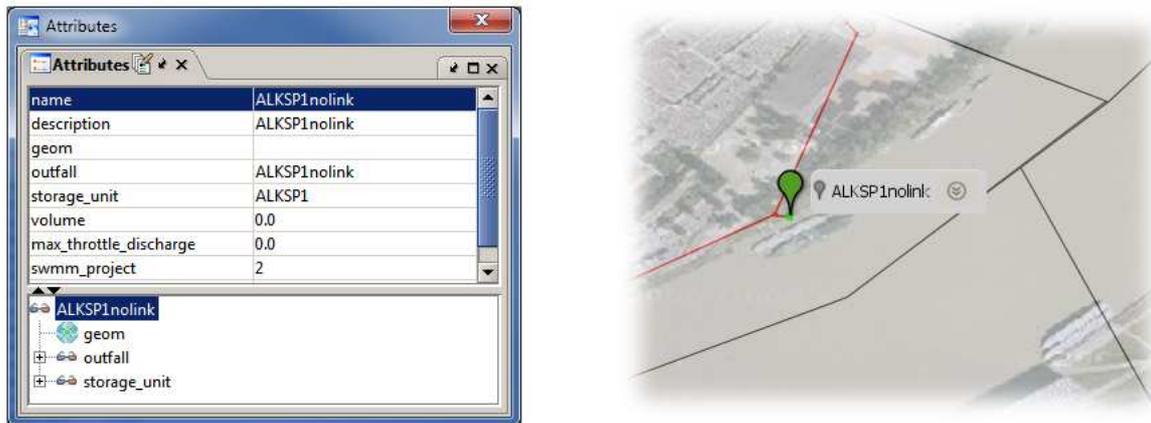
Figure 19: Visualisation of a CSO entity in the SMS

Since the SWMM model configuration is now available in a PostGIS data base, various geospatial visualisation possibilities can be used, e.g. Google Earth (Figure 20).
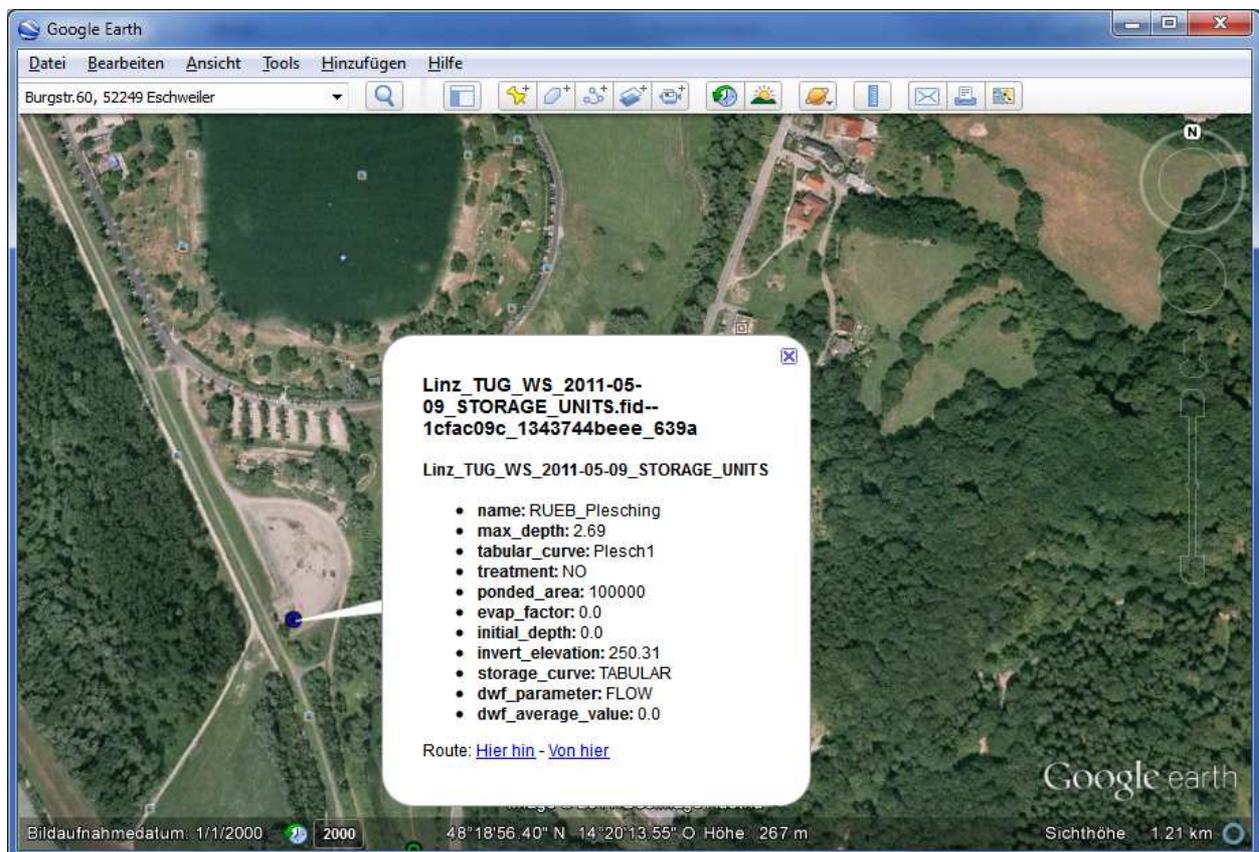
Figure 20: Geospatial Visualisation of a SWMM storage unit in Google Earth

However, the main advantage of the import is to be able to serve the SWMM entities via WMS and WFS and thus to show them in the SMS directly (Figure 21).
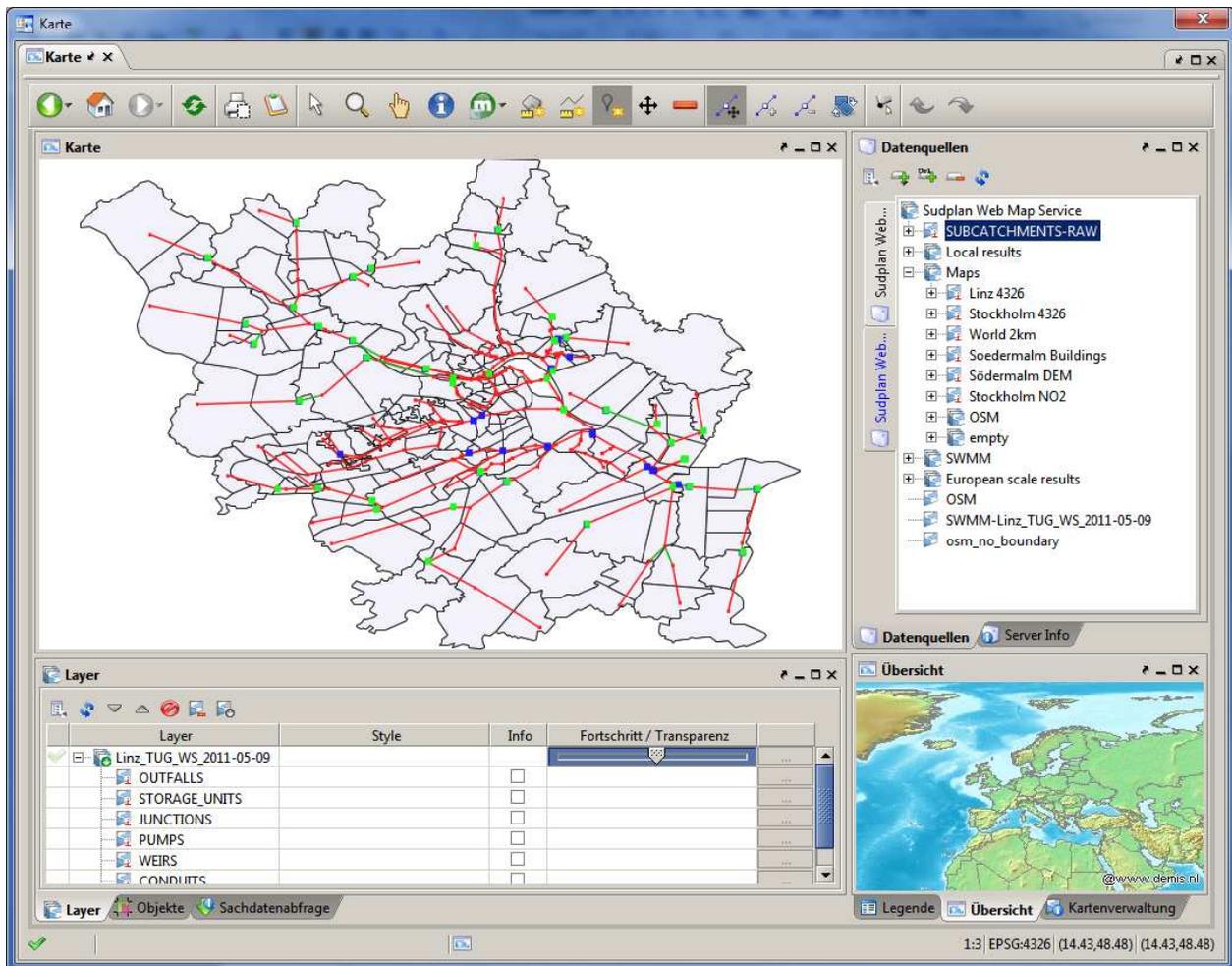
Figure 21: Geospatial Visualisation of the SWMM Model Configuration in the SMS

Besides the import of the SWMM Model Configuration, also its representation in the SMS catalogue had to be defined. The SMS catalogue can be dynamically generated which is important for the Linz Pilot, since several SWMM Model Configurations shall be supported.
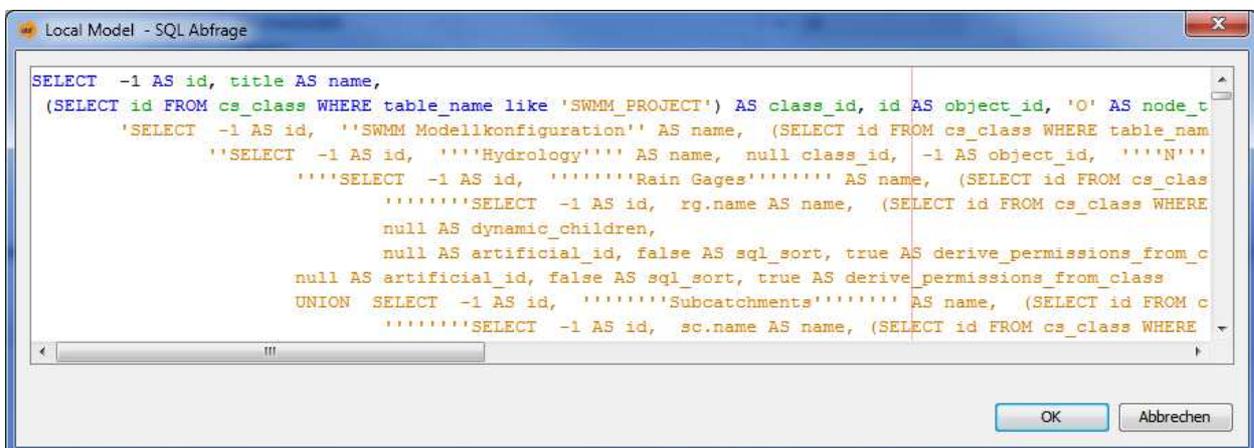
Figure 22: Dynamic Catalogue Configuration

When a new SWMM Model Configurations is imported according to the previously described process, the new entities appear automatically in the catalogue structure. This is possible thanks to the concept of dynamic nodes which is based on nested SQL statements as shown in Figure 22.
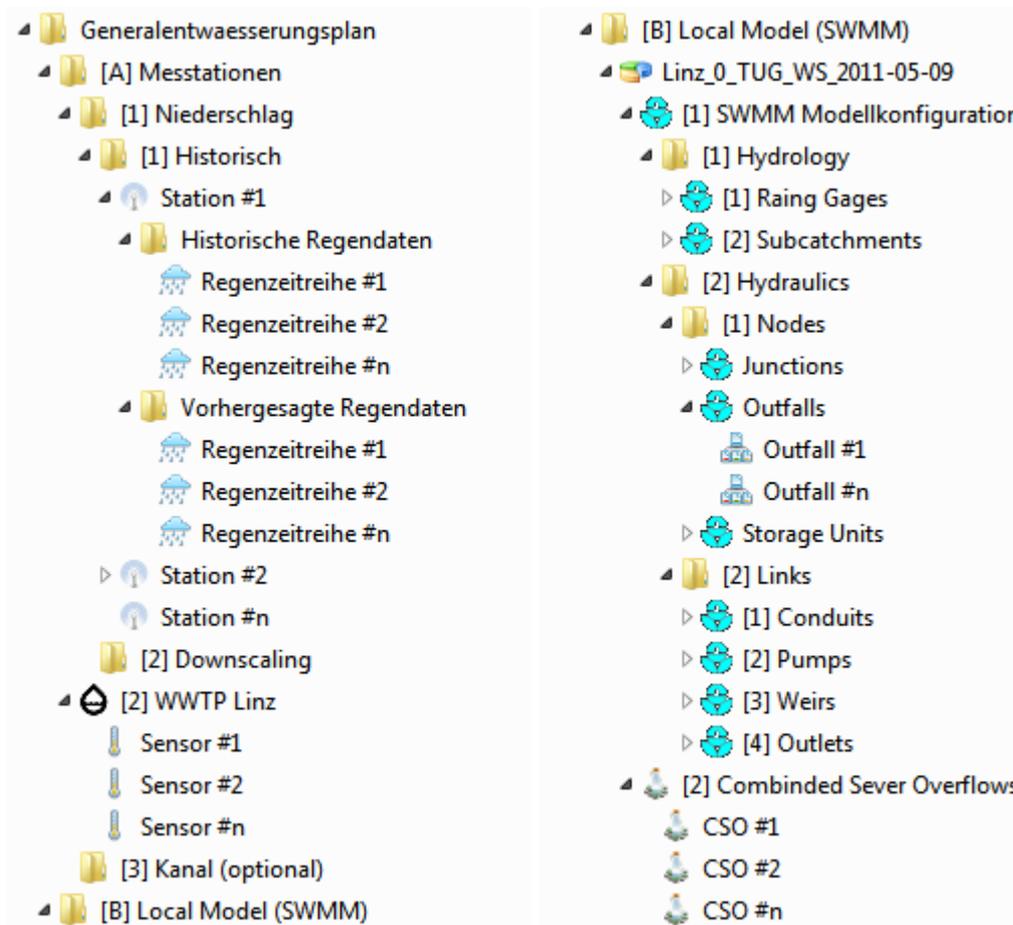
Figure 23: Linz Catalogue Structure

The catalogue structure shown in Figure 23 is composed of static and dynamic catalogue nodes. Some parts of the Linz catalogue are dependent on a certain SWMM Model configuration while others are not. Figure 24 shows the part of the catalogue that is specific to a certain SWMM Model configuration (*Linz_0_TUG_WS_2011-05-09*) and which dynamically generated according to the nested SQL statements presented Figure 22.

Figure 24: Model dependent Catalogue

Please note that the German language is used for the catalogue, the description of the entities as well as for the user interface of the SMS as requested by the end users of the Linz pilot application. The SMS UI is fully internationalised, so changing the locale is just a matter of configuration.

As already stated, the efficiency calculation of combined sewer overflows consist of two steps which require at least two independent model runs. The output of the SWMM model run is input of the efficiency calculation run, whereby also the SWMM model run may use the output of a preceding rainfall downscaling run. The SWMM Calculation Configuration is represented in the cids system as generic model input object. Figure 25 shows how this information is used in a SWMM model run. It provides information on the selected rainfall time series as well as information on the model specific input (INP) and hotstart files (HSF).
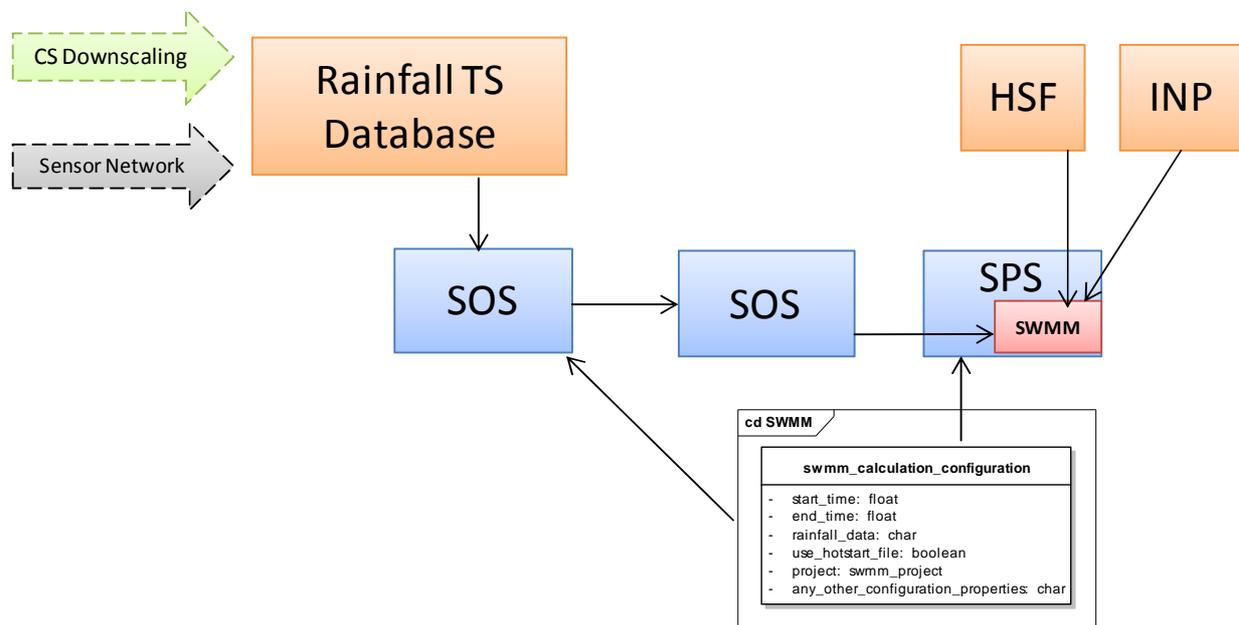
Figure 25: SWMM Model Run Configuration

The role and usage of SOS and SPS in the execution of the SWMM model is explained in section 5.2.

In V2 both steps, the SWMM Calculation and the Efficiency Calculation are performed directly one after another. So the output of the SWMM (Overflow) Calculation is directly fed into the Efficiency Calculation program. In V3 it is foreseen to execute those to steps independently from each other. It will be possible to run several Efficiency Calculation scenarios based upon the same overflow results. The model chaining capabilities (Figure 26) already exist, only the respective wizards have to be implemented.
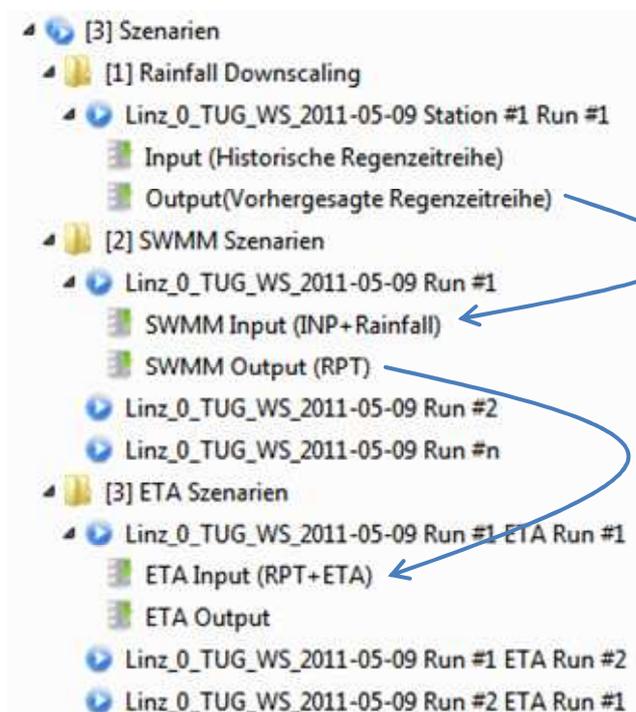
Figure 26: Model Chain

2.3.   Sensor Network at Linz WWTP

Preliminary model runs identified the primary clarifiers that also function as CSO tanks during rainfall events to have a major influence on the efficiency rates as defined in the ÖWAV Regelblatt 19 (OEWAV, 2007). Especially the assumption of the sedimentation efficiency has an important impact on the overall efficiency for particulate pollutants. Therefore, an assessment of the actual sedimentation efficiency is crucial in order to evaluate the whole systems performance.

In order to address this question a sensor network was installed in November 2011 at the primary clarifiers of the WWTP Linz, measuring hydraulic and water quality variables. An overview of the local situation at the WWTP Linz is given in Figure 27, Figure 28 and Figure 29.

For the estimation of the sedimentation efficiency both discharge and pollutant concentrations have to be measured in the inflow and in the outflow of the primary clarifiers (see Figure 28 and Figure 29). An overview of the measured variables and measurement devices is given in Table 2 and Table 3. In order to provide a valid mass balance for the pollutants in the primary clarifiers not only the inflow and outflow concentrations have to be determined but also the primary sludge removal has to be taken into account.

The measured variables (hydro- and pollutographs) shall be visualised in the SMS. In addition an event-detection algorithm will be implemented that allows automatically detecting overflow events from the measured data. Based on these events, the sedimentation efficiency of the structure during storm events can be estimated.

Figure 27: Map of WWTP Linz with the two primary clarifiers in green and indicated with No. 14
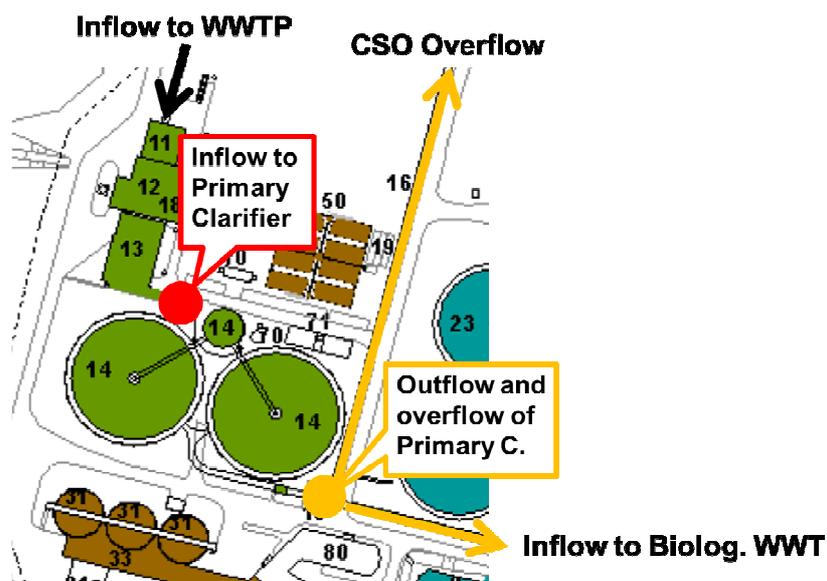
Figure 28: Overview of primary clarifiers at WWTP with inflow, overflow and outflow situation

Figure 29: **Photos of primary clarifiers indicating inflow, outflow and overflow situation**

Table 2: Variables measured by the SUDPLAN sensor network

Variables measured by SUDPLAN sensor network			
Location	**Variable**	**Unit**	**Sensor**
Inflow	COD_{eq}, TSS_{eq}	mg/L	UV/VIS spectrometer probe
	Water level	m	Ultrasonic water level meter
Outflow	COD_{eq}, TSS_{eq}	mg/L	UV/VIS spectrometer probe
	Water level	m	Ultrasonic water level meter

Table 3: Variables provided by LINZ AG from sensors already installed at the WWTP

Variables provided by LINZ AG			
Location	**Variable**	**Unit**	**Sensor**
Inflow	Q_{inflow}	m³/s	Ultrasonic device
Outflow	$Q_{overflow}$	m³/s	Ultrasonic device
	$Q_{inflow\text{-}bio}$	m³/s	Ultrasonic device
Primary sludge removal	Q_{PSR}	m³/s	Ultrasonic water level
	TSS_{PSR}	mg/L	unknown

2.3.1   Sensor network installation

Since the funding of the sensor network was not assured until August 2011 and no budget was available for the sensor network within the SUDPLAN project the installation was delayed. Fortunately LINZ AG decided for some extra funding for the sensor network in August 2011 to estimate the sedimentation efficiency of the primary clarifiers of the wastewater treatment plant Linz. Finally the installation of the two measurement stations in the inflow and in the outflow channel of the primary clarifiers could take place in November 2011.

Both measurement stations are equipped with identical sensors: an ultraviolet-visible (UV/VIS) spectrometer to estimate the pollution concentrations for TSS_{eq} and COD_{eq}, an ultrasonic probe to measure the water levels in the channels and an industrial PC which records the data in 1 minute intervals.

Figure 30 and Figure 31 show the installation site with the installed sensors at the end of the inflow channel to the primary clarifiers for the inflow devices and Figure 32 the enclosed outflow area for the outflow devices where the overflow weir of the CSO is situated. Since the turbulences in the outflow channel especially during wet weather conditions are quite high it can be assumed that the wastewater quality in the discharged overflow channel is more or less the same as in the outflow channel.

Figure 30: Installation site of the inflow measurement devices to the primary clarifiers

Figure 31 **Inflow measurement site with the installed UV/VIS spectrometer, the ultrasonic probe and the industrial PC for data recording.**
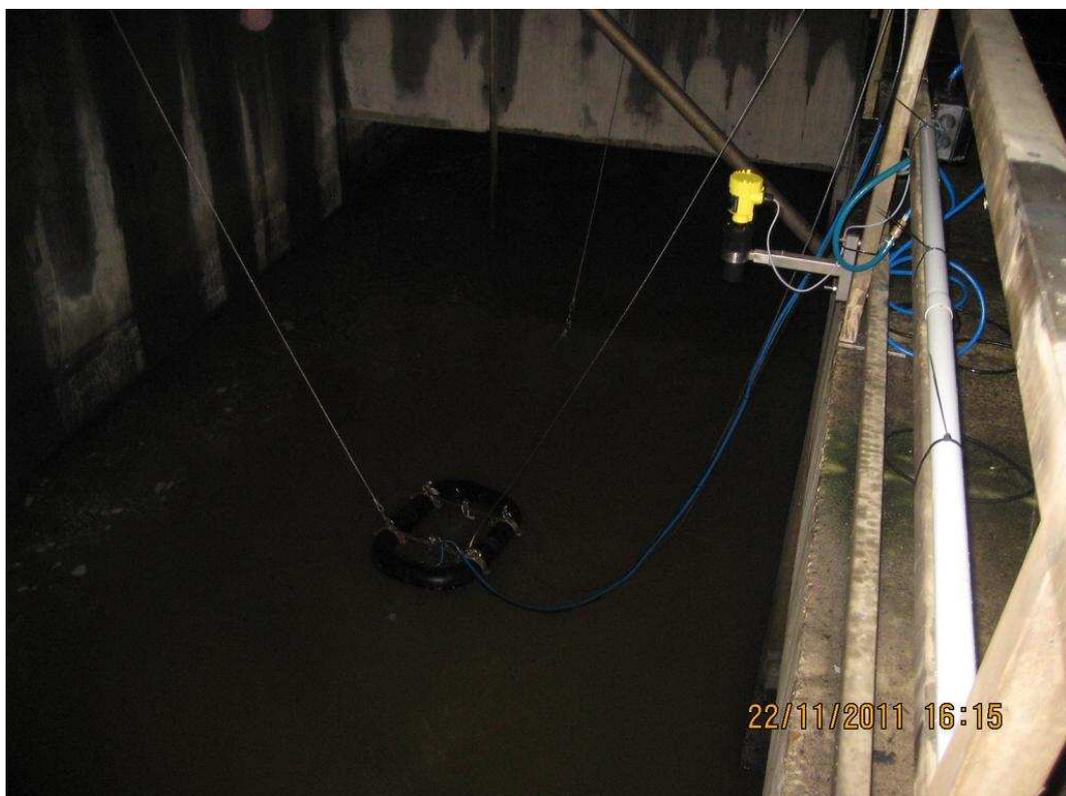
Figure 32: Installation site of the outflow devices (floating UV/VIS spectrometer and ultrasonic device)

While the UV/VIS probe in the inflow channel is fixed rigidly by a metal bar some centimetres above the bottom of the channel (Figure 33) the outflow probe is fixed in a floating device (Figure 32).
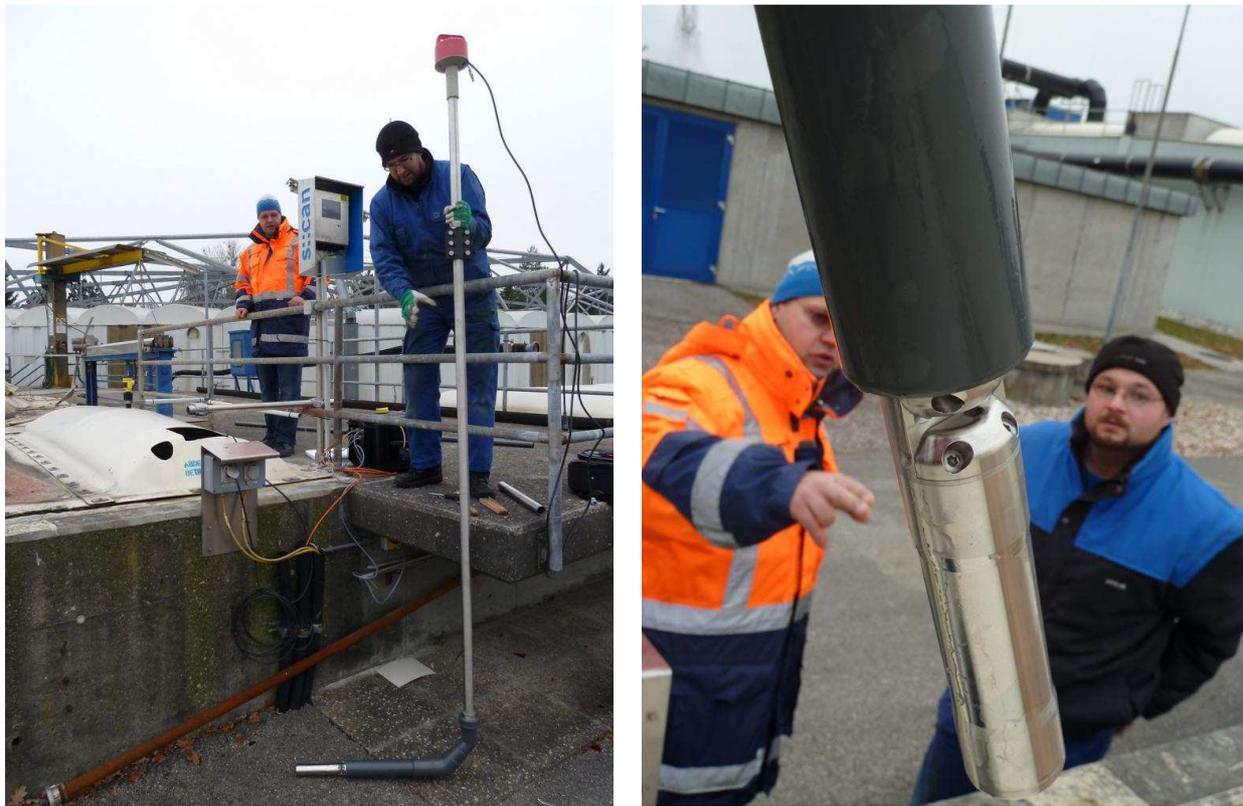
Figure 33: UV/VIS spectrometer fixed rigidly at the end of a metal bar in the inflow channel to the primary clarifiers of Linz WWTP

The two industrial PCs are connected to an UMTS router which transfers the recorded data regularly to the OpenSDM at TU Graz from where they are provided for the SUDPLAN SMS.

The additional data time series measured and provided by LINZ AG which are relevant for the estimation of the sedimentation efficiency are submitted to TU Graz once a day also with 1 minute intervals. From there they are also imported to the OpenSDM and provided automatically for the SUDPLAN SMS.

Figure 34 shows exemplarily the uncalibrated pollutographs for TSS_{eq}, $NO3\text{-}N_{eq}$, COD_{eq} and BSB_{eq} in the outflow channel of the primary clarifiers within a period of 22 days in December 2011. To improve the reliability of the resulting equivalent pollution concentration calculated by the UV/VIS spectrometer a measurement campaign to gain a set of reliable chemical reference samples is planned for the first half of 2012.

Within the SUDPLAN project all variables measured by the sensor network or provided by LINZ AG (hydro- and pollutographs) shall be visualised in the SMS. In addition an event-detection algorithm will be implemented that allows automatically detecting overflow events from the measured data. Based on these events, the sedimentation efficiency of the structure during storm events can be estimated.
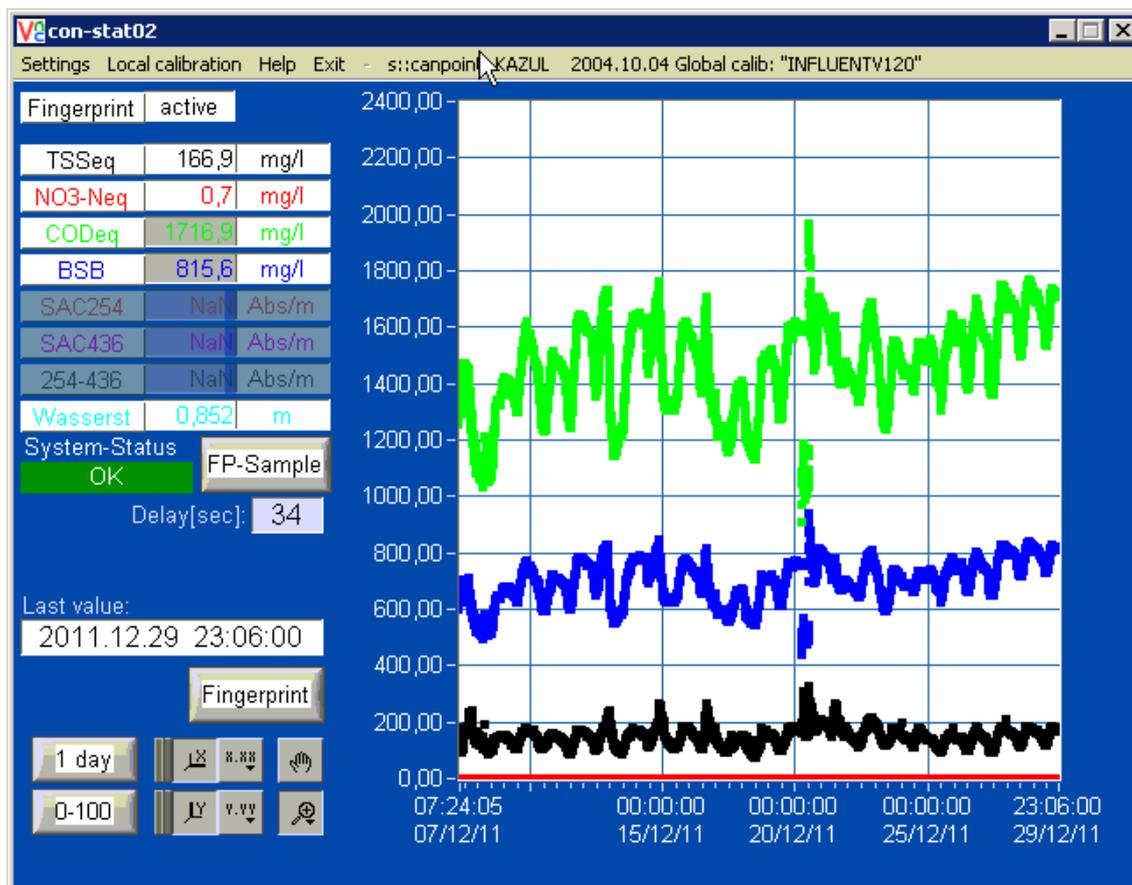
Figure 34: Recorded pollutographs for TSS_{eq}, $NO3\text{-}N_{eq}$, COD_{eq} and BSB_{eq} in the outflow channel of the primary clarifiers within a period 22 of days in December 2011

3. Inventory of data used

This chapter gives an overview of the data used in the Linz Pilot. Data acquisition, structure and exchange formats of the local climate data – i.e. the rainfall data as major driver of the combined sewer overflows – are explained. Secondly other relevant input data that is mainly linked to the local model as geometry data, sewer measurement data etc. are briefly listed.

3.1. Local Climate Data

Rainfall is the major driver of the hydraulic processes in combined sewer systems and impacts directly on the combined sewer overflows. The possible impacts of climate change effects on the Linz Pilot are described by the predicted changes in the rainfall data. Hence the local rainfall data is a crucial input for both the downscaling process and the sewer system model.

3.1.1 Data Acquisition

In the Linz Pilot, rainfall data is required as local climate data input for the simulation model.

- Local rainfall data for the rain gauge "Linz Stadt" is obtained from the NIEDA tool (hydro-IT 2007). The available time series covers 14 years (01.01.1993 to 01.01.2007) with a time resolution of 1, 5 or 10 minutes.

- Additional data will be obtained from the central meteorological service of Austria for 2007 to 2010 by LINZ AG and provided for the SUDLAN project.

- In addition rain gauges installed in the Linz area by LINZ AG were provided. They will be used to validate the model but not as historical data or for future scenarios in downscaling as their duration is limited (depending on the rain gauge from 2004 to 2006 onward).

3.1.2 Data Structure and Exchange Formats

The original rain time series (also referenced as "historical") as well as data from the sensor network and additional sources (consisting of CSV-files) are converted to the netCDF format from http://www.unidata.ucar.edu/software/netcdf/, so that additional metadata can be provided with it. These conversions are carried out with the help of a tool developed by TUG (OpenSDM). The existing OGC-compliant Sensor Observation Service (SOS) delivering the historical rain time series will be extended to deliver also this additional data.

A dedicated SOS server delivers data to be used by the SUDPLAN SMS and possibly other clients. This allows separating the SOS and the OpenSDM system, resulting in higher security and better overall performance.

As only the dedicated SOS server is accessible from the internet neither the internal functionality nor the data is prone to attacks from the internet. The SOS server itself, including published data can be recreated any time from the internal database without any data loss.

3.2. Other Relevant Input Data

Besides the rainfall data as major input, several other data is relevant for a proper assessment and evaluation of the Linz Pilot, namely geometrical information and geographical features as well as additional measurement data from the sewer system.

3.2.1 Geometry and geographical data

For the model set up and assessment as well as for visualisation of the sewer system model, data on the sewer geometry, special structures (e.g. CSO tanks), allocation of subcatchments and information on the surface (e.g. impervious area) are required.

- Geometry data for the sewer system and the special structures was available from (i) a detailed digital sewer map (ii) an overview diagram of the system and (iii) the SWMM model. All data was provided by LINZ AG. For visualisation purposes the validated, geo-referenced geometry data from the SWMM model is used.

- Allocation of subcatchments and surface information was available from (i) an overview diagram of the system and (ii) the SWMM model provided by Linz AG. Surface data was roughly validated by the aid of aerial view photos (Wendner 2011). For visualisation purposes the validated, geo-referenced data from the SWMM model is used.

- A digital elevation data model was provided by Linz AG.

3.2.2 Additional measurement data

For model calibration and model validation measurement data on hydraulics as water level or flow measurements directly in the sewer system are necessary. For the evaluation of the sedimentation efficiency, data from the measurement network at the WWTP is used.

- Measurement data of water levels and flow within the system were used in model calibration (adaption of model parameters to fit simulated to measured data) and model validation. The data and information on the measurement sites was provided by LINZ AG.

- Measurement data of the installed sensor network at the Linz WWTP and additional measurement data at the Linz WWTP provided by LINZ AG will be used for estimation of the sedimentation efficiency of the primary clarifiers,

4. Pilot application in V2

The pilot application in the first year mainly dealt with data and model evaluation as well as the assessment of the current system status. In the second year focus was put on the simulation and evaluation of historical and predicted scenarios and their comparison as well as the installation of the sensor network. The relevant tasks and use cases for V2 are discussed in the following.

4.1. Relevant Tasks for V2

The tasks that are presented in Table 4 and Table 5 have been the focus of the work performed in the Linz Pilot in the first two years. The tasks definition herein is taken from the Pilot Definition Plan V2 (D 7.2.1). Table 4 gives a short summary of the tasks treated in V1 as they are an essential basis for the tasks treated in V2.

Table 4: Tasks completed in V1 (year 1)

Task 1: Assess the current state of the sewer network Assess the current state of the sewer network by calculating the required CSO efficiency rates & calculating the actual CSO efficiency rates
Task 1.1: Calculating actual required CSO efficiency rates Calculate the actual required CSO efficiency rates based on the available catchment and rainfall data according to the guidelines
Task 1.2: Calculating actual existing CSO efficiency rates Calculate the actual CSO efficiency rates with the calibrated City Drain model and available historical rainfall time series
Task 2: Validate measurement data (rainfall, runoff and pollution concentrations) provided by LINZ AG Validate the data on rainfall, runoff and pollution concentrations provided by LINZ AG

A description of the tasks treated in V2 is given in Table 5. Several tasks that were defined in the Pilot Definition Plan V2 (D 7.2.1) are still under way, mainly due to the late installation of the network in November 2011.

Table 5: Tasks treated in V2 (year 2)

Task 3: Determine local rainfall data for future scenarios based on climate change models (downscaling) provided by common services
Different local rainfall data sources where provided to be used by the common services (e.g. rainfall data in different time resolutions). First success was achieved in creating OGC-compliant SOS services and in the downscaling procedures. One predicted rainfall time series was generated that was used for the following tasks.
Task 5: Assess possible impacts of climate change scenarios on the sewer system due to

future rainfall time series

In this task that includes several sub-tasks, the possible impacts of future scenarios on the combined sewer overflows are evaluated based on the current Austrian Regelblatt 19 guideline. In year 2 a script was developed that allows determining all relevant values according to the guideline from the used rainfall time series and the local model results. The script was successfully implemented in the local model run procedure.

Task 5.1: Calculate the required CSO efficiency rates for future scenarios

In this task the required CSO efficiency rates according to the guideline are calculated for a future, predicted catchment status (e.g. predicted land use data) and/or predicted rainfall data. In V2, calculation was carried out with one predicted rainfall time series obtained from the downscaling process.

Task 5.2: Calculating predicted CSO efficiency rates for future scenarios.

In this task the predicted CSO efficiency rates according to the guideline are calculated for a future, predicted catchment status (e.g. predicted land use data) and/or predicted rainfall data by the aid of the local model. In V2, calculation was carried out with one predicted rainfall time series obtained from the downscaling process.

Task 5.3: Comparison of required and predicted efficiency rates for several future rainfall scenarios

Based on the results from tasks 1.1 and 1.2 (using the historical rainfall time series) and 5.1 and 5.2 (using one predicted rainfall time series) a first comparison of required and predicted efficiency rates was carried out.

Task 6.1: Conception and installation of the sensor network at WWTP Linz

This task was completed in late 2011. The sensor network is in operation.

Task 7: Event detection at primary clarifiers

The aim of this task is an automated detection of overflow events at the primary clarifiers in order to determine the periods for which the data shall be evaluated to assess the sedimentation efficiency (Task 8). In V2 scripts were pre-developed and are ready for implementation.

Task 9: Adapt model calibration based on additional measurement data

This task spans over V2 and V3. In V2 the model was linked to a state-of-the art optimisation algorithm for automated model calibration. Several optimisation runs were successfully performed to fit the model results to the measured data. The model connector allows an easy implementation of new data acquired in V3.

Task 11: Visualize geographical features of the SWMM model and relevant parameters

This tasks that aims at the visualization of geographical (and geometrical) features and the relevant SWMM model parameters in the SUDPLAN SMS was completed in V2.

4.2. Relevant Use Cases for V2

The use cases defined in the Pilot Definition Plan V1 and V2 are the basis for the implementation effort in the second year. In the following, all use cases are listed and a short explanation on their fulfilment in the Linz Pilot V2 application is given.

Table 6: Relevant use cases in V2 (year 2)

UC-711: Upload pilot specific data *The actor wants to upload pilot specific data in preparation for a scenario execution.*
Concerning the model input data, this use case is covered by the SWMM Model Configuration import as described in section 2.2. Regarding the import of precipitation data, this is handled by the SOS as described in section 5.2. Integration of the SOS into the SMS is standard SMS functionality and is described in D3.3.2 - Integrated Scenario Management System V2 - Companion Report.
UC-712: Start Downscaling *The actor wants to start a downscaling scenario execution* **UC-713: Download downscaling results** *The actor wants to download some of the downscaling results.*
Downscaling is a standard SMS functionality and no pilot specific developments were necessary. Therefore, this use case is described in D3.3.2 - Integrated Scenario Management System V2 - Companion Report.
UC-714: Run local model *The actor wants to start a local model execution (SWMM)*
Implemented in V2 with help of the SMS Model as a Service capabilities. Pilot specific SPS and SOS services were developed which encapsulate the local Linz SWMM model. See section 5.1 and 5.2 for a detailed description.
UC-715: Calculate CSO efficiency rates *The actor wants to calculate the required and the actual CSO efficiency rates based on results of a local model execution (see UC-714) in a location managed by SMS.*
In V2 the CSO efficiency calculation is carried out in conjunction with the SWMM model run. In V3 it will be possible to calculate the efficiency independently
UC-716: Export data *The actor wants to export data (downscaled rainfall – see UC-712, results from the local model – see UC-714 or efficiency rates – see UC-715) from SUDPLAN into local files*
Export to local files is currently not implemented and will be added in V3
UC-717; Standard visualisations *The actor wants to visualize rainfall, local model results or CSO efficiency rates*

General visualisation functionality of the SMS is used, not pilot specific development were necessary. See section 5.1 for further explanations

UC-721: Visualize geographical features of the SWMM Model
The actor wants to visualize the geographical features and relevant parameters of the SWMM model.

The import of SWMM input files was realised in V2 as described in section 2.2. The geographical features of the SWMM Model are made available through WMS and WFS and can be visualised in the map with help of the standard SMS visualisation facilities.

UC-722: Export Measurement data
The actor wants to export time-series data delivered by the sensor network or data from external sources

See UC-716.

UC-723: Visualize Measurement data
The actor wants to visualize data from the sensor network or external sources

See UC-717.

UC-724: Event detection

The actor wants to detect events in the data delivered by the sensor network.

The installation of the sensor network and preparatory work was completed in V2 (see section 2.3), The implementation of the event detection is planned for V3.

UC-725: Visualize Event detection data

The actor wants to visualize the data which was produced by the event detection routine.

SeeUC-724

5.   Pilot Design V2

5.1.   Graphical User Interface

Besides the standard SMS functionalities (e.g. downscaling, generic model management, user group management, etc.) implemented by WP3, only mockups were available in version V1 of the Linz Pilot Application. In V2 pilot specific developments were carried out and the local SWMM model was successfully integrated.

For this reason, only the pilot specific parts of the GUI are presented in this document. For those parts that are related to use cases which are entirely covered by the standard SMS functionalities, please refer to the documents D3.2.2 - Product Implementation V2 - Companion Report and D3.3.2 - Integrated Scenario Management System V2 - Companion Report. Among those use cases are for example UC-723 Visualize Measurement, UC-712 "Start Downscaling", UC-717 "Standard visualisations" (Figure 35), etc.
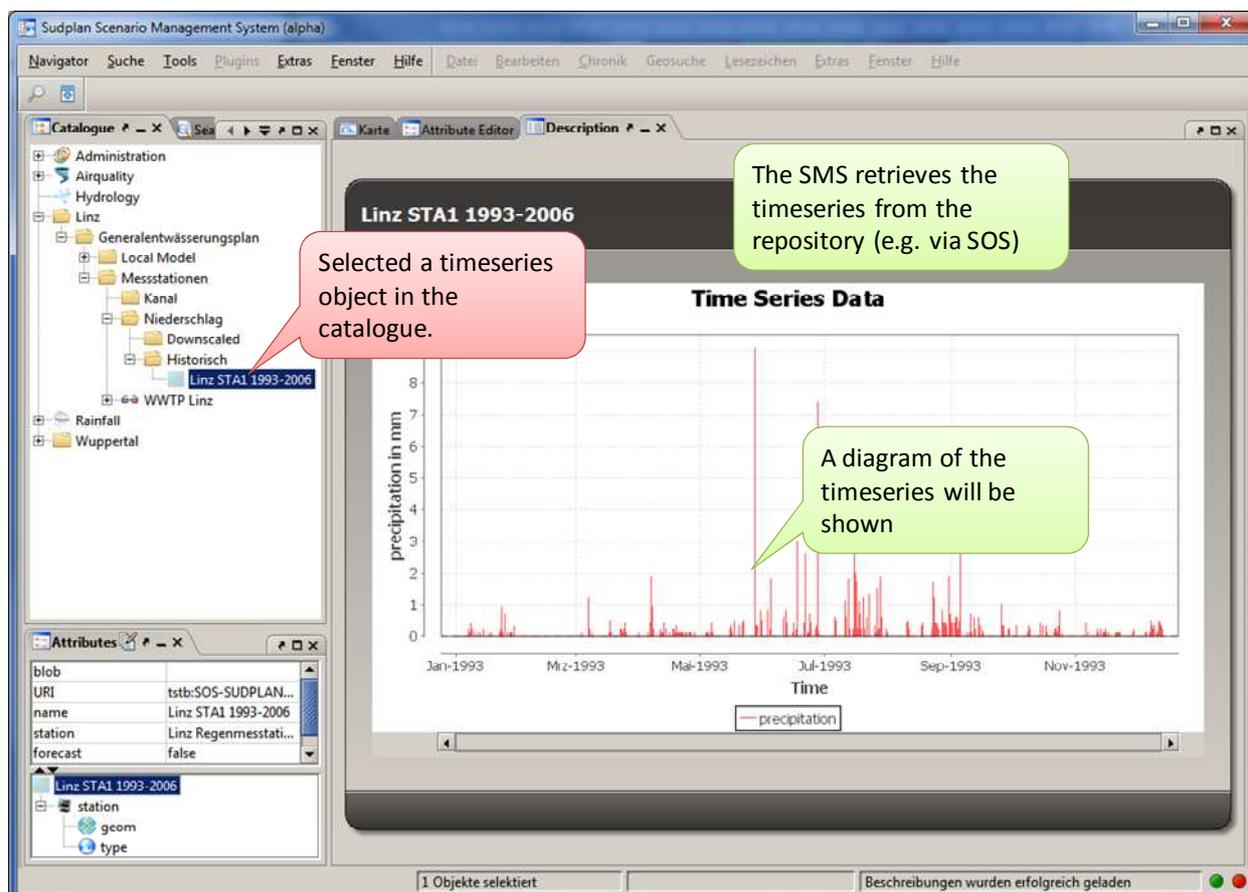
Figure 35: Standard Time series Visualisation Capabilities of the SMS

In the following, the Linz Pilot application GUI related to use cases UC-714 "run local model", UC-715 "calculate CSO efficiency rates" and UC-721 Visualize geographical features of the SWMM Model is presented.

The user can select a specific SWMM model configuration which is represented by the imported entities of SWMM input file as described in section 2.2. The description of the model

configuration shown in Figure 35 below consist of a geospatial preview of the model as it is displayed in the map component (Figure 27), some meta-information about the model configuration and a list of model runs that have been performed with this configuration. The user has furthermore the possibility to initiate a new model run by clicking on the button "SWMM + ETA Berechnung" (SWMM + Efficiency Calculation) which opens the SWMM & ETA Wizard (Figure 37).
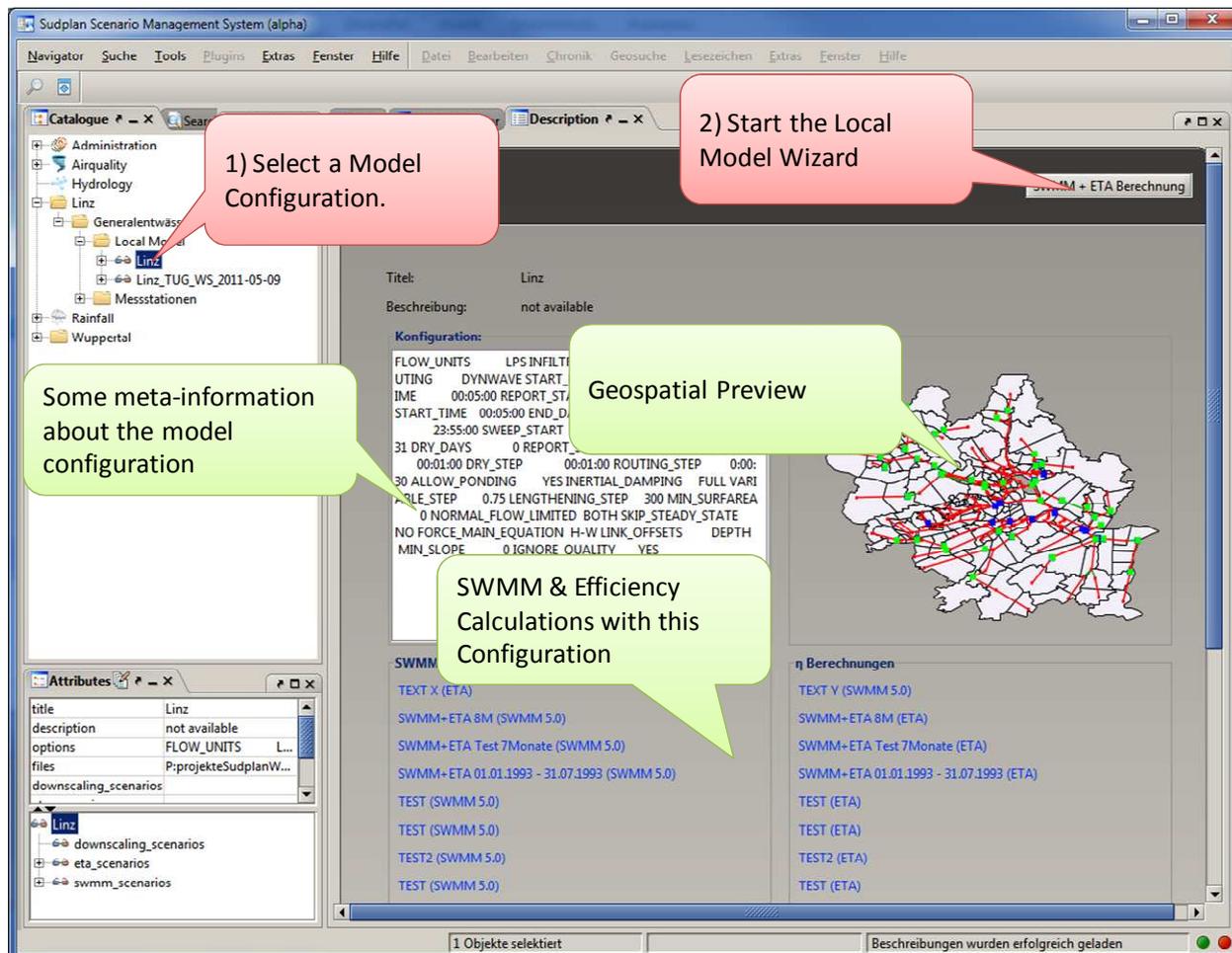
Figure 36: Select Model Configuration and run Local Model

On the first page of the SWMM & ETA Wizard, the user can select a specific SWMM model configuration (already preselected), specify or change the name of the input file at the model server (also already preselected) and select a start and end date for the model calculation. The start and end dates are furthermore checked for plausibility (Figure 38). Switching to the next wizard page is only possible when all required properties have to be filled in and when the dates are plausible.

In the current version of the Linz Pilot it is not possible to perform an efficiency calculation independently of a SWMM calculation. Therefore the check box "Wirkungsgrade berechnen" (calculate efficiency rates) is always checked. In the next version of the pilot, support for asynchronous efficiency calculation will be added.
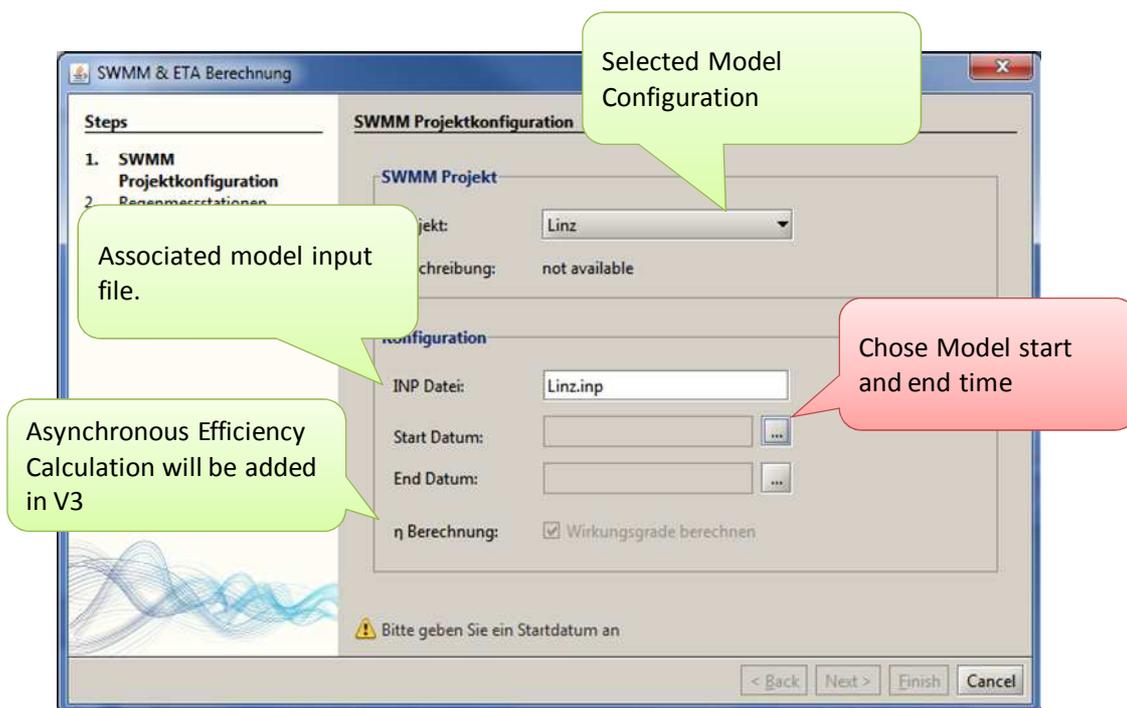
Figure 37: SWMM + ETA Wizard
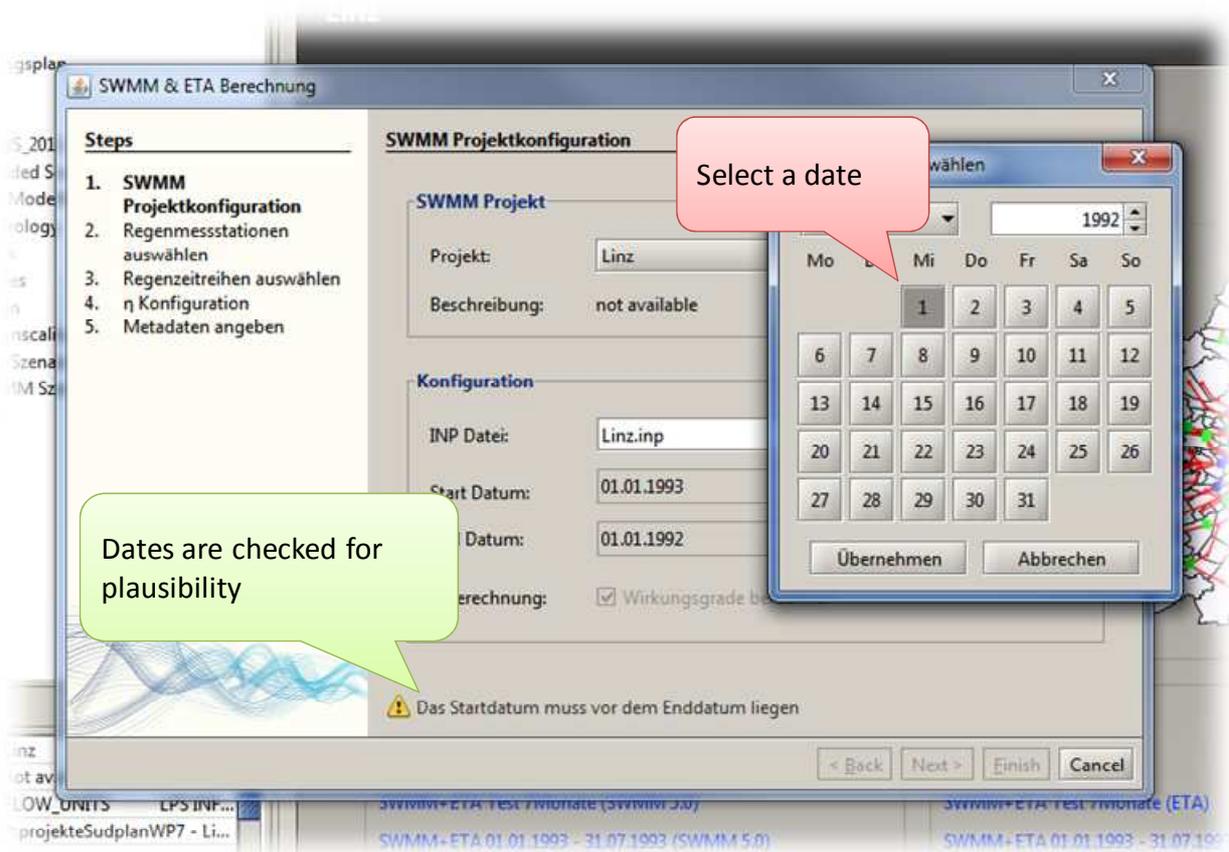
Figure 38: Date Plausibility Check

On the next wizard page (Figure 39) the user can select one or more rainfall measurement stations and decide whether he wants to run the model with historical or predicated (downscaled) rainfall time series. Again, it is not possible to advance to the next page unless at least one measurement station has been selected.
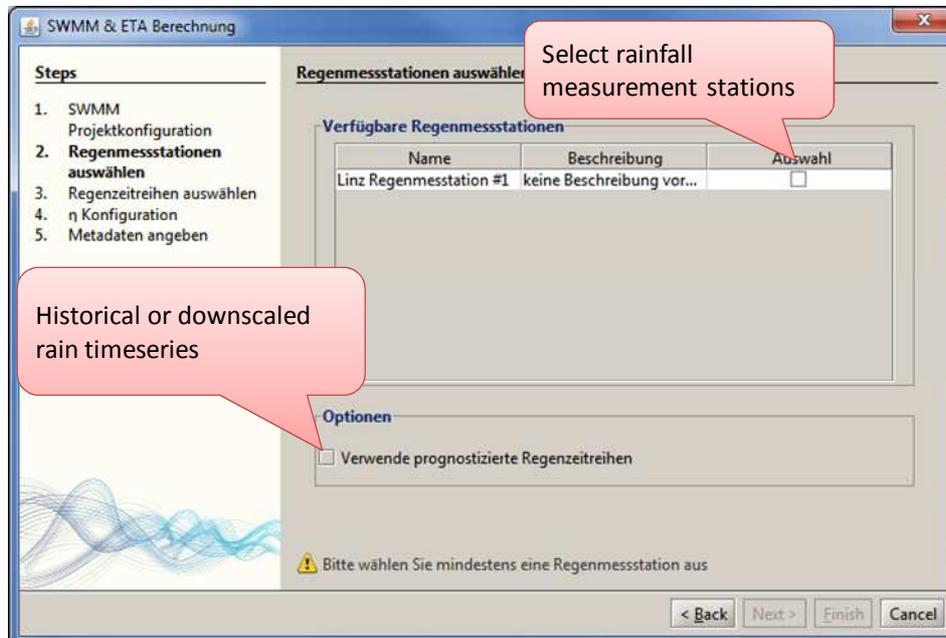
Figure 39: Select Rainfall Measurement Stations

On the next page (Figure 40) all rainfall time series of the rainfall measurement stations selected in the previous steps (Figure 39) are shown. The user has to select as least one time series in order to be able to advance to the next page. An additional plausibility check which checks the temporal coverage of the selected time series against the model start and end dates specified in Figure 38.
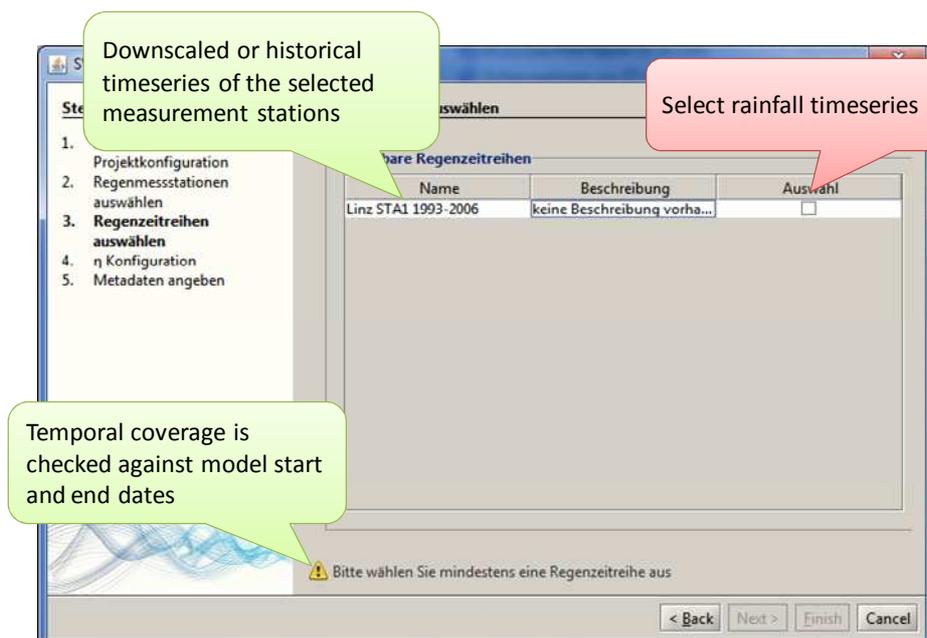
Figure 40: Select Rainfall Time series

Once the user has chosen the desired rainfall time series, he can furthermore specify the CSO sedimentation efficiency rates that will be used for the overall efficiency calculation (Figure 41). As already stated, the possibility for a separate efficiency calculation will be provided in V3 of the pilot. This case, the user can choose from a calculated SWMM model results (overflow calculation, see Figure 45), thus steps 1-4 of the current SWMM & ETA Wizard can be omitted.
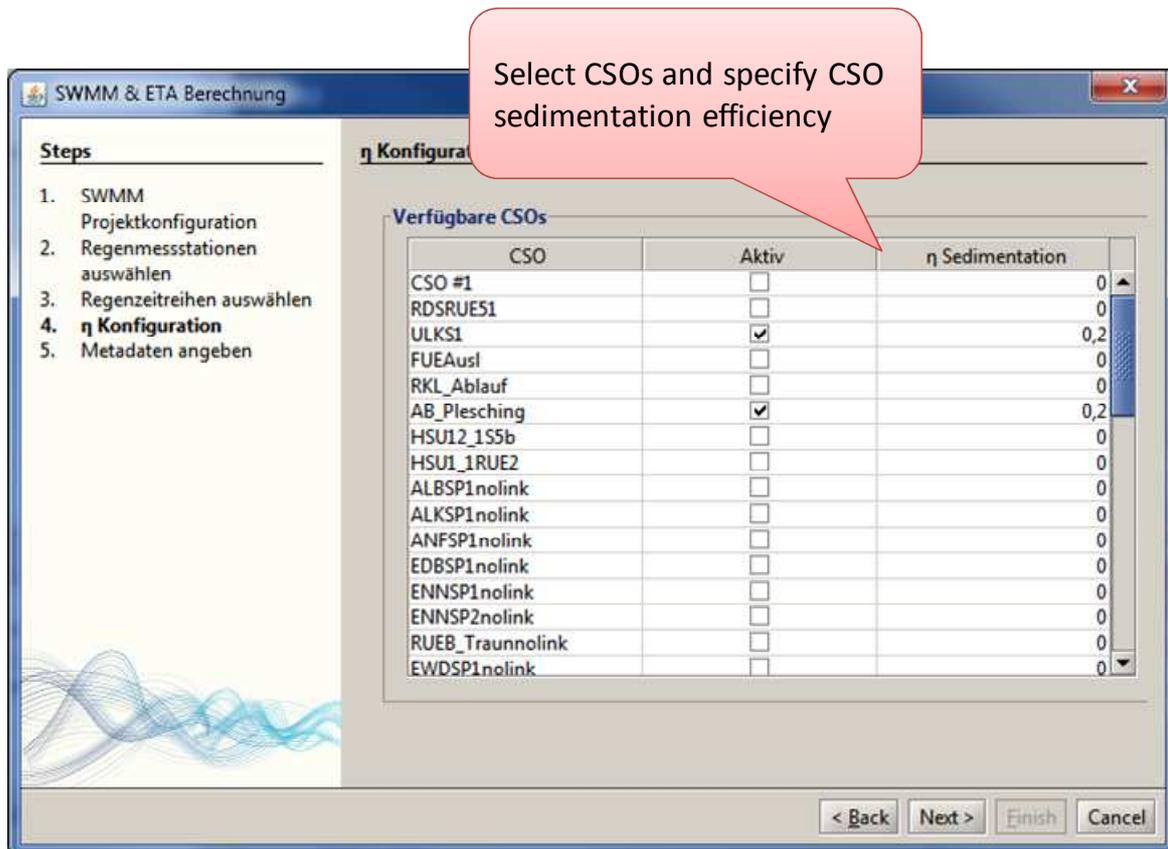
Figure 41: Specify CSO Sedimentation Efficiency

Although the wizard presents overflow and efficiency calculation as one unit, they are still two separate model runs which are executed synchronously. In V3 of the pilot application it will be possible to perform a separate efficiency calculation.

On the last page of the wizard (Figure 42) the user is asked to enter a name and an optional description of the model run. The configuration of the overflow and efficiency calculation is now complete. Upon click on the finish button, the SOS and SPS are invoked as described in section 5.2.
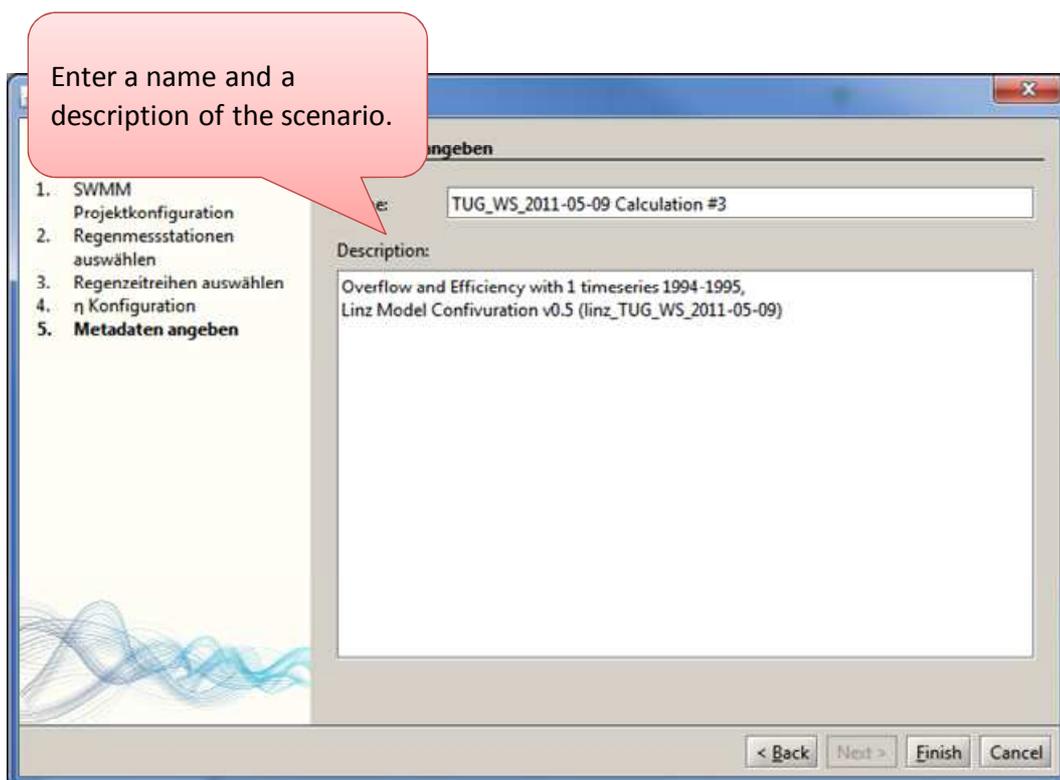
Figure 42: Name and Description of the Scenario

The SWMM model execution status can be monitored in the catalogue (Figure 26) and the respective description page (Figure 43). Among some descriptive meta-information like start of the model run and current status, the description page provides also direct links to the model results as well as to the input configuration.
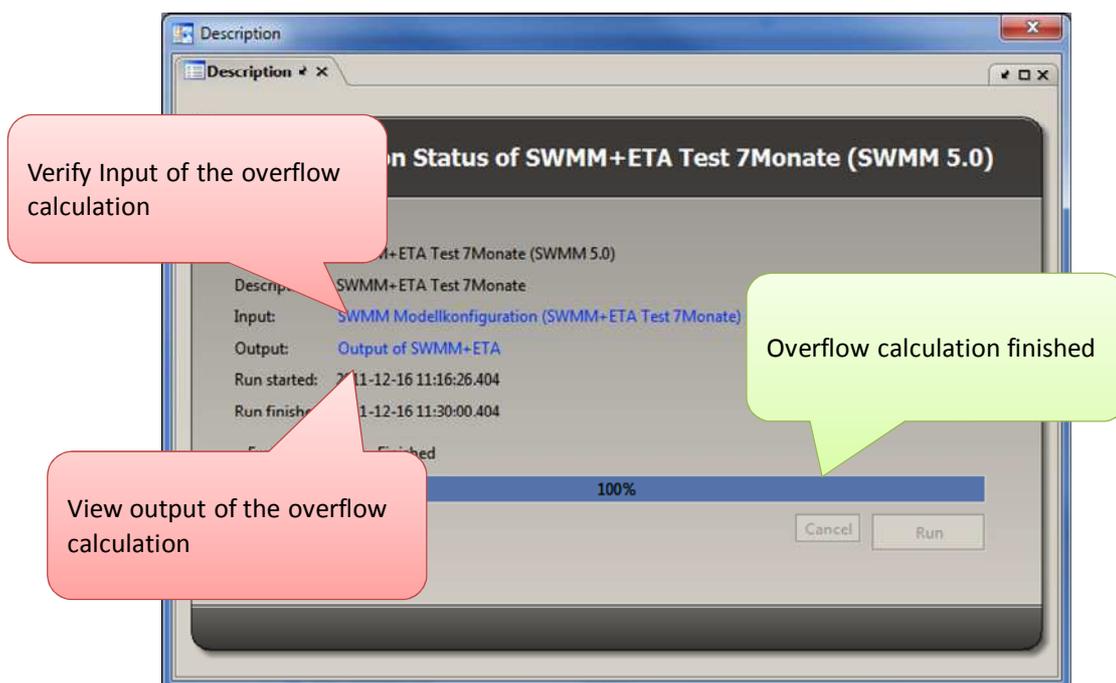
Figure 43: Overflow Calculation finished

The SWMM model input configuration shown in Figure 44 provides also links to the selected model configuration (Figure 36) and time series (Figure 35).
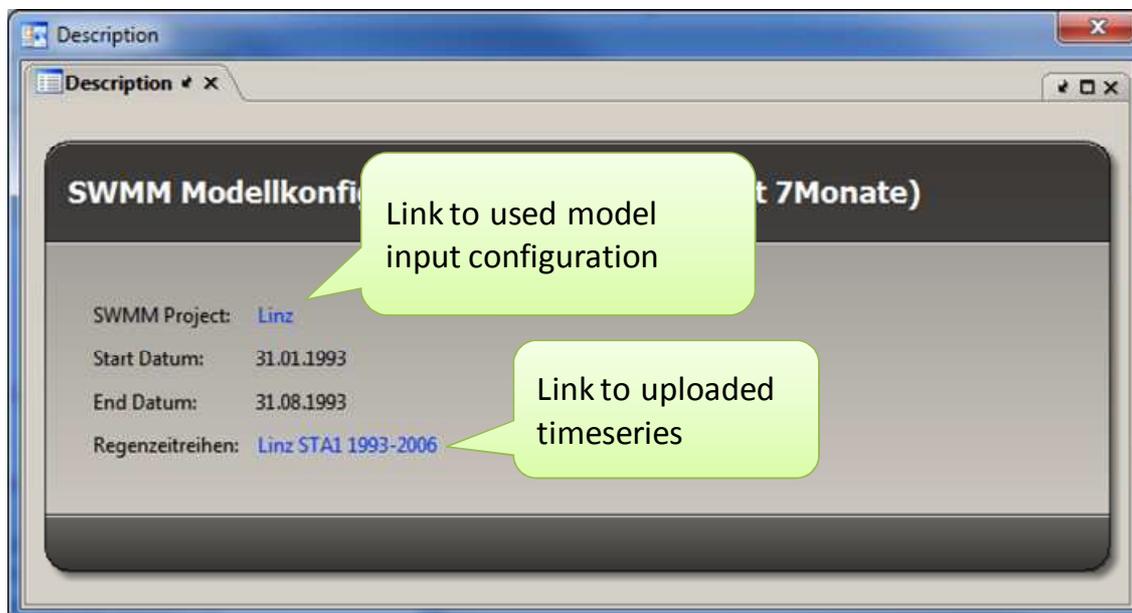
Figure 44: Verify Input of Overflow Calculation

In Figure 45 the results of the overflow calculation (SWMM) are shown.
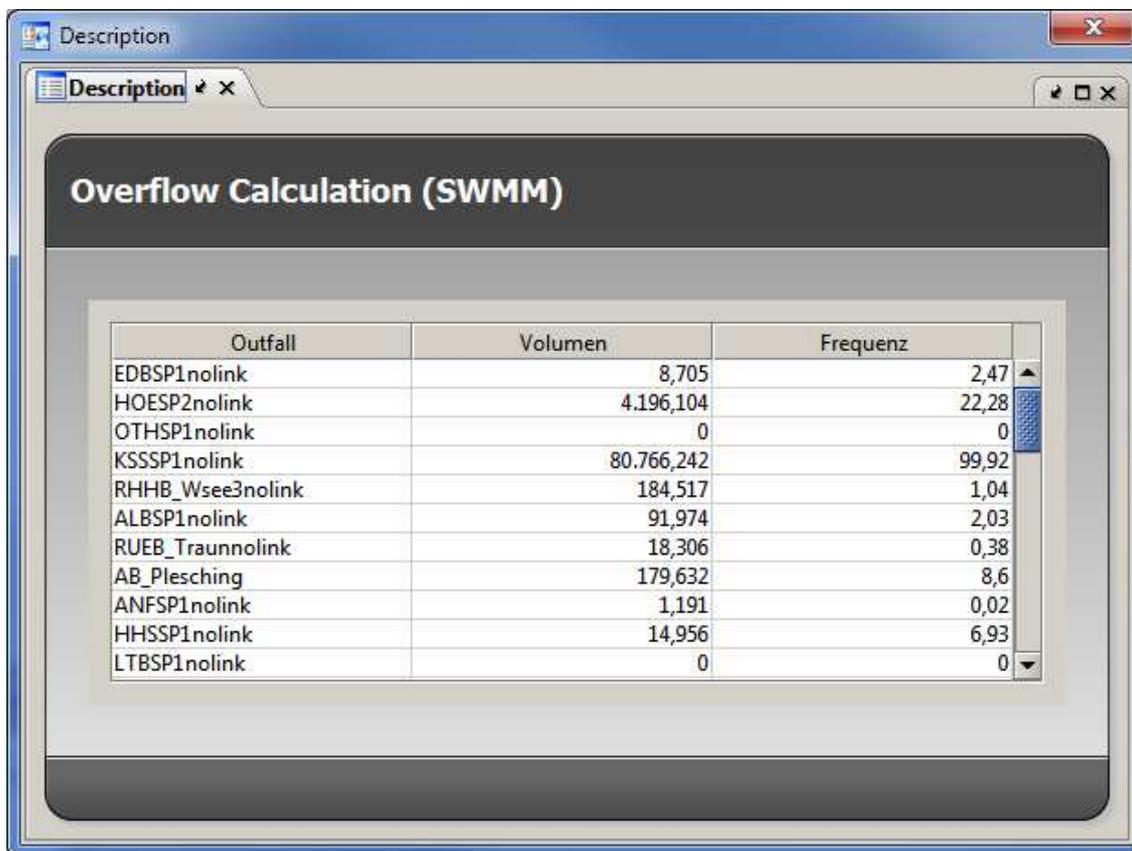
Figure 45: View Output of Overflow Calculation

The model run status page of the ETA calculation (Figure 46) provides also links to the input configuration and the model results.
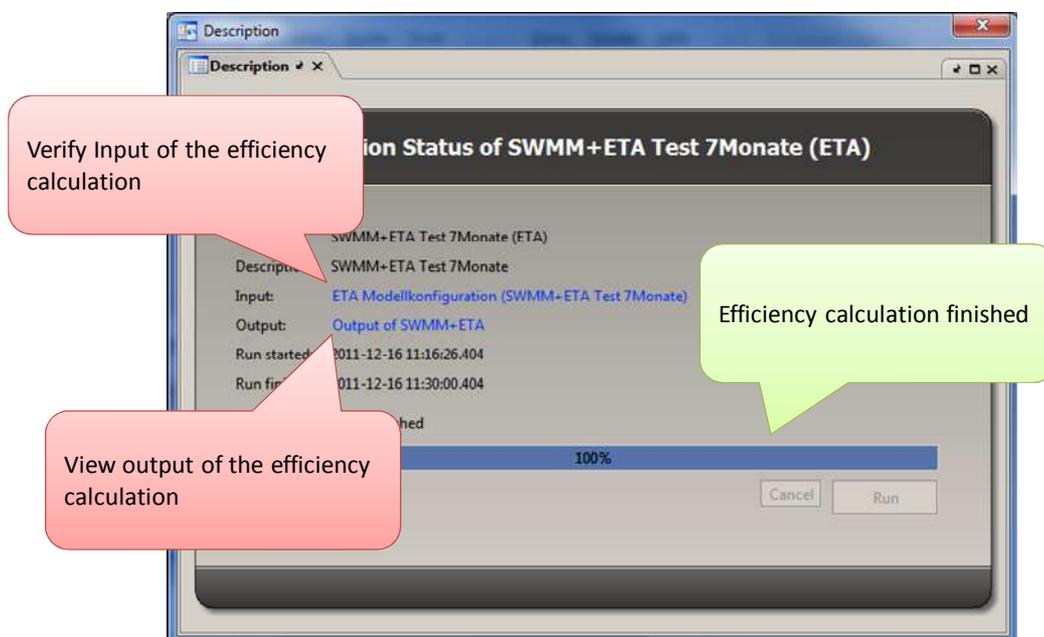
Figure 46: Efficiency Calculation finished

The input configuration of the ETA run can be verified as shown in Figure 47. Please note that this is the same table as previously filled out in the wizard (Figure 41).
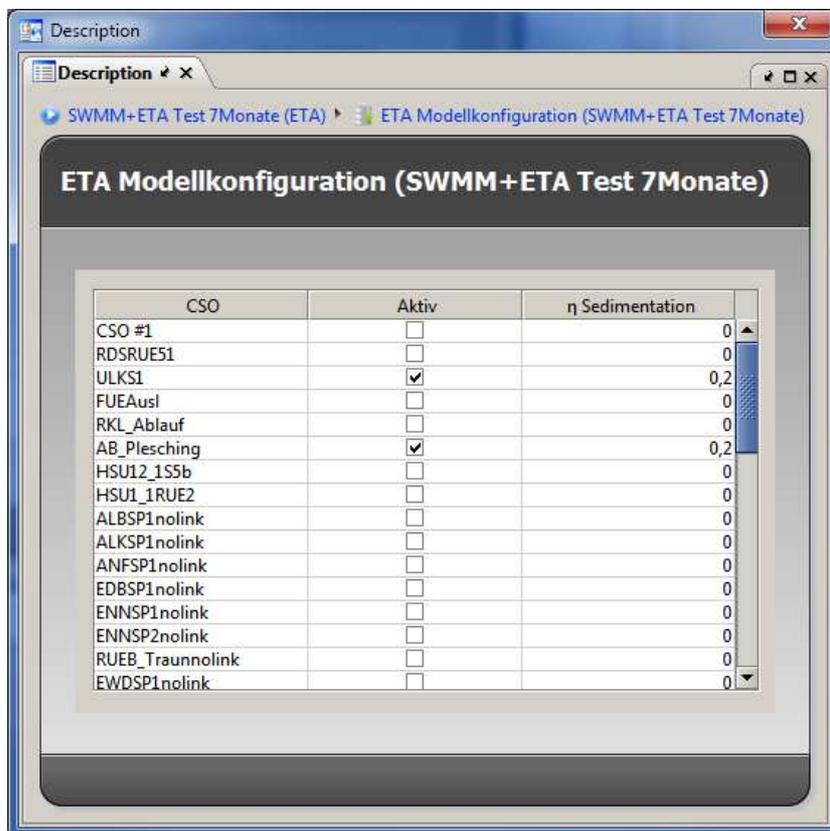
Figure 47: Verify Input of Efficiency Calculation

The output of the ETA calculation, the required and calculated efficiency rates, is shown in Figure 48. The meaning of the values is explained in section 2.1.4.
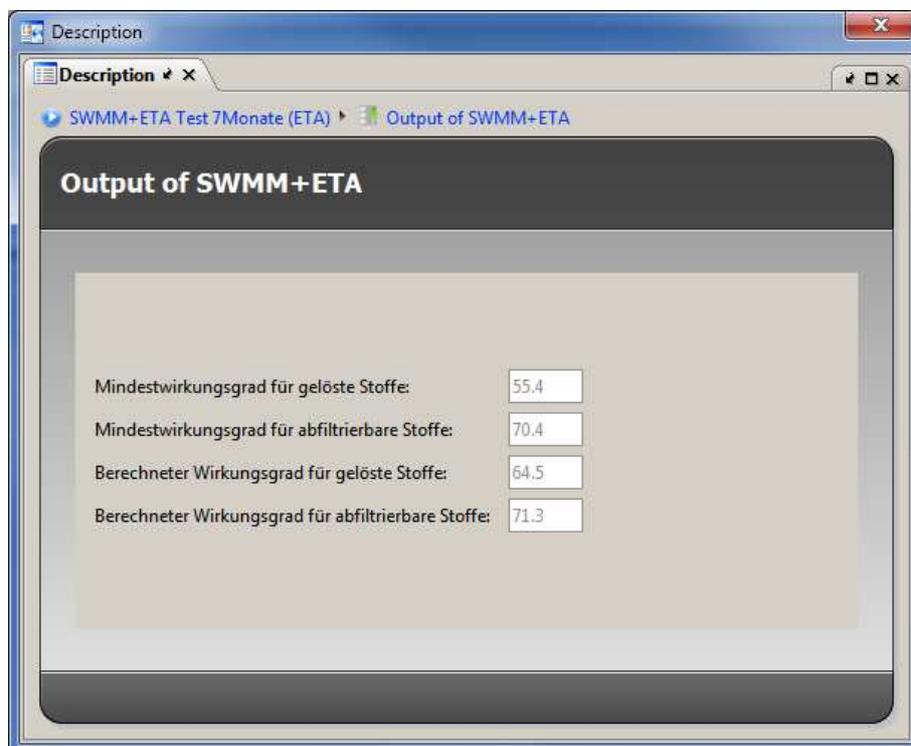
Figure 48: View Output of Efficiency Calculation

Visualisation of SWMM features is shown in Figure 49 and Figure 50. The user can double click on a feature to visualise it on the map. Depending on the type of the feature it is rendered as point or as polygon. It is also possible to customise the look & feel of a certain feature type (e.g. outfalls, subcatchments, etc) including also the feature name shown on the map (Figure 51).
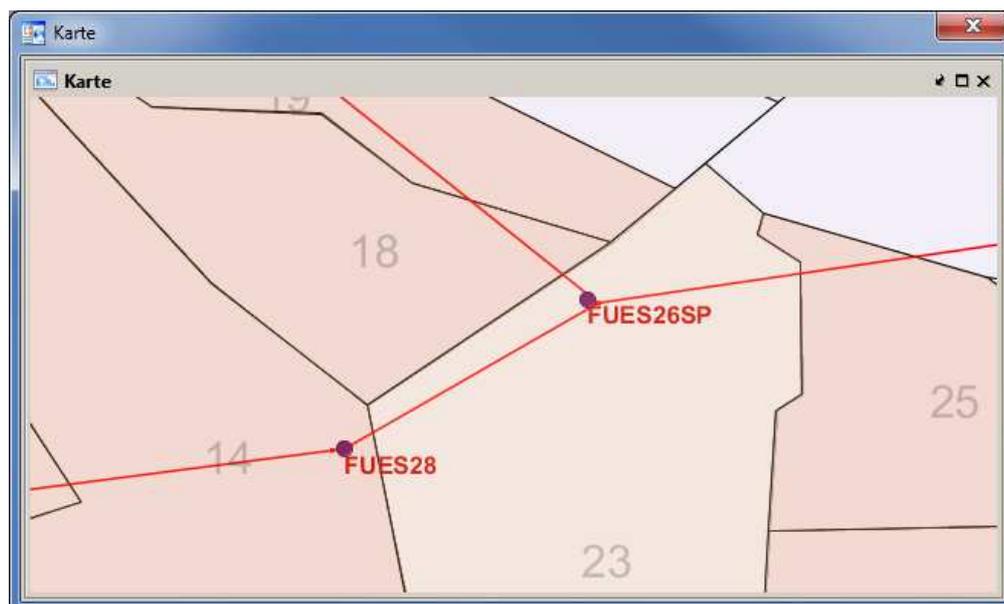
Figure 49: Visualisation of SWMM Features
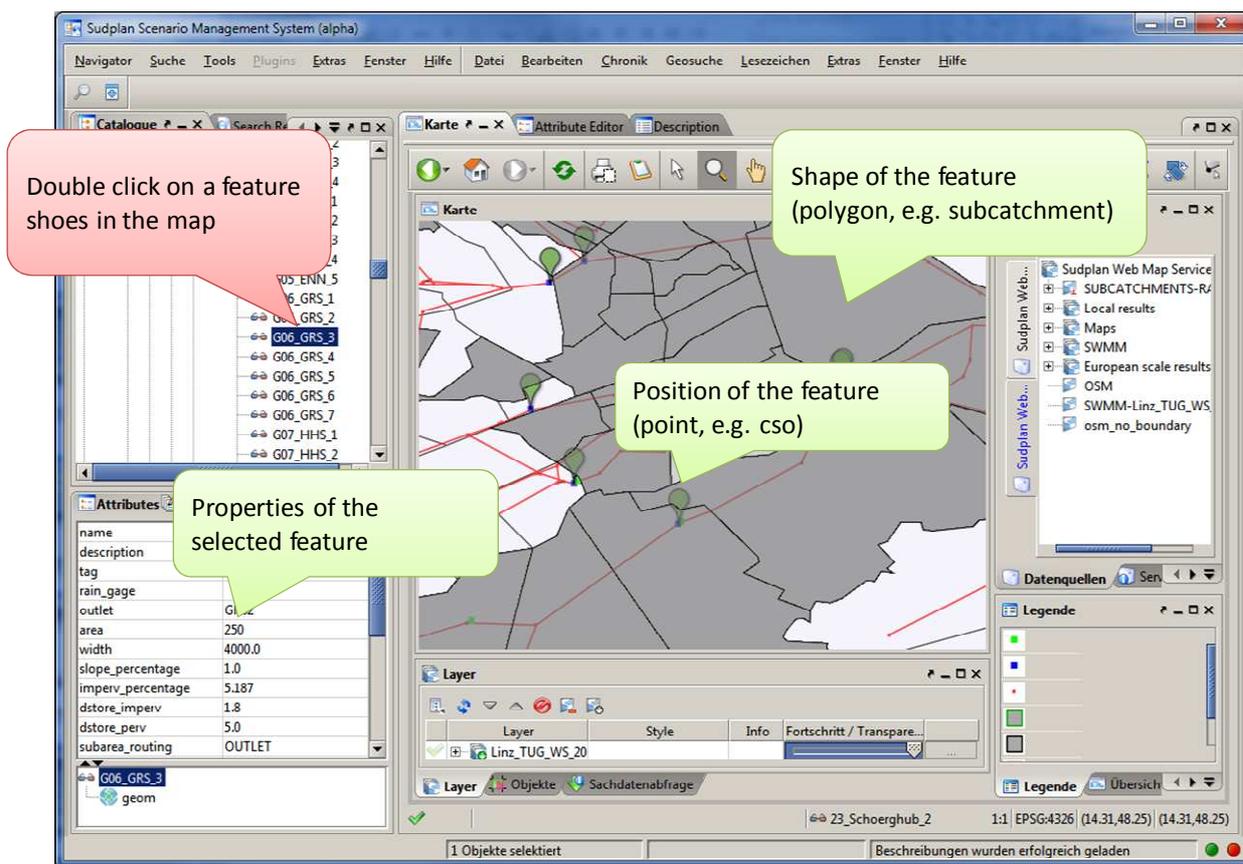
Figure 50: Show the SWMM Model Configuration on the Map
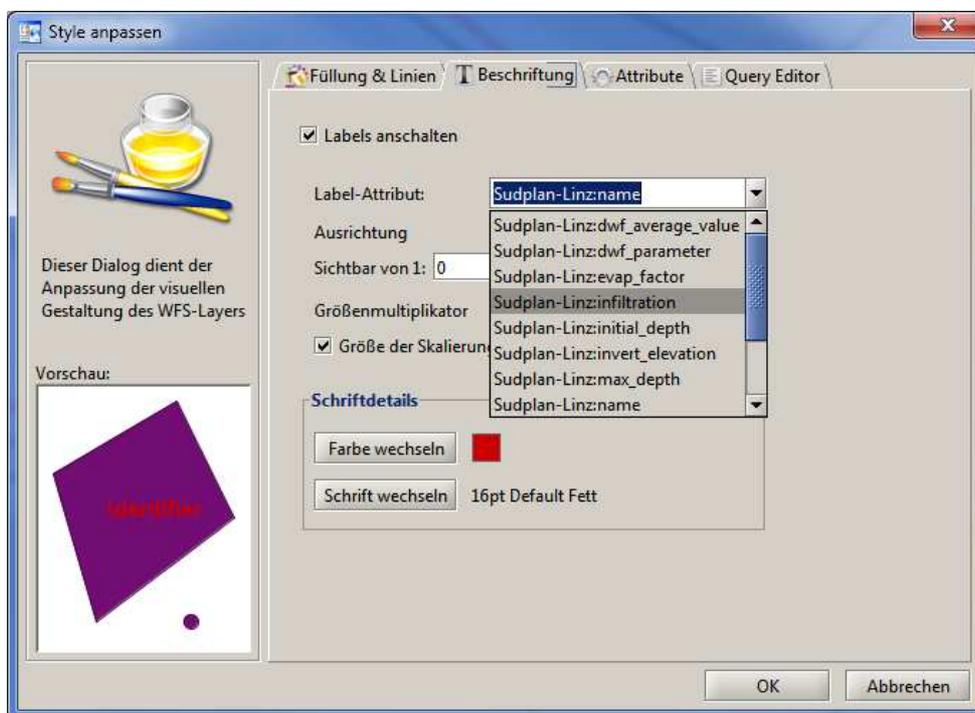
Figure 51: Customise Feature Look & Feel

5.2. Services

The Linz pilot uses some services from SUDPLAN which provide access to data and models. The services are briefly listed and described in the following. A generic description of the services used in SUDPLAN is given in the documentation of WP 4 (Common Services) and in the "Abstract Service Specification" document that is available from http://sudplan.ait.ac.at/SUDPLAN_service_specifications/.

The overall workflow between the pilot SMS and the services is shown in Figure 52.
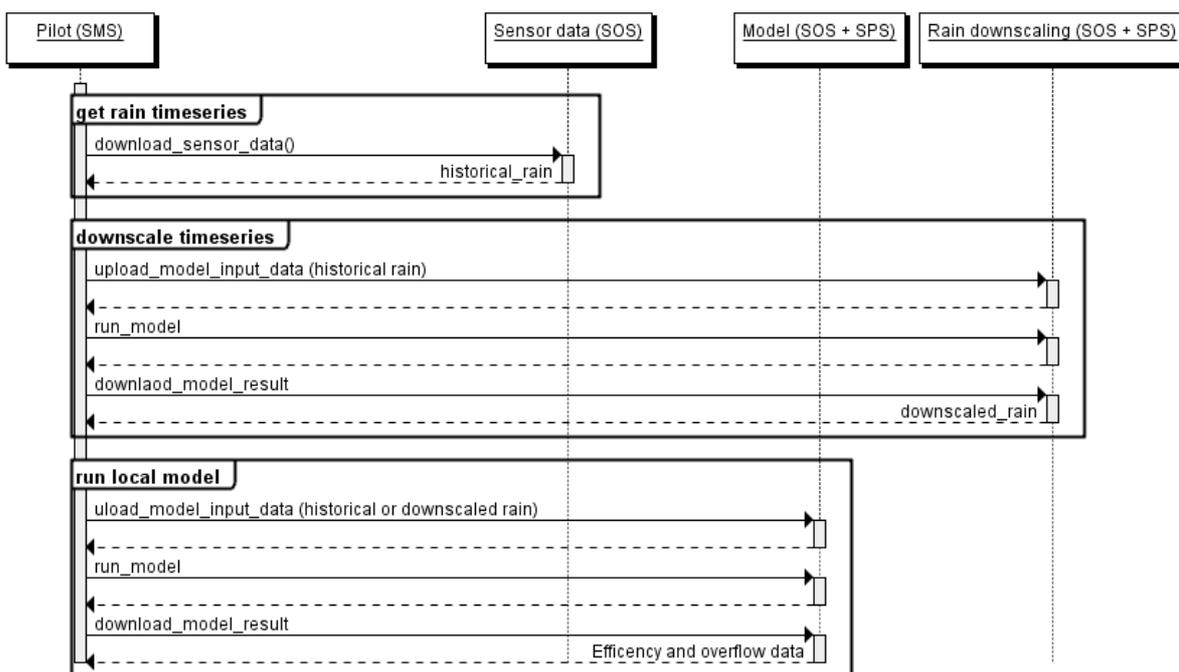
Figure 52: overall workflow between the pilot SMS and the services

5.2.1 Access to sensor data measured in the Linz area

The sensor data include a historical rain time series in the length and temporal resolution as required by the local Linz model. Additionally actual measurements from the wastewater treatment plant sensor network are provided.
All this data is provided using an OGC SOS interface. This interface is described in detail in the "SUDPLAN Service implementation specification - Local Linz Model" document that available from http://sudplan.ait.ac.at/SUDPLAN_service_specifications/.

5.2.2 Access to the local Linz model

Access to the local Linz model that is described in detail in 2.1 is provided by a pair of an OGC SOS and an OGC SPS interface. Both are described in detail in the "SUDPLAN Service implementation specification - Local Linz Model" document that is available from http://sudplan.ait.ac.at/SUDPLAN_service_specifications/.

5.2.3   Access to the rain time series downscaling service

This common service is running at SMHI and provides the ability to get a projection of a historical time series (as provided by the sensor data service described above) into the future under the assumptions of one of the provided climate scenarios. Access to the rain time series downscaling model is provided by a pair of an OGC SOS and an OGC SPS interface. Both are described in detail in "SUDPLAN Service implementation specification - Common Services - Rainfall Downscaling" available from http://sudplan.ait.ac.at/SUDPLAN_service_specifications/ and the WP 4 deliverables.

6. End User Involvement

End users have been involved on a continuous basis in dedicated workshops and meetings to discuss the required functionality of the Linz pilot application. Since the focus in the second year was on the integration of the Common Services, the used local model, the SMS and the design and installation of the sensor network, the most valuable input has come from one primary user who will intensely interact with these components in the future. The user concerning this matter is employed by the LINZ AG, has already experiences in the application of hydrological models and is also responsible for the SUDPLAN project. Fortunately he could also convince the management of LINZ AG to make some extra funding for the sensor network available. He is also a member of the 'Storm Water Management' group at LINZ AG.

Secondary users, especially urban planners of other departments than Urban Drainage, are supposed to have their focus on the visualizations and reports generated by the SMS, because they need a quick understanding of the outcome of a certain simulation. Hence they will be actively involved in the third year of the project, since the implementation of advanced visualizations and generated reports is part of the work in that year.

6.1. End User Profiles

As stated above, LINZ's Storm Water Managers constitute the first group of end users that has to be involved in this phase of the project. These individuals are very comfortable with computers. As modellers they will want to interact with the local models used in the pilot and they may have some familiarity with precipitation models. However, they will likely have little or no experience with climate models. They may or may not have sophisticated GIS experience.

The Storm Water Managers form a very small group within the LINZ AG.

In the course of the general wastewater management process most of the necessary engineering work is done by LINZ AG itself, in some cases they are also consulting engineering companies to support them. They have also some in house modelling capabilities. Therefore they will use the Linz pilot application in the future mainly by themselves.

6.2. Meeting Log

The following table gives an overview over the end user consultations for the Linz pilot application in the first two years of the SUDPLAN project:

No.	Type of meeting	Date	Location	End Users present	Main results
1	Start-up Meeting on available data and local models	09.02.2010	LINZ (AUT)	Storm Water Managers: Peter Schweighofer and Martin Hochedlinger (LINZ AG)	Survey on available data and local models for long term surface run-off modelling

2	Meeting	04.03.2010	WWTP Linz (AUT)	Martin Hochedlinger (LINZ AG) and Thomas Gamperer (Head of WWTP, LINZ AG)	Design and installation of the sensor network
3	Workshop on available local models	06.08.2010	LINZ (AUT)	Martin Hochedlinger (LINZ AG) and colleagues of University of Innsbruck	Pro and cons of available local models
4	SWMM Workshop	26.01.2011	LINZ (AUT)	Martin Hochedlinger (LINZ AG) and colleagues of University of Innsbruck	Introduction and requirements for the SWMM model
5	Meeting	27.01.2011	WWTP Linz (AUT)	Martin Hochedlinger (LINZ AG) and Raimund Erber (Austrian s::can Distributor)	Design and installation of the sensor network
6	Technical Tour	10.03.2011	LINZ (AUT)	Martin Hochedlinger (LINZ AG)	CSO Survey Tour in the Linz catchment area
7	Installation	22.11.2011	WWTP Linz (AUT)	Martin Hochedlinger (LINZ AG) and Raimund Erber (Austrian s::can Distributor)	Installation of the sensor network (Outflow) and commissioning
8	Installation	02.12.2011	WWTP Linz (AUT)	Martin Hochedlinger and Johann Schinninger (LINZ AG) and Raimund Erber (Austrian s::can Distributor)	Installation of the sensor network (Inflow) and commissioning; definition of additional data demand from WWTP

7. Conclusions

The Linz pilot focuses on the development and set up an information system based on WP3 and WP4 results that incorporate common services and local model components to include the aspects of climate change into the problem of combined sewer overflows into receiving waters. Since it can be assumed that during more frequent and heavier rainfalls the overflow duration of these facilities and the spilled out pollution loads to receiving waters will also increase, possible climate changes might have crucial impacts to the aquatic environment. By comparing the results of today's and of future scenarios possible effects and changes can be recognised and located and proper strategic adaptations can be developed within the catchment area in time.

During phase 1 of the SUDPLAN project preparatory work has been carried out

- to screen all available catchment and measurement data in the area of the Linz pilot,

- to decide on historical rainfall data which are used by Common Services for regional downscaling and for future scenarios and

- to select a proper simulation model for the calculation of CSO efficiency rates based on long term simulation runs.

From the two simulation models available for the Linz catchment area the SWMM model was selected.

During phase 2 the following tasks have been carried out successfully:

- An instance of the scenario management system was set up integrating the SWMM model configuration (basic Linz Pilot Application).

- The SWMM model was wrapped in a OGC compliant Service Implementation (Sensor Observation Service, Sensor Planning Service) to control and access results.

- The OGC compliant service was integrated into the Linz Pilot Application.

- Subsequently the model was analysed and calibrated using state-of-the art global sensitivity analysis methods and optimisation algorithms.

- Scripts were developed to automatically calculate the actual and required efficiency rates defined in the Austrian Regelblatt 19 guideline from any given rainfall time series and SWMM model output.

- With these prerequisites fulfilled a first evaluation and comparison of historical time series and one future predicted scenario was carried out.

- Recently the sensor network at Linz WWTP was installed and is now in full operation.

First implementation of the Linz Pilot Application on the basis of the Scenario Management System is now available, integrating the SWMM model with geographic referencing, the downscaled rainfall time series and the required additional information e.g. for sedimentation efficiency. SWMM model and scripts for evaluation run on servers and results are transferred.

Although a first integration of the essential elements (CS, SMS, SWMM) into the Linz Pilot Application has been achieved that can be the basis for the upcoming validation work, the current system is only in alpha state and need a considerable number of improvements to be applicable in the foreseen real word context. These improvements are the focus of Y3 work and will include: refactoring of the service implementation, stable service communication, consideration of frequency changes for downscaled time series, integration of the sensor network, and enhanced visualisation and use case support.

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9. Glossary

technical term	Explanation
CSO efficiency rate η	Indicator for yearly emitted CSO pollution loads from combined sewerage to receiving waters regarding to the Austrian standard ÖWAV Regelblatt 19 (OEWAV 2007). It distinguishes between two different kinds of CSO efficiency: one for dissolved pollutants (η_d) and one for particulate pollutants (η_p).
Mockup	A model of a design used for demonstrating the functionality of a system.

10. Acronyms and Abbreviations

acronym / abbreviation	Definition
AIT	Austrian Institute of Technology
cids	Component Integration for Distributed Systems
COD	Chemical Oxygen Demand
CSO	Combined Sewer Overflow
GSA	Global Sensitivity Analysis
netCDF	Network Common Data Form
OGC	Open Geospatial Consortium
OpenSDM	Open Scientific Data Management
SMS	Scenario Management System (SUDPLAN functionality)
SOS	Sensor Observation Service
SPS	Sensor Planning Service
SWMM	Storm Water Management Model
TSS	Total Suspended Solid
US-EPA	United States Environmental Protection Agency
WWTP	Waste Water Treatment Plant